SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES

WATERVOORSIENINGS- EN DREINERINGSDIENSTE IN ONTWIKKELENDE LANDE

PROCEEDINGS OF THE SEMINAR ON WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
VERRIGTINGE VAN DIE SEMINAAR OOR WATERVOORSIENINGS- EN DREINERINGSDIENSTE IN ONTWIKKELENDE LANDE

PRETORIA 1980

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LIST OF DELEGATES

LYS VAN AFGEVAARDIGDES

ADAMSON, A A
P O Box 1748
SALISBURY
Zimbabwe

AITCHISON, N H
(Delegate and Exhibitor)
P O Box 49
MEYERTON
1960

ANTONI, Pr Eng G F
P O Box 827
PINETOWN
3600

AUCAMP, Dr P J
South African Water Information Centre
CSIR
P O Box 395
PRETORIA
0001

BADENHORST, J G
P O Box 1341
PRETORIA
0001

BADENHORST, P J
P O Box 1987
BLOEMFONTEIN
9300

BADENHORST, T P
P O Box 384
PRETORIA
0001

BAILEY, K V
Castle Brass Works (Pty) Ltd
P O Box 4082
LUIPAARDSVLEI
1743

BARRY, E H
Private Bag X5083
UMTATA
Transkei

BATH, G E
(Author)
Dept of Community Development
Private Bag X149
PRETORIA
0001

BEKKER, A P
(Spreker)
Direktoraat van Waterwese
Privaatsak X313
PRETORIA
0001

BERTOT, Arq G J
Director
Nacional de Politica Habitacional
Secr de Estado de Desarollo
Urbano y Vivienda
Defensa 120-3o
BUENOS AIRES
Argentina

BESTER, J
P O Box 20286
ALKANTRANT
0005

BLAKEMORE, B W
(Exhibitor)
S A Rigid Plastic Pipe & Fittings
P O Box 6684
JOHANNESBURG
2000

BOTHA, J
(Rapporteur)
NBRI
CSIR
P O Box 395
PRETORIA
0001

BOTHMA, C H J
P O Box 384
PRETORIA
0001

BURGER, L
(Exhibitor)
c/o Miss L Fourie
Everite
P O Box 31166
BRAAMFONTEIN
2017

BURGESS, G
44 Flamboyant Ave Ext 1
P O MATAFFIN
1205

BURMEISTER, G D
P O Box 1496
WINDHOEK
9100

CARR, C J
P O Box 1583
SALISBURY
Zimbabwe

COETZEE, P S
Private Bag X30
ROODEPOORT
1725

CONRADIE, W G
Provinsielaan 36
STELLENBOSCH
7600

CRABTREE, P R
(Author and Chairman)
NBRI
CSIR
P O Box 395
PRETORIA
0001

CRAIG, R J
P O Box 38
KEWWYN
7780

DAVIS, A B
(Author)
c/o City Engineers Dept
P O Box 680
DURBAN
4000

DE JAGER, G T
P O Box 51242
RANDBURG
2125

DE KRUIJFF, G J W
(Author)
Univ of Nairobi
P O Box 30197
NAIROBI
Kenya

DE WET, E
(Exhibitor)
Sales Manager
Vitro Clay Pipes Ltd
P O Box 49
VEREENIGING
1930

DE WET, F J
NIWR
CSIR
P O Box 395
PRETORIA
0001

DU PLESSIS, C J
P O Box 3573
PRETORIA
0001

DU PLESSIS, M
Private Bag X228
PRETORIA
0001

DU PLESSIS, P A
(Author)
WRAB
P O Box 4414
JOHANNESBURG
2000

DU TOIT, F P
(Author)
Conservation & Extension
P O Box 8117
Causeway
SALISBURY
Zimbabwe

DU TOIT, J F S
P O Box 14
OTTERY
7808

EVANS. E T
S A Bureau of Standards
Private Bag X191
PRETORIA
0001

FINLAYSON, K A
NBRI
CSIR
P O Box 395
PRETORIA
0001

FRANKLIN, S
P O Box 17251
HILLBROW
Johannesburg

GERBER, C J
P O Box 19
GEORGE
6530

GERBER, R P
Pipekor (Pty) Ltd
P O Box 1119
Chamdor
KRUGERSDORP
1740

HABGOOD, M B
P O Box 1641
BULAWAYO
Zimbabwe

HEFER, F P
P O Box 20286
ALKANTRANT
0005

HOLLING, G
c/o Engineering Management Service
P O Box 585
BEDFORDVIEW
2008

HOLLINGWORTH, B E
Duropenta (Pty) Ltd
P O Box 86
NEW GERMANY
3620

ISAAC, P D
P O Box 3251
PRETORIA
0001

KELLER, H
P O Box 204
PRETORIA
0001

KELLY, E J
c/o Turnall A C (Pty) Ltd
P O Box 3985
SALISBURY
Zimbabwe

KEYSER, A J
P G J Meiring en Vennote
Posbus 28734
SUNNYSIDE
0132

KLEINVELDT, L L
Prestige Construction
P O Box 4
TSHANENI
Swaziland

KNOBLAUCH, Prof H J
(Author)
Heiligenseestr 622
D-1000
BERLIN 2F
West Germany

KOCKS, Dr D J
Private Bag X88
PRETORIA
0001

KOEN, J M
P O Box 384
PRETORIA
0001

KOORTS, C
City Engineer
Municipality of Parys
P O Box 359
PARYS
9585

KRIEL, P J
Drakensberg Administration Board
P O Box 1724
PIETERMARITZBURG
3200

LAME, E A
P O Box 60
SASOLBURG
9570

LANGLEY, P G
P O Box 275
MELMOTH
3835

LAWES, Eng J F
P O Box 1353
BULAWAYO
Zimbabwe

LAWLOR, B
P O Box 9859
JOHANNESBURG
2000

LEGG, H G
c/o Ninham Shand Ing
P O Box 1347
CAPE TOWN
8000

LOOTS, J J
Port Natal Administration Board
Private Bag X54310
DURBAN
4000

LOTRIET, A H
P O Box 905
PRETORIA
0001

LUNG, B G A
P O Box 61272
MARSHALLTOWN
2107

LUND, K A H
P O Box 3106
WINDHOEK
9000

MALAN, G J
(Rapporteur)
NBRI
CSIR
P O Box 395
PRETORIA
0001

MALAN, H B
201 Tygerberg Centre
BELLVILLE
7530

MAPHUMULO, M P
Senior Health Inspector
Dept of Health & Welfare
Private Bag X10
ULUNDI
3838

MATIELA, S M
Health Dept
UMTATA
Transkei

MATLOCK, R O
East Cape Administration Board
P O Box 14025
SIDWELL
Port Elizabeth
6061

MEAKER, G S
(Delegate & Exhibitor)
Cobra Brassware (Pty) Ltd
20 Wright Street
FACTORIA
1743

MEIER, R
Geberit AG
CH-8640 RAPPERSWIL
Switzerland

MILES, L C
(Rapporteur)
NBRI
CSIR
P O Box 395
PRETORIA
0001

MILLS, A J
P O Box 256
EAST LONDON
5200

MINNAAR, T H
P O Box 2313
BLOEMFONTEIN
9300

MKATINI, M W M
Dept of Local Government & Land Tenure
TRANSKEI

MLYNAREK, L H O
P O Box 31166
BRAAMFONTEIN
2017

MOORE, D
NBRI
CSIR
P O Box 395
PRETORIA
0001

MOORHOUSE, M A
Main Industries (Pty) Ltd
P O Box 2762
JOHANNESBURG
2000

MORGAN, R A
(Author)
Melbourne & Metropolitan Board of Works
625 Little Collins Street
MELBOURNE
Australia

MURDOCH, A
NBRI
CSIR
P O Box 395
PRETORIA
0001

NEGUKHULA, J
SIBASA
0970

NEPFUMBADA, H A
SIBASA
0970

NIELSEN, T P
East Cape Administration Board
P O Box 14025
SIDWELL
Port Elizabeth
6061

NORMAN, M F
P O Box 1748
SALISBURY
Zimbabwe

NORTJE, C J
P O Box 31166
BRAAMFONTEIN
2017

NORTON, G K
P O Box 4048
JOHANNESBURG
2000

OLIVEIRA, C A G R
417 Orion Avenue
PRETORIA
0002

OSBORNE, D C
Kwazulu Dept of Works
Private Bag X03
ULUNDI
3838

PEARSON
Consulting Engineer
P O Box 52179
SAXONWOLD
2132

PERRIER, F
(Author)
CSTB - 77428
MARNE-LA-VALLEE
Cedex 2
France

PITTAWAY, C D
(Exhibitor)
Asst Marketing Manager
Cobra Brass
P O Box 4095
LUIPAARDSVLEI
1743

POWELL, G E
Roodepoort City Council
Private Bag X30
ROODEPOORT
1725

PRINSLOO, C
NBRI
CSIR
P O Box 395
PRETORIA
0001

PYBUS, P J
Stewart, Sviridov & Olivier
P O Box 61672
MARSHALLTOWN
2107

RAAFF, C B
Campbell, Bernstein & Irving
P O Box 627
Sloane Park
RANDBURG
2125

RABE, J S
c/o Cobra Ceramics
ALBERTON
1450

RADFORD, M D
University of Fort Hare
P O Box 1314
ALICE
5700

READ, P C
NBRI
CSIR
P O Box 395
PRETORIA
0001

REINECKE, D T
Hawkins, Hawkins & Osborn
P O Box 244
RIVONIA
2128

RILEY, S P S
P O Box 1641
PRETORIA
0001

ROBERTSON, L H
(Author)
Private Bag 311
Capital City
LILONGWE 3
Malawi

SCANES, R L
P O Box 416
PIETERMARITZBURG
3200

SCOTT, D A N
Private Bag X9078
CAPE TOWN
8000

SEALBY, R T
P O Box 484
SPRINGS
1560

SEERY, J
c/o City Engineers Dept
P O Box 680
DURBAN
4000

SILBERSTEIN
(Author)
The Standard Institution of Israel
42 University Street
TEL-AVIV
69977

SIMPSON, G C
(Rapporteur)
NBRI
CSIR
P O Box 395
PRETORIA
0001

SKINNER, D H H
Stewart, Sviridov & Olivier
P O Box 61672
MARSHALLTOWN
2107

SMITH, A R
Nathan Milner (Pty) Ltd
P O Box 373
EPPINDUST
7475

SMUTS, M C T
Nathan Milner (Pty) Ltd
P O Box 373
EPPINDUST
7475

STEVENS, T
(Exhibitor)
Castle Brass Works (Pty) Ltd
P O Box 82
LUIPAARDSVLEI
1743

STEYN, The Honourable S J M (Opening address)
(Then) Minister of Community Development,
Coloured Relations and Indian Affairs
Private Bag
PRETORIA
0001

STIER, H
P O Box 484
SPRINGS
1560

STOKOE, D M
c/o Curopenta (Pty) Ltd
P O Box 86
NEW GERMANY
3620

SWART, Mrs M
(Seminar Organizer)
NBRI
CSIR
P O Box 395
PRETORIA
0001

SWIFT, B L
P O Box 2606
WINDHOEK
9000

TAKALA, S I
P O Box 29
ROSSLYN
0200

TAYLOR, W L
17 Lindenberg Avenue
DURBANVILLE
7550

TOWNSEND, G
(Exhibitor)
Marketing Manager
Kwikot Ltd
P O Box 389
BENONI
1500

TRINKLER, D
Institut für Bautechnik
Reichpietschufer 72-76
D-1000 BERLIN 30
West Germany

TURNER, R B
Hawkins, Hawkins & Osborn
P O Box 244
RIVONIA
2128

UYS, W J
(Author)
P O Box 384
PRETORIA
0001

VAN AARDE, D
Private Bag X88
PRETORIA
0001

VAN AURICH, T
Brakpan Town Council
P O Box 15
BRAKPAN
1540

VAN DER MERWE, B
Engineering Management Serv Ltd
P O Box 585
BEDFORDVIEW
2008

VAN DER MERWE, M C
P O Box 1226
VANDERBIJLPARK
1900

VAN DEVENTER, Dr E N
Vice President
CSIR
P O Box 395
PRETORIA
0001

VAN DUUREN, Dr F A
Hill Kaplan Scott Inc
240 Kingsley Centre
Church Street
ARCADIA
0007

VAN RENSBURG, L H J
Port Natal Administration Board
Private Bag X54310
DURBAN
4000

VAN STRAATEN, J F
NBRI
CSIR
P O Box 395
PRETORIA
0001

VERSTER, J C
Marley (SA) (Pty) Ltd
P O Box 67
NIGEL
1490

VISAGIE, G J C
P O Box 1641
PRETORIA
0001

VISSER, C J
P O Box 384
PRETORIA
0001

VOYSEY, J A
P O Box 18157
DALBRIDGE
Durban
4014

WALKER, R K
NBRI
CSIR
P O Box 395
PRETORIA
0001

WASSUNG, J
P O Box 3540
DURBAN
4000

WEBB, Dr T L
(Address of welcome)
Director
NBRI
CSIR
P O Box 395
PRETORIA
0001

WEBSTER, C J D
(Author)
Building Research Station
Garston
Watford
HERTS
England

WESSELS, B J S
P O Box 35086
NORTHCLIFF
2115

WESSELS, L
P O Box 11222
BROOKLYN
0011

WIGHTMAN, R A
c/o P O Box 4048
JOHANNESBURG
2000

ADDRESS OF WELCOME/VERWELKOMINGSREDE

by/deur

Dr T L Webb

Director of the NBRI/
Direkteur van die NBNI

I would like to welcome you, Mr Minister, and thank you for taking the time to open this important Seminar today, especially since you will so shortly be leaving South Africa to take up office as our Ambassador in the United Kingdom. Ladies and gentlemen, we have a special affection for Minister Marais Steyn because he has, in his capacity as Minister of Community Development, been a good friend of NBRI for many years, and he and his Department have done a great deal to make our work possible, and to help apply the results of research.

It is also appropriate to pay tribute now to the magnificant work which the Department of Community Development has done under the dynamic leadership of Minister Steyn and his Director-General of Community Development, Mr Louis Fouché, over the last 20 years.

I would also like to welcome the 150 delegates to this seminar, and express the hope that you will have an interesting and productive three days. I would also like to extend a special word of welcome to our 23 delegates from other countries, and an even more special welcome to the 9 speakers from other countries to whom I would like to add our appreciation for the work they have put into preparing their excellent papers.

It's an interesting reflection on both the world wide nature of the problem of water supply and drainage, and the width of the experience of our speakers that between them, they have worked and/or studied in no less than 22 countries on all 6 continents, namely North and South America, Europe, Asia, Australia and Africa. This is therefore a unique occasion on which this world-wide knowledge and experience will be pooled for the benefit of not only developing countries, but also developed countries, and I believe that we can, and should, learn a lot from one another. I also hope that this knowledge will, via bodies such as the CIB of which several of the participants today are active members, find its way to many other countries.

With the objective of providing a background to the papers and their discussion, I would like to make a few general remarks on how research, not only in the fields of water supply and drainage can in both developed and developing countries, be regarded as a resource, in much the same way as money, materials, manpower and energy are resources. In order to qualify as a useful resource, however, such research must meet certain criteria.

First, it must be completely objective. While meaningful research is necessary as a basis for policy decisions, it is not the function of research to determine policy - this is and must remain the prerogative of policymakers. It can, however, be most useful to policymakers if it is valid and impartial, and therefore gives a balanced picture of a matter under investigation. It is easier to be objective when relatively non-contentious technological matters are involved than when, for instance, policy, contractual procedures, economic matters or sociological topics are investigated.

Second, the research must be problem-oriented and realistic in terms of its priorities, scope, execution, and practical application. This means that the problem and the research approach must be such that there is at least a reasonable chance of success, that the nature and complexity of the project is within the limits of competence and other resources of the research workers and the organization undertaking it, and that the results can be applied economically without undue or radical changes in management, technology and labour.

Third, it must be demonstrably relevant and useful to the point where it is essential for the attainment of a given objective. In other words, the economic, social and technological impact of a valid research finding must meet a need and exceed a threshold value, either qualitatively in terms of its importance, or quantitatively in terms of the extent to which it can or will be used.

Fourth, meaningful building research must take into account all the factors concerned. In a complex, multi-disciplinary activity such as building, this means that, in order to be valid, research must cover a wide spectrum of disciplines or activities. These range from pure technology to sociology and finance, and include the assessment of people's wants and needs, management, training and economics - all integrated into a goal-oriented effort, under a single leader, and executed in a 'building' context.

Fifth, it must be planned, and carried out in close collaboration with those requiring the research. This demands good communication, mutual confidence and a full understanding by the research team of the needs of the 'customer', and an appreciation by the 'customer' of the principles and limitations of research. In this connection, research workers should remember that the industry, the professions, the national policymakers and above all the man-in-the-street are not interested in how clever research workers are: they are interested in how useful they can be.

Sixth, it must be completed, reported and applied in a reasonable time. A 'reasonable time' can be anything from a few days to several years. The duration of a research project is, however, frequently difficult to predict in advance, mainly because the project may involve many unknowns. Also, research projects are often interdependent and differ from a production activity in that the progress of the work cannot always be accelerated by putting more men on the job.

Seventh, valid building research must go beyond the mere acquisition and publication of new knowledge, particularly in developing countries, where it is likely that the industry will sometimes lack the necessary specialist expertise. It requires action to ensure not only that the information emerging from research reaches those to whom it can be of value, but that, where required, guidance is given in its interpretation and application. This is one of the reasons why it is necessary for the research organization to disseminate information rather than knowledge: this is what we are hoping to do during this seminar.

Eighth and lastly, it must represent good value for money seen in terms of the benefits derived - certainly in the long term, and where possible, also in the short term. Value and money have very different meanings in developed and developing countries, and in the latter particularly, the cost of research, in terms of a shortage of manpower as well as in monetary terms, must be very critically considered in relation to its likely value.

Planning, execution and application of research

While the same basic principles of planning, executing and applying research are valid in all countries, there are significant differences. Some of the more important considerations in developing countries are:

1. Planning: The research must be planned by people who either fully understand the local problems or who are fully prepared to do so - the 'man from outer space' syndrome must be avoided. This is because many of the attitudes that are valid in developed countries simply do not apply in developing countries and a different, though by no means necessarily less complex, set of criteria must be used.

   In meeting these differences it is neither necessary nor even possible for someone from a developed society to be fully aware of all these subtle differences and changes. However a high degree of sensitivity and tolerance and a preparedness to be guided by local circumstances and people is essential.

2. Execution: In the direction and execution of research, as in its planning, there is a real need to take and accept local resources and contraints into account, in terms of limited facilities, hardware, infrastructure, communication aids and specialized human skills. Qualities such as mental resilience, independence of mind, strong motivation, persistence, patience, and the ability to communicate, to simplify and to improvise, are infinitely more important than intellectual ability or academic achievements judged by the standards of developed countries.

3. Application: In the application of research, certain important principles also apply:

   (a) The whole process of disseminating information and applying research findings is relatively more important in a developing than in a developed country, and consequently requires far more emphasis and effort.

   (b) Because of inevitable limitations in physical facilities, funds and skilled research manpower to undertake research locally, much more use must be made of the research work done in other countries, developing as well as developed. For this reason there is a real need for good two-way communication between the over 600 research institutes in fifty-two countries as listed in the CIB directory of Building Research, Information and Development Organizations.

   (c) The need to adapt research findings to local conditions and circumstances is of special importance in applying the results of research undertaken in another country, particularly where there are big differences in the level of technology or development between the countries.

   (d) Because the traditional modes of communicating the results of research in developed countries, such as the publication of research reports in professional or scientific journals or text books, or academically oriented high level conferences, are impractical, ineffective non-existent or simply unintelligible, the emphasis should fall on visual demonstration and word of mouth communication in an intelligible and comprehensible way, and at the appropriate level.

(e) Repetition is frequently necessary, and if something is not initially understood, a different approach is often useful. It must also be remembered that misunderstandings often arise because the intrinsic courtesy of developing people, or a wish not to appear uninformed, often leads them to indicate that they have understood something when they have not done so. Audio-visual aids and simple guide books, which make use of vernacular language and phrases and simple illustrations, (ideally of the cartoon type and based on familiar or local concepts), are particularly effective.

(f) Education and training for building professionals and technicians is often best achieved in the classroom, and for artisans and operatives by means of on site workshops in the local environment where the trainees participate actively in the application of the research findings.

(g) Particular importance must be attached to regional and local factors especially in areas where transport is limited, expensive or difficult, and where language varies. A sound principle is to take the knowledge to the job rather than to try to bring those for whom the information is intended to a single centre.

(h) Information transfer in a developing country is much more personal than in a developed country, and therefore good human and personal relations are particularly important. In this connection, care must be taken to avoid any suggestion of paternalism and talking down to people must be avoided.

(i) It must be realized that different spatial perceptions, particularly in terms of dimensions, depth and scale, frequently complicate the communication process, especially where drawings or models are involved. Similarly, a frequent lack of understanding of physical or mechanical principles, and particularly of abstract concepts, hinders effective communication.

(j) Although this is not always easy, the recipients and users of research knowledge should also make a conscious effort to understand the objectives of the research work as well as the findings themselves, and must pass it on to their associates and subordinates.

To sum up what I have said in this welcoming address, I would like to give you six points which represent the essence of research and applying the results in developing countries:

(1) Meaningful research should, even more

than in developed countries, be directed at reducing costs, improving management and labour utilization, and developing new and existing materials and techniques.

(2) Research for and in developing countries should consciously aim at avoiding the mistakes inevitably made in the older developed countries - developing countries cannot afford too many mistakes financially.

(3) The dissemination and application of the results of research in a developing country is a much more informal and personal business and generally requires a very different approach.

(4) When developed countries undertake, finance or apply research in developing countries, it must be remembered that an entirely different set of circumstances applies and that extreme caution, sensitivity and local knowledge is a prerequisite to constructive and useful action.

(5) Traditional associations and compatibility in terms of language, ideologies and political systems can substantially enhance the effectiveness of research assistance extended by a developed country to a developing country.

(6) Research for developing countries must aim at the solution of real and immediate problems with limited technical, manpower and financial resources.

Finally, may I again say how glad we at NBRI are to have you at this seminar, and to express the hope that your participation will be enjoyable as well as productive.

OPENING ADDRESS/OPENINGSREDE

by/deur

THE HONOURABLE/SY EDELE S J M STEYN

Then Minister of Community Development,
Coloured Relations and Indian Affairs/
Destydse Minister van Gemeenskapsbou,
Kleurlingbetrekkinge en Indiërsake

Mr Chairman, Dr Webb, distinguished guests, ladies and gentlemen, I thank you warmly for the invitation extended to me to officiate at the opening of this international seminar organized by the National Building Research Institute. I can assure you that it is a great honour for me to deliver the opening address especially as water supply and drainage services, along with other engineering services, play such an important part in the role of my Department as the major provider of funds for housing and the related infrastructure in South Africa.

On behalf of the Government I wish to thank all the authors who have given so much of their time to the preparation of their contributions, and who have come from far-away countries, neighbouring states and from all parts of South Africa to be with us today. I would like particularly to welcome all our overseas speakers and all delegates from other countries. We trust that your stay with us will be enjoyable as well as productive.

This gathering offers us an opportunity for the exchange of ideas on a formal as well as an informal level, and I hope that you will not only find the debate interesting, but also be able to usefully apply the ideas expressed in the papers and discussions, and that this ongoing international cooperation and dialogue will continue to serve as a long term investment in the building industry throughout the world.

I believe that it is particularly significant and meaningful that this seminar takes place in South Africa as our country has both developing and developed components; an almost unique situation which has made it possible to transfer effectively the skills and technology of a developed community to a developing one. In all this work, much emphasis has of necessity been given to the housing and other building requirements of the developing section of the population.

Building research in this country has already made an important contribution to the building industry in its widest sense. In the years to come, policy makers and the indstry will, without any doubt, make even greater demands on building research. I need hardly remind you that the world's natural resources are being depleted at such a disturbing rate that not only a decent living standard but, ultimately, the survival of generations to come is dependent on our and their resourcefulness in coping with a problem of such magnitude that it will tax the greatest minds in all fields of human endeavour, and not least those in the building industry. I therefore think that it is appropriate to outline briefly the background to building research in South Africa, before discussing the particular role of the National Building Research Institute in the field of building and engineering services.

In 1936 contact was made by the then Department of Public Works with the then Building Research Station in the United Kingdom with a view to founding a similar organization in South Africa. Preliminary investigations were carried out, but were unfortunately interrupted by the outbreak of the Second World War. During the war it was foreseen that building activities would enjoy a revival after the war and further visits were paid to Britain and the United States. With the findings of their investigations as a guide, a start was made in 1946 on establishing a building research organization which was temporarily part of the then Department of Commerce and Industry. Today it is known as the National Building Research Institute, and it was one of the first national institutes of the Council for Scientific and Industrial Research. A building research advisory committee was also brought into being to guide the new organization's activities. This unique body, which today continues to fulfil an indispensable role in the work of the Institute, has met 156 times since its inception, and together with various Steering and other Committees, has admirably fulfilled its basic function of advising on the formulation of the research programme of the Institute.

These committees offer exceptionally effective forums for the exchange of ideas and they facilitate an essential liaison between the Institute and the building community which it serves. I would very much like to express my thanks to those who have served, or who are serving, on these committees for their valuable services and contributions to the welfare and development of the building community through the research which they guide.

At the time of its establishment the Institute had a staff of a mere 12 members. The Institute now has a staff of 250 under the leadership of Dr Webb, who became Director in 1959, and retires today after 21 years at the helm of this organization, which has contributed in no small way to the advancement of technology in all spheres of the local building industry. During this time regional offices were established in Cape Town, Durban, Windhoek and Port Elizabeth. The Institute's annual budget for the current financial year is some R4,2 million. The fact that the proportion of the budget earned from public and private sector contracts has risen over the past 20 years from about 15 per cent to well over 40 per cent, is an indication that the National Building Research Institute is not only practically oriented, but also renders a service for which a real need exists, and for which sponsors are prepared to pay.

One of the more important achievements of the National Building Research Institute is the research that has been and is still being done in the field of low-income housing. This work is not only of great importance to the Central Government and local authorities but, as a result of the Institute's support, has facilitated the provision of low-income housing and thereby made a contribution to the development of an increasingly well housed and correspondingly more stable society.

An important aspect of the functioning of the Institute is that its activities are not confined to the planning and execution of purely technical research, but also include work relating to building costs and building economics, and rightly place great emphasis on the dissemination and application of research findings, including those of overseas researchers with whom the Institute has close and mutually fruitful contacts. This work is usually conducted in close cooperation with government at central, provincial and local levels and also with the professions and the industry.

I have already mentioned that the then Department of Public Works initiated the establishment of a building research organization in South Africa some 44 years ago. Now that responsibility for this Department is a part of my own Ministry it is a source of pride to me as the responsible Minister that my Department is today still very much concerned with building research and in all facets of the building industry. My Department plays a leading role in the activities of a number of advisory bodies in the building and construction industry, and many of the projects undertaken by these bodies are either fully or partially financed by the Department. As many of you know, the Department is one of the building industry's biggest clients in South Africa since it is charged with the design and construction of public buildings, schools, hospitals and housing of all types. What I would like to emphasize without going into any great detail is that it is absolutely essential that the State as a whole, and my Department of Community Development and State Auxiliary Services in particular, should take note of new developments that take place in all sectors of the building industry.

Thus the contribution of the National Building Research Institute to the development of the building industry in South Africa must be underscored. During the 34 years of its existence this very dynamic organization has become much more than merely a research institute. It is, today, an integral part of our building community, playing a vital role in generating new knowledge and applying the results of its own work and that of its sister organizations in overseas countries. We in this country are indeed fortunate in having the NBRI to serve our building industry and professions both in the public and private sectors.

Let me turn now to the particular subject matter of this seminar which is concerned with the provision of the two essential piped engineering services to and from buildings.

As many of you are aware my Department is vitally concerned with the provision of essential engineering services, particularly in residential townships, and for many years now, has been sponsoring research by the NBRI in this field.

However, following the reports of the Niemand and Fouché Commissions, which were concerned with the escalating cost of serviced land for residential development as well as housing, the scope of research in the building and township service fields has greatly expanded, specifically at the instigation of my Department in response to the recommendations of the Fouché Commission of Inquiry into Housing Matters.

The NBRI has been contracted to undertake, in collaboration with all the bodies concerned, two major projects on behalf of the Department. The first concerns all aspects of the cost of middle income housing, including plumbing and electrical services, while the second entails the establishment of rational norms for all essential township engineering services, including water reticulation, sewerage, electricity distribution and roads and stormwater drainage. These norms are being formulated on a uniform national basis applicable to all types of residential township development, whether by private developer or public authority. Here again these projects have highlighted one of the basic problems that bedevil man in general and researchers in particular, namely that of technology transfer. Much of the knowledge we are striving for already exists, but we are constantly reminded that while research is a basic requirement for our progress, it is equally important that we have the means and the will to apply it and that we benefit from doing so.

As I have indicated, the NBRI is already doing this and I find this aspect of the Institute's policy most gratifying, and I stress that research, like any other productive activity, must be aimed at demonstrably benefitting the country and its people. While the generation of new knowledge is obviously essential, it is equally important that the results of this research be effectively applied in practice.

Research, and more particularly building research, must therefore move more and more out of the laboratory and into our daily life and must become an integral part of decision-making, both in the public and private sectors. Government as well as industry will benefit from this involvement of research in decision-making. This is particularly true of building research in developing countries, where we cannot afford to compete in terms of its technological sophistication with that in the older developed countries. It must be aimed at the solution of real problems. This, however, will require the recognition by all concerned of two principles: first, that it is the function and the responsibility of the research organization to ascertain the relevant facts and interpret and present them meaningfully and as objectively as possible to the policy maker; whether they are unpalatable or not is quite immaterial. Second, it must be understood and accepted that the policy-maker, who fully understands the implications and all the technicalities of the research findings, has the prerogative as well as the responsibility for the decision-making, and for the implementation of these decisions.

The problems of building and building research are not confined to any particular country, and the NBRI, in order to promote the exchange of ideas at all levels, is an active member of the Council for Building Research Studies and Documentation - the CIB - a seventy-nation international building research organization. It is also an active participant in a similar broad spectrum international building research group known as RILEM and, in addition, is a member of seventeen other international and overseas organizations. Productive international cooperation has been achieved by the regular exchange of ideas at conferences and other meetings in many parts of the world.

There is also active collaboration with neighbouring states, and two of these countries, namely Zimbabwe and Malaŵi, are represented on the Building Research Advisory Committee.

I therefore believe that during this seminar and ongoing action, you, as leaders in your particular fields, can provide a basis for fruitful cooperation in a fragmented industry in order to achieve not only improved buildings but a better built environment - an inheritance which we will hand on to future generations in the form of better served dwellings, schools, factories, hospitals, churches and offices - all within the current and new constraints in respect of material, manpower, money and energy.

Let me now turn to the future. Our increasing living standards are a manifestation of industrial development and economic growth. Such development and growth, however, bring in their train growing demands for labour and increases in real income as well as changes in the pattern of employment.

They also bring the realization that technology does not stand in isolation. Technological change can have profound socio-economic effects. Conversely socio-economic factors have a pronounced influence on the development of technology.

This is as true of the building industry as it is of any other and we must therefore, reconsider our approach to building and building research. We must do this from the point of view of those who invest in buildings, those who design buildings, those who erect buildings and, above all, those who live in buildings. The pressures in business, in government, and the ever-increasing demands for accommodation do not allow us to sit back and consider our basic requirements.

The papers which have been prepared for this seminar demonstrate the fact that we are particularly fortunate in having a group of distinguished authors with us. I would like to compliment the authors on the quality and usefulness of their contributions. It is only by the sharing of the available knowledge and the better utilization of our limited and finite resources that any country can obtain maximum benefit from its buildings. In this respect, delegates to this seminar have a very real responsibility, not only to the building industry but also to society in general, to contribute as much as possible in achieving the object of better building.

A special word of appreciation is also extended to all the local authors for the preparation of their papers and for sharing their experiences with those attending this seminar. Tribute must also be paid to the work of the organizing committee under the chairmanship of Mr P R Crabtree and to Mr Addis of the National Building Research Institute whose devoted and competent staff did the hard work.

Before opening this seminar I would like to address a special word of appreciation to the Director of the National Building Research Institute, Dr T L Webb, who, as I mentioned earlier, is retiring from the NBRI today. It is largely through his special brand of drive, pragmatism and enthusiasm over the 21 years of his service as Director of the Institute that building research in South Africa can boast of many noteworthy, and some internationally acclaimed, achievements. I would like to wish him everything of the best in his retirement, but knowing him, I am sure the building industry will continue to benefit from his influence, even after today.

Ladies and gentlemen it is now my great pleasure to declare this seminar open and to wish you every success in your deliberations. I thank you.

THANKS AND STATEMENT OF THEME/BEDANKING EN UITEENSETTING VAN TEMA

by/deur

P R CRABTREE

The pleasant duty has fallen to me today, of thanking the Honourable Minister, Mr Marais Steyn, firstly for finding the time in his very busy programme to be with us this morning, and secondly for his very thought-provoking and challenging opening address to this seminar.

You have clearly in your opening remarks stressed the vital role played by engineering and building services in the provision of housing for all in this country. You have also mentioned the importance of ongoing international cooperation and dialogue in technical research fields as a means to best serve mankind worldwide. We, as researchers, can only hope that this can continue without political interference and the senseless restrictions brought about by ideological differences.

The question of which norms should be applied to the provision of services is indeed a complex one, more particularly so as we are faced with the proportional cost of both in-house and infrastructural services per dwelling unit increasing as the cost of the housing itself decreases. Therefore, it is important to establish which standard of services can be afforded by the income group being catered for. It is quite useless burdening people with more than the essential services they can afford. This applies even to middle income group developments, where the cost of servicing land has more than trebled in the last decade, putting home ownership beyond the reach of a larger and larger portion of the population.

Turning not so much to the role of your Department in the provision of housing in South Africa, as to the role the Department plays in research, we at the NBRI can only endorse the fact that without the wholehearted support, both morally and financially, of the Department of Community Development in the field of housing research, many of our mutually productive projects would not have been possible. Not only does the Department sponsor the research, but it provides the vehicle for the effective implementation of the results.

I would also like to pay tribute to other public sector authorities that support and encourage research, on services in particular. I refer to our Provincial Administrations and many of our local authorities with whom we have close working relations. In the private sector we are also beholden to the engineering and architectural professions, the plumbing industry and the manufacturing industry, for the confidence they show in us and the tasks and aims we try to achieve. We rely on all these people for the attainment of the very essence of this research, namely the successful transfer of technology.

Mr Minister, you have briefly outlined the history of the NBRI and I think we can say with pride that we have come a long way during those 34 years. You have also emphasized the role of our Director, Dr Webb, in our achievements. We can only echo this, and you will appreciate that there is an air of nostalgia in the Institute today, as we realize that 'Pluto' Webb has this morning performed his last official function for us in welcoming you all to this seminar.

Mr Marais Steyn, on behalf of all the delegates present, and of the NBRI, I thank you again for opening this seminar.

Turning now to the seminar theme, 'Water Supply and Drainage Services in Developing Countries', I have to go back exactly five years to September 1975 when an invitation was first extended to overseas colleagues in the water supply and drainage research field to participate in a seminar in South Africa. It was nearly three years later that 1980 was chosen as the year of the seminar, and invitations could be formally sent out to our sister organizations to participate. I would like to quote the following paragraph from that invitation:

'We particularly welcome this decision as we feel the theme of the Symposium 'Water supply and drainage services in developing countries' will be very appropriate, because South Africa, as a mixture of a developed and a developing country, provides an ideal venue for study of the evolution of technology and its application in emerging countries. You of the developed countries, who are constantly being called upon to render technical assistance to the underdeveloped nations, will, I am sure, gain first hand experience of the problems involved and the evolutionary process in sanitation that is necessary to improve the quality of life in emerging countries'.

At about the same time the international building research organization, CIB, of which South Africa is a member, embarked on a programme aimed at assistance to developing countries. Also in 1977 the U N Water Resources Conference in Argentina approved the idea of the 1980's becoming the International Drinking Water Supply and Sanitation Decade under the auspices of the World Health Organization. The Decade will be launched officially at a full day session of the U N General Assembly in six weeks time.

The Steering Committee which represents the seven international agencies involved in the Decade programme has identified five major activities in support of the Decade:

(i) Studies of low-cost alternatives for water supply and sanitation;

(ii) A system to provide information for potential donors on developing countries plans and projects, and for these countries on donor aid availability and criteria;

(iii) A clearing house function for interchange of information on Decade activities;

(iv) Support activities for national Decade planning; and

(v) A public relations programme to develop and maintain the momentum of Decade activities.

With the population explosion still increasing in most developing regions, together with the added spectres of drought and famine, the task to be tackled seems mammoth indeed. Allow me first to quote a heading here, and a line there from recent reports on some of the Decade plans and problems:

- 'Appropriate technology' is the key to Water Decade success'.
- 'Water supply and sanitation problems in the developing world range from single houses to metropolitan cities of 5 - 8 million people'.
- 'If you were to serve 100 per cent of the people of the world with a 'reasonable' level of service you are talking anywhere from maybe $200 billion to as high as $500 billion'.
- 'Water, sanitation required for one billion extra by 2000 AD'.

- 'World Bank's data supports low technology'.
- 'The Sahel, where water is the key to survival'.
- 'Allies rearm for water-disease war'.
- 'Getting the appropriate technology message across'.
- 'U N's $60 billion sanitation plan: basic needs must come first'.
- 'Sanitary sewers for underdeveloped countries - necessity or luxury?'.
- 'Bombay a fast growing city of 7 million people, has a seriously inadequate and almost totally untreated water supply'.
- 'Millions of people take piped water for granted. Millions of other people, however, have to fetch every drop they need from muddy rivers and lakes. It is mostly like that in Africa'.

The Water Decade dossier which starts with Algeria and Angola and ends with Yemen and Zambia is written in the form of rapid assessment reports on all nations and outlines the magnitude of the world problem in condensed form. It makes frightening reading.

It is with these challenges as a background, and with our own experience in Africa to guide us, that we must approach the theme of this seminar, where not all the contributions are necessarily on either low technology or low cost technology, mainly because most research projects undertaken in the developed countries are still aimed at the refinement of systems in those countries, and at water and energy conservation measures.

One of the main objects of this seminar, and the pre-seminar technical tour arranged for our foreign visitors, has been to acquaint our overseas colleagues at first hand with the immense problem of providing adequate sanitary services to developing communities.

Finally, while our foreign visitors have been welcomed in general terms by both Dr Webb and the Minister, I would like to identify some of our visitors, and ask them to stand up as I mention their names.

We have:

1. Mr Gustavo Bertot from the Ministry of Housing, The Argentine.
2. Mr Gert-Jan de Kruijff from the University of Nairobi, Kenya.
3. Mr Fred du Toit of Zimbabwe.
4. Professor Hans Knoblauch from Berlin, West Germany.
5. Mr R Meier from Geberit, Switzerland.
6. Mr Ray Morgan from the Melbourne and Metropolitan Board of Works, Australia.
7. Mr Francois Perrier from the CSTB, France.
8. Mr Lindesay Robertson from Malaŵi.
9. Mr Israel Silberstein from the Standards Institution of Israel.

10. Mr Dieter Trinkler from the Institut für Bautecnnik, West Germany.

11. Mr Cyril Webster of the Building Research Establishment, United Kingdom.

Turning to the seminar programme you notice that a few changes have been made from the Final Announcement sent out some four months ago:

(a) Paper 3 - Session 1 - Mr Johnson from Argentina could not present his paper himself due to illness in his family.

(b) Paper 6 - Session 1 - Mr Montenegro withdrew from participation and his place has been taken by Mr de Kruijff of Kenya.

(c) Paper 7 - Session 2 - Due to commitments at NBS, Dr Galowin had to withdraw, and his place has been filled by Mr du Toit from Zimbabwe, who will present an extra paper on the developing countries.

(d) Session 3 - Technical Reports - It has become usual at seminars of this nature, involving an international group working in the same field, to include a session where particular research projects can be reported on more informally and discussed more fully by fellow researchers.

APPRAISAL : OORSIG

MR J F VAN STRAATEN, DIRECTOR, NBRI

It is indeed a great honour for me to summarize the papers and discussions presented at this seminar. To me it was a most interesting and productive meeting and I must congratulate you on the way it was organized and presented and for the lively discussions which followed all the presentations.

SESSION 1 : THE DEVELOPING COUNTRIES

Mr L H Robertson (Malawi)

Mr Robertson emphasized the realistic approach of the Malawian Government of assisting people in rural areas to provide water for themselves rather than doing it for them.

Schemes involving the piping of clean mountain water by gravity to villages on the plain are based on requirements of 27 litres per person per day and one water point conveniently located for every 160 people. A film showed the scheme in some detail.

The success of the schemes is attributed to the involvement of communities at all levels, using existing leadership structures, and making communities responsible for maintaining the service. In this way a sense of pride and ownership is generated. The development of this procedure based on the purely voluntary support of the people, which to many of us might appear simple, has taken at least a decade of patience and hard work from dedicated staff.

Mr A D van der Schyff (Zimbabwe) (Presented by Mr K A Finlayson)

In analysing the Zimbabwian situation, Mr Finlayson, in presenting Mr Van der Schyff's paper, pinpointed the dilemma of most developing countries with partly developed economies, namely the conflict of expectation and affordability plus the fact that wealth cannot be redistributed but must be created. Forty per cent of wage earners cannot afford any form of housing, a figure which illustrates the severity of the problem in Zimbabwe.

He outlined the strategy evolved to meet housing requirements and concluded that the cornerstone of this strategy is the provision of adequate water and drainage services in advance of the national building programme.

Water reticulation design is based on the supply of 700 litres per family per day and sewer reticulation design to cater for 85 per cent of water consumption.

He further emphasized the need to create a self-sufficient and self-employed population, keeping in mind that 80 per cent of the national population was still rural. He sketched the role and responsibility of the engineer in the development of the urban housing sector within the financial constraints of a developing economy. The following aspects were highlighted because of their effects on the final cost of housing:

(i) the engineer's own design philosophy and his reluctance to accept the consequences of limit state design;

(ii) the sometimes unnecessarily high standards of design followed;

(iii) contract procedures and the selection of contractors. The practice of providing sureties could add almost 1 per cent to the cost of the project and it was suggested that this could be done away with by careful selection of contractors;

(iv) excessively stringent and restrictive building regulations and national pollution standards which must be met.

Mr G J W Bertot (Argentina)

Mr Bertot reviewed the Argentinian scene where 46 per cent of the population serviced is supplied with piped water from surface sources, 30 per cent from both surface and underground sources, and 28 per cent from underground sources only. Some two-thirds of the urban population is serviced. The national average water supply is around 460 litres per capita per day. Tariffs are generally based on 'unrestricted supply' and not on consumption which explains the large variations in supply to individual dwelling units.

Only about 27½ per cent of the population is provided with piped sewerage systems; the remainder use other methods such as septic tanks, pit latrines, etc.

Mr Bertot further elaborated on other township services normally provided and gave some interesting cost comparisons. He also briefly dealt with financing procedures and regulatory aspects.

In conclusion he referred to research that is being done on the development of alternative systems for remote areas without much in the way of infrastructure. Special attention is being devoted to evaluation of the so-called 'Biological Bathroom' and solar stills for the purification of water.

Discussion - Papers 1 to 3

Mr Robertson confirmed that the design of the schemes is based on the total number of people which the particular area can support; and that their experience is that actual consumption is less than the design figure of 27 litres per capita per day. The ordinary bib tap has proved to be the best because of the low maintenance it requires. Donor agencies normally provide funds for these schemes.

On the question of first cost vs life-cycle costs in the case of low income housing, Mr Finlayson agreed that there was a need for balancing these costs and that maintenance costs should be kept as low as possible, although such calculations do not always work out in practice, particularly in rural areas where there is not sufficient control over the quality of the materials used.

Mr R A Morgan (Australia)

Mr Morgan dealt with the problems experienced and the procedure to be followed in the drafting of a national plumbing code which covers both drainage and water supply. Although this was done in the context of the 'Australian experience', much of what he said applies equally well to most developing countries. South Africa can certainly take a leaf out of the Australian experience.

Mr Morgan highlighted four important justifications for the establishment of a uniform or national plumbing code, each with its own economic potential, viz:

(i) the opportunity it offers for the rationalization of system and product design;

(ii) the wider application of cost-saving measures;

(iii) the effective application of the findings of research and investigation; and

(iv) a better understanding and sharing of experience between local authorities.

He outlined the need for a code drafting group to define at an early stage the ground to be covered, what detail is needed and he also stressed the need for standard terminology. The Australian plumbing industry gave preference to prescriptive rather than performance-type regulations.

He also emphasized the importance of the continued updating of codes and regulations and the need to implement a proper education programme.

Discussion - Paper 4

Reacting to a question on the thickness of pipe walls of 100 mm PVC drains, Mr Morgan said that 3 mm was the general thickness used but that this was not the only requirement as the method of backfilling was equally important. This was confirmed by another contributor.

On a question of foreign input in the Australian Code, Mr Morgan mentioned that they were guided mainly by British experience because of the strong British influence in Australia. He also mentioned that fire spread was no serious problem in large buildings as metal (not plastic) pipes were usually prescribed by designers for these buildings.

From discussions it became clear that the depth of trap seals in unvented systems was something that required further research.

I Silberstein (Israel)

Mr Silberstein dealt with the very important aspect of quality control and the system that has been developed in Israel over the last 15 years. Although Israel faced problems common to most developing countries, the large scale absorption of immigrants from many foreign countries over a relatively short period was a further complicating factor in that it had a considerable influence on the quality of work in the various trades in the building sector.

According to Mr Silberstein, the quality of sanitary installations depends on three factors, viz good design, good materials and equipment, and good workmanship, and all three factors are taken care of in the Israeli Plumbing Code. The regulations lay down procedures for preparing and submitting design plans for approval by local authorities; and it is mandatory to use only sanitary fittings and appliances that meet the requirements of Israeli standards, whether of local or foreign manufacture. Significantly, products which do not bear a 'Standards Mark' or a 'Supervision Mark' must first be tested. Quality of workmanship is assured by the obligatory testing of completed installations by the local authority concerned.

Mr G J W de Kruijff (Kenya)

Mr De Kruijff concentrated on the development of site and service schemes in the urban areas of Kenya, which involves the provision of serviced residential plots on which people can build their own houses. Individual rooms of houses are commonly occupied by separate families and there are many problems unique to low income housing in developing countries that require special attention.

In reviewing the constraints in site and service schemes, he concluded that water-borne sewerage was not really an appropriate technology for developing countries. He dealt with alternative options which are generally less expensive than conventional sewerage systems. For example, ventilated, improved, self-help pit latrines are only about 15 per cent of the cost of conventional sewerage. But here again the question of expectation vs affordability arises.

Perhaps the most important point made by Mr De Kruijff is that the engineering profession has been ruled for too long by European text-book knowledge which is not suited to developing countries. What is needed today is pragmatism, realism and creative thinking, or, to use his words, 'down-to-earth rather than sanitation engineers'.

Discussion - Papers 5 and 6

During the discussion it became clear that the pit latrine, if properly designed, and in particular the double pit latrine, can serve a useful purpose in developing countries, but the point was made that they should not be too small as they are generally a gathering place of mothers and their children. An interesting point made by Mr D Kruijff is that, contrary to that which applies in South Africa, water supply can be cut off in Kenya if the householder does not pay his bill.

On the question of allocation of the approval mark in Israel, Mr Silberstein replied that it can only be allocated by the Standards Organization and not by individual laboratories.

SESSION 2 : THE DEVELOPED COUNTRIES

Mr F P du Toit (Zimbabwe)

Mr Du Toit was the odd man out as far as this session was concerned as he was the only speaker in this session who was still intimately involved with the problem of supplying water to unsophisticated rural communities in the African context. His co-session speakers were all from highly developed countries.

According to his experience, there is sometimes a lack of understanding of the cultural and social traditions surrounding water use by agricultural workers rather than a lack of appropriate engineering technology.

He pointed out a very important fact not always realized, namely that the collection and use of household water in African communities are still largely considered the responsibility of the women, but that to them the collecting of water can be likened to a 'women's club', a break from work routine, when many interesting aspects of women's lives in a rural community are expressed.

He explained the essential ingredients of a typical village waterpoint developed by himself which has been well received in practice by African communities. This once more proves that solutions for African problems must come from Africa itself.

Mr C D Webster (Great Britain)

Mr Webster elaborated on some of the difficulties which can arise when countries indiscriminately import and apply technologies in the fields of water supply and drainage without familiarizing themselves with the conditions in which these systems are used in their country of origin. One wonders, however, whether it is a question of developing countries importing new technologies, or whether it is not more a question of indiscriminate exporting of technology by developed countries.

Although requirements differ from country to country, there is at least one common unifying influence - certain performance requirements for water supply and drainage systems. Protection against contamination, prevention of loss of water by leakage from either underground pipework or fixtures, prevention of explosion of hot water systems and minimizing the effects of blockage of drains are universal requirements. Developing countries should be aware that leakage from underground drains in the UK accounts for about 25 per cent of the total amount of water distributed and take the steps necessary to avoid this waste of such a scarce resource.

Discussion - Papers 7 and 8

The question of the international standardization of water supply and drainage regulations was again touched upon in these papers, but doubt was expressed as to whether this would ever materialize in view of the widely different requirements and priorities of individual countries.

In reply to a question on the extent to which the water trough in his design was polluted, Mr Du Toit explained that this indeed happened, but that it was not a real problem in practice.

In reply to another question he explained that his system must be seen mainly as a means of dispensing clean water in a manner acceptable to users (rather than just 'providing water') and thereby stopping people from making use of polluted river and other water.

Reacting to a question from the floor on the low rates of water for showering in the UK as compared with those for the USA, Mr Webster explained that the UK figures represent actual flow rates as measured in practice, whilst those for the USA refer to design figures and do not necessarily represent actual flow rates. Furthermore, one must be careful in comparing statistics from different countries without knowing how these were obtained and without taking account of the widely differing habits and requirements of different countries and even of communities within the same country.

Mr F Perrier (France)

Mr Perrier outlined the role played by international organizations such as the CIB and WHO; firstly in surveying the needs of developing countries and secondly, in determining how best these countries could be assisted.

He mentioned that in 1975, 62 per cent of the population of developing countries involving about 1 250 million people, did not have an acceptable water supply, while no less than 68 per cent had no proper means of sewage disposal. He also confirmed the point made by Mr De Kruijff, namely that techniques other than the 'wet drainage' type commonly used in developed countries should be developed for the rural areas of developing countries. Apart from the scarcity of potable water, other complicating factors common to all developing countries are:

(i) lack of trained labour;

(ii) low level of technology;

(iii) absence of community incentive;

(iv) poor infrastructure;

(v) unstable governments; etc.

He indicated the possible assistance that could be rendered to developing countries by affluent countries and spelt out several conditions which research must comply with to be effective. To we who are familiar with the problems and expectations of developing countries at least on the African continent, it was gratifying to hear that some of our European colleagues have a clear appreciation of the problems of developing communities; thus, for example, the off-loading of large numbers of WC pans on developing countries, as had happened, served no purpose whatsoever in solving the drainage problems of unsophisticated communities, but only contributed to the existing confusion.

Prof H J Knoblauch (*Germany*)

Prof Knoblauch was the first speaker to deal specifically with the more technical aspects of evaluating the flushing efficiencies of WC cisterns and bowls. He elaborated on research carried out in Germany to establish measurable parameters for quantifying the flushing performance of WC pans based on the requirement that flushing water should not only be sufficient to clear and rinse the closet bowl, but should also be sufficient to keep the drains clean. According to him, it had not been established yet whether flushing volumes of less than 9 litres would ensure self-cleansing of drainage pipes and he felt that more research was required on this aspect.

He distinguished between 'flushing out', i.e. the removal of solids from branches and stacks with a single flushing, and 'flushing down' where solids are not removed from the pipeline section during a single flushing. He concluded that the so-called afterflow, i.e. the flow that follows the solids and not the total flushing water, must be considered the more important criterion in evaluating flushing out performance. This means that water can be saved not only by optimizing the design of WC systems but also by designing drainage systems in such a way that they require the least possible afterflow for clearing solids.

Discussion - Papers 9 and 10

Asked whether the test procedures developed in Germany would be suitable for evaluating the performance of WC systems for use in developing countries, Prof Knoblauch said that they might have to be adapted to these conditions because of the likely presence of foreign materials in the waste products.

Several speakers from African countries expressed their disappointment at the way in which developed countries disseminate information in developing countries. Developing countries often find it difficult to explain their problems to, and to be understood by, developed countries. There is a need for a greater degree of communication and trust between developed and developing countries.

SESSION 3 : TECHNICAL REPORTS

Three papers were reviewed by the rapporteurs in this session, while two other papers which were received from India have also been considered for this summary as they will be included in the proceedings.

Mr A P Bekker

Mr Bekker strongly emphasized the need to conserve water in South Africa where predictions have it that by the year 2010, i.e. only 30 years from now, overall demand will outstrip supply.

He quoted several examples to prove that a saving in water consumption of from 30 to 50 per cent can be achieved by individual water metering. He went even a step further and suggested that individual metering with a charge for water at the current price offered the best interim financial solution when it comes to low income communities where it is essential to provide minimum supplies at a price people can afford.

During the discussion of this paper, the point was made that the selling of water at its economic value would not only lead to conservation but would also result in a more equitable distribution. On the other hand, metering of water for low income housing is a sensitive issue and should only be considered as a last resort.

It was also mentioned that water consumption of 20 to 40 litres per capita per day is considered the absolute minimum by health authorities.

Messrs S Holmberg, L Lindvall and E Olsson

Mr Malan presented this paper on behalf of the three authors who were not present. They dealt mainly with the Swedish situation where the most important consideration is not so much that of a saving of water per se, but that of conservation of energy. It was therefore necessary for them to look at hot water temperatures and they referred to instances where hot water costs were reduced considerably by lowering the temperature of hot water from 55 °C to 45 °C. In South Africa a great effort is being made to educate householders to lower the thermostat settings of their electric geysers from 70 °C to 55 °C.

Considerable success has already been achieved in Sweden in reducing the flushing volume of WC's from 9 to 6 litres. Investigations now in progress indicate that this can be reduced even further to 3 litres per flush in conventional sewerage systems. However, it is not yet known what the long term effects of this will be on the sewerage system as a whole. The authors made a plea for a coordinated research effort in this field. Although research should not be restricted by political barriers, a classic example of how politics have barred Scandinavian colleagues from actively participating in our seminar is to be found here.

Commenting on the statement that no problems were experienced with 3-litre flush toilets, Mr Morgan felt that this was true as far as highrise flats were concerned, but that this was not necessarily applicable to individual dwellings. Mr Webster pointed out however that it has been successful with long horizontal runs of drains.

The whole question of whether drains and sewers should necessarily be cleared by every flush is a debatable point, particularly in view of the fact that the WC is normally not the only water consuming fitting in any building.

Although efforts to conserve water are commendable, it must not be forgotten that it is a revenue earning source for most local authorities and that they may not be in favour of reducing consumption.

Mr Silberstein felt that the major need of developing countries was not that of establishing standards organizations, but rather that of evaluating and testing agencies for protecting end users from the installation and use of inferior products.

Mr T P Konen - Test kit - Sanitary performance of water closets

Mr Malan presented the contribution of Mr Konen, who unfortunately could also not be with us. He actually submitted a test kit setting out the required test media and instructions for completing several of the sanitary performance tests proposed for the American National Standard - Vitreous China Plumbing Fixtures.

The kit contains the necessary information, instructions and data sheets for carrying out the so-called ball test, granule test, surface wash test and removal of waste liquids test.

The primary objective of developing a uniform proven consensus standard for evaluating water closets is to stimulate manufacturers to concentrate on the production of water saving units. He identified three parameters as most important in the design of water closet systems, viz pressure within the plumbing drainage system, seal depth and the diameter of the branch drain.

Mr Malan expanded on this paper by comparing the results of three different performance tests, viz the British, the Scandinavian and the Stevens Institute of Technology tests on different designs of WC pans carried out by the NBRI.

In response to a question, the Chairman explained that these tests relate to the performance of the pan alone and not to the combination of pan and drain. The pans were not necessarily tested with specific cisterns as cisterns are often sold separately.

There was some disagreement as to whether the floating ball test was more representative of the actual situation than the sunken ball test and further investigation appears unavoidable. Mr Malan also indicated that he would like to carry out some of Prof Knoblauch's tests for comparative purposes.

Messrs S P Chakrabarti and S K Sharma

This paper deals with research done to determine the relationship between discharge from different appliances. The theory of probability is used to predict the likely simultaneous operation of a total number of different sanitary appliances in a building. Results of a limited survey are included to demonstrate the use frequency pattern of sanitary fixtures in domestic installations in India.

Relationships between probable maximum simultaneous flow and discharge unit values are compared with those obtained in the USA and the UK to show the marked differences in the design loads used in different countries.

Messrs S P Chakrabarti and S K Sharma

In their contribution our Indian colleagues review the performance and design parameters of both the Indian squatting pan and the conventional European bowl type water closets.

Their investigations also show that water consumption for flushing can be considerably reduced by rational design procedures and specific recommendations are made in this respect. Excellent results were obtained with a flush of 6,5 litres.

SESSION 4 : THE SOUTH AFRICAN SCENE

Mr F R Crabtree (South Africa)

Mr Crabtree in his usual eloquent way highlighted the research carried out at the National Building Research Institute in the fields of sewerage, building and stormwater drainage, water reticulation and supply in buildings and domestic water economy measures.

Of particular importance was the work being done to achieve a meaningful saving of water in the design and use of water supply fittings within the built environment and the work on the establishment of realistic design criteria and norms for township services.

He also touched on the very important aspect of training and education which, although of vital importance in developing countries, are still very much neglected activities. Experience has shown over and over again that the problems of developing countries can best be solved by the inhabitants of these countries themselves, and that they must be given the equipment and assistance to enable them to do so.

Mr G E Bath (South Africa)

Mr Bath defined 'low cost housing' as housing for persons who, due to insufficient income, are unable to provide their own houses with their own funds or with loans from conventional financial institutions.

He concentrated on the provision of water supply and sewerage for all low cost housing excluding that in the National States of South Africa and gave an indication of the extent to which the South African Government subsidizes low cost houses and township services. Until fairly recently, breadwinners with an income of up to R150 per month qualified for rented dwellings built on loans at a 1 per cent interest rate. However, they will in future have to pay 5 per cent of their income towards interest and redemption on the cost of the serviced site and dwelling with a maximum of R7,50 and a minimum of R2,50 per month. A sliding scale has been worked out for higher income groups.

While in the past the barest minimum standards of water supply and sewerage were set, most townships are now provided with facilities to full modern standards. He briefly referred to the important question of maintenance of services and showed several examples of services installed. The provision of full services is in many instances complicated by topographical factors.

Discussion - Papers 11 and 12

In response to a question, Mr Bath indicated that it was the policy of the South African Government to promote home ownership, although it must be accepted that this will remain beyond the means of the very low income earners.

The high standard of services insisted on by the Department was questioned, to which Mr Bath replied that these high standards reflect current Government policy, and that it was not a question of high initial capital costs but a question of balancing capital <u>and</u> maintenance or life cycle costs.

The problems created by plastic materials in sewers were highlighted and apart from developing more effective screening, it remains a question of educating people not to use sewers for refuse disposal.

Mr Botha drew attention to the misunderstanding that exists when reference is casually made to 'low technology' and 'high technology'. For example, there is a very great deal of difference indeed between a pit latrine and a water closet and the area between these two 'low' and 'high' technology systems respectively can with advantage be investigated and exploited.

He added that there is a need for the training of specialist sanitary engineers in South Africa but that such an idea is just not viable at present.

Mr Crabtree dealt with the question of the information explosion and the high costs of translating foreign material into one of the local languages.

Asked about the contribution of industry to the work of NBRI, it was explained that NBRI currently earns between 40 and 50 per cent of its budget by doing contract work for the building community.

In response to a question Mr Crabtree indicated that the National Building Regulations would be the vehicle through which water economy would be achieved.

Mr W J Uys (*South Africa*)

Mr Uys reviewed the water requirements for domestic and agricultural purposes in the National States of South Africa as well as the current state of water supply in both urban and rural areas. While all the larger urban communities are served by private connections for both water and water-borne sewage, urban settlements are mainly served with water through standpipes and with pit latrines or bucket systems for sanitation.

Actual per capita costs of typical water supply schemes in some of the National States were quoted to demonstrate that these were of the same order as for comparable schemes financed by the World Bank.

The question of sound tariff policies based on the true cost of supplying water to final consumers was touched on although this is often overridden by political and social considerations particularly in rural areas. The point was made that the metering of water consumed by individual consumers remains the most effective way of preventing wastage. This is even more so when coupled with flow control valves at house connections.

The high standards for the quality of water set by health authorities, as well as the high quality and engineering design standards generally used, were once more questioned.

Mr P A du Plessis (*South Africa*)

Mr Du Plessis dealt with the problems related to water supply and sewerage for Black communities in areas of rapid urban growth with particular emphasis on the upgrading of services and community facilities in Soweto. A factor of major concern is the exceptionally high water consumption figure per capita of almost 300 litres per day. Consumers pay a fixed rate of R3 per plot for their water which is not nearly enough to pay for the actual cost of the service.

He further dealt with the more technical design parameters and concluded that the only sensible way of preventing wastage of water would be to install meters and bill consumers according to their consumption. In this way an expected saving of 30 per cent in water consumption with almost an equal saving on the cost of sewage treatment could be achieved. Water for sewerage in Soweto constitutes about 95 per cent of the water consumption.

Discussion - Papers 13 and 14

In response to a question, Mr Du Plessis confirmed that the water supply figure of 20 Kilolitres per stand per month was arrived at after extensive investigations and that it was not considered too high. The income per household in Soweto varies a great deal but judging from some of the houses now going up some of them must be earning quite substantial incomes.

On the question of how regularly water meters will be read, Mr Du Plessis said that the idea is to read them quarterly but to bill the householders monthly.

In Zimbabwe, electricity is generally not metered but controlled by current limiters and charged for accordingly.

On the question of size of plots, Mr Du Plessis confirmed that stands must be big enough to allow for on-site parking of cars.

Mr Uys confirmed that water vendors in the National States were not controlled in any way.

Mr A B Davis (South Africa)

Mr Davis approached his subject from the point of view of the end user. In particular for anyone earning a low income it is important to keep his total 'rent' package as small as possible and Mr Davis felt that although much investigation has already been done to reduce the unit cost of the dwelling unit and the services that go with it, much still needs to be done to optimize the trunk services. He continued to discuss various ways and means of optimizing water supply and sewerage systems.

He confirmed the point made by an earlier speaker that it was more realistic for low income housing to base the design on the average water consumption per dwelling unit rather than on the per capita consumption. He also emphasized the importance of adequate control systems whether in the form of flow restrictor valves or meters, or both.

He further emphasized the need for a multidisciplinary approach to the planning and development of new townships for low income earners.

Mr G J Malan (South Africa)

Mr Malan dealt with the vitally important matter of urban water economy and highlighted current research being carried out at the NBRI under the sponsorship of the Water Research Commission. He elaborated on water closet flushing requirements and performance evaluation procedures and concluded that water saving in WC flushing could only be achieved by the development of more efficient WC suites and by user education and cooperation. Judging from the results of preliminary surveys in a group of typical office blocks in Pretoria, it appears that wastage of water through leakage from WC cisterns in this country is a matter for real concern. In this particular instance the total measured leakage of 38 litres per day equalled almost half the estimated total volume of water used for flushing purposes.

Similarly, wastage of water from urinal flushing is significant and is receiving attention. He briefly discussed the water saving potential of low flow rate taps.

Research on water economy measures will of course serve no useful purpose unless the findings can be applied in practice and, as already mentioned, the best vehicle for this is through national regulations. Mr Malan explained the South African approach: water supply installation regulations will be included in the new National Building Regulations now being drafted by the SA Bureau of Standards. These will be accompanied by a parallel document or Code of Practice outlining methods and procedures to be followed to satisfy the regulations.

Discussion - Papers 15 and 16

Mr De Kruijff recommended that in instances where water charges are included in the rent that they be shown as a separate item to prevent people believing that they receive water free of charge.

In response to another remark, the point was made that South Africa had not reached the stage yet where water must be saved at all costs - it was more a question of better utilization of available water resources.

Beta valves are not recommended for use in low income housing because they are not well designed mechanically and it is difficult to replace the washers. Other bottom opening cisterns are considered more efficient.

The point was also made that flushing tests should be relatively simple so that they can be used by manufacturers for quality control purposes.

CONCLUSIONS

The question may well be asked : What have we learned from this seminar? The answers in my view can be summarized as follows not necessarily in order of importance:

(i) A supply of water is essential for the well-being of any community and should, together with decent housing, receive the highest priority in the establishment of new settlements and towns;

(ii) despite the fact that emerging nations will always have the problem of expectation as against affordability, it is essential that every effort possible be made to keep the cost of accommodation and services as low as possible;

(iii) developing countries should be encouraged to help themselves - wealth can only be created and not supplied automatically;

(iv) community participation on both an individual and a collective basis is of paramount importance in defining housing needs and in providing them;

(v) different cultural and social traditions in developing countries should be recognized and respected;

(vi) the dissemination and application of the results of research in a developing country should be an informal and personal business which generally requires an approach very different to that normally followed in developed or affluent countries;

(vii) water and energy are scarce commodities in most developing countries, at least on the African continent, and conservation of these is an indispensible part of the formula for survival;

(viii) much more research is required to provide low income earners with the most cost-effective services - the possibility of doing away with 'wet' disposal systems and the development of innovative techniques based on the maximum utilization of indigenous materials should be a particular challenge to researchers;

(ix) more realistic regulations, norms, standards and design procedures are required not only in housing but also in township services;

(x) the drafting of national regulations and codes requires teamwork and the creation of a spirit of cooperation;

(xi) there is a real need for universally acceptable procedures for the technical evaluation of the performance of sanitary equipment. In fact it would be real progress if a model drainage and plumbing code could be prepared that could be applied universally;

(xii) a comprehensive quality control scheme to protect householders from the installation and use of inferior materials and products is an essential ingredient for a happy and satisfied community and should be the first priority in developing countries;

(xiii) basic technical training and education, aimed directly at real needs and productivity, and conducted at an appropriate level, should be top priority in developing countries; and

(xiv) last, but not least, world-wide cooperation on research affecting the quality of life of human beings can still be achieved despite political barriers.

DISCUSSION

SESSION/SITTING 1

PAPERS 1 - 6 : THE DEVELOPING COUNTRIES

RAPPORTEUR: G J MALAN

Question from Mr F P du Toit for Mr L H Robertson:

What allowance is made in the design to meet natural population increase with time?

Mr Robertson: The schemes are designed on the basis of the number of people the soil can sustain assuming that only agricultural settlements exist on it. The people use less than the design water demand rate except in the early morning and evening. Storage facilities cope with these peaks in demand.

Question from Mr D Trinkler for Mr Robertson:

What maintenance work has been necessary on the pipe system illustrated in the film?

Mr Robertson: Very little maintenance work has been necessary even though some schemes have been in use for twelve years. A maintenance training programme is being developed for the local population. Maintenance is the responsibility of the people and not the government.

Question from Mr D A N Scott for Mr Robertson:

It appears that the water is extracted from mountain streams or rivers which are accessible to humans and probably to animals. Is there not a danger of contamination of the water by diseases such as bilharzia?

Mr Robertson: The upper reaches of the rivers traverse six miles of uninhabited rocky terrain. Water sources will in future have to be situated closer to inhabited areas and will require slow sand filtration.

Question from Mr E H Barry for the chairman:

Is a design criterion for minimum fire-fighting flow included in the new design standards for water reticulation being drawn up? The provision of flow for fire-fighting greatly increases the cost of reticulation.

Mr Crabtree: The new national norms for township services currently being drawn up will include revised standards for water supply for fire-fighting.

Question from Mr Trinkler for Mr A D van der Schyff whose paper was presented by Mr K A Finlayson:

Where the cost of houses and services is low, are not maintenance costs high? One should take cognisance of the total cost, that is, construction and maintenance.

Mr Finlayson: Zimbabwe's main housing policy is to promote home ownership. The availability of capital governs the choice of building materials, and kiln burnt blocks and plaster are used extensively. Core houses are provided, which the home owner can extend.

Question from Mr K A H Lund for Mr Robertson:

The film appears to show that the pipeline network is not tested prior to commissioning. If this is so have any post-commissioning problems been experienced as a result of poor workmanship or of pipes being damaged during construction?

Mr Robertson: The pipelines are tested. The initial experience involved 23 miles of trench in which the pipe joints were left exposed for the pressure test. Only three broken pipes were found. It is much easier to complete the backfilling and then to do the test. Any leaks will show up later and can then be repaired.

Question from Mr G J W de Kruijff for Mr Robertson:

I have experienced problems in Kenya with PVC pipes being damaged by poor backfilling. The film shows that ordinary bib-taps are used in Malawi. Have you tried any other types of tap?

Mr Robertson: The backfill is normally soft and dry and local standards of workmanship are quite high, consequently few failures have occurred. The bib-tap requires the least maintenance and it is a simple matter to educate people to use it properly. The spring-loaded tap is too complicated and requires more maintenance.

Question from Mr Trinkler for Mr G J Bertot:

Do you make use of the results of research work carried out successfully in other countries with similar problems such as South Africa and Australia?

Mr Bertot: Research work is carried out in conjunction with the United Nations. Universities undertake research work for Provincial Authorities under contract. A lot of use is made of European expertise.

Question from Mr G Rivas for Mr Robertson:

(i) Did construction of the pipeline begin at the water source and progress downstream?

(ii) Who provided the tools such as picks and crowbars?

(iii) Was there much vandalism or theft of materials?

(iv) Who paid for the materials?

(v) Is there much wastage of water?

Mr Robertson:

(i) Construction was started at the intake and progressed downstream as each section of pipeline was completed it was flushed clean.

(ii) The Government provides the hand tools.

(iii) There is very little vandalism. If a tap is broken deliberately, it is reported to the police. The culprit, when found, has to pay for the tap.

(iv) Materials are paid for by donor agencies. There is no problem in obtaining finance.

(v) There is very little wastage of water. Leaking taps are repaired or replaced by the community at their own expense. The design criterion is being increased from 27 ℓ to 40 ℓ per person per day.

Question from Mr R O Matlock for Mr Robertson:

When a village decides it requires a tap, does this decision depend merely on the provision of local labour, or are financial aspects considered?

Mr Robertson: The decision is a joint one with the Government providing the materials. The village does not have to provide finance.

Question from Mr G J Malan for Mr R A Morgan:

What wall thickness is used in Australia for PVC drains? Have you had any experience with the use of thin wall PVC drainpipes?

Mr Morgan: The 3 mm wall thickness is used for 100 mm diameter drains. Of the two grades of piping available, namely light and heavy, only the heavy grade is used in Australia. In the USA an even heavier wall is used so that there is no need to worry about the standard of backfilling.

Comment from Mr J Botha:
Wall thickness for drains does not play an important role provided that pipes are laid and backfilled properly. The most important factor is the surround to the pipeline. With a sandy bedding and backfill, thin walled pipe can be used.

Comment from Mr Trinkler:
Wall thicknesses were agreed upon by members of ISO Technical Committee 138 of which both Australia and South Africa are members.

Comment from Mr Crabtree:
ISO TC 138 allows five wall thicknesses, only two of which are used in South Africa. The heavier of these, 3,2 mm, is also used in Australia.

Question from Mr Trinkler for Mr Morgan:

(i) Did the code drafting committee consider foreign plumbing codes when drawing up the National Code?

(ii) What is the Australian view on fire safety in plumbing systems?

(iii) Do you consider it necessary to have plumbing controls?

(iv) Agreeing on definitions is a major problem for international committees. Why did your committee not adopt definitions from the UK or USA?

(v) How are new materials considered for acceptance into the National Plumbing Code?

(vi) How are permitted loadings in discharge pipes calculated from fixture units?

(vii) How did you arrive at the depth for water seals in traps?

Mr Morgan:

(i) The foreign codes used were British and American. The Australian code is more closely allied to the British system from which it evolved. Not much research has been done in Australia. Language is a problem in considering other foreign codes.

(ii) The aspect of fire-safety is being looked at. Materials heavier than UPVC are generally preferred for use in large buildings because of the convenience of prefabrication.

(iii) The plumbing trade prefers a prescriptive code so that agreement on site can be reached. It is important to provide for the needs of the trade.

(iv) International codes will be considered by the code committee in Australia when these are available.

(v) A local authority may first allow a new material to be used on an experimental basis. If the experiment is successful, an Australian Standard may be drawn up for it, after which it will be included in the National Code.

(vi) The method of deriving flow rates from fixture units is the same as that used in Britain.

(vii) Mr Crabtree: The depth of seals in traps is arbitrary at present. Research is needed to establish correct seal depths.

Mr C J D Webster: The 75 mm seal depth is arbitrary. The 50 mm seal depth for WC traps is virtually universal. A more economical design might be achieved by allowing some loss of seal depth. In the UK research work is being done using a 75 mm seal depth.

Mr Crabtree: What is important is the net depth of seal left in the trap.

Question from Mr M B Habgood for Mr Morgan:

Does your code permit glass reinforced plastic (GRP) WCs and urinals?

Mr Morgan: No manufacturer has as yet produced GRP fittings. Vitreous china fittings are cheap. It is important that the material be easily cleaned.

Comment from Mr Crabtree:

Moulded plastics damage easily. In mine hostels in South Africa stainless steel WC pans are used which, although more expensive than ceramic, cannot be easily broken, thus minimising replacement costs.

Contribution by Mr du Toit on Mr de Kruijff's paper:

The homemade privy is larger than the modern prefabricated one. It is important for the door to be wide enough for a mother with a baby on her back to enter. Because of the danger of falling into the hole, small children are accompanied by their mother into the privy. The use of local materials offsets the extra cost of the larger building.

Mr de Kruijff: In Kenya an 800 mm wide door is used. The privy does not have to be built of concrete blocks, however washable materials should be used for the floor and for the walls to a height of one metre.

Question from Mr A A Adamson for Mr G J W de Kruijff:

In the sanitation systems presented by you, solid matter is excluded from the sewer and sewage treatment systems. How is the build-up of sludge eventually dealt with?

Mr de Kruijff: Sludge is removed by suction pump from the storage tanks of pour flush and aqua privies at four-to-five-yearly intervals. Research into methods of sludge removal is being done. Digested sludge in vented pit latrines is removed by hand excavation.

Question from Mr Malan for Mr I Silberstein:

What agency applies the supervision mark. Is it applied in the factory?

Mr Silberstein: In addition to the Standards Institution certain laboratories can also grant the supervision mark. Factories are required to have adequate quality control systems which are checked regularly by the Institution. Product samples for testing are taken from the factory or the building site. Products have to comply with the Standard Specifications.

Subsequently, during the technical report session, Mr Silberstein made the following clarification of the question:

My intention in this discussion is to inform you about the principles of standardisation as applied in developing countries. I would like to present some conclusions based on my twenty years of experience in the field of the standardisation and testing of water appliances. In a developing country, the first important consideration must be to ensure that an acceptable product is on the market, regardless of whether it is made locally or imported. Two situations can arise:

1. When all the components of a sanitary system, domestic water supply and waste disposal are imported: In this case, it is important to establish a policy in which only those products which comply with recognised standards, are imported. Compliance with the

standards can be proved by quality marks granted by standards institutions, or other recognised laboratories, or products can be batch tested before shipment by the same laboratories. A small national agency or organisation can act as the enforcement body. It is also recommended that small local laboratories be established for the purpose of testing.

2. Where some of the components are manufactured locally it is desirable to initiate a standardisation procedure in addition to the approval policy: A national standardisation organisation should be established which studies:

(a) Products and data from the manufacturers;

(b) ISO - standards;

(c) foreign standards;

(d) research and documentation; and

(e) local conditions and specific factors.

It is possible to prepare a draft standard. If the national economic policy encourages local industry, it may be possible to accept lower standards of quality for a transitional period. It would then be desirable to establish a national testing laboratory.

I believe, and I conclude from my own experience, that in both a small country and in a developing county, it is very useful to combine standardisation and testing procedures in the same organisation. A special problem arises when an international or foreign standard is not available for a special product, or for a local requirement. In that case it is necessary to use the services of foreign research institutes, or develop a special procedure, such as the one I describe in my paper, which results in what we in Israel call "controlled experimental products". In addition, it is possible to use the achievements of developed countries as a guide for elaborating on local specifications.

To summarise, it is necessary to:

(a) establish a policy and an agency for the approval of products;

(b) establish national testing laboratories and advisory bodies; and

(c) use standardisation.

Question from Mr Morgan for Mr Silberstein:

Could you comment on whether your remarks completely cover an installation which is done by private contractors, and which is connected to a municipal system? According to these discussions, it seems that most of the work in developing countries is done on a contract or self-help basis, controlled by a government department, and presumably with somebody responsible for the standard of the items involved. Is it essential that quality control on local projects be taken over by a standards association, rather than leaving it to a local authority or local contractor? The difference between the roles of the private and public sectors is not clear to me.

Mr Silberstein: The development of the system in Israel started with public housing schemes, because the Ministry of Housing was responsible for most of those schemes, and acted as an associate, which made the introduction of the system very much easier. It is probably also the case in developing countries. Having started with public schemes, the system can easily be extended to other types of building operation.

Comment by the Chairman:

I think Mr Morgan is questioning the necessity for exercising quality control independently of established local authorities, who have adequate technical people available to do it themselves. What you are saying, however, is that all such bodies should in fact be controlled by the same conditions and rules, whether they are a public authority or a private entrepeneur. It seems that one has to find a happy medium between too much control and no control at all. The schemes you saw in the Eastern Transvaal are mainly the responsibility of government agencies which employ large contractors to do the work for them. They normally welcome all the assistance they can get on quality control, and generally write into their own specifications that products have to comply with the requirements of some standard specification. The problem in South Africa is that not all the water supply and drainage materials in sanitary systems are presently covered by an approval scheme or standard.

Question from Mr B E Hollingworth for Mr Silberstein:

Any objections to extensive standardisation in the developing country context are probably due to the fact that standardisation is an extended process which poses a hindrance to the introduction of new technologies, products and materials. What does Mr Silberstein regard as a reasonable period for a national body to take to develop standards for new products or techniques?

Mr Silberstein: In Israel a standard is produced within four years, but specifications can be prepared in two to four months if one knows what to introduce into the specification. It is a very useful method of keeping pace with the development of technology, and should not be an obstacle to the development of new systems.

Question from Mr Rivas for Mr de Kruijff:

(i) Where does the nicely dressed stone shown in the slides come from?

(ii) How does the cost of dressed stone compare with that of concrete blocks?

(iii) Is the water metered. Does the figure of around 60 shillings a month for sewerage and water relate to the quantity of water consumed?

Mr de Kruijff:

(i) The stone is quarried in the vicinity of Nairobi. It is soft and easy to shape and its production creates jobs.

(ii) The cost difference is marginal.

(iii) Water is metered. Consumers pay about R0,26 per k ℓ for the first eight k ℓ; R0,33 per kℓ for the next ten k ℓ and R0,39 per k ℓ for more than 18 k ℓ.

Question from Mr R O Matlock for Mr de Kruijff:

The Eastern Cape Administration Board is responsible for 74 townships for Blacks in which the conversion from a nightsoil bucket system to waterborne sewerage would be almost impossible because of the cost involved. How does one persuade people to accept pit latrines?

Mr de Kruijff: The problem arises from most engineers' lack of sociological training. The authorities need to be educated. The people themselves should be consulted in the matter of deciding whether the money available should be spent on housing or sanitation. Most people don't mind spending money on the water supply but hesitate in the case of sanitation. A model study should be carried out including an opinion survey. Some tribes, for example, will not handle composted excreta.

Question from Mr E J Kelly for Mr de Kruijff:

Where the engineer is aware that one

house will be occupied by four or five families, does he take this into account when designing the sewer system?

Mr de Kruijff: It is a mystery what engineers allow for. They base the design of the water supply on 60 ℓ per person per day and the sewers on 120 ℓ.

Question from Mr A B Davis for Mr de Kruijff:
How often are water meters read. Are separate accounts sent to the householder, or is the cost included in a variable monthly rent?

Mr de Kruijff: Meters are read monthly and an account is presented. If the householder does not pay, the authority cuts off the water supply. The health authority permits the disconnection.

Comment by Mr S M Matiela:
The Umtata Department of Health does not permit pit latrines. With between three and ten families sharing the same house, the pit latrines would fill up too quickly. Pit latrines are only acceptable in rural areas.

Mr de Kruijff: The vented alternating pit shown in Figure 5 in the paper is a permanent solution. Each pit is given a two-year rést period after which the digested excreta can be composted. These latrines have been used successfully in a densely developed township in Kenya. Pit latrines of this alternating type remain workable indefinitely.

Question from Mr Trinkler for Mr Silberstein:
You have said that plumbers should preferably be certificated. What do you think of the "do-it-yourself" trend?

Mr Silberstein: "Do-it-yourself" is not widely practised in Israel.

Comment by Mr Trinkler:
Some countries should get together to discuss items of common interest and prepare an international model code. Better efficiency could be achieved through international cooperation.

Mr Crabtree: CIB Working Committee 62 is looking at the possibility of an international code, but it is a very difficult task.

Comment from Mr C J Carr on the paper by Mr de Kruijff:
In Salisbury 4 000 to 5 000 aqua privies were built using a system of 100 mm diameter sewers. The privies fill up in a year with sand and have to be cleared regularly at a cost of R17 each. The authorities are now converting to a waterborne sewerage system using 150 mm sewers.

Mr de Kruijff: Pot scouring with sand is the source of the problem. A separate settling channel for pot washing will keep sand out of the aqua privy.

Comment by Mr Crabtree:
From experience gained in Zimbabwe the aqua privy works well for one family but public facilities tend to be abused.

Question from Mr P J Kriel for Mr G J W de Kruijff:
What type of sanitation is provided at places where large groups congregate such as schools, community halls and sports meetings?

Mr de Kruijff: Pit latrines are used in rural areas. In towns waterborne sewerage is used but without much success, the system breaking down after two years in some cases. In Zaire communal latrines based on the aqua privy design are used with success.

DISCUSSION

SESSION/SITTING 2

PAPERS 7 - 10 : THE DEVELOPED COUNTRIES

Rapporteur: G C SIMPSON

Question from Mr J J Loots for Mr du Toit:
How did you decide on the level of the wash slab, and would a trough work as a substitute?

Mr du Toit: The women prefer the floor level slab, possibly because they can exert more pressure against it in a sitting position than against a raised surface from a standing position. It seems to be a question of individual preference. Troughs are not favoured because the water in which the clothes are being washed becomes dirty.

Question from Mr de Kruijff for Mr du Toit:
Please can you explain your Figure 1, page 7, a little further, in particular in relation to the working sequence of the women.

Mr du Toit: The women draw off some water from the trough to wash out their buckets. This lowers the level of the float, which in turn raises the outlet plug of the header tank. Water then flows from this tank through the outlet spigot. The breather pipe prevents vibration during discharge. The rate of flow is about 25 to 40 liters per minute.

Question from Mr A J Mills for Mr du Toit:
What arrangements are made to dispose of waste water, such as that used for cleaning the containers at the village water points?

Mr du Toit: No special arrangements are made. A soak-away concept could result in problems in wet weather. Instead, the Womans Institute Craft Club was asked to establish a garden at the experimental water point as part of the experiment. Only beans do not thrive on soapy water and so the garden concept seems to work.

Question from Mr W J Uys for Mr du Toit:
How many people can be served by a water point such as you have shown?

Mr du Toit: 20 families, that is about 100 - 120 people, were served by the experimental water point, but it was so successful that usage by visitors may have resulted in a far greater number of people being served.

Question from Mr A H Lotriet for Mr du Toit:
Wat is die graad van besoedeling wat voorkom in die bakke waaruit die water geskep word om die vloei van water aan die gang te sit? Uit die foto's blyk dit dat die mense wat kom water haal in die bakke rondstaan.

Mr du Toit: Pollution of the water in the trough is probably very high, but these people are used to the common waterborne diseases, and the situation is no more serious than if they were using a river. However since this water is used only for washing and cleaning, contamination of drinking and cooking water is unlikely to occur.

Question from Mr M D Radford for Mr du Toit:
Two approaches have been put forward: the village tap by Mr Robertson, and the waterpoint by Mr du Toit. How do we reconcile these two ideas?

Mr du Toit: Mr Robertson's solution is mainly concerned with the distribution of water to villages, while mine is concerned with the dispensation of water at its place of use.

Mr Robertson: I agree. In Malawi the people are left to solve their own dispensation problems. He noted that there appeared to be no difference between the water at the trough and that in the river, and queried the need for the trough.

Mr du Toit: One of the many functions of the waterpoint concept is to protect the environment; paths to the river are a cause of erosion. Diseases, such as bilharzia, can also be controlled if the cycle can be broken.

(Mr du Toit noted, out of session, that the water supplied to the waterpoint was treated where necessary, and was therefore "safe" water.)

Question by Mr Trinkler for Mr Webster: A 25 per cent water loss caused by leakage seems to be very high. What conclusions are drawn from this experience in the UK? In other words can the great differences originate in individual design philosophies? Why not use a supply system, such as the one used in Malawi, which has, as we have heard, nearly no problems?

Mr Webster: I agree that a 25 per cent distribution loss is high, and that the community should be aware of this problem. However, it is not easy to establish the source of the loss in an urban situation. Generally, losses from one large leak are easier to detect and fix than losses from several small leaks, where the cost of repair may exceed the available finance, or the cost of replacement. Therefore, it is often the financial aspect which dictates the solution to the problem.

Question by Mr Scott for Mr Webster: I seem to have misunderstood your slide showing that water at boiling point and at 12 bars pressure increases its volume 275 fold as the pressure is reduced to atmospheric while steam only increases its volume ten fold. Can you please clarify?

Mr Webster: It is often mistakenly presumed that hot water is not as dangerous at boiling point as steam. Steam is already in a gaseous state, and therefore expands in proportion to the pressure, whereas the same unit volume of water at boiling point and at 12 bars pressure contains considerably more energy than steam at the same pressure. Therefore, when the pressure is removed, the water generates a very much higher volume of steam at atmospheric pressure than the same unit volume of steam.

Mr Silberstein contributing to the discussion on Paper No 8 commented that the rate of 0,1 ℓ/s for showers seemed excessively low and asked "how was it achieved". Is a flow regulator used? In Israel a 10 to 12 per cent saving of water was achieved in certain cases by using a regulator. It seems that the atomiser shower is a good idea and information on these would be appreciated. It was Israel's experience that flush valves waste water and legislation requires the use of cisterns in domestic dwellings.

Mr Webster: The flow figures quoted are gleaned from design data applied in the UK. I do not know if flow regulators are used to achieve these flows.

Mr Silberstein: Flush valves require at least 3/4 inch piping, the assurance of a minimum pressure in the mains and good quality water. Fully automatic flush valves are preferable to semi-automatic valves, which can waste a lot of water while being held down. Almost 30 per cent of domestic consumption in Israel is used in flushing WC's.

Mr Crabtree: Garden watering forms a large part of domestic consumption in South Africa. However there is a wide variation in domestic water distribution figures from country to country, and town to town.

Question by Mr J Botha for Mr Webster: Access to the drainage installation is often misused resulting in a blockage which has to be cleared through the same opening. This leads to the view that a closed system in which access to the drain is limited to an absolute minimum would result in fewer blockages. Experience in Mitchell's Plain has shown that a closed system has considerable cost benefits in installation and maintenance. What are the requirements in this regard in the UK?

Mr Webster: Access to drains is provided in the UK because of the requirements of our building regulations. However, there is a current trend to use rodding eyes more widely instead of manholes. Closed systems are not used in the UK. Although this may have some economic merit this has probably been eroded to some extent in the UK by the use of prefabricated manholes, usually of plastic, and plastic rodding eyes.

Question from Mr Uys for Mr Webster:
What is the pressure required to operate the atomiser jet, and does it operate effectively when you have differential pressures for hot and cold water?

Mr Webster: Pressures of 3 or 4 bars are adequate. It is necessary to balance the hot and cold line pressures where these are supplied separately. This can often be achieved by a local instantaneous heater, especially since low flow rates are involved.

Question from Mr J J Loots for Mr Webster:
In your paper you say: "The designer must ensure that the blockage will occur at the point of introduction of the object" (Page 3, Para F). Can you suggest how this can be accomplished in, for example, a township?

Mr Webster: The paper suggests that this objective is one which should be aimed at where possible. One example is to ensure that the smallest diameter for a WC drainage branch is in the WC itself, so that successful clearance of the WC will usually ensure successful clearance through the rest of the drain.

Question from Mr de Kruijff for Mr Webster:
In a lot of developing countries sewage flows are already too low to keep the sewers operative. Are we not going to aggravate the situation in developing countries by the introduction of the low flush toilet in waterborne sewerage? For your information, atomiser showers have proved to be inefficient for washing the hair of Africans.

Mr Webster: WC's with a 6-litre flush are already in use on a wide scale in Scandinavia where they are used in all new installations. There are no reports of problems arising from their use. WC's with a 3-litre flush are at a more exploratory stage with regard to drains, but available information is encouraging. However, there is no substitute for tests under real-use conditions, and where conditions in developing countries are significantly different from those in which European tests have been made, it would be wise to do tests locally. However, relying merely on intuition, reaction against using less water in drains has not been substantiated by experiments in Europe, and this may also be the case in developing countries. I am interested in your comment on the difficulties of using atomiser showers for African hairstyles. Hair washing was also found to be the most exacting requirement for atomiser showers in the UK tests.

Question from Mr Botha for Mr Webster:
A recent survey in a South African town has shown that some drains, particularly those at service stations and restaurants, have to be cleaned regularly. This probably stems from the fact that special traps are not properly maintained. How is this phenomenon controlled in the UK? Can offences of this nature be handled legally through notices and fines without taking offenders to court?

Mr Webster: I agree with your analysis, and we have the same problem in the UK. Local authorities there have the power to clear blocked drains and charge the owner. However, I do not know if this power is widely used in the context that you have raised.

Question from Mr de Kruijff for Prof H J Knoblauch (Germany):
1. Are your Fakazell quantities and paper volumes representative of German stools

and faecal matter? Did you carry out research on this subject to determine the average size of deposits?

2. How do you think the results of your studies can be utilised in developing countries, where factors such as stool sizes, consistencies, and paper qualities differ?

Prof Knoblauch: Fakazell is 20 per cent cellular matter and 80 per cent water, which is much the same as faecal matter. Research carried out in London in faecal matter shows a wide variation in results, and it is therefore necessary for me to generalise.

Because our studies consider only the faecal matter and paper encountered in Europe, it would be difficult to translate the results to conditions in a developing country, where different solids and paper are used.

Question from Mr D C Osborne for Prof Knoblauch:

The WC bowl shape must surely have a critical bearing on the efficiency of the flushing system. Please elaborate on this aspect.

Prof Kroblauch: The geometric shape has a decisive effect on the performance of a WC. Of particular importance are the shape and dimensions of the trap. However, the type and quantity of solids to be flushed must also be considered in this regard.

Question from Mr Webster for Prof Knoblauch:

Is there any information on problems arising in actual installations as a result of using WC's which deposit solids in the branch pipe? Do these deposits clear themselves when the WC is used again later?

Prof Knoblauch: Generally, no problems have been found in the horizontal branch pipe because connections are made at 45^{0}. Deposition does sometimes occur, but such deposits are flushed out before they cause a blockage. Blockages usually occur for other reasons, such as insufficient slope of the pipe (20 mm/m min), foreign bodies or poor installation.

Question from Mr J A Voysey for Prof Knoblauch:

Can this type of research work be done in laboratories in developing countries using results from industrial countries as a basis for research?

Prof Knoblauch: Yes, but one should use solids which are representative of the area, and take local conditions into account. It is rarely possible for industrial countries to do research which is applicable to a developing country, and in the case of WC's it is possible that special shapes may be required to accommodate the relevant solids. This may lead to more water usage than in developed countries, and thus the hydraulic problems can also be different.

Comment by Mr Malan:

One should look at flushing efficiency at a national level, but one should also assume that the user can afford the service and knows how to use it. On this basis one should not design to meet the requirements of extremely under-developed peoples, but should rather try to raise their standard of living.

Mr de Kruijff: I would also like to see standards raised.

Mr du Toit contributed the following to Mr Perrier's paper:

The 11th commandment should state the need for a proper approach. It is difficult for a developing country to explain its problem and be understood by a developed country. There is a need for a greater degree of communication and trust between developing and developed countries. For example, if human excreta is left in areas where cattle graze, it can lead to diseased cattle. However, if one provides a gum-tree plantation in which cattle will not graze for the people to excrete in, the problem is solved to the benefit of both people and cattle.

Mr de Kruijff commented in regard to Mr Perrier's paper that he was disappointed in the way research work was devised by the industrial countries for use by the developing countries. The former's technology cannot readily be adopted to the latter, and it is preferable for developing countries to help themselves, using and adapting materials from industrial countries, where necessary.

Mr Swift: Many of the problems currently being experienced by developing countries have already been solved by the developed countries. The solutions applied at that time are available in old text and reference books, and should first be tested before further research is carried out.

SESSION/SITTING 3

THREE TECHNICAL REPORTS

REPORT/VERSLAG NO 1

PRESENTED BY/AANGEBIED DEUR: A P BEKKER

RAPPORTEUR: J BOTHA

Question from Mr Barry for Mr Bekker:
In his paper, Mr Bekker does not agree with a statement by Kinmont that water tariffs should discourage excessive water consumption and waste, and that these tariffs should be carefully framed so as to encourage the use of sufficient water to satisfy the minimum requirements for public health. Could he please explain his view on this in more detail? Could he also enlighten us on his preference for a straight tariff versus a disincentive or incentive sliding scale?

Mr Bekker: Water has a certain value as a commodity, and the Department of Water Affairs recommends that it be given its true value, and not undervalued, as in the past, through tariffs which remained constant irrespective of the volume consumed. The goal of applying a tariff which discourages excessive use corresponds with that of Kinmont. However, there are different approches to achieving this, and whether disincentive or incentive tariffs are the answer, I am not really qualified to say.

Question from Mr de Kruijff for Mr Bekker:
Referring to table 1: what is your justification for dividing the consumption per stand per day by a figure of six to get the per capita consumption? The latter depends a great deal on the type of service installed but I can state from experience in Kenya that a figure of 20-40 ℓ per day is far too low for a waterborne sewerage system.

Mr Bekker: The figure one should divide it by is debatable, but it does not make much difference as long as the minimum health requirements are complied with. The figure of 20-40 ℓ per day is the minimum required for public health, and it is subject to a variety of factors. As more flush toilets are installed this figure will change.

Question from Mr de Kruijff for Mr Bekker:
What is the per capita consumption for Europeans? One sector of the population should not be limited to the bare minimum of 20-40 ℓ per day while another is allowed to have ample water for purposes such as washing cars and watering gardens. Kenya applies an economic viable return policy, according to which water is cross-subsidised in that people who use more water have to pay more for it. The wealthier sectors of our society use much more water than the people who live in the poor areas, but that does not justify the poor having to reduce their water consumption. Is the curbing of excessive water consumption applied to all communities in South Africa? I agree that water should be metered.

Mr Bekker: My paper deals only with one group of the population. However the curbing of excessive consumption applies to all groups because of the limited water resources available in South Africa, and the cost involved in developing them. It is clearly not the intention of the authorities to restrict only one group of the population. It is pointed out in the paper that by curbing the abuse of water by a certain group, more water can be made available to others, in line with the minimum health standards. This is one way out of the dilemma of the water situation in this country.

Comment by the Chairman:
Water conservation, particularly in urban areas, is aimed at all sectors of the

population, regardless of race. The fact is that large sections of the urban population's consumption have been unmetered up to the present, and that their consumption has escalated out of all proportion, largely owing to the indiscriminate waste of water. Although the intention of the authorities is not to curtail only one sector of the population, it so happens that it is that sector that has been unmetered up to the present and needs to be curbed to bring the supply/demand situation into balance. Furthermore, when you start making people pay for their services, they should not suddenly find themselves unable to pay a water bill which is far beyond their means. The figures quoted are basic requirements set by the Department of Health for minimum health standards, and probably no other urban community anywhere has standards as low as their minimum standards. The figure for Soweto, for instance, is many times in excess of those absolutely minimal figures.

Comment by Mr de Kruijff:
When improving low income housing areas and bringing in waterborne sewage, one should design for a water supply of at least 100 ℓ per day.

Kommentaar deur Mnr Botha:
Met verwysing na Mnr Barry se navraag moet in aanmerking geneem word dat waterskemas in fases ontwikkel word, wat onvermydelik meebring dat 'n gemeenskap op 'n sekere tydstip 'n groot kapitale las moet dra terwyl die watervoorraad die aanvraag ver oorskry. Aan die einde van 'n skema se ekonomiese leeftyd is die watervoorraad weer beperk, maar is die kapitale las ook grootliks ingekort. In die eerste geval moet die tariewe waterverbruik aanmoedig om meer inkomste te verkry, en in die tweede geval moet waterverbruik ontmoedig word om die leeftyd van die skema te verleng. Om dus 'n vaste tariefpatroon op alle waterskemas, of selfs op die hele leeftyd van een skema, van toepassing te maak is onprakties. Hierdie wisseling in die balans tussen die beskikbaarheid van water en die aanmoediging of ontmoediging van waterverbruik kan moontlik in 'n mate uitgeskakel word deur die ontwikkeling van gesamentlike waterskemas vir aanliggende gemeenskappe op 'n soortgelyke patroon as die Randwaterraad in die PWV-gebied.

Question from Mr Rivas for Mr Bekker:
How did you arrive at supply figures if the supply was unmetered?

Mr Bekker: The figures were taken from a study by Garlipp. They were presumably determined through bulk metering in controlled areas.

Comment by Mr C J Carr:
The Salisbury water supply is fully metered and consumption varies from about 75 ℓ per person per day in the low income areas to 300 ℓ per person per day in the high income areas. Universal metering has an additional advantage in that by bulk and individual metering, losses can be ascertained. As in the UK, losses of up to 25 per cent have been experienced in Zimbabwe. Having discovered this, and taken action, it has been possible to reduce this to 10-12 per cent.

Mr Bekker: Studies of water consumption in the larger towns of South Africa have revealed losses of up to 40 per cent, of which the local authorities have not been aware. They were promptly encouraged to do something about these extremely high figures. However, figures of 10-15 per cent are not uncommon.

Comment by Mr Davis:
As Natal is in the fortunate position of having very good water resources, in contrast to the dismal position in the Transvaal, any directives from the Department of Water Affairs towards water conservation should not be made mandatory. They should be based on economic considerations. The administrative costs of a metered water supply are very high and must eventually be borne by the residents. It is therefore an equation of the cost of metering against that of providing additional water resources. Where the ordinary water resources are still available at a reasonable cost, the option to use alternatives to metering should be left open.

Comment by Mr Osborne:
In developing Black townships in the homelands throughout the country, great difficulties are being experienced in the conservation of water. With reference to the high water consumption figures in two large townships outside East London and Durban, the highest of which is 30 Mℓ/day for 22 000 houses, it is clear that tremendous savings could be effected by metering the water supply. From an engineering point of view, this is feasible, but it seems to be a political issue which has resulted in the supply of water remaining unmetered. It is therefore very difficult to use the available water resources efficiently.

Question from Mr G Holling for Mr Bekker:
Does the possible saving of 30-50 per cent in the cost of water take cognizance of the cost of installation, maintenance and administration of individual meters?

Mr Bekker: The figure of 30-50 per cent is applicable to the saving of water, and not to a reduction in costs. The latter is entirely another matter, which is very important as well. The percentage cost saving will not be nearly as much as the water saving.

REPORT/VERSLAG 2:

PRESENTED BY/AANGEBIED DEUR: G J MALAN

ON BEHALF OF/NAMENS: E OLSSON

Comment by Mr de Kruijff:
Consumption figures for Kenya of 25-40 ℓ per day are quoted in the paper, but they are not representative of the real situation. Where a house connection is provided, the water consumption is the same as in Salisbury, viz. 75-300 ℓ per day, depending on the type of housing estate. Another matter warranting comment is the influence of different cultures and different local conditions on the provision of bathing facilities in residential buildings. In the South African situation, it could be made mandatory to fit a shower whenever a bath was installed. I have noticed that in most hotels in South Africa only baths are available.

Mr Malan: The tendency in South Africa is for women to prefer baths and men showers. It often happens that both are provided in a house. Where the cost factor becomes more important, however, the woman's needs normally prevail, despite the fact that showering consumes less water.

Question from Mr Scott for Mr Malan:
Sweden is one of the most highly taxed countries in the world. Does the high cost of water in Sweden not include a further hidden tax?

Mr Malan: I am unable to tell from the paper whether this is a true cost or whether any additional tax has been added into the water charge. I suspect that the latter may be the case.

Comment by Mr Morgan:
Although the test results as presented in the paper indicate that a good, clear flushing effect is achieved in conventional sewerage systems with a flushing volume of three litres, it seems that these results refer only to flats, and therefore only to high rise buildings. The results, therefore, cover only the clearing of faecal matter from the WC bowls into the branch pipes, and from the branch pipes into the stack and drain, where wastewater of sufficient volume is collected to carry it without problems down to the sewer. It is, however, not clearly stated whether a 3 ℓ-flush would be suitable for single family dwellings. The tests carried out by Prof. Knoblauch indicate that six litres was only just enough. It therefore seems that a 3 ℓ-flush would give rise to problems in single family dwellings, except when a septic tank is provided, in which case the length of drain between the WC pan and the septic tank is normally restricted, thus enabling it to be cleared with only a few flushes.

Comment by the Chairman:
Three-litre flush toilets were first used in holiday homes in country places, and

certainly not in high rise flats. These homes were probably provided with septic tanks.

Comment by Mr Malan:
They are probably mostly intended for high rise buildings and septic tank applications, but one should not forget that depending on the configuration of the drains, one may have other contributors, such as baths and sinks, fairly close downstream which would provide the necessary flow.

Comment by Mr H B Malan:
There is no doubt that the introduction of water tariffs is the most effective way of curtailing waste in all communities, but tariffs should also be considered in the socio-economic sense, and not only in the economic sense. An investigation during 1968 indicated that the agricultural sector was the largest consumer of water, while it contributed only 10 per cent to the national income. One is therefore inclined to say that water consumption in the agricultural sector should be curtailed. This sector did, however, employ over 50 per cent of the South African population at that stage, which makes one understand why water must be subsidised. Another way to restrict water is through design standards. To curtail water consumption, one should limit the supply by some easy means. If people are aware of the shortage, they will accept the inconvenience of a limited supply. It seems that we are generally overdesigning our water reticulation systems, and pressures, sizes of pipes and appurtenances will have to be looked at very carefully.

Question from Mr J Bester for Mr Malan:
Do you have any comments on the restriction of water pressure as an aid to reducing water consumption?

Comment by the Chairman:
Pressure reduction is not only a means of curtailing water consumption, but also a means of reducing the cost of reticulation systems, because the need for high pressure piping and fittings is thereby obviated. It is common practice in the United States for water pressures to be limited as a means of water conservation. It tends, however, to be a negative approach, because the user's comfort standards are affected. Water users have a right to certain minimum comfort standards and those requirements must be satisfied. Mr Røsrud in Norway has done a lot to establish minimum requirements for user convenience.

Comment by Mr Habgood:
Water conservation, and the measures needed to achieve it as discussed here, are all very well in situations where there is a permanent shortage of water. Where shortages occur only irregularly, going to a lot of expense to curtail water consumption should be avoided. The water account never balances and the town treasurer tends to make cross bookings to and from other accounts, to make them balance. It sometimes even happens that water tariff has to be raised while the water storage dams are full. Water conservation measures can therefore not always be introduced on a permanent basis. When the metering of water is introduced as a means of water conservation in high density housing areas, it is important to have a basic minimum which is paid for by means of its incorporation in the rates paid for the house. Apart from satisfying the minimum health requirements, this basic minimum also ensures that the sewers operate properly, to which end it is important to strike the right level for that basic minimum. Experience in Zimbabwe indicates that a figure af approximately 14 K ℓ per month per house produces the desired results. As the water consumed in excess of the basic minimum has to be paid for, the residents quickly adapt themselves to use only the basic minimum volume of water per month. It is also important not to have external taps installed, because they lead to many problems, such as neighbours helping themselves when the householders are away. It is therefore not just a question of putting in meters when metering is introduced. All these additional factors have to be borne in mind, particularly in South Africa, where many metering schemes are being introduced at present.

Comment by the Chairman:

It is a very valid argument that a basic minimum for public health reasons and for the operation of the sanitation system should be incorporated. Mr de Kruijff also made the point that it is no use saving water to the point where the whole system breaks down. Another point to be remembered when introducing metering is to use wet-dial meters and to put them in places where, if the glass is broken, they will flood a porch or similarly exposed area. This will prevent meters from being willfully broken. One must think about problems of this nature when planning the metering of low-income developments, particularly in large townships such as Soweto.

Comment by Mr H B Malan:

A large proportion of the water loss mentioned earlier is actually the result of unmetered water used for purposes such as fire fighting, and the watering of parks. It is therefore unfair to call this a 'water loss'. It should rather be referred to as 'unaccounted water'.

Question from Mr Morgan for Mr Malan:

In the paper, it is stated that adequate flushing of the piping system will be achieved if a force of at least 0,25 kp/cm^2 is applied, and the flow depth does not exceed half the sewer diameter. Will full flow not clean the pipe anyway? The 0,5 flow depth has probably to do with the design of the system to allow for air flow through the pipes.

Mr Malan: The 0,5 flow depth is probably an old traditional rule which is not based rationally on present figures. In the past people tended to make excessive allowance for infiltration and stormwater influx. With the technology and laying methods available today, this is no longer necessary.

Comment by Mr Webster:

These are arbitrary requirements to ensure that a stoppage of solids does not become a permanent blockage. Experience in the UK indicates that a drain does not have to be flushed every day to prevent permanent blockages. The 0,5 flow depth seems to stem from a belief that a higher flow would cause an obstruction to the air flow in the drain, resulting in a negative pressure increase in the stack, which would cause the trap seals to be drawn. Experiments done in the UK indicate that the pipe has to flow to the point where it is nearly full before this will happen.

Comment by Mr M A Moorhouse:

There seems to be some doubt as to the capability of 3-litre flush toilets to clear solids from the downstream pipework. When one considers, however, that the average toilet is used more as a urinal than for the depositing of solids, and that when used as a urinal, it is usually flushed, this fear seems to be unwarranted. There will be sufficient flushes of water through the pipes to clear whatever solids may be left behind.

Comment by the Chairman:

This question of moving solids in drainage systems has been studied by a lot of researchers in the past. Experimental work done by Ackers in the UK indicates that the operation of a house drain is basically the constant formation of a series of partial blockages which are then moved further down the line by subsequent flushes and eventually cleared away. The improved technology and pipe jointing methods in use today have largely eliminated the possibility of permanent blockages as they occurred with the old earthenware pipe systems. It is therefore debatable whether a drain needs to be cleared with every flush. The solid content of the sewers in an average waterborne sanitation system is so small, that slight reductions in the water proportion will not make much difference, particularly if one takes cognizance of all the waste water contributed by baths and sinks.

It seems that we are making a mountain out of a molehill. We have a lot of townships in South Africa, which, because of the recent slump in the building industry, have not been fully built up. Their sewerage systems have not all become blocked because of the limited flow contributions from the widely spaced houses, and it seems, therefore, that this problem is generally overrated. However we must bear in mind that there are basic minimum design standards, especially in the very low water usage situation, as pointed out by Mr de kruijff.

Kommentaar deur Mnr Botha:
Weens die genoemde onderbroke vloei in dreineringspype is dit belangrik dat die vloei vanaf verskillende sanitêre toestelle so gou as moontlik saamgevoeg word om aanvullende spoelaksie in die perseelriool te verkry. Dit is veral van toepassing by enkelwonings waar ons in Suid-Afrika nog redelik baie gebruik maak van die sogenaamde tweepypstelsel. Ons kan in hierdie verband met goeie voordeel kyk na enkelstamtoepassings by perseelriole.

Comment by the Chairman:
Two-pipe systems are not generally used in Europe. It is a South African phenomenon which we have got to get rid of, particularly in low-income housing schemes. In a two-pipe system, waste-water is carried to the drain via a trapped gulley, while soil-water goes down a separate stack. This is not to be confused with the combined system in which sanitary sewage and rainwater are carried by the same system of pipes.

Comment by Mr Malan on Mr Olsson's paper:
(a) Table 1 lists the household water consumption of twelve developed countries in units of litres per person per day. The arithmetic average of eleven countries, (USA excluded), is 180 litres per person per day. This figure agrees with that obtained for the middle income group in South Africa.

(b) Figure 1 shows the breakdown of household water consumption according to various outlet points. The total hot water consumption is given as 75 litres per person per day. By comparison, similar consumption figures measured in Pretoria show a variation of between 40 ℓ/person/day summer minimum to 69 ℓ/person/day winter maximum.

(c) The authors state that in the sample of Swedish flats monitored energy consumption was reduced by lowering the temperature of the hot water from 55°C to 45°C. The volume of water stored at 45°C could, however, under certain circumstances be insufficient for the hot water needs of larger families. A further means of reducing energy consumption in hot water systems would be more efficient insulation of the storage cylinder.

REPORT/VERSLAG 3

PRESENTED BY/AANGEBIED DEUR G J MALAN

ON BEHALF OF/NAMENS T P KONEN

In presenting Mr Konen's Test Kit for the Sanitary Performance of Water Closets, Mr Malan was able to present to the conference a series of results obtained at the National Building Research Institute using Mr Konen's test method. The results obtained are compared with similar test results obtained with the same WC pans using two other tests. For the benefit of readers these results, presented only in slide form at the conference, are reproduced below.

Details of the other tests used are:

(a) The British test method: This test is included in BS1213 : 1945 - Ceramic washdown WC pans - Amendment Slip no 7, dated 30 September 1974, and;

(b) The Scandinavian test method: The test was developed as a result of co-operation between the building research institutes of the Scandinavian countries, and is reported by Mr V Nielsen in Document NOTAT 94 of the Swedish National Building Research Institute, dated June 1979.

Question from Mr Trinkler for Mr Malan:
How was the behaviour of faecal matter in the pipes simulated?

Chairman: The tests do not attempt to simulate the behaviour of faecal matter in the downstream pipework, merely the efficiency with which waste is cleared from the pan.
(*continued on page 54*)

WC FLUSHING TESTS

PAN MARK No. WDCC I

TEST METHOD		TEST RESULTS: 6ℓ FLUSH	TEST RESULTS: FLUSH	REMARKS
BRITISH:	PAPER	F		
	BALL	P		
	SAWDUST	P		
OVERALL RESULT		F		
SCANDINAVIAN:	SPONGE	P		
	BALL	P(413)		350 MIN. POINTS REQUIRED
	PAPER	F		
	DYE	F		
OVERALL RESULT		F(1413)		2500 MAX. OBTAINABLE
STEVENS INSTITUTE OF TECHNOLOGY:	BALL	P(85)		75 MIN. FLUSHED OUT
	GRANULE	F(159)		MAX. 125 REMAIN IN PAN
	DYE	F		
	SURFACE WASH	F		

WD = WASH DOWN LL = LOW LEVEL CISTERN
SY = SYPHONIC CC = CLOSE COUPLED CISTERN

WC FLUSHING TESTS

PAN MARK No. WDCC II

TEST METHOD		TEST RESULTS: 3ℓ FLUSH	TEST RESULTS: FLUSH	REMARKS
BRITISH:	PAPER	P		
	BALL	P		
	SAWDUST	P		
OVERALL RESULT		P		
SCANDINAVIAN:	SPONGE	P		
	BALL	P(483)		350 MIN. POINTS REQUIRED
	PAPER	F		
	DYE	P		
OVERALL RESULT		P(1883)		2500 MAX. OBTAINABLE
STEVENS INSTITUTE OF TECHNOLOGY:	BALL	P(97)		75 MIN. FLUSHED OUT
	GRANULE	P(14)		MAX. 125 REMAIN IN PAN
	DYE	P		
	SURFACE WASH	P		

WD = WASH DOWN LL = LOW LEVEL CISTERN
SY = SYPHONIC CC = CLOSE COUPLED CISTERN

WC FLUSHING TESTS

PAN MARK No. WDLL III

TEST METHOD		TEST RESULTS: 9ℓ FLUSH	TEST RESULTS: 7ℓ FLUSH	REMARKS
BRITISH:	PAPER	P	P	
	BALL	P	P	
	SAWDUST	P	P	
OVERALL RESULT		P	P	
SCANDINAVIAN:	SPONGE	P	P	
	BALL	P(476)	P(433)	350 MIN. POINTS REQUIRED
	PAPER	P	P	
	DYE	P	P	
OVERALL RESULT		P(2476)	P(2433)	2500 MAX. OBTAINABLE
STEVENS INSTITUTE OF TECHNOLOGY:	BALL	P(98)	P(91)	75 MIN. FLUSHED OUT
	GRANULE	P(6)	P(18)	MAX. 125 REMAIN IN PAN
	DYE	P	P	
	SURFACE WASH	P	P	

WD = WASH DOWN LL = LOW LEVEL CISTERN
SY = SYPHONIC CC = CLOSE COUPLED CISTERN

WC FLUSHING TESTS

PAN MARK No. WD LL IV

TEST METHOD		TEST RESULTS: 9ℓ FLUSH	TEST RESULTS: 7ℓ FLUSH	REMARKS
BRITISH:	PAPER	P	P	
	BALL	P	P	
	SAWDUST	P	P	
OVERALL RESULT		P	P	
SCANDINAVIAN:	SPONGE	P	P	
	BALL	F(208)	F(179)	350 MIN. POINTS REQUIRED
	PAPER	P	F	
	DYE	P	P	
OVERALL RESULT		P(2108)	F(1079)	2500 MAX. OBTAINABLE
STEVENS INSTITUTE OF TECHNOLOGY:	BALL	F(52)	F(43)	75 MIN. FLUSHED OUT
	GRANULE	P(67)	F(176)	MAX. 125 REMAIN IN PAN
	DYE	P	P(JUST)	
	SURFACE WASH	P	P	

WD = WASH DOWN LL = LOW LEVEL CISTERN
SY = SYPHONIC CC = CLOSE COUPLED CISTERN

WC FLUSHING TESTS

PAN MARK No. WD LL V

TEST METHOD		TEST RESULTS: 9ℓ FLUSH	TEST RESULTS: 7ℓ FLUSH	REMARKS
BRITISH:	PAPER	P	P	
	BALL	P	P	
	SAWDUST	P	P	
OVERALL RESULT		P	P	
SCANDINAVIAN:	SPONGE	P	P	
	BALL	P(493)	P(457)	350 MIN. POINTS REQUIRED
	PAPER	P	F	
	DYE	P	P	
OVERALL RESULT		P(2493)	P(2157)	2500 MAX. OBTAINABLE
STEVENS INSTITUTE OF TECHNOLOGY:	BALL	P(98)	P(91)	75 MIN. FLUSHED OUT
	GRANULE	P(6)	P(33)	MAX. 125 REMAIN IN PAN
	DYE	P	P	
	SURFACE WASH	P	P	

WD = WASH DOWN LL = LOW LEVEL CISTERN
SY = SYPHONIC CC = CLOSE COUPLED CISTERN

Pans marked "WDCC III", "IV" and "V" included in the test results are wash down, low level pans made by South African manufacturers. Pans marked "WDCC I" and "II" are wash down close coupled suites of Swedish manufacture.

In the flushing test results presented by Mr Malan, 'P' denotes "pass", and 'F' denotes "fail".

Pan marked "WDCC I" was flushed with a 6 litre flushing volume, according to the rating of the pan, and pan marked "WDCC II" was flushed likewise with a 3 litre flushing volume.

From early results obtained from the Stevens Institute of Technology test method, Mr Malan concludes that the test appears to be worthwhile. It is significant that both paper and sponges are excluded as test media. He added that the surface wash test could possibly be improved by raising the marked line from 25 mm below the rim outlet to, for example, 5 mm below the rim outlet.

Question from Mr Evans for Mr G J Malan:
Could you comment on whether or not a test on a pan should be carried out with a flushing device which will be coupled with that pan in practice? If so then that test result would only be relevant if the pan were installed in conjunction with that particular flushing device, and not with any other.

Mr Malan: It is partly right to say that a pan should be tested with the specific cistern with which it will be sold, but very often the washdown pan is not sold with a cistern and there are manufacturers in South Africa who make only cisterns. It should rather be said that some pans will have to be qualified as usable only with a certain cistern or flush valve.

Comment by the Chairman:
Close-coupled suites are sold as one entity, but it seems that the majority of pans will have to be certified as to what cisterns they should operate with, and similarly, cisterns will have to be certified as to what pans they will efficiently flush.

Question from Mr H B Malan for Mr G J Malan:
Are the shape and size of paper standardised for such paper tests?

Mr Malan: Yes, a particular size is specified, as well as that they should be lightly crumpled and dropped from the level of the rim into the bowl. However, we do not believe in the paper test, because it is far too variable to produce consistent results.

Question from Mr Rivas for Mr Malan:
Would two lines not be more efficient than the one prescribed by the Stevens test? The required lines could be 5 mm and 25 mm below the rim, each with its own pass criteria.

Mr Malan: It could be advantageous to have more than one line, but Mr Konen has presumably opted for one line because, as a result of the shape of the bowl, the flow tends to converge and become more vigorous towards the base of the bowl. The place this test is aimed at is at the rim of the bowl where the initial wetting takes place. We do not necessarily accept the Stevens test as it stands.

Comment by Mr Webster:
A relationship must still be established between these tests and reality. Ball tests are widely used, but they are misleading, because they differ from each other. In the UK ball test, a sunken ball is used, because in reality there are few failures caused by floating solids. Failures are generally caused by sunken solids, or paper. The UK test is therefore representative of real failures which occur in practice, although it cannot be deemed an ideal test. When we first used a floating ball test in the UK, we found that manufacturers tended to modify their pan designs so that they passed the floating ball test, only to realise later that their pans did not clear sunken solids and paper.

Mr Malan: I do not agree that floating solids are easier to flush than sunken solids; the latter are already halfway to the outlet. If a pan passes the floating ball test, it will certainly pass the sunken ball test. Floating solids are probably more representative in South Africa, where maize is the staple diet of a large section of the population. The higher standard of living in the northern hemisphere enables people to have a higher and heavier protein diet, resulting in predominantly sinking solids. In this regard it is interesting to note that the South African pan which produced the first test results I showed you, failed all the tests, except the UK test.

Question from Mr Trinkler for Mr Malan:
Could you please comment on the test method described in paper 10 in relation to the tests carried out by yourself? What is the possibility of running tests with South African pans according to the method described in paper 10?

Mr Malan: We would like to try this method, but we have not yet been able to establish what 'Fakazell' really is. We need more details on how it is made so that we can make it ourselves, for use in similar tests. If this can be done, we will report back to you at a later stage.

Comment by Mr Silberstein:
The question concerning all these tests is whether the tests done in the laboratory do in fact, give a reasonable index of performance for WC bowls in actual service. To investigate the validity of the flushing efficiency test, particularly the Sobolev test, a series of tests were run in Israel, on twelve washdown-type WC bowls, with three different types of low level cistern. The cisterns differ from each other mainly in their internal resistance characteristics, and consequently deliver different rates of flow. Four flushing volumes were used in the tests. (9,5 ℓ, 8 ℓ, 6,5 ℓ and 5,5 ℓ). Each test consisted of a particular combination of WC bowl, cistern and flushing volume. One hundred combinations were tested in the laboratory, thirty eight of which were repeated in actual service. The results of these tests indicate that the laboratory tests gave a reasonable index of the performance of WC bowls in actual service.

Comment by Mr Malan:
We obtained details of the latest British test from Mr Webster, and were surprised to learn that they did not use the Sobolev test. For this reason the tests we performed did not include the Sobolev test, although we consider it a good test method as it uses the 19 mm 0,85 specific gravity balls. It would be interesting to know why such valuable work has not received further national recognition or acceptance in the UK.

Comment by Mr Webster:
I have already stated that the particular situation in the UK, and probably also in Europe, is that a floating ball test is not a measure of the failures that actually occur in the pan. We use the sunken ball test, which is the main modification to the Sobolev test.

Question from Mr K V Bailey for Mr Malan:
Should the criteria for volume of flush not be substituted by a kinetic energy formula, e.g. high velocity requires lower volume, and lower velocity requires higher volume?

Mr Malan: Kinetic energy is obviously one of the variants in the whole mechanism of flushing. We have only just started investigating this subject, and the energy aspect will certainly be looked at in the future. However, one still has to have a test with which to control the manufacture of good pans, and to ensure that water economy is achieved.

Comment by Mr Evans:
In the book 'Flush with pride', the life story of Thomas Crapper, it is mentioned that tests were done in Britain on WC pans to evaluate the danger of spreading bacteria. It was found that a frightening number of bacteria were thrown out of the pan when it was flushed. It seems that the 6-litre Swedish pan described by Mr Malan, poses a real danger in this regard, and that it should be a case of "flush and run" when you use this system.

SESSION/SITTING 4

PAPERS 11 TO 16 : THE SOUTH AFRICAN SCENE

RAPPORTEUR : L C MILES

Question from Mr Habgood for Mr Bath: Large scale housing on a rental basis would surely lead to unmanageable maintenance costs. In Bulawayo, home ownership is encouraged, and 75 per cent of high density houses are owned. Those that are metered are costly to maintain. Are the rents paid in South Africa economical?

Mr Bath: Home ownership is encouraged, but cannot always be afforded by low income groups. The rents are not economical and in some cases they are a thirtieth of what they should be to repay capital costs. The government thus subsidises such houses.

Contribution from Mr de Kruijff: This approach is not a feasible solution. I wondered how the country could afford such a high outlay of funds. Are there many illegal settlements?

Mr Bath: It is government policy to provide such highly subsidised housing in an attempt to reduce slums. Squatter camps are still to be found, and the entry into the country of illegal immigrants continues, but this is difficult to prevent.

Question from Mr Trinkler for Mr Crabtree:

(i) How is foreign research used in South Africa, including that which is published in languages other than English?

(ii) What air pressure is used for the air testing of pipe lines, and what precautions are taken in the case of sudden leaks?

(iii) What deflection is acceptable when extrapolating the figures obtained for 50 or more years?

Mr Crabtree: (i) Attempts have been made to use the results of foreign research without having to repeat the work. However, it is usually necessary to verify that the results are applicable to South African conditions. Papers in languages other than English are a problem, as translation is costly.

(ii) In South Africa only low air pressure testing at 250 mm water gauge has been undertaken, and there is no danger to workmen. The tests are based on the drop in water head with time. Results are given in tables for various diameters of pipe.

(iii) Flexible pipes have only been used in South Africa for the past 10-15 years, so that our experience of their use is limited. The internationally accepted figure for deflection (5 per cent of the pipe diameter) is generally specified, although this may be increased to 7½ per cent. Work is in progress to ascertain if this deflection increases with time. The value of 5 per cent has been established as being realistic, and was not determined arbitrarily.

The test is suitable for small diameter pipes made from dense material such as clay, plastics and pitch fibres. It is not applicable to concrete pipes.

Question from Mr Morgan for Mr Crabtree: What sponsorship does the CSIR receive from private industry and from government.

Mr Crabtree: The CSIR receives a grant from the central Government. The NBRI earns up to 50 per cent of its funds from projects sponsored by private industry and other government agencies. NBRI operations are directed towards applied research, and it works in close collaboration with industry and government agencies, from whom ready cooperation is received in the application of research findings.

Question from Mr Bester for Mr Bath:
It has been stated that services are designed to suit the needs of a community. Why are the services provided by the Department of Community Development for low-income high-density areas of a very high standard?

Mr Bath: The policy is to provide services to meet the present requirements of the community. They are designed to be of such a standard that they can be upgraded at some future date when this is warranted.

Question from Mr M P Maphumulo for Mr Crabtree:
Do the chemicals used in households not destroy the biological agents in septic tanks in one-pipe systems?

Mr Crabtree: This is a common misconception. Research done by the National Institute for Water Research has firmly established that chemicals used in ordinary quantities in households do not affect the biological processes which take place in septic tanks. However, a large dose of a very strong chemical could have a serious effect.

Question from Mr J Venter for Mr Bath:
Do stand pipes located over gulleys cause blockages?

Mr Bath: Gulley stand-pipes are not favoured and if it is proposed that large townships be developed, the matter should be discussed with the Department of Community Development.

Question from Mr J C Verster for Mr Crabtree:
(i) How are domestic water economies to be achieved and controlled?

(ii) Is noise in plumbing systems caused by pressures which are too high? If so, will legislation be passed to restrict these pressures?

(iii) Has any research been done on the introduction of a more reliable flushing valve?

(iv) In regard to economies in hotwater supply systems, is the use of solar energy being considered?

(v) Are local authorities bound by by-laws? In my experience, each one seems to enforce additional requirements.

Mr Crabtree: (i & v) With regard to domestic building regulations, in the chapters dealing with drainage and water supply, and installation - which also refer to the limitation of appliances, such as WC cisterns - these regulations will be supported at Central Government level by the Water Research Commission and the Department of Water Affairs.

(ii) With regard to noise in plumbing systems - high water pressure is not the only cause of noise. Other causes are the bad design of through ports, and the poor fitting and fixing of pipe work to framed buildings. Many factors are involved, and there are varied opinions on the subject. High pressure is, however, a recognised cause, and pressure reduction is an accepted way of reducing noise.

(iii) Some flushing valves available locally do waste water. Unless their design is improved their use should be phased out.

Mr J F van Straaten: (iv) Solar heating is definitely being considered as a means of saving energy and several publications are available from the NBRI on this subject.

Question from Mr Matlock for Mr Bath:
In order to ensure that the Black population of the 74 Townships in the Eastern Cape is housed at the minimum standard acceptable to Mr Bath's Department and with a reasonable standard of services provided, and assuming 7 persons per house, the estimated capital

cost at today's prices is R640 million. If this programme is executed over the next 20 years, the total cost, escalating at 15 per cent per annum, will reach R3 500 million. Do you think that your Department will be able to provide this enormous amount of money for the Eastern Cape? I feel that the existing housing standards must be lowered, otherwise unacceptable living conditions will continue.

Mr Bath: I do not support the subsidising of housing. I too question whether it is possible to provide all the housing needs, unless low income earners increase their productivity and earn more.

Question from Mr R L Scanes for Mr Bath:
Can you please comment on the use of PVC sewers in schemes funded by the National Housing Commission?

Mr Bath: I have no personal objections to the use of PVC pipes, nor can I prevent it in such schemes. However, for permanent sewers, I prefer clay pipes which cost only slightly more than PVC pipes.

Question from Mr G F Antoni for Mr Crabtree:
By careful coordination of the design and construction of underground services, trench sharing can be achieved with an obvious saving in cost. Is this practice used by the Department of Community Development, and is the NBRI investigating it?

Mr Crabtree: The NBRI is looking at this possibility. This system is being used at present, and becoming more popular, especially in related services, such as post office and electrical cables. It requires careful coordination of construction by the contractors.

Question from Mr A J Mills for Mr Crabtree:
An increasing problem in sewer reticulation systems and sewage purification works, (especially from lower income housing), is the disposal of plastic bags (e.g. supermarket type packets), into the system. No matter what screening or other interception methods are employed, the plastic seems to get through and the effect on, for example, conventional biofilter distributor arms or digester mechanisation is disastrous. Has the NBRI looked at this problem? Do any other delegates have any comments about similar experiences?

Mr Crabtree: The NBRI does not deal with treatment aspects of sewage. However, with regard to the problem of plastic bags, there appears to be little that can be done at source apart from educating users.

Mr Trinkler: This is a universal problem. The method used in Germany to overcome it is to teach the public that sewers are not rubbish removal systems. Where possible, offenders should be prosecuted.

Question from Mr T P Nielsen for Mr Bath:
Both speakers this morning have stated that the standard of service provided, must be affordable by the users. The initial cost of the provision of these services is usually the lowest component of the monthly cost to the occupants, while maintenance, as time progresses, becomes increasingly high.

When approving schemes to be financed by the Department of Community Development, what consideration is given to the resulting maintenance costs, which are not financed or subsidised by the Department of Community Development? Quite often the scheme which is initially the most expensive, proves to be the cheapest over a period of time.

Mr Bath: The goal of service design should be to reduce maintenance costs. The problem is high material costs versus high maintenance costs. For roads, the type of surface can be readily decided on by considering car ownership, rainfall and ground slope in any particular township.

Mr van Straaten: The dilemma is that pressure is exerted on the authorities to reduce standards, and at the same time to consider maintenance and life cycle costs, which in turn leads back to high standards.

Mr Crabtree: This problem is being studied by the National Norms for Township Service Committees. Where should we set the limits? The alternatives are standards requiring little maintenance, or standards requiring more maintenance. The general feeling of local authorities is that increasingly higher standards should be provided. This would increase the lump-sum costs to be paid for stands and put them out of reach of more people.

Question from Mr Nielsen for Mr Bath: Why are 'site and service' schemes not financed by the Department of Community Development?

Mr van Straaten: This is government policy.

Question from Mr Scott for Mr Crabtree: It seems that extensive use is made of gratings over stormwater inlets. Has any research been done on the flow rate through these gratings? Our experience has been that the pipes never run to capacity in a flood. We use a minimum size of 300 mm stormwater pipes and use kerb inlets with 100 mm high openings.

Mr Crabtree: No work on stormwater inlets has yet been undertaken by the NBRI. Research into such aspects of stormwater drainage falls into a field of work which is undertaken by the National Institute for Transport and Road Research (NITRR), and some years ago they undertook research into side inlets. The NBRI however, has investigated stormwater control in townships, and concepts of disposal, rather than technical design detail.

Question from Mr Botha for Mr Bath: Dit blyk uit die besprekings tot dusver dat daar 'n misverstand bestaan oor die terme „lae tegnologie" en „hoë tegnologie" sanitasie, in soverre dat slegs die twee uiterstes oorweeg kan word, maar daar is 'n groot reeks moontlikhede tussenin wat oorweeg kan word, soos blyk uit 'n onlangse omvattende navorsingsverslag wat deur die Wêreldbank gepubliseer is. In die verslag word dit duidelik gestel dat gesondheidstandaarde soortgelyk aan dië van 'n spoelrioleringstelstel verkry kan word deur gebruik te maak van 'n toepaslike tegnologie vir 'n spesifieke aanwending. Gebruikersgerief is die enigste vereiste eie aan 'n spoelrioleringstelsel wat nie ten volle bevredig word deur die laer tegnologie alternatiewe nie. Die verslag handel verder oor die tegniese aspekte en ekonomiese vergelykings van die verskillende altenatiewe, 'n seleksieprosedure, gemeenskapsdeelname in die daarstelling van 'n toepaslike diens, asook opgraderingsmoontlikhede. Die klem val dus op 'n geleidelike verbetering van 'n sanitasiediens van onder af boontoe om aan te pas by die gebruikers daarvan se finansiële vermoë. Indien bewerings dat besluite in hierdie verband deur politici geneem word, korrek is, word die afleiding gemaak dat hulle nie kennis dra van bogenoemde alternatiewe nie. Wat is die moontlikheid dat hierdie inligting effektief aan hulle oorgedra kan word?

Mnr van Straaten: 'n Mens kan nie verwag dat die beleidmakers hul beslissings op onvoldoende gegewens moet grond nie. Die verpligting lê by die NBNI om die evalueringswerk in hierdie verband te doen, en dan met bepaalde voorstelle na vore te kom. Indien 'n bewese stelsel aan die owerhede voorgelê word, sal hulle dit heelwaarskynlik in aanmerking neem in die bepaling van hul beleid.

Question from Mr Botha for Mr Crabtree: Met verwysing na die NBNI se aandeel in die skepping van opleidingsfasiliteite vir loodgieterstegnici, word van die spreker verneem of die moontlikheid bestaan dat fasiliteite geskep kan word vir geboudienste-ingenieurs in eie reg, soos dit die geval is met die ander erkende ingenieursrigtings.

Mr Crabtree: This question has been raised a number of times before. In a small country such as South Africa, where human resources are limited, the tendency has been to have broadly-based engineering education. People have later tended to specialise through "on-the-job" training. In other larger and more sophisticated countries, there is scope for specialisation. It is a question of manpower availability, and it will improve as South Africa becomes more sophisticated and offers job opportunities to more people. We are probably ready for it, but job opportunity for all has first to be demonstrated before training facilities can be created. Our limited educational resources have also to be borne in mind when planning this type of specialist course.

Specialist training should be received within the framework of employment in that field.

Question from Mr Barry for Mr P A du Plessis:

I would like to question the validity of allowing for a basic water consumption of 20 K ℓ per month per stand. How was the figure arrived at? In Umtata we consider a basic consumption of 10 K ℓ per month per stand as ample.

Mr du Plessis: The figures were derived from a 4-year study undertaken by the consulting engineers who investigated the water supply and sewerage requirements for Soweto. The water standard was measured in bulk and correlated to sewerage effluent flows. This study showed that water was used indiscrimately, and it was decided to meter all water supplied to users individually.

Questions from Mr de Kruijff for Mr du Plessis:

(i) What are your minimum water pipe dimensions with regard to the flow requirements for fire fighting?

(ii) What is the average monthly income of the inhabitant of Soweto, and what is it as a percentage of that earned by the total population?

Mr du Plessis: (i) In reply to your first question: At present, fire fighting services are inadequate and consist of large tankers centrally stationed in Soweto. An advisory panel has been formed which has representatives from the Department of Community Development, the Transvaal Provincial Administration, the West Rand Administration Board, the Johannesburg Municipality, the CSIR, the SA Association of Consulting Engineers, and the SA Federation of Civil Engineering Contractors, to plan and regulate the upgrading of all the services in Soweto. This will take place during the next 3½ years. Another factor which will influence the provision of fire fighting services is the new 99-year-leasehold system by which lease holders can build their own houses. This will involve financial institutions such as building societies which have specific requirements regarding fire fighting services.

(ii) In reply to your second question, incomes vary very widely. There are about 1½ million people living in Soweto at present, and they range from contract workers living in hostels to very wealthy home owners. Usually more than one member of a household works, so that when one considers their incomes, it is more accurate to look at the income per living unit.

Question from Mr du Toit for Mr Uys:

(i) On page 1 of Paper 13, the water consumption per day per livestock unit is indicated as $^+ \frac{300\ 000}{6\ 000\ 000} \times 1\ 000 = 0{,}5$ litres. Surely the unit consumption should be of the order of 50 litres per animal per day?

(ii) Are water vendors controlled in any way? For instance must they obtain vending licences?

Mr Uys: (i) The figure of 50 litres per head is more correct than the one quoted in paper 13. (Mr Botha subsequently confirmed this).

(ii) Water vendors are not controlled, and operate on a free market system.

Mr Uys subsequently added that: The population in the national states is about 11 million, of which 9 million are in rural and 2 million in urban, areas. The rural areas are overpopulated and in the short term, the population will increase.

The population in urban areas will increase in the long term. The increase in population is expected to be 3,02 per cent per year, which will double the population over the next 20 to 25 years. Similar growth patterns can be expected in areas outside the national states.

Question from Mr Matlock for Mr du Plessis:

Is Mr du Plessis able to give a figure for the total cost of upgrading the services in Soweto? Where will this finance come from and what interest rate will apply?

Mr du Plessis: A full report on the cost of the services is still to be published. The Community Council has indicated that they are now in a position to approach the community for an increase in rent and rates, and that agreement in principle on this issue has been reached.

Question from Mr Osborne for Mr du Plessis:

Sewage treatment costs were quoted at about R400 000 per annum. There are about 120 000 equivalent housing units in Soweto: therefore the cost per house is R33 per year.

Mr du Plessis: The figures given in my paper were provided by the Johannesburg City Council Treasury. The Johannesburg Municipality treats the sewage and charges the West Rand Adminstration Board.

Questions from Mr Davis for Mr du Plessis:

(i) How will the reading of the new water meters be undertaken - monthly, quarterly or otherwise?

(ii) Will accounts be submitted to a person in a leasehold house and what will happen if he fails to pay the account?

Mr du Plessis:

(i) The meters will be read quarterly, but accounts will be sent out monthly, based on estimated amounts.

(ii) If accounts are not paid, the water supply will not be cut-off, as this is prohibited by health regulations, which also provide for water borne sewerage. The accounts Department will have to find alternate means of redress.

Question from Mr D van Aarde for Mr du Plessis:

(i) What is the minimum size of stand for existing houses in Soweto?

(ii) Can they consolidate stands when building new houses?

(iii) Are you modernising or rebuilding the majority of houses?

Mr du Plessis: Most of the stands are 140 m^2 . In new developments, large stands are being made available for those who want them. In Soweto the modernisation of houses is being undertaken by owners. In the older 4-room type house, extensions are made by building on to the existing house. In the township of Alexandria, which is a renewal project. some houses may be retained in their existing form, but in most areas they will be replanned because of the age of the buildings and the poor layout of the original planning.

Mr Matlock: While more and more money is being made available for the improvement of Soweto, people in the Eastern Cape are becoming concerned that funds will not be made available for upgrading services in their townships. The reasons for upgrading Soweto apply equally in Port Elizabeth, which has a township of 250 000 people.

Mr Crabtree: This is a political issue falling beyond the scope of the discussion. However, I am certain that in due course other areas will receive funds for the upgrading of their services.

Mr du Plessis: Soweto is apparently a more urgent problem, and in due course, other townships will receive the funds they require.

Question from Mr J C Verster for Mr Crabtree:

What precautions are being taken to prevent the damaging of water and electric meters by vandals?

Mr Crabtree: Electic meters will be installed in groups in kiosks away from houses and all metering will be done by remote reading.

Mr du Plessis: A sub-committee of the main advisory panel is investigating the planning and monitoring of water meters. These may be of the remote reading type. However, no decision has yet been reached.

Question from Mr Rivas for Mr du Plessis:
Is there any form of building control in Soweto such as the approval of plans or restrictions on construction materials?

Mr du Plessis: Building control is under the supervision of a building inspectorate. This is staffed by men who have been trained in the field, and have risen through the ranks from artisan to superintendent. They enforce building regulations strictly.

Question from Mr Carr for Mr du Plessis:
Although this question is outside the water and drainage field, may I ask if any provision has been made for on-site vehicle storage for houses? I believe the speaker referred to 50 000 vehicles in the township.

Mr du Plessis: Residents feel very strongly that their motor vehicles should be parked on their own property and not some distance away in a parking area. In planning new housing we are taking this into account.

Mr J F Lawes: In Bulawayo all water is metered, and in low cost housing, small meters have been attached to the walls of houses. Little vandalism has been experienced.

Electrical consumption is not metered, but current limiters are installed. These are of a different type from those used in the past and range from a 2½ amp current to a 30 amp current. Charges are based on the capacity of the limiter that the householder requests to have installed. This method obviates having to read meters.

With regard to fire hydrants in low cost housing areas, these are only installed near large buildings such as schools, community centres and shopping centres. The reasons for this procédure is that low cost houses are constructed of highly combustible material; no telephones are provided, so that the fire brigade cannot be readily alerted, (and even should they be called, the house would burn down before thay could extinguish the fire.) A fire tender has a water carrying capacity sufficient to extinguish a fire in a low cost house if it can get there in time.

Mr Crabtree: Electric load limiting is applied in several areas in South Africa and not only for low cost housing. There has been much discussion on the best method to be used in Soweto where for example, load limiting relays have been installed in all houses to reduce peak loads.

Mr du Plessis: Fire hydrants in Soweto, will be provided in new developments and in the areas which are now being upgraded. However, in certain areas of a lower standard, where rented houses are to be found, the status quo will be maintained.

The current code of practice for fire fighting services in Soweto will be superseded by the National Norms for Township Services, and a saving will probably result. In this regard, information now available at NBRI could be of great assistance in the design of the fire-fighting service. The design of the service by the Consulting Engineers, who use average flow figures rather than peak flow figures, will have little effect on pipe size.

Question from Mr Malan for Mr Lawes:
Are illegal connections made to the water pipes where they cross private property between the main and the meter?

Mr Lawes: Because the stands are relatively small, there is not a great length of pipe between the main and the house water meter. This pipe is below ground and rises vertically at the house wall. The stop cock is installed immediately below the meter so that it is not possible to close off the water supply to make a connection. The responsibility for the length of pipe from the water main to the meter should be that of the local authority. This avoids having to put the meter on the stand boundary which could lead to vandalism.

Question from Mr Barry for Mr du Plessis:
In connection with building controls, do inspectors have regulations from which to work, or do they give value judgements? When the new National Building Regulations are promulgated, will they be applied instead of current regulations?

Mr du Plessis: The West Rand Administration Boards' chief architect and town planner has made a study of local authority regulations and has prepared a comprehensive set of guide lines which is now being used. This will be superseded by the new regulations when they are promulgated.

Question from Mr Habgood for Mr Crabtree:
My impressions are that Messrs Crabtree and Malan are not in favour of the Beta valve. However, I have found that in high density housing areas in Bulawayo, the Beta valve system is more satisfactory than the syphonic system. This is because the syphonic system unlike the Beta system cannot be flushed until the cistern has been completely refilled. Because the users are unsophisticated, they do not understand the functioning of the syphonic system, and tend to flush it before the cistern has refilled, thereby eventually damaging it. The Beta valve system cannot be subjected to this abuse, and therefore lasts longer.

Mr Crabtree: I have no objections to the bottom-opening type of valve, and certain European valves are much less wasteful than the Beta valve. This is because of the poor design of the Beta valve. It is also difficult to replace the Beta valve washer, and this leads to systems which receive little attention, and which end up leaking water as fast as it can flow into the cistern.

Mr Malan: Repeated flushing is required because of the inefficient functioning of the pan. This is being investigated by the NBRI. Repeated flushing of the Beta valve system, without allowing the cistern to fill, together with inefficient pans, can also be frustating. The Beta valve is not only difficult to maintain, but the valve seat also wears away and replacement of the washer does not stop the leakage.

If the Beta valve can not be improved, it should be superceded by some other design. However, research at the NBRI has not advanced sufficiently to provide an answer to the problem at this stage.

Question from Mr N H Aitchison for Mr Malan:
Could you please comment on the SABS 497 requirement that the splash from a pan should not exceed 5 droplets.

Mr Malan: Pan splash is important, and although it is not included in some overseas standards, such as the Swedish standard, it should be included in all future South African standards.

Question from Mr de Kruijff for Mr Crabtree:
How many people from rural areas are expected to become urbanised during the next 20 years in South Africa, and will they be provided with water borne sewerage? Will sufficient water be available?

Mr Crabtree: Mr Bekker has indicated that we expect to have sufficient water until the end of the century. During this time, significant urbanisation is anticipated. Extensions to existing sewage treatment works, rather than the construction of new works will probably provide a partial solution to the problem. The treatment of sewage in urban areas will then be less of a problem than in rural areas, where it will be expensive. This does not appear to be a complete answer to this question.

Question from Mr Barry for Mr Davis:
I would like to question your contention that water conservation is not all that important in areas which are rich in water. In the Transkei, which has plenty of water, the capital and working costs involved have led to water being expensive. In developed countries, where the production of water for sale is an end in itself, this does not happen.

Mr Davis: I drew this conclusion from the economic consideration that it is less costly to provide for the use of water than for its conservation. Provided that the public is prepared to buy more water, and that it is available, they should be given the opportunity to do so.

Mr Crabtree: Conservation of a diminishing resource which has to be divided among a large number of people should not be confused with conservation for the sake of increasing the life of the facility. For example, in the UK and Europe, which are rich in water, authorities are looking to conservation to extend the life of capital invested in facilities, in other words at the conservation of capital. Water recycling is an example of this approach, and it has brought about a reduction in water consumption. In developing countries, there is no end in sight to rising consumption; therefore conservation is also directed at capital expenditure.

Question from Mr Botha for Mr Crabtree:
May we have your comments on dual flushing systems?

Mr Malan: The savings derived from dual-flush systems depend on the actions of the user. Where low flush efficient systems are provided, there appears to be little advantage in providing dual systems, since a saving is not assured.

Mr Webster: I agree with Mr Malan on the point of low flush systems. In the UK, dual flush systems are being used as an interim measure, and their use is being made mandatory as the water laws are periodically revised by local authorities. Dual-flush systems have been found to be unsuitable for installation in public buildings, because people do not know how to use them.

Mr Trinkler: In Germany, the use of dual flush cisterns is under consideration, but so far no decision has been reached. Much will depend upon future water requirements. With reference to Prof Knoblauch's paper, a flush of 6 litres is necessary for after flow, and it may not be feasible to reduce consumption further by using dual flush systems.

Mr Silberstein: The aims of water conservation are to reduce water loss, and through its efficient use to allow the consumer the unrestricted use of water. In 1970 field tests were undertaken in Israel on syphonic systems, and on many bottom type valve systems that had been installed some 3 to 5 years previously. These tests indicated that losses were small and, as a result, the use of this type of valve is now permitted. It is hoped that they will be able to repeat the tests on the same systems after a further 10 years service. The use of dual-flush systems is not mandatory in Israel because to date there is only one manufacturer of this type of system.

Question from Mr Maphumulo for Mr Davis:
Home owners in Kwa-Zulu are required to undertake the repair of structural defects at their own cost. What is the position in Durban with regard to leaking or burst water pipes, and blocked manholes?

Mr Davis: I am not conversant with the maintenance procedures used on reticulation systems but I assume that this would be along similar lines to those used in Kwa-Zulu. The local authority is responsible for maintenance to the stand boundary, and the house owner for that within the property.

Mr de Kruijff: Unless the overflow pipes for cisterns are placed in conspicuous places the repair of overflowing cisterns is usually neglected.

Mr Crabtree: The present regulations in South Africa require the overflow to discharge into the pan.

Question form Mr Malan for Mr Webster: Can you tell me about the formation of urine crystals in waterless urinals?

Mr Webster: Crystals do form. At present the system has not been fully developed and maintenance and design problems are being investigated. It has been found that it is easier to clean waterless urinals because hard deposits do not form as is the case when water is used for flushing. Only a soft sludge is formed in these urinals. Generally maintenance costs for the two systems are about the same.

Mr Morgan: Undiluted urine corrodes copper pipes and in Australia problems were experienced until flushing with water was introduced. Copper piping is not permitted in discharge pipes from urinals until a point beyond the connection of other waste water systems.

Mr Matlock: In the Transkei, where external pole latrines are used, men do not usually use the latrine, but prefer to urinate against the latrine wall. In clayey areas, where ash has been spread over the ground, copper pipes in the ground have corroded near the latrines, and it was originally thought that the ash was the cause. However, it now appears that it could have been urine percolating to the pipes.

Mr Webster: Tests of waterless urinals were made by placing a water repellant surface over the ceramic bowls. This did not lead to any improvement, because the ceramic bowl was itself water repellant. Oil seals were used, but tended to emulsify, with the result that the oil was lost. The only requirements appeared to be to omit the flushing water and reduce the trap size.

The trap size is reduced to the point where one usage will displace the urine in the trap. A series of systems is now being investigated, one of which has a large trap.

SEMINAR ON WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES : 1980

Organized by the National Building Research Institute of the CSIR

SEMINAR SECRETARIAT

Seminar Organizer: Marieta Swart
Telephone: (012) 869-211
International 27 12 869-211
(ext. 3868/3872)

Postal address: Seminar Secretariat
National Building Research Institute
of the CSIR
P O Box 395
0001 PRETORIA
South Africa

Telex number: SA 3-630
Telegrams: Navorsbou

GENERAL INFORMATION

VENUE
The CSIR Conference Centre, Pretoria.
The 450 Auditorium will be used for seminar sessions.

REGISTRATION
Registration will take place in the foyer of the CSIR Conference Centre between 08h00 and 09h00 on Tuesday 30 September 1980. Tea and coffee will be served.

TRANSPORT
Transport daily between the Conference Centre and the Hotel Boulevard and Hotel Manhattan in Pretoria will be available at no extra cost to delegates at the times indicated below:

30 September 1980 at 07h30 and 18h30
1 & 2 October 1980 at 08h00 and 17h00

The buses will return to the hotels from the Conference Centre after the cocktail party on Tuesday and at the end of the proceedings on Wednesday and Thursday.

TEAS AND LUNCHES
The cost of these is included in the registration fee.

COMMENCEMENT OF SESSIONS
A bell will ring at the start of each session and an announcement will be made. Delegates are requested to return to the auditorium promptly to avoid delays.

LANGUAGE AND INTERPRETING SERVICE
Papers will be presented in English; English and Afrikaans will be used for discussion at the discretion of the participants. Simultaneous Afrikaans/English interpreting services will be provided. (For paper 9 a simultaneous French/English and English/French interpreting service will be provided.) Delegates wishing to avail themselves of any of these services are requested to obtain a set of earphones from the Registration Desk.

DOCUMENTATION
One copy of the printed proceedings is included in the registration fee. Additional copies may be ordered at R25 per copy (GST inclusive).

SEMINAAR OOR WATERVOORSIENINGS- EN DREINERINGSDIENSTE IN ONTWIKKELENDE LANDE : 1980

Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

SEMINAARSEKRETARIAAT

Seminaarorganiseerder: Marieta Swart
Telefoon: (012) 869-211
Internasionaal 27 12 869-211
(bylyn 3868/3872)

Posadres: Seminaarsekretariaat
Nasionale Bounavorsingsinstituut
van die WNNR
Posbus 395
0001 PRETORIA
Suid-Afrika

Teleksnommer: SA 3-630
Telegramme: Navorsbou

ALGEMENE INLIGTING

PLEK
Die WNNR-konferensiesentrum, Pretoria.
Die 450-Ouditorium sal vir seminaarsessies gebruik word.

REGISTRASIE
Registrasie sal tussen 08h00 en 09h00 op Dinsdag 30 September 1980 in die voorportaal van die Konferensiesentrum plaasvind. Tee en koffie sal bedien word.

VERVOER
Gratis vervoer sal twee maal per dag vir afgevaardigdes op die tye hieronder aangedui tussen die Konferensiesentrum en die Hotel Boulevard en Hotel Manhattan in Pretoria beskikbaar wees:

30 September 1980 om 07h30 en 18h30
1 & 2 Oktober 1980 om 08h00 en 17h00

Die busse sal na afloop van die skemerkelkparty op Dinsdag en aan die einde van die verrigtinge op Woensdag en Donderdag vanaf die Konferensiesentrum na die hotelle terugkeer.

TEE EN MIDDAGETE
Die koste hiervan is by die registrasiegeld ingesluit.

AANVANG VAN SESSIES
'n Klokkie sal aan die begin van elke sessie lui en 'n aankondiging sal gemaak word. Afgevaardigdes word versoek om stiptelik na die ouditorium terug te keer om vertraging te voorkom.

TAALMEDIUM EN TOLKDIENS
Die referate sal in Engels aangebied word en die bespreking sal in Engels of Afrikaans plaasvind volgens die keuse van die deelnemers. Gelyktydige Afrikaans/Engelse tolkdienste sal voorsien word. (Vir referaat 9 sal gelyktydige Frans/Engelse en Engels/Franse tolkdienste verskaf word.) Afgevaardigdes wat van enige van hierdie dienste gebruik wil maak, word versoek om 'n hoorstuk by die Registrasietoonbank aan te vra.

DOKUMENTASIE
Die koste van een afskrif van die gedrukte verrigtinge is by die registrasiegeld ingesluit. Bykomende afskrifte kan bestel word teen R25 per afskrif (AVB ingesluit).

The views expressed in the papers are those of the authors and not necessarily those of the organizers. Although every effort has been made to ensure that the papers are factually correct, the NBRI can accept no responsibility for errors or omissions.

DISCUSSION
During discussion sessions delegates will have the opportunity to put written questions to speakers or to contribute to the discussion.

Question and contribution forms will be provided. If completed forms are handed in to the Chairman before or during the session, the delegates concerned will be given priority in participation. Delegates who do not put questions in writing or indicate in writing that they wish to participate will only be given an opportunity to speak if time allows.

THE DISCUSSIONS WILL BE RECORDED AND IT IS THEREFORE ESSENTIAL THAT ALL PARTICIPANTS MAKE USE OF THE MICROPHONES WHEN ADDRESSING THE MEETING AND ANNOUNCE THEIR NAME AND AFFILIATION PRIOR TO CONTRIBUTING TO THE DISCUSSION.

SOCIAL FUNCTION
The organizers extend a cordial invitation to all delegates and their partners to attend a cocktail party, to be held at the Conference Centre on Tuesday 30 September 1980 at 17h00.

Transport from the hotels mentioned earlier will be provided for the partners of delegates at 16h00. Buses will return to the hotels at 18h30.

INTERPRETING SERVICES: Mrs. M. Heese
AUDIO VISUAL SERVICES: Mr. J.A. Abranches

PAYMENTS
Registration fee: R100 per person.

EXHIBITION
There will be an exhibition of materials and equipment for water supply and drainage.

Exhibitors:

Kwikot Ltd.
Vitro-Henley Clay Pipes (Pty.) Ltd.
Vaal Potteries Ltd.
Cobra Brassware (Pty.) Ltd.
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S.A. Rigid Plastic Pipe & Fittings Manufacturers' Association
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ACKNOWLEDGEMENTS
The Organizing Committee is indebted to the following firms and organizations for their financial support or assistance:

Kwikot Ltd.
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Menings wat in die referate uitgespreek word is dié van outeurs en stem nie noodwendig ooreen met dié van die organiseerders nie. Hoewel alle moontlike pogings aangewend is om te verseker dat die referate feitelik korrek is, aanvaar die NBNI geen verantwoordelikheid vir foute of weglatings nie.

BESPREKING
Gedurende besprekingsessies sal afgevaardigdes die geleentheid kry om geskrewe vrae aan sprekers te rig of om aan die bespreking deel te neem.

Vraag- en deelnamevorms sal voorsien word. Indien voltooide vorms voor of gedurende die sessie by die Voorsitter ingehandig word, sal die betrokke afgevaardigdes voorkeur geniet. Afgevaardigdes wat nie vrae op skrif stel of skriftelik te kenne gee dat hulle aan die bespreking wil deelneem nie, sal alleenlik geleentheid daartoe kry indien daar tyd beskikbaar is.

DIE BESPREKINGS WORD OP BAND OPGENEEM EN DIT IS DUS NOODSAAKLIK DAT ALLE DEELNEMERS VAN DIE MIKROFONE GEBRUIK MAAK WANNEER HULLE DIE VERGADERING TOESPREEK EN OOK HULLE NAAM EN AFFILIASIE AANKONDIG VOORDAT HULLE MET DIE BESPREKING BEGIN.

SOSIALE FUNKSIE
Die organiseerders nooi alle afgevaardigdes en hul metgeselle hartlik uit na 'n skemerkelkparty wat om 17h00 op Dinsdag 30 September 1980 by die Konferensiesentrum gehou sal word.

Vervoer sal om 16h00 vir die metgeselle van afgevaardigdes verskaf word van die hotelle wat voorheen genoem is. Busse sal om 18h30 na die hotelle terugkeer.

TOLKDIENS: Mev. M. Heese
OUDIOVISUELE DIENS: Mnr. J.A. Abranches

BETALING
Registrasiegeld: R100 per persoon.

UITSTALLING
Daar sal 'n uitstalling wees van materiale en toerusting vir watervoorsiening- en dreinering.

Uuitstallers:

Kwikot Bpk.
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Castle Brass Works (Edms.) Bpk.
Everite Bpk.
S.A. Rigid Plastic Pipe & Fittings Manufacturers' Assocation
Maksal Tubes (Edms.) Bpk.

ERKENNING
Die Reëlingskomitee is veel dank aan die volgende firmas en organisasies verskuldig vir finansiële steun of bystand:

Kwikot Bpk.,
Vitro-Henley Kleipype (Edms.) Bpk.
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Everite Bpk.
S.A. Rigid Plastic Pipe & Fittings Manufacturers' Association
S.A. Copper Development Association (Pty.) Ltd.

ALPHABETICAL LIST OF PARTICIPANTS

ALFABETIESE LYS VAN DEELNEMERS

BATH, G.E.
B.Sc. (Eng.) (Civ.), Stellenbosch University, 1950.

Chief Engineer, Department of Community Development.

1951-52 Worked on reservoir construction for Clifford Harris (Pty.), Ltd.
1952-55 Employed by the Government of Southern Rhodesia and the Municipality of Bulawayo on the construction of national roads and the design of a water supply augmentation scheme.
1955-63 Employed by the Municipality of Paarl, firstly as Resident Engineer on water and sewerage augmentation schemes, and then as Assistant Town Engineer.
1964-68 Joined Ninham Shand & Partners in Cape Town.
1968 Joined the Department of Community Development, specializing in work on infrastructures for new townships which feature low-income housing.

BATH, G.E.
B.Sc. (Ing.) (Siv.), Universiteit van Stellenbosch, 1950.

Hoofingenieur, Departement van Gemeenskapsbou.

1951-52 Werk aan reservoirkonstruksie vir Clifford Harris (Edms.), Bpk.
1952-55 Werksaam in diens van die Regering van Suid-Rhodesië en die Munisipaliteit van Bulawayo aan die konstruksie van nasionale paaie en die ontwerp van 'n aanvullende watervoorsieningskema onderskeidelik.
1955-63 In diens van die Paarlse Munisipaliteit aanvanklik as Residentingenieur in beheer van aanvullende water- en rioleringskemas en daarna as Assistent-Stadsingenieur.
1964-68 Werksaam by Ninham Shand en Vennote in Kaapstad.
1968 Sluit aan by die Departement van Gemeenskapsbou en spesialiseer in werk oor infrastrukture vir nuwe dorpsgebiede met lae-inkomstebehuising as kenmerk.

BEKKER, A.P.
B.Sc. (Eng.) (Civ.), University of Cape Town, 1961. M.B.A., University of Pretoria, 1968.

Assistant Chief Engineer, Directorate of Water Affairs, Forestry and Environmental Conservation.

1961-64 Joined the Department of Water Affairs.
1964-65 Employed by Crawford, Lowe and Partners.
1965 Rejoined the Department of Water Affairs and worked on the design, planning and construction of various large projects.

BEKKER, A.P.
B.Sc. (Ing.) (Siv.), Universiteit van Kaapstad, 1961. M.B.A., Universiteit van Pretoria, 1968.

Assistent-Hoofingenieur, Direktoraat van Waterwese, Bosbou en Omgewingsbewaring.

1961-64 Sluit aan by die Departement van Waterwese.
1964-65 In diens van Crawford, Lowe en Vennote.
1965 Sluit weer aan by die Departement van Waterwese en werk aan die ontwerp, beplanning en konstruksie van verskeie groot projekte.

BERTOT, G.J.
Architectural Degree.

Director Nacional de Politica Habitacional, Buenos Aires, Argentina.

BERTOT, G.J.
Argitektuursgraad

Direkteur Nacional de Politica Habitacional, Buenos Aires, Argentinië.

CHAKRABARTI, S.P.
B.E. (Civ.), University of Calcutta, 1967.
M. Tech. (PHE), Indian Institute of Technology, Kharagpur, 1969.

Scientist-in-charge, Building Services Section, Central Building Research Institute, Roorkee, India.

1969-70 Senior Research Fellow at the Indian Institute of Technology.
1970-73 Assistant Engineer (PHE) at the All India Institute of Hygiene and Public Health, Calcutta.
1973 Joined the Central Building Research Institute.

CHAKRABARTI, S.P.
B.E. (Civ.), Universiteit van Kalkutta, 1967.
M.Tech. (PHE), Indian Institute of Technology, Kharagpur, 1969.

Wetenskaplike in beheer van die Afdeling Geboudienste, Central Building Research Institute, Roorkee, Indië.

1969-70 Senior-navorsingsbeurshouer aan die Indian Institute of Technology.
1970-73 Assistent-Ingenieur (PHE) aan die All India Institute of Hygiene and Public Health, Kalkutta.
1973 Sluit aan by die Central Building Research Institute.

CRABTREE, P.R.
Pr. Eng. B.Sc. (Eng.) (Civ.), University of Cape Town, 1953. M(SA) ICE, 1959, MICE (London), 1960. MIMunE (SA), 1961.

Head, Building Services Division, National Building Research Institute, CSIR since 1975.

1954-56 Employed by the Southern Rhodesian Government on irrigation and water supply projects and main road construction.
1957-62 Assistant Town Engineer of Gwelo and Town Engineer of Fort Victoria.
1963-65 Employed by Shell South Africa Ltd., where he was responsible for all engineering aspects of service station design and construction.
1966 Joined the NBRI, where he has been engaged in research in the fields of sewerage, water supply, drainage and plumbing.

CRABTREE, P.R.
Pr.Ing. B.Sc. (Ing.) (Siv.), Universiteit van Kaapstad, 1953. L(SA) ISI, 1959, MICE (Londen), 1960, LIMunI (SA), 1961.

Hoof, Afdeling Geboudienste, Nasionale Bounavorsingsinstituut, WNNR sedert 1975.

1954-56 In diens van die Regering van Suid-Rhodesië aan besproeiings- en watervoorsieningsprojekte en hoofpadkonstruksie.
1957-62 Assistent-Stadsingenieur van Gwelo en Stadsingenieur van Fort Victoria.
1963-65 In diens van Shell Suid-Afrika Bpk., en verantwoordelik vir alle aspekte van ingenieurswese ten opsigte van diensstasieontwerp en -konstruksie.
1966 Sluit aan by die NBNI waar hy navorsing doen op die terrein van riolering, watervoorsiening, dreinering en loodgieterswerk.

DAVIS, A.B.
C. Eng. (U.K.), B.Sc. (Eng.), Bristol University, 1960.

Assistant City Engineer (Hydraulics), Durban, since 1975.

1960-62 Engineer, City Engineer's Department, Bristol.
1962-65 Engineer and Senior Engineer, Mangla Dam Project, West Pakistan.
1965-69 Resident Engineer and Capital Works Engineer, Wessex Water Board.
1969-71 Senior Engineer (W&S) and Assistant City Engineer, Kitwe, Zambia.
1971-75 Project Engineer and Deputy Engineer, Umtali, Rhodesia.

DAVIS, A.B.
C. Eng. (V.K.) B.Sc. (Eng.), Universiteit van Bristol, 1960.

Assistent-Stadsingenieur (Hidroulika), Durban, sedert 1975.

1960-62 Ingenieur, Departement van die Stadsingenieur, Bristol.
1962-65 Ingenieur en Senior-Ingenieur, Mangladamprojek, Wes-Pakistan.
1965-69 Residentingenieur en Kapitaalwerke-ingenieur, Wessex Water Board.
1969-71 Senior-Ingenieur (W & R) en Assistent-Stadsingenieur, Kitwe, Zambië.
1971-75 Projekingenieur en Adjunk-Stadsingenieur, Umtali, Rhodesië.

DE KRUIJFF, G.J.W.
Ing. Hogere Technische School den Bosch.

Research Fellow, University of Nairobi, Housing and Development Unit.

1972-75 Project Engineer, Public Works, Curacao, Netherlands Antilles.
1975-76 Site Engineer, Grabowsky and Poort International.
1977 Joined the University of Nairobi as Aid Expert.

DE KRUIJFF, G.J.W.
Ing., Hogere Technische Schooi den Bosch.

Navorsingsbeurshouer, Behuisings- en Ontwikkelingseenheid van die Universiteit van Nairobi.

1972-75 Projekingenieur, Openbare Werke, Curacao, Nederlandse Antille.
1975-76 Terreiningenieur, Grabowsky and Poort International.
1977 Sluit aan by die Universiteit van Nairobi as Hulpdeskundige.

DU PLESSIS, P.A.
Pr. Eng. B.Sc. (Eng.) (Civ.), University of Stellenbosch, 1956.

Technical Director, West Rand Administration Board.

1947-52 Apprentice millwright, Iscor.
1957-60 Sales Engineer, Stewarts and Lloyds, dealing with water, sewerage, pumping schemes and pipe construction works.
1961-62 Assistant Roads Engineer, Germiston Municipality.
1963-73 Employed by Slagment as Sales, Production and Construction Consulting Engineer and Technical P.R.O.
1973 Joined the West Rand Administration Board.

DU PLESSIS, P.A.
Pr.Ing. B.Sc. (Ing.) (Siv.), Universiteit van Stellenbosch, 1956.

Tegniese Direkteur, Wesrandse-Administrasieraad.

1947-52 Vakleerling-masjienmonteur, Yskor.
1957-60 Verkoopsingenieur, Stewarts en Lloyds, betreffende water, riolering, pompskemas en pypkonstruksiewerke.
1961-62 Assistent-Padingenieur, Munisipaliteit van Germiston.
1963-73 In diens van Slagment as Raadgewende Verkoops-, Produksie- en Konstruksie-ingenieur en Tegniese Skakelbeampte.
1973 Sluit aan by die Wesrandse-Administrasieraad.

DU TOIT, F.P.
Qualified in Architecture at the University of Cape Town, 1955.

Senior Architect, Department of Conservation and Extension, Ministry of Agriculture, Zimbabwe.

1956-61 Worked in private practice in Southern Rhodesia.
1961 Joined the Ministry of Agriculture of the Federation of Rhodesia and Nyasaland as a member of its Farm Buildings Research and Advisory Section. Has served in this capacity under successive governments.

DU TOIT, F.P.
Kwalifiseer as Argitek aan die Universiteit van Kaapstad, 1955.

Senior-Argitek, Departement van Bewaring en Uitbreiding, Ministerie van Landbou, Zimbabwe.

1956-61 Werk in privaatpraktyk in Suid-Rhodesië.
1961 Sluit aan by die Ministerie van Landbou, Federasie van Rhodesië en Niassaland as lid van die Afdeling Plaasgebouenavorsing en Adviesdienste. Werk in hierdie hoedanigheid onder opeenvolgende regerings.

JOHNSON, E.L.
Eng. (Civ.), National University of La Plata, 1953. Urban and Regional Planning degree, University of Buenos Aires, 1960.

National State Undersecretary of Housing, Argentina.

1964-65 Technical Advisor to the President of the National Housing Bank - formulated the national housing plan.
1964-73 Professor in aspects of rural development, University of Buenos Aires.
1973-77 Representative of NEUQUEN at the Housing and Urbanism State Secretariat.
During the above periods worked in an advisory capacity on a number of official projects and also in a private professional capacity.

JOHNSON, E.L.
Eng. (Civ.), Nasionale Universiteit van La Plata, 1953. Graad in Stads- en Streeksbeplanning, Universiteit van Buenos Aires, 1960.

Nasionale Staatsondersekretaris van Behuising, Argentinië.

1964-65 Tegniese Adviseur vir die President van die Nasionale Behuisingsbank - formuleer die nasionale behuisingsplan.
1964-73 Professor in aspekte van landelike ontwikkeling, Universiteit van Buenos Aires.
1973-77 Verteenwoordiger van NEUQUEN by die Housing and Urbanism State Secretariat.
Werk gedurende bogenoemde tydperke in 'n raadgewende hoedanigheid aan 'n aantal amptelike projekte en ook in privaat professionele hoedanigheid.

KNOBLAUCH, H.J.
Professor, Berlin, 1971.

Chief of Laboratory for Sanitary Engineering at Technische Fachhochschule, Berlin.

1955-71 Sanitary Engineer.
1971 Appointed Professor at Technische Fachhochschule, Berlin.

KNOBLAUCH, H.J.
Professor, Berlyn, 1971.

Hoof, Laboratorium vir Sanitêre Ingenieurswese, Technische Fachhochschule, Berlyn.

1955-71 Sanitêre Ingenieur.
1971 Aangestel as Professor by die Technische Fachhochschule, Berlyn.

KONEN, T.P.
Davidson Laboratory, Stevens Institute of Technology, Hoboken, New Jersey, U.S.A.

KONEN, T.P.
Davidson Laboratorium, Stevens Institute of Technology, Hoboken, Nieu-Jersey, V.S.A.

MALAN, G.J.
B.Sc. (Eng.), University of the Witwatersrand, 1960.

Chief Research Officer, Building Services Division, National Building Research Institute, CSIR.

1961-66 Employed by the Electricity Supply Commission as Pupil Engineer, Design Engineer, Assistant Resident Engineer and Resident Engineer.
1967-69 Employed by the Vereeniging Town Council as Water and Sewerage Engineer and Assistant Town Engineer (Works), dealing with the design and departmental construction of sewerage and water reticulation schemes.
1969-78 Design Engineer and Director of Geustyn, Forsyth and Joubert Inc. (Consulting Civil and Structural Engineers), during which time his main projects were the water and sewerage schemes for the Richards Bay Town Board and the KwaZulu Government Service.
1978 Joined the National Building Research Institute, CSIR.

MALAN, G.J.
B.Sc. (Ing.), Universiteit van die Witwatersrand, 1960.

Hoofnavorsingsbeampte, Afdeling Geboudienste, Nasionale Bounavorsingsinstituut, WNNR.

1961-66 In diens van die Elektrisiteitsvoorsieningskommissie as Leerlingingenieur, Ontwerpingenieur, Assistent-Residentingenieur en Residentingenieur.
1967-69 In diens van die Stadsraad van Vereeniging as Water- en Rioleringsingenieur en Assistent-Stadsingenieur (Werke) verantwoordelik vir die ontwerp en departementele konstruksie van riolering- en waterbenettingskemas.
1969-78 Ontwerpingenieur en Direkteur van Geustyn, Forsyth en Joubert Geïnk. (Raadgewende Siviele en Strukturele Ingenieurs) waarydens sy hoofprojekte die water- en rioleringskemas vir die Dorpsraad van Richardsbaai en vir die Regeringsdiens van KwaZulu was.
1978 Sluit aan by die Nasionale Bounavorsingsinstituut, WNNR.

MORGAN, R.A.
Diploma of Mechanical Engineering, Swinburne Institute of Technology, 1962. Post-graduate Diploma in Industrial Management, Swinburne Institute of Technology, 1971. Completed the Advanced Management Program of the School of Business Administration, University of Melbourne, 1977. Norman Hanson Visiting Fellow for 1980.

Deputy Engineer for Property Services, Melbourne and Metropolitan Board of Works, Australia, since 1972.

1943-48 Technician, Postmaster General's Department.
1949-55 Draftsman (Mechanical) Postmaster General's Department.
1956-62 Buildings Project Officer, Postmaster General's Department.
1963-68 Buildings and Plant Engineer, Materials Research Laboratories, Department of Supply.
1968 Joined the Melbourne and Metropolitan Board of Works.

MORGAN, R.A.
Diploma in Meganiese Ingenieurswese, Swinburne Institute of Technology, 1962. Nagraadse Diploma in Nywerheidsbestuur, Swinburne Institute of Technology, 1971. Voltooi die Gevorderde Bestuursprogram van die School of Business Administration, Universiteit van Melbourne, 1977. Besoekende Norman Hanson-beurshouer vir 1980.

Adjunk-Ingenieur vir Eiendomsdienste, Melbourne and Metropolitan Board of Works, Australië, sedert 1972.

1943-48 Tegnikus, Departement van die Posmeester-Generaal.
1949-55 Tekenaar (Meganies), Departement van die Posmeester-Generaal.
1956-62 Projekbeampte, Geboue, Departement van die Posmeester-Generaal.
1963-68 Gebou- en Aanlegingenieur, Materiaalnavorsingslaboratoriums, Departement van Voorsiening.
1968 Sluit aan by die Melbourne and Metropolitan Board of Works.

OLSSON, E.
National Swedish Institute for Building Research

OLSSON, E.
National Swedish Institute for Building Research.

PERRIER, F.
B.Sc., University of Clermont-Ferrand, 1952. Ingènieur E.C.A.M., University of Lyon, 1956. Ingènieur I.S.M.C.M., University of Paris, 1957.

Chief Engineer, Centre Scientifique et Technique du Bâtiment, France.

1960 Joined the CSTB.

PERRIER, F.
B.Sc., Universiteit van Clermont-Ferrand, 1952. Ingènieur E.C.A.M., Universiteit van Lyon, 1956. Ingènieur I.S.M.C.M., Universiteit van Parys, 1957.

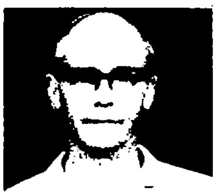
Hoofingenieur, Centre Scientifique et Technique du Bâtiment, Frankryk.

1960 Sluit aan by die CSTB.

ROBERTSON, L.
M.A. (Engineering) Cantab.

Principal Rural Water Engineer, Department of Lands, Valuation and Water, Office of the President and Cabinet, Lilongwe, Malawi, since 1979.

1959-68 Employed by the Missionary Church of Central Africa.
1968-79 Water Engineer, Ministry of Community Development, Malawi.



ROBERTSON, L.
M.A. (Engineering), Cantab.

Hoof Plattelandse Wateringenieur, Departement van Lande, Waardasie en Water, Kantoor van die President en Kabinet, Lilongwe, Malawi, sedert 1979.

1959-68 Werksaam in diens van die Missionary Church of Central Africa.
1969-79 Wateringenieur, Ministerie van Gemeenskapsontwikkeling, Malawi.

SHARMA, S.K.
Dip. C.E., A.M.I.E. (Civ.).

Scientist, Building Services Division, Central Building Research Institute, Roorkee, India, since 1975.

1962-67 Overseer (Civil), National Environmental Engineering Research Institute, Nagpur.
1967 Joined the CBRI as Scientific Assistant.

SHARMA, S.K.
Dip. C.E., A.M.I.E. (Civ.)

Wetenskaplike, Afdeling Geboudienste, Central Building Research Institute, Roorkee, Indië, sedert 1975.

1962-67 Opsiener (Siviel), National Environmental Engineering Research Institute, Nagpur.
1967 Sluit aan by die CBRI as Wetenskaplike Assistent.

SILBERSTEIN, I
Dipl. Engineer, M.Sc. (Mechanical), Polytechnic Institut Timisoara, Rumania.

Head, Hydraulics Laboratory, Standards Institution of Israel, Tel-Aviv.

He was formerly employed by the Thermal Electrical Power Station of the Department of Operation and Maintenance. Before being appointed Head of the Hydraulics Laboratory, he worked as a Mechanical Laboratory Test Engineer at the Standards Institution of Israel.

SILBERSTEIN, I.
Dipl. Engineer, M.Sc. (Mechanical), Polytechnic Institut Timisoara, Roemenië.

Hoof, Laboratorium vir Hidroulika, Instituut vir Standaarde van Israel, Tel Aviv.

Hy was voorheen werksaam by die Termiese Elektriese Kragstasie van die Departement van Bedryf en Instandhouding. Voor sy aanstelling as Hoof van die Laboratorium vir Hidroulika was hy werksaam as Toetsingenieur vir die Meganiese Laboratorium by die Instituut vir Standaarde van Israel.

STEYN, S.J.M., The Honourable Minister of Community Development, of Coloured Relations, and of Indian Affairs.

B.A., University of Cape Town, 1934.
Ll.B., University of the Witwatersrand, 1937.

1938-42 Journalist and member of staff of the State Information Office.
1942-48 Secretary of the United Party, (Witwatersrand).
1948 Elected as M.P.
1975 Appointed Minister of Indian Affairs and Tourism.
1976 Portfolio of Community Development added.
1978 Relieved of Portfolio of Tourism.
1979 Portfolio of Coloured Relations added.
1980 Appointed Ambassador to the United Kingdom.

STEYN, S.J.M., Sy Edele die Minister van Gemeenskapsbou, van Kleurlingbetrekkinge en van Indiërsake.

B.A., Universiteit van Kaapstad, 1934.
Ll.B., Universiteit van die Witwatersrand, 1937.

1938-42 Joernalis en personeellid van die Staatsinligtingskantoor.
1942-48 Sekretaris van die Verenigde Party, (Witwatersrand).
1948 Verkies as L.V.
1975 Word aangestel as Minister van Indiërsake en Toerisme.
1976 Portefeulje van Gemeenskapsbou word toegevoeg.
1978 Staan die portefeulje van Toerisme af.
1979 Portefeulje van Kleurlingbetrekkinge word toegevoeg.
1980 Aangestel as Ambassadeur in die Verenigde Koninkryk.

UYS, W.J.
B.Sc. (Agric. Eng.), University of Pretoria, 1958.

Assistant Chief Engineer (Civil), Department of Co-operation and Development, since 1975.

1959-60 Hydrologist, Department of Water Affairs.
1960-69 Assistant Parks Engineer, National Parks Board.
1969-75 Principal Engineer, Department of Agricultural Technical Services.

UYS, W.J.
B.Sc. (Landbou-ing.), Universiteit van Pretoria, 1958.

Assistent-Hoofingenieur (Siviel), Departement van Samewerking en Ontwikkeling, sedert 1975.

1959-60 Hidroloog, Departement van Waterwese.
1960-69 Assistent-Parkingenieur, Nasionale Parkeraad.
1969-75 Hoofingenieur, Departement van Landboutegniese Dienste.

VAN DER SCHYFF, A.D.
B.Sc. Eng. (Civ.), University of Cape Town, 1973. M.B.A., University of Cape Town, 1974.

Deputy Director, Housing Development, Ministry of Local Government and Housing, Zimbabwe.

He was previously Director of Tarmacadam Service, dealing with the construction of roads and airfields.

VAN DER SCHYFF, A.D.
B.Sc. Ing. (Siv.), Universiteit van Kaapstad, 1973. M.B.A., Universiteit van Kaapstad, 1974.

Adjunk-Direkteur, Behuisingsontwikkeling, Ministerie van Plaaslike Regering en Behuising, Zimbabwe.

Hy was voorheen Direkteur van Tarmacadam Service, betrokke by die konstruksie van paaie en vliegvelde.

VAN STRAATEN, J.F.
B.Sc., University of Stellenbosch, 1943. B.Sc. (Mech. Eng.), University of Stellenbosch, 1945. M.Sc. University of Stellenbosch, 1951.

Assistant Director, National Building Research Institute, CSIR, since 1975.

1946 Assistant Engineer, Atlantic Refining Company.
1946 Joined the Environmental Engineering Division of the National Building Research Institute, CSIR.
1958-75 Head of Environmental Engineering Division of the National Building Research Institute, CSIR.

VAN STRAATEN, J.F.
B.Sc., Universiteit van Stellenbosch, 1943. B.Sc. (Meg.Ing.), Universiteit van Stellenbosch, 1945. M.Sc., Universiteit van Stellenbosch, 1951.

Assistent-Direkteur, Nasionale Bounavorsingsinstituut, WNNR, sedert 1975.

1946 Assistent-Ingenieur, Atlantic Refining Company.
1946 Sluit aan by die Afdeling Omgewingsingenieurswese van die Nasionale Bounavorsingsinstituut, WNNR.
1958-75 Hoof van die Afdeling Omgewingsingenieurswese van die Nasionale Bounavorsingsinstituut, WNNR.

WEBB, T.L.
B.Sc. (Chem. & Geol.), Rhodes University, 1936. D.Sc. (cum laude), University of Pretoria, 1958.

Director of the National Building Research Institute, CSIR since 1959.

1947 Joined the National Building Research Institute, CSIR as a Research Officer.
1955 Appointed Head of the Materials Division, National Building Research Institute, CSIR.

WEBB, T.L.
B.Sc. (Chem. en Geol.), Rhodes Universiteit, 1936. D.Sc. (cum laude), Universiteit van Pretoria, 1958.

Direkteur van die Nasionale Bounavorsingsinstituut, WNNR sedert 1959.

1947 Sluit aan by die Nasionale Bounavorsingsinstituut, WNNR as Navorsingsbeampte.
1955 Aangestel as Hoof van die Afdeling Materiale, Nasionale Bounavorsingsinstituut, WNNR.

WEBSTER, C.J.D.
B.Sc. (Hons), University of London,. (C. Eng.), MIMechE.

Head, Public Health Engineering Section, Building Research Station, Garston, England.

WEBSTER, C.J.D.
B.Sc. (Hons.), Universiteit van Londen, (C. Eng.), MIMechE.

Hoof, Ingenieursafdeling vir Openbare Gesondheid, Building Research Station, Garston, Engeland.

PROGRAMME

DAY 1 : TUESDAY 30 SEPTEMBER 1980

08h00 - 09h00
Registration of delegates

OPENING SESSION:
Seminar Chairman: *P.R. Crabtree*

09h00 - 09h15
Address of Welcome
T.L. Webb

09h15 - 09h45
Opening Address
The Honourable S.J.M. Steyn, Minister of Community Development, of Coloured Relations and of Indian Affairs, Pretoria, South Africa

09h45 - 10h15
Thanks and statement of theme
P.R. Crabtree

10h15 - 10h40
TEA

SESSION 1 : The developing countries

10h40 - 11h10
Paper 1: The development of self-help gravity piped water projects in Malawi; management and planning
L.H. Robertson

11h10 - 11h40
Paper 2: An analysis of Zimbabwe's national development programme as it relates to urbanization and the provision of infrastructural services
A.D. van der Schyff

11h40 - 12h10
Paper 3: Policies adopted for water supply and drainage in low cost housing programmes
E.L. Johnson (presented by G.J.W. Bertot)

12h10 - 12h50
Discussion

12h50 - 14h00
LUNCH

14h00 - 14h30
Paper 4: The drafting of National Plumbing Codes
R.A. Morgan

14h30 - 15h00
Discussion

15h00 - 15h20
TEA

15h20 - 15h50
Paper 5: The Israel model of quality assurance in sanitary installations
I. Silberstein

PROGRAM

DAG 1 : DINSDAG 30 SEPTEMBER 1980

08h00 - 09h00
Registrasie van afgevaardigdes

OPENINGSESSIE:
Seminaarvoorsitter: *P.R. Crabtree*

09h00 - 09h15
Verwelkoming
T.L. Webb

09h15 - 09h45
Openingsrede
Sy Edele S.J.M. Steyn, Minister van Gemeenskapsbou, van Kleurlingbetrekkinge en van Indiërsake, Pretoria, Suid-Afrika

09h45 - 10h15
Bedankings en verklaring van tema
P.R. Crabtree

10h15 - 10h40
TEE

SESSIE 1 : Die ontwikkelende lande

10h40 - 11h10
Referaat 1: The development of self-help gravity piped water projects in Malawi; management and planning
L.H. Robertson

11h10 - 11h40
Referaat 2: An analysis of Zimbabwe's national development programme as it relates to urbanization and the provision of infrastructural services
A.D. van der Schyff

11h40 - 12h10
Referaat 3: Policies adopted for water supply and drainage in low cost housing programmes
E.L. Johnson (aangebied deur G.J.W. Bertot)

12h10 - 12h50
Bespreking

12h50 - 14h00
MIDDAGETE

14h00 - 14h30
Referaat 4: The drafting of National Plumbing Codes
R.A. Morgan

14h30 - 15h00
Bespreking

15h00 - 15h20
TEE

15h20 - 15h50
Referaat 5: The Israel model of quality assurance in sanitary installations
I. Silberstein

15h50 - 16h20
Paper 6: Aspects of sanitation for site and service schemes
G.J.W. de Kruijff

16h20 - 17h00
Discussion

DAY 2 : WEDNESDAY 1 OCTOBER 1980

SESSION 2 : The developed countries

08h30 - 09h00
Paper 7: A design for rural village water points in Zimbabwe
F.P. du Toit

09h00 - 09h30
Paper 8: A review of problems in sanitary engineering
C.D. Webster

09h30 - 10h10
Discussion

10h10 - 10h30
TEA

10h30 - 11h00
Paper 9: Les problèmes des pays en voie de développement dans le domain de la distribution et de l'évacuation des eaux (The problems of developing countries in the context of water supply and drainage services)
F. Perrier

11h00 - 11h30
Paper 10: New evaluation methods of WC-systems
H.J. Knoblauch

11h30 - 12h10
Discussion

12h10 - 13h20
LUNCH

SESSION 3 : Technical reports

13h20 - 13h35 1. *A.P. Bekker*

13h35 - 13h50
Discussion

13h50 - 14h20 2. *E. Olsson*

14h20 - 15h00
Discussion

15h00 - 15h30
TEA

15h30 - 16h00 3. *T.P. Konen*

16h00 - 17h00
Discussion

DAY 3 : THURSDAY 2 OCTOBER 1980

SESSION 4 : The South African scene

08h30 - 09h00
Paper 11: Water supply and drainage research at the National Building Research Institute
P.R. Crabtree

15h50 - 16h20
Referaat 6: Aspects of sanitation for site and service schemes
G.J.W. de Kruijff

16h20 - 17h00
Bespreking

DAG 2 : WOENSDAG 1 OKTOBER 1980

SESSIE 2 : Die ontwikkelde lande

08h30 - 09h00
Referaat 7: A design for rural village water points in Zimbabwe
F.P. du Toit

09h00 - 09h30
Referaat 8: A review of problems in sanitary engineering
C.D. Webster

09h30 - 10h10
Bespreking

10h10 - 10h30
TEE

10h30 - 11h00
Referaat 9: Les problèmes des pays en voie de développement dans le domain de la distribution et de l'évacuation des eaux (Die probleme van ontwikkelende lande in verband met watervoorsienings- en dreineringsdienste)
F. Perrier

11h00 - 11h30
Referaat 10: New evaluation methods of WC-systems
H.J. Knoblauch

11h30 - 12h10
Bespreking

12h10 - 13h20
MIDDAGETE

SESSIE 3 : Tegniese verslae

13h20 - 13h35 1. *A.P. Bekker*

13h35 - 13h50
Bespreking

13h50 - 14h20 2. *E. Olsson*

14h20 - 15h00
Bespreking

15h00 - 15h30
TEE

15h30 - 16h00 3. *T.P. Konen*

16h00 - 17h00
Bespreking

DAG 3 : DONDERDAG 2 OKTOBER 1980

SESSIE 4 : Die Suid-Afrikaanse toneel

08h30 - 09h00
Referaat 11: Water supply and drainage research at the National Building Research Institute
P.R. Crabtree

09h00 - 09h30
Paper 12: Water supply and sewerage for low cost housing in South Africa
G.E. Bath

09h30 - 10h10
Discussion

10h10 - 10h30
TEA

10h30 - 11h00
Paper 13: Water supply in the national states of South Africa
W.J. Uys

11h00 - 11h30
Paper 14: Water and sewerage in urban Black communities
P.A. du Plessis

11h30 - 12h10
Discussion

12h10 - 13h30
LUNCH

13h30 - 14h00
Paper 15: Factors of bulk water supply and main sewerage for low cost housing schemes
A.B. Davis

14h00 - 14h30
Paper 16: Towards urban water conservation in South Africa
G.J. Malan

14h30 - 15h10
Discussion

15h10 - 15h30
TEA

CLOSING SESSION

15h30
Appraisal
J.F. van Straaten

09h00 - 09h30
Referaat 12: Water supply and sewerage for low cost housing in South Africa
G.E. Bath

09h30 - 10h10
Bespreking

10h10 - 10h30
TEE

10h30 - 11h00
Referaat 13: Water supply in the national states of South Africa
W.J. Uys

11h00 - 11h30
Referaat 14: Water and sewerage in urban Black communities
P.A. du Plessis

11h30 - 12h10
Bespreking

12h10 - 13h30
MIDDAGETE

13h30 - 14h00
Referaat 15: Factors of bulk water supply and main sewerage for low cost housing schemes
A.B. Davis

14h00 - 14h30
Referaat 16: Towards urban water conservation in South Africa
G.J. Malan

14h30 - 15h10
Bespreking

15h10 - 15h30
TEE

AFSLUITING

15h30
Oorsig
J.F. van Straaten

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGSDIENSTE IN ONTWIKKELENDE LANDE

S 239
Paper 1
Referaat 1

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water, pipe, planning, self-help/
Water, pyp, beplanning, self-help.

THE DEVELOPMENT OF SELF-HELP PIPED WATER PROJECTS IN MALAWI : MANAGEMENT AND PLANNING

by L.H. Robertson*

SYNOPSIS

The design objective of these projects is to pipe mountain water by gravity system to villages on the plains. These are self-help projects - the whole rural community is involved and the government supplies the pipes and expertise. The villagers themselves have installed 2 700 village taps in rural areas in Malaŵi.

SAMEVATTING

Die doel van hierdie projekte is om bergwater in pype deur middel van 'n valwaterstelsel na dorpies op die vlaktes te lei. Dit is self-helpprojekte - die hele plaaslike gemeenskap word betrek en die owerheid voorsien die pype en vakkennis. Daar is alreeds 2 700 krane deur die inwoners van die dorpies self op die platteland van Malawi aangelê.

**Department of Lands, Valuation and Water, Office of the President and Cabinet, Lilongwe, Malawi.*

INTRODUCTION

There are now 420 000 people in Malawi in Rural Areas, who are served by 2 700 village taps which they themselves have installed by laying 2 000 kilometres of piping.

The total cost has been R2,000,000, that is an average of R740 per tap unit and a cost of R5 per head of population.

Malawi covers a land surface of 95 000 sq. km. including a number of mountains which are the sources of perennial rivers and streams. Malawi has a population of approximately 5 million.

THE INCREASING PROBLEM OF DOMESTIC WATER

The majority of people get their domestic water supply from shallow wells or streams, which dry up during the dry season when water has to be carried long distances.

With the growth of population and the increase of cultivation, rivers and wells dry up earlier in the year. Water supply therefore becomes more and more of a problem.

As the population becomes more dense the health hazard from polluted rivers becomes greater.

TECHNICAL BACKGROUND

The design objective is to pipe pure mountain water, by gravity systems, from mountain streams to villages on the fertile plain.

The design criteria are:

(i) 27 litres per person per day
(ii) one tap to approximately 160 people
(iii) design flow 0,075 l/s at each tap
(when all taps are open)

All taps are public stand-points. Water must be carried away (which limits consumption). This water is free - so it is used by everyone.

Population figures are obtained from census maps. The layout and details of villages are obtained from aerial photographs. Alignment of pipe lines is chosen from 1/50,000 ordinance survey maps and profiles are plotted for each line.

The overall design capacity, as well as being related to the existing population, takes into account the food production capacity of the soil, and is based on the (estimated) maximum population which the land can support.

From this data required flows and pipe sizes can be calculated and the network designed.

The full range of pipe sizes is used, 12 mm - 90 mm PVC and the larger sizes 100 mm - 250 mm asbestos cement.

Pressures used are up to 10 atmospheres. A suitable site is chosen for the header-tank at the right elevation, the intake being high enough to feed this tank. On large projects the main pipe line will feed a number of branch line tanks, which will then be header-tanks for the branch line systems, as well as providing for night-storage, enabling the main line to be used through the night.

The only purification is by screening and sedimentation, since the streams used come from mountain forest reserves. Work is now being done to introduce slow-sand-filtration. This would greatly increase the number of rivers which could then be utilized and would extend the scope of this programme.

MANAGEMENT AND PLANNING

The development of Project Management

As a result of the first two pilot projects of 1968 and 1969 four things became apparent:

The villagers and their leaders, having seen the possibilities, wanted more of these projects. They had become convinced that water could flow long distances in pipes (without an engine) and that government was able to help with pipes and expertise. The credibility gap was bridged.

It was essential to start with a small pilot project until the people were convinced. It would, however, become necessary to cover the whole area in a comprehensive way. This might involve 100,000 people in one project.

If projects of this size were to be attempted there would have to be proper technical supervision. Although the digging and the back-filling of all the pipe lines could be done by self-help labour, the actual laying and jointing must be done to a high standard and there are many aspects of the job which require the supervision of a technical assistant.

The project leadership and organization would require to be properly set up so that it could maintain enthusiasm through a prolonged period (2 years) between the start of a project and the completion when taps are turned on in the villages.

Project leadership and committees

The key to the success of these projects is the involvement of the whole community and the setting up of an organization which can handle the large amount of work that has to be done and ensure that everyone does his share.

A public meeting is first held to announce the project. At this meeting all leaders are present - Member of Parliament, Chiefs and Party leaders. At this meeting the Chief will ask his people if they want the project and are willing to work for it. In this way the self-help commitment is established from the start. The meeting then appoints a Project Committee to organize the work.

This Committee has the authority of the Chiefs and all the leaders and people. It is therefore able to control the work which has to be done, and overcome any problems that may arise. It is important that these committees are not appointed by the Government, but that they derive authority from the people, Chiefs and political leaders.

In a large project there will be, under the main Committee, a number of Section Committees which will be responsible for the different sections of the pipeline system.

Finally there will be a Village Committee in each village to see to the construction of the tap site and apron with soak-away pit, etc. This Committee will be responsible for the cleanliness of the tap surroundings, and for the maintenance of the tap (replacement of washers, etc.).

It will be clear from this that the Government is assisting the people to install their project. This is very different from the Government putting in a project for the people.

It is now widely recognized that participation by the people is essential for the success of the Rural Projects. When a Committee is made responsible it responds to the trust given to it.

It is, however, necessary for the project management to spell out the specific tasks that have to be done, i.e. the digging of a pipeline; the excavation of a tank site; collection of building stone; digging of river sand. It is essential that lines are marked out before digging starts. The technical assistant is the vital link between the project and the people.

The technical assistant

The technical assistants are carefully selected for their practical knowledge and suitability for working with people in the field. They are trained in all the necessary skills, mainly through in-service training. They become very proficient at their work and respected by the people. They are also personally involved in the success of their section of the project and become highly motivated.

Weekly staff meetings and annual refresher courses help to maintain high standards and build up a strong team spirit. These also give an opportunity for discussions and exchange of ideas on the problems of management in the field.

The role of the engineer

The necessary support for the field staff is given by the project engineer, who has previously designed accurate and easily interpreted plans for the project. He is responsible for the co-ordination of the work, for setting out standard procedures, for programming the work to fit in with the seasons and with the supply of pipes and other materials; and for solving all the technical and other problems which may arise in the field. In this way he ensures that the whole project goes ahead with a momentum which can maintain the local enthusiasm.

In addition to being competent, an engineer should have a high degree of motivation with qualities of leadership and sound judgement, which will enable him to evolve appropriate management techniques suitable for the rural project situation.

CONCLUSIONS

We have seen the design of these projects and how it is adapted to fit the conditions. We have seen how the community is involved at all levels, utilizing the existing leadership structure. We have also seen the importance of highly motivated field staff, who are the link between the Government and the people and who provide the necessary supervision. Can we identify the basic principles which contribute to the success of these projects?

The system has evolved from the bottom. The Community has been involved in the project at all levels and through the whole cycle of planning, implementation and maintenance.

As a result of this involvement and because of its basic importance to the success of the programme, a sense of pride and ownership in the project is generated within the local community.

Rural communities have always been conservative and, rightly, cautious of innovations until they have been tried and shown to be appropriate to the conditions in which they live. It has been possible to gain the confidence of the rural communities through successful demonstration and to involve them in a technical programme of development, which then generated confidence for further projects.

This did not, of course, happen overnight. It has taken ten years of patient understanding and persistent hard work from dedicated field staff.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 2
Referaat 2

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Reconstruction programme, economy, housing requirements/ Rekonstruksieprogram, ekonomie, behuisingsbehoeftes

AN ANALYSIS OF ZIMBABWE'S NATIONAL DEVELOPMENT PROGRAMME AS IT RELATES TO URBANIZATION AND THE PROVISION OF INFRASTRUCTURAL SERVICES

by A.D. van der Schyff*

SYNOPSIS

The reconstruction programme of Zimbabwe envisages a multi-pronged approach to the problems of human expectations, land pressure, unemployment, housing shortages and a generally depressed economic environment. The paper briefly develops the historic perspective, defines the existing problems and discusses their solution.

The paper analyses the magnitude of the housing requirement and the strategy evolved to meet it. The corner stone of that strategy is the provision of adequate water and drainage services in advance of the national building programme. The paper deals in detail with the design philosophy required to implement the strategy and provide the standard of service envisaged.

SAMEVATTING

Die rekonstruksieprogram vir Zimbabwe beoog 'n multi veeldoelige benadering tot die probleme van menslike verwagtinge, grondnood, werkloosheid, behuisingstekorte en 'n algemene verlaagde ekonomiese omgewing. Die referaat bring kortliks die geskiedkundige aspek in perspektief, definieer bestaande probleme en bespreek die oplossing daarvan.

Die referaat ontleed die omvang van die behuisingsbehoefte en die strategie om die probleem die hoof te bied. Die hoeksteen van hierdie strategie is die voorsiening van genoegsaam water- en dreineringsdienste voor die aanvang van die nasionale bouprogram. Die referaat handel in besonderhede oor die ontwerpfilosofie wat benodig word om die strategie te implementeer en die gehalte werk, wat beoog word, te lewer.

* *Deputy Director, Housing Development, Ministry of Local Government and Housing, Salisbury, Zimbabwe.*

1. INTRODUCTION

Zimbabwe suffers from the same problems as most developing countries, the major difference being that recent history has accelerated the growth of these problems and focused attention on them. In some ways the highlighting of the problems facing the country can be considered beneficial, as the formulation of development policy starts with a number of major pluses.

The first major plus can best be described as universal awareness of the real problems involved and a very real desire to see these problems resolved in the shortest possible time. The country is aware of the consequences of failure, and the spur to succeed is, therefore, possibly greater. Secondly, recent history has provided the country with the technology necessary to succeed and an extremely strong infrastructure on which to build. Thirdly, the very real change of thinking in the country has provided an opportunity to reflect on past performance and reconsider the planners' perspective, thus allowing them the possibility of learning, both from their own history and the recent history of the emergent, underdeveloped Third World.

Many very well thought out development strategies have gone astray throughout the developing world and these lessons must not be forgotten but rather used to best advantage.

2. HISTORICAL PERSPECTIVE

The development of Zimbabwe has historically been on economic rather than on socio-economic lines. The prime motive for the settlement of the country in the closing decade of the last century was the pursuit of wealth, primarily mineral wealth and subsequently agricultural wealth. While no criticism of this original motivation is implied the consequence of that original thinking was a very large discrepancy in the character of the emergent society.

On the one hand, the indigenous people perceived land use as an integral part of their society, while, on the other, the new community saw land as a means of gathering wealth. Earlier in the century this presented no major problems, as the total population of the country was about 600 000 people.

The original mining settlements failed to meet the aspirations of the new community and large areas of land fell under their direction. With the aid of advanced agricultural techniques they were able to develop a very strong agriculture based economy. The new community gradually became more economically dominant, until the time was reached when most of the easily developed tracts of the country became their domain.

The indigenous community, however, continued to hold on to its traditional values, with the direct result that, as its own population increased, the traditional role of land came under more pressure with the consequent denudation and, in some areas, almost total collapse of the eco-system. At the same time the new community flourished, and most infrastructural development was based on economic cost benefit. The new technologies that could have benefited the indigenous population were concentrated in the more economically viable areas of the land, and the disparity in the condition of the land continued to widen.

With the changing values in the world, the political aspirations of the local population grew, the land issue became politically extremely sensitive.

Large portions of the population had drifted to the new towns to seek work, but all retained, and were encouraged to retain one foot in what was then known as the tribal areas. Urban workers' dependants continued to subsist in these areas. The resultant imbalance in the population strained the eco-system in the tribal areas even further. The loss of large portions of the active sector of communities reduced the possibility of success for any policy of land and agricultural reform. The dual occupancy system was, in effect, an excuse for retaining low wage structures, as the urban worker was not considered a permanent member of the urban area owing to the fact that his traditional home and not his earning capacity provided for his family.

Furthermore, a national, cheap food policy had the effect of reducing the incentive of the rural community to produce the one crop that they knew how to grow. In effect, the rural population was subsidizing the more affluent urban worker. The policy of keeping the food prices at a low level automatically devalues rural farm production, even if it is self-consumed. It also encourages urban drift and the development of urban squatter settlements in which people subsist on informal economic activity and low cost food.

The Civil War in Zimbabwe aggravated the problem, as the small economic inroads that had been made in the now densely populated areas were soon wiped out, until the surviving rural population groups became almost entirely dependent on the more economically resilient commercial farmer for food supply. Displaced people drifted towards the cities to attempt some form of entry into the urban economic system, thus pressurizing existing housing and social services.

The urban housing pressure was further aggravated by the lack of employment opportunities in the cities. Since 1974 Zimbabwe has had a negative growth rate* and the unemployment backlog had in itself become a major problem. Large portions of the population have been unable either to afford or to acquire housing in the cities, with the result that squatting and lodging in existing accommodation is of extreme consequence.

Whatever the merits or demerits of the situation, the net effect of history has been to produce a complete economic and social imbalance between rural and urban areas.

3. DEFINITION OF THE PROBLEM

The exact nature of the problem resulting from the three major issues of land, war and declining economic growth can best be defined under the headings of land pressure, urban pressure, unemployment and crisis of expectation.

* Gross National Income

Land pressure

The existing urban population continues to perceive land as a form of social security and the urban-rural link continues to depress the rural area. Hughes[2] outlines the traditional role of tribal land as being:

(a) The provision of somewhere to build a dwelling;
(b) the provision of raw materials - for building, for domestic needs, for fuel and for handicrafts;
(c) the growth of crops for one's own and one's family consumption;
(d) the provision of grazing for one's stock - stock being a major store of wealth;
(e) the basis of a social security system;
(f) the potential source of monetary income.

These traditional roles have resulted in the poorer population using the tribal land as a haven in times of unemployment and in their old age. The imbalance in the structure of the rural population has resulted in the utilization of scarce land resources for purposes other than the production of crops.

Total national populations have increased from 710 000 in 1901 to an estimated 7 140 000 in 1979. Based on the 1969 census, 60 per cent of the population resides in the tribal area, i.e. a total of some 4 300 000 people.

In 1964 the total agricultural production from the tribal areas was Z$32,6 million and in 1977 $106 million. 1978 saw a substantial drop to Z$71,6 million, largely as a result of the war. During the same period, however, from 1965 to 1977, commercial agricultural output rose from $145 million to Z$426 million.

It is significant that as a percentage of commercial output the trend lines indicate decreasing productivity, as does the per capita output in the tribal area (see Graph. 1).

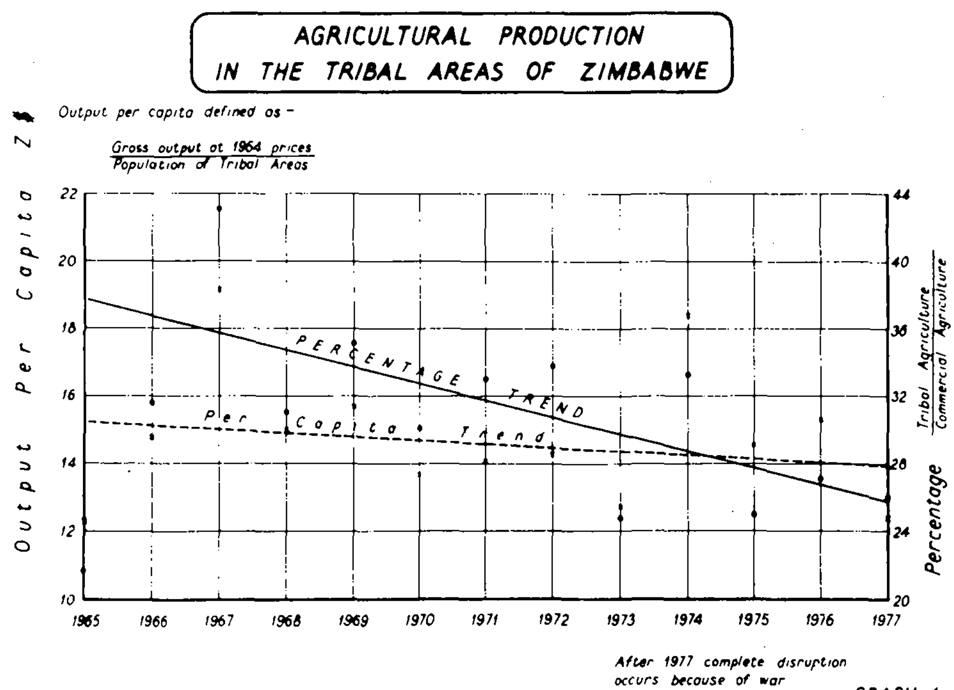
The slopes of both trend lines do not, however, exhibit dramatic declines but, rather, gradually increasing imbalances which indicate a gradual collapse of the tribal eco-systems. During the same period, the tribal population was increasing by some 46 per cent.

Land pressure has been further aggravated by the return to the country of tens of thousands of combatants and refugees.

On the assumption that the tribal lands have in fact reached saturation point, and the only result of continued subsistence farming practice would be a total collapse of the eco-system, the question of how to avert a disaster arises. Agricultural research in Zimbabwe has shown conclusively that existing tribal land can be commercially viable if modern farming techniques and inputs are available. These inputs are not readily available to the tribal farmer but must be made available in the shortest possible time.

Urban pressure

As a result of land pressure and war, large portions of the population have drifted to the cities. The reasons for urban drift are twofold.



GRAPH 1

* ± 0,8 Zimbabwe dollars = R1,00 (1980)

Firstly, there is the pressure on the land, which forces occupants to subsidize that land potential with cash. Secondly, there is the possibility of better financial and social prospects in the cities.

The size of the urban influx is undoubtedly enormous, and no accurate figures regarding the actual urban population exist. One estimate, taken from the Whitsun Report on Finance for Low Cost Housing, is detailed below:

Population	1975	1976	1977	1978
Total urban	1 236 000	1 241 000	1 316 000	1 355 000
Low income urban	983 000	991 000	1 074 000	1 113 000
Percentage of low income population urbanized	16,4	16,0	16,8	16,8

An analysis of the urban low income population figures for Salisbury and Bulawayo would officially be represented as follows:

Urban low income population	1975	1976	1977	1978	1979
Salisbury	498 465	493 782	501 024	500 810	525 390
Bulawayo	286 200	288 400	284 784	293 918	303 780
Percentage of urban population	79,5	79,9	81,6	82,1	83,0

If, however, we correlate existing house stock data with real occupancy rates in houses we get a completely different picture. Recent surveys show that population densities average nine people per dwelling unit and, in some instances, peak at 20 or more.

The total number of official bed spaces for Salisbury in 1978 was 312 969 and for Bulawayo 265 270. The estimated shortfall in housing for low income groups is calculated in the following table:

1978 Situation

		SALISBURY	BULAWAYO
	Low income population by projection	500 810	293 918
1.	Population by dwelling unit	554 561	340 773
2.	Official bed spaces	312 969	265 270
3.	Shortfall of bed spaces	241 592	75 503
4.	Shortfall in number of houses	40 265	12 853
5.	Official housing backlog from waiting lists	18 000	4 000

Notes:

1. Total housing stock x 9 + single berth x 1,5
2. Housing stock x 5 + single berth
3. 1 - 2
4. 3 divided by 6 people per dwelling unit
5. From housing waiting list.

The table contrasts the difference between the official need and the real need. In Salisbury, the real need for housing is more than double the official waiting list figures. This urban pressure obviously imposes tremendous strain on existing services and the infrastructure. In fact, the average water consumption figures per family per day have increased from 700 litres to 1 600 litres, confirming the estimated double occupancy rates for Salisbury.

The temptation is to rationalize and say that the problem will dissipate now that peace has returned to the country and the people can return to their homes. Unfortunately the probability is that, while there may be a temporary relief in the urban pressure, the immense land pressure problem will militate against many of the people returning. A large number of them have been assimilated into the urban informal sector and their lot, dismal as it may be in the city, is probably better than it would be in parts of the rural areas.

The second factor is that, despite massive rural renewal programmes in other developing countries, the urban drift has continued to accelerate. In many ways the successful Rural Renewal Programme may even encourage urban migration, because the economically aggressive person will want to broaden his horizons, and the only place where that would be possible is in the cities. (See Diagram 1.)

URBAN DRIFT AND DEVELOPMENT

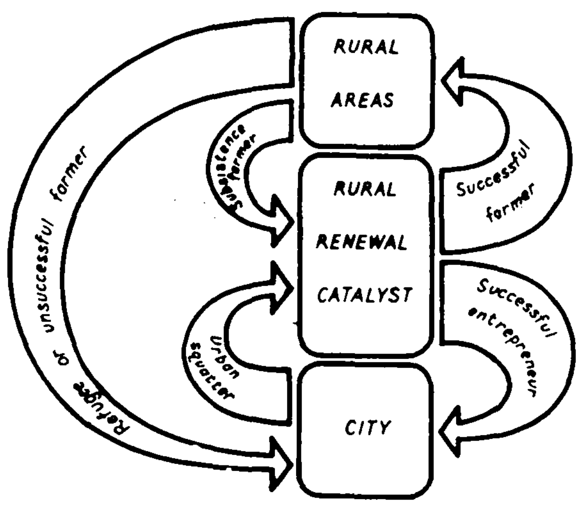


DIAGRAM 1

Unemployment (see graph 2)

In 1974 the commodity price slump, war and the accumulative effect of sanctions finally halted Zimbabwe's spectacular growth rate. From 1974 to 1978, not only did the gross number of people employed fall but so did their per capita earnings. During 1974, 1 040 000 people earned an average $1 279 per annum and, during 1978, 990 000 people earned $1 176 per annum in real terms. During 1978 there were some 50 000 fewer people in employment than at the peak, 1974, period. While this trend is undoubtedly being reversed the backlog of unemployment is enormous.

An estimated 275 000 people require work immediately, and a further 60 000 new jobs need to be created annually to prevent the backlog from increasing.

Crisis of expectation

One of the most difficult tasks facing the planner is the crisis of expectation.

As a direct result of the political upheavals in the country, people have been led to believe that the transformation of Zimbabwe into an independent State will bring about immediate wealth and benefit to the majority of the population.

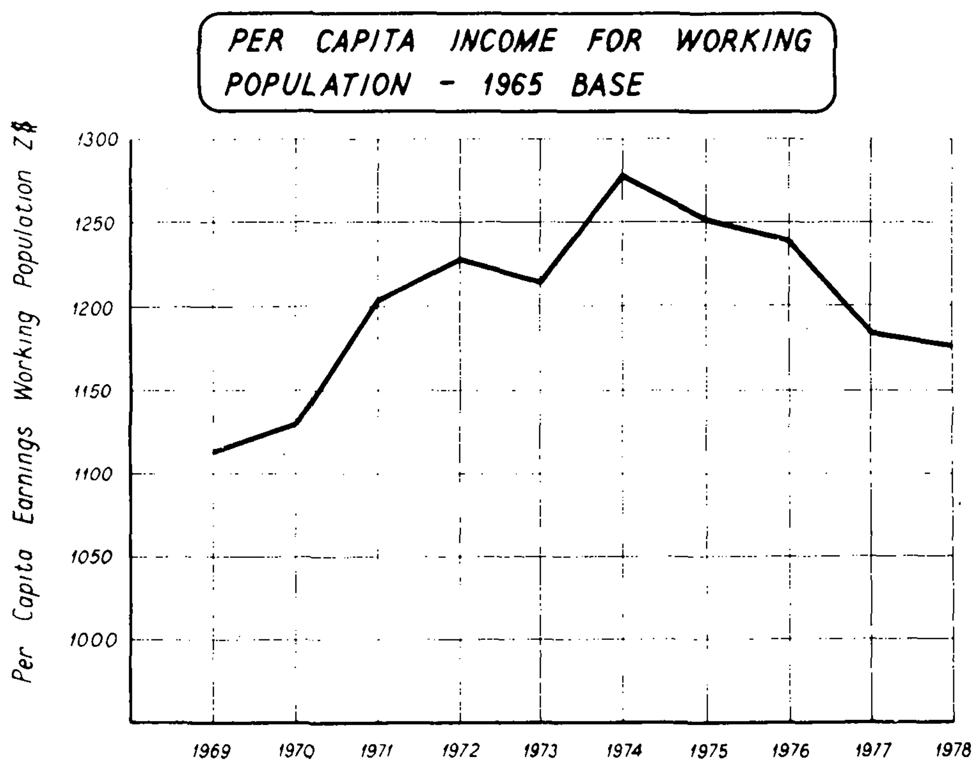
The hard facts are that the economy of Zimbabwe could not stand massive redistribution of wealth. Six years of austerity have taken whatever fat existed in the economy and transformed the economy into a lean machine.

The small wealthy portion of the community cannot alone carry the financial burden of paying for the essential social infrastructure and hope to survive as an economic force. The crisis remains, however, and must be overcome.

4. DEVELOPMENT CONSIDERATIONS

Given the factors outlined above, what other factors influence the concept plans for a National Development Strategy? Two underlying principles require amplification.

The first of these two factors can best be explained by the statement that wealth cannot be redistributed but rather recreated. The changing of a government's development priorities and spending does not in itself redistribute wealth, nor does high taxation greatly improve the lot of the underprivileged when the pool of wealth is small relative to the population. The money and expertise of government, coupled with the know-how and aggressiveness of entrepreneurial skill can, however, be directed to the attainment of real and viable goals aimed at creating wealth by using the will of the people themselves to succeed. Government and commercial enterprises must carry the burden of development and provide the catalysts and inputs for self improvement amongst the poorer sectors of the community. In short, the system must remove obvious barriers to progress and provide the means for the people to improve themselves. The system must not be seen only as a provider or pressure group, but rather as the natural extension of national identity so that the goals of the people and the goals of the State become impossible to separate.



GRAPH 2

The second of these two factors can again best be described by a statement: Development is not a political payoff.

As soon as development is construed either by the policy maker or by the receiver as a political payoff the reasons for failure are already well advanced. Either the policy maker distorts the delicate pyramid of goals, strategies and people-involvement to achieve political ends, or the people construe what may be very legitimate goals as political, rather than as beneficial objectives for their whole community. The concept which must always be remembered is that development is impossible without the willing co-operation of the people. It is not something that can be imposed on populations and it is not something that can be used as a bribe, for without the collective will of the community to make the development objectives succeed all the best laid development strategies will fail. Once again the concept of people-involvement is paramount, in that the development objectives must be the people's objectives, not the objectives, or even the perceived objectives, of the policy maker alone.

5. CONCEPTS FOR A SOLUTION

The first and foremost concept for a solution involves the integration of all facets of the problem and the necessity of tackling the whole problem on a broad front. At first glance this may appear impossible but, provided that the linkage factors between the various concepts are understood, no real problem need arise.

By redirecting the main thrust of national development, taking cognizance of the land pressure, urban pressure, crisis of expectation and the levels of unemployment, the principle of creating a self sufficient, self employed, population is highlighted. Add to this the fact that some 80 per cent of the national population is rural, and the concept of an integrated Rural Development Programme is formed.

An integrated Rural Development Programme is achieved by linking all the facets of the solution together to provide a coherent whole. The main thrust of the programme must be to upgrade the agricultural potential of the rural area and resettle misplaced people on the land.

The agricultural programme would be unsuccessful, however, without a very real upgrading of the rural infrastructure.

The communication system in the rural areas must be sufficiently developed to allow modern agricultural inputs to and outputs from the agricultural areas. Putting it simply, the farmer must be able to purchase fertilizer and sell his products without problems of costly and involved transport and marketing procedures.

To ensure the success of the agricultural and land resettlement programme, some of the attractions of urban dwelling must be made available to the local communities. Social services, in the form of schooling and medical care, must be centralized with administration and agricultural economic back-up services. Development nodes then form as centres for these services and link the chain of communications.

Finally, in order to ease the burden on the land and provide the economic and social base from which to launch the programme, existing urban development must be continued. In this way both rural and urban people who consider themselves dual occupants of the system are encouraged to choose their life style. If housing is provided in the urban areas for the worker and his family, land pressure is eased and so are the social problems which are encountered in the cities.

We can then summarize an integrated Rural Development Programme as consisting of the following components:

1. The agricultural and land distribution component.
2. The communication component.
3. Development node back-up for the rural area.
4. The urban development model.

The combined affects of these development sub-programmes, will largely achieve the objectives of easing the problems relating to unemployment, urban and land pressures, and crisis of expectation.

It is not the object of this paper to examine either the agricultural and land distribution models or the total communication system that is required, but rather to define the role that the water supply and drainage engineer would have to fulfil in the development node and urban housing sector.

6. DEVELOPMENT NODE

Urban centres in Zimbabwe can be graded for convenience into eight groups.

For example:
Salisbury being the top of the hierarchy, with a grading of eight, is followed by smaller centres. Rusape or Chiredzi would be graded four, with 120 functional units, and grade one developments like Mount Drawin consisting of 28 functional units.

The purpose of the development node or service centre will be to fill the gap between the existing very small rural business centres and the existing grade one centre. The centre should provide a base for all essential physical infrastructure; improved agricultural marketing facilities; cheaper and more efficient transport; all necessary farm inputs; an improved range of consumer goods; agricultural and other extension services; a range of employment opportunities; all basic social service and a residential component for all who wish to live there. If all these facilities are provided, the development node should become the focal point of social, administration and transportation interchanges.

Development nodes will be located around existing rural business centres and, as a result, a large portion of their raison d'être will already be established.

Each existing centre would be upgraded from a civil engineering service stand-point, and additional commercial, industrial and administrative stands would be made available. Approximately 100 residential stands will be required to supplement the 30 business sites to accommodate the people who are to provide the necessary services. The size of the typical development node on completion of the initial phase would be approximately as detailed below, but 50 business sites and 150 residential sites will be provided to allow for expansion.

7. TYPICAL DEVELOPMENT NODE

Activity description	No. of Functions	No. of Families
General dealers	8	24
Butcher	2	6
Eating houses	1	4
Beerhalls	1	3
Grinding mill	2	2
Service industry (cobbler, carpenter, tailor, etc.)	5	5
Postal agency	1	1
Market stall and bus terminus	1	3
Administration building	1	3
Primary school (21 classrooms)	1	24
Clinic	1	6
Agricultural Co-op	1	4
Police post	1	2
Ancillary government offices for extension services	2	4
Total number of functional units	28	91

Twenty-eight functional units would indicate grade one hierarchy centres. However, not all centres will be developed to the extent indicated in the table. If the initial figure of 20 functional operating units were achieved the development node would already have begun to achieve its objective of providing a community focal point.

The target for the service centre, translated into engineering terms, would then be as follows:

8. ENGINEERING INPUT REQUIREMENTS

Description	Quantity		Cost
Commercial stands	50	No.	
Residential stands	100	No.	
Water supply works	1	No.	30 000
Water reticulation	6 000	Metres	36 000
Sewage treatment (Aqua Privy or similar)	150	No.	30 000
Road network (gravel)	5 000	Metres	60 000
Electrical reticulation	6000	Metres	15 000
Survey costs, aerial photography and design fees	150	Stands	75 000
Sub-total:			Z$246 000
Electrical transmission			90 000
11 kV system and share of reinforced distribution systems			76 000
Main access road upgrade. Approximately 15 km per centre			150 000
Sub-total:			$316 000
Total engineering development cost per centre			Z$562 000

The figures indicated do not include the cost of essential buildings.

To fulfil the planning objective of this type of development, some three hundred of these centres would be required throughout the country. While the policy has not been officially accepted and the detail of the centres may well change, it would be fair to say that the outline as indicated contains the main elements of any Rural Centre development.

9. NATIONAL HOUSING OBJECTIVES

The National Housing Objective as it relates to the Integrated Rural Development Programme aims at encouraging urban families to become totally urbanized and providing adequate shelter for the urban worker, relative to his ability to afford the shelter. In this way some of the land pressure problems are relieved, in that unproductive rural dwellers have the opportunity to live with their family provider in adequate accommodation. At the same time the objectives allow for urbanization to provide a healthy socio-economic environment and a base for national development. In short, the National Development Strategy maintains an urban-rural balance.

The National Housing Objectives are defined as follows:

Housing objectives

1. To economize on the use of new resources so as to ensure that these resources are used in the most cost effective manner.
2. To optimize the use of the human resource and exploit the willingness and ability of people to contribute to their housing.
3. To provide a range of different standards of housing to match the resources and needs of different income groups.
4. To ensure a reasonably equitable distribution of available resources between different housing groups.

Strategy formulation

To achieve housing objectives as detailed above, a series of investigations is required to determine the housing need and the means to provide for that need. It must be clearly understood from the outset that the need for housing is greater than the demand for housing. The demand being ascertained by the size of official backlogs and the need from an assessment of demographic and employment trends in urban areas.

Basic data inputs required for such a study include:

1. detailed demographic population structure and statistics for a given region under consideration;
2. employment and incomes information and growth prospects;
3. an understanding of the basic housing requirements of a population; housing being defined as the physical environment in which the family must develop. This is not only shelter but all the facilities, services and utilities required to link the family to the community;
4. financial resource availability within various income groups, financial institutions and government.

Investigation results (see Graph 3)

The results of the analysis listed previously indicated the following national picture. 167 000 housing units would be required over the next five years both to overcome the housing backlog and keep up with demand so that the needs of three major income groups could be catered for.

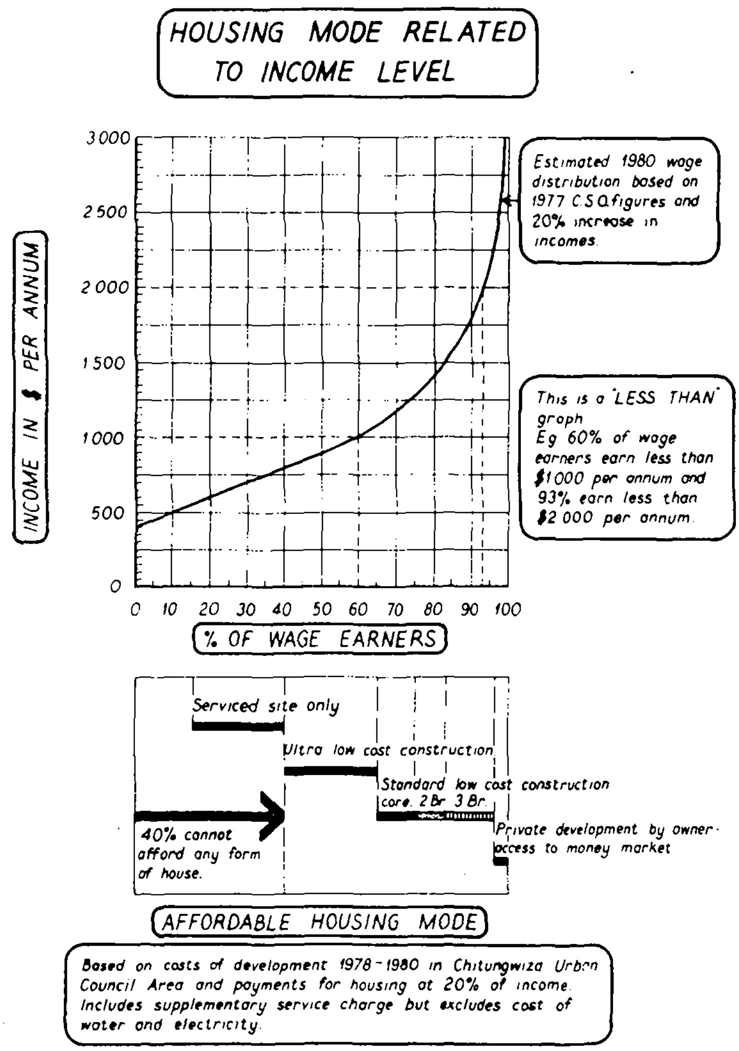
The lowest income group would be provided with an ultra low-cost shelter with water-borne sanitation and comprising two rooms, a shower and a toilet compartment and an open but roofed over kitchen. The standard of finishes that is initially envisaged is based on timber batten windows, earth flooring and electricity to provide a cheap energy source for cooking. The reason that a cheap dwelling was chosen, as opposed to a site and service scheme, was to provide the occupant with basic shelter immediately and relieve him of the burden of dual rentals or living in plastic shelters while he endeavoured to construct his own dwelling. With water-borne sanitation and reticulated water supply, health problems are greatly diminished and the house size can readily be increased as the occupant's upward mobility in employment manifests itself. An electrical hot plate provided with the dwelling unit greatly reduces the cost of cooking, just as the electrical lighting system reduces lighting costs.

The second income group would have a conventional core house that would provide the occupants with two small rooms, a kitchen and bathroom. Extension to the house can be carried out when the occupant can afford it.

The third income group is provided with a low cost, two or three bedroom house complete.

The above selection achieves the objectives of:

1. Providing shelter;
2. spreading the finance resource;
3. maximizing the number of houses built;
4. encouraging small business, in that all core extensions are undertaken by small contractors;
5. taking advantage of economies of scale;
6. allowing the occupant to spend more on his dwelling (i.e. above 22 per cent of his earnings on extending



GRAPH 3

and consolidating the house) without unduly burdening him in the first instance;

7. taking note of the fact that a high quality of shelter is not the priority need or requirement of the very poor. The total environment has greater significance.

Housing policy

The overall investigation resulted in the following definition of housing policy:

1. Government would not involve itself with housing for people who had access to the money market, i.e. could afford houses costing above Z$6 000.
2. Housing must be at a cost which various income groups can afford.
3. Services would include treated reticulated water, reticulated and treated sewage and a good standard of roads.
4. The first essential is to provide housing which gives adequate shelter from the elements and provides electrical energy supply.
5. The present official backlog would be eliminated in five years.
6. Estimated growth of industrial and commercial development in urban areas must be catered for year by year, together with an allowance for the usual drift from rural to urban areas.
7. The houses must have an estimated life of between 30 and 40 years and be capable of being sold to the occupants.
8. Continued efforts must be made to develop ways of lowering the housing threshold and, more especially, to find ways of housing the lower 15 per cent of the urban wage earners who cannot afford even the simplest form of shelter.

10. ENGINEER'S ROLE IN THE DEVELOPMENT PROGRAMME

Having outlined the concept of the integrated Rural Development Programme and its reason for existence, and having briefly detailed the steps taken to achieve various policies we must analyse the role the engineer has to fulfill in this programme.

His role includes:

(a) Implementation of policy objectives.
(b) The design process, taking into consideration the objectives.
(c) The physical establishment of the units analysed and decided on during the design process.

To fulfill this role he must have a thorough understanding of the reasons for various policies and understand that the two catchwords in his philosophy are:

(a) economy - look for the most economical solution not the most elaborate;
(b) adequacy - design to adequate standards that are appropriate to the objectives.

The implementation of that philosophy will require thorough investigation into all aspects of his profession.

11. DESIGN PROCESS

To achieve the objectives of various sectors of the integrated development plan the engineer must understand the design process. This may be broken down into three major sections:

1. Analysis.
2. Synthesis or design.
3. Evaluation.

Analysis involves the understanding of the problem. The broad policy outlines handed down by the policy maker must be analysed in detail and translated into goals. Those goals must clearly define the objectives that the engineering designer wishes to achieve. The engineer must translate guidelines into fact, in order to assist in the systhesis process.

The synthesis process involves the putting together of various solutions to achieve the design goals. Synthesis involves the selection of components and the ordering of their interrelationships.

Finally, having synthesized or designed to achieve the goals, a period of evaluation must be included in the process. There is no point in designing an elaborate water purification works if the user cannot afford the end product and the designer is unaware of his own folly.

12. CHANGES REQUIRED IN THE SYSTEM

The following example of changes that are required to achieve housing objectives outlines the introspection required by the engineer.

Providing housing

To achieve design goals the engineer will have to look at the whole spectrum of problems and consider what changes are necessary to lower the housing threshold.

The determinants of the housing cost threshold are:

1. Construction costs - building and services.
2. Town planning standards - density and land use.
3. Building and civil engineering standards and procedures.
4. Fees, overheads and administrative costs.
5. By-laws and regulations governing development.
6. Land survey costs.
7. Conveyancing and legal costs.
8. Tendering procedure and documentation.
9. Scale of development projects.
10. Finance charges.

13. THE ENGINEER'S ROLE IN CHANGES

It is the engineer's function to ensure that he contributes as much as possible to lowering the housing threshold, and the main provinces of his influence must be utilized to the maximum. The engineer must identify the areas of greatest cost by analysing the component cost in all developments to see what aspects of his project require improvement so that he may pay them the attention they deserve.

1. *Engineer's own attitude.* Too often the engineer designs for a situation where the probability of failure will be negligible. This attitude leads to the 'I'll increase it a little more to be sure' complex, which has disastrous effects on the cost. All too often the engineer is concerned with his own reputation and does not concern himself sufficiently with the end result of his design. The synthesis process becomes an end in itself. This reluctance to accept the consequences of limit state design often results in considerably increased cost. The author has been forced, on several occasions, to dictate lower standards to consultants, owing to their reluctance to work with standards that carry with them some risk of failure.

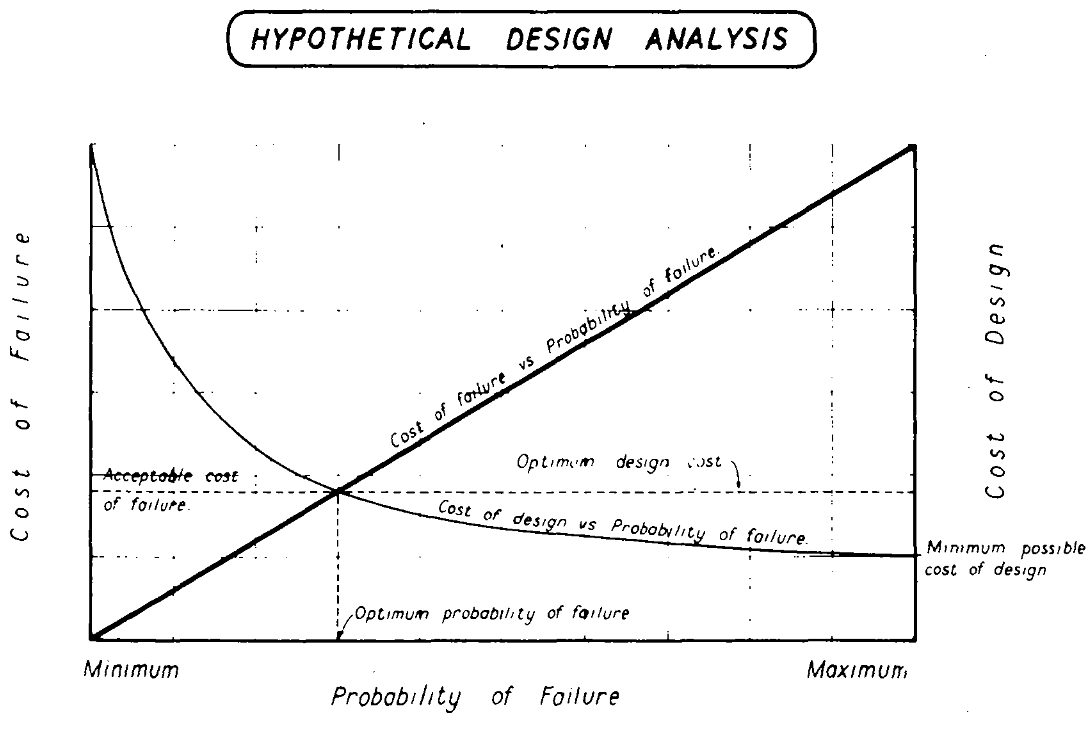
2. *Design standards too high.* For several reasons most of the design standards adopted in civil engineering works of this nature are too high. An example of this concerns water reticulation. Several years ago in Zimbabwe, water reticulation was being designed to cater for five people per family. Today, that same supply system is catering for average house occupancies of nine. The fact that there is absolutely no evidence of breakdown suggests that the system was hideously over designed in the first instance. The concept of probability of failure is considered to be an invaluable tool to overcome this type of problem. We know when things work and we must make more effort to find out where they fail. In addition, the consequences of failure must be analysed and the probability and consequences of failure optimized to fix the design standard. (See Graph 4.) In low cost housing the cost of failure is generally low for partial failure of a system.

3. *Contract procedure.* Two items immediately spring to mind when attempting to lower the housing threshold; both have enormous effects on the contract cost.

The first item concerns the practice of providing sureties for work to be undertaken. In Zimbabwe this normally consists of providing a guarantee of 10 per cent of the contract value. If the cost of these guarantees to the contractor is, say 8 per cent, the additional cost to the project is 0,8 per cent. Would it not be better, possibly, to select contractors more carefully and accept the consequences of the failure of a very small percentage of contractors? Of the total anticipated cost of Zimbabwe's housing over the next five years, the surety cost charged to government represents some Z$6,25 million or, to put it another way, the loss of 8 000 ultra low cost houses.

The second item concerns the practice of holding retention money to ensure that contractors make good any defects. This money represents 20 per cent of the project cost during construction, and, again assuming an 8 per cent cost for money, a further Z$13,5 million must be charged to the contracts. The practice obviously needs review.

4. *Too stringent by-law standards and national pollution standards.* Both these items have an enormous bearing on the cost of low cost housing. By-laws regarding buildings standards for fire control and sewerage systems, have to be ignored, and realistic goals set if any progress is to be achieved. With regard to pollution standards, Zimbabwe has some of



GRAPH 4

the highest standards in the world. While obviously there is some standard requirement, can we truly afford to pay the extra 20 per cent cost to achieve a marginal increase in standard at the top of the range?

The above represent only a few examples of the type of thinking required from the engineer.

14. ZIMBABWE EXPERIENCE

Appendix 1 shows the results that we have been able to achieve in Zimbabwe. They represent the analysis of a 30 000 house development undertaken, predominantly, outside Salisbury over the last three years.

Appendix 2 shows very briefly some of the design standards adopted. They are in no way comprehensive but rather indications of our design standard.

CONCLUSIONS

This paper has been intentionally broad in its concept in order to illustrate the necessity for the engineer to study every facet of his craft and environment. He must collate all information, interpret, crystallize and finally produce the end result - a socially and economically viable community.

CONSTRUCTION COST ANALYSIS

Stand Size	Item	Local Roads	Storm Water Drainage	Sewer Reticulation	Water Reticulation	Major Access Roads	Bulk Water Supply	Bulk Sewer	Eng. Fees	Total
		Direct Services				Remote Services				
12,5m x 25m	Cost	181,30	50.50	118.50	74.00	57.36	47.00	73.00	34.00	635.66
	% Total	28.6	7.9	18.6	11.6	9.0	7.5	11.5	5.3	100 %
10m x 20m	Cost	132,78	40,78	69.88	70,29	61,59	47.00	73,00	34.00	529.32
	% Total	25,1	7,7	13,2	13,3	11,6	8,9	13,8	6,4	100 %

Servicing and Housing Costs

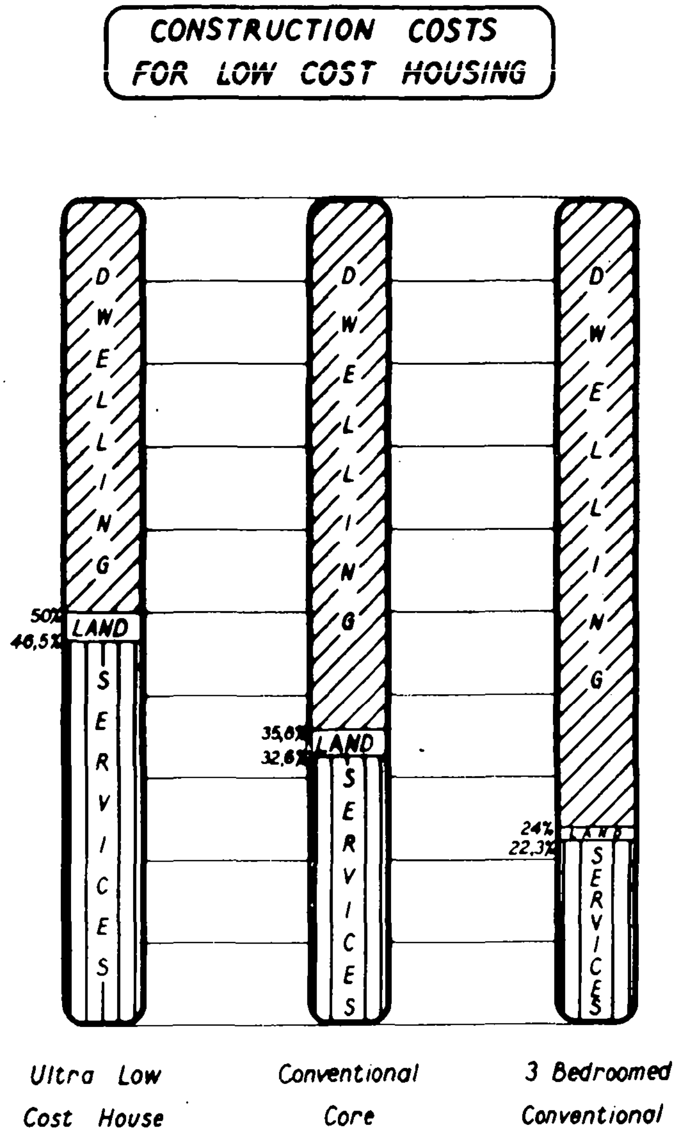
Ultra Low Cost Core 2 small rooms with wet core.			
Services	Land	House	Total
529	40	568	1137
46,5	3,5	50,0	100 %

Conventional Core			
Services	Land	House	Total
635	63	1 250	1948
32,6	3,2	64,2	100 %

3 Bedroomed Conventional			
Services	Land	House	Total
529	40	1 800	2 369
22,3	1,7	76,0	100 %

1. Cost in Zimbabwe Dollors
2. 10 351 10m × 20m stands analysed.
3. 3 337 12,5m × 25m stands analysed
4. Site Chitungwiza June 1980.

APPENDIX 1/1



APPENDIX 1/2

APPENDIX 2

(See standard drawings 1 - 5, pages 13 - 17)

Salient points of design standards

Roads

1. Road reserve width dictated by anticipated traffic generation.
2. Minor roads surfaced with single seal surfacing.
3. Major roads surfaced with double seal surfacing.
4. Bus routes surfaced with single stone tack and single slurry seal.
5. Minor road junctions have no culvert crossings but splash drains are used.
6. All road junctions kerbed, but no other kerbing.

Stormwater

1. All stormwater catered in open drains.
2. Lined drains kept to a minimum. Seldom more than 10 per cent of side drain length.
3. Haunched class S low pressure concrete culvert piping used in culverts.
4. Box culverts and structural concrete works minimised.
5. Concrete bolsters used in lieu of lined drains.

Water reticulation

1. Water reticulation designed for 700 litres per family per day consumption.

2. Residual head of water to be 10 metres at house connection at peak of three.
3. 50 mm asbestos pipe used instead of previous minimum pipe size of 75 mm.
4. Double house connections wherever possible.
5. Fire hydrants located on 100 mm pipes at schools, clinics and shopping centres only.
6. Reticulation is not designed to function normally in event of heavy draw down by fire fighting activities.
7. No additional water allowance made for day schools.
8. Gate valves located to isolate blocks of 150 houses.

Sewer reticulation

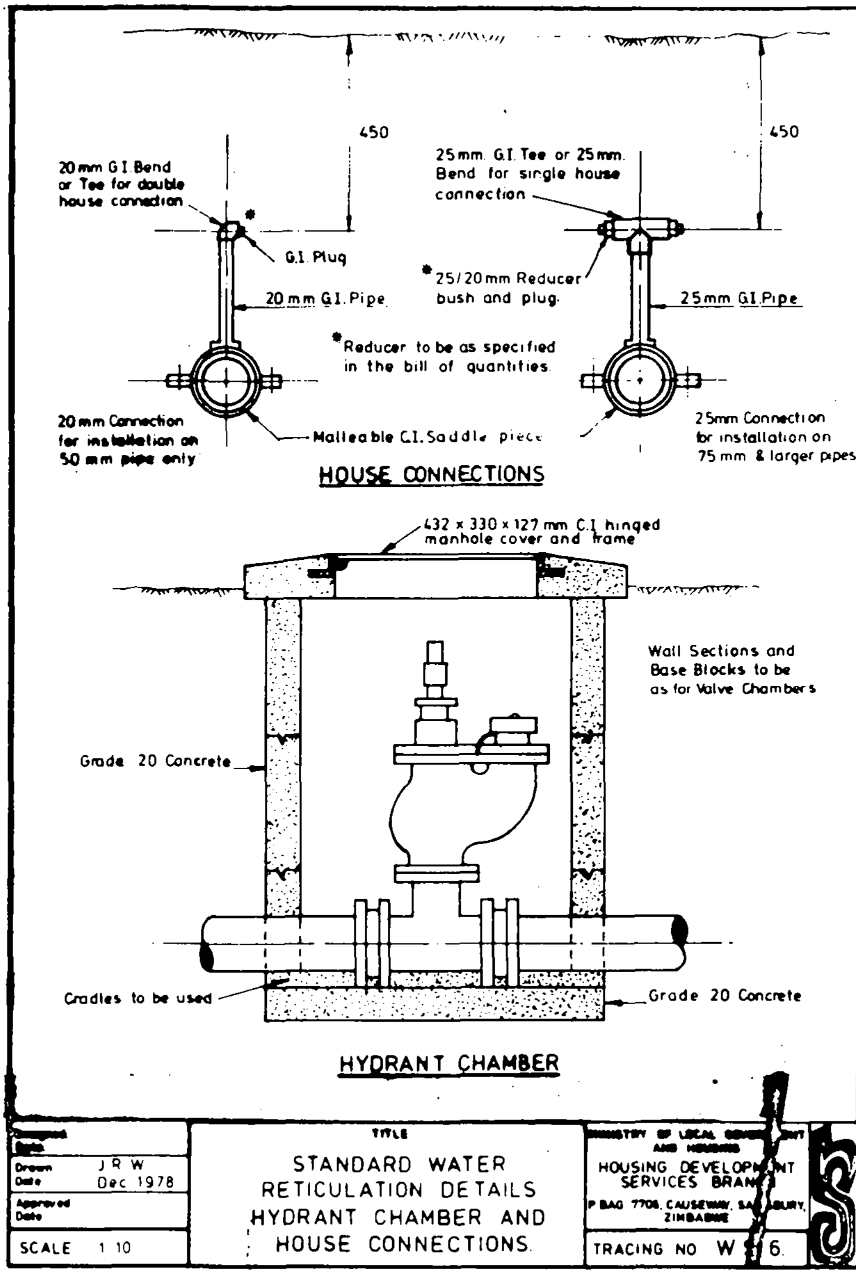
1. Designed to cater for 85 per cent of water consumption.
2. Sewers designed to run 75 per cent full at 3 x ADWF.
3. Minimum sewer size 150 mm with manhole spacing at 90 metres.
4. Sewer depth at start of the run to be not more than 750 mm to top of pipe.
5. Generally to concrete bedding in sewer reticulation or house connection.
6. Rodding ways consisting of 100 mm piping permitted at the head of a sewer run to cater for the top four houses.

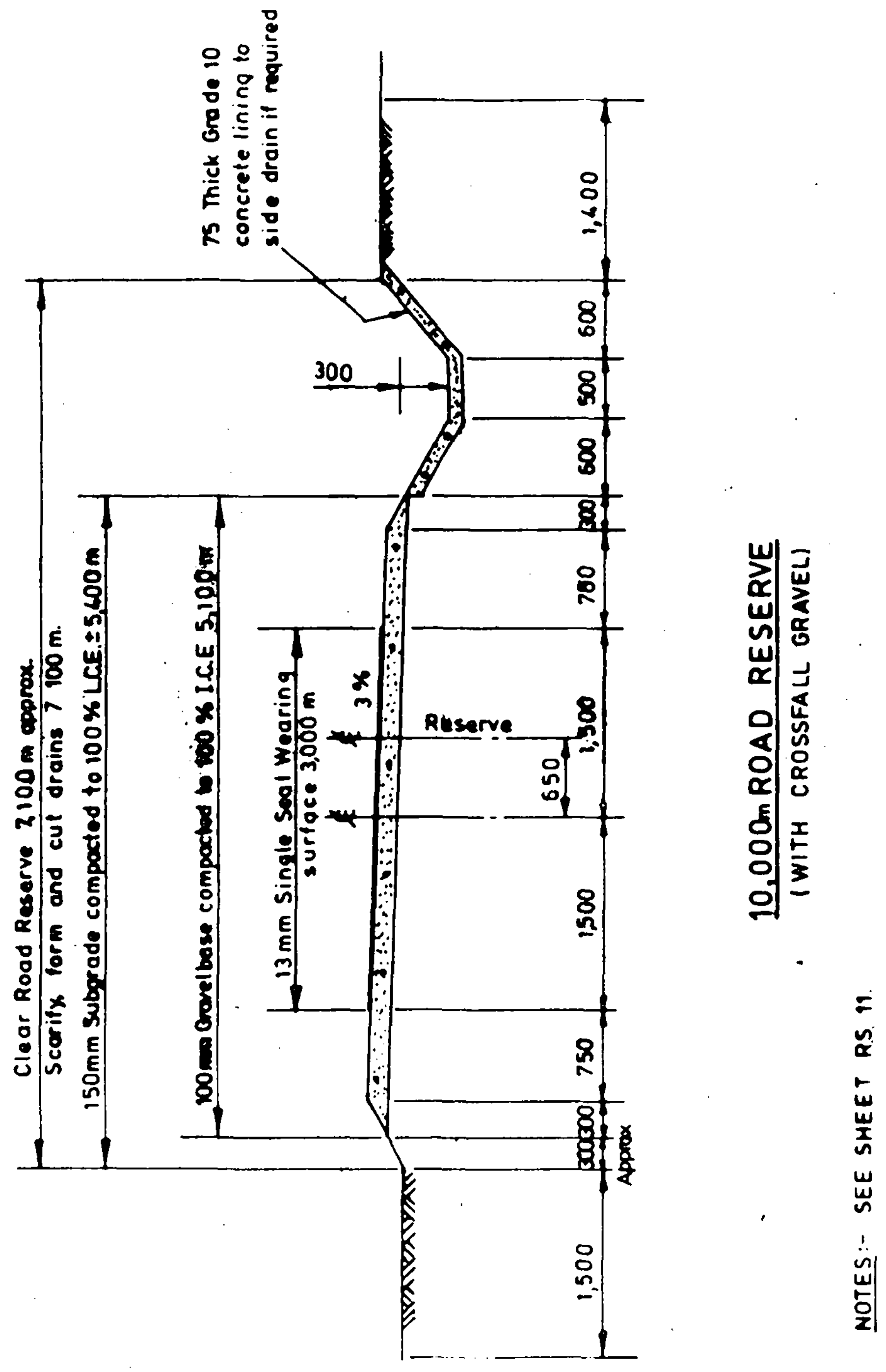
Services generally

1. All services located at back stand boundary.

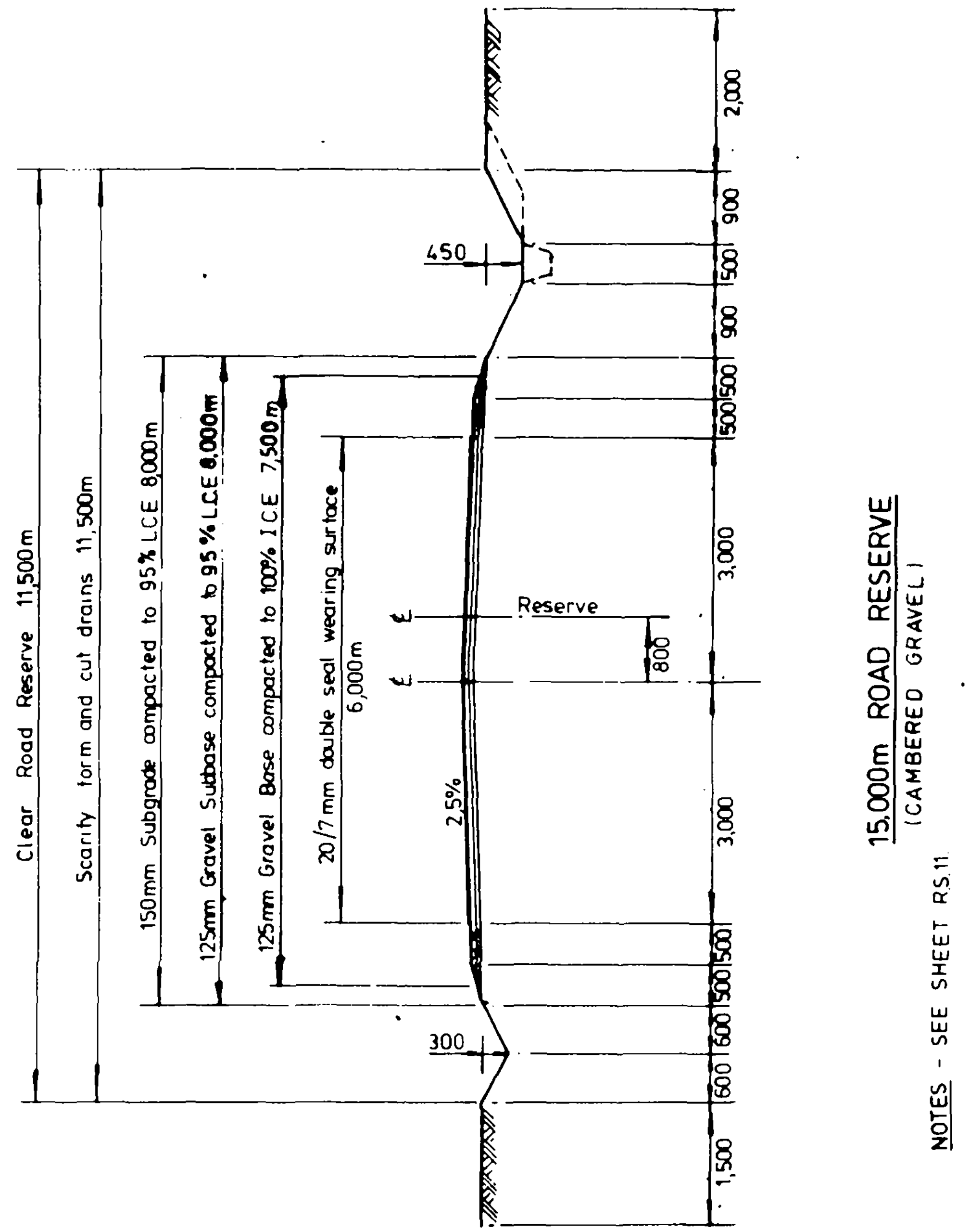
REFERENCES

1. GROSS, E.G. *The rural/urban condominium*, ACCOR General Meeting - 15 June 1979.
2. HUGHES, A.J.B. *Development in Rhodesian tribal areas,* Tribal Areas of Rhodesian Research Foundation.
3. Supplement to Monthly Digest of Statistics - January 1980.
4. WHITSUN FOUNDATION. *Finance for low income housing.*
5. NDLOVU, T. Preliminary Survey - Chitungwiza.
6. MERRINGTON, G.J. *Towards viable urban communities - the Rhodesian perspective.*
7. ZIMBABWE GOVERNMENT. *Urban development in main centres. Five year plan.*
8. ZIMBABWE GOVERNMENT. *Integrated plan for rural development - Five year plan.*
9. JORGENSEN, N. Ø. *Housing finance for low income groups.*
10. LIPTON, Michael. *Why poor people stay poor.*
11. WAKELY, MUMTAZ and KOENISBERGER. *Urban housing strategies.*
12. WILSON, BLACKBURN, BAYLISS and HUTCHINSON. *New directions in strategic transport planning.*
13. WHITSUN FOUNDATION. *Rural service centre development study.*
14. MERRINGTON, G.J. *Some aspects of the low cost housing problem in Zimbabwe.*

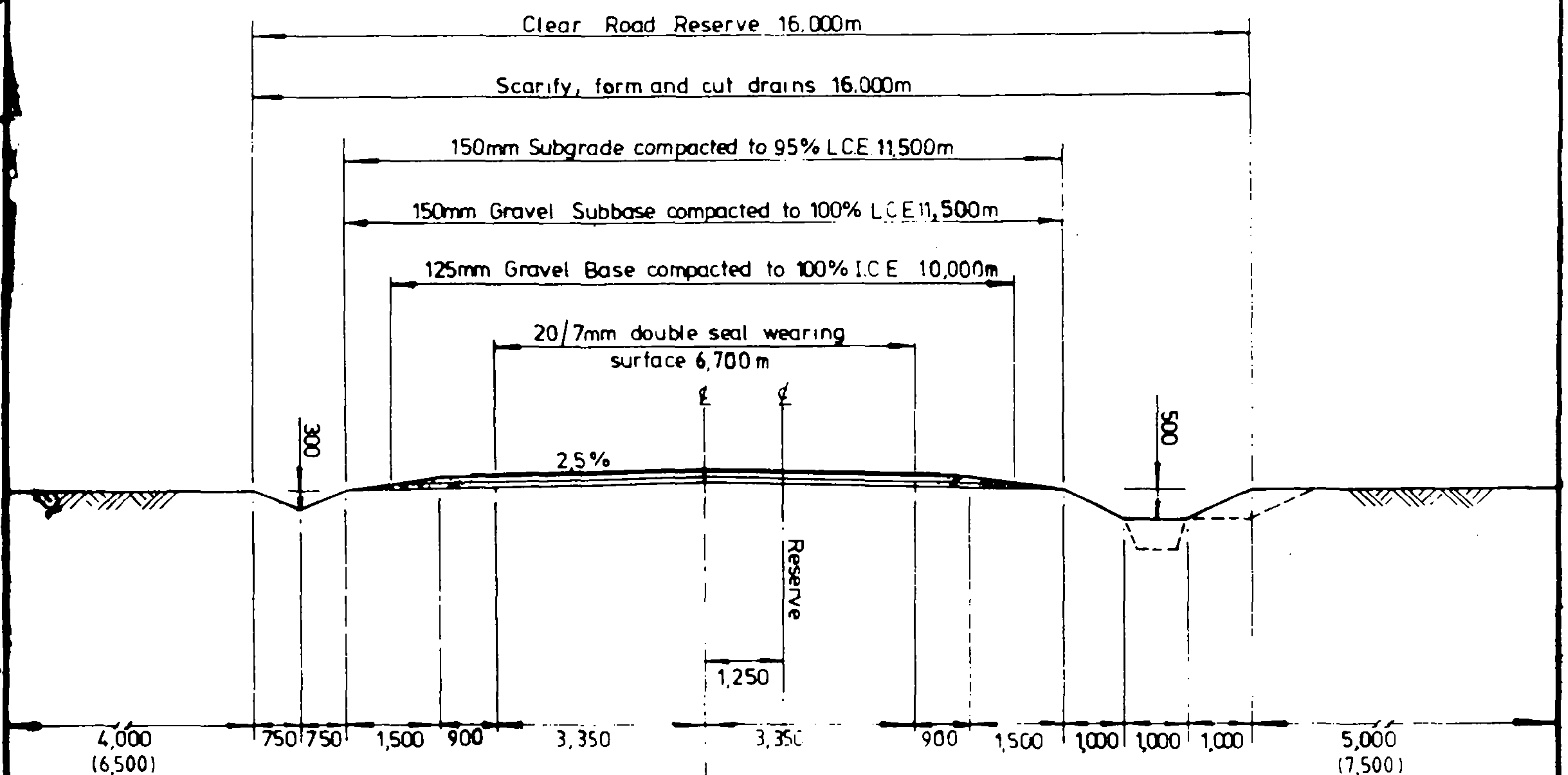

450
450
20 mm G.I. Bend or Tee for double house connection
G.I. Plug
20 mm G.I. Pipe
25 mm. G.I. Tee or 25 mm. Bend for single house connection
*25/20 mm Reducer bush and plug.
25 mm G.I. Pipe
*Reducer to be as specified in the bill of quantities.
20 mm Connection for installation on 50 mm pipe only
Malleable C.I. Saddle piece
25mm Connection for installation on 75 mm & larger pipes
HOUSE CONNECTIONS
432 x 330 x 127 mm C.I. hinged manhole cover and frame
Wall Sections and Base Blocks to be as for Valve Chambers
Grade 20 Concrete
Cradles to be used
Grade 20 Concrete
HYDRANT CHAMBER
Drawn J R W
Date Dec 1978
Approved
Date
SCALE 1 10
TITLE
STANDARD WATER RETICULATION DETAILS HYDRANT CHAMBER AND HOUSE CONNECTIONS.
HOUSING DEVELOPMENT SERVICES BRANCH
ZIMBABWE
TRACING NO W 6.



Designed Date: C E H	TITLE	MINISTRY OF LOCAL GOVERNMENT AND HOUSING	
Drawn Date: J R W Dec 1978	STANDARD ROAD CROSS SECTION	HOUSING DEVELOPMENT SERVICES BRANCH	
Approved Date	10,000m ROAD RESERVE	P. BAG 7706, CAUSEWAY, SALISBURY, ZIMBABWE.	
SCALE 1 50		TRACING NO RS 2	



Designed RAC Date	TITLE	MINISTRY OF LOCAL GOVERNMENT AND HOUSING	
Drawn ASCCN Date May 1978	STANDARD ROAD CROSS SECTION.	HOUSING DEVELOPMENT SERVICES BRANCH	
Approved Date	15,000 m ROAD RESERVE.	P. BAG 7706, CAUSEWAY, SALISBURY, ZIMBABWE	
SCALE 1 75		TRACING NO R.S.7.	

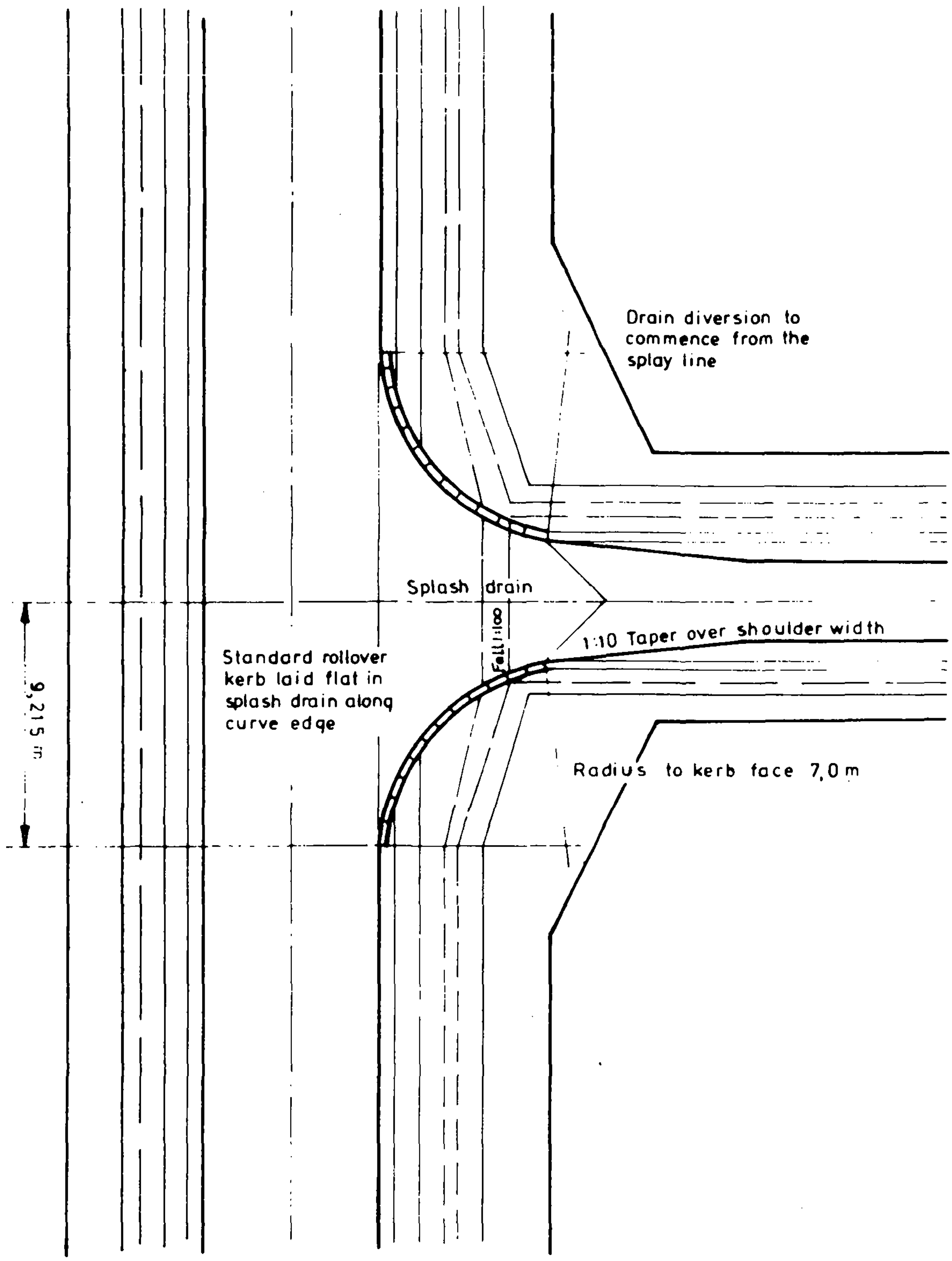


25 000 & 30 000 m ROAD RESERVE

NOTES

1. Trapezoidal ditch to be on high side of road
2. If specified ditches are to be lined with stone pitching or concrete as directed by the engineer
3. If specified by the engineer a concrete lined invert channel is to be formed in the base of the trapezoidal ditch
4. At multiple culverts the trapezoidal ditch is to be widened to a maximum of twice its original width or as specified by the engineer

Designed Date: R A C	TITLE	MINISTRY OF LOCAL GOVERNMENT AND HOUSING
Drawn: ASCON Date: May 1978	STANDARD ROAD CROSS SECTION.	HOUSING DEVELOPMENT SERVICES BRANCH.
Approved Date	25,000 m ROAD RESERVE.	P. BAG 7706, CAUSEWAY, SALISBURY, ZIMBABWE.
SCALE 1 100		TRACING NO. R.S. 11.



NOTE: This drawing is to be read in conjunction with the standard road cross sections

Designed CEH Date	TITLE	MINISTRY OF LOCAL GOVERNMENT AND HOUSING HOUSING DEVELOPMENT SERVICES BRANCH
Drawn JRW Date Dec 1978	STANDARD ROAD JUNCTIONS.	P. BAG 7706, CAUSEWAY, SALISBURY, ZIMBABWE.
Approved Date	MINOR ROAD (18,0 m. to 10,0 m.) 'T'	
SCALE 1 200	SHOWING SPLASH DRAIN POSITION.	TRACING NO R.S. 14.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 3
Referaat 3

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water, sewerage, low cost housing / Water, riolering, laekostebehuising.

POLICIES ADOPTED FOR WATER SUPPLY AND DRAINAGE SERVICES IN LOW COST HOUSING PROGRAMMES

by G J Bertot*

SYNOPSIS

A brief outline is given of the general characteristics of the Republic of Argentina including water resources, sewerage systems, infrastructure types and cost variations. Reference is made to the need for low cost housing and Law No 21.581 on the National Housing Fund and associated regulations are discussed.

SAMEVATTING

'n Beknopte oorsig word gegee van die algemene kenmerke van die Republiek van Argentinië insluitende watervoorrade, riolering, infrastruktuurtipes en prysskommelinge. Melding word gemaak van die behoefte aan laekostebehuising en Wet 21.581 oor die Nasionale Behuisingsfonds en verwante regulasies word bespreek.

* *Director Nacional de Politica Habitacional Buenos Aires, Argentina.*

A. GENERAL CHARACTERISTICS OF THE COUNTRY

1. SIZE

The Republic of Argentina, which is located in the southern hemisphere, occupies the southern extremity of the South American continent along with the Republic of Chile located to the west of Argentina. To the north are the Republics of Bolivia and Paraguay and to the east the Federal Republic of Brazil, the Republic of Uruguay and the South Atlantic Ocean.

The Republic of Argentina is the second largest country in South America, stretching approximately 3 700 Km from north to south between latitudes 55 and 22 south, with a maximum width of 1 500 Km. The overall area of the country is 3 761 274 Km² made up of 2 791 810 Km² of continental territory, 4 150 Km² of Southern Atlantic Islands and 965 384 Km² of Argentina's Antarctic Sector.

2. TOPOGRAPHY

Relief features result in a mountainous region in the western and central parts, a plain in the east and a region of plateaus in the south. As regards the mountainous region it is worth mentioning that the particular characteristics of the Andean mountain range result in three different sectors being identified. In the north there is an arid tableland surrounded by mountain ranges and sub-andean hills which gradually slope down toward the plains. In the central sector the mountains are highest and most arid and it is in this area that the highest peak in the western hemisphere, the Aconcagua, is located. In the south are found the Patagonian-Fuegian Andes, which are lower than the mountains of the central sector and are covered by snow and vegetation.

The plain region, while having an almost uniform relief, shows considerable differences across its extent. There is the Chaco Plain in the north, the Pampa Plain in the centre of the country and the Mesopotamian Plain, bounded by the Paraná and Uruguay Rivers, each of them characterised by their own particular weather conditions, vegetation and water resources.

In the south the country presents a relief of irregular, arid plateaus, traversed by river valleys that run down to the ocean from the Andean mountain range. The plateaus terminate in high cliffs at the coast.

To summarise the country's topography the following percentages of land area lying between various elevations above sea level are given:

0 to 100 m	-	24 per cent
100 to 200 m	-	21 per cent
200 to 500 m	-	20 per cent
500 to 2000 m	-	26 per cent
above 2000 m	-	9 per cent

3. CLIMATE

On account of its size climatic conditions vary considerably in Argentina. The weather is mostly mild, but there is a small tropical area north of the Tropic of Capricorn and the cold polar weather of the Antarctic Region.

In the inland parts of the country, the relief, distance from the sea and the wind and rainfall patterns create extensive regional differences. Subtropical climates with regular rainfall are found in the north-east and hot climates in the north. The central areas are largely temperate with the humidity decreasing considerably from east to west, resulting in an arid area running diagonally from the northern tableland to the southern Patagonian plateaus. In the south of the country the climates are cold with the Patagonian-Fuegian Andes region being damp and the Patagonian plateaus dry.

4. HYDROGRAPHIC FEATURES

The River Plate System is prominent in the Argentinian hydrographic network. (Its main reservoirs are the Paraná River (1800 Km), the Uruguay River (1100 Km), the Salado River (2000 Km) and the Bermejo River (1000 Km) which, together with the Paragauy River, have an exceptional economic importance for Argentina and its neighbouring countries.

The rivers of the Patagonian region, which run down the Atlantic slope, are fed by snow thaws and rainfall in the mountain ranges to the west. The most important are the Salado del Sur (700 Km), Colorado (860 Km), Negro (630 Km) and the Chubut (810 Km), which are used for irrigation.

Particular relief and climatic conditions determine the other interior watercourses in the north, the centre (Mar Chiquita Lagoon) and the west (Desagva Dero River system with 1200 Km of rivers). Lastly there are some short and steeply sloping rivers flowing from the Patagonian Andes through the Republic of Chile to the Pacific Ocean.

5. POPULATION

The total population of the country is approximately 27 million with a birth rate of 1,4 per cent per annum which is decreasing. By the end of the century it is estimated that the population will be 30 million.

Districts with more than 2000 inhabitants are considered to be urban. The urban population of the country constitutes 81,5 per cent of the total and it is expected to reach 85 per cent by the year 2000. Although the average density is 9,3 inhabitants per Km², the distribution over the country is very irregular, with high concentrations in agriculturally and industrially active areas. 63,5 per cent of the urban population resides in districts with more than 50 000 inhabitants.

Fifteen million people inhabit the geographic areas in and around the big cities of Buenos Aires, Córdoba and Rosario. These areas have an average population density of 50 per Km^2. On the other hand the western mountainous regions and the major portion of Patagonia have population densities of less than 1 per Km^2. At present there are eight cities in Argentina with populations of more than 250 000, the largest being the Buenos Aires metropolitan area, which with almost 9 million inhabitants accounts for a third of the population of Argentina.

6. ADMINISTRATION

The Federal Republic is divided into 22 Provinces, one National Territory and the Federal capital. Provinces are divided into Departments and the municipalities are responsible for local administrations.

Responsibility for infrastructural services has up to now been centralised under specialised national authorities, and it may be of interest to note that Obras Sanitarias de la Nación exercises this authority through regional offices, mainly in the urban areas. Districts not served in this way will fall under the Provincial Potable Water Service or receive a municipal supply.

At present in order to achieve decentralization, which recognises the importance of local conditions, the services are being gradually transferred to the Provinces. The different climatic conditions, production needs and population characteristics demand regional control and thus, with regard to the housing field and services infrastructure, the country is divided into six regions which are represented on an Inter regional commission which deals with general problems pertaining to the National development of the housing sector.

B. WATER RESOURCES

1. GENERAL

The renewable water resources of the country result from an average rainfall in continental Argentina of approximately 600 mm per annum, equivalent to a volume of 690 000 hm^3. The average flow of the rivers through the country amounts to 500 000 hm^3 per annum. It is estimated that 90 per cent of the rainfall is taken up by infiltration, and the evaporation process while the remaining 10 per cent adds to the surface runoff, representing an annual average volume of 170 000 hm^3. A large proportion of this surface runoff can be exploited and in addition there is a considerable volume of groundwater stored which can be economically utilized.

2. SOURCES

Catchment of surface runoff is the means used to obtain 46 per cent of water supplies. Systems which combine surface water with groundwater supply 30 per cent, while systems using only underground sources supply a further 22 per cent. The remaining 2 per cent is supplied from other sources. In order to evaluate the sources available it is necessary to take into account the distribution of such resources and of the population. Notwithstanding the 700 000 hm^3 of surface runoff per annum, its geographical location limits its area of application to 15 per cent of continental Argentinia. On the other hand, the underground resources, in terms of present technology, are not economically exploitable in many areas on account of their low volume, high salinity or the presence of toxic agents.

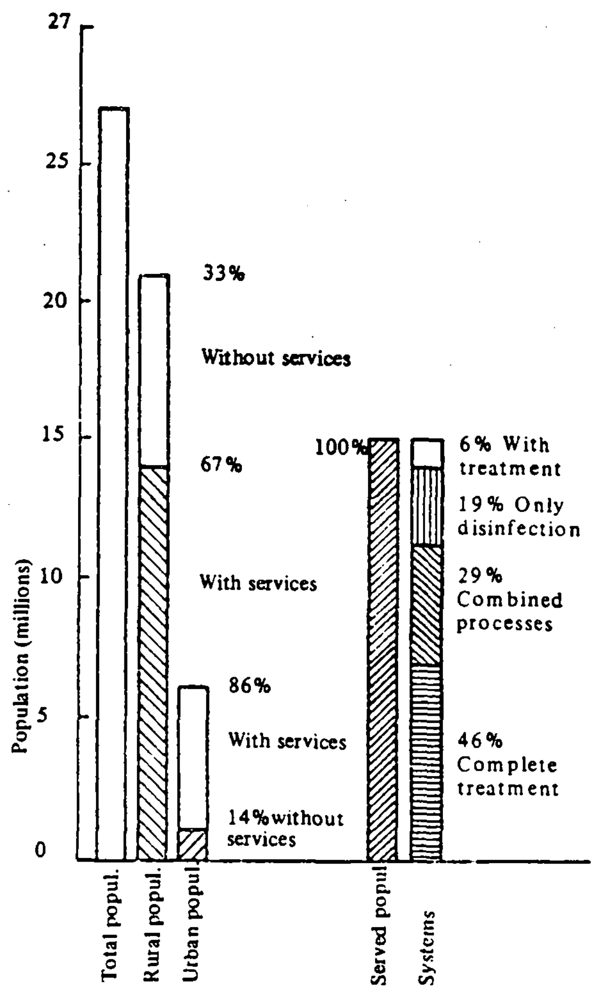
3. SUPPLY SERVICES

Public potable water supply systems serve almost 15 million inhabitants. Services are supplied to almost 67 per cent of the urban population but only 14 per cent of the rural population. If the very scattered portion of the rural population is disregarded this last figure rises to 64 per cent.

4. WATER QUALITY AND TREATMENT

The type of treatment applied to the potable water distributed through the various systems varies, and there are approximately 20 different types of treatment.

WATER SUPPLY:
1) Percentage of population with a public water supply
2) Treatment quality



Notwithstanding this variation, 46 per cent of the population is served with water that has been pre-treated by sedimentation, alkalisation, filtration and disinfection processes; 19 per cent is served with water disinfected only and 6 per cent is served by untreated water. The remaining 29 per cent are supplied with water to which various combinations of treatment processes have been applied.

5. WATER CONSUMPTION DATA

Considering the daily per capita consumption figures in litres for the various existing supply systems, marked differences are evident. It shows that 10 per cent of the population uses less than 200 litres per day, 44 per cent between 200 and 400 litres, 22 per cent between 400 and 600 litres, 3 per cent between 600 and 800 litres and the remaining 21 per cent more than 800 litres per day. The national average is in the region of 460 litres per capita per day. Those differences can readily be explained because the tariff rates applied to the greater part of the population are not based on consumption, but on the 'unrestricted supply' system. Thus the average reflects the capacity of the intake and treatment works. This causes supply differences within the sphere of many systems, because, during the hours of maximum consumption, water shortages often occur in the peripheral areas and under extreme conditions of drawoff may even cease completely.

C. SEWERAGE SYSTEMS

1. CHARACTERISTICS

The characteristics resulting from population distribution, water resources and soil composition demand different solutions in regard to sewerage systems.

Only 27,5 per cent of the population is served by a centralised system and 60 per cent of this population lives in the Metropolitan Area of Buenos Aires, while the remaining 40 per cent is located in the other big cities in the interior of the country (basically the capital cities of each province) some areas of which are provided with sewerage reticulation.

The greater portion of the population uses individual services to septic tanks and absorbtion pits, or disposal direct to cesspits in the areas where this is made possible by the soil composition and absorbtion characteristics, or by means of purifying trench and drainage field systems in those areas where the ground water level prevents the use of pits.

The big collective systems, such as the one provided in Buenos Aires, have a high collecting capacity discharging treated effluent downstream. The same procedure is used in many districts in the interior of the country, although in many cases due to the lack of treatment plant capacity or the non-existance of treatment works, the wastes are discharged to the receiving sources without treatment.

D. COSTS

1. INTRODUCTION

Although on the whole the infrastructure costs for the country are traditionally equivalent to 15 per cent of housing value, these values have since had to be adjusted (on account of the variety of conditions prevailing; infrastructure type, density, special situations) for the purpose of the planning of the future investment and the scaling of direct investment in these items.

The Secretariat of urban Development and Housing (SEDUV) and the National Mortgage Bank (BHN) have developed cost guidelines for each alternative, based on their experience and on some estimates. (Calculations were based on sub-division into 120m x 120m blocks with 19m wide streets and with total occupation factors ranging from 0,3 to 3,5 per family. Various types of family housing were considered from single units to flats with elevators). They took into account population densities and percentage indices for the integrated services corresponding to each possibility.

As a means of comparison the unit cost per square metre of covered area for a low cost housing unit of 80 m² may be used. The 31 January 1980 figures were as follows :

(i)	Single-family house	$602 220/m²	(US$ 369)
(ii)	Block of flats (without elevator)	$535 500/m²	(US$ 328)
(iii)	Block of flats (with elevator)	$574 260/m²	(US$ 352)

2. ITEMS INCLUDED IN THE BASIC INFRASTRUCTURE

The basic infrastructure includes a number of options available for development and which will influence the cost. The principle options are :

1. Roads
   - 1.1 Compacted street with open storm water drainage.
   - 1.2 Asphalt surface with concrete curbing.
   - 1.3 Non-reinforced concrete surface with concrete curbing.
2. Electric power and public lighting.
   - 2.1 Overhead aluminium power lines, timber poles and mercury vapour lamps.
   - 2.2 As above, but with spun concrete poles.

2.3 Underground cables throughout supplying 400 W mercury vapour lamps on 8 m high steel poles.

3. Water reticulation.

4. Sewerage system.

5. Medium-pressure gas reticulation

3. OPTIONS

Items from the above list can be combined in various ways to form a number of development types as can be seen from the four tables below.

TYPE 1

	OPTIONS	INCIDENCES
1.1	Compacted street with open storm water drainage	1
2.1	Overhead aluminium power lines, timber poles and mercury vapour lighting	15
3.	Water reticulation	21
4.	Sewerage system	24
5.	Medium-pressure gas reticulation	39
	TOTAL	100

TYPE 2

	OPTIONS	INCIDENCES
1.2	Asphalt surface with concrete curbing	38
2.2	Overhead aluminum power lines, spun concrete poles, and mercury vapour lighting	16
3.	Water reticulation	11
4.	Sewerage system	14
5.	Medium-pressure gas reticulation	21
	TOTAL	100

TYPE 3

	OPTIONS	INCIDENCES
1.3	Non-reinforced concrete surface with concrete curbstones	43
2.2	Overhead aluminium power lines, spun concrete poles and mercury vapour lighting	15
3.	Water reticulation	10
4.	Sewerage system	12
5.	Medium-pressure gas reticulation	19
	TOTAL	100

TYPE 4

	OPTIONS	INCIDENCES
1.3	Non-reinforced concrete surface with concrete curbstones	33
2.3	Underground cables throughout supplying 400 W mercury vapour lamps on 8 m high steel poles	36
3.	Water reticulation	7
4.	Sewerage system	9
5.	Medium-pressure gas reticulation	15
	TOTAL	100

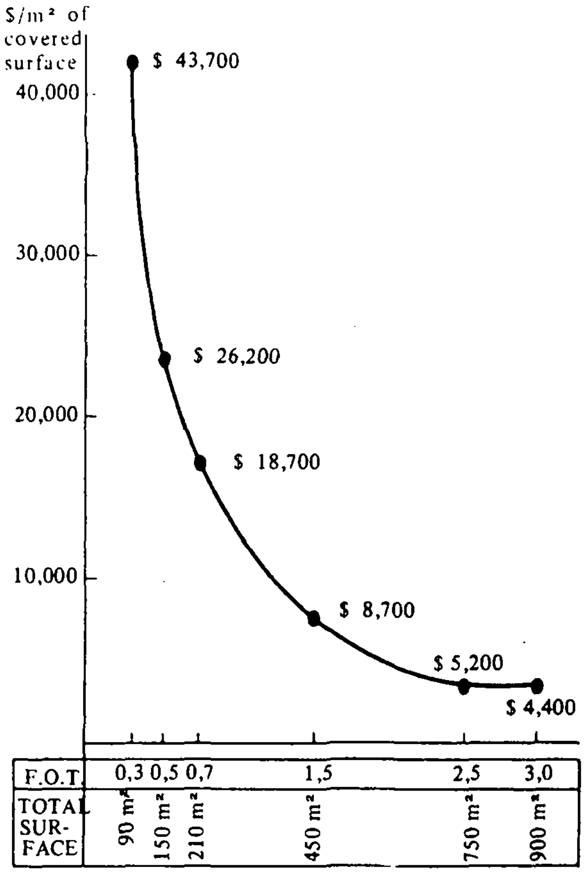
4. COST VARIATION OF TOTAL INFASTRUCTURE - CASE 1

The graph (Case 1) shows the cost variation of the total infrastructure per m² of covered area and based on the maximum cover permitted by the Factor of Occupation.

The horizontal axis defines the occupation factors applied to a plot and its total covered area. The vertical axis shows the cost variation per m² of covered surface.

In order to determine the cost of each item included in the total infrastructure we have to multiply the value obtained in the ordinate by the corresponding percentage coefficient or index.

Cost variations of the total infrastructure - Case 1.



Values as of April 30, 1980
Source: National Mortgage Bank

E. NATIONAL HOUSING FUND (FONAVI)

1. HISTORY

The Republic of Argentina has had a wide experience in the planning and implementation of low-income housing programmes, since the beginning of this century. The period has been characterised by the expansion of the National Organisations responsible for the supply of infrastructure to low income settlements.The magnitude of the programmes and funds available for townplanning and infrastructure projects made it unnecessary to anticipate where low densities and population behaviour would demand individual systems, or where new reticulation of communal systems or connections to existing networks did not involve major problems.

The rapid urbanization process in the country and the new concept of 'habitat', led to a drastic change in the situation. The 'habitat' concept in addition to housing now embraces aspects such as infrastructure and community services.

In addition to this, the development of health programmes, mainly in those areas of the country subject to endemic diseases, such as Chagas-Mazza's disease, amoebiasis, goitre, or seasonal diseases, such as summer diarrhea, has confirmed the importance of infrastructure and community services and led to their incorporation as standard components of low-income housing programmes.

As a final stage in this process, the National Housing Fund Act now specifies the need for infrastructure in low-income housing programmes.

2 NATIONAL HOUSING FUND ACT (FONAVI) – Law No. 21.581

This law ensures the formation of A National Housing Fund mainly by means of :

(i) A contribution by employers of a sum equal to 5 per cent of the salary of their workers;

(ii) A compulsory investment of 20 per cent of its income by the organisation which operates the state pension fund for self- employed workers;

(iii) Bond repayment according to Article 4 (b) of the law, one of its specific objectives is 'the execution of land development and infrastructure work'. The financing of this, according to the provisions of Article 5, should be agreed between the authorities in charge of executing the programmes and the public, private or mixed agencies specialising in the particular infrastructural service.

According to the provisions of Article 9 of the Act, Provincial Town planning bodies must approve the location of development projects, taking into account feasibility and soil conditions.

Once these installations have been completed, they must be handed over to the relevant agency at a national, provincial or municipal level.

The cost of linking dwellings to the Municipal reticulation system is added to the cost of the house and repaid over a period of thirty years by the occupier at a low rate of interest. The cost of Municipal Services, such as external reticulation, water supply towers, purification plants, sewage treatment plants, bore holes and pumping stations, is paid for by the Government agency concerned over a maximum period of ten years, also at a low rate of interest.

3. INVESTMENTS

Investment through the NATIONAL HOUSING FUND, (FONAVI), in millions of pesos, are as follows :

1977	: $100,416.5 (US 257,475,205)
1978	: $308,298.1 (US 393,488,322)
1979	: $1,200,000 (US 913,937,548)
1980 (estimated):	$2,100,000 (US 1,134,521,800)

As at 80/08/31 112.000 housing units were under construction; 7.000 units were scheduled to start very soon. Public tender has already been opened for another 5,000 units proposed and under study. A further 16,000 units, technically approved by SEDUV, are at the financial approval stage.

All these projects include infrastructure and different levels of community services, according to their size. Moreover, it is important to point out that, because of the lack of services in existing housing developments, or deficiencies observed in some of the proposed projects, SEDUV is presently financing 60 infrastructure projects, mainly for water supply and sewerage systems. In many cases the magnitude of the infrastructure work is greater than that of the housing development, because the reticulation has to be extended to the surrounding community afterwards.

4. REGULATIONS

The regulations of SEDUV provide for the following information and technical documents to be submitted to SEDUV before funds may be allocated for the implementation of the project :

(a) Details of existing networks, either complete or incomplete, and future extensions.

(b) Details of proposed infrastructure work, specifying its connection points and complementary work.

(c) Feasibility studies, future management and maintenance services, financing studies.

(d) Costing information and a detailed and work programme on technical and financing aspects.

On the other hand, in the case of partly completed medium and large housing developments it is compulsory to have the total infrastructure completed and in working condition by the time of the occupation of the first housing unit. The use of collective sewerage and water supply systems is compulsory for these housing developments.

Regulatory details have been incorporated in the National Technical Regulations of the body responsible for controlling main reticulations and individual installations to cover :

(a) installation design, taking use, flows, slopes, distances, etc, into consideration;

(b) requirements of materials, elements and appliances and the quality control thereof;

(c) inspections and testing for putting the system into operation for public use; and

(d) the qualifications of professionals and technicians in charge of the design and construction of projects.

5. RESEARCH

Current activities of SEDUV are complemented by specific research programmes aimed at the development of innovative solutions to water and sanitation problems for particular situations.

(a) Alternative systems for waste elimination and water conservation : The CLIVUS MULTRUM 'Biological Bathroom' adaption programme.

With the co-operation of the United Nations Argentina Project/006/78, an experimental project for a biological bathroom, built with local materials, was developed for warm dry climate areas.

The objective of this project is to find appropriate solutions suitable for rural areas without a services infrastructure, in order to prevent pollution by waste disposal. As a result, the technological feasibility of this project has been verified, and the need established for a social educational campaign, to promote the proper use of the system by the public.

(b) *Solar stills.* The problem of water purification for domestic use, in some areas of the country where water resources are not drinkable because of the presence of salts (mainly arsenical) detrimental to health, is very serious. Whenever insolation conditions have been good, the use of solar stills has been studied. Plants have been developed in Argentina by several organisations and, as a result, it has been found that individual solutions are only suitable in extremely isolated areas where insolation values are high (ie average annual performance is 5 distilled litres per day per square meter).

The aforementioned values are of interest for scattered rural houses with contaminated water problems. At present, an alternative system known as REVERSE OSMOSOS is being evaluated for its ability to produce large volumes of potable water. Although this system implies high initial cost, its application could be justified in certain areas. With a 10 hp motor, 30 m^3 of water per day can be obtained. A pilot plan of this type has been established in the Province of Santiago del Estero.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239
Paper 4
Referaat 4

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Plumbing code, sanitary drainage, water supply/ Loodsgieterskode, sanitêre dreinering, watervoorsiening

THE DRAFTING OF NATIONAL PLUMBING CODES

by R.A. Morgan*

SYNOPSIS

During the 70's Australia accepted a National Plumbing Code covering both sanitary drainage and water supply.

This paper is presented to share the thinking, experience and effort which went into the development of that code and, perhaps, to give some encouragement to those countries, regions or areas which may also be contemplating a similar national code.

The concepts, plumbing principles and technical detail which are discussed relate only to the 'Australian experience' and should be taken in that context. The introduction explains the plumbing and drainage background against which this paper is written.

SAMEVATTING

Gedurende die sewentigerjare het Australië 'n Nasionale Loodgieterskode vir sanitêre dreinering sowel as watervoorsiening aanvaar.

Hierdie referaat word aangebied om die dinkwerk, ondervinding en moeite wat met die ontwikkeling van hierdie kode gepaard gegaan het, bekend te stel en om, moontlik, daardie lande, streke of gebiede wat ook so 'n nasionale kode beoog, aan te moedig.

Die begrippe, loodgietersbeginsels en tegniese detail wat bespreek word, is slegs van toepassing op die 'Australiese ondervinding' en moet in sodanige verband gesien word. In die inleiding word die loodgieters- en dreineringsagtergrond waarteen hierdie referaat geskryf is, verduidelik.

* *Deputy Engineer for Property Services, Melbourne and Metropolitan Board of Works, Melbourne, Australia.*

1. INTRODUCTION

Australia is a nation of some 14 million people, more than half of whom live in the five capital cities of the mainland States. The largest cities, Sydney and Melbourne, have populations of 3,1 and 2,7 millions respectively. All major cities in each State are virtually fully sewered, as are most of the provincial cities. In addition, there are numbers of smaller country townships which also have both reticulated water and sewerage serving the town area.

The water supply and sewerage system in Australia are publicly owned and operated, each system generally being controlled by a local authority incorporated as a Board of Trust. These local authorities, of which there are many hundreds, establish and administer their own plumbing regulations, but in practice the rules of the principal authority in each State capital city are followed fairly closely by the smaller authorities in the State. Hence we find that the major differences which have emerged in Australian plumbing regulations and practices over the years stem from variations in the regulations of the five mainland capital city authorities.

Although reticulated water supply was introduced some decades earlier, sewerage reticulation and disposal schemes generally got under way in Australia at the end of last century. The plumbing rules, materials, fittings and fixtures initially followed the British pattern, since most materials and tradesmen came from Britain.

As distinctive Australian building designs and styles emerged and as materials and technology changed, developments in plumbing techniques followed, taking independent paths in the various major authority areas. These independent paths were no doubt fostered by isolation, having regard to the wide physical separation between the capital cities. Local changes were readily supported by the local manufacturing industries who saw in them some protection from overseas and interstate manufacturers in the supply of special design fittings. On the other hand, development of local plumbing systems caused national problems with respect to contract specifications, trade education and licensing.

Following World War 2, however, significant industrial and communication changes led to much rationalization of production and there was a demand for more standardization so that Australia-wide markets could be opened up. It was becoming essential that the diversity of special 'local regulation' requirements which had spawned a virtually closed local industry be looked at on a national level - it was now time for a National Code.

2. WHY A NATIONAL PLUMBING CODE?

In the introduction we have seen how a demand for rationalization of plumbing product design and plumbing system design is a pressing reason for development of a National Plumbing Code. There are many other reasons.

Reduction in the extent of pipework used in plumbing, e.g. a reduction in venting provision or in the size of discharge pipes, reduced both the material and the labour cost of installations. The possibility of achieving cost savings along such lines can be readily assessed by comparing, at a national level, the experience, investigation work and trials carried out by individual authorities, and then incorporating acceptable cost-saving developments in the National Code. In Australia it was found that some authorities had independently developed reduced-cost plumbing techniques for single storey work, whilst others had advanced further in the multistorey area.

The cost of research and investigation work is high and funds for such work are often difficult to obtain locally. Where authorities are working together on the development and maintenance of a National Plumbing Code there is an opportunity to pool effort, thus minimizing costs. This applies both to plumbing system design and to the assessment of new materials for water supply and for sanitary drainage.

Importantly, a most significant offshoot of national code drafting is the increased understanding and communication that is developed between authorities. Despite the odd drama of conflicting opinions over some code phrases or clauses, cooperation increases significantly as a sense of common achievement evolves. The development of communication and understanding also leads to many a side benefit from the exchange of experiences regarding authority management, inspection systems, staffing arrangements, fee charging, etc., none of which may be specifically included in the National Code.

There are, therefore, at least four important justifications for the establishment of a National Plumbing Code:

(i) the opportunity for rationalization of plumbing system design and plumbing product design;
(ii) wider availability of cost-saving plumbing systems;
(iii) an efficient approach to research and investigations effort;
(iv) increased understanding and sharing of experience between authorities.

Note that each of these can lead to a significant economic benefit.

3. GETTING THE CODE-DRAFTING TEAM TOGETHER

In Australia the formation of the national code-drafting group was an initiative of the Chief Engineers of major authorities at their Biennial Conference in 1971. Their recommendation was that a Standing Committee, Plumbing and Drainage, be formed to achieve:

(i) reciprocity of approvals and testing of plumbing products;
(ii) uniform codes and practices.

The proposal was subsequently agreed to by the individual major authority Boards.

It was decided that a Standing Committee, Plumbing and Drainage be established, with representation from the six major Australian authorities, one of the representatives being required to act as chairman. However, as work developed on the code drafting, it was found necessary to co-opt the full-time services of an engineer from the Federal Government Experimental Building Station to act as secretary and editor of the National Code. This was the key to real progress as code-editing is a most concentrated exercise and cannot be satisfactorily fitted in with normal work duties.

It was considered that, in the Australian situation, the non-involvement of representation from the plumbing trade, consultants and plumbing-ware manufacturers was justified, since such groups were strongly represented on Standards Association Committees which deal in detail with product specification and design and also with a variety of installation codes and practices. All relevant Australian Standards are incorporated directly into the National Plumbing Code.

Whilst the work of the drafting group of the National Code was not always carried out smoothly and without conflict, it is readily agreed that restriction of membership to authority officials was certainly the reason for the code being finalized in a reasonable time. From a starting point in 1972 the Sanitary Drainage section of the code was completed in 1975 and the Water Supply section in 1977. There has, in fact, been little complaint regarding the content of the final documents from bodies that were not offered a participating role.

It was found that best progress on the code drafting was made by forming small working parties from time to time who would meet for up to a week to formulate specific sections of the code. The chairman and secretary/editor of the drafting group always led such working parties to ensure that continuity and co-ordination were achieved. Final drafts of each section of the code were always reviewed and approved by the full code drafting committee.

4. DETERMINING THE SCOPE

It is essential that a code drafting group should establish at an early stage the principles of agreement as to the scope of the code.

In addition to the basic areas of coverage, i.e. sanitary drainage and water supply within properties, it is also necessary to decide how far to go in:

(i) materials selection and standards;
(ii) installation and practices detail;
(iii) numbers of alternative system options;
(iv) interface with building health and fire regulations;
(v) administrative and management aspects.

In the development of the Australian code it was agreed as a basic principle that the final code should be universally acceptable, i.e. that it could be applied in any authority area. It follows then that only fully agreed practices appear in the code, and that authorities should not put local restrictions on any aspects of code application. At the same time, it is acceptable that local authorities may permit materials or practices *additional* to those included in the code.

With respect to alternative plumbing system options it was agreed that all common systems currently in use should be included (initially at least) as well as the new developments which were emerging and were commonly agreed to. Hence the Australian code presently contains a variety of plumbing system options but these can be progressively pruned as the newer cost-saving systems make the older systems redundant.

Item (iv) above - the interface between plumbing, building and fire regulations - creates problems in a National Plumbing Code if there are no universally acceptable and complementary National Building and Fire Codes. Some minor problems in this area have still to be solved in Australia.

With respect to Item (v), as individual authorities are incorporated under differing legislatures, which give them a whole range of varying rights and responsibilities, it is difficult to lay down guidelines for the administrative and management aspects of plumbing control in a National Code. In Australia the National Plumbing Code deals solely with technical aspects.

5. DEFINING TERMS

When a code drafting body first sets out to survey the current scene before attempting to put together a National Code, it can come as quite a shock that there is a 'communication problem'.

Even if we are fortunate enough to use a common mother tongue, we quite often find ourselves on different wavelengths when it comes to expressing ourselves technically with respect to plumbing. Terms such as 'yard gully', 'yard sink', 'pot gully' or 'sink-stone' were all found to mean the same thing, as did the terms used for plumbing systems variously called the 'single pipe system (unvented)', 'fixtures connected direct to vented drains', and 'fixtures connected to unvented branch drains'. Even the basic term 'drain' proved to be a real problem - in some areas only underground pipes could be called 'drains', in other areas certain above-ground pipes could be designed and installed as 'drains', and in certain areas it was found that a pipe must be at least 100 mm in size for it to qualify as a 'drain'.

Because the 'Definition' section of a code usually appears at the beginning of the document, and since it makes sense to start off with an agreed technical language, careful attention needs to be given to the development of agreed and adequate 'definitions'.

It is also important to avoid conflict between definitions of those terms that are used both in water supply and sanitary drainage, e.g. 'nominal size', 'air gap', etc.

Figure 1, taken from the Australian National Plumbing Code, illustrates definitions of some of the terms used in the sanitary section of the code.

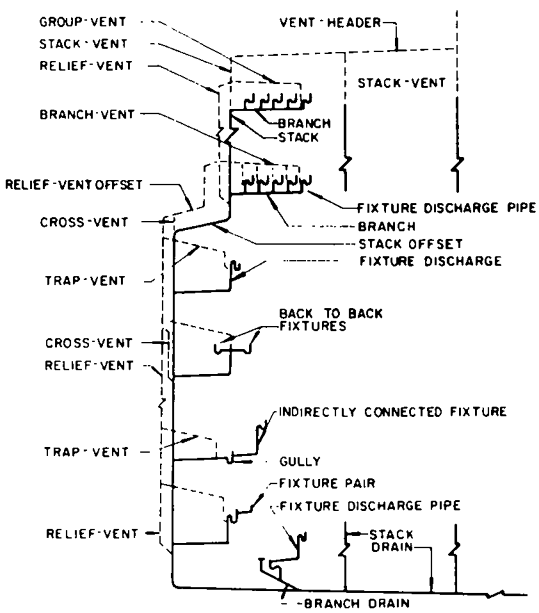


FIGURE 1

Illustrating definitions of terms

6. MATERIALS AND INSTALLATION STANDARDS

In Australia there is a single standards body, the 'Standards Association of Australia', and in preparing our National Plumbing Code we were, therefore, in an excellent position to select acceptable materials of standard quality, dimensions and performance.

Availability of agreed standards is virtually a pre-requisite to code preparation, and participation by authorities, both in standards and code-drafting committees ensures the necessary co-ordination between the standards body and the code body. Although most of the needs of the code body are in fact satisfied through its participating members at Standards Association meetings, it is often necessary for formal communications to pass between the two bodies on a correspondence basis.

Pipe materials presently included in the code and commonly used are listed below in order of general usage.

Sanitary

Below ground - UPVC (solvent joint)
Vitrified Clay (rubber ring joint)
Cast Iron (mechanical (bolted) joint)

Above ground - UPVC (solvent joint)
Copper (silver solder joint)
Brass (silver solder joint)
Cast Iron (mechanical (bolted) joint)
Galvanized Steel (screwed joint)

Water supply

Above and below ground - Copper (capillary or compression joint)
Galvanized steel (screwed joint)
Stainless steel (capillary joint)
*UPVC (solvent joint)
*Polyethylene (compression joint)

* Not approved inside buildings or for hot water.

For acceptance into the National Plumbing Code a new material must first be covered by an Australian Standard. During the Standards process considerable knowledge and experience of the material is built up and there is little subsequent contention to its acceptance by the code body.

7. DESIGN CRITERIA FOR THE AUSTRALIAN CODE

Fixture units

The concept of the 'fixture unit', first introduced in the early 30's by Dr. Roy Hunter of the United States, has proved to be an important 'tool' for simplifying the hydraulics design of sanitary plumbing.

In the Australian Code the fixture unit is defined as 'A unit of measure based on the rate of discharge, time of operation and frequency of use of a fixture that expresses the hydraulic load imposed by that fixture on the sanitary plumbing installation'.

The Code makes virtually no changes to the fixture unit (F.U.) ratings previously standardized in the 30's. These are typically as follows:

Basin	-	1 F.U.	Shower	-	2 F.U.
Trough	-	5 F.U.	Shower-bath	-	3 F.U.
Sink	-	3 F.U.	Bath	-	4 F.U.

W.C. Pan (cistern)	-	4 F.U.
W.C. Pan (flush valve)	-	6 F.U.
Urinal (single)	-	3 F.U.

Provision has been made on the fixture table for modern labour-saving devices such as dishwashers - 3 F.U. and clothes washers - 5 F.U.

It is appreciated that some sophistication of the present fixture table will eventually be aimed for in the Australian Code to take into account variations in the frequency of use of certain fixtures in commercial, industrial, school and public building installations.

Discharge pipe capacity

The maximum permitted loadings in graded discharge pipes are based on the following criteria:

(i) that no pipe runs more than half full, and

(ii) that when a pipe runs a quarter full, the flow rate must not be less than 0,74 m/s to ensure self-cleansing velocity.

Flow data for pipes were taken from 'Flow Chart for UPVC Pipes' published by the British Plastics Association.

In the case of vertical stacks, permissible capacities are restricted to 25 per cent of the cross-sectional area of the stack. Wyly and Eaton of the U.S. National Bureau of Standards found by experiment that the characteristic annular flow of water in a stack breaks down when the proportion of cross-section of a stack occupied by falling water exceeds 33 per cent.

Capacity of drains

The Code table for flow in drains was based on Colebrook and White's formula, using a roughness coefficient of 0,6.

As peak waste water flows tend to level out when the waste water reaches the ground drain, drain capacities were derived on the criterion that flow is 65 per cent of the drain diameter. This flow is cautiously lower than the British Code recommendation of a design flow depth of 75 per cent.

Protection of fixture trap seals

Except for W.C. pan traps which have 50 mm water seals, all other fixture traps are required to have 75 mm seals. System performance must be such that a minimum seal of 25 mm is maintained under working conditions.

8. IN-GROUND DRAINAGE SYSTEM

The section of sanitary pipework conveying sewage from a building to the public sewer, commonly below ground and generally known as a drain, usually needs special and separate attention in a plumbing code.

In achieving agreement for National Code purposes, considerable work is involved in finalizing an acceptable specification covering pipe materials, jointing systems, pipe bedding and laying, backfill, etc. If there are already national standards covering drainage pipes and their relevant installation practices, much time and effort can be saved by the code drafting committee. Also, the final code document becomes less cluttered by merely including approved standards reference numbers, thereby eliminating detailed requirements for pipe material and installation within the code itself.

As a sanitary plumbing code is usually designed to cover all work up to the connection to the public sewer, connection arrangements at the public sewer point should be included.

Provision is made in the Australian code for all drains to be vented at their upstream end - a drain having a loading of up to 30 F.U. has a 50 mm minimum size vent. 400 F.U. require provision of an 80 mm vent and more than 400 F.U. require a 100 mm vent. Main sections of drain have a minimum size of 100 mm, branch drains for single fixtures or a floor waste gully serving multiple fixtures may be 80 mm or 65 mm depending on loading.

9. SINGLE-STOREY SANITARY PLUMBING

Historically, in Australia, ground floor fixtures were connected to the drain by using the two pipe or separate pipe system. Soil fixtures were connected directly to the drain and kept separate from waste fixtures which were required to discharge to the drain via an external gully or vented drainage trap. In some authority areas, groups of non-soil fixtures in the bathroom were permitted to discharge to a common floor trap (termed 'floorwaste gully') and thence to the drainage system but still via an external gully or vented drainage trap.

During the 60's the requirement to take all waste fixtures to the drain via an external gully or vented drainage trap was eliminated from the regulations of several authorities, with varying rules with respect to the need to provide a trap vent. The technique was called the Single Pipe System (Unvented).

When the Australian Authorities came together in the early 70's to develop a National Code the unique cost-saving system illustrated in detail in Figure 2 (see page 5) was formulated from the most progressive systems developed by local authorities to that time. The cost-saving feature of the system, permitting extensive connection of ground-floor fixtures to unventilated branch drains, stems from using minimum size drains consistent with elimination of trap vents.

The arrangement whereby individual fixtures (except for soil fixtures) in, say, a bathroom, may be brought together to a Floorwaste Gully is shown below, together with a sketch showing a typical Floorwaste Gully fitting (see Figure 3, page 5). A Floorwaste Gully conveying discharges with a rating up to 10 F.U. may be connected to the main drain via a 65 mm unventilated branch drain if the length of the 65 mm drain is less than 8,5 metres.

In using this system for fixture connection, both main and branch drains may be installed either underground or above ground.

When compared with the previous Australian practice of making both main and branch drains 100 mm in size and requiring that such 100 mm drains be taken underground and extend close to the fixture locations, the connection method described above has significantly reduced costs. Venting provision has also generally been reduced and there is now less drain excavation work involved in connecting the property to the sewer.

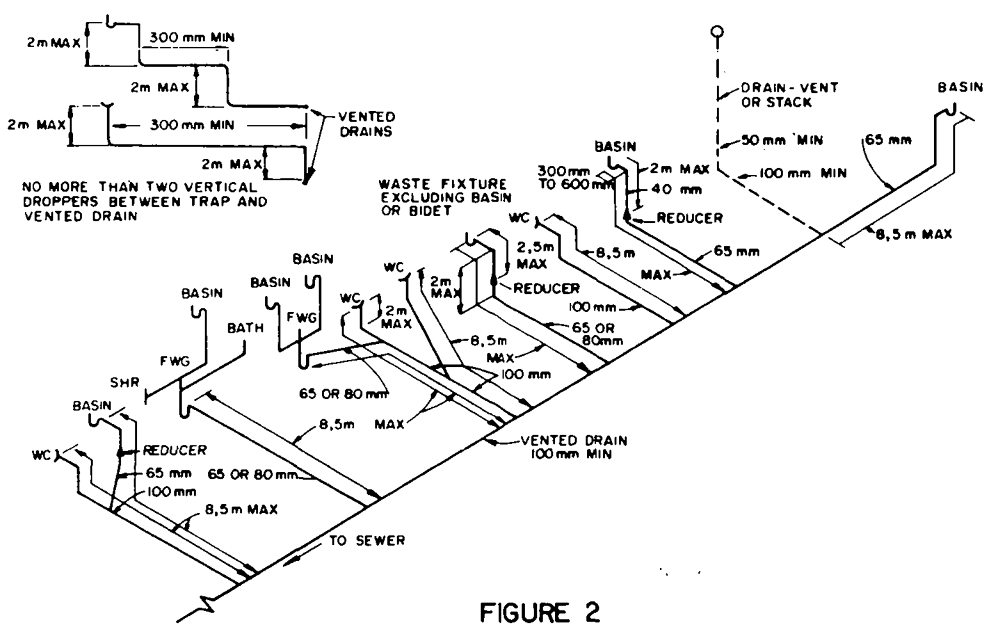
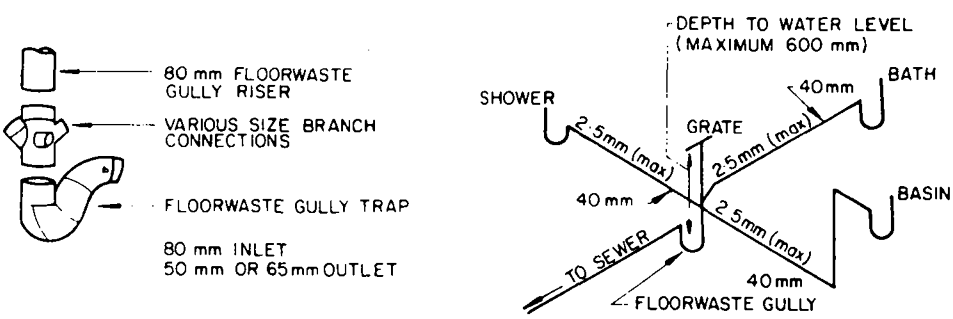


FIGURE 2

Illustrating connection of ground floor-fixtures to unvented branch-drains



(a) (b)

FIGURE 3 (a and b)

Illustrating connections to floorwaste gully

10. MULTI-STOREY SANITARY PLUMBING

In a similar manner to that used in formulating acceptable updated systems for connection of ground floor fixtures, the Australian code-drafting group looked for cost-saving opportunities when selecting suitable multistorey plumbing systems.

From experience gained in authority areas where advances had already been made, and from a study of overseas research and code development, it was agreed that the following four systems should be included in the National Code:

(1) Fully-Ventilated System.
(2) Fully-Ventilated System-Modified.
(3) Single-Stack System.
(4) Single-Stack System-Modified.

The 'Modified' Fully-Ventilated System uses the same fixture loading table as the Fully Ventilated System but there are some restrictions on the geometry of individual fixture connection pipes to ensure that fixture trap ventilation remains properly balanced.

The Single-Stack System (no fixture or stack-relief vents) permits the connection, in residential buildings, of two of each type of fixture at each floor. A stack of 150 mm size is permitted a maximum loading of 780 F.U. over 30 floors.

The 'Modified' Single-Stack System permits similar fixture connection at each floor but the provision of a relief vent and cross-vents increases the maximum loading permitted on the stack. As an example, a 100 mm stack, extending 20 floors in a residential building may have a fixture loading of 500 F.U. if cross-vents are installed at each floor level.

(1) Fully-Ventilated System (Figure 4a)

Defined as: A system of plumbing with provision for separate ventilation of every fixture trap connected other than to a floorwaste gully (and of the trap of every floorwaste gully).

(2) Fully-Ventilated System-Modified (Figure 4b)

Defined as: A system of plumbing differing from a Fully-Ventilated System in that the traps of any group of two or more fixtures (or floorwaste gullies) discharging to the same branch-pipe are ventilated in common by one or more 'group vents' leading from such pipe.

Although the final criterion for reducing provision for venting is the satisfactory 'performance' of a system, the trade generally is not sufficiently experienced to accept responsibility based on 'performance criteria' only. Hence codedrafters are still requested to provide sufficient prescriptive data to enable work to be designed and executed with confidence. The detail in Figure 6 and the associated Code clauses continue to be the appropriate response to the needs of the plumbing industry at this stage.

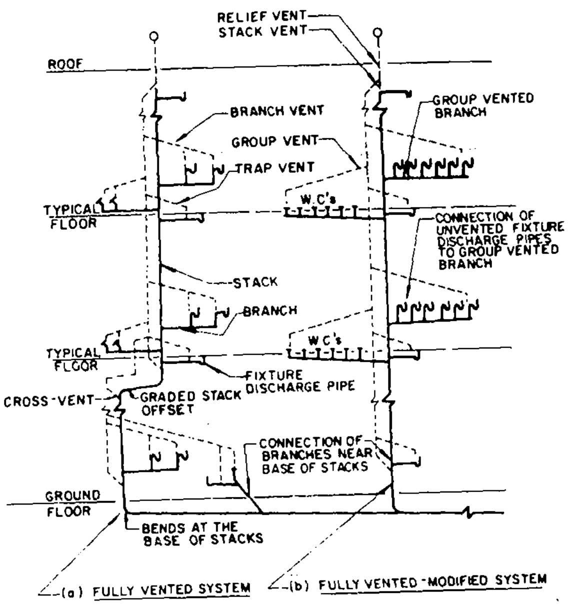


FIGURE 4

Illustrating concept of fully-vented systems

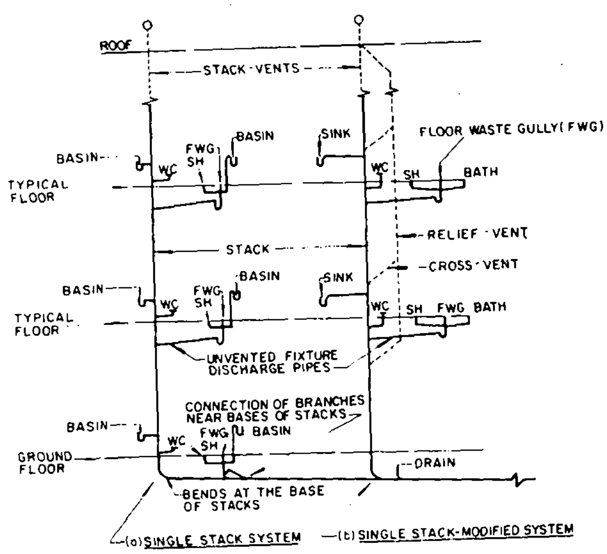


FIGURE 5

Illustrating concept of single stack systems

(3) Single-Stack System (Figure 5a)

Defined as: A system of plumbing in which the stack and discharge pipes serve also as ventpipes thereby eliminating the need for relief or fixture vents.

(4) Single-Stack System-Modified (Figure 5b)

Defined as: A system of plumbing differing from a single-stack system in that a relief vent is provided appurtenant to the discharge stack, and is interconnected therewith at alternate floors, or at every floor, by a cross-vent. The inclusion of ventilation provision increases capacity and adaptability of the system.

Some of the Australian Code requirements for the 'group-venting' of fixtures on a stack branch are illustrated in Figure 6 (see page 7).

11. WATER SUPPLY

Codes or regulations for water supply inevitably fail to get the attention given to codes for sanitary plumbing, and the lack of action and attention given them is invariably a point of embarrassment to code-drafters. Nevertheless, it is just as important to have uniformity in water supply plumbing matters as in sanitary plumbing - and for similar reasons.

Manufacturers of pressure pipes and fittings need relatively uniform national acceptance of their products in order to achieve cost-viability in production and in distribution. Manufacturers of domestic appliances that have water connections require to be able to design clothes-washing machines, dishwashers, etc., which have air-gaps for the avoidance of cross-connection which are accepted nationally by the various water authorities. Manufacturers of hot-water

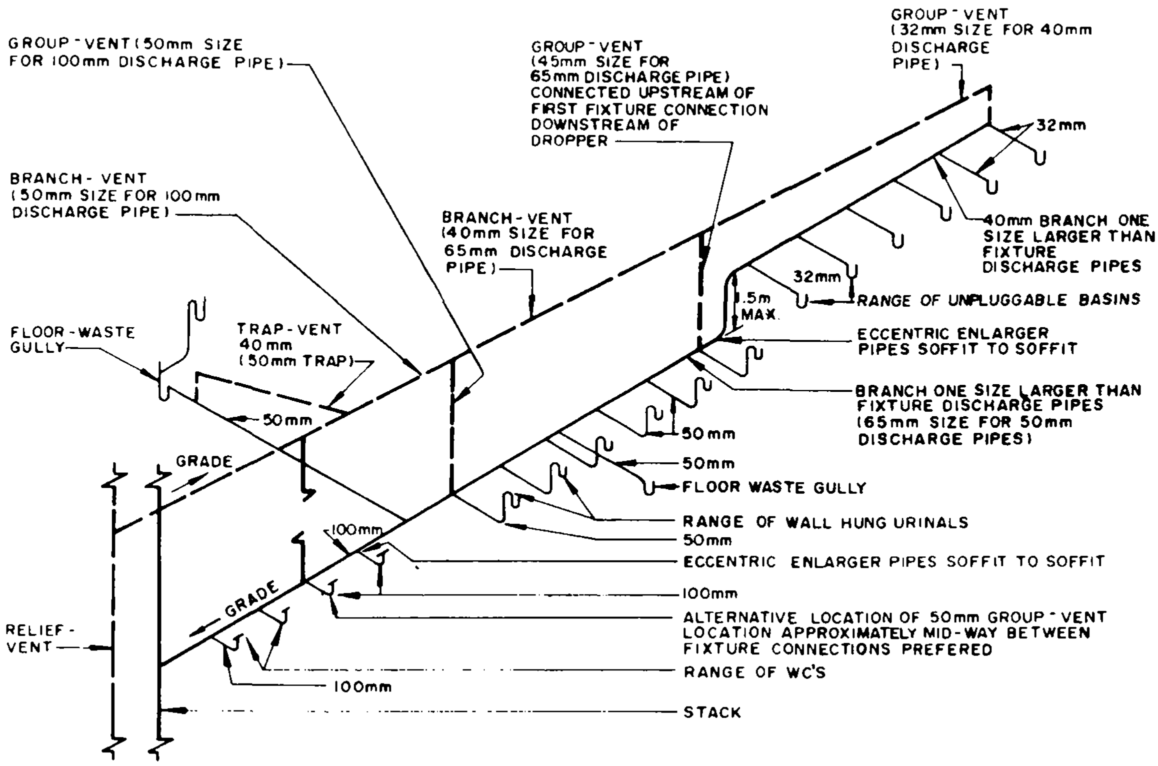


FIGURE 6

Illustrating group-venting on stack branch

heaters need to be assured of national acceptance for their product. It is most difficult to provide such assurance when the various local authorities have different regulations with respect to materials, control valves, safety valves, air-gaps, etc.

The Australian National Plumbing Code-Water Supply, covers the following main areas:

(i) Materials.
(ii) Installation of Pipework and Jointing.
(iii) Cross-Connection and Backflow Prevention.
(iv) Storage Tanks.
(v) Fire Services.
(vi) Hot Water Systems.

There are several new areas in the regulation of water supply installation which were not covered in earlier years and by earlier codes.

With the introduction of plastics pressure pipe for water (UPVC and Polyethylene in Australia) there is a need to co-operate with those responsible for electrical regulations when electrical earthing systems for building are connected or bonded to the metallic water service. Whilst new installations can be controlled, there is an element of danger where plastics pipes are used to replace metallic pipes in older houses. Co-ordination of codes and trade education are both most important.

The availability of acceptable types of mechanical backflow-preventers, which may be used as alternatives to the traditional air-gap disconnection, has introduced a new approach to cross-connection control. There is a significant amount of work in introducing such devices into a water supply code. Decisions need to be made on the circumstances under which devices can be permitted and also on the type of device which may be selected for the purpose. Further, it is necessary to determine the testing intervals for check on performance of each installation.

In Australia there is a strong trend to the use of direct mains-pressure hot water services in lieu of the cistern-fed low pressure storage type heaters. Mains pressure units require considerably more valve features than the older systems, particularly with respect to pressure and temperature control for safety (explosion) reasons. These requirements have been attended to both in the development of Australian Standards and in the National Plumbing Code. The trend to mains pressure hot water installations has also required authorities to exercise more control over the hot water pipework in buildings, which now operates at the same pressure as the cold water system.

At present the Australian National Code contains no guidance regarding the sizing of water supply pipework within a property. In domestic work the common practice is to use 20 mm (3/4 in.) size services from the main, with the same size pipe being taken through the building to supply each part of the house that requires a supply. Individual fixtures or groups of fixtures in bathrooms and laundries are supplied by 15 mm (1/2 in.) size pipes.

12. IMPLEMENTING THE NATIONAL CODE LOCALLY

As previously stated, the Australian National Plumbing Code is a technical document and does not include aspects of plumbing administration.

In preparing local regulations, aspects such as tradesmen licensing, material approvals, work permits, inspection and testing of work, charges, prohibited discharges, etc., relevant to local conditions must be added to the technical code requirements.

Currently the various major authorities in Australia are engaged in revising their existing regulations to incorporate the principles of the National Code. Such revision has been completed and implemented by the Melbourne and Victoria, authorities and several other authorities are at the final drafting stage.

It has been generally found that, whilst the principles of the National Code are commonly accepted and adopted, the local regulations drafting process introduces editorial demands which negate the possibility of direct translation in the style and order of the National Code into the local document. This is not considered to be a matter of concern, as the prime objective of the national code exercise is to develop uniformity of plumbing practices rather than uniformity of local code drafting.

Where there are significant changes to existing practices with the introduction of national regulations, it is important to plan and implement an education programme for the local plumbing industry. This can be effectively done by issuing newsletters and arranging lectures and discussion meetings both for tradesmen and trade-school teachers.

Australian authorities who have not yet finalized and issued their new regulations have permitted use of new National Code alternatives in their areas by issuing interim directions to the plumbing trade. Where such interim directives do not restrict current practice but in fact add to plumbing options, there is little likelihood of objection to their issue prior to the promulgation of an official code.

13. KEEPING THE CODE 'ALIVE'

Having developed a National Plumbing Code it is important for its continued credibility and usage that it be kept alive and up-to-date.

In Australia we have maintained the committee which was responsible for preparing the National Code and, at this introductory stage, where the various authorities are making extensive use of the National Code in developing their own regulations, it has been found necessary to meet at six-monthly intervals. Numerous amendments have already been made to the National Code where clarification or further detail is needed to assist in maintaining common interpretation. After the settling-in period it can be expected that review meetings may be held less frequently; it would seem that once annually would be appropriate.

Failure to retain strong and regular communication between members of the code-drafting body will soon lead to disinterest in the maintenance of a useful 'living' code, and a return to a proliferation of varied plumbing practices around the various authority areas.

14. CONCLUSION

It is hoped that this paper has served the purpose of drawing attention to the major issues and concerns which, in the view of the author, need to be recognized, considered and decided upon during the development of a National Plumbing Code.

Whilst the Australian experience, which has been used to illustrate and highlight the realities of National Plumbing Code drafting, may differ from the background and setting of many countries and regions, it is likely that many of the situations drawn upon as examples will find common or close-to-common parallels. After all, there are not many different ways of using pressure to supply water, and of using gravity to remove liquid waste - most differences are due to people.

The experience of getting people to sit down together in the first place, to accept argument during debate, to forget the scoreboard of points won and points lost, to be prepared to accept occasionally the mediocrity of compromise, and finally to feel the pride of a national achievement - these are the experiences of National Code drafters.

And the final experience is the lasting one.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 5
Referaat 5

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

System, quality control, sanitary installations/Stelsel, gehaltebeheer, sanitêre installasies

THE ISRAEL MODEL OF QUALITY ASSURANCE IN SANITARY INSTALLATIONS

by I. Silberstein*

SYNOPSIS

This paper briefly describes the various stages in the development of an effective system of quality control of building and the installation of sanitary systems. Controls are exercised through standards established by the Standards Institute of Israel, by frequent inspections of workmanship on sites and by requiring manufacturers to adopt quality control procedures in factories.

SAMEVATTING

Hierdie referaat beskryf kortliks die verskillende stappe in die ontwikkeling van 'n doeltreffende gehaltebeheerstelsel vir bouwerk en die installering van sanitêre stelsels in Israel. Beheer word toegepas deur middel van standaarde volgens die Israelse Instituut vir Standaarde, deur herhaalde inspeksie van vakmanskap by terreine en deur van vervaardigers te verwag om die nodige gehaltebeheerprosedures in hul fabrieke toe te pas.

* *Head, Hydraulics Laboratory, Standards Institution of Israel, Tel Aviv, Israel.*

A. HISTORICAL, ECONOMIC AND SOCIAL BACKGROUND

Quality assurance systems in the building industry develop according to the historical, economic and social background within which they grow. In Israel, the background derives partly from elements that exist also in other young, developing countries, and partly from elements that are characteristic of Israel and that are not readily found in other countries.

Israel is a country having a population which is equivalent to that of a large city in some other parts of the world. Nevertheless, it must function as a State, and must overcome the problems of a nation. In Israel the main problems are:

- Small number of inhabitants;
- Large scale absorption of new immigrants;
- Young industry;
- Deficit trade balance;
- Lack of natural resources;
- Serious security problems.

The number of inhabitants in Israel when the State was established, was less than one million. In the 32 years of the State's existence, this number has increased fourfold. The growth is due, primarily, to immigration from a considerable number of foreign countries. The social and economic absorption of the new immigrants, and their integration in industry, in manufacturing, in building and in agriculture, have been the main objectives of the State of Israel throughout its entire existence. All the means and energies of the country have been devoted to these efforts.

The immigrants come from vastly different social and cultural backgrounds and, in most cases, it was not possible to place them in occupations for which they had been trained in the countries of their origin. All of this necessitated a broad programme of reconditioning and technical training.

These factors exerted considerable influence on the quality level of work in the various trades in the building sector, and on the development of the local industry which supplies materials and products for building. In addition, a developing country must create new frameworks of supervision and control that can fill the lack of established manufacturing and building traditions.

The lack of industrial traditions is due to the influx of new immigrants in the manufacturing industries of Israel, and to the fact that during the early years of Israel's establishment, industry in Israel had reached only its first stages of development.

Due to the shortage of properly trained, qualified workers in the building trades, and because of the pressure exerted on construction companies to finish their work rapidly to meet the increasing demand for new dwellings, the general quality of workmanship was inferior. The lack of an effective quality control system further complicated matters.

As the rate of immigration increased, the shortage of skilled workers became more noticeable. Many of the new immigrants, who had to serve as skilled workers in the building industry, had not been sufficiently trained in their country of origin. The transition from regulations that were in effect during the days of the British Mandate to those enacted by the new State, occasionally created a vacuum in specific areas, which still further reduced the quality of workmanship in construction and plumbing.

A new immigrant, who finally obtains an apartment after a long period of waiting, is happy to get the apartment, and is not likely to complain about poor workmanship. Even people buying an apartment on the free market do not know what materials have been used for construction, and cannot be aware of hidden defects.

All these factors emphasized the need for intensified work over many years to raise the quality of workmanship in the building industry of Israel.

B. CHARACTERISTICS OF RESIDENTIAL BUILDING IN ISRAEL

Among the main characteristics of residential building in Israel are the following:

(a) Most of the residential buildings are owned and not rented. This means that the person who acquires an apartment must be prepared to bear the problems and expenses that arise when the construction is of inferior quality. In most cases, it is customary for the contractor to bear responsibility for one year only. After this period of time, it becomes necessary to take court action to correct any building defect. Obviously, the buyer is in a rather weak position.

(b) Basically, residential building is divided into two categories (see Table 1):

Private building, when the builder builds an apartment according to his own specifications, and sells it on the open market to anyone interested in buying it. Except for tests of strength of concrete, hardly any tests of building quality have been performed in this category in the past. (Laws and regulations applying to such tests will be discussed further on).

Public building, connected to the building programme established by the Government, where the construction is performed by private contractors, but is financed and subsidized by the Government. Apartments in this category are assigned by the Government to new immigrants, to young couples and to large families living in sub-standard conditions. The Government subsidies are based on grants, long-term loans, exclusion of land cost from price of apartment, and similar factors. Public building is connected to and controlled by the Ministry of Building and Housing, which acts as the 'employer' of the contractors, and establishes the conditions required for assuring the quality of construction.

(c) Construction of new housing in Israel is advancing at an accelerated pace, to keep up with the increasing population. Furthermore, the pace of building is not constant and varies with rising and falling demand (see Table 1). The uneven pace of building activity affects building quality, which becomes inferior during periods of accelerated activity.

(d) Most building construction is performed by traditional methods. In sanitary installations, prefabricated units (bathrooms, kitchens, etc.) have not as yet been used. Therefore, the installation of all sanitary elements is performed on site, and the quality of workmanship is dependent on the professional level of the workers available at the site of construction.

(e) Generally, the main contractor subcontracts some of the building activities, such as sanitary installations, electrical work, carpentry, heating and ventilating, painting and similar operations. The agreeements between main contractor and subcontractors relating to execution of work and payment, do not necessarily include written specifications as to quality of work. Customarily, the main contractor supplies the plumbing fixtures and accessories, while the subcontractor installs the equipment and adds the necessary piping and fittings. In the absence of effective quality control at the site, the subcontractor buys the cheapest materials on the market, so as to increase his profits.

TABLE 1: DEMAND FOR HOUSING IN ISRAEL SINCE 1970

Year	Number of dwelling units completed			Dwelling units per 1000 inhabitants
	Total	Private Housing	Public Housing	
1970	31 380	20 210	11 170	10.4
1972	47 349	26 899	20 450	14.7
1974	51 710	27 780	23 930	15.1
1976	55 640	28 170	27 470	15.5
1978	35 590	20 600	14 990	9.5
1979	32 000	20 000	12 000	

In summary, the characteristic properties of the building industry, which are quite different from industrial production, make it necessary to establish a special quality control system for this important economic sector.

C. INSTITUTIONAL BACKGROUND

1. Introduction

A quality control system in a specific industrial sector may develop along two avenues: free development, whose direction is determined naturally, as a result of the necessity to find solutions to problems as they arise, or a centrally directed development that is designed to achieve specific objectives.

The Israeli quality control model was not centrally planned, because Israel has a basically free economy, over which the central authorities exert much influence, but over which they have no conclusive, direct control.

The activities relating to quality assurance in the building industry are distributed among various governmental departments and other agencies. At times, this system of operation creates duplication of effort or lack of coordination.

2. Government Departments

The Government Ministries connected with quality control in the building industry are:

(a) *Ministry of the Interior*

The Ministry of the Interior and the local authorities belonging to it are responsible for enforcing the Building Act and the building and planning regulations. The building regulations also specify requirements relating to sanitary installations, which include the manner of supplying water, plumbing fixtures and traps, waste, drain and vent piping, building sewers, as well as their fittings and accessories.

In addition, the building and planning regulations contain a Plumbing Code which provides professional guidelines for designers and builders. The regulations include:

- details on the preparation of drawings for sanitary installations;
- details on the manner of installing sanitary facilities;
- an obligation to use standard products;
- details on the submission of plans to the authorities for approval;
- details on the manner of testing plumbing systems by the representative of the local authorities;
- instructions that prohibit the connection of a building to the municipal water supply, until the representative of the local authorities has certified that all sanitary installations comply with the applicable regulations.

It should be noted that the local authorities' lack of professional supervisory personnel has substantially limited the enforcement of the above-listed regulations.

Obviously, legislation alone cannot ensure high quality of building procedures or of the sanitary installation within a building.

(b) *Ministry of Building and Housing*

The Ministry of Building and Housing is responsible for most of the residential construction in Israel, as well as for public building. It alone has the power to compel contractors to acquire materials and components and to perform the construction in compliance with Israeli standards or specifications, even when these are not legally binding. Furthermore, the Ministry of Building and Housing can request that certain materials and components be purchased only from manufacturers who are under constant supervision by the Standards Institution and whose products bear the Standards Mark or Supervision Mark.

Actually, the supervisory personnel of the central and regional authorities of the Ministry of Building and Housing and their building inspectors at the building site (who are general inspectors without specific plumbing expertise), are unable to enforce the plumbing regulations or the contract clauses relating to quality. As a result, it became necessary to engage the Standards Institution of Israel as an outside supervisory agency at the building site, to ensure the quality of the sanitary installation.

To remedy this situation, a programme was initiated which empowers the Standards Institution to conduct the tests for building quality assurance. With each contract given out by the Ministry of Building and Housing, the contractor is required to make an agreement with the Standards Institution of Israel to conduct quality assurance tests on the various building services, including the plumbing installation.

The Standards Institution maintains a continuous check of all stages of operation and performs all the functions of inspection according to a preset programme. The Standards Institution reports all defects of materials and performance to the contractor and to the on-site inspector and, at the completion of construction, issues a certificate that summarizes the results of the quality assurance tests.

(c) *Ministry of Industry, Commerce and Tourism*

Many of the standards issued by the Standards Institution of Israel, have become 'official standards' and are legally binding. The responsibility and authority to inspect products for their compliance with official standards that have been issued, is in the hands of the Standardization Officer at the Ministry of Industry and Commerce, who makes use of the services of the laboratories of the Standards Institution of Israel (SII).

Because of the limited means at the disposal of the Standardization Officer, the inspections performed by his staff have not brought about satisfactory results. Furthermore, it must be noted that only some of the standards applying to sanitary appliances have been declared 'official'.

3. The Standards Institution of Israel (SII)

The Standards Institution of Israel is a statutory, nonprofit organization that was established about 35 years ago, and which operates in accordance with the Standardization Act.

SII is active in the following areas:

(a) *Preparation of Israel Standards.* To date, about 1 200 standards have been issued, of which about 80 apply to sanitation appliances.

About 15 per cent of Israeli standards issued to date are official standards and legally binding.

(b) *Preparation of Specifications.* Products for which no standards have been prepared as yet are covered as far as possible, by specifications which can be prepared and issued in a much shorter time than standards. For new products especially, the preparation of specifications generally precedes the preparation of standards.

(c) *Testing the compliance of products* with Israeli standards and specifications and issuing test certificates and test reports.

(d) *Supervising the production of products* and their quality, and licencing producers to mark their products with the Standards Mark (when the product complies with an Israeli standard) or with the Supervision Mark (when the product complies with an Israeli specification).

It must be emphasized that, in addition to ensuring compliance of a product with the Israeli standard or specification, the manufacturer must have an approved quality control system in his plant. Only when this essential condition has been met, can the manufacturer obtain a licence to mark his product with the Standards or Supervision Mark.

(e) *Providing counsel* on the establishment of quality control systems, their inspection and improvement. These activities relate partly to manufacturing plants that are under continuous supervision of the Standards Institution, and partly to other agencies that request permission from the Standards Institution to perform quality inspection on behalf of SII.

(f) *Performance of applied research.*
The Hydraulics Laboratory, (SII) - The Hydraulics Laboratory, one of the laboratories of the Standards Institution of Israel, deals with materials, appliances and equipment used in water systems.

The Hydraulics Laboratory concentrates its main activities in the following areas:

(i) Testing the quality and serviceability of locally manufactured and of imported water appliances and fittings used in domestic and industrial installations, as well as in municipal and irrigation systems.
(ii) Supervision of the manufacture of water appliances and fittings that bear the Standards Mark or Supervision Mark.
(iii) Checking the installation of sanitary appliances according to SII Specification No. 10, 'Plumbing systems and their testing'.

The Hydraulics Laboratory has a comprehensive selection of equipment for conducting accelerated tests, to evaluate the performance of the various products under service conditions. The Hydraulics Laboratory also conducts tests on products of novel construction or made of new materials.

The Hydraulics Laboratory is organized into the following branches:

- Plumbing products;
- Irrigation appliances;
- Plastics pipes and fittings;

- Inspectorate of water systems;
- General tests (measuring equipment, pumps and products relating to municipal pipelines).

D. SANITARY INSTALLATIONS

1. Quality of sanitary installations

Sanitary installations are among the most important and problematical areas of residential buildings. Effective operation of a sanitary system ensures a desirable living condition free from sanitary nuisances. Proper installation of the system ensures satisfactory long term operation, free from disagreeable problems and excessive maintenance expenses.

Although the cost of the sanitary appliances constitutes a relatively small part of the total cost of an apartment, the number of complaints by residents about malfunction of sanitary systems as compared to the total number of complaints about building quality greatly exceeds the cost ratio. In addition, the cost of plumbing repairs greatly exceeds the 'saving in price' derived from unsuitable materials and faulty installation of sanitary appliances.

The number of malfunctions and failures increases as the construction becomes more sophisticated and more complicated, requiring special means to increase pressure in high-rise buildings, central hot water supply systems, central heating systems, etc.

The quality of sanitary installations may be related to their ability to ensure the long term supply of potable water to a building and the effective removal of waste, without creating failings, such as leaks or clogging, and without causing large maintenance expenses.

The quality of the sanitary systems in residential buildings is dependent on the following factors:

(a) design according to professional regulations, specifications and guidelines;
(b) the use of products and fittings that comply with the requirements of the standards or specifications;
(c) the performance of installation operations by qualified personnel and in accordance with the requirements of specifications and of good workmanship.

Each of these factors exerts a decisive influence on the quality assurance of the system which, in turn, makes it necessary to exercise effective control over the manner of their implementation.

The complexity of the factors affecting the quality of the construction makes it very difficult for a person to evaluate the quality of the apartment at the time of its purchase and to discover its defects. Most of these become evident at a much later stage. This is the main reason why it is so important that the government and other public authorities take steps to ensure the quality of construction and of sanitary installations to protect the individual when he is acquiring an apartment.

2. Specific properties and characteristics of sanitary installations

The elements of sanitary installations may be classified in two major groups:

(a) Elements that are part of the building (frequently known as the 'concealed parts' of the installation) such as the water supply piping and the concealed waste piping system.

Characteristics of concealed parts of the sanitary installation system include:
- Inspection of quality can be made only before covering the concealed parts. When construction is completed, there is no free access to concealed parts.
- The repair of defects after the building is completed involves large expenditures.
- Metal piping is sensitive to corrosion.

(b) External elements which are the 'exposed parts' of the installation, include plumbing fixtures and their accessories (valves and taps), and the water heater and its accessories. Problems with these elements are relatively easy to trace.

Specific aspects of the entire sanitary installation system include:

(i) The sanitary system of a standard apartment contains about 40 different appliances, and their efficient long-term operation depends on the quality of each of these products. It is, therefore, important that standard quality products be available on the local market, since the quality of the elements determines the quality of the entire system. It should be remembered that, in Israel, certain elements are used, such as floor traps, waste collectors and similar items, that are not common in other countries.

(ii) To ensure good quality in the whole building, the quality control system must be in operation throughout the period of construction. A final inspection alone cannot possibly cover the quality of the complete installation, since, by then, there is no way to check the workmanship and the quality of the materials that went into the construction of concealed parts. It is only natural that most of the complaints are related to the concealed parts.

Sometimes the quality of the water supply system of an apartment is tested by testing its water tightness. Such tests can indicate that the system is watertight at the time of the test, but they cannot ensure its adequate long term performance.

(iii) Metal parts of the sanitary system are sensitive to environmental factors, such as corrosion. The design of the system must, therefore, be carefully thought out, and the workmanship of the installation must be of good quality, to minimize the effect of these factors as much as possible.

(iv) Special caution must be exercised in the use of new materials and new technologies that may increase the risk of failures and cause excessive expenditure on maintenance. New materials are frequently cheaper than conventional materials, at times even easier to use, and greatly appeal to plumbers. For example, a flexible, unreinforced PVC pipe was offered to serve as a connection between W.C. flushing cisterns and the water supply piping. The PVC pipe was equipped with unions at its ends and was proposed as a cheaper alternative to replace the customary copper tubing used for this purpose. The PVC pipe caught the fancy of the plumbers without being tested and approved for use. After many failures which caused flooding of apartments and much damage, the enthusiasm of the plumbers and of the public died out. Mention may be made at this point of the problems being presently encountered as a result of the growing use of plastics piping in waste disposal systems and even in domestic water supply systems.

(v) To improve the efficient utilization of water, it is recommended that water saving appliances be installed in the sanitary system, such as W.C. flushing cisterns, valves with special opening and closing mechanisms, flow regulators at shower heads, etc.

3. Conditions of quality assurance in sanitary installations

In paragraph D it was stated that the quality of sanitary installations was dependent on three factors: Good design, good materials and appliances, and good workmanship in installation. Let us analyze each of these factors and the conditions required for quality assurance in sanitary systems, as they exist in Israel today.

(a) The sanitary regulations of the Israeli Plumbing Code specify:
- the responsibility of preparing design plans for sanitary installations, and the manner of preparation, form and content of these plans:
- the manner of submitting the plans to the local authorities for approval.

The design work is generally performed by consulting engineers, and there is no problem in preparing the plans in accordance with legal requirements, standards and specifications. Design problems arose, because the requirements for submission of the plans for approval were not enforced. The Inspectorate of the Standards Institution of Israel will begin its operation only on the condition that the sanitary installation design plans have been submitted to the local authorities and have received their approval.

(b) According to the sanitary regulations of the Israeli Plumbing Code, it is mandatory to use only sanitary appliances and fittings that comply with the requirements of Israeli Standards. The problem was how to enforce the use of approved products, and only approved products.

The quality of materials and sanitary products must be assured at the source, namely by the local or foreign manufacturer. However, whether only approved products have been installed must be checked at the building site, while the installation of the sanitary system is in progress.

Compliance of the products with the requirements of the applicable standards or specifications may be ascertained by two methods:

- by identification - when the product bears a 'Standards Mark' or a 'Supervision Mark';
- by testing the shipment - when the products do not bear a recognized mark of quality.

Figure 1 shows the conditions necessary to determine the quality of the materials. Since the price of standard products generally exceeds that of products that do not comply with a standard, strict control must be exercised over the materials installed at the building site. When products that fail to comply with the Standard are discovered, the contractor must be obliged to replace them with products that do comply.

The conditions described in Figure 1 are presently in effect in Israel as follows:

- All elements used in sanitary installations are covered by Israeli standards or specifications.
- 45 types of products intended for use in sanitary installations bear the Standards Mark or the Supervision Mark. (The total number of licences issued to date is 172, which means that there are several manufacturers producing the same type of product). A number of additional types of products are undergoing tests for the purpose of being granted a licence to use the Standards Mark.
- On-site supervision is performed by that branch of the Inspectorate for sanitary installations, which operates within the framework of the Hydraulics Laboratory of the Standards Institution of Israel.
- The price paid by the contractor for on-site inspection of the sanitary installation work, is based on the condition that the contractor uses only products that bear the Standards or Supervision Mark. In the event that the contractor wants to use products that do not bear a Standards or Supervision Mark, the contractor is obligated to submit the products for acceptance tests, and must pay separately for these tests. It should be noted that the contractor is not obligated to buy products bearing a quality mark but, from an economic point of view, it is cheaper for him in the long run.

(c) The third factor that determines the quality of a sanitary installation is the workmanship of the installation. The conditions required for proper quality assurance and the means available for this purpose, are set out in Figure 2.

SII Specification 10 contains, in addition to requirements and guidelines for the performance of sanitary installation work, details on the manner of testing installation quality. Specification 10 is now being converted to an Israeli Standard by a special standardization committee.

Quality of workmanship is also checked by the Inspectorate for sanitary installations.

A problem which has not yet been solved in Israel is the certification of plumbers. At times the plumbers at the building site are of low professional competence and, in such event, it becomes necessary to give special instruction to plumbers instead of performing the required inspection work.

We hope that the problem of plumber certification will be settled in the near future, and that the first requisite will be that the person responsible for the installation work at a site will be a qualified and certified plumber.

E. DEVELOPMENT OF QUALITY ASSURANCE IN SANITARY INSTALLATIONS

The development of quality assurance in the installation of sanitary systems in Israel is divided into three typical stages:

Stage 1 - Acceptance tests of products arriving at the building site

During this stage, all operations were performed at the public housing site, within the framework of the Ministry of Building and Housing. The costs of the acceptance tests were also covered by the budget of this Ministry.

FIGURE 1 : NECESSARY STEPS TO ASSURE QUALITY OF MATERIALS

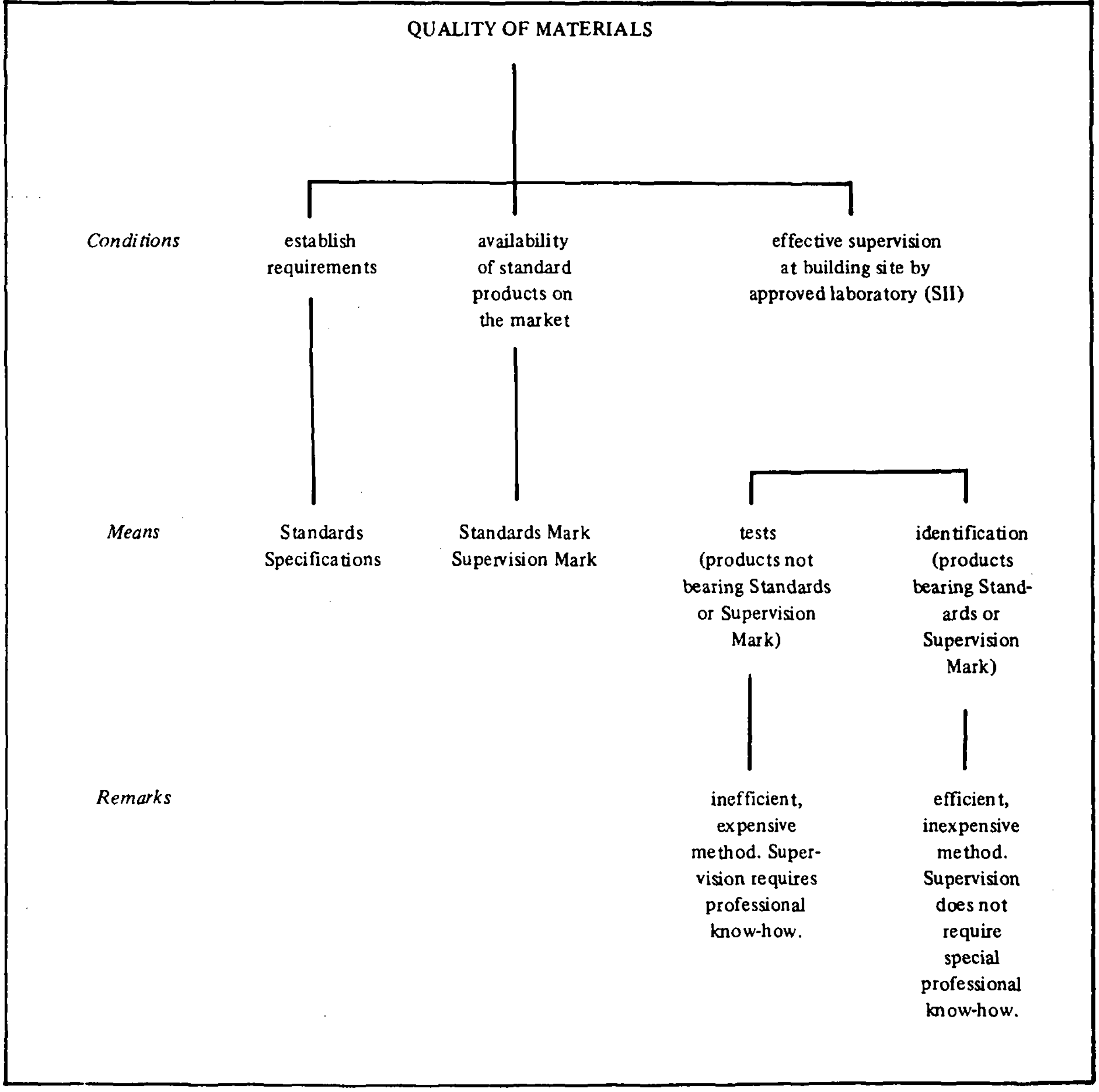
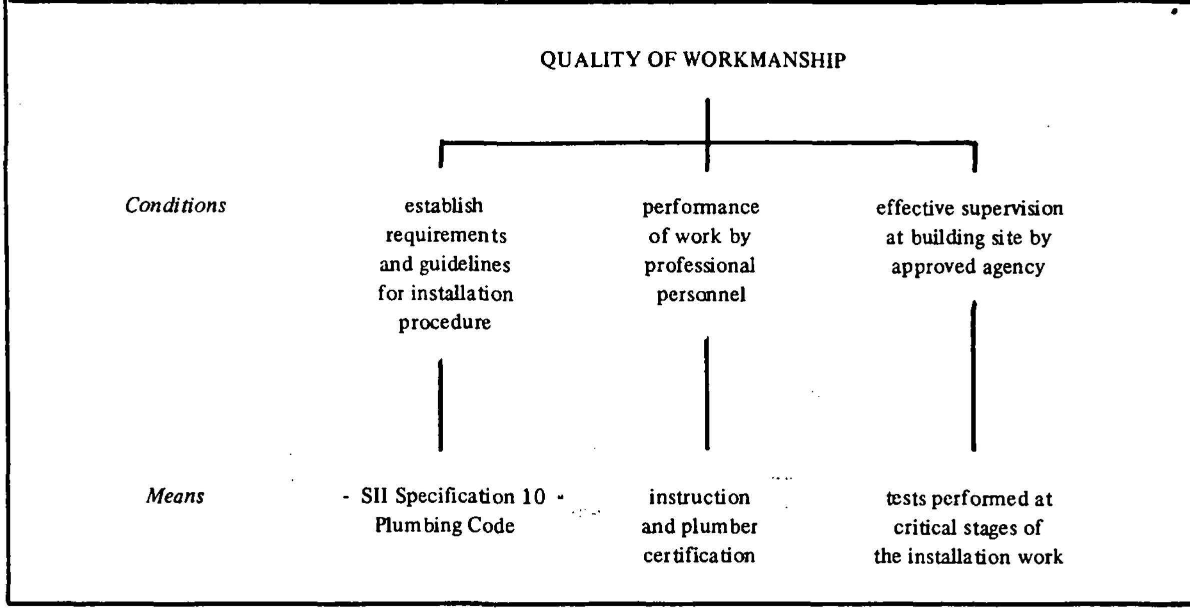


FIGURE 2 : NECESSARY STEPS TO ASSURE QUALITY OF WORKMANSHIP



When the work of this stage was begun, no standards or specifications existed for some of the elements of the sanitary installations. The necessary preparation of these documents continued throughout most of Stage 1, almost until its end. Consequently, acceptance tests could be perfomed only on elements for which standards or specifications were available.

The quality control system was based on the performance of laboratory tests of samples of sanitary installation elements taken from the building site. The tests showed that most of the samples did not meet the requirements (see Table 2). The taking of samples was performed according to statistical methods, and the sampling lot consisted of a quantity of elements of like type and produced by the same manufacturer.

TABLE 2 : RESULTS OF LABORATORY PERFORMANCE TESTS ON SANITARY ELEMENTS

Year	Elements comply with Standard or Specification (per cent)	Elements with slight defects (per cent)	Elements with serious defects, disqualified (per cent)
1968	10	10	80
1971	18	20	62
1975	45	35	20

The objectives of these tests were:

- To install at the building site only elements which had no serious defects. Since elements which complied with all the requirements of the standard were not available, the only realistic solution was to permit the installation of elements having only a small number of slight defects. Elements with serious defects were disqualified.
- To exert direct pressure on the manufacturers to improve the quality of their products and to place the products within the quality control framework of the Standards Institution of Israel (Standards Mark). Pressure was applied by constant harassment of the manufacturers to replace defective products supplied by them to the building site. The test results enabled the Ministry of Building and Housing to classify manufacturers, and to give preference to those offering better quality products. Some of the manufacturers took advantage of this opportunity to increase sales by improving their products and obtaining the Standards Mark for them.

The acceptance tests of Stage 1, which lasted from 1965 to 1975, did bring about the constant improvement of products (see Table 2) and a significant increase in the number of licences for Standards and Supervision Marks to manufacturers of sanitary installation elements (see Table 3).

TABLE 3 : NUMBER OF LICENCES ISSUED TO MANUFACTURERS

Year	1968	1971	1974	1977	1980
Number of licences for Standards Marks and Supervision Marks:	18	45	81	140	172

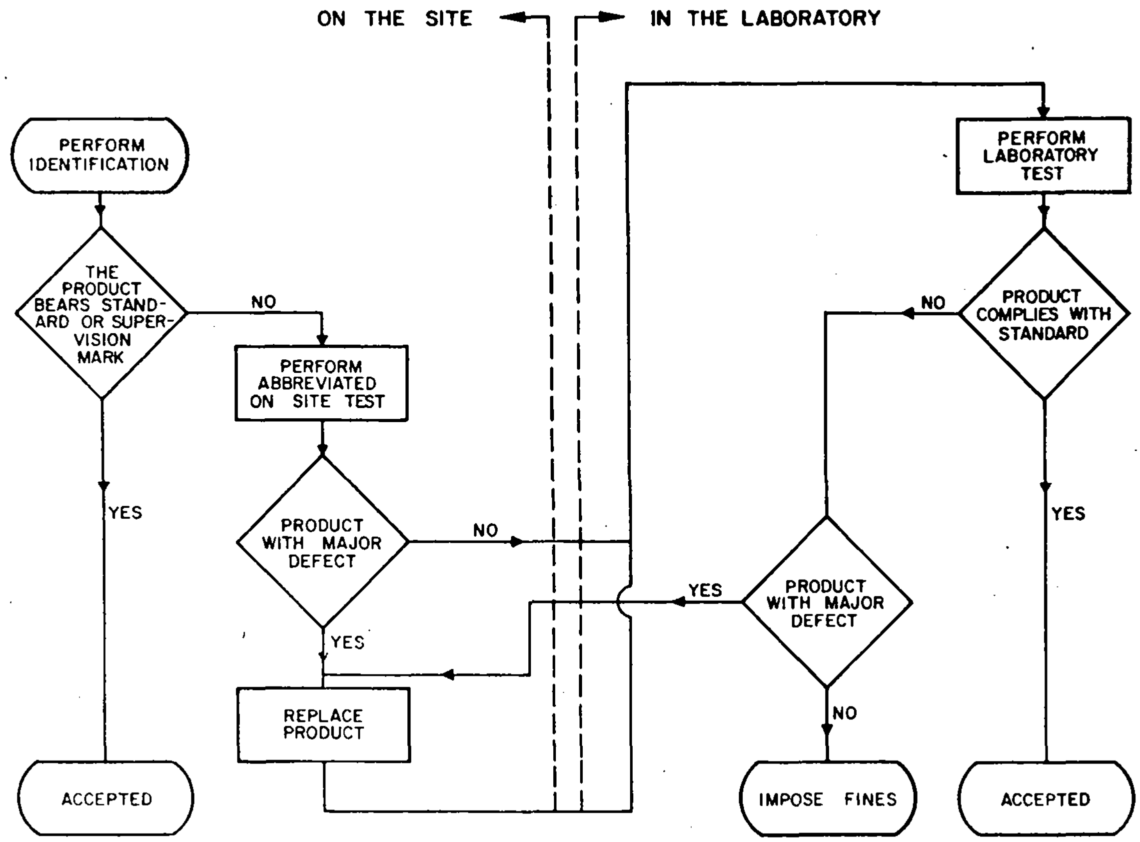


FIGURE 3

Organization of Test Programme of Sanitary Installation Products on Building Site

At the completion of Stage 1 a test programme of sanitary installation elements was initiated, as described in Figure 3.

This flow chart illustrates the policy of the Ministry of Building and Housing to ensure the quality of sanitary installation elements installed at the site of construction.

Stage 1 laid the foundation for the beginning of Stage 2 of the quality assurance development in sanitary installations.

Stage 2 - Test of the quality of installation of sanitary systems in public housing

In 1975, the Standards Institution of Israel prepared and published the SII Specification 10, titled 'Plumbing Systems and their Testing'. In conjunction with the Ministry of Building and Housing it was decided to institute the use of installation tests according to SII Specification 10 in a district where 1 000 residential units were being erected by various building companies.

This experiment made it possible:

(a) to check whether Specification 10 required technical changes and improvements, and

(b) to prove that an effective quality control system could be successfully applied to check the quality of installation of sanitary systems.

Based on the success of the experiment, the Ministry of Building and Housing decided to make it mandatory that all contractors have the installation of sanitary systems tested at the building site in accordance with SII Specification 10, as a condition to obtain the contract.

As a means for enforcing the correction of defects discovered in the tests, the Ministry of Building and Housing levied fines on the contractors or withheld payment, in proportion to the defects uncovered.

In parallel with the activities of the Ministry of Building and Housing, a number of municipalities adopted the quality control system developed by the Standards Institution of Israel, and obligated private construction within their jurisdiction to have their sanitary installations checked by the SII.

At all building sites where the quality control system was introduced, significant improvements were noted in the quality of sanitary installations, both as to the use of standard products and the level of workmanship.

Stage 3 - Obligatory testing of sanitary installations

In April 1980, an amendment to the Planning and Building Regulations was issued, which made it mandatory to test the sanitary installation of all buildings under construction. The tests must be performed according to SII Specification 10, by the laboratory of the SII or by any other legally authorized laboratory. The Regulations specify that 'All materials and products of sanitary systems, as well as their installation, shall be tested according to SII Specification 10 (until the Specification is replaced by an Israeli standard). The Regulations specifying 'mandatory testing' placed the responsibility for its enforcement directly on the local authorities. Since the introduction of Stage 2 in 1975, experience has shown that mandatory testing is meeting with success, the extent of success depending on the effective enforcement by the local authorities, that the tests be conducted as required. Lawful means of enforcement include stoppage of construction, court action, or even refusal to connect the building to the municipal water supply system.

F. SUMMARY

This paper briefly describes the various stages in the development of an effective system of quality control in Israel, and the steps taken to achieve an adequate level of quality in the installation of sanitary systems. This control system is part of an overall quality control system for building operations, although it incorporates characteristics that are peculiar to sanitary installations alone.

The development of the control system has extended over a period of about 15 years, and has not yet been completed. The accomplishments achieved to date are the result of unfaltering perseverance and the coordinated efforts of many agencies.

The Israeli model of quality assurance described herein may, perhaps, be of some service to other developing countries, who have to cope with similar problems to those encountered in Israel.

Among the most important achievements, mention may be made of the following:

(a) Practically all elements of sanitary installations that are now available on the market, bear the Standards or Supervision Mark.

(b) There is considerable improvement in the quality of sanitary installations, which is of distinct benefit to every person acquiring an apartment.

(c) The agencies concerned with housing are now exhibiting a favorable attitude toward quality assurance in sanitary installations.

(d) Introduction of the control system has induced contractors to observe laws and regulations which they did not observe before.

(e) The pliancy of the control system facilitates the introduction of new products, provided that they satisfactorily pass the tests required to determine their adequacy.

(f) The main benefits of the quality control system will be noted only a few years hence, when failures in the operation of sanitary appliances will be reduced to a minimum.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGSDIENSTE IN ONTWIKKELENDE LANDE

S 239
Paper 6
Referaat 6

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Sanitation, site, service/
Sanitasie, terrein, diens

ASPECTS OF SANITATION FOR SITE AND SERVICE SCHEMES

by G.J.W. de Kruijff*

SYNOPSIS

The history of site and service schemes in Kenya is outlined with particular reference to the development of sanitation. This site and service concept proved to be a major policy tool in spreading housing benefits to the majority of the urban low-income population.

SAMEVATTING

Die geskiedenis van terrein- en diensskemas in Kenia word geskets met besondere verwysing na ontwikkeling op die gebied van sanitasie. Hierdie terrein- en diensbeginsel het 'n groot beleidsfaktor geword om behuisingsvoordele aan die meerderheid van die stedelike lae-inkomstebevolking te verseker.

* *Research Fellow, Services Engineer, University of Nairobi.*

1. SITE AND SERVICE SCHEMES IN KENYA

One of the major housing developments in the urban areas of Kenya has been the site and service programme, which has been the major policy tool in spreading housing benefits to the majority of the urban low-income population.

The aim of this paper is briefly to outline the concept and the history of site and service schemes in Kenya and, in particular, to highlight the aspect of sanitation.

The following definition is used for 'Site and Service'.

'Site and service schemes' are projects in which residential plots of land are provided with basic services, i.e. water, sanitation, roads, surface water drainage, electricity, etc. and allocated to eligible applicants so that they can, through self-help construct permanent houses on them. These can initially be constructed to various standards in such a manner as to match the paying ability of low income households. Materials, loans and technical assistance on construction methods are offered to plot allottees. This type of housing is allocated to those households within the income range KShs.300 - KShs. 1 200/- (US $40 - US $160)* per month.

Experience with site and service schemes goes back to 1923 when the first site and service project in Nairobi was declared as an official Black township to accommodate the migrant population in Nairobi. It was not until 1954 that Kariobangi in Nairobi was suggested as a site and service project to solve the problem of illegal squatting. Ten years later, in 1964 after Kenya had become independent, this project was implemented.

At present the site and service programme in Kenya covers a range of local authorities, i.e. municipalities, towns, urban centres and counties throughout the country, in approximately 37 different localities. In addition, there is a wide range of sizes of schemes, i.e. from 30 plots to 6 000 plots, the latter figure being applicable to the Dandora Community Development Project in Nairobi, which is the first urban project to be financed by the Government of Kenya and the World Bank. A second urban project, which includes about 14 300 site and service units in Nairobi is also being implemented at present. According to an inventory prepared by the Housing Research and Development Unit, 84 site and service schemes with a total of about 27 820 serviced plots have been recorded during the period 1960 to 1977.

2. DEVELOPMENT STAGES OF SERVICED PLOTS

There is a range of levels of services for serviced plots which can be applied to a site and service scheme. The most common initial stages of serviced plot development in Kenya include:

(i) Site with only a manhole connection;
(ii) Site with toilet and shower wet-core.

In all the site and service schemes developed by the National Housing Corporation, the executing agency of the Ministry of Housing and Social Services, the plot is serviced by an individual water supply, water-borne sewerage, graded roads (gravel mainly), foot-paths, storm water drainage and, in some cases, street-lighting.

The initial level of services for plot development has related cost implications. The following example illustrates this relationship within the three levels of services shown below (1978 prices, prices per capita) (KShs. 7,5 = US $1):

Municipal standpipe services
Selling for cash payment at the tap.
Water consumption 10-15 litres/capita/day.
Excreta disposal by pit latrines.

Capital cost water supply	KShs.	20 - 80
Monthly consumer charges	KShs.	2 - 8

Single tap services
Metered or unmetered consumption.
Water consumption 30-60 litres/capita/day.
Excreta disposal by pit latrines.

Capital cost water supply	KShs.	60 - 120
Monthly consumer charges	KShs.	2 - 8

Multiple tap services
Metered consumption.
Water consumption 60-120 litres/capita/day.
Excreta disposal by water-borne sewage.

Capital cost water supply	KShs.	50 - 80
Capital cost sewerage	KShs.	240 - 400
Capital cost wet core	KShs.	820 - 1 360
Monthly consumer charges	KShs.	8 - 15

This shows that the cost implications of the conventional water-borne system are high. However, the use of pit latrines is not favoured by the public health authorities in the site and service schemes, despite decreased costs, as compared to water-borne sewerage.

When the site and service programme was written, non-water-borne sewerage was anticipated and pit latrines were proposed. During the implementation stage, the pit latrines were abandoned and all the site and service schemes have been implemented with water-borne sewerage.

3. SANITATION CONSTRAINTS IN SITE AND SERVICE SCHEMES

(a) Development constraints

During the period between handing over a site to the council and actual occupation of the plot, manhole covers start to disappear. Council officials claim that contractors return to the site and steal the covers. The uncovered manholes are then used as dumping places for garbage and have often become completely filled up. Also, during this period some plots are completely built up and occupants start to use their toilets with obvious resulting problems.

Unlike other housing schemes which are fully occupied almost instantaneously, site and service schemes are based on the gradual development of housing, and it takes years before a scheme reaches its designed density. However, sewers designed for the ultimate design flow have already been laid before the first occupants arrive. Investments which are only fully utilized after, for example, 10 years are very wasteful from an economic point of view.

* ± US $ 1,3 = R1,00 (1980)

(b) Self-cleansing velocities

Because of the relatively high solids content of sewage in low income estates (low income people normally do not use soft toilet paper but use more solid waste materials such as newspapers, corn cobs and coconut husks) self-cleansing velocities of 0,9 - 1,0 metres/sec should be reached once a day. This self-cleansing velocity should occur at the peakflows. A full flowing 160 mm UPVC sewer at a gradient of 1 per cent will discharge 20 litres/sec at a velocity of 1,1 metres/sec. If, however, the discharge is below this figure, the velocity will also drop for hydraulic reasons (see Figure 1).

Figure 1* : Gradients of 5 per cent or higher are very seldom reached because sites then become unsuitable for low cost housing construction. Figure 2 expresses the minimum gradient needed to transport a certain flow at 1 metre/sec in a 160 mm UPVC sewer. The relationship between plots and these flows is also shown. The problem with conventional sewerage is that a self-cleansing velocity will be reached only when a certain number of plots contribute their wastes to the sewer. In practice, this means that very large lengths of sewer runs will not be self-cleansing in site and service developments, and blockages are likely to occur regularly.

Figure 2 : Despite the facts given above, the relationship between water consumption and sewer design is rarely given adequate consideration. It seems that engineers are prepared to make false assumptions simply to make this conventional technology work, at least on paper. An example of this is afforded by an urban project in which design criteria for water supply is based on 60 litres/capita/day (a reasonable assumption), but where design criteria for the sewerage system is based on the generation of 120 litres/ capita/day of sewage.

In addition, house building does not develop in a planned sequence along the sewer line. Ideally house development should start at the lower end of the sewer laterals and gradually move upwards. In practice, house development in site and services schemes occurs at random over the site, depending on the financial capabilities of the allottee. This is very difficult to assess in the allocation phase. Observations of sewer flows in site and service schemes confirm that flows are insufficient to keep the solids in suspension.

(c) Pipe materials

Current practice is to construct sewers out of the cheapest material available. Most of the sewers constructed in Kenya are made of concrete. It is considered bad engineering practice to connect short rigid pipes with rigid joints. However, this is current practice in Kenya. These rigid pipelines will crack at the joints after a certain period due to settlements in the soil and will cause blockages. Rigid pipes should always be joined with rubber rings, but this does not appear to be popular in Kenya.

Widespread failures have occured where cemented joints were used. The tendency to crack or shrink, the possibility of poor workmanship in the installation of the joint, and the incorrect composition of the mix are all causes for unsatisfactory performance. A joint or junction in a sewer line must be water tight, resistant to root penetration, durable, reasonably flexible and unaffected by soil conditions. Cemented joints do not fulfill these criteria and sewer problems can often be traced back to poor joint performance.

(d) Corrosion

Extremely low flows in sewer pipes cause the sewage to turn septic and slime accumulates on the sewer walls under the water level. The slime provides an excellent breeding environment for sulphide producing organisms. Severe attack by these organisms can lead to the collapse of sewers, and concrete sewer pipes are particularly vulnerable to this phenomenon. For example, a 15 year old sewer pipe in the

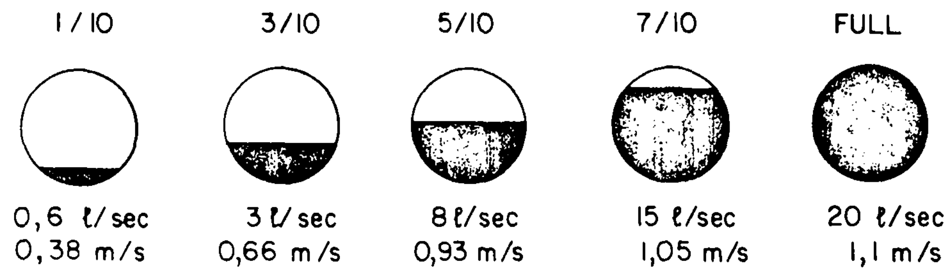


FIGURE 1

Illustrating the effect of depth of flow upon velocity and discharge, calculated for a 160 mm UPVC sewer laid at 1:100.

* Based on water consumption figures of 75 litres/person/day.

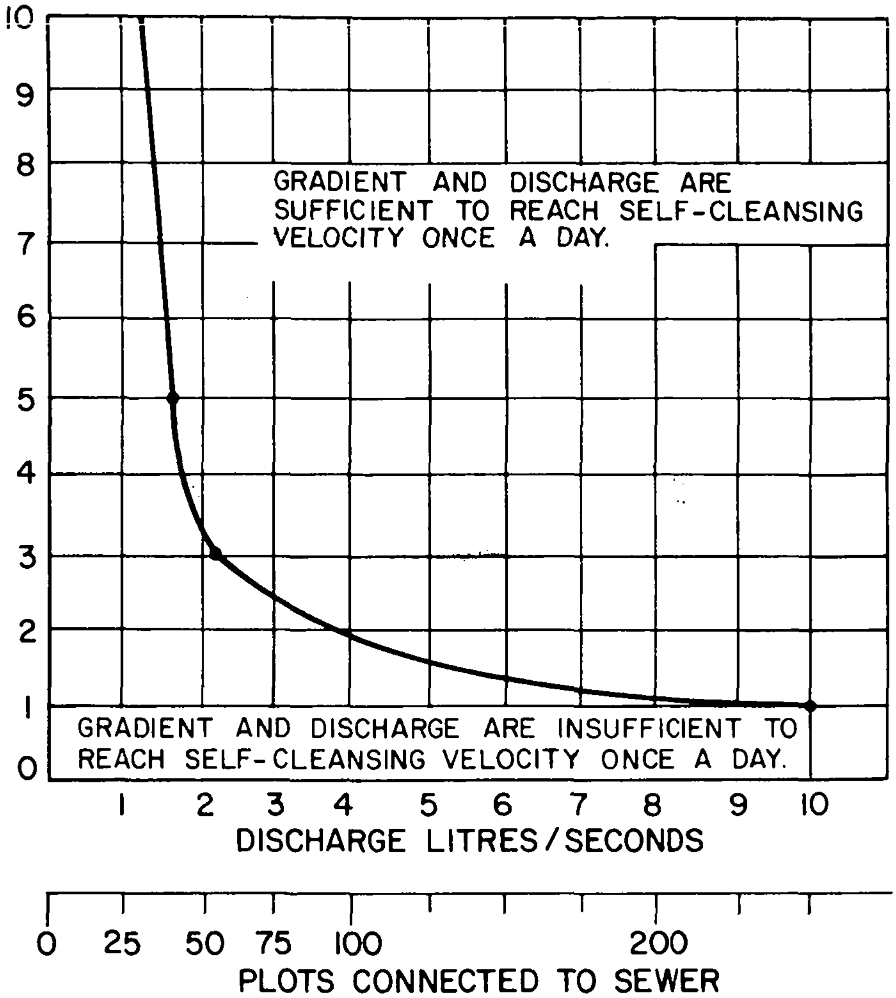


FIGURE II

Relationship between gradient and discharge to reach a self-cleansing velocity of 1 metre/second. (calculated for a 160 mm UPVC sewer pipe, 75 litres/ person sewage flow, peak flow 3 x average flow, minimum self-cleansing velocity 1m/sec. once a day)

Athi River was found completely corroded away at the crown. The lifespan of sewers can be severely reduced in this way. However, plastics are not sensitive to this type of corrosion.

(e) Water needs

This system is very extravagant with water. It is not uncommon to find that 40-60 litres/capita/day of potable water is needed for the flushing of a toilet pan. This is both expensive and wasteful. Large quantities of an often scarce resource are used to transport small quantities of excreta to a treatment works.

The environmental logic and expense of the whole process should be questioned : a conventional water-borne sewerage system means adding 40 litres of expensively treated and transported water to a half litre of excreta per person per day, and thereafter treating the resulting sewage to remove the excreta before the effluent can be discharged back into a lake or river. Sewage treatment costs are often even higher than those of water transport, and present problems in developing countries. Considerable management skills are required to supervise the process. Observations show that streams, which may be the main water source for individuals downstream, often become polluted.

It is very doubtful whether water can be made available in large enough quantities to fulfill the conventional sewerage

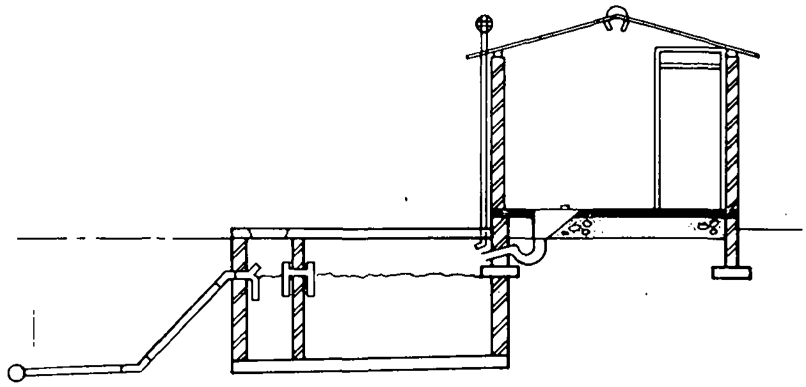


FIGURE 3

Sewered pour flush toilet

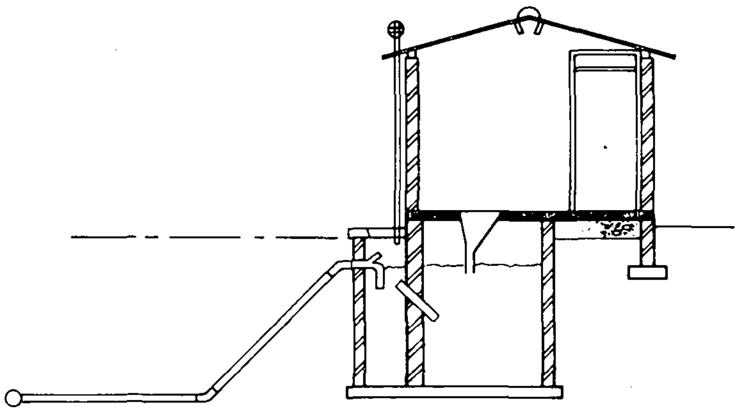


FIGURE 4

Sewered aqua privy toilet

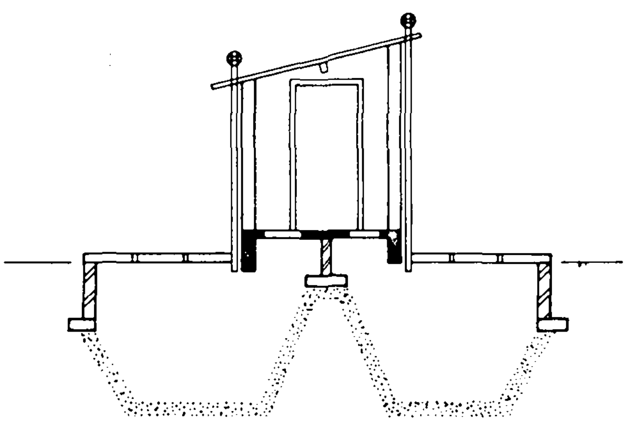


FIGURE 5

Reeds odourless earth closet

requirements for urban Kenya. However, if the waterflow into conventional sewerage systems is limited to below 70 litres/capita/day, sewers cease to function. Blockages will result and the maintenance costs will therefore become high.

(f) Unplanned settlements

It is almost impossible to introduce conventional sewerage into squatter settlements. Firstly, it is very difficult to establish the necessary straight runs through unplanned areas. Secondly, squatter settlement sites are often unsuitable for low cost housing developments and are frequently located on very steep or almost flat land. The latter causes severe sanitation problems since areas can then only be served with the assistance of pumping stations, which are costly and require high maintenance. Low water consumption in squatter areas is another problem.

(g) Summary

In short, conventional water-borne sewerage appears to have so many serious disadvantages for low-income urban housing that it cannot really be considered as an appropriate technology for developing countries. Therefore the need for alternative sanitation systems becomes inevitable.

4. POSSIBLE SANITATION OPTIONS

The following sanitation options have been reviewed for the purpose of this paper:

- (a) Sewered pour-flush toilets.
- (b) Sewered aqua privy toilets.
- (c) Ventilated improved pit latrines in a phased development.

(a) The sewered pour-flush toilets (Figure 3)

The sewered pour-flush toilet is a logical adaptation of the conventional waterborne sewerage system. The main idea is to reduce the amount of flushing water and to keep the solids out of the sewers. Pour-flush toilets are now used in East Asia and have proved to be successful. These pour-flush toilets are mostly provided with individual soakaways. Total waste flows are consequently low and, if soils are sufficiently permeable, the soakaways work satisfactorily.

The system as proposed here, however, uses small bore UPVC sewers of 63 mm laterals and 40 mm plot connections. The number of manholes is drastically reduced, (since the chance of a blockage in the sewerline becomes almost nil), without infringing on the ability to rod the sewer. Rodding points are provided to make the sewer accessible for cleaning.

The water distribution system is based on an improved system as discussed in more detail in 'Water supply improvements for upgrading areas' (de Kruijff 1979). Courtyard services with a 'Fordilla' automatic self-closing tap, which dispenses with expensive watermeters, are provided on every plot.

From the user's point of view there is little difference between the performance of this system and that of a conventional water-borne sewerage system.

(b) The sewered aqua privy toilet (Figure 4)

Aqua privies have been used for several years in Africa, often without much success. However, the high number of failures can often be traced to poor technical design. The system proposed here is based on an improved version of the aqua privy, which will eliminate earlier design failures. There is very little difference between the pour-flush toilet and the aqua privy. However, the aqua privy has two main advantages over the pour-flush toilet.

Firstly, it is able to deal with bulky anal cleansing material. The water seal can hardly be blocked with this material, or in case of a blockage it will be easy to rod through. Secondly, a temporary water shortage (as often occurs in Kenyan towns) will not make the system unusable. The disadvantage is that the system needs more careful construction than the pour-flush toilet. The tank should be watertight and the effluent pipe should be carefully positioned in relation to the down pipe of the squatting plate to maintain the water seal. The water distribution system and the sewer system are exactly the same as in the sewered pour-flush toilet system. There is very little difference in user convenience between the conventional sewerage, pour-flush and aqua privy toilet systems.

(c) Ventilated improved pit latrines (VIP) (Figure 5)

Ventilated improved pit latrines are basically pit latrines with a composting process. VIP's have been used very successfully in Southern Africa. They are designed for a two years minimum life-span. After two years, a second VIP has to be used and when this becomes full, the first one is emptied and reused. Pathogens have become almost harmless in the two years storage period and emptying can, therefore, be done by manual labour. The dug out compost can be used as fertilizer. Since VIP's have no water requirements at all, the water supply can be communal in the first years. The water system can be upgraded later to individual plot-connections similar to the pour-flush and aqua privy toilet systems.

(d) Economic comparison of the systems

An economic study suited to the Kenyan situation has been undertaken by the author*. The economic costing exercises have been 'shadow priced' and are based on the average incremental cost method. The results of this study indicate that not only can huge cost savings be achieved with the combined use of modern materials and techniques, but in addition, the alternatives are likely to perform better technically than the conventional system in low income housing areas.

The following figures show clearly that the conventional sewerage system is the most expensive system. The annual cost per plot for the sewered pour-flush toilet is only approximately 50 per cent of the conventional sewerage cost. The sewered aqua privy is slightly cheaper. The dry excreta disposal system is the cheapest: in spite of costing based on contractor built structures and excavation, it amounts to 30 per cent of the conventional sewerage cost. If self-help were included, it would be possible to reduce the cost further from 30 per cent to probably 15 per cent of the cost of conven-

* 'Sanitation for Site and Service Schemes', by G.J.W. de Kruijff, University of Nairobi, Kenya.

tional sewerage. In other words, 6 times the population served by conventional sewerage can be provided for at the same cost, with water and adequate excreta disposal facilities.

Cost comparison of sanitation alternatives	*per cent*
Conventional sewerage (includes water supply, sewerage and treatment)	100
Sewered pour-flush toilets (includes water supply, sewerage and treatment)	55
Sewered aqua privy toilets (includes water supply, sewerage and treatment)	47
Ventilated improved pit latrines, contractor built (includes water supply, on site disposal)	30
Ventilated improved pit latrines, self-help (includes water supply, on site disposal)	15

5. FUTURE DEVELOPMENT AND RESEARCH NEEDS

During the last 150 years the idea of water-borne sewerage systems has become generally accepted. The flushing systems which solve the waste problems of individuals by passing them on to others were for the first time recommended in 1842 by Edwin Chadwick. In the industrial western countries, the standard solution for the sanitary disposal of excreta is at present water-borne sewage. However, this method is designed not to maximize health benefits but rather to provide user convenience - a very important objective for developed countries but of little relevance for developing countries. The flush toilet and associated sewerage system is the result of slow progress over centuries. It is clear that we have reached the present stage of sanitation technology by a process of devising a solution to a problem created by a previous solution which eliminated a previous problem.

This cause and response relationship can be extended all the way back to the change from dry to water-borne excreta disposal. Unfortunately, at no time was a thorough examination undertaken to determine whether water-borne excreta disposal was the best solution, because its consequences were not adequately foreseen. It is quite possible that the developed countries will find in the future that they took the wrong road at the junction of the water-borne system and the dry system.

Unfortunately, developing countries have excreta disposal problems, the solution of which, in most cases, has not yet been pre-empted by past commitments. Furthermore, they do not have the time that the developed countries have had to progress from the latrine to the present system. Planners, engineers, economists and financing agencies are obliged to take another look at existing excreta disposal practices. This is of vital importance to the people in developing countries. If a less expensive method of solving the excreta disposal problem cannot be found, many people will be condemned to live their lives in unsatisfactory sanitation conditions. The number of sewerage master plans gathering dust on shelves in cities in developing countries with desperate excreta disposal problems indicates that the existing sewerage is not always appropriate.

Therefore sanitary engineering suited to developing countries is a challenge which has still to be met. Progress in this area appears to have ceased after the invention of the sewer. For too long the sanitary engineering profession has been ruled by European textbook knowledge that is not suited to developing countries. With modern materials, improvement of old methods and innovative techniques, the basic needs of more people can be met at lower cost. Every country has its own characteristics, cultural and social behaviour, soil conditions, water supply needs and diseases, and should therefore not be burdened by one 'universal' sanitation solution.

There is a great need for innovative sanitation demonstration projects, designed by those who can think creatively. The role of developed countries should be that they assist developing countries in achieving this goal without imposing their obsolete knowledge on them.

REFERENCES

1. ENGLAND, R. *Environmental health discussion paper,* Second World Bank/Government of Kenya Low-Cost Bylaw Study, Nairobi, November 1979 (draft).
2. FEACHEM, R. et al, *Alternative sanitation technologies for urban areas in Africa,* The World Bank, 1979.
3. FEACHEM, R. ed, *Water, wastes and health in hot climates,* John Wiley and Sons, 1977.
4. FEACHEM, R. et al, *Health aspects of excreta and waste water management,* The World Bank, 1978.
5. KALBERMATTEN, J. et al, *Appropriate sanitation alternatives, a technical and economic appraisal,* World Bank, 1978.
6. DE KRUIJFF, G.J. *Water supply improvements for upgrading areas,* Housing Research and Development Unit, University of Nairobi.
7. DE KRUIJFF, G.J. *Sanitation for site and service schemes,* Housing Research and Development Unit, University of Nairobi, 1980.
8. MARA, D. et al, *Appropriate sanitation alternatives - A field manual,* The World Bank, 1978.
9. PACEY, A. et al, *Sanitation in developing countries,* John Wiley and Sons, 1978.
10. VAN STRAATEN, J.J. *Sites and services schemes in Kenya,* Mimeo, Housing Research and Development Unit, Seminar Paper, Nairobi, 1977.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
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Paper 7
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Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Rural, water supply, tribal custom/
Landelik, watervoorsiening, stamgewoonte

A DESIGN FOR RURAL VILLAGE WATERPOINTS IN ZIMBABWE

by F.P. du Toit*

SYNOPSIS

The author points out that problems associated with designed water supply systems stem from a lack of understanding of the cultural and social traditions surrounding water use of the unsophisticated rural communities, rather than from a lack of appropriate engineering technology.

A water dispenser has been designed by the author and as an experiment, a prototype was erected close to a traditional village. Only after the waterpoint was screened off, was it used by the women of the village and replaced the traditional contact points on the river.

SAMEVATTING

Die outeur wys daarop dat die probleme wat met ontwerpte watervoorsieningstelsels ondervind word,wat eerder te wyte is aan 'n gebrek aan begrip van die kulturele en sosiale tradisies van ongesofistikeerde landelike gemeenskappe met betrekking tot watergebruik as uit 'n gebrek aan toepaslike ingenieurstegnologie.

'n Waterpunt is deur die outeur ontwerp en 'n prototipe is as eksperiment naby 'n tradisionele dorpie opgerig. Slegs nadat die waterpunt afgeskerm is, is dit deur die vroue van die dorpie gebruik en het dit die tradisionele bymekaarkomplekke by die rivier vervang.

* *Senior Architect, Department of Conservation and Extension, Ministry of Agriculture, Zimbabwe.*

INTRODUCTION

Commercial farmers in Zimbabwe have progressively striven to improve the living and working conditions of their Black employees. These workers traditionally live with their families in identifiable communities on the farms where they are employed. On average, such communities number between a hundred and six hundred or more people, depending on the size of farm and the type of farming enterprise.

The habitations of these communities were usually on self-chosen and scattered sites near open water in a river or dam or in a shallow well, dug at a vlei-margin. Footpaths linked the domestic, social and functional venues used by the community, which covered considerable tracts of land. The resultant degradation of the environment was not of any great concern until agricultural development took a marked upswing during the past two decades. During that time farm development intensified in all aspects, though least in the forms of workers' domicile. This was not for lack of farmers trying to improve matters; it was caused by resistance to change which is found particularly strongly among unsophisticated rural communities. Most attempts to provide urban-type water supply and sanitation services failed.

A research project was started by the author in 1969, encompassing all aspects of agricultural workers' habitation. It was soon shown that problems associated with designed water supply systems stemmed from a lack of understanding of the cultural and social traditions surrounding water use in these communities, rather than from a lack of appropriate engineering technology.

TRADITIONAL WATER USE AND ASSOCIATED FUNCTIONS

Factors such as the perennial or seasonal availability of open water in a region, the quality of that water and the size and type of population dependent upon it will dictate a social discipline of water use for the area. Nevertheless, a few general observations can be made which apply to almost every Black rural community in Zimbabwe.

Most important is the fact that since the collection and use of household water are domestic functions, it is "women's work".

These functions, together with many other domestic functions normal to a woman's life in a rural African household, including the production of food crops, leaves her very little leisure time. By tradition, her domestic chores have been modified and enriched from purely functional occupations to allow her to partake in pleasant social activities at the same time. Hence, water collecting becomes a daily excursion from home for self-selected groups of women. Small children and older girls accompany them to help in the task and to be instructed. Where circumstances allow, the essential function of drawing water is expanded to include bathing, laundering and washing of cooking utensils.

In ideal situations the water point is therefore private to women and can be likened to a "women's club" where aspects of women's life in a rural community are lived out.

The amount of water to be brought home is obviously kept to minimum domestic requirements, or at most that quantity which can reasonably be carried over the distance from the water point. On average, this may be twenty or thirty litres per day for each household. It will be kept in the kitchen for drinking and cooking and also in an outside wash shelter for personal ablutions, essentially for the menfolk.

It follows that very little water is available for maintaining the small vegetable and herb garden which is usually found behind the homestead huts and on which domestic waste water is expended. Larger gardens are cultivated near the water point, thus affording a further reason for women's excursions from the village.

These observations suggest that the "ideal concept" of piped water into every house is inappropriate to unsophisticated rural village communities until such time as wide-ranging cultural and social change has taken place.

ENVIRONMENTAL INFLUENCES ON HEALTH

As commercial farming land became more and more intensively developed over the past twenty years, large irrigation schemes were established, labour populations on farms grew and - partly also because of the prevailing war situation then in Rhodesia - scattered workers' habitations had to be consolidated into village sites on high ground. Irrigation schemes and improved livestock management systems accounted for a vast increase in the area of water impoundments on farms. This, in turn, reduced the seasonal fluctuations of flooding and drying up of rivers and streams. Of direct consequence was an incomparably large increase in the numbers of aquatic hosts for water-borne parasites.

The compounded results of these developments were that ever larger rural populations on farms relied on fewer sources of domestic water which, though more reliable than before, became heavily polluted at collecting points. Down-hill pathways leading from more densely populated locations than before, became eroded gullies. During the rains large quantities of soil and litter (including faeces) were washed directly into the water points. Gastro-enteric diseases and bilharzia not only affected more people - mainly children - but their respective forms of infection became more severe.

Since these consequences were clearly evident, farmers attempted to provide waterpoints in the villages, usually by means of a piped supply terminating in a standpipe with bib-cock. Such facilities could not meet the social traditions regarding water use and therefore had no lessening effect on the functional and casual human contact with open infected water.

New concentrations of pollution were created at tap-sites within inhabited areas, increased by excessive waste of water. Women would leave cocks open or weigh down pressure taps with stones or logs to allow a constant discharge. Taps soon broke and, in desperation, many farmers closed off supplies to villages, whereupon women resumed their custom of collecting water at rivers and dams.

DESIGN FOR A VILLAGE WATERPOINT

A built waterpoint has to afford an amenity which would attract the women of the village away from their traditional watering place at open water. Their customary functions and rituals of "water collecting" should be allowed there, in privacy and comfort.

Siting

To isolate the inevitable pollution that is incidental to a waterpoint and to maintain opportunity for women to make a daily excursion to collect water, the site should be located at least a hundred meters from the nearest habitation. Such siting would also provide sufficient area of ground on which waste water can be safely dispersed. The route from the village should be neither unsafe nor arduous. If at all possible the waterpoint should be out of sight but within earshot of the village.

The site should be dry and the soil well-drained. It could advantageously be on good arable land. If situated in an area of natural woodland, the women would also be attracted for its firewood and wild fruit resources.

Most importantly, the site should be as distant as possible from open waterbodies to reduce the preferential choice of watering place.

Design

A water dispenser surrounded by natural or built screening (see attached illustrations) of a type which the women of the village can maintain themselves is recommended.

The interior floor surface is paved in stone or hard bricks, laid to falls and draining to a perimeter surface channel. A few slightly raised and sloping laundering slabs are built on the paving. (It was found that women preferred these smoothly rendered slabs to be at floor level rather than at knee-height.)

The area about the water dispenser is roofed, though this does not extend to the whole of the paved area. Comfortable shelter is thereby afforded in all weathers and algae growth is inhibited in the open water sump. (The latter is an integral part of the water dispenser and is described later.) The eaves are high enough to permit penetration of sunlight to the floor area during early mornings and late afternoons.

The enclosed area should not be cramped but should be airy without inducing draughts.

Water supply

The water dispenser relies on a gravity flow or pumped supply under pressure to an elevated storage tank. To allow for minor repairs and maintenance of the reticulation system without interrupting supply at the dispenser, the tank capacity should be at least one day's water demand in the village. The tank is supported on a masonry tower which also houses the dispensing mechanism.

It is, of course, essential that the water supplied is of potable quality. If the source is suspect and tests indicate contamination, a purification plant will be necessary. Where required, this should be sited well away from the waterpoint in the reticulation system to prevent tampering and to ensure that specialist attention to its dosing and maintenance does not interfere with women's water collecting.

Water dispenser

The dispenser design affords a copious flow of clean water on demand without waste and without the operator having to manipulate any mechanical controls. Previous attempts at a design of this type were no more than open sumps from which water was ladled and the supply controlled by means of ball-cocks (the ball-cock being contained and protected in a tamperproof compartment). The water in the ladling sumps soon became foul, thus defeating the object of that type of dispenser.

The later design, as illustrated, affords a dual supply : one from the ladling sump for wash water; the second from the spigot for clean water.

In operation, women simply conform to the customary procedure of drawing water by first cleaning out the container in which they are to carry water home. They then usually take a little water in that container for washing cooking utensils or for laundering, and lastly fill the container prior to their homeward journey. Thus the first drawing is from the low-level ladling sump and, because it is a group activity, the collective drawings of a number of women rapidly deplete the available quantity in that sump sufficiently to lower a large float which rides freely in an enclosed extension of the ladling sump.

This float is attached by a vertical rod or chain to a level-arm which is pivoted at the top of the structure enclosing the mechanism, at a point above a header tank. The mass of the lowered float draws a plug in the bottom outlet of the header tank, via the action of the lever-arm and an opposing rod or chain which is attached to the plug (see schematic drawing of the water dispenser).

A simply modified suction footvalve, attached with suitable pipe fittings in the bottom of the header tank, serves as a reliable plug (see detail drawing of outlet plug to header tank). The opened plug discharges clean water through a pipe which passes through the wall of the enclosing structure to a spigot situated high enough above the floor to enable a container to be placed below it.

After all water demands have been met, the flow from the spigot continues and by its position above a sloping floor which drains to the ladling sump, restores the float to its original position and causes the outlet plug in the header tank to reseal itself. A breather pipe, attached to the upper end of the spigot pipe just below the plug, allows air to be sucked into the spigot pipe as it evacuates, and prevents the plug from juddering in its seating when closing.

While outflow is maintained from the header tank, water flows from the elevated storage tank and eventually refills the system; a ball-cock in the header tank then stops the flow. The elevated storage tank is refilled by daily pumping or by gravity flow from source; that flow is also controlled by a ball-cock.

EXPERIENCE GAINED FROM A PROTOTYPE INSTALLATION

The design of the waterpoint, as described, was developed by the author in 1970. A full-scale prototype was erected at the Ministry of Agriculture's Henderson Research Station near Salisbury late in that year. The site was close to a traditional village accommodating some of the lowest grade agricultural labourers on the estate and their families. The Blair Research Laboratory of the Ministry of Health collaborated in this trial, which was for investigating the acceptability of the amenity to the community rather than a test of its mechanical efficiency.

The following quotation from the Report of the Secretary for Health for the year ended 31 December, 1971 (p. 34) describes the initial results obtained:

> "The block, then known as 'Fred's Folly', remained totally unused. A split bamboo screen was subsequently built around it. This gave privacy and yet it remained light and airy. Thenceforth all the women used it, and it was renamed 'Fred's Fountain'. No attempt was made to persuade people to accept it, and no rules were made for its use. However, the community by mutual consent made its own unstated rules, the most important of which was that no males, except infants, were allowed near or into the enclosure. An elderly woman took over the responsibility for the block which has since remained clean and neat, and which has totally replaced the traditional contact points on the river. Women from other compounds, even over the river, are now crossing the river to participate in the social intercourse at 'Fred's Fountain'."

The women of this village also voluntarily established a small enclosed vegetable garden at the outlet of the surface channel draining from the waterpoint. Waste water was efficiently used to irrigate this garden. Chickens were seen to scavenge scraps of food residue washed out of cooking utensils and left lying in the waste channel. The health risk which may arise from poultry droppings is considered negligible in comparison to that of stale food residues, which may otherwise have been ingested by small children.

A complaint was lodged by the women regarding visits to "their" waterpoint by women from other villages, as reported by the Ministry of Health. They particularly objected to visits by female members and wives of the staff of a nearby school, who were presumably not of the same social group. It is significant that all staff houses at the school are fully serviced, including piped water to kitchens and bathrooms.

At the time of publication of the report quoted, a male sweeper was appointed to attend to the cleanliness of all communal latrines and waterpoints on this large research station. He was inadvertently allowed to visit this installation as well. The women immediately abandoned its use and it fell into disrepair as well as being vandalised by youngsters. When the mistake was noted, some weeks later, apologies were made by the research station authorities and the sweeper was banished from the site. The women soon repaired the screen and roof and normal use of the waterpoint was resumed until the village was evacuated (for wartime security reasons) in 1978. At no time during its functioning history were any mechanical repairs required to the water dispensing system.

Because of the widespread popularity of the trial installation, it was difficult to assess the actual rate of water consumption per capita of the population served by this amenity. Clandestine automatic electronic pedestrian counters were installed on footpaths leading to the waterpoint. These indicated volume and source of traffic to the site, and counts were checked by occasional personal observations. Nevertheless, only an estimate of numbers of users could be made, against a known quantity of water dispensed monthly (as measured by a water meter on the supply pipeline). The results indicated an average daily consumption of sixty litres per capita of the population that may have been served by the amenity, including those members of households who did not visit the waterpoint but who may have used water brought from there. This rate increased to about a hundred litres during hot dry weather.

Of these amounts, less than half was carried back to homesteads for domestic use. The remainder - estimated to be between 6 000 and 10 000 litres per day in total - was used at the waterpoint and disposed of as waste on the vegetable garden.

During the initial trial period a patented type of water dispensing cock (manufactured in the U.S.A.), which limited discharge from the supply pipe to a specific quantity over a specific time period at intervals, was surreptitiously installed in the waterpoint. It was irreparably damaged within two weeks.

ON-FARM APPLICATIONS OF THE PROVEN DESIGN

In the Report of the Secretary for Health for the year ended 31 December, 1972, it is quoted (p. 32) that:

> "This design has the minimum of working parts which could be subjected to damage and it may have practical applications on European-owned farming compounds".

The same Report for the year ended 31 December 1974, states (p. 29):

> "The assessment of the acceptability of such washing facilities (as described in this paper) is a painstaking process, and results cannot be achieved in a short space of time. However, already basic designs have been evaluated and in areas where piped water supplies are available, very cheap and very simple wash pads can be made so popular with the African community, particularly the women, that contact with natural waters becomes minimal."

That report also states that the design, with various modifications, had been tried on a number of farms in the most populated and well-watered commercial farming region of Zimbabwe, with such beneficial results that demands for advice and guidance on the design had increased considerably during that year.

The similar Report for 1975 reiterates the last statement (p. 27) and continues:

> "At least in localized areas, it is believed that this (design) has already led to considerable decrease in the extent of contact with open natural waterbodies".

The 1976 Report states (p. 27) that the design, with variations but adhering to the essential concept, is "having a significantly good reception by the African communities using them".

Therefore, the essential concept, at least, of providing a specially designed and built amenity outside rural African villages for the private and sociable use of the communities' women for purposes of using and collecting water appears to be valid. As will have been seen in this first report of this investigation, that concept was formulated on the evidence of sociological influences which were observed as operating in the functional activities of rural African communities, and not on the basis of purely technological considerations.

It is clear that successful innovation in the field of providing services and for purposes of large-scale amelioration of environmental degradation, accords with social and functional traditions of the involved communities - particularly unsophisticated communities - and is not accomplished by the imposition of imported technology. This is a well-worn lesson but frequently forgotten in the excitement and glamour of modern technological advances.

CUT-AWAY VIEW OF VILLAGE WATERPOINT

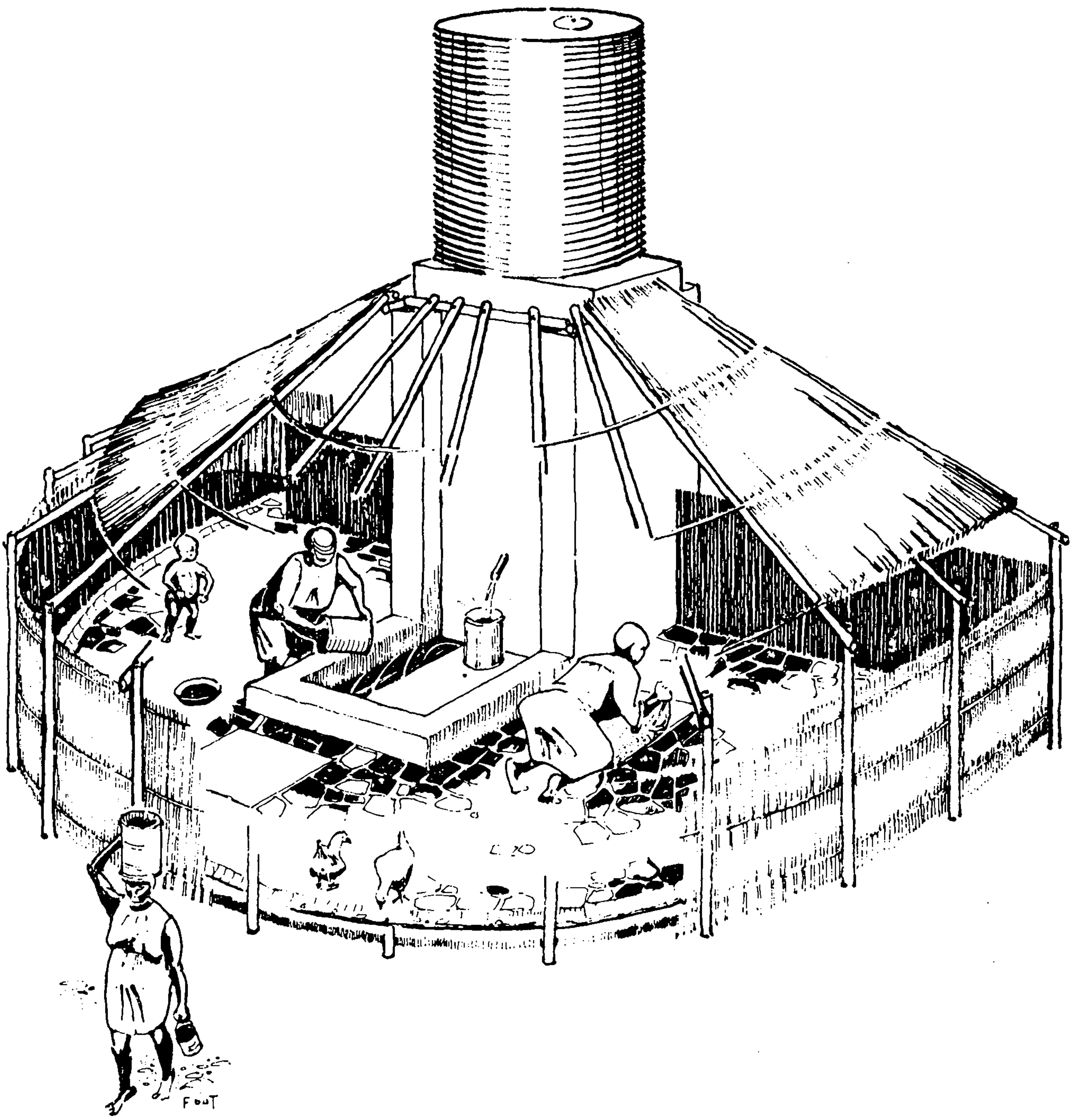

FIGURE II

PLAN OF WATERPOINT

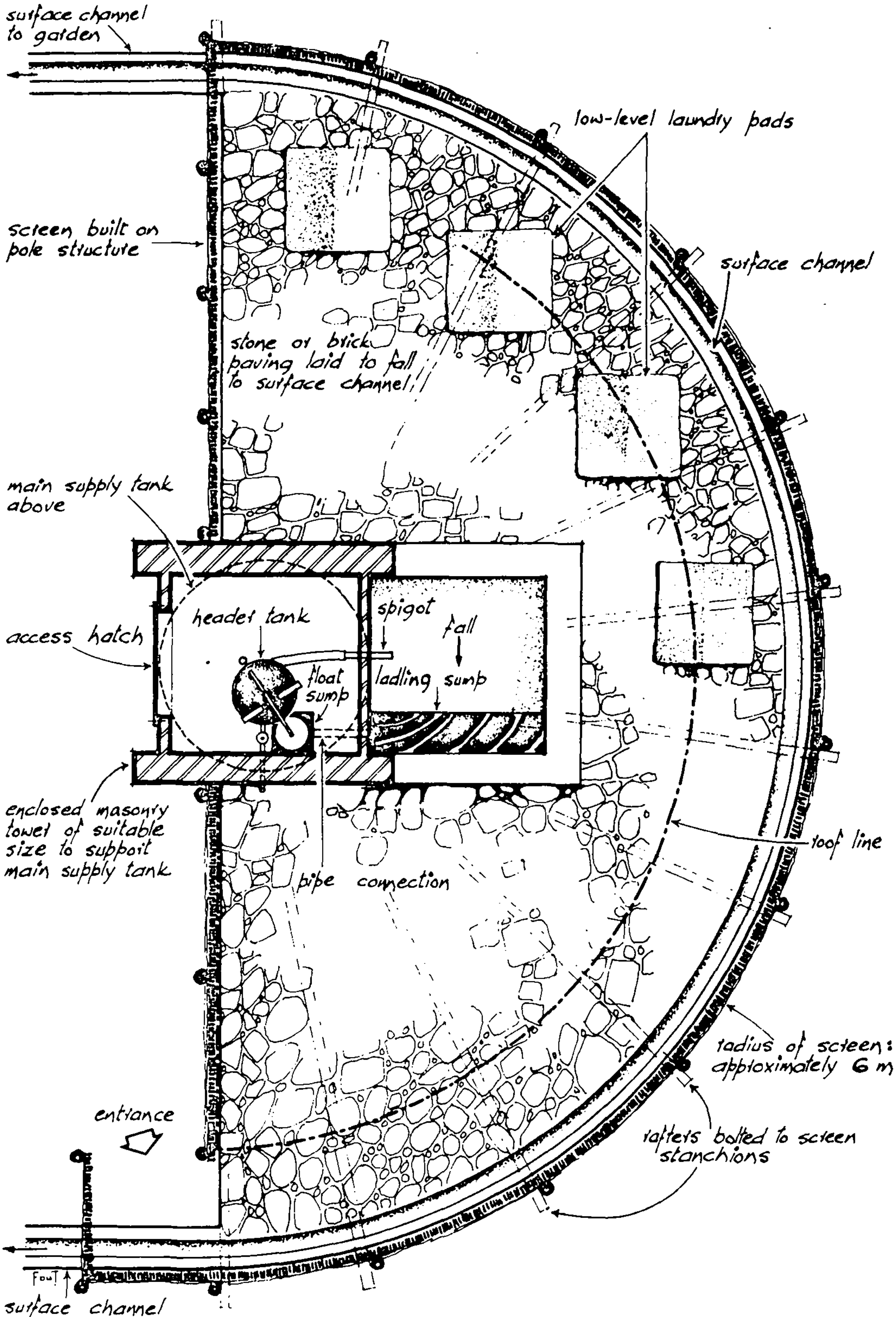

FIGURE IV

SCHEMATIC DRAWING OF WATER DISPENSER

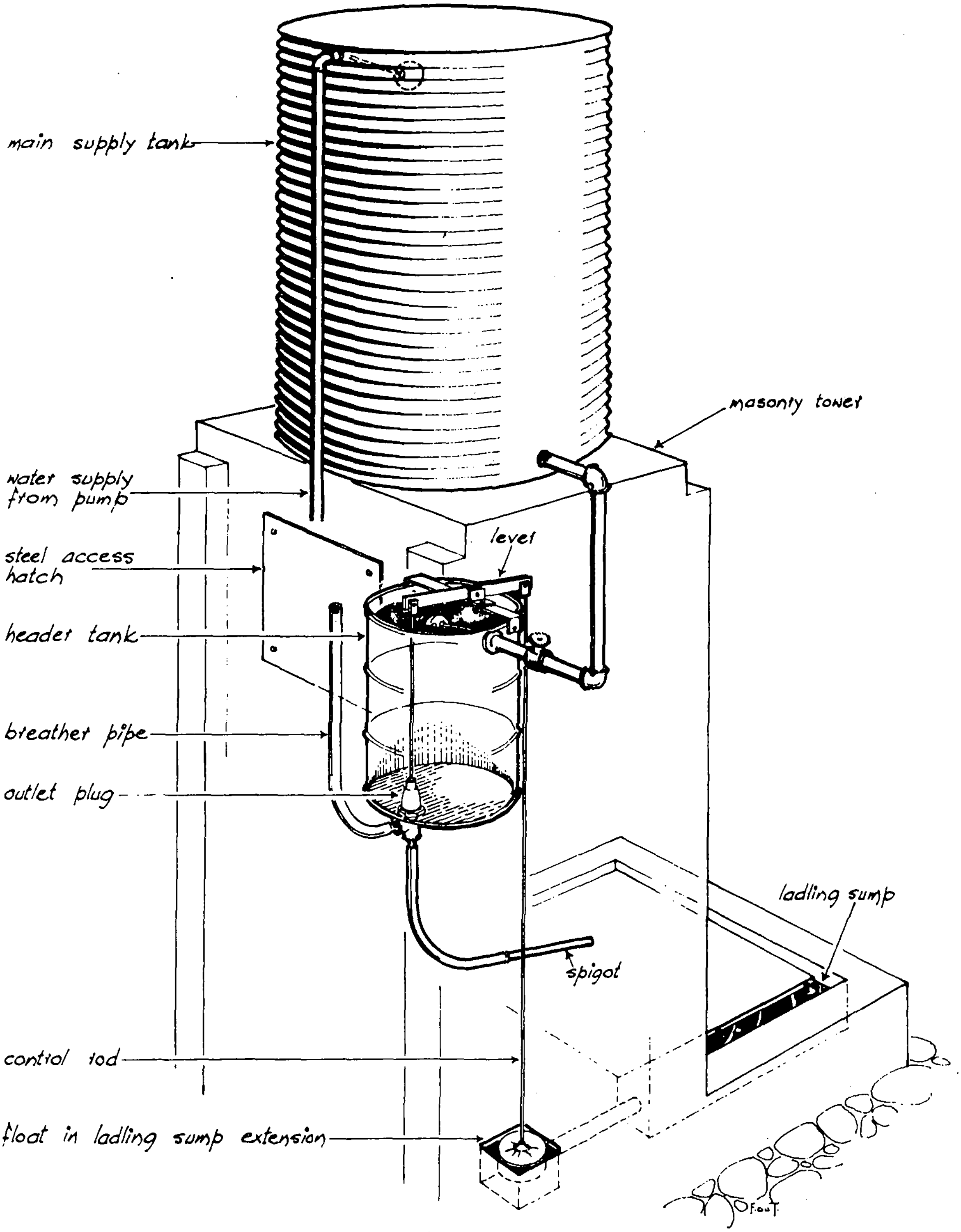

FIGURE I

DETAIL OF OUTLET PLUG TO HEADER TANK

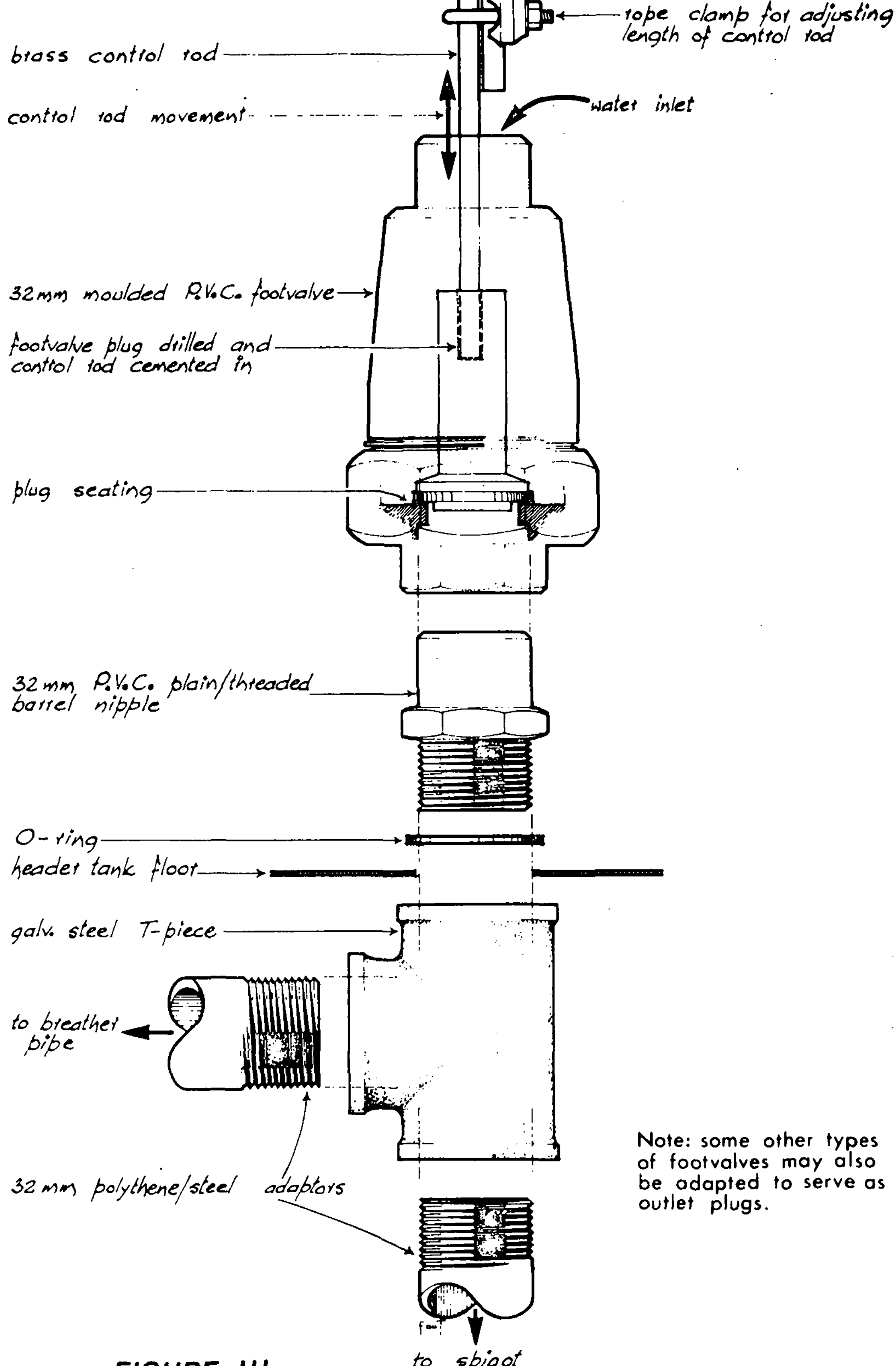

FIGURE III

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WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

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Paper 8
Referaat 8

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Sanitation, water supply, drainage/Sanitasie, watervoorsiening, dreinering

A REVIEW OF PROBLEMS IN SANITARY ENGINEERING

by C.J. D. Webster*

SYNOPSIS

This paper considers some of the difficulties that can arise when a country indiscriminately imports technology in the field of water supply and drainage in buildings. A knowledge of the behaviour of the alternative systems used elsewhere is not sufficient; it is also necessary to understand the context in which the systems have been successfully used, e.g. regulations and enforcement procedures. The more important performance requirements are considered and similarities, differences and trends are reviewed.

SAMEVATTING

Hierdie referaat neem sommige van die probleme in oorweging wat kan voorkom indien 'n land onoordeelkundig te werk gaan met die toepassing van tegnologie op die gebied van watervoorsiening en dreinering in geboue. Kennis van die gedrag van alternatiewe stelsels wat elders gebruik word, is onvoldoende; dit is ook noodsaaklik om die verband waarin die stelsels suksesvol aangewend is, te begryp, bv. regulasies en afdwingingsprosedures. Die belangriker gedragsvereistes word oorweeg en ooreenkomste, verskille en neigings word in oënskou geneem.

* *Head, Public Health Engineering Section, Building Research Station, Garston, Watford, England.*

A. INTRODUCTION

The design of water supply and drainage systems differs significantly from country to country, and sometimes also from region to region within countries. These differences arise from many factors: some arise only for historical reasons because each country has a traditional way of doing things and this is often reflected in what is acceptable within local regulations. Others arise from real differences in the users' behaviour, resulting from climate or cultural influences, or from the degree of concentration of the population, and also from the availability of resources, especially water and finance.

In any single country, the predominance of one or more of these factors will largely determine the system most likely to be used. Some countries also use regional variations of the 'typical' system which may be a response to local requirements. Occasionally these are analagous to the needs of another country.

When a country attempts to import technology in the field of water supply and drainage, the range of alternative systems should first be identified. Secondly the building control procedures, availability of skilled labour, charging policies for water, maintenance, etc. of the different systems need to be studied, all of which affect the successful operation of a system. Without this, a successful system can be 'transplanted' into different circumstances in good faith, and it will fail to perform satisfactorily. There is also a need to look at the value judgements which determine the main requirements of the system, since these may be unsuited to a different location. This calls for considerable time and a knowledge of sanitary practice in many different countries. Fortunately one unifying influence is that the more important performance factors for water supply and drainage systems are basically the same in all countries. These are:

(i) contamination of water supply;
(ii) water wastage;
(iii) safety;
(iv) contamination from the drains; and
(v) the blockage of the drains.

This paper is limited to an appraisal of these performance requirements, together with a brief review of some of the similarities and differences between countries, and hopefully provides a foundation on which a more detailed comparative study can be built.

B. CONTAMINATION OF WATER SUPPLY

Protection against contamination may be aimed simply at the level of protecting the distribution system from the user, or it can be designed to provide an additional level of protection between the different points of use within the same building. Looking at the situation internationally, there appears to be general agreement that the primary protection should be at the point of use, and that this should preferably be an air gap, which, if maintained at every outlet, gives protection at both levels. However, in some cases where the use of an air break between the supply and the contaminated water is impractical, an alternative must be used, which could consist of an anti-vacuum valve, i.e. a vacuum breaker, a check valve, a pipe interrupter, etc.

In addition to the primary protection at the point of use, sometimes a secondary level of protection is also used, partly because air gaps can be invalidated by hose connections. In Germany a terminal anti-vacuum valve is used at the head of the rising pipe together with a check valve in the consumer connection at the inlet to the property. In the United Kingdom, where storage cisterns are used, the discharge into the cistern provides a second air gap between the supply main and the point of use. In several countries a check valve is used in the consumer connection at the entry to the property.

In addition to the backsiphonage protection described above, the check valve, and other valves which have a similar check action are the major means for protection against cross connections. Another technique where practicable, is for the water supply to enter a storage vessel which overflows if a high pressure connection is made downstream of the outlet.

C. WATER WASTAGE

Serious losses of water can occur through leakage from underground water supply pipework. In the United Kingdom, for example, this has been estimated to account for up to 25 per cent of total water distributed by water supply authorities[1]. Measures are available for locating major leaks, but it can be uneconomical to repair an accumulation of minor leaks, depending on the local cost of water. Leakage inside buildings is much less of a problem, except with W.C.s, since leakage can be seen and will cause internal damage if neglected.

Apart from leakage, economy in the use of water is an important issue. It is estimated that in the United Kingdom about 20 per cent of the water supplied by water authorities is used for flushing W.C.s, either in the home, or elsewhere, and a further 30 per cent is consumed by other domestic uses.

The W.C. and its flushing mechanism are clearly of major significance in water economy. The flush volumes in widespread use range from 14 litres (and more) in the United States of America, to 9 litres in most of Europe, to 6 litres in Scandinavia. Three litre W.C.s are already available and have a promising performance although they are not yet widely used. Reliable clearance of solids is achieved with this small volume of flushing water, although the bowl surface of such W.C.'s may need more frequent cleaning than that of traditional pans. It is significant that so far there has been no confirmation of the fears that blocked drains would result from such a large reduction in flush volume.

The flushing mechanism for the W.C. is also an object of interest. It can be a flush valve, a valve operated cistern or a syphon operated cistern. The flush valve is not encouraged by water authorities in the United Kingdom, and possibly other countries, because tests showe that the initial discharge volume setting increases during the period after installation. The valve operated cistern provides a simple and effective flushing mechanism, but after a typical life of about 5 years, maintenance is required to ensure efficient seating of the valve, otherwise a continuous leakage of water into the pan will result. Because this leakage causes little or no inconvenience to the user, it is often neglected and negates any improvement in flushing efficiency that the valve cistern provides compared with a syphon type. These problems are avoided where regular inspections of the equipment are carried out, and also where metering charges are large enough to provide sufficient inducement. In the United Kingdom the problem has been reduced to negligible proportions by the use of syphontype cisterns, which dispense with the need for a valve of any sort and so prevents any leakage into the bowl.

Although urinals are estimated to use only 1 or 2 per cent of the total public water supply in the United Kingdom, and probably a similar amount in other countries, they do present some problems from the point of view of water economy. Flushing on a regular routine is an obvious waste when urinals are not in use, whereas individual flush valves will be just as prolific in water use with intensively used urinals as will also be the case with automatic sensing devices for flushing. Experiments are at present directed towards the use of urinals that use no water at all, and the results so far are very encouraging.

Washing and showering is another area where economy is possible. Spray taps for hand rinsing are available with flow rates of 0,04 ℓ/s, and experimental units which use as little as 0,005 ℓ/s have been developed and tested at Building Research Establishment (BRE), using atomiser jets. Rates of flow from showers vary widely. Quoted figures for the United States of America show a range from 0,25 ℓ/s to 0,5 ℓ/s, while those for most of Europe range from 0,4 ℓ/s to 0,6 ℓ/s. The United Kingdom has significantly lower flow rates of about 0,10 ℓ/s, and experiments with subjects using atomiser showers show that flows of as little as 0,015 ℓ/s can be envisaged.

D. SAFETY

The primary requirement for the safety of hot water systems is that explosions should be prevented. In the case of a steam vessel, it is impossible to eliminate the hazard of the pressure energy which is associated with any gas or vapour stored under pressure. Hot water stored at temperatures above boiling point at atmospheric pressure is even more hazardous since it can flash into steam violently in failure conditions, releasing the latent energy associated with the change of state. Such hazards are unnecessary in hot water systems where lower temperatures are adequate, and the fundamental requirement is therefore to limit the temperature. Different countries achieve this in different ways, using different numbers and combinations of devices. The thermostat is the main means of temperature control in all countries, but beyond this, differences arise. Both Germany and the United States of America, for example, use an energy cut out as a safety measure that will disconnect the energy supply if thermostatic control fails and allows the water temperature to approach boiling point. In the United States of America a third safety measure is used in the form of a thermal relief valve that limits the temperature by allowing the discharge of hot water, thus dissipating energy at the same rate as the power input without an unacceptable rise in pressure. In the United Kingdom, where vented systems are used, the vent is considered to perform an equivalent but not identical function.

The question of pressure relief valves is more complex as different countries appear to rate them for different duties. Where check valves or valves with a check action are installed on the supply to a heater, the need to release expansion water arises (unless an expansion vessel is used), to ensure that the heater does not fail. In Germany such expansion relief valves are fitted in the cold water supply pipe to the heater, and the rated capacity need only be low for this duty. In the United States of America, on the other hand, where check valves are not widely used in the supply pipe, and where pressure reducing valves can be fitted with facilities for reverse flow, the expansion relief is not normally required, and a pressure relief valve is incorporated with the temperature relief valve to provide an additional safety measure. Here the opportunity is taken to give the valve a steam rating commensurate with the power of the boiler, so that this acts as a another safety measure.

There are clearly significant differences between the practice in different countries and it is not easy to know how many safety measures are really necessary. This is not made any easier since the overall reliability of the safety measures is a function of the reliability of the devices which constitute each of the separate 'lines of defence', i.e. two reliable devices are better than three unreliable ones. Unfortunately, very little information on this subject is generally available.

E. CONTAMINATION FROM THE DRAINS

Drains should not leak, and good workmanship and inspection are important, but the major need is to seal off the foul drainage system from the building itself. The solution, which has been virtually universally adopted, is to use a water seal trap. However, in spite of this measure of uniformity, there are wide differences in standard depths of seal currently in use in different countries as is shown in Table 1. These figures are for nominal trap seal heights and the dimensions vary widely, but it cannot be assumed that all systems with deeper seal traps are safer than others. During the discharge of the appliance, some of the water seal from the trap is lost and this discharge loss reduces the effective seal height. Furthermore, some of the water that remains in the trap

Appliance	Trap depth of seal mm						
	Belgium	Switzerland	Denmark	Germany	Netherlands	Sweden	United Kingdom
Wash basin	60	70	50	60	60	50	75
Sink	50	70	50	60	60	50	75
Bath	50	70	50	60	60	50	75
Shower	50	70	50	50	?	50	75
Urinal Bowl							

TABLE 1 : DEPTH OF SEAL IN TRAPS

evaporates before the next discharge and this evaporation loss further reduces the effective seal height to a residual value. It is this value which is important and that dictates the maximum air pressure variation which can occur in the drainage stack without breakdown of the seal. The limiting values that need to be assigned to the three factors, namely discharge loss, evaporation loss and residual seal depend on different circumstances. Discharge loss depends largely on the configuration of the branch pipework connecting the appliance to the drainage stack, and vent stack, if any. The evaporation loss depends on frequency of use, ambient temperatures and humidity and increases in hot climates. The necessary residual seal depends on the air pressures in the drainage stack, which in turn depends largely on its configuration and loading. In low rise buildings, pressure variations can be small. Because the majority of W.C.s in use have a 50 mm nominal seal depth, this has internationally a unifying influence on design in practice. In the United Kingdom, a 25 mm evaporation loss is allowed for, and because W.C. branch pipework is sized so that there is no discharge loss, a residual seal of 25 mm is available to accommodate pressure fluctuations in the drainage stack. Design procedures are written to keep within this limitation. With other appliances, economical design of branch pipework results in some discharge loss, and traps of greater nominal seal are necessary. Conversely, though, lower depths of seal are used where appliances do not connect to stacks and are not subject to its pressure fluctuation. In hot countries, with low rise buildings and lightly loaded stacks, the situation would be different in that the evaporation loss could be higher, while the pressure variations in the stack, which dictate the residual seal, might be lower.

F. BLOCKAGE OF DRAINS

It is somewhat more difficult to form a coherent picture of developments internationally in this field. The cause of blockages are diverse, but can nevertheless be conveniently classified under:

(i) misuse;
(ii) poor design; and
(iii) poor installation.

The user today makes more onerous demands on the drainage system than in former times using disposable napkins, macerators, etc. but the tendency is to design these components to suit the drains so that they do not block rather than to design the drains to suit the components. On the other hand, blockages arising from blatant misuse are unavoidable unless the understanding of the user is improved. The best action for the designer is possibly to ensure as far as possible that such blockages occur at the point of the introduction of the object into the system.

The British Research Establishment used a T.V. camera to investigate the condition of installed drains in which blockages had occurred[2]. The results of this study showed that most of the drains were either badly installed or had been subjected to subsequent damage or had deteriorated. Defects arising from the design procedures were rarely encountered.

A survey done some years earlier on several hundred drains included a study of the effect of design parameters, and the researchers tried to relate design gradient to the frequency of blockage. However they were unable to identify any clear effect over a wide range of gradients. In general, drainage systems appear to tolerate wide departures from the design parameters of gradient and loading without significant numbers of blockages occurring. It is therefore not the design procedures that are usually as crucial as the correct installation procedures.

The survey above also resulted in the British Research Establishment questioning the viability of the traditional application of self-cleansing velocities in the upper reaches of drains, and to propose a different concept of drain operation. Flow is essentially intermittent, even when the pipework serves quite large numbers of dwellings. The discharge flow is normally of a wave form, close to the point of connection of the appliance or stack to the underground system. As this flush wave travels along the pipe, its velocity and depth decrease, the attenuation of the flush wave depending on the gradient, pipe diameter and roughness, as well as the occurrence of simultaneous discharges from other appliances connected to the system. Solids, etc, are transported in the water discharge a distance behind the front of the wave, but do not progress steadily through the whole length of the drainage system. When the velocity and depth of flow drops sufficiently, the material is deposited (as described in numerous papers from Brunel University[3]). The solids can then be picked up again by a subsequent flush wave arising from the same, or some other, appliance connected to the drain. If such flush waves are insufficient to move the deposited solids, the discharged water permeates through and past the deposits, and, in doing so, additional solids are filtered out. As more solids are added to the barrage, the permeability decreases and the height of the water accumulated upstream increases until there is sufficient hydraulic pressure for all the solids to move in what becomes a new and substantial secondary flush wave. Therefore, the normal mode of operation for the upper reaches of the drain includes the intermittent formation of stoppages. For these stoppages to become potential blockages, other factors must come into play, such as adhesion to the pipe in the case of longer term stoppages. The behaviour of drainage systems is also being increasingly studied in relation to the effect of W.C.s which use low flush volumes. The effect of W.C.s using a 3 litre flush on real drains is currently being studied in Denmark and elsewhere, and so far there has been little evidence of blocking of the drains.

G. CONCLUSIONS

Different countries have developed slightly different solutions to the problems of water supply and drainage buildings, and in many cases, national regulations inhibit the complete adoption of other systems. They all perform satisfactorily but the differences between them provide their own relative advantages and disadvantages.

It is not always easy to appreciate the subtleties of these differences in each case without a deeper understanding of the particular system and the whole context in which it is installed and used, together with some indication of the value judgements which originally favoured the particular alternative adopted. When using the technology of one country in another country, a re-examination of these value judgements is needed, since they are sometimes dependent on local conditions and climatic factors, and are even sometimes irrational.

It is not possible in a short paper to present a detailed picture of all the factors relevant to the differences between national systems, but this paper attempts to make a start by identifying some of the factors which form a common denominator to all the systems, and indicates some of the departures. It is hoped that it will contribute to a better understanding of the range of technology in the fields that is available to us.

REFERENCES

1. NATIONAL WATER COUNCIL. *First report of working group on waste of water,* United Kingdom 1976.

2. LILLYWHITE, M.S.T., WEBSTER, C.J.D. *Investigation of drain blockages and their implications on design.* The Public Health Engineer, April, 1979.

3. SWAFFIELD, J.A., WAKELIN, R.H.M. *An analysis of the transport of waste solids in internal drainage systems.* Proc. CIB W62, May, 1977. Symposia, Oslo.

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WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
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Paper 9
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Organized by the National Building Research Institute of the CSIR
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KEYWORDS
SLEUTELWOORDE

Developing countries, water supply, drainage/ Ontwikkelende lande, watervoorsiening, dreinering

THE PROBLEMS OF DEVELOPING COUNTRIES IN THE CONTEXT OF WATER SUPPLY AND DRAINAGE SERVICES

by F. Perrier*

SYNOPSIS

The needs of developing countries for water supply and drainage are very briefly reviewed, together with the problems these countries encounter and the assistance they expect from developed countries.

SAMEVATTING

Die behoefte van ontwikkelende lande aan watervoorsiening en dreinering word kortliks in oënskou geneem tesame met die probleme waarmee die lande te kampe het en die mate van bystand wat hulle van ontwikkelde lande verwag.

* *Centre Scientifique et Technique du Bâtiment, Paris, France.*

INTRODUCTION

In 1978, the CIB W62 Working Commission : 'Water supply and drainage in buildings' decided to study how best to assist developing countries.

Since then, an inquiry has been conducted among CIB members to establish the needs of developing countries and to define the actions W62 might undertake; the Commission has also been in touch with the World Health Organization (WHO).

This theme was placed on the agenda of the W62 seminar which took place in France in November 1979. Several papers were presented by delegates from developing countries.

The aim of the present paper, based on the data gathered by W62 over a period of two years, is briefly to survey the water supply and drainage problems of developing countries.

THE NEEDS

In this respect, two issues must be considered - water supply and the disposal of waste, such as polluted waters (waste and sewage waters and human excreta).

Despite the fact that water is plentiful on Earth, it is nevertheless a relatively scarce resource, since less than 1 per cent can be directly used by man. Moreover this water is not equally distributed, so that many countries (generally developing countries) have not enough of it for their needs.

This results in the use of contaminated waters and the existence of poor sanitary conditions which often generate diseases, including cholera, typhoid, dysentery and leptospirosis. Much has already been done to improve water supply and drainage, but much remains to be done, as shown in Tables 1 and 2 which have been compiled from the data given in a WHO report.

From Table 1, for instance, it can be seen that, in 1975, 62 per cent of the population of developing countries, that is about 1 250 million people, did not have a good water supply and 68 per cent of this population had no appropriate means of disposing of human excreta.

If we consider rural populations, these percentages are still more important since they reach 78 per cent and 86 per cent respectively.

In Table 2, some data from Table 1 are set out in more detail and the target percentages for 1980 are given.

The issue is so important that the UN Water Conference has asked the 1981 - 1990 decade to be called: 'International decade for potable water supply and sanitation'.

TABLE 1 : Estimated population having a public water supply and human excreta disposal systems in developing countries. (China not included.) (based on a mid-decade survey in 1975)

Water supply — Population reasonably supplied (connection to blocks of flats or reasonable access)

Area	1970 in millions	1970 Per cent of the total population	1975 in millions	1975 Per cent of the total population
Urban	315	67	445	76
Rural	180	14	310	22
Total	495	29	755	38

Excreta disposal — Population reasonably supplied (public sewers or domestic devices)

Area	1970 in millions	1970 Per cent of the total population	1975 in millions	1975 Per cent of the total population
Urban	340	72	435	75
Rural	115	9	195	14
Total	455	25	630	32

WATER AND WASTES

In the period of time during which water is collected, used, disposed of and then discharged or reused, a series of processes take place which are schematically shown on Figure 1.

THE PROBLEMS

In developing countries, problems are met with at every level of the 'chain' represented in Figure 1. (See page 4.) They will not all be considered here, for that would be going out of the W62 field. Therefore only water supply, use and drainage will be discussed.

In towns and urban centres, methods of supply are similar to those used in industrialized countries; this means that water is supplied directly to the place where it is used. In rural areas and in certain urban areas, the problem is different : 'sure' water-catching points must be provided, where they will be adequately accessible for a group of users, so that in the latter case 'the user goes to the water' while in the former case 'water goes to the user'.

WHO uses the term 'sure water' to describe surface waters, treated or untreated but uncontaminated, such as can be found in springs, protected drillings and sanitary wells.

TABLE 2 : 1980 objectives taking account of the progress achieved during the period 1971 - 1975

	Percentage of the urban population supplied									Percentage of rural population with easy access to 'sure' water			Percentage of total population supplied	
	By connection to blocks of flats			By public supply			Total (connections to buildings or public supply)							
	Achieved		Aim	Achieved		Aim	Achieved		Aim	Achieved		Aim	Achieved	
Water supply	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975
	50	57	68	17	19	23	67	76	91	14	22	26	29	38

	Percentage of the urban population supplied									Percentage of rural population with appropriate device			Percentage of total population supplied	
	By connection to a public sewers system			By domestic devices			Total (connections to sewers or domestic devices)							
	Achieved		Aim	Achieved		Aim	Achieved		Aim	Achieved		Aim	Achieved	
Excreta disposal	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975	1980	1970	1975
	28	25	38	(44)	(50)	56	72	75	94	9	14	24	25	32

By 'reasonable access' in an urban area, WHO means a fountain (or any other similar source) less than 200 m from a house. In rural areas 'reasonable access' means that the housewife or family members must not spend a considerable part of the day in fetching the water they require.

The same problems are met again when it comes to dealing with drainage and the treatment of human excreta. In towns and populated areas, the techniques used are of the 'wet drainage' type as in industrialized countries.Conversely, in rural areas where water is scarce, such techniques cannot easily be considered and other solutions must be found.

Besides these essential issues linked to water shortage and, especially, potable water shortage, other factors must also be taken into account such as lack of financial resources, lack of skilled labour, poor technological level, lack of community incentive, lack of infrastructures, unstable governments, and so on.

POSSIBLE HELP

The inquiry conducted among W62 members to ascertain how to help developing countries has revealed that most of them did not clearly appreciate what was to be done and what might be done. However, thanks to the investigation a certain number of actions have been defined concerning:

The spreading of knowledge: Developing countries want to be informed about research work that is being undertaken in the different institutes, and they wish to have:

- clear research reports, explicitly stating the results obtained;
- synthesized reports when several research studies have been done on the same subject;
- exchanges between institutes working in the same field;
- the setting up of common research programmes of interest both to developing and industrialized countries.

The working out of technical regulations: Many countries have no regulations or normative documents (Standards, Specifications, simple design rules) of their own; they adopt those of industrialized countries. But it is an error to adopt them as they stand. What they really need is assistance in drawing up simpler documents that are more suitable for their needs.

Research: To be effective, research must comply with several conditions. It must -

- be done when asked for by developing countries and specifically for them: it is up to them to define their own needs and not to have them defined by others;
- take into account the geographic, climatological, economic, socio-cultural circumstances of these countries, their surroundings and their way of life. Most problems are society oriented (way of life, customs, etc.). It is difficult suddenly to change ancestral habits.
  As Mr Ballance of WHO points out: *'A disposal system that requires periodic removal of the accumulated excreta is a non-starter in those areas of the world where the handling of excreta is a cultural taboo'*;
- take into account the fact that these countries require cheap, reliable and durable installations, which are easy to provide and maintain with local labour, using, whenever possible, equipment and materials that can be found or fabricated locally so as to have lower import and transportation costs and to develop local industry or craftmanship.

To be more specific, research work is necessary on:

- plastics pipes;
- prefabricated sanitary units : water-units, shower-units and WC-units and combined units;
- robust and economic taps : flush-cocks, automatically closing taps;
- devices for dry disposal of excreta;
- and so on.

CONCLUSIONS

These few considerations show that much remains to be done for developing countries concerning water supply and drainage in buildings. If results are to be achieved, there must be close cooperation between industrialized and developing countries. The socio-cultural characteristics of the final users must never be forgotten : adapting techniques is easier than changing people.

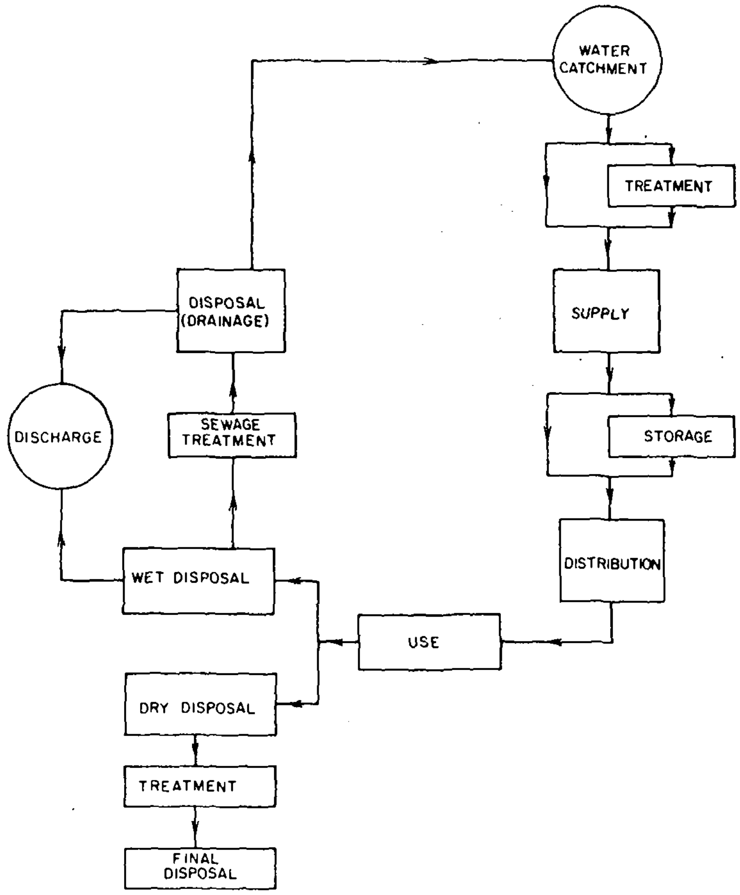

FIGURE 1

Processes in the cycle of collection, use, disposal, discharge and reuse of water

REFERENCES

DIETERICH, B.H. International collaboration for improving water supply in developing countries. *Journal AWWA*, November 1977.

BALLANCE, Dr Richard C. Water supply, sanitation and technology - (Community Water Supply and Sanitation Unit - World Health Organization - Geneva). *Interdisciplinary Science Reviews*, Vol. 3, No. 3, 1978.

HOOGENDOORN, W.K. Why WHO sets its POETRI in motion, *World water*, June 1979.

WORLD HEALTH ORGANIZATION, *Community water supply and waste water disposal* (mid-decade progress report), May 1976.

HANSLIN, R. (Switzerland), *Review of plumbing techniques for developing countries - Strategy possibilities*, Communication to W62 Seminar 27/28.11.1979.

LANDI, F.R. and MONTENEGRO, M.H.F. (Brazil), *Plumbing systems in Brazil - Situation and needs*, Communication to W62 Seminar 27/28.11.1979.

MATHUR, G.C. (India). *Management of potable water supply in the problem villages of developing countries*, Communication to W62 Seminar 27/28.11.1979.

DE KRUIJFF, G.J.W. (Kenya). *Water supply improvements for upgrading areas*, Communication to W62 Seminar 27/28.11.1979.

BIRKELAND, Ø. *Sanitary installation in developing countries*, Communication to W.62 Seminar 27/28.11.1979.

ZAWIDE, F. *Assessment of the sanitary section of the draft building code for Ethiopia*.

MATHIEU, H. L'eau et les déchets urbains, C.R.U. Paris. *Encyclopédie des sciences*, Grange Batelière, éditions Atlas, Paris.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 10
Referaat 10

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water closet, sewerage systems, measurements/ spoelkloset, rioolstelsels, afmetings

NEW EVALUATION METHODS OF W.C. SYSTEMS

By H.J. Knoblauch*

SYNOPSIS

The objective of a research project carried out at the 'Technische Fachhochschule' in Berlin was to establish which measurable factors influenced the flushing performance of W.C. cisterns and bowls. The measuring methods used are described and the results are evaluated in terms of desirable bowl design and cistern capacity.

SAMEVATTING

Die doel van 'n navorsingsprojek, wat by die 'Technische Fachhochschule' in Berlyn uitgevoer is, was om vas te stel watter meetbare faktore die uitspoelgedrag van spoelklosetwaterbakke beïnvloed. Die meetmetodes wat gebruik is, word beskryf en die resultate volgens gewenste bakontwerp en spoelbakkapasiteit geëvalueer.

* *Technische Fachhochschule, Berlin, Germany.*

1. INTRODUCTION

The flushing performance of a closet bowl is represented by its ability to evacuate faecal matter and paper in the flushing process. It would be a coincidence, if the flushing water volume required for this evacuation and the amount of water absolutely necessary to cause a self-cleaning of the drainage pipes behind the W.C. were identical.

At the beginning of this research project which was carried out at the 'Technische Fachhochschule' in Berlin in the laboratory for plumbing technology, the water volume needed to flush solids out of the bowl and to rinse the trap was not known. Therefore, the first goal of this research was to establish measurable factors for the purpose of evaluating the flushing performance. These factors had to be related to the W.C. and to the self-cleansing of a defined drainage system, or they had to be related to the flushing performance of the W.C., and to floating in the drainage system.

By using the measuring methods described below, it was possible to present the flushing performance of a W.C. in such a way that it could be evaluated, making possible a classification of W.C.'s with regard to flushing performance. It was necessary to use a flushing solid, which was very similar to natural faecal matter in rheological structure, as a test specimen.

2. NEW MEASURING METHOD TO EVALUATE FLUSHING PERFORMANCE

The common methods of evaluating W.C.'s currently used are limited to testing the evacuation of solid or spongelike faecal matter substitutes and paper separately.

These tests result in a positive or negative evaluation and do not identify the reasons for failure or success. In the first part of this research project, tests with 19 W.C. models manufactured in Germany showed that flushing performance can be classified using experimental data[1]. *Figure 1* shows:

(a) the *flow rate* Q_4 defined as the discharge rate of the W.C. of which the maximum value corresponds to a deviation of 1,5 sec., and

(b) the *afterflow* V_N defined as V_{NF} when referring to the faecal matter substitute and V_{NP} when referring to paper.

The flow measuring equipment developed by the Swiss firm, GEBERIT AG *(Figure 2)*, simultaneously records the flow volume - time diagram (ΣV) and the flow rate - time diagram $Q = dV/dt$.

The presence of flushing solids influences the pattern of both characteristic curves individually. The moment the flushing solid leaves the bowl can be registered on the third curve. After considering the delay values which depend on the flow rate, (i.e. the time difference between the exit of the solids and the recording of the flow rate), the afterflow criteria V_{NF} and V_{NP} can be projected on the flow rate-time and flow volume-time curves by registering the moment of evacuation of the solids.

The first requirement for the tests is to obtain a paste-like faecal matter substitute with the same consistency as natural faecal matter. The FAKAZELL mush[2], which was especially developed for this project, has the following characteristics:

(i) it has an adaptable density and consistency;
(ii) it does not decompose;
(iii) it has no unpleasant odour:
(iv) it does not disintegrate in water;
(v) it does not irritate the skin;
(vi) it is harmless to drainage systems; and
(vii) it can be uniformly coloured.

Figure 3(a) shows how FAKAZELL is placed in the bowl, and *Figure 3(b)* its rheological behaviour in the course of 10 days.

The following Figures show the evaluation characteristics of closet bowls on measurement recordings.

Figure 4 shows the characteristic curve without test objects for a closet bowl. The discharge rate is $Q_4 = 1{,}6$ ℓ/s with a total flushing water volume of $V_{ges} = 6{,}0$ ℓ/s.

Figure 5 shows the characteristic curve when 200 g of FAKAZELL, with a density of 1,03 kg/ℓ and a rigidity of 9 mm according to DIN 4211 (the measurement of consistency), together with 8 pieces of toilet paper were readily flushed from the bowl repeatedly. The final value of ΣV compared with the first value V_{ges} is considerably lower, because of the displacement volume of the flushing solids. The closer the characteristic curves are grouped together, the better the repeatability is.

Figure 6 shows the characteristic curve without test objects for a universal type closet bowl, which can be used with a cistern or a flushing valve. The discharge rate is $Q_4 = 1{,}2$ ℓ/s.

Figure 7 shows the characteristic curve when the flushing solid is caught in the trap of the bowl. The discharge rate drops to 0,5 ℓ/s. After two flushings the breakthrough of the flushing solid results. The solid still does not evacuate after the third flushing.

The closet bowl evaluated in the first two measurement recordings has a steady characteristic with a large afterflow. A flushing with $V_{ges} = 6{,}0$ ℓ guarantees a reliability. The measurement recordings in the last two curves clearly show the unreliability of the tested closet bowl. Flushing with $V_{ges} = 6{,}0$ ℓ is not justified.

Tests should be carried out using FAKAZELL samples which range both above and below the density of water. Not less than 10 tests should be carried out with each sample.

3. EVALUATION OF THE FLUSHING OUT PERFORMANCE IN BRANCHES AND STACKS

The flushing water volume should not only rinse the closet bowl, but should also guarantee the self-cleansing of drainage pipes. It has not yet been proved that flushing volumes of less than 9,0 ℓ will produce self-cleansing in drainage pipes.

Current testing regulations provide for approval of commercial W.C.'s with a 6,0 ℓ flushing water volume by means of tests which indicate pass or fail for the W.C. only and do not relate to the drainage system. Criteria necessary to evaluate drainage systems have recently been established, e.g.

(i) pipeline construction (i.e. length, quantity and type of branches and bends);
(ii) type of self-cleansing (i.e. should the solids be flushed out of a certain segment of the pipeline, or travel a minimum floating distance during a flushing process; or is the distance between the distance of travel of the closet bowl unimportant ?); and
(iii) hydraulic criteria (i.e. flow rate, velocity, pipeline gradient).

The minimum flushing volume which does not result in blockages in conventional drainage systems is as yet unknown.

The goal of the second part of this research project was to experiment with different flushing water volumes for different types of drainage systems. The distance of travel of solids which can be achieved by flushing with a particular flushing water volume should be viewed as a decisive criterion for evaluating the function of W.C.'s. Up to the present the total flushing water volume which produced a flushing effect was the basis used for analyses and decisions in the attempt to decrease the water consumption during flushing. The two traditional flush volumes of 9,0 and 6,0 ℓ have not been proved experimentally to be the most efficient.

Flushing is either of the following two processes:

(a) *Flushing out* means the removal of solids from branches and stacks with one flushing. The pipeline empties itself in the process of the flushing, or
(b) *Flushing down* means that the solids are not removed from the pipeline section during one flushing. Deposits occur in the branch between the W.C. and the vertical stack. In this case the flushing out process only results after additional flushing. The next flushings carry solids out of the branch. Flushing out the deposited solids requires additional force to move the solids, such as:

    (i) the subsequent flushing water;
    (ii) the following solids; and
    (iii) the accumulation of further solids which cause damming.

If flushing down in branches and stacks is tolerated, possible effects due to the reduction of the flushing water volume can only be determined with lengthy observations using complete units under varied conditions. The flushing out performance is unquestionably a definite evaluating criterion (i.e. 'pass' or 'fail'). However, only the afterflow V_{NF} (i.e. that which follows the solids) is effective in the flushing out performance. The afterflow - and not the total flushing water volume V_{ges} - would therefore be the criterion in testing.

In the scope of this research the following were experimentally determined:

1) the distances which a definite solid travels in different types of drainage systems with differentiated afterflows and flow rates; or
2) the flushing water volume needed to flush out the solids in the most complicated arrangement of branch and stack system constructed according to conventional rules.

To obtain as much information as possible, several test series with various degrees of difficulty were carried out when the floating distances, according to (1) were being determined.

Figure 8 shows a possible layout solution for 5 flow path situations (A - E). In *Figure 9* the corresponding measurement points for the flow path situation A and D - F are shown. The possible floating distance was determined as L = 10,0 m (ex).

In the flow path situations A and B, it was assumed that the water flowed into the connecting pipe from one W.C. placed at the beginning of the pipeline. In the flow path situations C - E the water was to flow into the stack from the side of a W.C. connecting pipe by way of a branch fitting (inlet branch). The branch connections were installed horizontally, i.e. without an elevation jump to the connecting branches. The flow path configuration F generally corresponds to E. However, there is an elevation jump between the branch and the stack, due to the slant of the connecting branch which results in a difference in elevation of 55 mm.

These flow path situations make it possible to analyze the influences on the flow in bends (2 x 45^{o}), horizontal and slanted inlet branches, as well as horizontal and slanted flow-through branches. If a way could be found to influence solids with differentiated afterflows and flow rates and different pipe gradients, much progress could be made.

Tests with determined differentiated afterflows and flow rates based on original W.C.'s cannot be carried out. Therefore, a corresponding system for simulation with the t-V and t-Q characteristics of an original W.C. have to be developed. Furthermore, it would have to be possible to place the solids in the closet bowl at an exact moment, which is calculated according to the pattern of the t-V characteristic curve with a differentiated Q_4. *Figure 10* illustrates the determination of the correct moment to place the solids in the closet bowl with the example V_{NF} = 3,0 ℓ.

Figures 1 - 13 show the simulation and feeding system.

From the many forms possible with FAKAZELL, the testing solid made of 150 g of FAKAZELL, as shown in *Figure 14,* produced a dispersion of deposits which made it possible to analyze an accumulation of deposits with an adequate number of flushes. In this way the afterflow could be varied from 10 ℓ.

The results of a wide range of tests showed that the simulation system corresponded to the original W.C.'s in the floating distance travelled and the floating velocity pattern, i.e.:

(i) after FAKAZELL had been placed directly in the bowl *(Figure 15)*;
(ii) after the feeding system had supplied it with a determined afterflow from the W.C. *(Figure 16)*; and
(iii) with the complete simulation system *(Figure 17)*.

3.1 Measuring instrument

In reference to the measuring technique with photocells used by Swaffield[3], a similar technique using a monitoring amplifier developed by GEBERIT was used in this case to serve the same purpose. At 1,0 and 0,5 m intervals, measuring cells with vertical light rays were built into a testing pipeline. When the light rays are interrupted by the passing FAKAZELL solid, the amplifier receives a signal which causes:

(a) the control light from the measuring cells to go out; and
(b) an output signal on the curve recorder *(Figure 18)*.

The floating velocity can be determined by using the time interval between the signals. The last signal marks the deposition or flushing out.

3.2 Analysis of the influences related to hydraulics

After survey measurements had been taken to determine the most effective measuring area, the following set values proved to be equally suitable for all flow path situations:

(i) pipeline gradient 1:50 (20 mm/m);
(ii) total flushing water volume $V_{ges} = 6{,}0$ ℓ;
(iii) afterflow $V_{NF} = 2{,}0 - 4{,}0$ ℓ; and
(iv) flow rate $Q_4 = 1{,}2$ ℓ/s and 1,8 ℓ/s.

It was originally planned to use $Q_4 = 1{,}0$ ℓ/s as the smallest flow rate. In the flow path situation A, which was favourable for the flow, (i.e. without bends and branches in the horizontal pipeline), no accumulation of the deposits could be analyzed from 113 flushing attempts, and therefore no characteristic curve could be recorded *(Figure 19)*. An accumulation of deposits resulted only when $Q_4 = 1{,}2$ ℓ/s. $Q_4 = 1{,}8$ ℓ/s was found to be the upper limit to obtain constancy of the set values.

Figure 20 shows the reduction of the attainable floating distances with a flow path which becomes increasingly complicated. Each bend and branch contributes to the reduction of the floating distance. This fact is evident from the hydraulic resistance. The inflow of water in connecting branch pipelines actually decreases not only the flow rate, but also the afterflow.

Finally the last branch (E) in the flow path situation E proved to be a *critical depositing zone*. With a low flow rate (1,2 ℓ/s), depositing of the testing solid resulted in most of the flushings. Therefore the characteristic curve E in *Figure 21* could be only approximately represented. This is why it was meaningless to test more difficult flow path situations by adding further branches horizontal to the branch pipes.

The overview of the attained floating distances of all the chosen flow path situations and flow rates in *Figure 22* shows that greater floating distances can be achieved with the flow rate $Q_4 = 1{,}8$ ℓ/s than with $Q_4 = 1{,}2$ ℓ/s.

After calculating the floating velocity, the causes for every reduction of the floating distance are distinguishable. For every combination of flow rate, flow path situation and afterflow, a typical velocity pattern results.

Flow path situation, example A (Figures 23 and 24):
The testing solid travels considerably faster into the connecting pipeline with a large flow rate than with a small flow rate.

Flow path situation, example B (Figures 25 and 26):
The addition of two 45° bends causes a considerable drop in the floating velocity. If the solid is in a favourable position, the velocity increases after the second bend. An unsettled solid and a small flow rate can lead to depositing of the solid.

Flow path situation, example C (Figures 27 and 28):
The inlet branch C causes greater reduction in the floating velocity than the double bend. In this case, the low points can also be overcome, if the flushing solid is in a favourable position.

Flow path situation, example D (Figures 29 and 30):
By the addition of a flow-through branch, the afterflow and the flow rate is decreased, due to the inflow of flushing water in the branch. A characteristic floating distance still results using $Q_4 = 1{,}2$ ℓ/s.

Flow path situation, example E (Figures 31 and 32):
A testing solid influenced by the flow rate $Q_4 = 1{,}2$ ℓ/s only occasionally passed through a second flow-through branch. The entrance of testing solids into branch E was also observed. This occurred less frequently with the flow rate $Q_4 = 1{,}8$ ℓ/s.

Flow path situation, example F (Figures 33 and 34):
Slanting the branches reduces depositing, the inflow of water from flushing and the inflow of other water. The floating distance increases, but compared to flow path situation E, the increase is insignificant. The flow resistance decreases when water flows through the pipe. However, when water flows into branch C, a greater turbulence results than in flow path situation E, which has a corresponding position. The wide dispersion behind this branch and the very sharp velocity drop prove that the inflow of water slows down the solids to a great extent, (see Figure 33). The inclination is, however, advantageous for the flow-through, especially with small flow rates.

3.3 Analysis of the influences related to usage

In reality the solids take on different forms, which can change several times on the flow path. The addition of paper helps the flushing out performance, because faecal matter with paper has more of a tendency to dam the water than faecal matter alone.

Three series of tests were carried out to determine which hydraulic conditions guarantee that the solids are flushed out in a certain flow path situation. The flow path situations E and F revealed critical factors influencing deposition in the preceding measurement series. The following test conditions were therefore applied:

(a) The solids on the flow path had to be taken into consideration when tests corresponding to usage were carried out. This meant placing FAKAZELL and paper in the closet bowl, i.e. FAKAZELL with uniform rheological values (size, density, consistency), and a uniform quality, and an amount of paper.

(b) Hydraulic set value of Q_4 = 1,8 ℓ/s using the W.C. 'PN', and Q_4 = 1,0 ℓ/s and 1,2 ℓ/s using the universal WC 'PH' which was flushed by way of a commercial flushing valve with a locking release mechanism above the TFH flushing unit to obtain a uniform flushing water volume.

The varying afterflows under the described conditions were determined approximately in a diagram drawn up from measurements of the points of evacuation and the t-V characteristic curve of the W.C., flushed without solids.

In all the measurement series, the afterflow V_{NF} = 3,0 ℓ showed itself to be a characteristic value whereby the solids were predominantly flushed out in both flow path situations when this value was exceeded. With V_{NF} < 3,0 ℓ, FAKAZELL and the paper were randomly deposited before reaching the flushing out goal. In the flow path situation E, the deposits accumulated either at the flow-through branch, or were flushed into the connecting pipes. In flow path situation F, the deposited solids could usually be flushed out with an immediate reflushing, whereas in flow path situation E, solids from repeated flushings often caused obstructions. An accumulation of flushing water in extended pipe sections and consequently, a high filling ratio is necessary to flush out the solids after desiccation (for example overnight).

4. SUMMARY

In pipeline systems as used in flow situations E and F, flushing out is guaranteed in an average of 80 per cent of all flushings, if the afterflow value is $V_{NF} \geq$ 3,0 ℓ. This is valid for flow rates Q_4 = 1,0 - 1,8 ℓ/s, pipeline gradients above 20 mm/m, and a solid corresponding to 200 g of FAKAZELL in the form of a sausage with densities 0,05 - 1,05 kg/ℓ and a rigidity (or consistency) of 6 - 13 mm measured according to DIN 4211, together with 4 double sheets of one or more layered conventional toilet paper which has good or average absorbency.

From these statements the flow rate appears to have no influence on the flushing out performance when paper is included. However, in a later test series, it was proved that after the solids had deposited, the forces which effect the further transportation (flushing down and flushing out) became greater as the flow rate increased.

The dependency of evacuation on the flow rate for the universal W.C.'s which were conventional at that time, already appeared in the first part of the project. Therefore, it was necessary to consider it in the second part. Figures 38 - 40 show that with larger densities of FAKAZELL mush, (in this case 1,03 - 1,04 kg/ℓ), far fewer evacuations were achieved with V_{NF} > 3,0 ℓ using the testing W.C. 'PH' than when the testing W.C. 'PN' was used.

The following summary gives an overview of the results of the tests.

W.C.	Q_4 in ℓ/s	Total number of flushings	Successful flushings (V_{NF} = 3,0 ℓ) number	per cent
PN	1,8	141	128	91
PH	1,2	124	88	71
	1,0	124	50	40

The 29 per cent difference between the result with Q_4 = 1,0 and 1,2 ℓ/s clearly indicates a functioning limit, which should be considered in future decisions.

5. CONCLUSIONS

The research revealed the following findings:

(1) The flushing performance in closet bowls expressed by their ability to evacuate faecal matter and paper during a flushing can be represented with technical measurements. The most important measurement result for the evaluation is the afterflow V_{NF}.

(2) The flushing out performance is a definite deciding criterion with regard to the floating effect in branches and stacks. The afterflow, rather than the total flushing water volume influences the flushing out performance. Consequently, the afterflow is also a criterion for the flushing performance of closet bowls.

(3) The flushing water volume V_{EF} required to evacuate a solid is largely dependent on the system. The smaller the V_{EF}, the more economical the W.C. unit flushes. Consequently, there is room for development in V_{EF}, if instead of the total flushing water volume the afterflow is considered the characteristic value. However, the total flushing water volume V_{ges}, the sum of V_{EF} and V_{NF}, have to be large enough to guarantee an adequate rinsing of the bowl (see diagram).

Depending on the configuration of the drainage system the evacuation of paper has to be guaranteed with V_{NP}

V_{EF} V_{NF} = V_{ges}

dependent on the W.C. system

flushing water volume must guarantee the rinsing of the bowl.

Possibilities of decreasing the water consumption are evident from this diagram:

(i) W.C. systems, which require as little water as possible to evacuate the solids; and

(ii) drainage systems, where less afterflow is required to flush out the solids.

An international standardization agreement would allow for national and regional latitude to determine the afterflow, (and consequently also the flushing water consumption), if afterflows were assigned to drainage systems individually.

(4) With the recognition of the afterflow, the flow rate Q_4 becomes a secondary value for the evacuation of solids from the closet bowl. However, it cannot be forgotton that with the increasing value of the flow rate Q_4, restrictions such as bends, branches, socket gaps, etc., can be better overcome.

(5) New W.C. units must be constructed in such a way that they can replace old units without it being necessary to change the drainage system, and so that they can function well under such conditions. New flushing apparatuses should be capable of being mounted onto old closet bowls, which generally have a longer lifetime than flushing apparatuses. The flushing water volumes and flow rates which can be supplied by new flushing systems must therefore meet the demands of older W.C. systems.

REFERENCES

1. KNOBLAUCH, H.J. Research report (part 1) : *'Analysis of the Flushing Characteristics of Closet Units'* (Analyse der Spüleigenschaften von Klosettanlagen), special print of the TFH Berlin.

2. KNOBLAUCH, H.J. *'FAKAZELL, a new method to simulate reality in W.C. system performance evaluation'*, report Brunel University, June, 1980.

3. SWAFFIELD, J.A. and WAKELIN, R.H.M. : 'Observation and analysis of the parameters affecting the transport of waste solids in internal drainage systems', *The Public Health Engineer*, No. 6, November, 1976.

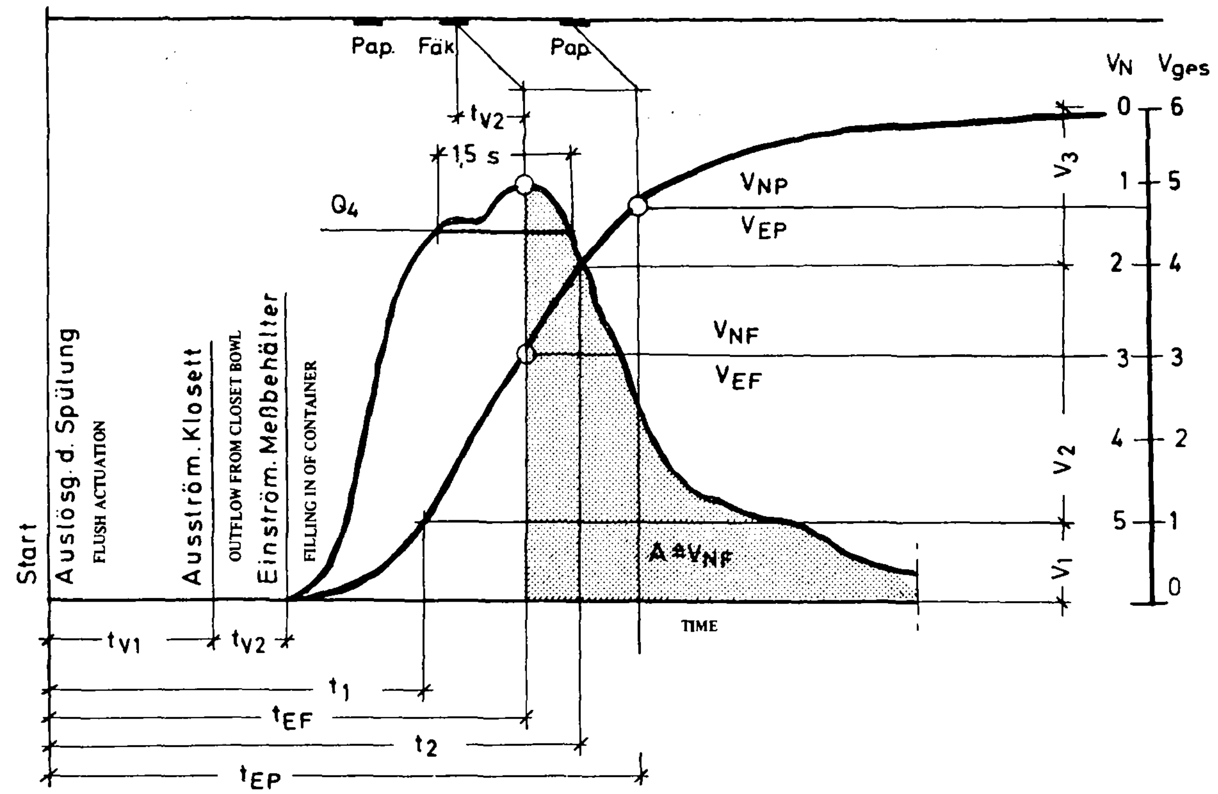

FIGURE 1 : Illustration of the measurement value recordings and the analysis to determine Q_4, V_E and V_N

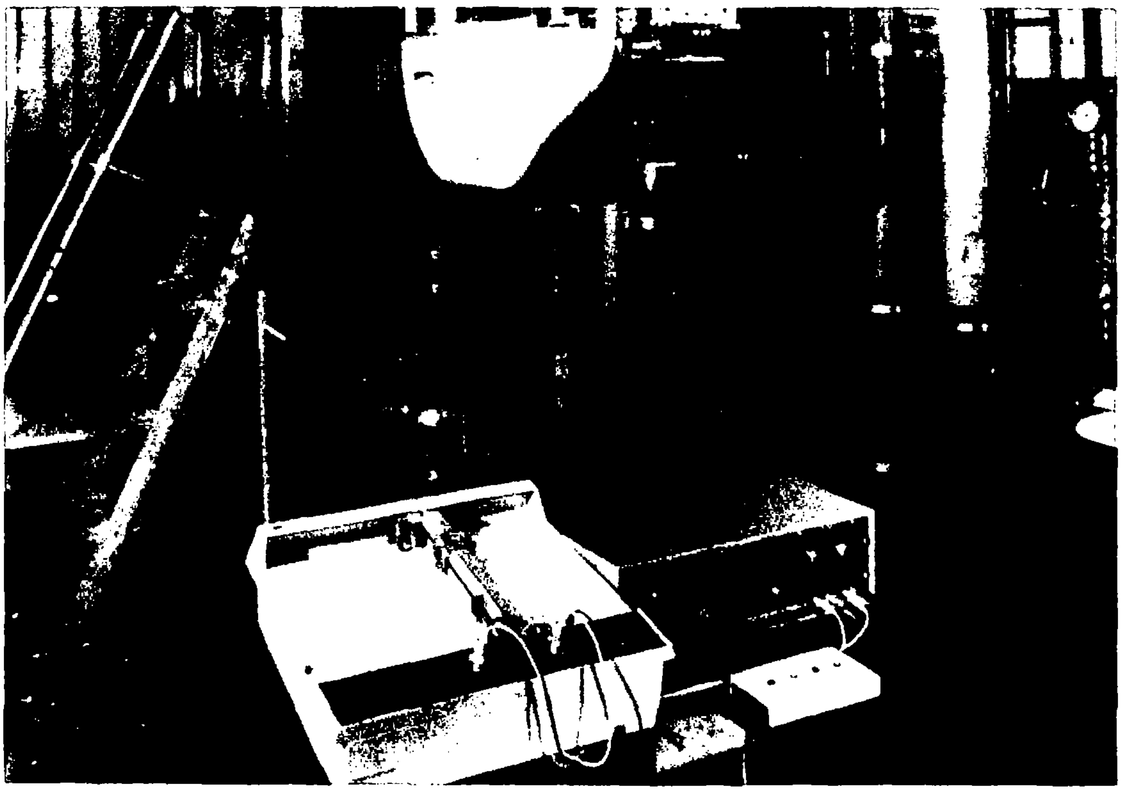

FIGURE 2 : Test set up showing container (under the W.C.), monitoring amplifier (right), signal transmitter (front right) and line recorder (left).

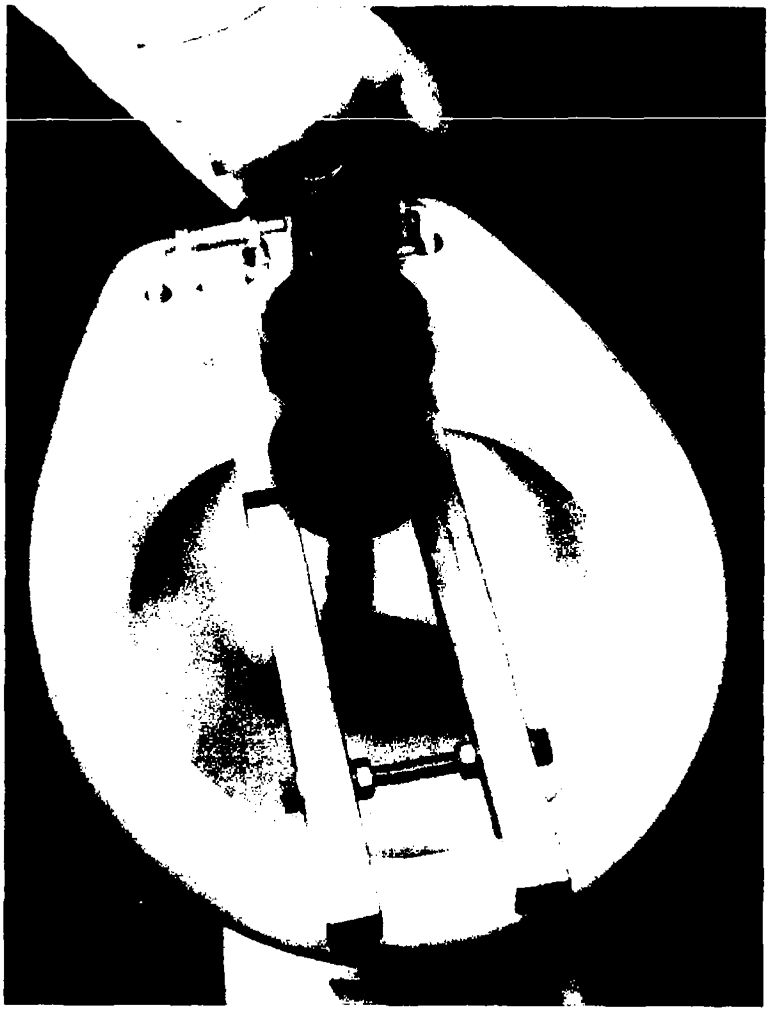

FIGURE 3(a) : Placing FAKAZELL into the closet bowl

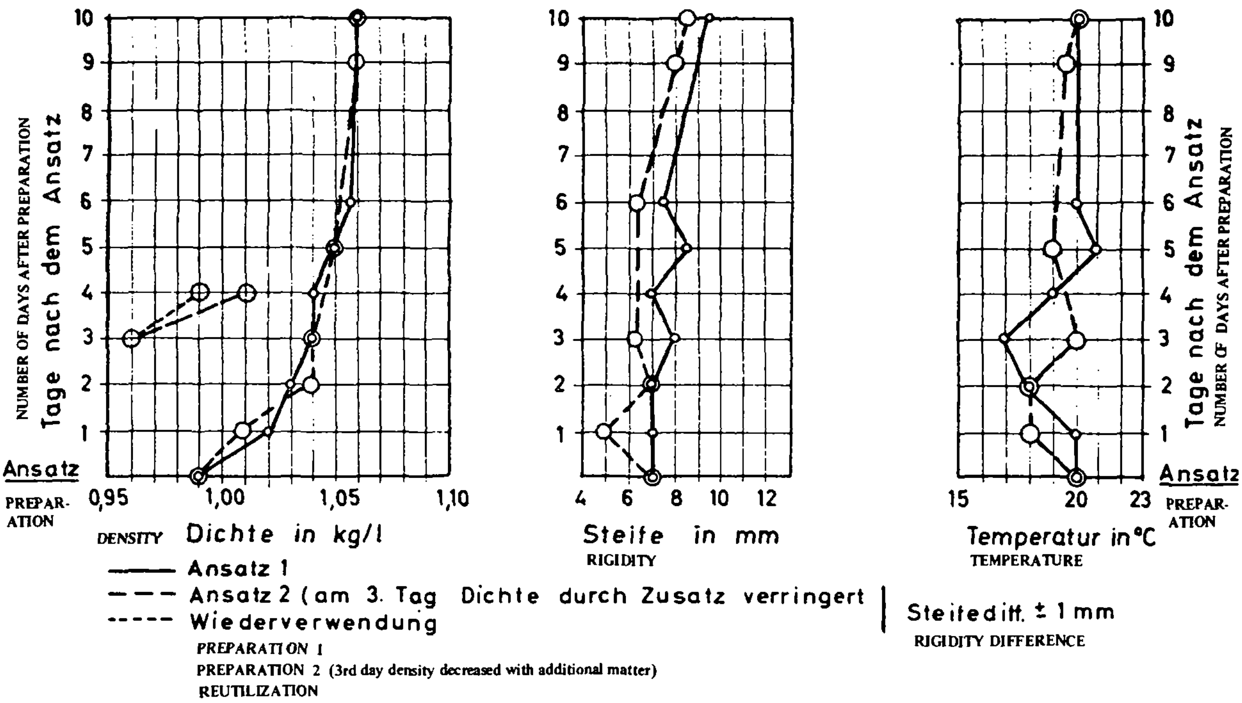

FIGURE 3(b) : Rheological behaviour in the course of ten days. The mush can be used from the third day on

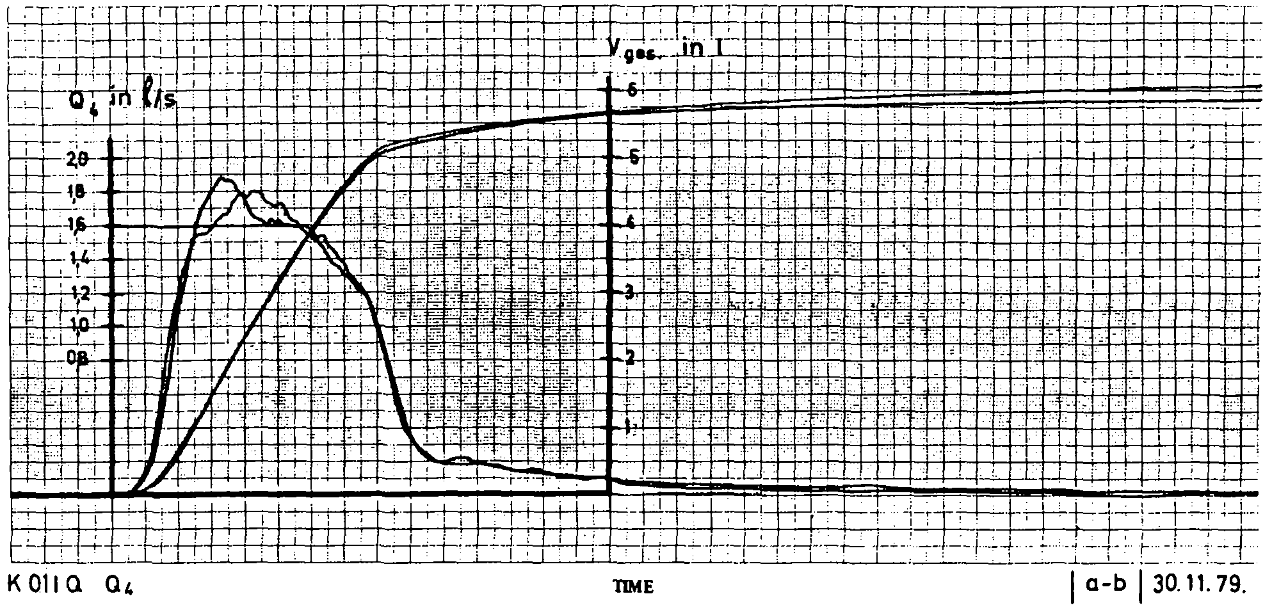

FIGURE 4 : Evaluation characteristics of closet bowls on measurement recordings. Characteristic curve without test objects

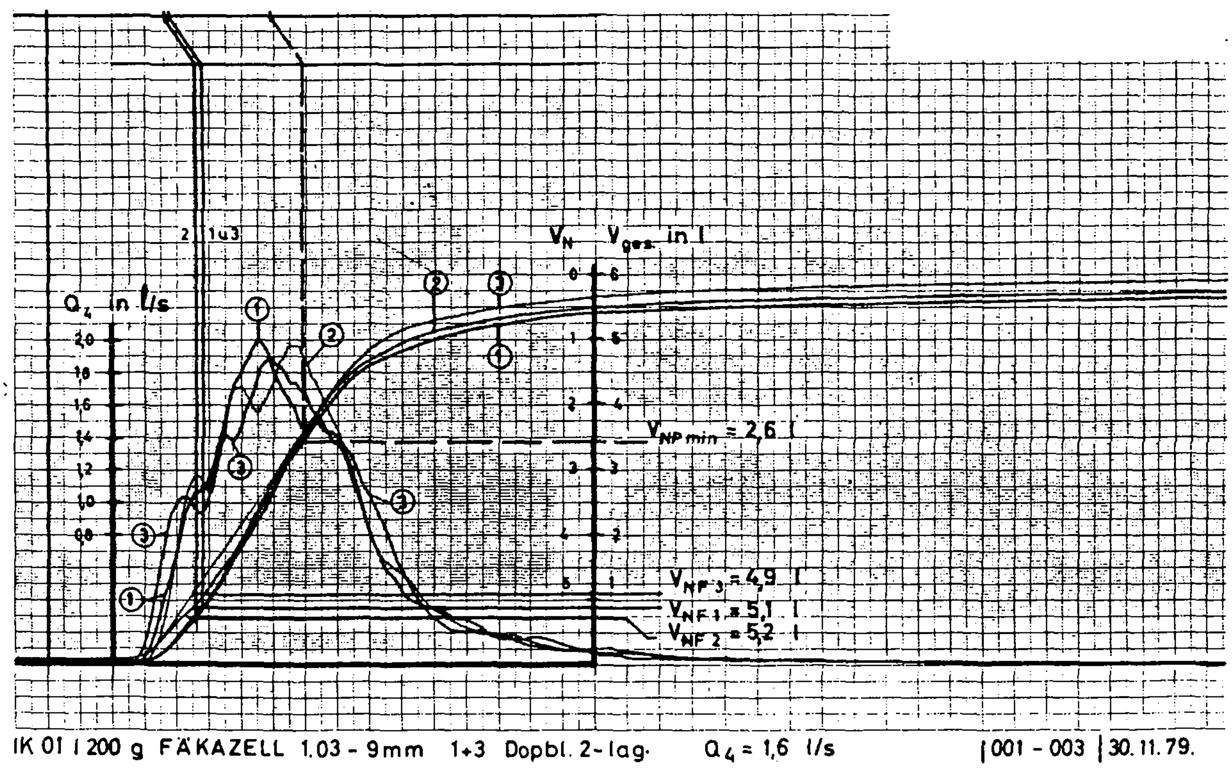

FIGURE 5 : Characteristic curve when 200 g of FAKAZELL and 8 pieces of toilet paper were readily flushed from the bowl repeatedly

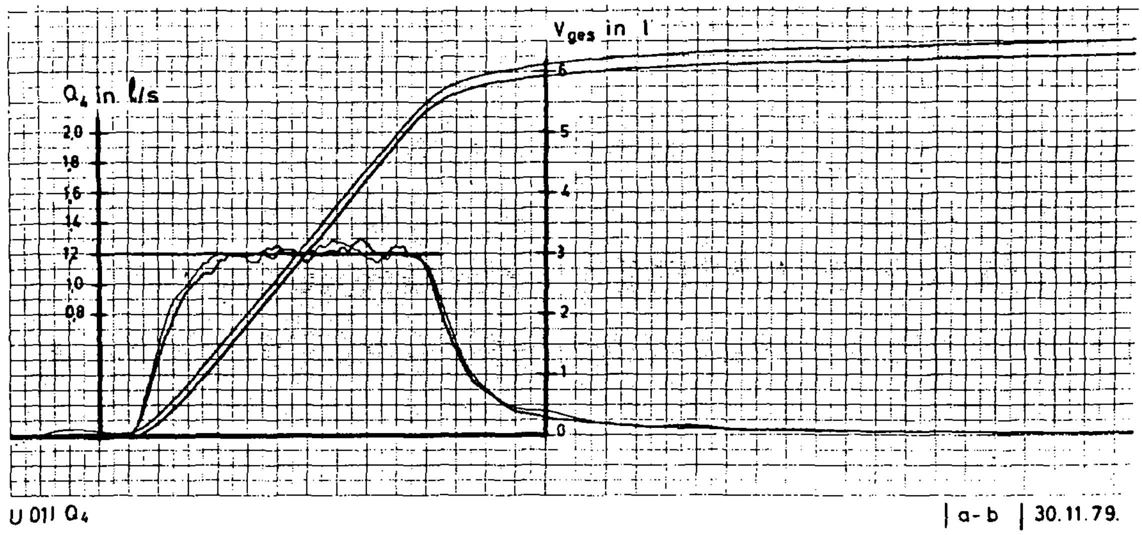

FIGURE 6 : Characteristic curve for a universal type bowl without test objects

Bild 7

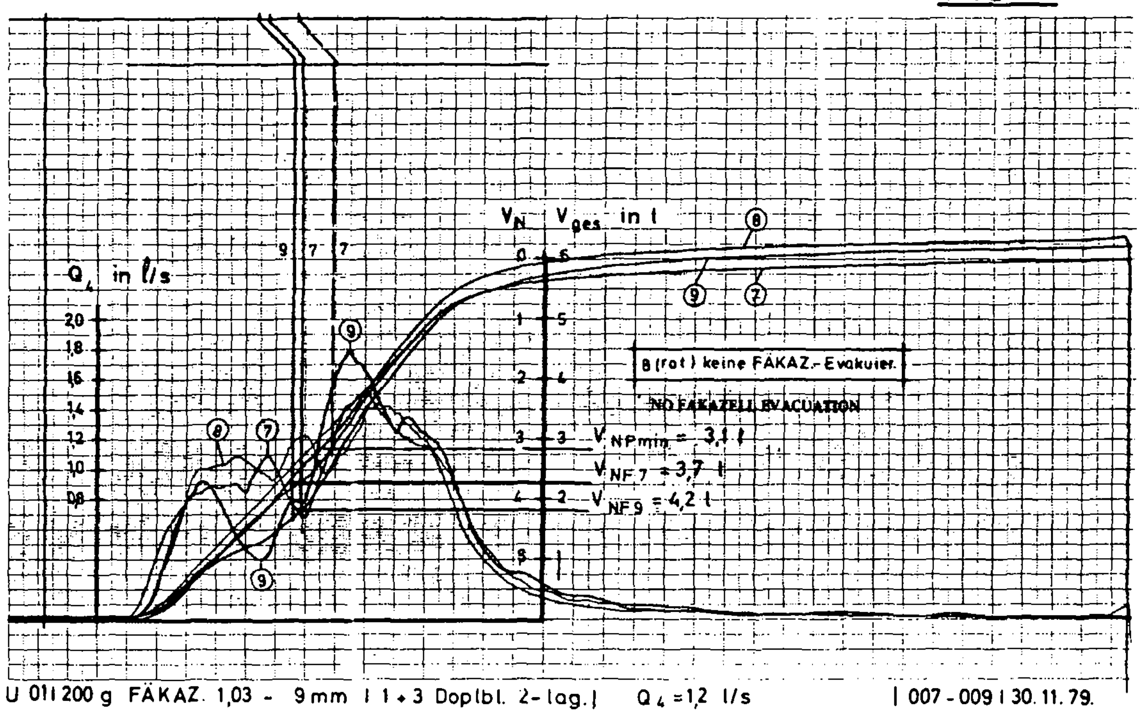

FIGURE 7 : Characteristic curve when flushing solid is caught in trap

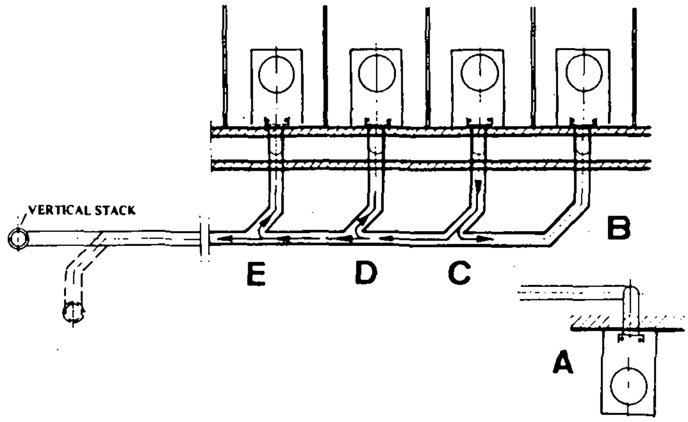

FIGURE 8 : Layout solution for velocity and floating path measurements. Systematic representation of the studied flow path situations A - E

Flow path situation A	:	1 W.C. with inlet bend A
Flow path situation B	:	1 W.C. with additional double bend
Flow path situation C	:	2 W.C.'s water inflow in branch C
Flow path situation D	:	3 W.C.'s water inflow in branch C
Flow path situation E	:	4 W.C.'s water inflow in branch C

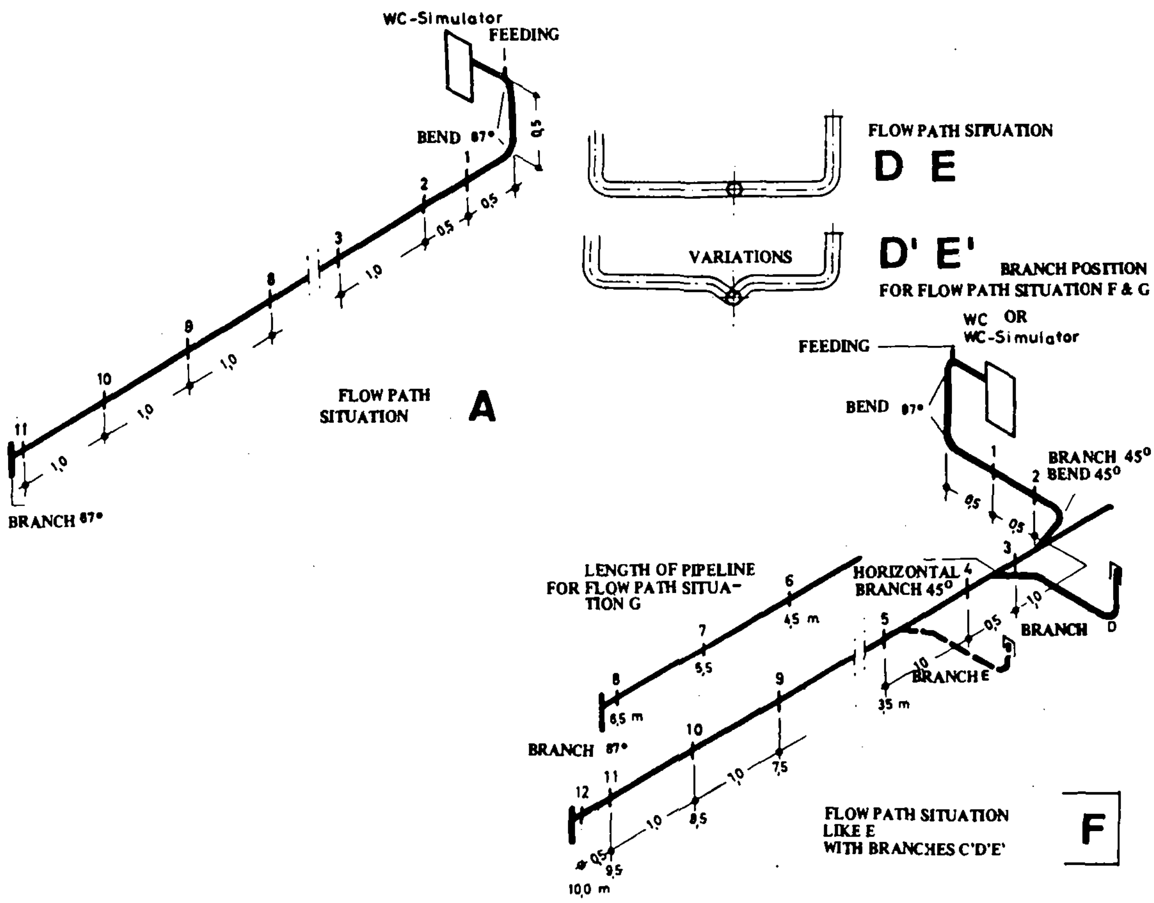

FIGURE 9 : Left, above : Flow path situation A with layout of measuring cells. Right, above : Flow path situations D to G with layout of measuring cells.

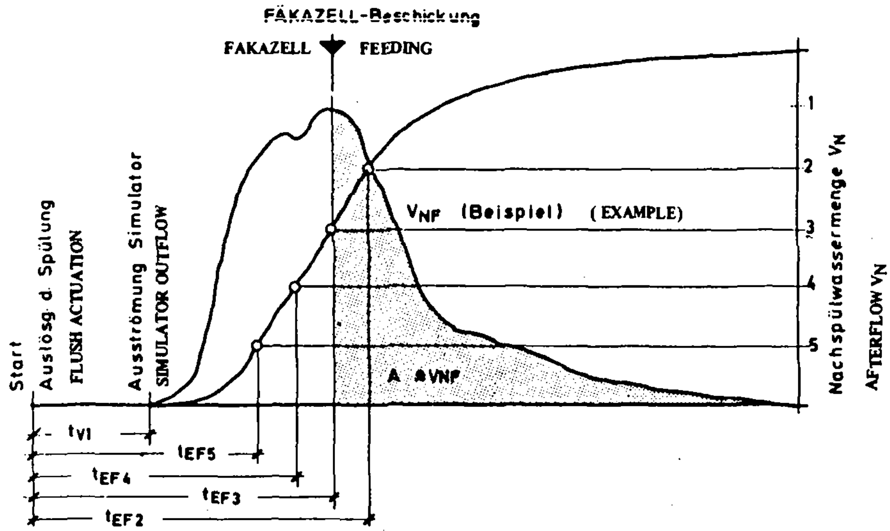

FIGURE 10 : With a previously set flow rate Q_4 the FAKAZELL solid should be placed in the bowl so that an after flow V_{NF} = 3,01 follows it. The solid should fall into the outlet connection after the amount of time t_{EF3} measured from the flow release

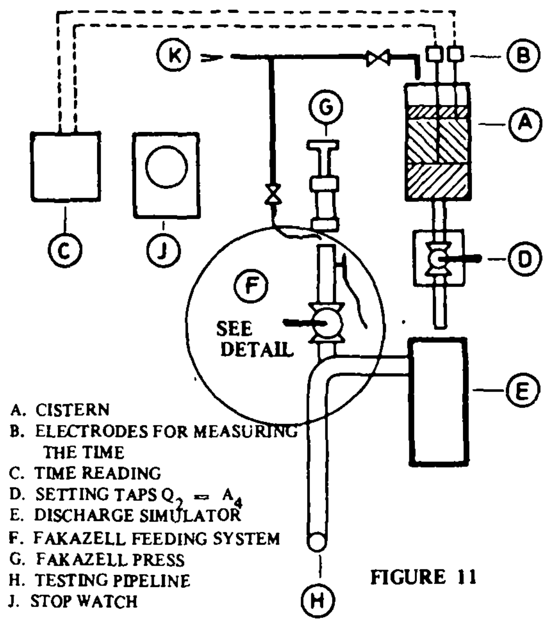

FIGURE 11 : Diagram of the simulation system used to supply FAKAZELL at the right moment.

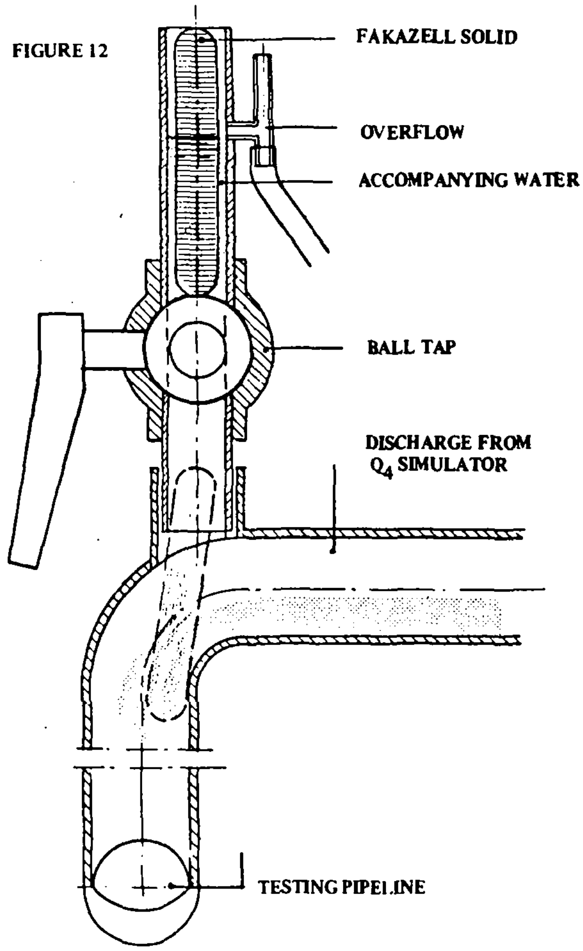

FIGURE 12 : Detailed diagram of the feeding system

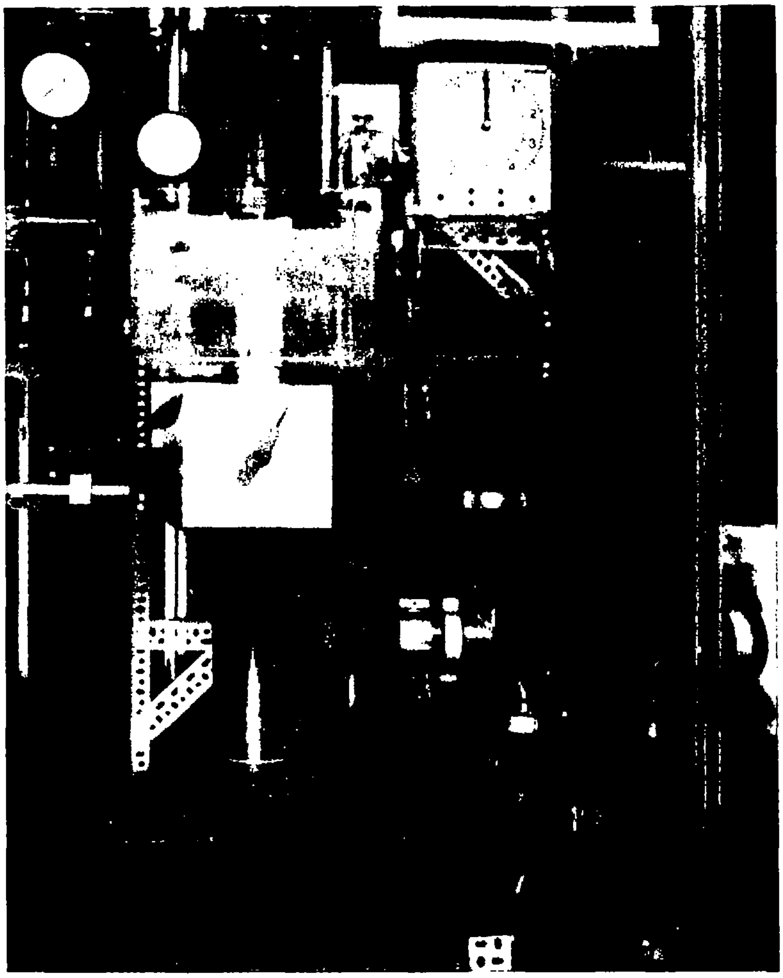

FIGURE 13 : Simulation and feeding system

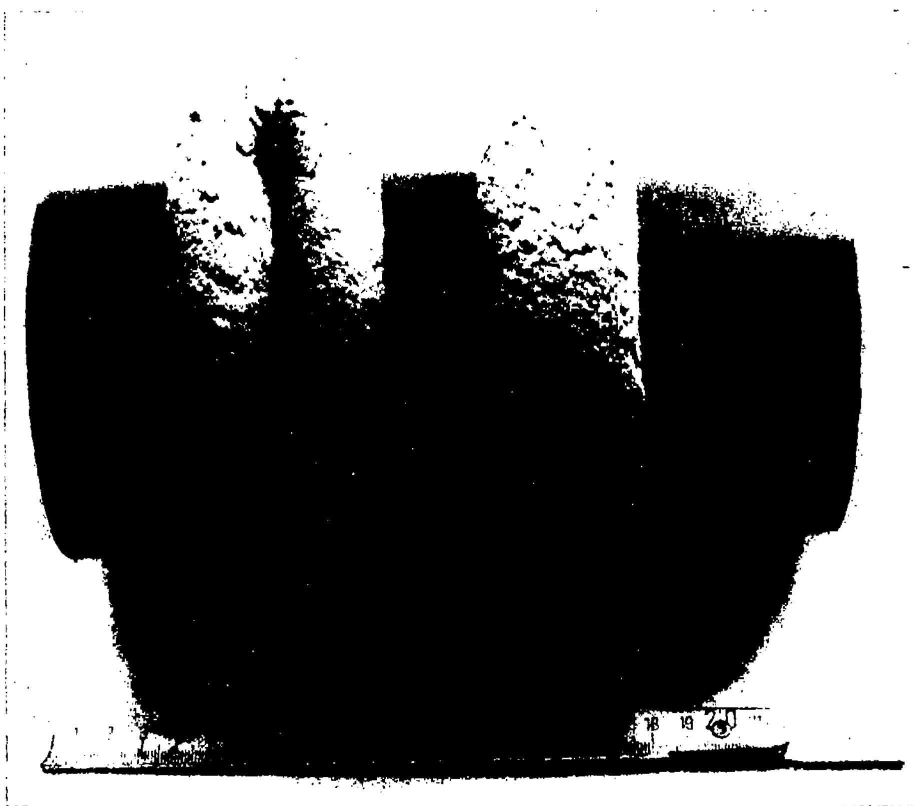

FIGURE 14 : FAKAZELL testing solid (right) is similar to the forms observed at the moment of evacuation (left)

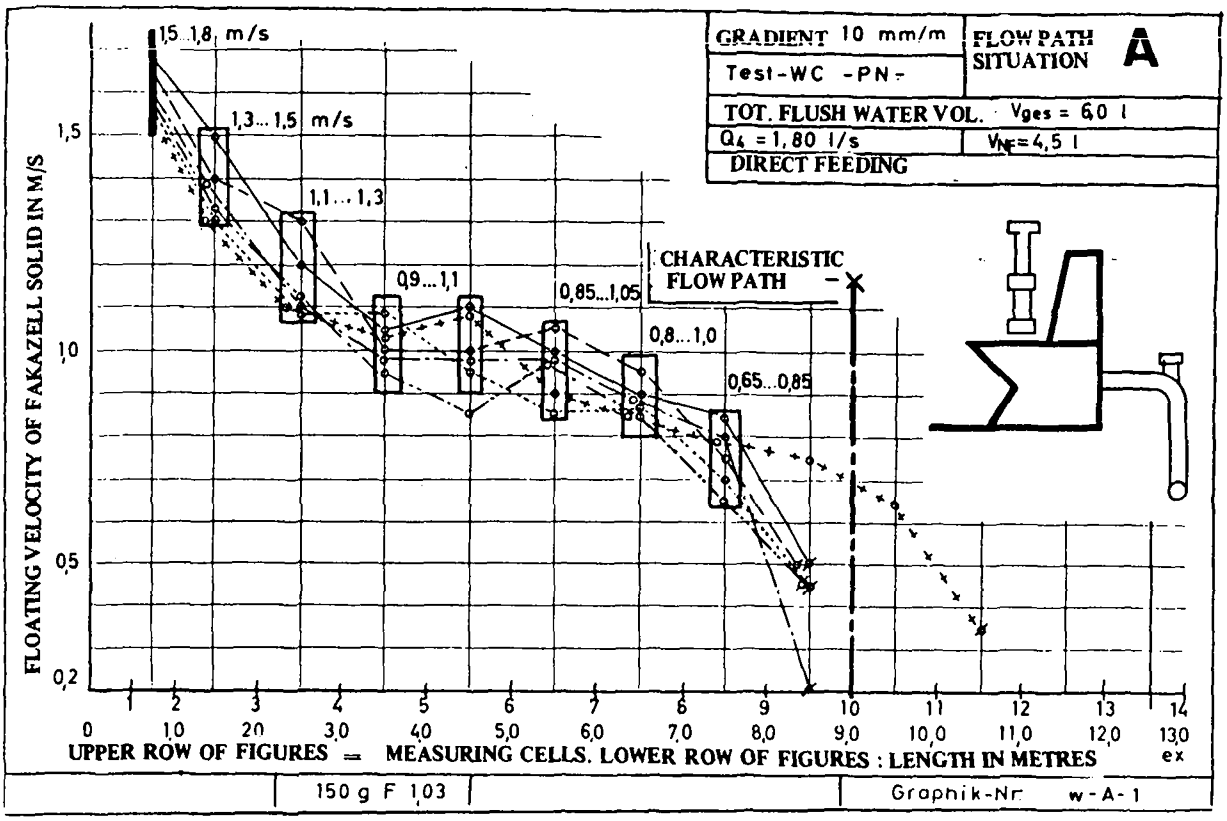

FIGURE 15 : Floating velocity pattern resulting from a flushing with testing W.C. 'PN' with *direct* feeding

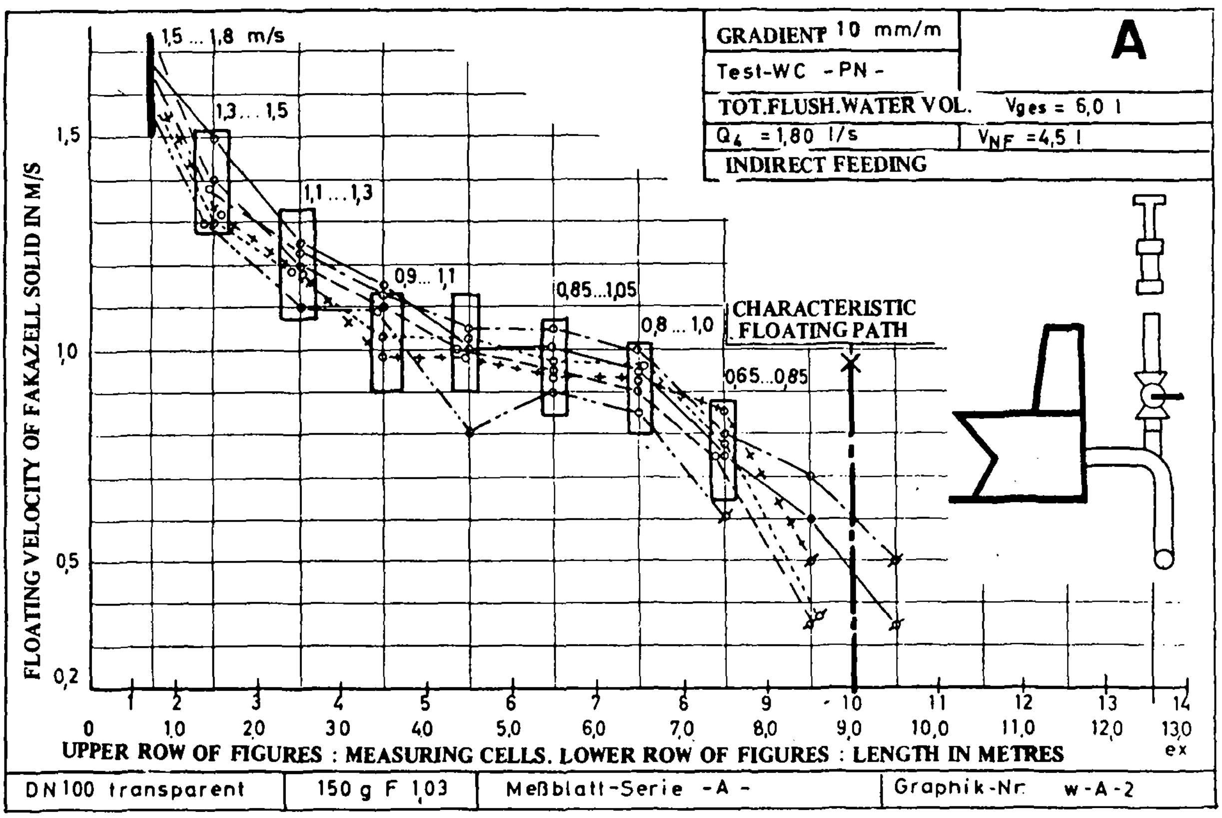

FIGURE 16 : Floating velocity pattern resulting from a flushing with testing W.C. 'PN' with *indirect* feeding

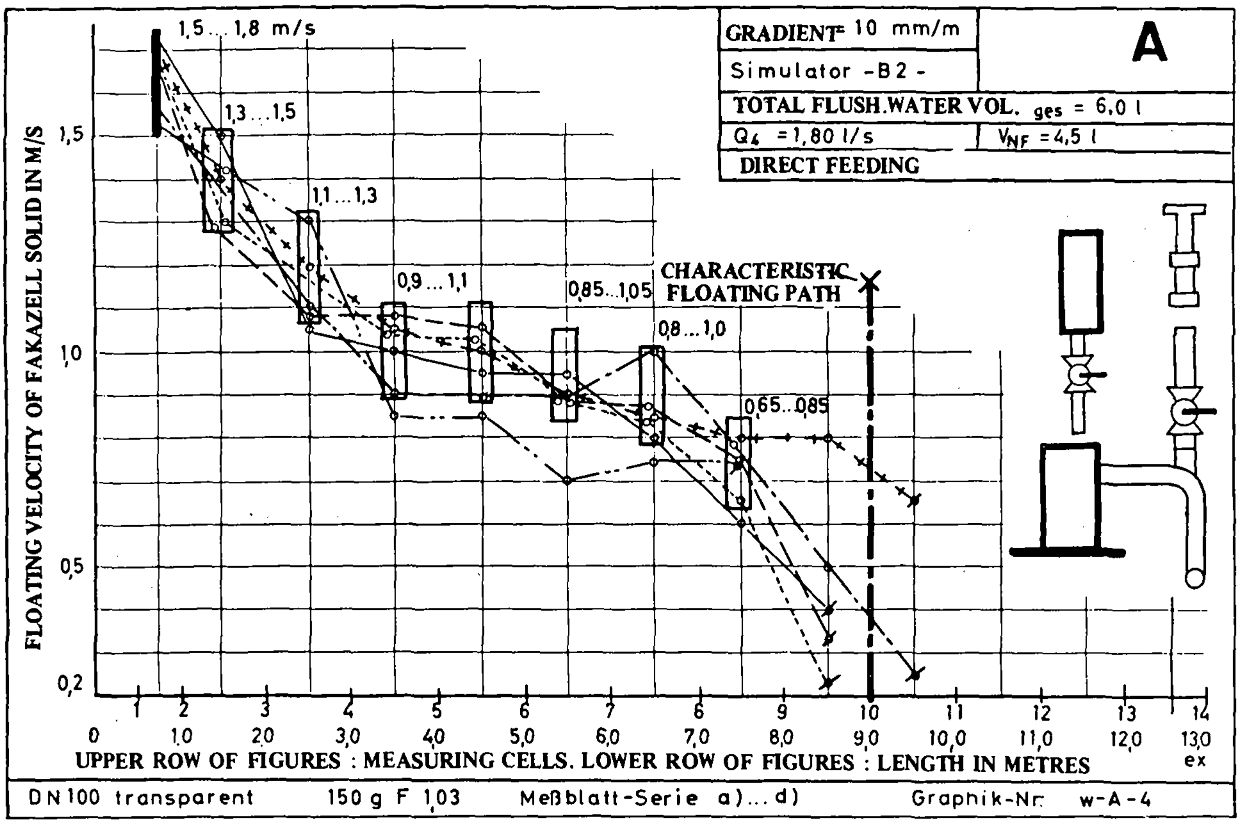

FIGURE 17 : Floating velocity pattern resulting from a flushing with simulator B2 with *indirect* feeding

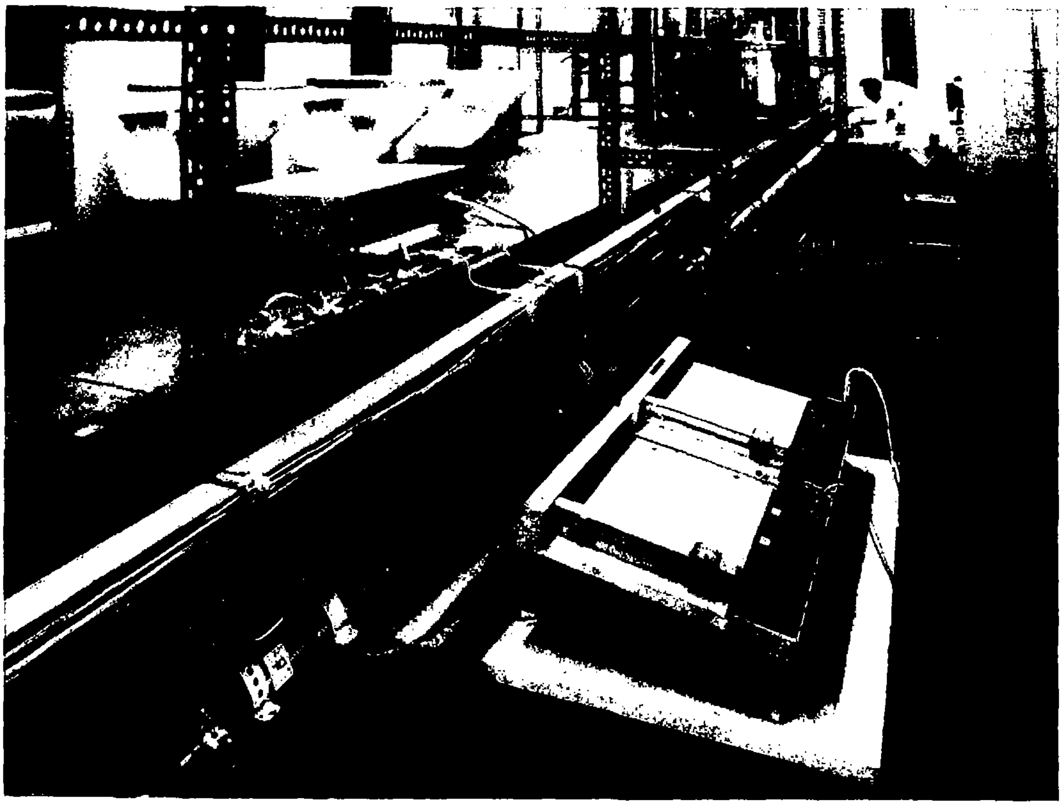

FIGURE 18 : Measuring instrument to determine the floating distances

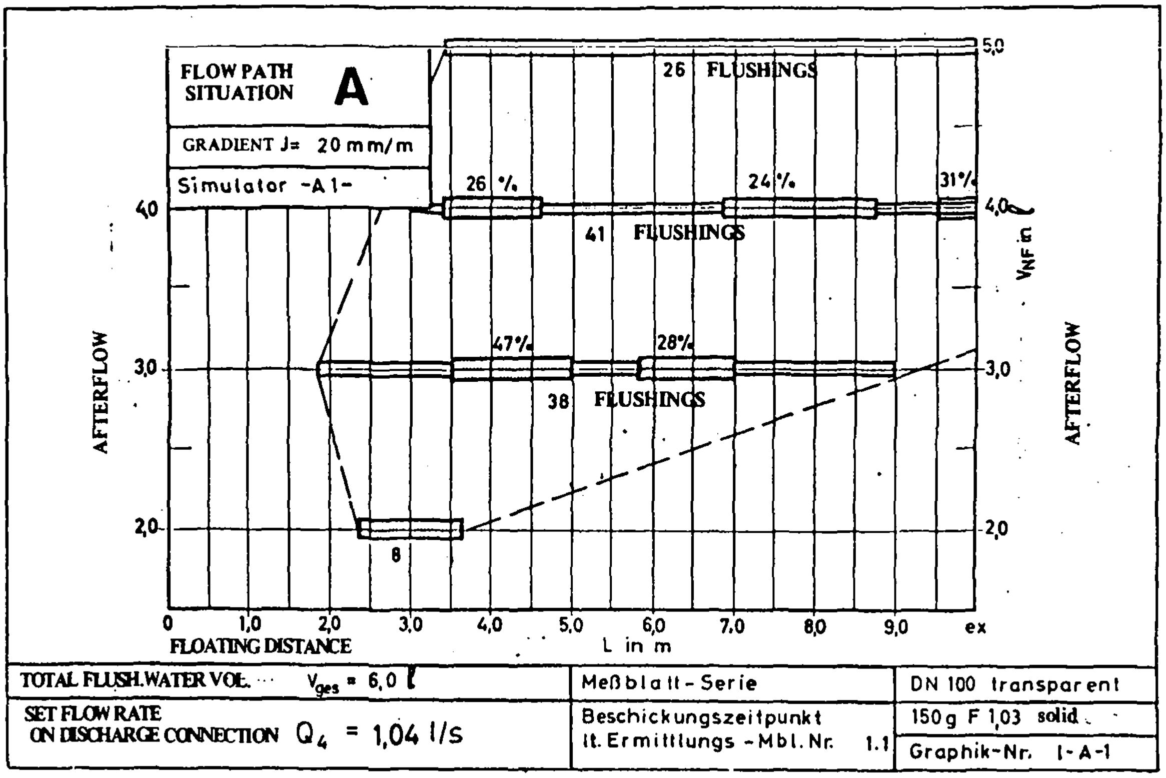

FIGURE 19 : A wide dispersion of the deposits with Q_4 = 1,0 ℓ/s. No characteristic curve pattern, which could be analyzed, resulted.

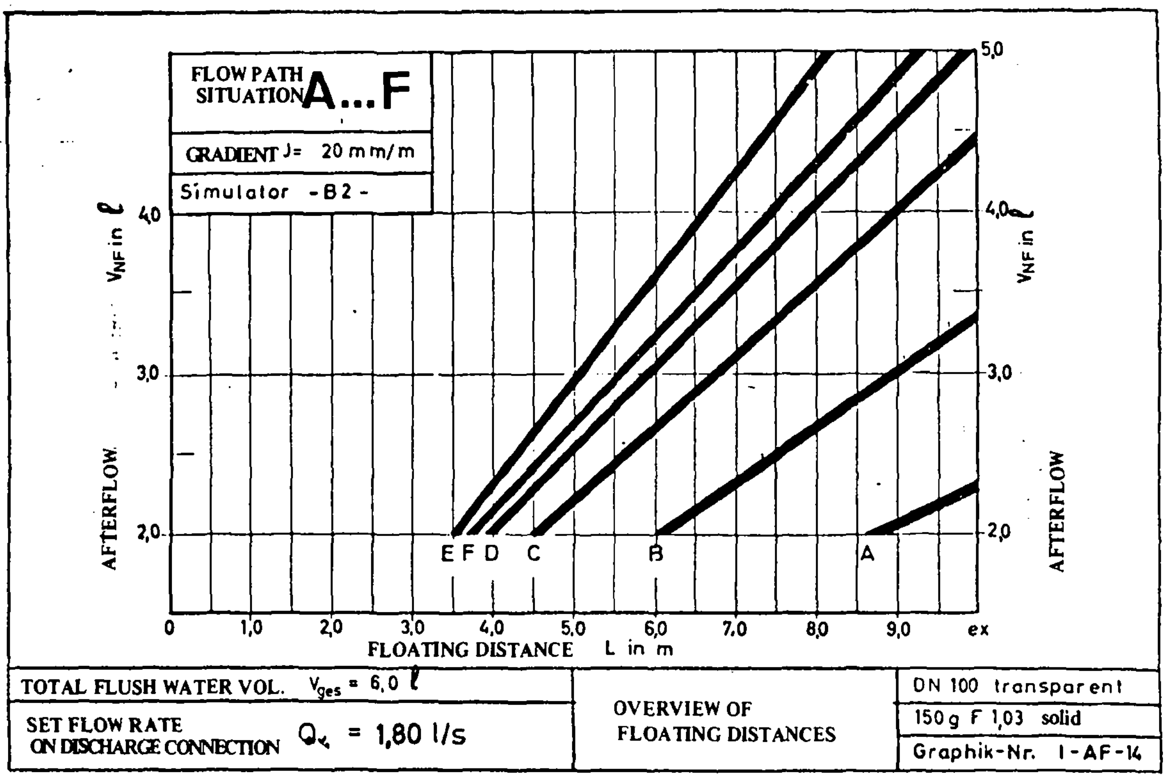

FIGURE 20 : A reduction of the floating distances with a flow path which becomes more difficult

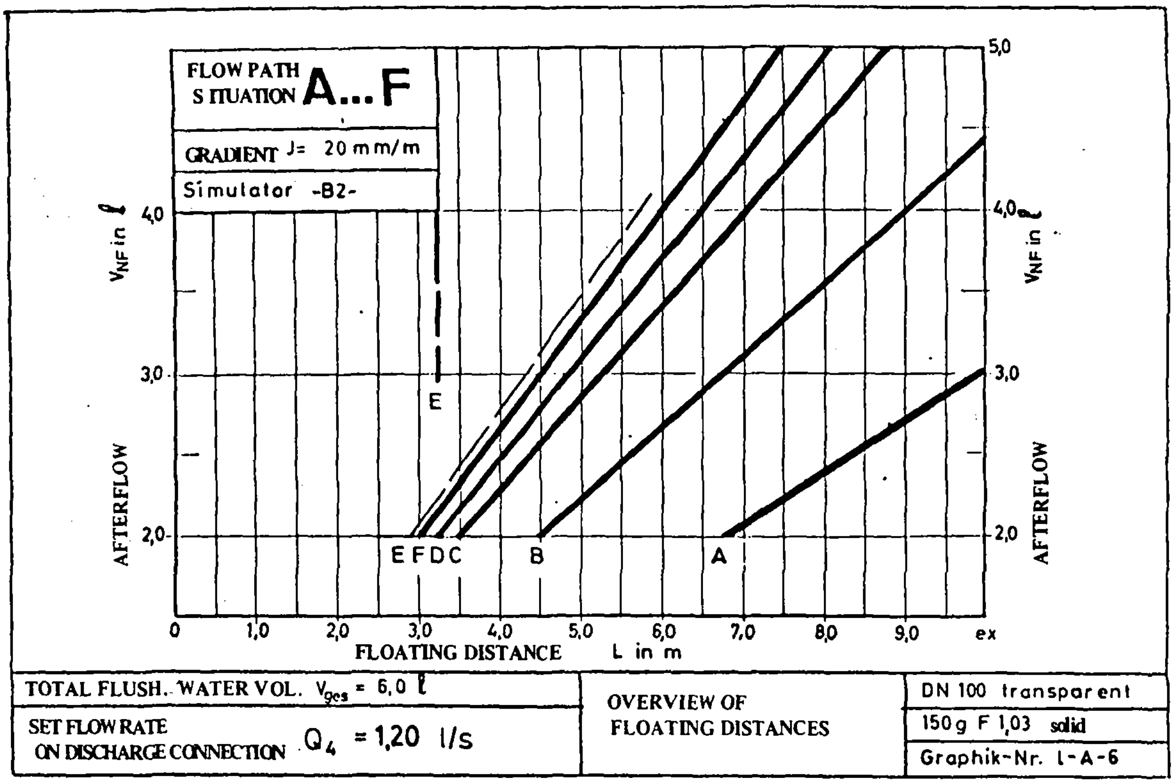

FIGURE 21 : A critical depositing zone in branch E (L = 3,2 m) in flow path situation E, especially with a small flow rate

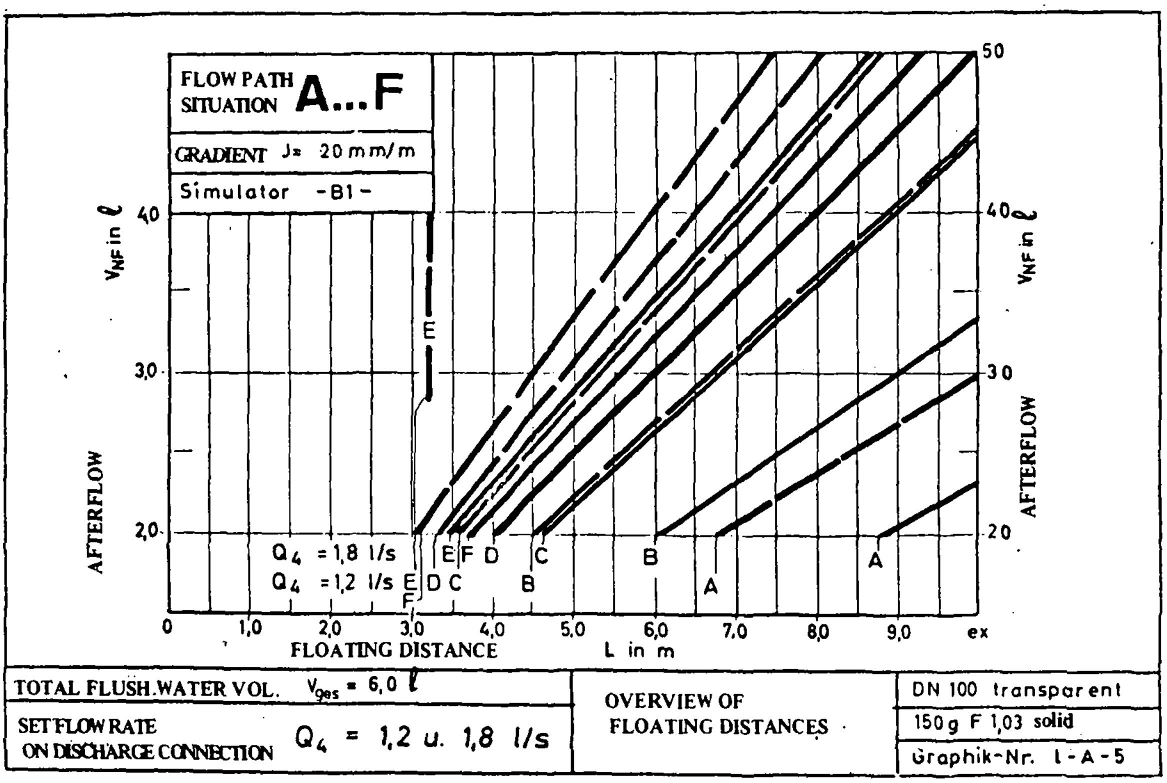

FIGURE 22 : Overview of attained floating distances

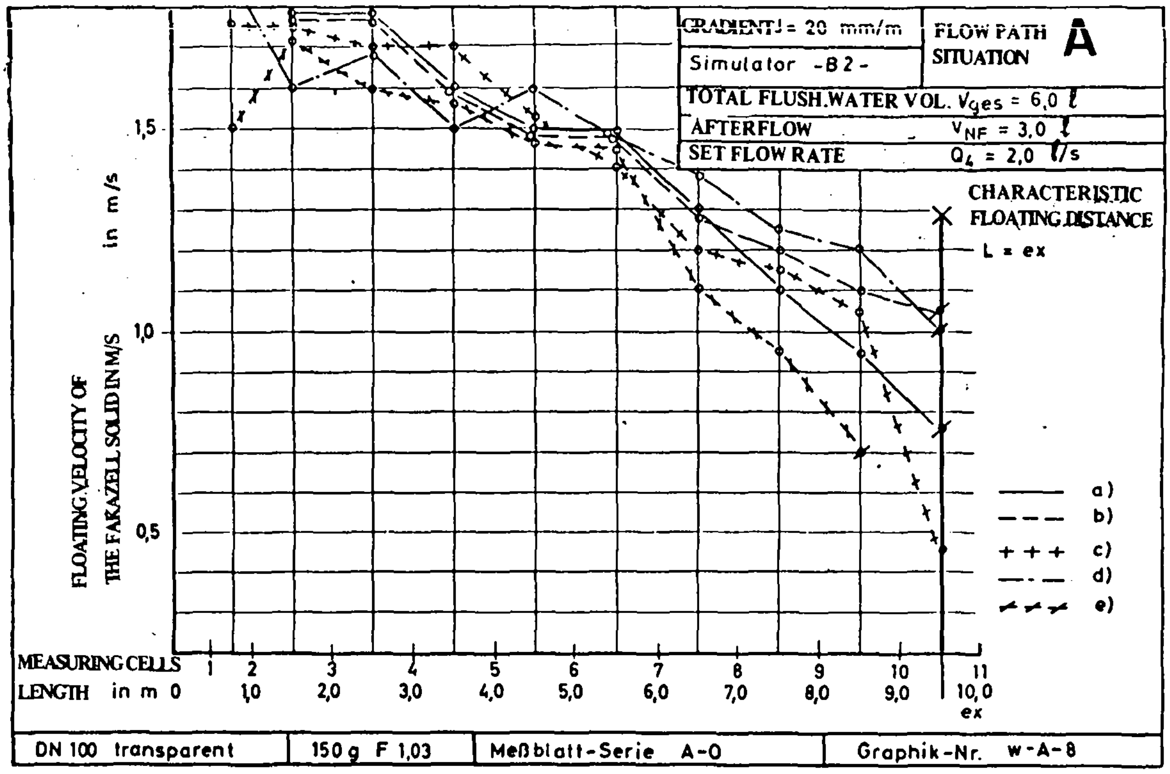

FIGURE 23 : Floating velocity pattern with a *large flow rate* in a testing pipeline without a turn. Compare with Figure 39

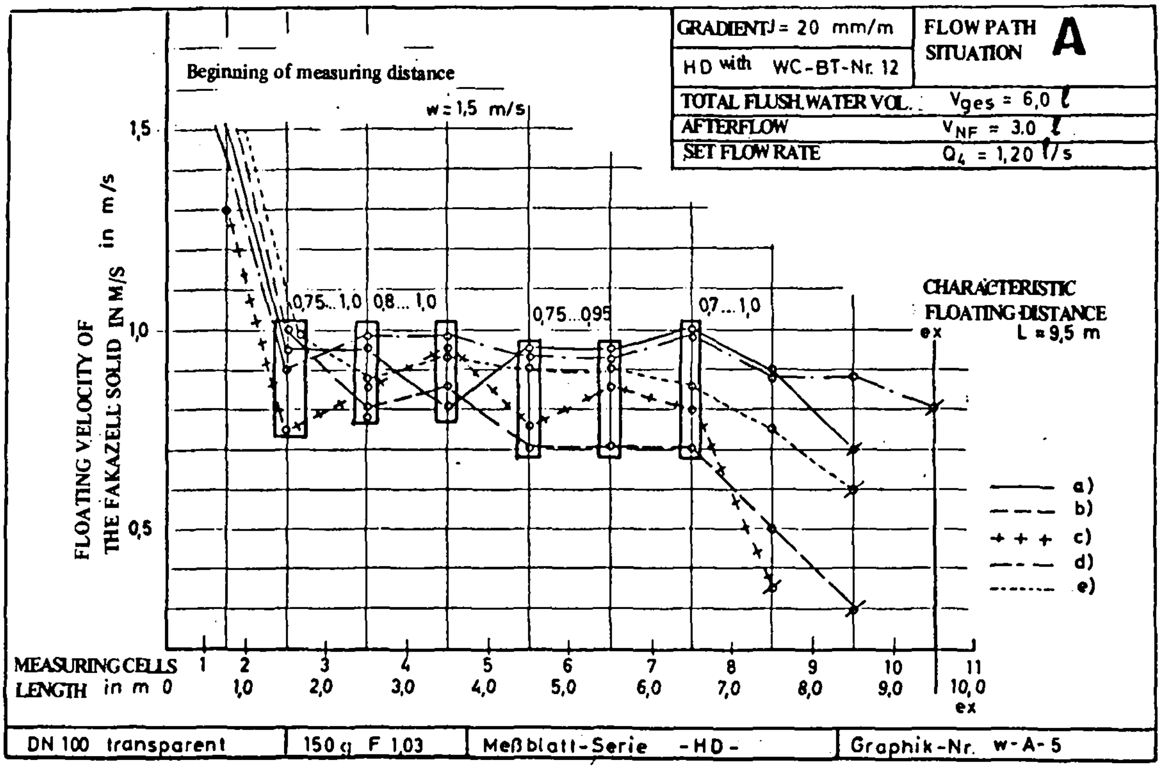

FIGURE 24 : Floating velocity pattern with a *small flow rate* in a testing pipeline *without* a turn. Compare with Figure 38

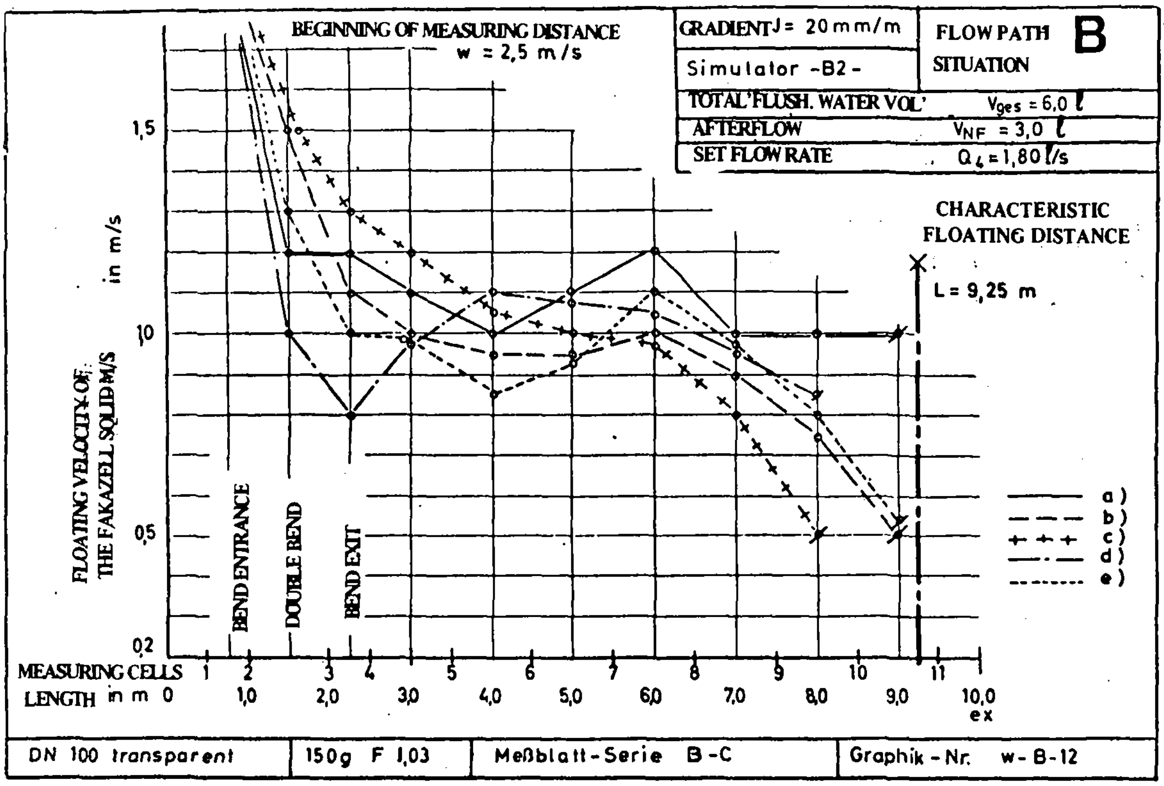

FIGURE 25 : A reduction of the floating velocity with two 45° bends (90° turn) with *a large flow rate*. Compare with Figures 38 and 41

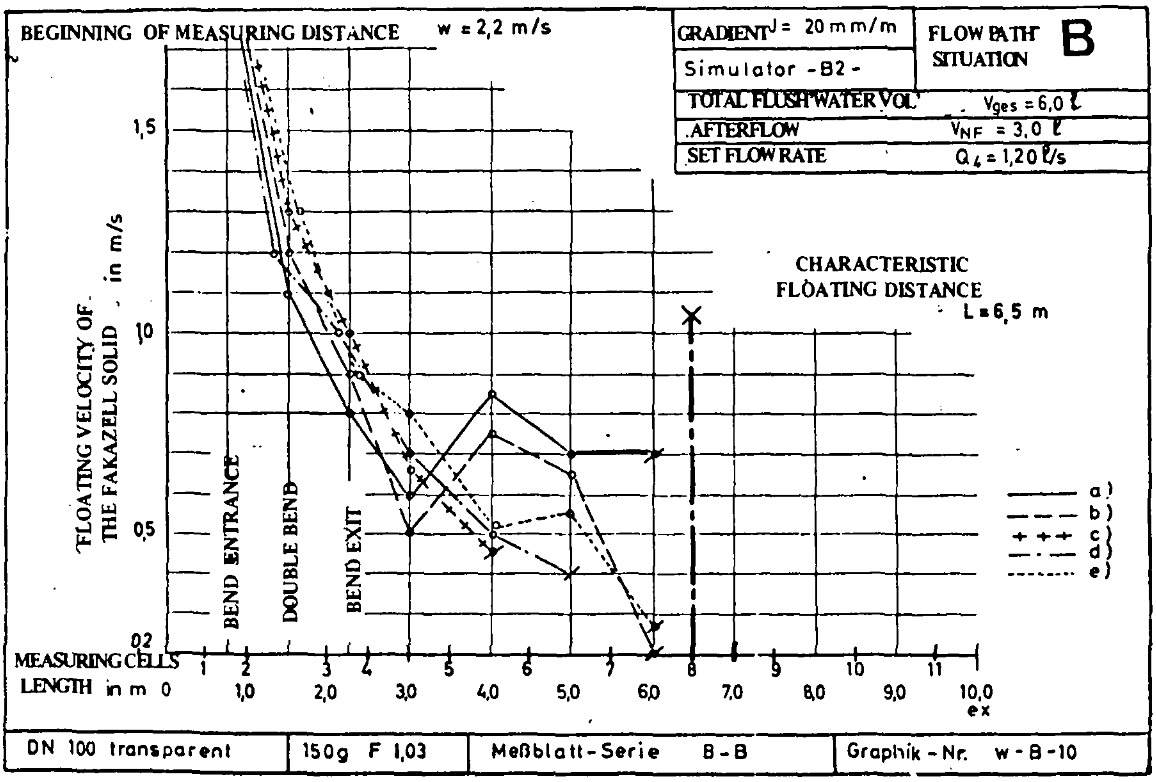

FIGURE 26 : A reduction of the floating velocity with two 45° bends (90° turn) with *a small flow rate*. Compare with Figures 39 and 40

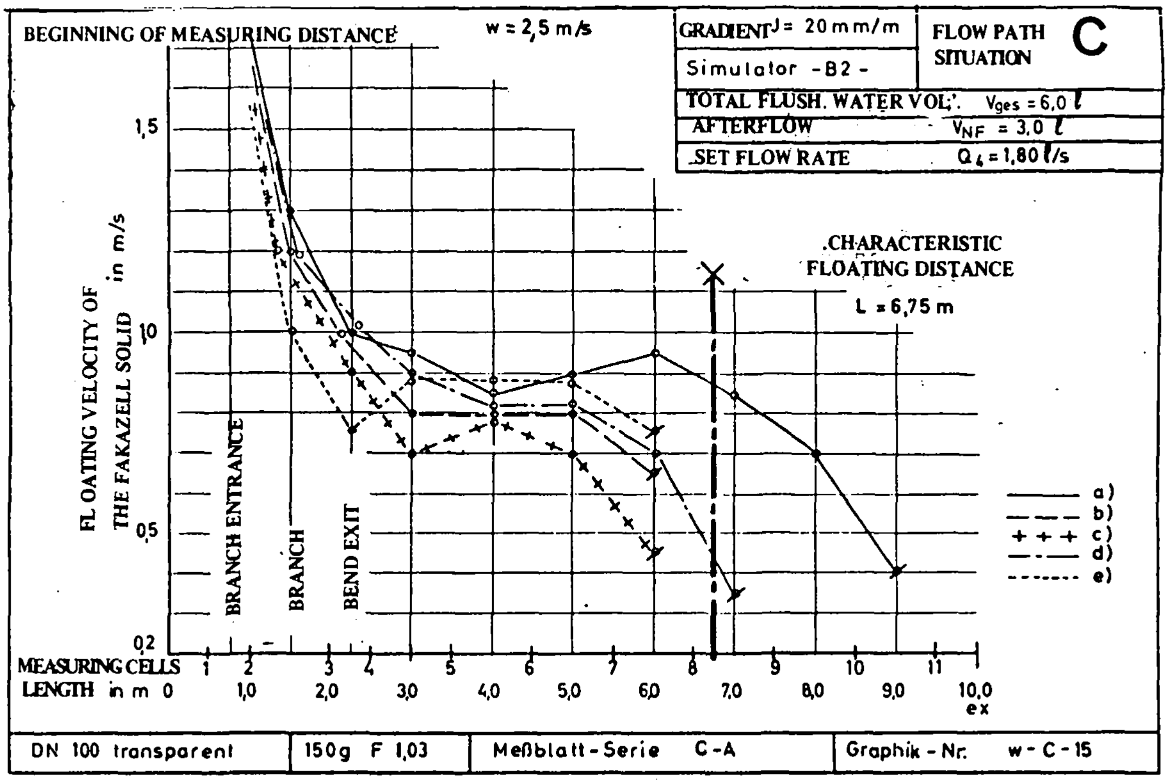

FIGURE 27 : Velocity drop with water inflow in a branch from the side with *a large flow rate.* Compare with Figure 40

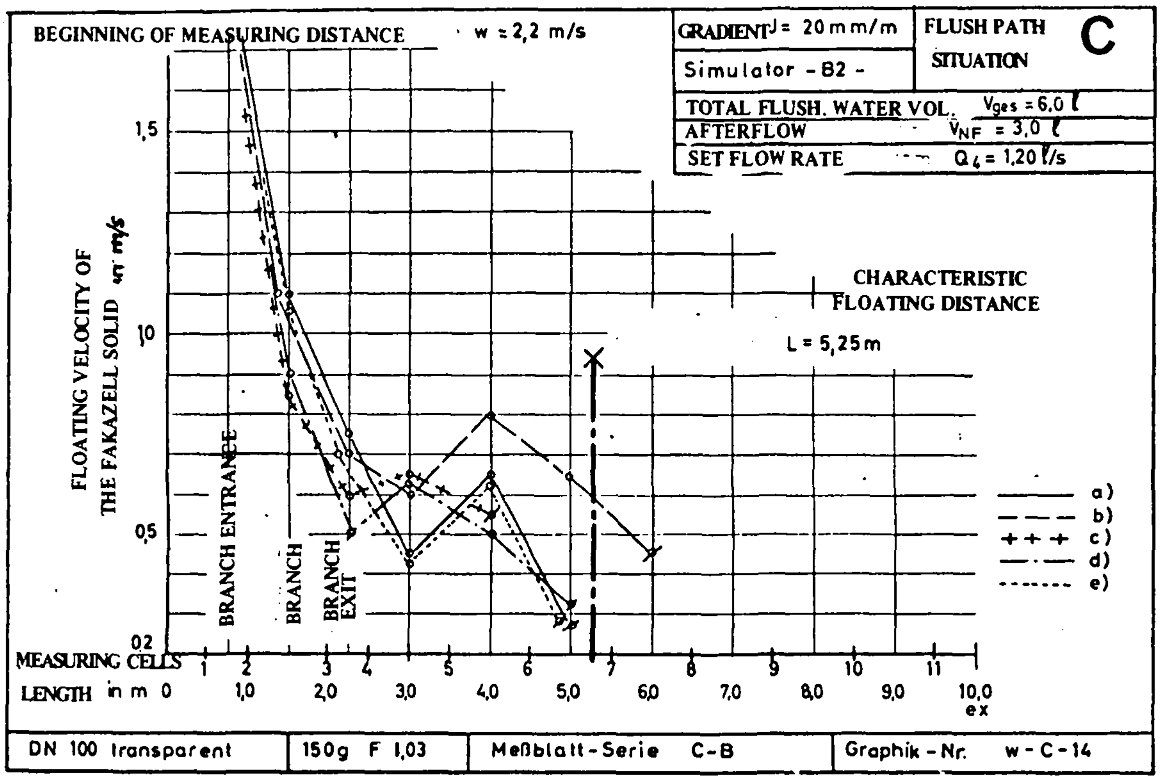

FIGURE 28 : With water inflow in a branch from the side with *a small flow rate* the floating velocity is only influenced to a small degree. Compare with Figure 41

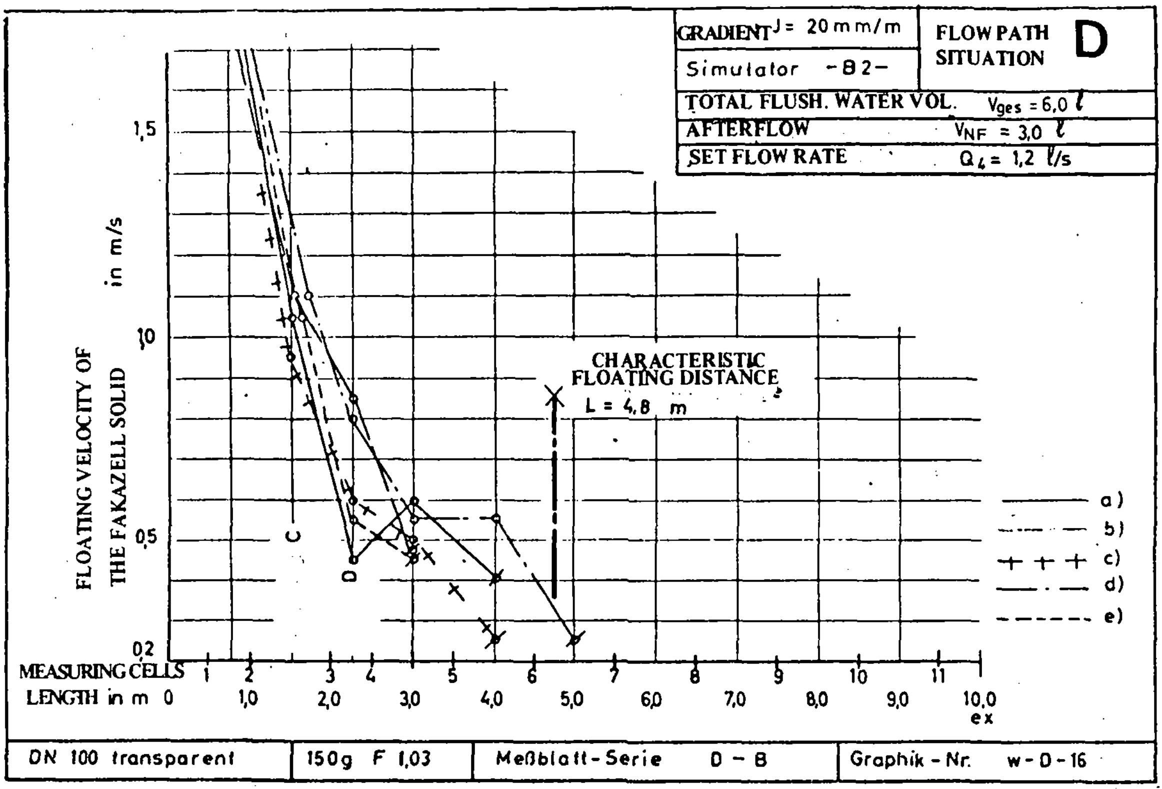

FIGURE 29 : Flow-through branches change the velocity pattern, because of the branching off of flushing water into the connecting pipelines. With a small flow rate the depositing velocity can be reached more easily

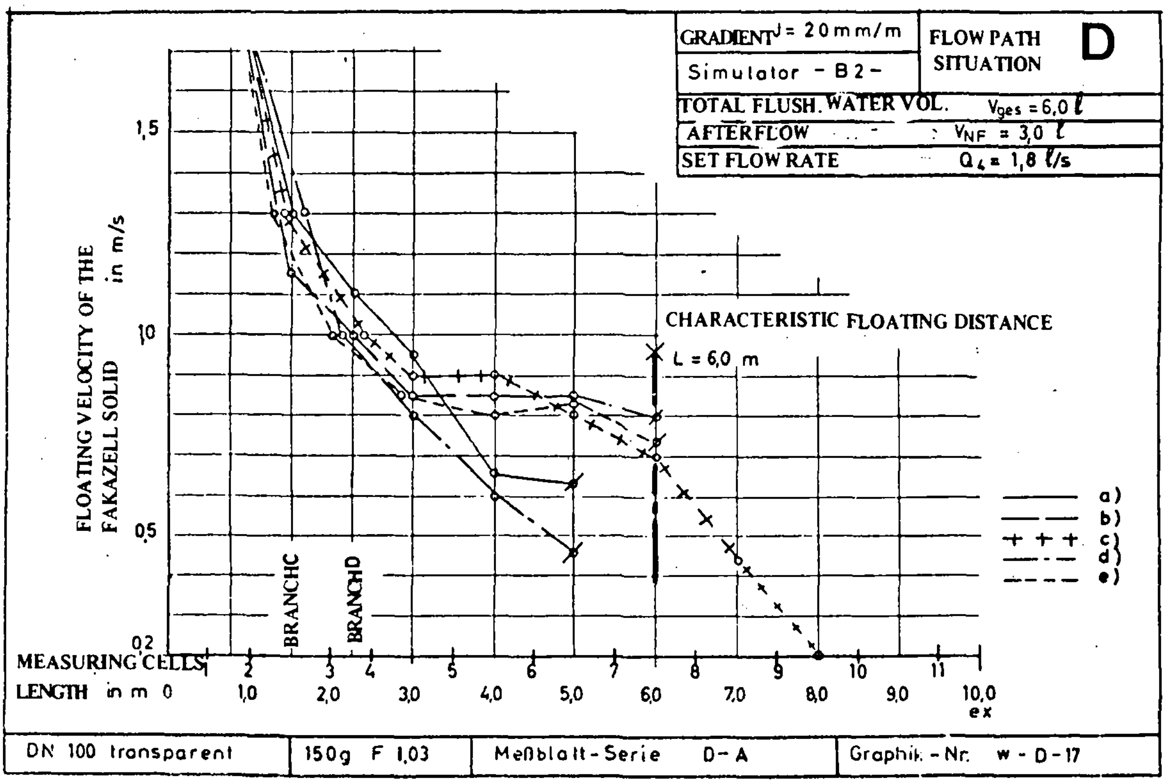

FIGURE 30 : Compare with Figure 44

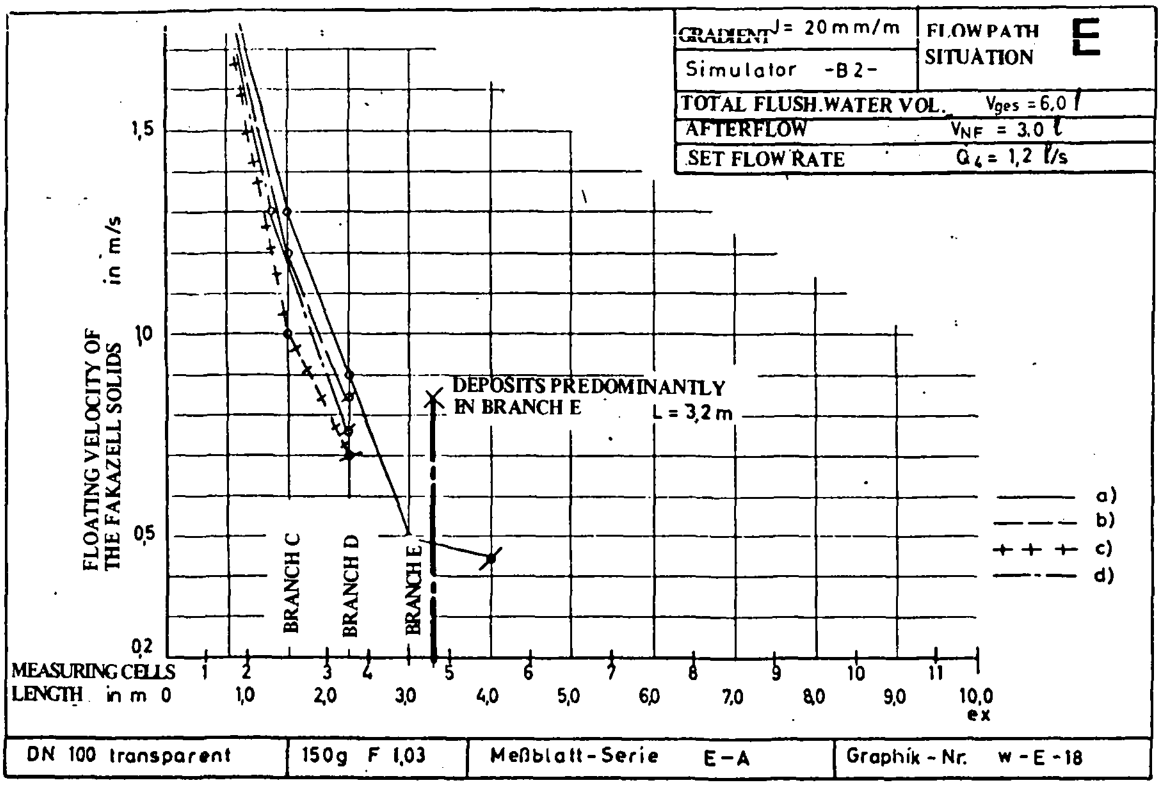

FIGURE 31 : Floating velocity pattern with installation situation E where there is a tendency towards deposition in branch E

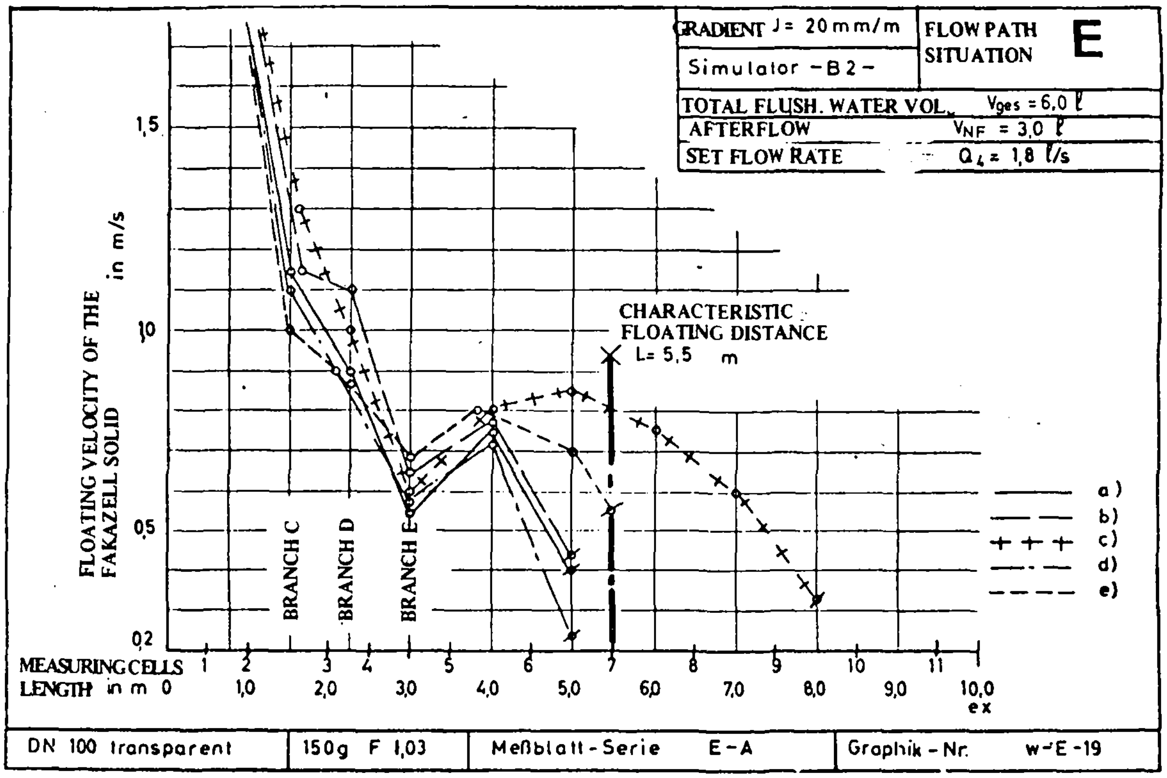

FIGURE 32 : In the flow path situation E there is a better chance that the solids pass through branch E with a large flow rate than with a small flow rate. Compare with Figure 31

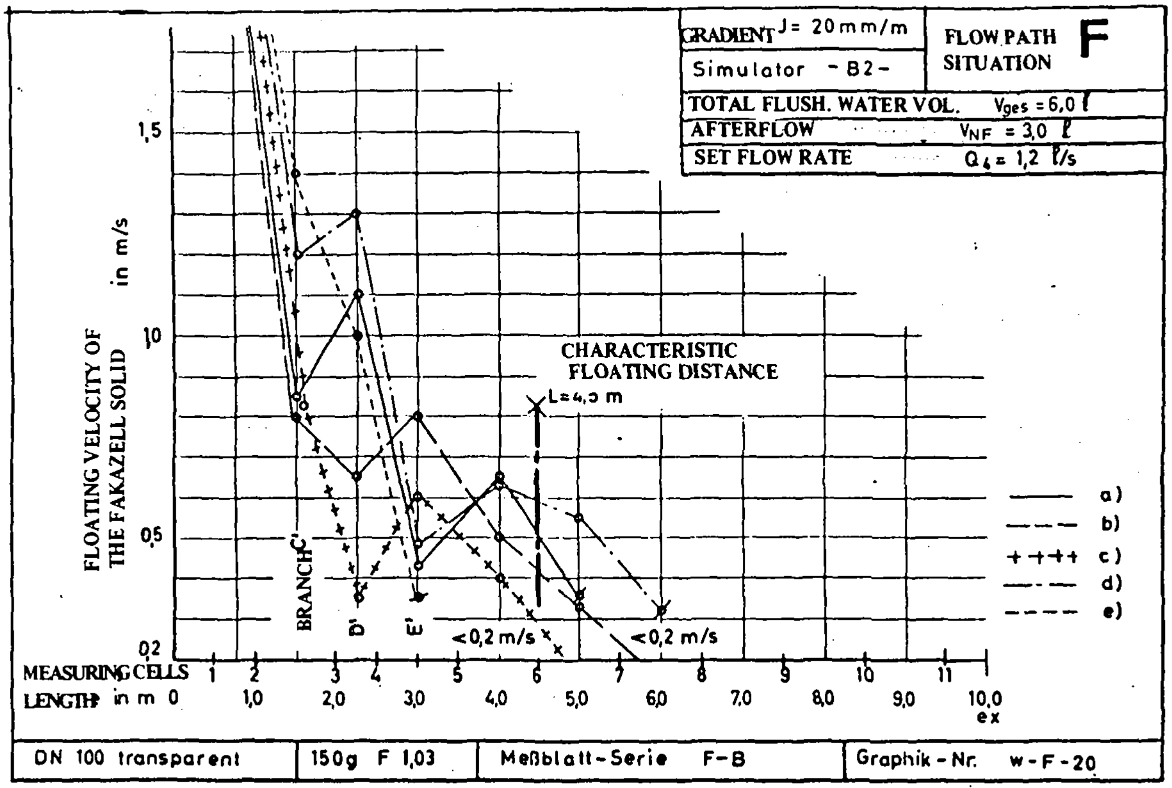

FIGURE 33 : Slanting the branches decreases the resistance in the flow-through branches. Advantage for small flow rates. A wide range of floating velocities in inlet branch C

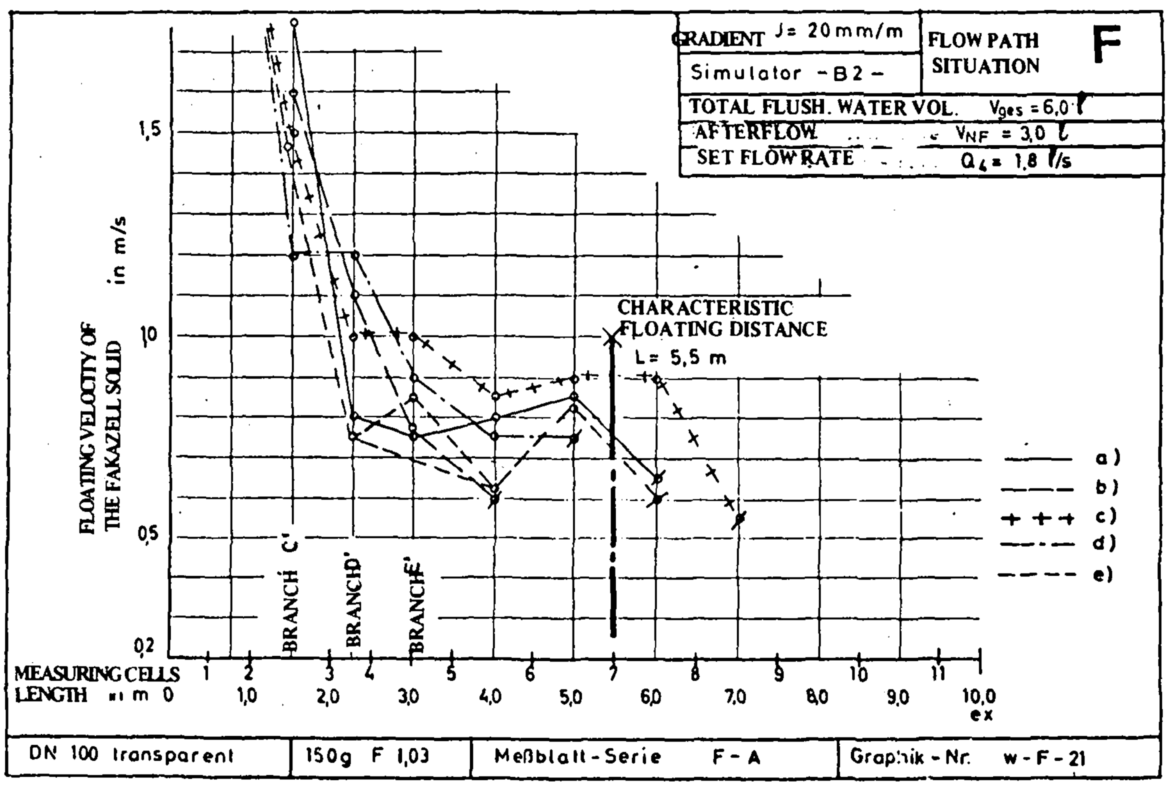

FIGURE 34 : Stabilizing of the flow-through, even with a large flow rate in the flow path situation F (inclination of the branches), however, a wider range of velocity on the inlet branch

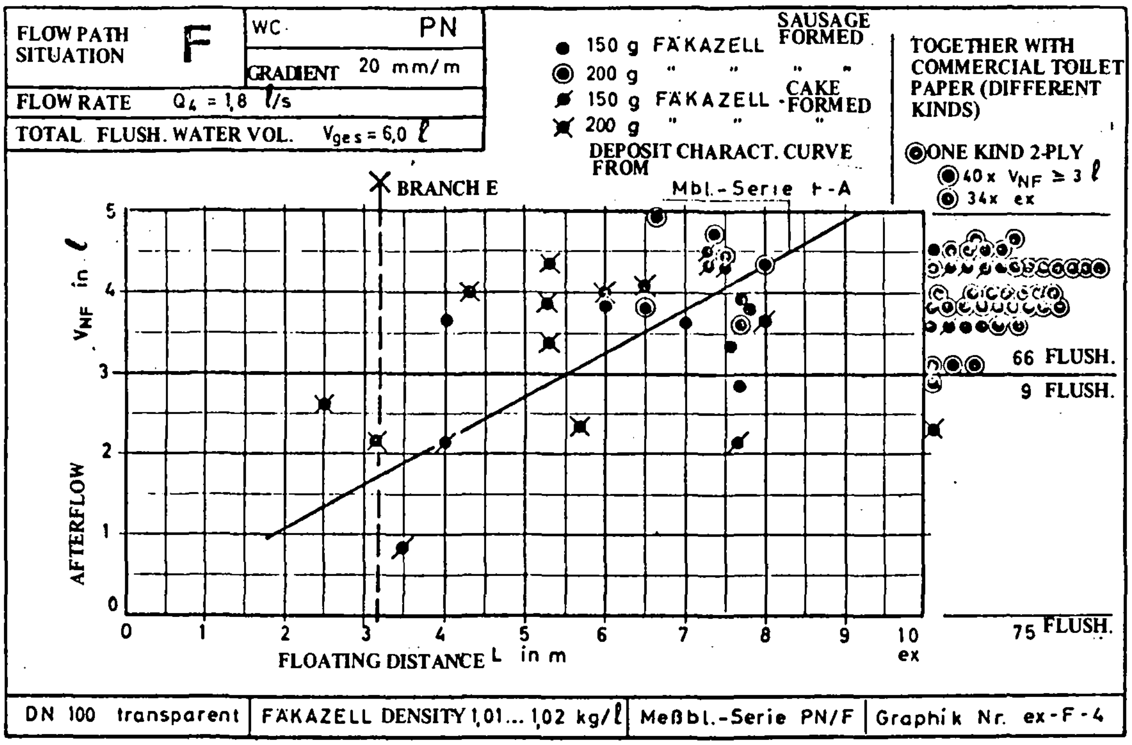

FIGURE 35 : Flushing out performance test with $Q_4 = 1,8$ ℓ/s.
Sausage-formed FAKAZELL is flushed out reliably with $V_{NF} \geq 3,01$

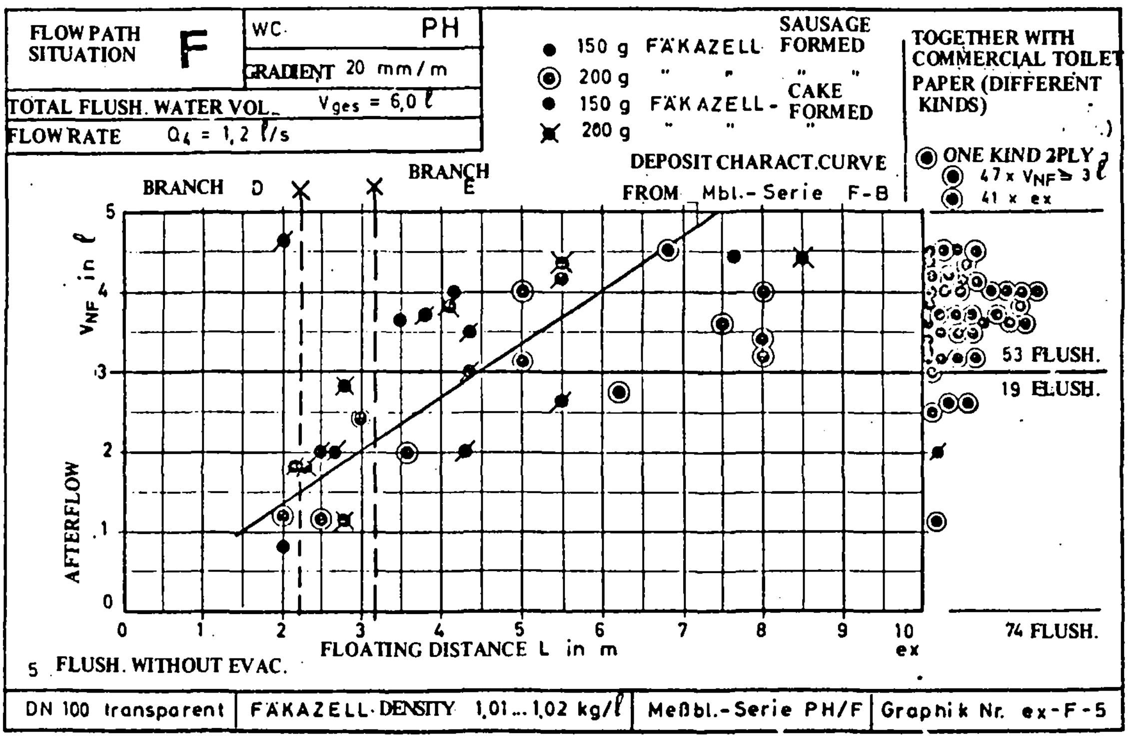

FIGURE 36 : Flushing out performance test with $Q_4 = 1,2$ ℓ/s.
Sausage-formed FAKAZELL is flushed out reliably with $V_{NF} \geq 3,01$.
A larger amount of flushings with $V_{NF} < 3,01$ compared with Figure 48

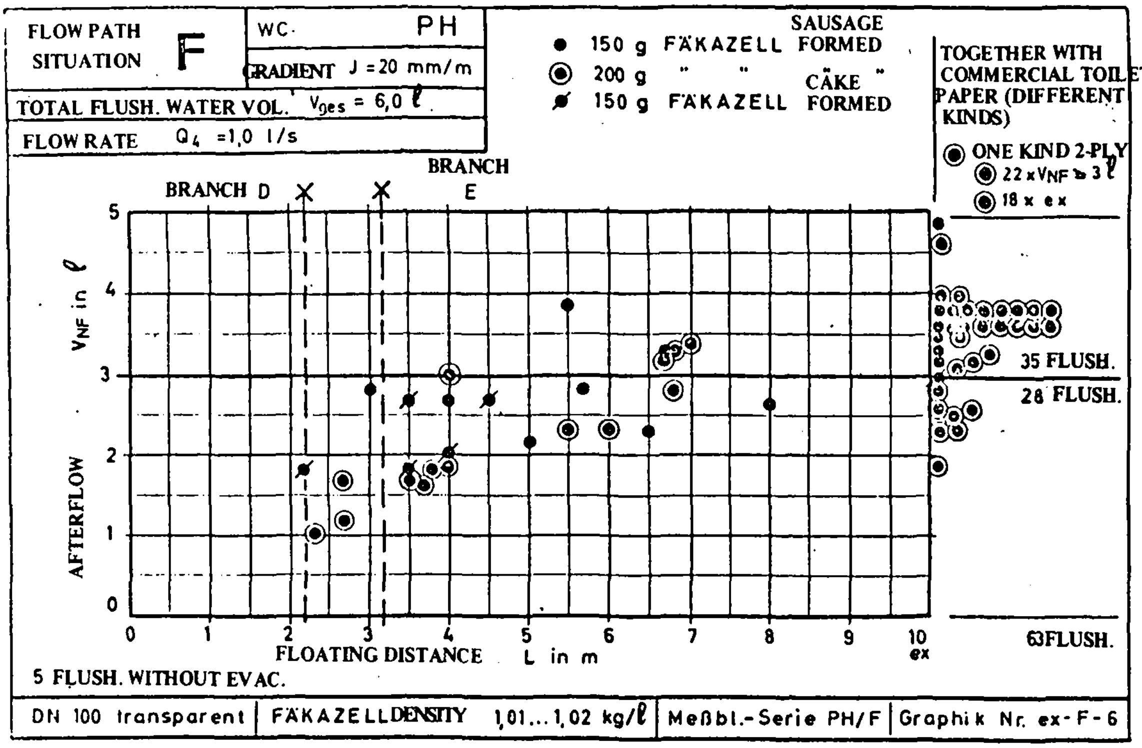

FIGURE 37 : Flushing out performance test with Q_4 = 1,0 ℓ/s.
Sausage-formed FAKAZELL is flushed out reliably with V_{NF} > 3,01.
A larger amount of flushings with V_{NF} < 3,01 compared with Figure 38

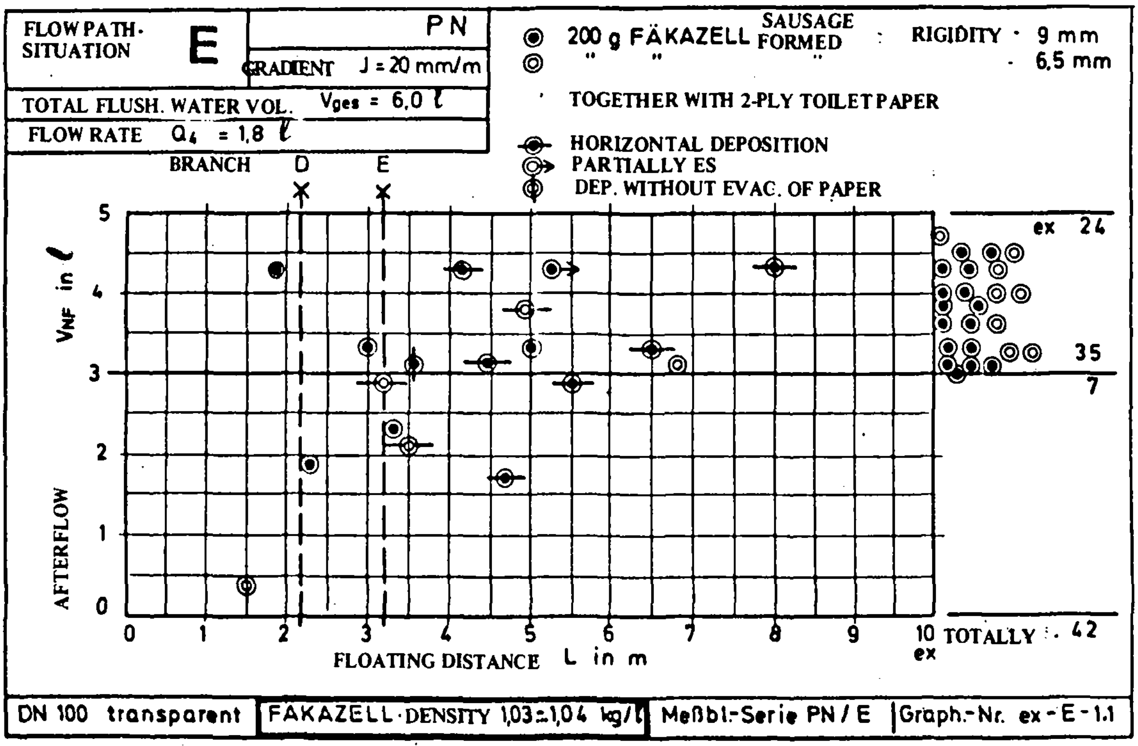

FIGURE 38 : Flushing out performance test with Q_4 = 1,8 ℓ/s.
FAKAZELL-paper-conglomerates are flushed out reliably, however early deposition results due to the extended form of the FAKAZELL solid.

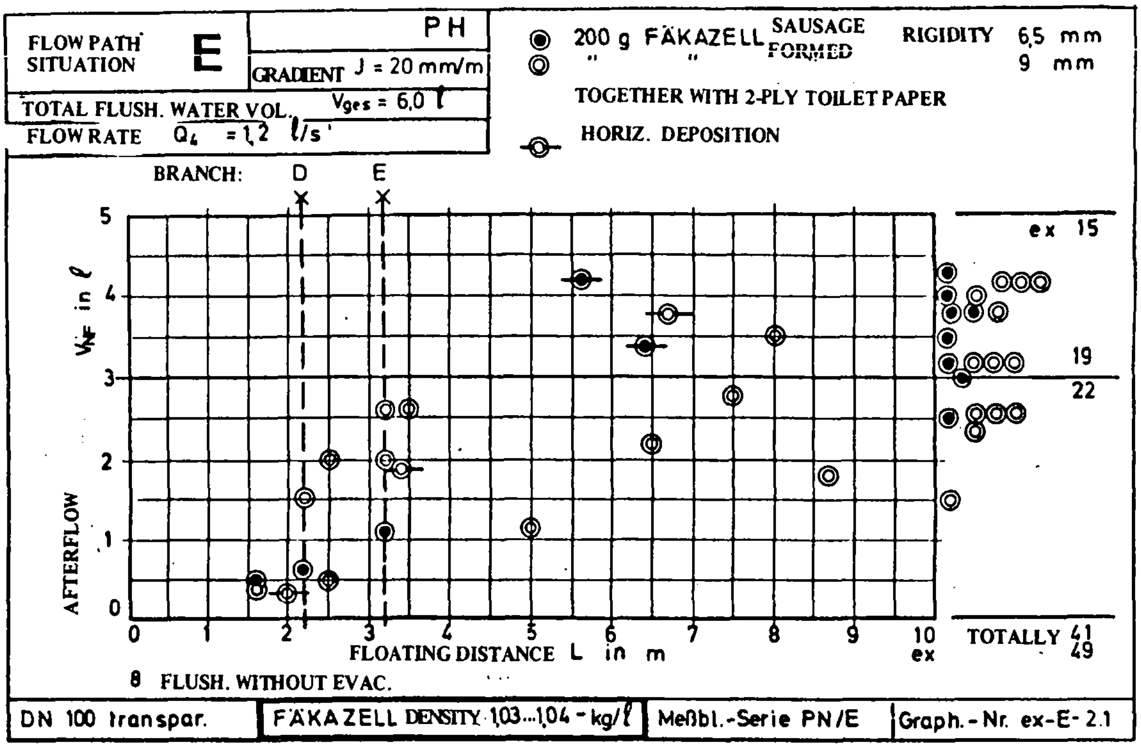

FIGURE 39 : Flushing out performance test with $Q_4 = 1{,}2$ ℓ/s.
Flushing out resulted mainly with $V_{NF} = 3{,}0$.
Dealyed evacuation of the flushing solids from the W.C. due to the density of the FAKAZELL

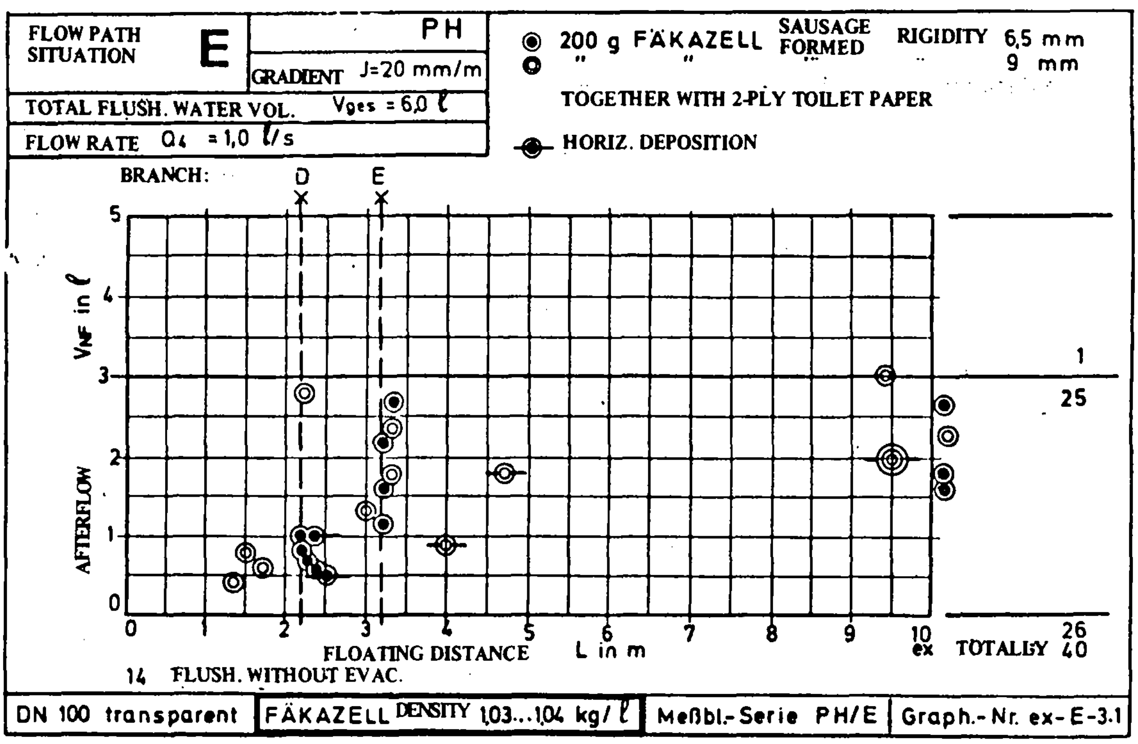

FIGURE 40 : Flushing out performance test with $Q_4 = 1{,}0$ ℓ/s.
The afterflow required for the flushing out performance is rarely achieved. A large number of deposits in the area of the flow-through branch. 14 out of 40 flushings without evacuation.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES

WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 11
Referaat 11

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water supply, drainage, sewerage, stormwater/ Watervoorsiening, dreinering, riolering, stormwater

WATER SUPPLY AND DRAINAGE RESEARCH AT THE NATIONAL BUILDING RESEARCH INSTITUTE

by P.R. Crabtree*

SYNOPSIS

This paper deals with the scope of research carried out at the NBRI, namely sewerage, building drainage, stormwater drainage, water reticulation, water supply in buildings, and domestic water economy measures. Current research programmes being undertaken by the Institute are described in detail.

SAMEVATTING

Hierdie referaat handel oor die omvang van navorsing wat deur die NBNI gedoen word, naamlik riolering, gebouriolering, stormwaterdreinering, waterbenetting, watervoorsiening in geboue en huishoudelike waterbesparingsmaatreëls. Navorsingsprogramme, waarmee die NBNI tans besig is, word in besonderhede beskryf.

* *Head, Building Services Division, National Building Research Institute, CSIR.*

A. INTRODUCTION

The scope of research carried out at the National Building Research Institute (NBRI) in the fields of water supply and drainage is perhaps somewhat wider than that of most comparable organizations in overseas countries. Whilst they confine themselves largely to these services as they occur on the building premises, the NBRI casts its net somewhat wider to encompass water reticulation and sewerage for whole townships. Thus, today, research at the NBRI on water supply and drainage falls into one or other of the following subdivisions, but because the supply of water and the removal of sewage are part of the same cycle there are both overlapping and contiguity at all times:

(a) *Sewerage* - foul water drainage in the public or municipal domain.

(b) *Building drainage* - foul water drainage on private premises.

(c) *Stormwater drainage* - on both private and public property.

(d) *Water reticulation* - water supply networks in the public or municipal domain.

(e) *Water supply in buildings* - on private premises.

(f) *Domestic water economy measures* - application to both (d) and (e) above.

What in fact separates these subdivisions far more clearly than technical considerations is the division of responsibility when it comes to factors such as design, installation, ownership and maintenance. To achieve any real degree of success, applied research establishments cannot carry out investigations in isolation, they must rely heavily on all interested parties for cooperation and collaboration. In the case of engineering and building services this means close liaison with the designers, installers and owners of the systems involved as well as with any control authorities when statutory approval and control are exercised. Thus, while a building drainage installation is physically part and parcel of the sewerage reticulation in an urban area, and nearly all the same design and construction criteria and materials apply to both, they are not designed, approved, installed, inspected, owned or maintained by the same category of persons, professions or organizations. Drainage installations are usually designed by architects, approved and inspected by the building surveyor's department (in terms of statutory regulations and by-laws) of the local authority under whose jurisdiction it falls, installed by plumbers, owned by private sector persons or firms and maintained by private plumbers. Sewerage on the other hand is designed by civil engineers (municipal or consultant) approved and inspected by municipal engineers in terms of their own requirements and owned and maintained by the same public authority. Exactly the same situation pertains to the water supply in buildings versus the water reticulation network and stormwater drainage on or off the private premises. Water economy measures may also apply either to the public supply system or the plumbing on the premises or within the building, again involving different sets of people.

It is because the people concerned are the most important channel of research application that research, on what is technically and otherwise a single integrated system with basically the same problems to be solved, is related to the separate people categories involved.

B. BRIEF HISTORY OF THE BUILDING SERVICES DIVISION

Work on sanitary services began at the NBRI in the early 1960's when a Sanitation Unit, then housed at the National Institute for Water Research, moved over to the NBRI. Until then the unit had been engaged on low-cost rural sanitation problems, with particular emphasis on maturation ponds and aqua privies. Early work at the NBRI continued to be aimed at low-income housing and concentrated on the development of sewer flow design criteria and the elimination of extraneous flows into sewers via gullies and by infiltration. This work was carried out by the Drainage Section of the then Civil Engineering Division.

By the late 1960's the scope of work had widened to include all sewer design criteria and materials and, with the advent of new pipe materials and pipe joints on the market, many evaluation projects related to these developments were carried out. The collection of sewer flow data from field gaugings in all types of residential townships continued as an ongoing exercise. At about that time the first projects in the building drainage field were also begun, in particular on promoting single-stack drainage, which had been developed by the Building Research Station in Britain, and on the use of plastics pipe for above and below ground drainage installations. It was about this time, too, that the first South African Bureau of Standards (SABS) Standard Specifications for UPVC pipe systems were being compiled and the NBRI played its part in this development. A contribution was also made to the compilation of the Drainage Chapter of the Standard Building Regulations, of which the metricated version was published in 1970.

As a result of pressures and requests from various sources a project on domestic water supply was established in 1972, the year that CIB Commission W.62 was constituted. Early work concerned the advent of plastics pipes in the water supply field in South Africa. A year later the Department of Water Affairs, through the Water Research Commission, first mooted a project to be undertaken at the NBRI on water economy measures in urban areas.

With growing indications that greater attention was going to be given to engineering and building services, including electrical services, it was decided in 1975 to create a new NBRI Division, the Building Services Division.

C. CURRENT RESEARCH PROGRAMME

1. Water supply for buildings

Overall objective: To obtain data on the criteria for the design of water supply *for* buildings.

So as to encompass all aspects of research on water supply systems both within buildings and in townships the word 'for' was substituted for 'in' in the title and objective a few years ago. Work on this project is carried out in collaboration with the Materials Divisions of the NBRI, manufacturers, government departments and local authorities. As in the case of all NBRI research projects the project is divided into broad and specific tasks some of which are ongoing while others are for completion within a specific period. The project as a whole is regarded as ongoing, and some tasks overlap to a greater or lesser degree with other project tasks, while all tasks have a priority rating commensurate with the availability of staff and funds.

(a) Design criteria for water supply systems in large buildings

This broad based and ongoing task specifically covers general design criteria for cold and hot water supply systems within buildings, and more particularly larger buildings such as blocks of flats, office blocks, hotels, hostels, colleges, universities and schools. Hydraulic and layout design criteria are studied along with all types of materials, fittings and appliances used in building water supply systems. Collaboration with the SABS on the formulation of new Water Supply Installation Regulations and Codes of Practice is taking place mainly under the auspices of the water economy project but most of these aspects would normally fall under this general task.

Some of the more specific tasks listed below of course form an input into the development of overall design criteria, although they are also designed to provide data that may be put out on their own as research findings for the use of designers and others in the industry.

(b) Water consumption data

The acquisition of water consumption data from the monitoring of existing buildings of various types is one of the prime ongoing tasks of this project and also of the water economy project. It is felt that this data base is required for South African conditions before flow and demand design criteria can be established for the various common categories of water usage.

However, unlike the case of sewer flow gauging, which has been carried out by the NBRI for twenty years now with relatively unsophisticated and inexpensive equipment, problems are being experienced with finding suitable transducers for monitoring the flow and demand patterns of water usage in larger buildings where several hundred water using appliances may be involved. Apart from the shear magnitude of the cost implications of using so many transducer probes, there is also the fact that these have to be 'cut' into the existing pipework.

Thus a first priority of this exercise is to try to develop simple and inexpensive on/off type switch probes that are small enough to be placed into existing pipework via the terminal fittings without major disruption and alterations. To date some success has been achieved and prototypes are under test. Overall unit or per capita consumptions are naturally no problem as the bulk hot or cold water supplies can be metered by recording meters, where overall peak draw-offs will also show up.

A number of NBRI staff houses have been monitored over a one year period where in-house and garden usage as well as hot and cold supply have been separated. This sample, however, requires to be increased in size and widened to cover various income groups and plot sizes.

(c) Study of noise in plumbing systems

This task which has a fairly low priority is being carried out in collaboration with the Environmental Engineering Division of the NBRI. It was instituted to carry out acoustic investigations on local water supply terminal fittings, pipe configurations and mountings similar to those being undertaken in most European countries, where such fittings are noise-rated and where regulations now demand the use of fittings with certain maximum ratings for particular applications.

To date, however, staff shortages have prevented progress on this task, although a test facility has been built and commissioned adjacent to the plumbing test tower facility of the Building Services Division.

(d) Water supply for fire-fighting in high-rise buildings

This is another specific task with a low priority to be carried out in collaboration with the Fire and Concrete Engineering Division as and when staff availability permits. This task also depends, to a certain extent, on progress in the general task (a) above and the general task (e) below covering water networks.

(e) Water reticulation networks

This task is in effect the general ongoing opposite number of task (a) pertaining to water supply in the public or township domain. It covers all aspects of design criteria, fittings and materials for township reticulation. The data from task (b) above are also relevant to this task.

At present the main effort in regard to township water reticulation is going into the preparation of rational norms under the auspices of a government sponsored project to be dealt with later. Some contract work, mainly on pipe and pipe joints, has been undertaken for manufacturers during the past few years.

2. Water economy measures in urban areas

Overall objective: To achieve a meaningful saving of water in the design and use of water supply fittings within the built environment.

To be strictly correct the project title and objective above should each have included the word 'domestic' as it is aimed at the conservation of water used for domestic purposes only. Others are carrying out research into industrial water economy.

The full scope and details of this 5 year project, sponsored by the Water Research Commission, have been described elsewhere(1)(2) as well as the roles of the various participants(3). A paper dealing with progress and findings to date follows at the end of this seminar(4). Suffice it to say that the following are some of the main tasks of the NBRI in this project, roughly in order of priority:

(i) investigation of water closet flushing requirements;

(ii) investigation of urinal design and flushing devices;

(iii) study of the design of household appliances, fittings and taps;

(iv) study of the water saving possibilities of pressure regulation in buildings;

(v) study of possible water saving aspects in hot water systems;

(vi) study of the individual metering of flats;

(vii) study of garden watering and water consumption for private swimming pools.

The NBRI is sub-contracting certain local authorities to carry out specific investigations and, as already mentioned, is also collaborating with the SABS with a view to instituting a system of national approval for all basic domestic water supply fittings and materials, and in drawing up the Water Supply Installation Part of the National Building Regulations together with the relevant Codes of Practice and Standard Specifications.

This project is administered under the guidance of a representative National Steering Committee and is being carried out in close collaboration with all interested bodies.

3. Sewer, drainage and plumbing design

Overall objective; To obtain data on the criteria for the design of sanitary and stormwater drainage.

This ongoing project was started in 1962 and is the oldest project in the services field at the NBRI. All the tasks in this project are ongoing and all but one are broadly based to cover a main subdivision.

(a) Gathering data on sewer flows

As already explained this ongoing work has been in progress for 20 years and, following a full coverage of all types of residential townships, has been widened in recent years to cover other special land usage categories such as schools, hospitals, blocks of flats, military camps, hotels, shopping centres, townhouses, office blocks and sports complexes. Thus design criteria have been developed for most of the categories concerned.

Just recently the Division has acquired more sophisticated ultrasonic depth monitoring equipment and electronic logging apparatus to eliminate the time-consuming, manual abstraction of data for computer processing. Directly recorded data can now be immediately processed by the Division's own mini-computer based processing system.

A feature of this programme is that, over the years, many local and other authorities have been encouraged to measure sewer flows for themselves, using the equipment developed by the NBRI and fibreglass flumes manufactured and supplied by the Institute. Thus many of these authorities have been able to develop their own design criteria. The NBRI has often assisted in processing the gauging data to produce the flow hydrographs.

(b) Field studies on behaviour of pipes

This task covers both laboratory and field investigations on all types of pipes, pipe fittings and joints in the fields of sanitary drainage and sewerage, and includes contract investigations of new products on behalf of manufacturers, and in-situ investigations of buried and above ground pipeline problems on behalf of local authorities, contractors and manufacturers.

Over the years a variety of test and evaluation programmes have been conducted on new materials, failures and operating systems. The development of flexible joints for sewers was carried out as a national project in 1968 and resulted in the adoption of the principle of flexible jointing for all sewerage schemes in South Africa.

The development and building of the necessary specialized research apparatus has played a large role in this task and such items as inspection cameras, deflectometers, joint test beds, loading test boxes, air-test apparatus and many ancillary items have been designed and built by the NBRI. A sophisticated closed circuit TV inspection system has also been built up for field work on sewers and drains.

Past work in regard to sewers has included work on curved sewers, minimum permissible grades, manhole spacing and the preparation of a guide to the use of various types of sewer and drain pipes available locally.

(c) The study of plumbing systems and practice

This general and ongoing task covers all work on foul drainage installations on the premises of buildings, i.e. the drainage side of plumbing. As already mentioned, early work in this field included the propagation of the principles of single-stack drainage and investigations on the use of UPVC drainage systems.

Much of the NBRI's effort in this field has been aimed at the updating and simplification of drainage regulations of local authorities. This applies particularly in regard to the use of modern systems and materials and the rationalization of ventilation and access requirements. The Building Services Division played an active role in the drawing up of the Transvaal Standard Drainage By-laws published in 1977 and, hopefully, much of the basic design material contained in these by-laws will be used for the Drainage Part of the National Building Regulations.

Present work on building drainage is concentrated on trying to evolve a discharge unit design concept specifically for local conditions, the present criteria being largely based on modified American and British practice. Hence an extensive monitoring programme is being planned to cover all the main categories of building occupancy.

To enable comprehensive monitoring of flows in large buildings a sophisticated data logging and processing system has been acquired, but the necessary transducer probes for installation in waste and soil pipes are still being developed. The most important factor to be determined is the frequency of occurrence of coincident discharge of various appliances in a mixed system. It is no longer logical to accept, particularly for blocks of flats, as is the case in certain overseas countries, that the WC constitutes the heaviest hydraulic load on a drainage installation.

The building of a multi-storey plumbing test facility was begun some six years ago. The facility consists basically of a six-storey structural steel test tower and an adjacent equipment-housing shed. The necessary pumps, tanks, sumps and pipework have been provided to set up hydraulic tests on plumbing and drainage systems. The first test work carried out at the tower was the evaluation of the demand, flow and discharge characteristics and patterns of some locally available sanitary appliances and their respective water supply fittings. This work is now being widened in scope to cover a much wider range.

This data, once established, will form the basis of several other projects and tasks in the future research programmes on drainage and water supply in buildings.

It is further planned to test and evaluate water supply fittings and appliances together with the evaluation of the associated sanitary appliances. Some of this work is likely to be directed at water conservation in domestic installations. Preliminary studies are likely to pinpoint research needs, particularly in relation to pressure control systems and automatic flushing devices.

Also being studied (using the tower) is the feasibility of a variety of single-stack layouts incorporating various locally available pipe materials and appliances, and certain standardized combined waste pipe systems which otherwise are not permitted in single-stack drainage.

(d) Structural design of sewers

Work has been carried out somewhat intermittently on this lower priority task, mostly on the basis of ad-hoc investigations of specific problems encountered by manufacturers or local authorities. An example was a recent evaluation of a revolutionary type of rib-reinforced foamed plastics pipe developed in South Africa and manufactured by the grow-moulding principle.

Present work under this heading is confined to a sponsored investigation into the bedding factors for large precast concrete pipes with particular regard to classical Class A concrete beddings. It is hoped to expand this study to cover all types and sizes of rigid pipes and also to a study of the bedding and backfilling requirements for flexible pipes with particular reference to the use of various typical kinds of South African soil.

(e) Stormwater drainage design

This task, instituted some four years ago, is directed particularly at research on urban stormwater drainage with special attention to residential township development.

A study of stormwater drainage design practice in townships indicates that inadequate provision is made for the drainage of major flood runoff. In future townships this problem can be overcome by providing two separate but intertwined systems. One of these is a minor system to be provided for the convenience of the public and to prevent minor damage from frequently occurring storms. The other is a major system designed for 50-year floods and based on natural and artificial watercourses. Fundamental to these systems is their planning at the same time as that of the township layout.

Methods of attenuating excess runoff by temporary storage, in parks, playing fields and parking areas, have been investigated. These investigations included a study to ascertain the storage potential of a catchment in a built-up area in Pretoria.

Because the implementation of the new concept of urban stormwater drainage will require the close cooperation of town planners, they will have to be acquainted with these new developments. To this end discussions have been held with the secretary of the Town Planners Association, and copies of the NBRI publication on stormwater drainage have been sent to all members. As it is felt that the new concepts should be included in town planning courses at universities, discussions were held with the Chairman of the Town Planners Association and different university faculties to ascertain the possible reactions to this view. In general, the reaction was positive.

The need has also been emphasized for cooperation between township planners and services engineers in the initial planning stages. Discussions have also been held with some of the

Chairmen of the regional committees for the National Building Regulations and the SABS on the inclusion in the regulations of measures of controlling stormwater on building sites.

Extensive discussions were also held with central and provincial government, municipal and divisional council engineers. The work on stormwater drainage design has a very real significance in respect of the work being done on behalf of the Department of Community Development and State Auxiliary Services discussed under Project 5. The concept of attenuation of runoff by storage is being implemented in several schemes. One problem that gives rise to concern is the possible danger to children of the large inlet structures to the storage areas.

A study is being made of sedimentation in pipelines and channels as this subject has an important bearing on both sewer and stormwater drainage design.

A study tour to North America and Britain has also been undertaken to become acquainted with the latest overseas developments on stormwater drainage. Following this visit it has become clear that the problem is not merely one of quantity but also of the quality of stormwater runoff to storage impoundments used for water supply. It thus becomes a case for total urban stormwater management.

4. Engineering and building services norms

Overall objective: To develop design criteria and norms for engineering and building services for health care buildings.

This project forms part of an overall programme of hospital research that has been carried out at the NBRI on behalf of the health authorities for many years, originally for the provincial administrations and now consolidated under the Department of Health. The work is guided by the Subcommittee : Buildings for Health Services and its Working Group on norms for Engineering Services for Health Care Facilities.

At a meeting of the former Hospitals Research Steering Committee* held in Durban during 1977 the committee agreed to the appointment of a working group to establish norms for engineering and building services for health care facilities. This decision was reinforced at the Second South African Hospital Symposium held during November 1977 where a resolution was passed to the effect that: 'immediate attention be given to the establishment of norms for engineering services for hospitals'.

The terms of reference of the subcommittee are to:

(i) establish a *priority* list of engineering items requiring national design parameters;

(ii) make the necessary ad-hoc investigations;

(iii) recommend *minimum acceptable interim national design* parameters for acceptance by the Subcommittee: Buildings for Health Services.

It was emphasized that the *ad hoc* investigations and recommendations were to be made by the group; this being so it would be a *working* group. In-depth or long-term research needs would of necessity have to be referred back to the subcommittee for deciding how and where it should be done.

During 1973 the NBRI made a broad investigation into hospital engineering services generally in order to establish research priorities. In addition, the Cape Provincial Administration has prepared a document that covers a wide field of engineering services and, in some instances, proposes certain design norms. These documents were used as a basis for discussion at the first formal meeting of the working group in 1978. They contained, inter alia, a list of 33 engineering items requiring attention. Priorities were allocated to the items, taking into account the need to conserve energy and the available manpower to collate the work. Documents were submitted to the second meeting of the group on a number of the top priority items. As a result, it was advocated and accepted that the Health Technical Memoranda of the Department of Health and Social Security in the United Kingdom would be used as a basis for establishing uniform hospital engineering guides and norms for South Africa. The drafting of the guides would be undertaken by small working panels. Three initial panels were appointed to cover:

- electrical services;
- water services; and
- piped gases and other specialities.

The three working panels have now virtually completed their tasks concerning the following basic services:

- calorifiers and hot water systems;
- cold water supply services;
- drainage services;
- compressed air, vacuum and medical gases systems;
- electrical services and power supply; and
- heating, ventilating and airconditioning.

The necessary computer programs have been developed enabling normative costs to be calculated for these engineering services, thus making it possible for designers and the hospital authorities to compare the cost implications of various options.

5. Rational norms for township services

The Building Services Division is involved in two projects on behalf of the Department of Community Development and State Auxiliary Services. These arose out of the recommendations of the Commission of Inquiry into Housing Matters (Fouché Commission). The proposed Steering Committees

* This Committee has now been replaced by the Subcommittee - Buildings for Health Services

for the two projects were constituted and held their inaugural meetings in November 1978.

All the coordinating functions regarding housing on a national basis were consolidated into the 'Coordination of Housing Matters Bill' passed by Parliament as Bill No. B 58 of 1978. To assist the Minister of Community Development and State Auxiliary Services in implementing those recommendations of the Fouché Commission that were accepted by the Government, two governmental bodies have been set up in terms of this Bill, *viz.* the Housing Matters Advisory Committee, under the Chairmanship of the Director General for Community Development and State Auxiliary Services, and the Housing Policy Council, under the Chairmanship of the Minister. The function of the Committee will be to institute investigations and make recommendations on the findings to the Minister, while the Council will consider these recommendations, and any comments on them by the Administrators of the provinces.

In execution of certain of the recommendations of the Fouché Commission, the NBRI, in collaboration with the other appropriate bodies, is undertaking the preparation of uniform, national and functional norms in respect of the essential engineering services for new residential townships. The responsible authorities should then take positive steps to ensure that the norms are applied both in public and private township developments throughout the country. The overall objective of the project is to provide information and guidance which would assist local authorities and private sector bodies concerned with township development in containing the costs of serviced land for housing.

At the inaugural meeting of the NBRI Steering Committee on Rational Norms for Township Services a proposed work programme was considered and approved. It was decided that the preparation of the necessary guide should be undertaken by four Working Subcommittees and coordinated by a national Coordinating Township Services Committee on which the provincial administrations are represented. With the approval of the Steering Committee a fifth subcommittee for Traffic and Transportation has now also been constituted.

This project is being coordinated by the Building Services Division and is aimed at the preparation and publication of a suitable guide manual on 'Norms for township services in South Africa'. The services covered are:

- water reticulation;
- sewerage;
- electricity distribution; and
- roads, sidewalks and stormwater drainage.

The terms of reference of the working subcommittees included the following three basic aspects of the provision of services:

(a) Physical planning

(i) Townplanning layouts of townships

To study and make recommendations to the Coordinating Committee on the process of township approval in regard to its possible effects on the cost of services; in particular, the concept of a services plan receiving approval by a competent engineering body prior to the final approval of the layout plan.

(ii) Guides for developers

To consider making recommendations to the Coordinating Committee on the question of requiring all interested authorities in the township establishment process to compile and publish clear guides laying down their policy as it effects township planning. This applies particularly to state and provincial departments and to semi-state statutory bodies.

(b) Fiscal policies

(i) Communal and mains services

While the matter of the financing of Local Authorities is still the subject of the Browne Committee of Inquiry and no doubt the Report of this Committee will deal with the funding of major capital works in municipal areas, the working groups may well have some recommendations to make in this regard from their own authority's experience.

(ii) Township services

To consider the present ways in which the financial responsibility is shared, in respect of each service, between local authority and developer in the various provinces/regions, and to make recommendations for a uniform national policy for each service. Here also consideration is to be given to the way in which local authorities, as developers of townships, recover the cost from the residents of such townships, i.e. either as a capital repayment by way of the price of the land or by way of tariffs and charges over a longer term.

Under this heading consideration will also have to be given to payment by residents for the upgrading of any service which has originally been provided to a lower standard or norm than the ideal.

(c) Technical or engineering norms

(i) Design and installation standards

To establish technical design, materials and installation norms for the four engineering services applicable to various types of residential township development, bearing in mind that a minimum essential standard should be laid down for each service which should be capable of being upgraded to higher norms and eventually to the ideal of fully installed services, if the circumstances so dictate in time.

(ii) Standard specifications

To consider the drawing up of standard specifications for the installation of all township engineering services.

(iii) Coordination and integration of services

To make recommendations to the Coordinating Committee on ways and means of ensuring better coordination in the design and construction of services to eliminate delays and damage during installation.

With regard to item (c)(ii) above this exercise had already been initiated. In 1975 the South African Institution of Civil Engineers, the South African Federation of Civil Engineering Contractors, the South African Association of Consulting Engineers and various other bodies involved in the civil engineering construction field got together and formed a committee to compile national standardized specifications for civil engineering construction (NSSEC) in collaboration with the South African Bureau of Standards. Thus the work of the township services committees in regard to the standardizing of specifications has joined forces with this exercise to help speed up the whole process.

The establishment of four Working Subcommittees got under way early in 1979. The committees agreed that questionnaires be drawn up and circulated throughout the Republic to local authorities, consultants, township developers and manufacturers. These questionnaires were aimed at getting a broad picture of present practice and views as regards tariffs, charges, connection fees, endowments and collation of financial responsibility in various regions and particular local authorities. Views were also required on the concept of a scale of standards or norms for services ranging from minimum or essential to fully constructed or desirable. At present the latter is the general requirement, but it is implicit in the views of the Fouché Commission, that different norms would apply to different communities. Clearly, also, services installed to lower standards should be capable of being upgraded at the request of a community when it is in a position to pay for upgrading.

Following an analysis of the questionnaire replies, certain interim recommendations were made to the Steering Committee in regard to the non-techncial items mentioned under items 5(a) and (b) above. These have been passed on to the appropriate authority considering administrative matters in regard to township establishment.

At the time of writing, the working subcommittees have already finalized the basic design criteria for each service and are now working on the Code of Practice material that will form the basis of the constructional norms and which will also be published as part of the NSSEC exercise by the South African Bureau of Standards.

6. Middle-income housing costs

The second NBRI Steering Committee arising from the Fouché Commission report on Housing Costs, was established with the following overall objective:

To provide information and guidance which will assist the public and private sectors in containing the costs of housing for the middle income groups to within modest levels and in obtaining best value for money.

The tasks of the Building Services Division under this project comprise the preparation of design and installation guides for domestic plumbing and electrical installations.

The task in regard to domestic plumbing has the following objective:

To prepare a guide on the rationalization of the design and installation of plumbing services in housing, based on economic considerations with a view to keeping costs within modest limits.

The necessary design and installation guides cannot be prepared until the relevant parts of the SABS National Building Regulations are gazetted. In the meantime the staff concerned are involved in the specialist committees set up by the SABS to prepare the Drainage and Water Supply Installation Regulations. While the draft of the Drainage part is virtually complete, based largely on the Transvaal Standard By-laws published in 1977, the Water Supply part is a long way from completion as it had to be started virtually from scratch. Four basic design criteria have been adopted for the Water Supply Installation Regulations, *viz.*

(i) water economy;

(ii) health;

(iii) safety; and

(iv) user comfort and convenience.

In order to achieve optimization of the use of materials in plumbing in houses, it has been necessary first to define a basis for the sound and rational design of plumbing systems. In this regard, aspects on which finality is now being reached, are pressure control, velocity limitations and optimum pipe sizing to achieve limited but adequate flow rates from the range of standard fittings in the conventional house plumbing.

The results of the Institute's research project in Urban Water Economy will ultimately impinge heavily on the regulations and on the national approval of fittings and components for water supply installations. At this stage recommendations based on the NBRI's existing knowledge, as well as on findings from other projects in this field are being channelled into the National Building Regulations drafts, but when the design and installation guides are prepared, recommendations regarding their use and application will be made.

D. TRAINING AND EDUCATION

While the NBRI is not directly involved in training and education in the building industry, the Institute nevertheless plays its part in encouraging these activities wherever it feels a shortcoming exists, and in some instances has acted to initiate action by those directly concerned.

Thus the training, certification and registration of plumbers have been particular problems on which the NBRI has tried for a number of years to get some action from the educational institutions, the industry and local authorities. The need has arisen as a result of a deteriorating skills situation in the plumbing industry and the call for uniformity which will be necessary once the National Building Regulations become mandatory.

It is gratifying that steps are now being taken at national level to reassess plumber training and to introduce training to technician level in the industry.

E. CONCLUSION

In conclusion it might be appropriate to stress two cardinal points that should run as a thread through all research programmes in the building and engineering services field. These are that design must be based on sound engineering principles and not just happen and that the integration and coordination of services at both design and construction stages can be one of the major economic factors in the provision of such services in buildings and township development.

REFERENCES

1. CRABTREE, P.R. *Water conservation in urban communities,* Proceedings 1978 Congress of S.A. Society for the Advancement of Science, Stellenbosch.

2. CRABTREE, P.R. *Urban water economy - a master plan,* IMIESA, Vol. 4, No. 5, May 1979.

3. CRABTREE, P.R. *Water conservation and the municipal engineer,* Proceedings 1980 Biennial Conference of the Institution of Municipal Engineers of South Africa, Bloemfontein.

4. MALAN, G.J. *Towards urban water conservation in South Africa,* Proceedings Water Supply and Drainage Services in Developing Countries, Pretoria, 1980

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 12
Referaat 12

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water supply, sewerage, low cost housing / Watervoorsiening, riolering, laekostebehuising.

WATER SUPPLY AND SEWERAGE FOR LOW COST HOUSING IN SOUTH AFRICA

by G E Bath*

SYNOPSIS

This paper deals with water supply and sewerage for all low cost housing in South Africa. This is the function of the Department of Community Development and State Auxilliary Services. The Housing Act, developments in state subsidisation of capital costs, and design and construction practice are discussed.

SAMEVATTING

Hierdie referaat handel oor watervoorsiening en riolering vir laekostebehuising in Suid-Afrika. Hierdie is 'n funksie van die Departement van Gemeenskapsontwikkeling en Owerheidshulpdienste. Die Behuisingswet, ontwikkelings in staatsubsidiëring van kapitaalkoste, ontwerp en konstruksiepraktyk word bespreek.

* *Chief Engineer, Department of Community Development and State Auxiliary Services, Pretoria, South Africa.*

A. INTRODUCTION

The words 'low cost housing' used in the title mean housing for all persons who, due to insufficient income, are unable to provide their own houses with their own funds, or with loans from Building Societies or from other financial institutions.

This paper deals with water supply and sewerage for all low cost housing in South Africa, which is the function of the Department of Community Development and State Auxiliary Services. It does not deal with development in the Homeland States, which is a function of a different department.

B. BACKGROUND

Over the years low cost housing in South Africa, i.e. the township services as well as the houses, has not only been subsidised but also financed by the Government. This subsidisation of capital costs has a direct relation to the standards of water and sewerage supply which can be provided: the less the subsidy, the smaller the amount of money available for water and sewerage, and standards consequently drop.

In the early days when only limited funds were available, subsidies were low; but as the country developed, and towns and cities expanded, so government expenditure on low cost housing increased and with it subsidies increased.

1. Housing Act

The first low cost houses in South Africa were produced 60 years ago through the first housing fund created in 1920. This was followed by two further housing funds. In 1957 the Housing Act was passed in terms of which all the previous housing funds were consolidated and transferred to the National Housing fund, the capital assets of which amounted to R218 million at the time.

In terms of the Act the Housing Fund can only provide loans for housing projects: it cannot make donations. Its capital is supplemented annually by means of Parliamentary votes, on which it never repays capital but only interest, plus loan capital repayments by local authorities. The loan capital repayments are used either for re-issue to local authorities or to the Department itself for the provision of further housing projects. The re-issue of capital repayments gives the fund its revolving character whereby its capital assets progressively increase. At present the amount is approximately R1 800 million.

2. Subsidisation of capital costs

To form an idea of the extent to which the State subsidises low cost houses and township services an outline is given below of the most recent system of subsidy applied over the last number of years, as well as the current system.

(a) Recent system of state subsidy

Family breadwinners with incomes up to R150 per month qualified for rented dwellings built by means of loans at a 1 per cent interest rate per annum repayable over 40 years. In this case borrowers repay only about R89 by way of interest and capital over the 40 years loan period for every R100 of the loan. This has been made possible in two ways. Firstly, the difference between the 1 per cent and the State Treasury rate of interest (10 per cent) was defrayed out of a parliamentary vote. Secondly, repaid capital was invested in a redemption fund for the unexpired portion of the loan. The interest earned was credited to the loan.

Family breadwinners with incomes between R150 and R250 per month, and R250 and R540 per month qualified for rented dwellings at 3 per cent over 40 years and 9 per cent over 30 years. The deficit between the State Treasury rate of interest, (i.e. 10 per cent) and the issued lower rates of interest have been defrayed by means of an interest subsidy out of a special Income Reserve fund of the National Housing Fund. (The former fund has been exhausted).

Between 1957 and 1979 the number of dwelling units built with National Housing funds amounted to approximately 640 000. Of these, approximately 412 000 dwellings were built from 1 per cent loan funds. Tenants of these houses paid only approximately one fifth of the actual cost of interest and capital redemption to the State whilst the State subsidised four fifths.

(b) Current system of state subsidy

Tenants with incomes up to R150 per month pay 5 per cent of their income towards interest and redemption on the cost of the serviced site and dwelling unit to a maximum of R7,50 per month and a minimum of R2,50 per month.

Tenants with incomes between R150 and R540 per month pay rentals calculated at the following rates of interest:

(i) Over R150 per month to R250 per month
 - 3 per cent over 40 years;

(ii) Over R250 per month to R350 per month
 - 5 per cent over 40 years;

(iii) Over R350 per month to R450 per month
 - 7 per cent over 30 years; and

(iv) Over R450 per month to R540 per month
 -9 per cent over 30 years.

The current cost limits laid down for a dwelling unit plus serviced site range from R10 000 for incomes up to R150 per month, to R14 000 for incomes up to R540 per month.

In addition to the existing facility of 9 per cent interest loans available to persons in the salary bracket of R450 to R540 per month, to purchase their own houses, it is now possible for persons with salaries between R250 and R450 per month to obtain loans at 5 per cent and 7 per cent interest rates to purchase houses.

The system of subsidy in respect of the lowest income category has therefore changed basically. Whereas with the previous system the rentals were related directly to the actual production cost of the house and the serviced site, this is no longer the case. Rentals are now determined solely at a fixed percentage of the tenants salary regardless of any requirement of rental income meeting any particular minimum percentage of interest and capital redemption of the actual production cost.

The cost to the State of interest and capital redemption on a 40 year loan at a Treasury interest rate of say 10 per cent amounts to R40 825. Repayments by tenants towards interest and redemption currently amounts to maximum and minimum amounts of R3 600 and R1 200 respectively, or to less than one tenth and one thirtieth of the actual cost to the State.

The degree and total cost of subsidy by the State in respect of this income category, which as pointed out previously constitutes the major portion of low cost housing financed from the National Housing Fund, has therefore increased dramatically.

C. STANDARDS OF WATER SUPPLY AND SEWERAGE

Low cost housing projects developed in the past by local authorities with government loan funds were usually provided with the barest minimum standards of water supply and sewerage. The reason for this was that the loans for these two services were not subsidised, and because local authorities themselves were poor in those days, they could not help. They themselves often had, (and many still have), low standard services, and their rate payers resent having to pay higher taxes in order to increase standards in housing projects at their expense. The loan repayments, therefore, had to be met out of the housing project's water and sewerage tariff incomes, which in turn had to be kept down to the levels which the tenants could afford. Because the tenants were very poor, they could not afford much.

Low standards resulted which, especially in the smaller towns in the rural areas of South Africa generally consisted of very small bore water mains with standpipes in the streets from which people collected water in buckets. Sanitation consisted by and large of pail closets or pit latrines built in the back yards of properties.

However, with the advent of larger housing projects, the old standards became more and more unacceptable. Large high density housing projects demanded different standards. They could not function under the old standards, and since local authorities found it impossible to assist financially in raising the standards, the government had no alternative but to introduce subsidisation of costs in order to obtain suitable standards of water supply and sewerage. Subsidies gradually increased through the years up to the present levels.

With this system it is now generally possible, except in cases of certain small towns, to provide low cost housing projects with water supply and sewerage facilities to full modern standards.

Standards of the other services and houses also increased. Not only did the houses increase in size and improve in appearance, but the old practice of building water closets in the back yards of erven was scrapped, and houses are now built complete with a bathroom and sink in the kitchen.

D. SOME ASPECTS OF DESIGN AND CONSTRUCTION PRACTICE

1. General

The designer of services for townships for the middle and upper income groups designs the services from the outset to their final or ultimate stages. His problem with designing and programming the installation of services for a low cost housing township is different.

He has to anticipate all the relevant conditions in the light of the capacities which will ultimately be required, and then produce a design for an initial installation which should, as far as possible form, an integral part of the ultimate total installation. His design and plans must also indicate the additional elements of the services which must be installed from time to time in the future when the demands exceed the capacities of the initial installations. By this means it is possible to augment or upgrade services in the course of time with the least wastage of existing capital assets.

This does not imply inferior services for low cost housing townships but rather takes into account the needs of the community and what they can afford. Unnecessary premature expenditure of capital is thus obviated.

Care must however be taken to ensure that services initially constructed are installed in their final ultimate positions so that when they are augmented, or other services are constructed, they will not conflict. This presents some problems with the very narrow road reserves of certain modern township layouts where the services become very congested. It is not a problem when all the services are installed initially, but when only some services are installed initially and others, (such as stormwater, electricity and telephone cables), follow piecemeal later. This necessitates sufficient detail in the initial designs, which, although a bit costly, is negligible compared to future savings.

In the metropolitan areas of South Africa, many townships have been constructed with the full range of services installed from the outset, including telephone services, leaving out only those additional elements of services to be installed when augmentation is required. The largest of these townships is Mitchells Plain near Cape Town (which has a population of approximately 250 000 persons) which is being developed by the Cape Town Municipality.

2. Water supply

Normally water supply presents no problems, since low cost housing projects are generally developed within existing municipal boundaries, and their reticulations are merely connected to the existing systems. There are, however, certain townships in rural areas where water sources have to be developed. Some are straight forward. Others, such as those being developed in the region of the Lower Orange River, present serious problems. They fall in the areas of jurisdiction of the Divisional Councils of Gordonia and Kenhardt in the Cape Province. There are approximately 18 of these townships which vary in size from 70 to 150 dwellings each, and they are spread over approximately 200 kilometres. Their water source is irrigation canal water fed from the Orange River. This water is heavily silt-laden and this silt load increases tremendously during floods. A centralised regional supply scheme is out of the question due to prohibitively high cost.

Each township will have to be provided with its own purification works, which, due to the long distances would not be visited frequently enough by the Divisional Council's operators, but would have to be operated by the inhabitants of the townships.

The works will have to be designed to lend themselves to simple operation so that it could be run by these unskilled people. To date no suitable and economical design has been found.

A few other townships in this area are fed by borehole water which has a very high floride content. Here too no suitable and economical design for the treatment of the water, or for an alternative suitable source, has as yet been found.

3. Sewerage

No problems are experienced with new low cost housing projects abutting towns and cities with existing sewerage systems since the sewer reticulation of the new townships is simply connected to the existing system, which is augmented where necessary.

Where new townships are built next to existing towns with no sewerage systems, every effort is made to initiate a sewerage system or the beginnings of a sewerage system. It often occurred that the construction of new low cost housing projects in municipalities precipitated the construction of sewerage systems because of the lower unit cost of sharing a facility common to 2 parties, such as an outfall sewer, as compared to the higher unit cost if 2 separate facilities have to be constructed.

When a new low cost township is developmed at an existing town servicec by vacuum tanker removals, and where the provision of treatment work is obviously premature, the new township is nevertheless provided with full internal sewer reticulation in such a manner that it will form an integral part of the ultimate fully developed sewerage system. One or more large conservancy tanks of cheap and temporary design are then constructed at a suitable point or points from which the local authorities vacuum tankers effect the removals. In order to keep costs within the means of the tenants the water closet only is installed initally in the bathroom. The bath and sink is installed at a later date after the local authority has constructed the balance of the sewerage system, which normally follows within a few years.

In localities where soils are sufficiently previous, large temporary septic tanks and soakaways are constructed instead of the conservancy tanks, and are abandoned when the local authority completes the balance of the sewerage system.

With the exception of very small townships where sewerage for obvious reasons is out of the question, virtually all new low cost towns developed entirely from scratch, remote from existing sewerage systems, are provided with full sewer reticulation and treatment works.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 13
Referaat 13

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water requirements, National States, wastage/Waterbehoeftes, Nasionale State, vermorsing

WATER SUPPLY IN THE NATIONAL STATES OF SOUTH AFRICA

by W.J. Uys*

SYNOPSIS

The water requirements for domestic and agricultural purposes in the National States of South Africa are given in two tables, together with World Bank estimates of total per capita costs of alternative types of water supply and sanitation systems.

The World Bank estimates are compared with the per capita costs of water supply schemes now being constructed in the National States.

Metering to reduce wastage and tariffication policies are discussed. Existing standards for water quality and the design of systems are questioned as being possibly too high and too costly, thus depriving large numbers of the population of water that might otherwise be provided for them from economical, well designed systems.

SAMEVATTING

Die waterbehoeftes vir huishoudelike en landboudoeleindes in die Nasionale State van Suid-Afrika word in twee tabelle aangetoon tesame met die Wêreldbank se ramings van die algehele per capita-koste van alternatiewe tipes watervoorsiening- en sanitasiestelsels.

Die wêreldbank-ramings word vergelyk met die per capita-koste van die watervoorsieningstelsels wat tans in die Nasionale State opgerig word.

Meting om vermorsing te bekamp en die tariefbepalingsbeleid word bespreek. Bestaande standaarde vir watergehalte en die ontwerp van stelsels word bevraagteken as sou dit moontlik te hoog en te duur wees, en sodoende groot getalle van die bevolking hul water ontsê wat andersins deur middel van ekonomiese, goedontwerpte skemas voorsien sou kon word.

* *Assistant Chief Engineer, (Civil), Department of Co-operation, Development and Education, Pretoria.*

INTRODUCTION

The National States with a total present population of eleven million people, are the historical and traditional homelands of the various Black nations of South Africa. Three of the ten National States are independent and the seven others are self-governing.

Water supply within these National States is part of a comprehensive programme to improve the living standards of the people, to aid and stimulate development and to make these States economically viable. Government institutions which take part in the development programmes are the South African Department of Co-operation and Development (which also administers the South African Development Trust), the Department of Education and Training, the Economic Development Corporation and the Governments of the National States.

2. WATER REQUIREMENTS OF THE NATIONAL STATES

(a) Domestic use

Table 1 shows the estimated urban (proclaimed towns) and rural (including larger settlements) population figures for 1980 in the National States, and the corresponding water requirements for domestic use. More accurate figures will be available shortly, when the returns of the May 1980 population census have been processed.

TABLE 1 : ESTIMATED POPULATION FIGURES AND DOMESTIC WATER REQUIREMENTS OF THE NATIONAL STATES IN 1980

National States	Population[1] (x 1 000)			Daily water requirements (x 10^3m^3)		
	Urban	Rural	Total	Urban *	Rural **	Total
Self-governing States:						
Ciskei	220	380	600	44,0	19,0	63,0
Gazankulu	13	372	385	2,6	18,6	21,2
kaNgwane	80	245	325	16,0	12,3	28,3
kwaNdebele	25	305	330	5,0	15,3	20,3
kwaZulu	860	2 340	3 200	172,0	117,0	289,0
Lebowa	200	1 400	1 600	40,0	70,0	110,0
Qwaqwa	8	122	130	1,6	6,1	7,7
Sub-total:	1 406	5 164	6 570	281,2	258,3	539,5
Independent States:						
Bophuthatswana	350	1 000	1 350	70,0	50,0	120,0
Transkei	138	2 612	2 750	27,6	137,5	165,1
Venda	13	377	390	2,6	18,9	21,5
Sub-total:	501	3 989	4 490	100,2	206,4	306,6
Total:	1 907	9 153	11 060	381,4	464,7	846,1

* At a unit consumption of 200 ℓ/c/d

** At a unit consumption of 50 ℓ/c/d.

(b) Agricultural use

The water requirements for existing agricultural production are shown in Table 2. The daily requirements for some six million livestock units amount to just over three thousand cubic metres per day. All livestock have been converted to large stock units (cattle as unit) for convenience. The requirements for irrigation vary with the seasons and some two hundred million cubic metres are presently used per annum to irrigate nearly nineteen thousand hectares.

TABLE 2 : TOTAL AREAS AND WATER REQUIREMENTS FOR AGRICULTURAL PURPOSES IN THE NATIONAL STATES (1978 FIGURES)

National State	Total area km^2	Stock watering		Irrigation	
		Large stock units (x 1 000)	Daily requirements (x 10^3m^3)	Irrigated area ha	Annual requirements (x 10^6m^3)
Self-governing States:					
Ciskei	533	268	13,4	500	2,5
Gazankulu	675	162	8,1	1 402	16,8
kaNgwane	372	63	3,2	990	11,9
kwaNdebele	75	7	0,4	30	0,3
kwaZulu	3 100	1 573	78,7	2 644	26,4
Lebowa	2 274	595	29,8	5 219	62,6
Qwaqwa	48	17	0,9	-	-
Sub-total:	7 077	2 685	134,5	10 785	120,5
Independent States					
Bophuthatswana	4 000	949	47,5	3 299	39,5
Transkei	4 162	2 302	115,1	2 000	10,0
Venda	650	132	6,6	2 703	32,4
Sub-total:	8 812	3 383	169,2	8 002	81,9
Total:	15 889	6 068	303,7	18,787	202,4

(c) Other consumers

The requirements of institutions such as schools, clinics, hospitals and offices and of commerce and industry, at present average about 20 per cent of urban consumption. The requirements of these consumers are calculated separately and are allowed for in the design of water supply systems.

Mines are important consumers of water in the mineral rich areas of South Africa. In 1974 there were seventy-nine working mines in the National States, all developing their own water resources.

(d) Future consumption

The natural population growth rate in the National States is slightly in excess of 3 per cent per annum, but the actual population growth is much higher due to return migration to the traditional homelands. The bulk of the growth will be taken up in the urban areas with the higher per capita water consumption, since the rural areas are already over-populated, and it is expected that the population density within the rural areas will, in fact, decrease in future.

Due to the rapid increase in wages of black people the standard of living is increasing rapidly and this requires a continuous upgrading of the standard of services in towns and settlements.

In the development programmes of the National States much emphasis is placed on agricultural development, and in particular on irrigation development, as well as on the mining industry since these constitute the most important natural resources of the National States. These sectors will therefore require a much larger share of water resources in future.

3. PRESENT STATE OF WATER SUPPLY

(a) Urban areas

All domestic and other consumers in urban areas with large populations are at present served by private connections both for water and water-borne sewage. Provision of these services forms part and parcel of the urban development programmes.

(b) Rural areas

(i) *Larger settlements*

Larger planned settlements are served with water by means of standpipes which are located within easy reach of every stand, and with either pit latrines or a bucket system for sanitation. As these settlements grow, full services are provided, as for urban areas, to prevent hazardous health conditions from developing.

In a report by the Department of Works for the Lebowa Government it was estimated that, in November 1978, approximately 65 per cent of the water requirements of these larger settlements had been satisfied in Lebowa. This backlog, however, varies from one National State to another.

(ii) *Small communities*

Small communities either are served by installations such as boreholes equipped with engine driven pumps, windmills or handpumps, or obtain water from wells, springs or perennial streams.

Much emphasis is presently placed on multi-purpose, regional water supply schemes, and small communities benefit from these schemes when they are within reasonable reach.

Water vendors who cart water from nearby sources often play an important part in the water supply of small communities that are not yet served by adequate water supply schemes.

(c) Agriculture

A total area of approximately nineteen thousand hectares of irrigated land is presently served by water supply schemes and requires an estimated 202 x $10^6 m^3$ of water per annum. Some of these schemes, where water supplies have not yet been adequately provided, are still dependent on normal river flow.

There is a backlog in the provision of water supplies for livestock in many areas and, consequently, livestock frequently has to graze far away from water supplies.

4. COST ASPECTS

(a) Per capita capital costs

Table 3 sets out the per capita costs of the total system (in Africa), as estimated by W.J.W. Gilling[2], for services to different standards, where these have been financed by the World Bank.

TABLE 3 : WORLD BANK ESTIMATES OF TOTAL PER CAPITA COSTS OF ALTERNATIVE TYPES OF WATER SUPPLY AND SANITATION, 1978.

Standard of service	Urban		Rural	
	US$	R	US$	R
Water supply				
With house connection	120	94	150	118
Standpipes with storage, but minimum distribution	40	31	40	31
Hand pumps	-	-	25	20
Sanitation				
Full water-borne sewage	250	196	250	196
Septic tanks	100	78	-	-
Latrines	30	24	20	16

The above are average cost figures, and large deviations may be expected for specific schemes.

Table 4 shows the per capita capital costs of a few typical water supply schemes at present under construction in the National States and costs are of the same order as the estimates by Gilling[2].

TABLE 4 : PER CAPITA COSTS OF TYPICAL WATER SUPPLY SCHEMES AT PRESENT UNDER CONSTRUCTION IN THE NATIONAL STATES

Scheme and standard of service	Cost	
	R	US$
House connections		
Ulundi	89	113
Nqutu	110	140
Eerstehoek	83	106
Standpipes with storage		
Kwaggafontein	30	38
Equipped borehole, storage, but no distribution : average	18	23

The above figures represent the per capita cost for the schemes when fully utilized to design capacity. This, however, is very seldom the case, because schemes are built for an estimated demand in 10 to 15 years' time for the fast-growing population, and have to be extended timeously when the demand increases to near its design capacity.

(b) Unit costs

As could be expected the cost per unit of water delivered varies widely for different schemes, and inflation has the effect of making water from new or extended schemes much more expensive than that from older schemes.

The unit cost of water delivered to a stand varies from approximately R0,20 to R0,50 ($0,26 - $0,64) per m^3 for existing schemes.

(c) Financing

Very little of the capital, maintenance and operational costs is recovered from consumers. Virtually all installations are financed by the various government institutions.

In this context water supply schemes have to compete for funds with other development programmes. The expenditure according to development programme by the various government institutions is listed in Table 5, where the funds for water supply schemes have been included in the programmes for population settlement and for the creation of physical infra-structure.

(d) Cost recovery

Regarding World Bank water tariff policies, W.J.W. Gilling[2] writes: 'It is clear that most governments will not be able to finance these investments without adopting sound tariff policies based on economic costs of supplying water to final consumers. The review of tariffs is an important part of project appraisal by the World Bank prior to the financing of any water supply project.' The purpose of a tariff is to discourage wastage as well as to ensure the viability of the water supply agency. Gilling[2] also states that, of the total investment requirements (in Africa), most will have to be made in rural areas where there are few proven means of cost recovery. In this connection, Chappey[3] states that: 'One of the important problems with which water suppliers in Africa struggle is that of unpaid bills.'

The South African Government through the Department of Co-operation and Development is the main contributor to the capital cost, maintenance and operation of water supply installations, either by directly financing the projects, or by contributing to the budgets of the National States. Since the National States are either self-governing or independent, the Department can only advise the local governments on tariffication but has no power to enforce it.

Only recently some of the National States introduced metering of the water supplied to stands in the urban areas so that they could bill consumers. Previously, water was distributed free of charge as is still the case in the rural areas. The main reasons for this are the unwillingness of politicians to institute unpopular measures and the administrative problems of measuring consumption, billing consumers and collecting debts.

The Department of Co-operation and Development uses and recommends subsidized uniform tariffs for water consumption; these are subject to revision from time to time. The present tariffs for domestic use are:

Metered water	:	R0,18	($0,23)/$m^3$
Unmetered water:			
House connections, stands with water-borne sewage	:	R3,00	($3,83)/month
House connections, stands without water-borne sewage	:	R1,50	($1,91)/month
Standpipes in streets	:	R0,60	($0,77)/month

5. WATER SUPPLY PRACTICE

(a) Water resources

The sources of water from which the needs could be satisfied are the direct use of natural precipitation, underground water and surface water from rivers and streams. Southern Africa does not have an abundance of water, and ingenious planning and savings measures are necessary to ensure that water shortages will not hamper future development.

The annual rainfall in Southern Africa is relatively low and erratic. It varies from about zero on the west coast where desert conditions prevail, to about 1 000 mm per anuum on the east coast, with the highest precipitation in the Drakensberg mountain range. The National States are all situated to the north-east or on the east coast where the rainfall is average to high. Direct use is made of the natural precipitation by way of dryland farming, and more than 1,3 million hectares of land are cultivated in this way in the National States.

The geological nature of South Africa is such that very little infiltration takes place and very little water is recoverable from underground sources, except from a few dolomitic areas. Nevertheless, underground water is an important source for smaller communities and for watering livestock in rural areas.

The flow in rivers and streams varies greatly through the seasons with very low flows in winter. Storage of surface water is, therefore, a pre-requisite for ensuring adequate yields from these sources.

(b) Water division

Surface water is quantitatively the most important water resource of the Republic of South Africa and the National States, and this resource is common to the different states. A fair division of water is necessary in order that each State can develop to its optimum.

During May 1980 a report by an Interdepartmental Committee concerning the division of water between the National

TABLE 5 : EXPENDITURE ACCORDING TO DEVELOPMENT PROGRAMME BY VARIOUS AUTHORITIES AND INSTITUTIONS IN THE 1978/79 FINANCIAL YEAR (X R1 000)

National State	Land planning and conservation	Population settlement	Employment creation and generation	Development of human potential	Provision of social services	Government planning and administration	Creation of physical infrastructure	Not specified	Total
Self governing States									
Ciskei	2 760	14 701	14 468	15 382	16 638	4 144	7 574	3 381	79 048
Gazankulu	677	1 745	9 868	6 876	6 531	2 380	6 540	1 801	36 418
kaNgwane	110	4 581	4 396	4 756	4 460	718	2 017	817	21 855
kwaNdebele	145	1 333	862	70	62	160	925	-	3 557
kwaZulu	2 821	38 788	50 028	41 646	68 964	13 727	12 406	8 189	236 569
Lebowa	1 436	10 687	18 782	18 989	27 047	9 204	8 104	4 225	98 474
Qwaqwa	78	2 173	4 546	4 276	3 032	948	5 403	654	21 110
Sub-total:	8 027	74 008	102 950	91 995	126 734	31 281	42 969	19 067	497 031
Independent States									
Bophuthatswana	-	6 227	1 965	150	-	15	900	123 211	132 465
Transkei	6 947	4 635	-	430	-	846	-	334 902	347 760
Venda	554	1 865	10 388	9 179	7 007	2 294	3 797	1 438	36 522
Sub-total:	7 501	12 727	12 353	9 759	7 007	3 155	4 697	459 551	516 747
Not specified	40 399	10 185	9 965	41 426	3 646	1 844	5 047	-	112 330
Total:	55 927	96 920	125 268	143 180	137 387	36 280	52 713	478 618	1 126 108

States, the remainder of the Republic of South Africa and the Republics of Bophuthatswana, Transkei and Venda was tabled in Parliament[4]. This report will form the basis for the allocation of water to the different States and will enable each State to launch water supply projects within its allocation, without entering into further negotiations with other States.

The guidelines for water division as recommended are based on the rules drafted by the International Law Association in Helsinki in 1966, and on the South African Water Act. The system for division basically provides for an equal, per capita allocation within a common catchment area, but with preferential treatment of existing water use should this exceed the available per capita resources. The South African Water Act protects the rights of all riparian owners.

Table 6 shows preliminary allocations to the National States made on the basis of the Committee's recommendations, although it is expected that final allocations could differ from these because of further refinements to the report.

TABLE 6 : PROPOSED PRELIMINARY TOTAL AND PER CAPITA ALLOCATION OF WATER TO THE NATIONAL STATES

National State	Proposed water allocation	
	Total allocation $m^3 \times 10^6$ / per annum	per capital allocation m^3/ per annum
Self-governing States:		
Ciskei	129,9	499,8
Gazankulu	255,7	716,5
kaNgwane	49,8	1 104,0
kwaNdebele	48,7	389,0
kwaZulu	1 671,7	907,0
Lebowa	572,4	486,7
Qwaqwa	1,5	52,9
Independent States:		
Bophuthatswana	83,6	107,1
Transkei	3 549,9	1 603,3
Venda	253,5	868,1

(c) Water development guide plans

To co-ordinate the development of water supply schemes, the Department of Co-operation and Development is assisting the National States in developing guide plans for water resource development. The goal is to determine present and future water demands, to locate water resources quantitatively and qualitatively and to prepare a guideplan for orderly, immediate and future water resource development.

As joint schemes between States using a common source may often be beneficial, these possibilities are also investigated and included in the guide plans.

Future development can not be forecast with certainty or accuracy and guide plans are therefore prepared to be flexible and to allow for periodic revision.

(d) Operation and maintenance

Operating and maintaining water supply schemes in the National States is one of the main problems the authorities have to deal with. These problems arise as a result of a lack of skilled operators to operate waterworks where the purifying process is complicated or to maintain equipment comprising many mechanical and electronic components.

Action from the Department of Co-operation and Development to counteract these problems is, in the first instance, to scrutinize designs of new and existing waterworks and eliminate, where possible, complicated processes and processes based on the excessive use of mechanical and electrical equipment. Secondly, the National Institute of Water Research, under contract with the Department, places trained technicians in the various National States to monitor and report on the operation of waterworks and to train operators in service. To back up the in-service training of operators the Department has launched a recruitment campaign at Black schools for scholars to attend a technician's course for operators of water and sewage purification plants.

(d) Rainwater harvesting

Due to the expense of supplying water to families living in sparsely populated areas, the Department of Co-operation and Development is presently investigating the old practice of harvesting rainwater for domestic use.

The assessed daily yield from a typical roof, with a surface area of 60 m^2 together with a corrugated iron storage tank, is shown in Table 7. The capital cost represents the provision of storage tanks as well as gutters and downpipes to an existing roof and the unit cost is calculated by taking interest at 10 per cent per annum over a redemption period of 20 years.

TABLE 7 : RAINWATER HARVESTING-YIELD AND COST FOR A TYPICAL 60 M^2 ROOF AREA IN DIFFERENT RAINFALL REGIONS

Area	Average rainfall (mm/year)	Capacity of tanks (ℓ)	Assessed yield (ℓ/day)	Capital cost R	Unit cost (R/m^3)
Babanango	-	4 500	27	270	3,21
(Natal)	940	9 000	60	450	2,41
Mafeking	490	9 000	25	450	5,74
(Bophuthatswana)	-	13 500	40	580	4,66
Pofadder	130	13 500	20	580	9,33
(Cape Province)	-	18 000	22	750	10,97
Pofadder	130	13 500	30	580	6,22
(100 m^2 roof)	-	18 000	32	750	7,54

6. CONSIDERATIONS IN WATER SUPPLY

(a) Objective

The objective of the authorities is to supply all inhabitants of a State with adequate supplies of water of an acceptable quality. In their pursuit of this objective the authorities make funds available on annual budgets which are usually limited to the total needs.

In the following paragraphs some considerations regarding water supply are discussed which will assist authorities better to achieve the objective of satisfying the seemingly unlimited need for water supply with limited funds.

It is evident that by keeping the cost of water supply, as expressed by the capital cost and calculated unit tariff, as low as possible, the population is served in two ways:

- An increased number of the population can be served if the per capita cost of water supply at an acceptable standard is kept as low as possible; and
- since the consumer ultimately pays for the water, whether directly or indirectly by way of taxation or in some other way, it is to his financial benefit if the cost of water supply is kept at a minimum.

The aspects discussed in the following sections influence cost, both directly and indirectly, and need careful consideration during planning of water supply schemes.

(b) Wastage

Any community that wastes water in an indirect way deprives other communities of this commodity. Probably the best way of preventing wastage is to meter the water used by individual consumers. Garlipp[5] reported on the effect of metering water consumption of individual stands in residential areas for Blacks. The comparative figures are shown in Table 8.

TABLE 8 : COMPARISON OF METERED AND UNMETERED INDIVIDUAL WATER SUPPLY IN SOME SOUTH AFRICAN RESIDENTIAL AREAS FOR BLACKS

Residential areas		Consumption in ℓ/stand/day	
		Metered	Unmetered
	Mabopane		1 332
	Daveyton	391	
Port Elizabeth :	Tembelethu		2 524
	Gunguluza		641
Bloemfontein :		147	
Windhoek :	Katutura	126	
Durban :	Umlazi		1 420
	kwaMashu	737	
Lebowa :	Sheshego	(955)	1 597
:	Namakgale		1 512
	Lengene		1 141
	Mahwelereng		2 065

It is sometimes claimed that metering has little effect in permanently reducing the water demand. Table 9 shows the increase in consumption that took place with time in two comparable Black townships near Durban. From this it is evident that the consumption increase in the township with metered supplies was still only about half that of the increase in the township with unmetered supplies.

TABLE 9 : COMPARISON BETWEEN INCREASES IN METERED AND UNMETERED WATER CONSUMPTION WITH TIME IN KWAMASHU AND UMLAZI TOWNSHIPS IN LITRES/STAND/DAY

Year	kwaMashu (metered)	Umlazi (unmetered)
1967	570	1 060
1973	737	1 420

At Namakgale, a Black township with house connections for water supply and with water-borne sewage, water meters were installed in 1977 and water consumption dropped 51 per cent. At the same time the average sewage flow reduced from from 3 600 m^3/day to 2 500 m^3/day, a reduction of approximately 30 per cent as a result of metering of the water supplies. The installation of water meters obviated costly extensions both to the water supply and the sewerage systems.

(c) Flow control

The use of flow control valves in conjunction with water meters at house connections further limits the excessive use of water, and it also has the advantage of controlling flow at peak consumption and thus prevents situations where consumers in low-lying areas use water excessively and to the detriment of consumers in higher areas. Table 10 shows the effect of flow control on consumption in Mabopane, as reported by Garlipp[5].

TABLE 10 : INFLUENCE OF FLOW CONTROL RESTRICTIONS ON WATER SUPPLY IN MABOPANE

Month	Consumption in ℓ/stand/day			
	Rainfall mm	Stands without flow control	Stands with flow control	Saving per cent
October	84	1 332	1 087	18,2
April	63	1 231	814	33,9
May	8	1 290	643	50,2

(d) Tariffication policy

In determining the water tariffs for underdeveloped areas, political and social considerations frequently override economic and financial principles. The objective with tariffication should be to make adequate quantities of water available to all consumers at affordable prices, but at the same time the supplies must be economically viable for the supplier. If water supply is subsidized, subsidies should be such as not to place an excessive burden on the authorities.

Water tariffs should, therefore, be based on sound economic and financial principles. However, due consideration should be given to the ability of the different sectors of the population to afford this commodity so as to ensure that, on the one hand, lower income groups are not deprived of it and on the other hand, the higher income groups are not subsidized unnecessarily.

A system of progressive tariffs will serve this objective and will have the further advantage of limiting the wastage of water.

(e) Water quality

There is no question that water supplies must at all times be of a quality which will be acceptable to the consumer and will not endanger the health of the consumer.

On the other hand, there is a tendency for health authorities and others to set unnecessarily high standards for quality, irrespective of the consumer's need. Instead of being a service to the consumer, excessively high standards for water supplies (qualitatively and quantitatively) have the effect of draining the funds that are available for supplying this commodity and increasing its cost unnecessarily, so that a large number of the population may be deprived of access to water from economically well designed and well operated schemes.

The prime objective should be to make water of adequate quality and quantity available to as many consumers as possible corresponding to their existing needs, and then to upgrade the service as the need arises.

(f) Design standards

As with quality standards, engineering design standards are also higher, more often than not, than need be to ensure a reliable service, with similar results.

Too often, waterworks are designed and built as perfect technological units, but without considering the levels of skill of those who have to operate and maintain these plants.

Careful planning and much thought are therefore necessary when planning and designing water supply systems for underdeveloped communities, to ensure that the additional restraints imposed by the shortage of adequately skilled manpower are taken into account.

7. CONCLUSION

Much has been accomplished in providing water of a satisfactory standard for the populations of the National States of South Africa, and water supplies for existing industry, mining and irrigation are adequate. However, much will have to be done in future to cope with the rapidly increasing demand and to catch up with the backlog that still exists in certain areas.

The objective of making adequate supplies of water of acceptable quality available to all consumers can best be achieved if the cost of water is minimized by careful consideration of all the factors involved.

REFERENCES

1. BUREAU FOR ECONOMIC RESEARCH : *Co-operation and Development - Statistical survey of Black Development*, 1979.
2. GILLING, W.J.W. World Bank Water Tariff Policies. *Aqua 2*, 1980.
3. CHAPPEY, M. Tariffication Systems in Africa, *Aqua 2*, 1980.
4. Report of the Interdepartmental Committee concerning the Division of Water between the National States, the remainder of the Republic of South Africa and the Republics of Bophuthatswana and Transkei.
5. GARLIPP, D.C.O. *Water Restrictions*. IMIESA, October, 1979.

Also various reports in the files of the Department of Co-operation and Development.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES

WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Paper 14
Referaat 14

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water supply, Soweto/
Watervoorsiening, Soweto

WATER AND SEWERAGE IN URBAN BLACK COMMUNITIES

by P.A. du Plessis*

SYNOPSIS

This paper deals with problems related to water supply and sewerage for Black communities in areas of rapid urban growth.

The situation is most relevant to Soweto, which is possibly the largest urban Black community with vast needs for development in a metropolitan set-up.

It is anticipated that the experience gained from the problems encountered in Soweto may be of some assistance to other developing nations, who are about to undergo urban growth at a terrific rate.

SAMEVATTING

Hierdie referaat handel oor probleme aangaande watervoorsiening en riolering vir Swart gemeenskappe in snelgroeiende stedelike gebiede.

Die situasie is grootliks van toepassing op Soweto wat heelwaarskynlik die grootste stedelike Swart gemeenskap is met 'n groot behoefte aan ontwikkeling in 'n metropolitaanse gebied.

Daar word verwag dat die ondervinding wat opgedoen word as gevolg van heersende probleme in Soweto van nut sal wees vir ander ontwikkelende nasies wat op die drumpel staan van stedelike groei teen 'n geweldige tempo.

* *Technical Director, West Rand Administration Board, Johannesburg.*

A.1. HISTORICAL BACKGROUND

Soweto (South Western Township) originated as far back as 1904 when plague broke out in the Black migrant population in central Johannesburg. The migrants, who were predominantly male, were evacuated to temporary dwellings on the farm Klipspruit approximately 10 kilometres south west of Johannesburg.

By 1919 the population had increased to 116 000 and the Johannesburg City Council embarked on a house building scheme. In 1930 more land was acquired, major housing schemes were planned and building began in 1931.

Owing to industrial growth during and following World War II, the demand for labour was insatiable. This caused a major influx of people to Soweto and by 1948 its population was 311 000.

Initially, water was supplied to residents by means of communal stand pipes in the streets and buckets were used for sanitation. As housing schemes were planned, water was provided at each individual plot and flushing water toilets were installed.

Soweto continued to grow. It is the second largest city in Africa, at present covering a gross area of 7 300 ha, with an official population of 680 000. Approximately 40 000 contract labourers are accommodated in hostels and the remainder of the population are housed in approximately 102 000 individual housing units, each of which has its own water supply and connection to a water borne sewage system.

2. Population density

Although the official population figure for Soweto is 680 000, more realistic estimates place the figure between 800 000 and 1 000 000. Population densities vary throughout the city from around 75 persons/ha to 140 persons/ha giving a weighted mean density of between 110 and 123 persons/ha.

At this point it must be stressed that no extensive 'Master Plan' for Soweto exists. There is only a Development Guide System. This makes planning for services extremely difficult and certain assumptions have had to be made before future planning could be looked at realistically.

It was assumed, firstly, that the existing boundaries of Soweto would not alter greatly, therefore strictly limiting the amount of ground available for development; secondly, that the population would continue to increase and the only way to accommodate this growth of an increasing population density, would be to upgrade certain areas and undertake urban renewal of others which are more than 60 years old.

Current statistics suggest that the population growth rate for Soweto is 2,5 per cent per annum, allowing for extensions to townships. It is, furthermore, understood that there is an absolute minimum growth rate of 1,5 per cent per annum. In view of the limited land available for development it has been calculated that the population density of Soweto could be expected to increase by 2,2 per cent per annum over the next 20 years to reach a maximum of 170 persons/ha.

This takes care of many factors but most important of all is the fact that urban renewal will have to take place and the older, less densely populated suburbs will have to be replaced with duplex type housing, and/or three storey flat accommodation.

3. Water consumption

The existing water reticulation in Soweto was designed to provide for a per capita consumption of between 40 and 80 litres per day.

At present the water consumption in Soweto is 295 litres per person per day, based on the official population figure, and even if the unofficial estimates for population are used it still exceeds 200 litres per person per day.

The average yearly increase in water consumption since reliable records were started has been 10,7 per cent per annum. This is exceptionally high, but what gives greater cause for concern is the fact that the rate of increase per year is for ever rising.

The water consumption figures of similar economic groups, as measured throughout the country, range from 50 to 160 litres per person per day.

The high water consumption figures experienced in Soweto can be attributed to three main factors, namely:

(a) the uncertainty in respect of the actual population figures for Soweto;
(b) irresponsible and indiscriminate water consumption;
(c) lack of finance for regular maintenance of water fittings in dwellings and hostels.

To predict a per capita water consumption figure for a 20 year design period, cognizance was taken of similar economic groups, the increasing standard of living, effective maintenance on domestic water fittings generally, larger plots and the effect of metering the water supply.

After due consideration of all the facts it was decided that a figure of 230 litres per person per day was adequate for a 20 year design period.

4. Water costs

The present average income for water is R3,00 per plot/month. In general, meters have not been installed and, as the number of plots provided with meters is indeed small, it can be assumed for the purpose of this calculation that the income per plot is R3,00 per month. The total income for water is therefore 102 000 plots at R3,00 per month.

i.e. 102 000 x 3 x 12 = R3 672 000 per annum

The total cost for water acquired for the previous year was approximately R8,5 x 10^6. This gives a shortfall on the water account of R4,86 x 10^6 for one year. Clearly this is not acceptable and measures to control water consumption are dealt with, generally, under metering in this paper, and, in detail, in Mr. G.J. Malan's paper: Towards urban water conservation in South Africa.

5. Design parameters

(a) Water supply

Soweto was initially planned and designed on minimum standards as laid down by the Government or Local Authority. These standards provided for one external toilet and tap per dwelling, with a per capital water consumption figure of between 40 and 80 litres per day.

The present per capita water consumption is totally unacceptable as a basis for projecting future design figures. Major guidance was sought when establishing design parameters and, as related in 2 above, a figure of 230 litres per person per day was decided as adequate for a 20 year design period.

(b) Peak consumption

For summer consumption, a factor of 1,5 x the average annual consumption has been accepted. A further peak factor of 3,0 x the average summer consumption has been accepted for daily peaks. A compound peak factor of 4,5 x the annual average daily flow is therefore applied.

(c) Water pressure

The minimum water pressure at the consumer point is 150 kPa whilst the maximum water pressure at the consumer point is 900 kPa.

(d) Flow velocities

The maximum water velocity in the pipelines is 3,0 m/s.

(e) Storage capacity

The water storage capacities are:

> Surface reservoirs : pumping scheme - 48 hours of average summer consumption.
>
> Gravitation schemes - 24 hours of average summer consumption.
>
> Elevated reservoirs - 4 hours of average summer consumption with replenishment every 8 hours.

(f) Hydrants for fire control

Considerable divergence of opinion generally exists as to which standard should be applied in the selection of fire flow. It has been decided to apply the South African Bureau of Standard's Code 090 on recommended fire flows, using average flow plus fire flow and not peak flow plus fire flow.

In terms of this code, areas can be classed as low, moderate, or high risk with corresponding requirements.

(g) Sewerage contribution

Unit contribution to a sewer is normally well correlated with water consumption in the case of homogeneous communities. In Soweto, water for sewerage constitutes approximately 95 per cent of the water consumption. This is considerably higher than normal, and it indicates that water is used almost exclusively for domestic purposes.

Over the last few years it has been found that sewage concentration diminished annually while water consumption increased. This is indicative of water wastage, and it supports the view that lack of maintenance on domestic water fittings is one of the major factors associated with controlling water consumption.

In deciding on a unit contribution of 200 litres per person per day cognizance was taken of all the factors previously mentioned.

(h) Peak flow calculation

Peak factors (F) are calculated according to Harmon's formula:

$$F = 1 \quad \frac{14}{4+\sqrt{n}}$$

where n is the number of contributors in thousands

Sewers are designed so that the peak design flow does not exceed 66 per cent of the capacity of the pipe.

(i) Minimum size of sewer

The minimum diameter of pipe used in sewer reticulation is 150 mm.

(j) Hydraulic design

The general parameters concerning velocity, friction and gradients, etc., are well documented throughout the world and it is not necessary to elaborate on them in this report.

B. WATER SUPPLY AND STORAGE

1. Reservoir storage capacity

The present surface storage capacity for Soweto is 126 M ℓ. This figure is totally inadequate when considering the present population which requires storage of approximately 250 M ℓ and by the year 2000 will require approximately 385 M ℓ storage.

Investigations as to the most favourable water supply zones led to the following observations:

(a) The primary distribution pipe system constitutes approximately 40 per cent of the total capital cost of establishing an upgraded system for Soweto.

(b) The larger the area of the supply zone, the larger will be the diameters of the primary distribution pipes and vice versa.

(c) It has been determined that the cost of water supply in the large supply zones is 15 per cent higher than the cost of supplying water to smaller supply zones.

(d) By selecting reservoir sites with caution, the need for elevated storage towers to serve the immediate vicinity of a reservoir, where pressure deficiences normally are experienced, can be minimized in the Soweto area. This normally requires reservoirs to be situated outside their own supply zones on higher lying land.

The above factors therefore became a major factor in planning Soweto's future water needs in decentralized zones.

The most important principles applied in the identification of separate reservoir zones are listed briefly below:

(i) availability of new reservoir sites;
(ii) maximum and minimum static pressure available from specific reservoir sites;
(iii) the available working pressure in the Rand Water Board main pipelines;
(iv) the optimum utilization of existing water reticulation systems;
(v) where possible, the identification of reservoir supply zones of similar size, in order to achieve a balanced distribution system.

2. Water reticulation

A fairly substantial primary distribution pipe system has been established over a period of time in Soweto. Most of these pipes are steel and a large proportion are 20 years old and more. The conditions of these pipes varies from average to poor and the escalating frequency of pipe failure confirms this situation.

Major use has been made of a substantial computer system in analysing both the existing and proposed primary reticulation systems. A suite of programs employing the pipe analysis theory accorded to Prof. Hardy Cross, has been used which takes into account all the pipe parameters, such as roughness, length and other factors, as well as the effects of all reservoirs on the system. Furthermore, the program employs optimization techniques, and pipe sizes are continuously readjusted until the optimum solution is achieved.

C. METERING OF WATER SUPPLY

From available information, it is clear that a pattern of water consumption has developed which leads to excessive water losses. Any improvements in the water reticulation system will lead to a higher average water pressure, which in turn may lead to increased water losses through irresponsible use.

The only proven method of combatting this problem and preventing a further deterioration of the situation is to install meters and to ensure that each consumer is responsible for the cost of water consumed, the maintenance of the fittings and paying economic tariffs.

It has been proposed that individual meters be installed to each stand in Soweto and that, when installing the meter, all water fittings be checked and repaired. Further maintenance of all water fittings then becomes the responsibility of the tenant and, for the basic fee of R3,00 per month which tenants are paying at present, they be allowed to consume 20 kℓ per month. Any water consumed in excess of that quantity, be subject to the payment per kilolitre at a tariff which is preferably higher than the cost of water supplied so as to prevent waste.

Clearly the installation of meters would be a costly exercise but the benefits would be immense. A saving of 30 per cent or more in water consumption is expected together with an equalizing of the water account. Also a saving of at least 30 per cent could be expected on the cost of sewage treatment.

A recent investigation concluded that the savings in water consumed and the decrease in cost of sewage treatment makes the installation of a system of water metering in Soweto a definite economic feasibility. The metering system, once installed, will give invaluable information regarding water consumption trends, upon which the future water requirements for the city can be based.

D. SEWERAGE

1. Treatment

All Soweto's sewage is treated by Johannesburg City Council at their treatment works to the South of Soweto.

Based on flow measurement figures a charge per kℓ is levied to cover Johannesburg's operating expenditure.

As reported earlier the concentration of sewage from Soweto has been decreasing indicating water wastage. From 1966 to 1974 the P.V. of the sewage averaged 55 mg/ℓ.

In 1974/75 the P.V. had dropped to 41 mg/ℓ and in 1975/76 it dropped further to 36 mg/ℓ.

Treatment costs are running at approximately R400 000 per year and if, as suggested, 30 per cent of the sewage treated is wasted fresh water, a considerable saving can be made by reducing water wastage.

2. Sewer reticulation

Soweto is sewered almost exclusively by a mid-block sewer system, this system being preferred due to economy of installation and space.

The capacity in the majority of sewers is adequate, and what little surcharging takes place is on the major outfall sewers. Plans are in hand to provide additional capacity in the outfall sewers and construction has already commenced.

The quality of sewage is a major problem in Soweto, large quantities of sand, grit and rags find their way into the sewer causing blockages. The majority of these blockages occur on 150 mm diameter sewers.

Maintenance teams attend to an average of 1 300 blockages per month. Three teams are permanently employed on systematically cleaning sewers. This takes the form of dragging scoops through the pipe to remove material that has settled.

SEMINAR 1980 SEMINAAR

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Paper 15
Referaat 15

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water supply, sewerage, low cost/Watervoorsiening, riolering, laekoste

FACTORS OF BULK WATER SUPPLY AND MAIN SEWERAGE FOR LOW COST HOUSING SCHEMES

by A.B. Davis*

SYNOPSIS

Efforts have been and are being made to reduce the total 'rent' expenses of low income people. These expenses include payments to cover water, sewerage and power charges as well as accommodation. Although means of reducing the unit cost of dwellings and their immediate local services have been investigated, little has been done to optimize trunk services. This paper deals with aspects of hydraulic trunk services that affect costs.

SAMEVATTING

Pogings is en word aangewend om die algehele 'huur'-uitgawes van persone met lae inkomste te verlaag. Hierdie uitgawe sluit betalings in om water-, riolering- en kragrekeninge sowel as huisvesting te dek. Alhoewel metodes om die eenheidkoste van wooneenhede en hul onmiddellike plaaslike dienste te verlaag reeds ondersoek is, is min gedoen om hooflyndienste optimaal te benut. Hierdie referaat behandel aspekte van hidrouliese hooflyndienste wat uitgawe beinvloed.

* *Assistant City Engineer (Hydraulics), Durban, South Africa.*

INTRODUCTION

One of the most important aspects of life for a person earning a low income is the amount of 'rent' he must pay for his accommodation. The 'rent' portion of his expenses includes not only the net rent for the accommodation but also water, sewerage and power charges, whether included in the net rent or charged separately.

The 'rent' is composed of a large number of factors, the most important of which are the interest and redemption on the capital utilized, the maintenance and operating costs of services and the overall administration costs.

Considerable investigation is being and has been carried out into reducing the unit cost of the dwelling unit and the immediate local services but little work has been done on optimization of the trunk services.

The trunk hydraulic services considered in this paper affect the gross rent greatly, particularly the interest and redemption and the operating costs portions. As will be shown later in the paper, for a particular investigation in Durban such costs made a scheme totally un-economic for low-income housing as the optimization exercise could not adequately reduce the rent portion.

In this paper a number of aspects of the trunk hydraulic services which can affect the costs are considered. For convenience it has been divided into separate sections under water supply and sewerage although certain general principles appertain to both.

1. WATER SUPPLY

The provision of an adequate, wholesome water supply is essential for the well-being of the community and should be one of the most important considerations in deciding whether an area is suitable for the development of a low income housing scheme.

To optimize the water system and hence minimize the cost and assist in utilizing a possible limited water source to its greatest extent, policy decisions are required to establish design parameters on which the detailed system design is based. These may be summarized as:

- (a) use control policy
- (b) distribution philosophy
- (c) source proximity
- (d) system reliability

(a) Use control policy

Obviously one of the major factors to be determined at an early stage of design is the anticipated unit water consumption. This can depend on a large number of variables including the type of water service, e.g. stand pipe, internal plumbing, etc., and the type of ablution facilities to be provided, e.g. pit latrine, communal ablution block, included toilet and bathroom. These policy decisions are frequently made on the basis of reducing the unit cost of the dwelling unit, bearing in mind the ultimate rent target, and not for purely engineering reasons. The engineeer should, however, clearly make available to the policy makers the likely effects of the alternatives on the water supply portion of the rent. Hence the design engineer, accepting the decision made, must estimate a reasonable water consumption and, more importantly, produce a water system that will enable actual consumption to be restricted to or below the design consumption. Typical water consumption design figures for dwelling units adopted by various authorities are indicated in the Table 1.

TABLE 1: Current water consumption design figures for dwelling units

Durban:			
Low income township design		- 1 200 ℓ/day	
Recent flow measurements:			
Chatsworth	(Indian)	- 1 200 ℓ/day	1971
Phoenix	(Indian)	- 1 060 ℓ/day	1978
Umlazi	(Black)	- 1 610 ℓ/day	1978
Ntuzuma	(Black)	- 1 490 ℓ/day	1977
Department of Co-operation and Development:			
Low income township design		- 1 200 ℓ/day	
Transvaal Provincial Administration:			
Dependent on plot size		- 750 ℓ/day for 0,05 ha. - 1 200 - 2 000 ℓ/day for 0,1 ha.	
Kitwe, Zambia:			
Low income township design		- 1 800 ℓ/day average peak day. (Assuming 1,5 summer peak gives 1 200 ℓ/day.)	

Experience has indicated that, for low income housing in particular, an assumed per capita consumption is not a realistic method of design, as the actual number of persons per dwelling unit is almost impossible to estimate accurately. An average consumption per dwelling unit is considered more appropriate. Even this could be criticized because of the varying number of rooms per dwelling unit, but in practice it is considered that there are no apparent direct relationships between the number of rooms, the number of people and the water consumption. The unit water consumption is obviously related to the type of ablution and cooking facilities provided and the number of persons accommodated, and could be of the form shown in Figure 1 (see Annexure).

The curve of consumption per dwelling is clearly not directly proportional to the population, therefore taking an average consumption per dwelling unit will lead to fewer errors than using consumption per capita. For instance, if the assumed consumption is based on occupancy of 6 persons per dwelling, but the actual average occupancy is 7, then the assumed water consumption could be 14 per cent lower compared to 4 per cent if the consumption per dwelling unit basis has been used. This 10 per cent difference could be significant in the scheme design and operation, and it has given rise to supply problems in the past.

Typical curves, as referred to above, are required for anticipated water consumptions for various social groups; they can normally be obtained in conjunction with administrators of an existing township where individual water meter records are maintained. The design consumption given in Table 1 normally includes the losses occurring within a distribution system but, if curves of the form in Figure 1 are used and obtained from individual meters, a 10 per cent distribution loss should be included. Some control is required to restrict actual consumption figures to assumed consumption. Control by metering is a somewhat controversial subject in the northern hemisphere at present but in southern Africa the concept of metering is generally accepted as the preferred means. The cost of metering must be carefully considered, not only for its initial provision but also for the subsequent setting up of a meter reading tariff and collection and administration systems.

The situation in a township close to Durban which has developed over the past 17 years has been well documented. Figure 2 shows a simplified curve of the average consumption per dwelling unit over that period.

At the commencement of the scheme the policy was that each dwelling unit should be metered, but that was subsequently altered so that the cost of water could be included within the rent on an average basis and not submitted as a separate account. Hence from 1971 to 1975 the daily unit consumption rose from 1 064 ℓ/unit to 1 757 ℓ/unit. The trunk services had adequate capacity to accommodate this increase as they had been designed for the ultimate development which was still in the future. However, the bulk supply authority expressed extreme concern to the controlling authority over the trend and it was eventually agreed that meters be installed in 1976. The consumption then dropped as indicated but, unfortunately, it has lately started increasing again, although not at the previous rate. The recent change has been caused by difficulties encountered in the reading and collection system. The cost of setting up a more frequent and sophisticated reading and collection system may not be justified. Instead it may be more economical to adopt a higher unit design figure and undertake the necessary augmenting of trunk mains. Either way will require the tenants to pay higher 'rents'.

A control system that has been utilized to some effect elsewhere, is the variable head flow restricter valve. It is a simple device, which permits a fixed flow rate from a tap regardless of the head available. This can obviously reduce the peak demand but does not necessarily reduce the consumption per unit, because hosepipes, etc., used for gardening purposes, are often left running continuously through the day rather than being hand held for shorter periods. It is essential for an effective control system to be installed initially, otherwise water consumption will rapidly get out of hand, particularly in dry, hot summers. It has been known for water to be used for spraying house roofs as a simple means of air-conditioning. If meters are installed then the reading must be monthly during the peak demand periods of the year and the accounts must be delivered promptly so that they have immediate effect. The meter reading must commence as soon as the first houses are occupied and not be left until the scheme is complete, otherwise considerable 'consumer resistance' will be met.

(b) Distribution philosophy

Distribution philosophy relates to the various decisions that are needed, for instance, in respect of pumping or gravity supply peak demand factors, bulk storage quantity, pipe materials and friction factors, etc.

When considering whether pumping or gravity methods of distribution should be used, it often develops that gravity methods could be utilized to a greater extent than pumping, although at a greater initial capital cost due, for instance, to the need for larger trunk mains. In system designs, the economic comparison between the two types is normally carried out on the basis of 15 or 30 year discounted cash flows. Whichever water system indicates a lower long term cost is normally proceeded with, but in making the comparison, care must be taken that the effect of inflation on power costs over the period chosen is truly recognized. Over recent years the unit costs of electricity and other energy sources have greatly outpaced both the general inflation rate and the interest rate on borrowed capital. In comparisons, therefore, the energy cost inflation rate assumed initially is frequently, with hindsight, found to be lower than that which should have been taken. The recent higher increases were, most probably, due to unusual self-financing requirements of the electricity supply authority. This type of variation could be repeated in the future and there is, therefore, more risk that a pumping scheme would be more expensive in real terms than when first calculated. Due to the greater variations in inflation and unit rates, which are occurring now, as compared with those of ten to twenty years ago, the reliability of such economic comparison calculations is considerably reduced.

The problems associated with operating a pumping scheme in a low income housing development are often greater due to the difficulty of ensuring adequate pump control and maintenance staff, an often less reliable bulk power supply and lack of alternative methods of meeting demand if failure occurs. These factors are difficult to include in a purely economic comparison but must be given considerable weight.

Consider now the minimum and maximum normal system pressures. These should be carefully determined in conjunction with the topography of the area concerned and not simply accepted from those that have been utilized previously.

The maximum system pressure should be kept as low as possible in order to reduce wastage from reticulation leaks and poorly maintained water fittings which are more likely to occur on low income housing schemes. A recommended maximum is 900 kPa with a preferred design of 800 kPa.

The designed minimum system pressure depends on whether or not a fire fighting supply is to be catered for and on correct prediction of the system peak factor. It is considered that further research is required into the actual peak factors and minimum system pressures occurring in practice in order to understand any inter-relationship and improve the design parameters. Current design factors are minimum system pressures of 120 kPa, and peak daily demand factors 4,5 times the average day of year demand for low income areas, whereas for mixed (normal urban development) areas the factors are 230 kPa and 4,2 respectively.

Again, the range of peak factors utilized is considerable and a realistic peak factor for a particular area must be considered. For example, the peak factor for a township being constructed for an isolated factory where all the labour force commences and finishes work at the same time, is obviously higher than for a township adjacent to a multi-industrial commercial complex (a mixed area).

With computer programs becoming more readily available for the design of networks, it would appear possible for alternative designs to be carried out, with little additional time, using various peak demand factors to assess the likely ranges to be met by the practical design finally used. For the larger networks, these programs could be further refined to have a variable peak factor demand through the area - i.e. the larger the area, the lower the peak factor applicable to the whole area - similar to the Harmon factor concept applied to the design of sewerage reticulation. This would enable a greater economy to be achieved in the bulk supply.

Two reticulation design criteria considered essential for ultimate economy are that the minimum diameter reticulation pipe should be 100 mm and that, for residential areas as opposed to commercial, industrial, school and community centres, no allowances should be made for fire fighting demand.

(c) Source proximity

In the siting of a low income township, due regard has to be paid to the availability of bulk water, whether utilizing an underground or surface raw water source, or obtaining a bulk supply from an existing water authority.

From an economic viewpoint, the latter method is obviously preferable, as the greater the spread of types of water consumers supplied from a source, the more chance there is of obtaining a low uniform unit water cost.

However, in the former cases, it must be realized that the time required to obtain and store potable water from a raw water source is considerable; it cannot be less than 3 years for a reasonably sized township. This is due to the proving of the source, obtaining the required abstraction permits, and designing, constructing and commissioning the system. Hence, frequently, in any new isolated township, the critical path for development is likely to be the potable water supply, rather than any problems of house construction, etc.

Before a firm decision is made to develop a township for low income earners in any particular area, detailed pre-investigation work into the water source must be completed. It will be too late after road construction has commenced to discover that the supposed reliable water source dries up every 5 years, or that the water requires an extremely expensive or technically difficult treatment process.

(d) System reliability

In any system design it is recognized that sooner or later something will go wrong, and safeguards are therefore incorporated to enable the system to continue to operate until the malfunction is corrected.

The cost of these safeguards can be high, and care should be taken to consider their extent and whether a cheaper alternative is available or whether the community would be prepared, in fact, to have minimal safeguards and accept the occasional malfunction.

The usual major supply safeguard is bulk storage, normally situated so that the area is gravity supplied. Bulk storage has two purposes; to reduce the peak demands on the bulk source to average daily demand and to provide water in the event of a source failure.

The size of the storage has traditionally been related to hours of average demand stored. In the United States a period of 24 hours storage is provided, while in South Africa various figures are used.

(i)	Durban City Industrial Areas	- 48 hours av. daily demand
	Durban City Residential/Commercial Areas	- 36 hours av. daily demand
(ii)	Department of Co-operation and Development and Transvaal Provincial Administration	
	Pumping schemes	- 48 hours summer peak demand - (72 hours av.daily demand)
	Gravity schemes	- 24 hours summer peak demand - (36 hours av.daily demand)
	(Summer peak demand is 1,5 times average demand)	
(iii)	Durban Asian Township	- 36 hours av. daily demand
(iv)	Durban Black Township	- 48 hours av. daily demand

In order to optimize the storage it is considered that more attention should be paid to the storage requirement by closely examining the quantity actually required for peak lopping and the likely response to system malfunction. As adopted in (ii) above, the likely failure of the gravity system is considerably less than that of a pumped system and the storage can be reduced. Once again the determination of peak factors on the system as a whole must be considered with care, as there is considerable variation in the summer peak demand factors between, for instance, winter and summer rainfall areas and inland and coastal areas. Hence it is not possible to take a general universal factor; the factor must be obtained from consideration of the climatological variations coupled with actual factors obtained from existing systems in the area.

For example, due to Durban's coastal situation and mixed type of demand, the overall summer peak demand factor is 1,13 (average day of peak week divided by average day of the year) and 1,24 (peak day of year divided by average day of the year), compared with a factor of 1,50 recommended above for a low income area. For residential areas in Durban the factor currently taken is 1,4 but this is at present under review.

The cost of providing storage for that difference in peak demand factors can be considerable, particularly if it is found to be unnecessary. It must be recommended that provision for storage should be made on the basis of a double rectangular tank, sized for the ultimate anticipated demands, but with only one half of the tank constructed initially. Frequently it is found in practice that a reservoir is constructed for the ultimate requirement and yet, due to delays in the infrastructure development and/or shortage of capital, the demand is delayed for a considerable period. This means that in their 'rent' for the service, the initial residents are paying for the ultimate requirements.

2. SEWERAGE

The sewerage system to be provided must meet all health requirements and yet must be simple and economical to operate. With the extension of urban sprawl, the greater concern over pollution of surface and underground waters, and the increased desirability of full ablution and toilet facilities, the disposal of liquid waste from low income housing is becoming a larger and more expensive portion of the development costs, and hence of the 'rent'.

In spread out rural settlements, the disposal of liquid wastes from dwellings can still be carried out in latrines and the like, but where the density of housing increases, such methods are no longer acceptable. In some small developments where suitable soil conditions prevail, and limited ablution facilities are provided, septic tanks, aqua privies and the like can still be appropriate and should not be rejected out of hand.

However, it must be accepted that, in most situations, current township developments require a piped collection service for the waste liquid, because such a scheme will normally provide the most economic and reliable method of disposal without creating major maintenance difficulties and health hazards.

Considerations in this paper are therefore primarily relevant to a traditional piped waterborne sanitation system including treatment prior to ultimate disposal.

The major points for discussion are:

(a) Topography
(b) Final effluent quality
(c) Regionalization
(d) Treatment plant sophistication
(e) Unit contribution.

(a) Topography

For a gravity system the question of topography of the area to be developed is of paramount importance and accurate contour plans of the area must be available, at an early stage in the design, for overall planning of the sewer system.

The planning of such a system must be a team exercise carried out in collaboration with the town planners. However, on numerous occasions the planners have completed a township layout using their particular favoured method currently in vogue, with culs de sac, cluster housing, etc. They have then been surprised when the sewerage engineer has thrown his hands up in horror and produced an estimate for the reticulation greatly in excess of that initially anticipated.

The most economical sewerage system is one with a two sided sewer - that is a sewer laid so that the houses on both the upper and lower sides (topographically) can be connected. For this to be achieved, the sewerage engineer must give to the planner - before detailed planning commences and once the typical plot size and typical ablution facility have been determined - the basic sewer parameters that are acceptable for the installation of a two-sided system. These parameters are often related to the angle that the sewer makes to the contour in relation to the maximum slope of the area. Frequently, in a marginal situation, the sewer alignment will fix the road alignment and not vice-versa.

It is obvious that a balance between the relative costs of the various services must exist and the optimal solution must be obtained.

The 'open space' criterion frequently affects the costs of the sewerage system as a whole. It must be accepted that 'active' open space has to be provided for the good of the community as a whole, but the positioning of such active open space can sometimes be optimized to reduce the lengths of non-collecting ('dead') sewer. The other open space, 'passive', is normally applied to land that for one reason or another is not suitable for any township activity. In a recent exercise carried out in Durban for areas adjacent to Chatsworth, the area of passive open space that had to be provided, due to steepness of ground, likelihood of flooding and access difficulties, resulted in the sewerage system having considerable 'dead' lengths of trunk sewer which, when costed and distributed as a unit capital cost per dwelling, was beyond the guidelines for lower income housing, i.e. would be too high a proportion of the 'rent'. The areas, therefore, have not been developed at this stage but remain as suitable areas for development by private enterprise for medium and high income earners.

Details of the scheme are given in the appendix.

In this case the team exercise was carried out before detailed design work was done, thus saving abortive effort.

(b) Effluent quality

In recent years, there has been greater environmental awareness of the effect of discharging treated sewage into water courses, and various approaches have been made world wide. Some countries impose a blanket requirement for discharge quality, irrespective of the quantity and quality of the receiving waters, while others consider in more detail the situation actually pertaining at the proposed site of discharge. Invariably the quality requirement laid down is based on a maximum or minimum unit quality per unit quantity, e.g. 20 mg/ℓ B.O.D. When this is considered in more depth it becomes apparent that this can lead to an uneconomical and illogical result.

What is basically required is an assessment by the determining authority of the acceptable ultimate quality of the receiving waters. This quality could be assessed on a number of factors, for instance, the subsequent use and/or storage of the water downstream, and could be related to the flow in the receiving water. For example, if a river is in flood, then the required quality of discharge could be lowered. It would be preferable if the discharge requirements could be expressed as a total daily load in kg/day of the pollutant that may be discharged into the receiving waters, and hence acceptable. Obviously direct health hazard limitations must still be maintained per unit of discharge.

The advantages of such an approach would be numerous. During the early stages, when a disproportionate amount of development cost is borne by the first residents, the treatment facilities required initially could be minimized and additions only provided when necessary, thus spreading the capital expenditure. Such additions could also be more accurately designed and economically constructed as actual unit flows and strengths would be known.

The initial treatment facilities could be operated at minimal cost to obtain the desired results and the design of the facilities, so often sized to accept a high storm flow, could be reduced if the discharge requirements were related to anticipated riverflows.

Treatment works designed for domestic flows only are often cheaper, both as regards initial capital costs and subsequent operating costs, than those works that have to accept industrial discharges. Such industrial discharges lead to a greater number of unknowns in the initial design and greater problems in subsequent operating. Although the planners frequently include an industrial area within a township in order to provide a 'balanced' community, it might be preferable for a separate industrial township to be provided with its own treatment works or, alternatively, for rigid industrial discharge requirements to be laid down and enforced.

(c) Regionalization

Following on from (b) above is the question of regionalization of sewage treatment facilities.

From a broad viewpoint the principle has obvious advantages, in that greater expertise can be utilized more economically in the operation of a single major works than in a number of small works. However, as has been considered at length by a working party in South Africa, the cost problems involved in the provision of 'dead' trunk sewers to connect separated areas of development are difficult to resolve.

Hence, the connection of a new township development into an existing or proposed regional scheme could, on initial consideration, appear to be the most economical, but often the capital cost and/or rent portion of the connecting 'dead' trunk sewer exceeds that of a treatment works.

Such an examination proved valid in the case mentioned previously in the areas adjacent to Chatsworth. The final economic examination indicated that four small treatment works were preferable, although initially it appeared that a connection to the existing regional works was the simplest solution. In this examination the works were based on acceptance of domestic sewage only, with no industrial sewage, as discussed previously. If industrial discharges had been considered then the expense of providing a link to the regional works might have been justified but that would have further increased the unit cost.

(d) Treatment plant sophistication

Where a separate works is necessary the design should be based on proven technology and capable of being operated by semi-skilled labour. It is considered undesirable that the works should be constructed on a 'package' or 'turn-key' basis, as such arrangements are frequently based on a particular imported technology and often involve imported plant and equipment. However economical this may appear to be, almost invariably the latest technology gives rise to operating problems in the early stages and the procurement of spare parts and replacements for the imported equipment leads to increasing frustration and costs.

It is considered desirable that the design for the treatment works should be based on proven technology based on biological treatment and minimal energy requirements. For solely domestic effluents, the conventional activated sludge approach, whether with surface or diffused air type of aeration, is not recommended, because it calls for a higher level of operational ability. A simpler system utilizing biological filters or, possibly, a system based on the Pasveer ditch concept, are preferable in giving a uniform final effluent quality, without the need for control expertise.

(e) Unit contribution

The anticipated contribution from the township must again be based on an average per dwelling unit and not per capita.

A recent investigation carried out for the development of a new low income township proved that previous estimated contributions were conservative compared to actual flows from existing townships. The equivalent previous contribution when converted to contribution per dwelling unit and including infiltration was 1,78 m^3 per unit per day, whereas from actual flows this has been reduced, including infiltration, to 1,00 m^3 per unit.

Such a reduction has obviously enabled considerable capital savings to be made.

Details of design factors utilized from various authorities are given in Table 2.

TABLE 2 : Current sewage contribution design figures

Durban:				
Low income township contributions pipes 2/3 full		-	1,0 m^3 per unit per day	
Recent flow measurements:				
Chatsworth	(Indian)	-	0,93 m^3	1970
Phoenix	(Indian)	-	0,68 m^3	1977/8/9
Ntuzuma	(Black)	-	0,91 m^3	1978
Department of Co-operation and Development:				
Low income township contributions pipes 60 per cent full		-	0,80 m^3 per unit per day	
Kitwe, Zambia:				
Low income township contribution		-	1,0 m^3 per unit per day	

SUMMARY

The contribution of trunk hydraulic services to the capital and operation of costs of the 'rent' of the lower income group can be minimized by the designer paying particular attention to the following:

Water:

(i) the anticipated water consumption per dwelling;
(ii) the proposed control and charging method for water supply;
(iii) optimization of the distribution method for water supply;
(iv) determination of maximum and minimum working pressures for water reticulation;
(v) determination of daily and summer peak factors;
(vi) optimization of raw water source development or supply source;
(vii) consideration of the treated water storage required and the timing of the required storage.

Sewerage:

(i) the anticipated sewage contribution, peak flows and sewage quality;
(ii) in conjunction with the planners, the desirable layouts to minimize sewer lengths;
(iii) the optimization of open space distribution, both active and passive, to reduce 'dead' sewers;
(iv) in conjunction with the relevant authorities, determination of realistic effluent discharge quality requirements;
(v) the ability to use an existing regional treatment works;
(vi) optimization of treatment works design by eliminating industrial discharges, keeping treatment simple and utilizing relevant local and appropriate technology.

CONCLUSIONS

To enable the 'rent' to be kept to a minimum for the low income earner, the design of the major hydraulic services should be optimized and must be considered at an early stage prior to formal establishment and the commencement of detailed planning.

The time scale required for the provision of such major hydraulic services must be made clear at an early stage of planning, as such services are frequently the critical path of providing the required accommodation.

It must be recognized by planners that, from the hydraulic services point of view the minimum 'rent' portion for such services is likely to be obtained if the township can be developed in such a way that both water supply and sewerage can take advantage of existing water and sewage treatment facilities.

The planning developments of new townships for low income earners must be carried out by a multi-disciplinary team from the early stages.

Appropriate technology must be utilized in order to minimize the operating and maintenance cost.

REFERENCES

1. Guide Lines for the Planning and Design of Water Supply Schemes and Reticulation Networks. Department of Plural Relations and Development, (now Department of Co-operation and Development), South Africa, January 1979.

2. Guide Lines for Sewerage Design. Department of Plural Relations and Development, (now Department of Co-operation and Development), South Africa, January 1979.

3. Design Criteria. Durban City Engineer's Department, 1980.

4. Guide Lines for Hydraulic Design. Kitwe City Council, Zambia, 1970.

ACKNOWLEDGEMENTS

The author is indebted to the City Engineer of Durban, Mr. D.C. Macleod for permission to present this paper. It must be stated that the views expressed in this report are the author's and do not necessarily represent those of the City Engineer's Department, Durban.

REPORT ON THE PROVISION OF SEWERAGE TO EXTENSIONS TO CHATSWORTH INDIAN TOWNSHIP

Introduction

As a result of increasing demands for housing for the Indian community, areas of land adjacent to the existing Chatsworth Township have been investigated. The land has up to now been considered too rugged for development of economic housing and may still be so. It is, however, possible, and indications from interested sub-developers support this, that schemes for high-class housing may be feasible.

The town planners have therefore indicated four areas in the Umlaas Valley that could possibly be developed and have indicated likely population densities.

Based on such information, investigations have been carried out into the possible alternative methods that are available for the provision of waterborne sanitation to the areas.

General

The areas considered are Welbedacht West, Welbedacht, Klaarwater and Bul Bul spread along the north bank of the Umlaas River from west to east.

Due to the severe topography of the river it is not possible to extend a trunk sewer from the Southern Waste Water Treatment Works to the downstream area of Bul Bul. The engineering costs of such a scheme and the long length of 'dead' sewer make such a solution un-economic.

The alternatives are therefore to pump the entire flow from the catchments over the ridge into the Chatsworth system. This would prove to be expensive due to the high head involved between the river level and the Chatsworth Ridge (± 180 m) and the subsequent need to augment the existing sewerage system through Chatsworth and downstream.

The only other alternative therefore is to provide a treatment works on the Umlaas River and discharge directly to the river. As the development will be entirely residential (with no industrial), works could be successfully operated with moderate supervision and should give little operational difficulty, bearing in mind interaccessibility between each works.

In general, it is considered undesirable for a proliferation of small works to occur. In this case, the topography creates engineering difficulties of taking a trunk sewer across bends of the Umlaas River, and such river crossings would mean maintenance difficulties. With the possible need for access to the south bank and the lengths of large diameter 'dead' trunk sewer which would occur, it is proposed that separate small works be developed for each area. Such development has advantages in that each area can be sewered independently in response to demand and the trunk sewer would not have to be laid from the downstream end to upstream areas if it was decided to develop the Welbedacht area first.

The cost of servicing this area is estimated at R463 000. A large proportion of the developable area can only be sewered by utilisation of pumping. It would be preferable if the gravity catchment could be developed as the first stage, if phasing is necessary.

The capital cost of conveyance and treatment, per site, is R654 (excluding reticulation).

Area B - Klaarwater

The cost of servicing is R658 000. Again a proportion of the area requires pumping and the areas are indicated. It should be noted that although the upstream pumping station catchment area connects with the area of the downstream pumping station area of the Welbedacht system, the limit should be the southern boundary of the proposed water reserve.

The capital cost of conveyance and treatment, per site, is R470 (excluding reticulation).

Area C - Welbedacht and Witteklip

The cost of servicing this area is R2 130 000. Four pumping stations are required to service the lower area as indicated and the phasing of development would reduce initial costs by utilising the upper areas. It is not possible to sewer the area to the west of the watershed line to the Umlaas River above the upstream pumping station due to topographical conditions.

The capital cost of conveyance and treatment, per site, is R832 (excluding reticulation).

Area D - Welbedacht West

Although, at this stage, this area is outside the Borough it appears to provide a worthwhile area for economic housing. The sewering of the area would cost R5 740 000. Two pumping stations are required to fully develop the area but a large proportion of the area can be sewered by gravity. The trunk sewer is, however, long compared with the area sewered. This is due to the topography, and particularly to the smaller watercourses at its upstream end. There may, however, be a comparative saving in the provision of sewerage reticulation.

The capital cost of conveyance and treatment per site is R929.

Area	No.of Sites	Capital Cost R	Cost per Site R	Total Area Ha	Usable Area Ha	Per cent Usable
A. Bul Bul	708	463 000	654	125	59	47
B. Klaarwater*	1 400	707 000	505	222	103	46
C. Welbedacht & Witteklip	2 560	2 130 000	832	545	200	37
D. Welbedacht East	6 176	5 740 000	929	1 282	534	42

* Although the cost per site is less for this area than North Phoenix the unit cost per site for roadworks makes the area non-viable.

It can be seen that the development of Klaarwater gives the most economical solution although it should be noted that the differences in per unit cost are significant, but their relationship could be altered by reticulation cost differences.

The construction period for the provision of the treatment facilities would be 2 years for Areas A and B, 2,5 years for Area C and 3 years for Area D on the assumption that permits have to be obtained from the Department of Water Affairs for discharge into the Umlaas River. For this investi-gation the treatment works costs have been based on a 'carousel' type of plant but until the Department of Water Affairs indicates the discharge standards required no more accurate costs can be presented.

NOTE:

The above estimates were carried out in 1978. Current estimates (1979) for the low income housing area of North Phoenix are:

E. North of Phoenix	11 000	R5 807 000	528	960	930	97 per cent

FIGURE _1_

TYPICAL CURVE OF WATER CONSUMPTION PER DWELLING UNIT

DESIGN CONSUMPTION ON: a) _ Per capita would be 1200 ℓ/unit for 6 persons.
b) _ Per dwelling unit would be 1340 ℓ/unit for 6 persons.
c) _ Actual consumption 1400 ℓ/unit.

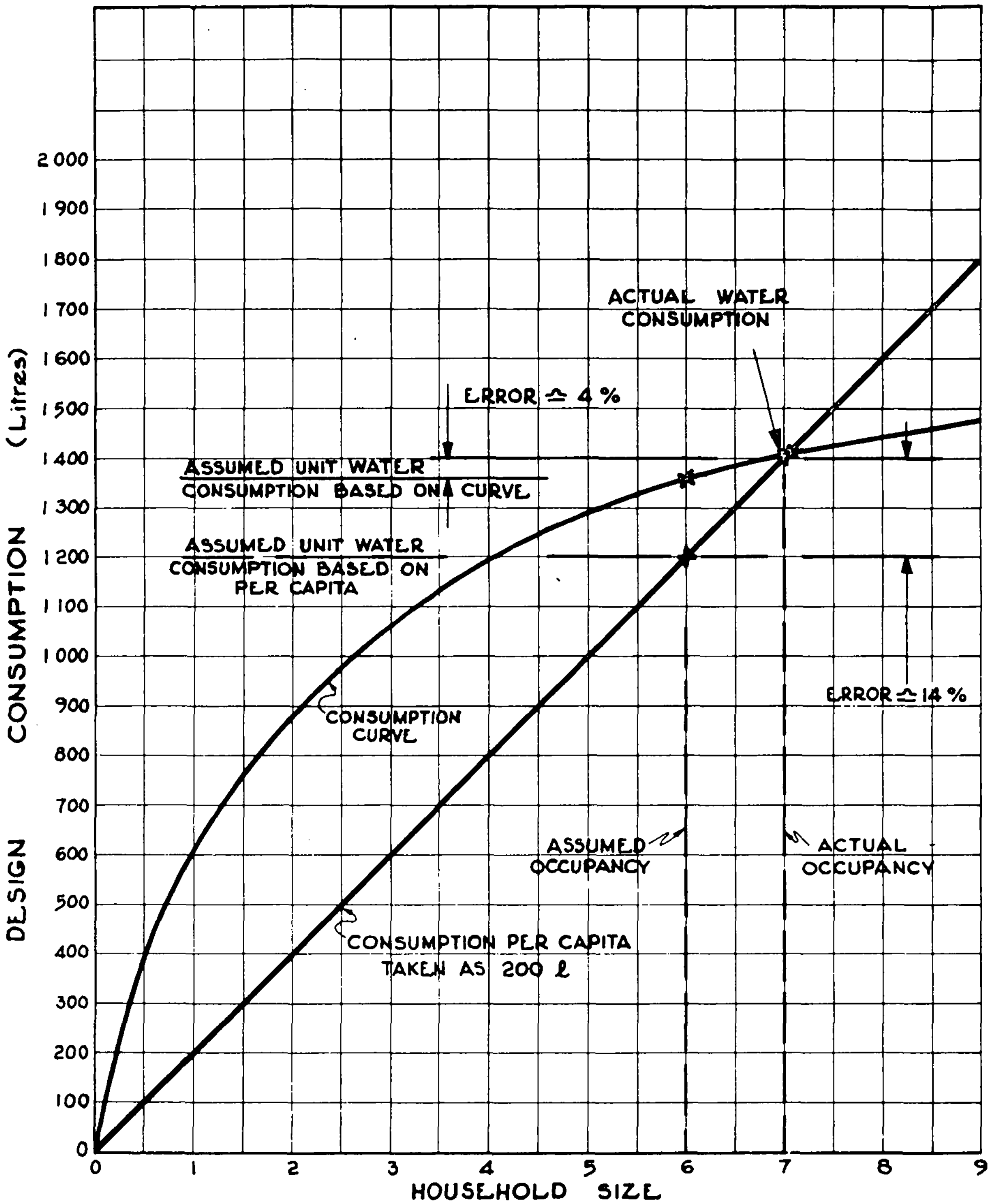
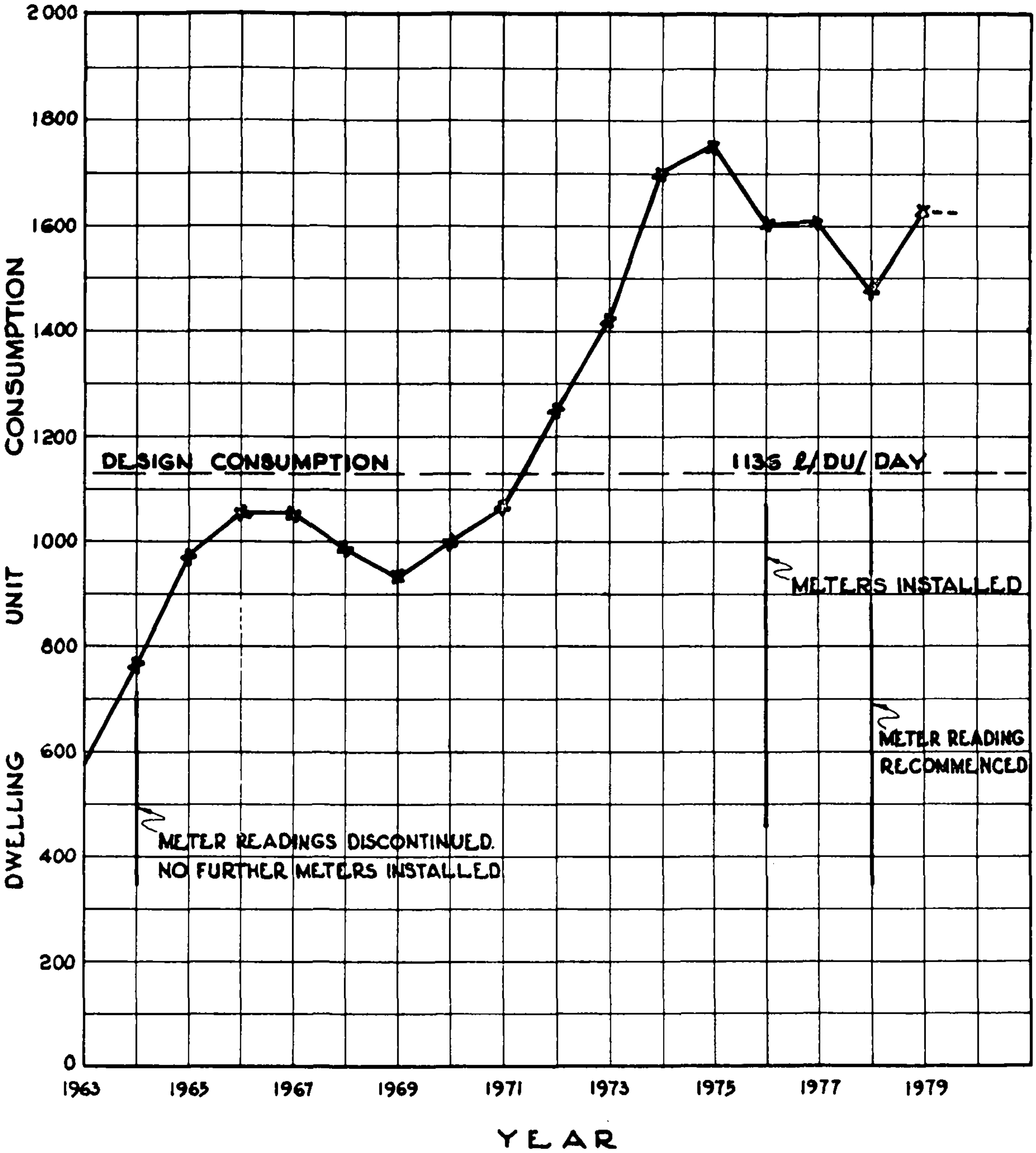


FIGURE _2_

VARIATION IN ACTUAL CONSUMPTION PER DWELLING UNIT
UMLAZI TOWNSHIP _ NEAR DURBAN



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Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

S 239

Paper 16
Referaat 16

KEYWORDS
SLEUTELWOORDE

W.C. flushing, water flow, conservation/ W.K.-spoeling, watervloei, bewaring

TOWARDS URBAN WATER CONSERVATION IN SOUTH AFRICA

by G.J. Malan*

SYNOPSIS

Investigation into water economy measures in urban areas includes research on a number of aspects. Since water used for flushing constitutes a significant portion of total daily urban water consumption, high priority must be given to the development of flushing efficiency tests.

Similarly, the need to look into urinal flushing and tap flow rates is being emphasized.

The results of a survey of water leakage from W.C. cisterns in a group of office blocks is included to show that leakage can be another major cause of water wastage.

Finally, the role that the NBRI is playing on the drafting committee for National Water Supply Installation Regulations and in the preparation of a parallel code of practice for hot and cold water supply systems in buildings is highlighted.

SAMEVATTING

'n Ondersoek na waterekonomiemaatreëls in stedelike gebiede sluit navorsing oor 'n aantal aspekte in. Aangesien water wat vir spoeling en waterklosette gebruik word, 'n beduidende deel van die daaglikse stedelike waterverbruik verteenwoordig, word hoë prioriteit verleen aan die ontwikkeling van spoeldoeltreffendheidstoetse.

Insgelyks word die behoefte om urinale spoeling en kraanvloeitempo te ondersoek, benadruk.

Die resultate van 'n opname van waterlekkasies by spoelbakke in 'n groep kantoorblokke word ingesluit om aan te toon dat dit 'n groot oorsaak van watervermorsing kan wees.

Ten slotte word nadruk gelê op die rol van die NBNI op die ontwerpkomitee vir die opstel van Regulasies vir Nasionale Watervoorsieningsinstallasies, sowel as die voorbereiding van 'n parallelle gedragskode vir warm- en kouwatervoorsieningstelsels in geboue.

* *Building Services Division, NBRI, CSIR, Pretoria.*

1. INTRODUCTION

Water conservation is of vital importance for South Africa. Current research being carried out by the National Building Research Institute (NBRI) under the sponsorship of the Water Research Commission is dealing in particular with conservation in the urban environment.

Specific research work by this Institute has only recently commenced and no detailed investigations have as yet been completed.

This paper deals with some thoughts on and approaches to some specific aspects to be investigated during the course of this project.

2. WATER CLOSET FLUSHING REQUIREMENTS

As in the case of other countries, water used for WC flushing forms a significant portion of daily urban water consumption.

The figures for South Africa, compared with similar figures obtained in the United Kingdom and United States, are as follows:

TABLE 1 : Comparison of average water consumption in dwellings in different countries.

Country/ Consumption ℓ per head per day	UK[1]	U.S.A.[2]	RSA
WC flushing	36,5	94,5	49
Total for dwelling (excludes external use)	110	241	180
Percentage of total used for WC flushing	33 %	39 %	27 %

In South Africa two standard capacity WC cisterns are manufactured with nominal capacities of 11 and 13 ℓ respectively. In the United Kingdom the standard cistern is 9 ℓ, and in the United States of America the most common cistern discharges 19 ℓ.

Flushing tests on some standard South African pans[3] indicate that the flush volume could safely be reduced to 8 ℓ on certain pans.

The Standard Specification for WC flushing cisterns (SABS 821-1975) covers cisterns of 11 ℓ nominal capacity. A dual flush unit is also included in the Specification and is defined as a unit that will deliver a short flush (approximately 5,5 ℓ or a full flush (11 ℓ) at the will of the operator. The dual flushing cistern is stated as being intended for washdown pans.

Research into flushing requirements which will lead to the development of reduced flush WC's, must be preceded by the development of a rational test method for establishing flushing efficiency.

It is envisaged that the flushing tests will be incorporated into the Standard Specifications for the manufacture of WC suites.

3. WC FLUSHING TESTS

The objective of a flushing test should be to guarantee (within limits) that a pan which has passed the test will also operate successfully under normal use. The flushing test should be suitable for inclusion in the quality control process by a manufacturer of WC's.

From the point of view of water economy, success in practice would be achieved if the user did not require to repeat a flush in order to clear a pan.

The efficiency of flushing is in practice entirely subjective. Some people may flush more than once after a particular use if faeces remained in the bowl after the first flush, but not if a piece of paper remained or if the water was still somewhat discoloured. Others on the other hand may repeat a flush until the water remaining was perfectly clear. It is, however, considered likely that the majority of people fall into the former group but this will have to be verified by means of an opinion survey.

From the water economy viewpoint it is considered that the most important aspect which the flushing test should simulate is the flushing of faecal matter.

Approval authorities around the world generally require the flushing tests to measure the efficiency of a pan in respect of two basic categories, namely:

(i) cleanliness: requiring the removal of solids and rinsing the surface of the bowl;

(ii) water change: requiring replacement of the contents with clean water thereby removing bacteria.

Tests falling into the first category make use of test objects such as paper, sponges and balls for removal of solids, and sawdust for monitoring the rinsing of the surface of the bowl.

Tests falling into the second category make use of dye for visual evaluation, or colorimetric concentration analysis, or chemical conductivity analysis.

Tests carried out by Boyd[3] show that paper and dyestuff were nearly always flushed out satisfactorily whereas balls were not. The tests showed the ball test to be the most reliable indicator of efficiency. The test methods used by Boyd are basically the same as described by Nielsen[4].

The unreliability of the use of paper as a test method is confirmed by Sobolev[5] and others[6]. Sobolev carried out tests using 19 mm diameter balls of relative density 0,88, of sufficient number to cover the surface of the water in the bowl. The number varied between 45 and 60 for different pans. Good repeatability was obtained and reasonable correlation between rated performance efficiency as determined by flushing tests, and individual assessment of the pans in terms of a 'good' or 'bad' classification by manufacturers.

Further work by Sobolev[7] showed that by using balls of a relative density of 0,85 as compared to 0,88 the lighter balls increase the range of test result values, lower the grading level to permit differentiation in the higher efficiency range, and respond better to small variations in efficency, thereby improving the sensitivity of the test.

The Standard Specification for Glazed Ceramic Sanitaryware (SABS 497-1973) includes flushing tests for WC pans. In terms of the specification the pans are required to comply with the following criteria:

(i) When tested with paper (see Appendix A for details of the paper test) the paper load shall be discharged (without clogging) at least three times out of four tests; and

(ii) during each flushing operation, the whole of the flushing surface of the pan up to 25 mm below the flushing rim shall be wetted; and

(iii) not more than five isolated water droplets shall be deposited on the top surface of the rim of the pan.

As stated earlier, the primary objective of a flushing test should be to simulate the flushing of faecal waste. The tests to be developed will, of course, also include efficiency of rinsing the internal surfaces of the bowl (for odour prevention) and water change (for bacteria reduction).

Preliminary figures obtained for people in South Africa indicate that the faecal waste to be flushed varies on the average between 50 - 100 g with a relative density of more than 1,0, and 200 g with a relative density of less than 1,0. The differences are probably due to the different eating habits of the two main ethnic groups in the country. The staple diet of a large sector of the population is derived from maize which would result in faecal matter of the latter category.

It is considered necessary for the flushing test to simulate the category that is more resistant to flushing.

In addition to the development of a flushing test for use in a laboratory or a factory test facility, it is considered necessary to develop a parallel test method for use in monitoring the efficiency of WC's already in use. Such a test would enable an assessment to be made of the potential success of possible water saving modifications to existing WC's. The field test objects would have to be biodegradable, such as pieces of bread, potato or apple.

Another advantage in having a parallel field test method, is that it would serve as a check against the laboratory test method. Where the number of pans of a particular make installed in a laboratory is of necessity limited, a large sample could be obtained in a block of flats or offices and hence provide better statistical correlation.

A large sample would provide a greater opportunity for locating an inefficient WC suite which could then be subjected to detailed investigation to isolate the cause of the inefficiency.

A further correlation procedure, between efficiency as predicted by flushing tests and actual efficiency in use, would be to monitor WC's in a men's toilet, in an office block or hostel with adequate urinal facilities, by installing a counter on the door of the WC cubicle and another on the float arm of the float valve on the cistern inlet. Comparison of the readings would indicate whether or not the cistern was being flushed more than once by the same user. The flushing counter could alternatively be connected to the operating lever for the Beta type flushing valve, but would have to be connected to the float arm in the case of a siphon flushing valve since in some cases the valve fails to operate first time.

4. FLUSHING VOLUMES AND RATES

SABS 821-1975 covers two types of flushing valves in WC cisterns, namely, the type in which a plunger is lifted off a seat at the bottom of the cistern (referred to as a Beta valve), and the siphonic type.

In terms of SABS 821-1975, the flushing valve is required to discharge 11 ℓ in not more than 7,5 seconds for the high level cistern (1,25 m minimum vertical distance between the top of the pan and the underside of the cistern); and 8,5 seconds for a low level cistern (380 mm minimum vertical distance between the top of the pan and the underside of the cistern), and also for a close coupled suite where the cistern is fixed directly to the pan without the need for a connecting pipe.

The average flow rate for the high level cistern in terms of the Specification is therefore 1,5 ℓ /s for the high level cistern, and 1,3 ℓ /s for the low level and close coupled cisterns.

In the case of automatic shut off flush valves covered by Standard Specification SABS 1240-1979 : *Flush Valves for Water Closets*, the flushing performance required for the two classes of valve specified (nominal size 20 mm, and nominal size 25 or 32 mm) is given in the Specification as per Table 2.

TABLE 2 : Performance requirement for flush valves as per SABS 1240-1979

Class of valve	Quantity of water flushed (litres)	Time (s)
A (20 mm)	6,5 ± 1	6 ± 1
B (25 or 32 mm)	7,5 ± 1	6 ± 1

The flushing rate allowed therefore varies between 0,8 ℓ /s and 1,5 ℓ /s for Class A valves and 0,9 ℓ /s and 1,7 ℓ /s for Class B valves, the nominal rates being 1,08 and 1,25 ℓ /s respectively.

The nominal flushing volumes and rates for flush valves are therefore lower than those allowed for WC flushing cisterns in terms of the relevant standard specifications.

Flush valves are, however, only used with certain specific types of washdown pan. The reasons for the apparently greater flushing efficiency obtained with flush valve WC suites will be investigated in detail during this research programme.

In terms of SABS 821-1975, the test for determining the actual flush volume discharged from a WC cistern is carried out by filling the cistern to the marked water line and discharging the flush with the inlet float valve closed off. In practice, of course, water does enter the cistern during the emptying cycle. A standard 15 mm high pressure pattern float valve (similar to the BS 1212 pattern) admits 0,6 ℓ at a flow pressure of 400 kPa during the 8,5 second test flush if left to open normally.

The effective flush in practice is therefore somewhat more than the volume discharged in accordance with the Standard Specification test.

5. REDUCED FLUSH WATER CLOSETS

There are two approaches to achieving water saving in WC flushing:

(a) engineering: the development of more efficient WC suites; and

(b) user education and cooperation: further savings achieved by dual flush and user controlled variable flush. Savings here are subject to the will of the user.

The former aspect must be tackled first. Savings achieved through the second approach are a bonus.

Research into the engineering aspect will be directed towards establishing the parameters which govern flushing effectiveness, by making use of the some 20 varieties of WC suite manufactured in this country. Investigations will be directed not only to the bowl and trap, but also to the cistern, valves and flush pipes.

Ilberg, Silberstein and Winter[6] carried out a valuable preliminary study and evaluation of certain parameters affecting flushing effectiveness. They arrived at the following conclusions:

(i) Variations in the seal trap depth of between 50 and 65 mm for the pans tested have no effect on the efficiency.

(ii) The efficiency is inversely proportional to the volume of water in the bowl under static conditions.

(iii) The efficiency is inversely proportional to the head loss coefficient determined for the bowls tested.

(iv) The efficiency increased with increasing rates of flow into the bowl up to a limit of 3,0 ℓ /s, whereafter no increase in efficiency could be achieved.

(v) The optimum efficiency (90 - 95 per cent) was achieved at an average flow rate of 1,75 ℓ /s for a 10 ℓ flush volume, 1,9 ℓ /s for 8 ℓ and 2,5 ℓ /s for 6 ℓ.

Ilberg et al[6] further investigated several geometric modifications to a standard pattern, Israeli type washdown bowl with varying degrees of success ranging from no appreciable increase in efficiency to an increase of 6 per cent. The latter increase was achieved by improving the roundness of the flow path through the base of the bowl.

The optimum design of a WC suite will, however, not be governed by hydraulic considerations only. Finally, acceptable designs must take into account other factors such as:

(i) sanitary requirements, e.g. no splash over the rim and ease of cleaning;

(ii) structural requirements;

(iii) cost of manufacture and installation; and

(iv) aesthetic acceptability.

With regard to the last mentioned factor, cisterns are usually required to be placed as low as possible thus eliminating the increased potential energy available from raising the cistern above the pan.

6. LEAKAGE IN WC CISTERNS

Wastage of water through leakage from WC cisterns takes place through the Beta type flushing valve, and the float valve on the inlet.

The siphon flushing valve is preferred for this reason and is the only type of valve permitted by local municipal by-laws in certain parts of the country.

It is interesting to note that the municipalities who do not permit the Beta valve are located at the coast. The reason for the currently available siphon valves not being popular in the Highveld areas (altitude about 1 500 m) may be due to the extra effort needed to activate the siphon as a result of the lower atmospheric pressure.

The siphon valve will be thoroughly investigated under this project since this type of valve positively eliminates one potential source of water leakage.

In terms of SABS 821-1975, the overflow resulting from failure of the float valve on the inlet to shut off may be disposed of either:

(i) through an overflow pipe arranged to discharge in an auspicious position outside the building (referred to as a warning pipe); or

(ii) into the pan via the siphon pipe or an overflow pipe built into the flush valve.

Where the overflow is taken into the pan a low leakage rate is often not conspicuous and is therefore usually left unattended by the owner for an indeterminate time.

A survey of WC leakage in a group of office blocks in Pretoria was carried out during January 1980. The majority of cisterns had Beta type flushing valves fitted. None of the automatic closing flushing valves were leaking.

Leakage rates were measured, and the number of potentially leaking float valves was also noted. By 'potentially leaking' is meant that the water level in the cistern was at the point of overflowing. Any further progressive compression or deterioration of the washer in the float valve would result in water overflowing to waste.

The results of the survey are summed up as follows:

Number of Beta flushing valves	=	505
Number of siphonic flushing valves	=	12
Number of flush valves	=	14
Total number of WC's checked	=	531
Number of float valves leaking	=	44 (8,5 per cent)
Number of Beta flushing valves leaking	=	23 (4,6 per cent)
Number of float valves potentially leaking	=	66 (12,8 per cent)

Further results of the survey were:

(i) The leakage rate, per WC measured, varied between 0,2 litre/hour to 150,0 litre/hour, with an average of 23,8 litre/hour per leaking WC.

(ii) The number of WC's whose measured leakage rate exceeded the average rate was 21 (31,3 per cent).

(iii) The sum of the leakage rates was 1 593 litre/hour which taken over 24 hours amounts to some 38 kℓ. The actual 24 hour quantity would in fact be even higher, since measurements were made during the day, i.e. over the period of peak draw-off and minimum mains pressures. Higher mains pressure at night would increase float valve leakage rates significantly.

The total measured leakage of 38 kℓ per day equals about 50 per cent of the estimated total volume of water actually flushed from the WC's during the day.

Research work aimed at reducing this type of water wastage is therefore well justified.

SABS 821-1975 requires a freeboard height of 25 mm to be provided between the water level mark in the cistern and the overflow. The purpose of this requirement is apparently to provide some storage for excess water, thus allowing for some progressive compression of the float valve washer, and to provide an increase in the buoyancy force on the float valve in the event of a leak.

In practice a leaking float valve would usually fill the reserve area anyway, and approximately 2 ℓ of extra water would be flushed each time resulting in waste.

In the case of the above survey, the wastage of water resulting from flushing the excess storage would amount to about 900 ℓ per day which is minor compared with the 38 kℓ lost through continuous leakage.

In an effort to curb wastage from leaking float valves, at least one municipality prohibits the discharge of leakage into the WC flush pipe, thus rendering the leak more noticeable to the owner.

7. URINAL FLUSHING

A survey of urinal flushing is being undertaken in the same group of Pretoria office blocks.

The urinals are mostly the stall and slab type with automatic flushing cisterns.

An attempt will be made to relate the quantity of water flushed per day to the number of users and the odour rating expressed as 'minor', 'moderate' or 'major'.

SABS 497-1973 requires the discharge capacity of a flushing fixture serving a single urinal to be 2 ℓ, and 3,5 ℓ per running meter for a urinal range.

In the case of one local authority, the by-laws call for a flush of more than 5 ℓ per stall or 400 mm running length of urinal slab.

Another local authority requires a flush of 2,25 ℓ per stall at intervals of not more than 20 minutes.

Wastage of water arising from urinal flushing is significant in this country and will be given close attention during this research project.

8. TAP FLOW RATES

Taps currently produced in this country vary from large port, high flow rate types, to small port, low flow rate types of modern design.

It is generally recognized, particularly in the case of office blocks where rinsing of hands only is required, that considerable savings can be achieved by using low flow rate taps. Examples of the reduction in flow rate compared with the conventional large port type are given in Table 3.

TABLE 3 : Flow rates for 15 mm pillar taps fully open (ℓ/min)			
Flow pressure (kPa)	Conventional tap	With aerator	With spray outlet
50	18	6	4,0
100	26	9	5,3
200	37	13	7,2

The fine holes in spray outlets tend to choke up due to lime deposits. Aerators on the other hand do not suffer from this disadvantage since air is drawn into the flow at the outlet by venturi action, and mixes with the water while passing through a sieve. As a result of diminishing flow rates due to liming, spray taps in public rooms tend to be damaged.

9. NATIONAL WATER INSTALLATION REGULATIONS

Assistance is being given by this Institute to the Committee engaged in the drawing up of Water Supply Installation Regulations which will be included in the new National Building Regulations.

The guiding principles adopted are: water economy, health, safety and user comfort.

The regulations will include, for example, a maximum limit for water pressure in buildings of say 500 kPa in order to reduce wastage of water through leakage, and also to extend the life of fittings and components; and a maximum limit of water velocity in pipes in buildings of say 2,5 m/s to reduce noise and water hammer.

It was further decided to produce a parallel document or Code of Practice in which the methods and procedures necessary to achieve the requirements of the regulations are described.

This Code of Practice is also in the course of preparation, and aspects such as criteria and methods for designing hot and cold water supply systems in buildings and layouts for the installation of fixed electric storage water heaters are presently being dealt with.

The work being done on the design part of the code has shown the need for local field measurements including the assimilation of data such as frequency of use, duration of use, patterns of use and flow rates for water-using fittings in buildings in order to develop an analytical procedure for predicting simultaneous design peak flows. The development of a rational mathematical model for design, which bears a close relationship to actual water requirements and use behaviour patterns, will not only provide the means of complying with the principles adopted for the regulations, but will also lead to the optimization of materials and water-related energy.

Researchers in the United States and the United Kingdom have shown that currently adopted design methods lead to oversizing of pipes.

The collection of field data by this Institute will commence with the monitoring of flats in a high rise building. Flow patterns will be monitored using flow switches installed inside pipes upstream of fittings, and flow rates measured using pulse emitting meters. The switches and meters will be wired up to a data acquisition system.

Prototypes of a simple sensitive flow switch shown in Figure 1 have been developed and are being tested. These switches can be positioned in the system without extensive alterations to the plumbing being necessary.

In order to increase the frequency of pulse emission from the water meters, thus enabling the intervals between scans of channels to be minimized, modifications are being carried out on a standard multijet fanwheel type water meter using a contactless electronic switch or pulsor mounted in the meter body above a metal target which rotates with the water flow.

Views on desirable design criteria for noise reduction differ widely. Røsrud[8] of the Norwegian Building Research Institute advocates that noise emitted by WC cisterns filling under high pressure could be reduced by decreasing pipe diameters thus dissipating the pressure energy in pipe friction. This view is contrary to the view held by the Code of Practice drafting committee, who consider the solution to be to limit pressures in the system by pressure reduction if necessary rather than to attempt to dissipate the energy by pipe friction. Providing small diameter pipes for the purpose suggested would result in poor pressure and flow starvation conditions in the system generally when other draw-offs occur simultaneously. It is felt that the problem of noise emission from a particular fitting should rather be overcome through research and development on the fitting itself.

From an energy conservation point of view, Røsrud further advocates small diameters and high velocities (8 - 10 m/s) for the purpose of reducing the quantity of hot water cooling off inside the pipe, and thus to reduce the waiting time for hot water to emerge from a tap.

The contrary view held here is that hot water wastage should be minimized by limiting the lengths of dead legs. Pipe sizes will be automatically minimized by correct design procedures provided in the Code of Practice. A remote hot water demand point is often better served by a separate locally situated water heater. The high velocities advocated by Røsrud would undoubtedly give rise to water hammer, noise and undue wear of components.

10. CONCLUSION

It is gratifying to observe that research into water economy measures is recognized internationally as being vitally important. Conservation of water leads to conservation of materials, energy and ultimately finance, and forms an indispensable part of the formula for survival.

REFERENCES

1. RUMP, M.E. *Demand management of domestic water use,* Building Research Establishment, UK, June 1978.

2. FOWELL,A.J., BRANSDORFER, A., FLETCHER, P., OREND, R.J., PAVEL, H.J. and WILLIAMS, G.H. *Water and water-related conservation in buildings,* Proceedings of International Symposium, Washington D.C., September 1976.

3. BOYD, H.R. *Comparative tests on the flushing efficiency of water closets,* National Building Research Institute, CSIR.

4. NIELSEN, V. *Comparative test methods on the flushing efficiency of water closets,* National Building Research Institute, Denmark, June 1979.

5. SOBOLEV, A. *Note on a flushing efficiency test for WC pans,* Building Research Station, UK, July 1961.

6. ILBERG, H., SILBERSTEIN, I., WINTER, E. *Water conservation measures in plumbing,* Standards Institution of Israel, July 1971.

7. SOBOLEV, A. *The modified flushing efficiency tests for WC pans of the washdown type,* Building Research Station, UK.

8. RØSRUD, T. *Cost benefit of plumbing: Large fringe benefits for sanitary installations by thorough analysis of system,* Building Research Institute, Norway, Proceedings of International Symposium, Washington D.C., September 1976.

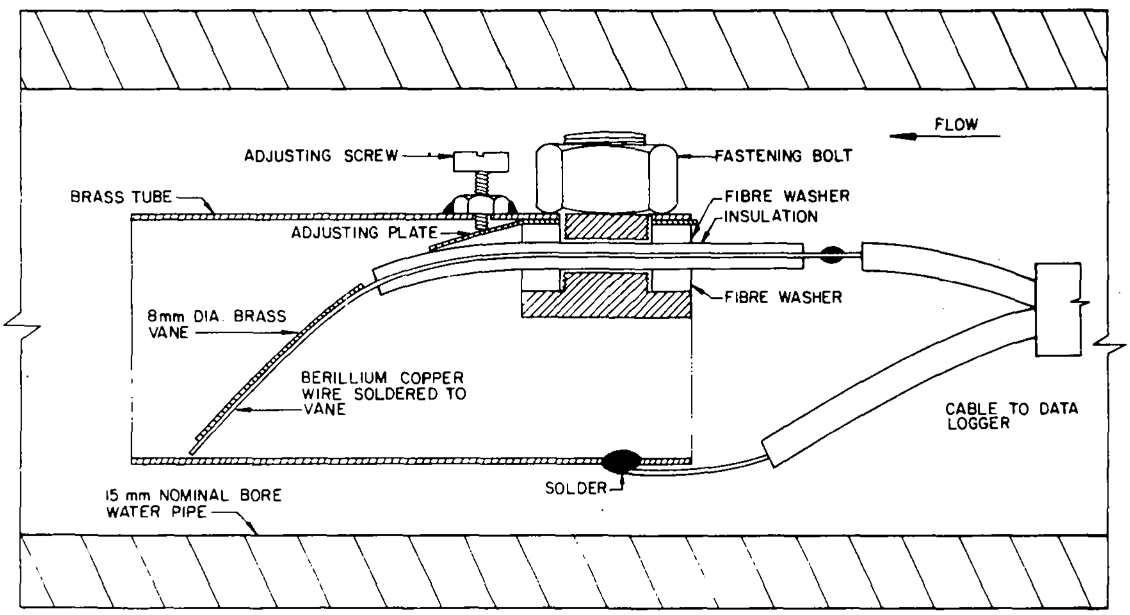


FIGURE 1
Section through flow switch

APPENDIX A

Flushing test (applicable to wash-down and siphonic closet pans only) from SABS 497-1973

APPARATUS

(a) An approved cistern for wash-down or siphonic pans

(b) Stop-watch

(c) Sink or other water container

(d) A roll of single-thickness toilet paper

Procedure

(a) Determine the water absorption time of the toilet paper as follows:

Detach from the toilet roll, at the perforations, two two-sheet pieces of paper. Superimpose one piece on the other so that the perforations are in line and there is uniform contact between the two strips.

Gently place the papers on the surface of water in a suitable container and record the time, to the nearest second, from the moment the paper touches the water until a spot of moisture appears on the upper strip of paper.

(b) Determine the amount of toilet paper to be used as follows:

Absorption time, as measured in (a), in seconds	0 - 3	4 - 6	7 - 15
Number of single thickness strips 750 mm long to be used	7	6	5

(c) Flushing: Fill the pan with water to the seal level and the cistern to the water line. Crumple each strip of paper into a loose ball 50-75 mm in diameter, deposit the balls in the bowl of the pan, and immediately flush the pan. Carry out this operation four times in unbroken succession.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239
Paper 17
Referaat 17

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water supply, flow rates, multistorey/ Watervoorsiening, vloeitempo, meerverdieping.

PEAK HYDRAULIC LOAD ON INTERMITTENT WATER SUPPLY SYSTEMS IN MULTISTOREYED RESIDENTIAL BUILDINGS

By S.P. Chakrabarti,* S.K. Sharma* and S.K. Sharma*

SYNOPSIS

The paper describes research carried out to determine the relationship between discharge for appliances in multi-storeyed residential buildings in India.

SAMEVATTING

Die referaat beskryf navorsing wat gedoen is om die verhouding tussen afvoereenhede en gelyktydige spitsvloei-tempo vir toebehore in meerverdieping woongeboue in Indië te bepaal.

* *Central Building Research Institute, Rourkee, India.*

1. INTRODUCTION

For the efficient hydraulic design of a water supply/drainage system, information is needed on the discharge load for which the system is to be designed. Water supply or drainage systems in multistoreyed buildings serve a large number of types of sanitary installations, e.g. W.C., bath, sink, washbasin, etc. It would be unrealistic, however, to design the pipework for the peak load on the assumption that all the appliances would be in simultaneous use; this would lead to overdesign. An estimate of the probable load caused by simultaneous use of appliances is, therefore, needed. From field observations on the frequency of use of different appliances, Wise and Croft[1] have shown the application of theory of probability in predicting simultaneous discharge for domestic buildings. This method yields satisfactory results for small numbers of appliances, but in the case of multistoreyed buildings, where the number of appliances is large, it leads to overestimation, since, in practice, the peak use hours of different appliances seldom coincide. Hunter[2] put forward an ingenious method of expressing the relative load-producing effects of various appliances in terms of fixture units (discharge units), which depend on the frequency of use of the appliance and the pipe flow capacities. Griffiths[3] reported discharge unit values, derived for appliances in domestic and public installations, based on frequency of use, rate of flow and the duration of discharge from the appliances. This study revealed that the same type of appliance may have different discharge unit values for domestic and public buildings. A recent study in the Building Research Establishment (U.K.) investigated the use of water outlets in multistorey flats[4].

In the absence of information based on experimental study, developing countries, such as India, have adopted relevant data from the U.S. National Plumbing Code (NPC) or the British Standard Code of Practice (BSCP) for design purposes. Since the uses of appliances in various countries are markedly different from the point of view of factors such as climatic conditions, users' habits and standard of living, configuration of appliances, etc., design information available from NPC and BSCP does not hold good for all countries. Moreover, the relationships put forward in the aforesaid codes of practice to arrive at simultaneous flow in the water supply system are applicable for constant supply conditions, whereas the loads in the case of an intermittent system of supply, which is most widely used in developing countries, are exorbitantly high resulting in non-availability of adequate pressure/flow in the outlets and rendering the system altogether unserviceable.

An attempt has, therefore, been made to establish relationships between discharge units and simultaneous peak flow rates for appliances in multistoreyed residential buildings under Indian conditions of usage by the application of the probability theory for an intermittent system of water supply so as to depict the water requirements in similar developing tropical countries.

2. ESTIMATION OF SIMULTANEOUS PEAK FLOW

Sanitary appliances which may be expected to operate simultaneously out of the total number installed in a building can be predicted for each type of appliance by using the theory of probability, provided that the duration of discharge and the time interval between consecutive discharges are known.

If an outlet has repeated cycles of use in which it is operated for an average time, t, and the average interval between uses is T, the probability, P, of the outlet being on at any instant is t/T.

$$P = \frac{t}{T} \qquad (1)$$

The corresponding probability of it being off at that instant is (1 - P). Probability of, r, outlets being on from a total of, n, such outlets is:

$$^{n}C_{r} \bullet P^{r} \bullet (1 - P)^{n-r}$$

The corresponding probability of r, or more outlets being on will be:

$$\sum_{r=r}^{r=n} {}^{n}C_{r} \; P^{r}(1 - P)^{n-r} = \sum_{r=r}^{r=n} \cdot \; nPr(\text{Say})$$

Hunter[2] formulated a design method for pipe systems based on the criterion of limited failures. If a group of, n, outlets does not give adequate flow when more than, r, are in operation simultaneously, the proportion of time the service remains unsatisfactory, (i.e. the system fails) is represented by:

$$\sum_{r=r}^{r=n} nPr = \text{Failure rate} = \frac{1}{\tau} \qquad (2)$$

assuming that the system fails for one second in τ seconds. The relationship (2) forms the basis of a design procedure in which the number of outlets that should be assumed to operate simultaneously, r, can be derived from the known total number of outlets in a system, n, the probability of an outlet being on, P, and the standard of service required, (i.e. failure rate, $1/\tau$). Design flow may be achieved by multiplying r by the rate of discharge from respective appliances.

In practice, water supply/drainage systems serve more than one type of appliance and the probability of use of each outlet is also different. For small numbers of appliances Wise and Croft[1] suggested that the flow load to be designed for a mixed system is the summation of design loads computed separately for each kind of appliance. For mixed systems, Hunter[2] puts forward the idea of assigning a 'loading weight' or fixture (discharge) unit value to each kind of appliance. Relationships have been derived from equation (2) for different numbers and types of appliances, using appropriate values of probability P but a common value for failure rate $1/\tau$. The same design flow may consist of discharges from 'a' outlets (say) of type A, or from 'b' outlets (say) of type B, etc. Hence the contribution of individual outlets of each type to the design flow may be taken as 1/a and 1/b, etc. A system of 'discharge units' proportional to these figures was devised so that each type of appliance has its own load rating. Design charts relating the number of fixture units to design flow were thus derived for ready reference in the design process.

3. EXPERIMENTAL SET-UP AND SCHEDULE OF EXPERIMENTS

The use frequency pattern of sanitary appliances in domestic installations was assessed through a survey conducted in Delhi in two blocks of eight storey residential buildings, comprising sixty-two flats (Type IV, four roomed) in each block, during peak summer months (i.e. May - July). These flats - accommodating government officials - are all identical. Each flat has one drawing-cum-dining space and three bedrooms, together with the normal service facilities, (e.g. kitchen, bath, and W.C.). Out of one hundred and twenty-four families residing in these flats, those consisting of five or six members (representing the average Indian family) were selected. Fifteen such families were surveyed for their water consumption from early morning till late at night. Each family was surveyed for three consecutive days to obtain reliable and reproducible data. Another fifteen flats in the same locality, accommodating similar families in Type III, three roomed flats, were also surveyed. Water supply installations in these flats were the same except that the kitchens were provided only with a tap instead of a sink. The total of thirty families represents people from all major regions of the country.

The survey was conducted for an intermittent system of water supply, (i.e. from 06h00 to 09h00, 13h00 to 14h00 and 18h00 to 21h00) which prevails in almost all the big cities in the country.

Use frequency and time of use, of each appliance separately and also of the system as a whole during supply hours, were studied by means of water flow detectors and strip chart recorders. The principle of experimentation is shown in Figure 1 by means of a block diagram, as discussed below:

Two electrodes were inserted in the conduit, through which the flow of water was to be measured. For W.C.'s the electrodes were fixed in the flush pipe and for washbasins provisions were made in the pipe adjacent to the lead connection of the taps. These electrodes were separated from the body of the conduit by means of insulator sleeves. The electrodes were then connected to a recorder via a flow detector which is basically an amplifier. Whenever there was any flow of water within the conduit, electrical impulses produced by a change in resistance between the electrodes were recorded after amplification in the detector.

4. USE FREQUENCY PATTERN

(a) Discharge rates of sanitary appliances

Hydraulic loads on water/supply/drainage systems in residential buildings consist of discharges to/from W.C., bath, kitchen sink and washbasin. The rate of discharge through the ball valve in a W.C. flushing tank is considerably less than the rate at which the W.C. is flushed. To arrive at a common relationship for both water supply and drainage, the discharge rate of a W.C. is assumed to be 110 ℓ/min which has been observed to be the peak rate of discharge from a 12,5 litre (3 gal.) W.C. flushing tank. The bathroom consists of a shower and a tap as the Indians, in general, habitually bathe under a shower-rose or by collecting water in buckets and pouring it over the body with small containers. Moreover, the bath is often not available because it is used for washing of clothes and storing water. The kitchen contains a sink and an extra tap for washing purposes. Since lavatory basins and sinks in India are used for washing without splashing under running taps, the rates of discharge through these appliances as used in western countries, (i.e. by filling the appliances up to the overflow level and discharging the entire volume by removing the plug after use) are not applicable in general for Indian conditions. A survey on the performance of the appliances revealed that a discharge rate of 9,0 ℓ/min. is most convenient for the users to avoid splashing of water while washing under running taps. The same flow rate has been considered in the course of the present study.

(b) Use frequency of appliances

From the survey conducted in Types III and IV residences, the peak hours of use of W.C.'s were observed to be the same (from 06h00 to 07h00) and the maximum number of uses recorded was four.

Direct measurements of the hourly probability of use in the case of bath, sink and washbasin were made by determining the average proportion of each hour the appliances are in use. For kitchens in Type IV residences, the probability of use values both for the sink and the extra tap were added up to provide a common basis for comparison with those of Type III residences. The use frequency data of the appliances revealed two peaks; one in the morning and one in the evening. Advertisement slots in T.V. programmes increase the use to some extent, but it is not appreciably high compared to peak use. However, the maximum use period has been considered in deriving the probability of use of respective appliances.

Duration of discharge, the interval between two consecutive discharges, probability of use and the rates of discharge of the various appliances on critical days for residential buildings are presented in Table 1 to facilitate calculation of the discharge unit values to be assigned to respective appliances. A relatively high value for probability of use for the bath was observed to be due to the storage of a considerable quantity of water taken from the bathroom tap to tide over non-water supply hours.

(c) Discharge unit valves

The number of appliances, r, which may discharge simultaneously out of total number, n, of a particular type of appliance has been found by applying the theory of probability and the relationships between simultaneous discharge (13h00) and the total number of appliances derived separately for W.C., bath, sink and washbasin have been shown in Figure 2 using the rates of discharge given in Table 1 and their log-log plots in Figure 3 for ease of extrapolation. From the above-mentioned figures relative load producing effects (load weightings) of the different appliances have been obtained by noting the number of appliances of each type re-

TABLE 1 : LOADING UNITS FOR VARIOUS SANITARY APPLIANCES

Appliances	Use time (sec.) t	Interval between uses (sec.) T	Probability of use P	Flow rate (ℓ/s)	Loading units	Assumed failure rate
HUNTER-PUBLIC USE[2]						
W.C.	60	300	0,20	0,30	5	0,01
Bath	120	1 800	0,067	0,61	3	
HUNTER-PRIVATE USE[2]						
W.C.				0,30	3	
Bath				0,61	1,50	
Basin				-	0,75	
Sink				-	1,50	
GRIFFITHS-PUBLIC USE[3]						
W.C. - 3 gal.	7	600	0,0117	2,25	10	0,01
W.C. - 2 gal.	5	600	0,0083	2,25	7	
Basin	10	600	0,0167	0,60	1	
Urinal (per stall)	15	1 200	0,0125	0,30	1	
GRIFFITHS-PRIVATE USE[3]						
W.C. - 3 gal.	7	1 140	0,0061	2,25	10	
W.C. - 2 gal.	5	1 140	0,0044	2,25	7	
Sink	25	1 500	0,0167	0,90	7	
Basin	10	1 500	0,0067	0,60	1	
Bath	75	no record	-	1,05	7	
NBC (India)[5]						
W.C.	-	-	-	-	4	
Bath	-	-	-	-	2	
Sink	-	-	-	-	2	
Basin	-	-	-	-	1	
CBRI-PRIVATE USE*						
W.C. - 3 gal.	9	900	0,010	1,87	9	0,01
Bath	-	-	0,3823	0,15	6	
Sink	-	-	0,1955	0,15	3	
Basin	-	-	0,0547	0,15	1	

* For intermittent system of water supply.

quired to produce a chosen probable maximum flow. For example, a peak load of one hundred and fifty (13h00) is probably from eighteen W.C.'s with 12,5 ℓ high level cisterns, twenty-eight baths, fifty-two sinks or one hundred and sixty-eight washbasins, so that the loading weightings at this load are in the ratios of 1/18 : 1/28 : 1/52 : 1/68 or more conveniently 9,33 : 6,00 : 3,23 : 1 assigning a loading unit of 1 for a washbasin. The procedure is repeated for several other selected flows and the relative average loading weightings (discharge units) determined are 9 : 6 : 3 : 1 for W.C., bath, sink and washbasin respectively.

(d) Design curve

Design curves for soil and waste pipes in residential buildings with an intermittent system of supply have been derived from Figure 3 after assigning the discharge unit values to different appliances. For discharge unit values up to 1000, the simultaneous flows for various appliances have been observed to be almost coincident and a straight line has been drawn combining the values of all the appliances (Figure 4). The correlation coefficient has been calculated to be 0,9878 reflecting the accuracy of the loading units assigned for each type of appliance. A parabolic plot of Figure 4 between discharge units and total simultaneous flow on arithmetic ordinates has been depicted in Figure 5. This is in keeping with the normal procedure for expressing the design curve along with similar relationships derived in BSCP and NPC for comparison.

(e) Water demand rate

The water requirement per capita per day has been estimated to be 200 ℓ for an intermittent system of water supply on a critical day, which is appreciably higher than the presently recommended value of 135 ℓ in the National Building Code of India[5]. This increased demand reflects the withdrawal of greater quantities of water near the source (reservoir) and a consequent drastic reduction in pressure and flow which is being experienced in the country at the furthest end of the system.

5. CONCLUSIONS

The study has been conducted on a relatively small number of flats taken at random during peak summer months under Indian conditions of usage in blocks of multistorey residential buildings with intermittent systems of water supply. Although the investigation does not provide information regarding water use patterns during other seasons of the year, the study furnishes sufficient data for critical months of the year for designing plumbing systems on the basis of probable hydraulic loads out of a total number of sanitary appliances installed. However, further research is warranted for a wider range of data on probabilities of use to improve on the relationship between simultaneous flow and discharge units established under the present investigation.

Probabilities of use of different appliances, their flow rates and the loading units assigned in this study for a chosen standard of service are presented in Table 1 along with the findings of earlier researchers. A relatively high probability of use of the appliances, observed in the present investigation, justifies the effect of climatic conditions over frequency of use in tropical countries such as India. Water requirement per capita per day has also been estimated for intermittent systems of water supply in such countries.

Relationships between simultaneous flow and discharge unit values reported in NPC (USA) and BSCP (UK) are compared (Figure 5) to depict the marked difference in the design loads used in different countries.

REFERENCES

1. WISE, A.F.E. and CROFT, J., *Investigations of single stack drainage for multistorey flats, J.R. Sanit. Inst.*, 74(9), pp. 797 - 826, 1954.

2. HUNTER, R.B., *Methods of estimating loads in plumbing systems*, U.S. National Bureau of Standards Report BMS 65.

3. GRIFFITHS, T.J., *The hydraulic design of drainage pipe work for domestic and for public buildings.* The Public Works and Municipal Services Congress in Conjunction with BRS (U.K.), 1962.

4. WEBSTER, C.J.D., *An investigation of the use of water outlets in multi-storey flats*, BRE Current Paper: CP 4/72.

5. NATIONAL BUILDING CODE OF INDIA, 1970.

ACKNOWLEDGEMENT

The authors are grateful to Prof. Dinesh Mohan, Director of the Central Building Research Institute, Roorkee, for giving valuable guidance and encouragement.

The work described in this paper forms part of the normal research programme of the Institute and is published with the permission of the Director, C.B.R.I., Roorkee.

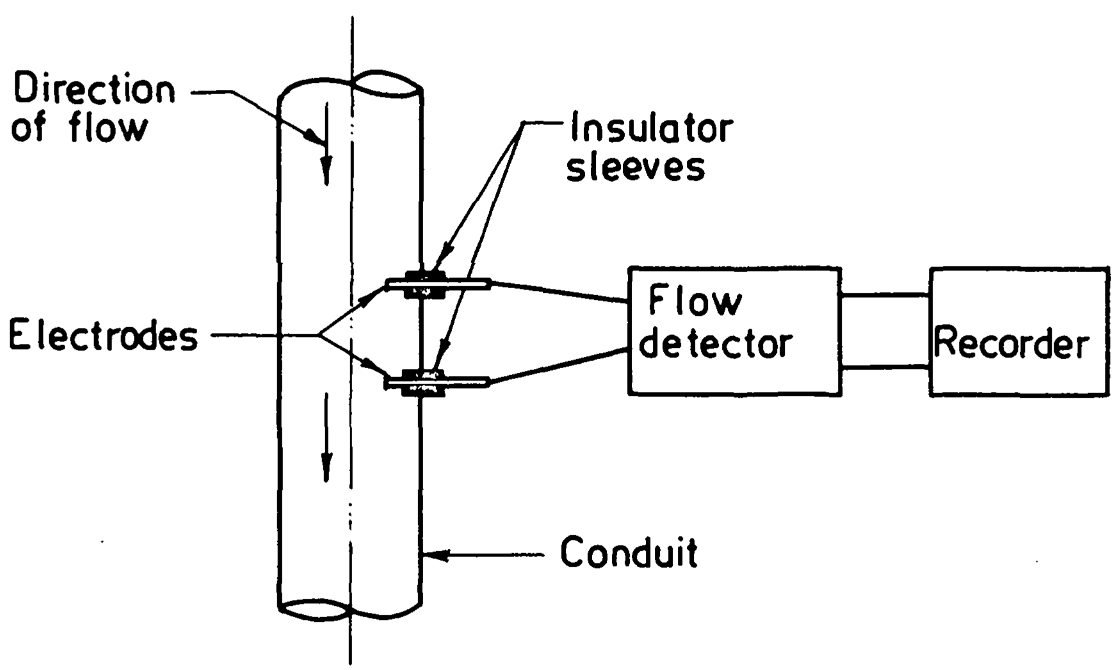


FIGURE 1 : TEST SET-UP FOR USE FREQUENCY STUDY OF SANITARY APPLIANCES

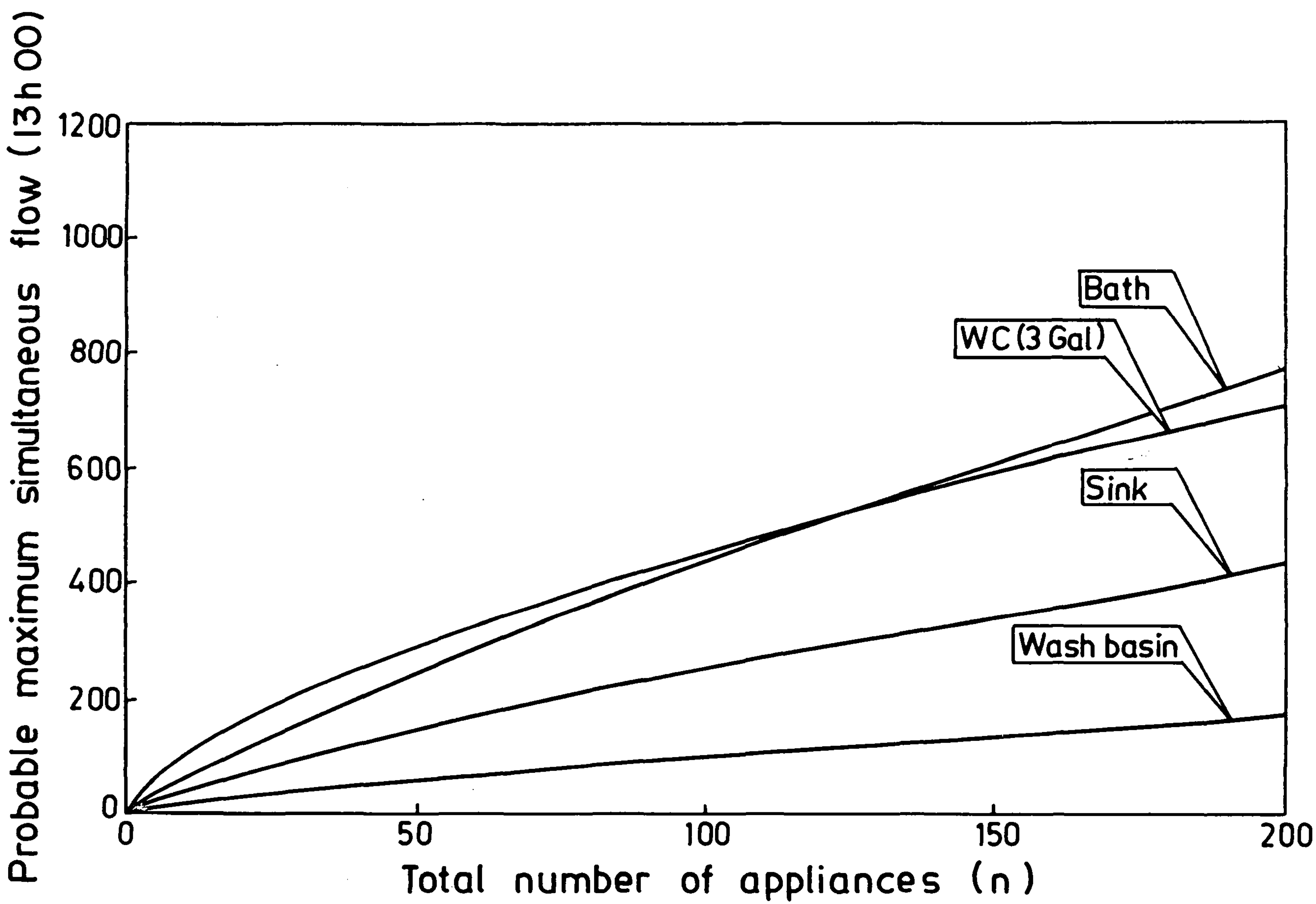


FIGURE 2 : PROBABLE MAXIMUM FLOW FROM VARIOUS APPLIANCES

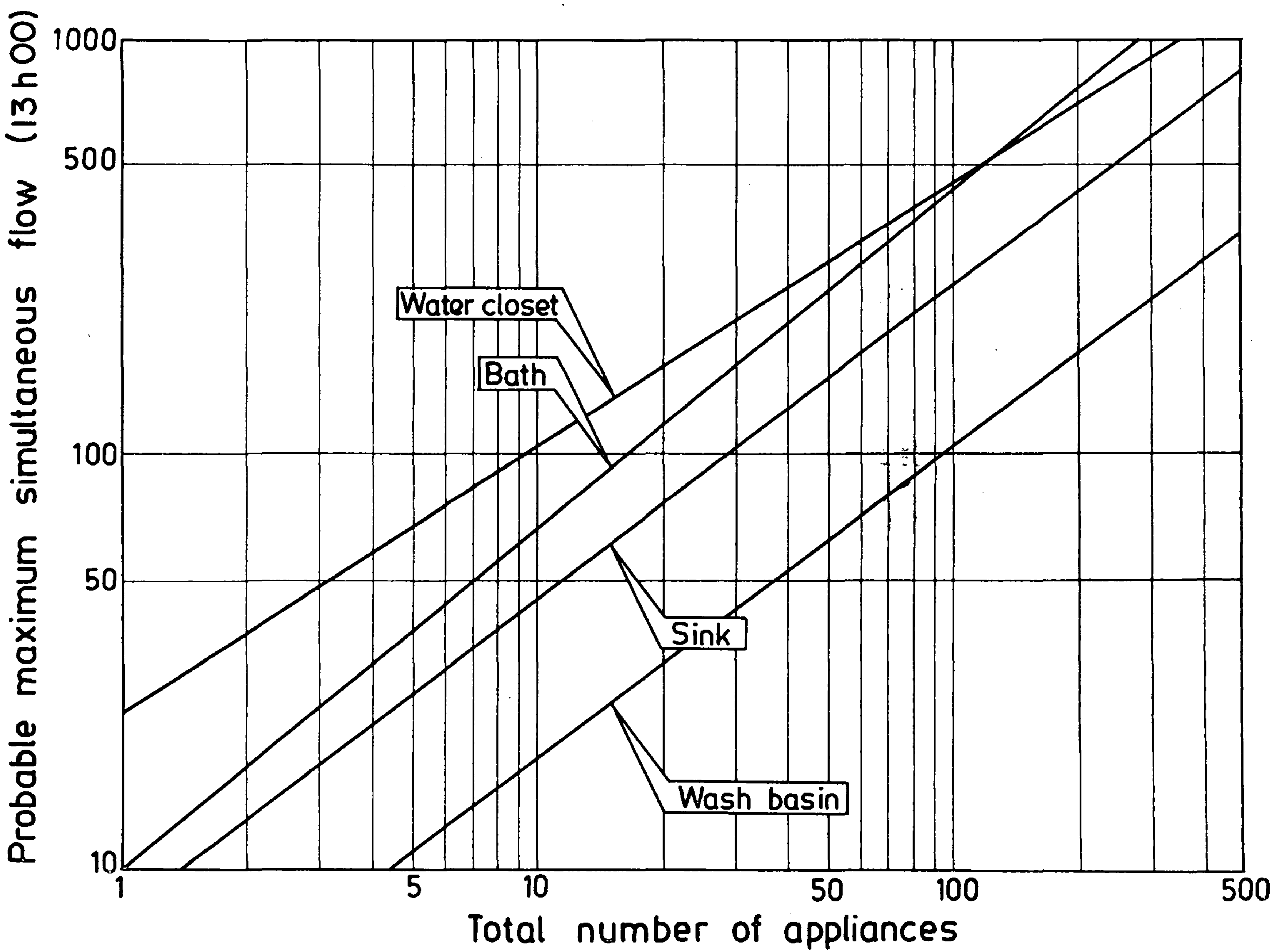


FIGURE 3 : REGRESSION ANALYSIS FOR SIMULTANEOUS FLOW AND TOTAL NUMBER OF APPLIANCES

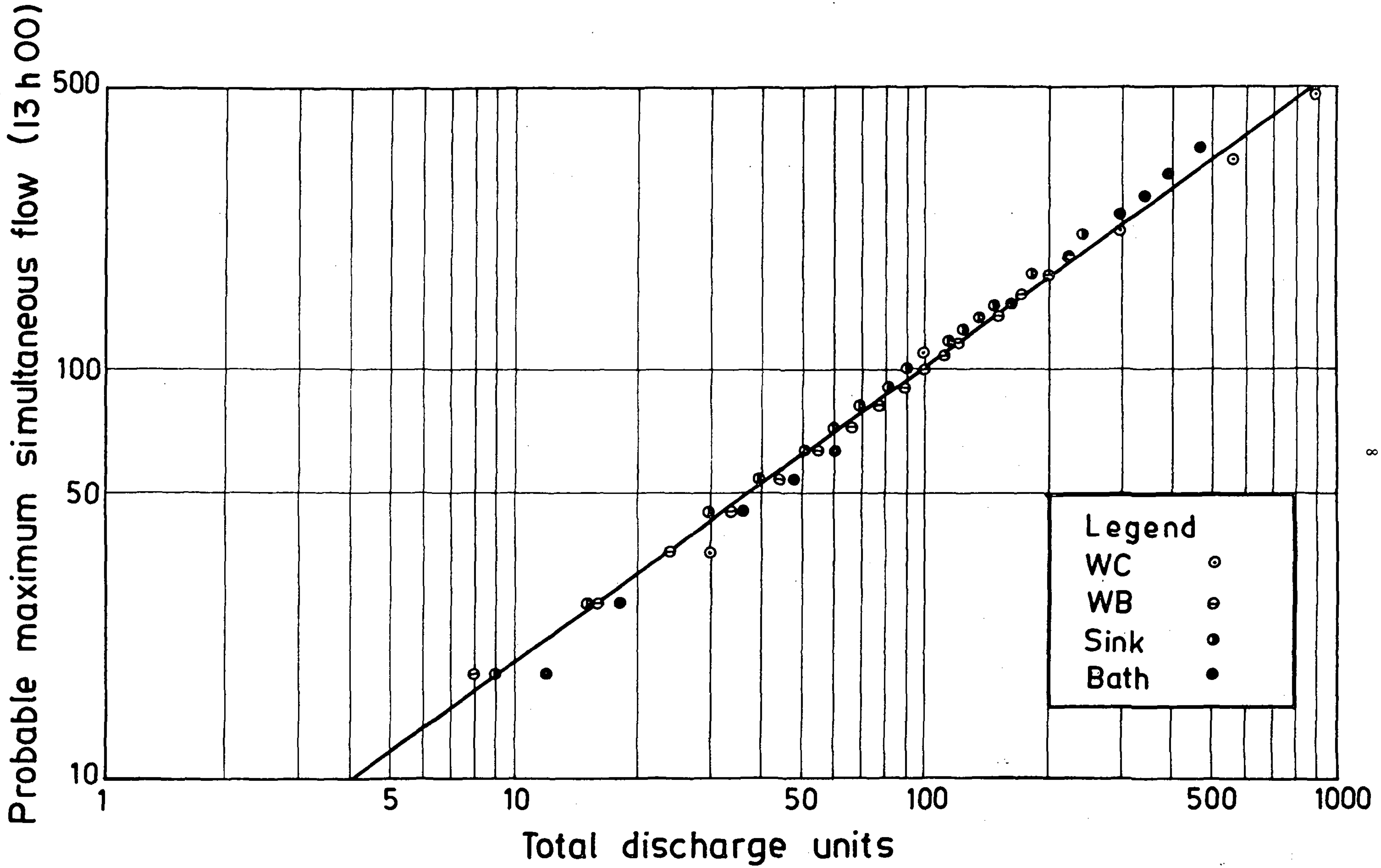


FIGURE 4 : DESIGN RELATIONSHIP FOR SOIL AND WASTE PIPES IN RESIDENTIAL BUILDINGS

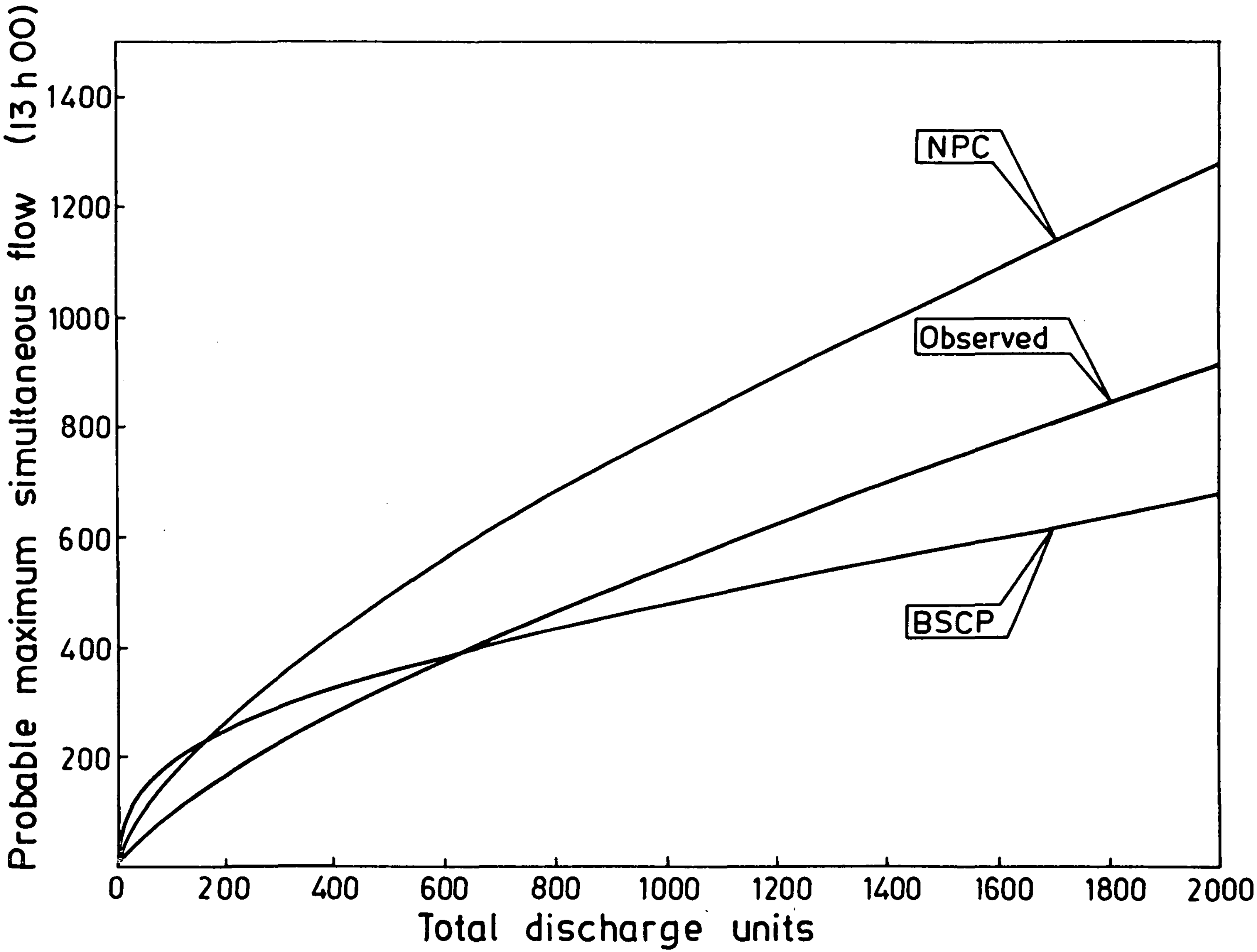


FIGURE 5 : SIMULTANEOUS FLOW AND DISCHARGE UNIT RELATIONSHIP FOR RESIDENTIAL BUILDINGS

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239
Paper 18
Referaat 18

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

W.C.'s, flushing cistern, water seal/ W.K.'s, spoelbakke, waterafsluitseël

NOT TO BE READ AT SEMINAR

A RATIONAL APPROACH TO THE DESIGN OF WATER CLOSETS IN THE CONTEXT OF WATER CONSERVATION

by S.K. Sharma and S.P. Chakrabarti*

SYNOPSIS

Numerous types of water closets are available on the market in India. These water closet bowls or pans can be used with several types of flushing cisterns. Experience shows that there are frequent complaints of improper functioning of water closets.

This paper gives an account of various types of water closets (Indian squatting pan and European bowl type) and flushing devices. Recommendations, based on experimental studies, are made for size and shape of water seal.

Modified water closets with reduced water seal areas give satisfactory results even with 6,5 litre flushing cisterns. These investigations show a way of considerable saving in treated water adopting low capacity flushing cisterns with rationally designed water closets.

SAMEVATTING

Talle soorte spoelklosette is tans in Indië verkrygbaar. Hierdie spoelklosetbakke of -panne kan met verskeie soorte spoelbakke gebruik word. Ondervinding het geleer dat daar herhaalde klagtes aangaande ondoeltreffende funksionering van spoelklosette is.

Hierdie referaat handel oor verskillende soorte waterklosette (Indiese hurkpan en Europese baktipe) en spoelmeganismes. Aanbevelings wat op eksperimentele studies gegrond is, word vir die grootte en vorm van die waterafsluitseël gegee.

Gewysigde spoelklosette met verkleinde area van waterafsluitseël lewer selfs met 6,5-liter spoelbakke bevredigende resultate. Hierdie ondersoeke toon aan hoe 'n beduidende besparing van behandelde water bewerkstellig kan word deur spoelbakke met lae spoelkapasiteit by rasioneel-ontwerpte spoelklosette aan te wend.

* *Central Building Research Institute, Roorkee, India.*

1. INTRODUCTION

Numerous types of water closets are manufactured in India. All these types can be broadly classified either as Indian squatting type or Western commode type. Normally the Indian squatting type is called W.C. pan and the Western commode type is knows as a W.C. bowl. The further subclassification of each type relates only to changes in their shape, size and profile. Normally, circular water seal surfaces are provided in W.C. pans and rectangular ones in W.C. bowls. Even the area of water seal surface differs in different makes.

The flushing cisterns used with W.C. pans/bowls can be broadly classified as high level, low level and integrated, depending upon the height of the cistern above the W.C. bowl/ pan. The capacity of flushing cisterns varies between 10 and 15 litres. IS : 774 - 1971[1] gives guidelines for performance tests of cisterns.

Conventionally, Indian squatting type W.C. pans are used only with high level flushing cisterns, and European type W.C. bowls with low level cisterns. Experience of these types in the field has indicated inefficient functioning and large scale wastage of water due to repeated flushings. Studies were, therefore, undertaken to investigate causes of malfunctioning of W.C. bowls/pans and to recommend performance tests for evaluating efficiency. Rational approaches to the hydraulic design of the water closets have also been high-lighted and the performance of modified W.C. bowls/ pans, developed to suit design recommendations, has been experimentally tested in simulated field conditions.

2. PERFORMANCE TEST

To evaluate performance efficiently, it is essential to lay down standard test procedures. The performance of W.C. bowls/pans is judged by the following tests:

- Solid removal or flushing efficiency
- Surface cleaning or smudge removal

Different codes and specifications were studied and the standard test procedures recommended therein were carried out in the laboratory with a view to rationalizing the test procedure.

Flushing efficiency test

This test is carried out to ascertain the effectiveness of removal of solids from bowls/pans. Different materials of varying specific gravity, e.g. toilet papers, newspapers, polyethylene sheets, plastic weeds, sponge, etc., have been specified in different codes. Some important tests are:

(i) *IS : 2556 (Part III) - 1967*[2] *:*

The water closet shall be filled with water to its normal water seal surface and charged with 6 pieces of normal toilet paper or polyethylene sheet of 0,05 mm thickness and approximately 150 x 115 mm size loosely crumpled. It shall then be flushed. The test shall be repeated four times and shall discharge the full charge of the paper at least three out of four times.

(ii) *DIN - 1386*[3] *:*

(a) Four water-saturated, large pored natural sponges having a diameter of 30 mm and a length of 100 mm are placed inside the bowl of the lavatory pan to be tested. It can be determined by flushing whether the sponges are washed away. The test is to be carried out 5 times, 4 tests of which must have been successful.

(b) Twelve sheets of toilet paper DIN A6, Orepetype, approximately 40 g/m^2, loosely crumpled, are placed in the lavatory pan to be tested. It can be determined by flushing, how many sheets of paper have been washed through the drain trap to the sewer pipe. The test is to be carried out 5 times, 4 tests of which must be successful.

(iii) *B.S. 1213 - 1945*[4] *:*

50 special hollow balls, 3/4 inch (19 mm) in diameter and of 0,85 specific gravity, are placed over the water seal area of the pan. The number of balls flushed out is counted and the test is repeated 10 times and the result is taken as the efficiency grading of the pan. The balls are injection moulded in two parts from polystyrene, with a spigot and socket joint between the two halves sealed with cement.

(iv) *B.S. 1213 : Amendment slip - 1974*[5] *:*

(a) Paper test - for each flush drop 12 sheets of paper, loosely crumpled, individually into the W.C. pan and flush the cistern within 20 seconds of the start of operation.

(b) Ball test - the balls shall be made of non-absorbent material. The relative density of the ball shall be between 1,075 to 1,080. The diameter of the ball shall be 43 ± 0,5 mm. The ball is placed into W.C. pan to be tested and the cistern is flushed.

The paper and ball tests are to be performed five times each. The trap shall be cleared completely 4 times out of 5 in each test for the pan to be deemed to have passed the test.

Smudge test

This test is carried out to ascertain the surface cleaning efficiency of the W.C. pan/bowl and different materials, e.g. lamp black, clay, saw dust, dye stuff, etc., have been recommended in different codes and specifications. Some of these are described below:

(i) *I.S. : 2556 (Part III) - 1967 :*

The whole of the interior surface of the water closet to 40 mm below the flushing rim shall be smudged with substance such as lamp black or clay and shall then be flushed. Immediately after flushing there shall be no smudge remaining on the bowl.

(ii) *DIN - 1386 :*

Approximately 20 g of dry sawdust is strewn, as completely and evenly as possible, on the inside of the bowl. By flushing with the flushing appliance provided it shall be ascertained whether the walls of the pan are effectively cleaned with the quantity of water prescribed. Each test is carried out 5 times. The test can be regarded as successful if the unflushed area measured from lower rim of water edge is not larger than 8 000 mm^2. Out of 5 tests 4 shall be successful.

(iii) *B.S. 1213 - 1945*[4] :

Sawdust test : The pan is flushed and the inside is immediately sprinkled as completely and evenly as possible with approximately 20 g of fine dry saw dust between the normal water level and flushing rim. The pan is then flushed again. It shall be deemed to pass this test if the unflushed area between water surface and the underside of the rim does not exceed 5 000 mm^2.

All these tests were carried out with different makes of W.C. bowls/pans with flushing cisterns of 15 ℓ, 10 ℓ and 6,5 ℓ capacity. The test results indicated that for consistent and reliable test results, the following tests shall be performed. The consistency of the result in the presently recommended test, as compared with the conventional paper test, is shown in Figure 1.

Recommended tests:

Flushing efficiency: 50 paraffin wax balls of 19 mm diameter and 0,84 to 0,86 specific gravity shall be placed over the water seal surface of the pan and the cistern shall be flushed. The percentage of balls flushed out is taken as the percentage efficiency. The test is repeated 10 times and the average is taken as the flushing efficiency of the pan.

Smudge removal: The whole of the interior of the W.C. pan below rim level is spread (over wet surface) with 5 g of dry quartz powder of contrasting colour to the W.C. surface. The W.C. is flushed and the area remaining smudged is measured. The area remaining unflushed shall be less than 8 000 mm^2. The test is to be repeated 5 times out of which it shall be successful 4 times.

3. EXPERIMENTAL INVESTIGATIONS

Different makes of W.C. bowls and pans were considered for initial investigation of their efficiency. The flushing efficiency test was carried out on W.C. bowls and pans in combination both with high and low level cisterns. In the case of the Indian squatting pan it was observed that in all cases efficiency was 95 to 100 per cent. Hence no further modifications were deemed necessary in this type of pan. The results of investigations on the efficiency of European W.C. bowls are given in Table 1.

TABLE 1 : EFFICIENCY OF DIFFERENT EUROPEAN W.C. BOWLS

S.No.	Make	Flushing device	Percentage efficiency
1	A	10 litre bell type	5,4
2	B	-do-	39,0
3	C	-do-	64,6
4	A	15 litre bell type	32,0
5	B	-do-	43,8
6	C	-do-	85,0
7	A	15 litre siphonic type	64,6
8	B	-do-	65,4
9	C	-do-	99,4

The above data clearly indicate that siphonic type flushing cisterns give better performance than the bell type in combination with any type of W.C. bowl. For further understanding of the performance of these bowls it should be realized that the efficiency of a W.C. unit is dependent on the individual efficiency of the bowl and the flushing cistern. It is essential, therefore, to identify and understand the parameters which account for poor efficiencies of W.C. bowls and flushing cisterns. It was felt that discharge rate curves of flushing cisterns rather than total capacity data might reveal more reliable information on their performance. Hence discharge rate curves through the flush pipes of all types of flushing cisterns were recorded as shown in Figures 2 to 4.

The other important parameter for judging the efficiency of W.C. bowls is the rate of flow through the water seal trap, caused by flushing the cistern. Observations were made for peak discharge rates through W.C. bowls of different makes in combination with calibrated flushing cisterns. Figure 5 shows the discharge rate curve through W.C. bowl 'A', in combination with a 15 litre bell type flushing cistern. The peak rate observed was 90 litres per minute; this was one of the least efficient combinations. Hence a minimum flow rate of 90 litres per minute can safely be assumed for design purposes.

4. HYDRAULIC DESIGN

The criteria for the design of an efficient W.C. bowl should be that flushing achieves speedy and complete removal of suspended particles through the water seal. The area, shape and volume of water seals of W.C.'s are, therefore, vital. IS : *2556 (Part III) - 1967*[2] recommends a minimum area of 15 000 mm^2 for water seal surface. The reason given for this recommendation is 'hygiene'. While realizing that too small a surface area would certainly cause unhygienic conditions, the arbitrary decision on the minimum area appears to be unacceptable. Also it is an established fact that the area requirement is governed by the drag velocity. The theoretical drag velocity V_D is arrived at from Newton's drag equation on sedimentation:

$$V_D = \sqrt{4/3\ (g/C_D)\ (1-S_s)\ d} \quad (1)$$

where

g = acceleration due to gravity

S_s = specific gravity of particle

d = diameter of particle

C_D = Newton's drag coefficient

Equation (1) is applicable for the rising of free and discrete spherical particles. In this equation C_D, the only unknown factor, can be expressed as a function of Reynold's number given by the following empirical relationship:

$$C_D = 24/R + 3/\sqrt{R} + 0,34$$

Again R is a function of velocity of water and diameter of particle and expressed as:

$$R = \frac{V_D \cdot d}{\nu}$$

where, ν is the kinematic viscosity of water. Taking ν at 30 °C as 0,804 mm^2/s, d as 18 mm and S_s as 0,84 (as specitied in the paraffin-wax ball test) the equation (1) could be rewritten after simplification as:

$$V_D (1 + 0{,}188\, V_D + 0{,}0317\, V_D) = 34{,}6 \qquad (2)$$

Solving for V_D by iterative procedure, the value of V_D is 160 mm/s through the water seal area during flushing. However, assuming a safety factor of 1,25 to account for field flaws, the recommended velocity through the W.C. water seal area is 200 mm/s. Hence considering minimum flow of 90 ℓ/min. and velocity of 200 mm/s through water seal area, the permissible maximum area of water seal is 7 500 mm^2. Therefore, area of water seal surface in W.C. bowl should not be more than 7 500 mm^2 for efficient performance[6] in all circumstances.

To compare the water seal surface area of different W.C. bowls and the volume of water in the traps, a study was carried out. Table 2 shows the comparative data on volume of water content in traps of different makes of W.C. bowls.

TABLE 2 : VOLUME OF WATER IN TRAPS OF DIFFERENT MAKES OF W.C. BOWLS

S.No.	Make	Water Seal Area mm^2	Volume of Water litre
1.	A	22 500	2,80
2.	B	20 900	2,40
3.	C	16 500	1,79

It can be seen from Table 2 that the W.C. bowl 'C' has the least area of seal. It is also relevant here to restate that W.C. bowl 'C' is the most efficient, as seen from Table 1. Therefore, it may be stated that as the area of water seal surface of a W.C. bowl decreases, the efficiency of the bowl increases. It was also noted that the shape of W.C. bowl and the volume of water in the seal have a bearing on the performance of W.C. bowls. Mere adherence to the recommendation for water seal alone may not give better results unless the shapes of the bowl and trap are considered.

The interior of the bowl just above the water seal area must be vertical for at least 50 to 75 mm. To facilitate smooth flow, there must be no sharp corners and sudden restrictions in the water seal passage. The volume of water in the trap should be as little as possible to maintain a minimum water seal of 50 mm depth. A small quantity of water gives a greater dilution ratio and hence results in easy washing out of pararticles. An ideal W.C. bowl has been designed as shown in Figure 6.

Indian type squatting pans are manufactured in various sizes ranging from 400 to 680 mm in length. Although the pans studied in the laboratory passed the flushing efficiency test, most of them failed in the smudge test. It was observed that small size pans, e.g. 400, 450 and 500 mm size, are unhygienic since there is considerable splashing during flushing and solids sometimes come over the floor. The 680 mm size is too big to be used by children and does not serve any special purpose though it is recommended for community latrines. Hence the most convenient sizes should be either 550 or 580 mm.

In box rim types of pan the spacing of holes varies between 60 mm and 100 mm centre to centre. Tests revealed that for most efficient surface cleaning the maximum spacing between holes should be 40 mm centre to centre. The flushing rim of open rim type pans should have a uniform cross section tapering towards the narrow end of the pan. An integral unit having pan and trap together (Figure 7) was found to be the most efficient. These pans cut down installation cost and minimize the risk of leakage by eliminating the most vulnerable joint between pan and trap.

5. CONFIRMATORY LABORATORY STUDIES

To confirm the validity of the above design recommendations, the least efficient W.C. bowl 'A' was taken for modifications. It had a water seal area of 22 500 mm^2. It was essential to reduce the water seal area and modify the shape of the bowl to improve its efficiency. The entire interior surface of the bowl was therefore hacked and covered with a layer of plaster of Paris and given a final coating of bitumen paint. The area could only be reduced to 15 600 mm^2 due to practical difficulties. The shape was modified as much as possible to suit the dimension recommended in Figure 6. The test results are given in Table 3.

TABLE 3 : EFFICIENCIES OF MODIFIED BOWL AS COMPARED WITH ORIGINAL DESIGN

Flushing device	*Percentage efficiency of W.C. bowl*	
	Original 22 500 mm^2	Modified 15 600 mm^2
15 - litre bell type	32,0	46,8
15 - litre siphonic type	64,4	81,8

The above results clearly indicate an increase in efficiency with reduction in water seal surface area in both cases. A modified W.C. bowl, based on the design recommendations, was manufactured. It had a water seal area of 9 000 mm^2 and test results revealed 100 per cent efficiency even with a 6,5 litre capacity flushing cistern.

Indian type W.C. pans were manufactured with holes in the box-rim spaced at 40 mm centres. The test results with 6,5 litre flushing cistern showed 100 per cent flushing efficiency and these pans also passed the smudge test.

6. RECOMMENDATIONS

Based on the present investigations the following recommendations have been made:

- The water seal area of the W.C. pan/bowl shall not be more than 7 500 mm^2.
- The volume of water in a trap shall be as little as possible, preferably not exceeding 1,75 litres.
- The interior of the bowl must be vertical for at least 50-75 mm just above water seal surface.
- The Indian squatting type pan should be 580 mm in length for best performance.
- The flushing rim of the open rim type pan must be of uniform cross section and in the box rim type holes should be at 40 mm centres.
- To conserve water without loss of efficiency, 6,5 litre capacity flushing tanks should be used with Indian type squatting pans and modified E.W.C. bowls.
- W.C. pan and trap should be manufactured in one piece (integral type) to reduce installation cost.

REFERENCES

1. IS : 774 - 1971, Indian Standard, 'Specification for flushing cisterns for water closets and urinals'.

2. IS : 2556 (Part III) - 1967, Indian Standard, 'Specific requirements of squatting pans and traps'.

3. DIN - 1386, German Standard, 'Water Closets - Testing Principles'.

4. B.S. 1213 - 1945, British Standard, 'Ceramic wash down W.C. Pans'.

5. B.S. 1213 - Amendment Slip - 7, 30th Sept. (1974).

6. RAO, P.B., SINGH, I and SHARMA, S.K., 'A rational approach to the design of water closet bowls', *Environmental Health*; Vol. 12, pp. 39-47 (1970).

ACKNOWLEDGEMENT

The investigations form part of a normal research programme at the Central Building Research Institute, Roorkee (India) and this paper is published with the permission of the Director.

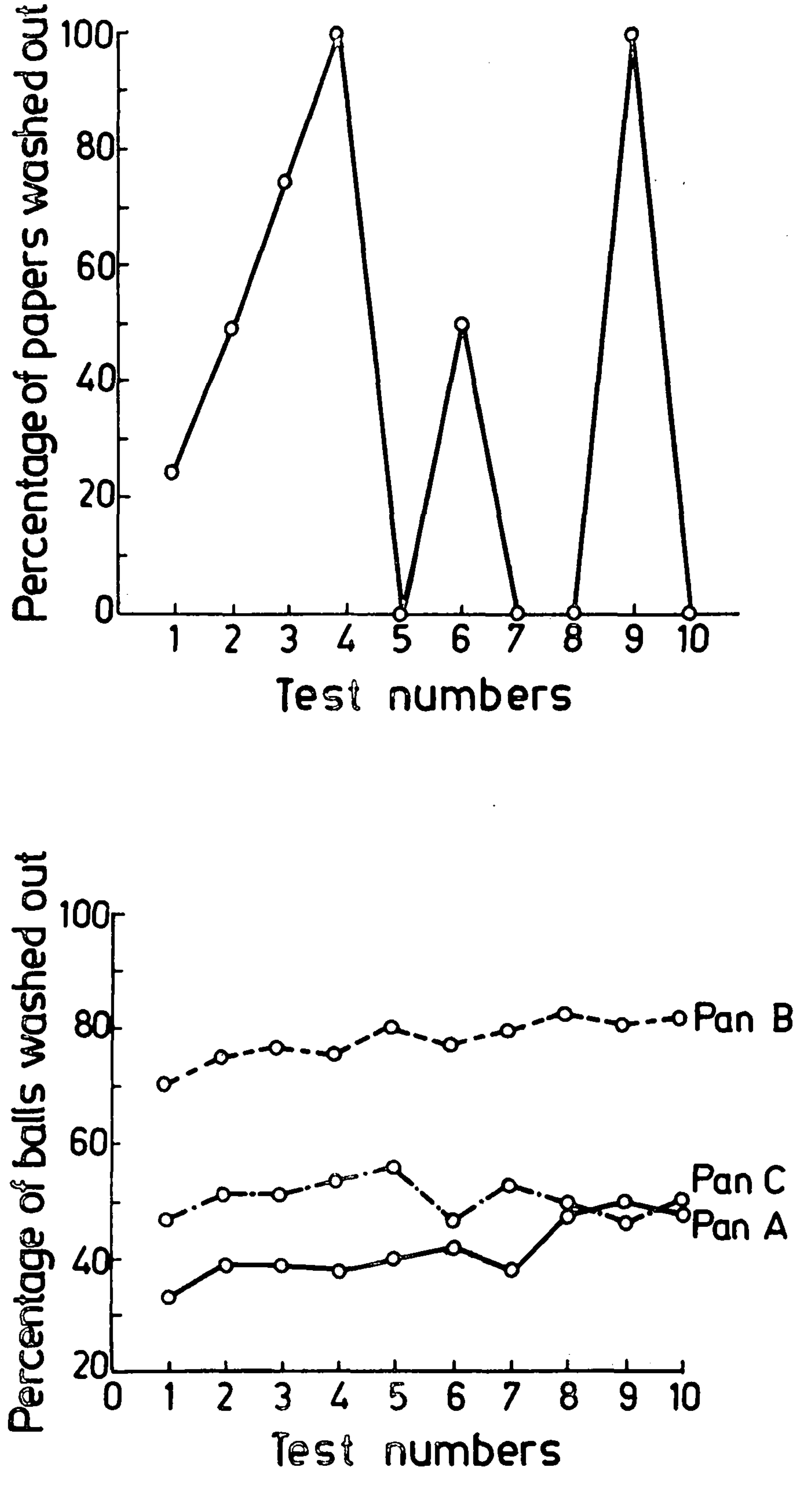


FIGURE 1 : COMPARATIVE FLUSHING EFFICIENCY TESTS

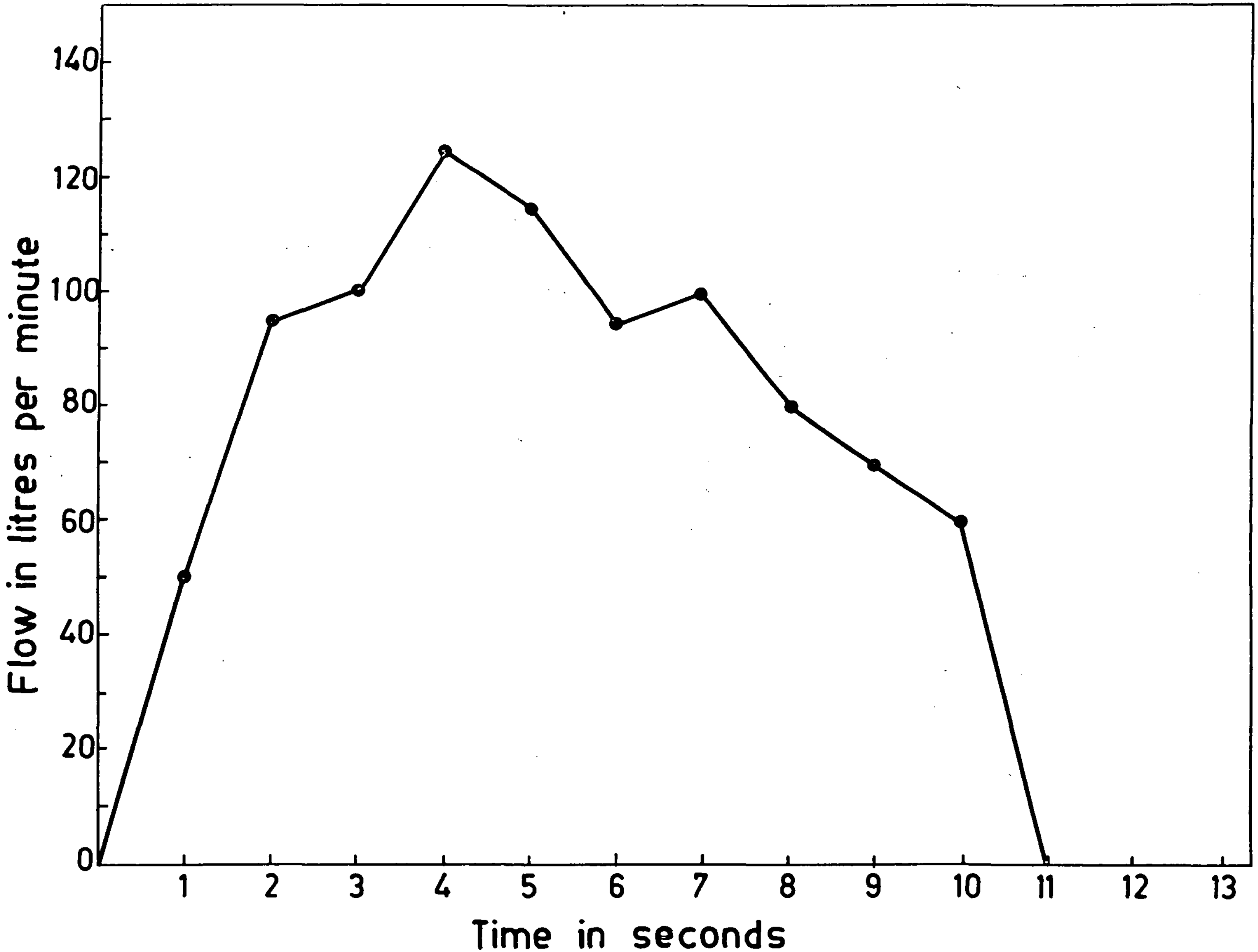


FIGURE 2 : FLOW RATE CURVE FOR 15 LITRE SIPHONIC TYPE FLUSHING TANK

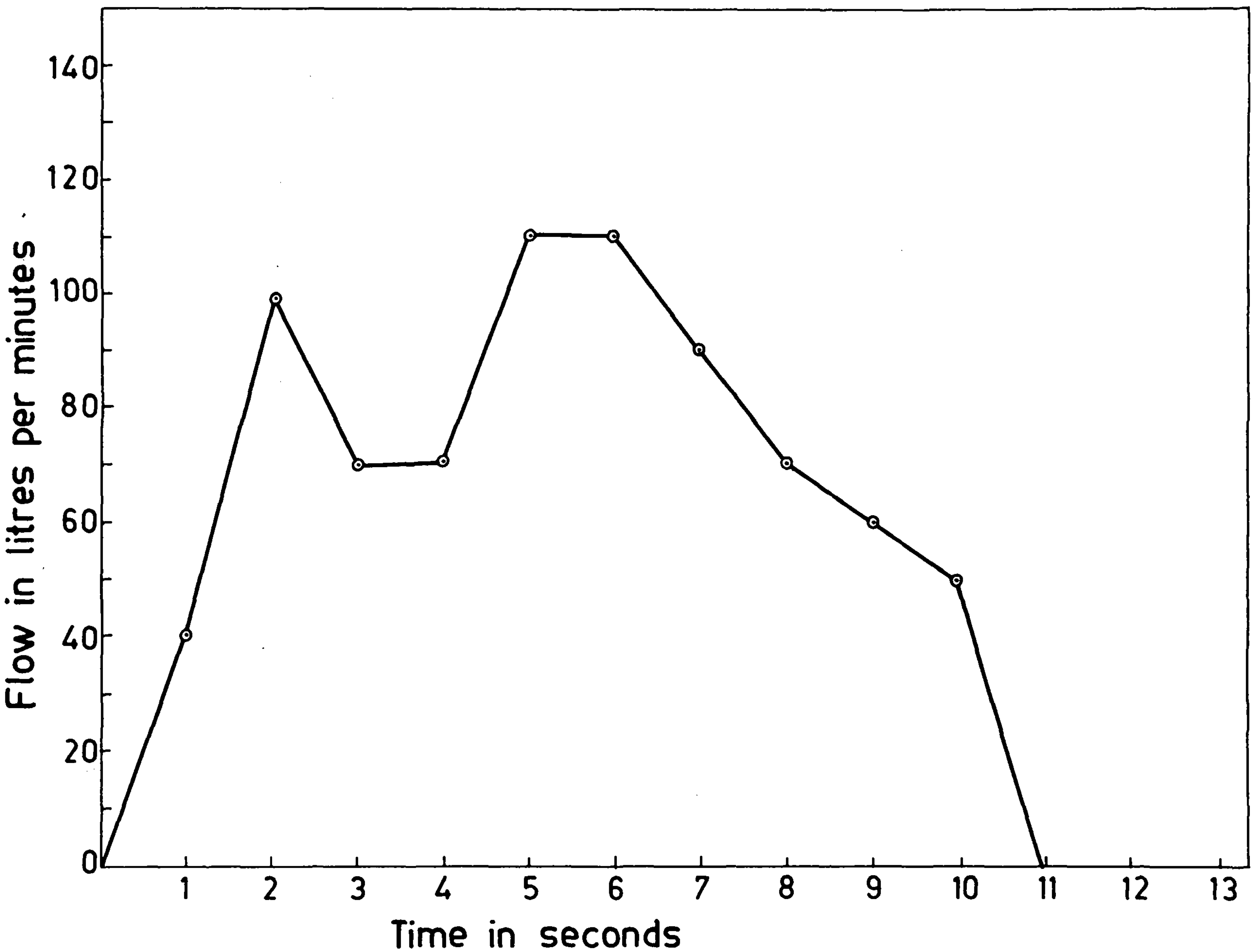


FIGURE 3 : FLOW RATE CURVE FOR 15 LITRE BELL TYPE FLUSHING TANK

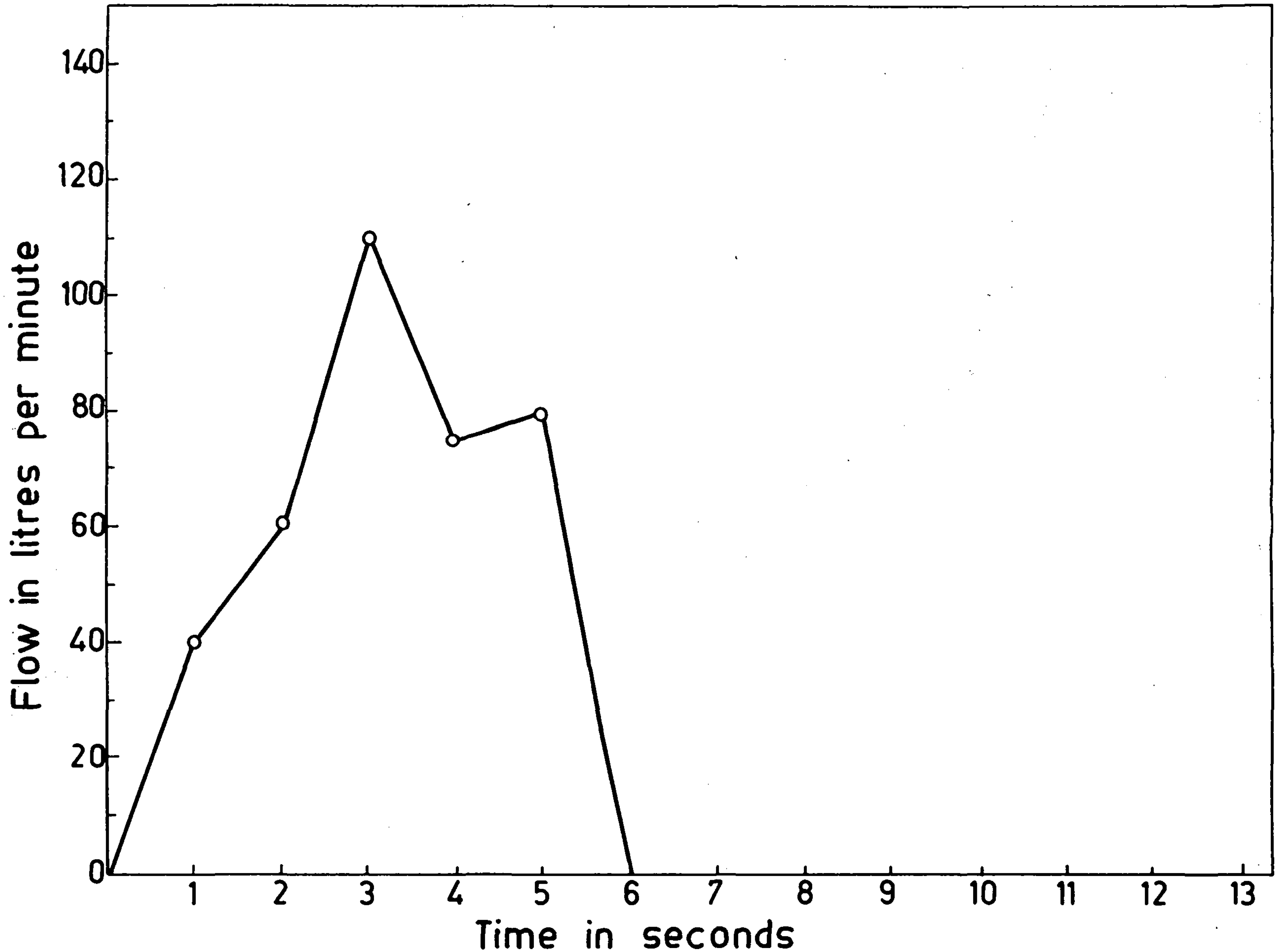


FIGURE 4 : FLOW RATE CURVE FOR 10 LITRE BELL TYPE FLUSHING TANK

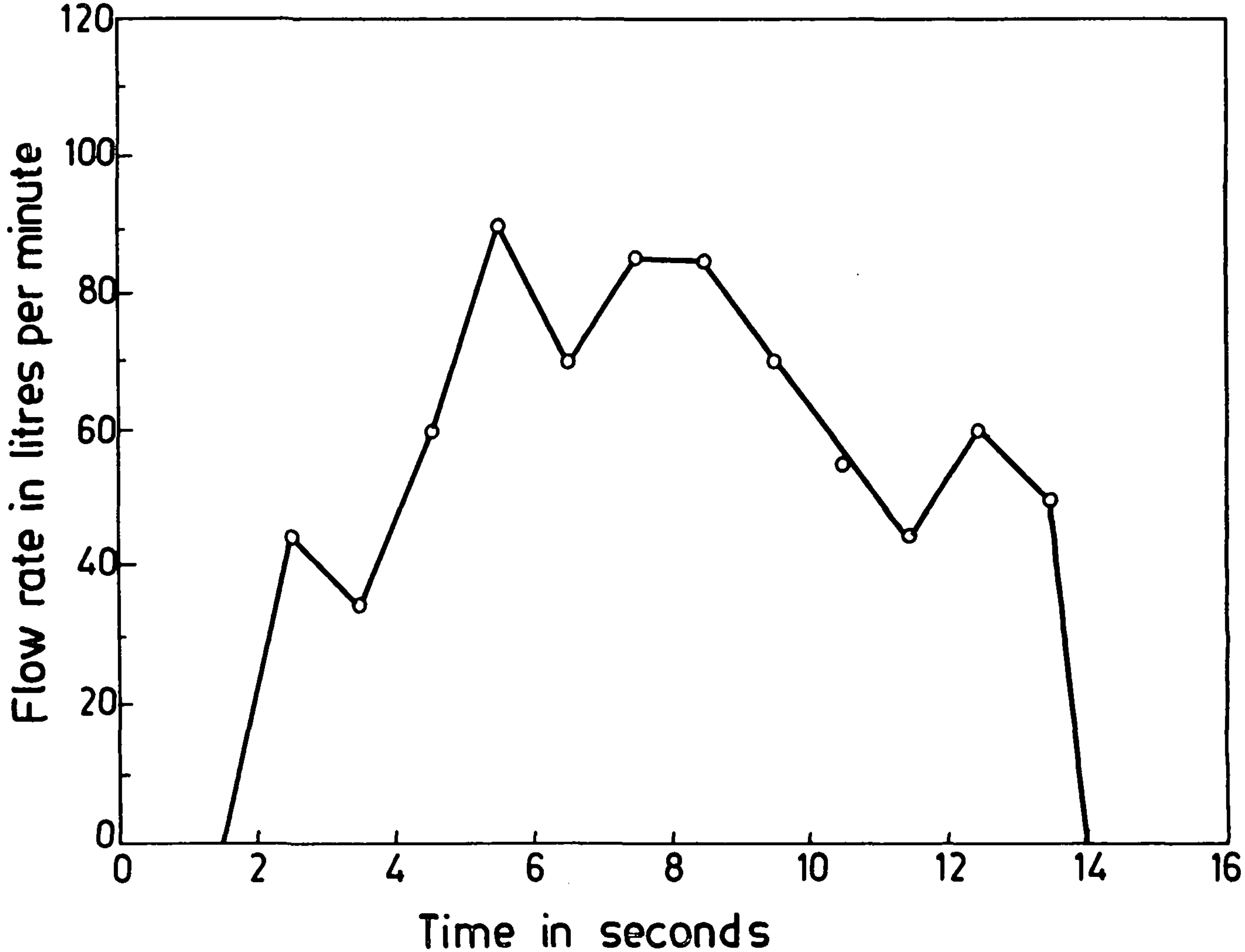


FIGURE 5 : FLOW RATE CURVE THROUGH WATER CLOSET - 'A', WITH 15 LITRE BELL TYPE FLUSHING TANK

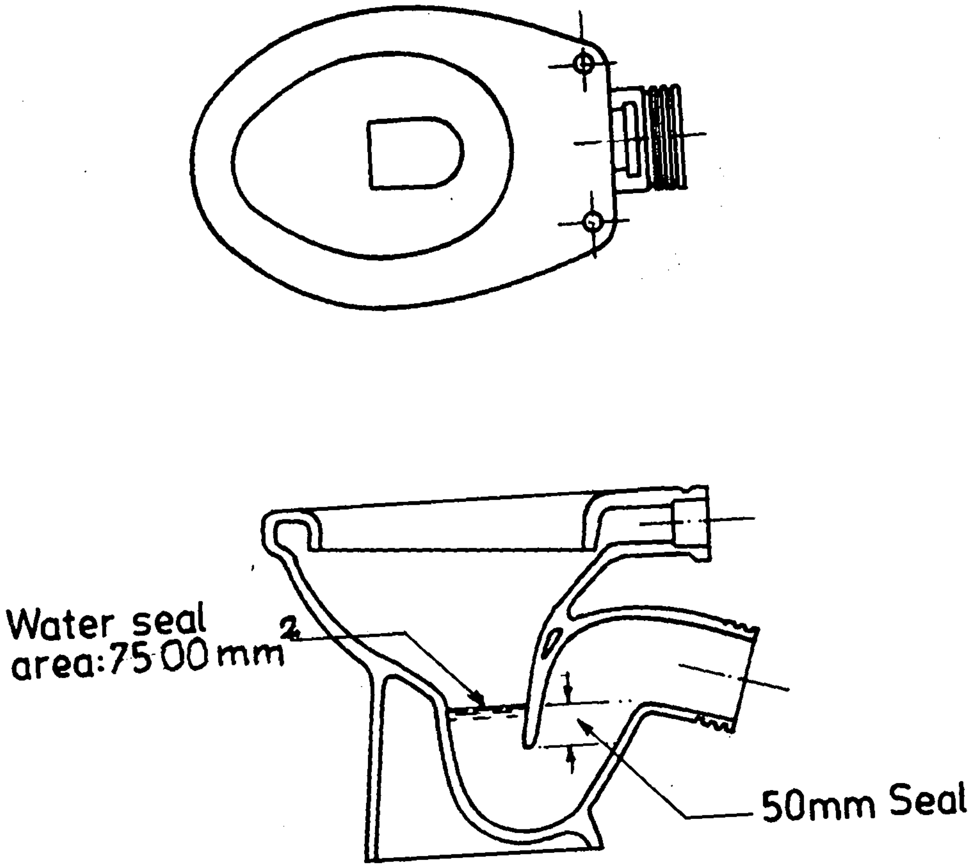


FIGURE 6 : AN IDEAL E.W.C. BOWL

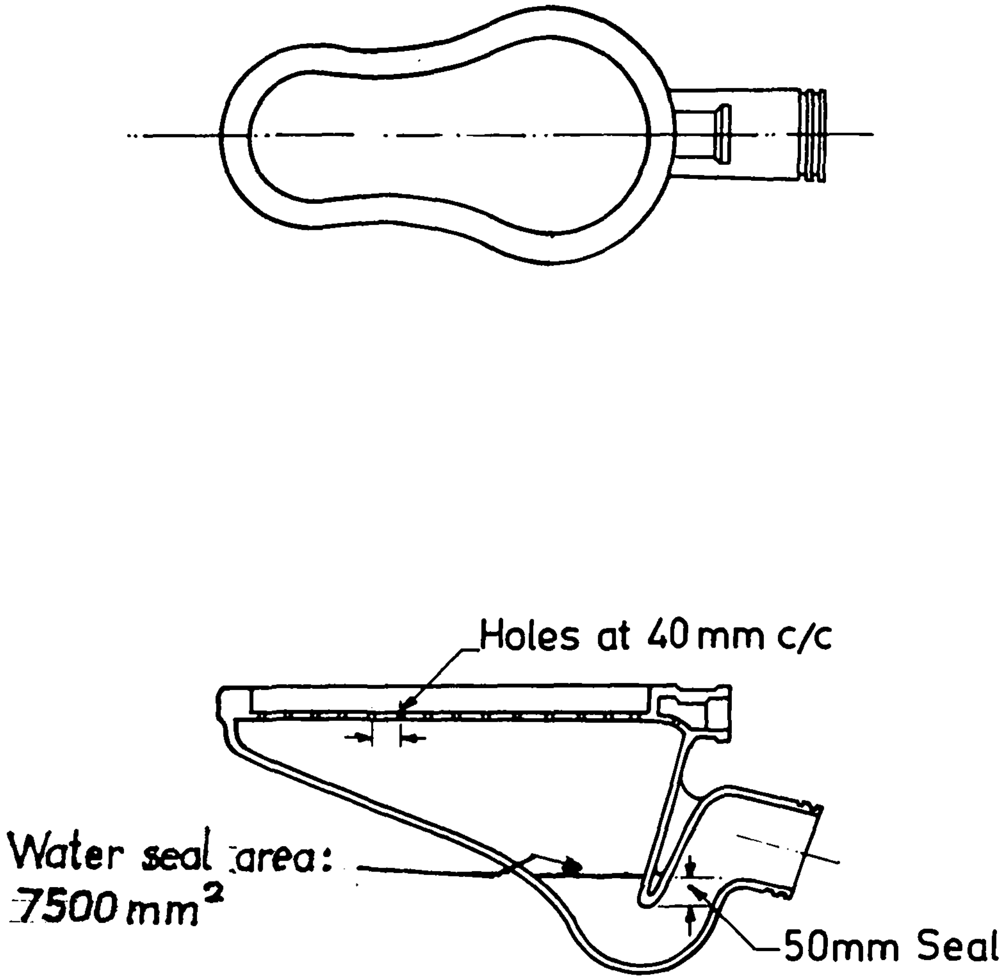


FIGURE 7 : AN INTEGRAL TYPE INDIAN SQUATTING PAN

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGS-DIENSTE IN ONTWIKKELENDE LANDE

S 239

Tech.Report 19
Teg. Report 19

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

KEYWORDS
SLEUTELWOORDE

Water, supply, consumption, low income/ Water, voorraad, verbruik, lae inkomste

NEED FOR CONTROL OF WATER CONSUMPTION IN LOW INCOME HOUSING PROJECTS - A TECHNICAL REPORT

by A.P. Bekker*

SYNOPSIS

Water supplies in the Republic of South Africa from conventional sources such as groundwater and storage of surface water are rapidly being exceeded by demand. Studies have shown that by installing individual metering in low income housing projects a saving in total water consumption of 30 to 50 per cent can be achieved. Individual metering, backed by a charge reflecting the true cost of water is, therefore, recommended.

SAMEVATTING

Watervoorraad uit konvensionele bronne in Suid-Afrika soos grondwater en oppervlakwater wat geberg word, word vinnig deur aanvraag bedreig. Ondersoeke het getoon dat, die voorsiening van afsonderlike watermeters in lae-inkomstebehuising, 'n besparing van 30 tot 50 persent in die afgehele waterverbruik meebring. Afsonderlike meting wat die werklike prys van die water weerspieël, word dus bepleit.

* *Assistant Chief Engineer, Directorate of Water Affairs, Pretoria.*

BACKGROUND

The stage is fast approaching when the quantity of water in the Republic of South Africa which can be practically and economically supplied from conventional sources (e.g. groundwater and storage of surface water) will be insufficient to satisfy the growing demand. This fact has repeatedly been emphasized in publications, at symposia and congresses and in policy speeches.

A recent prognosis by Du Plessis and Van Robbroeck(1) suggests that on an overall basis demand will outstrip supply by the year 2010, or just 30 years from now. Measures aimed at alleviating the impending crisis generally take the form of improving the supply potential, (e.g. desalination of sea water, exploitation of icebergs and modification of the weather), utilizing available supply better, (e.g. recycling, re-use) and/or controlling demand, (e.g. increasing water tariffs, metering, flow limiting devices and imposition of restrictions).

As the limit of available supplies is reached the cost of existing or new methods to make each additional cubic meter of water available rises dramatically, so that the question of economics becomes an overriding consideration. This is especially so when considering water supply to low income housing projects.

In order to avoid, or at least delay, the necessity of having to supply additional water at ever increasing cost, a more expedient, albeit unpopular, way of handling the problem is to curb demand, especially when it has been established on the basis of accepted norms of consumption that the demand is excessive.

This paper considers one aspect of controlling demand, namely that of controlling water consumption in low income housing projects. Furthermore, only one method is considered, viz. installing individual metering in previously unmetered houses. This being so, the paper is, therefore, confined to potable water supply only. For the purposes of quantifying the problem, the simplifying assumption is made that Black or Coloured housing projects generally fit the description of low income housing. This is not, of course, strictly true but does not invalidate the arguments presented. The opposite is also assumed, again not strictly true, that White residential areas represent the high income housing group.

PURPOSE OF INSTALLING METERING

If a flat rate for water consumed by individual households is charged, i.e. the charge is not related to the quantity of water individually consumed, the householder is not encouraged to use water sparingly. It is a well proven fact that when individual meters are installed and water is charged for on the basis of the quantity consumed by each household the unit consumption (in litres/capita/day or litres/stand/day) generally falls. This drop can be quite considerable but frequently tends to be greater in the initial stages, reducing somewhat on the longer term as the householder becomes accustomed to the higher charges normally resulting from such metering.

Garlipp(2) provides the following comparative figures for metered and unmetered individual water supply in some South African residential areas for Blacks.

TABLE 1 : Comparison of metered and unmetered individual water supply in some South African residential areas for Blacks (1979)

Residential areas	litre/stand/day	
	Metered	Unmetered
Mabopane		1 332
Daveyton	391	
Port Elizabeth:		
Thembelethu		2 524
Gunguluza		641
Windhoek (Katatura)	126	
Bloemfontein	147	
Durban:		
Umlazi		1 420
KwaMashu	737	
Lebowa homelands:		
Seshego*	(955)	1 597
Namakgale		1 512
Lenyenye		1 141
Mahwelereng		2 065

* The Figure in parenthesis is the consumption after metering was introduced.

Although there is considerable variation in the figures the average unmetered consumption is 1 530 litres/stand/day while the average metered consumption is 470 litres/stand/day. These figures are not directly comparable, except in the case of Seshego (Lebowa), as different areas are considered. Nevertheless it is not considered unreasonable to compare the averages in order to obtain some idea of what order of saving can be effected which, in this case, is about 69 per cent.

Garlipp also mentions a study of unit consumption carried out for Port Elizabeth, where the results showed that unmetered consumption on stands by relatively affluent Blacks was nearly double that of metered Whites. Furthermore, a comparison(2) of the unit consumption of two Black townships in Durban, namely KwaMashu (metered supply) and Umlazi (unmetered supply), with similar size and socio-economic development, showed that the unit consumption for the years 1967 and 1973 (litres/stand/day) was about twice as high in Umlazi as KwaMashu.

Gebhardt(3) showed from a study of consumptions by various Black units that the figure for unmetered consumption reached 1 045 litres/stand/day while the metered consumption did not exceed 682 litres/stand/day which suggests a saving of approximately 35 per cent, although here again the figures are not directly comparable. For Coloureds, the average of the figures provided by Gebhardt comes to 630 litres/stand/day for metered supplies which is considerablly less than 1 045 litres/stand/day for unmetered consumption by Blacks.

The effect on water consumption of installing individual metering in some South African cities has also been studied. Garlipp[2] mentions that there was a marked drop of 27 per cent in the overall consumption of Port Elizabeth after metering was installed in 1970 while Macleod[4] found that at the end of the approximately four and a half year period during which meters were installed in Durban (January 1976) the reduction in consumption was 40 per cent.

The foregoing studies point clearly to the fact that the installation of individual meters considerably reduces consumption. The need for metering of water consumption in low income housing projects stems specifically, therefore, from the fact that of all the primary consumption sectors this is the one sector which is largely not controlled at present, and available evidence suggests that, when compared with accepted consumption norms, the actual consumption in low income housing projects is frequently excessive.

Garlipp points out that metering, in order to be effective in reducing consumption, "must be backed by an efficient water tariff structure, regular metering, meter maintenance, billing of actual quantities of water consumed and a proper enforcement system to collect the money".

The installation of individual metering appears also to have direct financial benefits. Macleod makes the observation, based on the experience of installing individual metering in Durban, that the cost of installing meters, while being substantial, nevertheless "resulted in a saving of far greater capital expenditure than would have been required at that time to extend the conservation and purification works". The necessity of increasing the supply works was avoided merely by curtailing demand.

WATER TARIFFS

When considering affluent communities it is relatively simple to implement a tariff structure which reflects the true cost of water, but in poor communities this is a much greater problem. It is quite possible that charging poor communities for the full cost of water would lead to a consumption level which would be less than that which is considered necessary for public health.

Garlipp quotes Kinmont[5] as emphasizing the concept that "water tariffs should discourage excessive consumption and waste and to achieve this goal the tariffs for the payment of water should be carefully framed to encourage the lower income groups to use as much water as is essential for public health".

The standpoint of the Directorate of Water Affairs of the Republic of South Africa on this issue is that the water supply to lower income housing projects should be individually metered and that water should be paid for at the current price applicable to other consumers. If this level of tariff were to result in the consumption of less water than the minimum required for public health then a solution to the problem should be sought in limiting other costs experienced by low income families, e.g. rent, transport, etc., rather than by limiting the cost of water. The emphasis in the past has been on reflecting the true cost of other services, because there is little room for waste in these areas, while allowing water as a commodity to be abused because of the prevalent attitude that the supply of water is limitless. This attitude is no longer tenable and water as a scarce but vital commodity must be correctly valued economically.

These sentiments are backed by the Commission of Enquiry into Water Matters in Recommendation 33 of its report[6], which states that the water consumption of towns and cities should be individually metered for each consumer. This includes those Black and other Non-white townships where water is delivered directly to houses and other buildings.

CONCLUSION

In the prevailing situation where it is evident that water supplies which can be economically developed by conventional means are rapidly being overtaken by demand, the planner must look at every possible way of bringing the supply and demand of water into balance. It becomes increasingly important to distinguish between demands for water of differing quality before deciding how those demands are to be met. Potable water required for human consumption involves the additional cost of purification and is generally more expensive than waters having a lower quality requirement. Providing for the needs of low income housing, therefore, involves economics as much as supply.

The following conclusions are made:

(a) Individual metering in order to curtail excessive consumption in low income housing projects can play an important role in improving the supply/demand situation pertaining to potable water. It would appear that while there is considerable variation in the available evidence quoted in this paper, the installation of individual metering could result in average savings in consumption, at least in the short term, of 30 to 50 per cent.

(b) Individual metering together with a charge for water at the current price would appear to offer the best interim financial solution which is especially important when considering low income housing projects. Basically, metering would effect a redistribution of water by curbing waste and thus making potable water available for supplying a greater number of people with sufficient water to maintain health standards. This also avoids the immediate necessity of having to increase available supplies at relatively greater cost, which, in turn, makes it increasingly difficult to provide minimum supplies to low income housing projects at a price that can be afforded.

REFERENCES

1. DU PLESSIS, J.G. and VAN ROBBROECK, T.P.C. Paper entitled *"Toekomstige Waterbehoeftes van Suid-Afrika"* delivered at the Congress of the South African Association for the Advancement of Science held at Stellenbosch from 19 to 24 June 1978.

2. GARLIPP, K.D.C.O. *Water restrictions.* The Institution of Municipal Engineers of Southern Africa, October 1979.

3. GEBHARDT, D.S. *The influence of income on future domestic water consumption.* Paper delivered at the Convention : Water for the Future (Water Year 1970).

4. MACLEOD, D.C. *The effect of metering on urban water consumption.* Municipal Engineer, May/June 1979.

5. KINMONT, A. The Urban Water Supply and Demand Symposium : Water, Natal 1970.

6. *COMMISSION OF ENQUIRY INTO WATER MATTERS* (Republic of South Africa). Report No. R.P. 34/1970.

ACKNOWLEDGEMENT

Permission by the Director-General of the Department of Water Affairs, Forestry and Environmental Conservation to publish this paper is gratefully acknowledged.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGSDIENSTE IN ONTWIKKELENDE LANDE

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

S 239

Paper 20
Referaat 20

KEYWORDS
SLEUTELWOORDE

Water closet, test kit, performance/ Spoelkloset, toetsstel, werkverrigting.

TEST KIT FOR THE SANITARY PERFORMANCE OF WATER CLOSETS: MODEL 180-1

by T. P. Konen*

SYNOPSIS

A test kit which can measure the sanitary performance of water closets is described in terms of 6 performance tests and the interpretation of their results. The tests are listed as: the ball test, the granule test, the surface wash test, the dye test, the flush volume test, and cycle time test. Instructions are given for the operation of all tests.

SAMEVATTING

'n Toetsstel om die sanitêre werkverrigting van spoelklosette te bepaal word beskryf volgens 6 werkverrigtingstoetse en die interpretasie van die resultate. Die toetse word in volgorde geplaas as: die bal-, die korrel-, die oppervlakwas-, die kleursel- en die spoelvolume en siklustydtoets. Aanwysings vir die uitvoer van alle toetse word gegee.

Stevens Institute of Technology, New Jersey.

TEST KIT FOR THE SANITARY PERFORMANCE OF WATER CLOSETS: MODEL 180 - 1

A. *Objective:* The purpose of this test kit is to provide the required test media and instructions for completing several of the sanitary performance tests proposed for the American National Standard - Vitreous China Plumbing Fixtures, ANSI Standard A112.19.2 - 1979.

B. *Scope:* The kit contains the necessary media, instructions and data sheets* for completing the following tests:

Test description	ANSI standard reference
Ball test	Section 7.3.3.1
Granule test	Section 7.3.3.2
Surface wash test	Section 7.3.4.1
Removal of waste liquids	Section 7.3.5.1

C. *Kit contents:* The kit contains the following:

. 120 polypropylene balls	Diameter 3/4 ± .002 inch. Specific gravity 0,85 - 0,90
. 150 ml polyethylene granules	Diameter 2-3 mm, disc shape Specific gravity 0,90 - 0,95
. 2 marking pens	Pentel for film, PM 2.
. 4 oz. water soluble dye	Polar brilliant blue RAWL
. 1 set of instructions	
. 1 set of data sheets	

D. *Notice:* The information and material contained in this test kit has been gathered from knowledgeable sources and believed to be representative of the current plans for the proposed ANSI Standard. No warranty, guarantee or representation is made by Stevens Institute of Technology as to the correctness or sufficiency of any information, test procedure or representation contained in the Test Kit and Stevens Institute of Technology assumes no responsibility or liability in connection therewith.

INSTRUCTIONS FOR TESTS FOR SANITARY PERFORMANCE AND WATER CONSUMPTION

1. GENERAL

This section presents test methods and performance requirements for water closets with respect to sanitary performance and water consumption. These test methods and performance requirements apply to all vitreous china water closets. It is intended that these test methods and performance requirements be used by manufacturers, architects, engineers, builders and approving authorities as a standard basis of acceptance of water closets.

2. TEST APPARATUS AND PREPARATION FOR TESTING

The principal features of the test apparatus are shown in Figures 1 and 2. The water supply system shall be standardized for testing water closets as indicated in Figure 1. After making the required valve adjustment, the fixed orifice is removed and the supply connected to the water closet under test. The adjusting (stop) valve is not subsequently changed from this initial setting.

The pressure reducing valve (PRV) shall be 1-inch size conforming to ASSE Standard 1003/ANSI A112.26.2. Further preparations and general instructions for testing are as follows:

2.1 The bowl shall be level, trap and outlet clear, and the bowl filled to trap weir level before making each test run.

2.2 At each supply pressure specified for the individual tests (for tank-type water closets) the water level in the tank and the cycle time shall be adjusted according to the manufacturer's instructions and specifications for the tank. In the absence of such instructions and specifications, the tank shall be filled to the water line where marked and, in the absence of a mark, to a point 1-inch below top of overflow, and the float valve (ballcock) shall be adjusted to fill tank in not more than 3 minutes (cycle time).

No adjustments of flushometer or stop beyond those required by Figure 1 shall be made in connection with tests at different pressures.

The cycle time (for both tank-type and flushometer-type closets) shall be measured from the instant the flush release device is tripped until water stops flowing in the trap refill flow circuit following completion of the main flush.

Static pressures for the individual laboratory tests shall be set in accordance with Table 1.

Table 1 : Static test pressures for laboratory tests

Test No. and Title		Tank type	Static Pressure, psi Flushometer-type WC's	
			Siphonic bowls	Blowout bowls
3.1	Ball test	20	20	40
3.2	Granule test	20	20	40
4.1	Surface wash	20	20	40
5.1	Dye test	20	20	40
6.1	Flush volume & cycle time test	20 60,80	20 60,80	40

* See test reports at end of paper.

2.3 Place waste load in water closet well, if the particular test calls for a waste load.

2.4 Trip flush release device in a normal manner.

2.5 Allow water closet to discharge to receiving vessel. *Five runs* shall be made for each test condition, unless stated otherwise in the detailed procedures for the particular test.

2.6 Evaluate results and report data in accordance with the detailed procedures specified for each test. Suggested formats for reporting the test data are given as part of these instructions.

3. REMOVAL OF SOLIDS

(a) Ball test

Test method:

Test media. The test media shall be 100 polypropylene balls having a diameter of 3/4-inch and a specific gravity of 0,85 - 0,90.

Procedure. Drop the 100 balls in the well. Trip flush release device. After completion of this initial flush, count balls remaining visible in well and those passing completely through the trapway (out). Observe trap seal retention (see 6.3 for procedure). Then, if required, flush again one or more times *without* additional test media to flush all balls from the water closet. Observe the number of such additional flushes required. This completes one test run.

Repeat the procedure until five sets of data are obtained.

Report. Report number of balls remaining visible in well after initial flush, the number flushed out, the number remaining in the trapway, and the number of additional flushes, if any, required to flush all the balls out. Data Sheet 1 may be used for recording test results.

Performance requirement:

For acceptance, at least 75 balls shall be flushed through the bowl, based on the average of the five initial flushes.

(b) Granule test

Test method:

Test media. The test media shall be 100 ml of disc shaped polyethylene granules 2-3 mm diameter, thickness 1,6 (± 0,2) mm, and specific gravity 0,90 - 0,95.

Procedure. Add the 100 ml of PE granules to water in bowl. Trip flush release device. After completion of this initial flush, count granules remaining visible in well. Observe trap seal retention (see 6(c) for procedure). Then, if required, flush again one or more times *without* additional test media to remove all granules from view. This completes one test run.

Repeat the procedure until five sets of data are obtained.

Report. Report number of granules remaining visible in well after flushing, and number of additional flushes, if any, required to remove all granules from view in the well. Data Sheet 2 may be used for reporting the test results.

Performance requirement:

Not more than 125 granules, 5 per cent, shall be visible in the well after each initial flush.

4. WASHING OF FLUSHING SURFACE (SURFACE WASH)

Surface wash test

Test method:

Test media. The test media shall be marking pens with water soluble ink suitable for writing on film.

Procedure. The flushing surface shall first be scrubbed clean with commercial scouring powder to remove any buildup or deposits on the walls. The surface shall then be dried with oil-free air.

Draw a line around the circumference of the flushing surface at a level 1-inch below the rim jets of the bowl.

The flush release device shall be trippped and the inscribed line observed during and after the flush.

When the flushing cycle is completed (tank completely refilled or flushometer cycle completed and trap refill water delivery completed), measure the lengths of the unwashed line segments where the ink may have remained on the flushing surface, and record their approximate positions in the bowl.

If splashing occurs and removes any portion of the line, that test shall be disregarded and a retest shall be made.

Repeat the procedure until three sets of data are obtained..

Report. Report number, location and lengths of line segments remaining. Data sheet 3 may be used for reporting the test results.

Performance requirement:

The total length of line segments remaining on the flushing surface after each initial flush shall not exceed two inches based on the average of the three runs and no individual segment shall be longer than 1/2-inch.

5. REMOVAL OF WASTE LIQUIDS (WATER CHANGE)

Dye test

Test method:

Test media and apparatus. The test media shall be water soluble crystalline dye, polar blue brilliant RAWL. For volumetric measurements, use a 1 000 ml beaker and 500 ml and 100 ml graduated cylinders. For colour determinations, use a comparator.

Procedure:

(i) *Preparation of concentrated dye solution.* Prepare a concentrated dye solution*, 30 grams per litre, by adding crystalline dye to water taken from the test water supply source. The water shall be heated to 180 $^{\circ}$F, the dye added, and the solution allowed to cool to room temperature before use.

(ii) *Determine volume of trap seal.* Remove all the water from the water closet bowl. Pour measured volumes of water into the bowl until a slight amount of water is observed passing over the weir and then record the volume required to fill bowl to weir level. Only one determination need be made.

(iii) *Prepare colour comparator samples.* In a separate container, make up 1 litre solution containing 7,5 mg of dye crystals. This may be accomplished by adding 100 ml of the concentrated dye solution to 400 litres of the test water. Using this solution, fill a clean test tube, minimum length 25 cm, and set aside for comparison with the residual water after the flushing test.

(iv) *Add dye solution to bowl and flush closet.* As a first step, remove 1/4 of the volume of water in the bowl. Measure out a volume of concentrated dye solution (30 gm/1) equal to 1/40 of bowl volume and add to the bowl water and stir. Trip the flushing device. After the flushing cycle is complete, extract a sample of the water from the bowl.

(v) *Comparison with reference standard.* Pour the extracted water sample from the bowl into a vial identical to the one containing the reference sample. Looking downward into vials, determine whether the colour of the residual water sample exceeds the comparator reference sample. Before making each replicate test, the flushing surfaces of the bowl shall be wiped clean of any dye stain and the bowl flushed several times to remove any remaining traces of dye from the water. This completes one test run. If the colour of the water sample from the bowl is more intense than the reference sample, the dilution ratio is less than 100. A more definitive value for the dilution ratio may be obtained by preparing additional reference standards (other concentrations) as described in the ANS1 standard.

Repeat the procedure (iv) and (v) until three sets of data are obtained.

* Store away from light. Do not use after 30 days.

Report. Report water volume in bowl, volume of dye added, and the results of the comparison after each initial flush. Data sheet 4 may be used for reporting the test results.

Performance requirement:

A dilution ratio of at least 100 shall be obtained in each initial flush.

6. WATER CONSUMPTION AND HYDRAULIC CHARACTERISTICS

(a) **Flush volume and cycle time test.**

Test method:

Apparatus. (See Figure 2.) The receiving vessel may either be calibrated by volume in increments not exceeding 0,1 gallon or placed on a load cell or electronic scale with readout in increments not exceeding 0,1 gallon. A stop watch or electric timer graduated in increments not greater than 0,1 second shall be used to measure time.

Procedure. The flush release device shall be tripped and the stop watch or electric timer started. Observe the pressures at the water closet supply valve inlet and upstream pressures (initial and minimum values). Also observe peak flow rate indicated by the flow meter, if available.

When the main flush is completed, as indicated by cessation of the trailing flow which occurs at the end of the principal discharge, the volume received in the vessel is observed (main flush volume). Again observe the volume (total flush volume) after cessation of flow the excess trap refill water (afterflow) that occurs subsequent to the first observation. When water stops flowing in the trap refill circuit the stop watch or timer is stopped and the elapsed time is observed (cycle time). The amount of excess trap refill (afterflow) shall be determined by subtracting the main flush volume from the total flush volume. Measure trap seal retention (see Section 6,3 for procedure). This completes one test run.

Repeat the procedure until five sets of data are obtained for each test pressure.

Report. Static pressure, peak supply flow rate, flow pressure at both gages, cycle time, main and total flush volumes and afterflow shall be reported. Data sheet 5 may be used for reporting the test results.

Performance requirements:

Average water consumption (total flush volume) of water saving closets over the range of static supply pressures 20 psi to 80 psi shall not exceed 3,5 gallons, and the maximum at any pressure in this range (average value from the five run test sets) shall not exceed 4,0 gallons.

Cycle time shall not exceed 3 minutes at any static pressure over the range 20-80 psi.

(b) **Trap seal depth determination**

Test method:

Apparatus. Figure 3 depicts a suggested apparatus for determining trap seal depth.

Procedure. Lower probe until horizontal element is resting against the bottom of the trap dip. Observe corresponding scale value, h_1. Then disengage horizontal element from trap dip. Elevate probe point to approximately the water surface corresponding to a full trap seal. Pour water slowly in well until a slight overfill is indicated by dripping from the bowl outlet. Adjust probe so that point is at water surface. Observe corresponding scale value h_2. Calculate trap seal depth, $H = h_2 - h_1$.

Only one determination need be made.

Report. The values h_1, h_2 and H described above shall be reported.

Performance requirement:

The trap seal shall assure protection against suction and backpressure in the sanitary drainage system, and against destruction from evaporation during normal periods of non-use. A full seal depth not less than specified in 5.1.2 of the ANSI Standard A112.19.2 - 1980 shall be deemed adequate to satisfy this requirement.

(c) **Other hydraulic characteristics**

(i) Trap Seal restoration.

Procedure. When making the flush tests specified in 3(a) and (b) and 6(a), observations shall be made for trap seal restoration after flushing. The appearance of afterflow in the drain following the main flush is sufficient indication of adequate trap seal restoration. If no afterflow is observed, residual trap seal depth shall be measured by the procedure described in the 6(b) test method, omitting the addition of water to the well.

Report. Report whether afterflow is observed following each initial flush in the specified tests. Report measured residual trap seal depth if no after flow is observed.

Performance requirement. Trap seal shall not be reduced below the values given in section 5.1.2 of ANSI A112.19.2 - 1980.

(ii) Hydraulic profile.

Procedure. When making the required hydraulic tests specified in 6(a), data shall be obtained defining hydraulic profile:

- *Water supply.* Water consumption, ballcock or flushometer pressure drop (Δ P), cycle time (T), and maximum supply flow rate for each supply pressure.
- *Drainage.* Accumulative volume discharged as a function of time, and peak discharge rate for each supply pressure.

Prepare graphs from the data described in (a) and (b). The values plotted shall be the averages from five replicate runs at each supply pressure.

Report. Report the data described above in graphical format. See Figure 4 for an acceptable format.

Performance requirement. No specific requirements are set at this time. However, the reported data are needed in connection with evaluating certain water conservation parameters and iteraction parameters affecting overall plumbing system performance and fixture-unit loads. This will be of special importance as future designs are developed.

ACKNOWLEDGEMENT

The Davidson Laboratory at Stevens Institute of Technology acknowledges the co-operation and support of the Office of Policy Development and Research of the U.S. Department of Housing and Urban Development. The Laboratory specifically wishes to thank Mr. Jerome Rothenberg for his continuing interest in the Residential Water Conservation Research effort that has produced this Test Kit. While many have co-operated in this effort, we acknowledge the help of Dr. Lawrence Galowin of the National Bureau of Standards, Mr. Robert Wyly, Plumbing Consultant, and Mr. Stanley Backner, Chairman of the ANSI Vitreous China Plumbing Fixtures Standard.

APPENDIX A

COMMENTARY - WATER SUPPLY SYSTEM

The water supply system used in the evaluation of the water closets has been designed to:

- provide more than an adequate supply of water
- simulate the flow resistance typical of residences
- permit similar installations at other laboratories

The ANSI standard for ballcocks (ASSE 1002) requires the units to deliver 1.5 gpm at 8 psi flowing pressure. Assurance of an adequate supply of water is achieved by calibrating the system shown in Figure 1 at 20 psi static pressure such that the system will deliver 3 gpm at 8 psi flowing pressure with a simulated ballcock. Once this setting is established by adjusting both stop valves the control valve is not touched, the simulated ballcock removed and the water closet to be tested connected.

The simulated flow resistance typical of residences and agreement with other laboratories, may be accomplished by using similar control valves and piping. The flow characteristics of a system may be expressed by using the resistance co-efficient K. In our experimental setup the overall resistance co-efficient, from regulator to ballcock, was 43 based on the inside diameter of schedule 40 pipe for the nominal valve size, 3/8 inch.

FIGURES 1 - 4

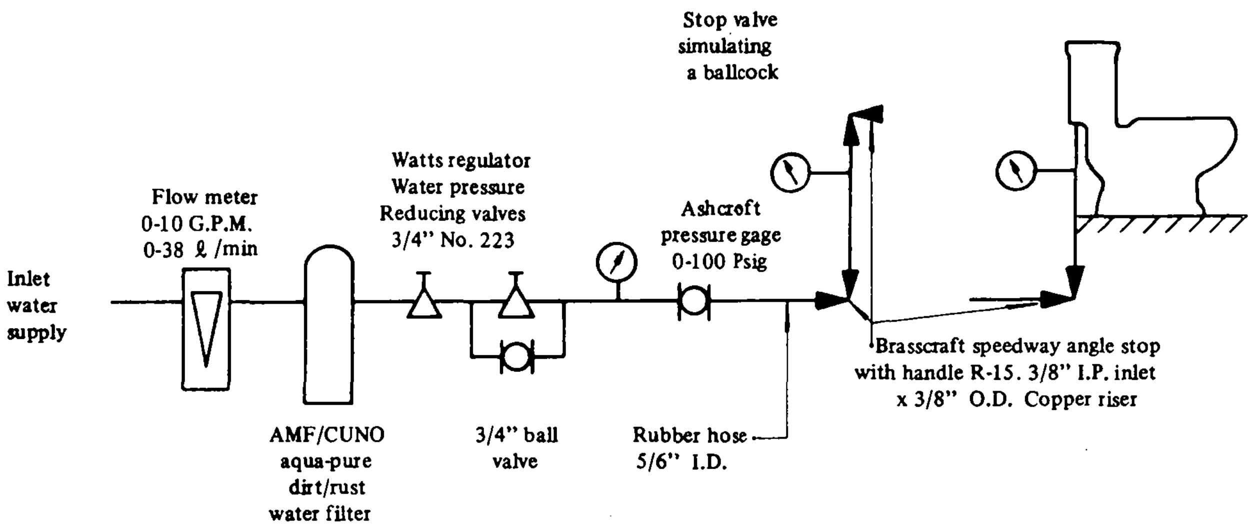


FIGURE 1 : REQUIRED STANDARDIZATION OF WATER SUPPLY FOR TESTING WATER CLOSETS

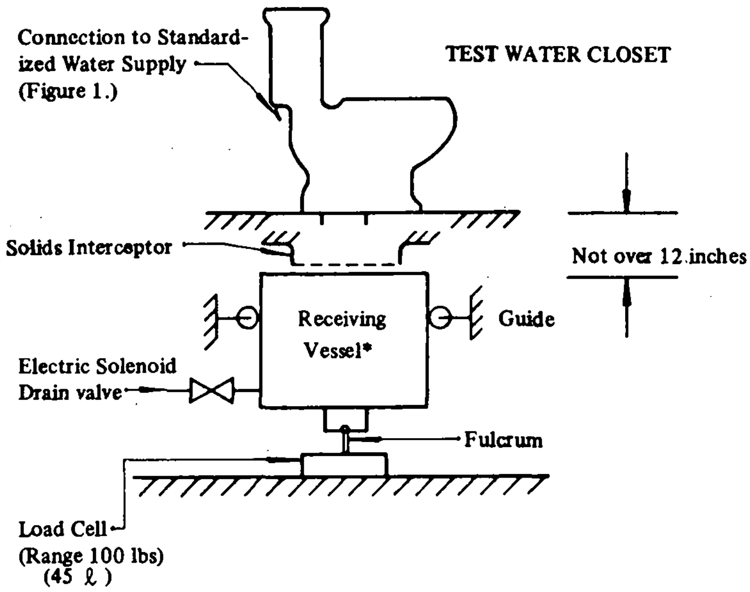
NOTES:

1. System shown above, 3/4-inch nominal pipe size, is suggested for tank units. Pipe and equipment sizes must be increased for flushometer units. Recommended parameters are:

   (a) 25-30 gpm flow rate at 10 psi flowing pressure and 20 psi static pressure (flushometer type closets with siphonic bowls).

   (b) 45-50 gpm flow rate at 20 psi flowing pressure and 40 psi static pressure (flushometer type closets with blowout bowls).

2. Many commercial products are available for building this system. Manufacturers names and model numbers are shown for convenience only.



*NOTES: Cylindrical, dia. 12" to 16", depth 20" to 24", maximum tare 20 lbs. An impact inhibitor suspended below and attached to the solids interceptor may be helpful.

FIGURE 2 : DIAGRAM DEPICTING SUGGESTED APPARATUS FOR MEASURING WATER CLOSET FLUSH VOLUME AND FOR INTERCEPTING SOLIDS

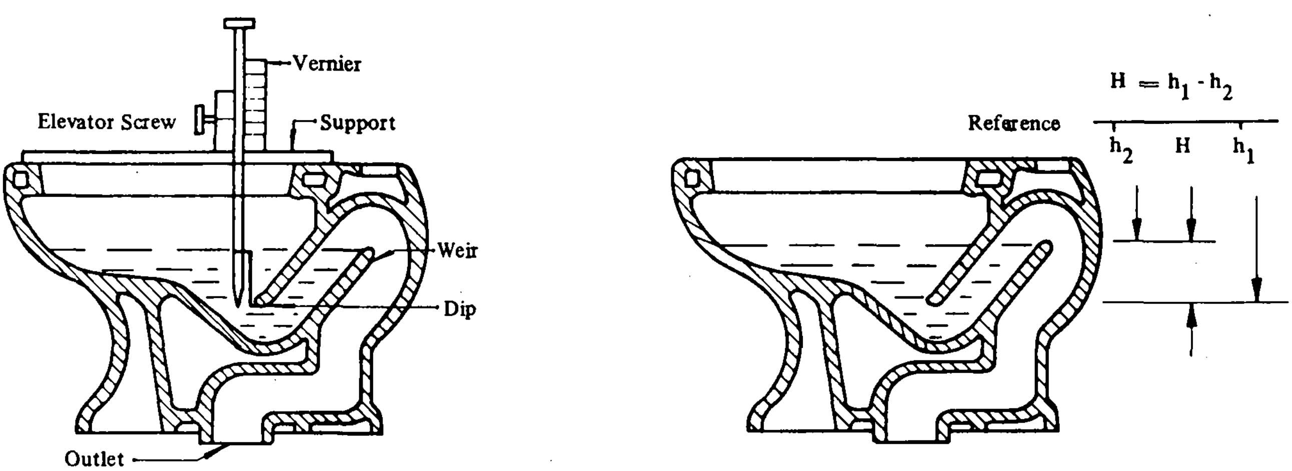
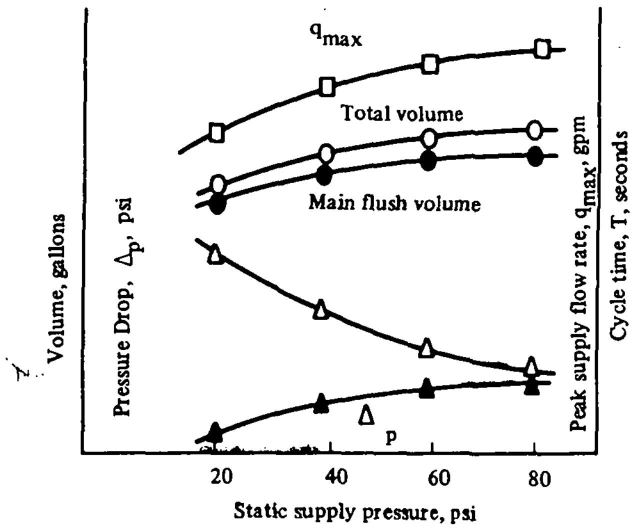
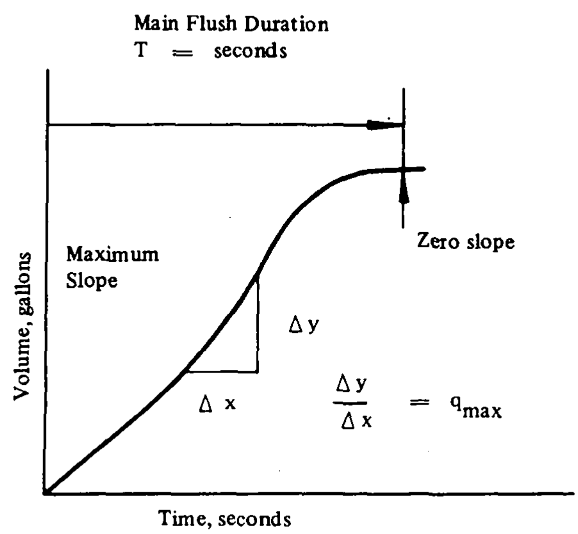


FIGURE 3 : DIAGRAM DEPICTING SUGGESTED APPARATUS FOR TRAP SEAL DEPTH DETERMINATION FOR WATER CLOSET



A. Hydraulic Profile - Water Supply



B. Hydraulic Profile - Drainage

FIGURE 4: SUGGESTED FORMAT FOR REPORTING HYDRAULIC PROFILE DATA (WATER CLOSET)

SANITARY PERFORMANCE AND WATER CONSUMPTION

Test Report

Product Mfg ____________ Model ____________ Serial No. ____________

Test date ____________ Facility ____________ Data taken by ____________

1 : Results of Ball Test - 3(a) - Static Pressure 20 psi

Test run no.	Status of Balls after initial flush: Number flushed out	Status of Balls after initial flush: Number remaining in well	Status of Balls after initial flush: Number remaining in trapway	Number of additional flushes, if any, required to flush all balls out	Trap seal automatically and fully restored after flushing*	
					YES	NO
1						
2						
3						
4						
5						
Average values						

* As evidenced by appearance of afterflow.

2 : Results of Granule Test - 3(b) - Static pressure 20 psi

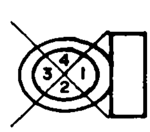
Test run no.	Number of granules remaining in well after initial flush	Number of additional flushes if any, required to remove all granules from well	Trap seal automatically and fully restored after flushing*	
			YES	NO
1				
2				
3				
4				
5				
Average values				

* As evidenced by appearance of afterflow.

3 : Results of Surface Wash Test - 4. - Static pressure 20 psi

Test run number	Status of ink line after initial flush			Total length of segments remaining, inches
	Number of segments remaining and their positions in bowl			
	Number of segments	Location quadrant*	Maximum individual length	
1				
2				
3				

* Quadrant numbering scheme



4 : Results of Dye Test - 5. - Static pressure 20 psi

Test run number	Bowl volume	Volume of dye added to bowl water	Dilution ratio greater than 100	
			YES	NO
1				
2				
3				

5 : Results of Flush Volume and Cycle Time Test - 6(a)

Static pressure, psi*	Test run number	Flow pressure		Maximum supply flow rate, gpm	Cycle time, sec	Flush Volume			**Trap seal automatically and fully restored after flushing	
		At PRV, psi	At WC, psi			Main flush, gal	After flow, gal	Total flush, gal	YES	NO
	1									
	2									
	3									
	4									
	5									
Average values										

* Data required at 20, 40, 60 and 80 psi static pressures.

** As evidenced by appearance of afterflow.

SEMINAR 1980 SEMINAAR

WATER SUPPLY AND DRAINAGE SERVICES IN DEVELOPING COUNTRIES
WATERVOORSIENINGS- EN DREINERINGSDIENSTE IN ONTWIKKELENDE LANDE

Organized by the National Building Research Institute of the CSIR
Georganiseer deur die Nasionale Bounavorsingsinstituut van die WNNR

S 239

Paper 21
Referaat 21

KEYWORDS
SLEUTELWOORDE

Water consumption, energy, WC flushing/ Waterverbruik, energie, WK-spoeling.

SAVE WATER - SAVE ENERGY

by

S. Holmberg, L. Lindvall and E. Olsson*

SYNOPSIS

An investigation was carried out in Sweden to estimate the amount of water consumed per day in 20 flats in Norrköping over several measuring periods. The paper covers different ways in which water, particularly hot water, can be saved and by which energy can therefore be saved. This can be done by changing consumer habits and by using water saving components. However, new ideas often meet with considerable resistance.

SAMEVATTING

Ondersoek is in Swede ingestel tydens verskeie meetperiodes om te bepaal hoeveel water per dag in 20 woonstelle in Norrköping verbruik is. Die referaat dek verskillende waterbesparingsmetodes, veral van warmwater, en gevolglike energiebesparing. Dit is moontlik deur die verandering van verbruikersgewoontes en deur die gebruik van waterbesparingskomponente. Nuwe idees het egter dikwels aansienlike teenstand uitgelok.

* The National Swedish Institute for Building Research, Water Laboratory.

1. Introduction

There is no shortage of water in Sweden. However, because of the energy situation we ought to use less water, in particular less hot water. In order to judge the effect of water-saving measures it is necessary to know how much water we use. This has been investigated in a high rise building in Norrköping, and the results are presented in this article. An account is also given of the Laboratory's study on flushing volumes for WC's, where the conclusion is drawn that a 3-litre WC is perfectly feasible and involves considerable cost savings.

The consumption of water in several different countries is shown in Table 1. It is difficult to give an explanation for the differences, though obviously living conditions and customs are important. The public water systems (dimensions) also have an effect on the water consumption. As can be seen from the table, the water consumption in Sweden is relatively high by comparison with other countries. Energy considerations make it desirable to tackle the consumption of water, in the first place hot water.

Table 1 : Mean household consumption in some different countries

Country	Year	Consumption, litres per person and day
Denmark	1977	176
Luxemburg	1977	180
Netherlands	1977	137
France	1975	101
U.K.	1977	204
West Germany	1977	135
Switzerland	1977	255
Italy	1972	225
Austria	1974	149
U.S.A.	1976	432
Japan	1978	220
Sweden	1978	197
Kenya	1977	25-40

It is very difficult to estimate development trends as regards water consumption. However, in current prognoses it is generally assumed that there will be an increase in the per capita consumption up to the year 2000. Obviously there must be some correlation between resources and utilisation. In order to achieve this adjustment, it is necessary to have clear and comprehensive aims plus good planning. However, some control is also needed and this calls for regulations.

2. Survey

In order to estimate the effects of water-saving measures in the home, it is necessary to have an accurate picture of the water consumption in the houses concerned before any water-saving measures are adopted. The Water Laboratory of the Swedish Building Research Institute has carried out a survey of water consumption in houses in the Swedish town of Norrköping. The aim was to first record the total water consumption in 20 flats. Five of these 20 flats were then studied in detail. In these five special cases, the water consumption was determined at each separate supply point by measuring the frequency and flow at each one.

The survey showed that the amount of water consumed in litres per person and day, 1/pd, often varied considerably from one flat to another. The distribution of the total amount of water consumed also varied. In some flats more hot water was used in the kitchen than in the bathroom, while in other flats the situation was the reverse. This was observed over several measuring periods, and is probably chiefly due to the inhabitants' different habits. For example, people who are out at work can often wash or shower at their place of work, while people who stay at home consume only water in their own flat.

In addition, not everybody has the same hygienic requirements. In a study at a Swedish university, the washing habits of about 200 persons were investigated. It was found that more than 50 per cent of the men washed the whole of their bodies 1 - 2 times per week. Less than 50 per cent of the men washed all over more frequently. More than 50 per cent of the women washed the whole of their bodies 3 - 6 times per week. Less than 50 per cent of the women washed all over more frequently. Different habits also mean that some people use too much water when they bath (shower), while others use too much water when they wash up, or at worst that they are wasting water both for bathing and for washing up. In the five Norrköping flats which form the basis of the summary of water consumption, shown in Figure 1, the amount of water consumed in the kitchen was relatively large by comparison with measurements in other flats. The figure also shows the distribution between hot and cold water, and the total consumption in 1/pd. By recording the consumption at each water outlet it is possible to estimate the significance of each separate point in a saving programme, and the importance of undertaking such a programme.

3. The importance of technical solutions

In blocks of flats, where the inhabitants are charged for the total amount of water consumed in the whole building, there is little inducement for the individual consumer to go in for systematic saving. In spite of information about the sharply rising costs of hot water, in particular, it is difficult to achieve the desired saving.

Thus we need technical solutions which will induce the consumers to save water and energy, promptly and conveniently. The Water Laboratory's measurements in Norrköping have shown, among other things, that hot-water costs can be reduced considerably by lowering the temperature of the hot water from 55 °C to 45 °C. In the same way, the costs increase if the temperature is raised to 65 °C. The lower hot-water temperature was acceptable to the inhabitants, while on the other hand a temperature of 65 °C was considered to be too hot.

The measurements in Norrköping also showed that people consumed different amounts of water depending upon the type of water tap installed in the flats. It was found that single-handle taps produced a saving by comparison with traditional taps with separate handles for hot and cold water.

An investigation carried out by the Swedish Consumer Institute has shown that washing up by hand. The same investigation, which bases its results on laboratory tests, has shown that washing clothes in a machine also uses less energy than washing them by hand. The Consumer Institute and the Water Laboratory at Studsvik have planned a joint survey to investigate these saving effects.

4. The importance of reducing running costs

In recent years more and more attention has been paid to the increasing running costs in both houses and flats, largely due to the rising oil prices.

The cost of heating water for hot-water taps is forming an ever larger proportion of these costs. The measurements in Norrköping have shown that a reduction in the temperature of the water supply reduces the energy costs for heating this water.

Other measures aimed at a reduction in the heating costs have been discussed, including the use of the hot water circulation as a direct source of heat at the water outlet point. In order to elucidate this aspect it will be necessary to have further surveys, new products and perhaps also new principles of dimensioning.

In a number of cases there has been talk of measuring individual hot-water consumption in apartment houses. Many people believe that this would be an effective way of reducing the ever-increasing running costs for houses. Stig Nilsson and Thomas Lundgren have carried out an investigation, using funds donated by the Building Research Committee, to determine the saving effected by individual hot-water metering in four housing areas in Gothenburg. According to their investigation, it may be assumed that individual metering will reduce the consumption of hot water by between 20 per cent and 30 per cent. A saving in hot water of 30 per cent means a saving in heating oil, besides the actual reduction in volume of water consumed. In our 20 test flats in Norrköping this would mean a saving of c. 2 000 litres of heating oil per annum.

Some years ago there began to be an increase in the use of WC's with a flushing volume of 6 litres instead of 9 litres. At that time the main reason was one of dimensioning, although the water-saving aspect was also cited. Today the situation is quite the reverse. Now we are searching high and low for systems and components which can reduce water consumption. Several measures have already been taken; for example, there are some fittings with a limited flow, systems have been equipped with flow limiters, etc. In addition the consumers themselves, in particular home owners, have been induced by various saving campaigns to alter their habits to a certain extent. For example, there is a tendency to shower instead of taking a bath, to rinse the dishes in a basin instead of under running water as before, etc.

5. A 3-litre WC is possible

We know that a lot of water is used for flushing WC's. The problem with a low flushing volume is that the flushing out of horizontal pipes will probably be ineffective, and this creates a sanitary nuisance. It is essential to have an adequate flushing out of the piping system, i.e. it must be flushed completely clear at least once every twenty-four hours. In the Swedish sanitary installation regulations it is stated that this will be achieved if the force applied is at least 0,25 kp/cm^2, and the height to which the pipes are filled does not exceed 0,5 (h/D, where h = depth of water and D = pipe diameter), (see Figure 2).

The Water Laboratory at Studsvik has for the last year been studying WC's with a flushing volume of 3 litres in combination with components whose principal function is based on an effective clear flushing of the piping network. These investigations are not quite complete, but the results hitherto obtained in connection with flow tests indicate that a good clear flushing effect is achieved in conventional sewage systems with a flushing volume of 3 litres.

What then are the advantages of a reduction in flushing volume from 6 to 3 litres from both a technical and an economic point of view?

Inside the building: Smaller pipe dimensions, thinner walls, a saving of space in openings and recesses, other savings in materials, new types of system.

Outside the building: Existing pipelines can be utilized for new housing projects, the risk of overloading at sewage works is reduced, smaller loadings on water pumps, etc.

The results of the measurements in Norrköping have shown clearly that the WC (6 litres) has the greatest water consumption, 55 l/pd, of all the water supply points, (see Figure 1). On the basis of these results it is possible to estimate the economic effect of using WC's with a 3-litre flushing volume as opposed to 9 or 6 litres.

It is reasonable to assume that most of the flats built between 1960 and 1975 were equipped with WC's having a flushing volume of 9 litres. From 1975 it became increasingly common to have WC's with a flushing volume of 6 litres. Nevertheless, the 9-litre WC's were still markedly in the majority. For the sake of comparison we can group the flushing volumes as follows:

1960 - 1975	9 litres
1975 - 1980	6 litres
1980 - 2000	3 litres

The average water rates in Sweden between 1960 and 1975 were 1,3 Skr*/m^3, and between 1975 and 1980 they were 4 Skr/m^3. It may be assumed that they will be 8 Skr between 1980 and 2000. The water rates per cubic metre of used water have increased from 1960 to 1980 by C. 900 per cent (from 0,6 to 5,2 Skr). On the basis of the figures

* 10 Skr = approx. 1 pound Sterling.

obtained for water consumption in WC's 55 l/pd, and assuming an average of 2,5 inhabitants per flat, we obtain the water consumption and water rates shown in Table 2.

Table 2: Estimated water consumption in WC's and water rates

Year	WC flushing volume, litres	litres/flat and year	cost in Skr/flat and year
1960-1975	9	75 000	97
1975-1980	6	50 000	197
1980-2000	3		198

At present the number of flats containing WC's with a flushing volume of 9 litres is high. The same applies for flats containing WC's with 6 litres. Considering current water rates (c. 5,2 Skr/m^3), and comparing them with the amount of water used in WC's per flat, the results shown in Table 3 are obtained. The table shows that a flat equipped with a WC having a flushing volume of 9 litres costs 250 Skr/year more than one where the WC contains 3 litres of water. This does not mean that the user saves this amount of money, since a large proportion of the water rates covers the water company's fixed charges, but from a management point of view it is interesting.

Table 3: Estimated water consumption in WC's and costs according to current rates

WC flushing volume	Water consumption in WC m^3/flat and year	Water rates Skr/flat and year, for WC
9	75	386
6	50	256
3	25	128

However, the results shown here cannot be applied either directly or generally, simply by, for example, cutting down the flushing volume in lavatories. A large-scale adoption of these measures would undoubtedly lead to sanitary nuisances, chiefly in the street sewers.

If the fittings supplied to the consumers are to be made more water-saving it is essential to know what effects this will have on the sewerage system as a whole.

6. On the right road, but the way is long

Forecasts made by the Swedish Water Board indicate that water consumption will continue to increase, which will in turn affect operating costs. However, a number of measures have already been taken to reduce water consumption, both by changing consumer habits and by using water-saving components.

Nevertheless, much remains to be done. The water laboratory at Studsvik is not alone in conducting research in this field; the area to be covered is large, and we believe that a coordinated research effort can be extremely useful.

New ideas often meet with considerable suspicion, both from the consumer and from the authorities. We consider that it is important to have a positive attitude to new ideas, and not to reject them before their function and consequences have been demonstrated in practice.

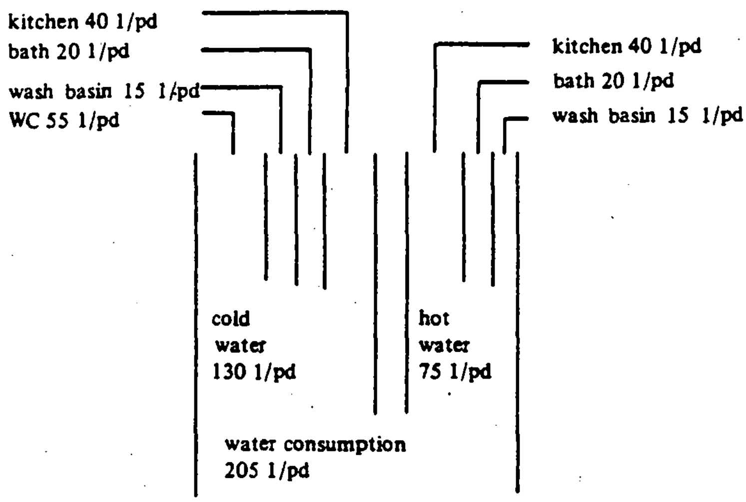


FIGURE 1 : Water consumption in five tests in flats in Norrköping

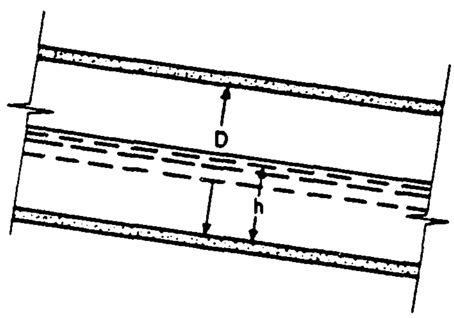


FIGURE 2 : Sanitary installation requirements for clear flushing of piping