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- Managing Projects in Bangladesh 1989
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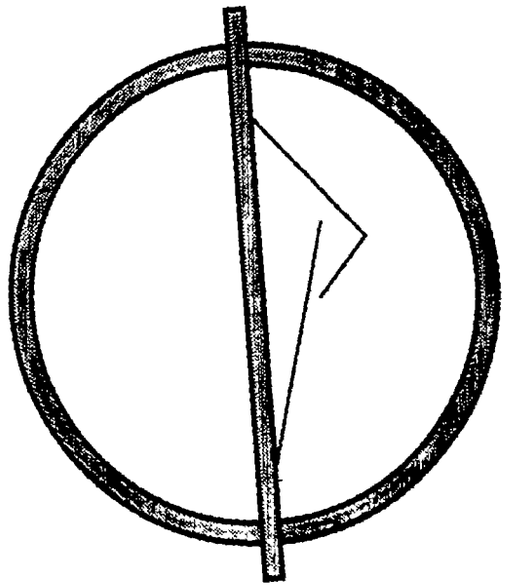
LOW-COST SANITATION RESEARCH

SKYLARK CHADHA

RABIUL ISLAM

A DOCUMENTATION ON

LOW-COST SANITATION RESEARCH



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The findings, interpretations, and conclusions expressed in this report are the result of a research study carried out by Interchain Project Consultants AB, Stockholm / Dhaka with some technical guidance from International Reference Centre for Waste Disposal (IRCWD), Switzerland. These observations are entirely those of the authors and do not necessarily coincide or reflect the opinion of Swiss Development Cooperation (SDC)

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Dedicated to:

Isharun Bibi

of Baliartan village, Ramnagar union, Nagarkanda upazila of Faridpur district who saved for a long time to purchase a latrine set After buying the latrine set from Talma VS centre, she had nothing left to pay for transportation charges To take the much-coveted latrine set home, she tried to carry it on her head to cover a distance of six kilometers Unfortunately, the strain was more than her frail body could bear and she fell down, breaking her valuable head load - a latrine ring

Foreword

Considering that access to drinking water and sanitation facilities as the basic needs of human life and also understanding the constant threat from diarrhoea diseases and other parasitic infections in Bangladesh, we have given for a long time now a top priority to this sector in our development cooperation programme in Bangladesh. Our assistance in the sector is mainly channeled through Unicef and implemented by the Development of Public Health Engineering (DPHE), complemented by action research studies on specific topics Additional support to the increased involvement of the NGOs and private sector is currently under appraisal Unlike the success of water coverage programmes in Bangladesh, the sanitation has always lagged behind

Sanitation is a topic which people would rather not talk about In the last century we in Switzerland suffered a number of complications due to unsatisfactory conditions of sanitation Like here in Bangladesh, the main reason for adoption of sanitary latrines was privacy and, therefore, the old names for latrines were "secret" or "prive" .

We have contributed in a humble way towards interventions to improve the sanitation coverage in this country. Fortunately, our efforts in this direction have been fully recognised and enthusiastically participated, amongst others, by the Ministry of Local Government, Rural Development and Cooperatives and DPHE Participation of a senior minister in our previous seminar on "Promotion of Rural Sanitation" last year and of the Prime Minister in the recent social mobilisation seminar, launching the national campaign on sanitation are some of the recent achievements which could have hardly been anticipated even a couple of years back.

Realising that cost reduction of sanitation components could contribute among others, towards increased coverage, we have commissioned Interchain Project Consultants AB, a Swedish management consulting firm with the technical guidance from International Reference Centre for Waste Disposal (IRCWD), Switzerland to carry out this important work related to both technical and economic aspects We congratulate the authors, Dr. Skylark Chadha and Mr. Rabiul Islam of Interchain and also the technical adviser Mr Martin Strauss of IRCWD, for their unique contributions which we feel can also be utilised else where in the world. We trust that this is yet another effort towards presenting new policy alternatives

Dr. Peter Arnold
Counsellor &
Head of Swiss Development Cooperation

April, 1992

Prologue

The various development assistance organisations and the world at large is recognising the importance of water and sanitation as the prerequisites of human living. However, the delivery mechanisms are yet to be improved and the coverage of these basic pre-requisites is only slowly creeping towards universal coverage. In Bangladesh sanitation intervention programmes have now existed for more than three decades but the combined effect of the formal government sector, NGOs and the private sector over the years has not been able to provide a sanitary latrine to more than one family from amongst ten. If one considers the large population of the country, population density, low life expectancy, high infant mortality and extreme poverty of this one of the least developed country, it is not difficult to conceptualise the complexities of the sanitation sector for the people of Bangladesh. The diarrhoea prone areas of Bangladesh perhaps present one of the most difficult task to any professional in this field anywhere in the world. The year 1989-90 documented the first thrust of the top level policy makers in the country when the targets for various related projects under DPHE were abruptly raised and many unnecessary bureaucratic process delays were eliminated

During phase I and phase III of the larger study on "Promotion of Rural Sanitation in Bangladesh" of which the present action research is a part, two areas for special attention were identified and special interventions were recommended. One recommended intervention was the motivational development which we can now see as being implemented under social mobilisation banner. The other recommendation concerned the reduction of costs how so ever small to bring the sanitation within the reach of teeming millions who have very limited cash, if at all. A 65% subsidised latrine priced at Tk 250 is only affordable by less than one third of the population. The actual procurement is done by a much smaller percentage of population because the procurement of sanitary latrine has to compete with other purchase priorities for individual families As the demand curve has a steep gradient at the present level of coverage, it was considered that even marginal savings in costs and pricing will lead to correspondingly significant increases in the sanitation coverage

In accordance with the above analysis and recommendations SDC commissioned Interchain Project Consultants AB, Sweden , Dhaka and International Reference Centre for Waste Disposal (IRCWD), Switzerland to inquire into low cost sanitation from a research angle. Although the work has been carried out in Bangladesh and for the Bangladesh environment, we believe that the work done, its modus-operandi and recommendations can be of wider interest and application in a number of least developed countries

The research inquiry has been carried out in the areas of pit stabilisation, slab, pan and superstructure. The results are being presented in as simple a language as possible.

We have enjoyed working with Dr. Peter Arnold, Head of Swiss Development Cooperation and Mr. Peter Tschumi, First Secretary Development, Mr. S. A. Karim, Senior Programme Officer and previously with Dr. Urs Heierli ex-Head of SDC in Bangladesh The work has been carried out under a very friendly but professional guidance of Mr. Martin Strauss of IRCWD who has provided his valuable comments and direction both during field visits and on the on-going monitoring reports Special thanks are recorded for Mr. Aminuddin Ahmed the DPHE Chief Engineer, Mr. Fariduddin Ahmed Mia the DPHE Superintending Engineer, Planning Circle, Mr. A. Moffazal Hossain, Executive Engineer, VS and Mr. Philip Wan, Chief WES and Mr. A. S. Azad, Project Officer of UNICEF for their ever ready cooperation We will also like to place on record our due thanks to Mr M. A. Karim, ex-Chief Engineer of DPHE for his valuable comments during meetings with him and Mr. Abu Moslem, Executive Engineer, DPHE Faridpur, Mr. Md. Ibrahim, Sub-Divisional Engineer, Mr. Abdur Rahim, Mr Abdul Barek and Mr. Aminuddin Ahmed all Sub-Assistant Engineers of DPHE for the pilot test upazilas.

The study participants will like to record appreciation of the cooperation of Professors Jamilur Reza Chowdhury, Feroz Ahmed, Habibur Rahman and Abdur Rouf all from BUET for their participation and interest in the unconventional laboratory tests in BUET Keen interest taken by Colin Glennie, Kieth Mackenzie, Andrew Sayles, Taufique Mujtaba and Shaila Khan all of UNICEF deserves a special eulogium. We are also in gratitude to HBRI, MAWTS, BCSIR, BFRI, NGO-Forum for their various inputs at different stages of the study

I would like to record my appreciation for my colleagues in Interchain for their valuable inputs to this inquiry: Mr. Rabiul Islam for overall coordination of the work, Mr. A.J.M. Shamsuddin for his work with initial activities with rings and mechanical casting device, Mr. P.K. Paul for mechanical improvements of the casting device, Mr. Abdu Wadud Rana for field testing of rings and work on superstructure and Mr. Golam Rabbani for monitoring of field activities, Mr. Utpal Paul and Ms Anju Roy for logistic support, Mr Md Ayaz for management of financial resources and Ms. Shamima Yasmin for seminar organisation Special thanks are deservingly due to Mr. Abdul Hasib and Mr. Sultanul Alam for providing the necessary computer support under very tight time constraints.

Assistance with regard to diagrams and photographs has been provided by Techno Mission and Studio Diana respectively. Special English editing to a simpler language has been carried out by Ms Zafrin Chowdhury of Dialogue and the book is brought to its present looks by Sristi press.

While thanking Swiss Development Cooperation once again for the opportunity provided, it will be relevant to put on record that special care has been taken that the action research work done is properly documented so that our modus-operandi is clear to the reader. The work is being presented in the form of this book so that the readers abroad and those who carry out similar type of work in future can have a mental dialogue with the authors to find out better and improved sanitary components, learning from our mistakes and proceeding forward from our learning, an opportunity we did not enjoy due to non-existence of any previous research documentation on this subject.

Skylark I S. Chadha
April, 1992.

ACRONYMS, ABBREVIATIONS AND TERMINOLOGY

A. ACCRONYMS AND ABBREVIATIONS

5P	Pilot Plan for Private Producers' Participation
AB	'Aktiebolag' in Swedish meaning Limited
ADB	Asian Development Bank
AE/AEN	Assistant Engineer
AfDB	African Development Bank
BCIC	Bangladesh Chemical Industries Corporation
BCSIR	Bangladesh Council of Scientific and Industrial Research
BSIF	Bangladesh Sanitary and Insulator Factory, Mirpur
BUET	Bangladesh University of Engineering and Technology
CC	Cement Concrete
CCA	Copper Chrome Arsenic
CCB	Copper Chrome Boron
CE	Chief Engineer
CI	Corrugated Iron
DANIDA	Danish International Development Agency
DPHE	Department of Public Health Engineering
EAWAG	Swiss Federal Institute for Water & Pollution Control
ESA	External Support Agency
FC	Ferro-Cement
FGP	Fibre Glass Plastic
GOB	Govt. of Bangladesh
HBRI	Housing Building Research Institute
HQ	Headquarters
IA	Integrated Approach (for sanitation)
IRCWD	International Research Centre for Water Disposal
KFW	German Credit Institute for Reconstruction
LGEB	Local Govt. Engineering Bureau
MAWTS	Mirpur Agricultural Workshop & Training School
MS	Mild Steel
NGO	Non-Government Organisation
NGO-FORUM	NGO-Forum for Water Supply & Sanitation
NORAD	Norwegian Agency for Development
PCC	Plain Cement Concrete

PP	Private Producer
PVC	Poly Vinyl Chloride
RC	Reinforced Concrete
RCC	Reinforced Cement Concrete (same as RC)
RDRS	Rangpur Dinajpur Rural Service
R&D	Research and Development
SAE	Sub-Asstt. Engineer
SDC	Swiss Development Cooperation
SDE	Sub-Divisional Engineer
SE	Superintending Engineer
SIDA	Swedish International Development Agency
SWG	Standard Wire Gauge
UNICEF	United Nations Childrens' Fund
VDP	Village Defence Party
VS	Village Sanitation
VSC	Village Sanitation Centre
VSRC	Village Sanitation Research Centre
WB	World Bank
WES	Water and Environmental Sanitation (Unicef)
WHO	World Health Organisation
XEN	Executive Engineer

B. LOCAL TERMINOLOGY

Borak	Thick-wall bamboo used for poles etc.
Katcha	Weak construction, with locally available cheaper materials
Khoa	Brick aggregates
Mistri	Small artisan contractor/technician
Muli	Thin-wall bamboo used for split, mat, etc
Pucca	Heavy construction with brick masonry and concrete
Rupban Sheet	Thin tin-sheets (usually misprint can plates,
Semi-pucca	Construction with brick masonry walls and C sheet roofing
Taka/Tk	Currency of Bangladesh (consists of 100 Paisha
Terza	Bamboo mat made from split bamboo
Upazila/UZ	A sub-division of Zila, (460 UZ in Bangladesh)
Zila	District, administrative unit (64 Zilas in Bangladesh)

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SYNOPSIS

1. Background

A five phase study on "Promotion of Sanitation in Bangladesh through the Private Sector" was sponsored by Swiss Development Copperation and initiated by Unicef in order to identify the basic constraints to the increased production and sale of water-seal latrine components by NGOs and private sectors, as well as to recommend ways and means to remove those constraints While conducting Phase I of the study in 1989, it was felt that in addition to heavy investment in motivational development, a less costly technology option will have a higher possibility to make latrines more accessible to its target group The need was further emphasized during the Phase II of the study It was agreed that positive outcome of the action research will enable a better coverage of sanitation in Bangladesh. Consequently, Interchain Project Consultants AB, Sweden with technical support from International Reference for Waste Disposal (IRCWD), Switzerland was commissioned to undertake the action research now being reported

Result of demand and supply curve showed that a very small percentage of population can afford and are willing to pay for even a subsidised latrine Realising the steepness of the demand curve at the present level of sanitation coverage and having understood that this is going to be rather a difficult area for action research, it was also realised that even a small saving in the area can lead to an increased market share of significant importance. An attempt was made to delve into the analytical documentation of previous efforts in this field. Findings revealed that very little of technically analytical work done in Bangladesh had been documented It was marked that it has been quite a few years after whatever scant was done so far. In the mean time, latest technological options have come up and tried in other parts of the world.

Recommended programme on action research was launched in the backdrop of above findings The programme was sponsored by SDC and executed in collaboration with the Department of Public Health Engineering (DPHE) and Unicef The latter supplied the materials of the research work and allowed the free use of existing moulds, tools etc., while DPHE allowed their research facilities at Village Sanitation Research Centre (VSRC) in Mohakhali to be used for the work. The SDC provided a major share of the expenses incurred in this programme including personnel, travel, moulds, tests etc.

This research enquiry on Low Cost Sanitation was carried out on the following components of a rural latrine

1. Latrine pit linings, RCC rings etc
2. Latrine slabs, with and without pans
3. Latrine pans, improved design and better hydraulic flow
4. Latrine superstructures

A second phase research was carried out to conduct field test on 1" thick RCC rings of new design recommended in the first phase of the action research, to confirm the validity and suitability of the new design of rings in actual field conditions

The summary of the findings and recommendations of the research study is briefly presented in this chapter for policy executives The details of the study on each of the components have been given in separate chapters in this book

2. Research on Rings

It was understood that any savings on the rings will be very conducive in lowering the cost of a latrine and that the ring thickness is the most cost-sensitive single dimension of the ring. After a brain storming session it was decided that 49 different types of rings with different ring thickness, ratio of concrete mix and reinforcement should be tried Therefore, a large number of produced rings were subjected to arduous handling and transportation tests. A rolling test was carried out on each type of ring on hard and rough roads. This test was much harder than the situation likely to be met in field Many of the rings broke during this test. It was also necessary to establish the relative strengths of the rings that had gone through the rolling test. Accordingly two types of laboratory tests were carried out, firstly with the compression strength testing machine in BUET and secondly by the sand bearing method. Special arrangements were made to carry out these tests

Extensive research in DPHE research centre and BUET laboratory demonstrated that manufacture and use of 1" thick rings with 1.2.5:5 mix and 1:3:6, instead of the standard 1.5" thick rings with 1:3.6 mix is technically feasible. It was then recommended and later on decided to carry out a field test for the selected two types of rings The field test was carried out in eight VS centres of three upazilas in Faridpur district After a couple of months production of 1' thick rings with a mix of 1:3:6 was discountinued and only production of 1' thick rings with a mix of 1.2.5 5 was continued During the one year of field test 5,076 rings were produced and 3,746 were sold and were actually installed in 1168 latrines. The percentage of breakage of the new rings has been less than the existing standard DPHE rings

The new design of ring is 20% cheaper at the same time, stronger than 1.5" traditional rings Field tests on 1" thick latrine rings of new design have proved to be successful and its adoption is recommended in place of existing standard 1.5" thick rings, in all the VS centres of DPHE all over the country This will result in substantial financial

saving considering the large production of the sanitary latrine components in the country. Only in the public sector with its 1000 VSCs and production of 1300 rings in each centre per year, the saving will be as high as of Tk. 20 million per year The accumulated saving over the years can be very rewarding

After adaptation by DPHE, some of the private producers of sanitary components have already started adopting this 1" thick ring design in Faridpur district However, the private producers need some training to be able to contribute more in wider national sanitation coverage This aspect will very well be highlighted in the forthcoming 5-P exercise in the pilot area of Faridpur district

Other side observations made during the field test in the three upazilas are the average depth of the pit is 5.2 ft., the average distance of transportation is 4 km and the most common means of transportation is the rickshaw van. 68% of the users made superstructures with jute sticks.

3. Research on Casting Device for Rings

Usually the RCC rings for latrines are cast by normal shutter of two vertical concentric cylinders The private producers use improvised shutters made of plain sheet. A mechanical device for casting of RCC rings was developed during this action research programme. In this device the inner cylinder with a concrete pouring trough is rotated on a vertical shaft. The inner ring is attached with arms welded with a hub nut This device was also used during the production of rings used for research purpose. This new device is very easy to operate and can be independently handled by an ordinary labour. Casting of RCC each latrine rings with the traditional moulds take approximately 22 minutes, whereas it takes only 12 minutes to cast one ring with this mechanical device.

The mechanical device for casting of rings will save time and energy and therefore result in increased production of latrine rings. This device involves some capital investment and therefore is suitable only where large scale production is desired

4. Research on Pans

An extensive search was done on different types of pans available in the market Keeping the aim of low-cost sanitation in mind, only concrete pans were throughly examined and improvements were tried

The standard DPHE pan which is being produced in all the VS centres in Bangladesh is a result of long experience The goose-neck of this pan makes an effective sanitary water-seal, at the same time the cost remains low However, there is scope for further improvement of the pan

Efforts were made for improvement of pan and many alternatives were tried in VSRC, Mohakhali Ultimately an improved design pan was produced which has the following variations from the existing DPHE pan.

- The bottom profile of the pan is wider
- The back wall of the pan is sloped inward
- The bottom opening of the pan is wider

In this improved design pan the goose-neck of DPHE type was used for water-seal

After casting and testing of many research pans of various designs, the finally adopted design was tested in comparison with standard DPHE pan Analytical tests were done on the improved design pan and DPHE pan to find out the quantity of water required to flush similar excreta replicas from the each pan The new pan design required less quantity of water for the purpose in comparison to the existing standard pan

The pans have been tested with different quantities of water used for flushing. A special test bench was designed with a sliding system on top to eliminate the human factor that could result in biased Inferences

This improved design pan may be tried through DPHE and private producers. DPHE may have difficulties in trying different types of pan in their VS centres but private producers can be motivated for popularising it to the public The private producers will need secondary concrete moulds for the pan

The main obstruction in easy flow of excreta in a low-cost latrine pan is the roughness of its surface This problem needs to be overcome because bacteria grows easily on the remnants of excreta on such a surface

In the current programme, information regarding available low-cost smooth pans were gathered This was generally done by neat cement or mosaic finish. Efforts were made to make the inner surface of the pan smooth by using linings of different materials such as white cement and marble touch material

Smoothening of pan by neat white cement finishing is cheaper than by any other lining materials The marble touch finish costs Tk. 70 extra per pan while cost for lining with white cement is only Tk. 30 The high cost of marble touch lining prohibits its use for low-cost sanitation purpose Therefore it was discarded from further testing

Analytical tests were performed on the following types of pans in VSRC with standard excreta replica to find out volume of water required to flush it

- Standard DPHE pan
- DPHE pan with lining
- Improved design pan without lining
- Improved design pan with lining

It was found that the improved design pan with white cement lining required the minimum amount of water, compared to the unlined pans or lined DPHE pans

It is recommended to introduce and popularise low cost pan with white cement lining at least as one of the alternatives This will provide more effective sanitation with slightly extra cost Such type of pan can also be popularised through private producers by giving them some training and credit facility 5-P exercise can look into this point.

5. Research on Slabs

It is often observed in the field that the goose-neck of the latrine pans is often broken by the users In spite of repeated message conveyed by the field officials regarding the utility and advantages of the water-seal the users break it for various reasons It was found that water non-availability is not the only reason but the users think the goose-neck as an obstruction to the easy passage of excreta to the pit This action of breaking the goose-neck causes unsanitary effects bad smell and problem of flies and insects.

Considering the above problems and the rapid promotion of home made latrines, a good deal of thought was given for trying some latrine-slabs without pans. In active collaboration with IRWCD/EAWAG Switzerland latrine slabs of different types without pan were designed during the research period. The following two types of latrine slabs which have been tried in Africa. were produced and tested in VSRC Mohakhali·

- Mozambique-type Dome slab
- Malawi-type Sanplat slab

Dome slabs are constructed without any reinforcement while the Sanplat requires only 4 small m s bars The Dome slab requires a little more concrete and additional skill at the form-making. The cost of such slabs is Tk. 64 or Tk 65, while the cost of a standard DPHE latrine (pan and slab) is Tk 132. The cost of FC slab only (without pan) for the DPHE design is Tk 92. Even the cost of a home-made bamboo latrine, if materials are purchased, comes to Tk. 55 The Sanplat latrine slab is better, stronger and more durable compared to the home-made latrines with a little extra cost

The Sanplat type latrine slab without pan and with lid, is recommended to be manufactured and sold through the private producers, specially in those places where the users tend to break the goose-neck of standard pans, and for those who find DPHE slab and pan too expensive. This can offer as intermediate technology option between DPHE's sanitary latrine and the home-made latrines However, the private producers will have to be trained first, which can be attempted during the 5-P exercise.

In addition to the above, comparative cost calculations have also been carried out for superstructures with CI sheets, thin tin sheets, bamboo mat wall and CI roof etc. Superstructures made of jute sticks and non traditional superstructures made of ferro cement have also been described in detail

6. Research on Superstructures

The study involved, research on various types of latrine superstructures Comparative costs and durability of different alternatives of superstructures were studied. Alternative materials used for the latrine superstructures were

- untreated normal bamboo materials
- thin plain tin sheet
- CI sheet
- treated bamboo materials

Latrine superstructures were erected with the following combinations
1. CI sheet walls & roof, timber poles
2 Thin tin sheet walls and roof, bamboo poles
3. Bamboo mat walls and CI sheet roof, bamboo poles
4 Split-bamboo walls and terza roof. bamboo poles
5 Bamboo-mat (terza) walls & roof, bamboo poles
6. Treated terza walls & roof, treated bamboo poles

It was found that in spite of its durability. CI sheets are not affordable by the target groups due to its high cost in making superstructure On the other hand, the plain thin tin sheet (rupban sheet) design is high in cost but does not last long and therefore is not a good choice So the only material alternative left is bamboo made superstructures constructed with treated or untreated bamboos

The untreated bamboo superstructure costs Tk 435 whereas the one with treated bamboos costs Tk 450 The cost increment is approx 3.5% only but the durability of treated bamboo is at least 2 5 times more than that of the untreated bamboo Normal life of a matured bamboo is 5 years whereas a properly treated bamboo will last for 12 to 15 years. The durability of the treated bamboo could not be practically tested during the action research because of the short period of its operation

Therefore, a latrine superstructure with treated bamboo mat (terza) walls and roof with treated bamboo posts is recommended to be used on a large scale.

It is also recommended that a standard collapsible and portable latrine superstructures with treated bamboo materials should be manufactured on a large scale. This will be economical and also convenient for quality control and treatment facilities.

The superstructures should be manufactured in a convenient place, by DPHE contractors or by private producers, near the regional stores of DPHE The manufactured superstructure units can be transported along with other stored materials, such as cement, wire-mesh etc., to upazila VS centres or even to union VS centres From these VS centres, the users should be able to get the ready-made latrine superstructures along with other latrine components

The private producers will need training on the treatment of bamboo and may be some financial assistance or credit facilities for the treatment equipment and materials which can be organised in the 5-P exercise. By regular and long term monitoring of treated bamboo structures, the exact life span of treated bamboos can also be determined in the process.

7. Forthcoming 5P Exercise

In continuation of the study on "Promotion of Rural Sanitation in Bangladesh" and to implement the results of Action Research on Sanitation Components. and in the interest of wider sanitation coverage in Bangladesh, the Swiss Development Cooperation, SDC, is planning to undertake the next programme entitled "Pilot Plan for Private Producers' Participation'. In short it is called as the 5P exercise

The objective of this programme will be to strive for an to actively promote the participation of private producers of sanitation components in Bangladesh The pilot project will be in the same area in which the field-tests of action research work had been carried out.

The aim of the programme will be to achieve an optimal mix of two delivery channels i e. the DPHE channel and the private producers, and this is very much in line with the GoB/DPHE country programme for giving more emphasis to the private sector for manufacturing sanitation components Some of the elements of the 5P exercise will be baseline survey of the sanitation environment in the pilot area. training of the private producers. one time assistance to the private producers, credit facilities to the private producers promotional activities, coordination with action research activities, monitoringing and evaluation of the programme and finally impact evaluation.

Current programme of GoB/DPHE on sanitation stresses that by 1995 DPHE will privatise the latrine production and will act mainly as policy maker in the sector of water supply and sanitation. According to the GoB / Unicef agreement for Rural Water Supply and Sanitation Programme, 1992-1995 "DPHE will develop a new strategy for private sector investment from 1995 onwards, in collaboration with GoB and ESA for which a pilot project will be launched and evaluated by 1995".

At present no model for promoting the private producers in sanitation sector is available to DPHE Therefore, the 5P exercise, its findings and recommendations are expected to be very useful in the strategic policy formulations in the sanitation sector

CHAPTER 1

INTRODUCTION

1. Rural Sanitation Scenario in Bangladesh

A five-phase study on "Promotion of Rural Sanitation in Bangladesh through the Private Sector" sponsored by Swiss Development Cooperation and initiated by Unicef was undertaken by the International Reference Centre for Waste Disposal (IRCWD), Switzerland together with Interchain Project Consultants AB of Sweden The former provided the professional and global expertise in sanitation and the latter provided its competence in economics, project management and knowledge of rural Bangladesh. The purpose of this parent study was to identify the basic constraints to the increased production and sale of water-seal latrine components by NGOs and private sectors, as well as to recommend ways and means to remove those constraints

During the course of this study a new need was felt and a clear distinction evolved between the rural sanitation and the urban sanitation because so few rural people in Bangladesh can afford more than the cheapest known technology in the field of sanitation

Surveys were undertaken to estimate willingness/ability-to-pay for the sanitary components and to assess the performance of delivery mechanisms

From a survey of 400 families who had already installed a latrine, and 2400 families who had not got a sanitary latrine yet, it was revealed that:

- The survey yielded the following results with respect to the willingness/ability to pay (full payment upon purchase):

4% can/want to pay	Tk 450 or more
27% can/want to pay in the range	Tk. 250 to Tk 450
69% cannot pay more than	Tk 250
19% cannot pay more than	Tk 100
7% cannot pay more than	Tk 70

  It may be mentioned here that
  Tk. 70 = DPHE sale price of 1 slab + 1 ring
  Tk.250 = DPHE sale price of 1 slab + 5 ring
  Tk 450 = Average sale price of private producer for a 5 set ring

- For payment by installments, more people would be willing/able to purchase at somewhat higher prices

Based on the results of the survey during phase II, the present demand and supply curves for latrine components in rural Bangladesh were plotted and these have the shape and character shown in the figure **on the next page.**

The demand curve 'D' shows the total prevailing demand, whereas the supply curve (Sp) represents of the situation of the private producers. The demand curve as applicable for payment in installment is shown here because this depicts the market coverage of the private producers better because they also sell in installments The hardline demand curve (Ds) shows the stated customer demand whereas Dp is the projected demand. Dg represent an interesting portion of the demand curve if the sale did not allow payment in installments as is the case with the government subsidised sale. An intersection of the demand curve at the DPHE selling price is shown. Qr is the DPHE potential coverage The present coverage is show by point Qp.

The presence of the subsidized price of Tk.250 in the public sector delivery channel influences the purchase behaviour of the buyers who can afford prices above this subsidized price They are reluctant to pay to the private producers more than Tk.100-150 or so above the DPHE selling price inspite of the procurement procedural problems. The projected demand curve has been drawn dotted to show no-subsidy situation.

The subsidies cause a downward distortion of the demand curve as explained above. The potential demand addressable by private producers is therefore reduced from 'c to 'a'. In absence of production constraints, Qr percent of the rural population could have been served by the subsidized price Potential sale of latrine quantities demanding even higher subsidy shall not be addressed by the present level of subsidy. The present share of the DPHE demand is shown by 'b . About 70% of the rural families are unable and/or unwilling to pay (single payment) Tk.250 for a latrine set. The remainder demand is at present, addressed neither by the private production sector nor by the subsidizing government programme.

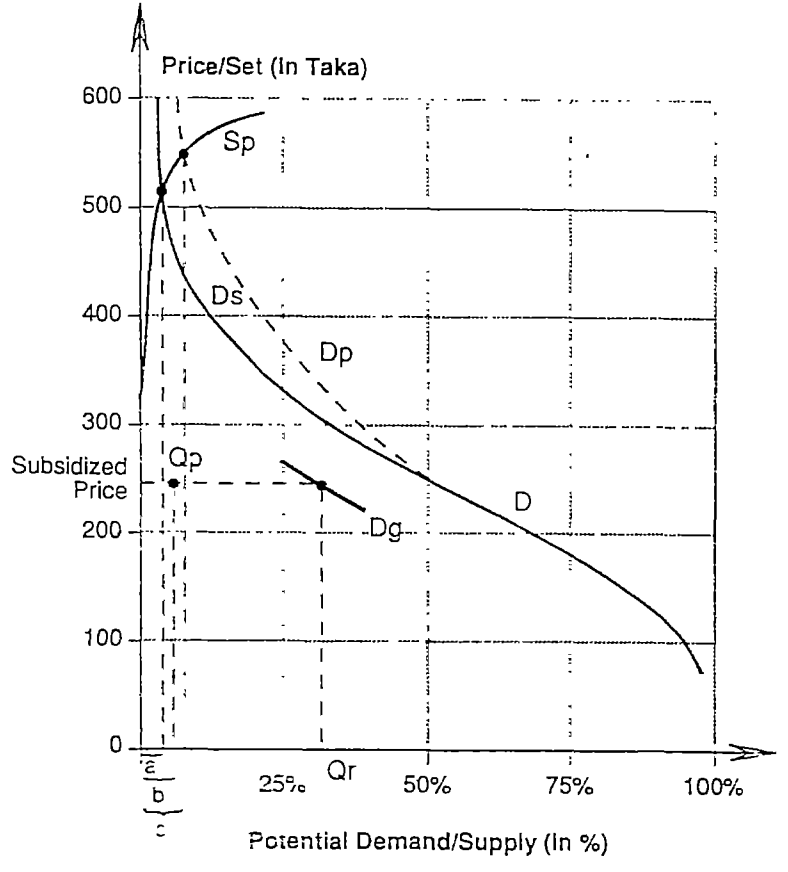
It is also estimated that even at 100% subsidy the willingness to obtain a latrine will not be 100% because of cultural, habitual and other reasons not necessarily based on poverty This is reinforced by the historical fact that at the very inception of the programme the latrines were distributed free but the demand was very low and most of the supplied latrines were not used.

For increasing the sanitation coverage it is important that the demand and supply curves are influenced by some interventions. A shift of the demand curve to the right is synonymous with a general increase of people's ability/willingness to pay for the latrine components. This could be done, among other factors, by the following means

DEMAND & SUPPLY CURVE

Based on Present Situation

Payment in Installments



a = Present Private Sector Demand
b = Present Coverage by the DPHE Supplied Latrines
c = Potential Demand for Private Producers
D = Demand Curve
Ds = Stated Demand
Dp = Projected Demand
Dg = Represents Demand Curve for DPHE Share
Qp = Present DPHE Production Coverage
Qr = Projected Demand for DPHE
Sp = Supply by Private Producers

- By motivational development
- By introducing credit for purchase
- By more efficient delivery channel

Similarly shifting of the supply curve downwards indicates that the technology is more accessible to the poor This curve could be shifted downwards by the following means

- Reduction of rings per unit latrine
- Finding cheaper technological options

This prompted concerted efforts on action research activities on sanitation components.

2. The Need for Action Research on Sanitation

While conducting Phase I of the project during May - June 1989 it was felt that in addition to heavy investments in motivational development, a less costly technology option will have a higher possibility to make latrines more accessible to its target groups Undertaking of an action research programme on sanitation technology was recommended at that point The need was further emphasised during the Phase II of the study It was firmly held that positive outcomes of the action research will enable a better coverage of sanitation in Bangladesh

Having understood that this is going to be rather a difficult area for action research, it was also realised that even a small savings in the area can lead to an increased market share of significant importance An attempt was made to delve into the analytical documentation of previous efforts in this field Findings revealed that very little of technically analytical work done in Bangladesh had been documented. It was marked that it has been quite a few years after whatever scant was done so far. In the mean time, latest technological options have come up and tried in other parts of the world.

Recommended special effort on action research exercise was launched in the backdrop of above findings The programme was sponsored by SDC and executed in collaboration with the Department of Public Health Engineering (DPHE) and Unicef Unicef supplied the materials of the programme and allowed the use of existing mould, tools etc while DPHE granted their research facilities at Village Sanitation Research Centre (VSRC) in Mohakhali to be used for the programme. The SDC provided a major share of the expenses incurred in this programme including personnel, travel, moulds, tests etc

Phase III of the study involved a field test in a pilot area of 1" thick rings recommended earlier in the current action research to test the suitability of the suggested rings in the actual field condition

3. Terms of Reference and Scope of Action Research

A copy of the TOR agreed between the partners is given in **Appendix 1.**

After the initial procedural formalities, the action research programme was carried out on the following aspects of latrine components.

- Alternate dimensions
- Alternate design of materials
- Alternate mix of materials
- Installation issues

As the ring component of the latrine structure is extremely cost sensitive, a small saving in the ring component is likely to bring about a substantial effect on the overall economy of the rural latrines. Therefore, the first ten months of the research programme concentrated mainly on the ring component, trying a number of alternatives and options. After the initial research for adaptation of 1" thick latrine rings with concrete mix of 1:2.5:5 was recommended instead of traditional 1.5" thick ring with concrete mix of 1:3:6, which enabled saving of 20% on the components. In the later part of the programme action research was conducted on other components of the latrines as well till end of the programme. The field tests of the recommended 1" thick R.C.C. latrine rings were done by casting these in DPHE VS centres in a pilot area which began in April 1991. Supervision of construction of 1' thick R.C.C rings and monitoring of latrines built with 1' thick rings continued till the end of the programme i e. April 1992.

The usual components of a village latrine are as follows

- The pit, (a well, a ditch or a trench)
- The lining for the pit
- The slab on top of the pit (which also holds the pan)
- The pan of the latrine (water seal or chute type)
- The superstructure

There is wide scope for varied research approach to improve rural sanitation technology But in order to limit our study within a well-defined framework, the reported action research was confined into following components and areas only.

1. Latrine pit linings
2. Latrine slabs
3. Latrine pan design
4. Latrine superstructures
5. Field Tests on 1" thick RCC latrine rings

During the programme we have carried out in-depth research on the following topics of the above components, and have tried to deduce analytical conclusions and recommendations

The detail research activities were carried out on the following topics

- Research on RCC latrine rings with varied dimension, concrete mix and reinforcement
- Improvement on casting technology of RCC rings
- Research on alternative pit linings
- Gathering information on top-soil types from all over Bangladesh in order to determine number of rings required for latrine construction in different areas
- Research on designs of improved pan from hydraulic flow point of view
- Smoothening of latrine pans with linings and analytical tests on various types of pans
- Research on Mozambique-type Dome and Sanplat type latrine slabs
- Research on latrine superstructure with normal and treated bamboos and other materials
- Field test of 1" thick rings

Extensive discussions on each of the topics has been presented in relevant chapters.

4. Research Activities

Detailed activities under each research item was considered and the following break-down list was prepared The whole programme was conducted according to the following modus operandi

4.1 Research concerning Latrine Pit Linings

Research work on this component involved following four items and detailed activities as mentioned below were carried out.

4.1.1 Research on R.C.C. Rings

- Reason for selecting ring as action research item (Activity # 1)
- Discussions with Unicef/DPHE (2)
- Fixation of Alternative dimensions (3)
- Determining variables for research on rings (4)
- Selection and approval of venue for action research (5)
- Trial castings of rings (6)
- Reducing the variables to form a pragmatic approach (7)

  - * Ring thickness
  - * Ratio of mix of concrete
  - * Reinforcement size, type & placement
- Casting schedules with selected variables (8)
- Casting of rings with various alternatives (9)
- Cost estimating for various alternatives (10)
- Holding of workshops on research on rings (11)
- Conducting tests on 1" thick rings (12)
  - * Handling and rolling tests
  - * Laboratory test on relative strength of various alternatives at BUET
- Cost and strength analysis (13)
- Recommendations of the action research (14)
- Reporting (15)

4.1.2 Improvement in Casting Technology of Rings

- Study of normal manual casting device of latrine rings (Activity # 1)
- Designing and manufacturing of mechanical casting device (2)
- Use of this device to save time and energy (3)
- Improvement of the device through study and research (4)
- Casting of rings with improved device and testing options for saving time (5)
- Cost estimation of the device (6)
- Reporting (7)

4.1.3 Research on Alternative Pit Linings

- Various alternative materials for pit lining (Activity# 1)
- Their use in specific conditions (2)
- Discussions with Unicef/DPHE (3)
- Recommendations (4)
- Reporting (5)

4.1.4 Study on Types of Top-soil

- Discussions with Unicef/DPHE (Activity # 1)
- Acquiring information from different secondary sources (2)
- Compilation of acquired information (3)
- Preparation of area maps, if possible (4)
- Reporting (5)

4.2 Research concerning Latrine Slabs (without pan)

- Study on different types of squatting plates (Activity # 1)
- Internal discussions between IRCWD and Interchain for technical details of slabs (2)
- Designing of latrine slabs without pan (3)
- Study of the documents, on different types of latrine slabs (4)
  - * Mozambique type Dome slab
  - * Malawi type Sanplat slab
- Modification of designs to suit local conditions (5)
- Making mould etc. for the slabs (6)
- Casting of Mozambique dome type slab (7)
- Testing of the Dome slab (8)
- Casting of Sanplat slab (9)
- Testing of the Sanplat slab (10)
- Material requirements and cost estimates for the slabs (11)
- Cost comparisons and other considerations (12)
- Discussions with Unicef/DPHE (13)
- Field test of the recommended slabs (14)
- Efforts to accelerate production and sale of such slabs in field by private producers (15)
- Recommendations emanating from field data (16)
- Reporting (17)

4.3 Research concerning Latrine Pans

In research of the pan component of latrine, following three varieties were tried, the detail activities of which are mentioned below.

4.3.1 New Design from Hydraulic Flow Point of View

- Study of existing types of latrine pans, their qualities and prices (Activity # 1)
- Designing of modified pan from hydraulic flow point of view (2)
- Making mould for the designed pan (3)
- Making few pans with this design (4)
- Study of pour-flush pan made by BSIF, Mirpur (5)
- Contacting with RDRS, MAWTS and private producers (6)
- Discussions with Unicef/DPHE (7)
- Modification of the design as necessary (8)
- Making new mould for the modified pan (9)

- Casting of new modified pan (10)
- Analytical tests with new pans, in comparison with standard DPHE type (11)
- Result of the test and recommendation (12)
- Reporting (13)

4.3.2 Smoothening of Pan by Special Lining

- Study of various types of lined pans made by private producers (Activity # 1)
- Procuring information on pour flush pan manufactured by BSIF under DPHE programme (2)
- Collection of sale prices of various types of pans produced by private producers (3)
- Finalisation of lining material for this action research work (4)
- Construction of lined pans with lining materials such as (5)
  - * with marble touch materials
  - * with white cement
- Cost comparison of the products (6)
- Analytical tests for estimating effectiveness (7)
- Result analysis and recommendations (8)
- Reporting (9)

4.3.3 Research on Plastic Pan

- Discussions with DPHE/Unicef (Activity # 1)
- Discussions with MAWTS (2)
- Decision regarding progress of work of research on plastic pan (3)
- Research work on plastic pans as required (4)
- Reporting (5)

4.4 Research concerning Latrine Superstructures

- Information collection regarding size and other specifications (Activity # 1)
- Study of the various potential alternatives (2)
- Designs and dimensional details (3)
- Construction of some superstructures from the selected alternatives (4)
- Preparation of material requirements and cost estimates (5)
- Comparison of cost and other considerations (6)
- Selecting fewer alternatives (7)
- Erection of superstructure from these alternatives (8)
  - * With treated bamboo terza
  - * With untreated bamboo terza

- Design of modular form of bamboo/terza superstructure and its components (9)
- Possibilities of building superstructures with other non-traditional alternative materials (10)
  - With Ferro-cement panels
  - With jute-sticks
- Prevailing technology for bamboo treatment from different sources (11)
  - BFRI
  - HBRI
  - BCSIR
- Procurement of bamboo treatment equipment and chemicals and training of some private producers in the field (12)
- Preparation of some superstructure with treated bamboo in the field (13)
- Cost analysis and recommendations (14)
- Placing proposal for distribution of treated bamboo superstructures through DPHE regional stores (15)
- Reporting (16)

4.5 Field test of 1" thick RCC Latrine Rings

- Preparing programmes for field test of recommended 1" thick rings (Activity #1)
- Discussions with Unicef and DPHE (2)
- Finalisation of pilot project area - 3 DPHE VS production centres (3)
- Completion of govt. formalities for taking up the work in the field (4)
- Appointment of field supervision for the work by the consultants (5)
- Supply of design, drawings and test results of 1" thick rings to DPHE field officials (6)
- Manufacturing of moulds for casting 1" thick rings (7)
- Supply of the moulds to DPHE field production centres (8)
- Training of DPHE masons (9
- Casting of 1" thick rings, instead of standard 2" thick rings, in selected DPHE VS production centres (10)
- Supervision of casting in the VS centres by consultants (11)
- IRCWD opinion on field tests
- Keeping record of production and sale of 1" thick rings at these VS centres (12)
- Maintaining close liaison with DPHE officials in the field at HQ (13)
- Paying occasional monitoring visits to field by consultants' senior officials (14)
- Monitoring of installed latrines with 1" thick rings (15)

- Regular exchange of views with DPHE and consultants' field officials (16)
- Organising workshop in the field HQ on the basis of collected data (17)
- Reporting (18)

5. Implementation of the Action Research

The entire research on sanitation components was carried out in accordance with the above mentioned activities The implementation was carried out in close cooperation with DPHE and Unicef officials in Dhaka and the field officers of DPHE in Faridpur district.

The work directly or indirectly connected with the action research has been implemented during 1990-92.

The study and the action research programme was conducted by officials of the regional office of the Interchain Project Consultants AB in Dhaka The programme activities were carried out at VSRC premises of DPHE at Mohakhali, Dhaka and in the VS centres of DPHE in Faridpur district Occasional monitoring has been done by the IRCWD, Switzerland by field visits and giving comments on the submitted monitoring reports. The detailed findings of the study have been recorded in the relevant chapters

6. Forthcoming 5-P Exercise

In continuation of the study on "Promotion of Rural Sanitation in Bangladesh" and in order to use the results of Action Research on Sanitation Components, and to achieve the goal of wider sanitation coverage in Bangladesh the Swiss Development Cooperation, SDC, is going to undertake the next programme on sanitation entitled "Pilot Plan for Private Producers' Participation"

It has been observed that on the supply side of sanitation components there are three delivery channels, viz

- the public sector i.e. DPHE
- NGOs
- the private sector

But in most of the existing interventions, the institutional assistance has been provided to the public sector channel and the delivery has taken place through NGOs The private sector has always been neglected

The objective of this programme is to actively promote participation of private producers of sanitation components in order to increase the sanitation coverage.

The pilot project will have coverage in a selected area, preferably the same area in which the field-tests of action research work has been carried out The aim of the programme will be optimal and balanced combining of two delivery channels i.e the DPHE channel and the private producers

Some of the elements of the 5P exercise will be

- baseline survey of the sanitation environment in the pilot area
- training of the private producers
- one time assistance to the private producers
- credit facilities to the private producers
- promotional activities
- coordination with action research activities
- monitoring and evaluation of the programme
- impact evaluation

On completion of the 5P exercise, which is expected to continue for two years, the final report will be submitted with final survey, impact results and recommendations

Current programme of GoB/DPHE on sanitation stresses that by 1995 DPHE will privatise the latrine production and will act mainly as policy maker on the sector of water supply and sanitation According to the GoB Unicef agreement for Rural Water Supply and Sanitation Programme, 1992-1995 "DPHE will develop a new strategy for private sector investment from 1995 onwards in collaboration with GoB and ESA for which a pilot project will be launched and evaluated by 1995"

At present no model for development of private producers in sanitation sector is available to DPHE Therefore the 5P exercise its findings and recommendations will be very useful in the strategic policy formulations in the sanitation sector

RESEARCH CONCERNING PIT LININGS

1. General

A latrine mainly consists of two parts viz. the superstructure and the sub-structure, partitioned by a slab in the middle on the ground level The sub-structure generally consists of the pit or trench dug in the ground to make space for holding the excreta For safety of the pit and proper encompassing of the excreta, the pit is usually lined by some suitable material

The 'Pit' is that component of a rural latrine which holds the human excreta within a well-protected area thereby stopping undesirable smell and spread of germs It acts as both a storage and isolation chamber for all germs connected with human wastes It is a very important part of a latrine from hygienic point of view

A standard pit may take from 4 to 10 years to fill up, depending upon the volume of the pit and the number of persons using it. A decomposition process takes place in the pit which decreases the volume of wastes deposited by about 50 percent. For a latrine used by 5 persons to last for 4 years without being filled up, a pit of 60 cft volume is required.

During the early stage of the study, experiments concentrated mainly on the pit lining component of the latrine

2. Types of Pit Linings

There are various types of materials used as lining of a latrine pit. Some of these are.

- bricks, placed in honey-comb style
- compressed clay blocks
- concrete hollow-blocks
- bamboo sticks, full or splits
- tree leaves, such as palm coconut etc
- banana tree trunks
- reinforced concrete rings
- plain concrete rings
- burnt clay rings
- firing in the pit

For low cost latrines, the burnt clay rings are good for utilisation as latrine pit rings These are produced as open-well rings and are capable of competing with concrete rings. The burnt clay rings are cheap in price, smaller in size, light in handling and effective as pit linings These are quite okay as latrine pit linings because more than 20 rings can be placed one above the other But main disadvantage is that these are very brittle and can break during transportation if not carefully handled Neither are these available in all parts of the country due to lack of desired quality of clay and artisan

Out of the above-mentioned pit linings, the reinforced concrete rings are the most versatile and most widely used as lining of latrines Other materials are used under specific conditions DPHE produces latrine rings of RCC and markets these for lining of rural latrines Private producers are also manufacturing and selling RCC rings of various dimensions to meet varied market demands

The reasons behind the use of RCC rings as latrine pit lining may be identified as follows:

- those can be manufactured in any place by anyone with a little training
- the materials, i.e. cement and GI wire are widely available
- these can be stored for a longer period
- these are safe for transportation and installation

In this enquiry special research was undertaken on the improvement of pit linings, especially on RCC rings

3. Research concerning RCC Rings

An usual rural latrine consists of a slab and a pan on the top and five rings in the sub-structure Some of the dimensions of the latrine components are very sensitive to the overall costing. A small change or saving in these ring component brings substantial effect on the cost of a rural latrine, as this amount or saving generally gets multiplied by five times in a single unit

3.1 Alternative Dimensions

In construction of RCC rings a number of variables are taken into account Such as

- height of a ring
- thickness of a ring
- diameter of a ring
- size of khoa (brick aggregate) and type of sand
- mixing ratio
- type, size and placement of reinforcement

After some initial work was done, the number of ring variables were reduced down to a pragmatic level The height of the ring was kept 12", as used by DPHE, considering the fact that this gives optimum handling effectiveness Some other parameters such as outer diameter of the ring, materials of the mix such as cement, sand and brick-aggregates etc. were also kept unchanged in accordance with DPHE standard rings for research purpose

3.2 Variables of Research Rings

After a brain-storming session during the action research, an attempt was made to minimise the number of variables. In the present study, the following variables were considered for investigation in the workshop based research.

- ring thickness- 3 types
- ratio of mixing of concrete- 6 types
- reinforcement- 6 types

The following varieties of rings were used in the action research

- 1" thick - 6 mix type - 6 reinf type = 36 varieties
- 3/4" thick - 2 mix types - 6 reinf. type = 12 varieties
- 1.5" thick - DPHE type = 1 variety

Total 49 varieties

3.2.1 Variation by Ring Thickness

As the five-ring latrine is the most common type used by the people, thickness of the ring is the most sensitive single dimension in the entire set of existing standard components of the latrine.

The ring thickness is the most cost sensitive single dimension in the entire set of latrine components. DPHE makes the RCC rings with 1.5" thickness In our research work alternate ring thicknesses of 1" and 3/4" were considered. Rings are manufactured with other variables for each of 1" and 3/4" thicknesses Standard 1.5 thick rings were also manufactured during our research for comparison purpose Finally, all these rings were subjected to tests in the field and in the laboratory

3.2.2 Variation by Mix Proportion

Following six ratios of concrete mix were used to manufacture RCC rings for the research purpose

- 1:2.5:5 (cement, sand & aggregate)
- 1.3:6

- 1:4:8
- 1:5.7
- 1:6·10
- 1·4 (2+2) (cement, local sand + Sylhet sand)

The above ratios of the mix correspond to the quantity of cement, sand and brick aggregate Only in the last named case the ratio represents the volume of cement to that of sand (local sand and Sylhet sand mixed in equal volume)

3.2.3 Variation by Reinforcement Type and Number

The following six types of reinforcement were tried during the research work.

Type-1
- No reinforcement
- The rings are installed without any reinforcement i e. in plain cement concrete (PCC)

Type-2
- Standard DPHE type reinforcement
- MS Wire of SWG-10 of DPHE/UNICEF Standard Three reinforcing circular rings are provided. The first ring is placed after casting 1" of height, second ring is placed after a 5 height and the last ring is fitted at a height of 11'. The MS wire ring should be positioned at the centre of the casting shutter.

Type-3
- Bamboo reinforcement
- The bamboo reinforcement is made of thin splits cut out of full bamboo. The bamboo splits make bamboo reinforcement rings are approximately 15 mm x 3 mm in size The first bamboo ring is placed after a casting 1" height, second ring is positioned after 5" height and the last ring is fixed at a height of 11". The placements are similar to that of steel rings

Type-4
- As used by Private Producers (PP)
- MS Wire of SWG-16 is used by some of the private producers Three circular rings are provided The first ring is given after casting 1" height, second ring is added after 5" height and the last ring is located at a height of 11'. The MS wire is positioned at the centre of the shutter mould

Type-5
- Less than DPHE reinforcement
- Only two circular rings are required in MS wire SWG-10 The placement of first MS wire is after casting 1-1/2 height and the last ring at a height of 10-1/2" The MS wire is placed at the centre of the shutter mould

Type-6
- Less than PP reinforcement
- The circular rings of MS wire SWG-16 are only two in number. The placement of first MS wire is after casting 1-1/2" height, and the last ring at a height of 10-1/2". The MS wire is placed at the centre of the shutter mould

3.3 Casting of Research Rings during Research

The castings of the experimental rings were done with a combination of the above three variables, keeping other factors unchanged

Unchanged factors or variables have been:
- Outer diameter = 30"
- Height = 12"

Other fixed parameters.
- Cement: Portland cement from market
- Sand: Local sand
- Aggregates: 3/8" down-graded
- Water-cement ratio = 0.50 to 0.55

3.3.1 Casting Schedule

A schedule for casting experimental rings was finalised in four groups, and the castings were done during the months from April 1990 to June 1990.

The following table gives various physical dimensions of the rings manufactured for the research programme in four different groups

Group	Wall Thickness	Variables by		Nos. of samples	Nos. of rings
		mix	reinf.		
A	1'	6	6	36	108
B	1'	6	6	36	72
C	3/4	2	6	12	36
D	1-1/2"	1	1	1	4

All the rings were cast in the Village Sanitation Research Centre (VSRC) of DPHE at Mohakhali, Dhaka. Total construction activities were as follows

Group A 1" thick rings with traditional shutter mould, 36 variables - (108 nos) April 1990

Group B 1" thick rings with mechanical device, 36 variables - (72 nos.) April - May 1990

Group C 3/4" thick rings, 12 variables - (36 nos) May 1990

Group D 1-1/2" thick ring, single variable - (4 nos) June 1990

Final Test 4 variables (20 nos) July 1990

In group C, the 3/4" rings were cast to experiment if rings of less then 1" thick were feasible Better quality concrete of richer mix was used to make this particular type of rings

The rings were later cured by dipping into the curing tank and were properly stacked after that marking each ring for its variables Later rolling tests and laboratory tests were done at the laboratory of Bangladesh University of Engineering and Technology (BUET), to ascertain their workability and strength

Each type of sample rings, with a set of variables was cast three times It was decided that one ring from each sample will be used for rolling and handling tests. Those samples which passed the rolling test were sent to laboratory for load bearing tests Two of each samples were tested in the laboratory to get an average result Apart from a number of rings cast in the trial-casting before the actual experimentation a total of 240 rings were cast using traditional shutter moulds with the help of a mechanical device, and combination of different variables

3.3.2 Cost Analysis of Rings with Variables

Detailed analysis of materials and cost estimates was undertaken for rings with different variables to evaluate the relative costs These materials and cost estimates have been tabulated and are given on the following pages.

The following unit costs and materials calculations have been included in these estimates.

The unit costs for the estimates are taken as

- Cement Tk 4 40 per kg
- Local sand Tk 6.80 per cft
- Sylhet sand Tk 10 00 per cft
- Aggregates Tk 20 00 per cft
- MS bar for reinf Tk 22.00 per kg
- Mason Tk. 52.00 per day
- Labour Tk 44 00 per day

CONSTRUCTION MATERIALS ESTIMATE PER RING (1" THICK)

Sl No	Reinf. Type	Mix Proportion	No of Ring	Quantity					Mason Cost/ Unit	Labour Cost/ Unit	Quantity Sylhet Sand	Remarks
				Cement kg	Sand cft	Khoa cft	S Wir	C Oil Tk				
1	2	3	4	5	6	7	8	9	10	11	12	13
1	T-1	1.2 5:5	1	4 40	0.27	0 54	–	0.50	3 25	2.75	–	
2	(No	1.3 6	1	3.60	0.28	0.55	–	0 50	3 25	2.75	–	
3	steel)	1:4.8	1	2.80	0 28	0 57	–	0 50	3 25	2.75	–	
4		1:5.7	1	2.80	0 35	0.50	–	0.50	3.25	2.75	–	
5		1:6 10	1	2.16	0 32	0.54	–	0 50	3.25	2.75	–	
6		1:4(2+2)	1	7 20	0.37	–	–	0.50	3.25	2.75	0 37	
7	T-2	1:2.5 5	1	4 40	0.27	0.54	–	0.50	3.25	2.75	–	
8	(DPHE)	1.3.6	1	3.60	0.28	0 55	–	0.50	3.25	2.75	–	
9		1:4.8	1	2.80	0.28	0.57	–	0.50	3 25	2.75	–	
10		1:5:7	1	2.80	0.35	0.50	–	0.50	3.25	2.75	–	
11		1:6 10	1	2.16	0.32	0.54	–	0.50	3 25	2.75	–	
12		1:4(2+2)	1	7.20	0 37	–	–	0.50	3.25	2.75	0 37	
13	T-3	1 2.5.5	1	4 40	0 27	0.54	–	0 50	3 25	2 75	–	
14	(Bamboo)	1.3:6	1	3.60	0 28	0.55	–	0.50	3 25	2 75	–	
15		1:4:8	1	2.80	0.28	0.57	–	0.50	3.25	2.75	–	
16		1:5:7	1	2.80	0 35	0.50	–	0.50	3.25	2.75	–	
17		1:6 10	1	2.16	0.32	0.54	–	0.50	3.25	2 75	–	
18		1:4(2+2)	1	7.20	0.37	–	–	0.50	3.25	2.75	0 37	
19	T-4	1·2.5.5	1	4.40	0 27	0 54	–	0.50	3.25	2.75	–	
20	(PP)	1:3 6	1	3.60	0.28	0.55	–	0 50	3.25	2.75	–	
21		1:4:8	1	2.80	0 28	0.57	–	0.50	3.25	2.75	–	
22		1:5:7	1	2.80	0 35	0 50	–	0 50	3.25	2.75	–	
23		1:6·10	1	2.16	0.32	0.54	–	0.50	3.25	2.75	–	
24		1·4(2+2)	1	7 20	0 37	–	–	0.50	3.25	2.75	0 37	
25	T-5	1.2.5 5	1	4 40	0.27	0.54	–	0.50	3.25	2.75	–	
26	(less	1.3.6	1	3 60	0.28	0.55	–	0.50	3.25	2.75	–	
27	DPHE)	1·4.8	1	2.80	0 28	0.57	–	0.50	3.25	2.75	–	
28		1:5·7	1	2.80	0.35	0 50	–	0.50	3.25	2.75	–	
29		1:6.10	1	2.16	0.32	0.54	–	0.50	3 25	2.75	–	
30		1:4(2+2)	1	7.20	0 37	–	–	0.50	3 25	2.75	0.37	
31	T-6	1·2.5:5	1	4 40	0.27	0 54	–	0.50	3 25	2 75	–	
32	(less	1:3 6	1	3.60	0 28	0.55	–	0.50	3.25	2.75	–	
33	PP)	1.4.8	1	2.80	0.28	0 57	–	0.50	3 25	2.75	–	
34		1:5·7	1	2 80	0 35	0 50	–	0.50	3 25	2.75	–	
35		1.6 10	1	2.16	0.32	0 54	–	0.50	3 25	2.75	–	
36		1 4(2+2)	1	7 20	0 37	–	–	0.50	3 25	2 75	0 37	

CALCULATION OF ACTUAL COST PER (1" THICK) RCC RING

Based on Prices as used by DPHE

1) Cement = Tk. 220 per 50 kg Bag = (Tk 4.40 per kg)
2) Reinforcement for ring, MS wire No.10 Tk. 22 per kg
3) Sand = Tk 6 80 per cubic ft.
4) Brick chips (khoa) = Tk 20 per cubic ft
5) Crude Oil = Tk 0.50 per ring
6) Sylhet sand = Tk 10 per cubic ft
7) Bamboo Reinforcement Tk 2 71 per ring (material+labour)
8) Mason Tk 3 25 per ring
9) Labour Tk. 2 75 per ring

Sl No.	Reinf. Type	Mix Proportion	COST Cement Tk.	Sand Tk.	Khoa Tk	S Wir Tk	C Oil Tk	Mason Tk	Labour Tk	Total Cost (Tk)	Remarks
1	2	3	4	5	6	7	8	9	10	11	12
1	T-1	1.2 5 5	18 97	1 83	10.78		0.50	3.25	2 75	38 08	
2	(No	1 3 6	16 13	1 87	11 00		0 50	3 25	2 75	35 5	
3	steel)	1 4 8	12 41	1.92	11 28		0 50	3.25	2.75	32 11	
4		1:5.7	12 41	2 40	9.86		0 50	3 25	2 75	31 17	
5		1:6.10	9 49	2.20	10.78		0.50	3 25	2.75	28 97	
6		1 4(2+2)	32.25	2.49	3.67		0 50	3.25	2.75	44 91	
7	T-2	1:2.5:5	18.97	1.83	10.78	12.54	0.50	3.25	2.75	50 62	
8	DPHE	1 3 6	16.13	1.87	11.00	12.54	0.50	3.25	2.75	48.04	
9		1 4 8	12.41	1 92	11.28	12 54	0,50	3.25	2 75	44 65	
10		1:5.7	12.41	2.40	9,86	12 54	0.50	3.25	2 75	43.71	
11		1.6 10	9 49	2.20	10 78	12.54	0.50	3.25	2.75	41.51	
12		1:4(2+2)	32.25	2.49	3.67	12.54	0,50	3.25	2.75	57 45	
13	T-3	1:2.5.5	18 97	1.83	10.78	8 13	0.50	3.25	2 75	46 21	
14	ambo	1.3:6	16.13	1 87	11.00	8.13	0 50	3 25	2.75	43.63	
15		1:4:8	12 41	1.92	11 28	8.13	0.50	3.25	2.75	40.24	
16		1 5:7	12.41	2.40	9,86	8 13	0.50	3.25	2.75	39 3	
17		1:6 10	9.49	2 20	10.78	8 13	0.50	3.25	2 75	37 1	
18		1:4(2+2)	32 25	2 49	3 67	8 13	0.50	3.25	2.75	53 04	
19	T-4	1:2.5 5	18.97	1 83	10.78	5 08	0.50	3.25	2.75	43 16	
20	(PP)	1 3 6	16.13	1.87	11,00	5 08	0,50	3.25	2 75	40.58	
21		1 4 8	12,41	1 92	11,28	5 08	0.50	3.25	2.75	37 19	
22		1:5.7	12.41	2,40	9,86	5.08	0.50	3 25	2 75	36 25	
23		1 6 10	9.49	2.20	10.78	5 08	0.50	3.25	2 75	34 05	
24		1 4(2+2)	32.25	2 49	3,67	5 08	0.50	3.25	2.75	49 99	
25	T-5	1:2 5.5	18 97	1.83	10,78	8 36	0.50	3.25	2.75	46 44	
26	(less	1.3 6	16 13	1.87	11.00	8 36	0.50	3.25	2.75	43 86	
27	PHE	1:4:8	12 41	1 92	11.28	8.36	0.50	3.25	2.75	40 47	
28		1.5.7	12 41	2.40	9.86	8 36	0 50	3.25	2 75	39 53	
29		1:6.10	9 49	2.20	10.78	8 36	0.50	3.25	2 75	37 33	
30		1:4(2+2)	32.25	2.49	3.67	8 36	0.50	3 25	2 75	53 27	
31	T-6	1:2.5:5	18.97	1.83	10.78	3 39	0.50	3 25	2 75	41 47	
32	(less	1 3 6	16 13	1.87	11.00	3.39	0 50	3.25	2 75	38 89	
33	PP)	1:4.8	12.41	1 92	11.28	3 39	0 50	3 25	2 75	35 5	
34		1:5.7	12.41	2.40	9.86	3.39	0 50	3 25	2 75	34.56	
35		1 6 10	9.49	2.20	10.78	3 39	0.50	3 25	2 75	32 36	
36		1 4(2+2)	32.25	2 49	3 67	3 39	0 50	3.25	2 75	48 3	

CALCULATION OF COST, RING (3/4" THICK)

Sl No	Reinf Type	Mix Proportion	COST Cement Tk	Sand Tk	Khoa Tk	MS Wire Tk	C Oil Tk	Mason Tk	Labour Tk	Total Cost (Tk)	Remarks
1	2	3	4	5	6	7	8	9	10	11	12
1	T-1	1.2 5 5	14 10	1 36	8 01		0 50	3 25	2.75	29.97	
2		1 3 6	11 99	1 39	8 17		0 50	3 25	2.75	28 05	
3	T-2	1 2 5 5	14 10	1 36	8 01	12.54	0 50	3 25	2.75	42.51	
4		1.3 6	11 99	1 39	8 17	12 54	0 50	3 25	2.75	40.59	
5	T-3	1:2.5:5	14.10	1 36	8 01	8 13	0 50	3.25	2 75	38.1	
6		1:3 6	11 99	1 39	8 17	8 13	0.50	3 25	2 75	36 18	
7	T-4	1 2 5 5	14 10	1 36	8 01	5 08	0 50	3.25	2.75	35 05	
8		1 3 6	11 99	1 39	8 17	5 08	0 50	3 25	2 75	33.13	
9	T-5	1 2 5 5	14 10	1.36	8 01	8 36	0 50	3 25	2 75	38.33	
10		1:3 6	11 99	1 39	8.17	8 36	0 50	3 25	2 75	36 4	
11	T-6	1 2 5 5	14 10	1.36	8 01	3 39	0 50	3 25	2 75	33.36	
12		1.3 6	11 99	1.39	8.17	3 39	0 50	3 25	2 75	31 44	

CALCULATION OF COST, RING (1-1/2" THICK)

Sl No.	Reinf. Type	Mix Proportion	COST Cement Tk	Sand Tk	Khoa Tk	MS Wire Tk	C.Oil Tk	Mason Tk	Labour Tk.	Total Cost (Tk)	10% Overhead Added
1	2	3	4	5	6	7	8	9	10	11	12
1	T-2 DPHE	1 3 6	24 62	2 85	16 78	12.54	0 50	3.25	2 75	63 29	70%

The volume of concrete in a ring has been calculated by using the following formula

$V = \pi \times (D2 - D1)/4 \times H$
$= 0.785 (D2 - D1) H$

where
V = volume of concrete in cft
D2 = outer diameter of ring in ft.
D1 = internal diameter of ring in ft
$\pi = 3.14$
H = height of ring in ft (in this case it is = 1 ft)

DPHE uses 3 nos 10 SWG wires as reinforcement for making RCC rings. Weight of 3 nos 10 SWG rings is 0.57 kg and therefore cost of each ring comes to Tk. 63.29.

The private producers normally use inferior quality steel for reinforcement. Usually they use MS wire of 16 SWG. One kg of 16 SWG wire produces approximately 13 rings of 30" diameter Weight of single ring is 0.077 kg and therefore cost of a ring comes to Tk. 40.58

To analyse the cost of bamboo reinforcement the following estimations have been made A bamboo of 3" diameter 16' long costs Tk. 25 This will produce approximately 40 bamboo splits of 10 mm x 4 mm size. A bamboo worker @ Tk.100 per day produces 50 bamboo reinforcements splits Therefore, the cost of bamboo reinforcement per piece comes to Tk. 2.71.

It is estimated that one mason and one labour cast 16 rings including mixing of concrete, preparation of reinforcement etc . in a working day of 8 hours

3.4 Testing of Rings

During discussion with various key informants one thing was confirmed that the real test of the latrine rings lay in the actual field handling i.e. their durability during transportation, loading and unloading It is felt that the laboratory proved strength of the ring is of less practical value It has been found that even earthen rings made by the potters were successfully used up to 20 in numbers in depth, and when those pits were re-excavated, these rings remained healthy and intact This indicates the relative importance of the handling test in comparison to their strength to withstand the earth pressure

It was decided that each type of manufactured ring will be tested by rolling these over on a rough surface for a distance of 300 feet as a first test The rings then were subjected to loading unloading and had been carried through a distance of 10 km Those samples which survived the rolling and handling tests, were crush-tested in

the laboratory to check their compression strength in order to determine their absolute and relative strengths

The following calculations show that the stress developed on the bottom-most ring of a five ring latrine is only 17 psi approximately, which is far less a strength than provided by any type of concrete

Calculation of earth pressure within soil mass, using Rankine's theory, is:

$$P = Ca.\gamma\ h,$$

Where P = Active earth pressure
γ = Unit Weight of soil
h = Height from original ground level to last RCC ring bottom
Ca = Co-efficient of soil

The co-efficient of soil Ca depends upon the angle of repose, θ

True values of the angle of internal friction can only be obtained by tests of the soil In the absence of laboratory tests, the angle θ may be approximated as follows:

Sl.No.	Soil Type	Angle of repose / Angle of internal friction of soil = θ
1.	dry, loose sand with round grains, uniform gradation	$\theta = 28.5^c$
2.	dry, dense sand with round grains, uniform gradation.	$\theta = 35.0^o$
3	dry, loose sand, angular grains well graded.	$\theta = 34.0^o$
4.	dry, dense sand, angular grains well graded.	$\theta = 46.0^o$
5.	dry, loose silt.	$\theta = 46.0^c$
6	dry, dense silt.	$\theta = 30.0^c$ to 35.0^c

(when the soil is saturated, the angle of internal friction is used as stated considering the buoyed unit weight of the soil particles + the hydrostatic pressure of the water)

Considering the soil as dry dense silt the value of $\theta = 30^c$

The co-efficient of soil $Ca = (1 - \sin\theta) / (1 + \sin\theta)$
$= (1 - \sin 30^o) / (1 + \sin 30^o)$
$= (1 - 0.50) / (1 + 0.50)$

$Ca = 0.33$

Unit weight of soil, $\gamma = \gamma$ sat (most critical condition) = 120 lbs/ft^3
Height of soil pressure h = 4 ft assuming one of the five rings above the ground level

Putting the values.
P = 0 33 x 120 lb/ft^3 x4 ft
P = 158 lb/ft^2

Earth pressure at the bottom ring will be
F = A x P
Where Area, A = 30" x 12" = 2 50 x 1 = 2 50 ft^2
and P = 158 lb/ft^2

Force F = 2.50 ft^2 x 158 lb/ft^2
= 395 lbs

Considering the RCC ring to be divided into two equal parts by a plane of section through the axis, with each plane section having an area of 1" x 12'

Force at any one plane = 2.50 x 158 / 2 = 198 lbs
Stress = 198 lbs / 1" x 12" = 16.5 Ps.
Say 17 Psi

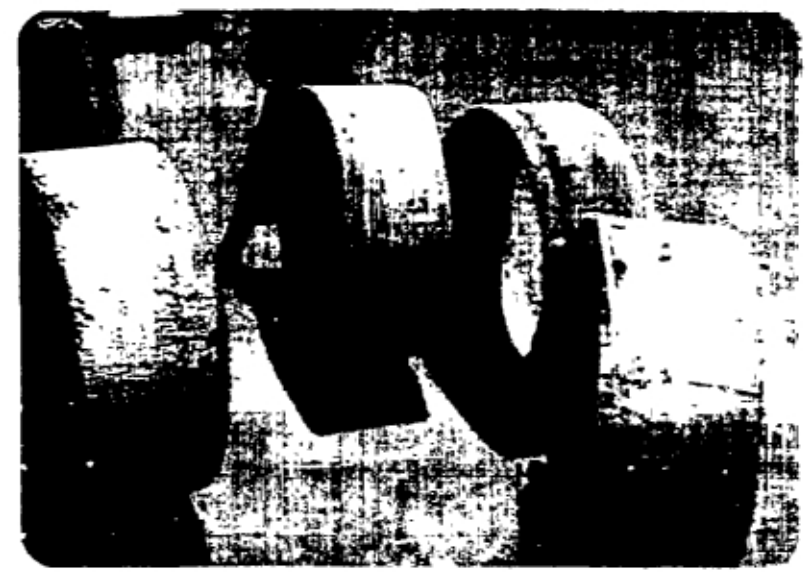
It is seen from the above calculations that the force developed at the lowest ring of the latrine pit in worst soil condition is only 17 psi which is very much lower than the strength of concrete of any nominal mix Therefore, we can be sure that rings made of any concrete mix will be safe against earth pressure in the field

3.4.1 Rolling Test

Observations confirm that the real test of the rings lay in the rolling test Only rolling tests on rough surface can predict its durability and also its practical application in different fields. The rolling test conducted during the action research was far too tough than the actual field handling of the rings All the UNICEF/DPHE staff who watched the test agreed on it

Unicef and DPHE officials were present when the first rolling tests for the rings produced during the action research were conducted on 5th June,1990 RCC rings of different thickness and various types were manually rolled on 300 ft of hard ground to foolproof its strength. HBB and aspnalt roads and even the concrete roads near the VSRC at Mohakhali, Dhaka were used for the test. It was deduced that when the rings survived this rolling operation then they are strong enough to withstand all the normal loads applied to a ring for installation of sanitary latrines

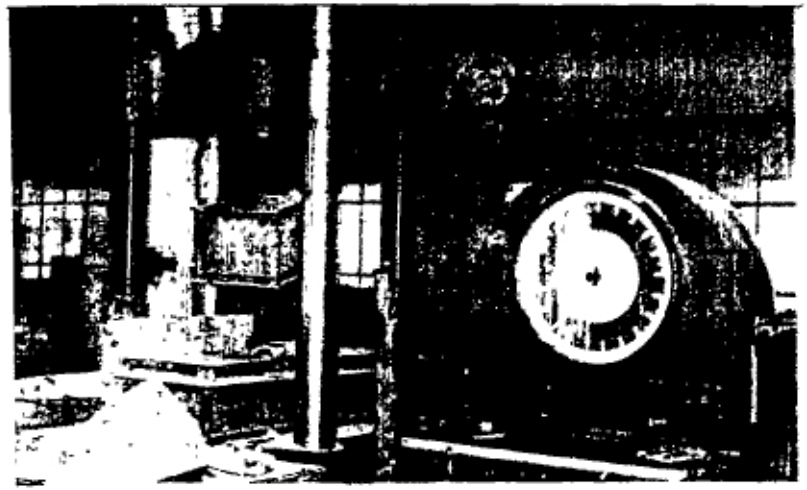
1" Thick Latrine Rings Constructed during Research Work at VSRC Mohakhali, Dhaka



Ring Components ready for Rolling Test

Casting of 1" Thick Latrine Rings at VS Centre, Nagarkanda with New supplied Mould

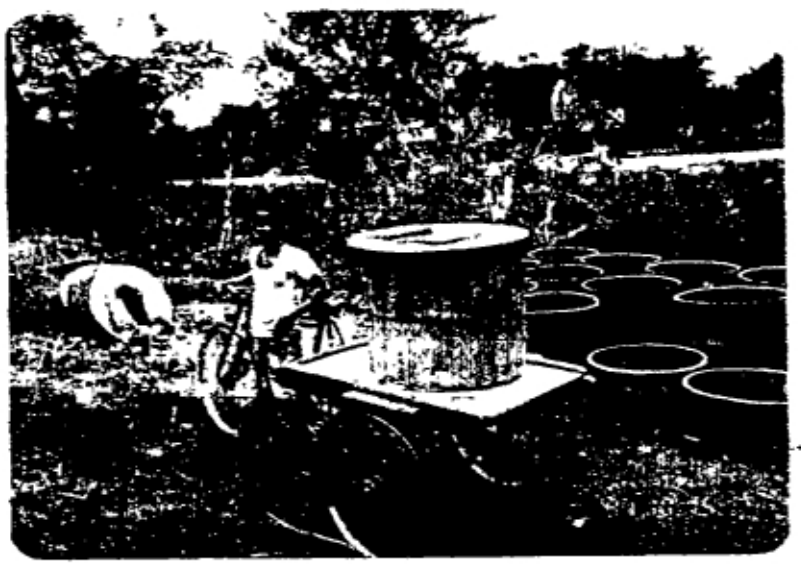
Casting of 1" Thick Ring by Mechanical Device Developed during Action Research Programme



Laboratory Strength Test of 1" Thick Rings at BUET by Mechanical Loading

Load Testing of 1" Thick Rings at BUET by Manual Loading

Thin Burnt Clay Rings for Latrines Produced by Artisan



Rickshaw Van, Traditional Mode of Transportation, with One Slab and Two Rings at Talma VS Centre

A table showing the results of the rolling tests performed is given **on the next page.** It is clear from the table that the bamboo reinforcement rings are not feasible, because almost all of them were broken during the rolling test. The weakest concrete mix of 1:6:10 also proved to be unsuccessful The rings with plain concrete, i e without any reinforcement also failed except in the case of very rich mix It may be mentioned here that in the actual field handling some of the broken rings without a reinforcement or with bamboo reinforcement might have survived because the experimental tests conducted were much severe in nature than the actual handling.

3.4.2 Handling and Carriage Test

Different types of manufactured rings were shifted and handled several times during the action research programme After the rolling test, the remaining rings were loaded in a pickup and transported to a distance of about 12 km at normal speed regardless of the fragility of the load. The rings were also carried to BUET laboratory for load bearing tests.

It is noted that if the rings survive the stress during their handling and normal loading, unloading, stacking and carrying it can be assumed that these are strong enough for our village sanitation purpose.

3.4.3 Laboratory Test of Sand Bearing Method

The RCC rings were subjected to load test in the laboratory, using sand bearing method It is necessary for the test that the testing machine should be of sufficient size and rigid throughout, so that it can provide a uniform pressure throughout the full length of the RCC rings to the maximum.

It was found after having a discussion with the concerned Professors of Civil Engineering of BUET, that there is no arrangement in the BUET to test the actual homogeneously applied stress around the RCC ring because of its large diameter. Therefore it was decided that the strength of RCC rings will be determined from the results of 'Sand Bearing Test Method' and the rings were tested accordingly.

Since the load is applied only on two sides and not all around the circumference of the ring, the conditions of the test is more severe than the actual field condition This also gives an added safety factor.

As shown in the sketch **on the following page** the lab test consists of the following items

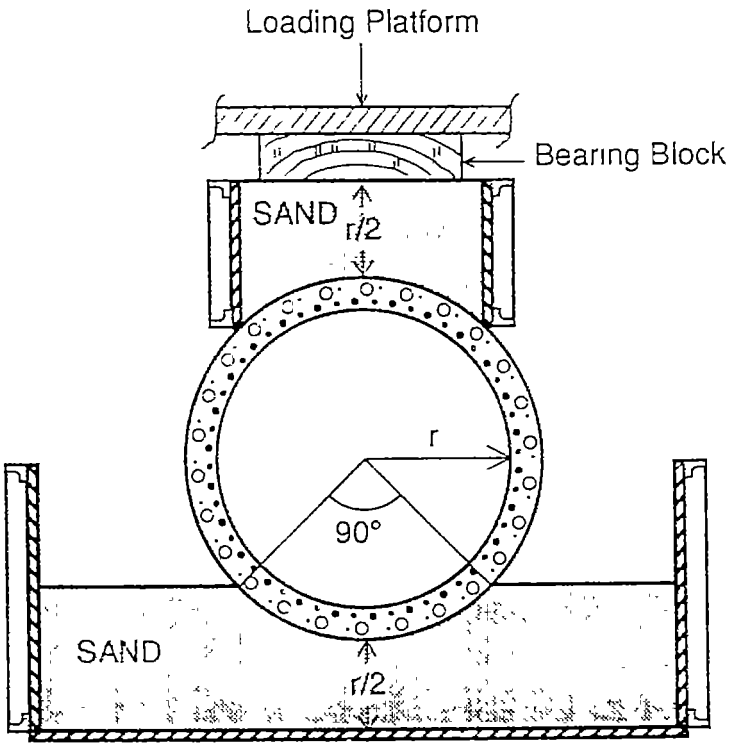
- A container of sufficient size to carry sand and to provide support to the ring at the bottom The outside walls of the steel box are required to be able to withstand the pressure.

RESULTS OF ROLLING TEST OF DIFFERENT RINGS

Rolling test done on hard ground and HBB road for a length of 300 ft.

Sl No	Wall Thick	Reinf Type	Mix-Proportion	Manufacture		Rolling Test Result		Remarks
				Date	Rolling Date	Distance Covered(ft)	Physical Condition	
1	2	3	4	5	6	7	8	9
1	1"	Type-1	1 2 5 5	22.04.90	05.06.90	300	OK	
2	1"	(No	1 3 6	21.04.90	05.06.90	300	OK	
3	1"	steel)	1 4 8	22.04.90	05.06.90	295	Broken	
4	1"		1:5 7	22.04.90	05.06.90	260	Broken	
5	1"		1.6 10	23.04.90	05.06.90	100	Broken	
6	1"		1.4 (2+2)	23.04.90	08.06.90	25	Broken	
7	1"	Type-2	1 2 5 5	25.04.90	08.06.90	300	OK	
8	1"	(DPHE)	1 3 6	18.04.90	08.06.90	300	OK	
9	1"		1:4 8	25.04.90	06.06.90	300	OK	
10	1"		1:5:7	22.04.90	06.06.90	300	OK	
11	1"		1.6 10	23.04.90	06.06.90	280	Broken	
12	1"		1:4 (2+2)	23.04.90	06.06.90	300	OK	
13	1"	Type-3	1 2 5.5	14.05.90	06.06.90	300	OK	
14	1"	(Bamboo)	1.3 6	21.05.90	07.06.90	290	Broken	
15	1"		1:4:8	14.05.90	07.06.90	150	Broken	
16	1"		1:5 7	14.05.90	07.06.90	120	Broken	
17	1"		1:6 10	14.05.90	07.06.90	100	Broken	
18	1"		1:4 (2+2)	18.05.90	07.06.90	200	Broken	
19	1"	Type-4	1 2.5.5	29.04.90	05.06.90	300	OK	
20	1"	(PP)	1:3.6	29.04.90	08.06.90	300	OK	
21	1"		1:4 8	30.04.90	08.06.90	300	OK	
22	1"		1:5:7	30.04.90	08.06.90	300	OK	
23	1"		1.6:10	19.05.90	08.06.90	200	Broken	
24	1"		1.4 (2+2)	19.05.90	08.06.90	300	OK	
25	1"	Type-5	1:2 5:5	03.05.90	05.06.90	300	OK	
26	1"	(Less	1:3 6	19.04.90	06.06.90	300	OK	
27	1"	DPHE)	1 4:8	03.05.90	06.06.90	300	OK	
28	1"		1:5;7	06.05.90	06.06.90	300	OK	
29	1"		1:6:10	06.05.90	06.06.90	100	Broken	
30	1"		1 4 (2+2)	10.05.90	07.06.90	400	OK	
31	1"	Type-6	1.2 5 5	02.05.90	07.06.90	300	OK	
32	1"	(Less	1 3:6	02.05.90	07.06.90	300	OK	
33	1"	PP)	1 4 8	02.05.90	07.06.90	300	OK	
34	1"		1:5 7	02.05.90	07.06.90	300	OK	
35	1"		1:6:10	07.05.90	07.06.90	100	Broken	
36	1"		1:4 (2+2)	07.05.90	07.06.90	300	OK	

Sand Bearing Method of Testing for Crushing Strength of RCC Rings



- A steel box open at the bottom and top and with adjustable side walls to suit the width of the ring.
- A wooden bearing block with about 1 cm clearance from the side of the above mentioned steel box placed on the top of the ring
- Load bearing steel plate of sufficient size to bear the applied load either manually or through the compressive strength testing machine.

Following working instructions concerning two tests were followed:

- The sand bearing steel box is filled with local sand containing five percent moisture The ring to be tested is placed in the sand bearing steel box as centrally as possible so that a segment of the ring is embedded in the sand and the embedded arc makes an angle of 90 degrees at the centre of the ring. The bottomless steel box is placed on top of it and sides are adjusted to snugly fit the width of the ring. The box is completely filled with sand. The sand thus provides a uniform pressure on the ring The wooden block is placed on top of it as centrally as possible and the loading plate is placed on top of the wooden block in a way that the whole arrangement on top of the ring is as horizontal as possible The load is applied on top of the load bearing steel plate so that the r. applies vertically through the axis of RCC ring. As the load is applied on a horizontal plane on the sand it will cover the entire horizontal plane of width of the ring

- The load is increased gradually until the ring fails under the applied pressure. The degree of load at which the ring fails is recorded.

- The tests of two sets of samples were conducted in BUET using two different methods In the first set the load to the ring was applied gradually by a mechanical device In the second sample the load was applied manually as described above with an increment of 20 kg load each time

A table has been prepared and is given **on the next page** with the result of the tests performed as above on various rings in the BUET Laboratory, and their corresponding costs Graphs prepared on the basis of these data are also given on the **following page**

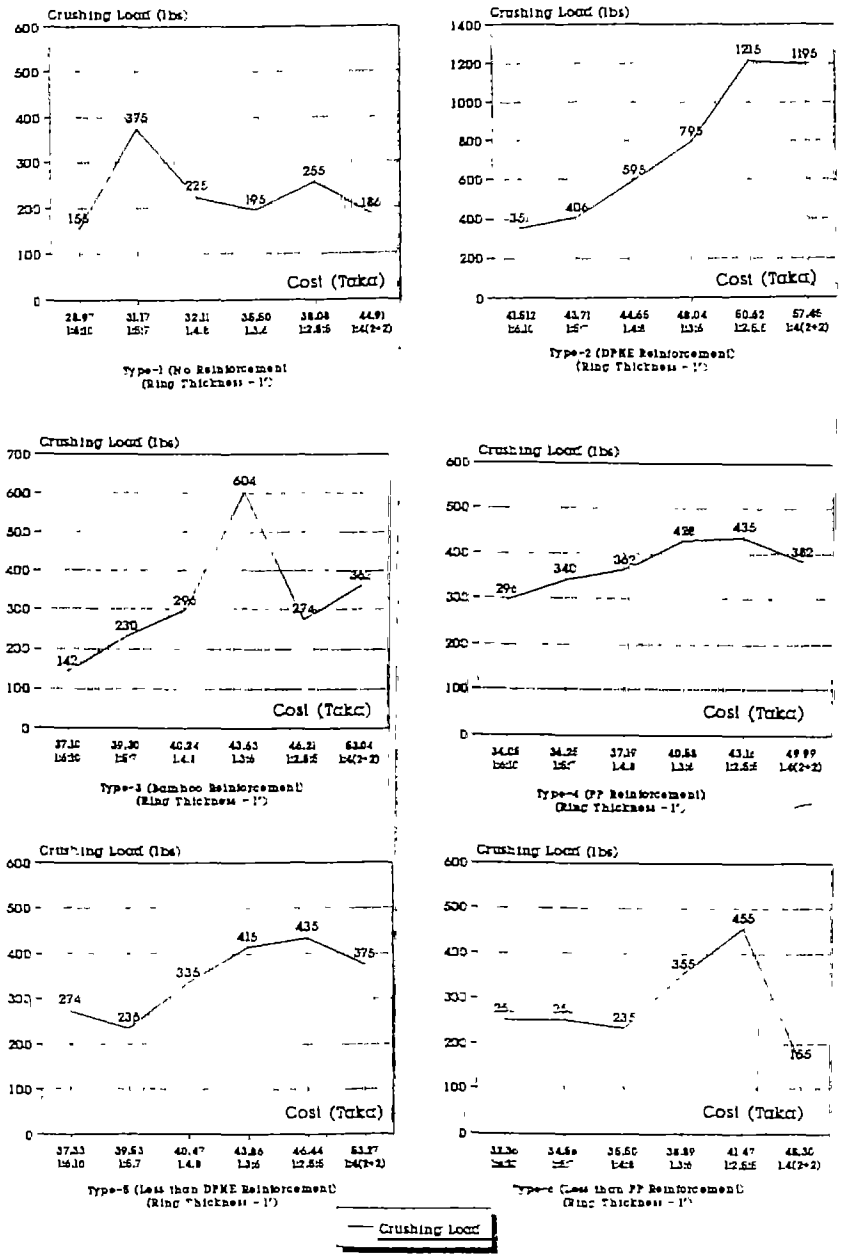
3.4.4 Final Test on Rings with Limited Variables

From the findings of the first batch of experiments on sanitary latrine rings, it was revealed that reinforcement type T-2 is most suitable from strength point of view Also 1" thick rings were found quite suitable in comparison to 1-1/2" thick rings The strength of 3/4" thick rings was found to be lower than those of 1" thick rings and

COMPARATIVE STATEMENT OF COST & STRENGTH

Sl. No	Reinf. Type	Mix-Proportion	1" Thick Rings		3/4" Thick Rings		1-1\2" Thick Rings		Remarks
			Manuf Cost (Tk)	Crushing Load (lbs)	Manuf Cost (Tk)	Crushing Load (lbs)	Manuf Cost (Tk)	Crushing Load (lbs)	
1	2	3	4	5	6	7	8	9	10
1	Type-1	1 2 5.5	38 08	255	29 97	162			
2	(No	1:3 6	35 50	195	28 05	70			
3	steel)	1.4.8	32 1*	225					
4		1:5.7	31 17	375					
5		1 6.10	28.97	155					
6		1:4 (2+2	44,9*	186					
7	Type-2	1:2:5.5	50 62	1215	42 51	150			
8	(DPHE)	1 3:6	48 04	795	40 59	360	63 29	1130	
9		1:4:8	44,65	595					
10		1:5:7	43 7:	406					
11		1:6:10	41.51	35*					
12		1:4 (2+2	57.45	1195					
13	Type-3	1:2.5 5	46.2*	274	38,1	50			
14	(Bamboo)	1;3:6	43.63	604	36 18	140			
15		1:4.8	40.24	296					
16		1:5:7	39.30	230					
17		1:6:10	37 10	142					
16		1:4 (2+2	53 04	362					
19	Type-4	1:2.5:5	43 16	435	35.05	140			
20	(PP)	1:3:6	40.58	428	33 13	240			
21		1:4:8	37.19	362					
22		1:5:7	36.25	340					
23		1.6:10	34.05	296					
24		1:4 (2+2	49.99	382					
25	Type-5	1:2.5 5	46.44	435	38 33	205			
26	(Less	1:3:6	43 86	415	36 41	190			
27	DPHE)	1:4:8	40.4*	335					
28		1:5:7	39.53	235					
29		1:6:10	37.33	27*					
30		1:4 (2+2)	53.2*	375					
31	Type-6	1:2.5:5	41 4*	455	33.36	151			
32	(LESS	1.3:6	38.89	355	31 44	151			
33	PP)	1:4:8	35.50	235					
34		1:5:7	34.56	250					
35		1:6:10	32.36	255					
36		1 4 (2+2	48 30	155					

Cost vs Strength of RCC Ring



were deemed to be unsuitable. The weaker mixes of concrete were also found to be unsuitable for manufacturing RCC rings for general applicability.

Therefore, it was decided to initiate more extensive experiments of rings cast with less number of variables. This time reinforcement type T-2, i.e. 3 Nos. 10 SWG wire, was selected as a constant parameter Thickness of the rings was also taken constant as 1". Only variable that was taken was the mix of concrete of following three types - 1:2.5:5, 1:3:6 and 1:4:8

In August 1990, a large number of rings of the above types were cast To compare the results of the above rings with that of the standard DPHE ring, DPHE standard rings were also cast.

Five numbers of each of the following four types of rings were again crush-tested in BUET laboratory by sand bearing method.

Type 1	1" thick	Mix 1.2 5.5	Reinf 3# 10 SWG wires
Type 2	1" thick	Mix 1:3:6	Reinf. 3# 10 SWG wires
Type 3	1" thick	Mix 1:4:8	Reinf. 3# 10 SWG wires
DPHE type	1.5" thick	Mix 1:3:6	Reinf 3# 10 SWG wires

Test results obtained from BUET are recorded **on the following pages** A graph on strength versus cost of the above four types of rings have been prepared and is presented for getting a clear picture of the research results.

3.5 Conclusions of Ring Experiments

From the manufacturing of ring component for rural latrines with different variables as mentioned in the report, and after testing these by rolling and in the laboratory the following conclusions are drawn.

1 The rings made with less thickness of 3/4" but with richer mixes do not have good strength as compared to 1" thick rings But it may be feasible to use 3/4" thick rings with rich mix in the field, because of its light weight and less cost. Further studies need to be done to establish this

2 The 1" thick rings made with no reinforcement or bamboo reinforcement were not feasible, as they easily broke during the rolling test These were not recommended for further investigation.

3 The 1" thick rings manufactured with weaker mix of 1:6 10 mortar with different types of reinforcement also failed during rolling test This mix was discarded

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DEPARTMENT OF CIVIL ENGINEERING

BRTC No 3045/89–90 dated 2.6.90
Sent by: Interchain Project Consultants AB
House No 76 Road 21 Banani, Dhaka–1213
Ref Letter dated May 30, 1990
Date of Test 11.07.90
Component Village Sanitation Latrine RCC Ring
Test Method Sand bearing tests of RCC Ring
Fixed Dimensions
a) Wall thickness of RCC Ring = 1", b) Internal dia = 27" Height of RCC Ring = 12"

Variables: Mix–proportion & reinforcement type
Type of variation by reinforcement
T–1– No Reinforcement
T–2– Reinforcement as used by DPHE (3 Nos SWG wires – 10 gauge
T–3– Bamboo Reinforcement (Bamboo splits approx 7mm dia)
T–4– Reinforc as used by Pvt Producers (3 Nos SWG wires–16 gauge
T–5– Less Reinforcement than by DPHE (2 Nos SWG wires – 10 gaug.
T–6– Less Reinf by than used by Pvt Prod (2 Nos SWG wires–16 gauge

Sl No	Type	Mix–Proportion	Mfg Date	No of RCC Ring for Lab Test	Crushing Load (lbs Sample–1	Sample–2	Remarks
1	2	3	4	5	6	7	8
1	Type–1	1.2.5 5	22 04 90	2	255	138	
2		1.3 6	21 04 90	2	195	136	
3		1 4 8	22.04 90	2	225	180	
4		1:5 7	22.04 90	2	375	75	
5		1 6 10	23 04 90	2	155	65	
6		1 4 (2+2)	23 04 90	2	186	184	
7	Type–2	1 2 5 5	25 04.90	2	1215	778	
8		1 3 6	18 04.90	2	795	362	
9		1:4 8	25 04 90	2	595	470	
10		1:5 7	22.04.90	2	406	536	
11		1:6.10	23.04 90	2	351	294	
12		1 4 (2+2)	23 04 90	2	1195	536	
13	Type–3	1:2.5:5	14 05 90	2	274	426	
14		1 3 6	21 05 90	2	304	206	
15		1 4 8	14 05.90	2	296	294	
16		1:5 7	14 05 90	2	230	184	
17		1:6:10	14 05.90	2	142	155	
18		1 4 (2+2)	18 05.90	2	362	184	
19	Type–4	1:2.5.5	29 04.90	2	435	514	
20		1 3:6	29 04 90	2	428	349	
21		1 4 8	30 04 90	2	362	305	
22		1:5.7	30 04.90	2	340	294	
23		1:6:10	19.05.90	2	296	393	
24		1:4 (2+2)	19 05.90	2	170	362	
25	Type–5	1.2.5 5	03 05.90	2	435	590	
26		1:3 6	19 04.90	2	415	492	
27		1 4 8	03.05.90	2	335	65	
28		1:5 7	06.05.90	2	235	206	
29		1:6 10	06.05.90	2	274	189	
30		1 4 (2+2)	10 05 90	2	375	932	
31	Type–6	1.2.5:5	02.05.90	2	455	426	
32		1:3:6	02.05.90	2	355	140	
33		1 4 8	02.05.90	2	235	184	
34		1:5 7	02.05.90	2	253	broken	brokandown during handling
35		1:6 10	07 05.90	2	253	184	
36		1 4 (2+2)	07 05 90	2	155	130	

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DEPARTMENT OF CIVIL ENGINEERING

BRTC No 3045/89–90 dated 2.6.90
Sent by: Interchain Project Consultants AB
House No 76, Road 21, Banani, Dhaka–1213
Ref Letter dated May 30 1990
Date of Test 15 07 90
Component Village Sanitation Latrine RCC Ring
Test Method Sand bearing tests of RCC Ring

Variables: Mix–proportion & reinforcement type
Type of variation by reinforcement
T–1– No Reinforcement
T–2– Reinforcement as used by DPHE (3 Nos. SWG wires – 10 gauge)
T–3– Bamboo Reinforcement (Bamboo splits approx 7mm dia)
T–4– Reinforc as used by Pvt Producers (3 Nos SWG wires–16 gauge)
T–5– Less Reinforcement than by DPHE (2 Nos SWG wires – 10 gauge)
T–6– Less Reinf by than used by Pvt Prod (2 Nos SWG wires–16 gauge)

Fixed Dimensions
a) Wall thickness of RCC Ring = 3/4", b) Internal dia = 27" c) Height of RCC Rings = 12"

Sl No	Type	Mix–Proportion	Mfg Date	No of RCC Ring for Lab Test	Crushing Load (lbs) Sample–1	Sample–2	Remarks
1	2	3	4	5	6	7	8
1	Type–1	1 2 5 5	26 05.90	2	162	184	
2		1:3 6	26 05 90	2	70	45	
3	Type–2	1:2.5.5	30 05 90	2	150	195	
4		1 3.6	30 05 90	2	360	broken	Brokendown during handling
5	Type–3	1.2.5 5	30 05 90	2	50	250	
6		1:3:6	30 05 90	2	140	338	
7	Type–4	1:2.5 5	26.05.90	2	140	140	
8		1:3:6	27 05 90	2	240	205	
9	Type–5	1:2.5.5	29 05.90	2	205	90	
10		1 3.6	29 05 90	2	199	130	
11	Type–6	1.2.5:5	28 05.90	2	151	145	
12		1.3:6	28 05.90	2	305	151	

Fixed Dimensions
a) Wall thickness of RCC Ring = 1 5" b) Internal dia = 27", c) Height of RCC Rings = 12"
T–2– Reinforcement as used by DPHE (3 Nos. SWG wires – 10 gauge)

Sl No	Type	Mix–Proportion	Mfg Date	No of RCC Ring for Lab Test	Crushing Load (lbs) Sample–1	Sample–2	Remarks
1	2	3	4	5	6	7	8
1	Type–2	1 3 6	01 07.90	2	1130	1174	

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Sent by: Interchain Project Consultants AB
House No 76 Road 21 Banani, Dhaka-1213
Ref Letter dated May 30 1990
Date of Test 11.07.90
Component Village Sanitation Latrine RCC Ring
Test Method Sand bearing tests of RCC Ring
Fixed Dimensions
a) Wall thickness of RCC Ring = 1" b) Internal dia = 2'" Height of RCC Ring = 12"

Variables Mix-proportion & reinforcement type
Type of variation by reinforcement.
T-1- No Reinforcement
T-2- Reinforcement as used by DPHE (3 Nos SWG wires - 10 gauge
T-3- Bamboo Reinforcement (Bamboo splits approx 7mm dia
T-4- Reinforc as used by Pvt Producers (3 Nos SWG wires-16 gauge
T-5- Less Reinforcement than by DPHE (2 Nos SWG wires - 10 gauge
T-6- Less Reinf by than used by Pvt Prod (2 Nos SWG wires-16 gauge

Sl No	Type	Mix-Proportion	Mfg Date	No of RCC Ring for Lab Test	Crushing Load (lbs Sample-1	Crushing Load (lbs Sample-2	Remarks
1	2	3	4	5	6	7	8
1	Type-1	1:2.5:5	22.04.90	2	255	138	
2		1:3:6	21.04.90	2	195	138	
3		1:4:8	22.04.90	2	225	180	
4		1:5:7	22.04.90	2	375	75	
5		1:6:10	23.04.90	2	155	65	
6		1:4:(2+2	23.04.90	2	186	184	
7	Type-2	1:2.5:5	25.04.90	2	1215	778	
8		1:3:6	18.04.90	2	795	362	
9		1:4:8	25.04.90	2	565	470	
10		1:5:7	22.04.90	2	408	536	
11		1:6:10	23.04.90	2	351	294	
12		1:4:(2+2)	23.04.90	2	1195	536	
13	Type-3	1:2.5:5	14.05.90	2	274	426	
14		1:3:6	21.05.90	2	604	206	
15		1:4:8	14.05.90	2	296	294	
16		1:5:7	14.05.90	2	230	184	
17		1:6:10	14.05.90	2	142	155	
18		1:4:(2+2)	18.05.90	2	362	184	
19	Type-4	1:2.5:5	29.04.90	2	435	514	
20		1:3:6	29.04.90	2	428	349	
21		1:4:8	30.04.90	2	362	305	
22		1:5:7	30.04.90	2	340	294	
23		1:6:10	19.05.90	2	296	393	
24		1:4:(2+2)	19.05.90	2	170	382	
25	Type-5	1:2.5:5	03.05.90	2	435	560	
26		1:3:6	19.04.90	2	415	492	
27		1:4:8	03.05.90	2	335	65	
28		1:5:7	06.05.90	2	235	208	
29		1:6:10	06.05.90	2	274	189	
30		1:4:(2+2)	10.05.90	2	375	932	
31	Type-6	1:2.5:5	02.05.90	2	455	428	
32		1:3:6	02.05.90	2	355	140	
33		1:4:8	02.05.90	2	235	184	
34		1:5:7	02.05.90	2	253	broken	brokandown during handling
35		1:6:10	07.05.90	2	253	184	
36		1:4:(2+2)	07.05.90	2	155	130	

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DEPARTMENT OF CIVIL ENGINEERING

BRTC No 3045/89-90 dated 2.6.90
Sent by: Interchain Project Consultants AB
House No 76, Road 21, Banani, Dhaka-1213
Ref Letter dated May 30 1990
Date of Test 15.07.90
Component: Village Sanitation Latrine RCC Ring
Test Method. Sand bearing tests of RCC Ring

Variables: Mix-proportion & reinforcement type
Type of variation by reinforcement
T-1- No Reinforcement
T-2- Reinforcement as used by DPHE (3 Nos SWG wires - 10 gauge)
T-3- Bamboo Reinforcement (Bamboo splits approx 7mm dia)
T-4- Reinforc as used by Pvt.Producers (3 Nos SWG wires-16 gauge)
T-5- Less Reinforcement than by DPHE (2 Nos SWG wires - 10 gauge
T-6- Less Reinf by than used by Pvt Prod (2 Nos SWG wires-16 gauge)

Fixed Dimensions
a) Wall thickness of RCC Ring = 3/4", b) Internal dia = 27" c) Height of RCC Rings = 12"

Sl No	Type	Mix-Proportion	Mfg Date	No of RCC Ring for Lab Test	Crushing Load (lbs) Sample-1	Crushing Load (lbs) Sample-2	Remarks
1	2	3	4	5	6	7	8
1	Type-1	1:2.5:5	26.05.90	2	162	184	
2		1:3:6	26.05.90	2	70	45	
3	Type-2	1:2.5:5	30.05.90	2	150	195	
4		1:3:6	30.05.90	2	360	broken	Brokendown during handling
5	Type-3	1:2.5:5	30.05.90	2	50	250	
6		1:3:6	30.05.90	2	140	338	
7	Type-4	1:2.5:5	28.05.90	2	140	140	
8		1:3:6	27.05.90	2	240	205	
9	Type-5	1:2.5:5	29.05.90	2	205	90	
10		1:3:6	29.05.90	2	190	130	
11	Type-6	1:2.5:5	28.05.90	2	151	145	
12		1:3:6	28.05.90	2	305	151	

Fixed Dimensions
a) Wall thickness of RCC Ring = 1.5" b) Internal dia = 27" c) Height of RCC Rings = 12"
T-2- Reinforcement as used by DPHE (3 Nos SWG wires - 10 gauge)

Sl No	Type	Mix-Proportion	Mfg Date	No of RCC Ring for Lab Test	Crushing Load (lbs Sample-1	Crushing Load (lbs Sample-2	Remarks
1	2	3	4	5	6	7	8
1	Type-2	1:3:6	01.07.90	2	1130	1174	

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4. The 1" rings manufactured with mix 1:4:(2+2) were found quite workable rich and strong But these were comparatively expensive This mix was also avoided from cost point of view

5 The 1" thick rings manufactured with different reinforcement variables such as i) used by private producers, ii) less than as used by DPHE and iii) less than as used by private producers, gave a lower strength with slight decrease in cost These were also discarded.

6. The 1" thick rings manufactured with standard DPHE reinforcement i.e with 3 nos 10-SWG MS wire were best and nearer to the strength of standard 1-1/2" thick DPHE rings. The mixes of 1:2 5:5, 1:3.6, and 1:4:8 produced good results and were considered worth investigating further

7 Further investigations on 1" thick rings with standard DPHE reinforcement and three different mixes (viz 1:2 5:5 1.3:6 and 1 4:8) showed that the ring with mix 1:2.5:5 gives higher strength than that of standard DPHE ring with less cost. The ring with mix 1.3:6 gives less strength than the standard DPHE ring but the cost is as less as Tk.15 25 per ring Also the strength is acceptable as it passed vigorous rolling and handling tests

8 Physical and laboratory tests confirmed that it is possible to reduce ring thickness

9. A saving of Tk. 12 67 per ring for a reduced thickness of 1" as per type-1 seems possible This means saving a cost of 20% on each ring and a saving of over 22% on each latrine set consisting of one slab and five rings. Incorporation of this recommendation and considering 1000 DPHE VS centres all over Bangladesh with a production capacity of average 1300 rings per year per centre a total saving of Tk.19.825 million can be achieved only in the government sector Similar substantial saving can be achieved in the private sector as well, if a reduced thickness of ring can be introduced at all level

   Saving connected with type-2 is somewhat bigger in magnitude than that of type-1 with a lesser strength However this type may be field tested for further research.

10. The mechanical device developed during the study for speedier manufacturing of rings has been tried with promising initial results

3.6. Interim Conclusions After Tests

Considering various factors of research on RCC latrine rings, construction and supply of 1" thick rings, instead of standard 1.5" thick rings was recommended It was suggested that initially ring design of type-1 and type-2 may be tried Type-1 ring is stronger than DPHE type ring and is less expensive Although type-2 ring is weaker than DPHE type, but seems strong enough for our purpose and tried in the field. However detailed field test will be required before adopting a final design

The finally recommended ring alternative were the following

Type-1

- Thickness 1"
- Concrete mix 1:2.5:5
- Reinforcement 3 nos 10-SWG wires

Type-2

- Thickness 1"
- Concrete mix 1.3.6
- Reinforcement 3 nos 10-SWG wires

Type-1 is preferable to Type-2 because of much higher strength with slightly higher cost. The cost and strength comparison table is as follows

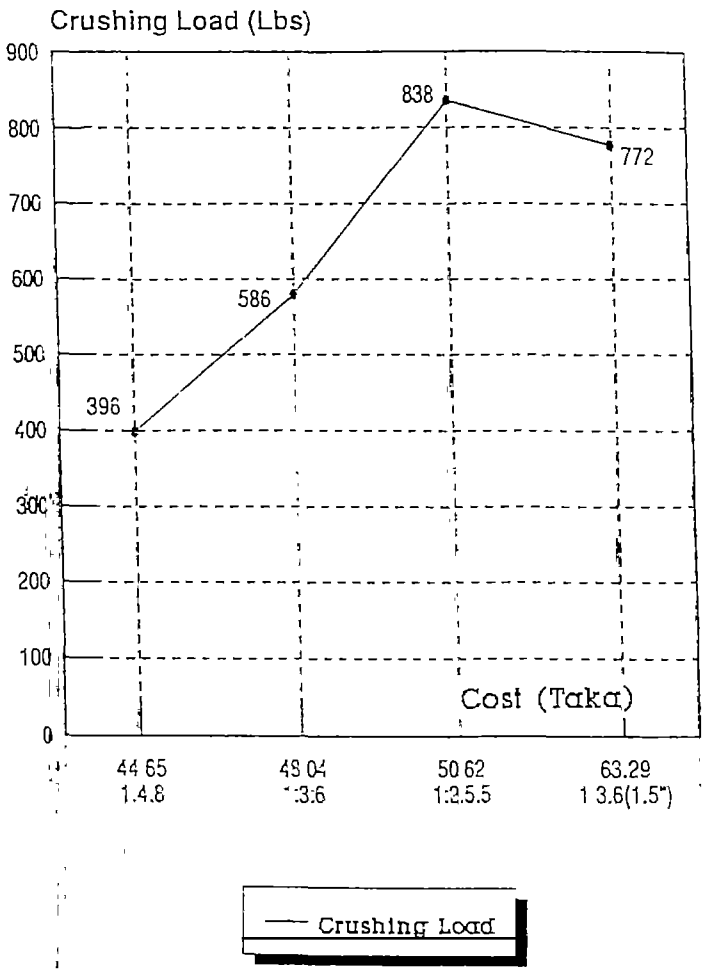
Type	Cost (Taka)	Strength (lbs)
Type-1	50.62	838
Type-2	48 04	586
DPHE	63.28	772

The above data has been used to compile a cost vs strength graph for the above types of rings which is given **on the next page.**

3.7 Field Test on 1" Thick Rings

To find the effectiveness of recommendation of the action research in research centre and laboratory it was recommended to initiate a field test in actual VS construction centres The field test was started in 3 upazilas of Faridpur in April,1991 and continued for a period of 12 months The details of this field test are given in a separate chapter later in this book

Results of Some Selected 1" Thick Rings and Standard DPHE Ring



4. Improvement in Casting Technology

Usually RCC rings are cast in a mould made of 2 nos. cylindrical MS shutters placed vertically and concentrically. After casting the inner mould is removed in two parts and then the outer layer of the mould is released

During initial days of action research on rings, a mechanical device for casting of the RCC rings was produced by our engineers. This mechanical casting device facilitates lifting of the inner ring for easiness and quickness of casting

The details of traditional shutter and mechanical device for casting rings are described in the following paragraphs

4.1 Traditional Shutter Mould for Ring Casting

For producing RCC ring vertical shutters made of mild steel sheet have been carefully designed The outer ring contains two sections and the inner circular shutter also contains two semi-circular sections, which are separated by 1/2" thick wooden strip in two sides for easy removal from the inside ring shutter The outer and inner circular shutters are required to be smooth and exactly circular for trouble free operation.

The shutter should be rigid enough to withstand the pressure applied due to compaction of the concrete It should not be disproportionate or loose its circular form, otherwise lifting of the shutter forms would become difficult after fresh casting. Before casting, the shutters have to be properly lined with burnt mobile oil, which will make the removal of the shutters from the RCC rings easier.

The mixed concrete for preparing RCC ring should be put into the shutter in stages where each layer has to be compacted replenished with a rod or stick After 5 to 10 minutes of complete casting of RCC ring the inner circular shutter can be removed. After about 10 to 15 minutes the outer part of the shutter can be opened

4.2 Mechanical Device for Ring Casting

A mechanical casting device to facilitate lifting of the inner ring was tried out and its impact during production and on economy was analyzed

The new device worked out for manufacturing of RCC rings is very simple and can even be independently handled by labourer The concrete is to be poured between inner & outer circular rings The inner ring which also has an inclined trough to facilitate polishing of concrete, then needs to be rotated on a vertically threaded shaft which is attached with arms and a hub nut to the inner circular ring.

The compaction of the concrete is done by creating centrifugal force due to rotation. After casting one RCC rings in the device, the outer part of circular shutter should be oiled with used mobil before going on to next casting operation It stops the steel form from sticking to the RCC ring surface

This device takes about 12 minutes to produce one ring. During action research work 72 rings were produced with the help of this device using different mix-proportions and reinforcement as variables

Similar type of casting was done with standard shutter method with which on an average it took 22 minutes to cast one ring Hence about 10 minutes of casting time per ring can be saved, which will also save the cost of production

4.3 Cost Comparison between Traditional Shutter & Mechanical Device

Traditional shutter for casting rings costs approximately Tk 3,000 whereas using a mechanical device woned cost approximately Tk. 8,000

4.4 Improvement of Mechanical Device for Casting

In the later part of the action research programme effort was made to increase the efficiency of the device by reducing the pitch of the threads of the lead shaft

After that handling of the equipment has become easier and more efficient.

It was felt that this improved mechanical device for casting of rings are more suitable for places where mass production is required It is unlikely that such possibility will arise in our area of study. Therefore, further research on this topic was abandoned However, the whole mechanical device still has scope for further improvement particularly pitch optimisation of the reads and tolerances of the lead shaft and the internal threads of the hub nut

5. Research on Alternative Pit Lining

The various alternatives of latrine pit lining have been described in the beginning of this chapter. These are RCC rings burnt clay ring hollow bricks, compressed clay blocks, bamboo sticks, trunk of banana trees etc. Most of these types are widely utilised by many people in various parts of the country.

The RCC rings are mostly in use in construction of village latrines among the above mentioned alternatives The bamboo sticks or bamboo mats are used in some places as a cheaper alternative The burnt clay rings are also cheap and are sufficiently

stable. Their availability is however limited in some areas as these require good quality local clay and of artisans. The bamboo tree trunk are usually used in sandy areas where the fibers of the trunks provide necessary resistance to the sand pit.

Some work has been done on compressed clay block lining The Housing and Building Research Institute (HBRI) was contacted for information on this. It was found that although the raw material costs almost nothing but the productivity of the manual block making machine is so meager that the production cost per unit brick becomes almost the same as the cost of a kiln burnt brick Therefore it is not feasible commercially and economically. This compressed clay block production can be feasible only in community participation projects where voluntary labour is available and may become worthy of consideration if cheap and high speed block making machines can be designed.

Another simple way of pit lining is just to light some fire inside a newly dug pit This hardens the surface of the pit and makes a natural burnt clay lining. Such improvised lining methods are generally used in places where the clay is naturally stiff.

Considering all the alternatives of latrine pit lining, it was concluded that the RCC rings are the most suitable alternative for mass production, distribution and general use

6. Study on Types of Top-soil

A low cost latrine is made of one slab with a set of rings The number of rings traditionally are five. However, the actual requirement of number of rings varies depending upon the condition of the soil and affordability of the user. Many latrines have been constructed with four, three, two, one ring or even without any ring.

Considering the limited purchasing power of the users and aiming for wider sanitation angle, Unicef advocated for one ring and one slab latrines. But the soil conditions in many places, specially in sandy char (alluvial soil) areas, are not suitable for one ring latrine construction.

As per a decision taken at a tripartite meeting of DPHE, Unicef and WHO a study was conducted by the end of 1990 to review the sale and performance of one slab one ring latrine sets The study recommended that the policy of sale of one slab and one ring latrine set should be area specific, based on hydro geological conditions. The areas where the soil is a mix of silt and clay and the ground water table is low, are most suitable for one slab one ring latrines In sandy soil with high ground water table, five rings in the pits should be continued to be used.

The same study also recommended that for sanitary disposal of human excreta for a 6 member family in Bangladesh, the depth of a latrine pit should be at least 5 ft This is applicable for both one-ring latrine in clay soil and five-ring latrine in sandy soil.

The depth requirement of normal latrine pit is 5 ft. But the requirements of latrine rings depends on the hardness and other qualities of the soil The question is whether the soil can withstand pressure without collapsing and up to what depth. The harder the soil, the lesser the number of rings required.

In the ADP of Village Sanitation Project (1991-92) of DPHE, provisions for the manufacturing and sale of one slab plus five rings latrine in certain areas of the country has been kept. Though in most of the areas, the VS centres of DPHE are selling one slab one ring latrine sets

However, in many cases, one slab one ring latrine purchasers are also buying additional rings from the private producers as per their requirements. One of the recommendation of the above mentioned WHO/DPHE/UNICEF study is also in line with this fact. It states that, private producers of latrine components should be encouraged to increase and maintain quality of their products and should be assisted in their market development

Discussions were held with DPHE for collection of secondary data on top soil condition. It is understood that Unicef is making a survey on types of top-soil. The survey is in progress and compilation of the data is not yet complete

We could not finalise compilation of regional map on top soil conditions of Bangladesh due to non-availability of secondary data We feel that union-wise detailed survey of the soil condition along with under-ground water-level data collection should be carried out in order to ascertain the number of rings in a latrine This survey should not only cover the top-soil but should also cover sub-soil down to the depth of minimum 5 ft. and this should be done by separate consultants. This work alone will, however, take a very long time On the basis of data accumulated from the survey, a regional map on soils conditions in Bangladesh can be prepared which may prove to be very useful.

7. Recommendations

Construction and use of 1" thick rings, instead of the existing standard 1.5" thick rings is technically feasible. The recommended design of 1" thick ring with 1:2.5:5 mix is 20% cheaper and still stronger than 1 5" traditional rings Field tests on 1" thick latrine rings have proved to be successful and its adoption is recommended it in the place of existing 1 5" thick rings in all the VS centres of DPHE all over the country.

This will cause substantial financial saving considering the large production of the sanitary latrine components in the country. In the government sector alone, the saving will amount to Tk. 20 million per year.

Using the mechanical device as suggested in this report will save time, production cost and energy in the production of latrine rings As this device involves some capital investment. It is suitable only for places where a larger scale production is required.

An extensive survey is recommended in order to carry out tests on sub-soil conditions and water table levels, so that the number of rings required for a normal latrine in different areas of Bangladesh can be determined

RESEARCH CONCERNING SLABS

1. General

Slab is that part of a latrine which divides the substructure i.e. the latrine pit, which holds the human excreta, and the superstructure which gives privacy to the user A user sits on this slab during defecation. The main function of a latrine slab is to cover the pit

The slab should preferably have the following properties.

- not too expensive
- easy to transport
- smooth surface for easy flow
- resistance against rot and termites
- durability
- easy to keep clean

Ease in cleaning the slab is very important and it enhances acceptability of latrine to the users

The slab can be made of concrete or by timber or bamboo as in the case of home-made latrines Considering the factors mentioned above, the concrete slabs are the most viable The concrete slab can be manufactured with or without a pan.

The major concern in a latrine construction from the user's point of view is the design of a slab, which is the only part in a pit latrine that calls for engineering skills This is where sanitary engineers come to the help of people

2. Types of Latrine Slabs

The following types of latrine slabs were investigated during our Action Research programme

- Standard latrine slab with a pan
- Split-type slab and pan
- Simple squatting plate without a pan
- Mozambique-type Dome slab
- Malawi-type Sanplat (sanitation platform)
- Improvised home-made latrine slab

The detail findings on the above types of pans are described in the following paragraphs.

3. Standard Latrine Slabs with Pan

The most common latrine slabs are made along with a pan together in one unit. This type is more convinient to install than the one in which slabs and pans made separately. The DPHE and most of the NGOs build latrine slabs in this manner. HBRI also recommends latrine slabs built along with pans in a single unit.

3.1 DPHE-Type Slab with Pan

Previously DPHE used to prepare the platform of the latrine with reinforced cement concrete (RCC) slab. They used to make RCC latrine slabs in square shape and make the slab and the pan in a single casting Now-a-days they have started casting this latrine platform in a circular shape and with ferro-cement (FC). This FC slab is quite convenient to cast, economical and easy to handle because of light weight and less thickness. DPHE make their FC slabs of 1" thickness and 30" to 33" in diameter

When latrine slab is cast a slot for the pan is kept. Then separately constructed cement concrete (CC) pan is fixed into this slot to make a single unit of pan and slab. This is convenient for installation of latrine units. The DPHE-type slab and pan is manufactured and sold in all the 1000 VS centres of DPHE all over Bangladesh.

3.2 Latrine Slabs by NGOs

The NGOs throughout Bangladesh manufacture and distribute the low cost latrines in DPHE-type slabs built with pans Most of the NGOs follow the DPHE design for manufacture of latrine slabs. Some big NGOs use their own models.

The Rangpur Dinajpur Rural Services (RDRS) have their own design for manufacturing rural latrine slabs The RDRS casts the pan and the water-seal using mould made of steel and concrete blocks Later the pan and the water-seal are attached together with concrete. This type of construction is very heavy and is more cumbersome. However, research and development activities are continuing in the field for improving the design

3.3 HBRI Latrine Slabs

The Housing and Building Research Institute (HBRI) has made a model for rural latrine slabs. They have made FC latrine slabs with pans in a single unit. Few years back they had produced some experimental pieces of such latrines and installed

them in a village in Dhaka district. But the HBRI did not follow up the project after that due to various reasons.

The HBRI made their latrine slabs in a larger size of 48" diameter for making bigger pits to accommodate larger volume of excreta. The thickness of the FC slab is 1". The construction cost at that time for the slab with pan was Tk. 300 only. The present cost, however, is not available at the moment.

4. Split-type Slab and Pan

The pan and slab cast together become heavy in weight and akward in shape for moving from one place to another. To avoid this problem, a split type pan and slab was considered. In this type the latrine slab is cast in the following three parts.

- two semi-circular slabs and
- the pan

The above three parts of the latrine are carried to the site separately and easily Then these are assembled at the site during installation of the rings and latrine

This idea of split type slab and pan was however discarded, at a later stage, due to the following difficulties:

- It needs skilled technician for the job which is not always available at the installation site
- It is difficult to seal the joints of three parts very effectively
- It becomes more expensive for using skilled technician and use of cement and other materials during installation.

5. Simple Squatting Plate without Pan

During very early stage, DPHE had used some simple squatting plates with hole in the centre of the slab. These were square size concrete floor slabs with a hole in the centre for defecation purpose. The slab was designed with a slope from each corner towards the squat hole for easy cleaning The opening of the squat hole, without lid, used to create stinks and draw insects.

During this study it was observed in the field that the goose-neck water-seal of many sanitary pans were broken by the users In spite of instructions by field workers regarding the usage and the advantages of the water-seal, the users broke the goose-neck The main reason is that they found the goose-neck as an obstruction for easy passage of excreta to the pit.

Breaking of the water-seal causes bad sanitary effect, bad smell and draws insects. Observing the above problem in the field and after discussion with local engineers, we decided to construct some latrine slabs without pans

Much thought was given on the above problems for finding a solution During this research efforts discussions were held in this regard with senior sanitary engineering staff of "International Reference Centre for Waste Disposal (IRCWD/EAWAG)" of Switzerland They suggested the use of some latrine slabs without pan but with lid, on experimental basis and also supplied some documents about such types of latrines experimented and utilised in a couple of African countries like Mozambique and Malawi.

On the basis of design and collected literature , work on the following two types of slabs were carried out:

- Mozambique-type Dome slab
- Malawi-type Sanplat

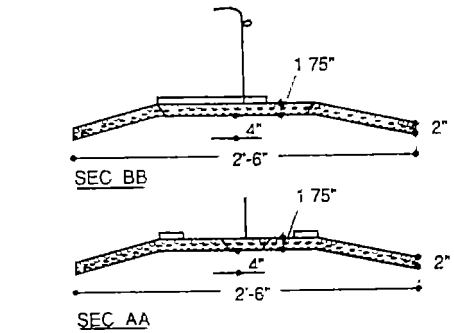
These latrine slabs without pans can serve as an intermediate technology option between the standard DPHE slab with pan and the so called home-made latrine with bamboo slabs.

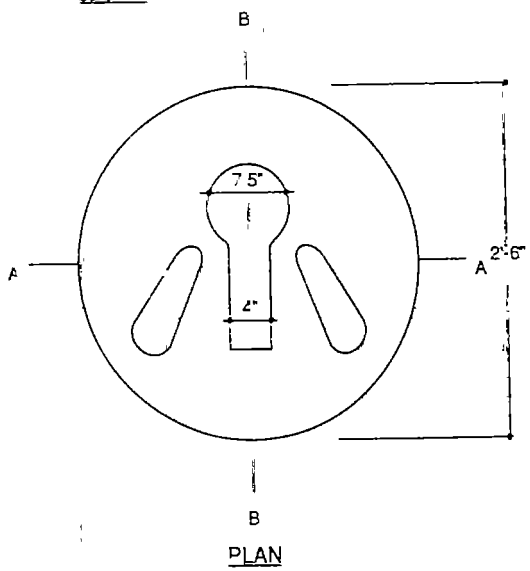
6. Mozambique-type Dome Slab

This is a simple slab with a key-hole shape opening in the centre to be used as latrine platform. The slab is cast in a convex shape or an arc of a circle. This dome shape makes it possible to cast the slab without reinforcement. The load on the slab is transferred through the edge of the dome to the ground.

The original drawings received from IRCWD/EAWAG had a bigger diameter of 1.5 meter. A revised drawing was prepared of a diameter of 2.5 ft. to suit the existing latrine rings in Bangladesh. A copy of the drawing is given **on the next page**. Such dome type slabs were constructed and tested in VSRC Mohakhali. Loading tests were done with 4 persons standing on the slab and it was found to be acceptably strong

In the actual research work in Mozambique, by the Mozambican National Directorate of Housing and the International Development Research Centre of Canada, some of the domes were constructed with ferro-cement reinforcement. But none of the chicken-wiremesh reinforced slabs passed the loading test, because the chicken-wiremesh did not allow the concrete to be fully compacted. Using chicken-wiremesh turned out to be time consuming because it had to be cut in order to fit it into the conical form which was expensive as well Also because use of





MOZAMBIQUE TYPE DOME SLAB LATRINE

reinforcement was not at all required due to the dome shape, this experiment of dome slabs with reinforcement was not continued.

The document followed in the development of this type of latrine is — "The Latrine Project, Mozambique, Manuscript Report, International Development Research Centre, Canada, September 1983."

A few Mozambique-type dome slabs were cast in the pilot project area of Faridpur district by private producers, through training and assistance given during the action research exercise. The acceptability and durability of such latrine slabs are yet to be tested in the field. This programme can, however, be implemented during the expected 5P exercise in this pilot area.

7. Malawi-type Sanplat Slab

Sanplat System offers a very simple alternative of a sanitary slab, developed with the motto -"The simpler the better, as long we don't compromise on safety or the health of the people' This is a simple flat slab, very low in cost and easy to install Since this is a flat slab (and not dome shaped), some reinforcement is needed. The steel requirement is only half a kilogram, mainly to make a hygienic handle for the tight fitting lid for the opening hole. It is very cheap because usually eight sanplats can be constructed from one bag of cement

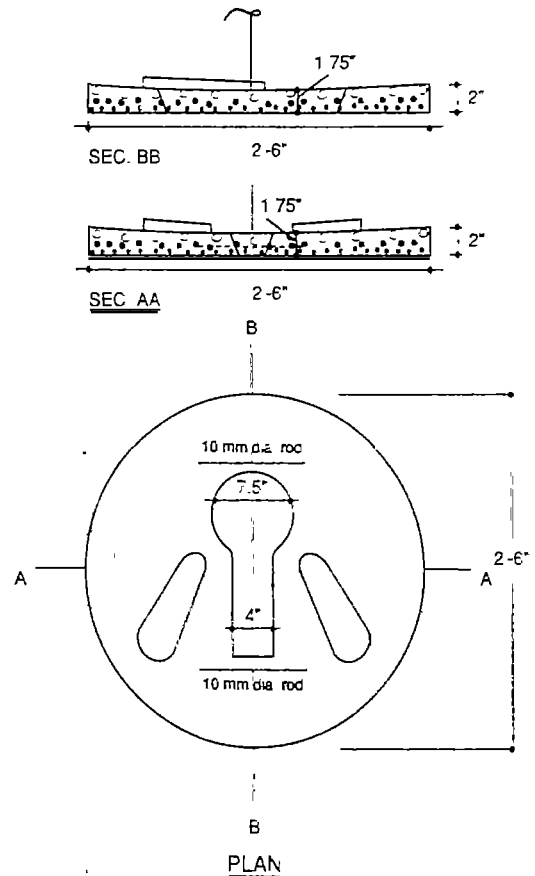
The Sanplat (sanitation platform) is a small locally prefabricated concrete slab designed to improve the floor around the drop-hole of the latrine. One of the great advantage of this system is that the Sanplat can be integrated in the floor of a traditional latrine which eliminates the need of on the site cement work in rural areas.

Sanplat latrine slabs were constructed at VSRC of DPHE at Mohakhali and have been tested with load of 4 persons at a time Some sanplats were made without any reinforcement, which also proved to be good enough for the loading test. However we recommend manufacturing of Sanplat with 2 nos reinforcing m.s bars as per design considering the handling and transportation needs

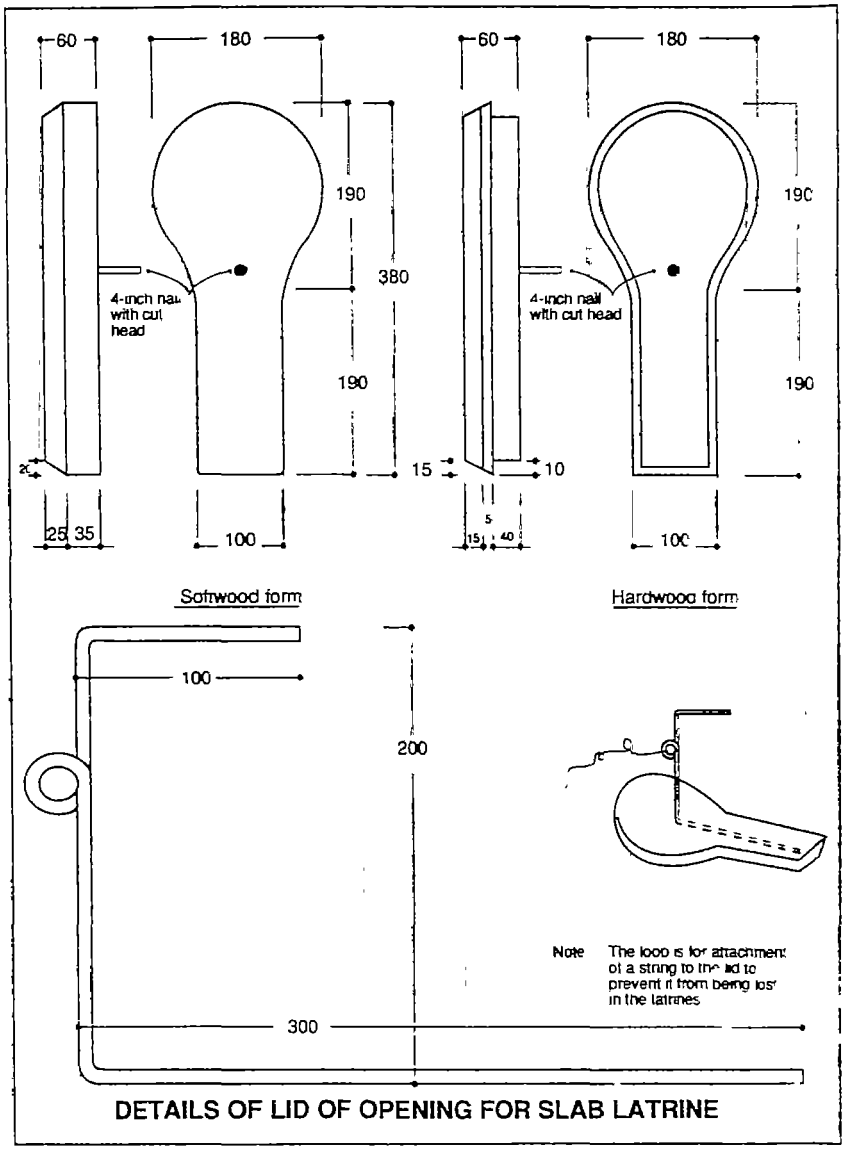
The drawings for the sanplat system have also been adopted to suit the latrine rings of 2.5 ft. diameter, and are given on the next pages. The document used for this purpose is – "The Sanplat System based on experiences from Malawi and Mozambique, by Bjorn Brandgerg, SB. Consulting International AB, Sweden".

The advantages of the Sanplat system are as follows

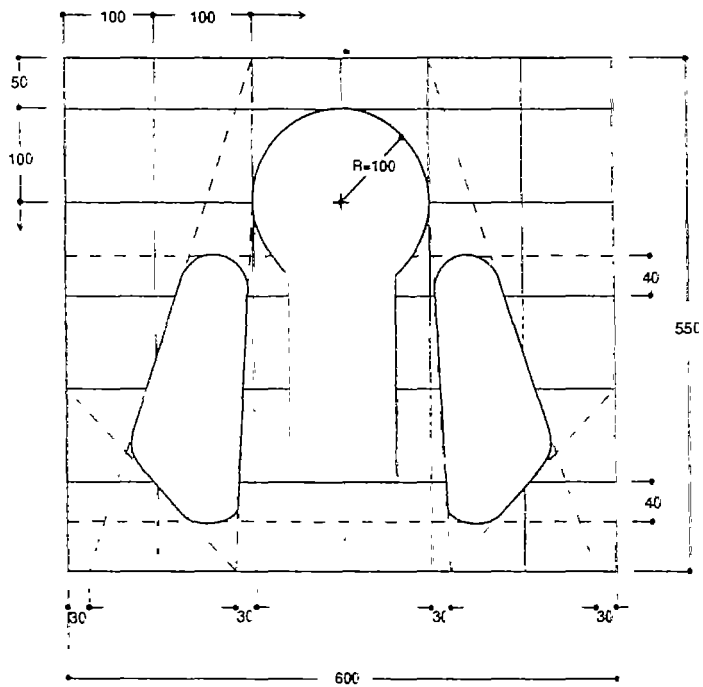
1 The Sanplat has standardised elevated footrests, which help the user to find his right position even in the dark A well studied design has essentially reduced the



MALAWI TYPE SANPLAT LATRINE



DETAILS OF LID OF OPENING FOR SLAB LATRINE



FOOT REST MOULD FOR SLAB LATRINE
(all dimensions in mm)

fouling of the squatting areas, especially in public and institutional latrines, as people now know where to place their feet.

2. The Sanplat has a drop-hole shaped like a key hole, which is safe even for a very small child. It is big enough for comfortable use and small enough to be completely safe.
3. The Sanplat has a tight fitting lid which is tight enough to shut out the smell, thereby making the toilet room odourless and free from flies and insects.
4. The Sanplat is easy to clean with water or a brush. Smooth and correctly inclined surface makes cleaning easy
5. The Sanplat is easy to transport and easy to install. Since no special skill is required even a layman can install it

The Malawi-type Sanplat slab has also been manufactured by private producers of the pilot area in Faridpur district through our training and assistance The mass production and monitoring of latrines made of Sanplat can also be carried out during the forthcoming 5P exercise in the pilot area

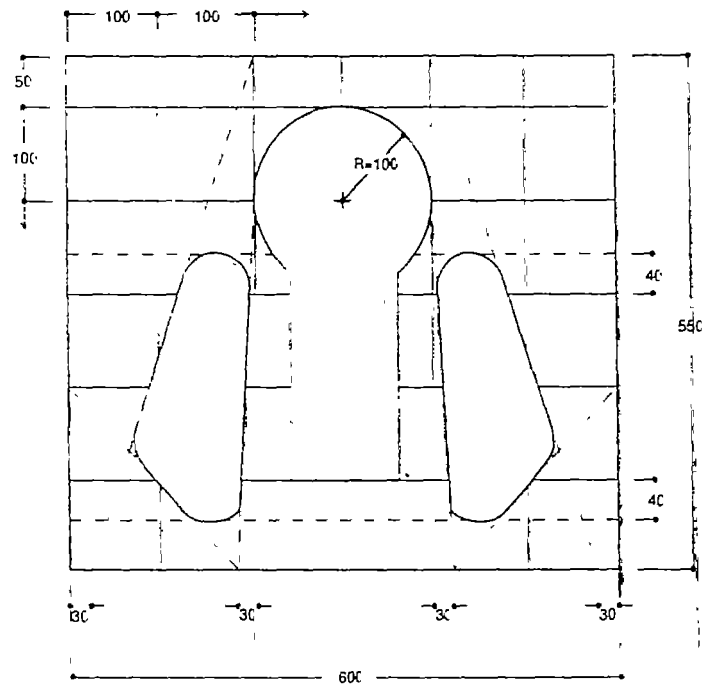
8. Home-made Latrine Slab

For those users who can not afford to have even the low cost latrine in their house, improvised home-made latrines are recommended. These are simple pit latrines with improvised slab made of bamboo and mud

A pit is dug into the ground approximately 4 ft. to 5 ft. deep without any lining. This pit is dug in a conical form or in a bucket shape, to give stability to the slopes Sometime, lining is given by split bamboo mats or bamboo frames.

On the top of this pit, at ground level, a layer of half-split bamboo sticks are laid cross-wise A hole is kept in the centre for defecation purpose These top layer bamboo sheets are tied with four bamboos placed across at the bottom The top of the bamboo layers are again covered and plastered horizontally with mud, to make it air-tight The opening is covered with a timber or bamboo lid with a tall handle. Use of this lid, when the latrine is not in use, prevents bad smell and flies

The pit of a home-made latrine is made of about 30" diameter and 4' to 5' deep The bamboo platform is made of size 36"x 36" square to have sufficient coverage and support on the ground The square slab is tied with 4 bamboo rafters placed across. The half-split bamboos are placed side by side and are nailed to the ground with 4, four feet long bamboos placed across An opening of 12"x 7" is kept in the centre for defecation



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Material requirements for the platform is total 26 ft. long bamboo of an average 3" diameter, which makes 12 pieces of half-split bamboo sticks of 3' length and 4 pieces of 4 ft. length. Sometimes additional length of bamboo is also required for the lid with handle and for strengthening of the pit. One medium size 'borak' bamboo of approx. 30' length is required for making the home-made latrine with bamboo slab.

A drawing of a home-made latrine with bamboo slab is given **on the next page**.

9. Cost Comparison

Detailed cost estimates have been done for different types of latrine slabs. These are given **on the following pages**. The abstract of costs is as follows:

1. Standard DPHE FC slab with pan	Tk.132
2. Standard DPHE FC slab without pan	Tk. 92
3. Mozambique-type Dome slab	Tk 64
4. Malawi-type Sanplat	Tk. 65
5. Home-made bamboo slab	Tk 55

10. Recommendations

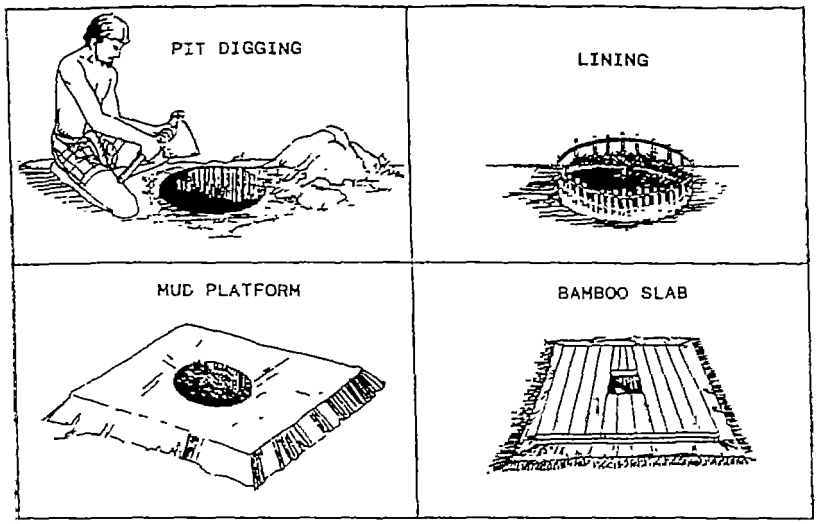
It is observed from the above findings that a slab-latrine without pan, Dome-slab or Sanplat (at Tk. 64 or 65) can be made at half the price of a standard DPHE slab with pan (at Tk. 132). A home-made latrine (at Tk. 55) costs about 85% of a slab latrine. All the different types of latrines have their own advantages, and are meant for different income-level groups of people.

The cost of home-made latrine seems to be very high in comparison to slab latrine. But as the home-made latrines are constructed by the users themselves and by using bamboo or other materials such as tree branch etc., from their own source, the actual cost of construction of bamboo-latrine becomes much less than Tk. 55.

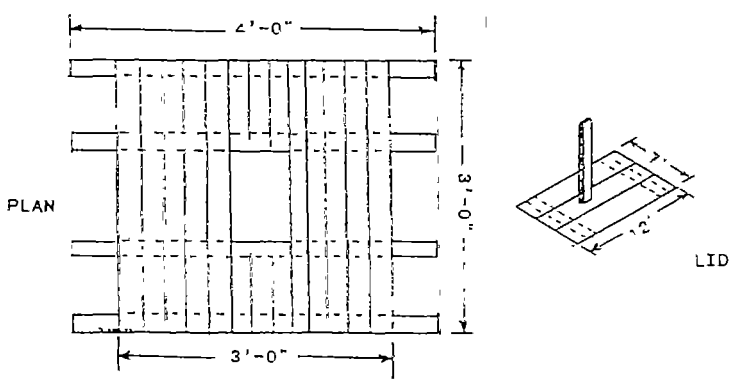
DPHE and NGOs are, in general, promoting latrines with water-seal pans. Unicef and Ansar/VDP are advocating for home-made latrines for those people who can not afford water-seal latrines.

Action research inquiry concludes that RCC slab latrines with concrete lid can provide a much needed intermediate technology option between the DPHE water-seal pans and the home-made latrines. Between the Dome-slab and Sanplat, Sanplat slab is recommendable for the following reasons:

- Sanplat is simpler in construction and installation
- Transportation of Sanplat is easier than that of the Dome slab



STEPS OF CONSTRUCTION OF HOME-MADE LATRINE



BAMBOO PLATFORM OF HOME-MADE LATRIFNE

COST ESTIMATES OF VARIOUS LATRINE SLABS
(Based on actual Market Price - July 1991)

Basic Costs for Estimate of Latrine Slabs

1. Cement	Tk.	4.40	per kg
2. Sand	Tk.	7.00	per cft
3. Coarse Sand (Sylhet type,	Tk.	12.00	per cft
4. Khoa (Brick Agregate)	Tk.	20.00	per cft
5. M.S Bar (6mm dia.)	Tk.	18.00	per kg
6. Wire Mesh	Tk.	2.25	per sft
7. Masor	Tk.	100.00	per no./day
8. Labour	Tk.	50.00	per no./day

1.Standard DPHE Slab and Pan
(Mix proportion: 1:3 and 1:1)

Sl. No.	Item	Quantity		Total Qty	Unit	Rate Taka	Amount Taka
		Slab	Pan				
1	Cement	7.73	4.54	12.27	kg	4.40	54.00
2	Sand(Sylnet)	0.56	0.15	0.70	cft	12.00	8.40
3	Wire Mesh	16.00	0.25	16.25	sft	2.25	36.60
4	Crude Oil/Wax	-	L.S.	L.S.	-	-	3.00
5	Mason	0.10	1.10	0.20	No.	100.00	20.00
6	Labour	0.10	0.10	0.20	No.	50.00	10.00
	TOTAL					Taka	132.00

2.Standard DPHE F.C.Slab without Pan
(Mix proportion: 1:3)
Size: 33" dia. and 2" thick

Sl. No.	Item	Qty	Unit	Rate	Amount
1	Cement	7.73	kg	4.40	34.99
2	Sand (Sylnet)	0.56	cft	12.00	6.72
3	Wire Mesh	16.00	sft	2.25	36.00
4	Mason	0.10	No.	100.00	10.00
5	Labour	0.10	No.	50.00	91.72
	TOTAL			Taka	91.72
				Say Taka	92.00

3.Mozambique-type Dome Slab
(Mix Proportions: 1:2.5:2)
Size: 30" dia. and 2" thick

Sl.#	Name of the Item	Qty	Unit	Rate	Amount
1	Cement	8.00	kg	4.40	35.20
2	Sand	0.50	cft	7.00	3.50
3	Khoa	0.40	cft	20.00	8.00
4	M.S.Bar for handle	1.75	rft	1.40	2.45
5	Mason	0.10	No.	100.00	10.00
6	Labour	0.10	No.	50.00	5.00
	TOTAL			Taka	64.15
				Say Taka	64.00

4.Malawi-type Flat Slab (Sanplat)
(Mix proportions: 1:2.5:2)
Size. 30" dia. and 2" thick

Sl.#	Name of the Item	Qty	Unit	Rate	Amount
1	Cement	7.20	kg	4.40	31.68
2	Sand	0.45	cft	7.00	3.15
3	Khoa	0.36	cft	20.00	7.20
4	M.S.Bar for slab & handle	5.50	rft	1.40	7.70
5	Mason	0.10	No.	100.00	10.00
6	Labour	0.10	No.	50.00	5.00
	TOTAL			Taka	64.73
				Say Taka	65.00

5.Home-made Bamboo Slab
Size: 36" squire, and half bamboo thick (1.5")

Sl.#	Name of the Item	Qty	Unit	Rate	Amount
1	Bamboo 3 dia. 30 long	1	No.	40.00	40.00
2	Wire-nail 2" size	L.S	-	-	5.00
3	Labour	0.20	No.	50	10.00
	TOTAL			Taka	55.00

CHAPTER 4

RESEARCH CONCERNING PANS

1. General

The 'Pan' is the most important part of a rural latrine structure. The function of a latrine pan is to be a receptacle for the human excreta during defecation, and to drain it out in a convenient way to an underground pit.

Many different types of pans are available in the market Most of these are cast separately while some are cast in combination with the top slab The latter type is easier to place directly over a single pit, as it is done in low cost rural latrines Most pans in the market are cast without a water-seal and require additional syphon or water trap to protect it hygienically against bad odour and insects The low-cost rural latrines produced by DPHE, with assistance from Unicef, in their Village Sanitation Centres (VSCs) are cast with an in-built waterseal Most of the NGOs, such as Rangpur Dinajpur Rural Services (RDRS), partner NGOs of NGO-Forum working in rural areas, also produce the pans with in-built waterseal

During the action research, efforts were made to improve the quality of the pan by the following approaches:

- Improving designs of pan for better hydraulic flow
- Smoothening the inner surface of the pan with lining
- Making improved low cost pans made with plastic

2. Types of Pans available

Various types of latrine pans are available in the market These also vary widely in sizes However the most common size of latrine pan is 16" long x 10" wide (in the back portion) x 7" deep Some pans are sold with top slab in one piece, some are sold together with two footsteps, but usually these are manufactured separately and sold as single units.

From manufacturing type and materials point of view the following types of pans are available in the market.

- simple ceramic long pans
- ceramic long pans with in-built foot-stands
- pans made with mosaic concrete
- concrete pans with red cement neat finish
- concrete pans with white powder finish
- simple concrete pans with normal finish
- pans with low cost pozzolona cement

The pans manufactured in ceramic are termed as long pans

3. Classification of Pans by the Type of Manufacturer

The available latrine pans in the market may be classified broadly into the following three groups from manufacturers' point of view

Group 1 Pans manufactured by ceramic/Insulation factories.
Group 2 Pans manufactured at DPHE VS centres and VS centres of NGOs
Group 3 Pans manufactured by private producers

Pans of group 1 usually are of a higher price and are aimed for urban consumers. while those of types 2 & 3 are usually cheaper and are used by lower income groups of urban population and the rural population. Since pans of group-1 are meant for urban areas, these are made with of cistern flushing facilities Group-2 pans are exclusively for rural areas and these are pour-flush type, without option for cistern flushing Pans of group-3 type targets for wider market Both cistern-flushing & pour flushing type pans are made by the private producers

The pans of group-1 are made with ceramic clay burnt in modern kilns. There are a few factories situated in and around Dhaka for manufacturing ceramic pans Bangladesh Sanitary and Insulation Factory (BSIF) of BCIC, a govt sector corporation, is the main and the biggest supplier of sanitary latrine components in the country. Another manufacturer M/s Dhaka Ceramic, with their factory at Tongi, is also a large supplier of pans in the market.

Pans of group-2 and group-3 are produced all over the country, and these are made with cement concrete materials

3.1. Factory Manufactured Pans

The factory manufactured pans are of good quality, properly ceramic coated/glazed and moisture free, which is very effective against bacteria growth. There are mainly two types of manufactured pans available in the market

- Long pan (simple pan, footsteps available separately)
- Oriental pan (orissa type) includes footsteps as a built-in unit.

Present (1992) price of factory manufactured pans varies from Tk 350 to Tk 500 for simple long pan and from Tk 900 to Tk 1600 for oriental pans These pans require a syphon/water trap (S-type) to make it water-seal Casting cost of iron syphon is Tk. 60 to Tk. 100 and those made of PVC are slightly cheaper

It may be mentioned here, for information, that the western type commode (water-closet) and the ceramic cistern manufactured by BSIF are sold at Tk 1700 and Tk 1600 respectively

3.2 Pan made in Village Sanitation Centres of DPHE

With assistance from Unicef, DPHE had long back undertaken an exercise for production of a low cost latrine pan suitable for and affordable by rural population of Bangladesh. The type of pan presently manufactured by DPHE at their VS centres is the outcome of that work This type of pan comes with an in-built waterseal, known as goose-neck. The idea of the goose-neck was transferred from Thailand to Bangladesh Goose-neck is a small semi-spherical tube, fitted at the circular bottom end of the pan in such a way, that it holds water in it and seals gases, bad smell and insects from passing through it When excreta is flusned, it passes to the pit through the water in goose-neck, but again fresh water fills the water seal and the level of water at the bottom of the pan remains the same. The in-built goose-neck curbs the need of additional syphons or water-traps and makes it even cheaper This pan is made with cement mortar, a mix of cement and sand of 1.1 proportion and with normal finish Present manufacturing cost of pan with goose-neck is Tk.40 only

Previously, DPHE used to make the reinforced cement (RCC) concrete pan and the 3 ft.X 3 ft. square slab both cast together In that process the moulds were cumbersome and used to take longer time for casting of the pans with the slab

Presently, in DPHE VS centres, the 33" dia and 1' thick ferro-cement circular slabs are manufactured Later the pan is embedded into the slot kept for it in the slab to make it one unit. It makes the installation of the latrine component very easy. Just the slab is put on top of the top ring A diagram of DPHE-type pan along with the slab is given on **the following page.**

The total manufacturing cost of pan and slab in DPHE comes to Tk. 145. But the set is sold at a subsidised rate of Tk. 50 Rings are also sold at a subsidised rate The first ring is sold at Tk 20 only, while its manufacturing cost is Tk. 85. Subsequent rings, are sold at Tk. 45 each, up to a maximum number of 5 rings

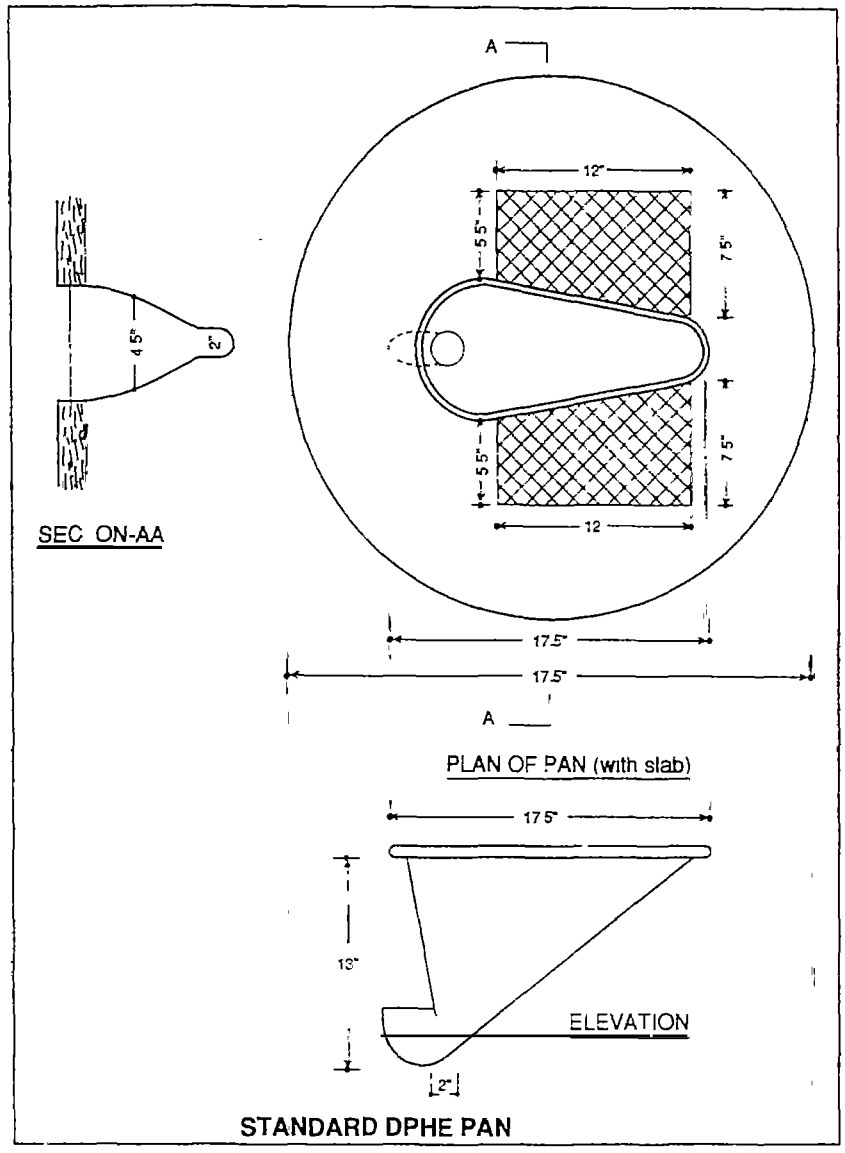
3.3 Pans made in VS Centres of NGOs

Some NGOs also manufacture the latrine pans and the slab together to facilitate easy installation Some NGOs make latrines using their own design But most other NGOs specially those who get assistance from Unicef or NGO-Forum use the DPHE design

The NGOs usually sell the latrines at a no-profit no-loss basis Their sale price therefore varies from one NGO to another But the average sale price is as follows:

- One pan and slab Tk 150
- One ring Tk. 60

A set of one slab and 5 rings costs Tk.450



STANDARD DPHE PAN

RDRS, a big NGO, working in the northern districts of Bangladesh produces another type of pan with in-built waterseal It has been observed that the construction method of the DPHE type pans are much easier than that of RDRS Most local NGOs prefer the DPHE/Unicef type of pan to the RDRS type However, RDRS is doing continuous research on different types of pans

3.4 Pans made by Private Producers.

The product range of private producers is very wide In addition to sanitary latrine pans, these producers make various other concrete products, such as rings, pipes boundary pillars, room ventilators etc The latrine pan constitutes an important product for them, and this item is also produced in different varieties The different types of pans produced by private producers along with the price range is given below.

- Normal cement concrete pans from Tk 40 to Tk. 60
- Light-weight pozzolona cement pans from Tk. 30 to Tk. 40
- Concrete pan with neat cement finish from Tk. 50 to Tk. 60
- Concrete pan with red cement finish from Tk. 60 to Tk 70
- Ordinary mosaic finish c.c. pan from Tk. 60 to Tk. 80
- Good quality mosaic finish c.c pan from Tk. 80 to Tk. 125

The pans produced by private producers are usually without goose-neck waterseal. Therefore, additional syphon/water-tap is required for installation of such latrines The private producers also make cement concrete syphons, price of which varies from Tk. 25 to Tk. 50. The waterseal type of pans made by the private sector have been often found to be defective. The improperly made waterseal can actually not function in the installed latrines Targetted training is necessary to remedy this defect.

Price range of the pans made by private producers varies widely depending on their quality. The following price range is a reasonable assessment.

4. Study of Pour-Flush Pan made by BISF

During the development phase of DPHE pans considerable work was done in their Village Sanitation Research Centre (VSRC) Mohakhali, Dhaka As a part of the village sanitation programme, DPHE came to an arrangement with BSIF Mirpur for manufacturing low-cost pour-flush pans, according to the design supplied by DPHE

Usually BSIF makes sanitary pans with cistern flushing system. But as per DPHE design, and to make the pan cheaper, BSIF have intermittently produced pour-flush type pans in their factory In 1987 BSIF produced and supplied 500 pour-flush pans

to DPHE which were distributed through them. Till the end of 1990, DPHE had procured about 3,000 units of such pans.

This pan is very neat, easy to use and cheap It is quite suitable for people of moderate means and good taste living in semi-urban areas, where running water for cistern flushing is not available.

In addition to supplying the DPHE, the BSIF is also marketing such pans through their regular dealers. These are quite popular among the knowledgeable users and are commonly termed as "Upazila-pans"

The factory sale price of this pan is Tk.215 per piece. Adding approximately 30% overhead and taxes, these are sold in Dhaka at Tk.260 In remote corners of the country, the dealers charge extra transportation costs and sell each pans at approximately Tk. 300.

5. Improved Design of Pan

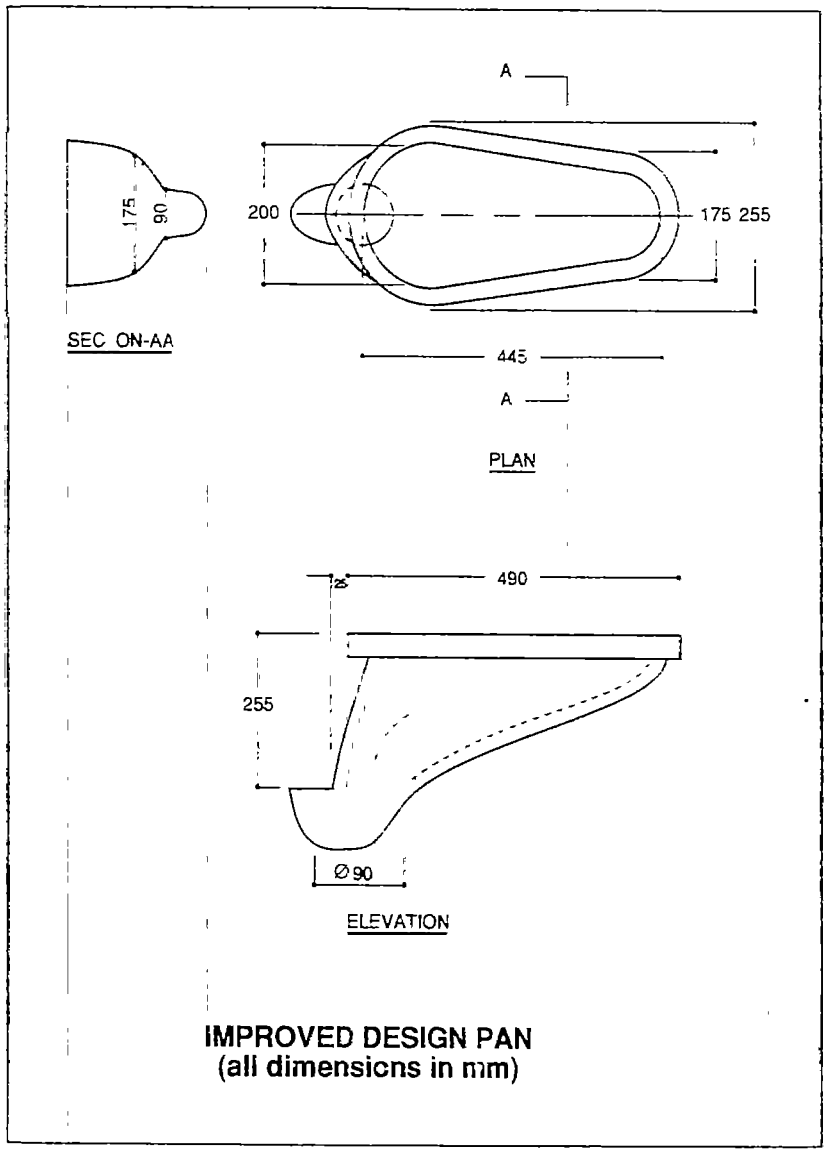
During this research work, it was noted that the existing DPHE type pan has the following three special characteristics.

1. The slope of the whole pan bottom is very steep
2. The curvature at the bottom is very narrow
3. The slope of back-wall of the pan is inward

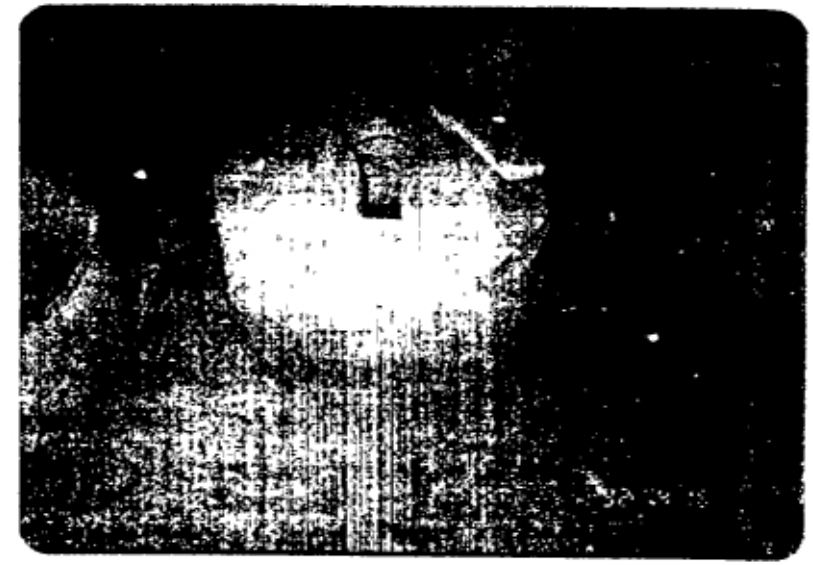
We observed that the back-wall of the pan should be outwardly slanted to create better hydraulic flow in the pan. When the pour water hits the inward sloped back-wall, part of it spills back. But if the slope is in the direction of water flow, it moves without obstruction

Considering all the above points, various alternative designs were planned After the designing stage, moulds were made and later concrete pans were cast with these moulds. After trying different alternatives, it was decided to adopt the design which is given on the next page.

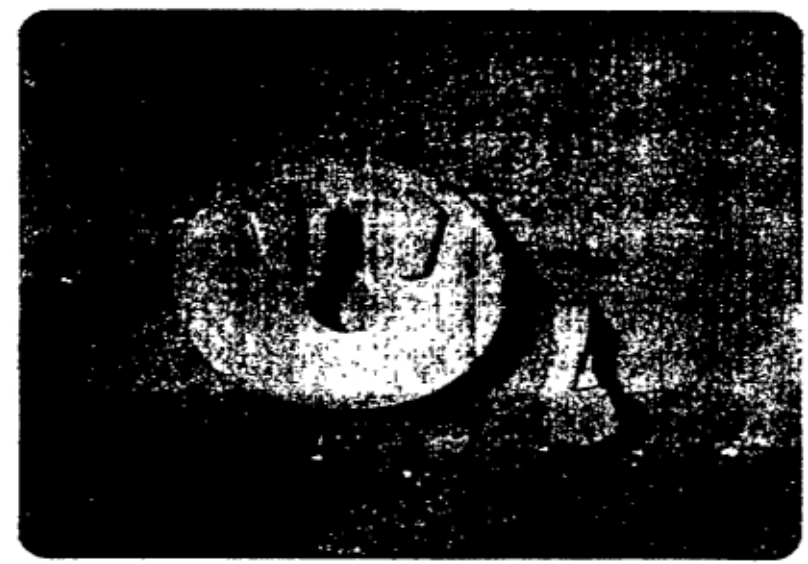
A number of pans were made using the adopted design and analytic tests were conducted on this in comparison with other pans



IMPROVED DESIGN PAN
(all dimensions in mm)

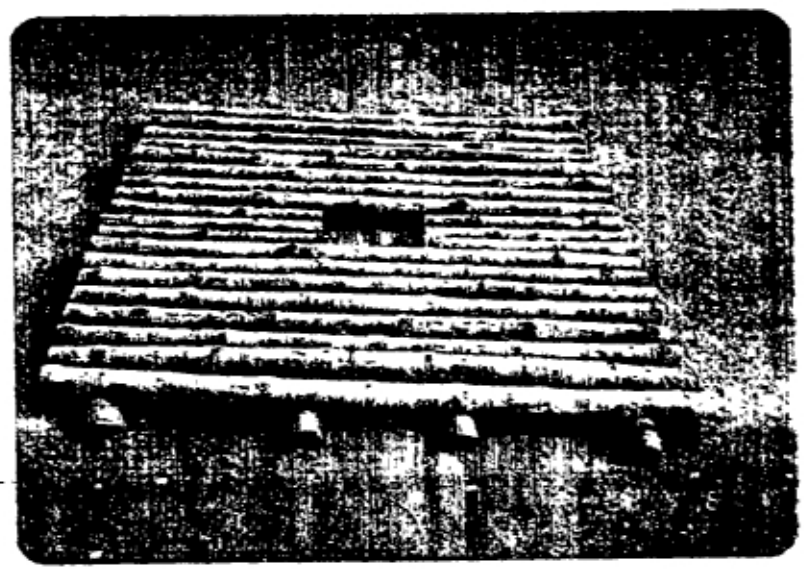


Mozambique-Type Dome Slab Latrine cast at VSRC Mohakhali



Malawi-Type Sanplat Latrine Slab cast at VSRC Mohakhali

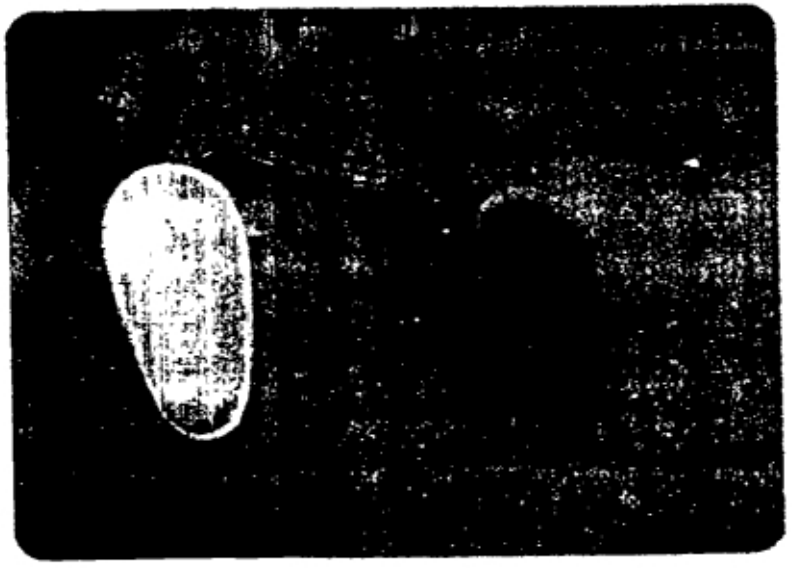
Sanplat Latrine Slab being constructed by Private Producer in Faridpur District



Typical Bamboo Slab of Home-made Latrine constructed at VSRC Mohakhali

CC Pan and Water-seal cast with RDRS Mould during Action Research Programme

Plastic Pan Developed in MAWTS



Improved Designed Pan Developed during Action Research Programme, Lined with White Cement and without Lining

Equipment of Trolley-Test for Analytic of Test of Pans for finding their effectiveness

5.1 Comparison with Standard DPHE Pan

The following table gives the salient features of the standard DPHE pan and the improved design pan:

Description	DPHE pan	Improved design pan
Length	450 mm	445 mm
Breadth:		
In front	150 mm	175 mm
In middle	200 mm	188 mm
At the end	250 mm	200 mm
Height/Depth	300 mm	250 mm
Bottom profile	25 mm dia	50 mm dia
Back wall slope	inward	outward
Pan slope	1:1.2	1:0.8

5.2 Test on Improve Designed Pans

There is always a scope for further improvement of the modified pan But for this some pans will have to be manufactured and distributed to the users in the field and then properly monitored to see how these can be improved in performance and effectiveness. The forthcoming 5P exercise will provide a suitable opportunity for monitoring After successful trial tests this Improved designed pans may be produced in mass scale through the private producers in a pilot area. However, concrete moulds will have to be supplied to the private producers. The concrete moulds however do not cost much.

Once being successfully tested the improved design pans may also be accepted by DPHE for production in the VS centres Although it is true that the public sector has limited opportunity for manufacturing varied designs of pans in their production centres, the private producers are at liberty and have wider scope for adaptation.

6. Smoothening of Pans with Linings

The main obstruction to the easy flow of excreta in a low-cost pan is its roughness If the inner-surface of the pans can be smoothened by linings the pans will work more effectively. In the market many pans are lined with various materials, such as

- Mosaic pans
- Pans with neat cement lining
- Pans with white powder lining etc.

During the action research we have tried two types of materials for lining of pans.

- Marble touch
- White cement

6.1 Lining with Marble Touch

Marble touch is a special technique for smoothening concrete surfaces by using powder marble and other materials This is done by a company in old Dhaka and they have patented the technique The firm uses the name "Marble Touch" as their trade mark.

Usually marble touch is done better on larger flat area such as floors and walls. We have, nevertheless, tried to use marble touch coating on the inner surface of pans The result was good but too expensive an alternative for smoothening pans The mentioned firm charges Tk 70 for each pan lining. Mass production of pan lining may reduce the rate a little but it will still be no less than Tk 60, which makes it prohibitive for mass application.

6.2 Lining with White Cement

In the action research, lining the pans with white cement in order to make these smooth has been tried. Lining the pans with white cement is relatively cheaper and effective. Usually 2 kg of white cement is required for one pan and a mason can work on 10 pans per day.

For comparing the cost and effectiveness of lined pans, standard DPHE pans were also lined with white cement.

7. Analytical Tests on different types of Pans

Analytical tests were performed on various types of pans to ascertain the relative improvement in the excreta flow by measuring the quantity for water required for flushing similar quantity of excreta replica

7.1 Initial Manual Test

This initial test required a person to throw water from ankle height into the pan with a moderate thrust. Force is not measured in this simple test It just shows which kind of pan disposes excreta from it more quickly and easily.

In the later tests the standard DPHE and improved design pans were used both with or without lining of white cement. Pans lined with marble touch material was excluded due to its high cost

7.2 The Trolley Test Method

The above simple test could not be considered entirely dependable. Therefore, an improved testing method was adopted. This test method has been termed "Trolley Test". A test trolley is made of wooden framework. On this trolley different pans to be tested are kept uniformly and in order. The trolley has an elevated position where a water-sink can be placed and moved horizontally This water-sink used was of 16"x 6 5" in size and had a water outlet in the centre of the bottom The outlet hole had a vertical delivery pipe of 1.25' diameter and 27" in length The water-sink was calibrated for measuring water content with half liter markings. The water in the sink could be stored by putting a rubber stopper on the outlet hole.

False excreta was made by mixing flour with saw-dust half-half. Moulds for the false excreta were made of approximately 3/4"in diameter, 3" in length and about 50 grams in weight.

Similar pieces of the above mix were kept on different pans Then the pan was flushed with water from the sink from a fixed height. If the false excreta was not flushed out of the water-seal, the water content was increased and the test was repeated. Water was increased by 0.5 liter. Every time the rubber stopper was released abruptly so that the water in the sink was released uniformly over the pan which flushed the false waste through the water-seal This operation was repeated by increasing water level 0.5 liter every time until the excreta replica completely flushed through the water-seal

The same experiment was repeated on different types of pans under test. In the final tests, we tested the following four types of pans to measure their relative smoothness and ease for discharging excreta

- Standard DPHE pan
- DPHE pan with lining
- Improved design pan without lining
- Improved design pan with lining

All four types of pans were strongly placed in the slots of the test trolley platform and had to go through the test by sliding overhead water-sink with varied quantities of water.

In this way flushing trial is also done with each type of pan separately The quantity of water needed for sufficient flushing in each pan is recorded.

7.3 The Test Results

The following table shows the results of the analytical test done in Village Sanitation Research Centre (VSRC) of DPHE at Mohakhali, Dhaka The figures give the quantity of water required to flush a lump of false excreta through the water seal of that type of latrine pan.

1.	Standard DPHE pan	2.0 liter
2.	DPHE pan with lining	1.5 liter
3.	Improved design pan without lining	1.5 liter
4.	Improved design pan with lining	1.0 liter

It has been deduced from the above tests that lining makes a pan more effective in use. It also shows that the improved design pan, as recommended by this research, function is more effectively than the existing DPHE type pan Among the above four types of pans the improved design pan with white cement lining gives the best functional result.

8. Cost comparison

Detailed cost estimates have been done for standard DPHE and Improved design pans It is found that the manufacturing costs of both the pans are the same The detailed breakdowns of cost analysis of pans smoothened with marble touch material and with white cement are also done and these cost estimates are given on the following pages.

The following is the abstract of cost analysis of various types of pans.

1.	Standard DPHE pan	Tk 40
2.	Standard DPHE pan with lining	Tk 70
3.	Improved design pan	Tk 40
4.	Improved design pan with lining.	Tk. 70
5.	Improved designed pan with marble touch lining	Tk.110

It is seen from the above table that the production cost of Improved design pan is the same as that of standard DPHE pans Lining of pans with white cement makes it costlier by Tk 30, but provides a more effective application Lining of the pans with marble touch makes the pans very expensive and is thereby not recommended

9. Research on Plastic Pans

Plastic Pans were tried by Unicef/DPHE as a cheap alternative of existing different types of pans Applied research on plastic pans was carried out by MAWTS (Mirpur Agricultural Works and Training School) at Mirpur

COST ESTIMATES OF PANS AND THEIR LININGS
(Based on actual Market Price - July 1991)

Basic Costs for Estimate of Latrine Pans

1. Cement	Tk.	4.40	per kg
2. White Cement	Tk.	14.00	per kg
3. Coarse Sand (Sylhet type)	Tk.	12.00	per cft
4. Wire Mesh	Tk.	2.25	per sft
5. Mason	Tk.	100.00	per no./day
6. Labour	Tk.	50.00	per no./day

1.Standard DPHE Pan
(Mix 1:2)

Sl. No.	Item	Qty	Unit	Rate	Amount
1	Cement	4.54	kg	4.40	19.98
2	Sand (Sylhet)	0.15	cft	12.00	1.80
3	Wire Mesh	0.25	sft	2.25	0.56
4	Crude Oil/Wax	L.S.	-	-	3.00
5	Mason	0.10	No.	100.00	10.00
6	Labour	0.10	No.	50.00	5.00
	TOTAL			Taka	40.28
				Say Taka	40.00

2.Improved designed pan
(Mix 1:2)

Sl. No.	Item	Qty	Unit	Rate	Amount
1	Cement	4.50	kg	4.40	19.80
2	Sand (Sylhet)	0.12	cft	12.00	1.44
3	Wire Mesh	0.25	sft	2.25	0.56
4	Crude Oil/Wax	L.S.	-	-	3.00
5	Mason	0.10	No	100.00	10.00
6	Labour	0.10	No.	50.00	5.00
	TOTAL			Taka	39.80
				Say Taka	40.00

3.Estimate for Improved Designed Pan with White Cement Lining

Sl. No.	Item	Qty	Unit	Rate	Amount
1	Concrete Pan	1	No	40.00	40.00
2	White Cement	1	kg	20.00	20.00
3	Extra Labour	0.10	No	100.00	10.00
	TOTAL			Taka	70.00

4.Estimate for Improved Designed Pan with Marble Touch Lining

Sl. No.	Item	Qty	Unit	Rate	Amount
1	Concrete Pan	1	No.	40.00	40.00
2	Marble Touch mat	L.S.	-	-	50.00
3	Extra Labour	0.20	No	100.00	20.00
	TOTAL			Taka	110.00

Two standard designs of pans one with water-seal and the other with chute (without water-seal) were prepared by DPHE/Unicef and given to MAWTS for making prototypes. MAWTS have made a few sample pans according to these designs with fibre-glass-plastic (FGP) and gave these to Unicef for trial. MAWTS have made the fibre-glass pans with long and short chutes and with gravity flaps at the end. These are specially designed for the areas where water is scarce and water seal latrines are not feasible. Unicef has a plan to field-test some of these pans to determine their suitability and acceptability to the users

The pans were made in FGP instead of normal plastic because the initial cost of metal mould is very high for normal plastic applications. The FGP pan costs in the range of Tk 650 per piece which makes it prohibitively expensive for normal use. Even the plastic pans are likely to be costlier than originally anticipated. The original enthusiasm has worked and Unicef is yet to take any decision on the newly developed pans.

During the action research the plastic manufacturers were interviewed regarding the future prospects of plastic pans. It is understood that the metallic mould for the pan involves a heavy initial investment of approximately Tk 400,000. A mass production of plastic pans may bring down the cost to Tk.100 per piece. The entrepreneurs are not yet sure about the market of the product If marketing of these pans can be guaranteed they are ready to manufacture it.

10. Recommendations

Improved design pan as developed during the research work by changing the back slope and shape of the existing DPHE pans, and using the existing DPHE goose-neck is recommended for wide adaptation. This will ensure more effective and easy excreta disposal This may be tried through DPHE VS centres and through private producers for popularising it to the public. However, secondary moulds of the pan, made of concrete, are to be supplied to the private producers. This work can be attempted and well-monitored during the 5-P exercise in the pilot area

For smoothening of pans white cement lining is recommended It is relatively cheaper and effective. Lining with marble touch is not recommended because of its high cost.

It is recommended that research on plastic pans should continue in order to find an alternative low-cost solution for latrine pans with perhaps waste plastics Some agencies may come forward to provide loans to help private entrepreneurs provided assurance of sale in reasonable quantities is available.

CHAPTER 5

RESEARCH CONCERNING SUPERSTRUCTURE

1. General

The superstructure component of a latrine is required for the privacy and protection against rain and sun It has nothing to do with whether a latrine is sanitary or not. In rural areas, there are some latrines with excellent superstructures but without any water-seal It is more important to have a sanitary latrine than to have an expensive superstructure This means that a latrine must have water seal and an excreta enclosing pit, even if it is seemingly a simple one

Even though the substructure of a latrine is more important from sanitary point of view, each latrine should have a superstructure But till now little importance has been given to this component by the public sector and other agencies. A moderate superstructure is necessary for convenience, privacy and prestige of the owner Therefore the consultants have investigated into various types of latrine superstructures available in the rural areas aiming to bring about an overall improvement in the standard of superstructures

A latrine superstructure should have the following qualities

- should be easy to construct
- should have low cost
- should have durability
- should have enough ventilation
- should look acceptable
- should provide privacy and protection

2. Design and Dimension

Various sizes and types of latrine superstructures are found all over the country However the minimum size of a latrine is considered to be 3 ft x 3 ft or 3.5 ft x 3 ft. The usual height of latrine superstructure is 7 ft. to 8 ft. for 'pucca' structures and even less for 'katcha' structures

The minimum dimension of 3 ft x 3 ft has been considered most suitable for economic reason At least this size is required to completely encircle the standard latrine slabs of 2.5 ft diameter The height of the low- cost latrines should be minimum 6 ft at the front and 5 ft. at the back

In the action research the above dimensions have been kept as standard and we recommend building of latrine superstructures in standard portable form, which can be produced in one place under quality control supervision and then can be easily transported to other places. The design and dimensions of the portable type of superstructures are given **on the following pages.**

3. Types of Superstructures

The latrine superstructures are broadly classified into the following two types

- 'pucca' superstructure
- 'katcha' superstructure

The 'pucca' latrine superstructures, made of brick and cement mortar, are expensive. The installation cost of 'pucca' superstructures can be many times more than that of a 'katcha' one. The reasons behind customer preference to 'pucca' latrines are durability and prestige No standard designs for 'pucca' or 'katcha' latrine structures are available, and the construction is done on site by professional masons as instructed by the user

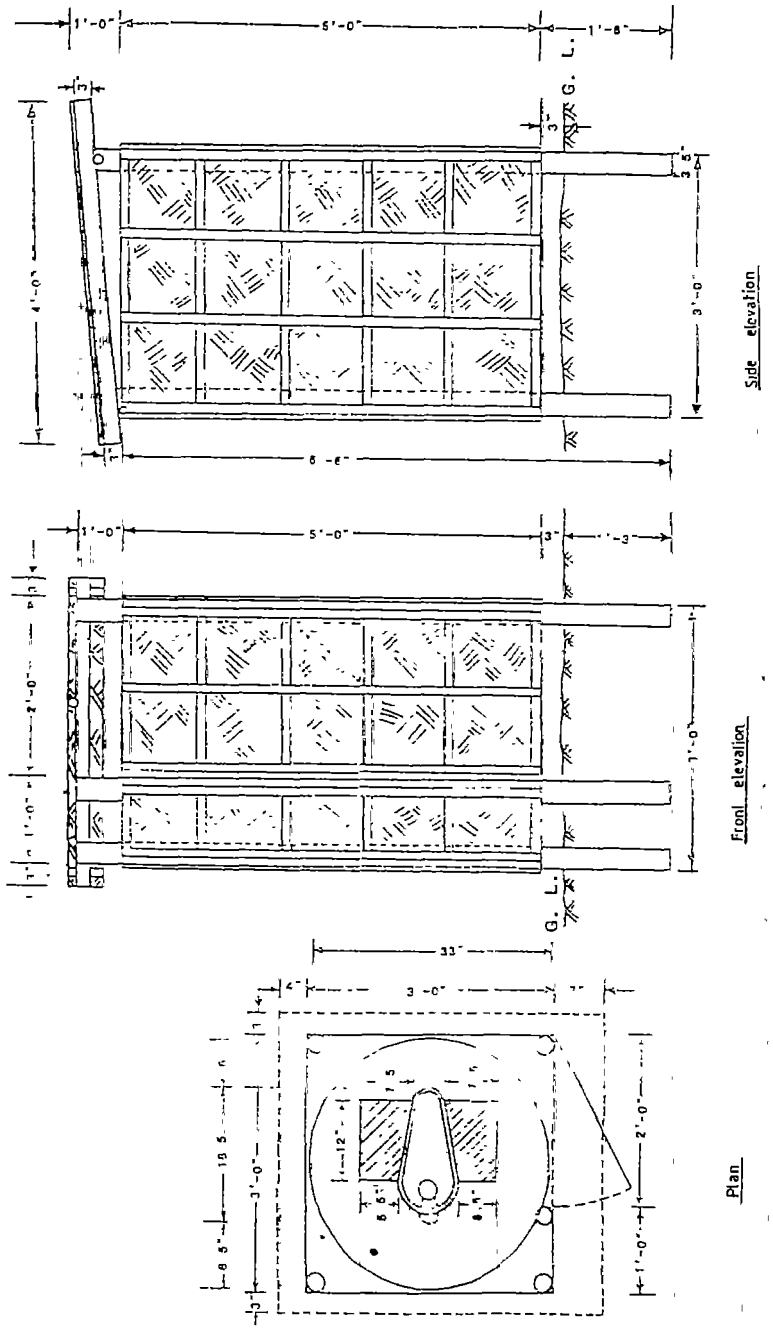
A 'katcha' latrine superstructure is made of indigenous, low-price, easily available materials which can be put together and installed by locally available skills. A large variety of 'katcha' superstructures are found in rural areas and are mainly made of inexpensive local or industrial materials:

- bamboos
- jute sticks
- straws or dry grasses
- wood or timber
- mud blocks with mud plastering
- jute sacks
- polyethylene or plastic sheet
- corrugated iron or plastic
- thin tin plates etc.

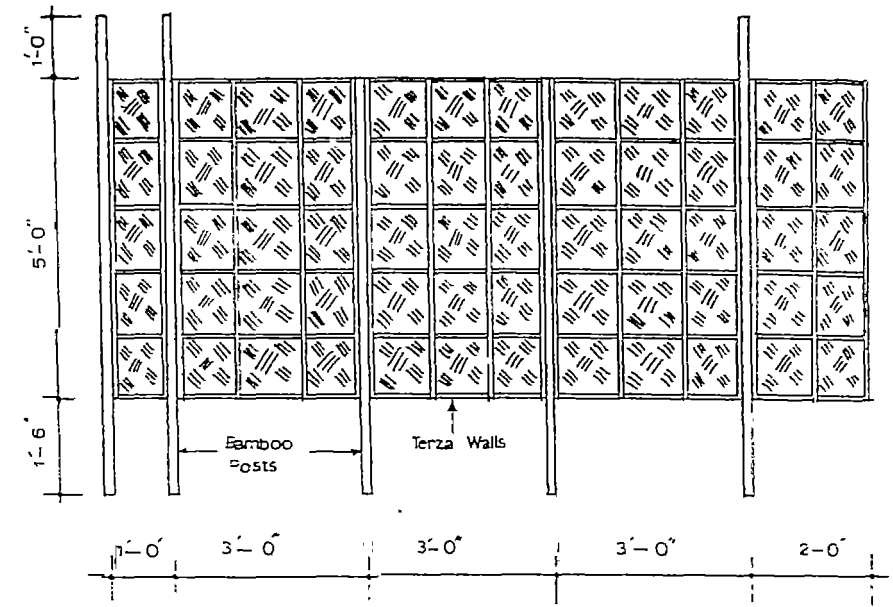
In fact every available waste material has been utilised for the purpose.

It has been observed in the pilot project areas in Faridpur district, that almost 70% of latrine superstructures are erected with jute sticks This alternative is described in the following paragraphs

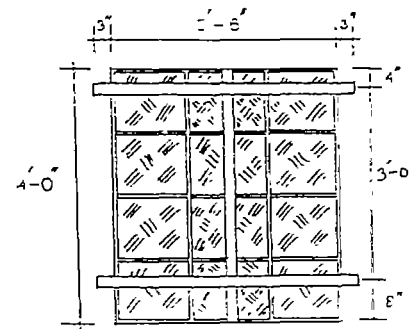
Jute sticks are, in fact, waste products of the jute plant. after peeling of the jute fibers out of it Although jute sticks are brittle and of low durability, these are used in the



LATRINE SUPERSTRUCTURE WITH BAMBOO AND TERZA



WALL TERZA PANELS WITH BAMBOO POSTS



ROOF PLAN

Materials:

BAMBOO MAT WALL
5'-0" x 3'-0" — 3 =
5'-0" x 2'-0" — 1 =
5'-0" x 1'-0" — 1 =

BAMBOO POSTS
7'-6" — 3 =
6'-6" — 2 =

BAMBOO MAT ROOF
4'-0" x 3'-6" — 2 =

POLYETHELYN SHEET
4'-0" x 3'-6" — 1 =

BAMBOO RAFTER
4'-0" — 3 =

PRE-FABRICATED BAMBOO SUPERSTRUCTURE

superstructures because of their very low price. Jute sticks are otherwise used only as domestic fuel.

For a latrine superstructure of 3 ft x 3 ft size and 5 ft height, a bundle of jute sticks containing approximately 600 sticks of average 1/2 inches diameter are enough The cost estimation can be as follows.

Cost of jute stick bundle	Tk 25
Two small bamboos for framework	Tk 50
Labour charges for installation	Tk 25
Total	Tk. 100

Since the jute sticks usually comes from users' own resources and almost free of cost and the installation is also done by themselves, the actual expenditure for installation of one jute stick latrine superstructure can be much less than Tk.100

This type of superstructure lasts only six months and needs to be replaced twice a year The jute sticks can be chemically treated This may be attempted by other organisations such as HBRI or BCSIR The economic viability of this is yet to be established

4. Non-traditional Latrine Superstructures

In addition to the types of latrine superstructures mentioned above, there are some other types latrine superstructures built, with non-traditional materials are also in use One such material is the ferro cement pans

May be there are other non-traditional materials with which latrine superstructures can be built. In the following paragraphs the superstructure with above mentioned item is described.

It is possible to make collapsible type of latrine superstructures using ferro-cement panels The cost of one FC panel latrine superstructure is approx Tk.3,000 which is equal to the cost of making a 'pucca' latrine superstructure with brick masonry. Its high cost does not make it suitable for users of rural areas who are the target group of this study It is felt that this type of structure will be very suitable for semi-urban areas, such as upazila headquarters and small towns The advantage of this type over 'pucca' structure is its light weight and portable which makes the superstructure easy to handle, transport and install

5. Superstructure Alternatives

In the research, a low cost, durable and easy to construct model of latrine superstructure was sought. Various alternatives in combination with the already described materials were designed and tried. The following six types of latrine superstructures were erected and monitored in the VSRC compound at Mohakhali, Dhaka.

1. CI sheet walls and roof with bamboo poles
2. Thin plain tin sheet (Rupban) walls and roof with bamboo poles
3. Untreated bamboo mat (terza) walls, CI sheet roof, bamboo poles
4. Untreated split bamboo walls, terza roof and bamboo pillars
5. Untreated bamboo mat (terza) walls and roof with bamboo poles
6. Treated bamboo mat (terza) walls and roof, with treated bamboo poles

In April 1991, two latrine superstructures were constructed with untreated bamboo and another two with treated bamboo at the VSRC premises at Mohakhali Later in September 1991 the same four superstructure models were shifted and rebuilt at the Housing and Building Research Institute (HBRI).

During the action research regular monitoring on the weathering effect on these treated and untreated bamboo structures had been done It was clearly visible that the treated bamboos have sustained the weathering effect better than the untreated ones. However, the time was too short to made a final assessment of the life of the treated bamboo structures, or their durability In the forthcoming 5P study exercise better estimation is expected of the longevity of treated bamboo structures The secondary data indicates that the life of the treated bamboo can be upto three times the life of the untreated bamboo.

6. Bamboo Treatment Processes

The bamboo treatment processes for better preservation and durability are described below in brief

Bamboo is a very versatile material which has multi-purpose use In fact, it is used from cradle to grave in Bangladesh, including building of low-cost houses It is preferred for constructional uses because of its low-cost compared to other materials, easy availability especially in rural areas, its high strength-weight ratio and good working qualities But major disadvantage of bamboo its low durability and weaker natural resistance

Normal life time of untreated bamboo is:

- less than 1 year when in contact with saline water.
- 1 to 3 years when in contact with atmosphere and soil
- 4 to 6 years under cover
- 10 to 15 years under cover in favourable condition, dry and non humid climate

Split bamboo decays more rapidly compared to the full round bamboo The bottom part of a bamboo has on an average a higher durability than the middle and top portion The inner part of a bamboo culm is weaker than the outer part. Highly matured bamboo has higher resistance against rot but are more brittle

6.1 Bamboo Preservation types

Bamboo can be made more durable by treatment Normally bamboos are damaged by attacks from fungi when it is moist, and it is also attacked by insects such as beetles and termites

The process bamboo processes can be classified broadly in the following two methods

- Traditional (non-chemical) treatment
- Chemical treatment

6.1.1 Traditional Treatments

The traditional methods for bamboo treatment are the followings.

- Culm-curing, in which culms are cut, but left in their place in a vertical position.
- Smoking method, in which cut bamboos are stored above the fire place which blackens the culms.
- Water soaking, in which the freshly cut bamboos are put in water with stones on top to keep the bamboo immersed

The traditional methods are very cheap and can be done without special equipments The effects of such curing/treatment on the durability is not the same in all cases Over-curing and drying of soaked bamboo in sun cracks the bamboo

6.1.2 Chemical Treatments

Chemical treatments, are of two types

- treatment with oil based chemicals
- treatment with water-based chemicals

Water-based chemicals are usually CCA, i.e. copper-chrome-arsenic or CCB i.e copper-chrome boron of borax compound and the oil- based chemical are creosote etc. which is a by-product during petroleum production.

6.2 Methods of Chemical Treatment of Bamboo

There are three methods of chemical treatment of bamboo. These are

- Butt Treatment Method
- Open Tank Method
- Bouchene Method

6.2.1 Butt Treatment

The bottoms of the freshly cut culms are immediately put into a drum of preservative. The leaves, still at their place, act as a pump, due to evaporation After one or two weeks, the preservative reaches the top. This can be noticed by watching the change in colour of the leaves. Then the bamboos are placed into an empty drum, to obtain the surplus preservative from the culms. This method can be used instead of the Bouchene method, when less number of culms are treated.

6.2.2 Open Tank Method

An open tank is a trough of about 4 meters long This can be made by cutting two 200 liter drums into halves and welding them together like a canoe. The drums are cut with a cold chisel and a hammer, then the sharp edges are flattened with a hammer After welding them together, the inside is painted with bitumen, tar, or anything like that to protect the drums from corrosion. The solution is put into the trough with a plastic bucket. The bamboo is cut to the required length before it is put into the trough. The bamboo can be split in order to avoid treating the parts that will not be used. A big stone is placed on the bamboo, to keep them immersed The bamboo must soak a full week (split bamboos three days). The trough should be covered with plastic to keep the rain out. Children and animals should stay away! After soaking lift the bamboo into sticks across the trough and let the preservative drain back into the trough for a few hours After that, let it dry for a week in a vertical position, in a rack, protected from sun and rain.

Treated bamboo must not be burned, the gases of such a fire are toxic. Bamboos then are buried in the ground, away from waterwells.

6.2.3 Boucherie Method

A drum of preservative is put on a tower about 10 meters high and connected by tubes to the ends of the bamboos, the height causes pressure and this takes the

preservative into the bamboo. The bamboo has to be very fresh. From the far end of the bamboos, at first sap will drip which has to be discarded During the process the concentration of preservative in this sap will steadily increase.

The extra preservative can be recollected and reused, if some fresh preservative is added to the original concentration The culm is ready when preservative in the original concentration drips out from the far end. This lasts several days. An air pump on top of the drum might reduce this time to a few hours. Then the bamboos are put into the a vertical position in an empty drum to regain surplus preservative from the culm

The HBRI recommends for Boucherie method of chemical treatment with CCB liquid for preserving full bamboo The BCSIR advocates for open tank method with the same chemical The BFRI recommends boucherie method for treatment of full bamboo, and open tank method for treatment of bamboo mats, terza, bamboo-splits and other material such as thatch straws, palm leaves, etc Jute sticks can also be chemically preserved by the open tank method

In the action research, full bamboos were chemically treated by simple Boucherie method with CCB liquid. The equipment used was procured through HBRI. For walls of superstructures, terza were manufactured from the splits of treated bamboos.

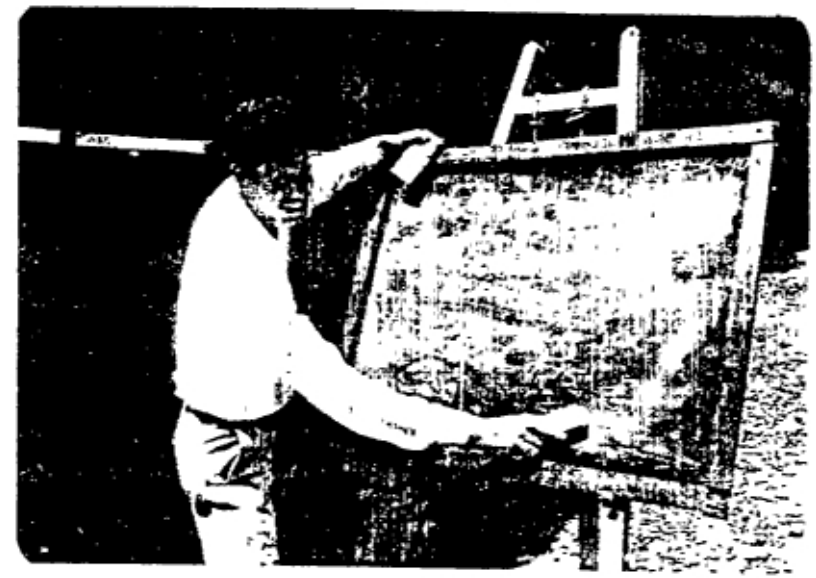
7. Cost Comparison

The material break-down and cost estimates for the different alternatives of latrine superstructures which are mentioned in para-4 above. have been worked out in detail and are given **on the following pages**

The abstracts of cost of different superstructures are as follows

1.	With CI sheets	Tk. 1,125.00
2.	With thin tin sheets	Tk 692.00
3.	Bamboo mat wall & CI roof	Tk. 630.00
4.	Split bamboo wall & terza roof	Tk. 525.00
5	With bamboo mat (terza)	Tk 435.00
6.	With treated bamboo mat	Tk 450.00

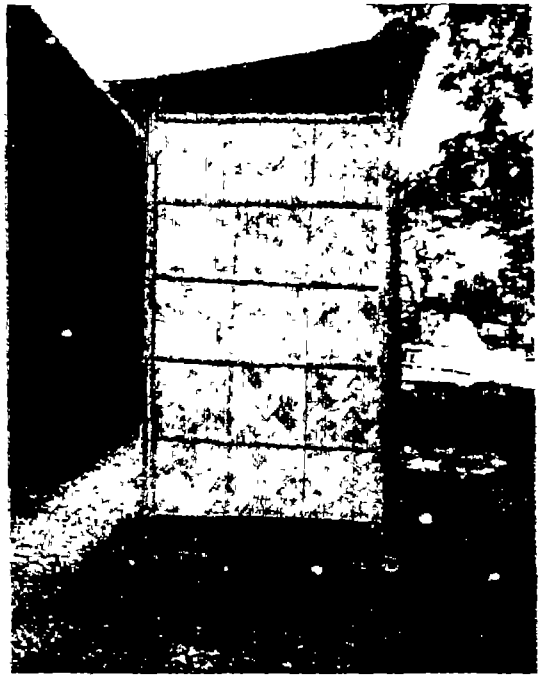
These cost estimates are made with the assumption that the buyer has to pay for all materials. In practice, however, some of the material may be locally available to a user and may not cause as much spending.



A discussion Seminar held in VSRC Mohakhali during our Action Research Programme

Participants from DPHE, UNICEF, WHO and others in the discussion Seminar

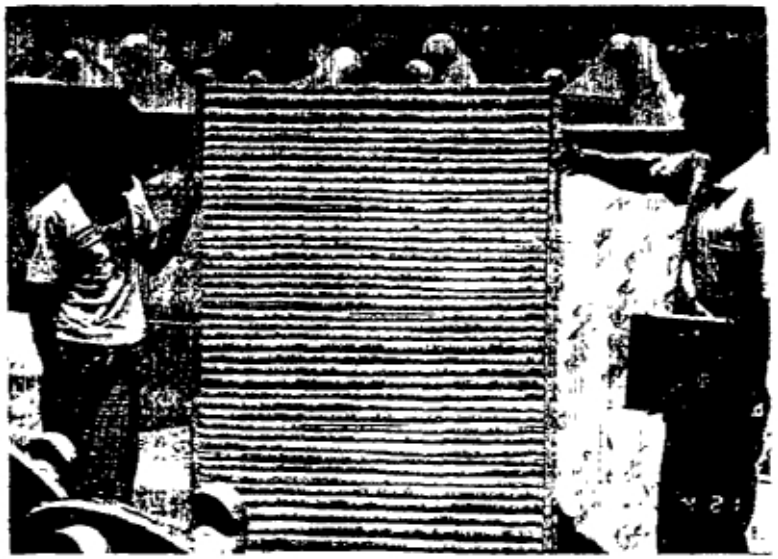
Demonstration Latrine Superstructures constructed with Treated and Untreated Bamboo Elements, installed at HBRI premises at Mirpur



Latrine Superstructure with Treated Terza and Bamboo Posts installed during Action Research Programme

Treatment of Bamboo with Simple Equipment Designed by HBRI

Weaving of Terza (Bamboo Mat) from Split-Bamboo portions



Bamboo Superstructure Walls with Split Bamboo and Terza. erected during Action Research Programme

Typical Low-Cost Rural Latrine Superstructure with inferior Terza

COST ANALYSIS FOR VARIOUS LATRINE SUPERSTRUCTURES
(Based on actual Market Price - Jan, 1992)

1. SUPERSTRUCTURE WITH C.I. SHEET WALLS & ROOF, AND TIMBER POLES

MATERIALS REQUIREMENT

Sl.#	Materials	Size	Quantity
1	C.I. Sheet (26 BWG)	5'-0"x 2'-6"	5 Nos.
2	Timber for front pillars	2" x 3" x 7'-0"	3 Nos
3	Timber for back pillars	2" x 3" x 6'-3"	2 Nos
4	Timber for purlin	1"x 2-1/2"	60 rft.
5	Screw	1-1/2" long	4 dozen
6	Wire Nails	3" long	300 gm

COST ESTIMATE

Sl.	Item	Qty	Unit	Rate	Amount
1	C.I. Sheet	5	Nos.	130.00	650.00
2	Timber (Mango/Jam)	2.5	cft	250.00	625.00
3	Screw	4	doz.	6.00	24.00
4	Wire Nails	0.3	kg	33.00	11.00
5	Carpenter	1	No	100.00	100.00
	TOTAL TAKA:				**1,410.00**

2. SUPERSTRUCTURE WITH THIN TIN SHEET WALLS & ROOF, AND BAMBOO POLES

MATERIALS REQUIREMENT

Sl.#	Materials	Size	Quantity
1	Thin tin (Rupban) sheet	34 x 35"	11 Nos.
2	Bamboo for front pillars	7'-0" long	3 Nos.
3	Bamboo for back pillars	6 -3" long	2 Nos.
4	Bamboo for rafter	3"-6" long	2 Nos.
5	Bamboo for purlin	1-1/4" wide	200 rft
6	G.I. Wire	22 BWG	100 gms
7	Wire Nail	1-1/2" long	300 gms
8	Coconut Coir Rope	3/16" dia	200 gms

Note: 3 Nos. 30 ft. borak bamboos are required for Sl. 2,3,4 & 5.

COST ESTIMATE

Sl.	Item	Qty	Unit	Rate	Amount
1	Pupban Sheet	11	Nos.	36.00	396.00
2	Borak bamboo (30'long)	3	Nos.	50.00	150.00
3	G.I. Wire	0.10	kg	60.00	6.00
4	Wire Nails	0.30	kg	40.00	12.00
5	Coconut Coir Rope	0.20	kg	40.00	8.00
6	Labour (Sohel)	2x1/2	No	100.00	100.00
	TOTAL TAKA:				**672.00**

3. SUPERSTRUCTURE WITH BAMBOO MAT WALLS, C.I. SHEET ROOF AND BAMBOO POLES

MATERIALS REQUIREMENT

Sl.#	Materials	Size	Quantity
1	Terza (Bamboo mat Walls	3'-0"x 5'-3'	4 Nos.
2	C.I. sheet for roof	3'-6"x 4 -0"	1 No.
3	Bamboo for front pillars	7'-0 long	3 Nos.
4	Bamboo for back pillars	6'-3" long	2 Nos.
5	Bamboo for purlin	1-1/4" wide	458 rft
6	G.I. Wire	22 BWG	200 gms
7	Coconut coir rope	3/16" DIA	200 gms

Notes: 2 Nos. 30' long borak bamboos are required for Sl.# 3 & 4.
4 Nos. 20 long muli bamboos are required for Sl. 5.

COST ESTIMATE

Sl.	Item	Qty	Unit	Rate	Amount
1	Terza walls	64	sft	1.50	96.00
2	C.I. Sheet (8' long	1	Nos.	130.00	130.00
3	Borak bamboos(30'long	2	Nos.	50.00	100.00
4	Muli Bamboos (20'long)	4	Nos	12.00	48.00
5	G.I.Wire & Coir Rope	L.S	-	-	20.00
6	Labour (Sohel)	2x1/2	No	100.00	100.00
	TOTAL TAKA:				**494.00**

4. SUPERSTRUCTURE WITH FULL SPLIT BAMBOO WALLS, TERZA ROOF AND BAMBOO POLES

MATERIALS REQUIREMENT

Sl.#	Materials	Size	Quantity
1	Split Bamboo for Walls	1-1/4' wide	700 rft
2	Split Bamboo for Purlin	1-1/4" wide	100 rft
3	Terza Roofs	3'-6"x 4'-0"	2 Nos.
4	Bamboo for front Pillars	7'-0" long	3 Nos.
5	Bamboo for back Pillars	6'-3" long	2 Nos.
6	Bamboo for Raftor	3'-6" long	3 Nos.
7	Polyetnylene Sheet	3'-6"x 4'-0"	1 No.
8	G.I. Wire	22 BWG	200 gr
9	Coconut Coir Rope	3/16" dia	200 gm
10	Wire Nail	3/4" long	300 gr

Notes: 16 Nos. 20 ft. long bamboos are required for Sl. 1,2 & 3
2 Nos. 30 ft.long borak bamboos are required for Sl.4,5 & 6

COST ESTIMATE

Sl.	Item	Qty	Unit	Rate	Amount
1	Muli Bamboo 20 ft.long	16	Nos	12.00	192.00
2	Borak Bamboo 30' long	2	Nos.	50.00	100.00
3	Polyetnylene Sheet	14	sft	1.50	21.00
4	G. I. Wire	0.20	Kg	60.00	12.00
5	Coconut Coir Rope	0.20	kg	40.00	8.00
6	Wire Nail (Small size)	0.30	kg	50.00	15.00
7	Labour (Sohel)	2x1/2	No	100.00	100.00
	TOTAL TAKA:				**445.00**

5. SUPERSTRUCTURE WITH BAMBOO MAT (TERZA) WALLS & ROOF AND BAMBOO POLES

MATERIALS REQUIREMENT

Sl.#	Materials	Size	Quantity
1	Terza (Bamboo mat Walls	3'-0"x 5'-3'	4 Nos.
2	Terza Roofs	3 -6"x 4 -0"	2 Nos.
3	Bamboo for Front Pillars	7'-0" long	3 Nos.
4	Bamboo for Back Pillars	6'-3" long	2 Nos.
5	Bamboo for Rafter	3'-6' long	3 Nos.
6	Split Bamboo for Purlin	1.25" wide	502 rft
7	Polyethylene Sheet	3'-6"x 4'-0"	1 No.
8	G.I. Wire	22 BWG	200 gms
9	Coconut Coir Rope	3/16" dia	200 gms

Notes: 2 Nos. 30 ft.long Borak Bamboos are required for Sl.3,4 & 5
5 Nos. 20 ft.long Muli Bamboos are required for Sl 6

COST ESTIMATE

Sl.	Item	Qty	Unit	Rate	Amount
1	Terza (Walls & Roof)	100	sft	1.50	150.00
2	Borak Bamboo 30' long	2	Nos.	50.00	100.00
3	Muli Bamboo 20' long	5	Nos.	12.00	60.00
4	Polyethylene Sheet	14	sft	1.50	21.00
5	G.I. Wire	0.20	kg	60.00	12.00
6	Coconut Coir Rope	0.20	kg	40.00	8.00
7	Labour (Sohel)	2x1/2	No	100.00	100.00
	TOTAL TAKA:				**451.00**

6. SUPERSTRUCTURE WITH TREATED BAMBOO MAT WALLS & ROOF AND TREATED BAMBOO POLES

MATERIALS REQUIREMENT

Sl.#	Materials	Size	Quantity
	Materials requirement are same as those of Item # 5. Only the terza and bamboo needs to be treated chemically.		

Notes: 2 Nos. 30' borak bamboos are reqd. for pillars and rafter.
5 Nos. 20' long Muli bamboos are required for Purlin.

Cost break-down for treating one bamboo and weaving of terza

In this case terza is made from Muli bamboo, duly treated with chemical fluid, and then splitting them into thin strips and after that weaving these splits

1. Cost of treating one 20 ft. long Muli bamboo	Tk.	12.00
2. Cost of treating it with chemical & labour	Tk.	10.00
3. Labour for splitting one bamboo	Tk.	2.50
4. Labour for making small slices	Tk.	0.75
5. Labour for weaving the splits	Tk.	1.25
TOTAL:	Tk.	26.50

One Muli bamboo will give 16.00 sft of woven terza.
So, cost of treated terza = 26.50/16 = Tk. 1.65 per sft.
This is 10% higher than normal untreated terza price in the market.

Cost of chemical treatment of one 30' long borak bamboo for post is Tk. 10.00, making it 20% costlier than untreated one.

COST ESTIMATE

Sl.	Item	Qty	Unit	Rate	Amount
1	Terza (Walls & Roof)	100	sft	1.65	165.00
2	Borak Bamboo 30' long	2	Nos.	60.00	120.00
3	Muli Bamboo 20' long	5	Nos.	22.00	110.00
4	Polyethylene Sheet	14	sft	1.50	21.00
5	G.I. Wire	0.20	kg	60.00	12.00
6	Coconut Coir Rope	0.20	kg	40.00	8.00
7	Labour (Sohel)	2x1/2	No	100.00	100.00
	TOTAL TAKA:				**536.00**

8. Recommendations

It becomes evident from the above findings that in spite of its durability, CI sheets are not affordable by our target groups due to its high cost as superstructure material On the other hand, the plain thin tin sheet (rupban sheet) are high in cost but does not last long and therefore is not a good choice. The only alternative left is bamboo made superstructures constructed with treated or untreated bamboos

The untreated bamboo superstructure costs Tk. 435 whereas the one with treated bamboos costs Tk 450. The cost increment is approx. 3.5% only. It is learnt that the durability of treated bamboos is at least 2 5 times more than that of untreated bamboos Normal life of a matured bamboo is 5 years whereas a properly treated bamboo might last for 12 to 15 years. Therefore, a latrine superstructure with treated bamboo mat (terza) walls and roofs with treated bamboo posts is recommended to be used on a large scale.

It is recommended, for easy delivery, that the standard components of latrine superstructures made of treated bamboo materials should be manufactured on a large scale in a centrally located place A centrally located production unit will facilitate quality control and economic facilities for treatment and preservation of bamboos This is not possible if only a single or a few units are produced at different places.

The superstructures should be manufactured in a convenient place, by DPHE contractors or by private producers, near the regional stores of DPHE The manufactured superstructures can be transported along with other stored materials such as cement, wire-mesh etc., to upazila VS centres or even to union VS centres From these VS centres, the target group should be able to buy the ready-made latrine superstructures along with other latrine components. An attempt should be made to implement this suggestion.

CHAPTER 6

FIELD TESTING OF 1" THICK RINGS

1. Background

This chapter deals with the field testing part of the previously recommended (see chapter 2) 1" thick rings with 1:2 5:5 mix It is a second generation work of the action research to establish the validity of laboratory research results in actual field

During the early stages of this Action Research extensive study had been carried out on latrine rings in VSRC of DPHE at Mohakhali and at the laboratories of BUET in Dhaka The details of that research work have been discussed in chapter 2 of this book At the end of the laboratory research work, an interim report on Action Research work was prepared in December 1990 and circulated to DPHE, Unicef, SDC and other concerned agencies In the interim report the use 1" thick latrine rings with richer 1:2 5:5 mix instead of the traditional 1.5" thick rings was recommended It was felt at that point, that the newly-designed recommended rings should go through vigorous field test in order to prove their stability

Consequently, the field test was initiated in April 1991 after preliminary discussions with Unicef, DPHE staff at the head office and at the district and upazila offices The field test continued till April 1992

2. Collaboration with DPHE/Unicef

Discussions were held with senior DPHE and Unicef personnel in order to finalise the test area and modus-operandi for the field test

Unicef suggested a more extensive field test rather than the originally envisaged field test in one upazila only Simultaneous field tests in three upazilas was advised

DPHE agreed to manufacture 1" thick rings in all their VS centres in the upazilas selected for the pilot test.

3. Pilot Area for the Test

After a series of discussions with the Chief, WES section of Unicef and Superintending Engineer, Planning Circle of DPHE in Dhaka, it was decided that the three upazilas namely Bhanga, Nagarkanda and Sadarpur in Faridpur district should be selected as the pilot area for the purpose.

The criteria for selecting of pilot areas were the following.

- the upazilas should be adjoining to each other for proper supervision and monitoring
- the area should cover wide range of soil conditions as far as possible
- the area should not be very difficult to travel from Dhaka

Another reason for selecting the above three upazilas is that the consultants already had a credit line project running in the area. It was thought that benefit of this credit line schemes may be obtained during the intended 5-P exercise for training and generating credit facilities to the private producers

The above mentioned three upazilas have the following eight latrines component manufacturing VS centres:

- Bhanga sadar, VS center. in Bhanga upazila
- Ghaura union, VS sub-center ,,
- Manikdah union, VS sub-center ,,
- Nagarkanda sadar, VS center in Nagarkanda upazila
- Talma union, VS sub-center ,,
- Bhawal union, VS sub-center ,,
- Sadarpur sadar, VS center in Sadarpur upazila
- Dheukhali union, VS sub-center ,,

4. Modus Operandi for Field Test

Before the beginning of this work the following Modus Operandi for the field test works was agreed upon by the DPHE, Unicef and the consultants.

1 The rings shall be produced at the DPHE centres in the same procedure as applied to the present system. The only difference would be that instead of present 1.5" thickness, 1" thick rings shall be produced, based on consultants' supplied specification i.e. the concrete mix shall be 1:2.5:5 instead of 1:3:6 mix. The reinforcement will, however remain the same

2 DPHE shall, as usual, be responsible for the production and sale of rings

3 The consultants shall depute one field supervisor to coordinate production in the changed design (mix and thickness), and to supervise installations and monitor results. Occasional visits will be paid by senior official of the consultants and the DPHE. Originally only one supervising engineer was supposed to be deputed for one upazila but later since number of upazilas was increased to three, two supervisors were appointed for all three upazilas and eight VS centres with a view of not having too strict a construction supervision. The aim was that the supervision should be similar to that observed by DPHE

4 Material supplies and manpower shall be as per the DPHE's present arrangements.

5 DPHE's Upazila production centres will supply the consultants with production and sales data for proper monitoring of the project

The above conditions had been adhered to and arrangements were made to cast 1" thick rings in all the eight village sanitation centres (VSC) of DPHE in the three upazilas of Faridpur district, since April 1991.

The DPHE personnel i.e. the Executive Engineer, Faridpur, the three Sub-Asstt. Engineers of Bhanga, Nagarkanda and Sadarpur upazilas, and the masons of eight VS centres were very cooperative throughout the pilot tests. They have successfully produced 1" thick latrine rings as per the new design and sold more than 3,700 rings of the new type to public which have in turn been used for installation of nearly 1200 latrines in the area.

5. Design of New 1" Thick Rings

Initially following designs were recommended for field testing of 1" thick rings.

Type-1

- Thickness 1"
- Concrete mix 1:2.5:5
- Reinforcement 3 nos 10-SWG wires

Type-2

- Thickness 1"
- Concrete mix 1:3:6
- Reinforcement 3 nos 10-SWG wires

The other dimensions of both the types are as follows:

- outer diameter 30"
- internal diameter 28"
- height 12"

Although type-1 was much superior to type-2 and only marginally costlier, the idea of including type-2 was only to establish the lower limit of acceptable ring strength from practical application point of view.

Both these designs were used in the beginning of the field test. After a couple of months of practical supervision it was felt that design of type one is far more superior than the design of the type 2. The cost difference of the rings of the two designs was

very small. Therefore, it was finally decided to continue with production of rings of type-1 only. All the 1" thick rings after that were manufactured in that design

6. Casting of New Rings in VS centres

After the decision in March 1991 and completion of initial work, the first batch of new moulds for the newly designed rings were supplied to the VS centres of the pilot area and the construction of 1" thick rings started after that in April 1991. In the first month only one out of the 8 designated VS centres manufactured the new type of rings Most of the other VS centres started casting of the 1" thick rings from May 1991.

Actual full scale production and sale of 1" thick rings had started after September 1991 Following factors contributed to the delay:

- The VSCs had reached their annual targets of production for the current financial year which ended in June
- The targets for the next financial year starting from July are not announced before some time into the new financial year.
- Due to the rainy season which lasts upto September.

6.1 Production and Sale of Rings

Following table gives the month-wise record of production and sale of 1" thick rings in the eight DPHE VS centres of Faridpur district, the field test area. It may be mentioned here that the reporting month starts from 26th of the preceding month and upto 25th of the current month This is because the monthly reports are required at HQ of DPHE at the beginning of the following month.

Sl. No.	Month	No. of VSC involved	1' Thick Rings Produced	Sold
1	Apr 1991	1	39	17
2	May 1991	5	286	45
3	Jun. 1991	4	331	166
4	Jul 1991	6	154	153
5	Aug. 1991	6	350	175
6	Sep 1991	7	347	423
7	Oct 1991	7	545	651
8	Nov 1991	7	661	600
9	Dec 1991	7	706	478
10	Jan 1992	7	594	387
11	Feb 1992	7	543	305
12	Mar 1992	7	518	346
	TOTAL		5076	3746

Seven VS centres out of the total eight centres in the pilot area have manufactured and sold 1" thick rings. There has been no production of rings at Manikdah VS centre due to stock-pile of the previously produced 1.5" thick rings. After beginning of the action research casting of 1.5" thick rings had stopped In all the above mentioned VS centres. However, first the previously manufactured 1.5" thick rings were all sold. In Manikdah VS centre no production of rings was carried out during the whole test period, because unsold 1 5" thick rings were still in stock-pile The location of this particular VS centre is not very suitable from marketing point of view.

7. Inspection of Installed Latrines

One supervising engineer was permanently posted in the project area for occasional supervision of production of 1" thick rings and inspection of latrines installed with these new rings The second engineer was only partially used for this purpose. Special formats were designed for recording the manufacture and sale data of 1" thick rings at designated VS centres and for recording detailed information of inspection of installed latrines Sample copies of filled-in forms of the formats used are reproduced on the following pages.

The field engineer made regular visits to DPHE VS centres and DPHE upazila offices for the supervision of production and data collection. Regular inspection of the installed latrines with 1" thick rings manufactured at VS centres was also carried out by him throughout the test period. The information collected by the field engineer was analysed later Opinions were often shared, on the collected and analysed data. with other related agencies

8. Analysis of Related Field Data

During the field inspection of VS centres and installed latrines in the pilot area records were kept on various items related to rural latrines construction and their delivery mechanism. These date were tabulated in the monitoring sheet designed for the purpose

Various data from these monitoring sheets have been analysed and the deduced information is presented in the following tables

8.1 Latrine Installation Percentage

The following chart gives the overall findings of the data collected during inspection visits of the rural latrines installed with 1" thick rings in the pilot area till the end of March 1992.

PROMOTION OF RURAL SANITATION IN BANGLADESH

Production and sale of 1" thick latrine rings at DPHE VS Centres.

REPORT ON ACTION RESEARCH FIELD TEST FOR THE MONTH 'October 91'

UPAZILA	BHANGHA						NAGARKANDA						SADARPUR			
Name of VSC	1. DHANDA		2. GUARIA		3. MANIKDAH		4. NAYANKANDA		5. TALMA		6. BHAWAL		7. SADARPUR		8. DHEURGHATI	
Mix type																
DATE	PRODUCT	SALE	PRODUCT	SALE	PRODUCT	SALE	PRODUCT	SALE	PRODUCT	SALE	PRODUCT	SALE	PRODUCT	SALE	PRODUCT	SALE
B/F	102	40	90	56	NIL	NIL	135	115	414	319	148	56	460	366	60	49
26/9	5						10								10	
27/9							10								5	
28/9									5					9	5	
29/9																
30/9									3				12		5	19
1/10		26						49	2			6	10	1		
2/10							7		2				5	9		
3/10							6		2	6					6	
4/10																
5/10		3	5				5	12	8	2			6	3	8	
6/10	5			4			10			9			5			
7/10	10		10				11		5	22			7		5	
8/10	10	17					5	13	6				6	7	6	9
9/10	5	7	10										6	10		
10/10		9	10				5				5		6			
11/10																
12/10							6	10	5	5	5	10		5		
13/10		2	10	23					5		3			4	3	17
14/10				24						4				7		
15/10		9													6	
16/10		6	10				6		5		5				6	
17/10	5						6				5					
18/10	5		10													
19/10		3					10		5			10	5	33	6	18
20/10		9					10	20	5	4		52	6		6	
21/10	5	14					10								5	
22/10		15					5	5	2				3	6	6	6
23/10	5	11	5	30			5							8		
24/10	15						5						7			
25/10	10									5			10			14
Month Total	80	151	70	91	NIL	NIL	134	109	57	57	25	78	94	102	85	83
Upto date	272	171	160	147	NIL	NIL	389	222	471	376	173	114	554	468	155	132

Report prepared by _____ Date _____

PROMOTION OF RURAL SANITATION IN BANGLADESH

Page No 4/3

Monitoring Sheet of Village Latrines

Installed with 1" thick rings from DPHE VS Centres

Name of VS Centre NAGARKANDA VSC No. 4 District Faridpur, Upazila NAGARKANDA

Sl no of LATRINE	INSTALLATION					LOCATION			MONITORING				
	Purchase Date	No of Rings	Transport Mode	Distance from VSC	Install Date	Name of Owner	Village	Union	Date of Visit	Ring Conditions	Slab/Pan Conditions	Pit Depth	Super-structure
4/33	01 10 91	5	Boat	2½ Km	20 10 91	Salam Chowdhury	Fulsuti	Fulsuti	15 12 91	OK	OK	6 ft	CI Sheet Chowdhury
4/34	"	1	Boat	2 Km	10 10 91	Abdul Wahab	Kaisal	Kaisal	15 12 91	OK	OK	4 ft	Jute Stick Chowdhury
4/35	"	3	Van & Boat	1½ Km	5 10 91	Babul	Jungurdi	Nagarkanda	9 1 92	OK	OK	4 ft	"
4/36	"	1	Van & Boat	1½ Km	5 10 91	Akbar	Jungurdi	"	9 1 92	OK	OK	4 ft	"
4/37	"	1	Boat	2 Km	20 10 91	Abdul Jabbar	Nandidi	Kaisal	15 12 91	OK	OK	4 ft	"
4/38	"	1	Van	1 Km	25 10 91	Abdul Mannan	Nagarkanda	Nagarkanda	9 1 92	OK	OK	4 ft	"
4/39	05 10 91	5	Van & Boat	2 Km	20 10 91	Anwar	Jungurdi	"	9 1 92	OK	OK	4 ft	"
4/40	"	3	Van & Boat	2 Km	28 10 91	Makam Mondol	Jungurdi	"	9 1 92	OK	OK	4 ft	"
4/41	"	3	Van & Boat	2 Km	15 10 91	Sridhar Sarker	Jungurdi	"	9 1 92	OK	OK	4 ft	"
4/42	"	3	Van & Boat	2 Km	15 10 91	Shamsher	Jungurdi	"	9 1 92	OK	OK	4 ft	"
4/43	08 10 91	15	Boat	2½ Km	10 11 91	Abdul Wahab	Kaisal	Kaisal	15 12 91	OK	OK	15 ft	CI Sheet Chowdhury
4/44	12 10 91	1	Van	2 Km	5 11 91	Karim	Jadumati	Jadumati	21 12 91	OK	OK	5 ft	Jute Stick Chowdhury
4/45	"	3	Boat	2 Km	25 11 91	Kudi Miah	Goaldi	Nagarkanda	3 1 92	OK	OK	4 ft	Jute Stick Chowdhury
4/46	"	5	Boat	6 Km	20 10 91	Samad Mridha	Bhawal	Bhawal	21 12 91	OK	OK	7 ft	CI Sheet Chowdhury

Report Prepared by _____ Date _____ Checked by _____

Sl. No	Name of VSC	LATRINES (IN NUMBERS)		
		Total sold	Installed	Not Installed
1.	Bhanga	243	206	37
2	Ghaura	176	124	52
3.	Nagarkanda	136	119	17
4	Talma	318	311	7
5	Bhawal	64	50	14
6	Sadarpur	313	296	17
7	Dheukhali	69	62	7
	Total	1319	1168	151

From analysing the above data obtained at the end of the field test it is found that 89% of the purchased latrines were actually installed during that period. The average number of rings installed per latrine were 2.4. The maximum and minimum number of rings used per latrine were 13 and 0 respectively.

These figures are updated till March 1992. It has been observed that some 10 to 20 percent of the latrines remained un-installed for approx. 2 months after purchase due to some reasons, including lack of money and manpower needed for installation.

Thorough inquiry was carried out to find out the non-installation of purchased latrines and different reasons were stated for this. Some of the latrine purchasers took the latrines just to fulfill the obligation for taking loans from some govt. agencies such as Sonali Welfare Department and some NGOs. They do not feel the necessity for using a latrines. These people need more motivation for the purpose. In some other cases the purchasers had deposited the money to buy the latrine sets. The sets have been shown as sold, but were not actually picked up from the VS centres for more than two months. Such cases were, however, rare.

8.2 Breakage of Rings and Slabs

The following table gives the statistics of the 1" thick rings broken during transportation or installation during the field test period of one year in the following seven VS centres. Figures for broken slabs during the same period were also recorded and have been tabulated below.

Sl. No.	Name of VS Centre	1" Rings broken	Slabs broken
1.	Bhanga	8	7
2.	Ghaura	4	0
3.	Nagarkanda	6	3
4.	Talma	11	11
5	Bhawal	0	0
6.	Sadarpur	12	12
7.	Dheukhali	1	0
	Total	42	33

Out of total 5076 rings manufactured and handled, only 42 were broken mostly during transportation and due to mishandling. This brings the breakage figure to 0.82%. Larger number of the breakage of rings took place during the initial phase and were of the type-2 rings which had been tried only for the first two months. Most of the breakage of the rings occurred during transportation on village HBB roads. Breakage in normal handling in VS centres has not been reported except in two cases where rings were not yet properly 'cured'. This emphasises the utility of water curing and essentiality for curing tank in every VS centre.

Earlier records of breakage of 1.5' thick rings in VS centres are not properly kept and were not available to the consultants. It was, however, gathered from interviews with DPHE staff that the breakage figures have been about 2% to 3%.

These figures demonstrate the superiority of the new 1" thick rings of 1.2.5:5 mix over the traditional 1.5" thick rings of 1:3:6 mix.

8.3 Union-wise Distribution of Latrines with New Type of Rings

A detailed analysis table is reproduced on the **next page** to show the source of latrine sets and their final union destination. Besides, other deviations, it was seen that most latrines were installed in the union in which they were produced.

8.4 Pit Depth Analysis

Following is the area-wise analysis of pit depth of the installed latrines in the pilot areas:

UNION-WISE SANITARY LATRINE COVERAGE
IN PILOT AREA OF 3 UPAZILAS IN FARIDPUR

Name of Union	VSC-1	VSC-2	VSC-3	VSC-4	VSC-5	VSC-6	VSC-7	VSC-8	
	Bhanga	Gharua	Manikda	N'Kanda	Talma	Bhawal	Sadarpur	Dheukhali	TOTAL
Bhanga Upazila									
1 Bhanga	68							1	69
2 Azimnagar		17							17
3 Alp	44								44
4 Chandra	2	97							99
5 Gharua	20	22							42
6 Hamird	54	0							54
7 Kalamridha	10	25							35
8 Kaolibera	5	9					2	1	17
9 Manikdar	5						4		9
10 Nasirabad	9	6							15
11 Nurulahganj	12						33		45
12 Tuzarpur	14								14
Nagarkanda Upazila									
1 Nagarkanda				51					51
2 Ballabhdi				10					10
3 Bhawal				6		14			20
4 Char Jasordi				4					4
5 Dang				1	24				25
6 Phulsuri				5					5
7 Gatti					5	17			22
8 Jadunand				10					10
9 Kaicha				15					15
10 Laskardia				15	20				35
11 Malhardia				5					5
12 Atghar						8			8
13 Purapara				3					3
14 Ramkantapur						2			21
15 Ramnagar					59				59
16 Sonapur				10		4			14
17 Talma					100				101
18 Kandi							1		1
19 Gerda					11				11
20 Faridpur					1				1
Sadarpur Upazila									
1 Sadarpur							133	3	136
2 Bhasanchar					1		38	4	43
3 Char Bishnapur							40	3	43
4 Char Manair								1	1
5 Char Nasirpur							2	2	4
6 Krishnapur					97		27		124
7 Narikelbaria							1		1
8 Aktercha							2	7	9
9 Dheuknali							30	47	77
TOTAL	243	176	0	136	318	64	313	69	1319

Sl No	Name of VS Centre	PIT DEPTH OF LATRINES			
		upto 3ft	3ft to 6ft	6ft to 10ft	above 10ft
		No. of Latrines			
1.	Bhanga	0	196	7	1
2	Gharua	0	124	0	0
3.	Nagarkanda	1	88	29	1
4.	Talma	1	286	22	2
5.	Bhawal	0	43	5	2
6.	Sadarpur	14	239	44	0
7.	Dheukhali	0	57	5	0
TOTAL (1167)		16	1033	112	6
Percentage		1.37%	88 51%	9.59%	0.51%

It is observed that about 89% of the latrines were made with 3 ft to 6 ft deep pit, and the pit depth is seldom less than 3 ft. and more than 10 ft. The average pit depth calculated was 5.2 ft The minimum depth recorded was 3 ft. and the maximum was 13 ft.

8.5 VSC Distance from Users

During the field test and inspection of latrines, records were kept of the distances of the installed latrines from VS centre from where the latrines were purchased

SL NO	Name of VS Centre	DISTANCE			
		Within 3km	3 to 6 km	6 to 10km	Above10km
		No. of Latrines			
1	Bhanga	150	72	16	5
2	Gharua	119	54	3	0
3	Nagarkanda	91	25	10	10
4	Talma	101	106	111	0
5.	Bhawal	33	15	16	0
6	Sadarpur	142	140	31	0
7	Dheukhali	43	26	0	0
TOTAL (1319)		679	438	187	15
Percentage		51 48%	33.21%	14 18%	1.14%

It was found that 51% of the latrines installed fall within the distance of 3 km, 33% within 3 to 6 km distance, and 14% within 6 to 10 km distance Only 1% latrines were found to have been installed at a distance of more than 10 km The minimum and the maximum distances were 0 5 km and 15 km respectively and the average distance recorded was 4 km

8.6 Mode of Transportation of Latrine Component

SL No	Name of VS centre	TRANSPORTATION MODE			
		Head load	Boat	Van	Van & Boat
		No. of Latrines			
1	Bhanga	0	60	178	5
2	Gharua	0	10	166	0
3.	Nagarkanda	0	56	71	9
4	Talma	0	0	311	7
5	Bhawal	7	11	46	0
6	Sadarpur	0	42	271	0
7	Dheukhali	0	24	45	0
TOTAL		7	203	1088	21
Percentage		53%	15.39%	82 48%	1.59%

8.7 Information regarding Superstructure Types

During the field test and inspection work records were kept for the types of superstructure used for the installed latrines The following figures have been obtained as a result of this exercise

1	Superstructures with jute sticks	68%
2	Superstructures with Tarpaulin	21%
3	Superstructures with C.I sheet	9%
4	Superstructures with Masonry	2%

The above statistics has been obtained from a sample survey of 682 rural latrines in the pilot area

9. Findings and Recommendations

Construction and use of 1" thick rings of 1:2.5:5 mix instead of standard 1.5" thick rings of 1:3:6 mix is technically feasible No complains or adverse remarks were received from users regarding 1" thick rings manufactured and sold at the DPHE VS

centre in the pilot area from April 1991 to March 1992 At the beginning of the field tests the authors were very apprehensive that the villagers will not buy the 1" thick rings when they can see the stock piled 1.5" thick rings It was also anticipated that perhaps the buyers would buy the rings or latrine sets from other upazilas which, however, did not happen in any of the field tests upazilas. The percentage of breakage of the new 1" thick rings had been less than those of the traditional 1.5" thick rings

The field test confirmed the findings of the action research held in December 1990 in VS research centre and BUET laboratory in Dhaka that the newly designed 1" thick ring of 1:2 5.5 mix is stronger, lighter and therefore, better than the traditional 1.5" thick rings of 1.3:6 mix.

Some of the private producers of the pilot test areas of Faridpur district have already started casting and selling 1" thick rings after DPHE's adaptation of the same However, the private producers will be technically capable and more useful factor in wider national sanitation coverage, if proper training is given to them This aspect is likely to be stressed in the forthcoming 5-P exercise in the pilot area

The new 1" thick ring is 20% cheaper and stronger than 1.5 thick traditional rings Since the field tests on 1" thick latrine rings have proved to be successful their adoption is recommended in place of the existing 1.5" thick rings in all the VS centres of DPHE all over the country. This will result in substantial financial saving annually In the public sector alone, i.e. in the 1000 VS centres producing 1300 rings per centre. the saving will amount to Tk 20 million per year. However in all the DPHE VS centres new steel moulds for 1" thick rings will have to be supplied

Some of the DPHE officials have expressed a second opinion that, instead of going for production of 1" thick rings in all the DPHE VS centers immediately, a further field test may be undertaken in other geographical areas of Bangladesh where the soil conditions are different from the present pilot area in Faridpur However, the consultants feel that any subsequent tests with 1" thick rings are also likely to be successful Therefore universal use of 1" thick RCC latrine rings with 1:2 5.5 mix instead of the present 1.5" thick rings should be initiated

APPENDIX-1

TERMS OF REFERENCE

Action Research on Sanitation Technology For Promotion of Rural Sanitation in Bangladesh

It is proposed to inquire into the following aspects of the design of the rural sanitation components

1. Alternate Dimensions

1.1 Some of the dimensions of the latrine components are very sensitive to the overall costs. The most important dimension to be addressed is the thickness of the ring. Other dimensions like the thickness of slab may also be looked into. This will necessitate that new casting moulds are prepared for production of alternately dimensioned rings which will then be both field and lab tested for their functional strength. For carrying out this, assistance is required from UNICEF and one of the nearby located DPHE centres. Mr. Colin Gelnnie and Mr. Taufique Mujtaba had promised necessary support.

2. Alternate Design and Materials

2.1 Often there is a thinking that an inquiry is made into alternate materials in order to search for cheaper alternatives. Particularly low quality plastics and plastic waste has been thought to be of interest. This will require contacts with plastic manufacturers, see their technical capability for manufacturing these components, assess the cost of production particularly when looked through the economy of scale.

2.2 The water seal design at present requires considerable amount of water for flushing - a constraint in many areas. Alternate possibilities should be looked into.

2.3 Reinforcement material for the slabs and the rings is quite a large component in the total cost. The quality of material supplied by UNICEF is very good whereas the private producers use quite inferior materials. At least one NGO uses bamboo sticks for reinforcement. The study should look into the cost versus material strength in order to arrive at economically most defendable material quality level.

2.4 To look into the possibilities of production of suitable pans in plastics to reduce breakage of water seals and decrease the quantity of water required for flushing. In some areas we have been reported that people have resorted to deliberate breaking of the water seals.

2.5 Use of hardpressed clay blocks for lining of the latrine pits is emerging as a viable alternative which needs to be looked into.

2.6 Superstructure plays a very dominant part in the installation of latrines and the share of costs is significant in the total cost. Investigation should be carried out to suggest standard materials and sizes to decrease the cost for the buyers.

3. Alternate Mix of Materials

Presently the standard civil engineering compositions of various materials like 1:2:4 or 1:3:6 are used in the manufacture of latrine components. Since in our present context every increase of price in Taka has an impact on the size of the potential buyers, it is important that these standard mixes are inquired into and optimal mix level is reached through laboratory tests.

4. Installation Issues

4.1 An inquiry into the number of rings required for different types of soils and their co-relation with the depth of the pit and the likely impact of flood proneness.

4.2 To analyse the reasons for the collapse of the latrine pits on the basis of the data collected during the survey (Phase-II) of the study.

4.3 To analyse the impact of safety factors and life expectancy of the latrines made purely from to-the-site local materials.

5. Miscellaneous

Any other issues not covered above but found recommendable during the action research period.

Terms of Reference for further Action Research on Sanitation Technology

Besides the above other research activities shall be carried out to cover the following to the extend possible within the avialble time upto the end October 1991. The work shall be carried out in close coordination with UNICEF/DPHE

6. Field Testing of Proposed Design of Rings.

The proposed alternate design of rings shall have to be field tested in actual environment for a considerable period of time and for a large number of rings before such an exercise can be adopted on a country-wide basis For this purpose two or three adjoining Upazilas will be selected and the proposals shall be field tested under special supervision and well monitored to assess the acceptibility of the proposed rings

This work shall be carried out upto end October 1991 to cover a rainy season for field test durability

7. Research Concerning Slab

It is suggested not to attempt any experimentation with regard to slab thickness and that the discharge hole size is not changed from the one at present. However following areas should be tested.

See the suitability of the dome type of slab not needing any reinforcement (with and without first ring) which has been used with success in Mozambique
Attempt a split type of slab/pan (slab with a hole for insertion of separately producec collared pan) to reduce the cost during transport as the slab is the single heavies: item for transport.

8. Action Research Concerning Pan

To attempt the following

- To improve the pan from the hydraulic flow point of view
- To make plastic pans with water seal in plastic
- To make plastic pan with offset pit plastic pipe with flap
- To produce plastic water seal part
- Use of proper adhesive
- Smoothening of pan surface with some kind of lining

During discussions with UNICEF it was suggested that research pertaining to plastic components is carried out by MAWTS/UNICEF It was also felt important that both types of research works are carried out in conformity and harmony with each other

9. Alternate Lining for Pits

- To investigate into the use of cheap bricks for lining of the latrine pits
- Type and size of mix (pure clay, clay cement)
- Improvements in the mechanical device for pressure brick production
- Cost calculation taking into consideration cost of transport

Suitable lining for water logged and sandy areas is specially important

10. Superstructure

A substantial proportion (28%) of households will like to buy a superstructure rather than make it themselves. DPHE has also emphasized the need of improved, cheaper and standardized superstructure as an optional sale item It is important that the standard superstructure, as an example is exhibited at the DPHE centres for demonstration purposes. It is also necessary to make an initial assessment of the marketing possibilities of such a superstructure either through the DPHE production centre or through the private sector as a part of the private producers programme as suggested in section 4 of phase III report.

Proposals for standardized latrine superstructure components from cost effectiveness and from the ease of installation point of view

Effort will be made on trial basis to manufacture superstructure materials at one of the divisional stores so that these can be transported along with other materials to the DPHE production centres The actual demand of these elements will be thus field tested.

11. Improvements in Casting Technology

A mechanical casting device to facilitate lifting of the inner ring shall be tried out and its impact during production and on economy shall be analyzed

Other ideas concerning similar approaches shall be also tested

12. Improved Technologies

An important segment of the market is interested in purchasing technologies of a higher standard than that marketed by DPHE Therefore an effort should be made to improve the quality of the products like pans, water seal, slabs and superstructure. **It is understood that people are more interested in the improved quality of visible components and superstructure than the substructure.**

A number of applications of improved quality concerning mosaic and porcelain materials are being tried more on ad hoc basis rather than as a result of techno-economic effort This work will involve contact with many production workshops in the private sector and some NGOs

13. Type of Top Soil

The cohesiveness of the soil particularly under wet and rainy conditions is quite important for the use of the proper selection of the latrine technology. It is important that the latrine pit does not collapse. An area mapping will be attempted from secondary resources of data. Some monitoring effort will have to be carried out to analyst the life of about 40 one-pit latrines to be installed in sandy soil

14. Reporting and Cost Analysis

All the works carried out shall be properly documented with technical and economic evaluation. Items recommended for elaborate field tests shall be presented in a summary.

The final report on the overall action research and the results of field tests shall be presented during end 1991 It will be supported by cost calculations and technical data for finding out the economic viability of introduction in production.

APPENDIX-2

PERSONS MET / INTERVIEWED

For the research work

DPHE
Mr. Aminuddin Ahmed, Chief Engineer, DPHE (from January 1992)
Mr. M.A. Karim, Ex-Chief Engineer, DPHE
Mr Fariduddin Ahmmed Mia, Superintending Engineer, Planning Circle
Mr. Quadir-uz-Zaman, Superintending Engineer, Planning Circle
Mr. A.B Siddique, Superintending Engineer, Planning Circle
Mr. Abdur Rahman Mirdha, Project Director, Village Sanitation Project
Mr. Ahmed Mofazzal Haque, Executive Engineer, VS Division-I
Mr. Abdur Rahman, Assistant Engineer, VS-1
Mr. Mostafizur Rahman, Sub-Asst. Engineer, VS Centre, Dhaka
Mr Abu Moslem, Executive Engineer, Faridpur
Mr. Md. Ibrahim, SDE, Faridpur (from Sept 1991)
Mr. Md Waliullah, SDE, Faridpur
Mr. Aminuddin Ahmed, SAE, Bhanga
Mr Abdur Rahim, SAE, Nagarkanda
Mr. Abdul Barek, SAE, Sadarpur

UNICEF
Mr. Cole P. Dodge, Country Representative
Mr. Philip Wan, Coordinator, WES
Mr. Colin Glennie, Coordinator, WES
Mr. John D. Skoda, Coordinator, WES
Mr. Andrew M. Sayles, Project Officer WES
Mr. Keith Mackenzie, Project Officer, WES
Mr. Dilawar A. Khan, Sr. Programme Coordinator
Mr. A.S. Azad, Acting Coordinator, WES
Mr. Taufique Mujtaba, Programme Officer, WES
Mr. Shamsuddin Ahmed, Programme Officer, ICS
Mr. Jahangir Kabir, Programme Officer
Ms Shaila Khan, Asst Programme Officer, WES

W H O
Mr. John Pospisilik, Sanitary Engineer, Dhaka
Mr Mofazzal Haque, Field Officer, Dhaka

S D C
Dr. Peter Arnold, Head SDC, (from December 1991)
Dr. Urs Heierli, Head SDC
Mr. Peter Tschumi, First Secretary (Dev.)
Mr. S. A. Karim, Senior Programme Officer

BUET
Dr. Jamil Reza Chowdhury, Professor, Civil Engg Deptt
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Ms. Kazi Nasreen Faruk, Sr. Scientific Officer, Chemical, BCSIR
Mr. Md Moniruzzaman, Research Chemist, Bldg Material, BCSIR

NGOs
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Mr. Zia-us Sabur, Programme Officer, NGO-Forum
Mr. A. Milon Khan, Programme Officer, RDRS
Ms. Jannat-e-Quanine, Programme Officer, Grameen Bank
Mr. Ashraful Hossain Executive Engineer, Grameen Bank
Mr. Hasinur Rahman, Production Manager, MAWTS
Mr Hamidul Bari, Manger, R&D MAWTS
Mr. Hafizul Hassan, Senior Manager, Marketing MAWTS

MANUFACTURERS
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Mr. Gobinda Lal Ghose, Dy.Manager (Marketing), BISF
Mr. Golam M Khan, Bengal Friends & Co , Tar manufacturers, Tejgaon, Dhaka
Mr. Atiquzzaman Khan, Bengal Friends & Co
Mr. Ahmed S.K Engg Ltd , Hatkhola, Dhaka
Mr. N Islam, Bangladesh Machineries, Nawabpur Road, Dhaka
Mr Sadequl Alma, Bismillah Sanitary Mfg. Co., Mirpur, Dhaka
Mr S.A Fazal, Marble Touch, Toyenbee Circular Road, Dhaka

APPENDIX-3

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