FINAL REPORT

# APPLICATION OF FERROCEMENT AND RELATED COMPOSITE MATERIALS IN INDONESIA

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10-8-'83
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**FINAL REPORT**

# APPLICATION OF FERROCEMENT AND RELATED COMPOSITE MATERIALS IN INDONESIA

GOVERNMENT OF INDONESIA
AND
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
PROJECT NO. 497 – 0268
"APPROPRIATE AND LOW COST TECHNOLOGY"



CONDUCTED BY :
THE DEVELOPMENT TECHNOLOGY CENTER
INSTITUTE OF TECHNOLOGY BANDUNG

301/ICP–02–78/82

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JANUARY 1982



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# F O R E W O R D

This report covers the work done by the Development Technology Center, Institute of Technology of Bandung, in the development of ferrocement technology for a variety of village needs. This project was sponsored by the United States Government and the Government of Indonesia through a USAID/Indonesia Grant Agreement. The project was marked as Project Grant Agreement between the Republic of Indonesia and the United States of America for "Appropriate and Low Cost Technology", A.I.D. Project Number 497-0268. The Agreement was signed by Prof. Dr. D.A. Tisna Amidjaja, Director General for Higher Education, Ministry of Education and Culture, representing the Government of the Republic of Indonesia and Mr. Thomas C. Niblock, Director USAID/Indonesia, representing the Government of the United States of America.

The Government of Indonesia institution responsible for the execution of this project is the Development Technology Center at the Institute of Technology of Bandung (DTC-ITB), under the Directorate General for Higher Education, Ministry of Education and Culture. The Director General for Higher Education delegated authority to Dr. Filino Harahap, Director of the DTC-ITB and Mr. Moh. Arsjad, of the Directorate General of Higher Education, to exercise the required powers for this project.

Originally the Project Assistance Completion Date (PACD) was scheduled to be April 1980. However delays were unavoidable in implementation of the project, in view that there were four institutions which were involved in the execution. Extension was amended as stated in Project

Impelentation Letter no. 6, 8, 10, and 12, which provided final project extension to January 31, 1982, to complete the project activities.

The general coordination of the project was handled by DTC-ITB Operational Board, chaired by Dr. Ir. Filino Harahap, who also acted as the Project Director. The Operational Board of DTC-ITB consisted of Prof. Dr. Harsono Wirjosumarto, Dr. Saswinadi Sasmojo, Dr. Bana Kartasasmita. Support was given by Ir. B. Tarigant as executive secretary, and Mrs. Dra. Sri Sunardi, Head of the finance section of DTC-ITB. In carrying out the daily project administration. the Director was assisted by a project administrator, Mrs. E.D.Y. Tamin, specially appointed for the project. The administration and logistic back up were provided by the Secretariat of the DTC-ITB.

A.I.D. Project Number 497 - 0268: "Appropriate and Low Cost Technology" consists of two components which appear eminnently suitable for the Indonesian scene. These are:

1. Pyrolytic conversion of agricultural waste to alternative energy sources in Indonesia.
2. Application of ferrocement technology for variety of village needs.

This report covers only the work done by the ferrocement technology teams, and results of the pyrolytic conversion team are compiled and issued in another report.

Within the framework of this project, ferrocement technology was interpreted broadly, including nonferrous indigenous fibers as reinforcement. The project also provided training assistance and technical support for

DTC-ITB and other Indonesian Agencies, from the ferrocement technology group at the Asian Institute of Technology (AIT), Bangkok. AIT conducted training for nine Indonesian engineers in structural engineering properties of ferrocement through a special four-months course in 1978 and, to a limited extent, served as consultant for evaluation.

In executing the project DTC-ITB collaborated with two provincial universities and local government administrative units, particularly in field applications, testing and evaluation. The universities selected were Universitas Syiah Kuala, at Banda Aceh in Sumatra, and Universitas Hasanuddin at Ujung Pandang in South Sulawesi. These universities executed sub-projects under the coordination of DTC-ITB. The district of Sukabumi in West Java, the provinces of North Sumatra and South Sulawesi were sites for project hardware try-outs.

Those who participate in this project were:

I. Syiah Kuala University

| | |
|---|---|
| Coordinator | : Dr. Abdullah Ali |
| Team Leader | : Ir. Maasri St. Bandoro, and Ir. Bustam Husin |
| Technicians | : Anwar, Nurdin, and Jamil |
| Trainees | : Azmi, Yusri, Zumara, Ali Akbar, Zukia, Mukhsin, Rusyuszar, Sakban, Fahrial, and Suardi |

II. Hasanuddin University

| | |
|---|---|
| Advisor | : Prof. Dr. A. Amiruddin |
| Supervisor | : Dr. Anwar Hafid M.Sc. |
| Consultant | : Ir. Samuel Sanka |

Task Force : Dr. Hasan Walinono, Ir. Yahya Hanafie, Ir.Amin Hayat, Ir. J.B. Manga, Ir. Muhidin Rauf, and Ir. A. Mappangara

Technicians : Surya Darma, M. Natsir, and Hilal

Administrative support: Drs. Umar Ubbe, J. Asmal, and Latifa.

III. Development Technology Center - Institute of Technology Bandung

Team Leaders : Prof. Dr. Harsono Wirjosumarto, and Dr. Bana Kartasasmita

Sub Team Leader : Ir. Anshori Djausal

Technicians : Surapati, Ali Sulaiman, Apep Maman, Agus Rachmat, Mauluddin, Yana Cahyana, Buchori, Yan Nirwan, Sriyanto, and Agus Anwar.

Administrative support: Tati Karmiati, and Ike Mustikawati.

Contributions of all involved in the project were highly appreciated, and made possible the successful completion of the project.

Dr.Filino Harahap

Project Director

TABLE OF CONTENTS

Page

## LIST OF FIGURES

Page

Page

## 1.0. INTRODUCTION

## 1.1. BACKGROUND

### 1.1.1. General Considerations

The goals of Appropriate and Low Cost Technology may be stated as: a) to improve the quality of life and increase the income of the rural poor; b) to promote rural development and generate employment through low-cost, labor-intensive technology.

The most widely accepted definition of appropriate technology may be stated as the adaptation of technologies to the environment and conditions of the locality where they will be applied. From an AID viewpoint, we would add that the technology must contribute to the social and economic development of a developing nation, with particular attention to the benefits for the poor. In Indonesia, (and in many of the developing countries), this means that the technology require relatively small capital and practically no foreign capital, use common and locally - available resources and materials, maximize the use of local semi-skilled and unskilled labor, meet local needs and markets, and generate new employment opportunities particularly through development of small industry.

### 1.1.2. Appropriate Technology in Indonesia

In 1973, Indonesia presented a paper, "Indonesia's Present Setting and Perspective for Technology Transfer", at the International Conference on Technology Transfer in Modernizing Nations,

Karachi, Pakistan, November 13-14, 1973. The paper was written by Dr. D.A. Tisna Amidjaja (now Director General of Higher Education), and Dr. Filino Harahap (now Director, Development Technology Center (DTC), Institute of Technology Bandung (ITB)). It pointed out that ITB (which is Indonesia's leading technical school) has been exploring since 1969 ways in which ITB could support Indonesia's development efforts and had concluded in 1970 that the basic ITB philosophy should be oriented and committed to the development of the country. Regarding the role of technology transfer, the paper examined technology transfer and encouraged "more appropriate operations and technologies, especially in the consumer goods sector ..." and stated, "the rural sector would obtain more attention". It concluded, "We (ITB) are concerned in making the concepts of appropriate technology ... operational within the context of our development efforts, especially with reference to the crucial issues of employment and rural social technology generation. Within ITB, concern is manifested in an agency (neo) called the Development Technology Center (DTC)". It is this appropriate technology organization, created and administered by Indonesians, which would take the responsibility for this role.

## 1.2. FERROCEMENT TECHNOLOGY

### 1.2.1. Ferrocement Application in Developing Countries

In 1973, a U.S. National Academy of Sciences committee, working under an AID - funded project to seek technologies particularly appropriate and useful to the conditions and needs of developing

countries, produced a study, "Ferrocement Applications in Developing Countries". The point of the report was that the very factor that prevented the use of ferrocement in highly industrialized economies, namely it is labor-intensive, made it ideal for those developing countries which were short on capital but had an over-abundance of unskilled and semi-skilled labor, provided they had cement, sand, water and wire. Historically, ferrocement had been used often in building boats thus causing the public to equate ferrocement technology only with boat building; however, the Academy report suggested possibilities for uses in food and seed storage, water (or other liquid) storage, water catchments, troughs, vats, leather-processing facilities, grain and copra dryers, engine beds (ferrocement is particularly resistant to vibration) drying pads, cattle dips and feeders, housing components (particularly roofing slabs and shingles), well linings, emergency buildings for disaster relief and mitigation purposes wuch as boats, barges, dock pontoons. The Academy study panel recommended on-site adaptation and experimentation in developing countries, a recommendation to which this present project responded. The Academy panel also recommended that an "International Ferrocement Information Services" be established, since only sparse and scattered information was followed up in 1976 by the establishment of such a center at the Asian Institute of Technology (AIT), Bangkok, under the sponsorship of the New Zealand Government, the Canadian Government (through CIDA) and the U.S. Government (through AID/Washington). The AIT has been

doing research and development concerning ferrocement applica - tions since about 1959, and was the host institution to an AID-sponsored regional meeting in late 1974, which produced a report called "Ferrocement, a Versatile Construction Material: Its increasing use in Asia", in cooperation in the meeting with the U.S. National Academy of Sciences. Further information on the IFIC (International Ferrocement Information Center) at the AIT in Bangkok can be found in Annex E, of Ref. No. (1) which describes AIT, and ferrocement and its applications.

1.2.2. Description of Ferrocement Technology

Ferrocement is a highly versatile form of reinforced concrete made by plastering a mortar of cement, sand and water into a wire mesh, giving it not only unique qualities of strength, crack-resistance and serviceability, but also its ability to follow compound curves and lines in free form, thus being adaptable to shapes and sizes to fit the local needs. In this project, the word "ferrocement" is used broadly. That is, its conventional and literal meaning of "plastered concrete with ferrous (steel and iron) content" is used only when considerable strength is needed, (e.g. boats). Where only moderate strength is needed to serve the purpose, (e.g. roof panels) reinforcement with indigenous natural fibers (e.g. bamboo, coir, bagasse, palm tree fiber, etc.) will be stressed. In the cases where no reinforcement is needed (e.g. moderate-sized and specifically shaped water and food storage containers), the "ferrocement" will be simply cement mortar hand-plastered into a temporary surface acting as a mold.

1.2.3. Historical Background

Historically, "ferrocement" was invented in 1847 by a Frenchman, Joseph Louis Lambot, who in 1848 pressed a cement mortar into and around wire mesh made in the form of a row-boat. The boat can still be seen in the Brignoles Museum in France. Another row-boat, built in Holland in 1887, was still afloat in 1967 on a pond in the Amsterdam Zoo. This demonstrated durability of ferrocement is one of its strong points, particularly for tropical areas where wooden materials are destroyed by termites and other insects as well as by the teredo "worm" in a marine environment, steel materials are corroded from tropical humidity, and plastic material ruined by high intensity ultra-violet radiation from the tropical sun.

Attention to ferrocement technology declined for several reasons; the fact that hand-plastering required much labor which was costly in highly industrialized societies, and the competition of mass-produced thin steel plate. Reinforced concrete is still preferable for compression uses such as supporting beams and roadways. For other uses, however, such as boat hulls and thin shell domed roofs, ferrocement is superior in technical performance. On occasion, even in developed economies, ferrocement is used without the public being aware of it; for example, the distinctive arched roofs of the Sydney Opera House, Australia are of ferrocement.

The technology of ferrocement was given a boost in the early 1940's by an Italian engineer, Piere Luigi Nervi, when he noted

that reinforcing concrete with layers of wire mesh (i.e. ferro - cement) produced a material capable of resisting high impact. Thin (less than 1 inch) slabs of concrete reinforced in this manner proved to be flexible, elastic and exceptionally strong. After WW II, Nervi's firm built a 165 ton motor sailer Irene with a ferrocement hull 1.4 inches thick, weighing 5 percent less than a comparable wood hull, and costing 40 percent less. The Irene proved entirely seaworthy, surviving two serious accidents. Other than simple replastering necessitated by the accidents, the hull required little maintenance, pointing to another of the advantage of ferrocement: it is easily repairable and nearly maintenance-free. In 1965, an American-owned ferrocement yacht built in New Zealand, the 53 foot Awahnee, circumnavigated the world without serious mishap, although it encountered 70-knot gales, collided with an iceberg, and was rammed by a steel-hulled yacht. Nervi also applied ferrocement to buildings, constructing a small storehouse in 1947, a 50-foot vault ceiling over a swimming pool, and the famous Turin Exhibition Hall--a roofing system spanning 300 feet made of a combination of ferrocement and reinforced concrete.

In summary, ferrocement is particularly suited to developing countries for the following reasons:

- Its basic raw materials are available in most countries
- It can be fabricated into almost any shape to meet the needs of the user; traditional designs can be produced and often improved
- If properly fabricated it is more durable than wood and cheaper than imported steel and it can be used as substitute for these materials in many cases

- The skills required for ferrocement construction are quickly acquired and include many traditional skills of developing countries. Ferrocement construction does not need heavy plant or machinery; it is labor-intensive. Except for sophisticated and highly stressed designs, such as deep-water vessels, a trained supervisor can achieve the requisite degree of quality control using fairly unskilled labor for the fabrication.
- The concern of most developing countries for its rapid rate of deforestation makes ferrocement very attractive as possible replacement for wood in its many uses.

## 1.3. PROJECT

### 1.3.1. Project Initiation

To sharpen the focus of the ferrocement technology activity, AID sponsored in October, 1977, a two-week feasibility study by the leading, ferrocement expert from the Asian Institute of Technology, Professor Ricardo Pama, accompanied by Mr. Opas Phromratanapongse, Head of the Product Development Department, Siam Cement Co., Bangkok, Thailand. This team of experts worked closely with the DTC-ITB (Institute of Technology Bandung-Development Technology Center) on a program consisting of a technical seminar at DTC-ITB, a visit to the Sukabumi Regency in rural West Java, a visit to Ujung Pandang area and Hasanuddin University in South Sulawesi, visit to Banda Aceh area and Syiah Kuala University in Aceh Province in North Sumatra and a "wrap up" Confe -

rence at the University of Singapore with Professor Seng Lip Lee, formerly of AIT Bangkok. All arrangements were made by the DTC-ITB, and the study and field reception proved to be an unquali - fied success, with great enthusiasm expressed by all participants for the concept and proposed activity. In-depth discussions were held with a variety of local administrators from the village chief level to the Bupati level, with faculty and students from the mentioned universities, with village private entrepeneurs, and with three individuals who are already doing limited work with ferrocement in Indonesia. Two of these are private concerns working in the Jakarta area making housing panels and tugboats respectively, and the third a U.N. expert from New Zealand, who is teaching and working with ferrocement boat building in Jaya-pura, Irian Jaya. They were not aware of each other's activi - ties prior to the feasibility study, which indicate a typical situation of small, individual and isolated efforts in the field to date, and the need for the information center recently esta-blished at AIT, Bangkok.

These local activities would be correlated with the project in an advisory capacity, so that their experience, although limited, will contribute to the success of this project.

The AIT (Asian Institute of Technology) would also participate in the activity by training around nine Indonesian engineers or scientists in the structural engineering properties of ferroce-ment through a special four-month course and, to a limited ex -

tent, by providing consultant services for technical problems and evaluations. Other worldwide experts may be also be used on occasion for short-term (1-2 weeks) consultations.

Mr. Opas Phromratanapongse hoped that Siam Cement Company may release him for short periods to assist in training in Thailand at the non-academic level, particularly in a simple technique for making unreinforced water jars, toilet traps and food storage containers. This training would be for about two weeks, at the "foreman" level. The water jar, toilet trap and food bin techniques were devised and developed by Mr. Opas Phromratanapongse, and have been successfully applied at the village level in Thailand. The techniques for making water jars and food bins are described in detail in Annex I and J of this Project Paper.[1)] Given the general lack of ferrocement technology activity in the United States, there is no involvement of an American institution, other than the possibility of a short term consultant for specific technological problems and for evaluation assistance. The U.S. Government through AID, has been a major contributor to the expansion and development of the Asian Institute of Technology, and AID has a policy to use the educational and R & D institutions in the developing countries where those institutions are qualified and capable. AIT is uniquely qualified in this respect, as explained in Annex D,[2)] which justifies its competency for ferrocement training, consultation and information source.

### 1.3.2. Experts Recommendations

The technical results of the DTC-ITB ferrocement technology feasibility study are described in further detail in the sections on technical and economic analyses and the Annexes. In summary, the main recommendations are:

1. To establish the project activity as described;
2. Use the DTC-ITB as the managerial and technical leader for the overall activity as well as for field operations in the Sukabumi Regency area;
3. Use Syiah Kuala University and its new Rural Development Center as the managerial and technical leader for field operations in the Aceh Province area;
4. Use Hasanuddin University and its Regional Adaptative Technology Center as the managerial and technical leader for field operations in South Sulawesi;
5. Concentrate initially on the following potential applications of ferrocement and related materials for rural use in Indonesia--
   a. pontoons for river crossings, replacing steel pontoons,
   b. dug-out canoes replacing prime logs which are expensive and wear out quickly,
   c. fishing and cargo boats replacing wood which have a limited life span,

d. large water catchments and containers which are presently unavailable or are costly, causing villagers to walk up to wells five to six kilometers distance to obtain and carry water in small tin or plastic containers, then storing in small clay jars or used oil drums,

e. toilet bowls with water traps for sanitary and aesthetic reasons,

f. well casings, replacing thick, breakable, heavy casings, which have to be transported,

g. farm grain storage bins to reduce post harvest losses,

h. building boards with natural fibers as reinforcement, for various uses such as roofs and wall panels, replacing wood and tile, corrugated iron sheets, or thatch;

6. Provide special training for four months for a nucleus of academically qualified people; and

7. Provide technical training (two weeks) for a nucleus of technical people for teaching the simpler techniques of the unreinforced cement water jars, food containers and toilet bowls.

1.3.3. Project Description

The principle of appropriate technology requires that adaptation and testing be done, as explained earlier, to assure the economic and market viability and the social acceptance of the technology before it is promoted on a commercial scale. The second major activity in this appropriate technology project would be to sup-

port the design, adaptation, laboratory and field testing, demonstration, acceptability trials, formulation of training and application/utilization programs, training of trainers, market analyses, and market development program, for ferrocement technology. These must logically be accomplished with positive results before entering into a program of widespread production of ferrocement products in rural Indonesia.

Presuming positive results in the adaptation and testing, the activity would also design a broad-based dissemination and utilization project, in the form of a project paper draft for ferrocement technology application in a large scale involving other institutions, e.g. BUTSI (the local "Peace Corps"), several GOI agencies, and the cement industry.

The primary output of the subproject on ferrocement would be to arrive at one or more optimized designs and actual constructions of ferrocement (or fiber-reinforced cement, or unreinforced cement) for a variety of products made at the village level suitable for Indonesian conditions, and fully tested and demonstrated in the field performance, construction and operating costs, and local acceptability. Within the limitations of funds available to this activity, these designs should be at least for the priority uses identified in the feasibility study, and described in the preceding section on "background".

The output of the project activity would also include five or six university graduate Indonesian engineers trained in the mechanical

properties of ferrocement through a special graduate course arranged at the Asian Institute of Technology (AIT), Bangkok, Thailand.

Details of AIT's competency to do this training are given in Annex D. In addition, the AIT would provide limited consultation and evaluation services. The AIT proposal for this training and technical assistance is given in Annex K.

The universities of Syiah Kuala and Hasanuddin agreed to collaborate with DTC-ITB, particularly in the field aspects of adaptation, testing, and evaluation, under contractual agreements with DTC-ITB. Other appropriate technology or small entrepreneur institutions or organizations, such as Dian Desa, Yogyakarta or an existing cement product manufacturer (village), would also be able to assist in field testing, under small sub-constracts from DTC-ITB. The purpose of involving these other institutions and organizations is to make the designs, testing and evaluation activities as widespread and realistic as possible. The early involvement of these organizations would help in the subsequent follow-up of the project.

The marketing analyses and programs should stress not only the primary utility of the products but also the generation of employment through small industry development. In developing short training programs for the "foreman" level, consideration should be given to retraining of entrepreneurs who may be affected by the new products. There will be benefits to women as a result of the project.

## 1.4. RAW MATERIAL AVAILABILITY

All the basic raw materials needed in ferrocement construction are available in Indonesia. The six cement companies in the country now produce 2.8 million tons of cement per year. With three of these companies now undergoing expansion and another one under construction, it is estimated that by 1978 cement production in Indonesia will reach 3.2 million tons with a projected surplus of 200,000 tons for export. In 1979, Indonesia will be exporting approximately one million tons of cement. It is expected that by then the cost of cement, which at present is Rp. 35/kg will fall considerably.

Sand is easily available in Indonesia, although in remote areas the cost of transportation makes the cost prohibitive, as much as Rp. 8,000*/cu.m.

Indonesia manufactures a wide range of wire meshes. Like other developing countries in Asia, Indonesia imports steel from abroad. Wire mesh cost from Rp. 500 - 1,200/sq.m. depending on the size and type of the mesh.

## 1.5. BASIC REFERENCE DOCUMENTS

(1) "Appropriate and Low Cost Technology", Project Paper Department of State, US Agency for International Development, American Embassy, Jakarta, Indonesia; USAID/INDONESIA Grant Project 497-0268 March, 1978.

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*The price in 1978.

(2) "Project Grant Agreement between the Republic of Indonesia and the United States of America for Appropriate and Low Cost Technology", March 31, 1978; signed by D.A. Tisna Amidjaja, Director General for Higher Education, Department of Education and Culture, for the Republic Indonesia, and Thomas C. Niblock, Director, USAID/INDONESIA, for the United States of America.

(3) The Potentials of Ferrocement and Related Materials for Rural Indonesia, A Feasibility Study Prepared for USAID, Indonesia by the Asian Institute of Technology, Bangkok, Thailand, October, 1977.

(4) "Ferrocement: Applications in Developing Countries", Report of the National Academy of Sciences, Washingthon, D.C., February, 1973.

(5) Perjanjian Kerjasama (No. 605/ICP-02/78) antara Pusat Teknologi Pembangunan, Institut Teknologi Bandung dengan Univer - sitas Hasanuddin tentang Pengembangan Teknologi Ferrocement, Proyek USAID Grant Project No. 497-0268, signed on 14 Fe - bruary 1979.

(6) Perjanjian Kerjasama (No. 606/ICP-02/78) antara Pusat Teknologi Pembangunan, Institut Teknologi Bandung dengan Universitas Syiah Kuala tentang Pengembangan Teknologi Ferrocement, Proyek USAID Grand Project No. 497-0268, signed on 28 February 1979.

## 2.0. PROJECT ACTIVITY

### 2.1. FIELD SURVEY AND RECOMMENDATION

#### 2.1.1. Selection of Center for Ferrocement Development

The AIT team visited several villages in Bandung, Sukabumi and the coastal town of Pelabuhan Ratu in West Java on October 4 - 9, 1977. Meetings were held with the staff of the Development Technology Center (DTC) of Bandung Institute of Technology (ITB). The meetings were also attended by faculty members from departments of Civil Engineering, Mechanical Engineering and Architecture of ITB, and representatives from the U.N. Regional Housing Center, the Cement Association of Indonesia, P.T. Cement Gresik and the Ceramics Institute. Field trips were then made to several farming communities around Bandung and Sukabumi District and coastal villages in Pelabuhan Ratu to obtain first hand information about the conditions of the rural people.

On October 8 - 11, 1977 the team visited Ujung Pandang in South Sulawesi. Discussions were held with the Rector and faculty members of Hasanuddin University. Similar visits were made to inland and coastal villages in Maros District of South Sulawesi and discussions were held in local district officials.

Finally, on October 12-14, 1977 the team visited Banda Aceh in North Sumatra. Similar meetings were held with faculty members of Syiah Kuala University to which local entrepreneurs and provincials from Aceh Province were invited to attend. Field vi-

sits were later made to observe various cottage industries in Banda Aceh and its surrounding villages.

An evaluation of the trip was subsequently held in Singapore on October 18, 1977.

This field survey confirmed that the following three provinces visited could be selected as centers for ferrocement development:

(1) Province of West Java

(2) Province of South Sulawesi and

(3) Province of Aceh

2.1.2. Identification of the Agent for the Development

Beside selecting the site for development, the agent for development must also be found. The Development Technology Center (DTC) as the research and Development arm of Bandung Institute of Techno - logy (ITB) has the capabilities to adapt and introduce ferrocement technology in Indonesia. The DTC is multi-disciplinary in approach and has the support of the different faculties in ITB. They have many projects in the rural areas and could easily integrate ferro-cement technology in their rural development program.

In order to accelerate the introduction of ferrocement technology in different areas in Indonesia, national institutions such as University of Hasanuddin in South Sulawesi and Syiah Kuala in North Sumatra can be made agents for the transfer of this technology in their respective areas. This two Institutions have Rural Development Centers which work with the various faculties in their

respective universities on rural development projects. They have staff members to carryout basic structural testing and conduct field demonstrations.

### 2.1.3. Possible Applications of Ferrocement

(1) Existing Activity

From discussion with university staff, local entrepreneurs, government officials at the district level and people in the villages, it was obvious that the potentials of ferrocement are not fully realized. After they were shown slides of various ferrocement applications in other developing countries, they were enthusiastic and convinced that ferrocement can also be introduced in Indonesia to benefit the people in the rural areas. One of the problems in introducing ferrocement technology in Indonesia is the lack of indigenous personnel that can demonstrate and teach the rural people how to build ferrocement structures and related objects for use in their daily lives. Two ferrocement construction facilities exist in Indonesia. One is a commercial boat building company in Jakarta which branched off to building ferrocement boats with the help of a New Zealand company. This company, P.T. Kodja, builds ferrocement boats and barges. The other facility is a boat-building company in Jayapura, West Irian. This project was undertaken by the Irian Jaya Joint Development Foundation with financial support from

the United Nations Development Programme. The project is managed by Mr. David J. Wells, a U.N. Expert on ferrocement boat-building from New Zealand. It is to be noted that Mr. Wells joined the team in Ujung Pandang and participated in the subsequent evaluation held in Singapore.

(2) Possible Application

The feasibility study for this project investigated the possible social benefits to the rural poor through the use of ferrocement technology. The study identified seven potentially beneficial applications as starting points.

(a) Pontoon Ferries

These ferries, which are used to cross many of the rivers in Indonesia, are made of steel or wood pontoons, which are costly and short-lived. Their break-downs cause delays in replacement, and a consequent disruption of transportation of goods and people. This in turn causes prices to rise, which is very detrimental to the poor, rural consumer. Ferrocement pontoons will be longer-lasting, cheaper and easier to repair. It is also important to note that the substitution of ferrocement for wood will help reduce the depletion of forests and resultant soil erosion problems.

(b) Dug-out Canoes

Small-scale fishermen and small-scale ferries now use wooden dug-out canoes that last only 1 1/2 to 3 years. Ferrocement boats can be made at less expense and last 30 or more years, greatly reducing both the original cost and long-range operational expenses. This will benefit boat owners and at the same time will reduce the cost of water transportation of people and goods. It will also reduce the demand for the prime logs now used for such canoes.

(c) Water Containers

Cement mortar jars with a capacity of up to 1000 gallons can be made cheaply without any metal reinforcement. These can be used to collect water during the rainy season so that farm and village families can have a source of pure water, without the women and children having to haul water daily long distances during the dry season.

(d) Toilet Bowls with Traps

A ferrocement toilet bowl with a sanitary trap, based on a design developed in Thailand, can replace the present unsanitary open facilities that are widely used, thus improving health and sanitation in the rural area.

(e) Well Casings

Presently heavy concrete casings are being used to line rural water wells. These have to be transported by truck from the place of manufacture, are heavy, and break easily during transportation and handling. Ferrocement casing is as serviceable, lighter, and can be built on site with a better fit between rings. The useful ferrocement casing should make possible the widespread use of casing thus giving village wells better protection from contamination.

(f) Grain Storage Bins

Normally grain is stored in structures constructed of woven bamboo or with wooden walls so that the loss to insects and rodents is estimated at 10 - 15%. A ferrocement structure, though initially more expensive, would be within the price reach of the average Indonesian farmer and would reduce such losses to a small fraction of the present losses.

(g) Housing Components

Experiments are proposed to use a mixture of cement and available natural fibers to produce housepanels and roofing that would be cheaper and/or more durable than materials currently being used. The use of ferrocement would cause some small dislocation of employment; however, adjustments to offset this circumstance can easily

be made. For example, the manufacturers of conventional cement products can be diversified to make or supervise the making of ferrocement products.

In addition to the uses mentioned above, ferrocement applications are so flexible that is it believed that many other socially-beneficial uses will evolve as the technology becomes widely employed. For example, the desired round domes for mosque can easily be fabricated from ferrocement once the expertise for its use becomes available. The use in a religious context presumably should enhance the general acceptability of the material, but this assumption should be tested.

2.1.4. Recommendations

(1) Basic Consideration

Once the design has been optimized for the local conditions, the technique of using ferrocement (and unreinforced or fiber-reinforced cement) to meet village requirements is dependent primarily upon the availability of unskilled labor directed by a semi-skilled person. Labor costs are relatively low in Indonesia, and a semi-skilled foreman can be trained within one to two weeks. He should be able to teach others in turn. The main skills required involve how to prepare the right mixture of materials required for the mortar, to master the techniques of plastering the mortar to avoid air pockets

(voids), to be able to keep uniform wall thickness, and generally to be able to maintain a quality control, thereby assuring cost-effective performance according to de - sign. The key to the success of the activity will be the original design, which must be the product of a skilled person, normally a specially trained engineer. Although the design must fit the need with respect to shape, size and strength, it must not be over - engineered, as to be wasteful in material and labor.

Fortunately, the high cost of designing something like a well casing can be spread over thousands of well casings, whereas the actual construction, on a one-by-one basis, is done at the relatively unskilled and inexpensive labor level.

Cost for materials for unreinforced cement products are limited to the purchase of cement and sand. As Indonesia is now self-sufficient in cement production, costs should drop somewhat or at least stabilize. Sophisticated uses are not discussed here. For requirements where moderate strength is needed local fibers may be added at additional, moderate cost. Where even greater strength is needed, as in boat hulls, the cost of wire mesh must be added to the total material cost.

All the basic raw materials needed in ferrocement construction are available in Indonesia.

In summary, the feasibility team, calling upon their experience and knowledge of the material, found there were many cases where ferrocement would provide a good, long-lasting, strong, easily repairable, locally made product at very competitive costs. Further, its use would have a favorable environmental effect by reducing pressures on demand for wood. As replacement for steel (e.g. ferry pontoons), considerable foreign currency savings and reduced maintenance costs would result. As replacement for poured cement in well casings for e.g., breakage and transportation costs would be drastically reduced, and performance, longevity and maintenance would be improved. The project will further test these claims and determine actual cost-effectiveness.

(2) Training Recommendation

For an effective transfer of ferrocement technology to these three institutions, it is recommended that a three-tier training program be implemented as an integral part of the project.

(a) The first part of the training program should consist of training technicians. It is recommended that two and more technicians be identified from each of these three institutions for a 2-week training on the construction of simple objects such as water jars and toilet bowls. The best place for this type of training is the Siam

Cement Co. Ltd., in Bangkok, Thailand because of their experience in this type of activity.

Very recently, the Siam Cement Co. Ltd. conducted a training program for villagers in sixteen (16) provinces in Thailand at the request of the Government. The villagers were taught by Siam Cement technicians how to make water jars and toilet bowls for their own use.

After this 2-week training program, the technicians should start to introduce the construction of water jars and related objects such as toilet bowls to their respective areas. These technicians should be part of the team which will implement the project.

(b) The second part of the training is a 4-month training program on ferrocement technology to be undertaken by one or two staff members from each of these three institutions who will later serve as project coordinator in their respective areas.

It is important that the project coordinators understand ferrocement as a material, its usefulness and limitations. The training program should have three essential components, namely (1) fundamental studies on the properties of ferrocement as a construction materials, (2) laboratory experimentation and (3) field demonstration on various ferrocement applications.

(c) The third part of the training program is a long-term training program to develop resource persons in Indonesia with ferrocement specialty. Since AIT has already a large number of Indonesian students now studying for their masters degrees, it is recommended that some of these students, especially those in the Division of Structural Engineering and Construction, be encouraged do take up ferrocement as their thesis topic. This part of the training can be done under existing scholarship program of AIT and hence it will not entail additional expense to the present project.

(3) Application and Field Test

The following applications should be tested in the field and evaluated before full-scale implementation:

- Pontoons
- Dug-out canoes
- Water jars
- Building boards with indigenous fibers as reinforcement
- Toilet bowls
- Well casings
- Grain storage bins

Although fishing and cargo boats have been identified as possible applications of ferrocement in Indonesia, it is recommended that they be excluded in the field testing for the following reasons:

(a) The capital investment required in ferrocement fishing or cargo boat (about Rp. 2.000.000,--) is large in

relation to the other application identified previously.

(b) The construction of a ferrocement boat requires special expertise and will take several months to complete. Since the project is only of 2-year duration it is felt that only a very limited time will be left to try out other applications if building a boat were to be undertaken. It will take a long time before the villagers can see the actual results, whereas, with other simple applications the villagers can see the results in a matter of weeks.

To ensure the rapid acceptance by the villagers of ferrocement as a material, it is recommended that in the project, attempts should be made to build a ferrocement dome for a village mosque. Ferrocement is an ideal material for this spherical dome. Since the mosque is a holy place of worship and a place where the community meets socially, a ferrocement dome will be the center of attention and devotion of the people.

## 2.2. TRAINING PRIOR TO PROJECT ACTIVITY

Prior to the project activity in the three areas of development, a 4-month training course on ferrocement technology was undertaken by 9 engineers from Indonesia at AIT, Bangkok. The parti-

cipants of the training taken from the three institutions, would later serve as project coordinator in their project areas. Beside the staff from DTC (1 person), UNSYIAH (2 persons), UNHAS (2 persons), the participants from the ff. institutions were also invited: Yayasan Dian Desa (1 person) which is known as an active agent in introducing ferrocement water container in Central Java, University of North Sumatra (1 person) and Department of Public Works (2 persons); hopefully all will support the efforts of wide application of ferrocement technology in Indonesia.

The training program consisted of theoretical studies, laboratory experiments, field demonstration project, and field trip. A brief description of the training program is as follows:

Theoretical Component: this aspect exposed the trainees to the theoretical aspects of ferrocement, since a good understanding of the theory is essential for a good design, and the material is still in the development stage. The lectures touched the various aspects of ferrocement, its historical development, constitutive materials, construction methods, mechanical properties and potential applications. Also included was a section on the technology and application of related construction materials such as fiber-reinforced concrete and mortar, organic fiber reinforcement etc.

A series of lectures on the fundamentals of structural analysis of plates and shells was included, since most of the ferrocement application are in the form of plate and shell element.

Experimental Component: the experimental component consisted of the study of the various types of tests on ferrocement and its constituent materials (cement mortar, wire mesh, skeletal steel) to determine their mechanical properties in tension, compression, flexure etc. This was followed by laboratory experiments in which the trainees themselves performed the fabrication and testing of the specimen and analysed the test results.

Field Demonstration Project: the core of the training program was the field demonstration project in which each of the trainee was assigned a particular ferrocement application. Suggestions were received from the trainees as to their areas of interest and the projects were assigned to them on this basis. The projects selected for field demonstration are listed in Appendix B. As part of the field demonstration, the trainees visited the ferrocement boat construction yard at Sriracha where there was actual construction of ferrocement fishing boats. After completing their training the participants held a symposium on Ferrocement Technology at ITB. Invited to attend were the staff from the Building Research Center, Testing Material Institute and the student body and Faculty members of the Department of Civil Engineering and Architecture. On returning to their Regional Centers the trainees set up a program assigned by the project which included

- site selection
- on-site training of technicians and skilled laborers
- field demonstration
- field test

## 2.3. PROJECT DESIGN AND SITE SELECTION

This chapter includes the report from the three areas of West-Java South Sulawesi and Aceh.

### 2.3.1. West Java

#### 2.3.1.1. Field Survey and Site Selection

The project commenced with a series of field surveys in a number of villages in Sukabumi as well as several places in the Bandung urban area. Then several sites were selected to obtain the criteria for designing the hardware components to be developed and tested. The sites selected were based on the optimization of meeting the local needs as well as the social, economic and environmental appropriateness. The results of the field survey were: the formulation of the problem and the selection of the following sites for field testing:

(1) District of Sukabumi

- (a) Village of Sukabumi
- (b) Village of Citarik
- (c) Village of Cikarang

(2) District of Bandung

The facilities of fiber-cement/Ferrocement hardware development system of DTC-ITB were to be made available to the sites selected.

#### 2.3.1.2. Site Selected

(1) District of Sukabumi

The site selection was carried out through the cooperation

of DTC-ITB with the District of Sukabumi, a cooperation which has been in progress for several years now. After several visits to the area, the village of Buniwangi was selected. This village is typical of the area. It is poorly developed because of lack of proper infrastructure such as good roads. The problems of its water supply include lack of a proper distribution system, lack of adequate supply and poor quality.

(a) The Condition of Water Supply in the Village of Buniwangi.

The village is located about 6 kms North of Pelabuhan Ratu and can reached by road through a rubber plantation only by high-chassis vehicles. The road is paved with gravel and stones. The village is in a hilly area and the main activities of the population are cultivation of cloves, rubber and rice.

The daily water supply for village consumption is from a stream, fed by a spring located 1,500 meters from the settlement area. (See Appendix 1) Although water is available the whole year, during the dry season the water supply is reduced. From the survey of 4 different settlement groups, different ways of obtaining water were observed. The water was transported through open-earth channels and then trans - ported to the houses by bamboo pipe or PVC pipe. Some

use the stream directly for their needs. Whenever necessary, open water storage tanks made of brick with a capacity of 500 - 1000 liters were used. Ponds with bigger capacity were also dug to store water. Analyzing the different sources of water in the area, it was determined that the amount of water needed by the village can be adequately supplied. If the supply system is improved, the quality and quantity of water supply can be improved.

Contamination from pesticides, human and animal waste would be prevented. Efficient utilization and distribution of water would greatly reduce needless waste and loss of water supply.

Design and Approach of Water Supply Project in Buniwangi

From the results of the survey together with the parties who had previous contact with the village people (KKN-IPB), several alternatives to improve the water supply were proposed:

(i) To improve the distribution of water supply by the introduction of ferrocement in the construction of:

- open canal
- closed channel
- water conveyor

(ii) To study the technical and economic feasibility in the improvement of water supply

(iii) To improve the water storage system through the intoduction of

- ferrocement water tank
- bamboo cement water tank
- simple water filter

(iv) To make the village people aware of the importance of clean water for daily use through spontaneous informal contacts with the DTC staff

(v) To train the local youth and workers the technique of ferrocement construction

(vi) To use any possible local material available for the water supply system.

From the very start of the project, the approach through the different levels of local leaders, both formal and informal, played a very important role, and a regular contact was maintained. In this village it was felt that there was a strong influence from some informal leadership. After approaching these leaders properly, two meetings with the village people were held. As a result the people of Buniwangi supported the project by supplying the manpower regularly during the execution of the project.

(b) Condition of Water Supply in the Village of Citarik

The village of Citarik is one of the field testing areas of DTC-ITB projects since 1977. Various hardware components had been developed within the area. Most of the project development was interrelated. The problems of water supply were more or less similar to Buniwangi. The area has adequate water supply throughout the year but the distribution was not managed well, therefore some part of the village still lacked water. In addition, the water was not free from external contamination. Based on the experience at Buniwangi, a similar study was undertaken for Citarik. Two sites were selected: the community of Babakan Jayanti and the community of Ciawun. The alternatives proposed for the area were as follows:

(i) To improve the quality and distribution of water within the area through the introduction of

- Water storage ferrocement tank for Babakan Jayanti
- Public toilet, washing and bathing facilities in Babakan Jayanti utilizing bamboo cement

(ii) To improve the water supply and distribution at Ciawun/Cisoka through the introduction of:

- Locally available fibrecement pipe, including its method of manufacture
- Public bathing and washing facilities at Ciawun, Cilimus.

(2) District of Bandung

(a) The Development of ferrocement shell type of structure.

Because of the versatility of the material, i.e., its free form and high strength in tension and compression, ferrocement is highly recommended for thin shell and space structure.

For this purpose design and construction of such a building was tested. Due to its religious significance for the people, it was apparent that introducing the new technology to the local people through a public building such as a prototype of a mosque would mean a definite breakthrough for its acceptability.

Prior to the actual field construction, several types of construction were studied through modelling. The types studied were various hyperbolic paraboloid shells, customarily called gothic vaults. The shell structures tested were at the request of the local community, executed after a period of contact and negotiation through formal and informal meetings. These meetings discussed not only their relationship to the project, the finan -

cial arrangement and local manpower recruitment, but also the early concepts of the design.

(3) Fibercement Hardware Development

In the production of starch flour, one the main raw materials is the trunk of the sugar palm tree. The waste material produced includes the fiber from the tree. Starch flour industries are located throughout West Java, mostly in the south and the east. On the recommendation of one feasibility study, DTC-ITB developed a system that would utilize this waste material. The applications of those fibers in the project were:

- Production of fibercement pipe with a diameter of 4 - 6 inches and a length of 2 - 2.5 meters to be used in the village piping system. The simple manufacturing procedure can be done locally. (See manual)
- Production of fibercement corrugated roofing sheet, 1 meter x 1 meter; also with simple production procedure. (See leaflet and manual)
- Fibercement bamboo matting wall. This is ordinary bamboo matting with hollow weaving, plastered with fiber, lime and sand. When these fibercement bamboo mattings are nailed into a framework of closely spaced studs of thin metal steel or wood, the result is a wall with properties that compete with normally constructed walls including being earthquake-resistant.

The development of fibercement as an alternate material is based on its simplicity of production, the availability of the materials and low cost. These components would also be developed and tested in the projects in Buniwangi, Citarik, etc. ...

(4) Pontoon Ferry at Cikarang

The increase in agricultural yield in the remote rural areas necessitates that the produce reach the market as soon as possible. This means that the land trafic also grows significantly. The answer to the problem of marketing the yield from the remote regions is better infra - structure of roads for better transportation. In these regions where the trafic of goods is still low, the in - vestment for that infrastructure would be unproportionately high, especially where it involves building bridges. Bridges imply permanence and long term use and hence properly belongs to long-range planning and budget. Therefore in the remote and not so populated areas, the bridge is substituted by a pontoon ferry in the transportation road network. It is designed for temporary service and low financial investment. It can also adjust to the flow of traffic. Conventionally the pontoon is made by arranging a number of steel cylinders or wooden canoes and then provided with a deck. It can ferry vehicles, goods and people. Undoubtedly, the role of the ferry in establishing

quick communication and transportation to the remote areas is indispendable.

From the field study at the beginning of the project, one crossing site along the river of Cikarang was found to be suitable for a ferrocement pontoon ferry development. Already in use was an old steel pontoon ferry operated by the Provincial Public Works Department. It was proposed to develop a ferrocement pontoon ferry as an alternative to the steel one for the ff. reasons:

(a) Low cost of construction

(b) Can be constructed at the site

(c) Only low-skilled labor required

(d) Corrosion-resistant

(e) Easily repaired

(f) Easily maintained

(g) Water-tight.

### 2.3.2. South Sulawesi

The selection of the project site is based on the goal of introducing the ferrocement technology to the rural people. Under the supervision of Hasanuddin University, the region was classified into three different areas, namely:

(1) Mountainous area

(2) Seashore area

(3) Agricultural area

From a survey of a number of villages, one village from each of these different areas was selected to be the center of development of ferrocement technology.

From the mountainous area, the village of Tonrokassi, District of Jeneponto, 80 km south of Ujung Pandang was selected. This area is known for its critical situation of water supply. The water table is about 30 meters deep and for their daily consumption the people have to go a distance of 10 - 15 km to the source of their water supply. The ground is rocky and at the height of the dry season, the level of water in the river falls to a minimum. Hasanuddin University also has set up a Rural Adaptive Technology Center (RATC) in the village.

From the seashore area, the village of Pajjukukang, District of Maros, 37 km North of Ujung Pandang was chosen as top priority for the following reasons:

(1) The majority of the people make their living as fisherman and providing sea transportation.

(2) There is lack of good water supply in most of the area.

(3) The social and economic level is still relatively low.

(4) It is necessary to create another source of income other than fishing which is seasonal.

From the inland agricultural area, a village 190 km north of Ujung Pandang in the District of Sidiap was selected. The people are mostly farmers and it was hoped that they could be-

nefit from the ferrocement technology for grain storage, irrigation canals as well as water supply tanks.

### 2.3.3. A c e h

#### 2.3.3.1. Survey and Site Selection

The first important step of the project was to select the alternative locations where the technology can be carried out and adapted quickly by the people. Also considered were the social and economic activities of the people and the available resources.

After receiving an orientation from the Rector of the University of Syiah Kuala and Dr. Abdullah Ali as the person responsible for the project, the team leader of the project held a survey in Octover, 1978 in the District of Aceh Besar and around Banda Aceh. Later the survey was extended to the District of West Aceh and South Aceh in March and April, 1979.

The following areas were the sites selected together with the corresponding considerations for their selection:

(1) District of Aceh Besar

(a) The campus of the University of Syiah Kuala is located here and is the logical center for the dissemination of technology in the province of Aceh.

(b) This area is near the provincial city of Banda Aceh where any materials needed are easily obtained at relatively low prices.

(c) Sand is locally available from the Aceh River.

(d) Brick is expensive priced at Rp. 50,- each.

(e) Unemployment due to high school drop-outs is high.

(f) The domes from the many mosques do not last long because of corrosion and ferrocement may be a substitute.

(g) The people living near the seashore need water storage facilities (water tanks, jars, etc. ...).

(h) The water facilities used for purification rites in the mosques are inadequate because of the high cost of concrete and bricks.

(2) District of West Aceh and South Aceh

(a) Because of its great distance (450 km) from the Provincial City of Banda Aceh, the District of West Aceh has not progressed much in technology.

(b) It would take in consideration the equal distribution of technology development between the rural and urban area.

(c) Because brick is rarely available, the construction cost of houses using concrete is high.

(d) Sand is easily avilable.

(e) Many mosques need water tanks for the purification rites and the domes made of steel are easily corroded

because of proximity to the sea.

(f) The fishing boats are made of wood which is not long-lasting.

From the survey of a number of villages, it was observed that in general the standard of living of the people is low. By introducing ferrocement technology applicable for rural use, the quality of life may be improved.

From these districts then were selected the strategic sites for ferrocement technology development. In the district of Aceh Besar were selected Darussalam, Lhueng Bata and Deyah Baro; in the District of South Aceh, Jambu Apha, Hulu community, the port area and the center of the city (main mosque).

The population density in these sites is high and so the demonstration effect was assumed to be more effective. One effective approach to the community was through the mosque where the people from the surrounding area congregate. By means of the conferences held there, information can be conveyed. Coincidentally the two team leaders of the project were prominent religious leaders in their respective mosques, thus facilitating the implementation of the project.

2.3.3.2. Training Program

For the process of transferring the knowledge and skill to the local people, a training program was organized for those interested. The level of participation could be divided into:

(1) Special trainees

These participants actually composed the local staff that would be involved later in the project. They received training on the various field applications of ferrocement. Those who completed the prepared curriculum received a certificate. This group received remuneration during the training period.

(2) Volunteer trainees

This group was not committed to the project because they already had full-time jobs in either government or private enterprise. Considered only as observers, this group did not received a certificate nor remuneration.

## 2.4. COMPONENT DESIGN CONSIDERATIONS

### 2.4.1. West Java

#### 2.4.1.1. Development of Alternatives for the Village of Buniwangi

After the observation and field study in February, 1979, the overall planning of the water supply system was divided into 4 (four) steps, each containing its design, experiment, field testing and tests for acceptability. The sites selected within the village of Buniwangi were:

- Community of Cimanggu
- Community of Citapen
- Community of Babakan

The steps in the project design are:

Step 1. <u>First development phase</u>: February - July 1979

Before the first step started, surveys were carried out for:

- Reconnaisance study
- Site selection
- Land survey (topography)
- Meeting with the youth volunteer group (Taruna Karya)
- Manpower recruitment
- Project aims discussion
- Study of the total output of water supply from the different sources

After the study, the community of Cimanggu was selected for the first development phase (step). The system design included:

- Construction of a ferrocement channel lining of a trapezoidal shape, 40 meters long, made in small units
- Construction of ferrocement settling tank, 1 m x 1 m
- Construction of one curve bridge with a span of around 8 meter and width of 1,5 meter made from bamboo and ferrocement

- Construction of water facilities for a mosque, with a capacity of 2500 liters, made of bamboo cement, cy - lindrical in shape.

During the execution of this phase, 5 local youth were selected to be trained for the project. In addition about 5 volunteers regularly came to help in the pro - ject in the afternoon after finishing their work in their own farm.

Step 2. Second development phase: September - December 1979

After the first phase, the project was evaluated with regard to its technical progress and its social acceptability, the understanding and the response of the community to the project. This lasted for 3 months. It was observed that the acceptability of the prototype built in phase I was rated good. This was obtained by direct interviews and reflected through the attempts of the people to expand the system and to make the similar components by themselves. During the evaluation period, the plan and design for the second development phase was drawn up and studied. The second phase was carried out in a bigger community area with a bigger system at Citapen:

- Construction of a diversion gate upstream at Cisalada
- Construction of an intake structure from the stream

to the system at Cisalada

- Construction of a public washing facility upstream at Cisalada
- Construction of a ferrocement channel lining shaped like a half cylinder with a diameter of 20 cms.

In this phase, 5 (five) more youth were recruited to be trained to work in the project. These were residents of the community living upstream at Cisalada.

Step 3. Third development phase: January 1980 - February 1980

While phase 2 was under construction, the general plan and design was being revised for some adjustments at the corresponding site selected. In phase 3 the steps were:

- Earth excavation for the ferrocement channel
- Continuation of the manufacturing of ferrocement channel lining
- Creation of the manufacturing procedure for fibercement pipe
- Design of four public facilities consisting of:
  (1) open ferrocement tank with a capacity of 5000 liters for use as filter basin
  (2) one ferrocement tank with a covered top and a capacity of 5000 liters as storage tank elliptical in shape

(3) one ferrocement tank with a covered top and a capacity of 6000 liters as storage tank

(4) 4 public facilities for washing and bathing

- Design of distribution system

During this phase, the number of DTC-ITB staff personnel assigned to the project was reduced and more local people were involved in the project on a voluntary basis. Manpower was minimized.

Step 4. Fourth development phase: February 1980 - April 1980

- Construction of four public facilities mentioned above
- Construction of distribution pipes
- Testing of the distribution system
- Evaluation of the quality of water

Step 5. Fifth development phase: May 1980 - May 1981

- Field observation and maintenance during the height of the dry and rainy season
- Establishment of the social organization to be responsible for the system
- Monitoring and evaluation

2.4.1.2. Ferrocement, Bamboo Cement and Fibercement as Alternatives for the Village of Citarik

After a period of field study and contact with the local community (April 1981), the plan design of hardware development was proposed to utilize ferrocement as alternatives.

The general plan of the project was:

- Construction of a water tank with a capacity of 700 liters to be used as a storage tank, the excess water being pumped by a hydraulic ram pump to the settlement area at Babakan Jayanti, Citarik
- Development of a proper water supply distribution from the storage tank
- Design and construction of a water supply system using the fibercement pipe made of waste fibers from a local starch factory at Ciawun. The length of the pipe system would be 300 meters.
- Manufacturing of fibercement pipe at Ciawun after a short training of the local villagers, the pipe to be used in the project
- Design and construction of two public washing and bathing facilities at Ciawun and Cilimus using bamboo cement construction.

2.4.1.3. District of Bandung

Ferrocement building and components being tested in the field:

(1) Design and construction of a ferrocement minaret with project funds as per request from the Ar-rohim Mosque, Cisitu Lama, Bandung. The minaret consisted of a tubular-shaped tower 12.5 meters high and 2,5 meters thick made of ferrocement walls on slender concrete columns and an upper dome with a 3.5 meter mid-section diameter.

(2) Design and construction of a gothic vault shelter (hyperbolic paraboloid) with an effective coverage area of 3.5 x 3.5 m at the ferry site in Cikarang. The function of this structure is to shelter people who are waiting to be ferried.

(3) Design and construction of a small mosque based on the experience in building the ferrocement hyperbolic paraboloid shells in Cikarang. The mosque, situated in the village of Soreang, District of Bandung, has a better and unique shape. Roof coverage was 5 x 5 meters.

(4) Design and construction of a bus shelter at Jalan Ganesha in front of the ITB campus. This attractive roof form was inspired by the traditional design of the building located near the main entrance of the ITB campus. The covered area within the shelter is 2.5 x 6 meters.

Through a number of direct contacts with the local people design requirement for local adaptability was duly recognized. In

the process of building, there was a transfer of knowledge to the local workers. The free shape design lends itself to local innovation in the future application of the material.

2.4.1.4. Cikarang

Design and construction of a ferrocement pontoon ferry with these specifications:

- Three ferrocement open cylinders, 2.5 cm thick, 105 cm deep, 130 cm diameter and 6.5 m long
- Maximum loading capacity = 11 tons
- Recommended carrying capacity = 8 tons for a single trip.

The construction of the pontoon at the site itself was with the cooperation of the Provincial Public Works Department. For this, local workers were trained within the project. These workers were to become the permanent staff for the operation and maintenance of the pontoon and eventually transfer the technology for similar purposes.

2.4.2. South Sulawesi

To attain the objective of the project described in Section 2.3., the project was divided into the following phases:

(1) Field Experimentation on the various types of application

(2) Evaluation of the field applications

(3) Report and information services

2.4.2.1. Design Criteria

The introductory survey held by UNHAS and AIT - DTC-ITB and USAID in October 1977 at the city of Ujung Pandang and at the village of Pajjukukang, District of Maros was followed with a field survey by the team of R.A.T.C. UNHAS in the Districts of Jeneponto and Sidrap. The results of the survey recognized the possibility of ferrocement technology application.

The selection of those three villages was based on the ff.:

(1) Availability of raw materials for ferrocement construction including several organic fibers and sand;

(2) Ferrocement is an appropriate substitute for wood;

(3) Availability of skilled and non-skilled manpower who can be trained.

In order to promote and develop the use of ferrocement technology especially in the village settlements, certain principles were set up by RATC - UNHAS.

The development of ferrocement must be oriented towards

(1) the promotion of the participation and initiative of the local people

(2) the promotion of the home industries which provide work opportunities

(3) efforts to support the agricultural sector, small industries, clean water supply, handicrafts, sea transport, local tools and implements

(4) the widest possible use of locally available supplies in the village

(5) the production of materials and commodities needed by the people.

2.4.2.2. Object of the Development Program

In connection with the development of ferrocement in South Sulawesi, a series of activities had been started since 1978 and continuing up to 1981.

1978 - Training of personnel for the staff of ferrocement technology at RATC

- Seminar and discussions on ferrocement in the Department of Civil Engineering and Architecture (Shipping) and in the district and subdistrict levels

- Slide show introducing ferrocement followd by discussion at the university including the laboratory tests and project demonstrations held at AIT.

1979 - Field demonstration of several ferrocement constructions for the heads of the villages and subdistricts and the Makole (Tator) Vocational High School, at the same time training two graduates from the School to become field technicians

- Field demonstration on how to make ferrocement drum, water basin and water tank in Tonrokassi, District of Jeneponto
- Training of undergraduate Civil Engineering students of UNHAS
- Trial building of a ferrocement canoe at UNHAS campus
- Demonstration of the building of a water storage with a capacity larger than that in Tonrokassi (UNHAS Social Laboratory)
- Demonstration of the construction of a septic tank at Tonrokassi (UNHAS Social Laboratory)
- Consultation with the Makassar Shipyard Company regarding the possibility of constructing a boat from ferro - cement at their dockyard for sea transportation
- Demonstration of the construction of a well casing from ferrocement at Tonrokassi (UNHAS Social Lab)
- Setting up a plan to construct the dome of the mosque from ferrocement in the village of Tolo, Jeneponto
- Provision of clean water with a pumping system that uses collecting and storage tanks made of ferrocement. This would be a joint effort of RATC UNHAS, the government office in Jeneponto and the Foster Parents Plan International (FPPI).

- Plan to build a tank for collecting rain water to supply clean water for Pajjukukang District of Maros. (This village was visited by a team from USAID and DTC-ITB at the time the joint project was set up)
- Plan to build a fishing boat from ferrocement at Pajjukukang
- The construction of the dome of the mosque at Takalar District which would be a self-help project by the local people with a task force from RATC UNHAS providing field supervision
- Plan to construct a storage bin for rice and secondary crops at Sidrap District
- Probe the possibility of developing ferrocement technology in the other areas of South Sulawesi
- Plan for training in ferrocement technology skills. This is primarily to produce technical personnel who are needed to promote and develop the technology. There were also plans to train personnel from UNHAS, government agencies (BUTSI, Bangdes, Transmigration), prospective Field Service Students and other institutes of higher learning in Ujung Pandang.
- Plan for extension to the Districts of Sidrap, Bone, Enrekang, Pinrang and Tana Toraja. This would be done by demonstration of construction of various ferrocement

components such as water drums, water tank, storage bins for grain and secondary crops. There would also be slide show and discussion with the local people and government.

- Construction of the dome of the mosque from ferrocement at the Muslim University of Indonesia (UMI) at Ujung Pandang
- Construction of well lining made of bamboo ferrocement at Ujung Pandang
- Construction of electric poles made of bamboo layered with ferrocement
- Construction of septic tank from bamboo cement in Ujung Pandang.

1980 - Applied Research Activity. This was intended for software and to involve Civil Engineering students.

The research topics were:

(1) Mechanical properties of ferrocement from the point of view of its cracking stage, done by M. Ridwan Abdullah (Civil Engineering, UNHAS)

(2) Rectangular water tank from ferrocement done by Iskandar Renta (Civil Engineering, UNHAS)

(3) Cylindrical Dome Roof from ferrocement, done by Untung A. Siradju (Civil Engineering, UNHAS)

- Plan to design the use for ferrocement for low-cost housing as a project in cooperation with the government of the District of Sidrap and a private company. The implementation of this project depended on the approval of the 1980 budget for the district.
- Plan to construct the dome of the mosque at Benteng, District of Selayar
- Pond for breeding shrimps at Paotere
- Well casing from bamboo cement in Tarongko and Makale, District of Tana Toraja
- Model of water basin (drum) from mortar cement in Amaparita, District of Sidrap
- Plan to construct a ferrocement boat.

2.4.3. A c e h

2.4.3.1. General Consideration

After the survey the type of project appropriate to each place surveyed was duly considered. It was desired that the type of project chosen would answer the particular needs of the local people. For example, the lack of adequate facilities or means to store water supply due to high costs indicate the possibility of ferrocement as a cheaper substitute. Depending on the local people, several model alternatives were planned which would be quickly developed by the people.

### 2.4.3.2. Darussalam (Aceh Besar)

Darussalam located about 7 km from the provincial city of Banda Aceh is the educational center for higher learning in Istimewa Aceh, hence it was designated as the center for ferrocement technology in that area. A complete set of testing material equipment is·also available for the use of both faculty members and students for the research. For this purpose, the rector of the University of Syiah Kuala set aside a piece of land, 400 $m^2$ in area, as a center for training and collection of data from the different activities of the ferrocement development research.

Types of ferrocement components that would be made were:

1. House type 70
2. Well diameter 80 cm
3. Septic tank, both rectangular and cylindrical in shape
4. Garden fence
5. Roof, folded plate or corrugated
6. Gutter plank
7. Rain gutter
8. Culvert
9. Water tanks, both rectangular and cylindrical in shape
10. Wall units
11. Purification tank for drinking water
12. D o m e
13. T a b l e

14. Garden benches
15. Children's slide
16. Water tank in the place for purification rite at the mosque
17. Canal lining
18. Rice bin
19. C a n o e
20. Flower pots

All the components made were intended for exhibit. However, in their construction, special technical personnel and volunteer trainees were utilized. These volunteer trainees were requested from all parts of the province through contact with the regional heads, the number of trainees depending on the project targeted for each place. The house built was eventually used as an administrative office and also as a place to file all information and reports of activities.

2.4.3.3. Deyah Baro (Aceh Besar)

Deyah Baro, about 3 km from the provincial city of Banda Aceh is located near the seashore. Hence the suitable ferrocement components were canoes, boats and vessels for water storage.

The major source of income is fishing. The fishing boats were commonly made of hard wood which lasted from 2-3 years, after which the boat started to leak. The cost of repairs

were prohibitive hence a fisherman normally owned at least a second boat as reserve.

Results from field testing indicate that ferrocement has higher durability than wood although it is heavier.

Published literature report ferrocement as lasting between 10 - 20 years, a fact which local people can prove for themselves. However there is a local belief that fish are repelled by the odor of iron or cement but attracted to wood. From the scientific point of view this is not tenable. Moreover fishing trawlers made of iron and steel are capable of catching enormous amounts of fish with modern methods such as suction. This belief which may constitute an obstacle to development of ferrocement boat is being overcome by continued training of people, usually high school drop outs, and exposure using photographs and diagrams of the ferrocement boats already in use in other parts of Indonesia and other countries such as New Zealand, Taiwan, Hong Kong etc. ...

2.4.3.4. Lhueng Bata (Aceh Besar)

Lhueng Bata is situated about 5 km from Banda Aceh towards Medan. The sources of livelihood of the people are farming, small business and to a small extent government employment. Since this village is near the provincial city, the standard of living is better than those in the other villages. Throug self-help and contributions from outside the village, the re

sidents of Lhueng Bata constructed a mosque near the main road between Banda Aceh and Medan (North Sumatra). It is the biggest and most beautiful mosque in the area. At the time the team leader of ferrocement technology came to the village, the people had been thinking of how to raise the funds to construct a ceiling dome. The plan was to con - struct it from reinforced concrete 6 cm thick and 10 meters in diameter at a cost of Rp. 2 million. After being infor- med with the aid of photographs and literature about the existence of a type of concrete from ferrocement with thin- ner construction in Asia and Europe, the group expressed in- terest but was not yet convinced of its strength be - cause of its apparent thinnes. The committee in charge of the construction of the mosque was having a dif- ficult time raising funds to continue the construction of the mosque. The ferrocement team leader therefore offered to build the ceiling dome from ferrocement. The committee ac- cepted on the condition that the team leader assure the peo- ple that it was strong and would not collapse. The ferroce- ment team leader gave informational talks in the different mosques in the area.

A blue print was drawn up to construct the ceiling dome from ferrocement with a average thickness of 3 cm and a diameter of 10 meters at the cost of Rp. 750,000. Local laborers who were available were very interested in participating in this

new method of construction which is relatively cheap compared to conventional reinforced concrete. Other volunteers to be trained were also recruited from among the high school drop outs and other interested parties.

2.4.3.5. Tapak Tuan (South Aceh)

Two areas were considered, West Aceh with its capital Meulabah situated around 300 km from Banda Aceh, and South Aceh with its capital Tapak Tuan situated around 450 km from Banda Aceh. Both these areas are not accessible by car because of the poor roads. It takes one week to travel between Banda Aceh and Tapak Tuan during the rainy season. Fortunately there is a temporary landing field built by the government that can be used by small airplanes. Because of the lack of the infrastructure of a road network necessary for economic development, this area has not progressed. For this reason the University authorities and the team leader of ferrocement technology decided to designate Tapak Tuan as the center for development for the two areas considered. The livelihood of the people consists of farming, fishing, small business, government employment and raising home crops.

Like the other areas of Aceh, the people here are very religious. During prayer times many people congregate and fill up the mosques and religious training centers. Hence the development programs revolved around these religious centers.

After studying first hand the situation, the following types of ferrocement components were set up to answer the needs of the people, with the expectation that in carrying out the plan, local laboreres will be trained to further the deve - lopment of ferrocement technology.

1. Religious training center/small mosque
2. Place for the purification rite in the mosque
3. Water tank for the purification rite, cylindrical in shape
4. Cylindrical water tank with its place for the purification rite
5. Water tank and the place for the purification rite
6. Small water reservoir and place for the purification rite
7. Entrance to a small mosque
8. Fishing boat
9. C a n o e
10. Ceiling dome for the main mosque, gutter and walls
11. Ceiling dome for mosque
12. Benches
13. Flower pots
14. Septic tank
15. Water jar

## 2.5. PERFORMANCE UTILIZATION

### 2.5.1. West Java

#### 2.5.1.1. Project Design Criteria

In this project, DTC-ITB developed the hardware through the steps of planning, field testing, demonstration and acceptability trial, training and selected application programs. In setting up the plan and field programs, sound criteria which facilitates smooth running of the programs was always taken into consideration. This criteria generally included:

(1) Raw materials to be used

(2) Available skills

(3) Equipment/tools

(4) Social acceptability

(5) Maintenance ability

These can further be expressed in detail as follows:

(1) More use of local materials

(2) Low cost

(3) Technique used must be capable of being understood by the local people, generating subsequent innovations

(4) Method of maintenance of the hardware being developed must be understood by the local people

(5) Should not be in conflict with the local costums

(6) Must take into consideration control and protection of the local environment

(7) Must take into consideration local skills

Below is the chronological order of the steps followed:

(1) <u>Project Design</u>

(a) Community need assessment criteria

- kinds of service
- magnitude of service

(b) Hardware service criteria

- utilization
- techniques to be used
- environmental protection/control

(c) Hardware design criteria

- magnitude of the performance
- technical limitations
- economic limitations
- concept of design
- hardware specifications

(d) Hardware design

- location
- technique
- blueprint design (if needed)
- bill of materials
- time and cost analysis

(2) <u>Project Organization</u>

(a) Pre-field program

- self-help strategy
- preparation of administration and organization

(b) Project execution or field program

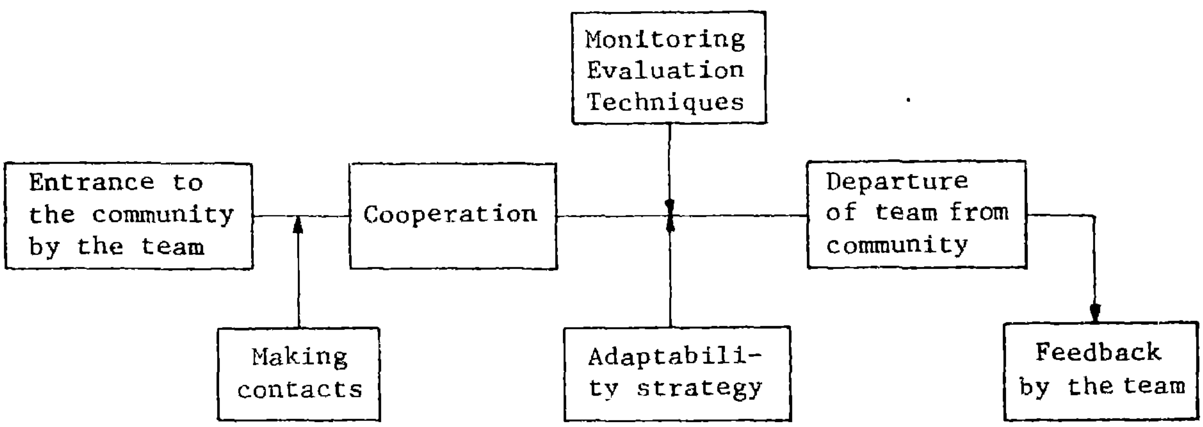
(3) Monitoring and evaluation

These steps constitute the primary orientation in determining how to handle the project well, especially since the sociological factor greatly influences the success or failure of the program in question.

2.5.1.2. Monitoring and Evaluation

The monitoring and evaluation of the performance of the project was carried out before, during and after the execution of the project.

The method and procedure include the training of local manpower, establishing contacts with the local community, joint decision-making, transferring of knowledge and maintenance ability, and the possibility of further development. The schema is as fol - lows:



Because almost all the field work meant direct contact with the local people, the procedure above was very important in the organization of the project in the field. Although sometimes the problems did not involve technical aspects, the above approach facilitated handling of the technical problems. The procedure in organizing the project was carried out phase by phase, until gradually sufficient manpower was trained, either individually or in groups, which would eventually be responsible for the maintenance. Subsequent monitoring and evaluation provided opportunity to improve the performance of the component being developed.

Briefly, the monitoring and evaluation phases are the ff.:

(1) Prior Monitoring and Evaluation

Carried out before and during the execution of the project with emphasis on training the local manpower, and cooperation, including giving feedback for any revision on the technical design.

(2) After the Project Execution

Carried out periodically. Besides technical observation to revise the system, the utilization of the component and inquiries for its improvement were also noted down. This input was then developed to help organize the community for the subsequent maintenance ability.

(3) Advanced Monitoring and Evaluation

Carried out after the physical part of the project was done and the local community was able to maintain the system. This phase focused on the inquiries from the local people with similar needs.

2.5.1.3. Adaptability and Maintenance

In the beginning of the development of the technology in the rural community, the entrance to the community should be properly studied. The stages of the development deeply concerned the broad local aspect. The plan and approaches must attract the local people to utilize the component being developed. The social acceptability of the introduction of the technology should be geared to fill the needs of the community. In the early stages of utilization of the component problem of maintenance, including costs was expected from the project. Through positive participation, the responsibility of the local community will be encouraged. The technique used should be capable of being understood by the local community. Pro - portionately within the social strategy will be generated the adaptability and responsibility of the local community.

2.5.2. South Sulawesi

2.5.2.1. Monitor and Evaluation Method

For en effective monitoring of the construction of the ferrocement components and their benefit to the people, there must

regular reports from the users in the village. This was done monthly through the Field Service Students. RATC also through the supervision of the Field Service Students and the conti - nuation of the ferrocement constructions in Tonrokassi in Je- neponto District, was able to supervise the evaluation of the results of the components already in use. People also report- ed indirectly by means of their request to construct new fer- rocement components after seeing and observing the previous models.

2.5.2.2. Adaptability and Maintenance

- The reception of the people regarding the use of the ferro- cement components such as water tank, mosque dome and other components related to agriculture was satisfactory. This was signified by the increasing requests both from the vil- lage people and government agencies in the area for lecture and demonstration of the method of construction and use of the ferrocement components.
- There was a sufficient number of vocational graduates as well as bricklayers and welders who were willing to be in - volved and participate whenever there was a ferrocement con- struction.
- Manpower from BUTSI, Bangdes and Transmigration and Field Service Students who will work in the village wished to be trained as caders.

### 2.5.3. A c e h

#### 2.5.3.1. Monitoring System and Evaluation

The method of observation and supervision was by means of contacts with the local village leaders at definite intervals. After each project was finished and before being used by the local people, certain specified persons were given instructions as to its use and maintenance. They also gave reports on the extent of use of the ferrocement components in accordance with its intended function. People who came to Banda Aceh were also requested to drop by the office of the Center of Ferrocement Technology at Darussalam, especially those who took the training course. The team leader was also expected to go and check at definite times if the project was running as it should. Students who went home to their village were asked for information on their return to Darussalam, as well as the students on Field Service assigned to the sites where there were ferrocement projects.

In summary, monitoring was carried out by:

1. Direct check-up in the site
2. Reports from villagers
3. Reports from the local trainees
4. Reports from students who visited their village
5. Reports from students on Field Service
6. Reports from local leaders.

From the reports obtained, an evaluation of the benefits of the project to the people was done. The use and development of the project by the people indicated a positive evaluation. In 1979 the ferrocement projects in the villages of Lhueng Bata and Darussalam were inspected by a team from USAID and government officials from the Subdistrict of Aceh, wherein the team expressed satisfaction at the results. Toward the end of December, 1980, Prof. Harsono Wirjosumarto from DTC-ITB and Mr. Moh. Arsyad from the agency of Cooperation between the Institutes of Higher Learning and the Dept. of Education and Culture in Jakarta came to observe in Aceh. The results of the observation signified a positive direction in the progress of the development of ferrocement technology.

2.5.3.2. Adaptability and Maintenance

In the early stages of the introduction of ferrocement, the local community, as yet not convinced of its serviceability, was reluctant to accept it. However, several incidents occurring during the field demonstration led to its acceptance.

(1) A ferrocement water tank was constructed in the laboratory of the Engineering Faculty at Darussalam by the students and the laboratory staff. It had no conventional steel framework and the walls were springy after plastering and before the curing period. While lifting the tank which was one-third full of water, up to a platform 3 meters high, the cable of the crane broke.

The tank suffered slight damage (cracks) which was easily repaired with no subsequent leakage.

(2) The strength and workability of the ferrocement canoe was also in question. During its construction and training of local manpower, not all participated whole-heartedly. Some were even critical. On the day of launching a traditional ceremony attended by prominent leaders of the community was held. The local people were curious to see whether the canoe would float. Many men helped launch the canoe which was built 100 m from the shore. The canoe did float and at the precise designated water level.

(3) In Tapak Tuan another incident occurred during the construction of the water tank for use in the purification rite. Several youth who still doubted the strength of ferrocement decided to test it during the night, repeatedly striking and jumping on top of the tank which was just cured. The tank survived the test and the next morning the youth admitted to the team leader the durability of the ferrocement construction.

Thus the acceptance of the ferrocement was assured, further evidenced by the different requests from the people. Below is a list which gives the areas with their respective requests:

- Singkil, construction of mosque dome, 8 meter in diameter
- Labuhan Haji, construction of mosque dome, diameter 7 m.

- Bakongan, construction of mosque dome, diameter 6 m.
- Silolo Terbangan, construction of mosque dome, diameter 8 meter.
- Bandar Baru, construction of mosque dome, diameter 20 m.
- Tungkop, construction of mosque dome, diameter 8 m.
- Padang Mamplam, construction of mosque dome, diameter 8 m.
- Banda Aceh, low-cost housing, type 62 sq.m.
- Tapak Tuan, residential house, type 70 sq.m.
- Tapak Tuan, construction of a store.
- Banda Aceh, construction of a reservoir, capacity 10,000 liters.
- Banda Aceh, construction of fishing boat 20 m. long (owned by PT. Pantja Niaga)
- Meulaboh, construction of an irrigation distribution box and tertiary and quarternary canals, aided by PDP - USAID.
- Banda Aceh, construction of fishing boat, Bureau of Fishery.
- Sinabang, construction of a mosque dome, diameter 10 m.
- Sinabang, construction of residential houses.

However the belief that fish are afraid of cement still persisted, requiring more intensive education on the part of the people.

The problem of maintenance, including the costs, was turned over to the community leader or the mosque committee. Several local people already participated in the training course for the ferrocement repairs. Although the cost of maintenance was to be the responsibility of the local people, aid from USAID through the management of ITB was still expected.

# 3.0 FERROCEMENT COMPONENT

## 3.1. WEST JAVA

The sites which serve as centers of activities for the develop - ment of ferrocement technology can be located on the map of West Java area (Figure 29).

### 3.1.1. Component Specification

Ferrocement components which had been designed and constructed at the sites its locations, dimension and bill of materials can be summarized as follows:

(1) Component : Ferrocement Pontoon Ferry (Figure 3)

Location : River of Cikarang Village of Cikarang Dis - trict of Sukabumi

Purposes : Ferry for crossing the river

Dimension : - Three ferrocement open half cylinder
thickness 2.5 cm
105 cm depth
130 cm diameter
6,5 m long
- Connected with steel beam
- Wooden deck floor 6 x 6 m area
- Operated by strong cable wire utilizing the river current

Capacity : Maximum load 11 ton
allowable carrying load 8 tons for a single trip

Construction Steps:

The whole construction of the pontoon was divided into three steps.

Step 1 : <u>Construction of ferrocement Cylinder</u>

(a) construction of framework

(b) reinforcement of the cylinder

(c) plastering of the shell, two steps

(d) side frame construction

(e) finishing and coating

Step 2 : <u>Deck floor assembly</u>

(a) steel beam arrangement

(b) wooden floor arrangement

(c) construction of boarding and landing gate

(d) pontoon fence

(e) finishing

Step 3 : <u>Construction of operation system</u>

(a) arrangement of gate mechanism

(b) arrangement of operation mechanism

(c) trial run

Construction period: 6 months effective

Personnel : 1 supervisor

2 technicians

6 local workers

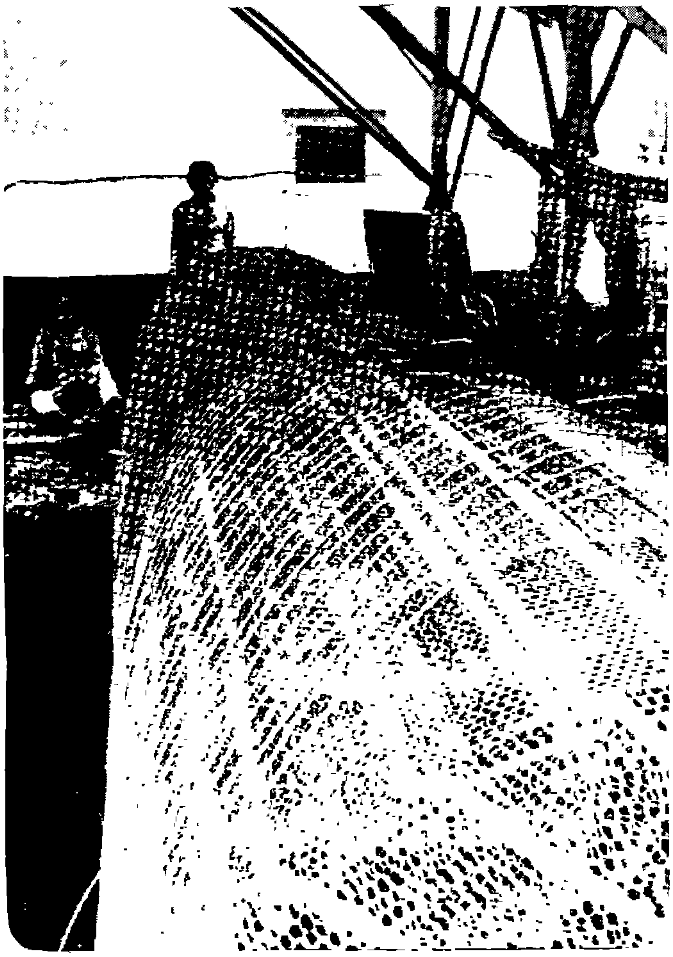


Fig. 1 Reinforcement of Pontoon Cylinder

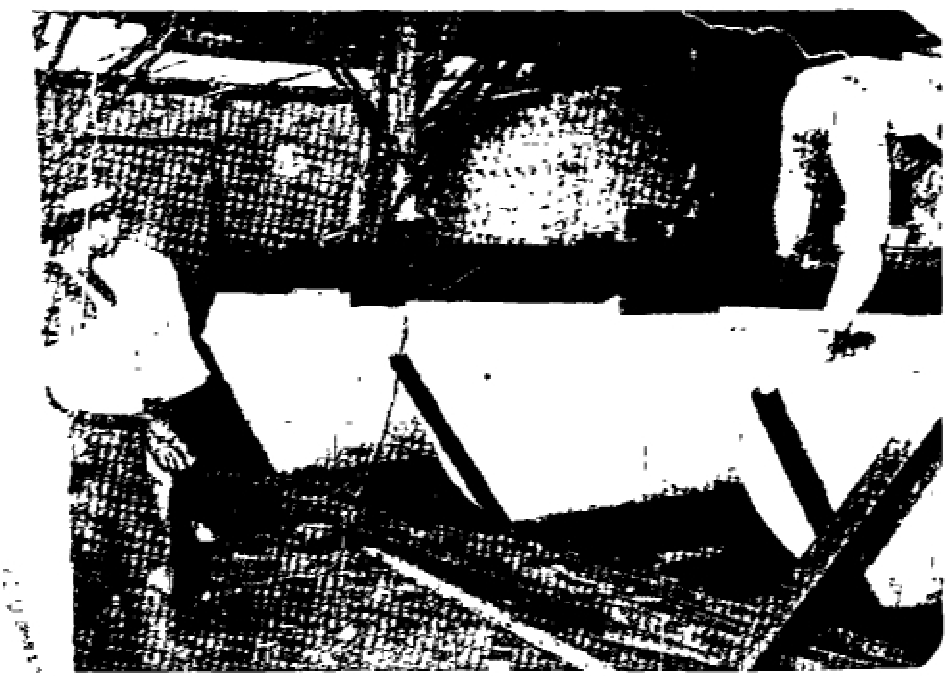


Fig. 2 Pontoon ferry cylinder after curing and steel beam arrangement

Bill of Material :

A. Cylinder

| | | Amount |
|---|---|---|
| 1. | Chicken wire | 12 rolls |
| 2. | Wire Ø 3 mm | 5 rolls |
| 3. | Iron rod Ø 12 mm | 9 pieces |
| 4. | Iron rod Ø 14 mm | 30 pieces |
| 5. | Cement (PC) | 40 bags |
| 6. | Fine sand | 3 m3 |
| 7. | Additive | 15 liters |
| 8. | Angle steel 75.75 . 70 mm | 18 pieces |
| 9. | Channel C 8 . 12 | 3 pieces |
| 10. | Bolt 3/8" x 15 cm/10 cm | 200 pieces |
| 11. | Ring 3/8" | 450 pieces |
| 12. | Bolt 1/2" | 50 pieces |
| 13. | Ring plate 1/2" | 50 plates |
| 14. | Tie wire | 10 kgs |

B. Frame and Formwork

| | | |
|---|---|---|
| 1. | Iron rod Ø 10 mm | 12 pieces |
| | Iron rod Ø 12 mm | 12 pieces |
| | Iron rod Ø 6 mm | 28 pieces |
| 2. | PVC Pipe Ø 1/2" | 90 pieces |
| 3. | Pipe (GI) 1/2" | 30 pieces |
| 4. | Electrode Ø 2.6 m | 5 kgs |
| | Electrode Ø 5 m | 5 kgs |
| 5. | Tie Wire | 5 kgs |

| | | Amount | |
|---|---|---|---|
| 6. | Wood Plank 20 x 200 x 2.5 | 20 | pieces |
| 7. | Nail 2" | 2 | kgs |
| 8. | Wood plank 5 x 12 x 400 | 12 | pieces |
| 9. | Nail 1" | 2 | kgs |
| 10. | Thread | 1 | roll |
| 11. | Plastic hose | 5 | meters |
| 12. | Plumb | 1 | piece |

C. Floor and Gate

| | | | |
|---|---|---|---|
| 1. | Channel C 12 cm | 28 | pieces |
| | Channel C 8 cm | 4 | pieces |
| 2. | Steel angle 7.7 . 07 | 4 | pieces |
| 3. | Steel plate 01 x 10 x 6 | 1 | plate |
| 4. | Steel plate 5 x 50 x 6 | 6 | plate |
| 5. | Massive steel rod Ø 5 cm | 1 | piece |
| 6. | Steel plate 1.5 x 25 x 2 m | 1 | plate |
| 7. | Hinges Ø 15 cm | 4 | pieces |
| 8. | Pipe (GI) Ø 4" | 2 | pieces |
| 9. | Pipe (GI) Ø 5" | 2 | meters |
| 10. | Steel plate 1 x 25 x 2 m | 1 | plate |
| 11. | Bolt | 4 | pieces |
| 12. | Wrench 3/4" | 12 | pieces |
| 13. | Sling 1/2" | 28 | meters |
| 14. | Bolt 3/4" x 4 cm | 400 | pieces |
| 15. | Bolt 3/4" | 800 | pieces |
| 16. | Bolt 1/2" x 6 cm | 300 | pieces |

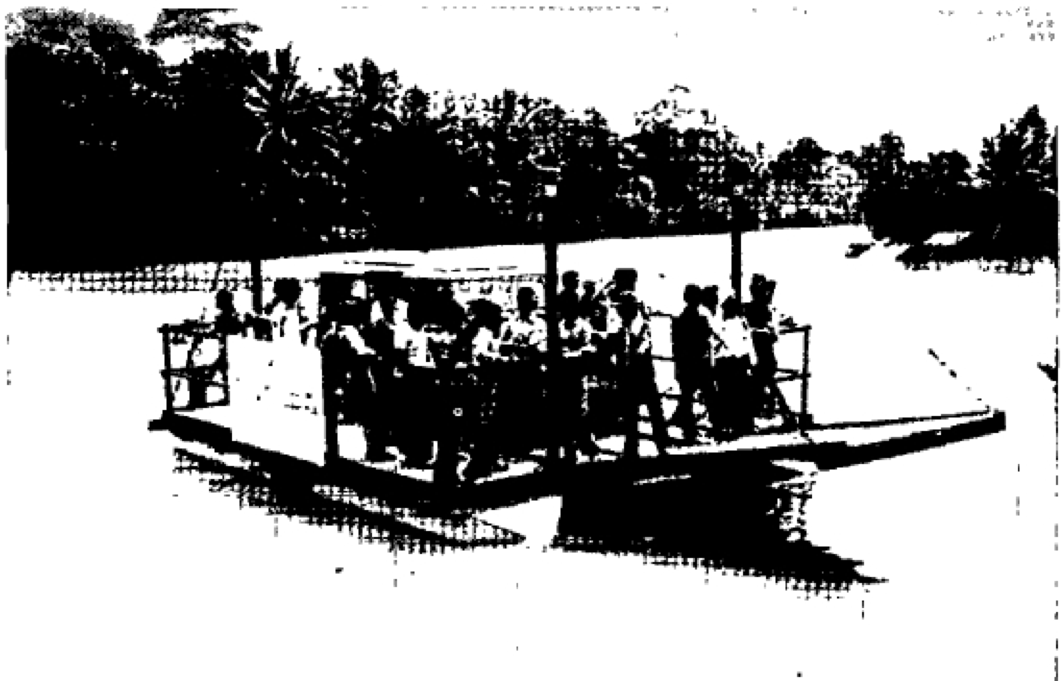
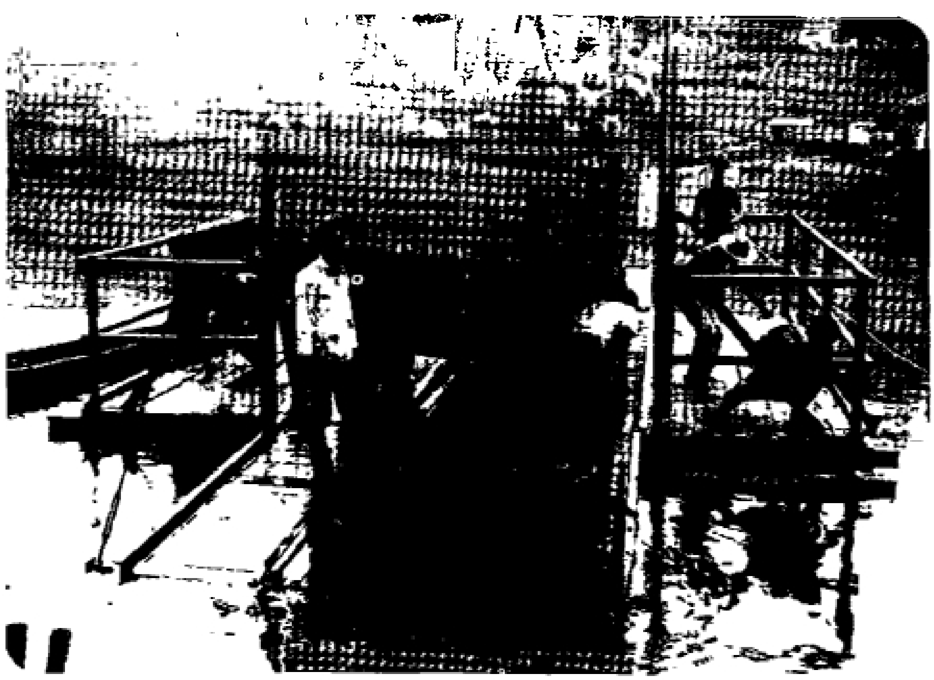


Fig. 3 & 4  Ferrocement Pontoon ferry in operation



| | | Amount |
|---|---|---|
| 17. | Bolt 3/8" x 10 cm | 300 pieces |
| 18. | Ring 1/2" | 600 pieces |
| 19. | Ring 3/8" | 600 pieces |
| 20. | Steel plate 0.5 x 10 x 2 m | 1 plate |
| 21. | Steel rod Ø 20 mm | 1 meter |

D. Fences

| | | |
|---|---|---|
| 1. | Steel angle 5.5 . 05 | 4 pieces |
| | Steel angle 7.7 . 07 | 4 pieces |
| 2. | Bolt 1/2" x 5 cm | 100 pieces |
| 3. | Steel angle 7.7 . 07 | 2 pieces |

E. Deck Floor

| | | |
|---|---|---|
| 1. | Hard Wood 25 x 3 x 6 | 2.5 m3 |
| 2. | Steel angle 5.5 . 05 | 2 plates |

F. Finishing

| | | |
|---|---|---|
| 1. | Primer (Steel) | 40 liters |
| 2. | Primer (Wood) | 20 liters |
| 3. | Enamel blue marine paint | 2 gallons |
| 4. | Enamel red marine paint | 1 gallon |
| 5. | Build grey (primer) | 4 gallons |
| 6. | Anti-fouling tropic paint | 3 gallons |
| 7. | Sand paper | 75 sheets |

(2) Component : Ferrobamboo cement curved bridge (Figure 7)

(Ferro-bamboo-cement)

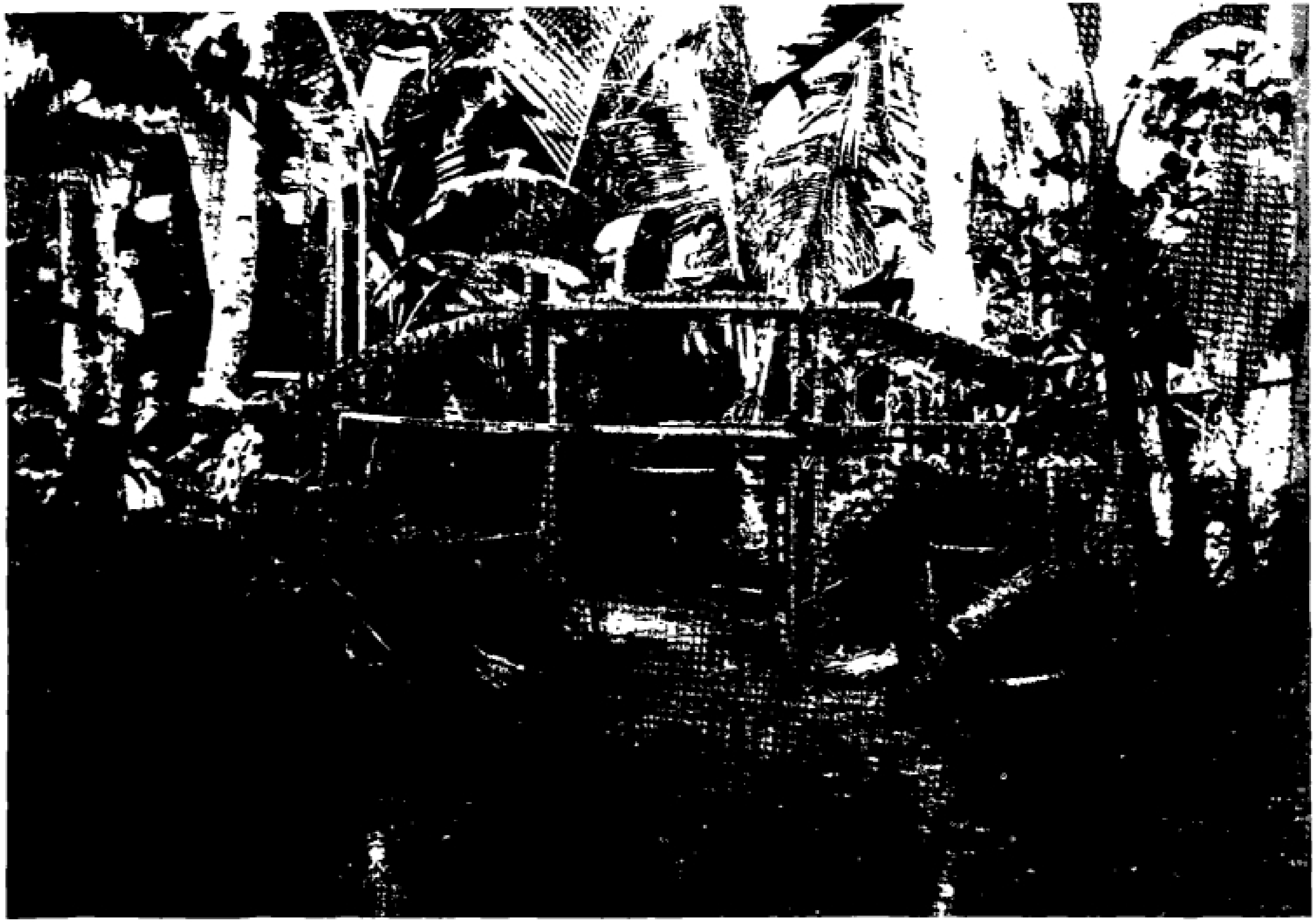


Fig. 5 Reinforcement of ferromboo curved bridge

Location : Kampung Cimanggu, Village of Buniwangi

Purpose : - Foot bridge to cross a small stream to replace the traditional coconut trunk bridge;

- Curved upward so that it is not flushed away in a heavy flood from upland

Dimension : - Span 7.8 m

- Width 1.5 m

- Curved upward at mid section 1.25 m

Main structure:

Bamboo strip mat, combined with wire and steel reinforcement plaster with cement mortar

Load carrying capacity:

- maximum load 300 kg per sq m
- allowable load 200 kg per sq m

Construction procedures:

(a) Construction of stone-laid foundation (the stones were available from the site)

(b) Bamboo mat weaving. The bamboo strip 2 cm wide woven along the span

(c) Construction of longitudinal frame made with steel rod frame

(d) Wire mesh reinforcement

(e) Upper plastering

(f) Curing upper part

(g) Plastering lower part

(h) C u r i n g

Construction time: 12 days

Personnel : 1 supervisor
2 technicians
4 workers

Bill of Materials:

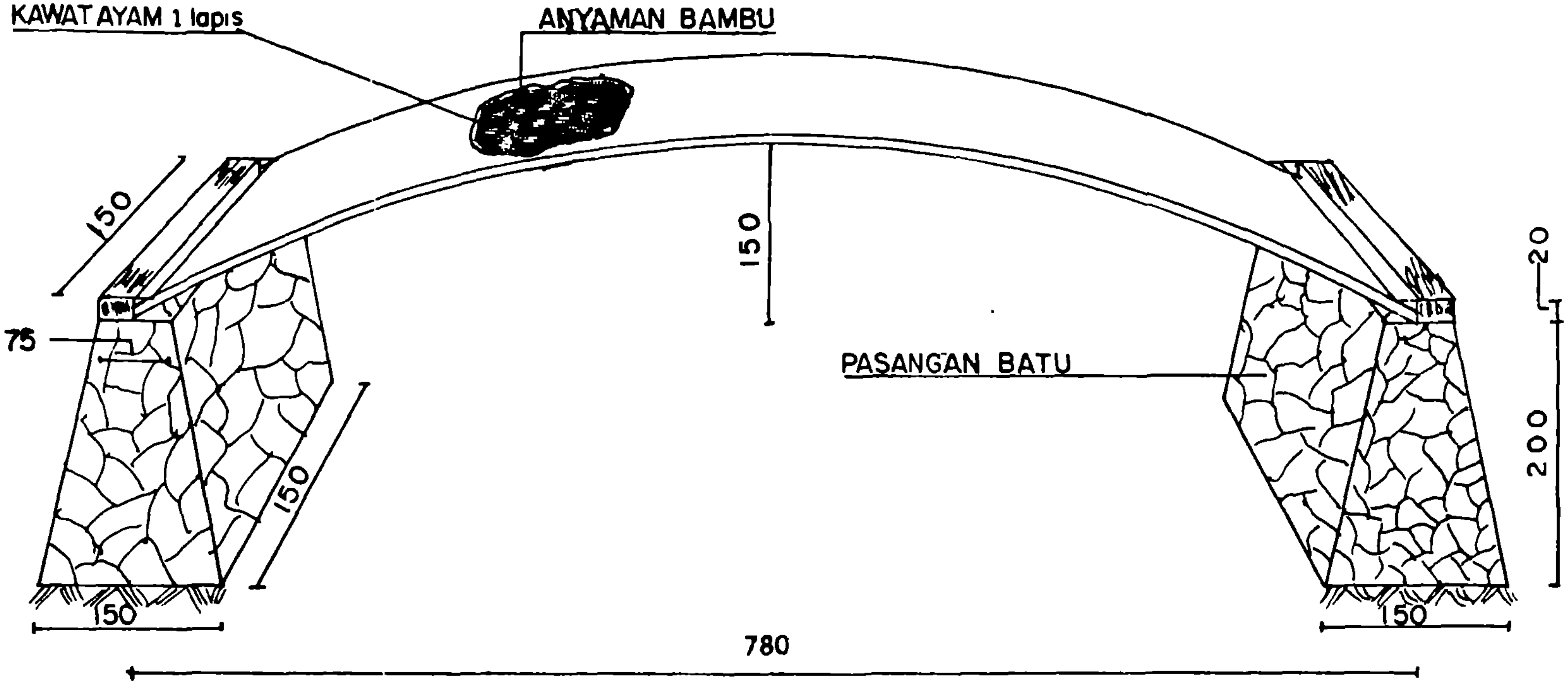
A. Foundation and bridge

| | Amount | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Chicken wire | 57 rolls | 700 | 39,900 |
| 2. Iron rod Ø 318" | 4 pieces | 1800 | 7,200 |
| 3. Iron rod Ø 1/4" | 8 pieces | 1200 | 9,600 |
| 4. Tie Wire | 3 kgs | 600 | 1,800 |
| 5. Cement | 18 bags | 2000 | 36,000 |
| 6. Sand | 4 m3 | 3000 | 12,000 |
| 7. Gravel | 0.5 m3 | 5500 | 2,750 |
| 8. Bamboo | 18 pieces | 500 | 9,000 |
| 9. Stones | 3 m3 | 4500 | 13,500 |
| | | Total | 131,750 |

B. Formwork and Scaffolding

| | | | |
|---|---|---|---|
| 1. Bamboo mat 2x3 m | 4 pieces | 850 | 3,400 |
| 2. Wood 5/7 x 3 m | 10 pieces | 750 | 7,500 |
| 3. Nail 2" | 2 kgs | 600 | 1,200 |
| 4. Gunny sack | 10 pieces | 300 | 3,000 |
| | | Total | 15,100 |

# JEMBATAN LENGKUNG FERROMBU




KETERANGAN

UKURAN DALAM CM
TEBAL 2CM

Fig. 6 Ferromboo curved foot bridge

GOES'T

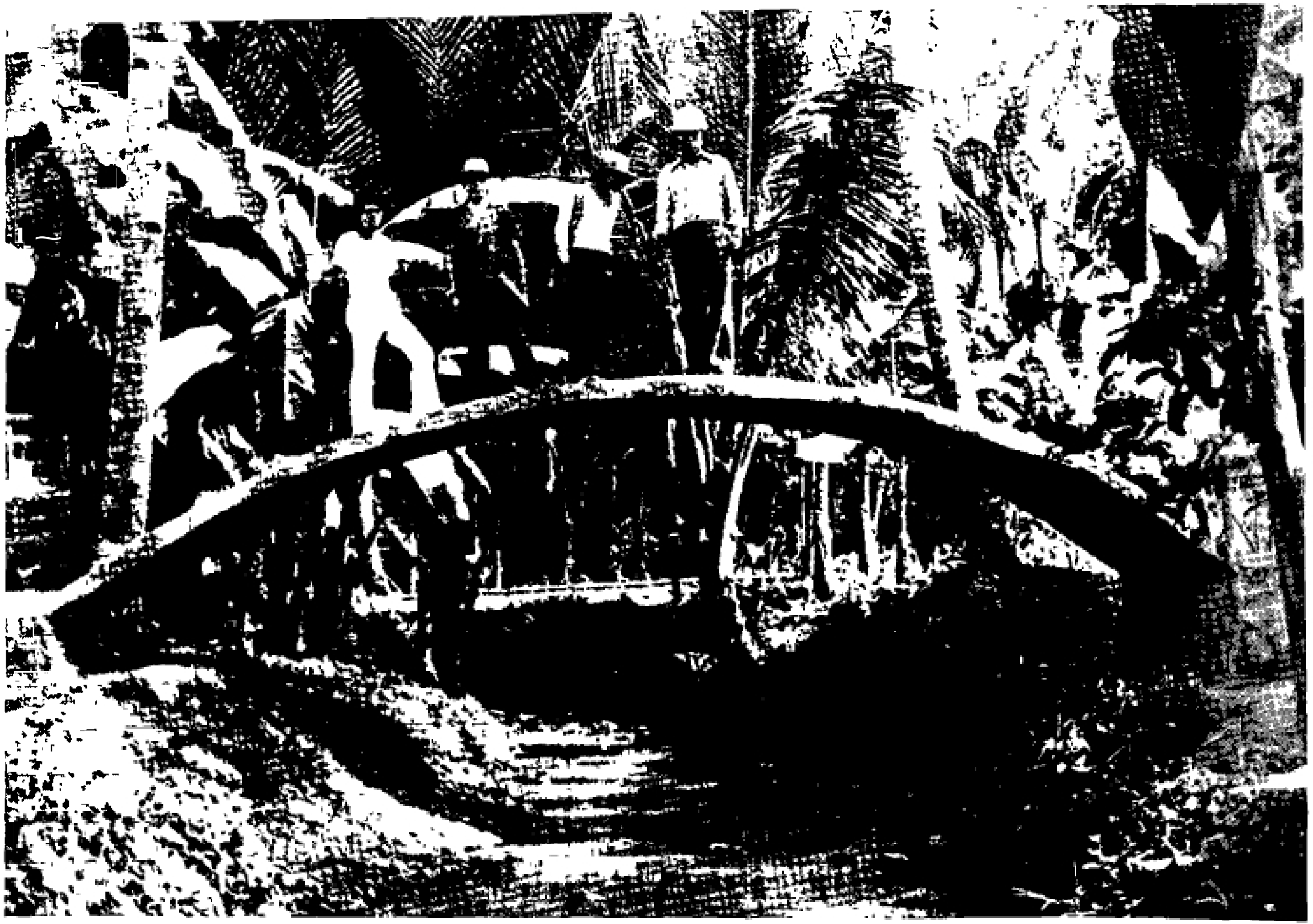


Fig. 7 (Ferrombo) of bridge: Bamboo reinforced combined with chicken wire span 7.8 m: 1.5 m width: curved shape prevents damage from flood.

| Manpower | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Foreman | 1/12 | 2.000 | 24,000 |
| 2. Worker | 2/12 | 1.500 | 36,000 |
| 3. Assistant Worker | 2/12 | 750 | 18,000 |
| | | | 78,000 |

(3) Component : Ferrocement water distribution box (Figure 8)

Location : Kampung Cimanggu, Village of Buniwangi

Purpose : Water diversion open box

Dimension : 2 m long

1 m wide

1 m high

1.5 m thick

Construction procedures:

(a) Reinforcement placing

(b) Plastering

(c) Curing

Construction time: 5 days

Personnel : 1 worker

2 assistant workers

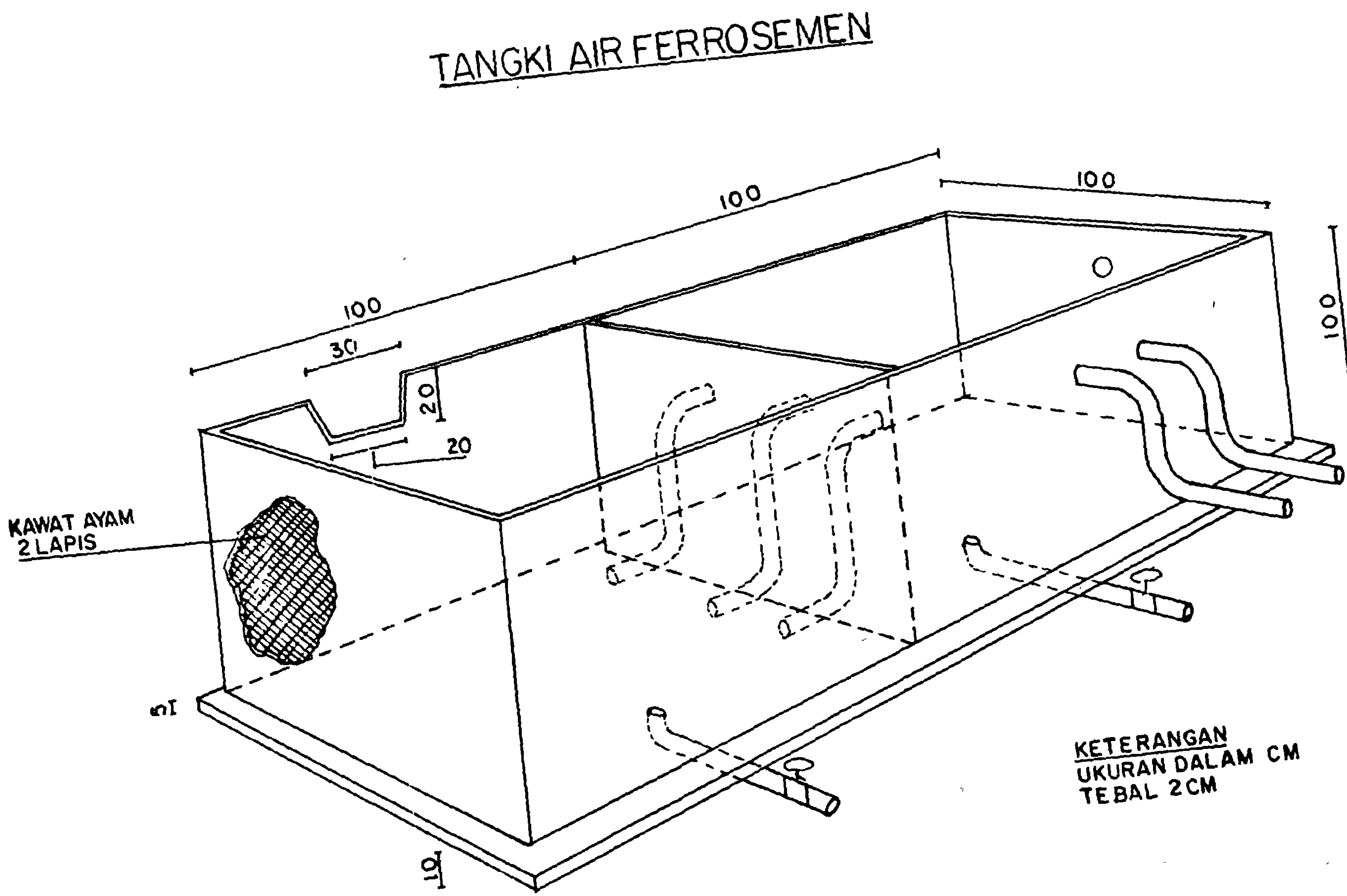





Fig. 8 Water distribution box.

Bill of materials:

A. Wall & Foundation

| | Amount | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Chicken wire | 12 m | 700 | 8,000 |
| 2. Wire Ø 3 mm | 15 kgs | 700 | 10,500 |
| 3. Tie Wire | 1/2 kg | 600 | 300 |
| 4. Cement | 4 bags | 2000 | 8,000 |
| 5. Sand | 1 m3 | 3000 | 3,000 |
| 6. Gravel | 0,25 m3 | 5500 | 1,375 |
| | Total A | | 31,175 |

b. Supporting materials

| | | | |
|---|---|---|---|
| 1. Triplex 0.3 cm | 2 sheets | 2600 | 7,800 |
| 2. Wood 5/7 x 3 m | 3 pieces | 750 | 2,250 |
| 3. Nail 2" | 1 kg | 600 | 600 |
| 4. Plastic sheet | 3 ms | 300 | 600 |
| | Total B | | 11,250 |

(4) Component : Bamboo cement water tank (Figure 9)

Location : Kampung Cimanggu, Village of Buniwangi

Purposes : Water storage, facilities for moslem prayers

Dimension : Cylinder type

1.2 m height

1.3 m diameter

3 cm thickness

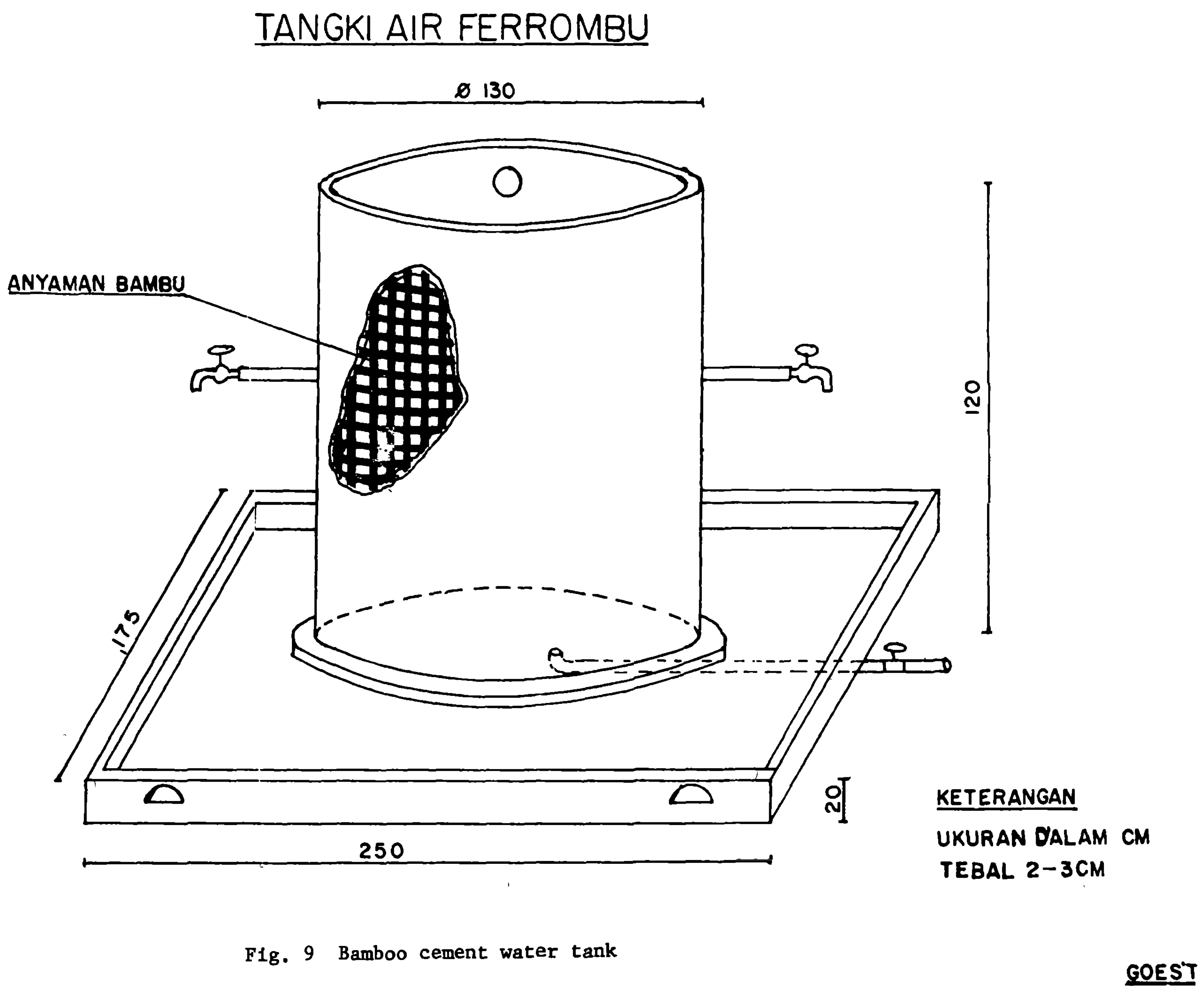



Fig. 9 Bamboo cement water tank

Fig. 10  Bamboo cement water tank, after 20 months

Construction procedures:

(a) Bamboo strip weaving

(b) Bamboo strip reinforcement

(c) Plastering

(d) Curing

Construction time : 4 days

Personnel : Man/days

| | | |
|---|---|---|
| 1 | worker | Rp. 6.000,-- |
| 2 | assistant workers | Rp. 6.000,-- |
| | | Rp. 12.000,-- |

Bill of Materials:

| A. Wall materials | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Bamboo | 6 pieces | 500 | 3,000 |
| 2. Cement | 4 bags | 2000 | 8,000 |
| 3. Sand | 1 m3 | 3000 | 3,000 |
| 4. Gravel | 0,25 m3 | 5500 | 1,375 |
| | | | 15,375 |
| B. Supporting materials | | | |
| 1. Bamboo mat | 1 sheet | 850 | 850 |
| 2. Ijuk Rope | 30 m | 25 | 750 |
| 3. Plastic sheet | 3 m | 200 | 600 |
| | | | 2,200 |

C. Extra materials

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Pipe (GI) Ø 12 | 2 m | 1000 | 2,000 |
| 2. Faucet (tap) | 4 pieces | 1500 | 6,000 |
| | | | 8,000 |

(5) Component : Ferrocement tank, box types (Figure 11)

Location : Kampung Cimanggu, Village of Buniwangi

Purpose : To store the water from the distribution box

Dimension : 2 m length

1 m width

1 m height

Construction procedures:

(a) Foundation and wall reinforcement

(b) Plastering

(c) Curing

Construction time : 7 days

Personnel : 2 workers

3 assistant workers

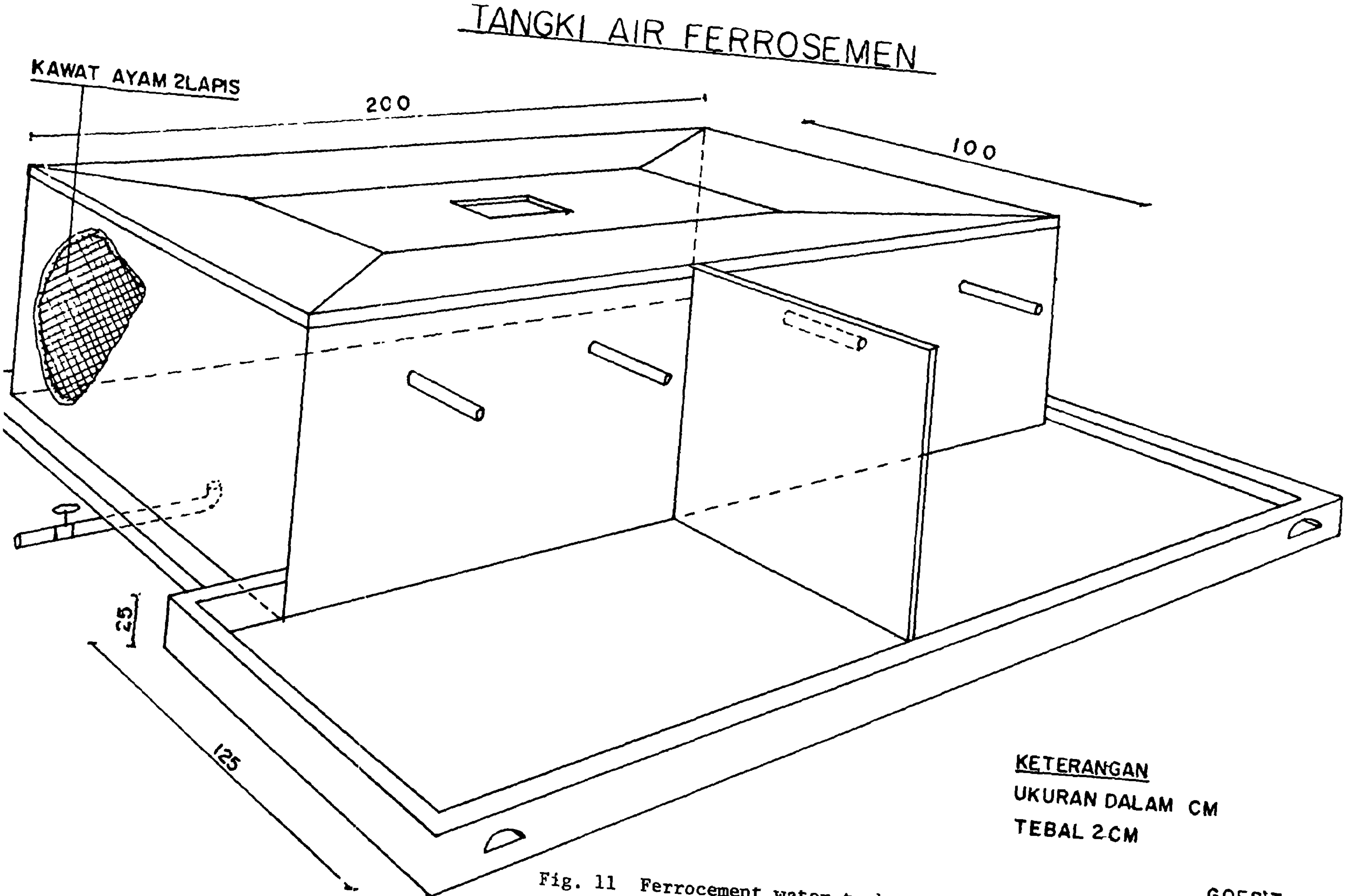



Fig. 11 Ferrocement water tank

Bill of Materials :

A. Wall & Foundation

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Wire | 10 kgs | 700 | 7,000 |
| 2. Brick | 200 pieces | 25 | 5,000 |
| 3. Cement | 8 bags | 2000 | 16,000 |
| 4. Sand | 1.5 m3 | 3000 | 4,500 |
| 5 Chicken wire | 14 m | 700 | 9,800 |
| | Total A | | 42,300 |

B. Extra materials

| | | | |
|---|---|---|---|
| 1. PVC pipe Ø 1" | 1 m | 450 | 450 |
| 2. PVC pipe Ø 2" | 0.5 m | 600 | 300 |
| 3. Wood 5/7 x 3 m | 3 pieces | 750 | 2,250 |
| | Total B | | 3,000 |

(6) Component : Ferrocement ditch lining (Figure 12)

Location : Kampung Cimanggu, Village of Buniwangi

Purpose/function: To protect the water from the source from direct contamination from the earth

Dimension : Trapezoid shape

20 cm height

40 cm width at the top opening

25 cm bottom width

2.0 m length

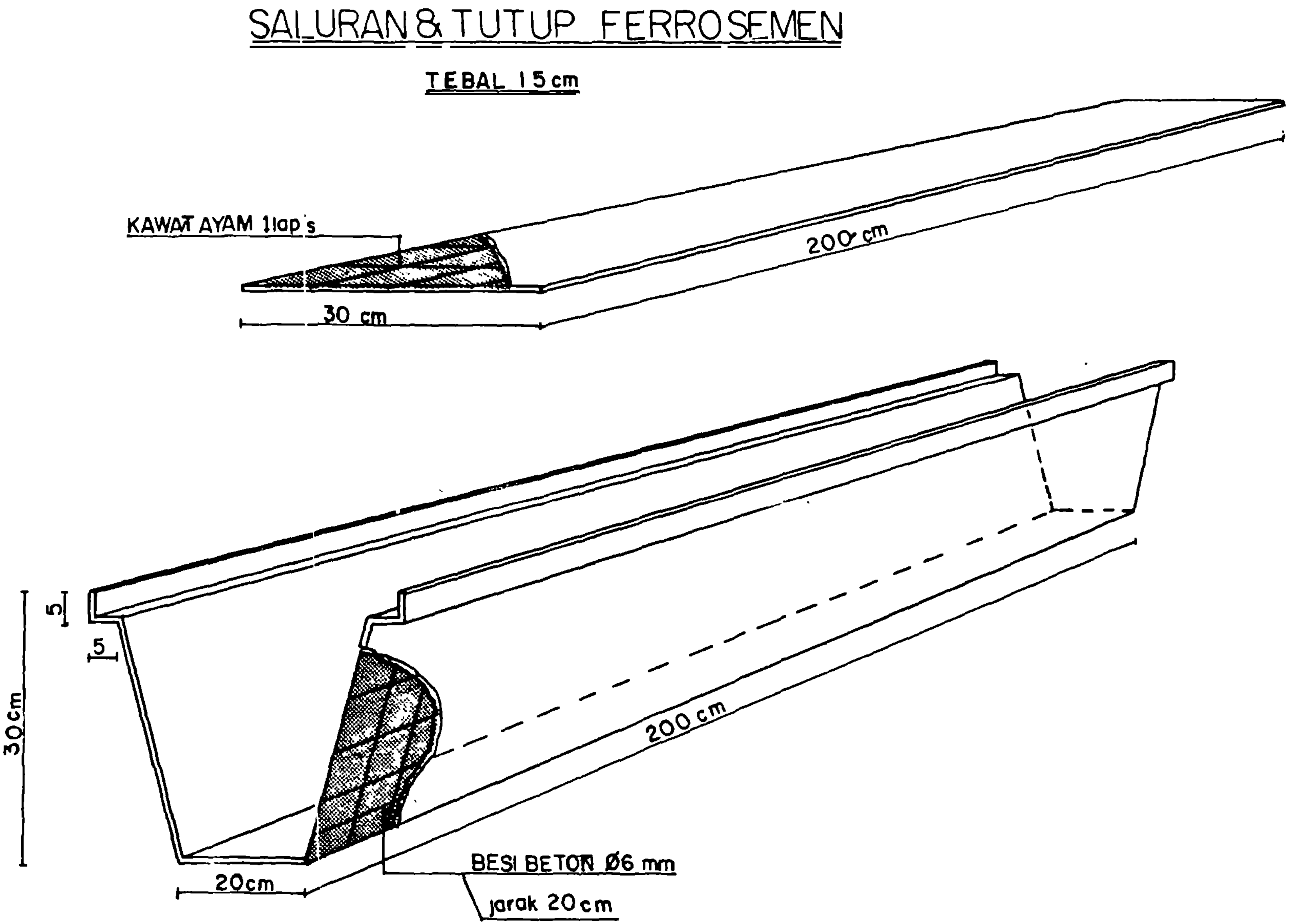



Fig. 12 Ferrocement ditch lining

GOES'T

Construction procedures:

(a) Reinforcement on the mold

(b) Plastering

(c) Curing

Construction time: 4 hours

Personnel : 1 worker

2 assistant workers

Rp. 1.200,--

Bill of Materials:

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Chicken wire | 2 m | 700 | 1,400 |
| 2. Wire | 2 kgs | 700 | 1,400 |
| 3. Tie wire | 1.2 oz | 60 | 30 |
| 4. Cement | 12 kgs | 50 | 600 |
| 5. Sand | 0.1 m3 | 3000 | 300 |
| | | | 3,730 |

(7) Component : Ferrocement channel (Figure 13)

Location : Cisalada, Village of Buniwangi

Purpose/ : Channel lining, transport water

Dimension : Half cylinder

covered top

30 cm diameter

2.2 m long

2 cm thick

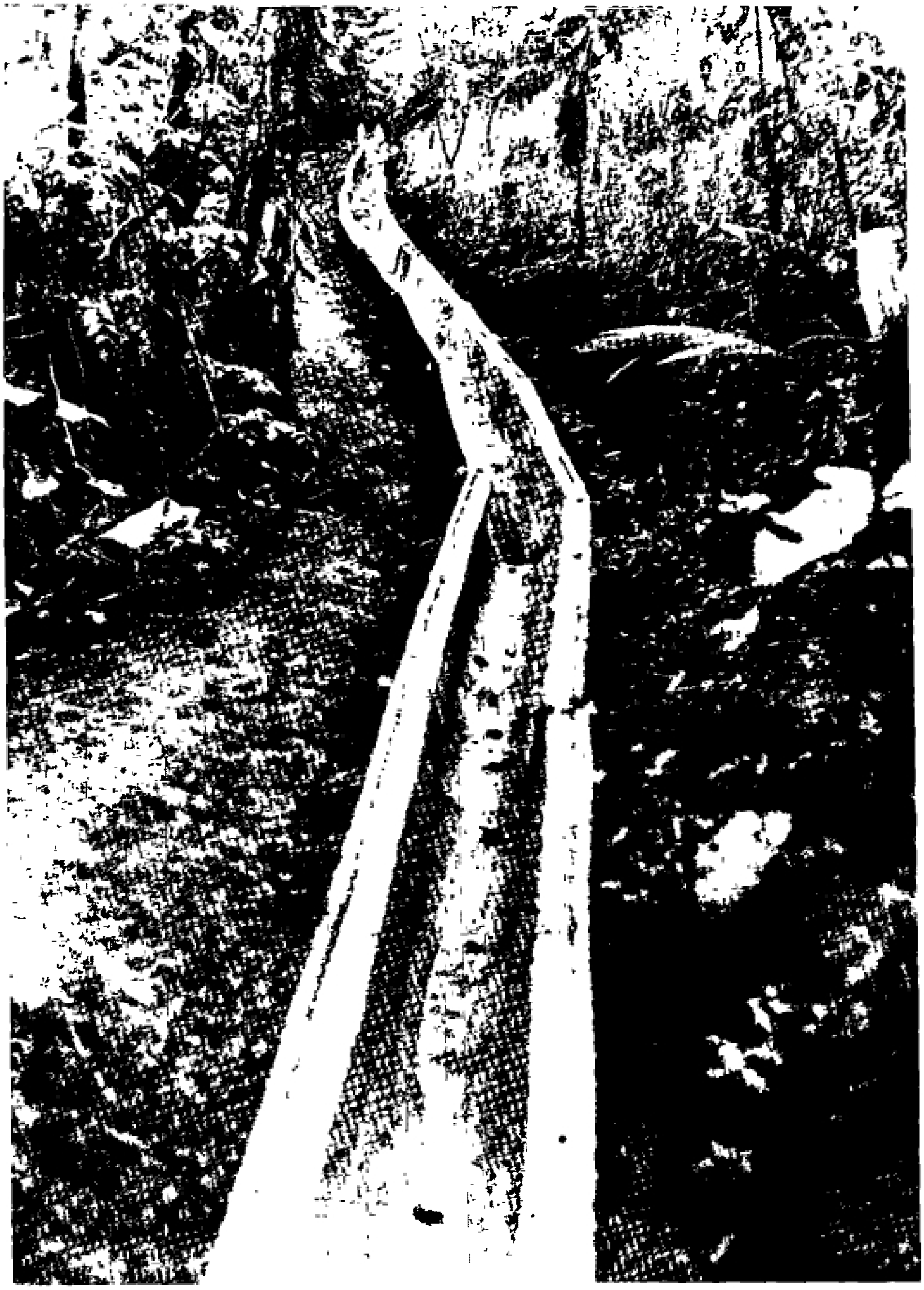


Fig. 13 Ferrocement channel in line as distribution system

Construction procedures:

(a) Reinforcement on the mold

(b) Plastering

(c) Curing

Construction time: 4 hours

Personnel : 1 worker

2 assistants

Bill of Materials:

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Chicken wire | 2.5 m | 700 | 1,750 |
| 2. G.I. wire | 2 kgs | 700 | 1,400 |
| 3. Tie Wire | 1/2 oz | 60 | 30 |
| 4. Cement | 12.5 kgs | 50 | 625 |
| 5. Sand | 0.1 m3 | 3000 | 300 |
| 6. Mould | - | - | 172 |
| | | | 4,272 |

(8) Component : Fibrecement pipe (Figure 16)

Location : Kampung Babakan, Village of Buniwangi,
Kampung Ciawun, Village of Citarik

Function : Water transportation

Diameter : Ø 4" to 6" diameter pipe
2.0 m length

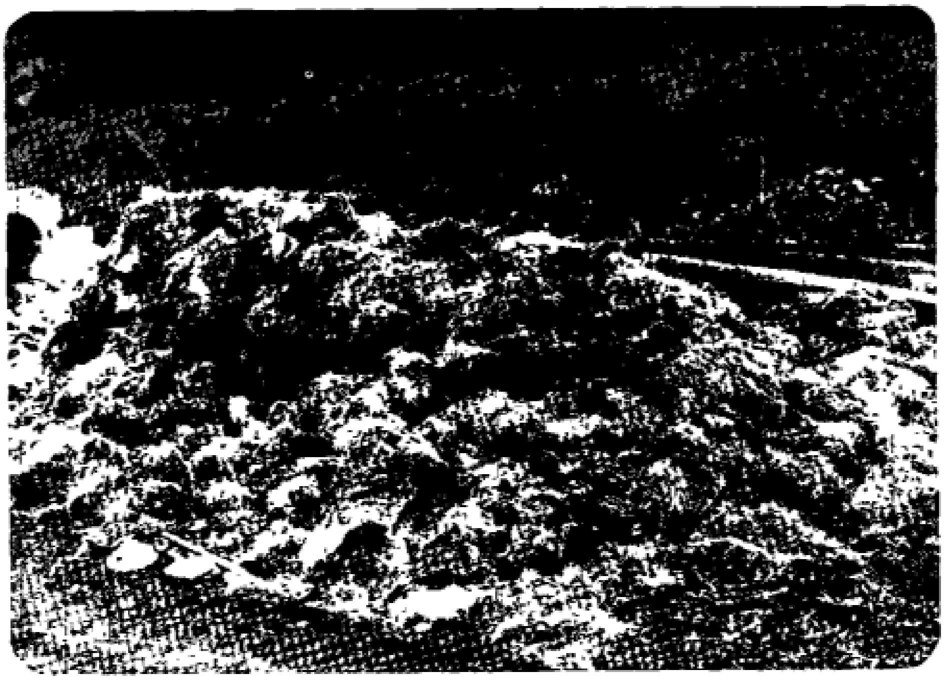


Fig. 14 Local available organic fiber

Fig. 15 Fibercement pipe manufacturing

Construction procedure: (see manual)

(a) Fibercement mortar mix

(b) Lay mortar sheet on the mold bench

(c) Casting with pipe mold

(d) One day curing

(e) Remolding

(f) One week curing

Construction time : 50 minutes

Bill of Materials :

| A. Pipe materials | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Cement | 7 kgs | 50 | 350 |
| 2. Sand | 0.01 m3 | 3000 | 30 |
| 3. Fibers | 0.2 kgs | 150 | 30 |
| | | | 410 |
| B. Pipe mould | | | |
| 1. PVC Pipe Ø 4" | 2 ms | 1500 | 3,000 |
| 2. Wood strip 4 m | 2 pieces | 400 | 800 |
| | | | 3,800 |

Assumed to be used 50 times $\frac{3,800}{50}$ = Rp. 76,--

Personnel : 1 worker

2 assistants

Rp. 350,-- per pipe

Fig. 16 Fibercement pipe after curing

Fig. 17 Fibercement pipe used in rural water supply, Ciawun

(9) Component : Water tank 5000 liters (Figure 18)

Location : Kampung Babakan, Kampung Citapen

Village of Buniwangi

Purpose : Water storage

Diameter : Elliptical shape

Diameter -- 2,2 m

Height -- 1,4 m

Covered top

Construction procedure:

(a) Frame arrangement

(b) Construction of foundation

(c) Wall formwork

(d) Reinforcement

(e) Plastering

(f) Curing

Construction time : 7 days

Bill of Materials:

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| A. 1. Chicken wire | 18 ms | 700 | 12,600 |
| 2. G.I. wire | 40 kgs | 700 | 28,000 |
| 3. Sand | 2 m3 | 300 | 6,000 |
| 4. Cement | 12 zag | 2000 | 24,000 |
| 5. Tie wire | 2 kgs | 600 | 1,200 |
| | | Total A | 71,800 |

Fig. 18 Ferrocement and bamboo cement rural water facilities; filter container, water tank and bathing & washing facilities

B. Supporting material

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Plastic sheet | 10 m | 250 | 2,500 |
| 2. Mould | - | - | 5,000 |
| | | | 7,500 |

Personnel :

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1 Worker | 7 days | 2000 | 14,000 |
| 2 Assistant Workers | 7 days | 1500 | 10,500 |
| | | | 24,500 |

(10) Component : Water tank 7500 liters

Location : Babakan Jayanti, Village of Citarik

Purpose/function : Water storage, prior to distribution

Dimension : Cylinder shape

Diameter 1.8 m

Height 2 m

Cover on top

Construction procedures:

(a) Frame arrangement

(b) Construction of foundation

(c) Wall formwork

(d) Reinforcement

(e) Plastering

(f) Curing

Construction time : 10 days

Bill of Materials :

A. Foundation

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Iron rod Ø 8 mm | 8 pieces | 1750 | 14,000 |
| 2. Sand | 1/2 m3 | 3000 | 2,000 |
| 3. Cement | 4 zag | 2000 | 14,000 |
| 4. Gravel | 1/2 m3 | 5000 | 2,500 |
| | Total A | | 26,500 |

B. Wall

| | | | |
|---|---|---|---|
| 1. Chicken wire | 30 m | 700 | 21,000 |
| 2. GI Wire | 50 kgs | 700 | 35,000 |
| 3. Tie wire | 2 kgs | 600 | 1,200 |
| 4. Sand | 3 m3 | 3000 | 9,000 |
| 5. Cement | 10 bags | 2000 | 20,000 |
| 6. Wood 2/20-200 | 34 pieces | 600 | 20,000 |
| | Total B | | 106,200 |

Personnel :

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1 Worker | 10 days | 2000 | 20,000 |
| 2 Assistant workers | 10 days | 1500 | 30,000 |
| | | | 50,000 |

(10) Component : MCK Bamboo Cement (Figure 20)

Location : Kampung Babakan, Kampung Citapen, Village of Buniwangi
Kampung Ciawun, Kampung Cilimus, Babakan Jayanti, Village of Citarik

Purpose/function : Public facility for bathing and washing

Dimension : Curved thin wall of bamboo cement plastered with mortar.
The size is adjusted to the space available in the site.

Construction time : 5 days

Bill of Materials :

A. Foundation and Distribution Box

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Bricks | 20 pieces | 25 | 5,000 |
| 2. Cement | 2 bags | 1000 | 4,000 |
| 3. Sand | 0,47 m3 | 3000 | 2,250 |
| | | | 11,250 |

B. Wall

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Cement | 3 bags | 2000 | 6,000 |
| 2. Sand | 1 m3 | 3000 | 3,000 |
| 3. Bamboo mat | 10 m2 | 250 | 2,500 |
| 4. Fibers | - | - | - |
| | | | 11,500 |

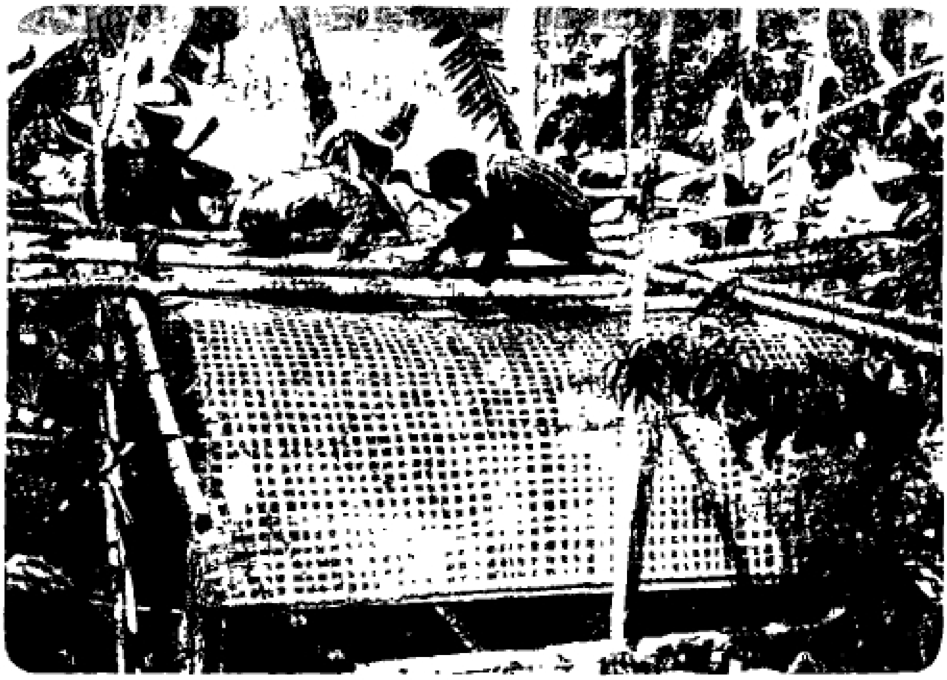
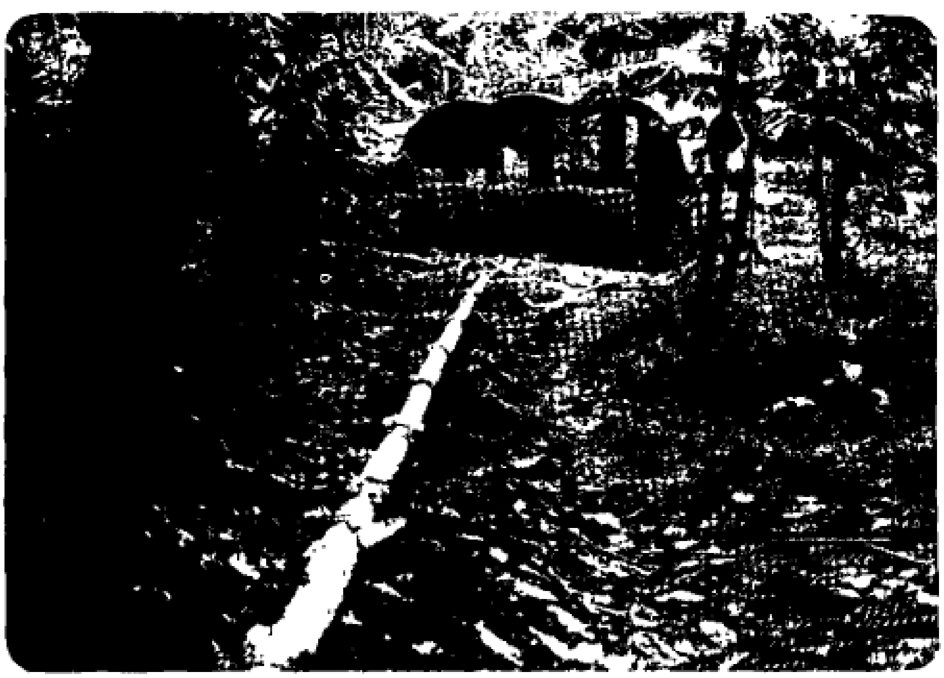


Fig. 19 & 20 Bamboo cement public water facilities



Personnel :

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1 Worker | 5 days | 2000 | 10,000 |
| 2 Assistant workers | 5 days | 1500 | 15,000 |
| | | | 25,000 |

Construction procedures:

(a) Construction of brick layers and foundation

(b) Bamboo mat placing

(c) Plastering

(d) Curing

(12) Component : Septic tank bambo cement

Location : Babakan Jayanti, Village of Citarik

Dimension : 1.5 m3 capacity

0.75 diameter

1.5 m high

Bamboo mat plastered with mortar

Construction procedures:

(a) Bamboo mat weaving

(b) Preparation of the site

(c) Plastering

(d) Curing

Construction time : 5 days

Bill of Materials:

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Bamboo mat | 10 m2 | 250 | 2,500 |
| 2. Sand | 1.5 m3 | 3000 | 4,500 |
| 3. Cement | 8 bags | 2000 | 16,000 |
| 4. Gravel | 0.5 m3 | 5000 | 2,500 |
| | | | 25,500 |

Personnel

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1 Worker | 5 days | 2000 | 10,000 |
| 2 Assistant Workers | 10 days | 1500 | 30,000 |
| | | | 40,000 |

(13) Component : Gothic vault shelter (Figure 22)

Location : Cikarang, Village of Pasir Ipis

Function : Shelter

Dimension : - Curved-shape shell structure

- Four side-opening
- 2.5 height
- 3.5 m x 3.5 cover area
- 2.5 cm thick ferrocement

Construction procedure:

(a) Construction of foundation

(b) Frame arrangement

(c) Reinforcement

(d) Plastering

(e) Curing

Construction time : 21 days

Bill of Materials :

A. Shell skin

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Cement | 15 bags | 2000 | 30,000 |
| 2. Sand | 2 m3 | 3000 | 6,000 |
| 3. Iron rod: | | | |
| Ø 9 mm | 6 pieces | 1900 | 11,400 |
| Ø 6 mm | 12 pieces | 1750 | 21,000 |
| Ø 4 mm | 60 pieces | 1000 | 60,000 |
| 4. Chicken wire | 4 rolls | 22500 | 90,000 |
| 5. Tie Wire | 15 kgs | 700 | 10,000 |
| 6. Electrode | 1 box | 4000 | 4,000 |
| | | Total A | 232,900 |

B. Supporting materials

| | | | |
|---|---|---|---|
| 1. Gunny sack | 30 sheets | 250 | 7,500 |
| 2. Bamboo mat | 8 pieces | 800 | 6,400 |
| 3. Wood 3/4 | 20 pieces | 200 | 4,000 |
| 4. Bamboo | 20 pieces | 850 | 17,000 |
| | | Total B | 34,900 |

Fig. 21 Gothic vault under model study

Fig. 22 Ferrocement gothic vault shelter

Personnel :

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 2 Workers | 21 days | 1500 | 63,000 |
| 3 Assistant Workers | 21 days | 1000 | 63,000 |
| | | | 126,000 |

(14) Component : Hypar mosque (Figure 24)

Location : Village of Sadu, Soreang
District of Bandung

Function : Small community mosque

Dimension : Hyperbolic paraboloid shell structure;
Four side-opening
3 m height
5 x 5 m covered area
2,5 cm thickness

Construction procedures:

(a) Construction of foundation
(b) Frame arrangement
(c) Reinforcement
(d) Plastering
(e) Curing

Construction time : 27 days

Bill of Materials :

A. Shell skin

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Cement | 20 bags | 2000 | 40,000 |
| 2. Sand | 5 m3 | 5000 | 25,000 |
| 3. Iron rod: | | | |
| ø 9 mm | 10 pieces | 1900 | 19,000 |
| ø 6 mm | 15 pieces | 1750 | 26,250 |
| ø 4 mm | 70 pieces | 1000 | 70,000 |
| 4. Chicken wire | 5 rolls | 21500 | 132,500 |
| 5. Tie wire | 15 kgs | 700 | 10,500 |
| 6. Electrode | 1 box | 4000 | 4,000 |
| | Total A | | 327,250 |

B. Supporting materials

| | | | |
|---|---|---|---|
| 1. Gunny sack | 30 sheets | 250 | 7,500 |
| 2. Bamboo mat | 8 pieces | 800 | 6,400 |
| 3. Wood 4/6 | 30 pieces | 750 | 22,500 |
| 4. Bamboo | 20 pieces | 850 | 17,000 |
| | Total B | | 53,900 |

Personnel :

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 2 Workers | 27 days | 1500 | 40,500 |
| 3 Assistant Workers | 27 days | 1000 | 27,000 |
| | | | 67,500 |

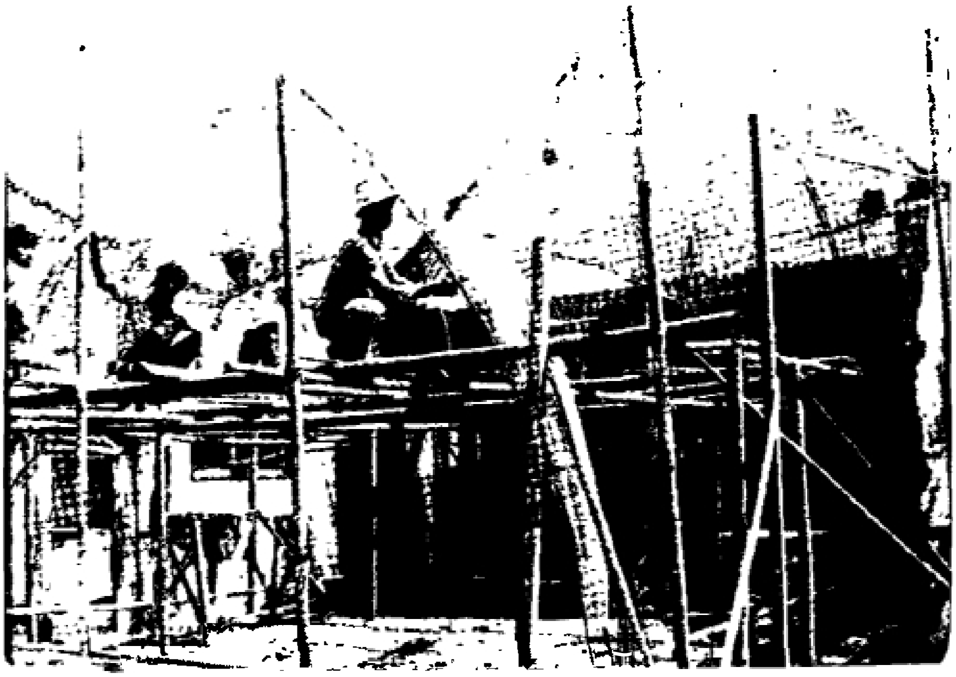


Fig. 23 Ferrocement hypar mosque during mesh reinforcement

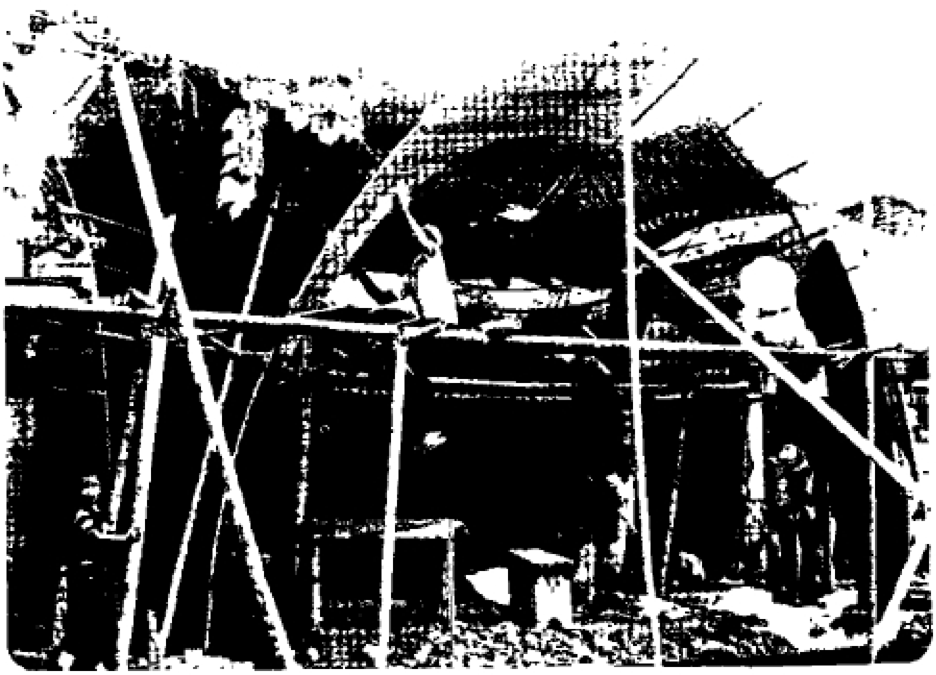


Fig. 24 First plastering of ferrocement hypar mosque

(15) Component : Ferrocement bus shelter (Figure 26)

Location : Jalan Ganesha, Bandung

Function : Shelter for bus passengers

Dimension : - 3 m height

- 2.5 x 6 m covered area

- four concrete columns

Construction procedures :

(a) Construction of foundation

(b) Frame arrangement

(c) Reinforcement

(d) Plastering

(e) Curing

Construction time : 3 weeks

Personnel :

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 2 Workers | 21 days | 2.250 | 94,500 |
| 3 Assistant Workers | 21 days | 1.500 | 63,000 |
| | | | 157,500 |

Bill of Materials :

| A. Foundation | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Sand | 2 m3 | 8.000 | 16,000 |
| 2. Cement | 15 bags | 2.000 | 30,000 |
| 3. Gravel | 2 m3 | 10.000 | 20,000 |
| | | | 60,000 |

B. Columns

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Iron rod Ø 8 mm | 6 pieces | 1750 | 10,500 |
| 2. Iron rod Ø 8 mm | 7 pieces | 1000 | 7,000 |
| 3. Plywood | 1 piece | 4500 | 4,500 |
| 4. Nail | 1 kg | 550 | 550 |
| 5. Sand | 1.5 m3 | 8000 | 12,000 |
| 6. Gravel | 1 m3 | 10000 | 10,000 |
| | | | 44,550 |

C. Shell Roof Frame

| | | | |
|---|---|---|---|
| 1. Iron rods Ø 8 mm | 4 pieces | 1750 | 7,000 |
| 2. Iron rods Ø 6 mm | 7 pieces | 1000 | 7,000 |
| 3. Welding rod | 2 kgs | 1000 | 2,000 |
| 4. Nails | 5 kgs | 550 | 2,750 |
| 5. Plywood | 1 piece | 9500 | 9,500 |
| 6. Gasoline | 20 liters | 200 | 4,000 |
| | | | 32,250 |

D. Shell Roof Reinforcement

| | | | |
|---|---|---|---|
| 1. Iron rods Ø 6 mm | 3 pieces | 1000 | 3,000 |
| 2. Iron rods Ø 4 mm | 100 pieces | 700 | 70,000 |
| 3. Chicken wire | 4 rolls | 22500 | 90,000 |
| 4. Tie wire | 10 kgs | 600 | 6,000 |
| | | | 169,000 |

Fig. 25 Mesh reinforcement of ferrocement bus shelter

Fig. 26 Ferrocement bus shelter from side view; shown the shell thinness

E. Shell Roof Plaster

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Washed sand | 2 m3 | 15.000 | 30,000 |
| 2. Cement | 20 kgs | 2.000 | 40,000 |
| | | | 70,000 |

F. Finishing

| | | | |
|---|---|---|---|
| 1. Paint | 20 liters | 2.500 | 50,000 |
| 2. Curing | 10 pieces | 300 | 3,000 |
| | | | 53,000 |

G. Supporting Materials

| | | | |
|---|---|---|---|
| 1. Wood plank 2/20 - 4 m | 11 pieces | 1.000 | 11,000 |
| 2. Wood studs 5/7 - 9 m | 10 pieces | 1.500 | 15,000 |
| 3. R o p e | 10 rolls | 300 | 3,000 |
| 4. Nails | 5 kgs | 550 | 2,750 |
| 5. Bucket | 6 | 500 | 3,000 |
| | | | 34,750 |

(16) Component : Minaret and Dome on top (Figure 28)

Location : Cisitu Lama, Bandung

Function : Minaret for calling the prayer at Ar Rahim Mosque

Dimension : - Minaret : Tubular minaret with ferrocement skin wall
12 m height
3 cm thick
imbedded in three cylinder concrete columns

- Dome on top; ferrocement skin 2.5 cm thick, mid section 3.5 m

Construction procedures:

(a) Construction of foundation
(b) Construction of concrete columns
(c) Frame and wall reinforcement
(d) Dome reinforcement on the ground
(e) Wall plastering
(f) Lifting the dome
(g) Plastering the dome
(h) Curing

Construction time : six weeks

Personnel :

| | Man/days | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 3 Workers | 36 days | 2,250 | 324,000 |
| 4 Assistant workers | 36 days | 1,500 | 216,000 |
| | | | 540,000 |

Bill of Materials :

A. Foundation

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Iron rod Ø 9 mm | 10 pieces | 1.900 | 19,000 |
| Ø 6 mm | 20 pieces | 1.750 | 35,000 |
| 2. Cement | 15 bags | 2.000 | 30,000 |
| 3. Fine sand | 5 m3 | 5.500 | 27,500 |
| 4. Sand | 2 m3 | 3.500 | 7,000 |
| 5. Gravel | 2 m3 | 6.000 | 12,000 |
| | | | 130,500 |

B. Cylinder wall frame

| | | | |
|---|---|---|---|
| 1. Wood 3/20 - 4 m | 20 pieces | 2.500 | 50,000 |
| 2. Iron rod Ø 6 mm | 10 pieces | 1.000 | 30,000 |
| 3. Iron rod Ø 4 mm | 20 pieces | 700 | 14,000 |
| 4. Wood studs 6/15 - 3 m | 1 piece | 2.500 | 2,500 |
| 5. Nail | 5 kgs | 550 | 2,750 |
| 6. Electrode rod | 1 dooz | 4.000 | 4,000 |
| | | | 103,250 |

C. Cylinder reinforcement

| | | | |
|---|---|---|---|
| 1. Iron rod Ø 6 mm | 12 pieces | 1.000 | 12,000 |
| 2. Iron rod Ø 4 mm | 20 pieces | 700 | 14,000 |
| 3. Tie Wire | 20 kgs | 600 | 12,000 |
| 4. Chicken wire | 7 rolls | 22.500 | 157,500 |
| 5. Wood stud 5/7 - 4 m | 48 pieces | 3.000 | 96,000 |
| | | | 291,500 |

D. Cylinder wall plaster

| | Amount | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Cement | 29 zags | 2.000 | 58,000 |
| 2. Washed sand | 2 m3 | 15.000 | 30,000 |
| | | | 88,000 |

E. Dome framing

| | | | |
|---|---|---|---|
| 1. Iron rod Ø6 mm | 12 pieces | 1.000 | 12,000 |
| 2. Iron rod Ø4 mm | 24 pieces | 700 | 14,800 |
| 3. Nail | 5 kgs | 500 | 2,500 |
| 4. Electrode rod | 1 box | 4.000 | 4,000 |
| | | | 33,300 |

F. Dome reinforcement

| | | | |
|---|---|---|---|
| 1. Iron rod Ø6 mm | 19 pieces | 1.000 | 19,000 |
| 2. Iron rod Ø4 mm | 20 pieces | 700 | 14,000 |
| 3. Tie wire | 10 kgs | 600 | 6, 000 |
| 4. Chicken wire | 11 rolls | 22.500 | 247, 500 |
| 5. Woods studs 5/7 - 3 m | 9 pieces | 1.500 | 13, 500 |
| 5/7 - 4 m | 5 pieces | 2.000 | 10,000 |
| | | | 310,000 |

G. Dome plaster

| | | | |
|---|---|---|---|
| 1. Cement | 31 bags | 2,000 | 62,000 |
| 2. Washed sand | 2.5 m3 | 15.000 | 37,500 |
| | | | 99,500 |

H. Finishing

| | Amounts | Unit Price (Rp) | Total (Rp) |
|---|---|---|---|
| 1. Floor | | | |
| - sand | 2 m3 | 4.000 | 8,000 |
| - gravel | 2 m3 | 6.000 | 12,000 |
| - cement | 20 bags | 2.000 | 40,000 |
| 2. Paint | 20 kgs | 2.000 | 40,000 |
| 3. Top dome | | | 50,000 |
| | | | 150,000 |

I. Supporting Materials

| | | | |
|---|---|---|---|
| 1. Bamboo | 120 pieces | 1.000 | 120,000 |
| 2. Rope | 60 rolls | 300 | 18,000 |
| 3. Woods 3/20 - 4 m | 5 pieces | 2.500 | 12,500 |
| | | | 150,500 |

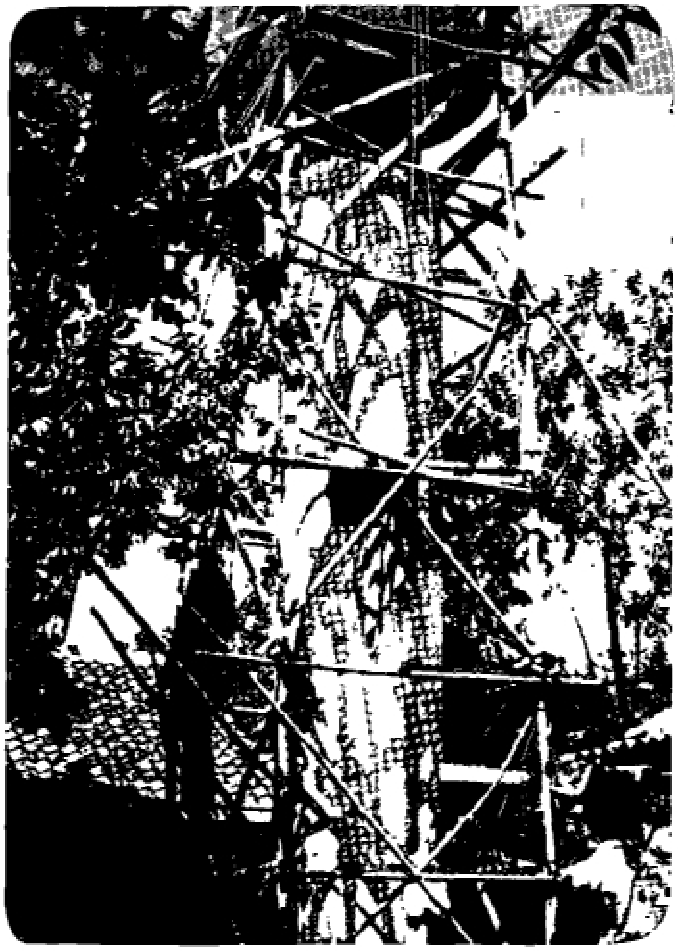


Fig. 27 Ferrocement minaret

Fig. 28 Ferrocement dome on top minaret

# MAP OF WEST JAVA PROVINCE

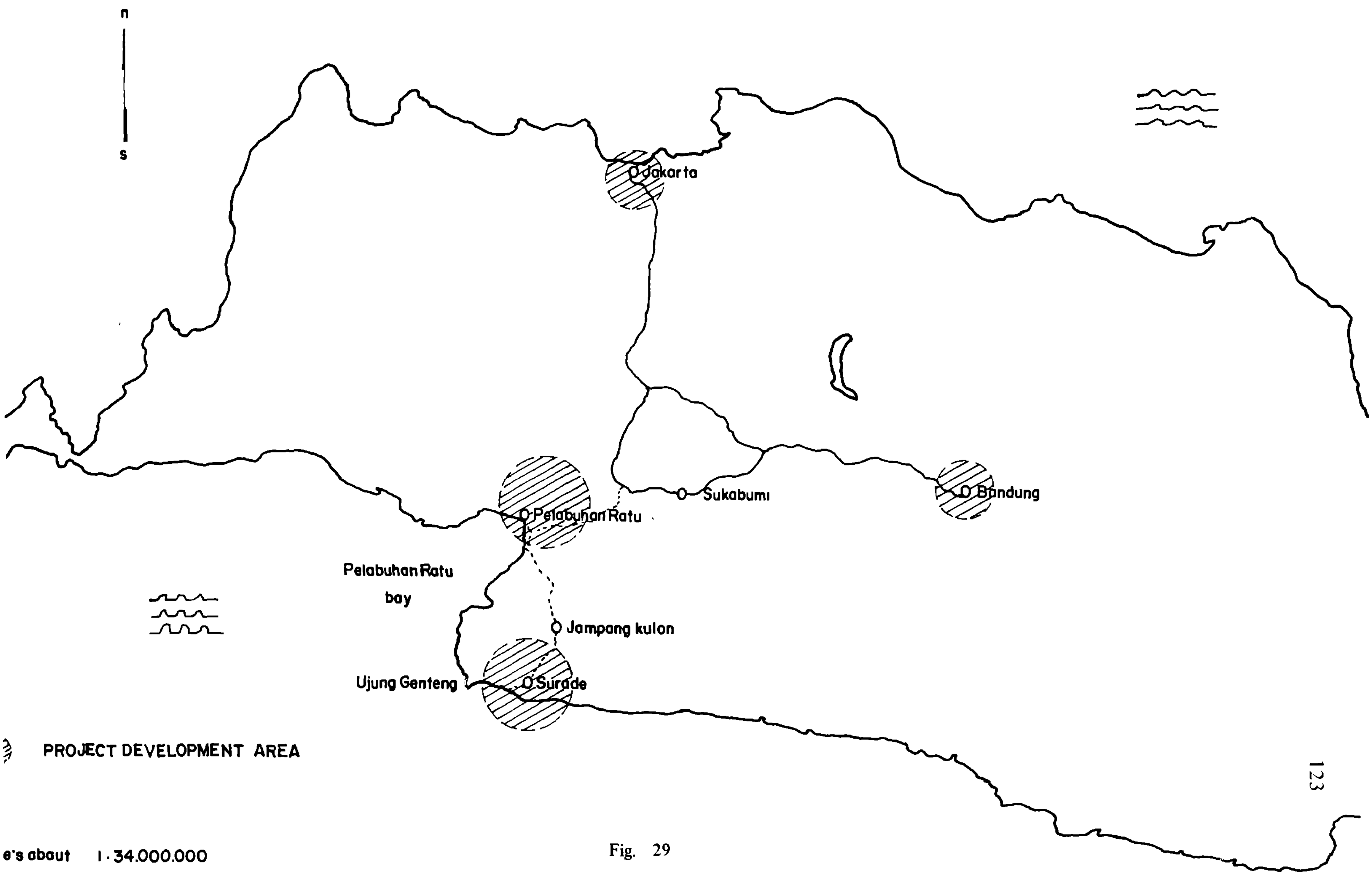



Fig. 29

## 3.2. SOUTH SULAWESI

The sites which serve as centers of activities for the develop - ment of ferrocement echnology can be located on the map of the South Sulawesi area. (Figure 52)

(1) Ujung Pandang

- Training of the RATC staff for ferrocement technology
- Seminar and discussion on ferrocement
- Trial construction of a ferrocement canoe in the UNHAS campus
- Consultation with the Makassar Shipyard Company
- Construction of a ferrocement mosque dome at the Muslim University of Indonesia
- Well casing from bamboo cement
- Septic tank from bamboo cement
- Construction of bamboo electric poles layered with ferro-cement
- Breeding tank for shrimps

(2) Tonrokassi (District of Jeneponto)

- Field demonstration of the construction of water tank, ba-sin, well casing, septic tank
- Construction of collecting tank and distribution tank from ferrocement (Joint effort of RATC-UNHAS, Jeneponto govern-ment office and Foster Parents Plan International)

(3) Pajjukukang (Maros District)

- Plan to construct a water tank to collect rain water
- Plan to construct a ferrocement fishing boat

(4) Tana Toraja District

- Plan for extension services for ferrocement technology
- Field demonstration of the construction of various ferrocement components for the district and village heads and the Makale Vocational School. At the same time two staff members of the school were trained to become the field technicians.
- Well casing from bamboo at Tarongko and Makale

(5) Takalar District

- Extension services on ferrocement technology
- Development of ferrocement in the construction of the dome of the main mosque in Takalar

(6) Sidrap District

- Plan for extension services on ferrocement technology
- Plan to construct a storage bin for rice and other secondary crops
- Plan to build low-cost houses
- Construction of a water tank model from mortar cement

(7) Benteng (Selayar District)

- Plan to construct dome of the main mosque in the city of Benteng

(8) Watampone (Bone District)

- Plan for extension services on ferrocement technology together with demonstrations on how to construct the components

(9) Enrekang District

- Plan for extension services on ferrocement technology together with demonstrations on how to construct the components

(10) Pinrang District

- Plan for extension services on ferrocement technology together with demonstration on how to construct the components.

3.2.1. Component Specification

Ferrocement component which had been designed and constructed at sites, can be divided into two categories:

(1) Component being constructed financed by the project

(2) Component being constructed financed outside of the project, only supervised by project staff.

(a) Ferrocement component financed by the project:

1) Component : Gentong (Water jar) (Figure 30)

Location : Tonrokassi

Dimension : Top diameter 125 cm

Bottom diameter 80 cm

Depth 112 cm

Capacity : 250 liters, 3 water jars made

Construction steps:

(i) purchasing materials

(ii) mold preparation

(iii) plastering

(iv) curing

Construction time : 9 days

Personnel : 2 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Cement | 14 kgs |
| 2. | Sand | 30 kgs |
| 3. | Gunny sack | 1 piece |
| 4. | Water | 12 liters |

2) Component : Gentong (Water jar)

Location : Tonrokassi

Dimension : Top diameter 35 cm

Bottom diameter 58 cm

Depth 65 cm

Capacity : 10 liters, 3 water jars

Construction Steps:

(i) purchasing of materials

(ii) mold preparation

(iii) plastering

(iv) curing

Fig. 30 Mortar cement water jar

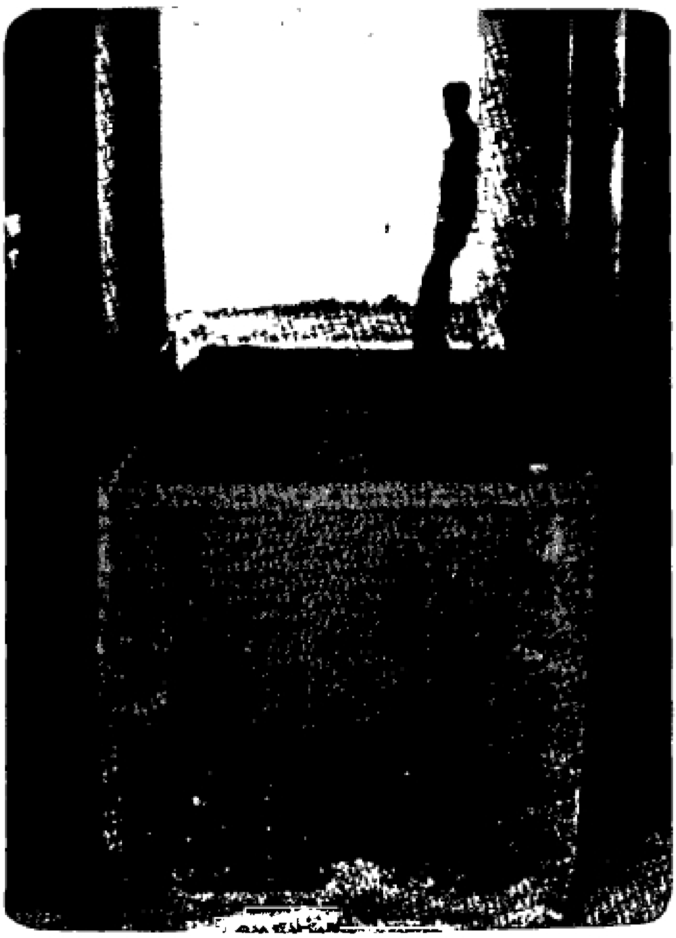


Fig. 31 Ferrocement water container

Construction time : 9 days

Personnel : 2 workers

Bill of Materials :

1. Cement 3.5 kgs
2. Sand 7 kgs
3. Flour bag 2 meters
4. Water 1.1 liters

3) Component : Water container: box type (Figure 31)

Location : Tonrokassi

Dimension : Length 60 cm

Width 50 cm

Depth 50 cm

Capacity : 150 liters

Construction steps:

(i) purchasing of materials

(ii) reinforcement

(iii) plastering

(iv) curing

Construction time : 9 days

Personnel : 3 workers

Bill of Materials :

1. Iron rod Ø 10 mm 1 piece
2. Iron rod Ø 6 mm 2 pieces
3. Tie wire 0.5 kgs

| | | |
|---|---|---|
| 4. | Electrode Ø 3.2 mm | 0.5 kgs |
| 5. | Chicken wire | 3.4 ms |
| 6. | Cement | 20 kgs |
| 7. | Sand | 40 kgs |
| 8. | Water | 1 liter |

4. Component : Water container: box type without steel skeleton

Location : Tonrokassi

Dimension : length 60 cm

width 50 cm

depth 50 cm

Capacity : 150 liters

Construction Steps:

(i) purchasing of materials

(ii) mold preparation

(iii) plastering

(iv) curing

Construction time: 9 days

Personnel : 3 workers

Bill of Materials:

| | | |
|---|---|---|
| 1. | Tie wire | 0.5 kgs |
| 2. | Triplex | 1 sheet |
| 3. | Cement | 20 kgs |
| 4. | Chicken wire | 3.4 m |
| 5. | Sand | 40 kgs |

5. Component : Water tank, Cylinder type

Location : Tonrokassi

Dimension : Diameter 132 cm

Depth 150 cm

Manhole 66 cm

Thickness of wall 3 cm

Capacity : 2000 liters

Construction Steps:

(i) purchasing of materials

(ii) reinforcement

(iii) plastering

(ic) curing

Construction time : 14 days

Personnel : 3 workers

Bill of Materials :

| | | | |
|---|---|---|---|
| 1. | Cement | 40 kgs | 40 kgs |
| 2. | Sand | 650 kgs | 650 kgs |
| 3. | Chicken wire | | 30 ms |
| 4. | Iron rod Ø 6 mm | | 60 ms |
| 5. | Iron rod Ø 9 mm | | 10 ms |
| 6. | Tie wire | | 1 kg |
| 7. | Water | | 16 liters |

6. Component : Septic tank, box type

Location : Tonrokassi

Dimension : Length 2,5 m

Width 1.2 m

Height 1.5 m

Capacity : 4,500 liters

Construction Steps:

(i) purchasing of materials

(ii) reinforcing

(iii) plastering

(iv) curing

Construction time : 14 days

Personnel : 4 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Iron rod Ø 10 mm | 6 pieces |
| 2. | Iron rod Ø 6 mm | 12 pieces |
| 3. | Chicken wire | 85 meters |
| 4. | Electrode | 3 kgs |
| 5. | Cement | 440 kgs |
| 6. | Sand | 663 kgs |
| 7. | Tie wire | 2 kgs |
| 8. | Triplex | 1 sheet |
| 9. | Gunny sack | 10 pieces |

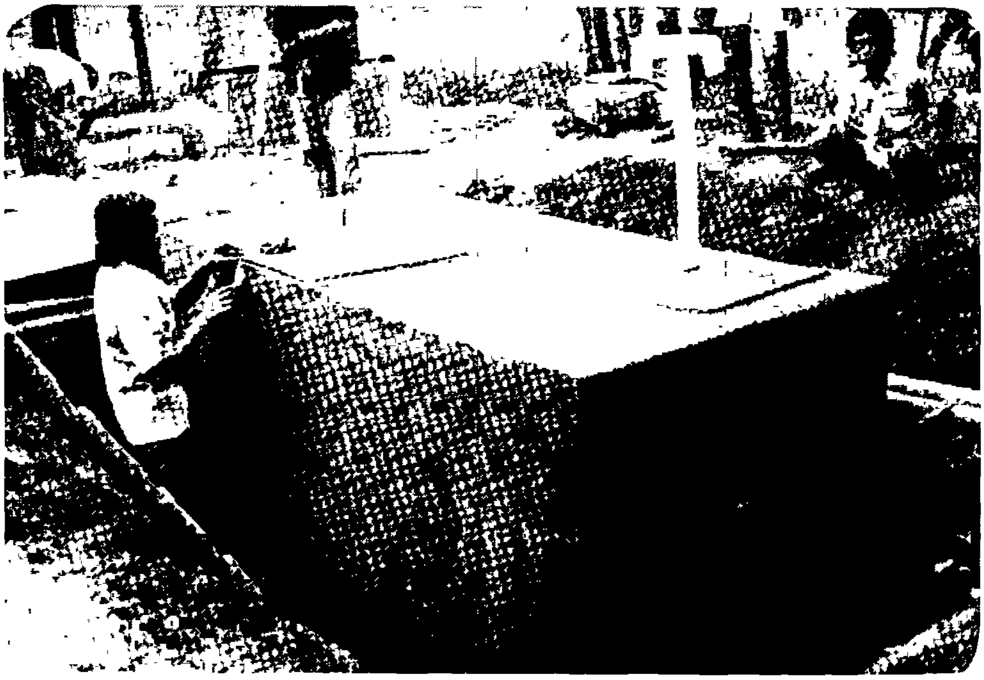


Fig. 32 Ferrocement septic tank, Jeneponto;
Ujung Pandang

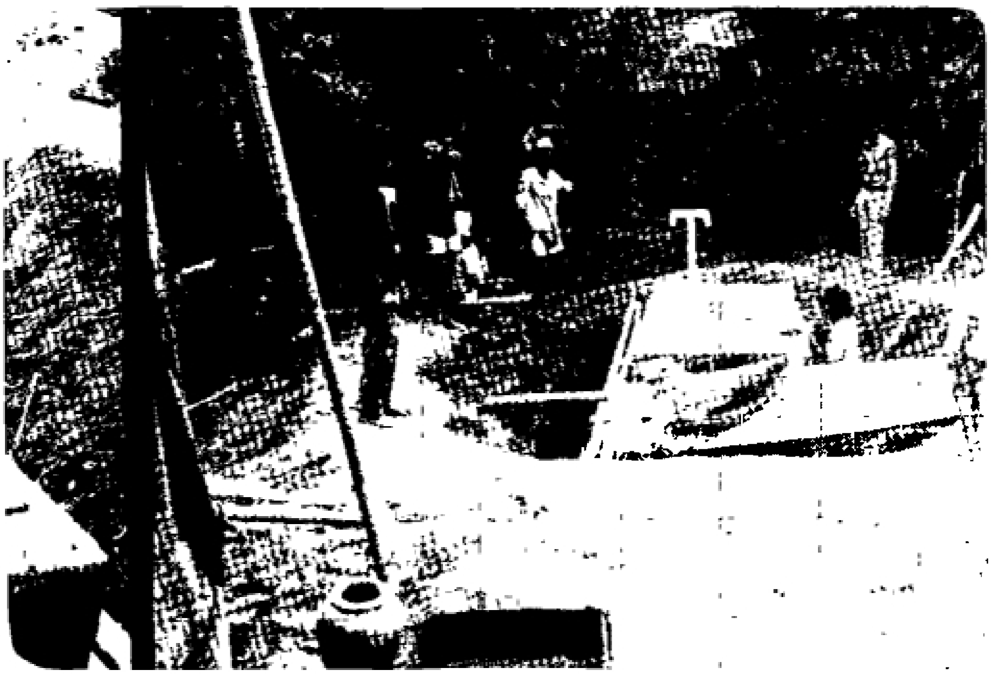


Fig. 33 Installation of ferrocement septic tank

7. Component : Well casing (Figure 35)

   Location : Tonrokassi, 7 casings made

   Dimension : diameter 0.8 m

   height 1.6 m

   wall thickness 2 cm

   Construction Steps:

   (i) purchasing of materials

   (ii) reinforcement

   (iii) plastering

   (iv) curing

   Construction time : 14 days

   Personnel : 6 workers

   Bill of Materials :

| | | |
|---|---|---|
| 1. Iron rod Ø 6 mm | 79.2 | m |
| 2. Chicken wire | 42 | m |
| 3. Tie wire | 1 | kg |
| 4. Sand | 1 | m3 |
| 5. Cement | 640 | kgs |

8. Component : Sampan (canoe) (Figure 36)

   Location : Ujung Pandang

   Dimension : length 6 m

   beam 0.8 m

   height 0.6 m

Fig. 34 & 35 Installation of ferrocement well casings, Ujung Pandang

Fig. 36 Ferrocement canoe


Fig. 37 Ferrocement canoe model in exhibit

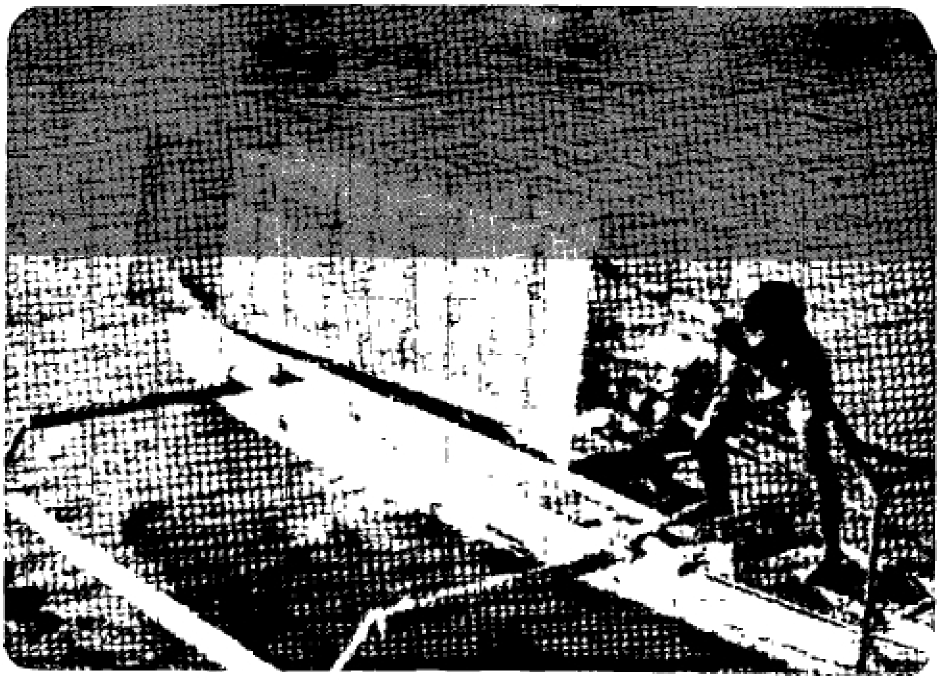


Fig. 38 Ferrocement irrigation box towed to site before plastering

Fig. 39 The site of ferrocement irrigation box

Construction steps:

(i) purchasing of materials

(ii) reinforcement

(iii) plastering

(iv) curing

Construction time : 36 days

Personnel : 4 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Iron rod Ø 10 mm | 4 pieces |
| 2. | Iron rod Ø 6 mm | 14 pieces |
| 3. | Chicken wire | 60 m |
| 4. | Cement | 160 kgs |
| 5. | Sand | 2 m3 |
| 6. | Plywood 3/8" | 1 sheet |
| 7. | Electrode | 4 kgs |
| 8. | Paint | 1 gallon |
| 9. | Gunny sack | 6 pieces |
| 10. | Plastic rope | 20 m |

(b) Ferrocement component financed outside of the project, only under supervised by project staff

1) Component : Mosque Dome - Kelara

Location : Tolo - Jeneponto

Dimension : 3/4 sphere

diameter 2 m

height 1.68 m

thickness 2.5 cm

Construction Steps:

(i) purchasing of materials

(ii) welding the skeleton

(iii) reinforcement chicken wire

(iv) plastering

(v) curing

Construction time : 16 days

Personnel : 8 workers

Bill of Materials:

| | | |
|---|---|---|
| 1. | Cement | 560 kgs |
| 2. | Sand | 0.5 m3 |
| 3. | Chicken wire | 84.4 m |
| 4. | Tie wire | 1 kg |
| 5. | GI Pipe Ø 1/2" | 2 pieces |

2) Component : Mosque Dome - Takalar (Figure 41)

Location : Takalar

Dimension : Diameter 10 m

height 5 m

thickness 3.5 cm

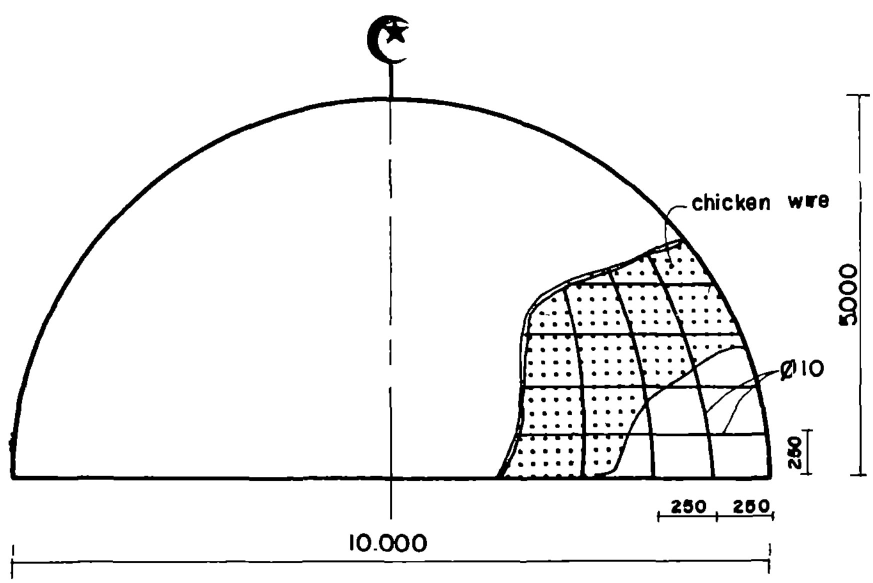
Construction steps:

(i) purchasing of materials

(ii) reinforcement and welding

SKETCH MOSQUE DOME AT TAKALAR

1 1000




Chicken wire : – Hexagonal mesh

– Six layers (3 inner side, 3 outer side)

Fig. 40 Takalar mosque dome

PROYEK PENGEMBANGAN TEKNOLOGI FERROCEMENT
DI SULAWESI SELATAN
RATC - UNHAS & PTP - ITB

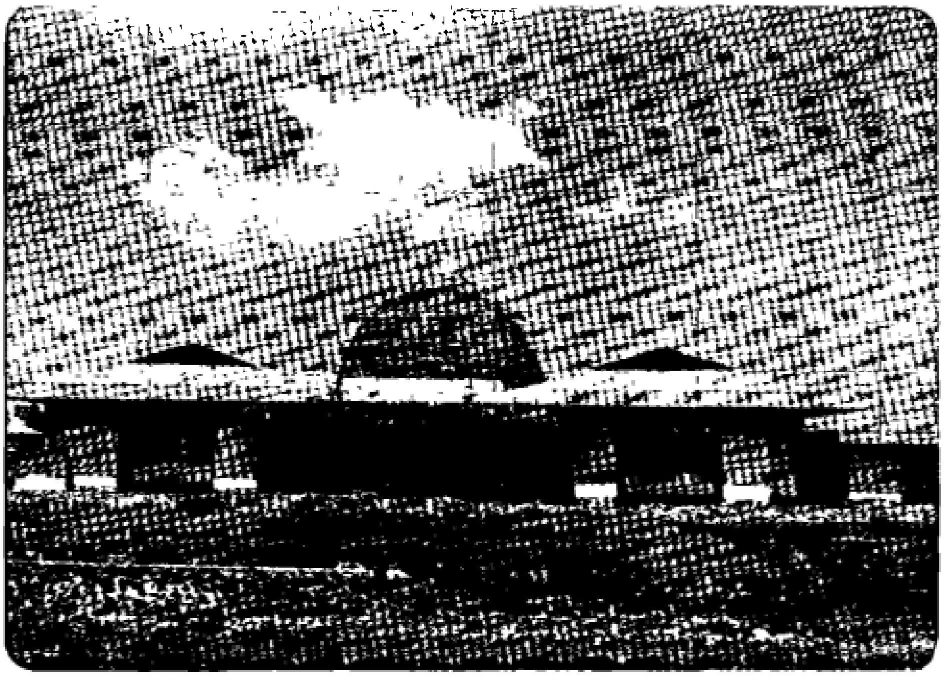
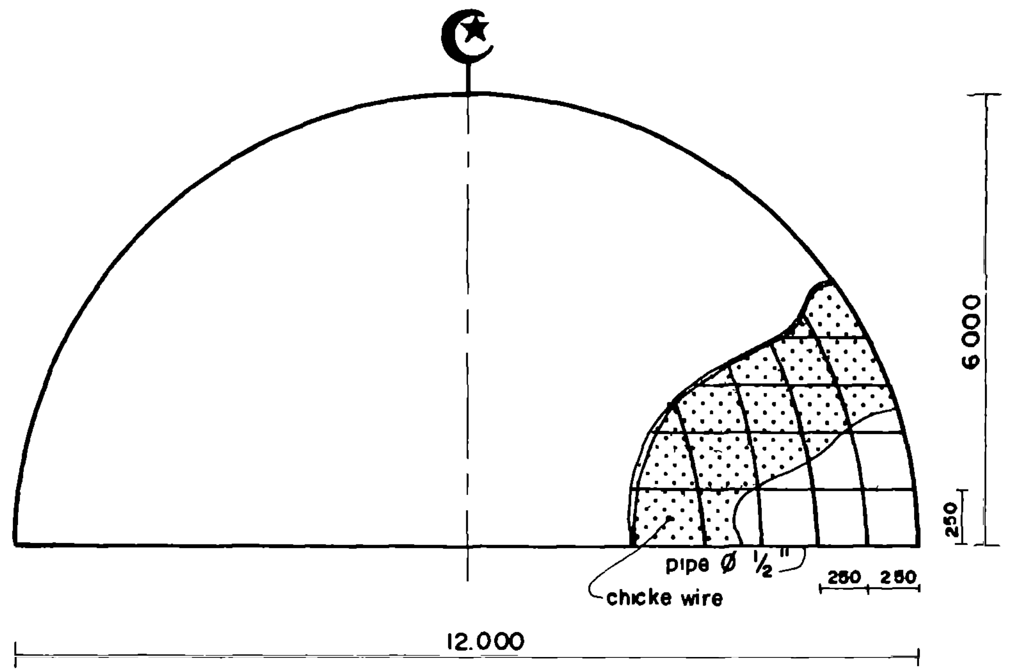


Fig. 41  Takalar mosque dome

Fig. 42  Soppeng mosque dome; under supervision of the project staff

SKETCH BENTENG SELAYAR MOSQUE DOME

1 1000




Chicken wire : Hexogonal mesh

- Six loyers ( 3 inner side, 3 outer )

Fig. 43 Selayar mosque dome

PROYEK PENGEMBANGAN TEKNOLOGI FERROCEMENT
DI SULAWESI SELATAN
RATC-UNHAS & PTP-ITB

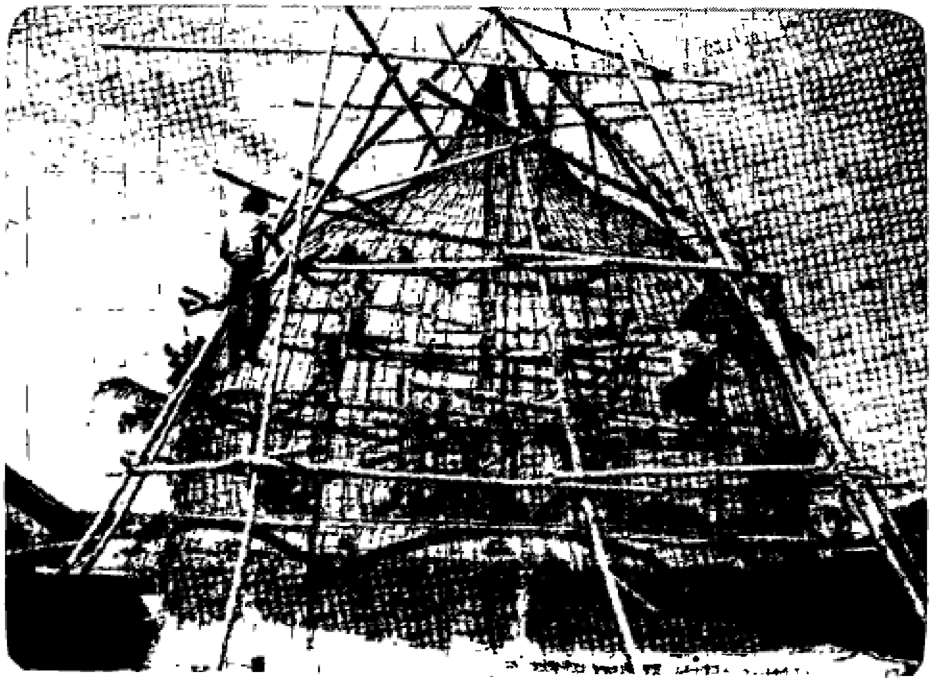


Fig. 44 UMI mosque dome during the reinforcing

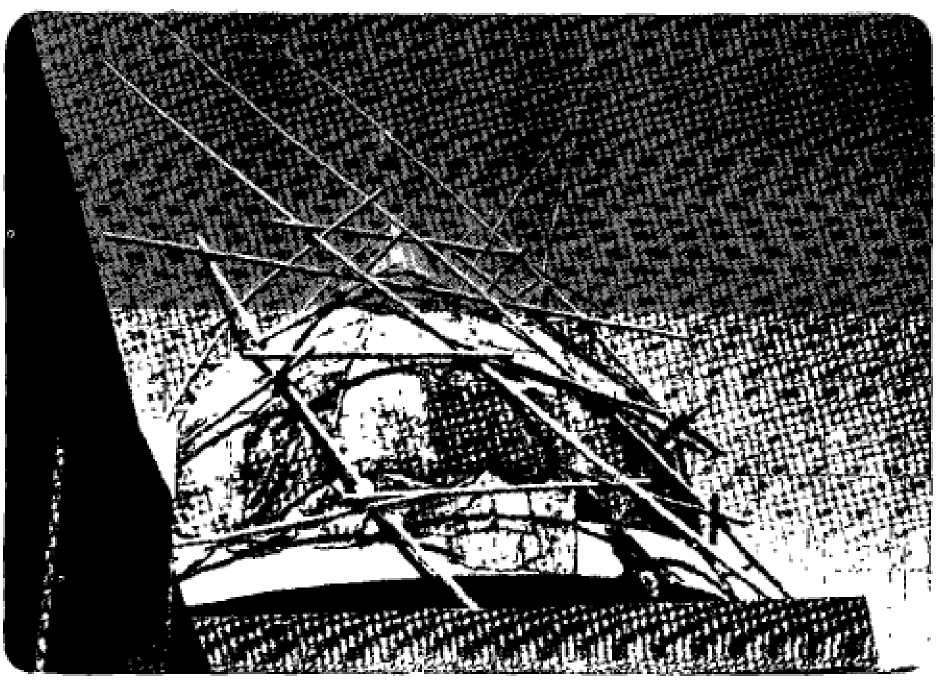


Fig. 45 Critical step in ferrocement, curing UMI mosque dome

(iii) plastering

(iv) curing

Construction time : 32 days

Personnel : 10 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Cement | 110 bags |
| 2. | Sand | 6 m3 |
| 3. | GI Pipe ø 1/2" | 6 pieces |
| 4. | Iron rod ø 10 mm | 268 pieces |
| 5. | Chicken wire | 66 rolls |
| 6. | GI wire | 20 kgs |

3. Components : Shrimp breeding tank (Figure 46)

Location : Ujung Pandang, 4 tanks made

Dimension : diameter 2 m

height 0.75 m

thickness 2.5 cm

Construction steps:

(i) purchasing of materials

(ii) reinforcement and welding

(iii) plastering

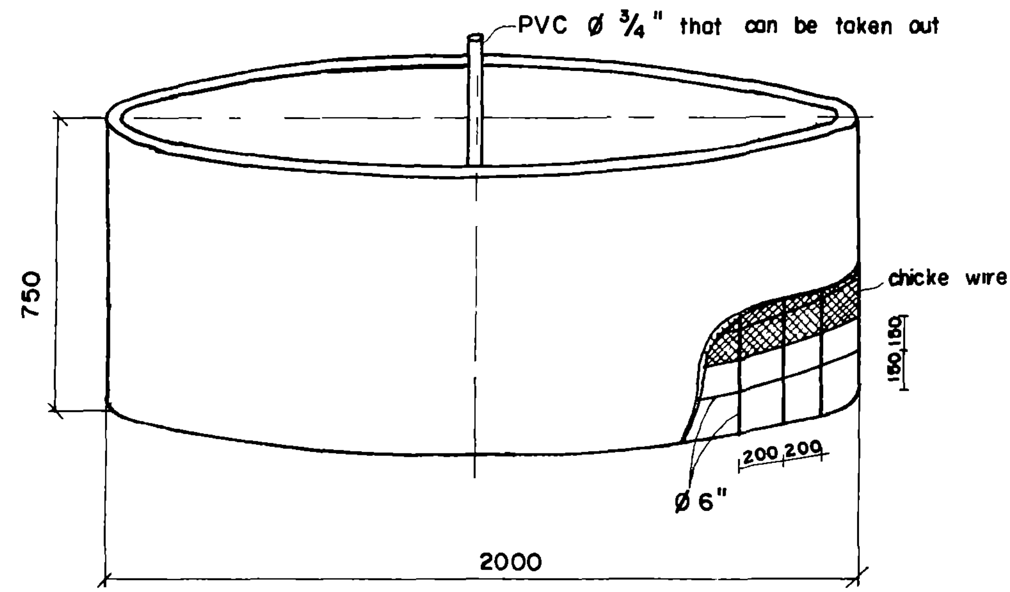
(iv) curing

Construction time : 24 days

Personnel : 8 workers

SKETCH SHRIMP BREEDING TANK

1:20




Remark : PVC pipe is used for feeding purpose

Fig. 46 Shrimp breeding tank

PROYEK PENGEMBANGAN TEKNOLOGI FERROCEMENT
DI SULAWESI SELATAN
RATC - UNHAS & PTP-ITB

Bill of materials:

| | | |
|---|---|---|
| 1. | Iron rod Ø 10 mm | 16 pieces |
| 2. | PVC pipe Ø 3/4" | 1 pieces |
| 3. | GI pipe joint Ø 3/4" | 4 pieces |
| 4. | Electrode | 4 kgs |
| 5. | Steel plate t: 5 mm | 0.5 sheet |
| 6. | PVC glue | 1 tube |
| 7. | Cement | 20 bags |
| 8. | Sand | 1 m3 |

4. Component : Well casing, bamboo reinforcement (Fig. 48)

Location : Ujung Pandang, made 5 pieces

Dimension : Diameter 0.8 m
Height 1.2 m
Thickness 2.5 cm

Construction Steps:

(i) purchasing of materials

(ii) bamboo reinforcement

(iii) plastering

(iv) curing

Construction time: 16 days, for 5 casings

Personnel : 8 workers

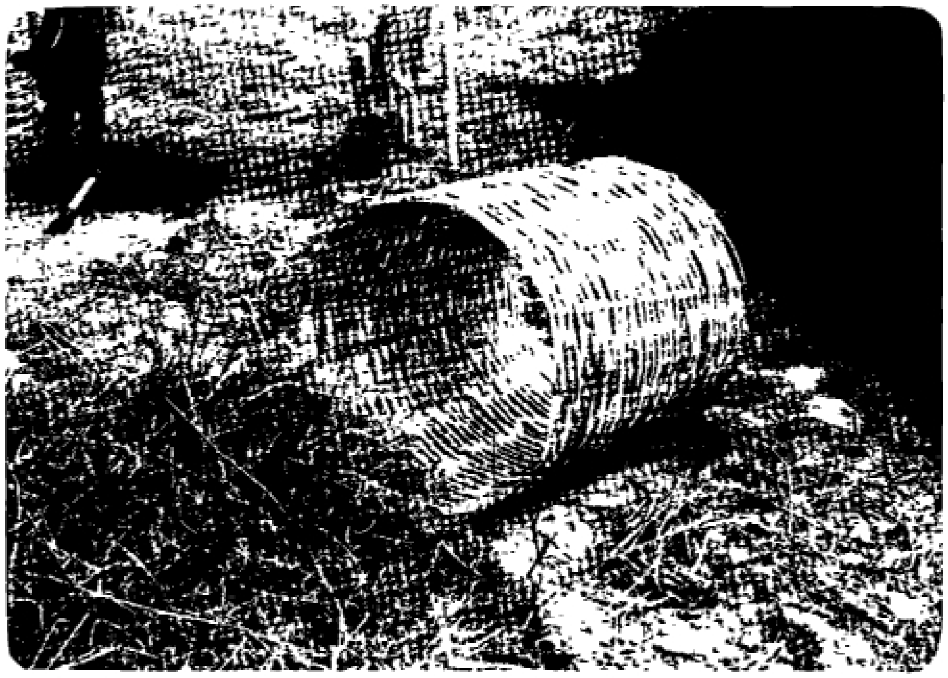
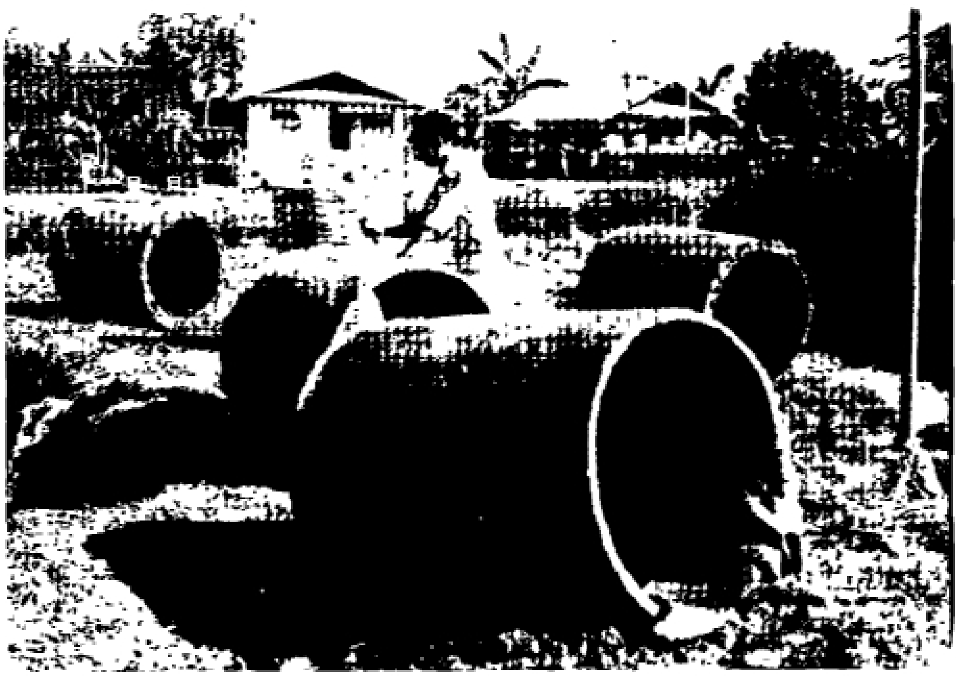
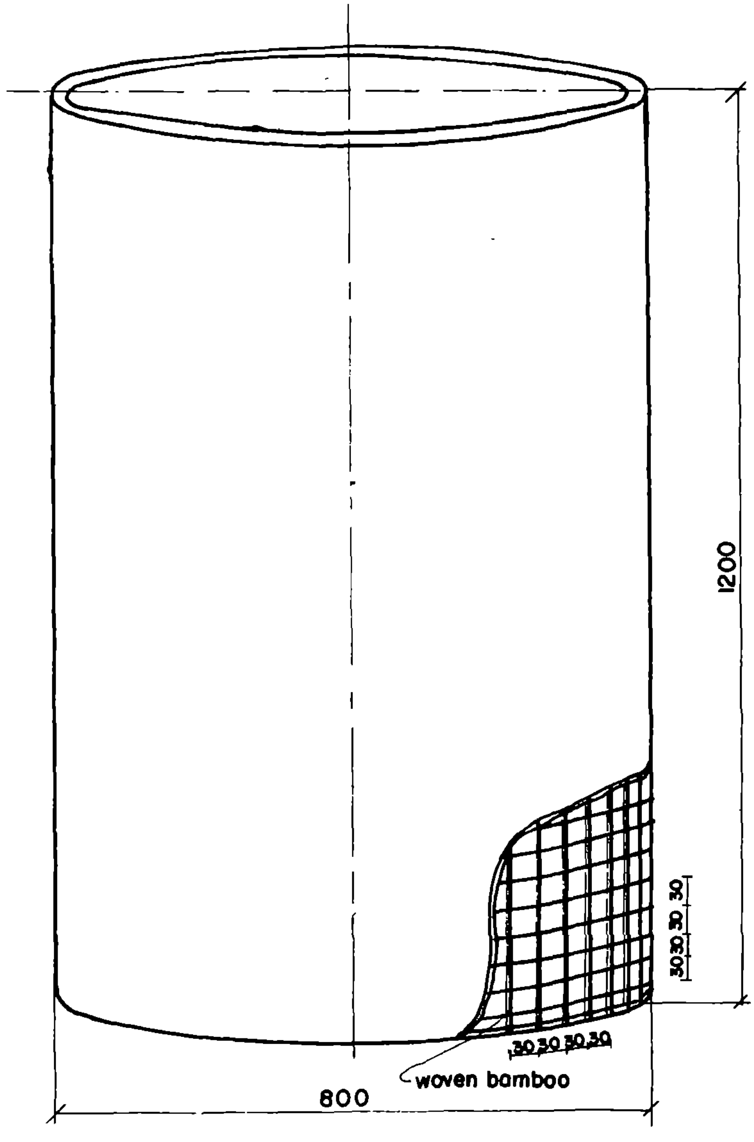


Fig. 47 & 48  Bamboo cement well casings



WELL CASING UNIT MADE OF BAMBOO CEMENT
1:10




Woven bamboo reinforcement

Fig. 49 Bamboo cement well casing

PROYEK PENGEMBANGAN TEKNOLOGI FERROCEMENT
DI SULAWESI SELATAN
RATC - UNHAS & PTP - ITB

Fig. 50 Plastering ferrocement-bamboo electric pole

Fig. 51 Bamboo-ferrocement electric pole

Bill of Materials:

1. Cement 2 bags
2. Sand 1 m3
3. Bamboo 4 pieces

5. Component : Ferrocement ditch lining, 10 pieces made

6. Component : Electric pole, bamboo and ferrocement

7. Component : Ferrocement boat

Location : Ujung Pandang

Dimension : Height 1.46 m

| | |
|---|---|
| Height | 1.46 m |
| Thickness | 4 cm |
| LOA | 4 m |
| $LWL^2$ | 9 m |
| Width | 2.85 m |

Construction Steps:

(i) purchasing of materials

(ii) framing and welding

(iii) reinforcement

(iv) plastering

(v) curing

Construction time : 32 days

Personnel : 5 - 10 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Web frame RB Ø 1/2" (iron rod) | 310 m |
| 2. | Longitudinal RB Ø 3/8" | 500 m |
| 3. | Keel frame RB 5/8" | 15 m |
| 4. | Cement | 25 bags |
| 5. | GI wire | 20 kgs |
| 6. | Transverse frame RB Ø 3/16" | 500 m |
| 7. | Electrode | 35 kgs |
| 8. | Mesh wilder netting | 135 m2 |
| 9. | Ply-wood | 15 sheets |
| 10. | Paint ACI | 15 kgs |
| 11. | Wood 500 x 15 x 3<br>400 x 7 x 3 | |

Materials and manpower price list in Ujung Pandang, January to May 1979

| No. | Name of Materials | Unit | Price (Rp) |
| --- | --- | --- | --- |
| 1. | Cement | bag | 2,250 |
| 2. | Chicken wire | meter | 750 |
| 3. | Sand | m3 | 2,250 |
| 4. | Iron rod Ø 6 mm | pieces | 1,750 |
| 5. | Iron rod Ø 10 mm | pieces | 2,250 |
| 6. | Tie wire | kg | 1,000 |
| 7. | Electrode Ø 3.2 mm | kg | 1,000 |
| 8. | Triplex | sheet | 4,500 |
| 9. | Gunny sack | pieces | 500 |

Labor Cost

| No. | Skill | Unit | Amount (Rp) |
| --- | --- | --- | --- |
| 1. | Technician | per day | 1,250 |
| 2. | Skilled worker | per day | 1,000 |
| 3. | Worker | per day | 750 |
| 4. | Helper | per day | 500 |

# MAP OF SOUTH SULAWESI PROVINCE



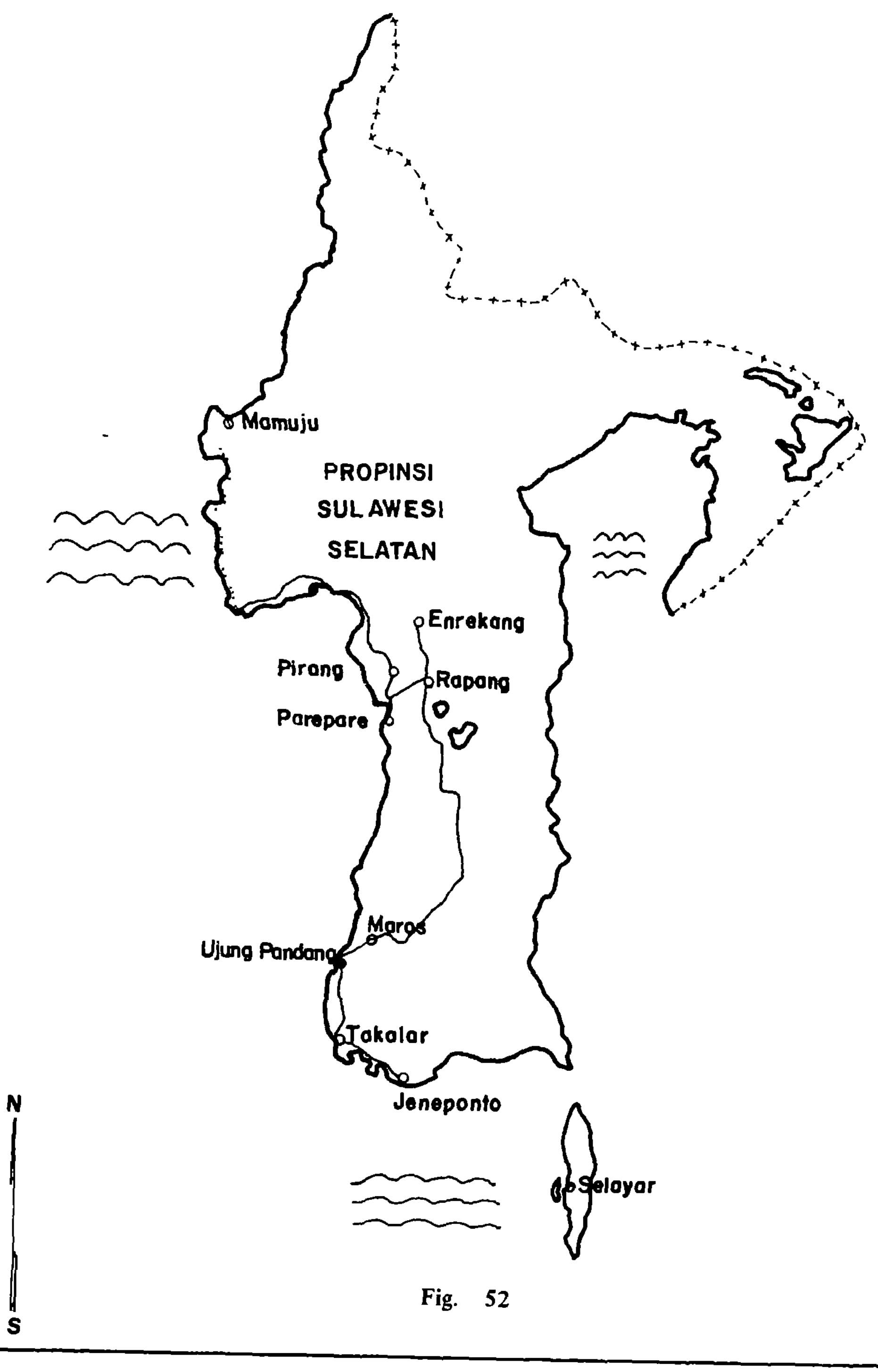



Fig. 52

## 3.3. A C E H

Ferrocement technology development carried out in the Province of Aceh can be located on the map of Province of Aceh (Figure 80).

### 3.3.1. Component Specification

Ferrocement component which had been designed and constructed at sites can be divided into two categories:

(a) Component being constructed financed by the project

(b) Component being constructed financed from outside of the project, only supervised by project staff.

(a) Ferrocement component financed by the projecc

(1) Component : Rectangular Septic Tank/Reservoir (Figure 53)

Location : Darussalam

Dimension : Length 1.5 m

Width 1.5 m

Height 1.5 m

Thickness 2 cm

Capacity : 2500 liters, 1 constructed

Construction Steps:

(i) preparation work

(ii) mesh reinforcement

(iii) wood work

(iv) plastering

(v) curing

(vi) finishing

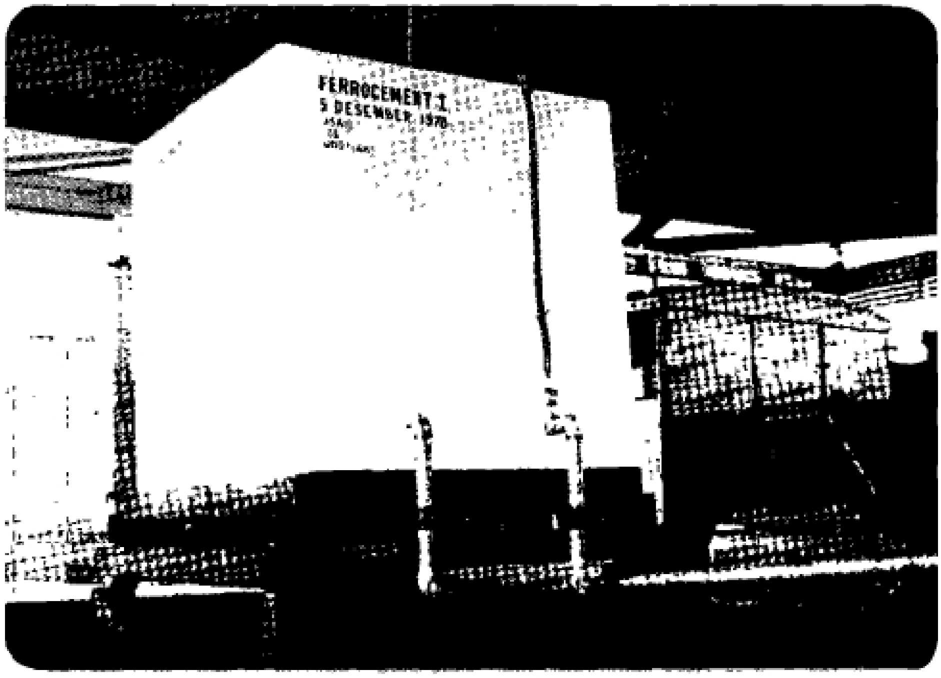



Fig. 53  Rectangular ferrocement water tank

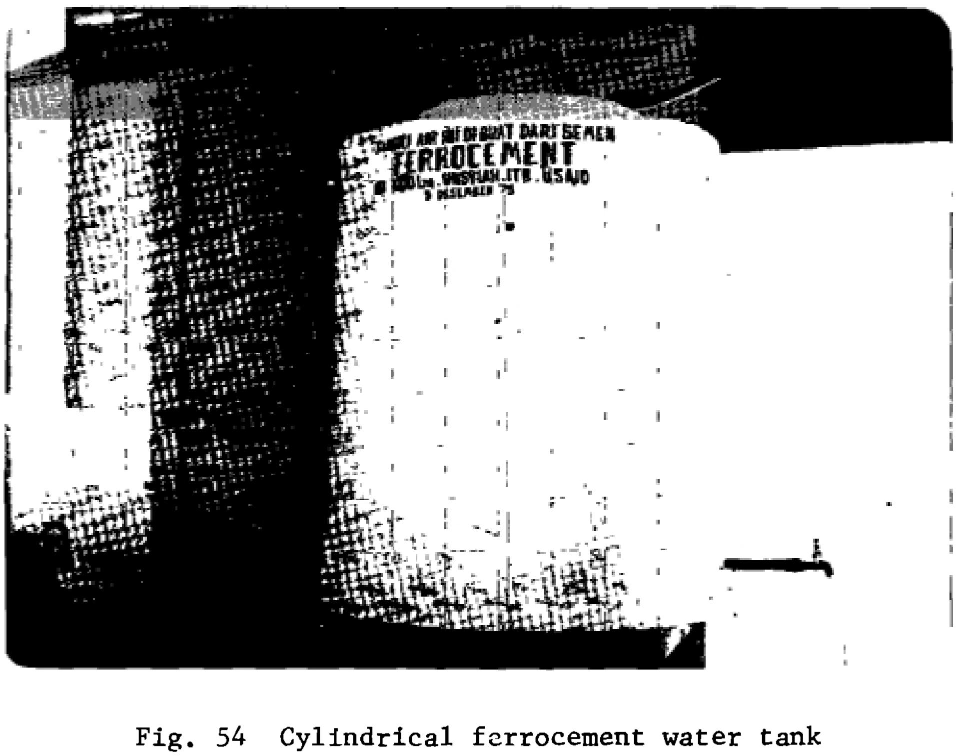



Fig. 54  Cylindrical ferrocement water tank

Construction time : 3 weeks

Personnel : 4 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 30 m |
| 2. | Iron rod Ø 3/8" | 2 pieces |
| 3. | Iron rod Ø 4 mm | 6 pieces |
| 4. | Cement | 7 bags |
| 5. | Tie wire | 2 kgs |
| 6. | Pipe joint | 3 pieces |
| 7. | Sand | 1 m3 |
| 8. | Gunny sack | 6 pieces |
| 9. | Plastic sheet | 10 m |
| 10. | Plastic rope | 20 m |
| 11. | L i m e | 5 kgs |
| 12. | W o o d | 0.5 m3 |
| 13. | B o l t | 8 kgs |
| 14. | N a i l s | 4 kgs |

(2) Component : Water tank, cylinder type (Figure 54)

Location : Darussalam, 1 constructed

Dimension : Diameter 1 m

Height 1.3 m

Thickness 2 cm

Capacity : 1000 liters

Construction Steps:

(i) Preparation work

(ii) mesh reinforcement

(iii) wood work

(iv) plastering

(v) curing

(vi) finishing

Construction time: 2 weeks

Personnel : 3 workers

Bill of materials:

| | | |
|---|---|---|
| 1. | Chicken wire | 20 m |
| 2. | Iron rod Ø 3/8" | 9 pieces |
| 3. | Tie wire | 0.5 kg |
| 4. | Cement | 4 bags |
| 5. | Sand | 0.5 m3 |
| 6. | Paint | 2 kgs |
| 7. | Pipe joint | 3 pieces |
| 8. | Wood | 0.25 m3 |
| 9. | Bolt | 2 kgs |
| 10. | Nails | 1 kg |

(3) Component : Small boat/canoe (Figure 55)

Location : Darussalam

Dimension : Length 3.8 m

Width 1.2 m

Wall thickness 2.5 cm

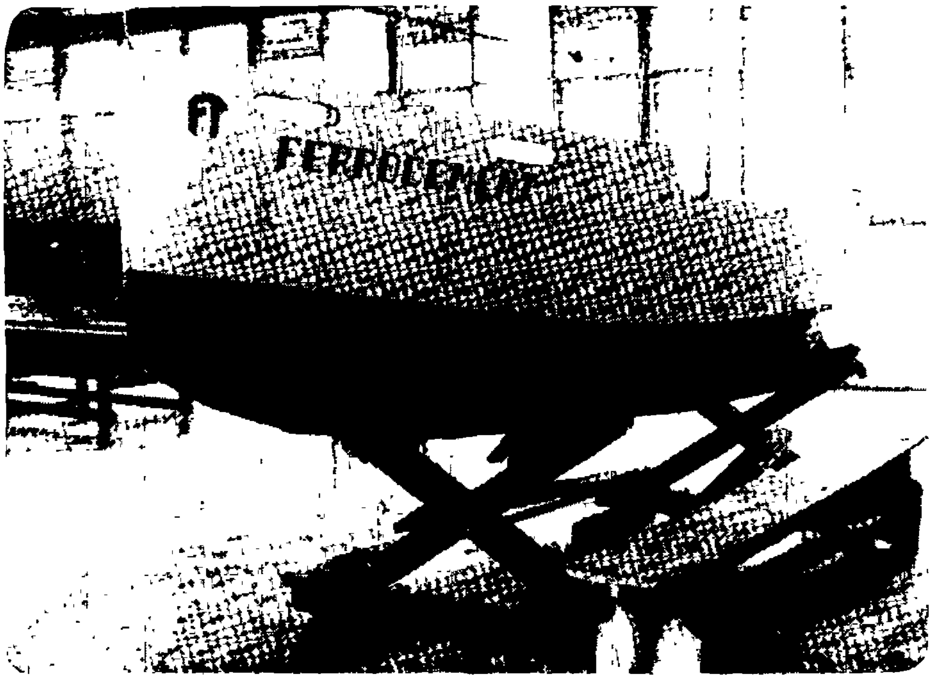



Fig. 55 Ferrocement small boat

Fig. 56 Ferrocement canoe, Deyah Baro

Construction Steps:

(i) preparation work

(ii) reinforcement

(iii) plastering

(iv) curing

(v) finishing

Construction time : 3 weeks

Personnel : 5 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 60 m |
| 2. | Iron rod Ø 3/8" | 20 pieces |
| 3. | Cement | 11 bags |
| 4. | Tie wire | 0.5 kgs |
| 5. | GI pipe Ø 3/4" | 2 pieces |
| 6. | Paint | 3 kgs |
| 7. | Sand | 1 m3 |
| 8. | Gunny sack | 6 pieces |
| 9. | Plastic sheet | 5 m |
| 10. | Plastic rope | 10 m |

(4) Component : Water container (Figure 57)

Location : Darussalam

Dimension : Length 1 m

Width 1 m

Height 1 m

Capacity : 1000 liters

Fig. 57 Ferrocement water container

Fig. 58 Ferrocement garden bench

Construction Steps:

(i) preparation work

(ii) reinforcement

(iii) plastering

(iv) curing and finishing

Construction time : 1 week

Personnel : 2 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 12 m |
| 2. | Iron rod Ø 3/8" | 4 pieces |
| 3. | Tie wire | 0.25 kg |
| 4. | Cement | 3 bags |
| 5. | Sand | 0.5 m3 |
| 6. | Gunny sack | 2 pieces |
| 7. | Plastic sheet | 2 m |

(5) Training Unit

| | | Amount |
|---|---|---|
| Component of Training : | - Rice bin | 1 |
| | - Culvert | 1 |
| | - Wall element | 2 |
| | - Containers | 9 |
| | - Garden benches | 2 |
| | - Garden stool | 8 |
| | - Children's slide | 1 |
| | - Ditch element | 2 |

| | Amount |
|---|---|
| - Water tank 1000 liters | 1 |
| - Flower Pot | 10 |
| - Dome | 1 |

Location : Darussalam - Aceh Besar

Duration of Training: 4 months

Personnel : 20 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 11 rolls |
| 2. | Iron rod Ø 3/8" | 112 pieces |
| 3. | Tie wire | 4 rolls |
| 4. | Cement | 102 bags |
| 5. | Sand | 21 m3 |
| 6. | GI pipe | 5 pieces |
| 7. | Paint & lime | 10 kgs |
| 8. | Rubber hand glove | 10 pairs |
| 9. | Gunny sack | 10 pieces |
| 10. | Plastic sheet | 20 m |
| 11. | Plastic rope | 30 m |
| 12. | Plastic bucket | 4 |

(6) Component : Boat (Figure 56)

Location : Deyah Baro - Aceh Besar, made 1

Dimension : Length 6.7 m

Width 1.2 m

Height 1.05 m

Wall thickness 2.5 cm

Construction Steps:

(i) preparation work

(ii) framing

(iii) mesh reinforcement

(iv) plastering

(v) curing and finishing

Construction time : 2 weeks

Personnel : 8 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 45 m |
| 2. | Iron rod Ø 3/8" | 10 pieces |
| 3. | Tie wire | 1 kg |
| 4. | Cement | 8 bags |
| 5. | Sand | 0.5 m3 |
| 6. | GI sheet | 2 sheets |
| 7. | Wood plank | 2 pieces |
| 8. | Paint | 5 kgs |
| 9. | Nail and bolt | 1 kg |
| 10. | Plastic rope | 10 m |
| 11. | Gunny sack | 10 pieces |

(7) Component : Ceiling Mosque Dome (Figure 59)

Location : Lhueng Bata - Aceh Timur

Dimension : Diameter 10 m

Height 2 m

Construction Steps:

(i) preparation work

(ii) scaffolding construction

(iii) framing and skeleton

(iv) mesh reinforcement

(v) plastering

(vi) curing and finishing

Construction time : 1 month

Personnel : 10 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 400 m |
| 2. | GI pipe Ø 1 1/4" | 14 pieces |
| 3. | Iron rod Ø 3/8" | 40 pieces |
| 4. | Iron rod Ø 1/4" | 30 pieces |
| 5. | Tie wire | 3 kgs |
| 6. | Electroda | 3 dooz |
| 7. | Scaffold materials (wood) | 1 m3 |
| 8. | Sand | 3 m3 |
| 9. | Gunny sack | 20 pieces |
| 10. | Plastic rope | 50 m |

(7) Component : Ceiling Mosque Dome (Figure 59)

Location : Lhueng Bata - Aceh Timur

Dimension : Diameter 10 m

Height 2 m

Construction Steps:

(i) preparation work

(ii) scaffolding construction

(iii) framing and skeleton

(iv) mesh reinforcement

(v) plastering

(vi) curing and finishing

Construction time : 1 month

Personnel : 10 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 400 m |
| 2. | GI pipe Ø 1 1/4" | 14 pieces |
| 3. | Iron rod Ø 3/8" | 40 pieces |
| 4. | Iron rod Ø 1/4" | 30 pieces |
| 5. | Tie wire | 3 kgs |
| 6. | Electroda | 3 dooz |
| 7. | Scaffold materials (wood) | 1 m3 |
| 8. | Sand | 3 m3 |
| 9. | Gunny sack | 20 pieces |
| 10. | Plastic rope | 50 m |

Fig. 59 Plastering ferrocement ceiling dome

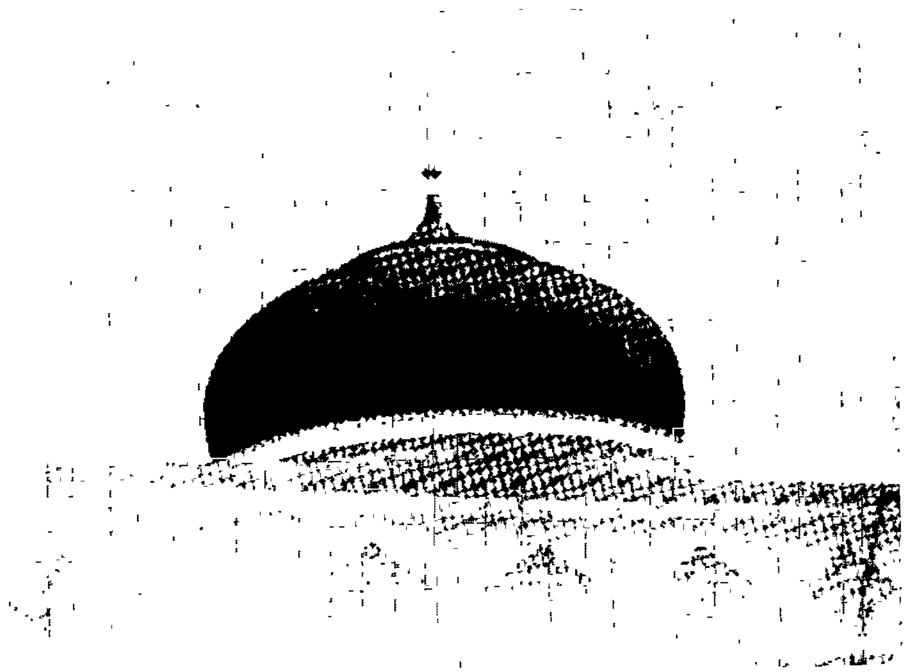


Fig. 60 The mosque dome viewed from the outside

(8) Component : Small Mosque (Mushalla)

Location : Tapak Tuan - Aceh Selatan, Desa Jambu Apha

Dimension : 3 by 4 m (12 m2)

Construction Steps:

(i) preparation work

(ii) foundation and floor construction

(iii) roof construction

(iv) reinforcement

(v) plastering

(vi) curing and finishing

Construction time : 2 weeks

Personnel : 6 - 10 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 43 m |
| 2. | Iron rod Ø 3/8" | 15 pieces |
| 3. | Tie wire | 0.5 kg |
| 4. | Cement | 9 bags |
| 5. | Sand | 2 m3 |
| 6. | Paint | 4 kgs |
| 7. | Wood 6/8 cm | 22 pieces |
| 8. | Wood plank | 3 pieces |
| 9. | GI sheet BWG 32 | 10 sheets |
| 10. | Nail | 6 kgs |
| 11. | Gravel | 2 m3 |
| 12. | Sand for soil improvement | 15 m3 |

(9) Component : Water tank, washing facilities for the mosque (Figure 61)

Location : Desa Tengah, Tapak Tuan - Aceh Besar

Dimension : The area of facilities: 4 by 4 (16 m2)

water tank: diameter 1.20 m

height 1.50 m

Capacity : 1600 liters

Construction Steps:

(i) preparation work

(ii) framing

(iii) mesh reinforcement

(iv) plastering

(v) curing and finishing

Construction time : 2 weeks

Personnel : 8 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 22 m |
| 2. | Iron rod Ø 3/8" | 8 pieces |
| 3. | Tie wire | 1.5 kgs |
| 4. | Cement | 6 bags |
| 5. | Paint | 1 kg |
| 6. | Sand | 0.75 m3 |
| 7. | Split stone | 2 m3 |
| 8. | Faucet | 6 sets |
| 9. | GI pipe Ø 1" | 6 m |
| 10. | Zinc plate | 10 m |

11. Cement 3 bags

12. Sand 2 m3

(10) Component : Water tank, washing facilities for the mosque (Figure 62)

Location : Desa Tengah, Tapak Tuan - Aceh Selatan

Dimension : wall area : 23.2 m2

water tank : diameter 1.5 m

height 0.7 m

Capacity : 1200 liters

Construction Steps:

(i) preparation work

(ii) framing

(iii) reinforcement

(iv) plastering

(v) curing and finishing

Construction time : 2 weeks

Personnel : 8 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 76 m |
| 2. | Iron rod Ø 3/8" | 19 pieces |
| 3. | Cement | 13 bags |
| 4. | Tie wire | 0.75 kgs |
| 5. | Sand | 2.5 m3 |
| 6. | Gravel | 2 m3 |

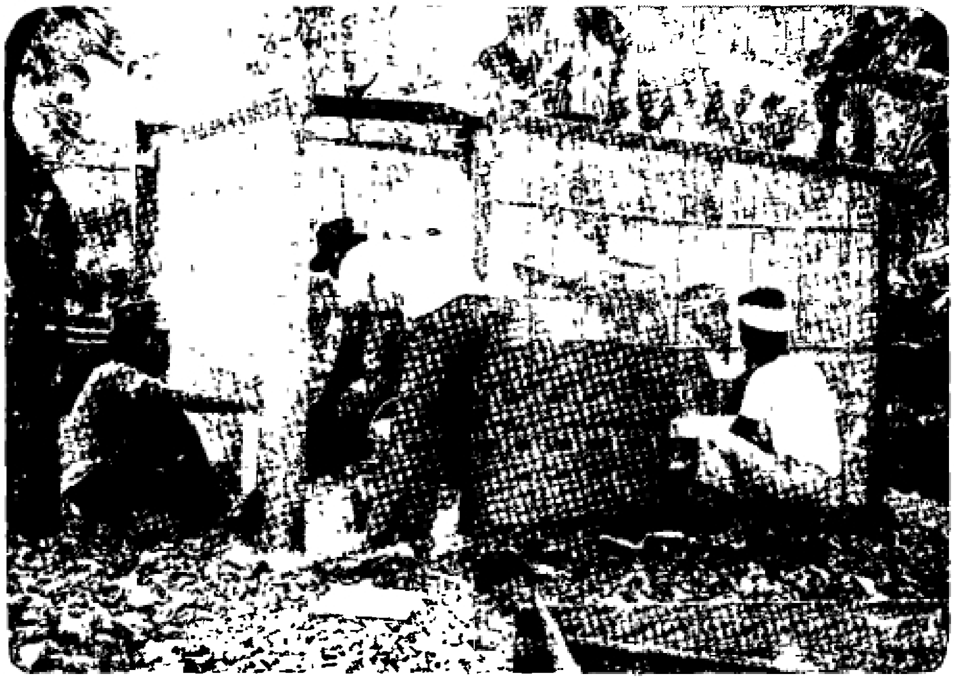
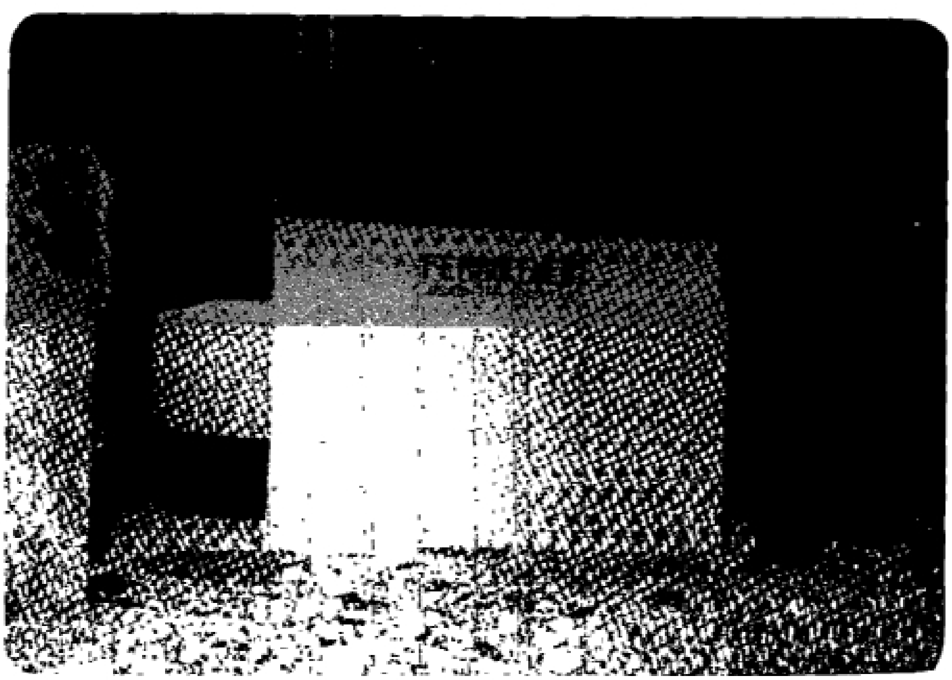


Fig. 61 & 62 Water facilities for purification rite
at the mosque ferrocement wall & water tank



| | | |
|---|---|---|
| 7. | Split stone | 2 m3 |
| 8. | Faucet | 4 sets |
| 9. | GI pipe 1/2" | 1 piece |
| 10. | Wood plank 4 cm thick | 2 pieces |
| 11. | GI sheet | 2 sheets |
| 12. | Nail | 1 kg |
| 13. | Paint | 4 kgs |

(11) Component : Water tank, washing facilities for the mosque (Figure 63)

Location : Desa Jambu Apha, Tapak Tuan Aceh Selatan

Dimension : Floor area 3 m x 3 m

Water tank : diameter 1.2 m

height 1.2 m

Capacity : 1300 liters

Construction Steps:

(i) preparation work

(ii) framing

(iii) reinforcement

(iv) plastering

(v) curing and finishing

Construction time : 2 weeks

Personnel : 7 workers

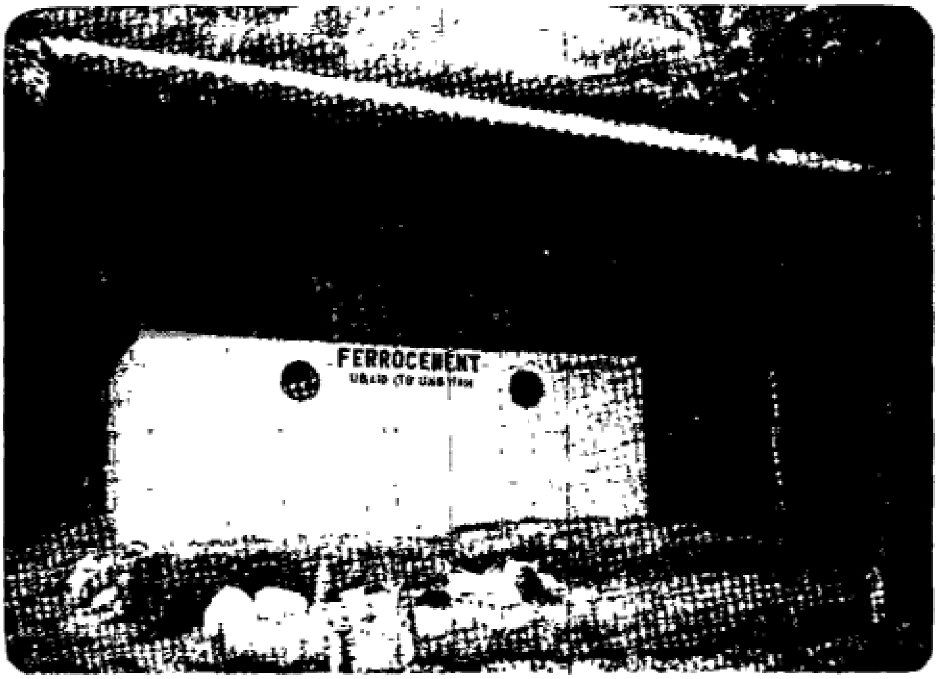



Fig. 63 & 64 Water facilities for purification rite at the mosque; ferrocement wall & water tank

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 15 m |
| 2. | Iron rod Ø 3/8" | 8 pieces |
| 3. | Tie wire | 1 kg |
| 4. | Cement | 3 bags |
| 5. | Paint | 2 kgs |
| 6. | Sand | 0.5 kg |
| 7. | Foundation stone | 3 m3 |
| 8. | Gravel | 2 m3 |
| 9. | Sand | 1.5 m |
| 10. | Cement | 4 bags |
| 11. | Faucet | 4 sets |
| 12. | GI pipe | 1 piece |
| 13. | Zinc plate | 10 m |

(11) Component : Water tank, washing facilities for the mosque (Figure 64)

Location : Desa Pantai Tapak Tuan
Aceh Selatan

Dimension : Floor area 4 by 4 (16 m2)
Wall area 36 m2
Water tank: diameter 1.20 m
height 1.20 m

Capacity : 1300 liters

Construction Steps:

(i) preparation work

(ii) framing

(iii) mesh reinforcement

(iv) plastering

(v) curing and finishing

Construction time : 3 weeks

Personnel : 8 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 102 m |
| 2. | Iron rod Ø 3/8" | 47 pieces |
| 3. | Tie wire | 6 kgs |
| 4. | Cement | 12 bags |
| 5. | Paint | 7 kgs |
| 6. | Sand | 3 m3 |
| 7. | Foundation stone | 1.5 m3 |
| 8. | Gravel | 3 m3 |
| 9. | Sand | 3 m3 |
| 10. | Wood 5/7 cm | 16 pieces |
| 11. | Pipe joint and faucet | 5 sets |
| 12. | Nail | 1 kg |
| 13. | Cement | 5 bags |

(13) Component : Mosque entrance Verandah (Figure 66)

Location : Desa Hilir, Tapak Tuan
Aceh Selatan

Dimension : Floor area : 2.5 m x 14 m
Entrance height : 3 m

Construction Steps:

(i) preparation work
(ii) framing
(iii) mesh reinforcement
(iv) plastering
(v) curing and finishing

Construction time : 3 weeks

Personnel : 9 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 200 m |
| 2. | Iron rod Ø 3/8" | 50 pieces |
| 3. | Cement | 20 bags |
| 4. | Tie wire | 10 kgs |
| 5. | Paint | 10 kgs |
| 6. | Sand | 4 m3 |
| 7. | Wood | 1.5 m3 |
| 8. | Zinc plate | 20 sheets |
| 9. | Nail | 10 kgs |

Fig. 65 & 66 Ferrocement entrance mosque and verandah

(14) Component : Fishing boat (Figure 67)

Location : Desa Jambu Apha, Tapak Tuan
Aceh Selatan

Dimension : Length 7 m
Width 1.40 m

Construction Steps:

(i) preparation work
(ii) framing
(iii) mesh reinforcement
(iv) plastering
(v) curing and finishing

Construction time : 2 weeks

Personnel : 8 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 95 m |
| 2. | Iron rod Ø 3/8" | 17 pieces |
| 3. | Tie wire | 1.5 kgs |
| 4. | Cement | 8 bags |
| 5. | Sand | 1.5 m3 |
| 6. | Paint | 4 kgs |
| 7. | Wood 3/6 - 8 m | 2 pieces |
| 8. | Wood 6/8 cm | 6 pieces |
| 9. | Bamboo | 10 pieces |
| 10. | Nail | 0.5 kg |
| 11. | Plastic rope | 10 m |

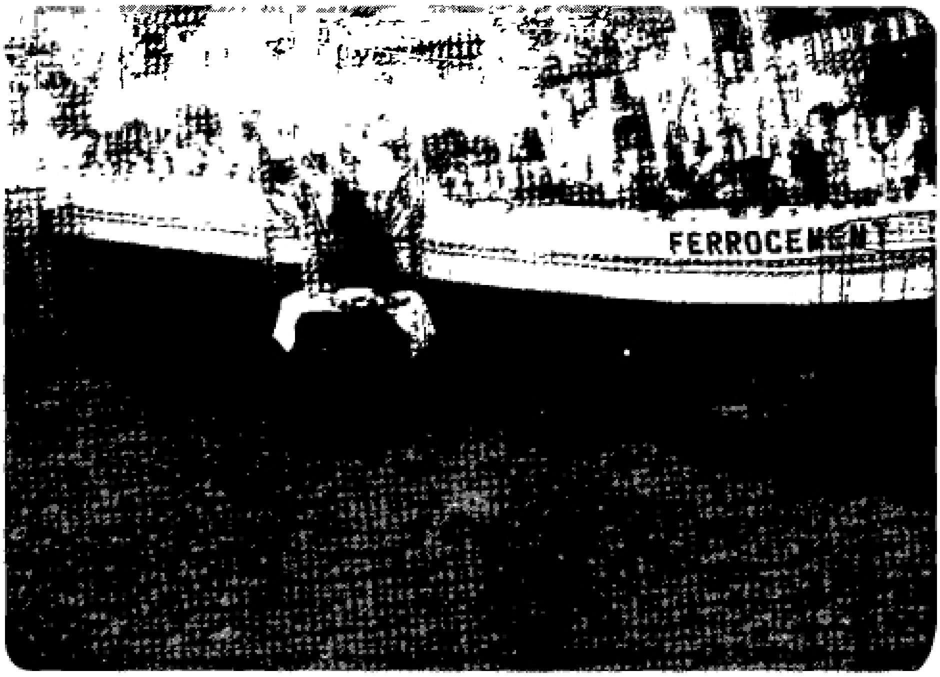



Fig. 67 Ferrocement fishing boat in launching ceremony

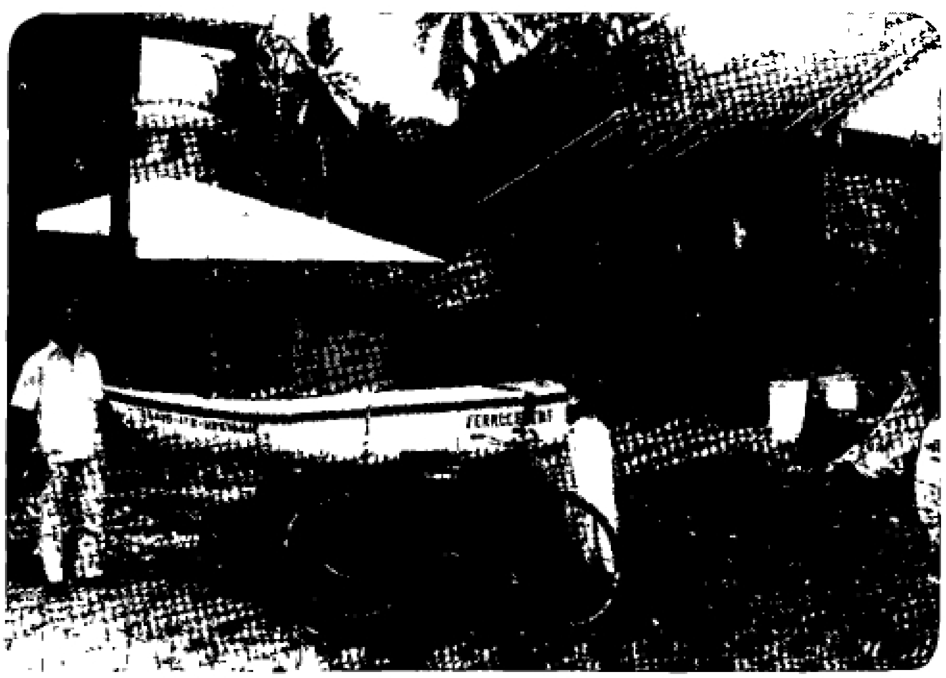


Fig. 68 Ferrocement sampan about to be launched

12. Plastic sheet 20 m
13. Gunny sack 10 pieces
14. Screws 30 pieces

(15) Component : Sampan (Canoe) (Figure 68)

Location : Desa Tengah, Tapak Tuan
Aceh Selatan

Dimension : Length 3.5 m
Width 0.8 m

Construction Steps:

(i) preparation work
(ii) framing
(iii) mesh reinforcement
(iv) plastering
(v) curing and finishing

Construction time : 1 week

Personnel : 4 workers

Bill of Materials :

1. Chicken wire 25 m
2. Iron rod Ø 3/8" 8 pieces
3. Tie wire 1 kg
4. Cement 3 bags
5. Paint 1.5 kgs
6. Sand 0.5 m3
7. Gunny sack 3 pieces

(16) Component : Small mosque dome (Figure 70)

Location : Desa Jambu Apha, Tapak Tuan
Aceh Selatan

Dimension : Diameter 3 m
Height 1.5 m

Construction Steps:

(i) preparation work

(ii) framing

(iii) mesh reinforcement

(iv) plastering

(v) curing and finishing

Construction time : 2 weeks

Personnel : 8 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 108 m |
| 2. | Iron rod Ø 3/8" | 20 pieces |
| 3. | Tie wire | 1.5 kgs |
| 4. | Cement | 13 bags |
| 5. | Paint | 10 kgs |
| 6. | Sand | 1.5 m3 |
| 7. | Wood 12/12 and 5/12 | 4 pieces |
| 8. | Bolt | 12 pieces |
| 9. | Gunny sack | 10 pieces |
| 10. | Plastic rope | 20 m |

Fig. 69 Plastering of small ferrocement dome

Fig. 70 A finished ferrocement small dome,
Tapak Tuan

(17) Component : Dome and gutter

Location : Kota Tapak Tuan
Aceh Selatan

Dimension : Dome : diameter 10 m
height 8.7 m
Gutter : length 150 m

Construction Steps:

(i) preparation work
(ii) framing and skeleton
(iii) mesh reinforcement
(iv) plastering
(v) curing and finishing

Construction time : 1.5 months

Personnel : 8 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 783 m |
| 2. | Iron rod Ø 3/8" | 152 pieces |
| 3. | Tie wire | 25 kgs |
| 4. | Cement | 85 bags |
| 5. | Sand | 6 m3 |
| 6. | Wood 5/12 | 20 pieces |
| 7. | Nail | 1 kg |
| 8. | Plastic rope | 40 m |
| 9. | Gunny sack | 20 pieces |
| 10. | Paint | 25 kgs |

(18) Component : Ferrocement house: type 70 (Figure 72) one made

Location : Darussalam

Dimension :

| | | |
|---|---|---|
| Terras | 2,5m x 3 m | |
| Living Room | 3 m x 5.5 m | |
| Dining Room | 3 m x 3 m | |
| Bed Room | 3 m x 3 m | |
| Bed Room | 3 m x 4 m | |
| Bath Room | 2 m x 2 m | |
| Kitchen | 3 m x 3 m | |

Wall thickness 3 cm

Construction Steps:

(i) preparation work

(ii) skeleton and reinforcement

(iii) wood work

(iv) foundation and floor construction

(v) plastering wall

(vi) roof work

(vii) curing

(viii) finishing

Construction time : 2 months

Personnel : 6 to 11 workers

Bill of Materials :

1. Chicken wire 21 rolls
2. Tie wire 32 kgs
3. Cement 149 bags
4. Sand 5 trucks

Fig. 71 Ferrocement folded plate terras roof of the house

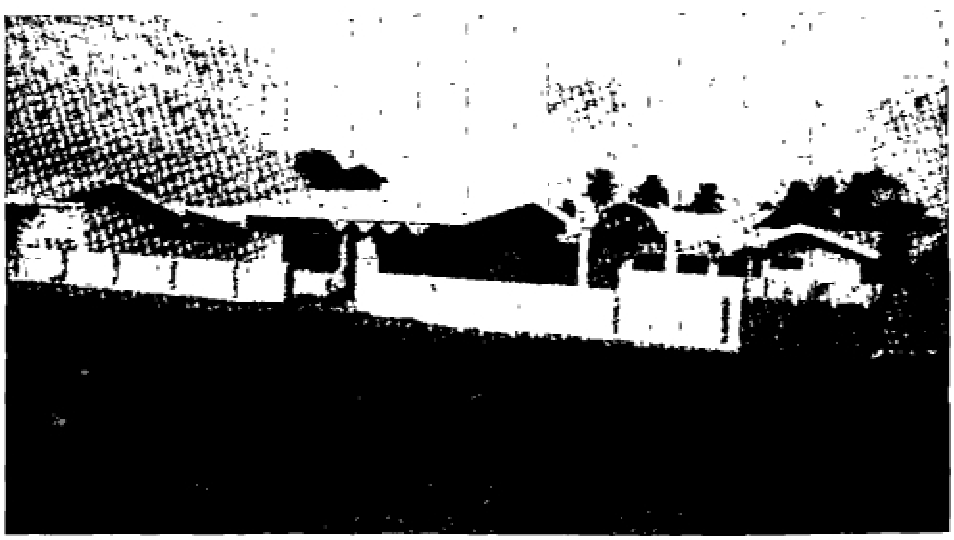


Fig. 72 Prototype of ferrocemént house, type 70. All main structures are ferrocement, including the wall

| | | |
|---|---|---|
| 5. | Iron rod Ø 3/8" | 225 pieces |
| 6. | Iron rod Ø 1/4" | 104 pieces |
| 7. | Paint | 10 pints |
| 8. | Cement | 178 bags |
| 9. | Sand | 3 trucks |
| 10. | Gravel | 4 trucks |
| 11. | Sand for land improvement | 40 trucks |
| 12. | Door | 7 sets |
| 13. | Window | 10 sets |
| 14. | Wood | 1.3 m3 |
| 15. | GI sheet | 42 sheets |
| 16. | Nail | 5 kgs |
| 17. | Nail | 5 kgs |
| 18. | Door lock | 7 sets |
| 19. | Hinge | 14 sets |
| 20. | Plastic sheet | 2 rolls |
| 21. | Gunny sack | 20 pieces |
| 22. | Plastic rope | 20 m |
| 23. | Bolt | 10 kgs |
| 24. | Lime | 25 kgs |

(19) Component : Car garage (Figure 74)

Location : Darussalam

Dimension : Barrel shell type roof

Cover area 3 m x 6 m

Construction Steps:

(i) preparation work

(ii) skeleton and framing

(iii) mesh reinforcement

(iv) plastering

(v) curing and finishing

Construction time : 3 weeks

Personnel : 6 workers

Bill of Materials :

| | | |
|---|---|---|
| 1. | Chicken wire | 310 m |
| 2. | Iron rod Ø 3/8" | 84 pieces |
| 3. | Iron rod Ø 1/4" | 30 pieces |
| 4. | Tie wire | 15 kgs |
| 5. | Cement | 62 bags |
| 6. | Sand | 12 m3 |
| 7. | Paint | 4 pints |
| 8. | Foundation stone | 6 m3 |
| 9. | Sand for soil improvement | 8 m3 |
| 10. | Gravel mixed with soil | 6 m3 |

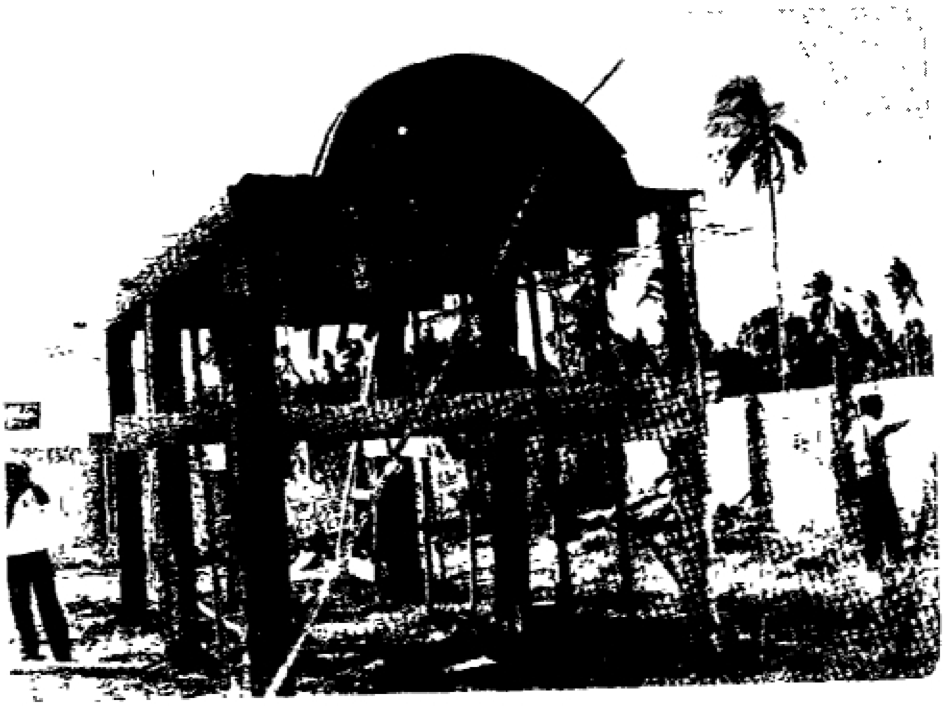


Fig. 73 Ferrocement garage during construction

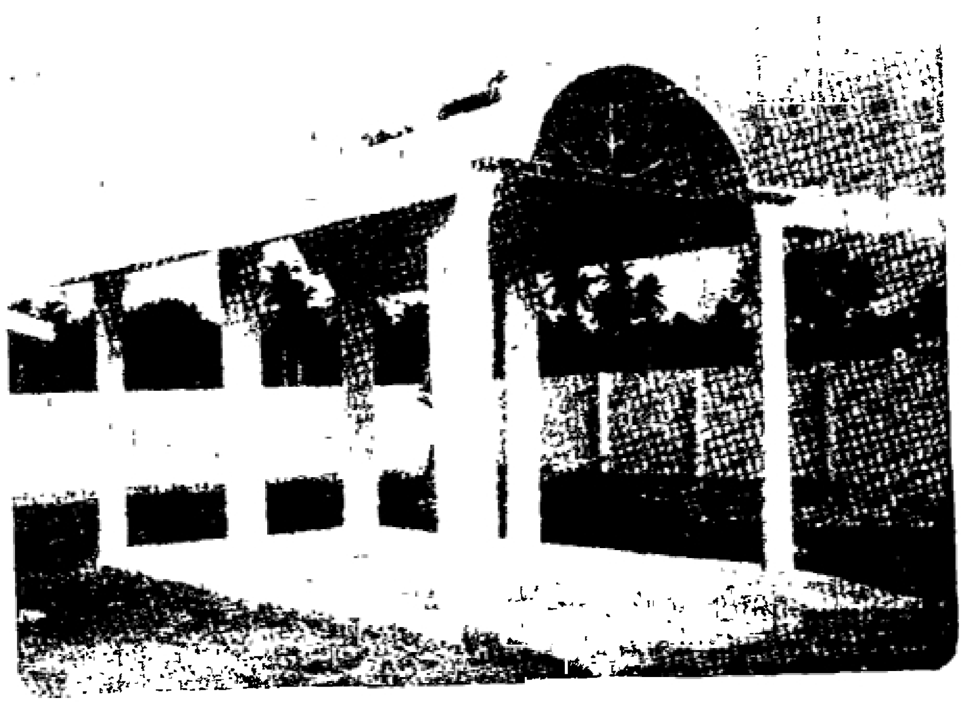


Fig. 74 Ferrocement barrel shell garage

Materials price list in Banda Aceh for 1979 and 1980

| No. | Name of Materials | 1979 Rp. | 1980 Rp. | Unit |
|---|---|---|---|---|
| 1. | Chicken wire | 700 | 900 | meter |
| 2. | Tie wire | 600 | 800 | kg |
| 3. | Iron rod Ø 3/8" | 1,600 | 1,800 | piece |
| | Ø 6 mm | 750 | 1,000 | piece |
| | Ø 8 mm | 1,150 | 1,400 | piece |
| 4. | Plaster mesh | 2,200 | 2,500 | piece |
| 5. | GI pipe Ø 1/2" | 3,100 | 3,500 | piece |
| | Ø 3/4" | 4,600 | 5,000 | piece |
| | Ø 1" | 6,150 | 6,500 | piece |
| 6. | PVC Ø 1/2" | 2,500 | 2,800 | piece |
| | Ø 1" | 4,200 | 4,500 | piece |
| 7. | Faucet Ø 1/2" Brass | 750 | 880 | set |
| | Chrome | 1,500 | 1,650 | set |
| 8. | N a i l | 550 | 650 | kg |
| 9. | GI sheet BWG 32" - 8' | 2,500 | 2,750 | sheet |
| | BWG 32" - 6' | 1,950 | 2,100 | sheet |
| 10. | Cement - Padang | 2,250 | 2,750 | bag |
| 11. | S a n d | 6,000 | 7,000 | m3 |
| 12. | Gravel | 7,000 | 8,500 | m3 |
| 13. | River stone (foundation) | 5,500 | 7,000 | m3 |
| 14. | Brick (clay) | 40 | 50 | piece |
| 15. | L i m e | 100 | 125 | kg |
| 16. | Wall paint | 3,000 | 3,300 | kg |
| 17. | Wood paint | 800 | 1,000 | kg |
| 18. | Wood Semantok | 111,000 | 125,000 | m3 |
| | Wood Meranti | 65,000 | 80,000 | m3 |
| 19. | Wood Bakan | 450 | 650 | piece |
| 20. | B o l t | 125 | 175 | piece |

Labor cost list in Banda Aceh for 1979 and 1980

| No. | Skill | 1979 | 1980 |
|---|---|---|---|
| | | Rp/day | Rp/day |
| 1. | Worker | 1,000 | 1,250 |
| 2. | Foreman | 1,250 | 1,500 |
| 3. | Head Worker | 2,250 | 2,500 |
| 4. | Masonry Worker | 1,250 | 1,500 |
| 5. | Head of Masonry Worker | 2,500 | 3,000 |
| 6. | Electrician | 1,500 | 2,000 |
| 7. | Steel Worker | 1,500 | 2,000 |
| 8. | Carpenter | 1,200 | 1,500 |
| 9. | Head of Steel work | 2,500 | 3,000 |
| 10. | Painter | 1,250 | 1,500 |
| 11. | Head of Painter | 2,500 | 3,000 |
| 12. | Earth Worker | 1,000 | 1,250 |

(b) Component being constructed financed from outside of the project, supervised by the project staff

| No. | Name of Component | Location | Number of Component |
|---|---|---|---|
| 1. | Small Mosque (roof, wall from ferrocement) | Tapak Tuan Aceh Selatan | 1 |
| 2. | Mosque Dome - owned by Local Public Works Department | Tapak Tuan Aceh Selatan | 1 |
| 3. | Wall of two-floor house | Lam Nyong (Aceh Besar) | 1 |
| 4. | Mosque Dome | Sukaramai Banda Aceh | 1 |
| 5. | Wall Construction | Campus Darussalam | 1 |
| 6. | Water tank | Campus Darussalam | 1 |
| 7. | House Terras Canopy | Lamprit Banda Aceh | 1 |
| 8. | Two-floor house | Punge Banda Aceh | 1 |
| 9. | Two-floor shopping complex | Banda Aceh | 1 |
| 10. | Wall of a church | Banda Aceh | 1 |
| 11. | Children's play ground | Banda Aceh | 1 |
| 12. | Wall of a house | Deyah Baro Aceh Besar | 1 |
| 13. | Septic tank | Punge Banda Aceh | 1 |
| 14. | Mosque Dome | Batee Aceh Pidie | 1 |

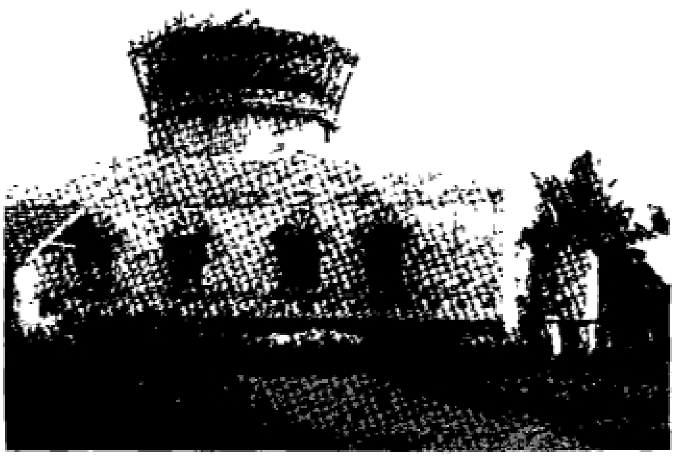


Fig. 75 Ferrocement mosque dome at Tapak Tuan, diameter of 10 m

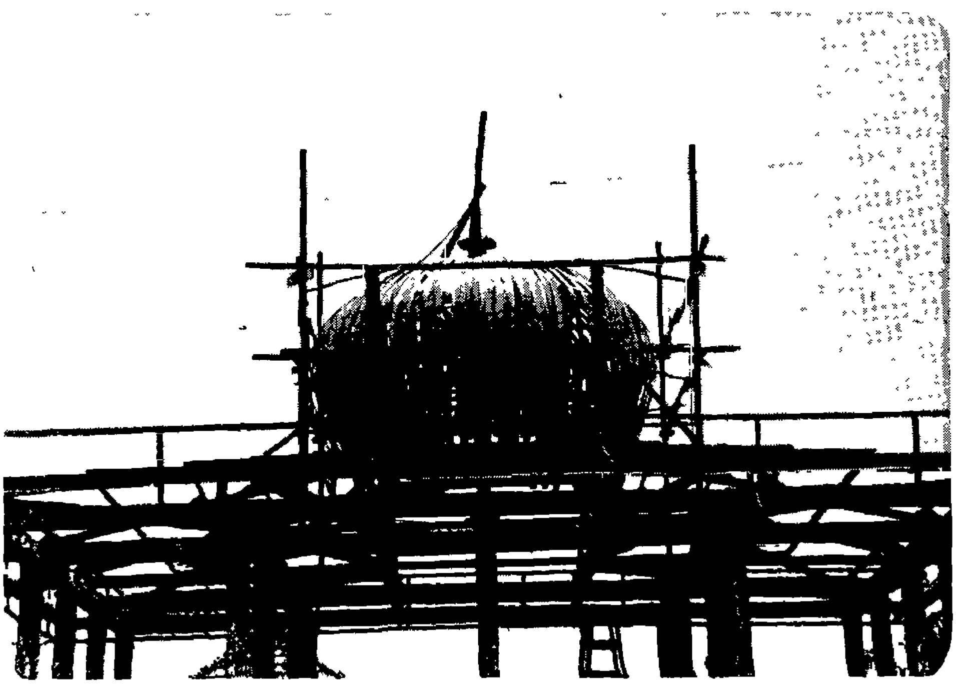


Fig. 76 The conventional method of mosque dome construction

Fig. 77 Ferrocement terras canopy

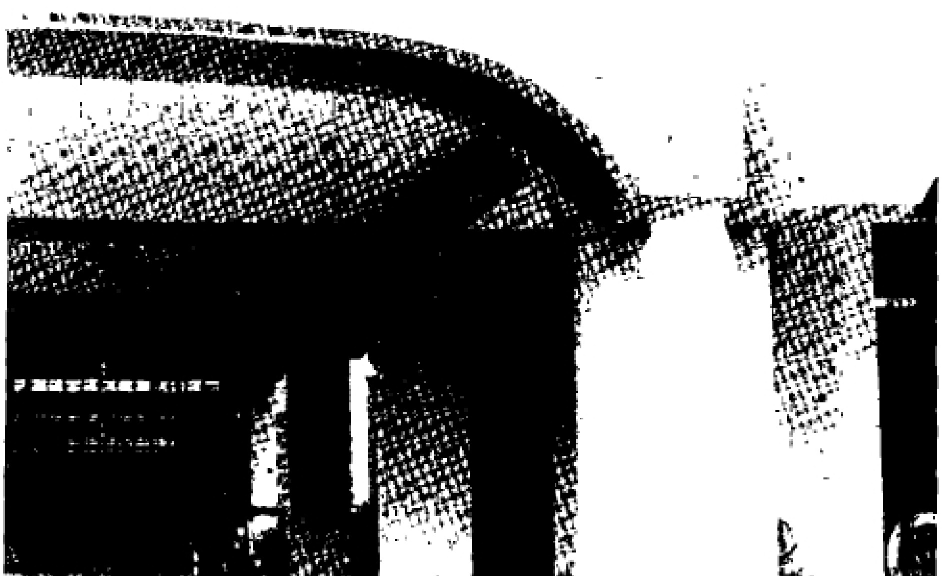


Fig. 78 Typical rib structure of ferrocement canopy

Fig. 79 Ferrocement shopping complex; wall and floor

Fig. 80 Another ferrocement house completed; owned by Ir. Bustam Husin, one of the project staff

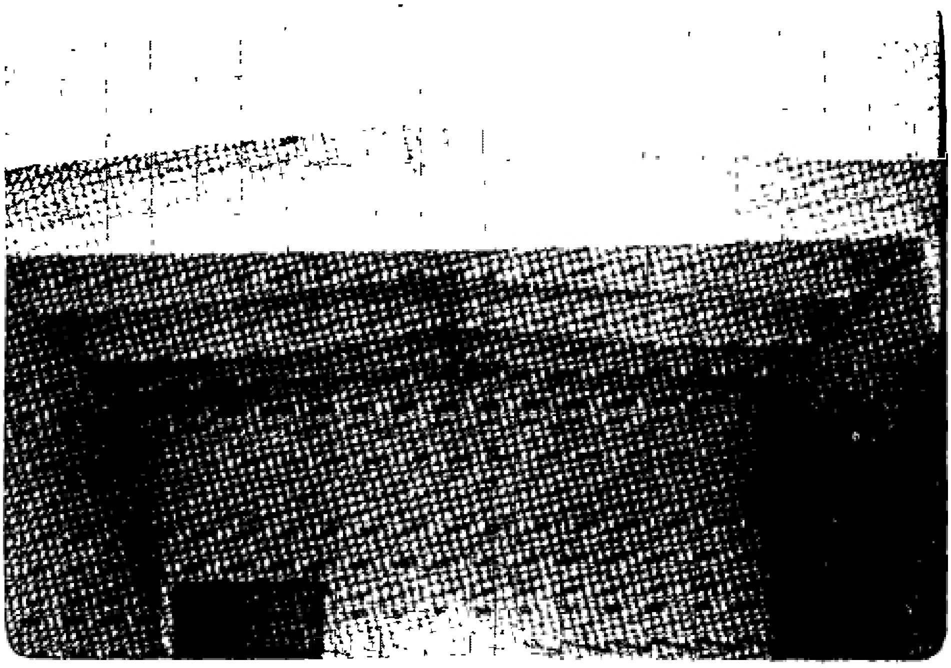


Fig. 81 Typical rib slab ferrocement floor of the shopping complex

Fig. 82 Living room ceiling of the house, thin shell structure

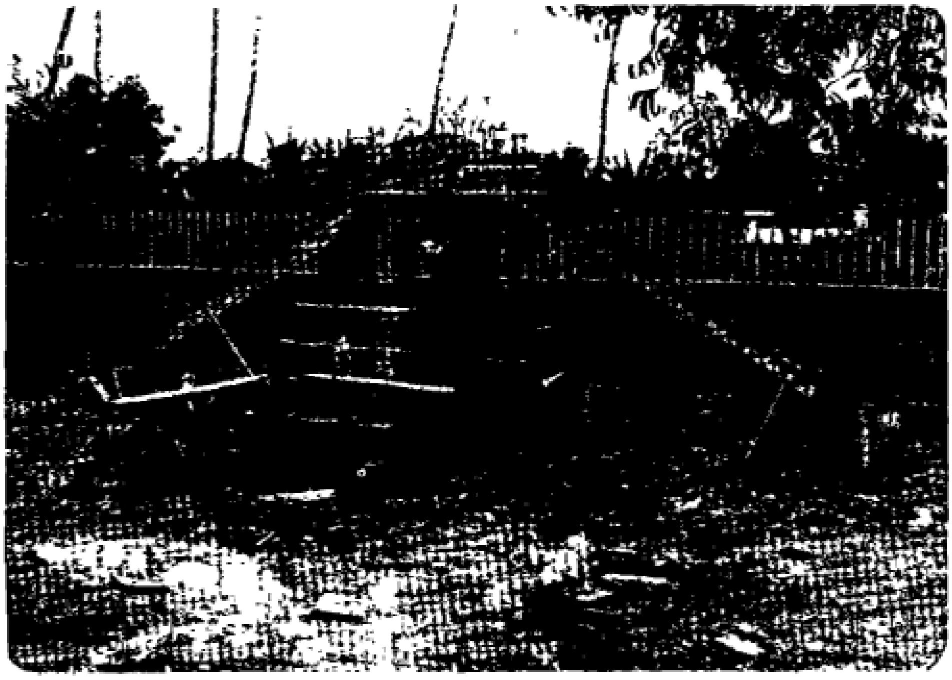
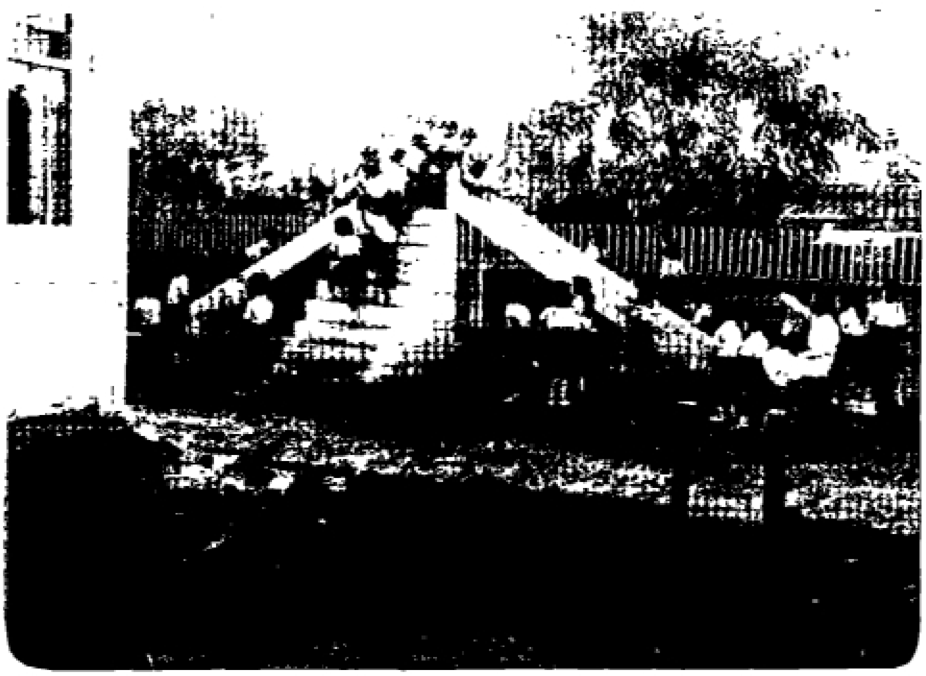


Fig. 83 & 84  Ferrocement slide in the children's play ground



# MAP OF ACEH PROVINCE

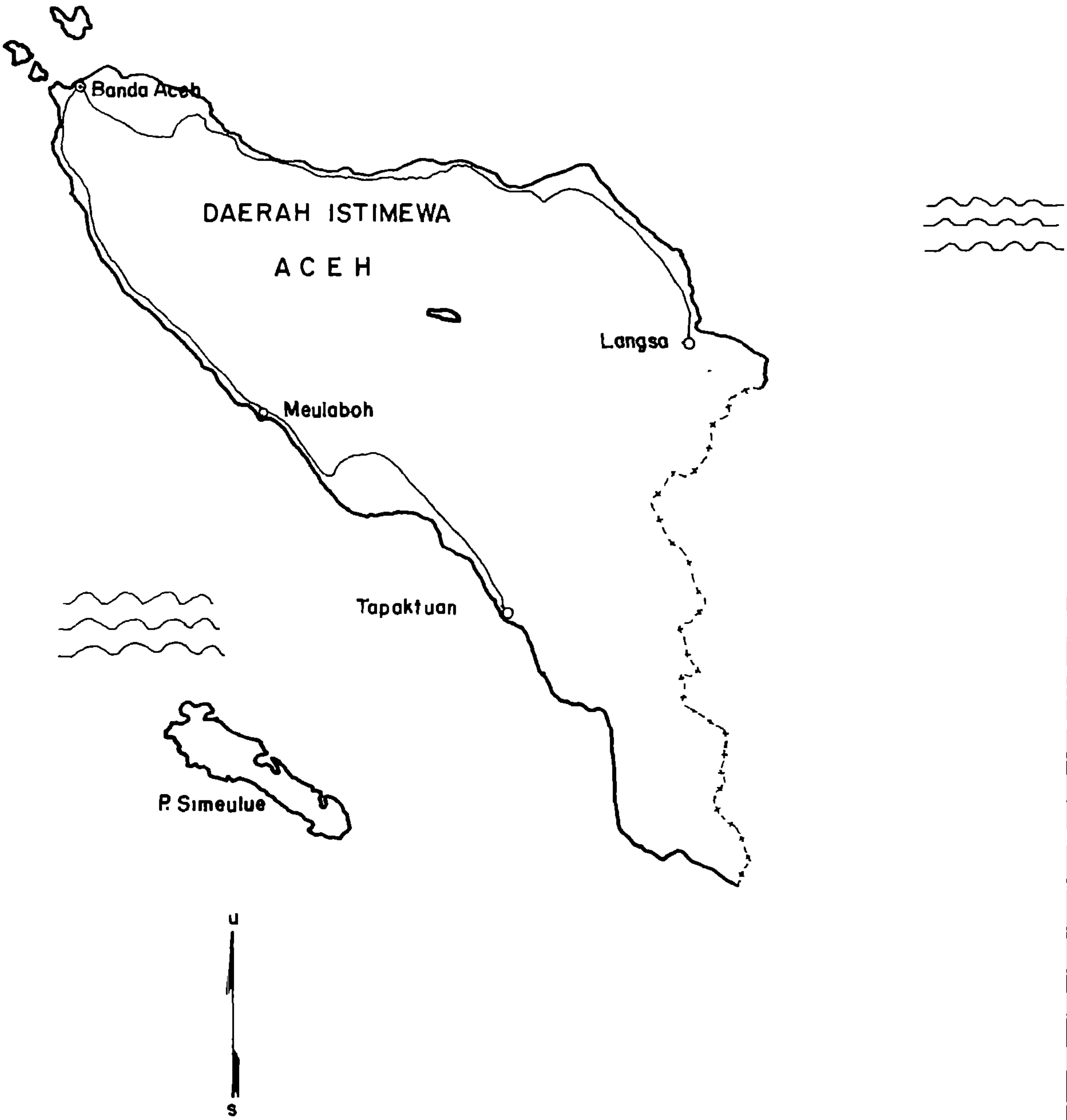



Fig. 85

Scale 1: 34 000.000

# 4.0. PROJECT RESULTS

## 4.1. WEST JAVA

### 4.1.1. Hardware Output

The "output" from the projects done in the sites selected by DTC-ITB can be classified according to the approach done:

1. Community development approach
2. Hardware development approach
3. Hardware development implementation approach

#### 4.1.1.1. Community Development Approach

In this approach the hardware being developed is aimed principally at community development based on the study of the local needs, taking into account the fact of local support for the working out of the technology to be developed. The sequence of development always considers the social aspect of community development as mentioned in section 2.5.1.1. The output from this approach is generally a hardware net - work that will be utilized in a proposed system. In this case it is the rural water supply system which is still a serious problem in West Java. Because the object is community development, the determination of the project and site selection constitutes a critical step in the planning. Of the several possibilities surfaced, DTC-ITB designated several projects for clean water supply in the village of Buniwangi, Sukabumi District. It encompasses:

1. Water source conservation and protection
2. Water transportation and distribution
3. Water storage
4. Water clarification

- Community of Cimanggu

  Water supply system consisting of water storage tank, ditch lining and a foot bridge

- Community of Cisalada and Citapen

  Water supply system consisting of a small dam, piping of ferrocement and fiber cement, water storage tank, and public facilities.

4.1.1.2. Hardware Development Approach

In this approach the component that is going to be applied is first developed. Even while the hardware was in its first stages of development, the project design and project design and project execution took into account the social and economic viability in terms of its future application, hence it followed the project design criteria described in Section 2.5.1.1. During the actual execution, it was found that the social and economic aspects played very important roles, the location and the component under development being strictly related.

1. Village of Cikarang
   - Ferrocement shelter, hypar type, to be utilized as shelter and small public building
   - Ferrocement pontoon ferry as part of the road system
2. District of Bandung
   - Ferrocement tower and dome to be used as a minaret for a mosque
3. Fiber Cement development
   - Material to be developed utilize the available organic fiber to make:
     - fiber cement pipes to be used in the water supply system
     - fiber cement corrugated roofing sheet for low-cost housing
     - fiber cement bamboo matting wall to be used in light and shock-proof construction.

Most of these hardware developed and tested are parallel to the community development project in Section 4.1.1.1. The results from the testing of the components are written up as manuals. (See manuals)

4.1.1.3. Hardware Development Implementation Approach

In this approach the hardware previously developed in one location is revised to be applied in a different location with similar circumstances.

1. District of Bandung

   - Ferrocement Hypar Mosque: developed and implemented from the development of the shelter in Cikarang
   - Bus shelter: shell-type in front of ITB

2. Village of Citarik District of Sukabumi

   - Water supply system: developed and implemented from the results of the field development in the village of Buniwangi
   - Community of Cijayanti

     Water supply system consisting of water storage tank, public toilet and faucet
   - Community of Cilimus

     Water storage tank and public water facilities
   - Community of Ciawun

     Water supply system consisting of water catchment, fiber cement piping, public water facilities.

# MAP OF DISTRICT OF SUKABUMI



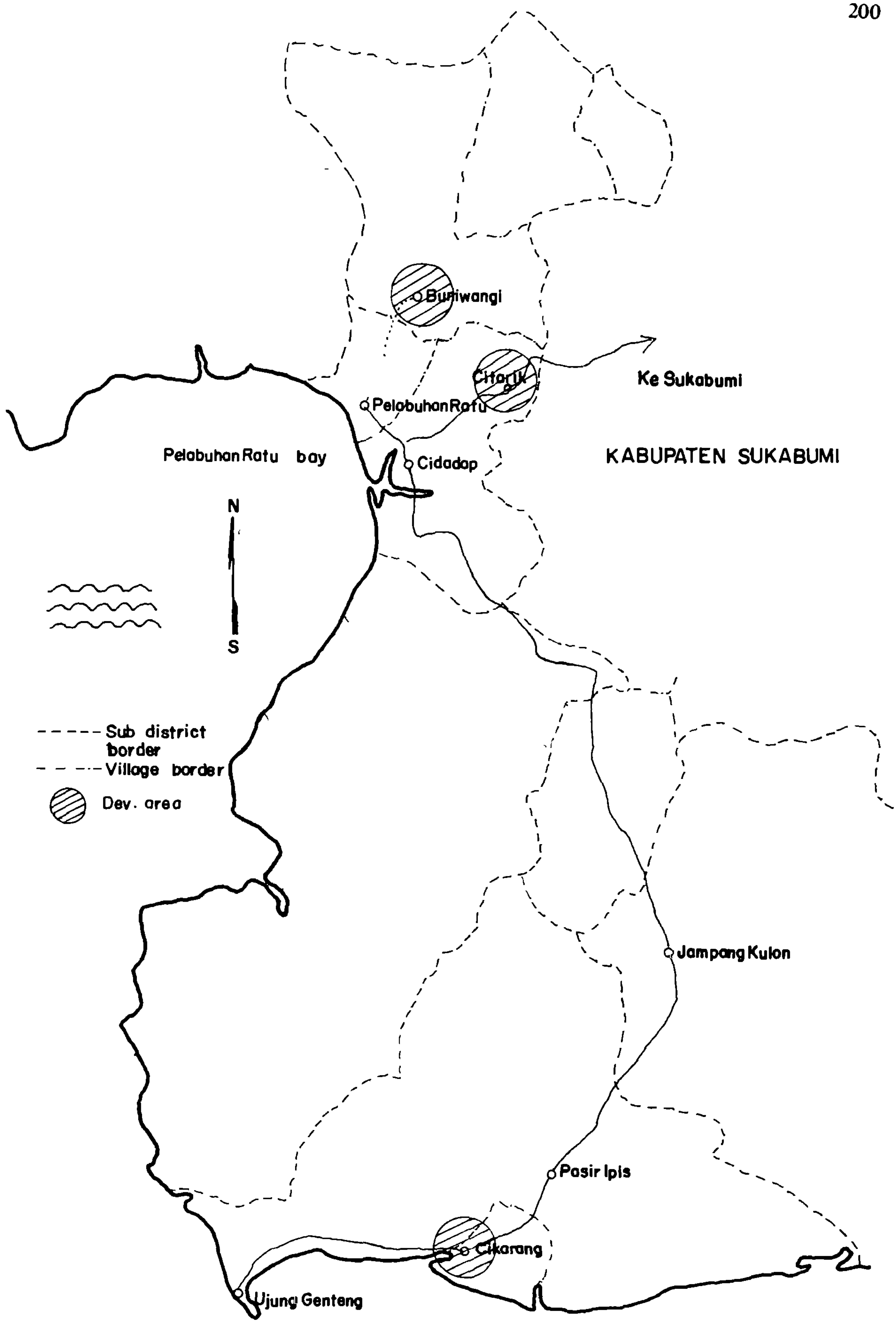



Fig. 86

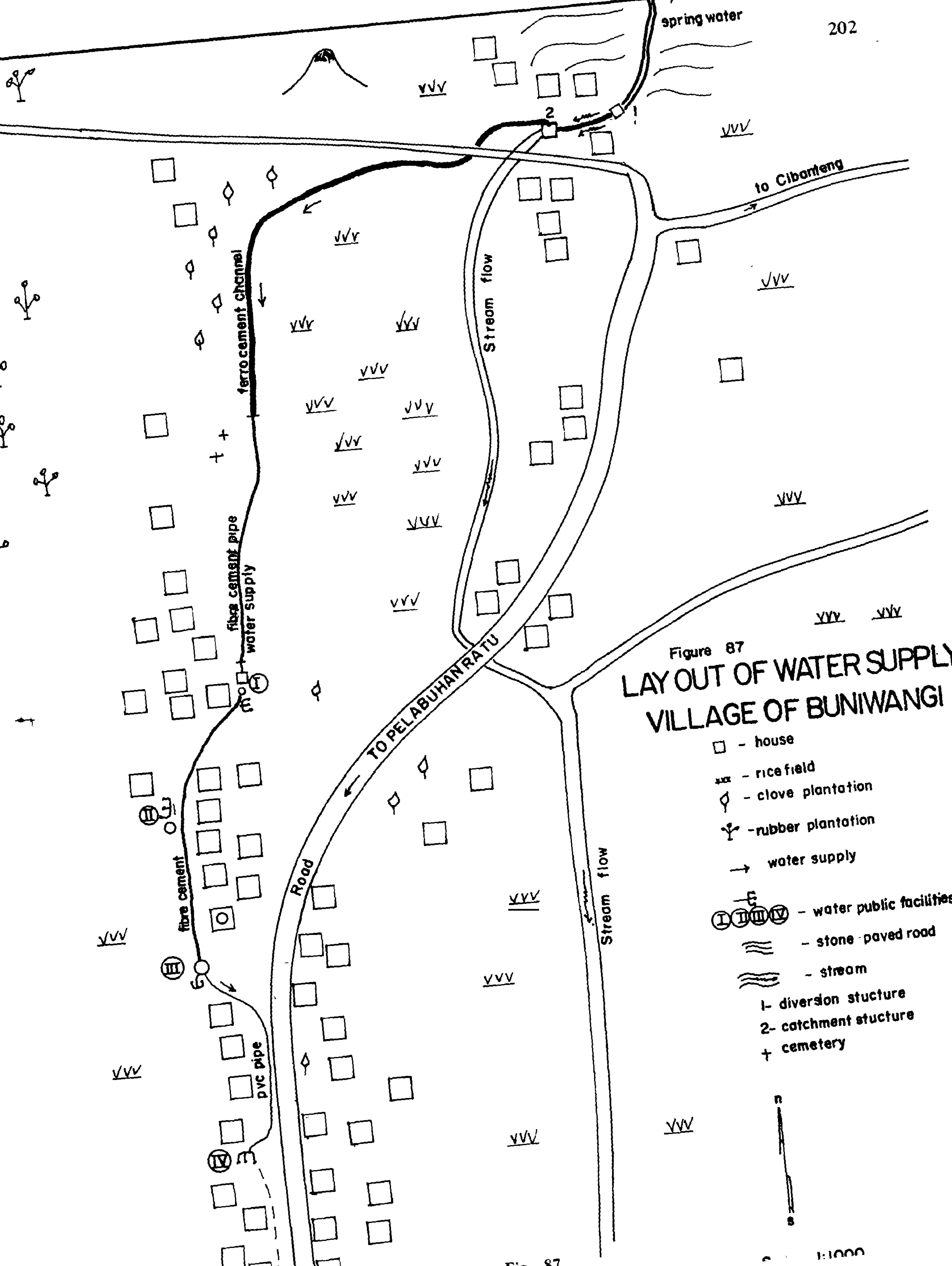
Scale 1: 34.000

4.1.1.4. Hardware Result

Hardware results which were developed in the field can be summarized as follows:

| No. | Name of Component | Location | Dimension/ Capacity | Amount |
|---|---|---|---|---|
| 1. | Ferrocement Pontoon Ferry | Cikarang | Carrying Load 8 tons | 1 |
| 2. | Ferrobamboo curved Bridge | Village of Buniwangi | 7.8 span | 1 |
| 3. | Water distribution box | Village of Buniwangi | 2.000 liters | 1 |
| 4. | Bamboo cement water tank | Village of Buniwangi | 2.000 liters | 1 |
| 5. | Rectangular (box) water tank | Village of Buniwangi | 2.000 liters | 1 |
| 6. | Ditch lining (trapezoidal) | Village of Buniwangi | 2 m/unit | 15 |
| 7. | Channel lining, semi cylinder | Cisalada, Village of Buniwangi | 2.2 m/unit | 312 unit installed |
| 8. | Fibercement pipe | Cisalada, Village of Buniwangi and Village of Citarik | 2.2 m/unit | 413 unit installed |
| 9. | Ferrocement water tank, cylinder | Village of Buniwangi& Village of Citarik | 1.500 to 750 liters | 4 |
| 10. | Bamboo cement bathing and washing facilities | Village of Buniwangi & Village of Citarik | - | 7 |
| 11. | Bamboo cement septic tank | Village of Citarik | 1.500 m3 | 1 |
| 12. | Gothic vault shelter | Village of Cikarang | 3.5 by 3.5 m | 1 |

Continued



spring water
2
1
to Cibanteng
ferrocement channel
Stream flow
fibre cement pipe
water supply
TO PELABUHAN RATU
Road
fibre cement
pvc pipe
Stream flow
I
II
III
IV
Figure 87
LAY OUT OF WATER SUPPLY
VILLAGE OF BUNIWANGI
- house
- rice field
- clove plantation
-rubber plantation
water supply
- water public facilities
- stone paved road
- stream
1- diversion stucture
2- catchment stucture
+ cemetery
n
s
1:1000


Fig. 87

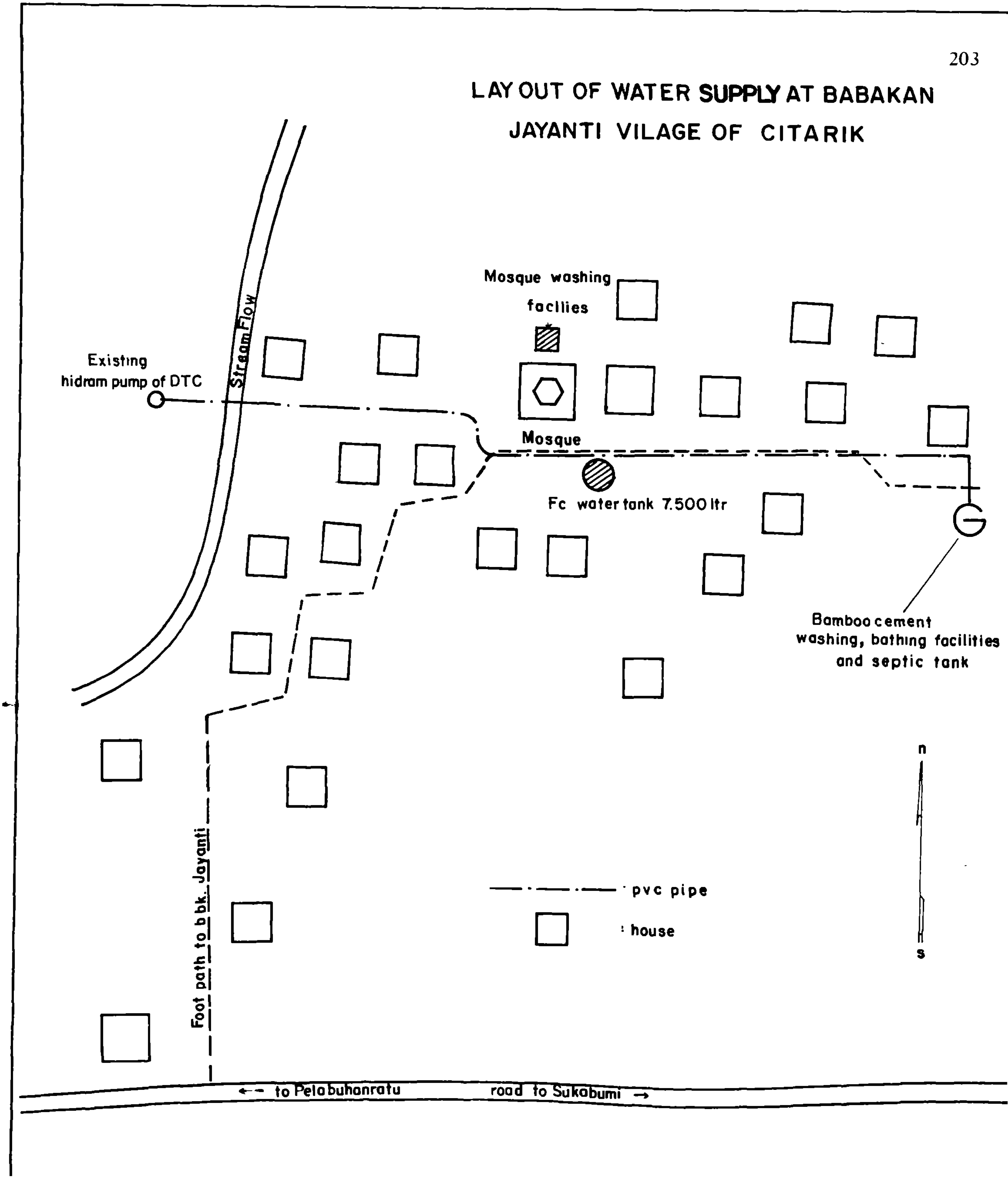



Fig. 88

Scale 1.1000

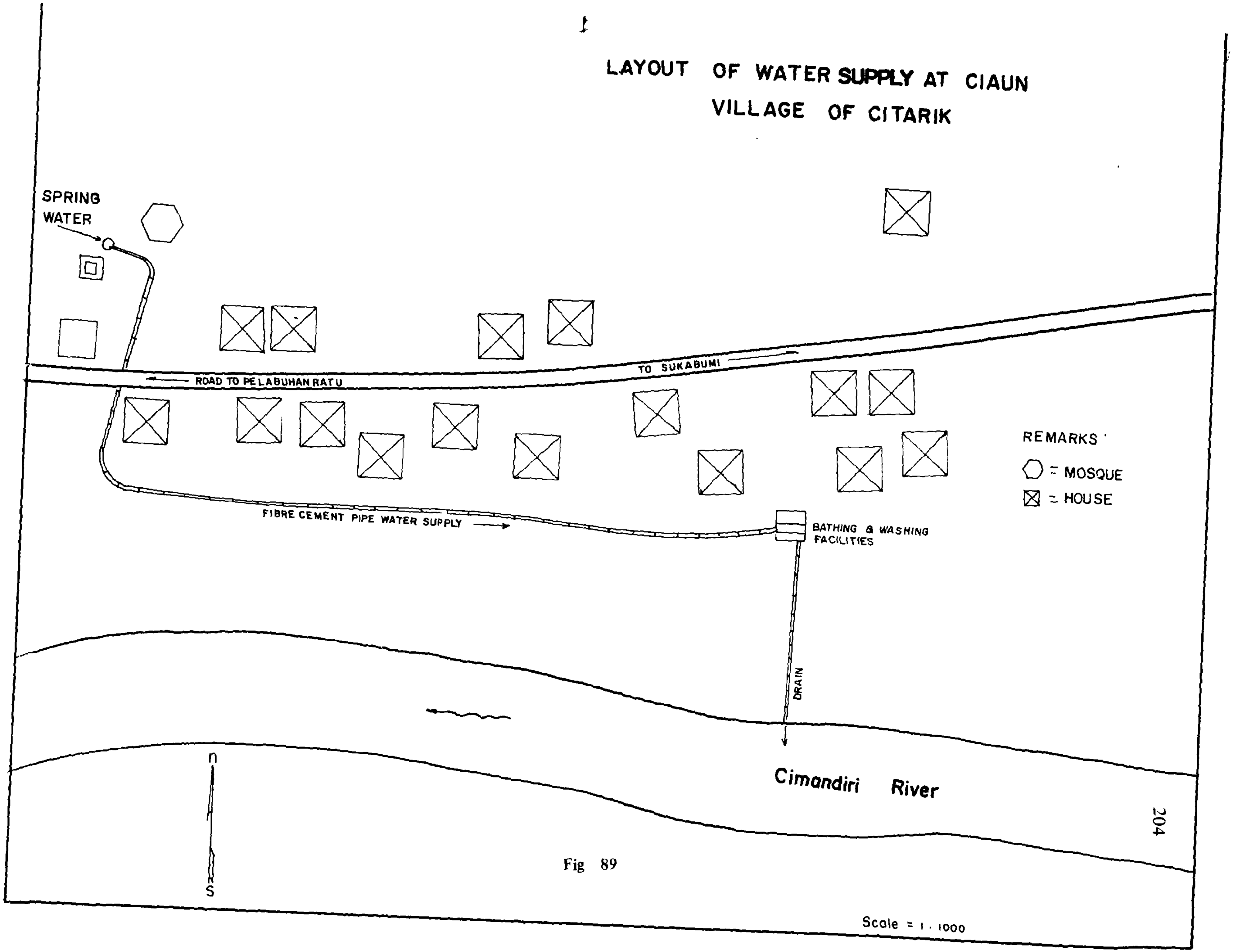

LAYOUT OF WATER SUPPLY AT CIAUN
VILLAGE OF CITARIK
SPRING WATER
ROAD TO PELABUHAN RATU
TO SUKABUMI
FIBRE CEMENT PIPE WATER SUPPLY
BATHING & WASHING FACILITIES
DRAIN
REMARKS
= MOSQUE
= HOUSE
Cimandiri River
n
S
Scale = 1 : 1000

Fig 89

| No. | Name of component | Location | Dimension/ Capacity | Amount |
|---|---|---|---|---|
| 13. | Hypar mosque | Village of Sadu Soreang | 5m x 5 m | 1 |
| 14. | Bus shelter | City of Bandung | 2,5m x 6 m | 1 |
| 15. | Minaret and Dome | City of Bandung | 12 m height | 1 |

4.1.2. South Sulawesi

The hardware results which had been constructed in the field are listed as follows:

4.1.2.1. Ferrocement components financed by the project:

| No. | Name of component | Location | Capacity | Amount |
|---|---|---|---|---|
| 1. | Gentong water jar | Tonrokassi (Jeneponto) | 250 liters | 2 |
| 2. | Gentong Water jar | Tonrokassi (Jeneponto) | 10 liters | 3 |
| 3. | Water container with skeletal steel | Tonrokassi (Jeneponto) | 150 liters | 1 |
| 4. | Water container without skeletal steel | Tonrokassi (Jeneponto) | 150 liters | |
| 5. | Water tank | Tonrokassi (Jeneponto) | 2,000 liters | 1 |
| 6. | Septic tank | Tonrokassi (Jeneponto) | 4,500 liters | 1 |
| 7. | Well casing | Tonrokassi (Jeneponto) | - | 7 |
| 8. | C a n o e | Ujung Pandang (UNHAS) | - | 1 |
| 9. | Well casing | Ujung Pandang | - | 3 |

4.1.2.2. Ferrocement components financed from outside the project only supervised by project staff

| No. | Name of component | Location | Capacity | Amount |
|---|---|---|---|---|
| 1. | Mosque Dome UMI Ujung Pandang | Ujung Pandang | - | 1 |
| 2. | Mosque Dome | Takalar | - | 1 |
| 3. | Shrimp breeding tank Paotere | Ujung Pandang | 12.420 m3 | 4 |
| 4. | Mosque Dome Benteng | Selayar | - | 1 |
| 5. | Bamboo cement well casing | Ujung Pandang | - | 5 |
| 6. | Ditch lining | Ujung Pandang | - | 10 |
| 7. | Electric poles | Ujung Pandang | - | - |

4.1.3. A C E H

All the components planned through January 1979 to December 1980, a numbers of hardware results are:

4.1.3.1. Ferrocement component financed by the project

| No. | Name of Component | Location | Capacity | Amount |
|---|---|---|---|---|
| 1. | House type 70 | Darussalam (Aceh Besar) | - | 1 |
| 2. | Well casing | Darussalam (Aceh Besar) | - | 1 |
| 3. | Cylindrical Septic Tank | Darussalam (Aceh Besar) | 1.25 m3 | 1 |
| 4. | Water Container | Darussalam (Aceh Besar) | 1,000 liters | 1 |
| 5. | Fence | Darussalam (Aceh Besar) | - | 1 unit |
| 6. | Folded plate roofing | Darussalam (Aceh Besar) | - | 1 unit |
| 7. | Gutter plank | Darussalam (Aceh Besar) | - | 1 unit |
| 8. | Ditch lining | Darussalam (Aceh Besar) | - | 1 unit |
| 9. | Culvert | Darussalam (Aceh Besar) | - | 1 unit |
| 10. | Reservoir (rectangular) | Darussalam (Aceh Besar) | 2,500 liters | 1 |
| 11. | Reservoir Cylindrical Tank | Darussalam (Aceh Besar) | 1,000 liters | 1 |
| 12. | Wall element | Darussalam (Aceh Besar) | - | 2 |
| 13. | Water container | Darussalam (Aceh Besar) | 300 liters | 9 |

Continued

| No. | Name of Component | Location | Capacity | Amount |
|---|---|---|---|---|
| 14. | Garden table | Darussalam (Aceh Besar) | - | 2 |
| 15. | Garden benches | Darussalam (Aceh Besar) | - | 8 |
| 16. | Children's slide | Darussalam (Aceh Besar) | - | 1 |
| 17. | Water tank and facilities | Darussalam (Aceh Besar) | $\pm$ 1,000 liters | 1 |
| 18. | Canoe | Darussalam (Aceh Besar) | - | 1 |
| 19. | Flower Pot | Darussalam (Aceh Besar) | - | 10 |
| 20. | Canoe | Deyah Baro (Aceh Besar) | - | 1 |
| 21. | Ceiling Dome | Lhueng Bata (Aceh Besar) | - | 1 |
| 22. | Small Mosque | Desa Jambu Apha (Aceh Selatan) | - | 1 |
| 23. | Water facilities for the Mosque | Kampung Tengah (Aceh Selatan) | 1,600 liters | 1 unit |
| 24. | Water facilities for the Mosque | Desa Jambu Apha (Aceh Selatan) | 1,200 liters | 1 unit |
| 25. | Water facilities for the Mosque | Desa Pantai (Aceh Selatan) | 1,300 liters | 1 unit |
| 26. | Water facilities for the Mosque | Kampung Hilir (Aceh Selatan) | 1,300 liters | 1 unit |
| 27. | Mosque entrance Verandah | Kampung Hilir (Aceh Selatan) | - | 1 unit |
| 28. | B o a t | Desa Jampu Apha (Aceh Selatan) | - | 1 unit |
| 29. | Canoe | Kampung Tengah (Aceh Selatan) | - | 1 |
| 30. | Small Dome | Desa Jambu Apha (Aceh Selatan) | - | 1 |
| 31. | Mosque Dome and Gutter | Tapak Tuan (Aceh Selatan) | - | 1 unit |

4.1.3.2. Ferrocement component financed from outside the project, supervised by the project staff :

| No. | Name of Component | Location | Amount |
|---|---|---|---|
| 1. | Mosque, roof and wall | Tapak Tuan (Aceh Selatan) | 1 |
| 2. | Mosque Dome DPU Aceh Selatan | Tapak Tuan | 1 |
| 3. | Wall of two-floor house | Lam Nyong (Aceh Besar) | 1 |
| 4. | Mosque Dome | Sukaramai (Kodya B. Aceh) | 1 |
| 5. | Wall construction | Campus Darussalam | 1 |
| 6. | Water tank | Campus Darussalam | 1 |
| 7. | House terras canopy | Lamprit (Banda Aceh) | 1 unit |
| 8. | Two-floor house | Punge (Banda Aceh) | 1 unit |
| 9. | Two-floor shopping Complex | Banda Aceh | 1 unit |
| 10. | Wall of a church | Banda Aceh | 1 unit |
| 11. | Children's slide | Banda Aceh | 1 unit |
| 12. | Wall construction | Deyah Baro (Aceh Besar) | 1 unit |
| 13. | Septic tank | Punge (Aceh Besar) | 1 |
| 14. | Mosque Dome | Batee (Aceh Pidie) | 1 |

## 4.2. UTILIZATION AND MAINTENANCE

### 4.2.1. West Java

There were less difficulties anticipated in the field during construction and installation of the component being developed provided the materials and the skills needed were readily available. Within the project stages through the on-the-spot training and mutual cooperation with the local community, the local participation and responsibility increased from 15% at the beginning to 70% at the end of the field project.

Since the local acceptance was good, the effort of building the attitude to the technology and the improvement of the local skill to support the serviceability of the technology was seen to be worthwhile. Through careful planning at proper stages, the component developed in the field reflected the local needs.

The technical problem of maintenance was turned over to the local villagers to whom the knowledge was effectively transferred during the project execution. Although the cost of maintenance in the period of monitoring and evaluation was still supposedly from the project, several local people already proposed to contribute. After a certain period all cost of maintenance was to be the responsibility of the local community.

### 4.2.2. South Sulawesi

After the period of field construction, all components developed were utilized and maintained by the local users. It was through these local users that the technology was introduced to other areas.

Besides the components constructed from the funds of the project, the project staff also supervised other construction at the request of the local people. These included:

| | |
|---|---|
| - Mosque dome at Takalar | Ø 11 m |
| - Mosque dome at Salayar | Ø 12 m |
| - Mosque dome at Palopo | Ø 16 m |
| - Mosque dome at Ujung Pandang | Ø 14 m |
| | Ø 8 m |
| and six (6) domes of | Ø 4 m |

- Shrimp breeding tank at Paotere
- Well casing
- Ditch lining

Since these components were requested by the local people, the subsquent utilization and maintenance of the components would be the direct responsibility of the users.

### 4.2.3. A c e h

After the construction of the component at the location, the project team demonstrated how to use the system, including its maintenance. Normally the local people who will be in charge were the local people who were involved in the project, whether on a paid or voluntary basis. The turn-over of the component to the local authorities was done during a traditional "adat" ceremony. In this transfer, the component became the responsibility of the highest authority in the community, namely the head of the village or the sub-district. Therefore the maintenance cost was financed from an official source, such as from the annual allocation for villages (Bantuan Desa) under the Department of Interior.

The component constructed for a mosque became the responsibility of the committee for the particular mosque.

## 4.3. SOCIO-ECONOMIC BENEFITS

### 4.3.1. West Java

Because of the characteristics of ferrocement, such as low-cost, high strength and durability, easily repaired and wide range of uses, ferrocement could make significant contribution to both rural and urban development. Although ferrocement products are still relatively new, the acceptability of ferrocement technology in the rural as well as in the urban area shows good prospects in terms of new and useful structures.

It can also be concluded from the projects completed that there is an understanding of the techniques involved and that the local acceptability of the technology is high. The beneficiaries are the villagers and other users who now have cheaper and better facilities for water supply, better river transport, etc. ... The direct beneficiaries are the workers who were trained during the project. Aside from gaining employment in ferrocement manufacturing and marketing, they also would act as agents of change and extension agencs for the ferrocement technology.

These and similar applications of the technology will also provide new opportunities for small local industries.

4.3.2. South Sulawesi

Islam is the primary religion in South Sulawesi, most of the population being Moslem. Because of this situation, the introduction of ferrocement mosque dome attracted local attention. From the point of view of its spherical shape, strength and the availability of raw materials, it was worthwhile de - veloping, with the aim of gradually replacing conventional materials such as GI roofing sheet, wood shingles, clay tiles and other materials which need extra maintenance and supporting construction such as steel and concrete. In thus replacing conventional construction material there is less consumption

of other raw materials such as sand, wood, lime and cement, hence reducing costs. Ferrocement components also require less maintenance, are easily repaired and more durable.

The ferrocement water tanks were also structurally better, as well as more economical in the raw materials used for their construction.

4.3.3. A c e h

Considering the ferrocement projects, mosque dome, water tanks, canoe, etc., it is evident that they are of service and benefit to people of all sectors, including the low-income bracket. The water-related projects, water tanks and purification vessels in the mosques, guarantee safe water supply is also immeasurable. Since the mosque is the center of activities, the ferrocement project touches the heart of the people. Indeed, the ferrocement projects are very well accepted and used by the people.

## 4.4. CONCLUSIONS

From the results of the projects in the three different areas, it can be concluded that ferrocement technology has reached social acceptability. The method of approach played an important part, always taking into consideration the needs and participation of the people at every stage of decision-making. It is also now a proven fact that there are socio-economic benefits for people of all levels with far-reaching benefits. This includes improved sanitation and better health conditions, increased job opportunities and skills, as well as the socio-religious benefits from the mosque. In addition there is a sense of achievement in the field of technology among the local people, cooperating in the development of their area.

## APPENDIX A

### LIST OF PARTICIPANTS OF FERROCEMENT TRAINING PROGRAM

### JUNE - OCTOBER 1978 AIT, BANGKOK

| | Name | Institution |
|---|---|---|
| 1. | Mr. Maasri Sutan Bandaro | University of Syiah Kuala |
| 2. | Mr. Bustam Husin | University of Syiah Kuala |
| 3. | Mr. Arifin Taher | Indonesian Road Research Institute |
| 4. | Mr. Iskandar | Indonesian Road Research Institute |
| 5. | Mr. Syarifuddin Harahap | University of North Sumatra |
| 6. | Mr. Muhammad Amin Hayat | Hasanuddin University |
| 7. | Mr. John Biring Manga | Hasanuddin University |
| 8. | Mr. Anshori Djausal | Institut Teknologi Bandung |
| 9. | Mr. Winarto | Dian Desa |

APPENDIX B

# FERROCEMENT TECHNOLOGY TRAINING PROGRAM

## PART I: THEORETICAL COMPONENT

1. Introduction

   (a) Definition of Ferrocement
   (b) Historical Background

2. Constituent Materials

   (a) C e m e n t
   (b) Wire Mesh
   (c) W a t e r
   (d) Additives

3. Construction Methods

   (a) General Procedures

      (i) mix proportion
      (ii) mixing
      (iii) plastering
      (ix) curing

   (b) Concrete Mix Design

      (i) characteristic strength
      (ii) water-cement ratio law
      (iii) s l u m p
      (iv) maximum size of aggregate
      (v) concrete density
      (vi) grading of fine and coarse aggregate

4. Mechanical Properties

   (a) Uncracked Range - Tension and Compression

      (i) strength
      (ii) moduli of elasticity
      (iii) Poisson's ratio

   (b) Cracked Range - Tension and Compression

      (i) strength
      (ii) moduli of elasticity
      (iii) Poison's ratio

(c) Ultimate Condition - Tension and Compression

(i) strength

(d) Moment - Curvature Relations

(i) uncracked range
(ii) cracked range
(iii) ultimate condition

(e) Moment - Deflection Relations

(i) uncracked range
(ii) cracked range
(iii) ultimate condition

(f) Shearing properties
(g) Design of Ferrocement
(h) Impact and Gatigue
(i) Durability
(j) Corrosion Resistance

5. Potential Applications

(a) Boats
(b) Water jars and tanks
(c) Rice storage bins
(d) Canal linings
(e) Well casings
(f) Roofing
(g) Wall panels, etc.

6. Related Materials

(a) Properties of composite with short steel fibers
(b) Properties of coir-fiber boards
(c) Properties of sugar cane baggase-cement composite
(d) Properties of bamboo fiber-cement composite
(e) Properties of rice hull-ash-lime mixture

7. Theory and Design Criteria of Plate and Shell Structures

(a) Simplified basic theory of plates

(b) Design criteria of reinforced concrete plates, and common plate structures

(c) Design charts for plates subjected to uniform and hydro - static loads [1]:

(i) simply supported rectangular plates;
(ii) rectangular plates with two opposite edges simply supported and the other edges clamped;
(iii) rectangular plates with three edges simply supported and one edge built in;

(iv) rectangular plates with all edges built in;
(v) rectangular plates with one edge or two adjacent edges built in;
(vi) rectangular plates with two opposite edges simply supported, the third edge free, and the fourth edge built in or simply supported;
(vii) rectangular plates with three edges built in and the fourth edge free; and
(viii) rectangular plates with two opposite edges simply supported and other two edges free or supported elastically,

(d) Type of shells; shells of revolution, and shells of translation

(e) Simplified membrane analysis of shells of revolution with intention to apply to concrete water tanks, shell roofs, rice bins, etc.

(f) Reinforced concrete shell roofs, and their design charts [2]

(g) Design of hyperbolic paraboloid shell roof.

NOTE:

References


1. S. Timoshenko, and S. Voinowsky-Krieger, Theory of Plates and Shells, 2nd edition, McGraw-Hill, 1959, pp. 114, 118, 119, 120, 124, 126-133, 185, 187, 190-192, 194-197, 202, 204, 208, 210, 214-216.

2. M. Fintel (editor), Handbook of Concrete Engineering, Van Nostrand Reinhold, 1974, pp. 457-473.

3. T.N.W. Akroyd, "Concrete-Properties and Manufacture", Pergamon Press Ltd., 1962.

4. A.M. Neville, "Properties of Concrete", 2nd edition, Pitman Publishing, 1972.


## PART II: EXPERIMENTAL COMPONENT

1. Experiment on mix design
2. Compression test of concrete cylinders and cubes
3. Splitting test of concrete cylinders
4. Rupture test of concrete beams
5. Tension test of wire mesh

6. Tension test of skeletal steel
7. Tension test of ferrocement specimen
8. Compression test of ferrocement specimen
9. Cylindrical bending of ferrocement specimen
10. Anticlastic test of of ferrocement plate

## PART III: FIELD DEMONSTRATION PROJECTS

1. C a n o e
2. Pipe Culvert
3. Cylindrical Water Tank
4. S a m p a n
5. Cylindrical Pontoon
6. Dome-Shell Roof
7. Rectangular Pontoon for Pump House
8. Folded Plate Roofing Element
9. Septic Tank

## PART IV: FIELD TRIP AND CONFERENCE

1. A field trip to see ferrocement boat construction at Sriracha
2. Participation in International Conference on Materials of Construction for Developing Countries, August 22-24, 1978, Bangkok, Thailand.