# INTERIM REPORT
# FERROCEMENT TECHNOLOGY IN INDONESIA

GOVERNMENT OF INDONESIA
AND
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT NO. 497 – 0268
"APPROPRIATE AND LOW COST TECHNOLOGY"

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THE DEVELOPMENT TECHNOLOGY CENTER
INSTITUTE OF TECHNOLOGY BANDUNG

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DTC – ITB

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# FERROCEMENT DEVELOPMENT PROJECT IN INDONESIA

## I. INTRODUCTION

Ferrocement technology is a relatively simple method of making and building structural components which mainly consists of relatively thin walls of sheets of reinforced mortar of cement, sand and water. Structural reinforcement material can be either steel, bamboo or indigenous natural fibres such as baggase, coconut, or palm. By using wire mesh or bamboo reinforcement, ferrocement can be easily formed to almost any shape. Thus ferrocement has the capability of being adaptable to a variety of local structural needs, replacing scarce wood or imported steel.

Given the properties of ferro - (or fibre - ) cement, plus the fact that it can be made using local material and labor, makes ferrocement technology suitable for rural development in developing countries. It is low cost and labor intensive.

## II. FERROCEMENT DEVELOPMENT IN INDONESIA

### II.1. BACKGROUND

On October 4 and 5, 1977, a seminar organized by DTC - ITB and USAID was held on the potential of ferrocement technology development in Indonesia. The seminar resulted in ferrocement technology project sponsored by USAID, Jakarta, and executed by DTC - ITB. The project consists of three parts: experimentation, field testing, and training. Three schools were selected (University of Hasanuddin, Syiah Kuala University, and the Development Technology Center Bandung) to conduct research in ferrocement technology as well as to design and construct a variety of ferrocement products suitable for Indonesian conditions.

The following products initially were suggested as possibly suited to ferrocement technology:

i. Pontoon for docks or river ferries
ii. Well casings
iii. Water containers, particularly large size
iv. Grain storage bins
v. Toilet bowels with water traps
vi. Small and medium sized boats
vii. Low cost housing components

## II.2. PROJECT ACTIVITIES

The project was initiated by a training program involving nine engineers from various Indonesian institutions. The training, held at the Asian Institute of Technology, Bangkok, Thailand, lasted four months and consisted of theoretical studies, laboratory experiments, field demonstration projects, and field trips. The knowledge gained from the training enabled the participants to strengthen their respective institutions in carrying out the ferrocement technology project.

The trainees were from the three institutions mentioned, the Yayasan Dian Desa, the University of North Sumatra, and the Ministry of Public Works.

The design and testing of ferrocement technology for rural community situations is geared to fill the needs of the rural population. The following are summaries of field project activities designed to meet local community needs:

II.2.1 University of Syiah Kuala, Aceh, Project Activities

The introduction of ferrocement technology to the faculty of engineering was held prior to the field project activities. Hardware components de - veloped within the project are:

- Water tank : box and cylinder shape
- Small boat : 5.5 m length, 1.1 m deep
- "Dug out" canoe : 3.5 m length, 0,8 m wide, 0.6 deep
- Mosque domes : dia. 11 m (and other sizes)
- Washing facilities : for the mosque
  - water tank: 1.2 m x 1.2 m
  - 4 m x 4 m floor
  - 36 $m^2$ wall
- Ferrocement building: 70 m2 building with ferrocement walls used as the Ferrocement Technology Center in Syiah Kuala

- Shopping Center : 12 kiosks, two stories, built by local contractors

- Ferrocement house : Two stories, built by a family

Social acceptability of the technology has been positive. One key to this acceptance was the introduction of ferrocement through the construction of Mosque domes in Aceh rural communities.

II.2.2 University of Hasanuddin, Ujung Pandang, Project Activities

Ferrocement technology was introduced to the engineering faculty and is of considerable interest to Technical High School students, the local cement industry and the local dockyard companies. Hardware components which have been developed using ferrocement include:

- Water tanks; range of 200 lt to 4500 lt capacity
- Septic tank (1.5 x 2.5 x 1.2 m)
- Well casings
- Containers for shrimp husbandry
- Cattle breeder box, half cylinder shape
- Mosque domes; dia. 6 and 11 meters, and other sizes
- Small boat of 6 m length, 0.6 depth, and 0.8 m wide

The necessity and acceptability of ferrocement technology has been demonstrated by the interest of local institutions, local companies, and local people in dome construction for the mosques and the need for water tanks and feed containers for animal husbandry.

Besides the experimental construction funded under this project, the project staff has also supervised other constructions outside of the project, because of local demand.

### II.2.3 DTC-ITB Project Activities

Activities started with research and development of the materials: ferrocement used as load bearing structure and organic fibres as a waste from flour factories used together with cement for some structural purposes. Hardware components which have been developed using ferrocement are:

- Pontoon river ferry: capacity of 11 tons
- Bamboo/ferrocement foot bridge: span 8 meters
- Water tanks of various sizes: 500 lt to 5000 lt
- Ferrocement covered aquaduct: modular units 2.2 m in length installed for 625 m, placed on the ground and partly underground
- Fibrecement pipe: circumference 10 cm; unit length 2.2 m; 526 m has been installed
- Water supply system: to transport water from the source to the village; for a distance of about 1.5 km
- Corrugated fibrecement roofing element: each unit covers 0.9 m2 and costs Rp 600/unit
- Bamboo and fibrecement wall: combined with a training system for a wall construction and using normal bamboo sheeting (gedeg) with special arrangement of fibrecement with a higher lime content is being tested

From the field testing, it was found that based on the concept of water retaining capacity and simplicity of construction, the acceptability and transfer of technical capability is good. Local participation and responsibility increased from 15% at the beginning of the project to 70% at the end of the project.

## II.3 SOME REMARKS ON THE PROJECT ACTIVITIES

Although ferrocement is not a new material, there is a growing interest in its use for structural purposes. The Development Technology Center of the Institute of Technology Bandung (DTC-ITB) began developing and transferring the idea of ferrocement about three years ago, after initial discussions with USAID. Because ferrocement technology can be easily and quickly transferred and adapted to the rural situation in Indonesia, and because of the enthusiasm exhibited by the villagers, government authorities, universities, and other development agents during the introduction, demonstration and field testing, it can be concluded that ferrocement technology is now on the threshold of dissemination to a wider service area.

During the period of demonstration and field testing of construction, the applications within the three institutions resulted in products applicable to both domestic and commercial use. Completed projects can be grouped as follows:

1. Marine Structures

As in the case of most developing countries, Indonesia also faces a rapid rate of deforestation. On the assumption that there will be a wood shortage on Java and some other islands, the wood prices will propably rise 20 to 30% annually. This problem makes ferrocement attractive as a possible replacement for wood, such as for fishing boat construction. It does not rot or suffer teredo (shipwarm), termite, or other infestations.

Both Syiah Kuala University and Hasanuddin University began boat construction in their field projects. The interest, acceptability, and cooperation by local authorities and dockyard companies was a positive sign for future development.

Another application for marine structures are ferrocement pontoon ferries for river crossings, pontoon docks or mooring floats. The project demonstrated that ferrocement pontoons require less skill and less cost to construct vis-a-vis steel pontoons.

2. Water Tight Structures

Taking advantage of the water tight character of ferrocement, and to overcome water storage problems in most of rural and urban areas of Indonesia, the three project activities considered ferrocement as an alternative material for water retaining structures.

Containers of various shapes and capacities have been tested. Septic tanks were also developed in Ujung Pandang.

Instead of using relatively expensive steel mesh, bamboo was also use as a substitute wherever lesser strength was required. Bamboo was found to be suitable for water tanks of capacity 1000 lt to 2000 lt.

3. Building Structures

As ferrocement is a thin wall material (max. thick - ness 1.5"), it suits the requirements for curved, shelled structures. Using this characteristic, both Syiah Kuala and Hasanuddin Universities built quite interesting dome structures for mosques. As one of the local social aspects in Aceh and Ujung Pandang is the strong religious environment, dome construction proved to be an attractive approach in the introduction of ferrocement as a building material. Besides the domes built with project funds, at least two other mosque domes were built in Ujung Pan - dang under the supervision of project staff, and many more are "on order".

The shell structure concept was used by DTC-ITB in building curved foot-bridges in West Java. In Aceh, a house was constructed using ferrocement walls which reduced the total weight of the building and minimized the cost by as much as 70% compared to conventional build- ing materials !

4. Fibre Cement Using Organic Fiber

In the production of starch flour one of the raw materials is the trunk of the sugar palm tree. The wastes produced includes fibres of the tree. This organic fibre is thrown away, thus it can be obtained free of charge. Starch flour industries are located throughout West Java, but many are located in the south and east. DTC-ITB designed fibre cement roofing material using the sugar palm fibre waste and it proved competitive with other kinds of roofing material available in Indonesia.

One promising application is in the manufacturing of fibrecement pipe of diameter 4 to 6 in. with unit length of 2.2 m. The pipes are now being tested in one water supply project in West Java. The manufacturing procedures could be developed in the rural area on a self-help basis.

Most of the old houses in rural areas in West Java use bamboo mats plastered with lime and sand, or normal bamboo mats painted with lime. The houses built by this system around 1930's are still in good condition. Based on this system, DTC-ITB developed a hollow bamboo network mat to support plastered cement, and used as wall material. Combined with closely spaced studs in walls of thin metal sheet or wood frames, these walls were found to be competitive with normal wall construction and with earthquake resistant properties. This type of wall is now being tested in a school building in West Java, replacing a school destroyed by an earthquake.

## III. RESULTS AND OPTIONS

There were less difficulties than anticipated in the field during construction and installation o· the components mentioned above, provided that the materials and the skills needed were readily available. Although ferrocement products are still re - latively new, the acceptability of ferrocement technology in the rural areas shows good prospects in terms of new and useful structures.

The progress from the beginning of the project until the end of the project was positive. The knowledge gained by the nine engineers from their higher level of training which was then transferred by on-the-spot training in the field to the less edu- cated workers and to unskilled workers in the villages showed a specific character of technology well adapted to various levels of background.

It can be concluded from the projects completed at the three locations that the understanding of the concept and the development of the technique and the local acceptability of the technology is well developed. It is assumed that with the proper support and follow-on research and development, the ferrocement technology will soon be recognized in professional engineering circumstances.

From experience in the recruitment of the staff at the Tech - nical High School level and in giving short training to rural people, the supervision for the construction of the ferrocement components can be minimal. In addition, further innovations are needed to achieve a wider range of services for ferrocement tech - nology.

Because of the characteristics of ferrocement, such as low cost, high strength and durability, and easily repairable and because of the wide range of its uses, ferrocement can make significant contributions to both rural and urban development. Therefore as a follow-on activity, informal local village groups should be encouraged to apply ferrocement technology to their local needs. The development of cadies trained at all levels is required, market studies and market development is needed, and a back-up system capable of trouble-shooting, demonstration, continued experimentation and market promotion must be developed and in place. Scaling up, disseminating.

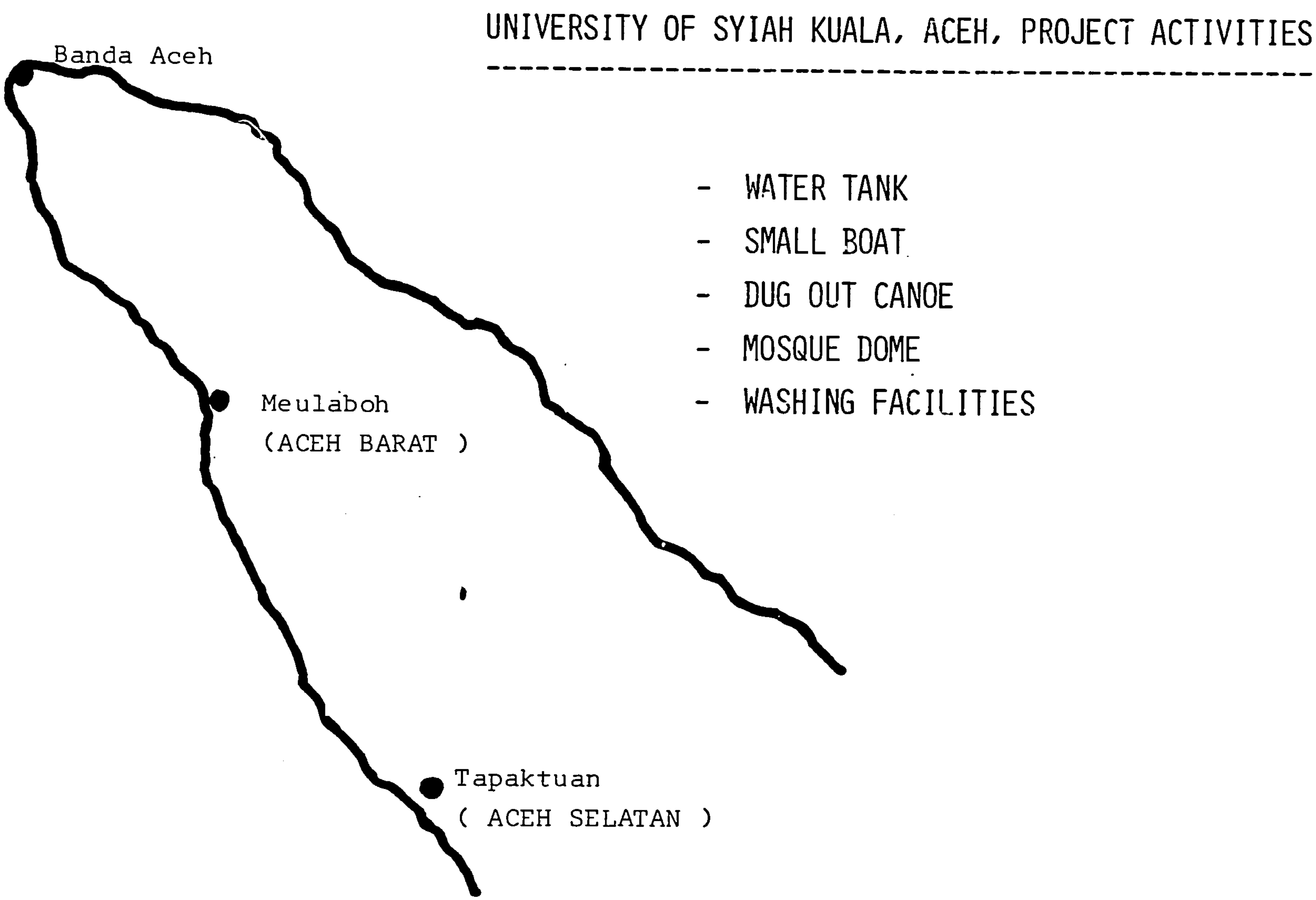

UNIVERSITY OF SYIAH KUALA, ACEH, PROJECT ACTIVITIES
- WATER TANK
- SMALL BOAT
- DUG OUT CANOE
- MOSQUE DOME
- WASHING FACILITIES
Banda Aceh
Meulaboh
(ACEH BARAT )
Tapaktuan
( ACEH SELATAN )

Figure 1

Figure 2
THREE LAYERS CWM
$\phi$ 10 M
H. 8,2 M

MOSQUE DOME, DIAMETER 3 M, HEIGHT 1,5 M TWO LAYERS OF CHICKEN WIRE, TAPAK TUAN

Figure 3
ANOTHER MOSQUE DOME
DIAMETER 10 M
HEIGHT 8,2 M
THREE LAYERS OF CHICKEN
WIRES; TAPAK TUAN

Figure 4
FIRST PLASTERING OF THE DOME, FROM INSIDE

Figure 5

Figure 6
THE FIRST FERROCEMENT BOAT UNDERGOING TESTING' BANDA ACEH

Figure 7
ANOTHER BOAT DURING PLASTERING

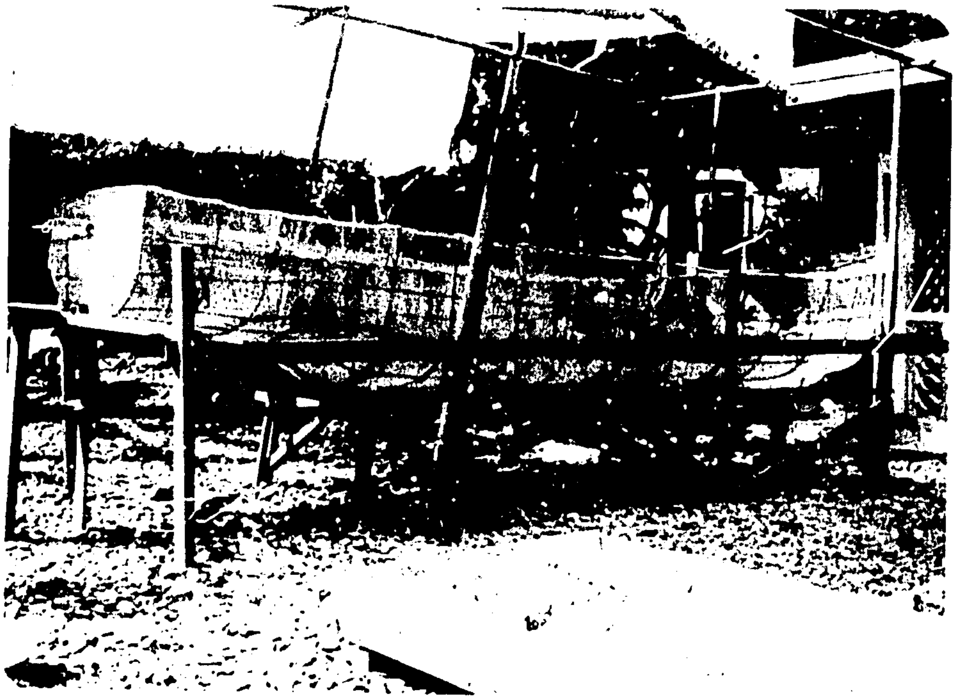


Figure 8
THE BIGGER BOAT READY FOR PLASTERING

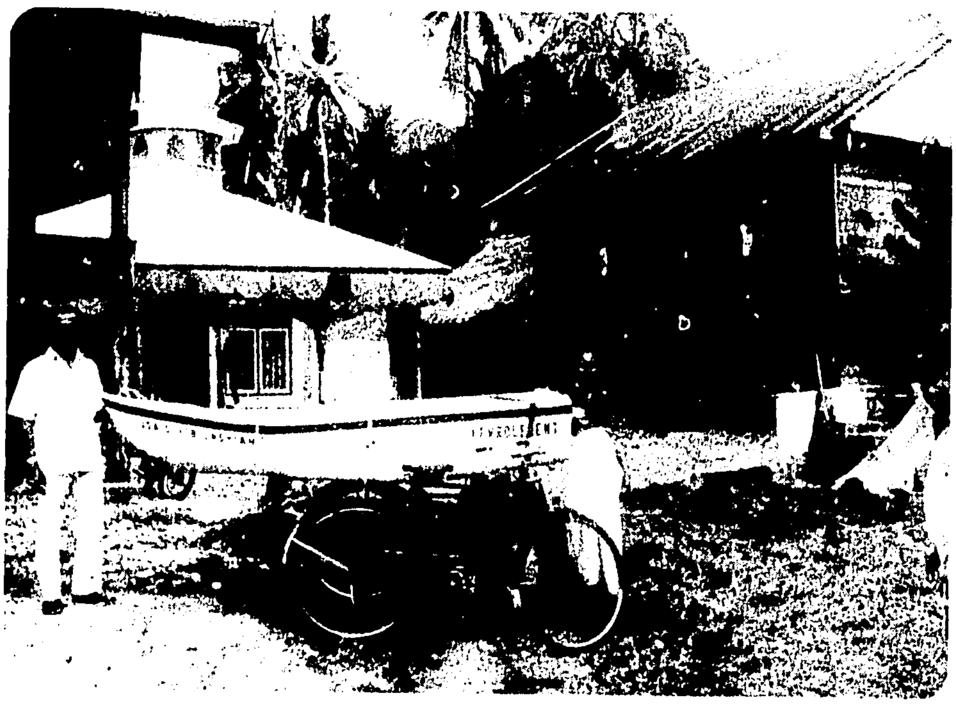
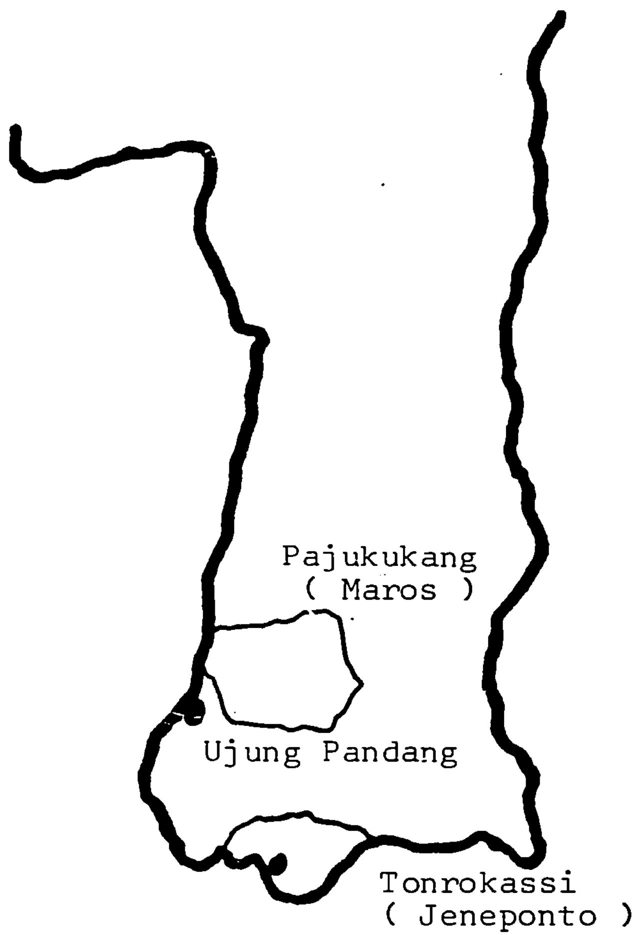


Figure 9
SPEED BOAT TYPE; BANDA ACEH

Figure 10
FERROCEMENT HOUSE COST REDUCED 30% THAN THE KONVENSIONAL SYSTEM, BANDA ACEH

## UNIVERSITY OF HASSANUDDIN, UJUNG PANDANG, PROJECT ACTIVITIES




- SEPTIC TANK
- WELL CASING, AS A FABRICATED SEGMENT
- CONTAINERS FOR SHRIMP HUSBANDRY
- CATTLE FEEDER BOX, HALF CYLINDER SHAPE
- MOSQUE DOME
- SMALL BOAT

Figure 11

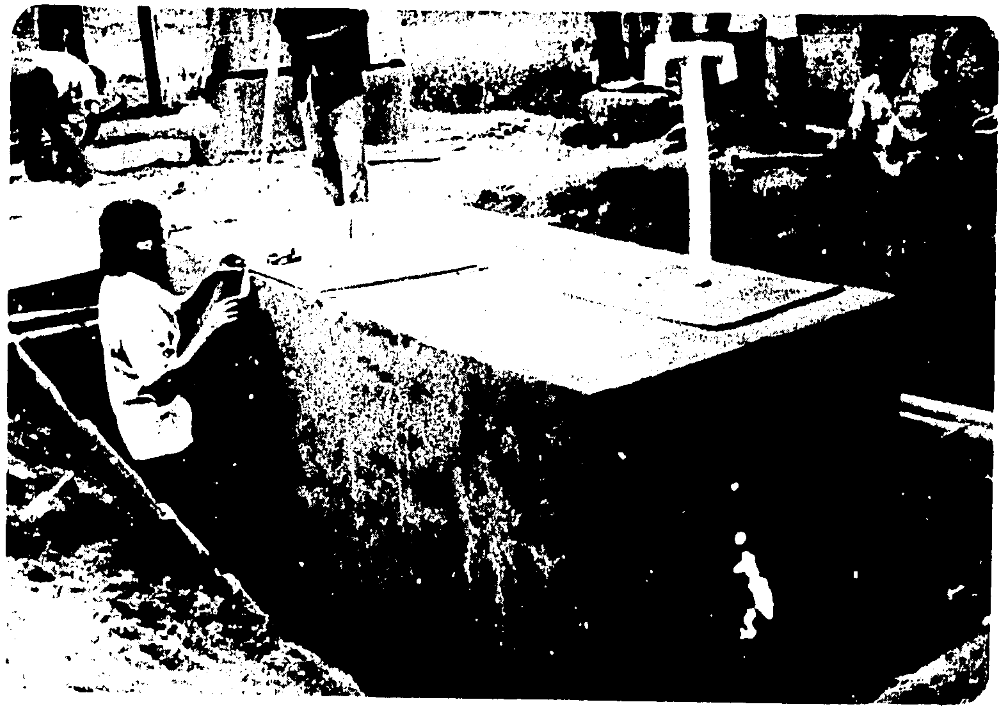


Figure 12
SEPTIC TANK, JENEPONTO; UJUNG PANDANG

Figure 13
DUG OUT TYPE CANOE, UJUNG PANDANG

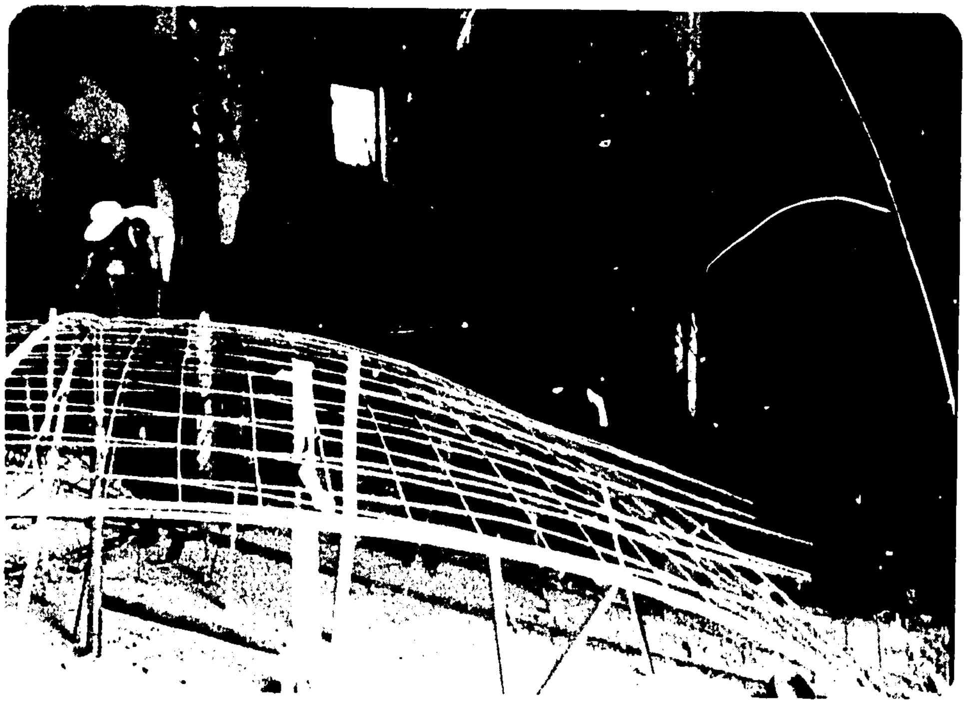


Figure 14
STEEL REINFORCEMENT WELDED ON THE GROUND,
SALAYAR MOSQUE DOME, UJUNG PANDANG

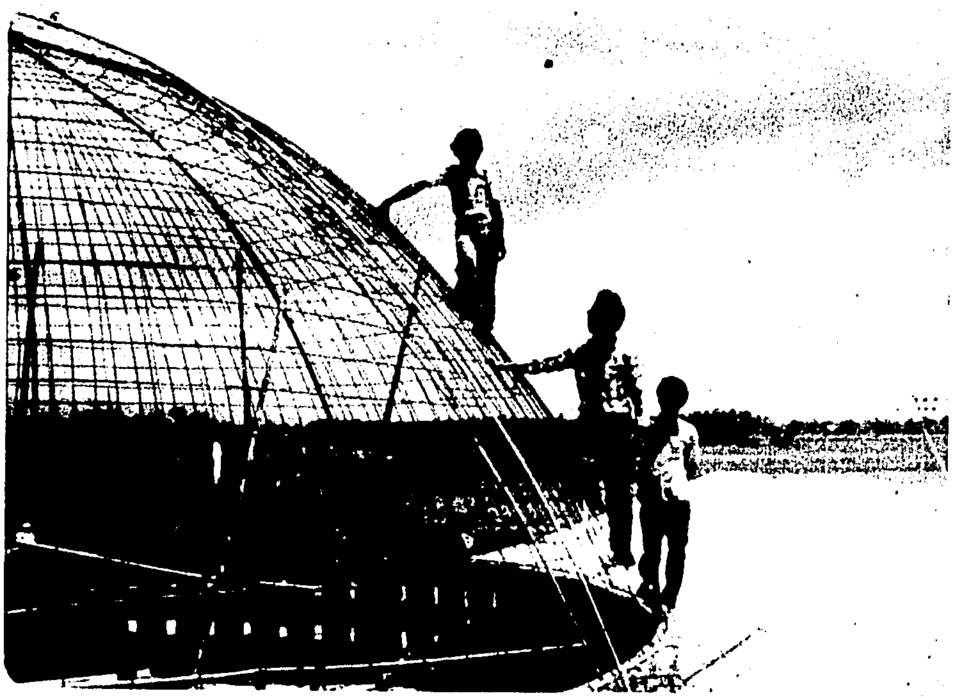


Figure 15
READY FOR CHICKEN WIRE REINFORCING
DOME: DIAMETER OF 12 M, HEIGHT 6 M

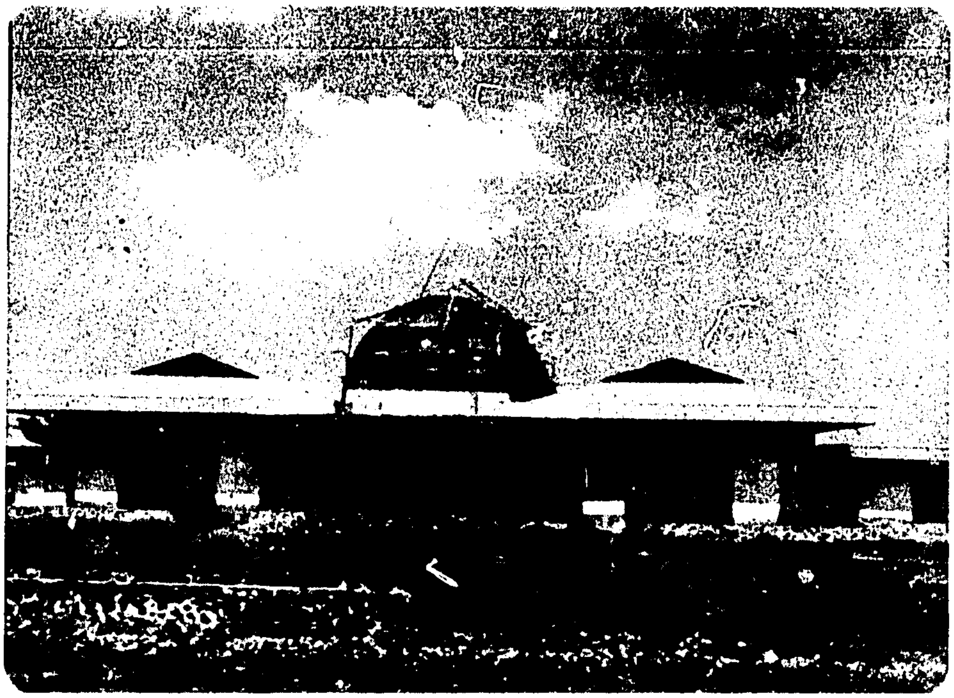


Figure 16
TAKALAR MOSQUE DOME; DIAMETER OF 12 M
MINIMUM SCAFFOLDING

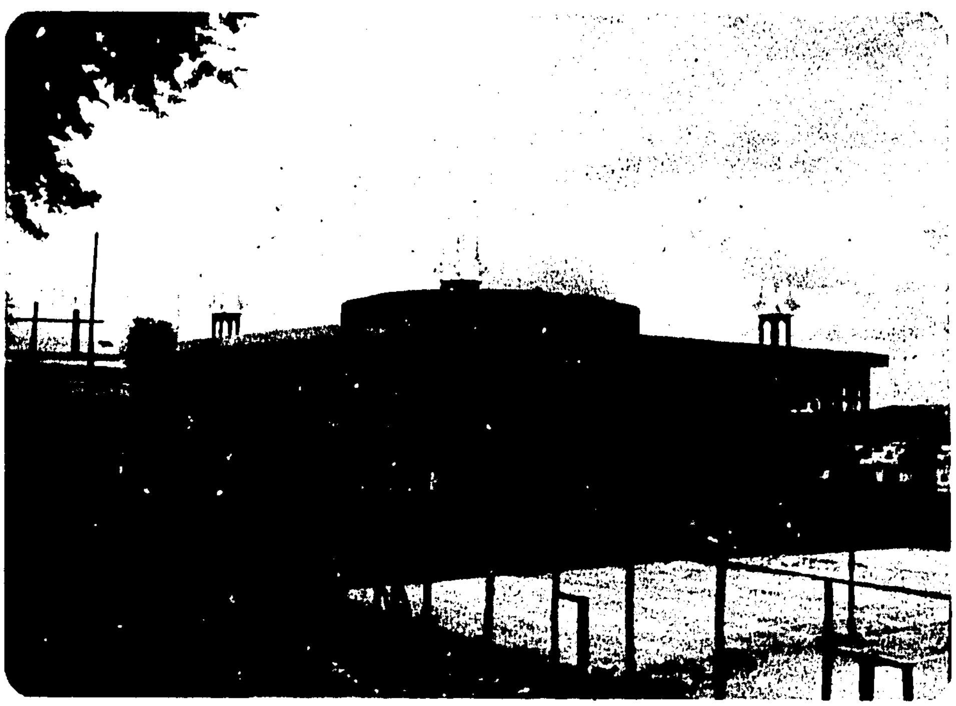


Figure 17
SOPPENG MOSQUE DOME; UNDER SUPERVISION
OF THE PROJECT STAFF

Figure 18
WELL CASING; UJUNG PANDANG

## DTC - ITB PROJECT ACTIVITIES

- PONTOON RIVER FERRY
- BAMBOO CEMENT FOOT BRIDGE
- VARIOUS CAPACITY OF WATER TANK
- FERROCEMENT DITCH LINING
- FIBRE CEMENT PIPE
- WATER SUPPLY SYSTEM
- CORRUGATED FIBRECEMENT ROOFING ELEMENT
- BAMBOO AND FIBRECEMENT WALL

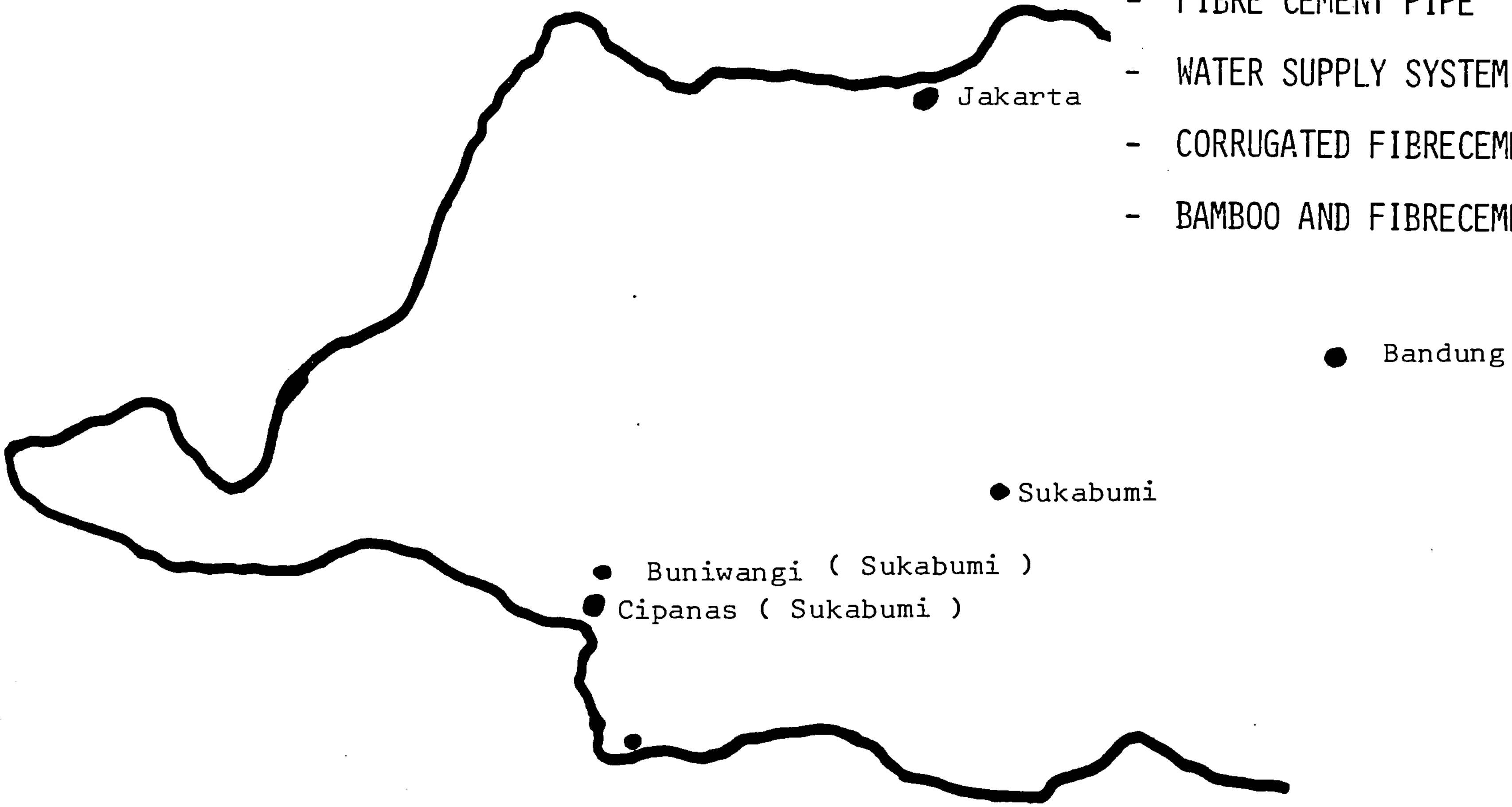



Figure 19

Figure 20
BAMBOO CEMENT WATER TANK, AFTER 20 MONTHS

Figure 21
(FERROMBU) BRIDGE; BAMBOO REINFORCED COMBINED WITH CHICKEN WIRE
SPAN 9 M; 1,5 M WIDTH; CURVED SHAPE PREVENTS LOSS FROM FLOOD

Figure 22
MANUFACTURING FERROCEMENT CHANEL

Figure 23
IN PLACE, READY FOR SEALING JOINTS, AND COVERING WITH FERROCEMENT PLATE

Figure 24
FERROCEMENT CHANEL IN LINE AS DISTRIBUTION SYSTEM

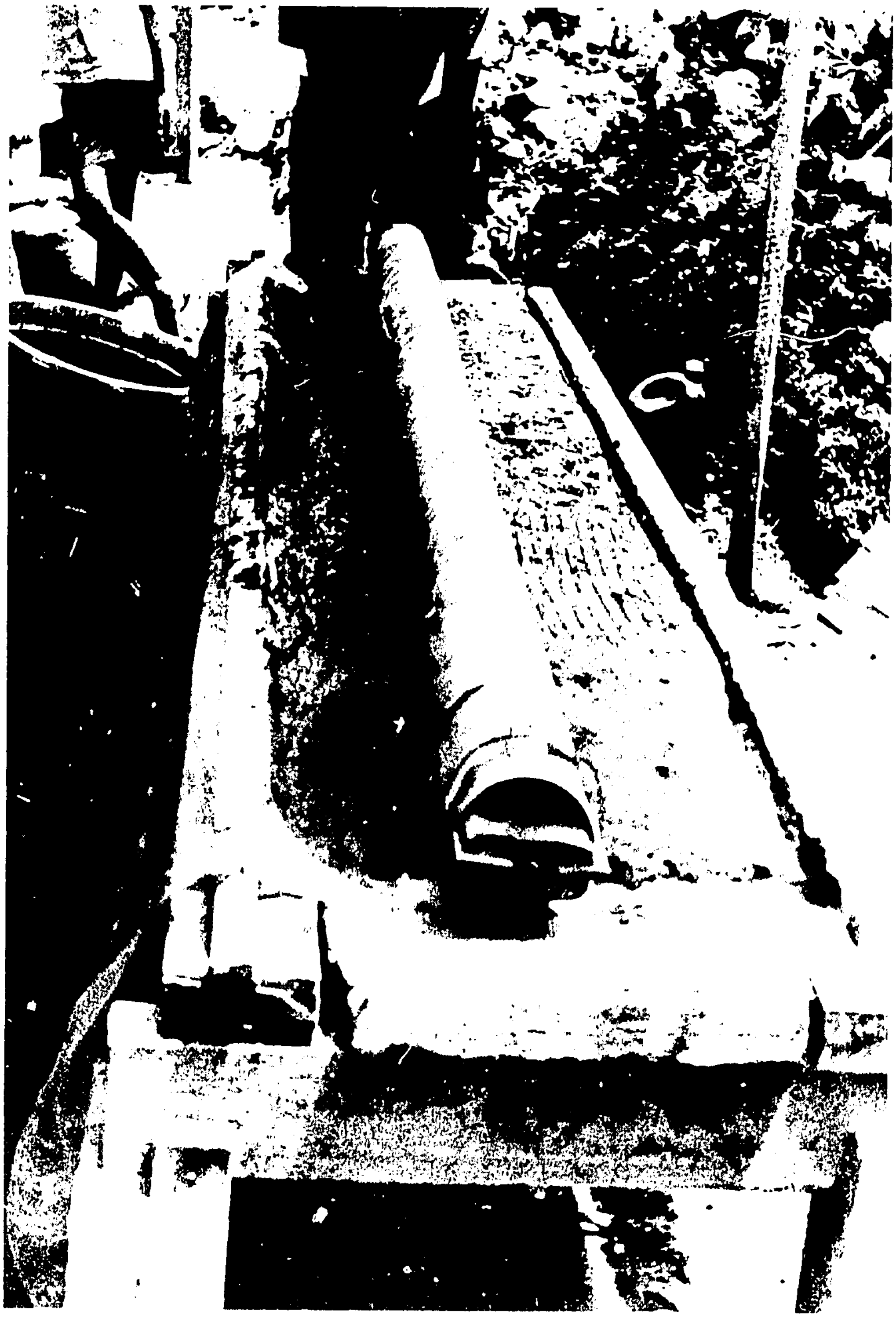


Figure 25
MANUFACTURING FIBRE CEMENT PIPE

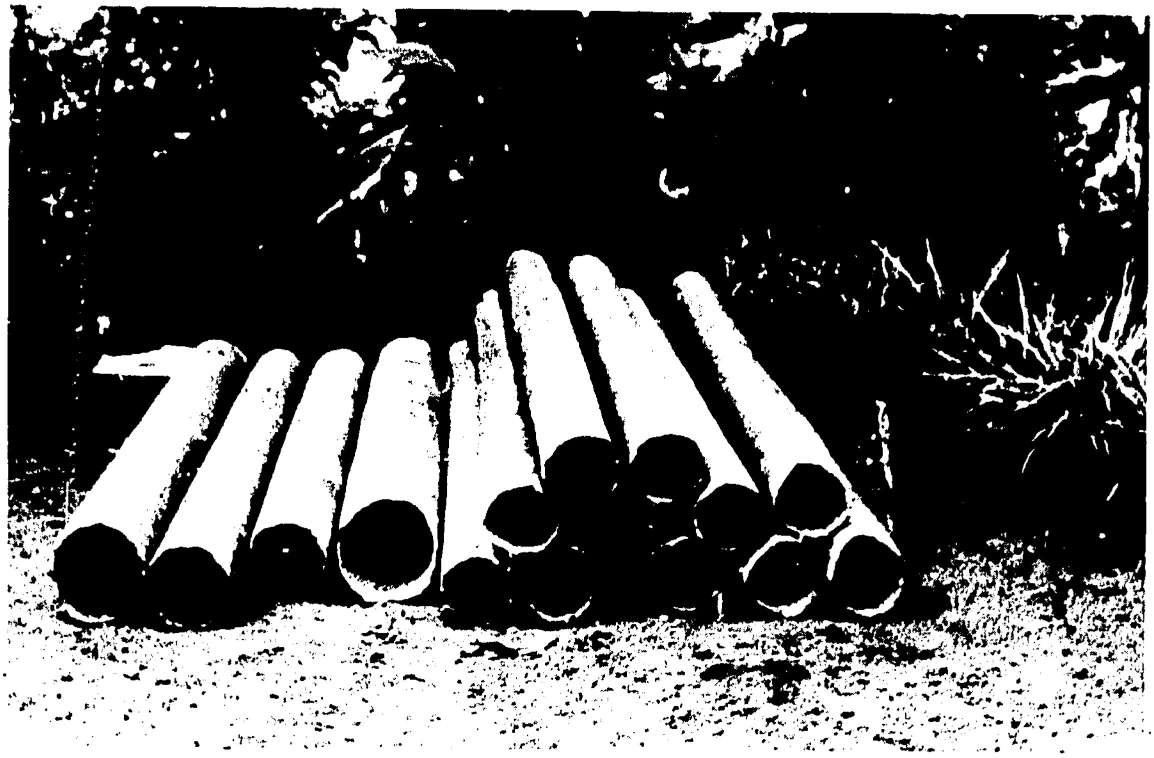


Figure 26
FIBRECEMENT PIPE $\phi 4''$, UNDER CURING PERIOD

Figure 27
FIBRECEMENT PIPE PLACED UNDERGROUND

Figure 28
MCK; A SIMPLE FILTER SYSTEM, WATER TANK AND WATER TAP FACILITIES, BUNIWANGI

Figure 29
REINFORCEMENT OF PONTOON

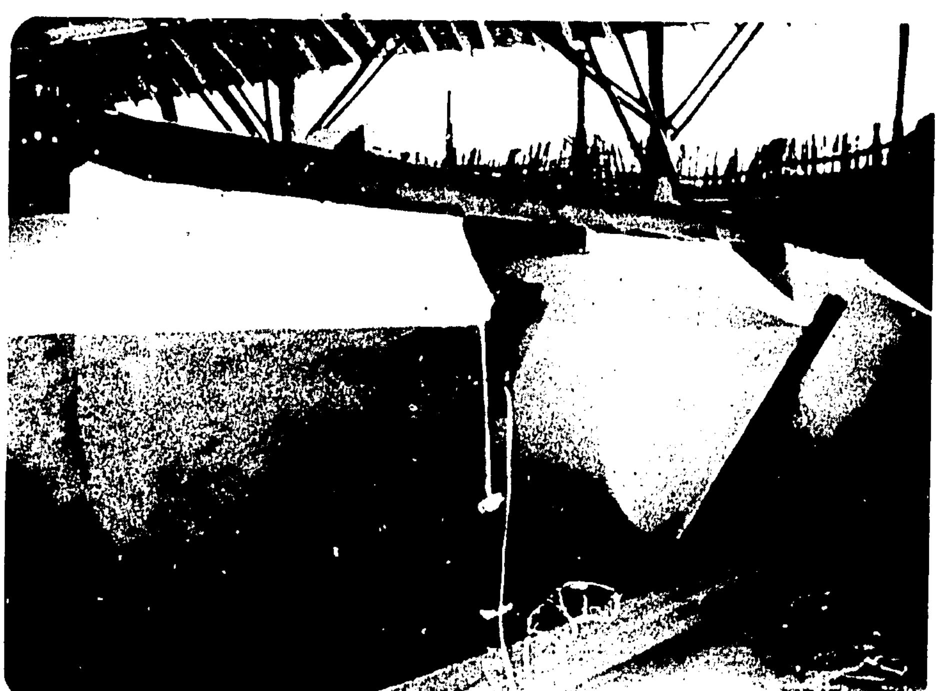


Figure 30
ASSEMBLING THE CYLINDERS

Figure 31
FERROCEMENT FERRY PONTOON IN OPERATION

Figure 33
FIBRECEMENT CORRUGATED ROOF PANEL; 1 M BY 0,9 M
DTC-ITB