FERROCEMENT WATERTOWERS IN INDONESIA

H = 9,50 m, V = 20 m^3, Cost = US$ 2,500

by

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WEST JAVA RURAL WATER SUPPLY PROJECT OTA-33

Bandung, December 1983

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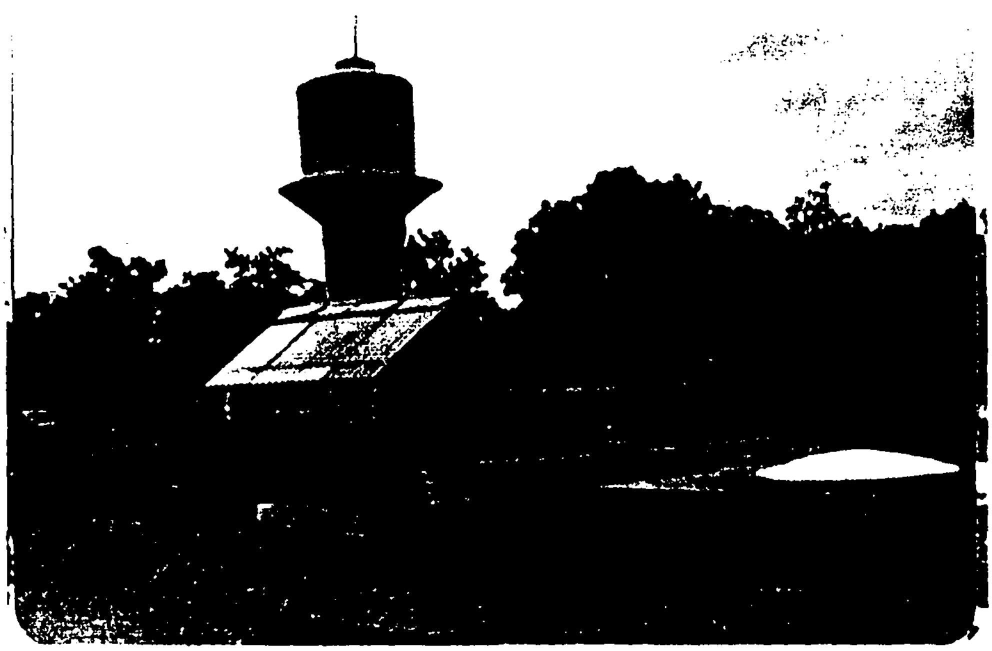
SUMMARY

FERROCEMENT WATERTOWERS IN INDONESIA

A 20 m^3 watertower is built with the use of ferrocement for a cost of ca. 2,500 US$ (pump house included). Further development using a combination of brickwork and ferrocement will decrease the costs and result in an easier way of construction.



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INTRODUCTION

In the year 1976 the Indonesian and the Dutch Governments decided to start the West Java Rural Water Supply Project OTA-33.
This Project is aimed at the development of rural water supply options, appropriate to the West Javanese conditions.
In connection with the efficient use of available water resources a handpump of sturdy design, the Bandung Pump and ferrocement as as material for construction were promoted. Within the scope of the Project ferrocement, introduced as a building material in Indonesia in the late 70's by agencies such as the ITB based DTC (Development & Technology Center of the University of Technology) Bandung and the Dian Desa Foundation Yogyakarta, has been used for prototypes. Based on the experiences of DTC and Dian Desa no further experiments with the new material were undertaken.
A prototype rainwater collector of ferrocement was built by Tuinhof and van Kerkvoorden. The former wrote a detailed manual for building a tank of 10 m³ capacity and also devised a method for calculation and design.
At present thousands of ferrocement rainwater catchment tanks are to be found all over Java. Other applications of ferrocement were the construction, by Hofman, of small scale water purification plants in Karawang and of the slow sand filters of the so-called MCKS-500 system by Pompe in Indramayu. The latter system is a water purification scheme serving 500 people, whose consumption patterns dictate the process of slow sand filtration. The abbreviation MCKS consists of the first letters of the Indonesian words for bathing, washing, toilet and filter, in that order, designating a sanitary unit, annex to the slow sand filter. In 1983, after 2 years of experience, the MCKS-500 has been enlarged into a MCKS-2000 system. This unit or plant has only recently started to deliver clean water to the users through house connections and public sanitary units at which delivery points small reservoirs, commonly used in Indonesia catch the water flow.

The reservoirs allow a restricted outflow at those points and make for a distribution system in which no peak flows occur so that smaller pipes can be used. However, to maintain a constant pressure in the system in the absence of connection to an electric grid, the needed power has to be supplied by either:

a. A genset producing electricity to drive small electric pumps, readily available at local markets (e.g. the Japanese Sanyo series). These pumps automatically switch on when pressure falls below a certain level (up to 10 Ato).
The plant designed by Hofman used this set-up.

b. A diesel engine pumping water into an elevated reservoir to maintain a "constant" head (head varies between 6,5 and 9,5 meters (0,65 - 0,95 Ato).
Several times a day the reservoir is replenished. This "direct Drive" approach is applied in the MCKS-2000.
Operation is rather simple and skills to run and maintain a diesel engine is available in the village.

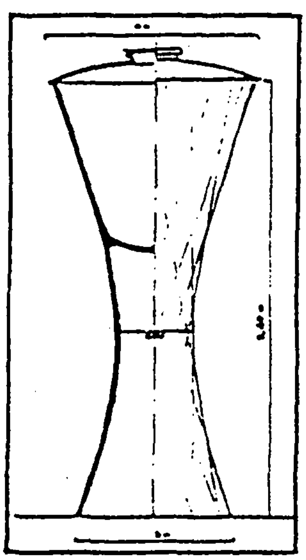
So the next step in ferrocement promotion by the Project has been the construction of ferrocement watertowers.

A WATERTOWER OF FERROCEMENT

A watertower of ferrocement! Sounds challenging. But why ferrocement? Watertowers, as we know them, are built in brick, concrete or steel and often dominate their environment as monuments of functional architecture.
However, in Java there are many draw backs in standard building techniques.
Locally available bricks are of poor quality and heavy constructions in brick are easily damaged by the frequent earth tremors and earth quakes of Java.

Building in steel and concrete is expensive. Steel also needs proper coating against corrosion and concrete's main drawback is the construction of the formwork, a building in itself. Working in steel and concrete, moreover needs special skills which are not available in a village-setting. Construction in ferrocement, its low cost materials easily transported, makes use of a typical village-skill i.e. plastering.

The design first thought of took the form of a hyperboloid, a form which in a mechanical sense is optimally suited to the properties of ferrocement. Regretfully the idea had to be abandoned for 2 reasons. Firstly construction work itself would tax the capabilities of the locally available labour to the utmost. Scaffolding would raise enormous problems.
Secondly the calculations involved, proved to be difficult to work out *).

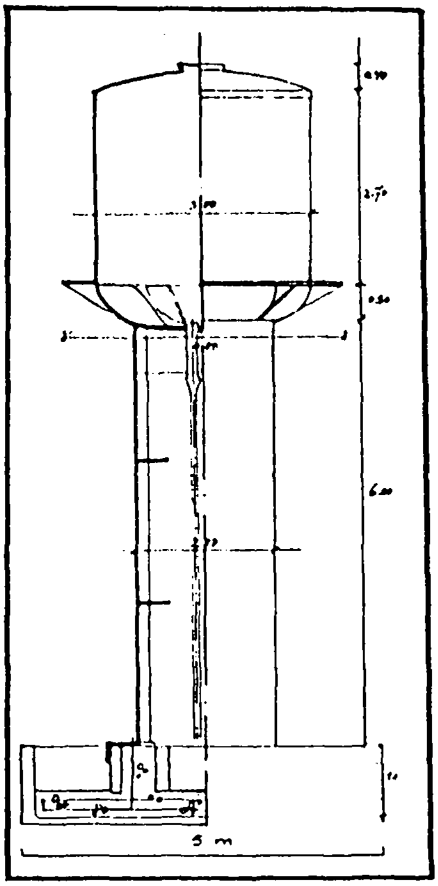


Two watertowers have now been built according to the design discussed in this paper. After a pictorial report of their construction a sketch of an alternative design, will be given.

*) If somebody wishes to tackle the problem, please let me know.

DESIGN OF THE WATERTOWER

Basically the watertower consists of 3 elements one on top of the other, a ferrocement watertank (D = 3 m, H = 3 m) on top of a brickwork/ferrocement tube (D = 2 m) on a foundation slab (D = 5 m) of reinforced concrete which stands directly on a stiff undisturbed underground of heavy solid clay. The resulting soil stress in only about 0,02N/mm² (soil stress under the authors shoes amounts to about 0,03 N/mm²). So no piling is required.
The engineering firm Triweger Indonesia has checked the design on earthquake resistance and structural strength. As it is the intention of the author to report on these matters separately in the Journal of Ferrocement, in this paper only the structural background of the design will be discussed.



FOUNDATION SLAB

The circular foundation slab is of reinforced concrete with a thickness of 0,4 m. Formwork for the slab is a brickwork basin with a diameter of 5 m and a depth of 1 m.

TOWER

To keep construction simple, a lost mold method has been applied. The tube of brickwork meaning 2 m diameter is erected first. Bricks have no structual function and in calculating the strength of the construction are disregarded; in calculating the loads in relation to dynamic be haviour (of the construction as a whole) they are included.

FLOOR OF THE WATER TANK

The saucer shaped bottom of the tank, upon which the tank will be constructed and forming the connection between the trunk of the tower and the tank, consists of a groid of steel rods "wrapped-up" in chickenwire mesh. Great care should be given to the proper anchoring of trunk and tank wall to the floor.
Dimensioning of the (reinforcing) rods is based at the assumption that only the rods take the load; the mesh being disregarded in the calculation. Optimisation of reinforcement of concrete is expected here.

TANK

The tank is just a conventional water tank, designed according to the formulas determined by Naaman & Shah.
In the center of the tank a pipe gives access into the tank from insede of the tower.

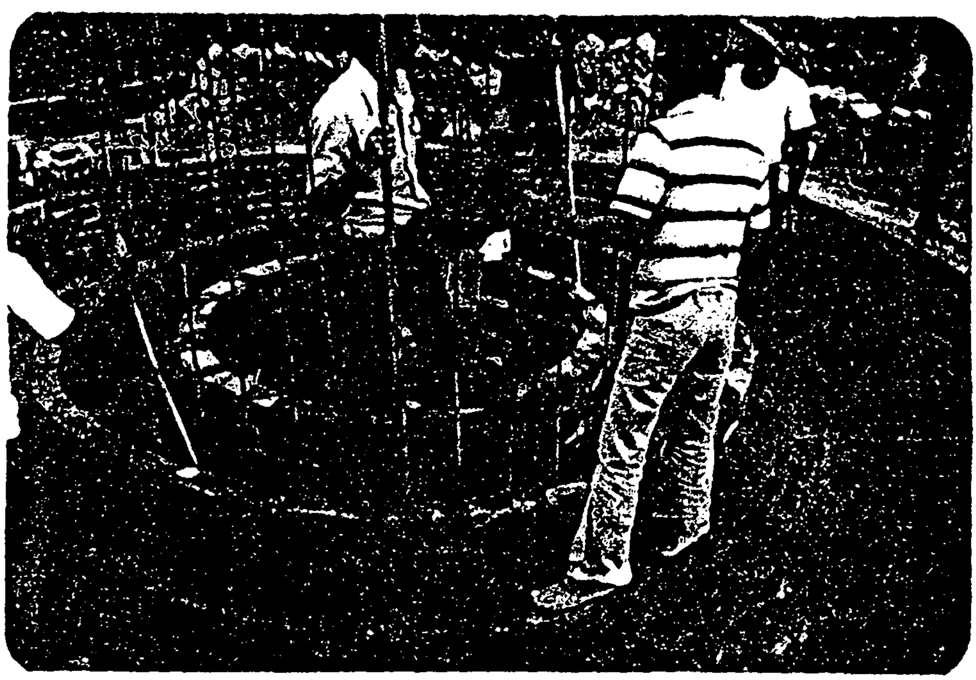
The first tank built had a manwhole on top of the tank which had to be reached by climbing 9,5 m up a vertical flight of stairs on the outside of the tank wall, which not many people liked to do.

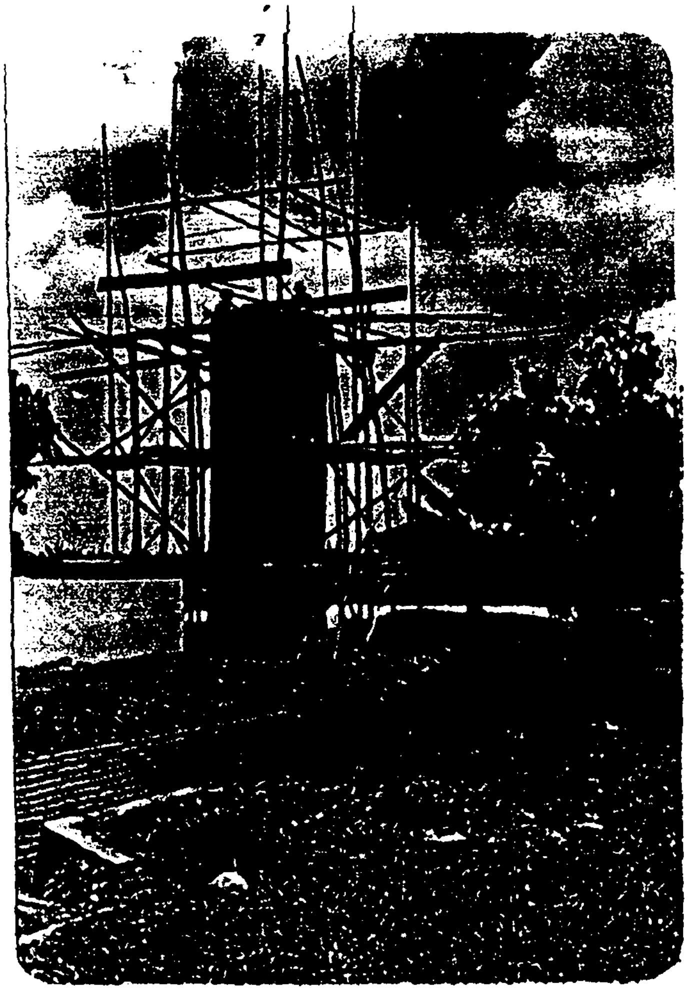
An overflow outlet, together with a piece of painted wood connected to a rubber bulb floating inside the tank provide visual contact from the outside of the water level in the tanl.

The following pictures give an impression of the different stages in construction of the watertower.

CONSTRUCTION OF THE WATERTOWER

Casting the foundation.

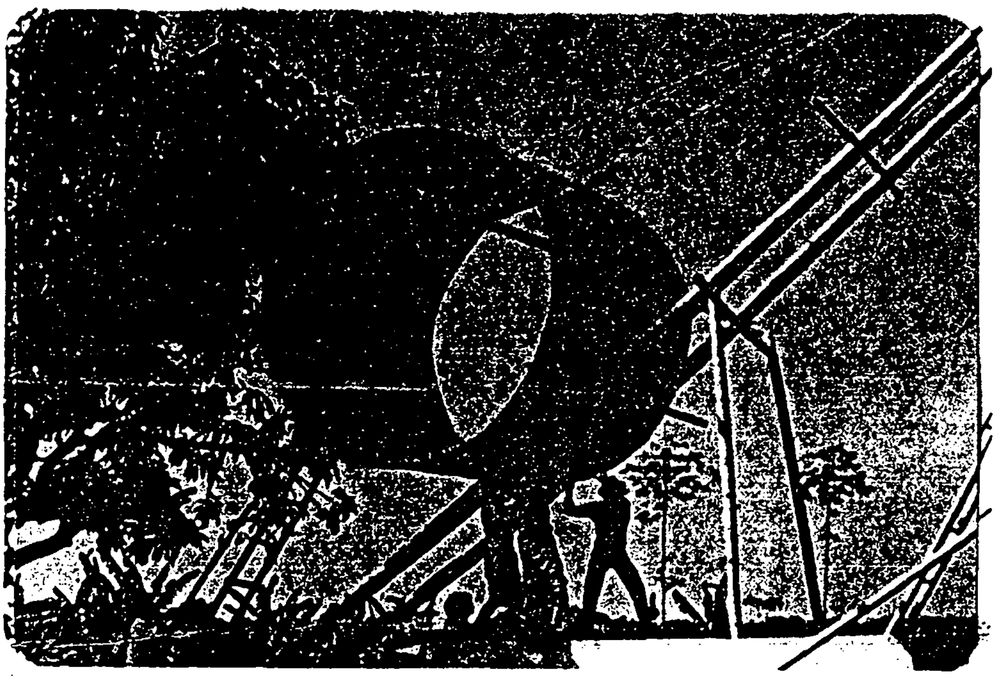




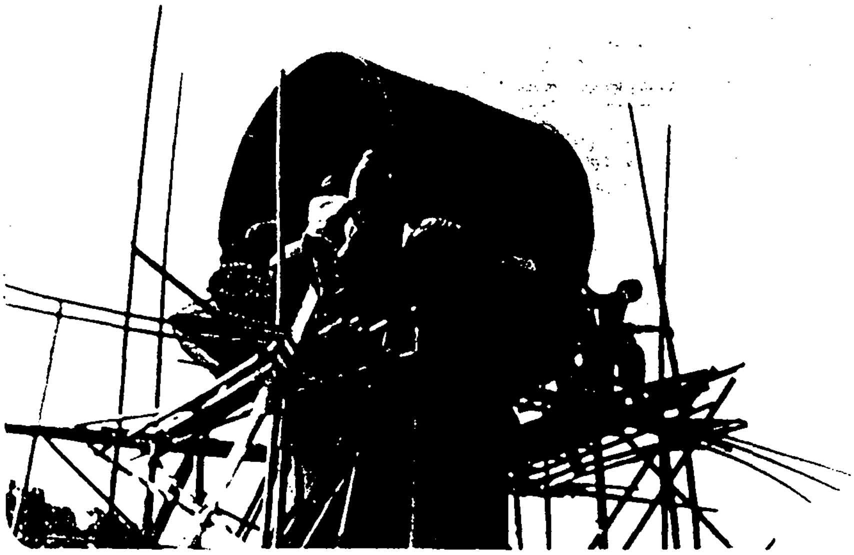
brickwork tower "wrapped" in ferrocement.

Saucer shape bottom of tank.

Tank bottom hauled by manpower.

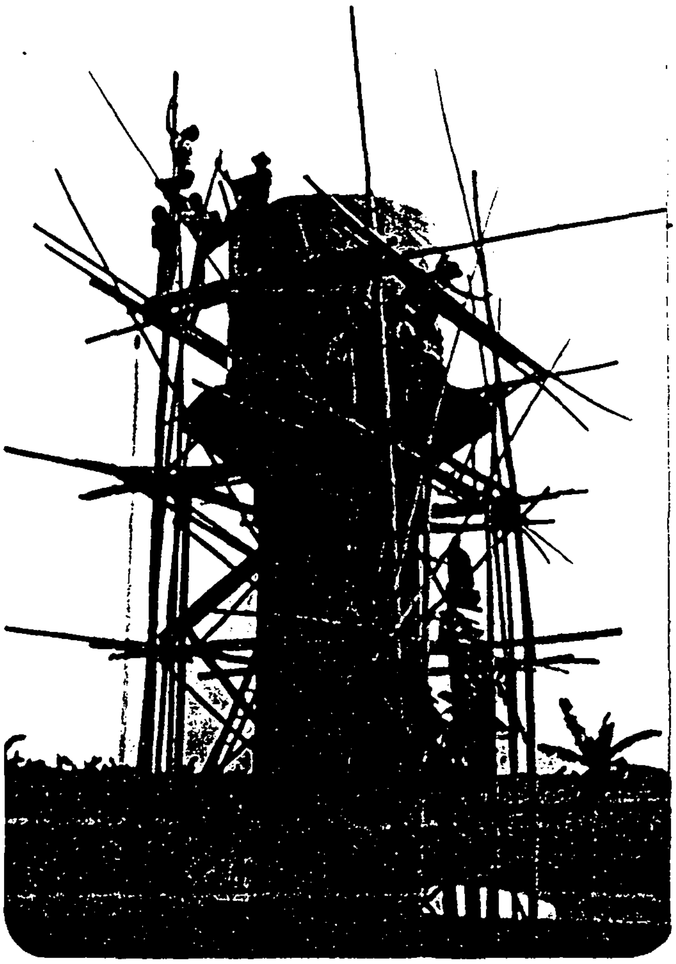


form work of tank rolled up.

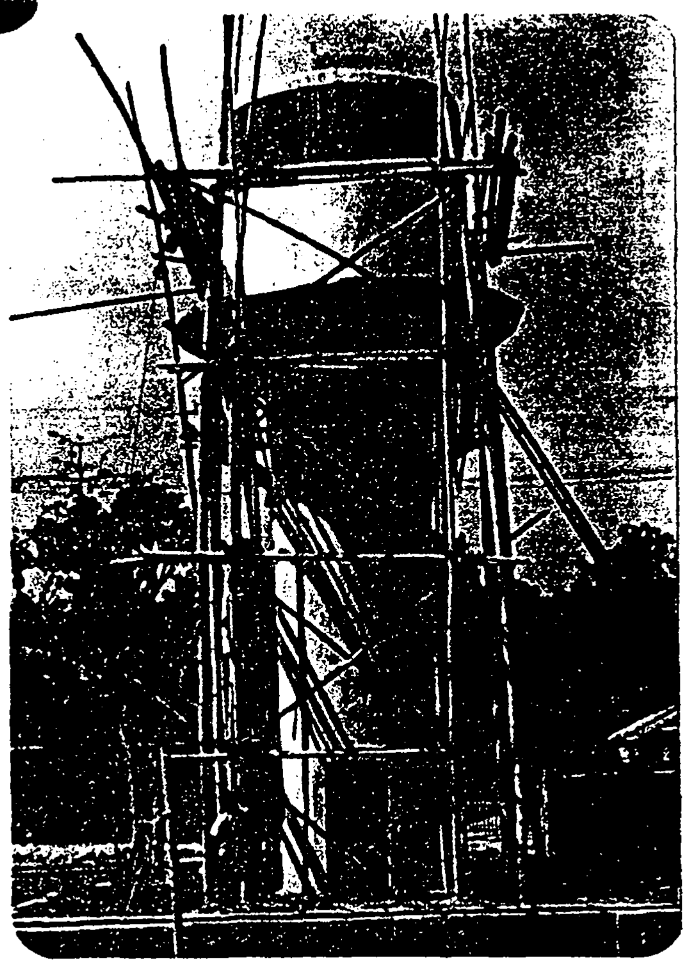


how to tackle
this problem ?

after plastering .....



........the tank must be cured well !..



........and given a nice colour.

CONSIDERATIONS FOR FURTHER IMPROVEMENTS

Hoisting the tank bottom and its mold up to the top of the supporting column involves time consuming labour and prefabrication of its skeleton grid of concrete iron is relatively costly.
To save time and money the next design has incorporated the utilization of a lost mold of bricks: on the inner side of the brickwork hollow column (H = ± 6 m; ϕ = 2,5 - 3 m) ferrocement is applied in one layer.
The tank bottom, ± 6 m above groundlevel together with its iron/steel skeleton will be constructed in situ.
In cross section the structure resembles that of bamboo.