CONSTRUCTION OF A DOMED BRICK ROOF

by

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Introduction

The construction of brick domes goes far back into history and is believed to be originated in China. As the quest for alternate energy became popular in Asian countries, brick domes have been constructed to store biogas.

Up to now, most of the brick domes have been constructed underground where the load transmitted from the dome due to self weight and other imposed loads are transmitted directly to the ground with no further complications; bending moment action on walls etc.

The purpose of this paper is to discuss the design and construction of brick domes above ground level where the circumferential force does not get transmitted to the ground directly. Such applications include the construction of brick dome roofs of dwelling units, summer houses and water tanks.

Normally shell structures are economical due to the fact that the material is stressed uniformely to its fullest capacity everywhere. The material for the domes under consideration are bricks and mud or mortar. A major factor which leads to higher costs of construction, shuttering, is not required in the construction of brick domes. This is a great advantage specially in the construction of water tanks where reinforcing steel and form work are required in the usual practice. Only a small frame which does not provide any supporting action is required to get the spherical shape.

The amount of skilled labour required to construct the dome is very little. Unskilled people can be made familiar with the technique of construction in a very short time and the dome can be constructed very quickly.

Theoretical Considerations

From membrane theory of shells it could be shown that the membrane stresses will be, compressive for a uniformely distributed load if the shell angle (see figure 1) is kept less than 51°50'.

Table 1, shows the membrane force (P) that has to be restrained by the ring beam for a shell angle of 45°.

Based on the properties of standard bricks and using a computer programme, the number of brick layers necessary to construct a dome of a particular diameter was calculated. It was found that, upto a floor diameter of 34m, one could use a single brick layer.

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Method of Construction

A brick dome of 11 feet diameter was constructed by the authors, at the, Faculty of Engineering, University of Peradeniya in 1981.

First, the radius of the floor area and the angle of inclination at the circumferential periphery of the sphere (shell angle) should be selected. A concrete ring beam or a steel member bent appropriately is used to withstand the lateral force. (Figure 2). The supporting surface of this member will hold the first ring of bricks at the required angle. The ring beam should be fixed to the supporting structure (walls etc.).

Supporting System for bricks

If we place a brick at the appropriate angle supported by a rod with a rail (as shown in figure 3) and two other bricks are placed on either side of the first bricks with similar rods, then due to wedge action of the three bricks, the supporting rod of the middle brick could be removed. Continuing in a similar manner, one could complete a ring of bricks. Proceeding with the rings in a continuous operation, the dome could be completed. As the construction of the dome proceeds, rods of different sizes are required. This problem can be over come by using telescopic rods with adjustable lengths.

Types of Brick

The whole idea behind this simple method of brick dome construction is the wedge action between adjascent bricks. Therefore it is very important to maintain a good quality control of bricks. In order to improve the wedge action between two bricks resulting in better strength of the structure, one could use a special type of bricks. The additional cost incurred on the improvement of bricks could be offset, if this method of construction can be used for a large number of structures.

Figure 4 gives the number of standard bricks required to construct a dome for a particular diameter with a selected shell angle.

Type of Mixture of Mud

The important characteristic that is to be considered is that once the mixture of mud gets dried up, it should not show appreciable changes in volume. Also there should be no excessive cracking. One should take necessary steps remove all extraneous matter such as decomposed organic matter, tree roots, leaves etc.

Since the adopted technique is not a very sophisticated method, careful sieving need not be done, and a very crude grading method is sufficient.

Scaffolding System

A strong but cheap scaffolding system is necessary for the workmen to stand. Practically it is not possible to build the dome with only one scaffolding system. It may be required to erect two scaffolding systems above and below the dome. This will facilitate in proper application of mud and filling-in of voids.

Maintaining the required shape

A major difficulty in constructing the dome is to maintain the required shape. This can be facilitated by using a frame made of cane to suit the shape of the dome required.

Another method is to errect a pole at the middle of the dome. A wire bent according to the profile of the dome is fixed to the top of the pole and this wire can be rotated round the pole to maintain the shape of dome.

Surfacing

Once the dome is constructed, the interior and exterior surfaces could be plastered with cement-mortar. In order to minimize the heat absorption

the exterior surface can be made smooth. This is done by applying a grout mixture or a wax polish or a suitable paint.

Dynamic Considerations

These domes cannot be subject to large vibrations. Hence these structures are not suitable for tectonic regions. This way, Sri Lanka poses no hindrance for its wide use. However, it is advisable to refrain from building these domes in places where vibrations could occur, such as near Railway tracks.

Conclusions

1. Although the design was based on distributed loads, the dome constructed at University of Peradeniya carried the three authors (Point Loads), thus demonstrating the abilily of the dome to withstand any accidental imposed loads.

2. Due to its ease of construction, and low cost these domes are suitable for the roofs of dwelling units, summer houses, ware houses, digesters, water storage structures (such as Intze-type) & bio-gas tanks.

3. Although the authors used mud, one could use cement-mortar, thus making the structure even stronger. One could make the structure, water resistant by using a bituminous material coating.

4. It is advisable to construct these domes away from areas where excessive vibrations could occur such as near railway tracks.

Acknowledgement

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TABLE NO. 1

r (m)	p (kN/m)
4	2.03
5	2.54
6	3.05
7	3.56
8	4.07
9	4.55
10	5.09

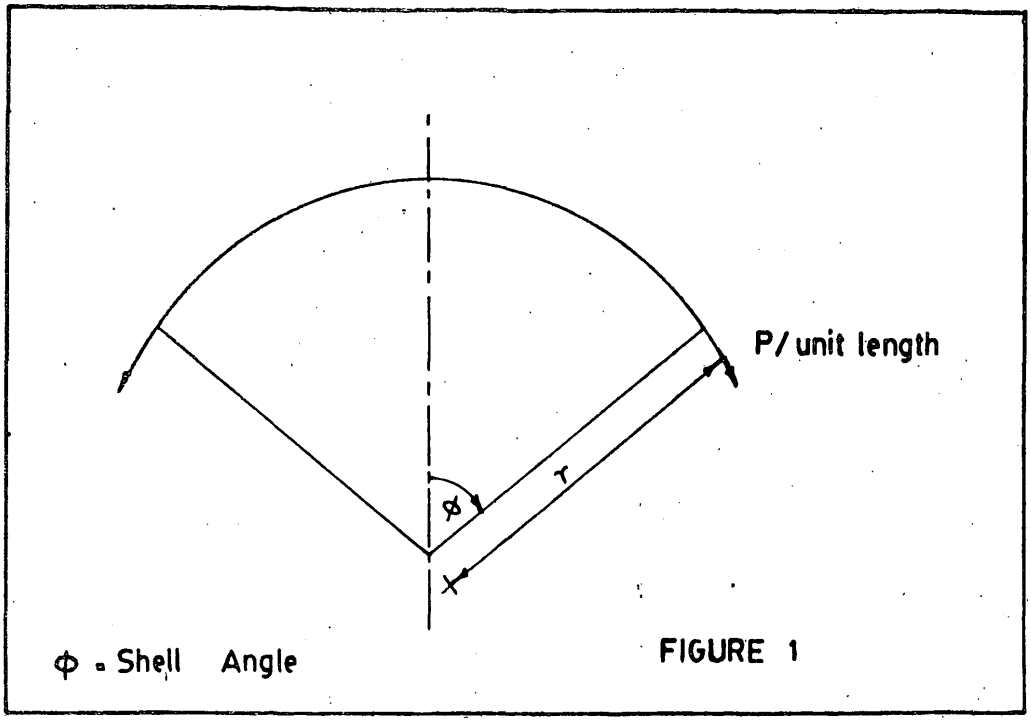


FIGURE 1

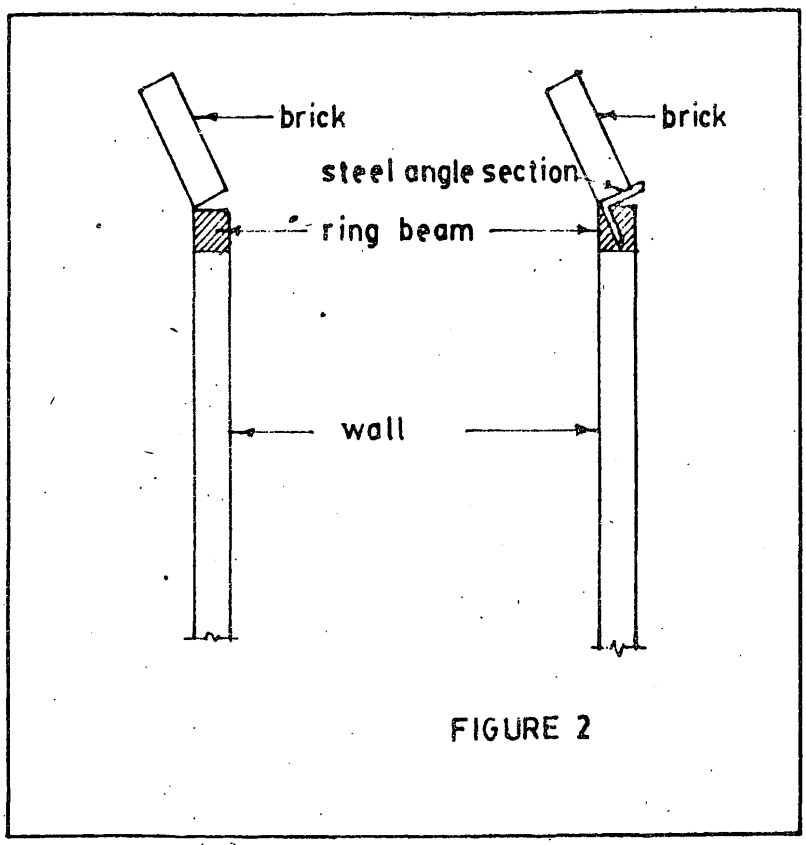


FIGURE 2

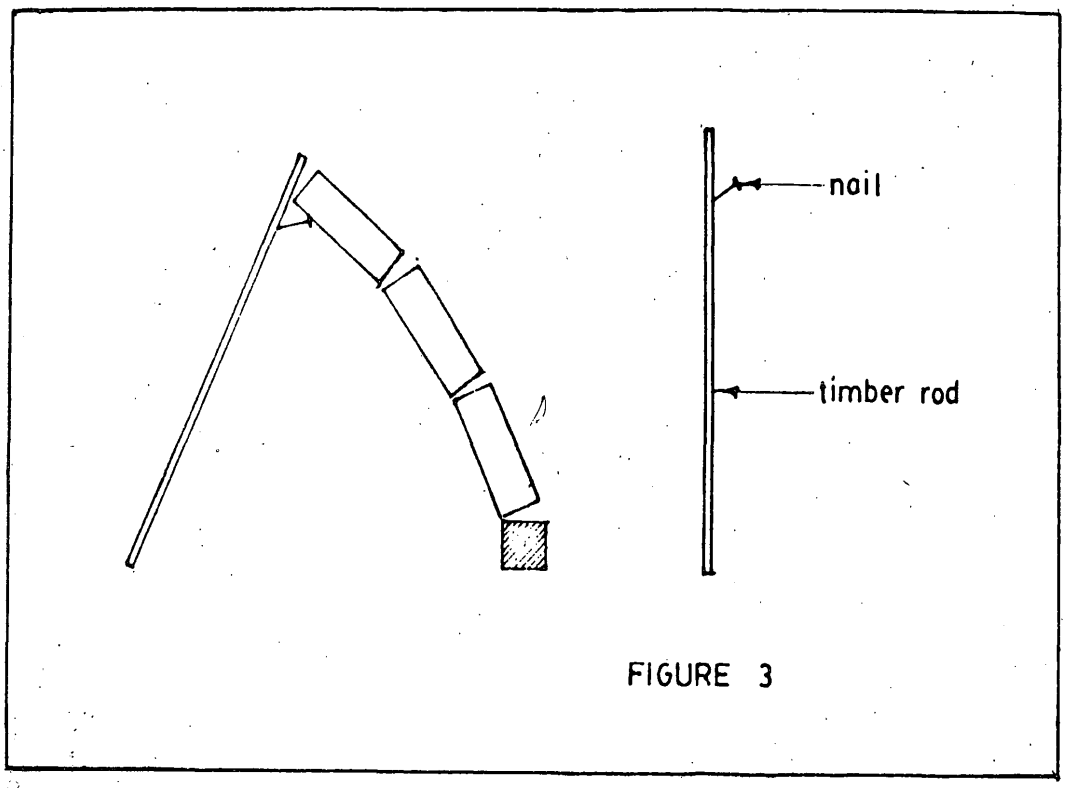


FIGURE 3

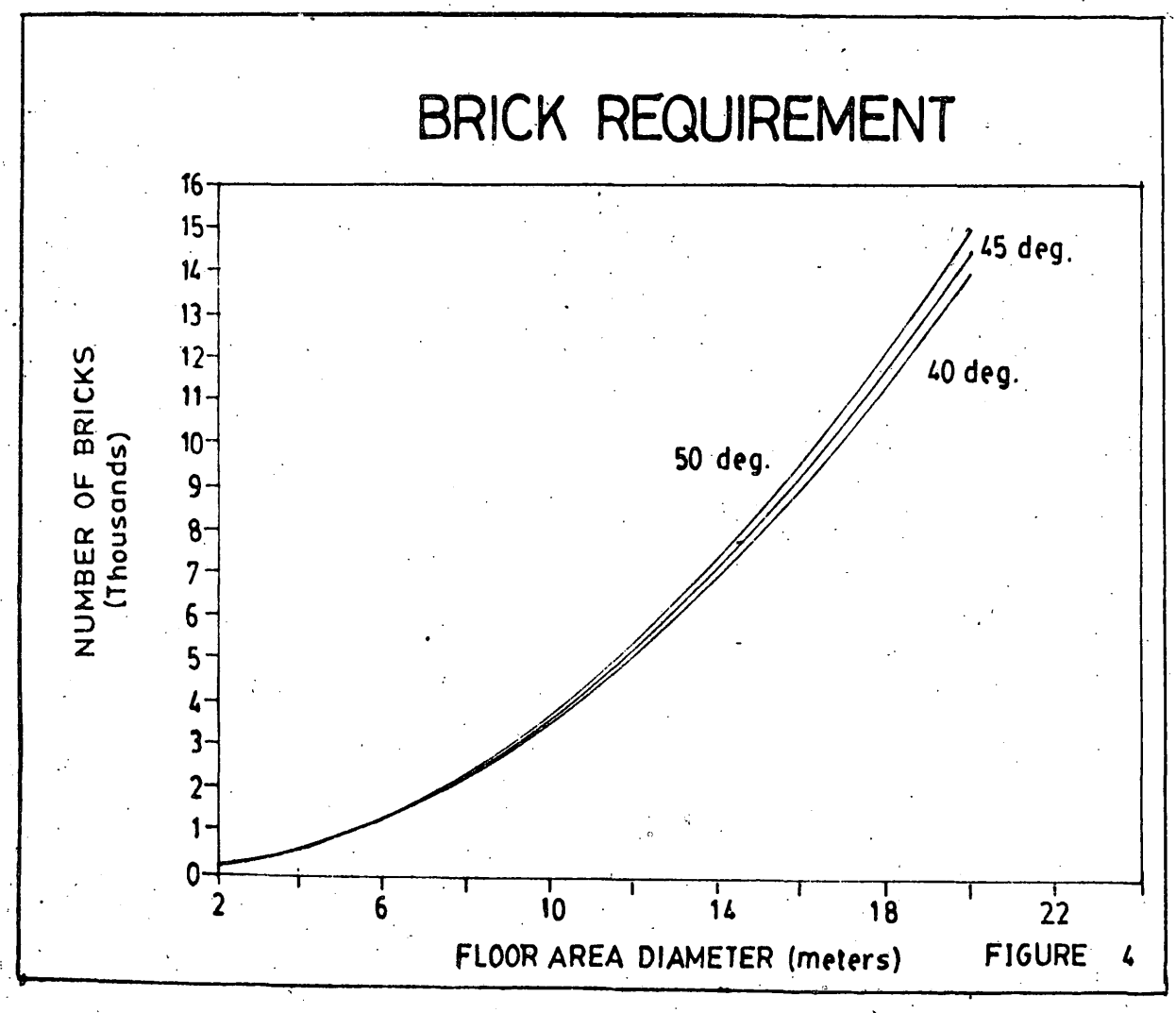
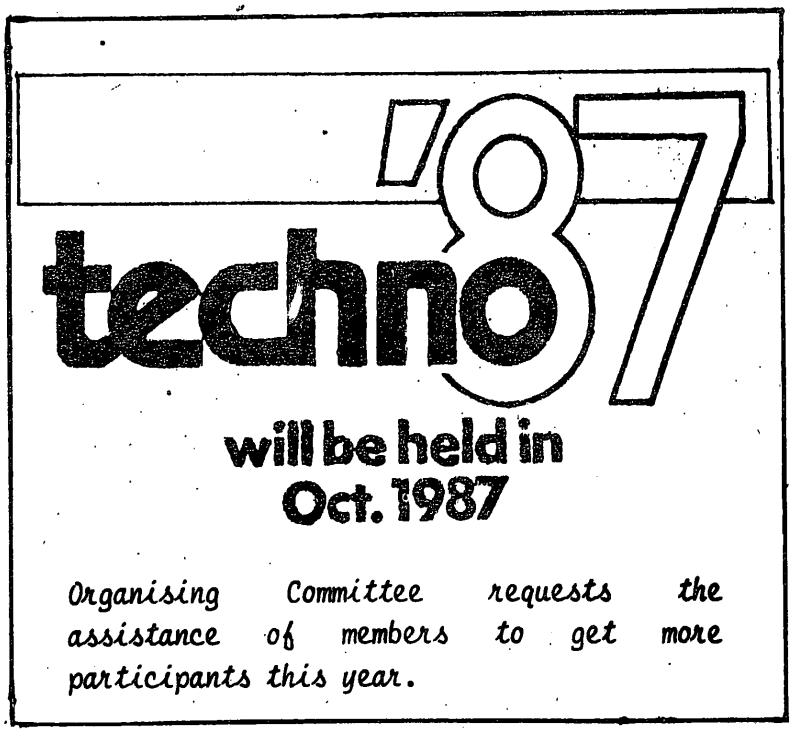


FIGURE 4



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