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GEOTECHNICAL PROBLEMS OF DESERT AREAS WITH PARTICULAR REFERENCE TO WATER STORAGE

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ABSTRACT

Geotechnical problems of desert areas are numerous. Besides the problems of constructing satisfactory road network for transportation of men and materials, there is a need for developing suitable water storage facilities. In the north western part of Rajasthan, nearly sixty percent of which is covered by sands, the problems acquire special significance.

The paper outlines the problems of transforming natural depressions into water reservoirs and presents a novel method of constructing underground water storage tanks. Taking cue from the use of RCC diaphragm walls in a variety of civil engineering constructions viz., the cut and cover sections of the metropolitan Transport Project, Calcutta and the water cut-off at the Sarada Sahayak Pariyojana in U. P. the authors believe that a simple semimechanised process of diaphragm walling developed by the CBRI (Mohan et. al. 1975) can be adopted for construction of underground storage tanks in all types of sandy deposits.

Design and construction details are provided for tanks 3m to 6m deep. Requirements of leak proof joits to control seepage losses are highlighted and a surface treatment of exposed tank walls is proposed as an added safety measure.

It is concluded that water storage tanks constructed by diaphragm walling technique are economical and their construction is less time consuming compared to underground talks constructed using conventional methods.

INTRODUCTION

Geomorphology of Ripples, sand dunes and sandy ridges of the North-Western Rajasthan have been studied and the related geotechnical problems have been identified in some detail, (see eg. ALAM SINGH 1973; KAYERKAR 1975) but serious efforts are yet to be made to find out satisfactory engineering solutions to these problems. Sand drift in the desert areas proves hazardous when it accumulates on the roads, railway tracks or when it chokes the flow of canals. Several attempts have been made to evolve easily erectible, maintainable and less expensive measures to check sand drift. Measures like installing Sand Screens close to a road or building shallow flexible obstructions by brush wood or local grass a short distance from the windwardside of an affected zone have been tried with varying degrees of success. Researchers have toyed with the idea of densifying loose sand deposits by detonating explosive charges but no definite conclusions are available so far. Perhaps, Vibrofloatation may also find application in situations where densification of sand deposits is to be achieved in order to eliminate possibility of liquefaction in a given situation.

Natural Depressions As Water Reservoirs

The Irrigation Department of the Government of Rajasthan is already attempting to take advantage of the presence of enormous natural depressions which exist banked by sand dunes. The plans are to convert them into Water Reservoirs by constructing saddle dams bridging the gap between sand dunes, Fig. 1. The reservoirs so created can be utilized for irrigation purposes and saddle dam can also serve as a measure of flood control. Natural depressions are sometimes found to be about a couple of kilometer wide and about 6-7 km long. The dunes flanking them are usually about 10-28m high and nearly 400m to 600m wide at the base. The saddle dams usually planned are of the order of 8m to 16m high and 30m to 70m base width. Foundation of saddle dams being highly pervious, there always remains a danger of their failure by piping and consquent flooding the adjoining areas. The diaphragm walling, the use

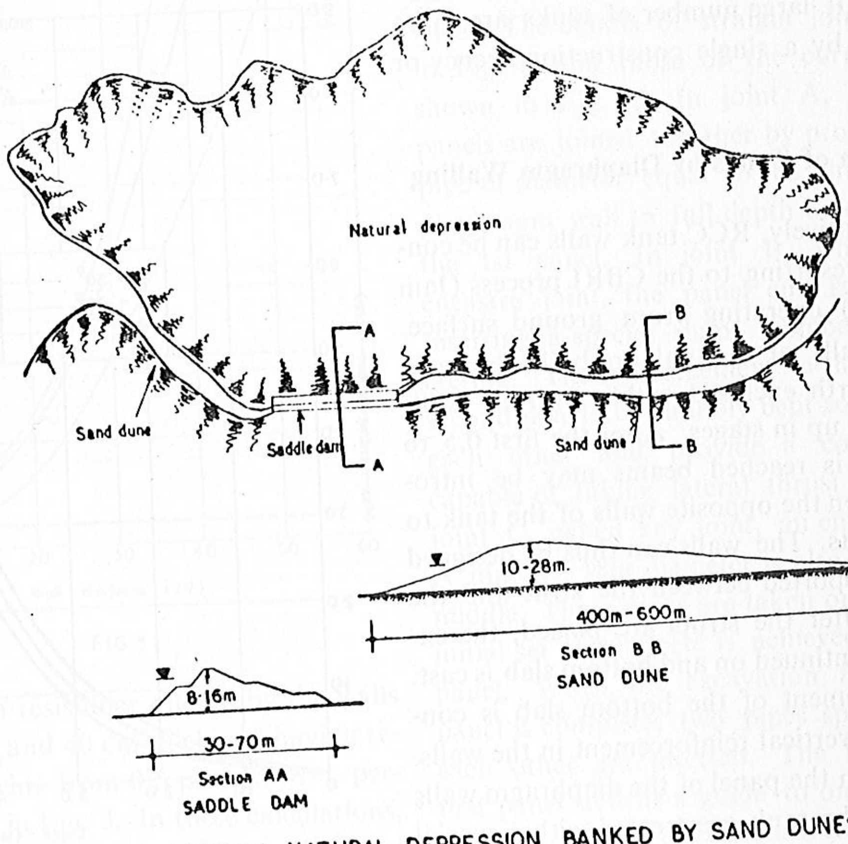

FIG. 1 A TYPICAL NATURAL DEPRESSION BANKED BY SAND DUNES

of which is advocated for construction of underground water tanks, may therefore also find application as water cut-offs in some such situations.

Construction of Under-Ground Tank by Open Excavation

Conventionally, underground tanks are constructed by achieving excavation upto the required depth letting the sides of excavation adjust themselves to the angle of repose, which they do, regardless of the depth of excavation. An RCC tank can then be built by designing its walls as simple cantilevers and its base as a flat slab. This method of tank construction requires enough space around the tank and enormous earth work. The construction is also likely to be more time consuming and uneconomical particularly if large number of tanks are to be constructed by a single construction agency or department.

Construction of Tanks by Diaphragm Walling

Alternatively, RCC tank walls can be constructed by resorting to the CBRI process (Jain et. al. 1974) operating from ground surface. Once the walls of the tank are built, the excavation of earth enclosed within its four walls can be taken up in stages. After the first 0.5 to 1.0m depth is reached beams may be introduced between the opposite walls of the tank to serve as struts. The walls can thus be designed as simply supported between the strut and the base slab. After the struts are placed, the excavation is continued on and bottom slab is cast. The reinforcement of the bottom slab is connected to the vertical reinforcement in the walls. Joints between the panel of the diaphragm walls constituting the tank are treated with a special sealant for water proofness.

Design Consideration

RCC diaphragm walls used for underground tank construction are normally designed to take up the active earth pressure considering the tank empty condition. The earth pressure distribution diagram may be assumed in accordance with the recommendations made by Terzaghi and Peck (1967). The maximum bending moment computed for 3 to 6m deep tank walls are shown in Fig. 2. The calculations are based on the assumption that the tank walls are simply supported, water table is very deep and there are no surcharge effects. The properties of sandy soils considered in the design are given in Table 1.

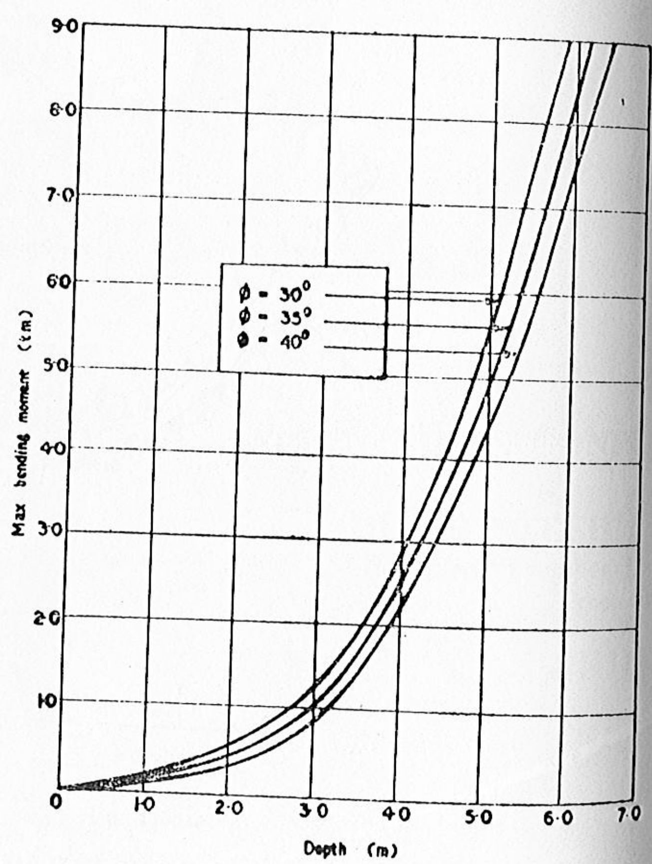

FIG 2

Table 1

Relative Density of packing	N value	Unit Weight γ (t/m³)	Angle of shearing resistance Ø
Loose	10	1.6	30°
Medium	10 to 30	1.8	35°
Dense	30	2.0	40°

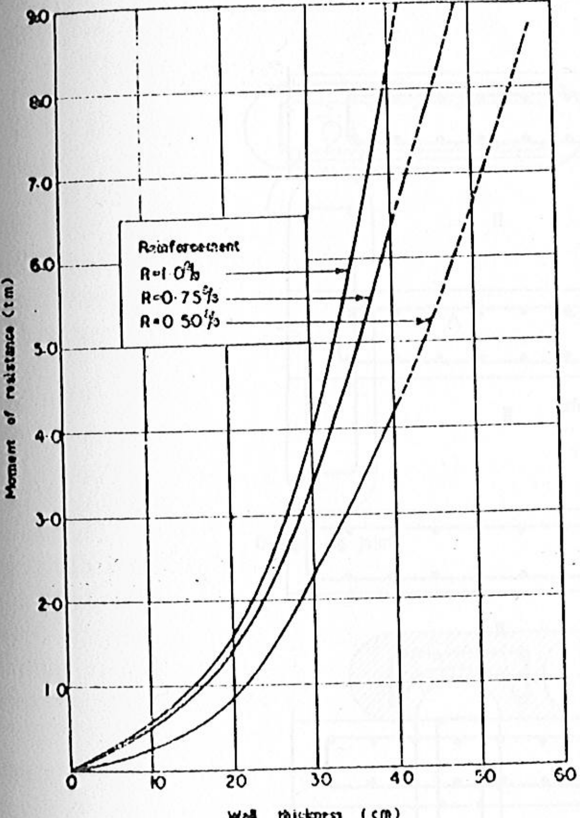

FIG 3

Moment of resistance offered by the walls of 20 cm, 30 cm and 40 cm thickness having reinforcement varying from 0.5 percent to 1 percent are shown in Fig. 3. In these calculations, walls have been assumed as doubly reinforced beams made of 1:1. 5:3 concrete of slump equal to 150 to 200 mm taken as equivalent to M 150 concrete.

From the results it could be concluded that a thin wall of about 40 cm thickness can be adequate for tanks of depth up to 5.5 m in loose sands and up to 6m in dense sands, when 1 Percent reinforcement is used. Conventional 60 cm thick walls, therefore, represent a conservative design.

CONSTRUCTION

The Process of diaphragm walling is fully described by Mohan *et. al.* (loc. cit). The only aspect which needs, detailed look is the nature and requirements of joints between the panels. Details on, joints between the straight panels and those at the corners of the tank are provided. The details of straight joints are shown in Fig. 4. and those of the corner joints are shown in Fig. 5. In joint A, two straight panels are joined together by providing an end pipe of diameter equal to the thickness of the diaphragm wall to full depth before concreting the 1st panel. In joint B, which is called encastre joint, the panel end is prepared by inserting a special shape member before concreting. The reinforcement in the first and the second panel are suitably bent so as to overlap each other and provide a continuous wall capable of taking lateral thrust and shear. In joint C, called key joint, an end pipe is used. A pipe, O. 18m diameter is also inserted in the middle. These pipes are taken out just after the initial set of concrete is achieved in the trench panel. When the excavation for the second panel is complete, two pipes spot welded with each other are inserted. The hole left in the first panel acts as a guide to one of the pipes. After initial set of the concrete in the second panel is achieved both the pipes are taken out. The holes are chiselled to rectangular shape to full depth and cleared with wire brush and water jet. Afterwards, the opening is filled back with expanding cement grout or concrete containing Aluminium powder. A ladder reinforcement is normally used. This joint performs well where structural continuity is required. The overlapping joint, D, has been used with success where water cut-off is the prime consideration such as in the hydraulic structures. The end shape of the first panel is made by a cutter and after excavation of the second panel, a special shape semicircular cutter is used near the joint to make excavation overlap the end of the first panel. This cutter is shown in Fig. 6. After concreting, an overlapping leak proof joint is ensured upto full depth of the wall. Joint E is similar to joint D excepting that the shape of the jointing cutter is slightly modified so as to result in a flush joint rather than an overlapping joint. When face of the wall is exposed, the concrete at the joint may be chipped off and replaced by an

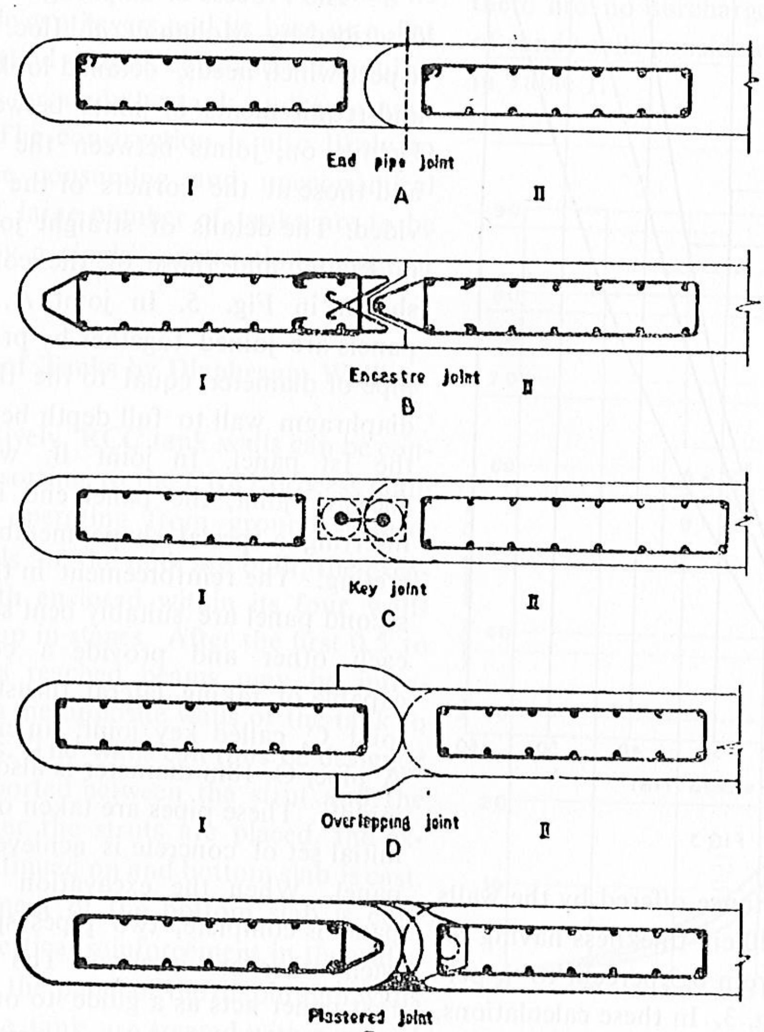

FIG. 4 JOINTS BETWEEN STRAIGHT PANELS.

impermeable sealant mortar. This type of joint is recommended for underground water storage tanks.

Corner joints are illustrated in Fig. 5. The shape of cutter and overlap provided at the corner are shown. In making this joint, the cutter is required to be rotated by 90°.

For making a plastered joint, B, a modified semicircular jointing cutter is required. The corners are plastered after the wall is exposed. Fig. 5 shows a precast joint in which the end member is a precast RCC member. It is inserted in the trench panel I at the end before concreting. The excavation for the panel II starts from the groove provided in the precast panels. This is likely to provide a suitable joint for the corner.

CONCLUSIONS

1. RCC diaphragm walls of thickness 40cm or less with 1 per cent main reinforcement are generally adequate for underground

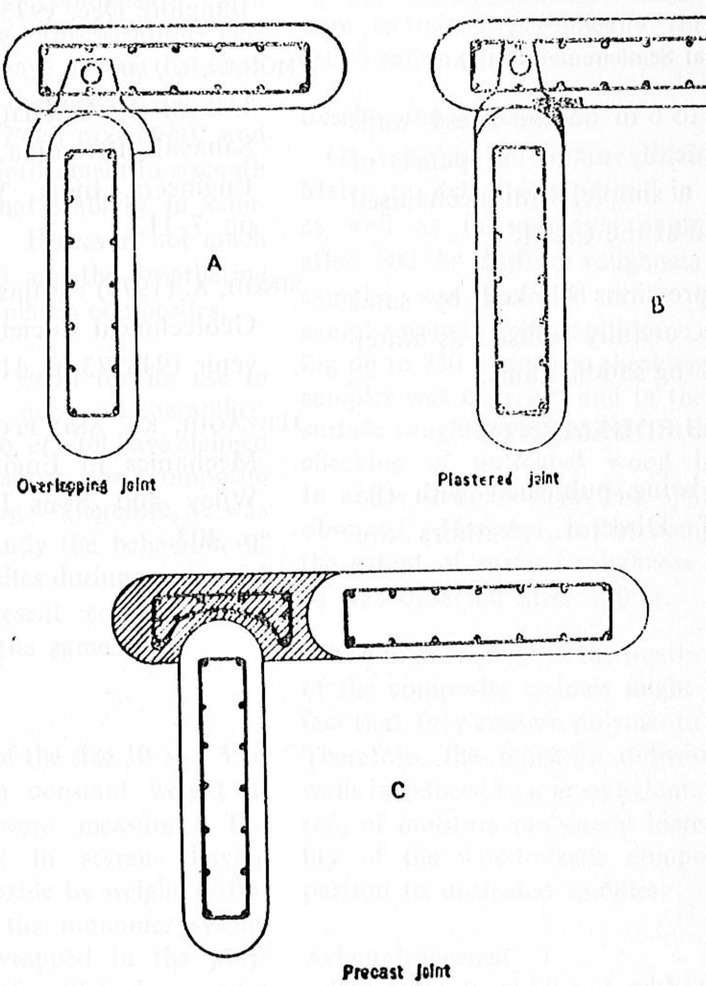

FIG.5 JOINTS BETWEEN CORNER PANELS

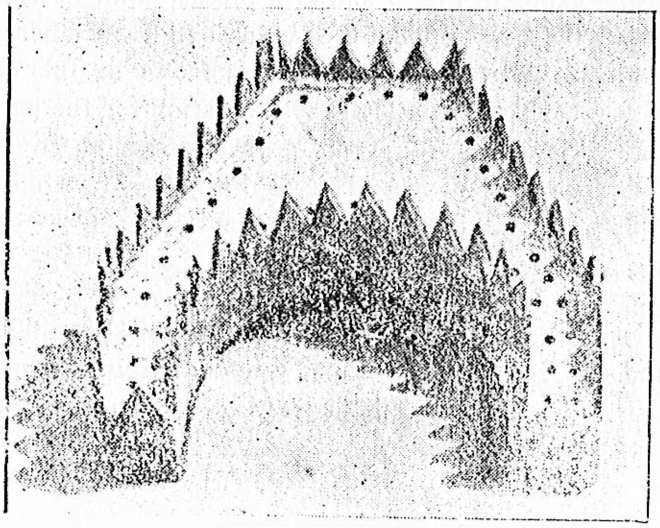

Fig. 6. Special Semicircular Cutter

water tanks of 3 to 6 m depth. These walls may be economically made, in panels of 1.5m length, by a simple, semi-mechanised process developed at the CBRI.

2. The natural depressions banked by sand dunes can be successfully utilised as water reservoirs by making saddle dams.

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