BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

SIMPLIFIED SOIL BORING & SAMPLING THROUGH BENTONITE SLURRY

Introduction

During recent years construction of heavy structures has considerably increased and the importance of adequate soil exploration is being increasingly felt. In this digest a simplified proces.s of soil exploration through bentonite slurry has been described. The method is economical, fast and efficient. The equipment is manually operated and consists of simple parts which are readily available.* The method can be used for all types of soil exploration jobs.

Boring Technique

The process of boring consists of drilling by using bentonite slurry. Use of casing pipes has been eliminated. The bore hole is stabilized by the lining of bentonite mud. The continuous flow of slurry through the bore hole carries the cut material to the surface. It is the colloidal property that checks sedimentation and the increased weight of the slurry prevents sandboiling. Its thixotropic property prevents the sides from caving in. The technique helps in carrying out standard penetration tests at the required depths. Collection of undisturbed soil samples is also simplified.

Bentonite Slurry

Bentonite is a heavy clay of the montmorillonite group and it is pumped into the bore hole in the form of a slurry. During boring operations, the slurry, due to constant agitation, stays in the fluid form. It flows through the drill rods into the bore hole and then flows upwards carrying the cut material to the surface. As soon as the drilling equipment is withdrawn the slurry starts setting to a gel-form. This prevents sedimentation by arresting the soil particles in suspension.

The bentonites available in India and their properties are given in Appendix I. The bentonite from Rajasthan is of good variety and a 5 per cent (by wt.) slurry of this bentonite in water would be suitable as a drilling fluid. Poorer grade of bentonite can be used by activating it with a little soap solution. The slurry should be of uniform consistency since presence of lumps will cause choking up of the equipment. The method of preparing the slurry has been detailed in Appendix II.

Boring Procedure

The details of the boring equipment has been shown in Fig. 1. The direction of flow of the bentonite slurry is also indicated. Boring operation and pumping in of the slurry is carried out simultaneously. About 5 persons are required to operate the equipment.

The drilling equipment consists of a soil cutter (a), connected to 'A' type or larger size drill rods (b), which pass through a boring guide (c). This guide maintains the alignment of the drilling system and is anchored to the ground with the help of spikes. Two persons keep on rotating the drill rods by means of a pipe wrench (d) A water swivel assembly (e) is fitted on drill rods. Two persons operate the double piston reciprocating type hand pump (f), pumping bentonite slurry from the slurry tank (g), into the drilling system through the water swivel. The slurry, flowing out of the cutter at the bottom, mixes up with the cut soil and brings it up to the surface. It flows into a settling tank (h), and from there back to the slurry tank. The lay-out of the tanks, channels etc. is shown in Fig. 2. The process is a continuous one and the same slurry is used over and over again. A workable consistency of the slurry can be found out with experience and it is best felt by touch. One person gradually lowers the drilling system by releasing the rope (i) passing over a fixed pulley (j) fitted on to a tripod hoist provided with a manually operated winch (k). Too fast a lowering of the drilling system may cause jamming of the cutter making it difficult to rotate the system.

Full list of the equipment required is given in Appendix III. Details of assembly are given in Appendix IV.

Gravel Trap

Beds of gravel and kankar are sometimes encountered which connot be kept in suspension and washed

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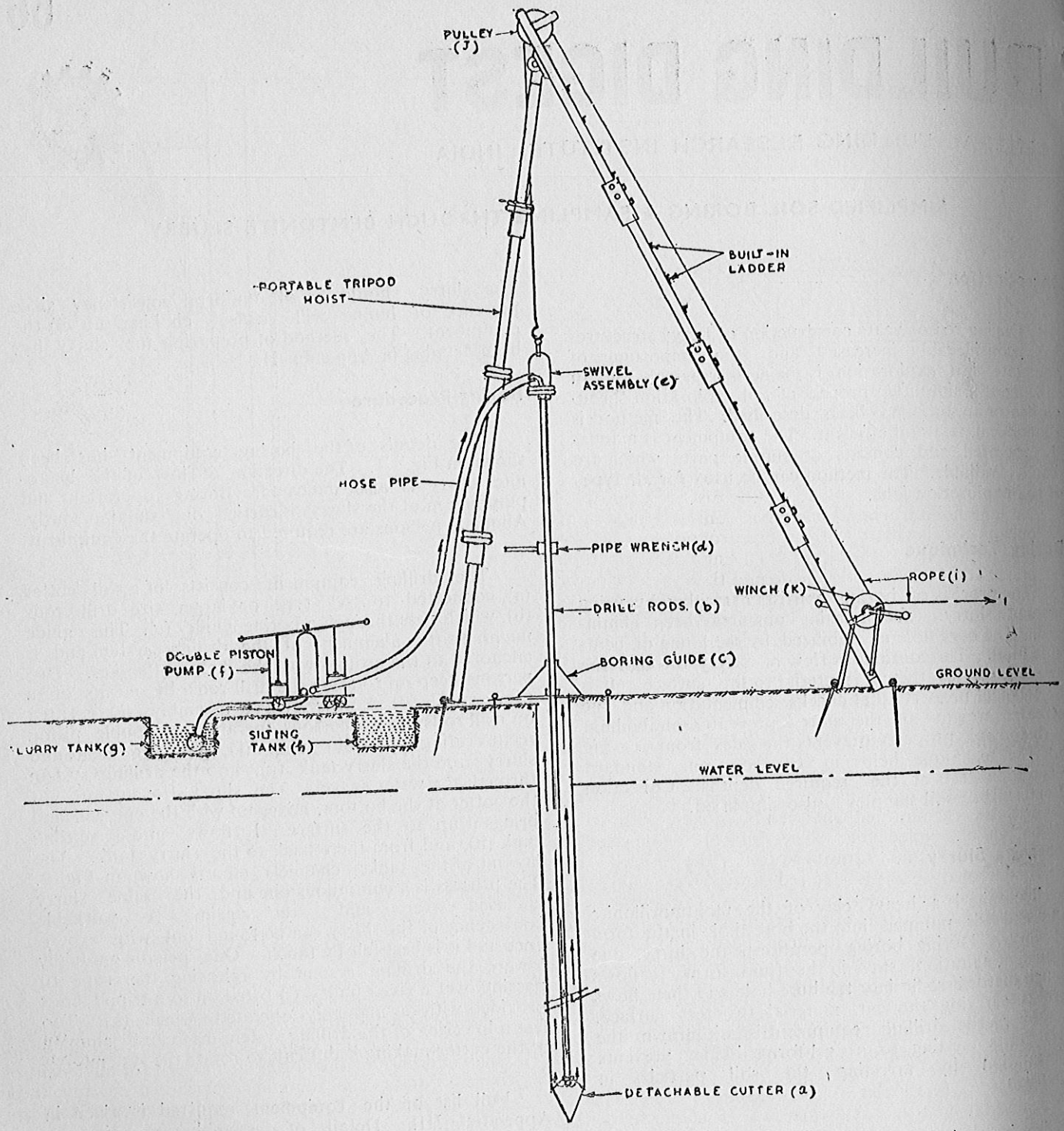

FIG. 1 DETAILS OF BORING SET UP

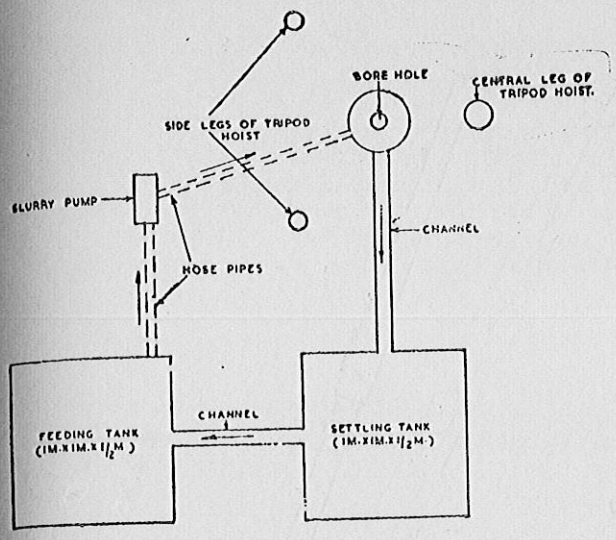

FIG. 2 LAY OUT PLAN OF BORING SET UP

out by pumping. In such cases a gravel trap (Fig. 3) can be used with advantage. It consists of a 80 to 100 cm long hollow cylinder having a conical shape at the bottom. It is fitted with stays around the extension tube a little above the cutter. During boring operations gravel and kankar rise a little and then settle into the trap. To avoid filling up of the trap by finer particles which can be carried up by the slurry. a few 3 mm dia. holes are drilled in the extension tube within the trap as well as in the conical portion of the trap. A continuous flow of slurry through these holes removes the finer particles deposited in the trap.

Chiselling

If small beds of silt-stone, sand stone or other hard beds are encountered they can be broken with conical or chisel ended bits. The bits are connected to drill rods and dropped on the hard bed. If additional weight is required, heavy steel sinker bars may be used. The broken pieces can subsequently be removed by means of the gravel trap. This method may however not work for deep hard beds.

Undisturbed Soil Sampling

For obtaining undisturbed soil samples a special piston type sampler is used. The open end of the sampling tube is kept closed by a conical piston provided with a flat fin. A leather washer placed behind the cone acts as a valve. It is connected with a rod to a knob provided with two pins. These can move in the two slots provided in the socket, which is screwed on to the adopter. The sampler is lowered into the bore hole and seated at the required depth so that the fin is embeded in firm ground. The drill rod is then given a few quick turns. This releases the pins in the slot and the piston is set free. The sampler is next pushed into the ground at a constant rate. On completion of driving a few turns are again given to shear the sample and the sampler is withdrawn.

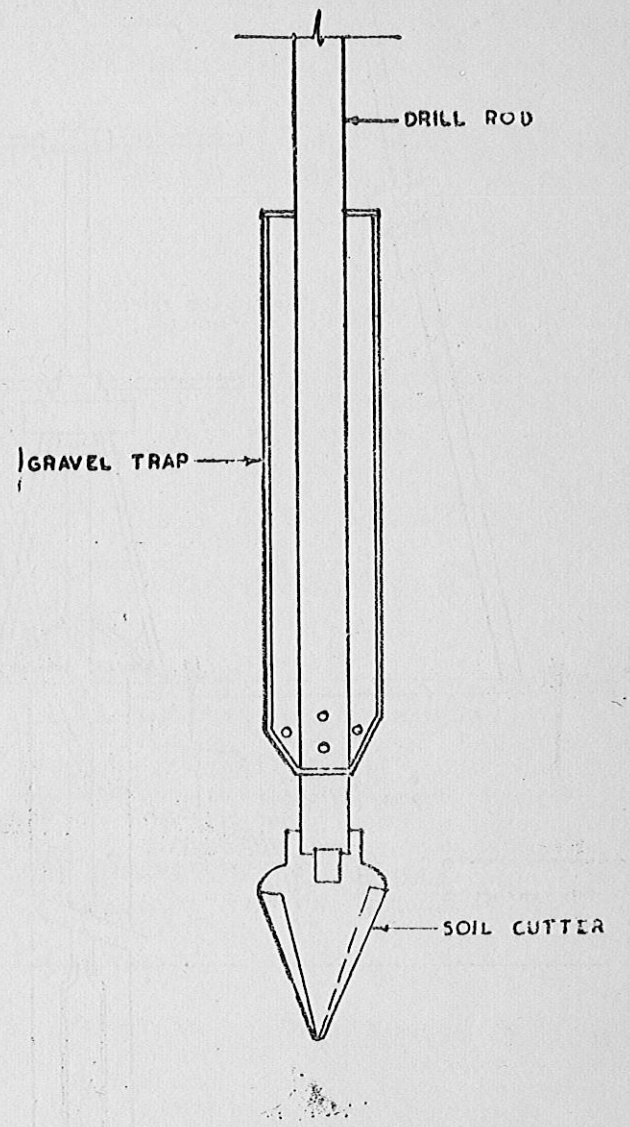

FIG. 3 GRAVEL TRAP

The operation of the sampler is controlled by a sampling device (Fig. 4) which can be fitted on to the anchored base of the boring guide used for alignment of boring rods. The sampling device has an advantage that the sampling tube can be advanced at a uniform rate into the ground.

Standard Penetration Test

Standard penetration test can also be carried out at any desired depth without using casing pipes. In case, there is some sedimentation at the bottom of the

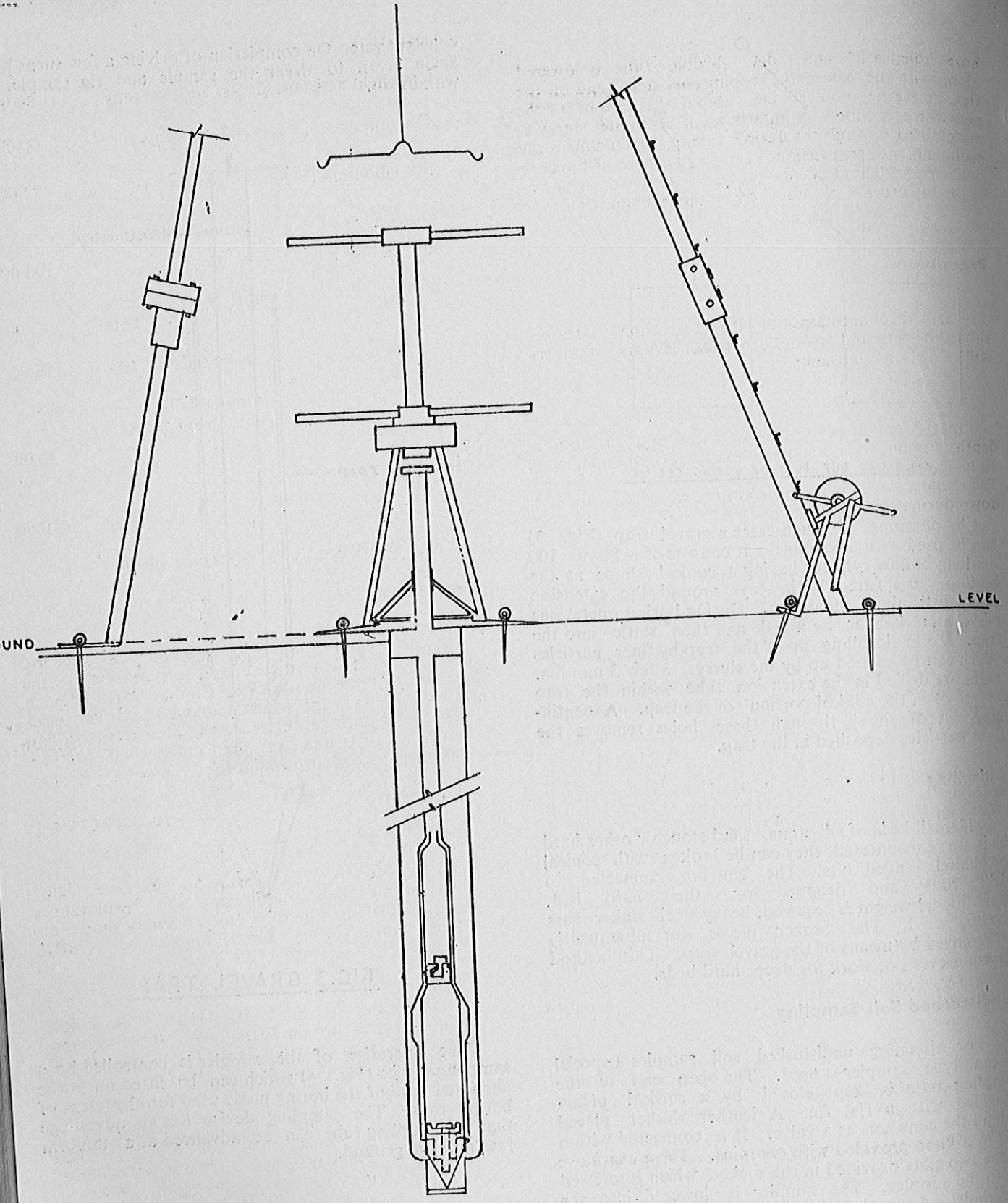

FIG.4 UNDISTURBED SOIL SAMPLING SET UP

bore hole, a 25 mm. dia. flexible tube is lowered along with the assembly keeping the open end of the flexible tubing about 80 cm above the bottom of the penetrometer tube. A mild flow of bentonite slurry is maintained through the flexible tubing, which churns the sediments into suspension keeping the base of the bore hole clean. The flow should be so adjusted as not to cause any erosion of virgin soil by the jetting action.

Precautions

(i) All connections in the bore hole assembly should be firm and strong, otherwise, leaking of slurry will cause some nuisance.

(ii) After the boring has advanced upto the desired depth, pumping of the slurry should be continued for 10 to 15 minutes to ensure cleaning of the bore hole. The drilling system should be gradually moved up and down during this operation.

(iii) The settling tank should be cleaned from time to time. After a few uses, the used slurry may have to be completely replaced by fresh slurry.

(iv) The soil sampler should be in good shape and all moving parts should be properly cleaned and oiled before use.

(v) Prior to use, all the parts of the boring assembly should be cleaned and the valves and washers of the piston pump checked to avoid failure during operation.

Estimated cost

Rough estimated cost of the equipment and the operational cost for boring, sampling and conducting Standard Penetration Tests upto a depth of 15 meters are given below:—

		Rupees
(a)	Cost of equipment	6,000.00
(b)	**Operational cost upto 15 meters in 4 days**	
	One field assistant @ Rs. 20/- per day	80.00
	One operator @ Rs. 10/- per day	40.00
	Six labourers @ Rs. 3/- per day	72.00
	Other expenditure including cost of bentonite etc. @ Rs. 25/- per day	100.00
	Total	292.00
	Overheads @ 40%	116.80
	Depreciation of equipment @ Rs. 8/- per day	32.00
	Total	440.80

Often works out to Rs. 30.00 per meter.

Performance

The major application of the method was recently made at Patna for carrying out soil exploration at the Ganga Bridge Project and at the Haldia Port Project. The technique was successfully employed to drive uncased bore holes upto depths exceeding 80 meters through the sandy strata of the river and undisturbed samples were extracted from various depths.

References

(1) Dinesh Mohan, D. P. Sengupta & G. S. Jain, "Expediting and simplifying soil exploration through drilling mud" Proc. Symposium on 'Site Investigation for Foundations', CBRI, Roorkee, India, March, 1967.

(2) A. Banerjee & A. K. Datta Gupta, "A Simple Bentonite Mud Boring Technique", Proc. Symposium on 'Site Investigations for Foundations', CBRI, Roorkee, India, March, 1967.

(3) D. P. Sengupta & V. S. Aggarwal, "Prevention of sand boiling in casing pipes for deep bore hole studies in cohesionless soil below water table" Jr. C.B.I. &P. Vol. 21, No. 2, April, 1964.

Appendix—I

Properties of Indian Bentonites

Bentonites are available in various parts of India but their grades are different. Properties of some of the bentonites are given below:—

Location	Montmorillonite content %	Exchangeable Na m. e./ 100 gm.	Base exchange capacity m.e./ 100 gm.	L. L.	P. L.	Swelling %
Rajasthan	50	100	150	353	43	325
Kashmir	40	75	100	283	33	225
Bihar	30	10	85	120	25	125

Rajasthan bentonite is of good variety and is recommended for use. Other good commercial varieties if available may also be used.

The suitability of a bentonite can be judged by the following swelling test.

30 c. c. of distilled water and kerosene are taken in two separate 50 c.c. graduated glass cylinders. 10 gms. of oven-dry bentonite passing 35 I.S. sieve is slowly poured into the cylinders. The latter are shaken thoroughly and allowed to stand for 24 hours. The volumes of the suspensions is measured for finding the swelling per cent.

$$\text{Swell (\%)} = \frac{\text{Diff. in volumes of suspensions}}{\text{Volume of suspension in kerosene}} \times 100$$

Normally, a bentonite with swell percentage less than 100 should not be used.

To improve the colloidal property of a bentonite some soap (sodium-oleate, sodium-palmitate etc.) may be added in the slurry. Concentration of soap in the solution may be about 0.5%. The exact amount will, however, depend upon the exchangable cations of the bentonite.

Appendix—II

Preparation of Bentonite Slurry

The slurry should be kept ready at least one day ahead of the boring operation. It should first be made in barells and then transferred to the tanks. Some reserve slurry may also be kept in an adjoining vat or barrel.

To start with, the feeding and settling tanks, should be dug in the ground. These should be lined with a thick paste of bentonite to avoid loss by percolation. The size of the tanks can be about 1m × 1m × ½m deep. These should be filled with slurry which should be thinned by adding water and slowly stirring the whole mass thoroughly. In the absence of ready made slurry the tanks may be first filled with water. Bentonite can be added by sprinking in small quantities and the water stirred vigorously. In Fig 5, a simple method of stirring is shown. A bamboo or a ballah (a) is embeded in the soil beside the tank. A bamboo stirrer (b) is then inserted through the two loops (c) fastened on the embeded bamboo or ballah. A person rotates the stirrer by pulling the rope (d) wound round the stirrer. At no stage the dispersion should be hurried up. Fresh bentonite should not be added until the dispersion is complete. If bentonite is added in heaps, lumps will be formed and it will be very difficult to disperse them.

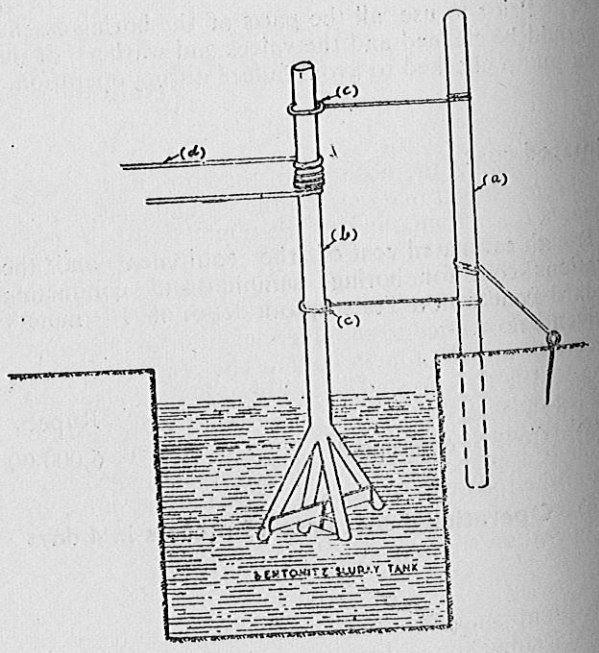

FIG. 5 BAMBOO STIRRER FOR DISPERSION OF BENTONITE IN WATER.

Appendix—III

Various parts of the equipment

Boring

(1) Soil cutters (10 to 15 cm. wide), provided with discharge holes—2 Nos.

(2) 'A' type or heavier drill rods.

(3) Water swivel fitted with an adopter for connection with drill rods and a bent tube for connection to hose-pipe.

(4) Rubber Hose delivery tube—8 m provided with circular clamps.

(5) Double piston reciprocating hand pump.

(6) Suction Hose pipe, 8 m provided with foot-valve and a clamp for connecting it to the pump.

(7) Tripod hoist with manually operated winch, a fixed pulley and rope assembly.

(8) Wrench for rotating the drill rods.

(9) Boring guide* (Covered by Indian Patent No. 82303)

(10) Two chopping bits, one with a chisel end and the other conical.

(11) Gravel trap

(12) A spare pulley

Sampling

(1) New soil sampler* (covered by Indian Patent No. 91411).

Standard Penetration Test

(1) Standard Spoon Sampler

(2) 64 Kg drop weight with driving head assembly.

Appendix—IV

Hoisting of equipmentat site

To start with, the position of the bore hole, tanks, channels etc. is first marked on the ground. The tanks and channels are then dug and the tripod hoist is installed at the location of the bore hole. To erect the tripod, it is laid on the ground with all the legs stretched apart. Two of its legs are then positioned and pegged. The hoist is now lifted to shoulder height from the centre by three persons, the fourth holding the central leg from slipping. It is now hoisted in position by moving the central leg only by all the four persons. It is then firmly anchored to the ground. The exact location of the bore-hole is now marked by using the plumb-line hanging from the pulleys of the hoist. The boring guide is next placed in position and suitably anchored. The boring operation is then started.

The pump should be placed on some firm base so that the splashing slurry does not soften it. Soft ground below a pump will make it unstable and difficult to operate. If possible, the pump should also be anchored to the ground.

Operation of the Drop weight (Monkey)

Two persons rotate the handle of the winch. Another person pulls the rope holding the drop weight and wound twice round the winch drum. This makes the drop weight to rise. The pull required is nominal. When the drop weight reaches the requisite height of 75 cm (30 inches) a slight release in the pull keeps the weight in position. To drop the weight, the grip on the rope is released. This makes the drop weight fall under gravity.

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