Sub-Strata treatment for building using roper drains*

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While congratulating the authors on their interesting paper on the use, installation and efficacy of rope drains, the following observations are presented for further elucidation.

(1) No idea was given about the depth where the piezometer was installed. During the period of piezometric observations when it was serviceable, it was obvious that there was development of excess pore-pressure. Did the construction programme hint till the pore pressures equalised? Or did the progressive loading go on uninturrupted?

(2) This has considerable significance because due to excessive pore pressures, there is reduction in the shear strength of the subsoil which might lead to a local shear failure leading to plastic flow. There might have been considerable heaving beyond the loaded area which might not be detected with the naked eye.

(3) The settlement is not only due to the instantaneous, primary and secondary consolidations but also due to subsidence resulting due to lateral plastic flow. In essence, the subsoil might not have gained the expected strength through 90 percent consolidation as supposed by the authors but would in fact have gainad partial benefit. It might have also got thoroughly disturbed due to sub soil movements and punch shear.

Mere achievement of settlement cannot be directly related to gain in strength in as much as no measured strength data was made available. A post treatment static cone data may belie the expected strength gain.

(4) While the cost analysis proved the indisputable economy in the use of rope-drains, a comparative analysis with that of sand-drain and sandwick installation (which are extensively used in our country) and not merely with that of concrete piles, would have been more approximate.

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The Authors have relied on settlement observations for judging the efficacy of rope drains without, however, discriminating between time-dependent primary consolidation settlement, the rate of which alone is influenced by vertical drains, and that occurring instantaneously due to elastic deformation of the ground (Bjerrum, (1972). Much of the settlement experienced during construction may be of the latter category, especially so long as the surcharge pressure applied is less than the pre-consolidation pressure (Tavenas and Leroueil, 1980). Information regarding pre-consolidation pressures prevailing in the subsoil strata has not been furnished in the paper, which is an important omission. It is most usual, however, to encounter preconsolidation pressures of the order of 10 to 15 tons per sq. metres even in clayey strata commonly termed as normally consolidated. It is also seen from Figure 5 that the settlements observed during the construction period of 30 days are nearly proportional to the surcharge height, which accords with elastic compression.

A positive indication of the efficacy of a vertical drain installation is provided by the rate of dissipation of pore pressures. The Authors have mentioned that the piezometers ceased to function after 25 days when the placements load was nearing completion. However, it is also reported that within the first 25 days piezometric height rose by nearly 3.5. metres. This represents about half of the applied surcharge pressure at 25 days and considering that only part of the surcharge pressure applied at ground level might have been transmitted to the saturated soil lying 3.5 metres below the ground level, it might be concluded that there was not much dissipation of pore pressures within the first 25 days, notwithstanding the presence of rope drains.

The Authors have assessent that it would have taken nearly 10 years for dissipation of pore pressures if no rope drains were provided. It is not clear, however, how a uniform value of C_v was derived for the entire depth of 10 metres below ground level. In case C_v values were determined from laboratory tests, it is to be pointed out that C_v values under field conditions can be easily 5 to 10 time larger than those determined in laboratory (Murray and Symons, 1974). The first 3.5 metre depth of subsoil lying above G.W.T. should not be included in the thickness of the layer undergoing consolidation. The peaks in cone resistence along the subsoil profile, as shown in Figure 3, appear to be indicative of strata discontinuities caused by silt or sand seams, which can have significant influence on drainage boundary conditions. A more precise assessment of the rate of consulidation of the untreated ground than what has been attempted in the paper is called for, if the performance of the system of rope drains is to be assessed beyond doubt. It is to be noted in this connection that improvement in undrained strength by itself is not a convincing demonstration of the efficacy of a system of vertical drains, since a similar end result would be achieved under a surcharge fill not provided with sand drains, if the rate of dissipation of pore pressure in the untreated ground is of the same order due to presence of seams, etc. in the subsoil.

As with C_v values, the basis of the use of uniform C_c value for the entire subsoil profile is not clear. In particular, consolidation settlement

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for the top 3.5 metres above the ground water table should not have been taken into consideration.

The subsoil profile given in Figure 3 is incomplete in the absence of LL, PI and natural moisture content values for different layers, which are very essential for an overall appreciation for ground conditions.

In the light of the discussions above, it appears to be not fully established that the rope drains were really needed or effective in the site situation mentioned in the paper. More rigorous monitoring and also comparison with performance under control fills not provided with rope drains are required for convincing demonstration of the efficacy of rope drains. It is also to be borne in mind that the efficacy of different types of vertical drains may vary from one ground condition to another and as such field trials under different types of ground conditions will have to be gone through before an innovative system of vertical drains may be expected to find general acceptance.

References

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Author's reply

The authors are thankful to S/Shri B.K. Roy and E.S. Rao for their comments with respect to their paper 'Sub-strata treatment for a building using Rope-drains'.

Before answering the question it may be pointed out that the normally consolidated soil layer in Calcutta region calls for the need of perconsolidation using artificial drainage path beyond doubt for certain grades of shallow foundations. In fact, large number of instances can be quoted in which buildings in Calcutta have suffered heavily when constructed on vergin ground. Instances can also be quoted in which buildings constructed after strengthening of ground by preconsolidation are functioning properly.

To tackle this basic problem, we have simply used successfully a technique, the performance of which was already established and reported earlier.

The authors have to give the following answers in the present case.

(*i*) The piezometer was installed just below 3.5 m depth. The loading was progressive as indicated in Figure 5.

(*ii*) Generally shear failures are immediate, which are associated with heaving of ground outside the loaded area. We claim that no such heaving was noticed. In fact, a very light brick pavement boardering the loaded area showed heavy settlement. Moreover, any such failure would have caused subsidence of the embankment. No abrupt and sudden movements of the settlement gauges were noticed.

In view of the above, failure of ground is not accepted. This view is further strengthened on basis of positive increment of shear strength determined at two levels.

(*iii*) It is obvious that the cost of rope wick, sand wick and sand drains including price of material and installation charge will not be far apart. In the present case, as pile foundation was considered to be the alternate feasible solution against strengthening of ground, cost between them was compared.

(*iv*) The elastic settlement of the soft clayey ground would be negligible compared to consolidation settlement. Besides, we were interested to establish that the consolidation settlement became stabilized within a very short period.

(*v*) The soil layers involved are normally consolidated and assumption of $10t$ to $15t$ per m^2 preconsolidation pressure for Calcutta soil is not in order.

(*vi*) It is obvious that prediction of time from C_v values is most unreliable. Yet, we included this unreliable figure for untreated ground just to highlight the efficiency of the rope wicks.

(*vii*) A point has been raised with respect of dissipation of pore pressure. It may be argued that there was progressive built-up of pore pressure with progress of loading. At the same time, there was dissipation of pore pressure for earlier stages of loading. In other words, the whole mechanism was mixed up and no conclusion can be drawn from the readings recorded prior to damage of the piezometer.

(*viii*) In the following table properties of the soil layers have been entered

TABLE 1

Depth in metre	Particle size distribution			Index Test			C_c	Classification
	Sand %	Silt %	Clay %	L_w %	P_w %	P.I.		
1	—	69	31	46	20	26	0.4	CI
3	—	70	30	45	20	25	0.33	CI
6	—	72	28	48	21	27	0.34	CI
9	10	58	32	45	22	23	0.33	CI

It can be noticed from the table that the clay content of the stiff to very stiff stratum underlaying the compressible layers is nearly 32 per cent. This means that the layer is quite impermeable. Moreover, the layer in Calcutta region is about 10 m thick. Therefore, drainage through such a layer within the short period is practically impossible. In other words, the argument that strengthening of ground would be possible even without rope drains within the short period is not accepted. It can also be noticed from the table that C_c values were determined for various depths and these values were used for assessment of settlement.

To conclude it may be placed that the proposed building was constructed about two years back and is functioning absolutely safe.

References

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