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A New Method of Stabilization of Soft Soils

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SYNOPSIS A new method of stabilization of soft soils using split-bamboo poles filled up with coconut coir wicks has been described. The results of the field tests of this new method on an actual construction site have been critically analysed and discussed.

INTRODUCTION

Stabilization is a process of improving subsoil engineering properties prior to construction. This can be accomplished in several ways such as preloading of the grounds (Broms 1979), application of high energy impacts (Menard 1972; Menard and Broise 1975; Scott and Pearce 1975; Andreason and Hansbo 1977; Hansbo 1978; Aziz et al. 1980; Daulah and Aziz 1981), use of sand drains and sand wicks (Barron 1948; Richart 1959; Dastidar et al. 1969), prefabricated wick drains (Kjellman 1948; Hansbo 1979, Choa et al. 1979, 1981; Morrison 1982; Ramaswamy et al. 1982), and chemical additives (Lambe 1962; Ingles and Metcalf 1972; Ramaswamy et al. 1982).

Preloading is a slow process. In case of soft clayey soils of low permeability, the gain in shear strength is at a very slow rate and the loads should remain in position for longer periods. For quicker stabilization, sand drains and sand wicks have been in use for quite sometime. They accelerate the process of stabilization by providing easy drainage path. Drawbacks of sand drains and sand wicks are the large scale handling of sand which is very often required to be brought from long distances, creation of large disturbance of soils around the sand drains and sand wicks and thereby reduction of permeability of the soils, and shear failure in case of rapid preloading. The high energy impact technique is another method of quicker stabilization of subsoils. Menard (1972) first introduced this new technique in the name of Dynamic Consolidation for in-depth stabilization of various soil types. The technique basically consists of dropping by free fall a weight of 10 to 40 tonnes from a height varying between 10 to 40 m on the ground to be stabilized. The depth of soil in meter which can be stabilized has been found to be generally proportional to the square roof of energy per drop expressed in tonne-meter (Menard and Broise 1975; Andreason and Hansbo 1977; Hansbo 1978). This rule-of-thumb has been found to be fairly reliable when the subsoil consists of silt, sand and gravel (Hansbo 1974). However, in cases where the soil is very fine-grained (silt and clay) or very coarse-grained (rock fills), the above rule-of-thumb is too optimistic (Broms 1979; Ramaswamy et al. 1979 and 1980; Aziz et al. 1980).

The use of prefabricated wick drains (made out of polyethylene or PVC) with paper filters is another method of in-dpeth rapid stabilization of soft compressible soils. There are today over 50 types of plastic vertical drains but of these only five are currently being used all over the world. They are: the Alidrain, developed in Sweden, now made in Canada and currently dominating in the United States; the Bando Wick Drain, made in Japan; the Castle Board Drain, another Japanese product; the Geodrain, developed in Sweden by Oleg Wager who later designed the Alidrain; and the Membradrain, developed in Holland (Morrison 1982). Soft sub-soil stabilization by using wick drains has been found to be satisfactory (Choa et al. 1979, 1981; Morrison 1982; Ramaswamy et al. 1982) but in the context of poor but developing countries, most of these are highly sophisticated and patented techniques of manufacture and/or installation and need initial heavy investments. Again, the stabilization of soft soils by using chemical additives has lots of drawbacks (Ingles and Metcalf 1972; Ramaswamy et al. 1982).

Keeping in view of economy and simplicity, a new method of soil stabilization using split-bamboo poles filled up coconut coir strands (termed as bamboo drains) has been field-tested.

Bamboo is an ancient building material abundantly grown in the Southeast Asian region and its use so far has been more traditional than technical. It has long served many purposes but the application of materials technology to bamboo took place only in comparatively recent years (Aziz and Ramaswamy 1980, 1981). Yet it has not been fully exploited for major engineering applications. Economic and other related factors in developing countries now require civil engineers to apply appropriate engineering and technology to utilize bamboo as effectively and economically as possible in various construction works and in stabilizing poor subsoils. Bamboo to some extent, has been used in compaction piling for improving bearing capacity of granular soils for the construction of light structures, in slope stability and land reclamation (Broms 1979; Aziz and Ramaswamy 1980). But for in-depth stabilization of soft compressible soils, the use of specially made bamboo drains is a maiden venture.

METHODOLOGY

The materials used in the method were bamboos, coconut coir strands, jute threads and jute fabric. The split bamboo poles were filled up with the coconut coir wicks about 40 mm diameter each, made out of loosely wound coconut coir strands of about 6 mm diameter tied up with spirally wound jute thread of about 3 mm diameter along its length and then rapped the same with a layer of thickly knit jute fabric (Fig. 1). Treated split-bamboo trips were holed at random points and tied up together at regular

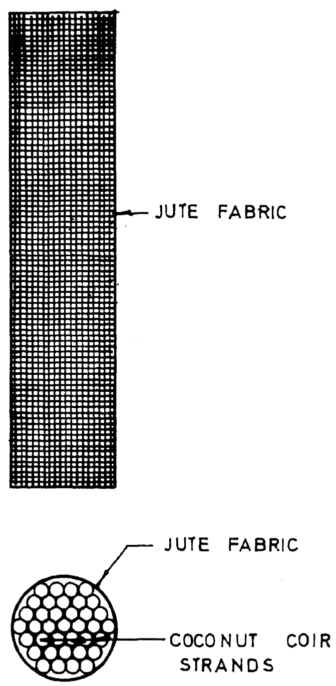

Fig. 1 Elevation and Cross-section of Coconut-Coir Wick

interval with galvanized iron wire after putting the coconut coir wick inside along its entire length (Fig. 2), the final product being termed as bamboo drain. The bamboo poles were of 80 to 100 mm diameter and of 8 to 10 m long.

A full-scale field trial was carried out in an area of 50 m x 100 m as shown in Fig. 3. A total number of 800 bamboo drains were installed in a square grid pattern with about 2.5 m spacing. The bamboo drains were driven by a drop hammer.

The soil profile of the site consisted of a top layer of about 2 m thick soft to medium sandy clayey silt underlain by a layer of about

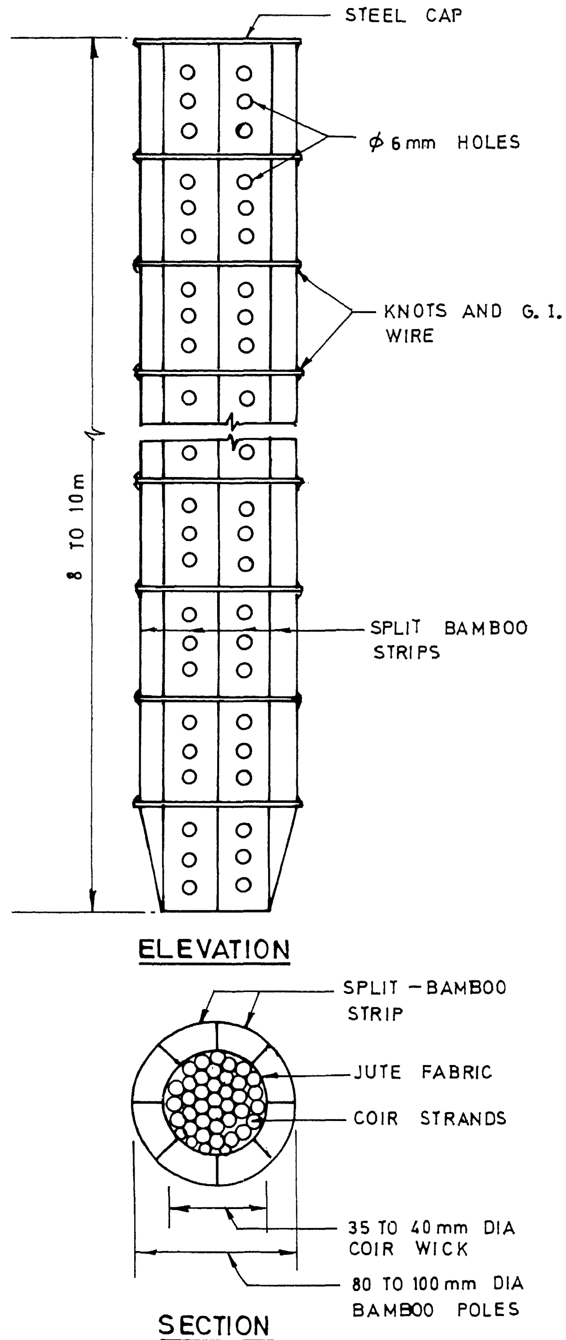

Fig 2 Elevation and Cross-section of Bamboo Drains

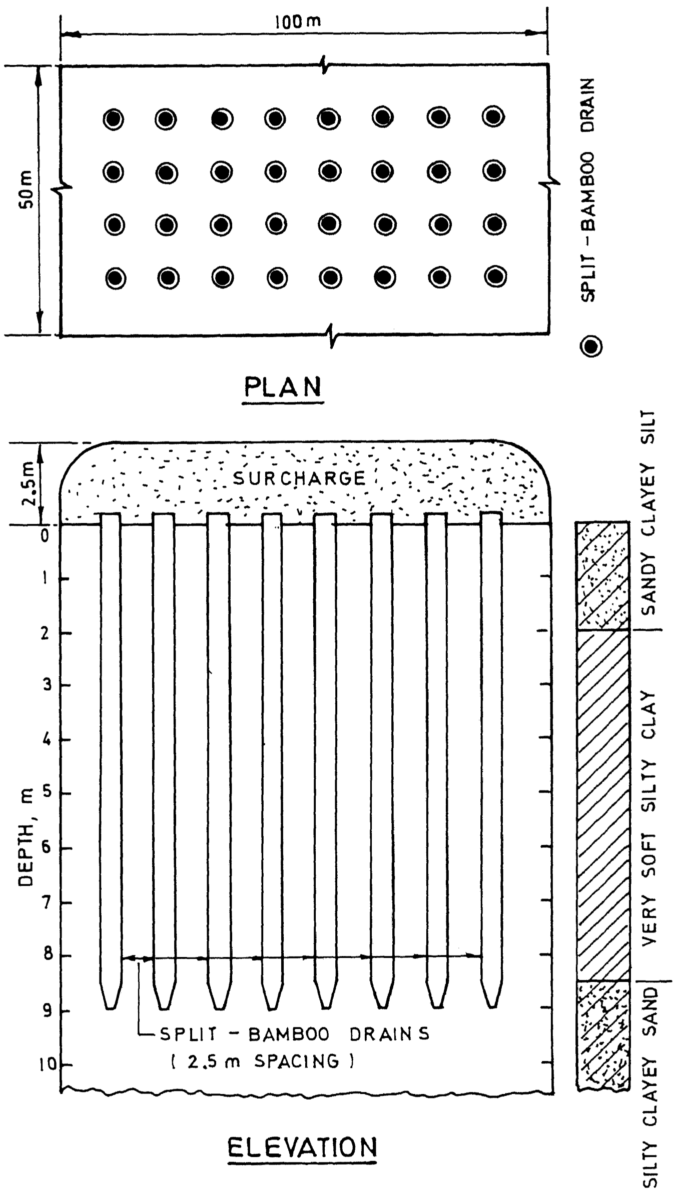

Fig. 3 Site showing Soil Profile and Layout of Bamboo Drains

6.5 m thick very soft silty-clay of high plasticity which was followed by a layer of medium dense to dense silty clayey sand (Fig. 3). After the installation of the bamboo drains, the entire area was covered with about 2.5 m depth of surcharge of land-cut sandy soils. A few settlement plates and porewater pressure measuring devices were established within the test area for recording the progress of settlement and dissipation of porewater pressure respectively.

The surcharge was kept in position for 24 months and then, a few test boreholes were made (very near to the boreholes made before the application of the method) in order to collect soil samples at regular interval for laboratory analysis. A few plate load tests were also conducted on a footing type square plate measuring 0.8 m x 0.8 m about 0.5 m below the ground surface.

FIELD-TESTING RESULTS AND DISCUSSIONS

The soil properties before and after the treatment are shown in Fig. 4. It can be observed from Fig. 4 that there is a considerable improvement in soil properties. The natural water content has been reduced to around 30 percent

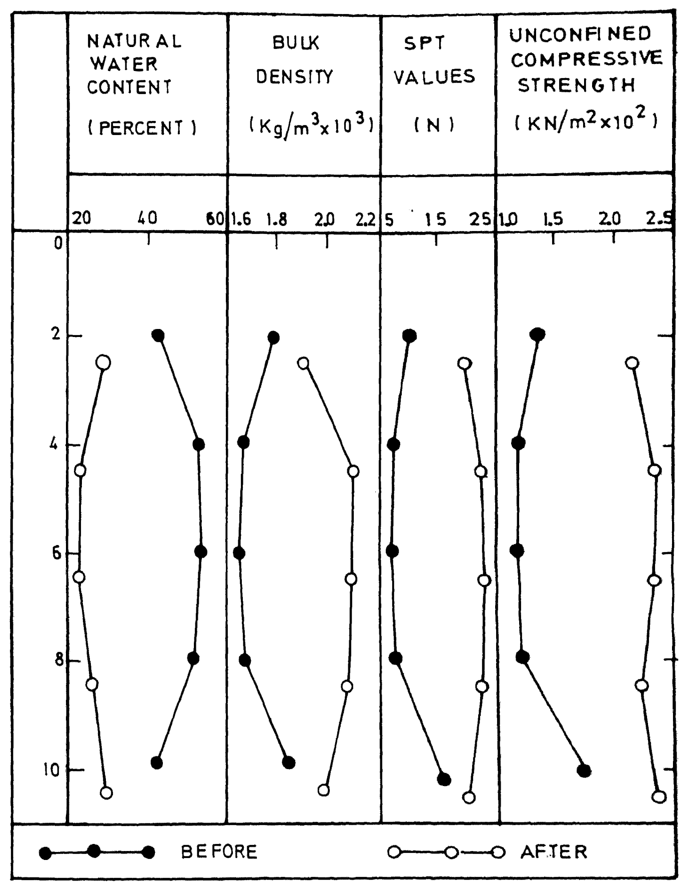

Fig. 4 Improvement in Soil Properties

and the bulk densities increase from around 1700 kg/m³ to 2200 kg/m³. An average SPT value of around 23 blows/30 cm has been observed after the treatment. The unconfined compressive strength has been found to increase from the range of 100 to 130 kN/m² to the range of 210 to 240 kN/m². The safe bearing capacity (with a factor of safety of 2.5) has been found to increase to more than 150 kN/m². From the laboratory consolidation study, the expected total settlement was computed as 48 cm but the average settlement observed in the field after 24 months was 42 cm (Fig. 5).

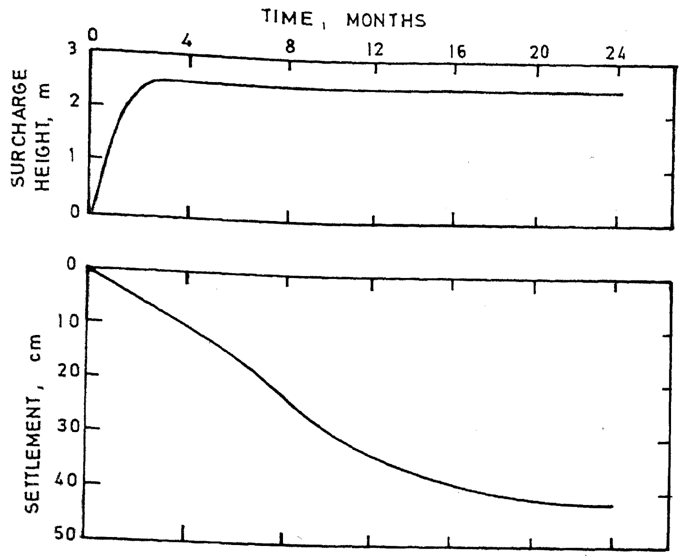

Fig. 5 Progress of Surcharge Loading and Settlement

This new method of soft soil stabilization has been found to be effective for shallow depths not exceeding 10 m. By cost-comparison, it has been found that this method is at least 30 percent cheaper than other alternate conventional techniques. An analysis of cost reveals that the major part of the cost is due to loading and unloading of surcharge materials. In this field test, the ratio of the cost of installation, the cost of materials and the cost of loading and unloading of surcharge materials was found to be around 1 : 4 : 12. But in cases such as highways where the surcharge materials is not required to be removed, the cost of the last item will be reduced by about 50 percent.

CONCLUSIONS

The new method, reported herein, for soft soil stabilization has, like other methods, its goal to decrease the porewater pressure by allowing the water to drain out through artificial channels. If left alone, a site like the one field-tested, could take 100 years or more to achieve the same degree of stabilization.

The results of field trials have shown that the specially made bamboo drains have positive advantages over conventional sand drains, imported versions of synthetic drains (wick drains) and other types of vertical drains for stabilizing soft soils of shallow depths. The materials used inside the bamboo poles is highly permeable and ensures uninterrupted passage for drainage of water. The fabrication of bamboo drains and also their installation are simple, easy and quick but the stabilization process itself is time-consuming. This new method must, therefore, be considered as a simple cost-effective technique for stabilizing soft soils of shallow depths where time is not a crucial factor.

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