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A Review Paper on Pile Encased Sand Cushion in Clayey Soil Bed

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Abstract: Clayey soil has less friction between pile surface and clay layer. To increase the pile capacity a cushion of sand layer is placed around the periphery of the pile surface which will increase friction resistance of the pile and ultimately will increase pile capacity. A granular pile is the bored hole which is filled with granular material having higher frictional resistance in which concrete pile is cast in places. In this paper we are going to review pile encased with sand cushion in clayey soil bed.
Keywords: Sand cushion, granular pile, pile foundation.

I. INTRODUCTION

When the soil at or near the ground surface is not capable of supporting a structure, deep foundations are required to transfer the load to deeper strata. Deep foundations are used when surface soil is unsuitable for shallow foundation, and a firm stratum is so deep and due to which shallow foundations cannot be economical. Most common types of deep foundations are piles, piers and caissons. The mechanism of transfer of the load to the soil is essentially the same in all types of deep foundation. Deep foundation is much more expensive than a shallow foundation. A pile is a slender structural member made of steel, concrete or wooden Piles and these are used to transmit surface loads to deeper layers. Pile is either driven into the soil or formed in-situ by excavating a hole and filling it with concrete. Typical cross section of pile foundation is shown in figure 1

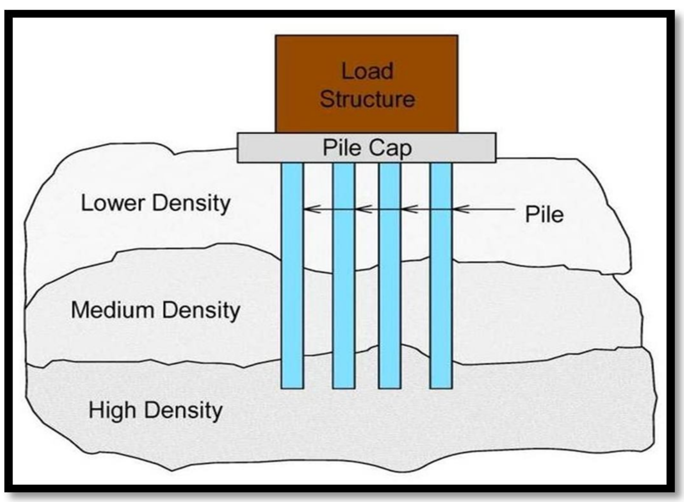

Fig 1: Cross section of pile foundation

II. CLASSIFICATION OF PILES BASED ON MODE OF LOAD TRANSFER

A. *End-Bearing Piles Or Point Bearing Piles*

End-bearing piles transmit the loads through their bottom tips. Such piles act as columns and transmit the load through a weak material to a firm stratum below. If bed rock is located within a reasonable depth, piles can be extended to the rock. The ultimate load carried by the pile (Q_u) is equal to the load carried by the point or bottom end (Q_p).

B. *Friction Piles*

Friction piles do not reach the hard stratum. These piles transfer the load through skin friction between the embedded surface of the pile and the surrounding soil. Friction piles are used when a hard stratum does not exist at a reasonable depth. The ultimate load (Q_u) carried by the pile is equal to the load transferred by the skin friction (Q_s).

C. Combined End-Bearing and Friction Piles

These piles transfer loads by a combination of end bearing at the bottom of the pile and friction along the surface of the pile shaft. The ultimate load carried by the pile is equal to the sum of load carried by the point (Q_p), and the load carried by the skin friction (Q_s).

III. GRANULAR PILE

A suitable technique of ground improvement for foundations on soft clay is to install vertical granular piles in the ground. Granular pile are essentially a method of soil reinforcement in which soft cohesive soil is replaced by gravel or crushed rock in pre-bored vertical holes to form columns within the soil. The granular piles serve two basic functions, namely

A. Providing strength reinforcement to the soil

B. Acting as vertical drains to allow subsoil consolidation to occur quickly under any given loading.

Granular pile application has its advantage among the other modification techniques. It is much simpler than many other techniques. The Granular pile technique is applied either by a replacement or a displacement method. Owing to improve the mechanical treatment of soft cohesive soils and to quicken construction, the acceleration of the consolidation rate is very important. Among many methods for ground reinforcement, granular pile reinforcement is applied worldwide. Based on the stiffness of granular piles, they work similar to piles as good as vertical drains. Cross section of granular pile is shown in figure2

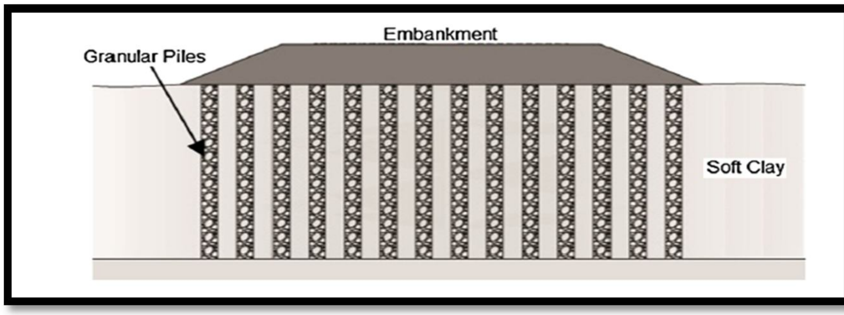

Fig 2: Cross section of granular pile

IV. PILE ENCASED SAND CUSHION

Elevation and plan of pile encased sand cushion is shown in figure 3. Cushioned pile is a concrete pile surrounded by sand of higher angle of friction provided in case of clayey soil bed. It can be used as an alternative to under reamed pile, as its construction is difficult. For construction of pile encased sand cushion a bore hole is drilled. It is filled with sand or granular material to form a granular pile. A concrete pile is driven or cast in placed in granular pile to form a pile encased with sand cushion.

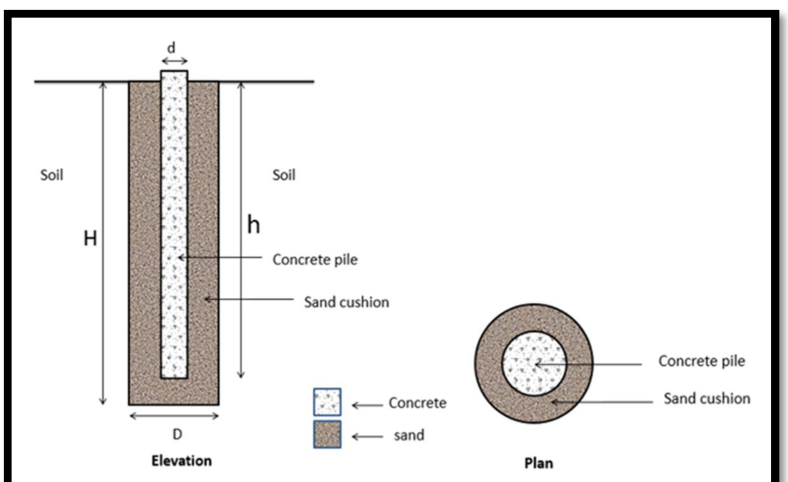

Fig 3: Elevation and plan of pile encased sand cushion

V. LITERATURE REVIEW

The study regarding the behaviour of pile encased sand cushion has been not carried out yet hence literature is reviewed by taking the references of pile foundation in sand and granular piles in clay soil.

Gandhi S. R[1] (2016) reviewed the design and construction practices on pile foundation being adopted in India. The factors that affects the choice of the pile had been discussed highlighting the necessity of initial field tests prior to the detailed design. The common problems faced during pile construction in each type of pile with possible remedial measures that can improve the performance were described. Various pile such as bored pile and driven pile, there method of construction, problem during construction were described. Various issues in pile design were reviewed with some of the experimental and numerical work carried out on lateral load on piles in slope, pile group effect under lateral load, negative drag force, rock-socketed pile, etc. The need for full-scale field tests and monitoring with instrumentation was emphasized to achieve an optimum pile design along with few case studies on such tests carried out. Their review reveals remarkable improvements, both in the design and construction, comparable with that in other countries.

B P Naveen *et.al* [2] (2011) carried out analytical work on full scale vertical loaded pile tests on 1.2 m diameter bored cast in-situ piles in residual soils. In their study, a FEM model for simulating these field vertical load tests on large diameter piles embedded in residual soils was developed using PLAXIS 2D. The simulation was carried out for a single pile with vertical load at pile top, so as to evaluate the settlement of the pile in residual soils. The soil stratum was idealized by 15 noded triangular elements with elastic-plastic Mohr Coulomb model and the pile behaviour was assumed to be linear-elastic. Interface elements was used to model the interface between the pile and the soil models. The vertical load versus settlement plots on single pile was obtained from field tests and were compared with the finite element simulation results using PLAXIS 2D, showing reasonable agreement. They concluded that there was good comparison of load–displacement relation obtained through field test and that obtained by numerical methods. The Mohr-Coulomb (MC) model with a medium mesh (328 soil elements and 31 interface elements) was optimum to simulate the settlement of a vertical loaded pile in residual soil. It was suggested that the FEM boundaries be placed at about 5D beside of the pile model and about 3D-5D below the bottom of the pile model. The skin resistance was maximum in soft weathered rock layers.

Riyadh Salim *et.al* [3] (2017) carried out finite elements method to investigate the response of a single cast in place pile, embedded in multi-layers soil at the Project of AL-Nasiriya New Oil Depot, under the effect of vertical static load. ABAQUS 6.14.3 program was used in their analysis. The piles and the surrounding soil were modeled using three-dimensional brick linear elements. Several cases of pile diameters (0.6 m, 0.8 m, 1.0 m, and 1.2 m) and lengths (16 m, 18 m, 20 m, and 22 m) were adopted to study their effects on the pile capacity. They concluded that for the piles of (18m) length, increasing of pile’s diameter from (0.6m) to (0.8m, 1.0m, and 1.2m) caused an increasing of the estimated ultimate load capacity, which computed using Davisson's method, for the piles about (46.4%, 128.9%, and 244.4%, respectively). For the piles of (18m) length, increasing of pile’s diameter from (0.6m) to (0.8m, 1.0m, and 1.2m) caused a decreasing in the maximum values of the axial stresses computed at the top faces of piles about (7.6%, 12.6%, and 38.8%, respectively). For the piles of (0.8m) diameter, the estimated ultimate load capacity for the pile increased to about (6.1%, 48.8% and 84.1%) with increasing the pile lengths from (16m) to (18m, 20m, and 22m, respectively). For the piles of (0.8m) diameter, the computed maximum axial stresses at the top faces of the modelled piles increased about (2.1%, 28.2%, and 31.5%) with increasing the pile lengths from (16) to (18m, 20m, and 22m, respectively).

A. W. Skempton,[4] (1959) conducted loading tests on bored piles in London Clay from ten sites. The ratio of the adhesion developed on the shaft (α), to the average undisturbed shear strength of the clay within a depth equal to the embedded length of the pile in the clay, was found to be typically about 0.45. The value of α was less than unity, chiefly because the clay immediately adjacent to the pile shaft absorbed water during the drilling operations and from the concrete. They concluded that as the water content of the soil increases, adhesion decreases. Water from concrete of bored piles installed in an unlined auger borehole softens the clay and this softening could not be avoided except by an unworkable dry mix. While the point resistance can be based on the natural shearing strength, the skin friction of these bored piles is closely given by the fully softened strength.

A. M. Hanna *et.al* [5] (2013) carried out analytical study on theories developed for a single column, ignoring the group interaction and therefore the group efficiency. A numerical model was developed to simulate the case of a single stone column and a group of stone column installed in soft clay. The model established the level of interaction between individual columns and therefore determined the mode of failure of a given geometry, soil, and loading condition. The model was validated with the available experimental data in the literature and used to generate data for a potential mode of failure. They concluded that the load ratio (n) increases in a hyperbolic fashion because of the increase of the ratio D/B. The rate of the increase was significantly high when the ratio D/B was less than 0.6.

The value of the load ratio (n) was roughly constant when D/B reaches a value of for a given value of D/B, the load ratio (n) decreases because of the increase of Poisson's ratio of the clay, whereas it increases because of the increase of Poisson's ratio of the sand. The capacity of the reinforcement system was significantly improved because of the increase of the angle of shearing resistance of the stones or the increase of the modulus ratio (Es/Ec). The bulging mode of failure for individual columns in a group was noted only when the ratio as is less than 10%.

A. P. Ambily *et.al*[6] (2011) carried out detailed experimental study on behavior of single column and group of seven columns by varying parameters like spacing between the columns, shear strength of soft clay, and loading condition Laboratory tests were carried out on a column of 100 mm diameter surrounded by soft clay of different consistency. The tests were carried out either with an entire equivalent area loaded to estimate the stiffness of improved ground or only a column loaded to estimate the limiting axial capacity. During the group experiments, the actual stress on column and clay were measured by fixing pressure cells in the loading plate. Finite-element analyses was also been performed using 15-noded triangular elements with the software package PLAXIS. A drained analysis was carried out using Mohr-Coulomb's criterion for soft clay, stones, and sand. The numerical results from the FEM were compared with the experimental results which showed good agreement between the results. Columns arranged with spacing's more than 3 times the diameter of the column doesn't give any significant improvement. They concluded that when column area alone is loaded, failure is by bulging with maximum bulging at a depth of about 0.5 times the diameter of stone column. As spacing increases, axial capacity of the column decreases and settlement increases up to an s/d of 3, beyond which the change was negligible. The ratio of limiting axial stress on column to corresponding shear strength of surrounding clay was found to be constant for any given s/d and angle of internal friction of stones and it was independent of the shear strength of the surrounding clay. The load settlement behaviour of a unit cell with an entire area loaded was almost linear and it was possible to find the stiffness of improved ground. Single column tests with an entire unit cell area loaded compare well with the group test results. Hence the single column behaviour with unit cell concept can simulate the field behaviour for an interior column when large number of columns were simultaneously loaded.

VI. CONCLUSION

From the review of pile foundation and granular pile it is concluded that pile capacity can be increased by providing sand cushion around the pile in clayey bed. Although it has been proposed that the pile foundation can improve load carrying capacity of foundation, the efficiency of pile encased with sand cushion in clay are still unknown. This research work is to be undertaken to assess the behaviour of pile encased with sand cushion under vertical loading in cohesive soil. In order to achieve the aim analysis of pile encased with sand cushion in clayey soil shall be done.

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