To Investigate Behavior of Piles In Soil Liquefaction Condition

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Abstract- *The study focuses on investigating the settlement behavior of a piled raft on clay soils under vertical loading. The average settlement could be reduced effectively with wider spaced pile groups with the same number of piles. Furthermore, the efficiency of piles in a piled raft was maximized when the magnitude of the applied load of the piled raft was similar to the ultimate capacity of pile groups in the piled raft. It was shown that the reduction ratio was relatively smaller than that of stiff clay, although the real average settlement of soft clay was larger than that of stiff clay.Piles which support the superstructure damaged not only due to axial load as well as the inertia load while earthquake. If liquefiable soil is present in the soil strata, then it behaves like the suspension solid and exerts additional force on the pile leads to failure of pile. Past earthquakes studies revealed that, most of the structures collapsed due to liquefaction. Due to pore water pressure, saturated soil loses its shear strength and stiffness*

I. INTRODUCTION

1.1 General

The piled raft foundation is a composite structure which consists of three bearing parts – the piles, mat and underground soil. The overall load from the superstructure is partly carried by the mat through the effect of subsoil and the remaining load only carried by the piles under the effect of negative skin friction. The pile raft foundation is mainly used to reduce the settlement – particularly the differential settlement. It is an economical design without affecting the safety criteria. The behavior of piled raft foundation mainly depends on the complex soil structure interaction effects and an understanding of these effects is necessary for the reliable design of such foundation. In a pile foundation the contribution of pile cap that functions as raft is completely neglected. It is used only for the supporting the structure. The piles alone carry the loads and transmit the load to the deep stratum. On the other hand, in a raft foundation the total building load is carried only by the raft demanding a very thick raft, which thereby increases the cost of the foundation as well as it undergoes a large settlement. Structural failure by the formation of plastic hinges in piles passing through liquefiable soils has been observed in many of the recent strong earthquakes. It shows two such cases from past earthquakes. This suggests that the bending moments or shear forces that are experienced by the piles exceed those predicted by design methods (or codes of practice). All current design codes apparently provide a high margin of safety (using partial safety factors on load, material stress which increases the overall safety factor), yet occurrences of pile failure due to liquefaction are abundant. This implies that the actual moments or shear forces experienced by the pile are many times those predicted. It may be concluded that design methods may not be consistent with the physical mechanisms that govern the failure. The liquefaction is one of the challenging issues in geotechnical engineering and it damages structures and facilities during earthquakes. This phenomenon was reported as the main cause of damage to pile foundations during the major earthquakes (Kramer,1996).

1.1 Objective Of Study

1. To investigate deformation, shear stress, normal stress and strain energy of pile foundation considering soil structure interaction .
2. To perform time history analysis for group of pile
3. To investigate performance of pile group of different size and various spacing for soft soil.
4. To investigate effect of different size pile cap during liquefaction on pile group.

II. LITERATURE REVIEW

W. D. L. Finnanabuki Komuten And Kagawa University, Japan N. Fujita Anabuki Komuten and Kagawa University, Japan Behavior of Piles in Liquefiable Soils During Earthquakes: Analysis and Design Issues A general picture of the current state of the art and the emerging technology for dealing effectively with the seismic design and analysis of pile foundations in liquefiable soils is presented. Two distinct design cases are considered and illustrated by case histories. One is the static response of pile foundations to the pressures and displacements caused by lateral spreading of liquefied ground. The other is the seismic response of piles to strong shaking accompanied by the development of high pour water pressures or liquefaction. Design for lateral spreading is examined in the context of developments in design practice and the findings from shake table and centrifuge tests. Response of piles to earthquake shaking in liquefiable soils is examined in the context of 1.5m cast in place reinforced concrete piles supporting a 14 storey apartment building.

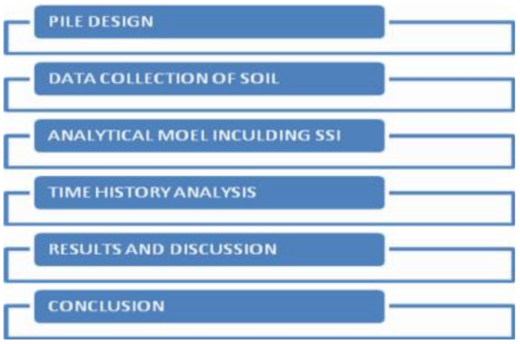
Nysdot (2015)" Geotechnical Engineering Manual "A pile is a small diameter reinforced and grouted pile, constructed within a previously drilled borehole that provides axial capacity, or resistance, for a substructure. Unlike a driven pile, where each pile is a “tested” pile, the resulting axial capacity of each pile is not directly determinate unless a load test is performed on it. In addition, pile capacity is very sensitive to installation methods. Therefore, the role of the inspector is vital to ensure that the final product meets the expectations of the designer and the owner. Proper design and installation of piles is as much art as science, and their use should not be employed by the inexperienced. To understand pile installation techniques, a working knowledge of the methods and tools used by Contractors is essential, as well as an understanding of the effects that these have on the resulting performance of the pile. This manual is not intended or designed to certify or qualify an inspector to perform pile installation inspection. It is highly recommended that any inspector unfamiliar with pile construction take NHI course No. 132078 Pile Design and Construction.

elifix (2015) "Sustainable Structural Solutions" Dixie Micro-Piles providing structural support to stabilize foundations. Backed by considerable structural engineering experience and expertise, Helifix Dixie micro-piles provide a technically advanced solution to the problems of subsidence and foundation settlement. These innovatively designed pipe piles offer a far more cost effective and non-disruptive means of stabilization than traditional methods of major piling or mass underpinning.

ELARABI, H ET AL (2014) “Piles for Structural Support” Piles are generally classified firstly according to design application and grouting method. The design application dictates the function of pile while the grouting method defined the grout/ground bond capacity. In the design application, there are two types of application. The first type is where the pile is directly loaded either axially or laterally and the pile reinforcement resists the majority of the applied load. This type of pile is used to transfer structural loads to deeper, more competent or stable stratum and may be used to restrict the movement of the failure plane in slopes. The loads are primarily resisted by the steel reinforcement structurally and by the grout/ground bond zone geotechnical. Second type of design application is where the pile reinforces the soil to make a reinforced soil composite that resist the applied load and known as reticulated pile network. This application of pile serves to circumscribe and internally strengthen the reinforced soil composite. The method of grouting is generally the most sensitive construction control over grout/ground bond capacity and varies directly with the grouting method. The second part of the pile classification is based primarily the method of placement and pressure under which grouting is used during construction.

G.L. Sivakumar Et.Al(2004)"Bearing capacity improvement using pile" Piles are often used to improve the bearing capacity of the foundation against applied loading. In many cases, steel pipes of 50 to 200 mm diameters are used as piles. The strengthened ground acts as coherent mass and behaves remarkably well, capable of sustaining very high compressive loads at defined settlement or alternatively defined loads at reduced movement. Lizzi (1982) and Plumelle (1984) showed that piles create an in situ coherent composite reinforced soil system and the engineering behavior of pile-reinforced soil is highly dependent on the group and network effects that influence the overall resistance and shear strength of composite soil pile system. Juran et al. (1999) presented an excellent state of art review, covering all the studies and contributions, on the state of practice using piles. Considerable information on single pile design, evaluation of load bearing capacity, movement estimation models as well as effect of group and network effect have been covered in considerable detail. The authors also reviewed geotechnical design guidelines in different countries for axial, lateral load capacities and approach for movement estimation. SRIDHARAN ET AL (1993) described a case study in which a ten-storied building, originally in a precarious condition due to differential settlement, was restored to safety using piles. Galvanized steel pipes of 100 mm diameter and 10 m long with bottom end closed with shoe, driven at an angle of 60o with the horizontal were used and the friction between the pile and the soil was used as the design basis in evolving the remedial measures.

III. METHODOLOGIES



3.1Soil and Pile

3.1.1 Soil

Kaolin powder available from local market was mixed with water and this mixture was used for preparing the bed of soft cohesive soil. The soil was light yellowish in color. Hydrometer test indicated that it contains 60% clay, 40 % silt and traces of sand. The liquid limit and the plastic limit of the soil were found to be 52% and 30% respectively, with the value of plasticity index as 22%. From standard Proctor compaction test, the maximum dry density of the soil was reported as 15.2 KN/m2 with the optimum moisture content of 28%. The specific gravity of soil particle was obtained as 2.6. In order to prepare the test bed, the kaolin powder is first of all thoroughly and uniformly mixed with water at a moisture content of 45%. This moisture content is near to the liquid limit of the soil and the workability was also observed to be adequate. After mixing, the soil was filled in the test tank in six equal layers manually. Each layer was compacted initially by hand compaction and thereafter by ten blows of a rammer. After the completion of the filling, the top surface was trimmed off by a spatula to obtain a leveled soil surface. A few samples were taken from finished test bed to carry out undrainedtriaxial compression test. The average value of cu and ϕu were obtained as 5 KN/m2 and 50respectively. The rammer used for compacting soil was specially manufactured. It consisted of a base platform to be placed on the soil surface. Compaction was achieved by repeated dropping of a weight of 60N from a height of 0.6m on the top of this platform.

3.1.2 Pile

Experiments were carried out using 2 x 2 pile group, each pile being hollow circular stainless-steel bar having 20 mm outer diameter and 600 mm overall length. The depth of embedment was 500 mm (L/d = 20) and the lateral load was imparted at a height of 90 mm above the soil surface. In order to insert the piles easily through the soil medium, the tips of the piles were pointed in shape. The piles were threaded at the top to attach with the pile cap by means of nuts. The piles were attached to a common pile cap which was actually a 16mm thick square steel plate. The c/c distances between the piles in the group was 60 mm. (= 3d).

3.3 Problem Statement

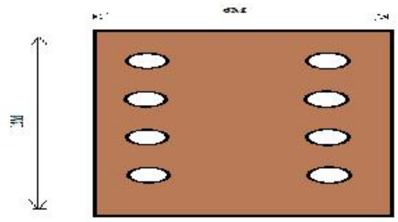


Fig :3 Pile Foundations

- Diameter of pile = 1300mm,
- No of piles = 8
- Depth of pile cap =1500mm
- Dead weight of pier , pier cap and pile cap
- With 15% buoyancy =16250 KN
- With 100% buoyancy= 11200KN
- Dead weight of girder and footpath =1337.3KN
- Live load (two span loaded) = 3719.5KN
- (one span loaded) = 2052.7 KN
- Frictional force due to DL = 40 KN
- Moment = 949.5 KN
- Longitudinal force(for two span loaded)=688.8KN
- Moment= 688.8*23.677KNm
- For one span loaded=728.92KN
- Moment=728.92*23.677KNm

IV. RESULT

4.1 Fea Model of Liquefaction Of Pile Foundation In Ansys

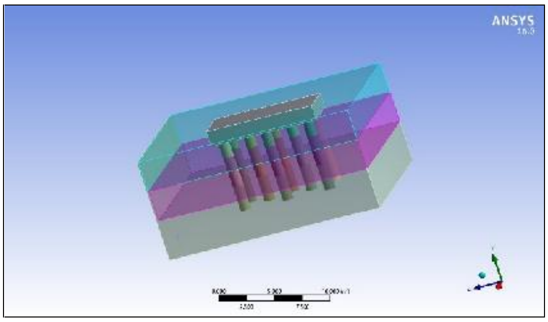


Fig: 4 Pile Foundation Model With Ansys

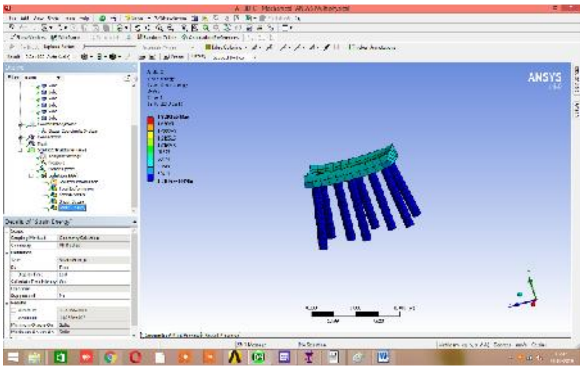


Fig: 5 Strain Energy

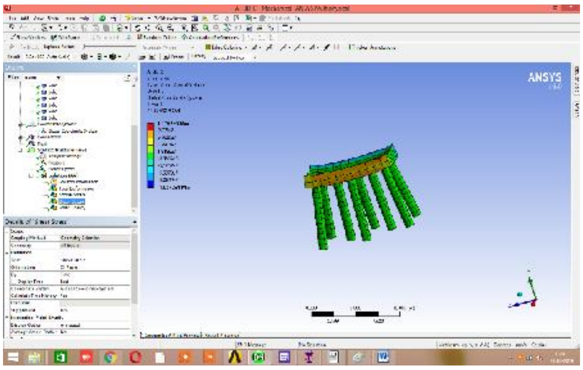


Fig: 6Shear stress

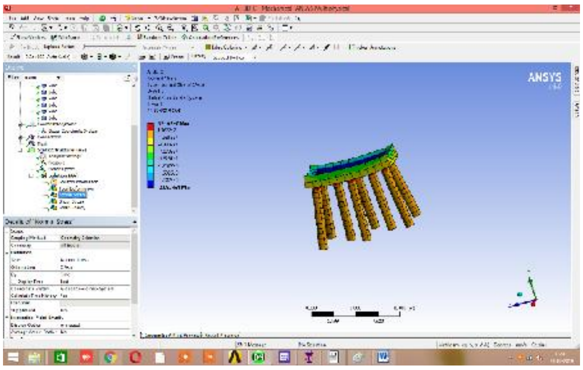
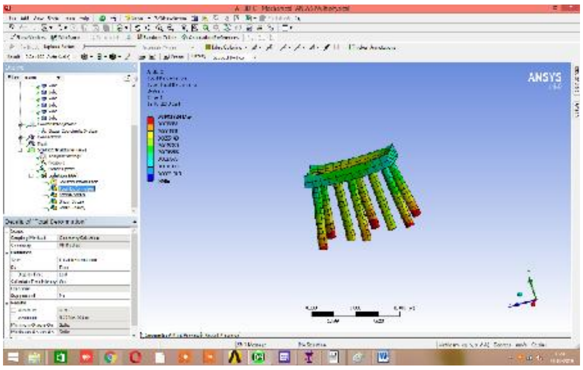


Fig.7 Normal stress



Fig,8 Total deformation

V. CONCLUSION

Pile spacing affects greatly the maximum settlement, the ultimate settlement and the load carrying capacity of the piles during soil liquefaction. In first stage from literature study it is concluded that the spacing between the piles should be within the permissible range that depend upon the loading conditions also. If the load acts at the centre of the mat structure then we have to provide lesser pile spacing. Increasing the number of piles decreases the total and ultimate settlement and increases the load carrying capacity up to certain limit that depends upon the loading condition. In later stage Pile cap and pile foundation is modeled with reference to Krishna Bridge in ANSYS tool and deformation observed is 96mm during soil liquefaction. In the first stage of study all IS 11841 code provision for design of NDCT is studied and finite element model in ANSYS is proposed against self-weight and lateral load against various dimensions. Following conclusions can be made after analysis.

- In this study effect of cyclic lateral load using time history analysis, the time history data selected is Electro which contains high amplitude, medium and low amplitude.
- The total deformations, normal stress, shear stress and equivalent stress is studied with various soil condition and soil types.
- The soil type is considered is soft, medium and hard as per IS 1893-2016 which is modeled in ANSYS.
- It can be concluded that for silty and clay soil layer. The total deformation, normal stress, shear stress and equivalent stress considerably reduced to 25-30%.
- Hence on site if sandy soil or Type-I is observed then deep excavation or soil treatment is recommended.

Results of Pile Foundation by using different diameters and different thickness:

In different diameters, results found by using diameter sizes are 1300mm, 1400mm and 1500mm. whereas in different thickness, results found by using different thickness are 300mm, 400mm, and 500mm.

Results for different diameters:

- Total deformation graph describes the result total deformation, total deformation for diameter 1300mm is 0.0308, for diameter 1400 is 0.0331 and for diameter 1500 is 0.0332. As per diameter the result is in increasing order.
- Strain energy graph describes the result Strain Energy, Strain Energy for diameter 1300mm is 157.99, for

diameter 1400 is 160.78 and for diameter 1500 is 162.72. As per diameter the result is in increasing order.

- Shear stress graph describes the result Shear stress, Shear stress for diameter 1300mm is 0.0277, for diameter 1400 is 0.0286 and for diameter 1500 is 0.0315. As per diameter the result is in increasing order.
- Normal stress graph describes the result Normal stress, Normal stress for diameter 1300mm is 0.0150, for diameter 1400 is 0.0144 and for diameter 1500 is 0.0288. As per diameter the result is in increasing order.

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