ASSESSMENT OF FLUCTUATION POTENTIAL OF DYNAMIC WAVES ON A FOOTING FOUNDED ON SOIL WITH VARIED SATURATIONS

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ABSTRACT: This report presents the review of literature pertaining to characterizing the performance of footing resting on soil subjected to dynamic push load, for the varied subsurface saturation levels and to quantify the propagation potential of the induced dynamic waves in the soil medium across the control volume. A composite model is proposed to developed to simulate the Soil-Structure Interaction under dynamic loads and to determine the settlement profile of the footing . The degree of improvement generated by for several embedment depths of a footing resting on soil medium is a subject of investigation in this proposed work, Dynamic loads of broad band excitation are selected in this proposed work to study the influence of it on the interaction between the soil and the footing (SSI) and to determine the performance under static loads and lateral excitations.

Keywords: Soil-Structure Interaction, Dynamic load.

1. INTRODUCTION

1.1 General

Reducing the accessibility of real building sites has contributed to an expansion in the usage of smaller areas, in which the bearing limit of the fundamental sediments is exceedingly limited. The conventional strategy would be to get a deep and exclusive base for these weak stores. There is a necessity to create real-world provisions that have made ground improvement a significant exploration area.

The settlement of shallow foundations and bearing capacity as a cost-effective foundation system. The foundation beds are laid on the thin soil in low-lying, poorly-drained soil. The resulting improved granulated layer decreases the settlements by providing a better pressure distribution and strengthening the performance to bear the underlying weak soils' load. To support shallow foundations, the use of reinforced soils has received considerable attention during the past 35 years.

Various researchers have expanded knowledge of strengthened soil support's possible benefits on bearing capacity, shallow base settlement, and failure mechanisms. Several empirical and experimental experiments have been shown to test the bearing ability of strengthened soil footings (Hataf et al., 2009).

1.2 Scope and Objective of Research

The behavior properties of soil, such as settlement and bearing capacity, could be enhanced by adding a compact over granular bed lying on weak soil. The degree of improvement generated by for several embedment depths of a footing resting on soil medium is a subject of investigation in this proposed work, Dynamic loads of broad band excitation are selected in this proposed work to study the influence of it on the interaction between the soil and the footing (SSI) and to determine the performance under static loads and lateral excitations.

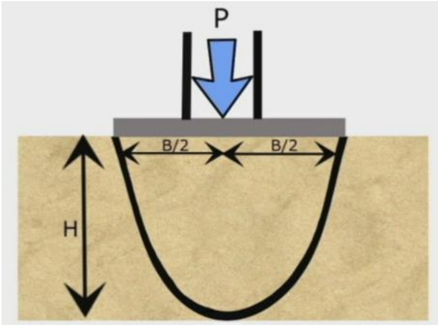

Fig.1.1 Loaded Footing Resting at Engineered RGB

Due to initial settlement, the strain in the Reinforcement is insufficient to assemble the requisite tensile tension. Hence, a technique is needed to increase the soil's load-bearing ability to eliminate the incidence of huge settlements.

A promising technique called pre-stressing the reinforcement eliminates the incidence of large settlements and the load-carrying capacity of a soil. Lovias et al. (2010) does a study on the strength of an unclamped clamp, clamped footing, a two-phase finite element analysis, and a laboratory testing model study. Placing reinforcing pre-stress led to a substantial decrease in base settlement and increased carrying capacity.

The bearing capacity of the footings is increased by supplying strengthened granulated beds over the poor soil. Instead of a circular base, square or rectangular foundations are widely utilized. Therefore, a study is developed to enhance the bearing capacity of granulated slabs on poor soil and determine the effects of reinforcing pegs. The core objectives of the present research are:

i. Impact of void formation in the GB besides the weak ground.

ii. The association of granular beds with weak soil.

iii. Proposing an empirical template for predicting granulated bed efficiency

iv. Dynamic behaviour of pressed reinforced bed subjected to Broadband excitation.

Because of the pre-stressing of strengthening, bearing capacity increased over poor soil. The physical structure of the strengthened granulated bed is witnessed by directing lab-scale studies on the plate load test. Nonlinear FEA is performed to use FE software PLAXIS V8 towards validating the outcomes attained after analytical and experimental work.

1.3 Organization of Dissertation

In Chapter 1, an overview of PRGB and the aims and prospect of the research. There is also a complete outline and review of the chapters that follow in Chapter 2; a review of related literature is provided. It provides a research assessment on experimental studies, analytical modeling, and finite elements analysis on reinforced soil. Chapter 3 defines the materials, test configurations, experimental methods, and testing were used in this investigation. Chapter 4 discusses the finite element analyses carried out for various examples of GB, RGB, PRGB bed. This chapter also discusses comparing results acquired through exploratory research with the analysis of finite elements. The creation of an empirical model to quantify the improvement in bearing capacity owing to the pre-stressing of the reinforcement is addressed in this section is discussed in chapter 5.

Chapter 6 contrasts the ultimate load ratios expected by the empirical model proposed and those observed from the studies of experimental and finite elements. The findings of finite element analysis on PRGB through voids at different locations remain described in-depth and presented. Chapter 7 examines the settlements as well as stresses at the interface between weak soil and granular bed, as determined using FEA.

Chapter 8 discusses the impacts of dynamic loading extensively,

1.4 Effects of SSI

The three main effects of SSI which need to be addressed in any SSI model are categorized as inertial interaction effects, kinematic inertial effects and soil-foundation flexibility effects.

Kinematic Interaction

The soil displacement caused by the earthquake ground motion is called as the free-field motion. This free field motion is not followed by the foundation that is located on the soil. The kinematic interaction is caused by the inability of thefoundation to sink with the free field motion of the ground.

Inertial Interaction

The additional deformation caused in the soil due to the transmission of inertialforce to the soil by the superstructure is called as the inertial interaction.When the ground shaking is of low level, the kinematic effect of SSI is more prominent. This results in the lengthening of period and there is increase in the radiation damping. When stronger shaking commences, the radiation damping is limited by the soil modulus degradation in the near field and the soil pile gaping.

At this situation, the inertial damping is more prominent. This will hence cause excessive displacements near the ground surface. This will bring damage of thepile foundations.

These effects can be related to structural analysis in terms of:

Foundation stiffness and damping

As compared to the normal assumption of rigid foundation, the inertial forces (base shear, moment and torsion) generate lateral displacement and rotation at the foundation level. These effects introduce flexibility in the structure and lead to period elongation. Since, these effects are rooted in structural inertia, they are referred to as inertial interaction effects.

Foundation deformations

Flexural, axial and shear deformation of structural foundation elements occur as result of forces and displacements applied by the superstructure and the soil medium. These represent the seismic demand for which foundation component should be designed and they could be significant, especially for flexible foundations such as rafts and piles.

Variation between foundation input motions and free filed ground motion

Kinematic effects of SSI represent the change in response of structure when response is obtained using free-field motions and when the presence of structure is considered. It doesn’t depend on the mass of the structure and is affected by the geometry and configuration of the structure, the foundation embedment, the composition of incident free-field waves, and the angle of incidence of the waves. This effect is called kinematic interaction effect as it does not involve any inertial forces.

1.5 Soil-Structure Interaction and Structural Response

Based on conventional theories it has been said that the soil structure

interaction has effects that are beneficial for the structural response. Most of the design codes for structures recommends neglecting the effect of SSI in the seismic analysis of the structure.

This recommendation is because of the false myth that the SSI brings good response of the structure and hence have chances to increase the safety margins.

More flexible structural design can be obtained if we consider the effects of soil structure interaction. This helps in increasing the natural period of the structure. This provides an improved structure when compared to a corresponding rigid structure.

Incorporation of SSI effects on the structural design helps in increasing the damping ratio of the structure. This study is limited or neglected for conservative design procedures. The SSI analysis is very complicated in nature. The neglection will reduce the complexity in the analysis of the structures.

This means that the myth put forward that the SSI effects are good for structures is not true. In fact, SSI can bring detrimental effects to structures. Neglecting SSI effect can bring unsafe design of the superstructure and the substructure.

1.6 Consideration in Soil-Structure Interaction Effects

A structure, when analyzed by considering its foundation to be rigid, is said to have no soil-structure interaction effects. Now, this case is considered even if the interaction force impacts the foundation.

The influence on the soil motion by the interaction forces will depend upon:

- The magnitude of the force
- The flexibility of the soil foundation

The base mat acceleration and the inertia of the structure can be used to estimate the value of interaction forces. The heavier the structure the more is the soil-structure interaction effects for a particular soil site and for a given free-field seismic excitation. Most of the civil structure, whether it is lying on the hard or medium soil does not show any sign of SSI effects. We can conclude that the soil interaction in earthquake engineering study was mainly developed and applied for these fields of construction industry.

Another condition considered the soil-structure interaction effects are the soil flexibility. Softer is the soil, more is the chances for the occurrence of SSI effects. This is for a given structure and a site that have a free -field seismic

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1.7 Dynamic Soil-Structure Interaction

One of the fundamental problems in dynamic soil-structure interaction is the characterization of the dynamic response of surface foundations resting on a soil medium under time-dependent loads.

Earthquake ground motion causes soil deformation known as free-field motion. Such ground motions that are not influenced by the presence of structures are called free field motions. When they interact owing to very presence of structure, soil structure vibration as a process becomes very important. These interactions have little effects on some systems and larger influences on the response of other system. Stiff or heavy structures resting on relatively soft soilare more prone to such influence. On the other side, for flexible or light structures on stiff soils soils-structure interaction effects are generally smaller. Under the influence of such interactions the natural frequency of a soil- structure system shall be lower than the natural frequency of the structure itself.

Despite its importance to various soil dynamics and earthquake applications, a clear understanding of the problem has yet to be established owing to the complexity of real soil behaviour and its constitutive modelling, the in-situ and stress-induced heterogeneity in the soil's modulus, and the three-dimensional nature of the underlying wave propagation phenomenon.

2. OBJECTIVES OF WORK

- To quantify the Dynamic wave propagation potential in a soil medium with varied saturation.
- To assess the stability of foundation under above condition.

3. TESTS CONDUCTED ON THE SOIL

3.1 Red Soil

The red soil used in the current study was collected from Hosur region. The red soil taken for testing is sieved using 4.75mm IS sieve, since testing was proposed to be conducted using fine grained soil. The moisture content of the soil is varied according to the testing conditions required.

3.2 Soil Properties

Sl.No	Tests Conducted	Results Obtained
1	Specific Gravity (G)	2.65 kg/m3
2	Fineness Modulus	5.59
3	Natural Water Content	10%
4	Uniformity Coefficient Cu	1.28
	Coefficient of Curvature	2.63
5	Liquid Limit	28%
	Plastic Limit	12%
	Shrinkage Limit	2%
6	Plasticity Index (Ip)	10%
7	Optimum Moisture Content (OMC)	9.36%
8	Dry density of Soil	1.32KN/m3

Table 3.1 Soil Properties

4. DYNAMIC TEST SYSTEM

4.1 Experimental Setup

The system consists of portal frame with cubic box 750mm*750mm*750mm with base plate and hydraulic actuator fixing arrangement for applying vertical and horizontal loads. A servo-hydraulic actuator capacity of 10 kN is provided to apply designed static vertical load. Another servo-hydraulic actuator of capacity 5kN is to be operated to provide dynamic loading while vertical load has been applied, the type of actuator is double ended, double acting. The rated pressure is 215kg/cm^2. The stroke length that can be applied is ± 50mm.

Fig 4.1- Dynamic Test System

Two LVDT's are installed to measure movements, which it can convert into corresponding electrical signals. The safe overload capacity is 150%. Application software for computerized setup, operation, data storage, online and offline graph plotting and generation of test reports is achieved in pre-specified formats. Universal load cell of capacity 500kg with load indicator for tension measurement system using 4no's of accelerometers and data acquisition system with lab top is provided.

4.2 SAMPLE PREPERATION

The cubic box of size 750*750*750mm is filled with the red soil which is passing through 4.75 mm IS sieve. The soil is poured into the container with the cleared height of disposition and the soil is well compacted inside the container.

The footing model made of mild steel of size 150*150mm and 5mm thickness is placed on the surface of the soil to serve as a medium to transfer the vertical static load into the soil.

The dynamic load is applied by means of servo-hydraulic actuator whose intensity can be varied up to 5kN. The horizontal load is applied in the form of stroke to induce dynamic loads to the soil. The soil is saturated with various saturation level. The graphs are recorded for the proposed testing with the help of pre- specified plotter setup.

4.3 LOAD APPLICATION:

Initially the static vertical load of 1kN is applied, with a force of 1kN given by means of hydraulic actuator and this load is maintained constant. Then, the horizontal loading is applied, this load is given in the form of strokes whose frequency and the target cycles for varied soil saturation.

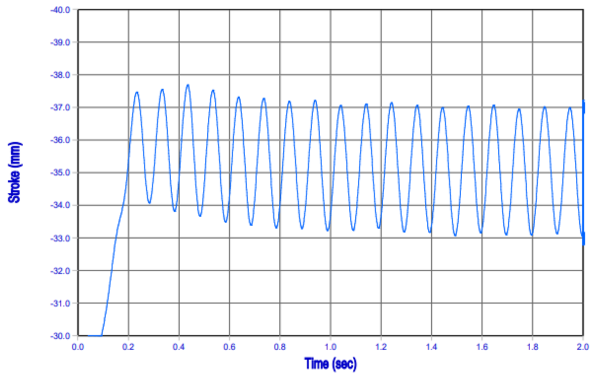
For the above mentioned conditions, the graphs are plotted.

ASSUMPTIONS:

1. Boundary effects of the test chambers are neglected.
2. Down to the depth of influence of stresses, the bearing strata is reasonably uniform.

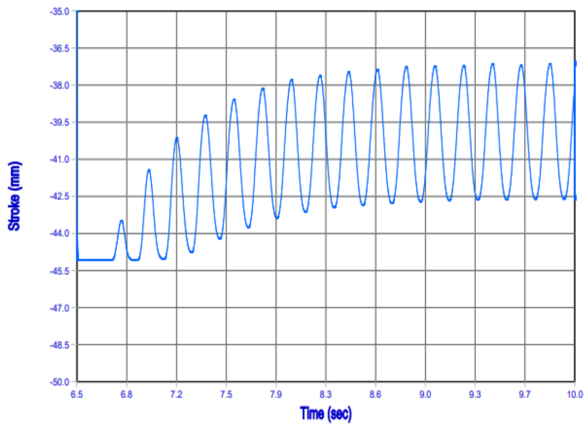
5. RESULTS

5.1 Graphs Obtained for 1kN Loading on

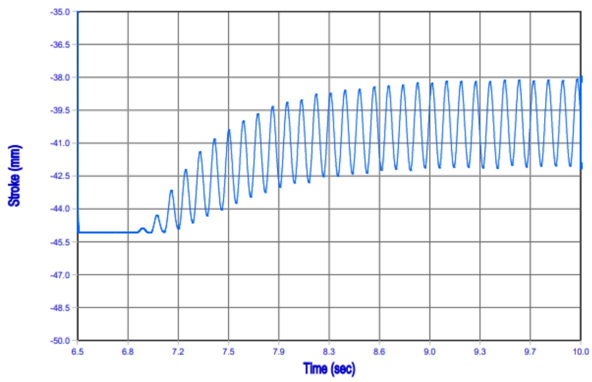


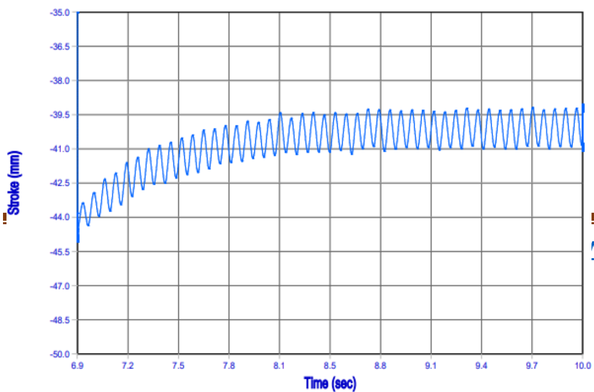
Dry Soil:

5.2 Graphs Obtained for 1kN Loading on 10% Saturated Soil



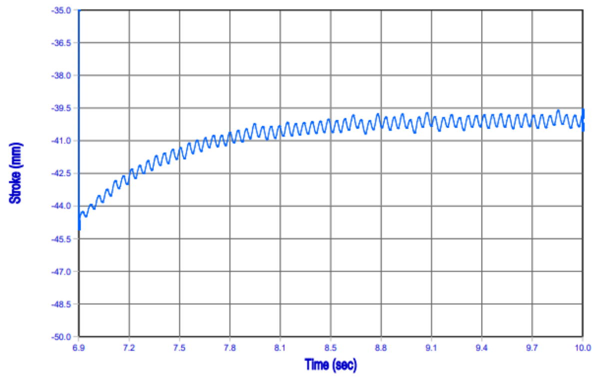
5.3 Graphs Obtained for 1kN Loading on 20% Saturated Soil





5.4 Graphs Obtained for 1kN Loading on 30% Saturated Soil

5.5 Graphs Obtained for 1kN Loading on 40% Saturated Soil



Note: Test Parameters

Control Priority	: Stroke
Wave Form	: Sinusoidal
Frequency	: 10.0 Hz
Amplitude	: 5.0 mm(peak to peak)
Target Cycle	: 500 cycles

PERFORMANCE ANALYSIS The analysis is made keeping the vertical static load constant and gradually increasing the magnitude of dynamic load with varied saturation, this is because for any structure the load from the structure to the foundation remains much or less uniform with respect to time. From the stroke vs time graphs plotted for varying test parameters, it is found that the dynamic waves propagating through the mediumremains uniform for a particular time period and raises gradually until the applied load has been released. However there has been slight variation in their amplitudes at a particular frequency. With the increase in the frequencies, the saturation of the soil increases for the same time period. The negative value of stroke indicates reference used is below the FRF (Frequency Response Function). The main aim of this study is to notice the frequency under different saturations.

6. CONCLUSION

Based on the plurality of the experimental investigation and subsequently the graphical analyzation, the following conclusions are drawn.

- Quantified the Dynamic wave propagation potential in a soil medium with varied saturations.

- Assessed the stability of foundation under above conditions.

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