ISSN: 2278-0181
Vol. 1 Issue 8, October - 2012

Effect Of Embedment And Geogrid Reinforcement On Dynamic Elastic Properties Of Silty Sand

***Bhishm Singh Khati*[1] *Swami Saran*[2] *S.Mukerjee*[3] *Dilip Kumar*[4]**

[1] Asst. Prof., Dept. of Civil Engineering, G B Pant Engg College,Pauri, India,

[2] Professor and Emeritus Fellow, Dept. of Earthquake Engineering, IIT Roorkee, India,

[3] Asst. Prof., Dept. of Earthquake Engineering, IIT Roorkee, India,

4 Asst. Prof., Dept. of Civil Engineering, G B Pant Engg College,Pauri, India,

ABSTRACT. The present paper has been carried out to study the dynamic response of foundation on unreinforced and reinforced sand beds experimentally and to interpret the dynamic properties of reinforced sand on the basis of experimental data. It is anticipated that the study would help in better understanding of the dynamic behaviour of foundations on reinforced sand beds and lead to realistic and safe design. Efforts have been made to present a report on experimental investigation carried out on model concrete block. The experimental investigation consists of performing vertical block vibration tests (total number 36) on unreinforced and reinforced sand beds with evaluation of embedment effect. The study has been carried out on the effect of influencing parameters (considered here) viz. embedment ratio, excitation force level and number of reinforcement layers on the response parameters viz. resonant amplitude, resonant frequency, damping ratio, coefficient of elastic uniform compression, elastic modulus and shear modulus. The results of this study are especially useful in the design of foundations of machines, where the natural frequency of the soil-foundation system may lie close to the operating frequency of machine and the maximum amplitude is likely to the exceed permissible limits. The maximum amplitudes can be brought under control and the disturbance during the starting and stopping stages of the machine can be reduced.

Key words. Dynamic Soil Properties, Silty Sand, Geogrid Reinforcement.

INTRODUCTION

Safe and economic design of machine foundations as well as the structures is essential for any industry and the dynamic parameters like modulus, damping, stiffness and amplitude etc. including the dynamic elastic constants of the soil must be determined for the purpose of analyzing machine foundations and the substructures subjected to dynamic loading / earthquakes. Reinforcement soil is one of the most popular and the fastest growing technique for the improvement of poor soils or modification of its properties. The reinforcement of the soil by the inclusion of high tensile strength materials like stripes, sheets, nets, mats and grids of metals, geo-synthetics and fibers to reduce the tensile strain or to increase the tensile strength, shear resistance and stiffness of soil are most common. Of the above, geo-synthetics, either as geo-grids or geo-nets inclusions has become predominant.

The idea behind this work is to limit the displacement amplitude to a safe level and to avoid resonant frequency so that they neither endanger the satisfactory operation of machine, nor disturb the people or structure in the immediate vicinity.

The effect of embedment on block foundation is of considerable interest because of the following reasons:

1. To rest the block on a good bearing stratum,
2. To provide the block top at a level convenient for operating the machine it supports.

For an embedment foundation, the soil resistance is mobilized both below the base and on the sides. The additional soil reaction that comes into play on the sides of an embedded footing has significant influence on its dynamic response.

The dynamic response parameters e.g. amplitude, frequency and damping etc. are determined from laboratory model tests performed on un-reinforced and reinforced base conditions along with embedment.

MATERIAL USED FOR TESTING

Soil Used

The sand obtained from Solani River, the grain size distribution curve of the sand is shown in Fig.1. The relevant physical and mechanical properties are listed in Table 1.

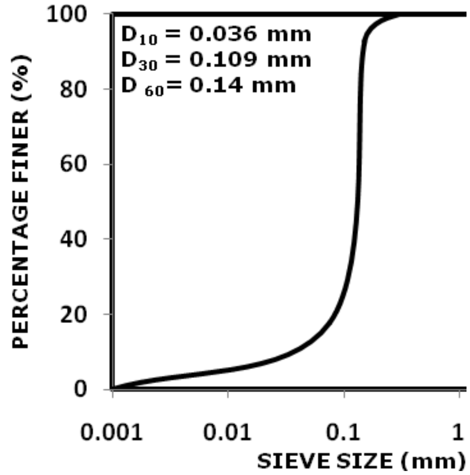

Fig.1 Grain Size Distribution Curve for Solani Sand

Table 1 Physical and Mechanical Properties of Soil

S.No	Property	Quantity
1.	Soil type	SM
2.	Uniformity coefficient (C_u)	3.89
3.	Coefficient of curvature (C_c)	2.4
4.	Mean specific gravity (G)	2.604
5.	Maximum void ratio (e_{max})	0.875
6.	Minimum void ratio(e_{min})	0.488
7.	Angle of internal friction (Φ) at R. D.50%	34º

Reinforcing Material

The reinforcing material used in the tests was Geogrid Netlon. The physical, chemical and mechanical properties of the reinforcement are listed in Table 2.

Table 2 Properties of reinforcement material, Geogrid Netlon

S.No.	Property	Description
1.	Physical	Colour - Black Roll width – 2.5 m Roll length – 15 m Mess aperture -20mm×20mm Mess thickness -3.3mm Structure weight -720gm/sqm
2.	Chemical	100% High density polyethylene Excellent resistance to chemical and microbiological agents. Poor resistance to oxidizing agents and ultraviolet light.
3.	Mechanical	Maximum load – 7.68 kN/m

Fig. 2 Experimental Test Set Up

Test Procedure

The vibration tests were conducted as per the procedure laid down in IS: 5249-1977. The procedure is briefly described below.

The sand bed was prepared afresh for each test and the motor, oscillator and block assembly was gently placed over the smooth finished sand bed. The sand was back filled and finished smooth as per the requirement of the embedment. The usual connections were made between different components as per the requirements of test laid down earlier. The angle of eccentricity of the oscillator was arranged to the desired level of excitation. The speed of the motor was gradually increased using the speed control unit and the corresponding frequency and acceleration values displayed on the computer screen had been recorded. The frequency values were also recorded from tachometer in order to cross-check the frequency values. Likewise the tests were done for unreinforcement and different reinforcement layers at different embedment and excitation levels for vertical modes of vibration.

Tests Performed

A series of vertical vibration tests were conducted on M20 blocks at three excitation levels. The sand bed was prepared at 50% relative density for different embedment ratios for keeping both unreinforcement and number of reinforcement layers 2, 3 and 4. The following parameters were used as variable in the experimental programme:

i) Number of reinforcement layers
ii) Different embedment ratios
iii) Three excitation levels in terms of the eccentricity setting of the eccentric mass of the oscillator.

TEST RESULTS

Data obtained from various test-results were used to draw the Frequency-Amplitude plots as mentioned below. The values of the excitation force levels (eccentricity values), embedment ratio and number of reinforcement layers are also shown.

Figures 3 to 18 represent the response curves drawn from the frequency and amplitude values obtained from the vertical vibration tests on block placed over the surface and with the embedment in both unreinforced and reinforced sand beds. The force levels (eccentricity values), embedment ratio, number of reinforcement layers and corresponding values of resonant frequency and the maximum amplitude are shown along.

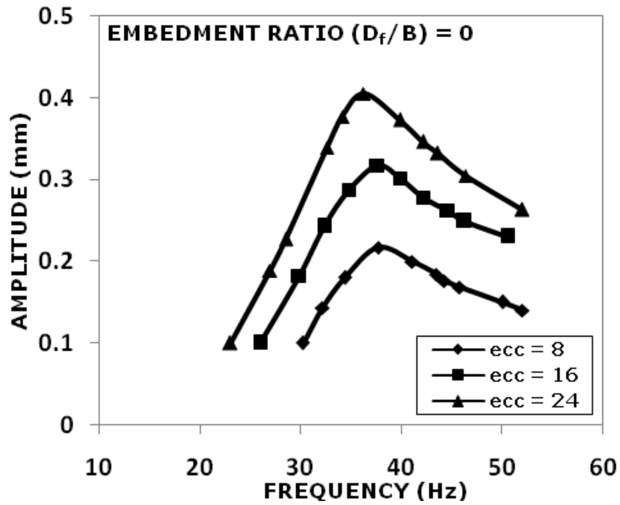

FIG 3 VERTICAL VIBRATION TEST ON UNREINFORCED SAND

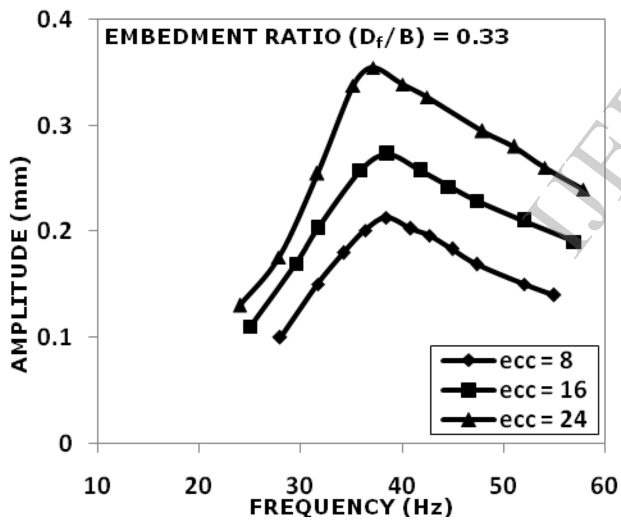

FIG 4 VERTICAL VIBRATION TEST ON UNREINFORCED SAND

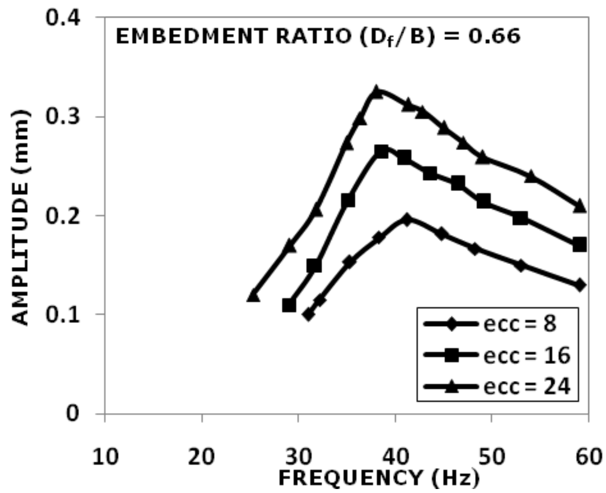

FIG 5 VERTICAL VIBRATION TEST ON UNREINFORCED SAND

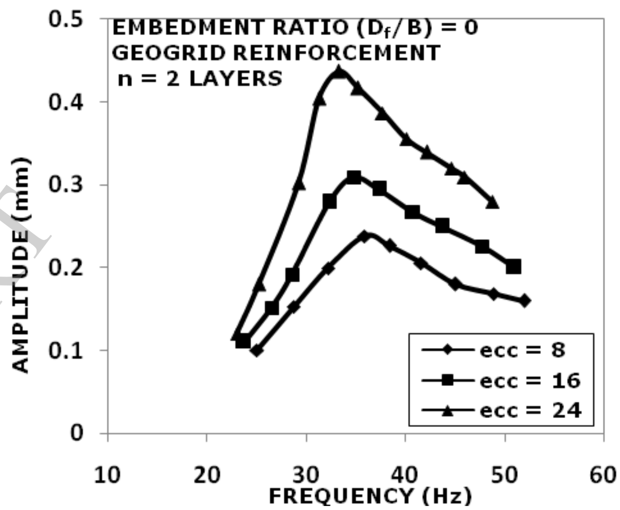

FIG 6 VERTICAL VIBRATION TEST ON REINFORCED SAND

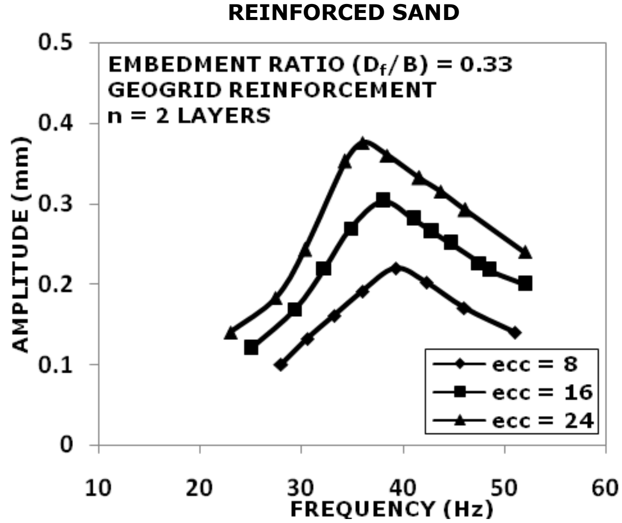

FIG 7 VERTICAL VIBRATION TEST ON REINFORCED SAND

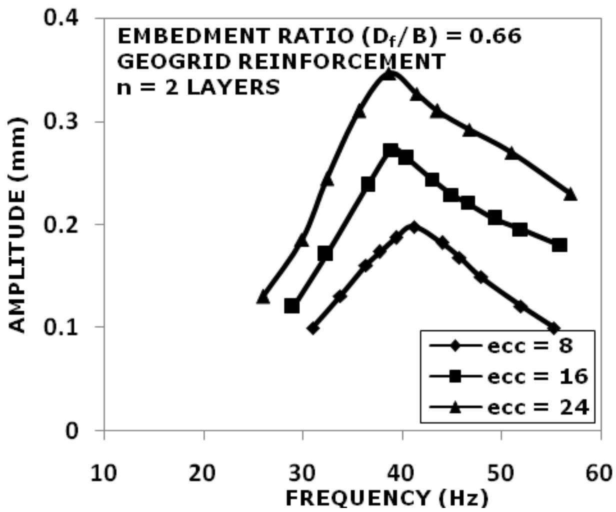

FIG 8 VERTICAL VIBRATION TEST ON REINFORCED SAND

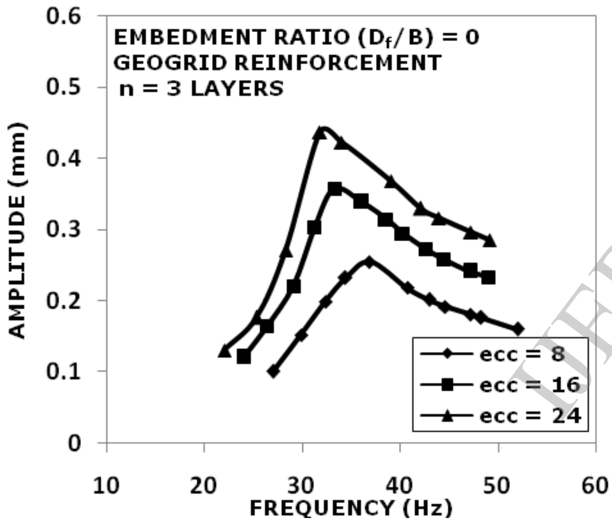

FIG 9 VERTICAL VIBRATION TEST ON REINFORCED SAND

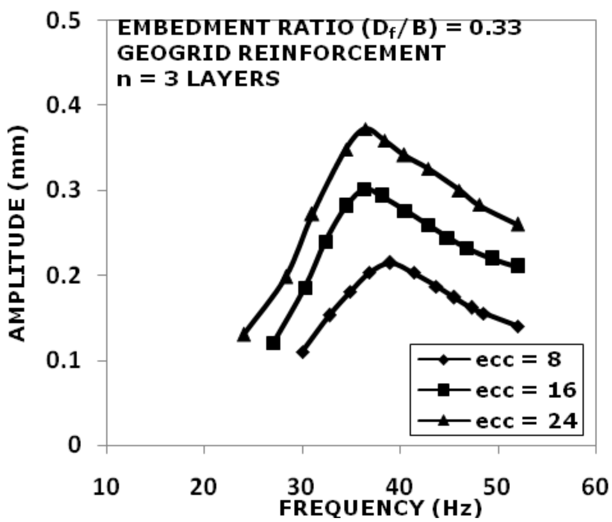

FIG 10 VERTICAL VIBRATION TEST ON REINFORCED SAND

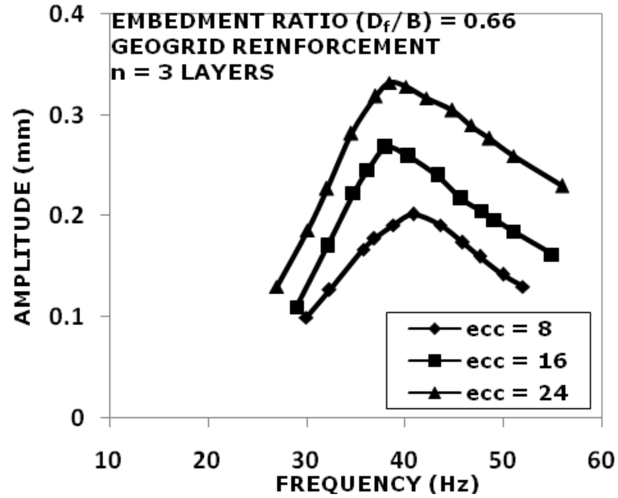

FIG 11 VERTICAL VIBRATION TEST ON REINFORCED SAND

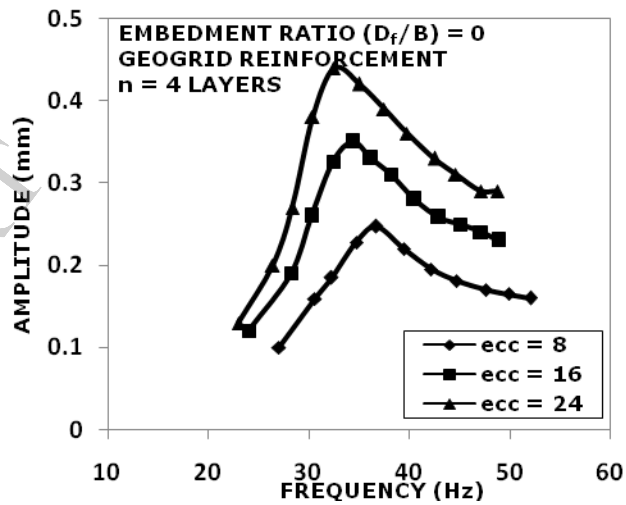

FIG 12 VERTICAL VIBRATION TEST ON REINFORCED SAND

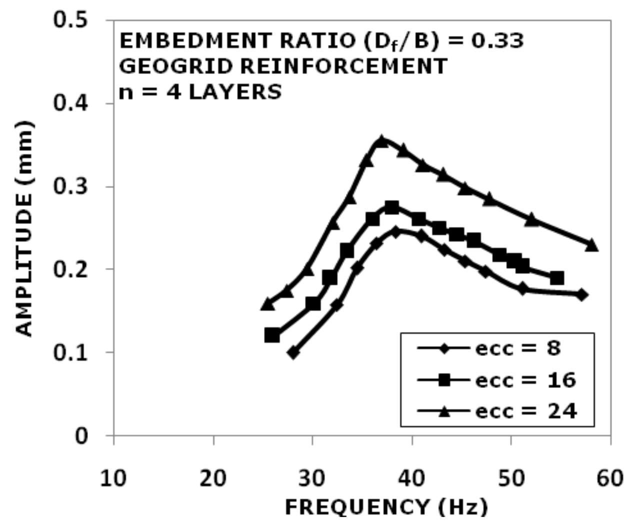

FIG 13 VERTICAL VIBRATION TEST ON REINFORCED SAND

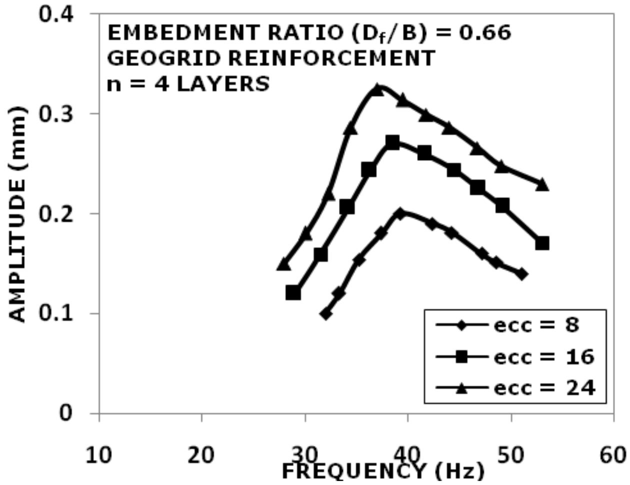

FIG 14 VERTICAL VIBRATION TEST ON REINFORCED SAND

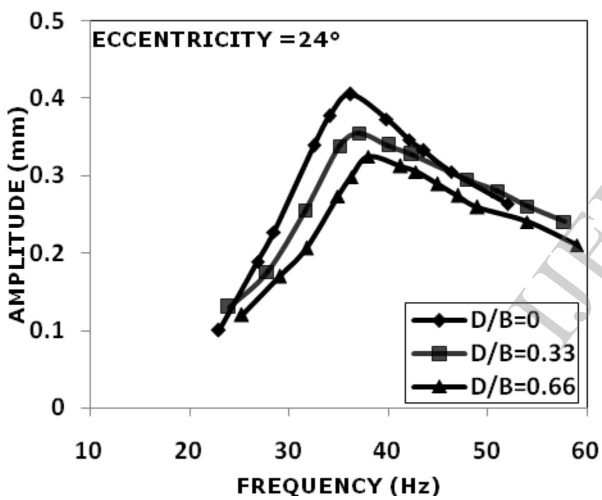

FIG 15 VERTICAL VIBRATION TEST ON UNREINFORCED SAND

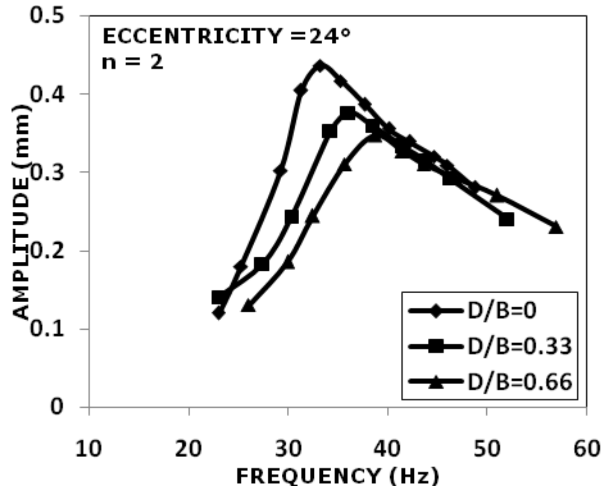

FIG 16 VERTICAL VIBRATION TEST ON REINFORCED SAND

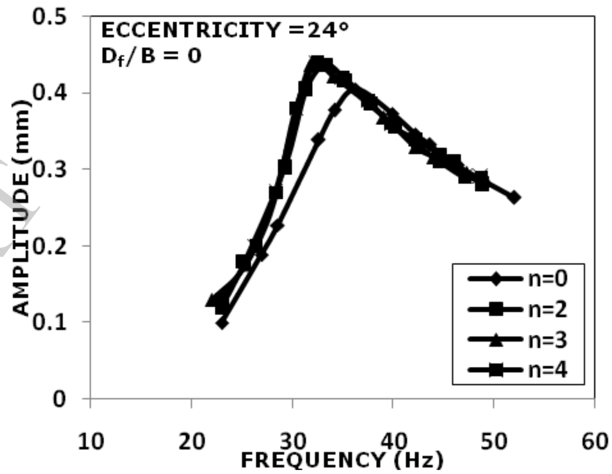

FIG 17 VERTICAL VIBRATION TEST ON UNREINFORCED AND REINFORCED SAND

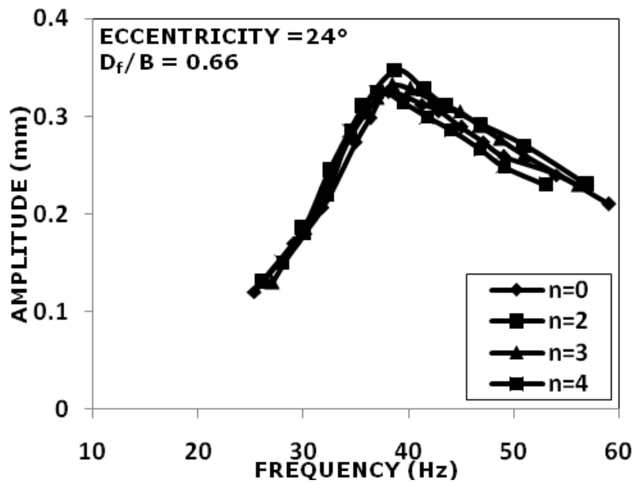

FIG 18 VERTICAL VIBRATION TEST ON UNREINFORCED AND REINFORCED SAND

RESULTS AND DISCUSSION

Analysis of the Amplitude-Frequency Data

The procedure followed to find out the above mentioned parameters for each case i.e., for a particular combination of embedment ratio, force level and number of reinforcement layers, is as follows:

Damping Ratio (ξ)

$$\xi = \frac{f_2 - f_1}{2 f_{nz}} \quad (1)$$

Coefficient of Elastic Uniform Compression (Cu)

$$C_u = 4\pi^2 f_{nz}^2 \frac{m}{A} \quad (2)$$

Elastic Modulus (E)

$$E = \frac{(1-\mu^2)}{1.13} \sqrt{A} . C_u \quad (3)$$

Shear Modulus (G)

$$G = \frac{E}{2(1+\mu)} \quad (4)$$

Correction for Confining Pressure and Area

$$(C_{u10})_{10} = C_u \sqrt{\frac{\sigma_{02} * A1}{\sigma_{01} * A2}} \quad (5)$$

Effect of Embedment Ratio

With the increase in the embedment ratio, the maximum amplitude of vibration is decreasing for the reinforced sand likewise the unreinforced sand. The decrease in amplitude is about 10% to 20% for an embedment ratio of 0.33 and 15% to 25% for an embedment ratio of 0.66 as compared to surface block.
Frequency is increasing slightly with increase in embedment for the reinforced sand likewise the unreinforced sand.
The coefficient of elastic uniform compression is increasing with the increase in embedment ratio for the reinforced sand likewise the unreinforced sand.

Effect of Force

With the increase in force level, the maximum amplitude of vibration is increasing in both surface and embedded blocks for reinforced sand likewise the unreinforced sand. The increase in amplitude is about 20% to 30% when the eccentricity increased from 8º to 16º and 35% to 45% when the eccentricity increased from 8º to 24º for both the cases.
With the increase in force level, the resonant frequency decreases slightly in both surface and embedded blocks for both the cases.
When the force is increased, the coefficient of elastic uniform compression decreases in both the cases.

Effect of Reinforcement

When the number of reinforcement layers is increased, the maximum amplitude of vibration is generally more in both surface and embedded blocks. The increase in amplitude is about 5% to 7% when the two layers of geogrid reinforcement used, 7% to 10% when the three layers and 9% to 12% when the four layers of reinforcement used as compared to unreinforced.

When the number of geogrid reinforced layer increased, the resonant frequency is reduced slightly in both surface and embedded blocks.

The coefficient of elastic uniform compression is decreases and damping ratio increases in both surface and embedded blocks, depending upon the number of reinforced layers. The Cu values of reinforced sand beds are less than the Cu-values of unreinforced sand bed for surface block, whereas for embedded block, Cu- values for reinforced sand beds are more.

CONCLUSIONS

On the basis of the worked here-in, the following conclusions can be drawn:

i) With an increase in the excitation force level, the maximum amplitude increases significantly whereas the resonant frequency drops slightly for both reinforced and unreinforced sand; for a constant embedment ratio.
ii) With an increase in embedment ratio, for a constant excitation level, the maximum amplitude decreases significantly whereas the resonant frequency increases slightly for both reinforced and unreinforced sand.
iii) The maximum amplitude increases and resonant frequency decreases generally with an increase in the number of reinforcement layers.
iv) The damping ratio increases with the increase in the excitation level and it increase generally with the increase in the number of the layers of geogrid.
v) The damping ratio increases with the increase in the embedment ratio.
vi) Coefficient of elastic uniform compression increases with an increase in the embedment ratio and decreases with an increase in excitation level, for both reinforced and unreinforced sand.
vii) The coefficient of elastic uniform compression decreases with an increase in the number of reinforcement layers.
viii) Elastic modulus and Shear modulus increases with an increase in the embedment ratio and decreases with an increase in the excitation level, for both reinforced and unreinforced sand.
ix) Elastic modulus and Shear modulus decreases with an increase in the number of reinforcement layers.

REFERENCES

1. IS: 1498-1970, Classification and Identification of Soil for General Engineering Purposes, Indian Standards Institution, New Delhi.
2. IS: 5249-1977, "Indian Standard Method of Test for Determination of Dynamic Properties of Soil", Ist Revision, Indian Standards Institution, New Delhi.
3. Ghosh, S., (2001) ''Effect of Embedment on Block Foundation Vibration'', M.Tech Dissertation, Department of Civil Engineering, Indian Institute of Technology, Roorkee, India, January, 2001.
4. Saran, S., (2006), "Soil Dynamics and Machine Foundation", Department of Civil Engineering, Galgotia Pub.pvt.ltd, University of Roorkee, Roorkee, India.
5. Sharma, R.K., (1997) ''Dynamic Properties of Reinforced Sand'', Ph.D.Thesis, Department of Civil Engineering, Indian Institute of Technology, Roorkee, India, September, 1997.
6. Vijayvargiya, R.C., (1980), "Dynamic Behaviour of Embedded Block Foundation", Ph.D.Thesis, U.O.R., Roorkee, India.