



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 6, June 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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Performance of Adjacent Block Machine Foundations Resting on Reinforced Soil Bed: A Review

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ABSTRACT: As a machine foundation, a block foundation is commonly utilized. The machine's moving elements generate a dynamic force, and the machine's foundations are constantly subjected to dynamic loads. Because of the recurrent nature of dynamic stress, foundation soil settling increases. Reduced cyclic loads induced by machine vibrations can help to reduce excessive soil settlement. One approach of dealing with cyclic loads is to increase the stiffness of the soil. Soil reinforcement with geosynthetics is one of various methods for enhancing soil stiffness. The dynamic response of a machine foundation lying on a reinforced soil bed is discussed in this review paper. Using soil reinforcement with geosynthetic material to lower the peak vertical displacement and resonance frequency.

KEYWORDS: Dynamic Force, Geocell, Peak displacement, Resonant frequency, Infill Material, Machine Foundation.

I. INTRODUCTION

The interaction of adjacent foundations laden with dynamic force is quite important in practice. Harmonic and periodic vibrations are experienced by the soil that supports the machine base. The behavior of the earth and foundation under such vibrations is extremely intricate and differs significantly from that under static load. Under such vibrations, the soil must stay elastic or else deformation grows monotonically with each cycle, resulting in excessive settlement. When designing the machine foundation, the natural frequency of the machine foundation system and the maximum displacement amplitude of the machine at its operating frequency are critical factors to consider. The primary goal of machine foundation design is to keep the maximum amplitude of foundation motion within safe limits.

Soil reinforcement is a technique for enhancing soil stiffness and strength. Different tension resistant features, such as geogrid and geocell, are used to improve soil strength and are positioned inside the soil mass to minimize or suppress any possible tensile strain induced by gravity and boundary forces. There are several applications for reinforced soil technology. The performance of unreinforced soil differs greatly from that of reinforced soil. It has a high tensile strength capacity and is comprised of reinforcing strips and soil fill. Soil reinforcement, a common procedure utilized in many projects, prevents soil slopes from loosening and increases the load carrying capacity of the soil. Geocell as shown in the Figure 1 can be used as reinforced material to enhance the properties of soil. Geocell is a manufactured novel polymeric alloy. Polyolefin and thermoplastic designing polymer were the main components of the novel polymeric alloy. It was a three-dimensional shaped structure confinement system that significantly boosted the load carrying capacity of soft soils, particularly in foundation and road surface applications. The connecting strips function as the walls of a three-dimensional, flexible cellular structure into which the stated infill materials were placed and crushed. Tensile reinforcement provides confinement, resulting in a free-draining system that eliminates mass

movements and keeps infill materials in place. Cellular confinement technologies improve the structural and functional behaviour of soils and aggregate infill materials.



Figure 1. Geocell

Quarry dust as shown in the Figure 2 is the infill material can be used in the geocell pocket. Quarry dust is a natural outcome of the crushing process that produced a concentrated material suitable for use as aggregates in concrete, particularly fine aggregates. Quarry dust is the dust produced when rock is crushed into various sizes during quarrying activities.



Figure 2. Quarry Dust

II. LITERATURE REVIEW

Various scholars conducted the following experimental and numerical investigations on machine foundations resting on reinforced soil.

M.V.S. Sreedhar *et.al* (2016) investigated the better response of a geosynthetic reinforced soil bed positioned beneath a model machine foundation, block resonance tests were conducted on the soil bed prepared either way using geosynthetic reinforcement. The test soil bed was strengthened using a bi-axial geogrid and a non-woven geotextile. Experimental investigation was carried out to know the resonance frequency and peak amplitude of the reinforced soil bed as well as other dynamic parameters. As indicated in Figure 3a, a test pit measuring 1.80 m by 1.60 m by 1.20 m was created for the test block measuring 0.60 m by 0.50 m by 0.40 m. On top of the test soil bed, the test block with the oscillator installed was put. Through the use of a flexible shaft, the DC motor is linked to the oscillator. It was noted that the peak amplitude had significantly decreased and the resonance frequency had shifted. The usage of geosynthetics beneath the machine foundations was shown to be helpful in changing the frequency ratio and lowering the peak amplitude, which were the two primary requirements of machine foundation design. When the test bed was reinforced, the peak displacement at resonance decreased, as can be seen from the nature of peak vertical displacement vs frequency displayed in figure 3b.

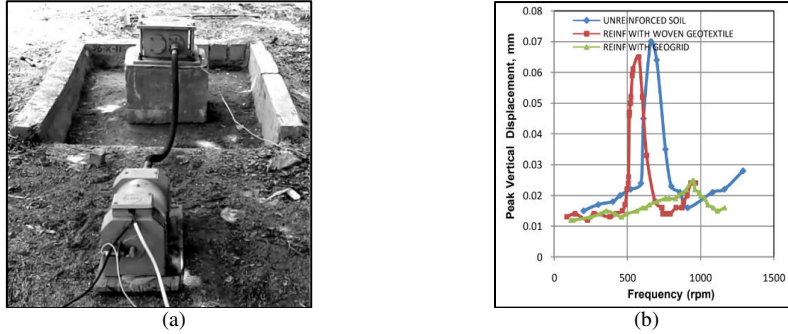


Figure 3. (a) A view of the experimental setup (b) Peak Vertical Displacement (vs) Frequency plot

When reinforced, the magnification factor in Table 1 decreases to a level of 47.70%, demonstrating the effectiveness of reinforcement. Due to its larger modulus and improved interaction, geogrid performed relatively better than geotextile.

Table 1: Summary of results

Test Condition	Peak displacement at Resonance		Magnification Factor at resonance	
	(mm)	% Drop	Value	% Drop
Soil	0.07	0.00	7.34	0.00
Soil + Woven Geotextile	0.065	7.10	6.58	10.40
Soil + Biaxial Geogrid	0.025	64.30	3.84	47.70

The conclusions that were reached based on the experimental investigations are as follows.

1. The model machine foundation's geosynthetic reinforcement showed a noticeable improvement in the foundation soil's responsiveness.
2. Peak Vertical displacement and Peak Magnification factor at resonance condition both showed a sizable decline. This supports Geosynthetics potential to improve the earth beneath machine foundations.
3. A change in resonance frequency was noticed, indicating that geosynthetics play a part in fine-tuning machine foundations.
4. The in-isolation modulus and interaction parameters were thought to be related to the relative efficacy of improvement by the geosynthetics.

Abhijeet Swain *et.al* (2015) performed study on the dynamic interaction effect of square foundations that are closely spaced under mechanical vibration. Several investigations on the isolated and interacting footing reaction resting on the local soil were conducted in the field under dynamic settings in Kanpur, India. Two model footings of dimension 0.55m x 0.55m x 0.2m for F1 and 0.65m x 0.65m x 0.2m for F2 were casted as a RCC M20 grade square footings. Different amounts of dynamic stress (S) were applied to both footings, which were positioned at various clear-space intervals. The observations were put together and shown as the displacement amplitude frequency fluctuation. Calculated gearbox ratios indicated how dynamic excitation of the active footing would affect the passive footing. A variable speed 3HP DC motor was used to operate the mechanical oscillator to run at different frequency ranging from 120 rpm – 3000 rpm. The DC motor was placed and clamped over the oscillator and their shafts were connected with belt as shown in Figure 4.

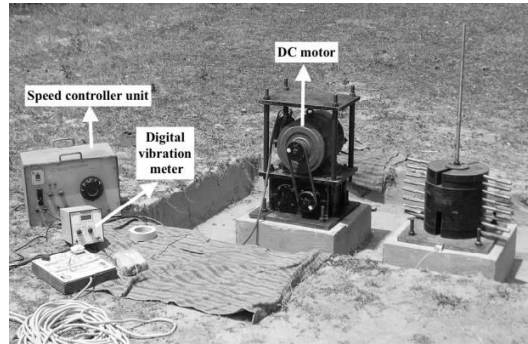


Figure 4: Photographic view of the experimental setup

Several tests were conducted on the interfering footings F1 and F2 in four basic combinations (F1-F1, F1-F2, F2-F1 and F2-F2) to explore the dynamic interaction between two nearby footings. The variations of the displacement amplitude with the frequency for both active and passive footings are shown in Figures 5 and 6.

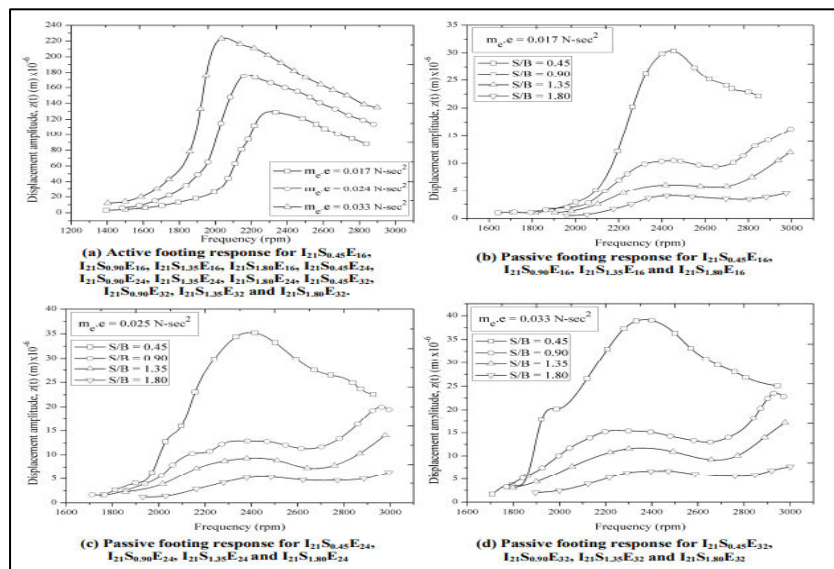


Figure 5: Dynamic response due to interaction between active and passive footings

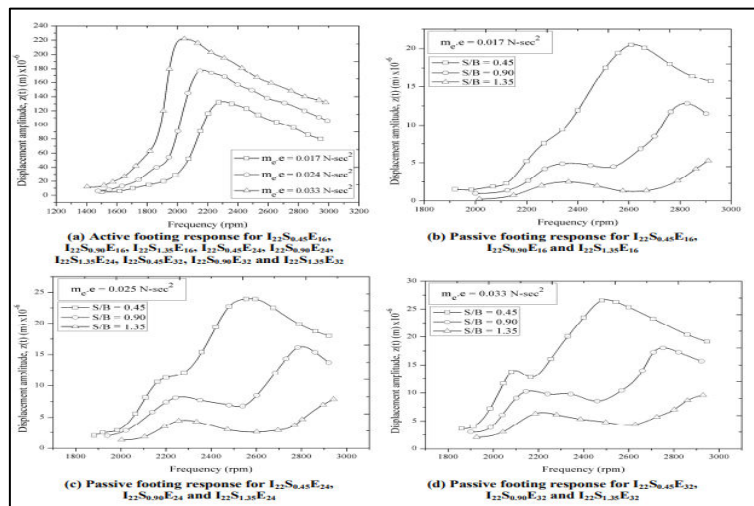


Figure 6: Dynamic response due to interaction between active and passive footings

The result that came out was as follows based on the experimental research. It was discovered that the dynamic excitation on the active footing causes resonance in the passive footings, although this resonance occurs with a phase lag from the active footing's resonant frequency.

H. Venkateswarlu *et.al* (2017) investigated geosynthetics-enhanced soil beds supporting model machine foundations: Results on the field testing and analytical simulations. Several lateral mode block vibration tests are performed on a stable concrete platform reinforced by various reinforcing soil conditions. Geocell reinforcement, one layer of geogrid reinforcement, two layers of geogrid reinforcement, and no reinforcement were all subjected to evaluations. A total of 38 field experiments are conducted using a mechanical oscillator of the Lazen type and six different dynamic force ranges. Peak particle velocity (PPV), resonant frequency reduction, and improved soil dynamic properties are all considered when analysing the dynamic behaviour. The findings of the experiment show that the presence of geosynthetics significantly reduced the displacement amplitude of vibration. When compared with the other conditions, the existence of geocell reinforcement results in the greatest reduction. In comparison to the unreinforced state, the addition of geocell reinforcement decrease resonant frequency by 61% while increasing the soil system's natural frequency by 1.38 times. Additionally, it was found that the geocell reinforcement decreased the PPV by 48% at 0.5 meters from the side of the foundation. The foundation bed's elastic uniform deformation is 91% better when geocell reinforcement is used. The schematic representation of the block vibration test setup is shown in Figure 7.

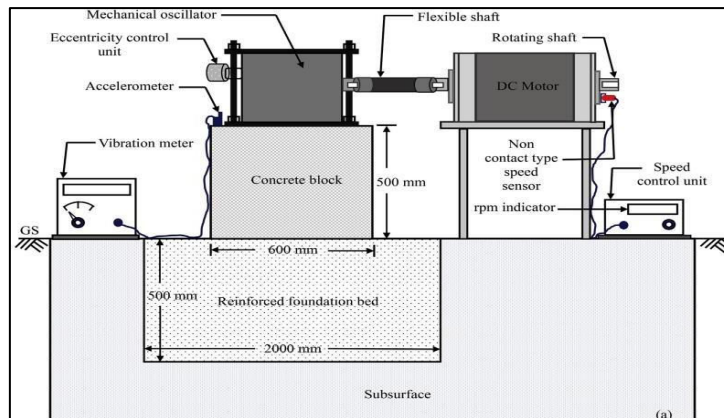


Figure 7: A Block vibration test setup

The variation in dynamic force with the change in frequency and eccentricity angle is shown in Figure 8. Figure 9 shows the dynamic response of a geogrid reinforced condition.

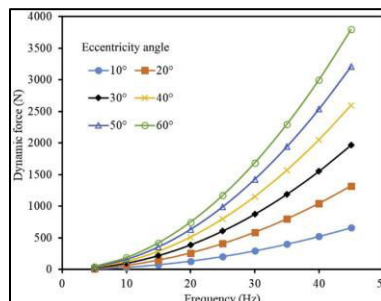


Figure 8: Variation of dynamic force with increase in eccentricity angle and frequency of the excitation

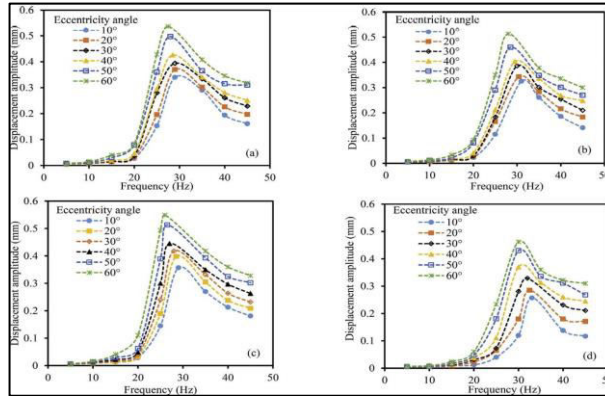


Figure 9: Displacement amplitude versus frequency response for geogrid reinforced condition: (a) geogrid @ 0.15B; (b) geogrid @ 0.3B; (c) geogrid @ 0.45B; (d) reinforced with two layers of geogrid

Figure 9 shows that, in comparison to the single geogrid reinforced condition, the rate of reduction of displacement amplitude is rapid. The addition of a second layer has substantially improved the system's natural frequency as well.

The conclusions that were reached based on the experimental investigations are as follows.

1. It was discovered that the performance of soil with geosynthetic reinforcement was beneficial in reducing machine vibrations.
2. In the instance of a geogrid reinforced situation, the ideal depth for geogrid deployment was determined to be 0.3B.
3. When compared to the other factors taken into account in this investigation, geocell performance was determined to be more effective.

R. Zakeri *et al.* (2020) Studied the efficiency of employing rubber sheets to modify the dynamic response of a concrete machine foundation model of size 400 x 400 mm by conducting a series of steady-state vertical vibration tests. Rubber is a simple to use material that can be laid directly beneath foundations and is a low-cost energy dissipator with strong erosion resistance. The test soil material was selected as granular soil passing through the 20 mm screen with a specific gravity of 2.66. The rubber sheets utilized had a plan dimension of 500 mm by 500 mm and came in four different thicknesses: 6, 12, 18, and 24 mm. The decision was made to make them 100 mm wider than the foundation. The rubber sheet's density was found to be roughly 16.7 kN/m³. The rubber sheet utilized in experimental research is depicted in Figure 10.



Figure 10: The rubber sheet

Experiments were performed using rubber sheets 500 x 500 mm in plan with thicknesses of 6, 12, 18, and 24 mm directly beneath the foundation to determine the impact of rubber sheet thickness on the dynamic response of the machine foundation model. These experiments used a dead weight of 144 kg and a dynamic angular force of 0.0956 Nm (D1). Figure 11 illustrates the results as a change in vertical displacement vs vibration frequency.

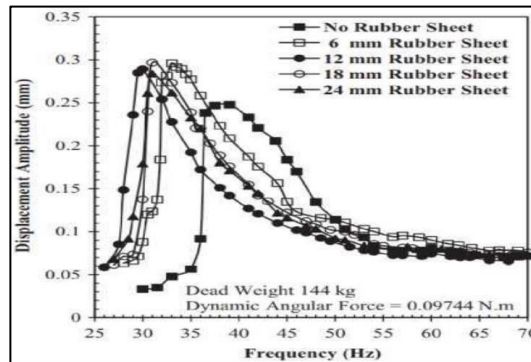


Figure 11: Variation of vertical displacement versus frequency for different rubber sheet thickness

The conclusions that were reached based on the experimental investigations are as follows.

1. Adding a rubber sheet to a machine foundation model to improve its dynamic response throughout a series of steady-state vibration testing.
2. It was discovered that when the amount of soil between the foundation and a hard layer increases, both the resonance frequency and dynamic amplitude decrease.

III. CONCLUSION

From the brief literature review it can be concluded that many studies have been carried out experimentally and analytically to investigate, the effect of dynamic load on reinforced soil bed. The maximum investigations were performed on single dynamic loaded footing. Therefore, it is necessary to carry out the future research on adjacent footing and study of dynamic interaction of the adjacent footings.

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