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Analysis of Machine Foundation Interference on Reinforced Soil to Limit Dynamic Settlement: A Review

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Abstract. The foundations of machines are one of the critical foundations in industry. The soil having machine foundation is subjected to hazardous harmonic as well as periodic vibrations. The response of the ground and the machinery foundation under these disturbances is challenging to predict and differs from the commonly known performance under static loads. A faulty dynamic interaction between a machine and foundations can lead to dangerous failures impact in human lives and the environment. Hence reinforcement is added beneath soil to provide stiffness to soil and limit the settlement. The impact of interference on static foundations demonstrated that interference has a significant impact on the response and bearing capacity of static foundations. Few initiatives have been taken to examine the response and configuration of machine foundation interference. in dynamic settlement. Thus, present work mainly reviews the study of machine foundation interference on the reinforced soil to limit dynamic settlement..

Keywords: Machine foundation, Geogrid, Dynamic settlement

1 Introduction

Interference with both neighbouring foundations has a larger actual effect because, in many cases, foundations commonly faced in practise are not separated and oftenly connect with one another because of their close placement, causing serious structural damage from both a strength and serviceability point of view especially under dynamic conditions. Heavy machinery, moving cars, or running trains can all induce harmonic and periodic vibrations, causing the supporting foundations to respond differently. Interfering foundations should thus be correctly engineered to withstand such dynamic loads to have improved serviceability and lifespan. As a result, there is a need to investigate a simpler way for capturing the influence of foundation interference during dynamic excitation.

One of the most rapidly increasing geotechnical engineering approaches is the using geosynthetic reinforcement to strengthen the soil beneath shallow foundations. Though significant advances have been made to research the interference influence on unreinforced sand, geogrid-reinforced sand, and geocell-geogrid reinforced soil, Researchers have constantly paid attention to a close investigation that addresses the evaluation of the interference impact of machine foundation on reinforced soil bed to examine the influence of these impact loading because of the vibrations of machine on the behaviour of the foundations.

2 Review of Literature

The foundations are constantly subjected to dynamic loads as a function of the machine's moving parts. Due to the repeated nature of dynamic stress, excessive foundation soil sinking occurs. To avoid nonlinear behaviour of soil, dynamic loads imparted to machine foundations are restricted to 20% of the static loads (Prakash and Puri 1988). When building a machine foundation, important design criteria like criteria for resonance (frequency of operation, natural frequency, n) and minimum criteria of amplitude (permissible limit of amplitude: 20 to 200 μm based on the machinery and its operating frequencies) must be met and even destroy parts of machines (Richart 1962). Deep foundations like pile foundations or ground strength enhanced procedures such as strengthening, grouting, and dynamic compaction are often employed when the conditions are not satisfied. Ground augmentation raises soil tensile strength, which preserves dynamic characteristics within acceptable limits. Through model experiments, the soil and foundation system has undergone extensive research to evaluate the influence of numerous aspects such as embedment depth, saturation, and reinforcement (Mandal 2004; Samal 2011; Khati et al. 2012; Clement et al. 2015)

Severe soil settling may be prevented by reducing the stresses induced by vibrations of the machines. Increasing the stiffness of the soil is one approach of minimising cyclic stresses. Among numerous methods for enhancing soil stiffness, geosynthetic soil reinforcement is one (Dash et al. 2001). Numerous academics have studied monotonic and cyclic processes, beginning with Binquet and Lee's (1975a,b) fundamental work on soil reactivity with geosynthetic reinforcement. A.K. P.L. Ashmawy and P.L. Boudreau (1995) provided a detailed examination and comparison of approaches for planning repetitive loading of geosynthetic reinforced soils. A modest number of research have been conducted with the goal of changing soil properties that vary over time. D.K. Baidya (2004) and A. Rathi, D.K.G. Muralikrishna, and P. K. Pradhan (2006), Hoe I Ling and colleagues (2004) have investigated this area.

The standards for machinery foundation design are based on minimising dynamic settlements to less than 1 mm based on excitation frequency. (Srinivasulu 2007); this limited settlement is set to allow these machines to run correctly (Ali et al. 2017). Swain and Ghosh (2016) discovered anomalous harmonic and periodic vibrations in soil beneath machine foundations. Because the foundation is exceptionally robust during such shocks, the soil's behavior is complex and unique from the well-known observed behaviour under static pressures as well as because of its complexity, this topic has a high loading complexity. Based on laboratory study, researchers were always paying attention to study the influence of these created dynamic loads and the effect of vibrations of machine on the response of the foundations. (Al- Homoud, 1996; Al-Wakel et al. 2015; Fattah et al. 2016), field-based studies (Ghosh 2016), and analytical studies (Ghosh 2012; Vivek and Ghosh 2012; Fattah et al. 2012, 2014, 2015a, b; Javdanian 2018).

Al-Hamoud (1996) used lab studies to assess the influence of periodic vibrations and impact load on the performance of modeled circular, rectangular and square foundations. Fattah et al. (2012) created a one-of-a-kind elastic completely plastic compositional model to forecast the performance of a strip machine foundation laid on saturated soil and exposed to repetitive vibration. Ghosh (2012) used three-dimensional finite difference analysis to study the interaction of two neighbouring machines and static foundations built on layered soil. A dynamic load with variable amplitude was used to replicate the machine load. The results revealed that the settlements induced by machine vibration reduced as the space between both the foundations went on increasing and rose as the length to breadth ratio of the machine foundation grew for dynamic and static foundations.

Vivek and Ghosh (2012) evaluated the interaction of two neighbouring static and machine foundations using two-dimensional finite element analysis. Harmonic loads with same amplitudes and harmonic loads with different amplitudes were examined to represent the machine's vibration. The results showed that when the distance between the foundations was twice the width of the dynamic foundation, the dynamic foundation had the least impact on the static foundation. Fattah et al. (2014) used the Quake/W programme to investigate the extreme pore water pressure and danger of liquefaction of saturated sand caused by the effect of a constant harmonic excitations on a strip foundation. The contour lines provided in the study revealed the formation of liquefaction beneath the foundation because of machine vibration. Al-Wakel et al. (2015) used a laboratory experiments and three-dimensional finite element analysis to study the reactivity of saturated sand to machine vibration.

The dynamic behavior of a surfaced and imbedded strip foundation exposed to constant periodic vibrations and supported by saturated sandy soil was explored by Fattah et al. (2015a). The findings demonstrated that as the foundation embedment increased, so did the settlement induce by machinery vibration. Fattah et al. (2015b) used three-dimensional numerical methods to explore the dynamic behaviour of a piled foundation exposed to machine vibrations. The impact of pile cap’s thickness, diameter of pile , spacing of pile, and size of pile cap was explored. Swain (2016) used field research to study the interaction of machines and static foundations.

Fattah et al. (2016) investigated the generation of increased pore water pressure caused by vibration of a machine foundation based on wet sand using an experimental model. Fattah et al. (2018) assessed the liquefaction potential and settlements of a machine foundation lying on wet sand using a simple experimental model. Javdanian (2018) explored the impact of interference on bearing capacity of machine foundation. However, the study didn’t consider the influence of interference on dynamic settlement.

In the last few years, geosynthetics have become commonly used in numerous geotechnical engineering applications like foundations and Pavements, Railway lines, hidden lifelines, and embankments retaining walls.

However, the use of these reinforcement materials to support the machine foundation beds has not been thoroughly investigated. Only a little amount of research has been done so far on the use of geosynthetics for machine foundation.

Block resonance tests were performed by Boominathan et al. (1991) to examine the dynamic characteristics of geosynthetic reinforced soil. According to test results, the presence of a high tensile wire grid caused a considerable improvement in elastic compression and a decrease in amplitude. According to an experimental investigation by Clement (2015), adding geogrid beneath the machine foundation increased the soil mass's stiffness and damping ratio.

Sreedhar and Abhishek (2016) discovered that adding biaxial geogrid to the foundation soil system drastically changed its resonance frequency. However, there haven't been much research done to look at how well cellular systems perform when supported by machines. Azzam (2015) performed numerical analyses to determine how well the geocell-reinforced soil under the machine foundation performed. From the numerical findings, putting the geocell slightly below the surface of the earth minimized soil disturbance and increased subgrade damping by 230%.

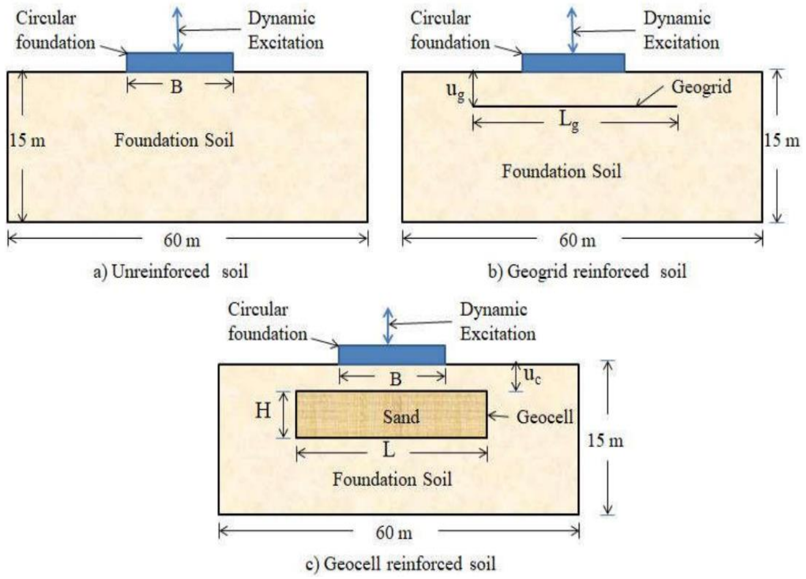
Wang et al. (2009) investigated the efficacy of enlarged polystyrene geofoam in protecting underground buildings under blasting loading circumstances. Through experimental and computational research, Haldar (2009) investigated the effectiveness of reinforced soil bed in enhancing machine foundation behaviour. Majumder et al., 2017 used the FEM programme PLAXIS2D to conduct parametric research to explore the screening efficacy of geofoam material under vibrations of machine.

H. Venkateswarlu and A. Hegde (2018) carried out numerical study of machine foundation resting on the soil beds reinforced with geocell. The response of these cases was investigated by altering the dynamic loading frequency while keeping the force amplitude same. The depth of placement of the geocell and geogrid arrangement was modified. As the geocell was placed optimally, the displacement amplitude was reduced by 61% when compared to the unreinforced foundation bed. Similarly, when compared to geogrid, the addition of geocell resulted in a more than 50% reduction in displacement. The resonance frequency was discovered to fluctuate depending on the reinforcing system. Figure 1 represents different reinforced soil bases under dynamic loading. Foundation soil was reinforced using geogrid and geocell.

Hegde and Sitharam (2016) conducted cyclic plate load tests to illustrate the efficiency of geocell reinforcement under machine foundation in a recent study. The addition of geocell greatly enhanced the dynamic properties of soil, according to the results. However, there is presently no comprehensive understanding of the performance of geocells under dynamic loading.

3 Literature Gap

According to the available literature, there is a shortage of field research as well as extensive numerical investigations to evaluate the efficacy of reinforcements under machine foundations. A thorough investigation of the interference impact of ma-chine foundations based on reinforced soil beds is also lacking



a) Unreinforced soil b) Geogrid reinforced soil c) Geocell reinforced soil

Fig. 1. Schematic diagram of the different reinforced soil beds (Venkateswarlu and A. Hegde, 2018)

Conclusions

From the literature studied following broad conclusions can be drawn:

1. Under dynamic conditions, the amount of maximum and steady state settling of the machine foundation normally increases as the aspect ratio increases.
2. At the conclusion of the dynamic excitation, for closely spaced square foundations, a little heave formation may be seen at the ground level around the failure domain's center line.
3. The computational findings revealed that the inclusion of geocell reinforcement greatly decreased displacement.

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