Muthanna Journal of Engineering and Technology, Vol. (13), Issue (1), Year (2025)

Muthanna Journal of Engineering and Technology

Website: https://muthjet.mu.edu.iq/

Submitted 16 February 2025, Accepted 1 March 2025, Published online 1 March 2025

Reducing the effect of pile driving on adjacent shallow foundations: an improved investigation

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DOI:10.52113/3/eng/mjet/2025-13-01-/34-37

Abstract

Deep foundations are often constructed using pile-driving techniques, which are inefficient in shallow foundation areas. However, this method creates ground vibrations that may affect surrounding structures, notably weaker ones, as they can develop fractures, experience irregular settlement, deform, or suffer issues related to the longevity of the building. This study comprehensively analyses vibration energy, its possible structural effects, and many mitigation options. The study integrates real measurement data, simulations, and other illustrative examples to make recommendations to reduce construction vibrations effectively.

Keywords: *Vibration mitigation, structural damage, fracture settlement, bounding techniques, shallow structures, vibration recommendations, vibrations moderation, piles driven.*

1. Introduction

For many years, creation jobs that hire pile driving were diagnosed for creating robust deep foundations. However, the vibratory consequences of piling may additionally cause huge harm to homes inside the area in city websites or in areas in which older buildings are gifted. The problem is a way to obtain the construction's desired purpose without destroying the present works. For this motive, it needs to recognize the strategies that occur at some point in the pile driving regarding vibration propagation and its effect on adjoining systems. Utilizing real website online observations and calculations, the paper outlines unique mitigation procedures for various situations that permit production work to proceed without endangering different systems. Some studies have examined the effect of pile driving on neighbouring structures, including the paintings of Woods (1997) [1]. Lately, Athanasopoulos-Zekkos et al. (2013) [2] laid the groundwork by defining important parameters along with the soil kind, pile substance, and the using method used as influential elements to vibration depth. Newer research enlarges on in advanced investigations by supplying further insights into the nonlinear behaviour of soils enduring dynamic loading and the necessity of real-time monitoring systems. These studies show that even though vibrations are an indispensable characteristic of pile use, their bad impacts can be reduced to a first-rate volume due to strengthened engineering measures. This study builds upon this base by incorporating new field statistics and in-intensity numerical simulations into valuable resources to develop more excellent mitigation techniques, as shown in Figure 1.
This study aims to investigate and mitigate the impact of pile driving on adjacent shallow foundations by improving analytical and experimental approaches. The research identifies key factors influencing foundation stability, evaluates ground vibrations and settlement effects, and proposes effective measures to minimize adverse consequences.

Fig. 1: A construction site with concrete and steel piles set into the ground, with a pile driver driving a pile into the soil.

2. The dissemination system and vibration

When a pile works in the ground, it produces three primary types of seismic waves:

2.1. Compression waves (P waves)

P-waves spread through the soil by compressing and improving the debris. These waves mainly cause vertical displacement and can lead to localized agreement at the bottom and the entire structure.

2.2. Shrinking waves (S waves)

S-waves are charged for side moves. Their effect may be poorer because they induce horizontal shear stresses, perhaps leading to the difference agreement - a condition where an extraordinary-size element is unevenly arranged.

2.3. Rayele waves

The real wave flows horizontally and vertically as waves of the ground. They regularly cause the most disturbance in the floor space or, if most, which will increase the chances of clear structural damage.
Due to the effect of soil layers, substance materials and separate technical properties, the spread of these waves is not the same.
According to discipline measurement, dense soil may be more in destroying strength, while soft soil tends to increase the dimensions of these waves.

3. Effects on adjacent structures

Nearby shallow foundations may be impacted by pile drive vibration transmission in a number of ways:

3.1. Cracking and structural damage

Both load-bearing and non-load-bearing elements may develop cracks due to ongoing exposure to dynamic loads. These fissures may eventually jeopardize the structural soundness of beams, floors, and walls.

3.2. Differential settlement

Due to vibrations, a building's foundation may settle more quickly in some areas than others. This uneven settlement may cause the structure to become misaligned, windows and door frames to distort, and, ultimately, the building's performance to deteriorate.

3.3. Problems with serviceability

Even little vibrations can cause malfunctions or harm fragile equipment in facilities used for sensitive operations, such as data centres, labs, or hospitals.
Effective mitigation methods during the pile-driving operation are necessary since field case studies have shown that even mild vibrations can cause obvious cracks and misalignments in structures [3].

4. Approach and subject conclusions

4.1. Modelling the use of numbers

The last detailed analysis was utilized in numerical simulation to estimate the spread of vibrations via one-of-a-kind soil profiles. The model considered different soil situations, hammer electricity and pile types. Area records and simulated results had been compared to affirm the model's accuracy. The welcoming velocity, measurement and vibration frequency were many of the parameters that have been evaluated [4].

4.2. Overview in the place

The accelerometer and vibration sensor have been used to offer actual-time tracking at many production websites. During working operations, vibration frequency and intensity were monitored by the usage of statistics logs. Engineers have been able to compare the effect of different mitigation strategies underneath the actual layout settings for these measurements. It shed light on two case studies:

4.2.1. Case look at A

A city development project that uses pre-drilling. According to discipline statistics, observable structural harm was an important deficiency, where the level of top vibration fell to about 50%.

4.2.2. Case look at B

A project to extend a toll road close to housing structures. The general vibration transfer changed into reduced by way of 85% using vibration limitations in combination with hydraulic stress-in-playing.
These occasions emphasize the significance of adjusting mitigation strategies beneath unique occasions.

5. Comparative analysis of mitigation strategies

Based on each numerical and field research, Table 1 below affords an overview of the success charge of different mitigation techniques [5].

Table 1: The successful charge of different mitigation techniques

Mitigation Strategy	Vibration Reduction (%)	Practical Effectiveness
No Mitigation	0%	High risk of structural damage
Vibration Barriers	~40%	Moderate improvement in reducing surface vibrations
Pre-Boring	~50%	Significant reduction in peak vibration levels
Hydraulic Press-in Piling	~70%	Highly effective; minimal ground disturbance
Combined Methods	~85	% Optimal solution under varied site conditions

The first-class results are typically acquired when mitigation techniques are blended, especially in complicated geotechnical environments.

6. Conclusion

Nearby, thin foundations are at full-size chance based on the dynamic results of the pile used. However, cautiously combining field information, numerical modelling, and adaptive mitigation techniques may significantly reduce these dangers. The depth and transmission of ground vibrations may be successfully controlled through methods which include vibration limitations, hydraulic press-in piling, and pre-uninteresting. In order to determine the best mitigation techniques for every website online, destiny tasks should combine actual-time monitoring systems and carry out comprehensive geotechnical checks. By doing this, engineers can ensure pile driving's continued viability as a production technique without endangering the close.

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