EFFECTS OF EARTHQUAKE ON PILE FOUNDATION

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Abstract

The Puqian Bridge is situated in an area that is highly vulnerable to earthquakes, and the region has been fortified with seismic measures that can withstand an intensity of up to 8 degrees, and its concept features the world's best-in-class height floor motion arrangement. "However, Regarding earthquake damage, the seismic performance of the pile foundation has not been fully researched, and the seismic problems associated with the pile foundation are particularly important. In order to learn about the pile foundation's dynamic properties, we performed a large-scale shaking desk test (STT)." The pile-ground interaction method for a bridge changed into determined using an artificial mass version, and chose the height of ground acceleration variation between 0.15g-0.60g (g is gravitational acceleration) according to seismic depth. The results show that the acceleration increases as the height of the bridge pile increases from top to bottom and decreases when the seismic activity appears stable. As long as the magnitude of the earthquake exceeds 0.50 g, the factor that amplifies the acceleration at the pile's peak will remain at 1.32. It was shown that the bedrock floor had a little effect on seismic wave amplification, but the overburden played a significant role in both wave amplification and filtering, the pile foundation was compromised at the depth where the seismic magnitude reached 0.50 g. As the earthquake depth exceeded zero.50 g, pile foundation's fundamental frequency gradually fall off and eventually stabilized at 0.87Hz.

"Pile cap contact surface, soft and hard soil interface, bedrock surface all had a greater increase in bending second, where cracking occurred without difficulty." Pile foundations in meizoseismic zones need to be specifically aimed at particular locations.

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1. Introduction

The destructive power of earthquakes is unprece dented among natural disasters. Major damage has been observed on bridge supports in many earthquakes around the world, exceptionally in China, where the land is approximately 50% in the seismic reinforcement zone which surpasses seven levels; China's seismic zoning map is provedin Exhibit 1. Over the last few years, In meizoseis mal areas, bridges with high bearing capacity and seismic performance have been constructed, however they have been damaged. Earthquake damage does not justconsist of failing of the top form, like main beam failure, support member failure, and slide of bridge pier, but also the development of concrete cracks and group rings collapse or even post-earthquakes collapse.

" If the piling foundation of a bridge is weakened, the entire structure may become hazardous.."

Many scholars have examined the way in which the pile foundation reacts or responds mechani- cally to kinetic energy, both experimentally and statistically. An analysis of the seismic behavior or response of bridge piers that sit on vertical piles, as well as the arrangement of the piles, in soil that has multiple layers was suggested by Mylonakis et al. [2]. Haeri et al. [3] used a large 1 g shaking desk test to examine the behaviour of a bunch of piles that are exposed to lateral spreading predicted by liquefaction, and they suggested a straightforward numerical approach to anticipate the behaviour of single piles under lateral spreading. Pile foundations for houses are evaluated for seismic performance using a seismic deformation method (SDM) proposed by Montejo et al. (reference [4]), Naggar and Mostafa (reference[5]), and Gazetas and Naggar (reference [6]). This method takes into account the interaction between the pile, the soil, and the shape of the house in terms of inertia. Boulanger et al. (reference [7]) used a nonlinear Winkl model to test the dynamic beam.

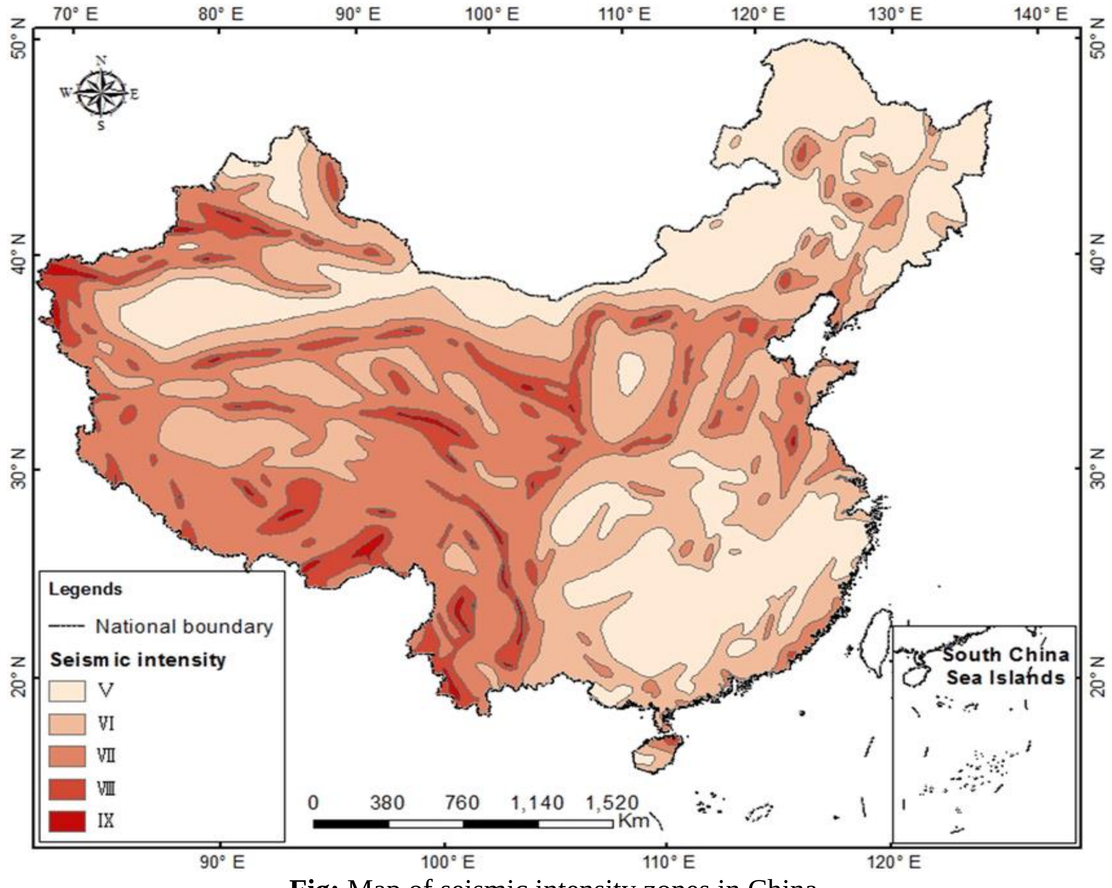


Fig: Map of seismic intensity zones in China.

The mechanical behavior of pile foundations under dynamic or moving forces has been the subject of numerous studies, which have explored the topic through both experimental and computa- tional means. Mylonakis et al. (reference [3]) proposed a sub structuring approach for the seismic evaluation of bridge piers that are supported by perpendicular piles, as well as the arrangement of the piles, in soil that has multiple layers. In their study, Haeri et al. [3] carried out a significant shaking desk test, with an acceleration of 1 g, to examine how a pile group reacts subjected to lateral spreading triggered by liquefaction. They also proposed a straightforward numerical method to forecast the performance of individual piles under such circumstances. To evaluate the seismic response of residential pile foundations, Mostafa and Naggar [5], Montejo et al. [4] and Gazetas and Naggar [6] suggested employing a seismic deformation method (SDM) that explains how the pile, the soil, and the building interact inertially. Additionally, Boulanger et al. [7] employed the Winkler foundation analysis approach, which is nonlinear to investigate the interaction between soil, piles, and structure during seismic events, based on dynamic centrifuge test results that evaluated the dynamic behavior of a beam. To assess the seismic performance of pile foundations, three distinct approaches based on three-dimensional elastic-plastic finite element analysis were employed, as discussed in references [8, 9]. Di Laora and Rovithis (reference[10]) simplified Winkler basis beam version, proposed the notion of the powerful length of the pile basis, and theoretically calculated liquefaction at the site to investigate the dynamic characteristics of the pile. Shaking desk tests (STTs) are often performed to evaluate the performance of piles buried in various soil types. For the length of seismic events occurring in dry sand, Suzuki et al [11] studied the variables affecting pressure distributions of pile businesses by conducting a large-scale STT. Dynamic behaviour of pile foundations during liquefaction was investigated by Dungca et al. (reference[12]), Yao et al. (reference[13]), and Motamed and Towhata (reference[14]) using Shaking table test. Nonlinear behaviour of pile companies exposed to lateral stress at some moment in a fully huge earthquake was studied using a large-scale Shaking table test and numerical representation by Shirato et al. (reference[15]) and Ecemis (reference[16]).

Previous studies have analysed soil dynamics and weak soil bases, in particular during liquefaction under seismic loads. However, the Bridge's rock-socketed piling bases' characteristics of seismic response to high seismic intensities have received less attention. Consequently, it is crucial to research the rock-socketed pile foundations seismic reaction characteristics with a signifi- cantly large diameter.

An artificial mass model was utilized in this study to investigate the dynamic reactivity of rock-socketed pile foundations across a seismic depth range of 0.15 g to 0.60 g. Soil-pile interaction processes and the use of a large-scale STT were studied. Engineers in the field may use this research's findings as a guide and a resource.

2. Trendy task statistics

Connecting Wenchang town and Haikou city in China's northeastern Hainan province lays the Puqian Bridge. The bridge web page is located precisely in the epicenter of the 7.five Richter scale 1605 Qiongshan earthquake. Seismic activity is high in the area, and many earthquakes have been recorded there. The bridge's location has an eight-degree seismic fortification depth, and 0.35 g (0.59 g) height ground acceleration with a 10% probability of exceedance in 50 years (corresponding to a 2% annual probability of exceedance) was considered. According to Section 5.2.2 of the Specification of Seismic Design for Dual carriageway Engineering (JTG B02-2013) [25], The maximum ground acceleration is greater than the maximum acceleration response spectrum of the bridge's horizontal design. The pile foundation is highly susceptible to damage from seismic events.

A total of 4 RC piles with a 38# cap have been chosen as prototypes, and their specificationsare: The pile specifications are as follows: diameter of 2.4 meters, length of 54 meters, distance of 5.5 meters between piles, and dimensions of 9.2 meters by 9.2 meters by 3.0 meters in length, width, and height, respectively.; stop-bearing piles (top). The soil profile at the pile site can be described from bottom to top as follows: 14 meters of cohesive clay, a 10-meter layer of coarse sand, 22 meters of gravelly soil, and a 6-meter layer of weathered granite with a relatively soft consistency.

3. Shaking table check

This test was performed by the Institute of Engineering Mechanics (IEM) of the China Earthquake Administration, utilizing their shaking table technology for earthquake engineering and vibration engineering.

The IEM shaking table is a 5x5-meter, 3-degrees-of-freedom (3DOFS) facility that can withstand vertical hundreds of up to 300 kN. The shaking table reached a maximum acceleration of 1.0g in the lateral direction, a peak acceleration of 0.077 g in the vertical direction, and a vibration frequency of 0.1 Hz to 50 Hz.

Fig: Shaking Table Test(STT)

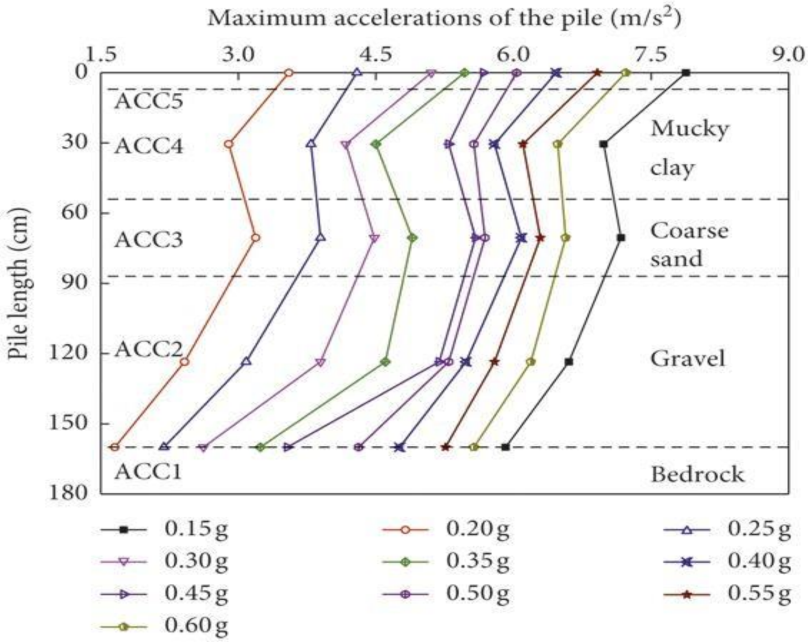
3.1. Version box

For the purpose of studying dynamic response of the pile base, a laminate shear model box was employed while keeping the STT's operability in mind. As can be seen in Figure 3, the overall dimensions of the container were as follows: 3.0m (period) 2.8m (width) 2.0m (height). To reduce the potential error caused by the the waveform, the Fourier amplitude spectrum, and the height acceleration of the soil layer, a shaking desk was used to replicate the seismic response of the unrestrained region. "The significance of the study's boundary conditions is marginal." As long as the length and breadth of a laminate shear version box are both no less than 2 meters and 1.5 meters, respectively, the frequency variation within the STT is five% and effect of the box's height may be disregarded [26].

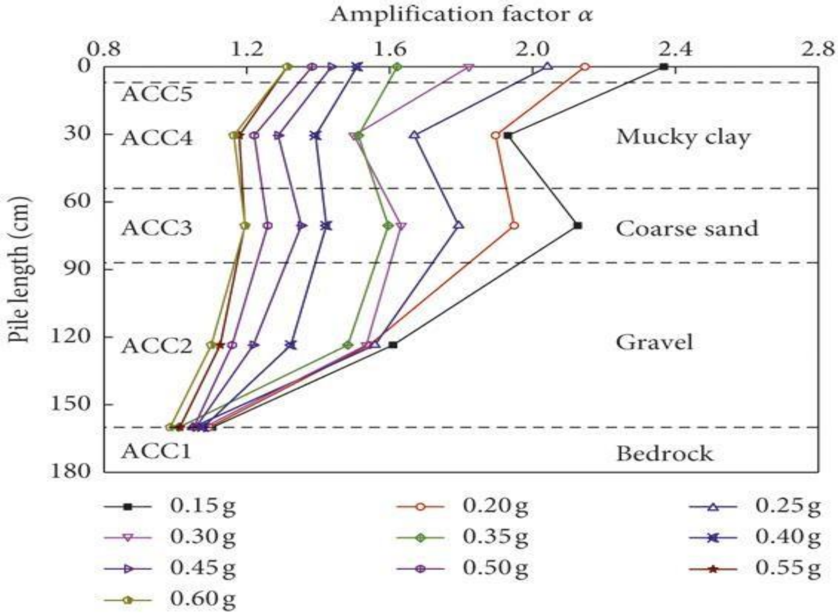
Outcomes and Analysis

4.1. Pile Acceleration Response

The spread of the highest acceleration and magnification factor of the pile throughout its length for varying seismic intensities are depicted. The amplification factor α, which is the ratio of the pile's (*a*input max) and the input (*a*pile max)'s maximum acceleration



(a)



(b)

Figure: Response to pile acceleration: (a) maximum pile acceleration for different seismic intensities; (b) amplification factor α for different seismic intensities.

The figure shows that regardless of the seismic intensity, both the the pile's greatest rate of acceleration and amplification follow a similar pattern along the pile length. It can be observed that for all intensities, the amplification factor and acceleration increase from the top to the bottom of the pile. It appears that the characteristics of the soil are related to the fact that the curves represent ting the maximum acceleration and amplification factor distribution exhibit a turning point in the slimy clay layer at a pile length of 54 cm (ACC4), with the maximum rate of acceleration and factor of magnification being lower compared to those of the nearby upper and lower soil layers. The soil layer of slimy clay has a higher void ratio and greater water content compared to the other layers, although the strength of the soil decreases from the bottom to the top.

At the base of the pile, the maximum acceleration approaches the seismic intensity values and the corresponding amplification factors are found to be below 1.1. The top of the pile experiences higher maximum acceleration compared to its bottom, and the factor of amplification at the top is more than 1.3.The findings indicate that the soil's weak layer can dissipate some of seismic wave energy and that the bed rock has a notable embedding effect on the pile. Furthermore, gravel and coarse sand layers' amplifying effects on the acceleration is prominent under various seismic intensities, While the mucky clay layer's ability to amplify the acceleration is lessened.

The maximum acceleration of the pile grew dramatically when the seismic intensity rose to 0.60g from 0.15 g in increments of 0.05 g. "The highest acceleration of ACC1ACC5 rose by 257.3%, 173.6%, 124.9%, 141.1%, and 121.8% successively, from the minimum to the maximum seismic intensity". The opposite is true for earthquakes, where the amplification factor declines with increasing intensity and hardly shifts beyond 0.50 g. Soil shear strain, stiffness modulus, damping ratio, and amplification factor all change as the magnitude of an earthquake becomes stronger. Furthermore, prolonged seismic shaking has been shown to cause the foundation soil to grow denser, thus reducing the seismic amplification impact.

We found that as seismic intensity rises, acceleration at the pile top grows linearly while the amplification factor declines. The maximum acceleration experiences a progressive increase of 20.9%, 43.7%, 53.9%, 59.7%, 69%, 82.0%, 94.7%, 103.4%, and 121.8% as the seismic intensity is incremented to 0.60g from 0.15 g. However, amplification factor experiences a decrease of 20.9%, 43.7%, 53.9%, 59.7%, 69%, 82.0%, 94.7%, 103.4%, and 121.8% for the same seismic intensity increments.

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