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Finite Element Modelling and Analysis of Hollow and Concrete Infilled Spun Pile

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Abstract: ***In the medium to high seismic zone, spun pile for structural foundation should be designed with elastic behaviour due to low ductility and dissipated energy. Spun pile is also termed as prestressed hollow concrete pile (PHC). Spun pile is one of the types of piles are widely used in the world construction, for example in building and bridge. However, it is important to note that spun piles have limited ductility so that they are not intended to response inelastically during major earthquakes. spun piles behave brittle manner in both axial force domination and flexural moment domination. Recently spun piles are commonly used directly as the piers of elevated slab such as viaduct called pile-supported slab viaduct (PSSV). In this paper the hollow spun pile is infilled with concrete and concentric load analysis is carried out. Then comparing the axial load carrying capacity of hollow and concrete infilled spun pile.***

Keywords: Concentric load, prestressed hollow concrete pile, pile supported slab viaduct.

I. INTRODUCTION

Spun piles are hollow, precast and prestressed concrete piles, in sizes generally ranging from 300 to 1200 mm outside diameter, that are fabricated by prestressing methods. The dimension of spun pile that is generally used according to Japan Industrial Standard (JIS) 5335 1987. For spun piles with large diameter (ranging from 915 to 1676 mm) generally called as cylinder pile. It is introduced in 1950 by the Raymond Concrete Pile Company. Spun pile used in Hong Kong also defined as closed-ended tubular sections of 400 to 600 mm with maximum allowable axial load 3000 kN. Pile sections are usually 12 m long, for specially made until 20 m. In the medium to high seismic zone, spun pile for structural foundation should be designed with elastic behaviour due to low ductility and dissipated energy. Spun pile is also termed as prestressed hollow concrete pile (PHC).

In Indonesia, recently prestressed hollow concrete (PHC) piles are commonly used directly as the piers of elevated slab such as viaduct called pile-supported slab viaduct (PSSV). Some field investigation reports after earthquake hazard showed that severe damage occurred in the pile foundations, not only cast-in-situ but also precast pile. Inertial forces due to building shaking induce overturning moment and base shear force. Both forces cause a high bending moment at the pile-to-pile cap connection and in the pile shaft beneath soil.

The sufficient moment capacity of the pile is required to prevent the pile damaged. Required confinement conducting by transverse reinforcement is also essential to avoid brittle failure. In the 1995 Hyougoken-Nanbu (Kobe) earthquake, more than thirty cases of pile damage were reported by Mizuno et al. post-earthquake investigations discovered some failure patterns occurred on precast prestressed concrete pile foundations, such as due to compressive, shear, combining shear and compressive, and flexure. These types of failure were occurred on precast centrifugally compacted prestressed concrete piles (spun pile). In this paper the hollow spun pile is infilled with concrete and concentric load analysis is carried out. And the comparing the axial load carrying capacity of hollow and concrete infilled spun pile.

II. MODELLING

A. Modelling of hollow spun pile

The specimen of eight-meter length spun piles were modelled by ANSYS software. The spun piles section with 600 mm and 400 mm outside and inside diameter respectively can be seen in Fig.1. The compressive concrete strength (f_{ck}) was 50 MPa. Ten pre-stressed steel (PC) bar with 8 mm diameter with 20 number of bars were used as longitudinal reinforcements of the PHC pile. Based on the tension loading test, the PC bars had the average values of elastic modulus, yield stress and ultimate stress were 220,200 MPa, 1370 MPa and 1424 MPa respectively. The PC bar's initial strain at pre-stressing was 5,000 μs.

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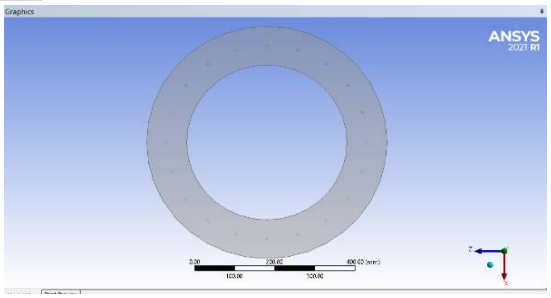

Fig.1 Top view of hollow spun pile

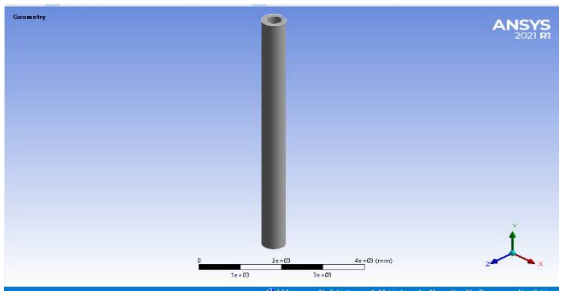

Fig.2 Longitudinal view of hollow spun pile

B. Modelling Of Concrete Infilled Spun Pile

The specimen of eight-meter length spun piles is modeled by ANSYS software and concrete infilling is provided. The concrete of characteristic strength 50 MPa is used for the infilling of spun pile. The spun piles section with 600 mm and 400 mm outside and inside diameter respectively. The other properties of spun pile is same as the properties of pile mentioned in the modelling of hollow spun pile.

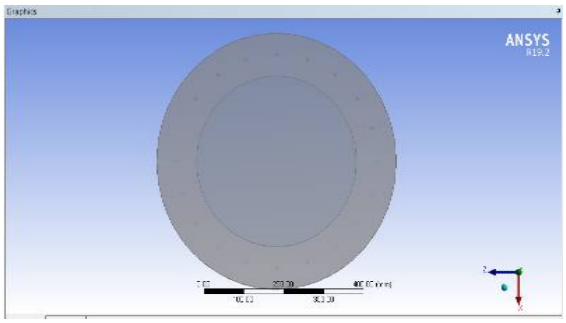

Fig.3 Top view of concrete infilled spun pile

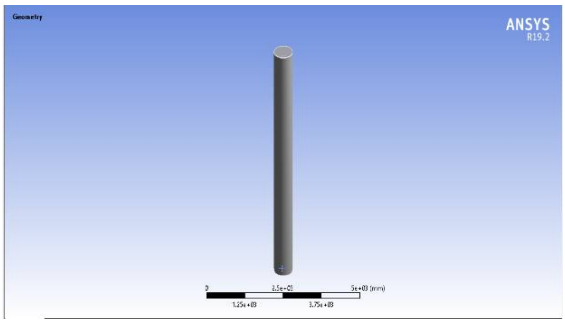

Fig.4 Longitudinal view of concrete infilled spun pile

III.ANALYSIS

Using ANSYS software monotonic flexural loading is provide in the longitudinal direction. And the fixed support condition is provided in the bottom of spun pile. Load increases and calculated at the breaking point. Axial loading is provided in the downward direction.

A. Analysis of hollow spun pile

First loading and support condition is provided with axial loading in the top of the pile and fixed support is provided at the bottom of pile shown in figure 5. Finally, deformation pattern is assessed from the ANSYS software as shown in the figure 6. And the axial load deformation variation is shown in the figure 7.

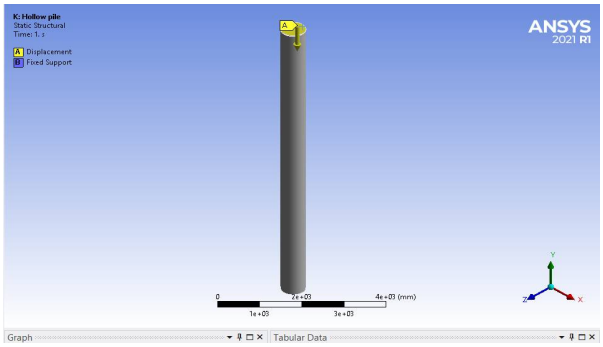

Fig.5 Load and support condition

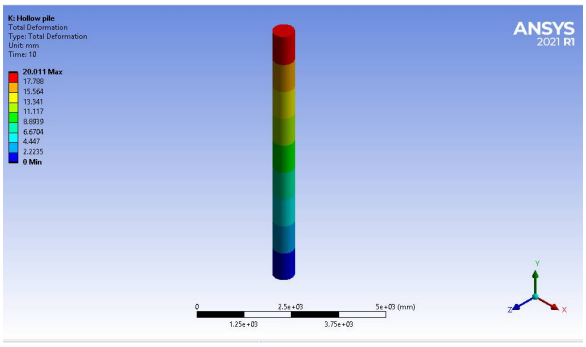

Fig.6 Deformation pattern

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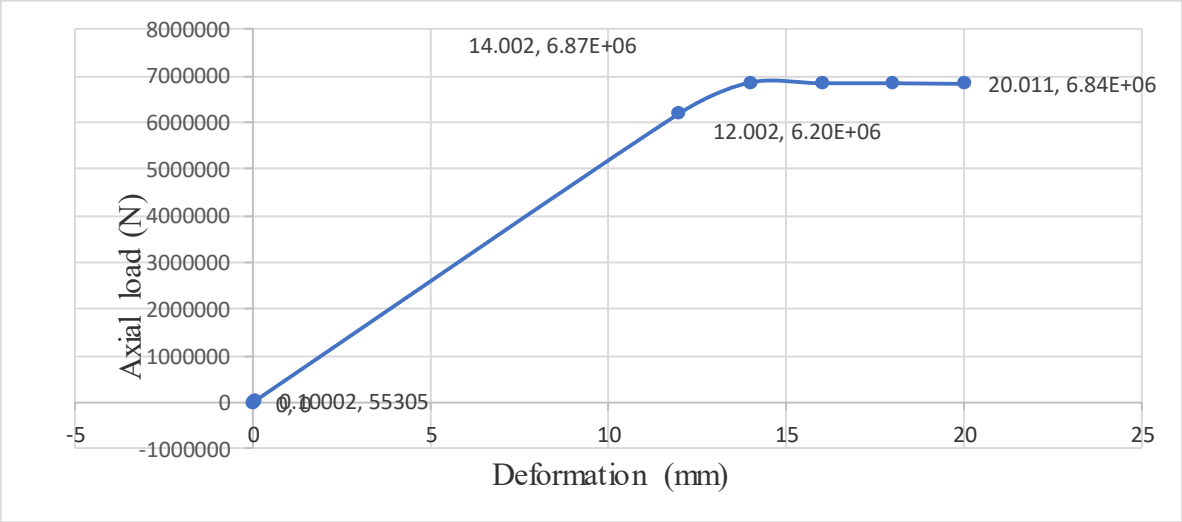

Fig.7 Axial load deformation curve for hollow spun pile

B. Analysis of concrete infilled spun pile

In hollow spun pile M_{50} grade is filled and loading and support condition is provided with axial loading in the top of the pile and fixed support is provided at the bottom of pile shown in figure.8. Finally, deformation pattern is assessed from the ANSYS software as shown in the figure 9. The load deformation variation is given in the figure 10.

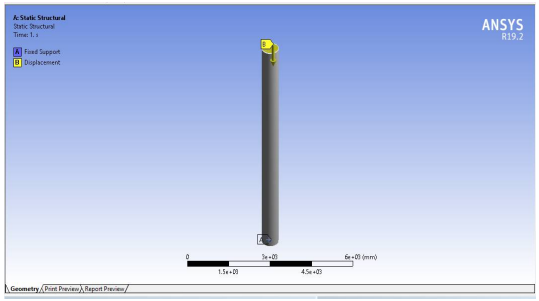

Fig.8 Loading and support condition

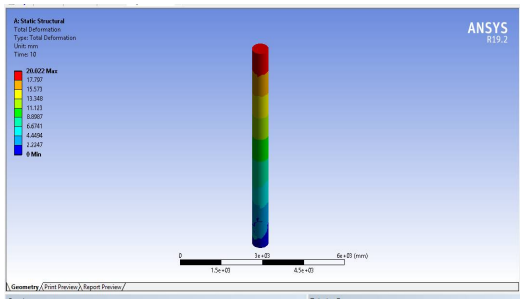

Fig.9 Deformation pattern

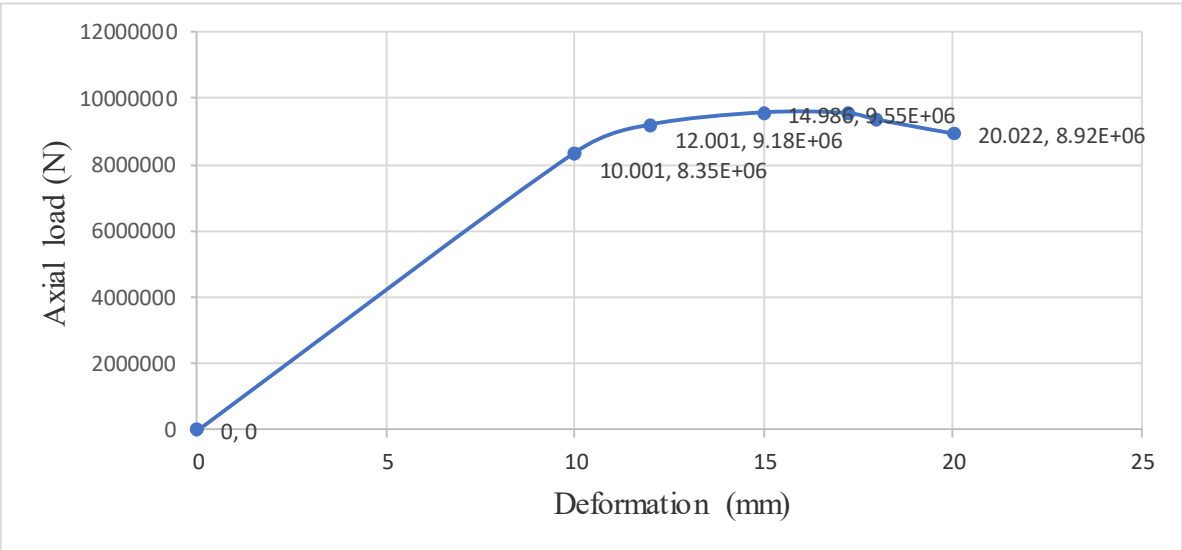

Fig.10 Axial load deformation of concrete infilled spun pile

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IV. CONCLUSIONS

Based on the numerical method of analysis on concrete infilled spun pile and hollow spun pile using ANSYS, the main results can be summarised as follows

A. The hollow spun pile undergoes concentric loading, the load deformation is linear up to a load of 6200 kN. The maximum load carrying capacity is 6870 kN.
B. The concrete infilled spun pile undergoes concentric loading, the load deformation is linear up to a load of 8350 k N. The maximum load carrying capacity is 9550 kN.
C. The concrete infilling in spun pile increases load carrying capacity by 40% when comparing the maximum load carrying capacity
D. The proposed concrete infilled spun pile can carry more axial load than hollow spun pile.

V. ACKNOWLEDGMENT

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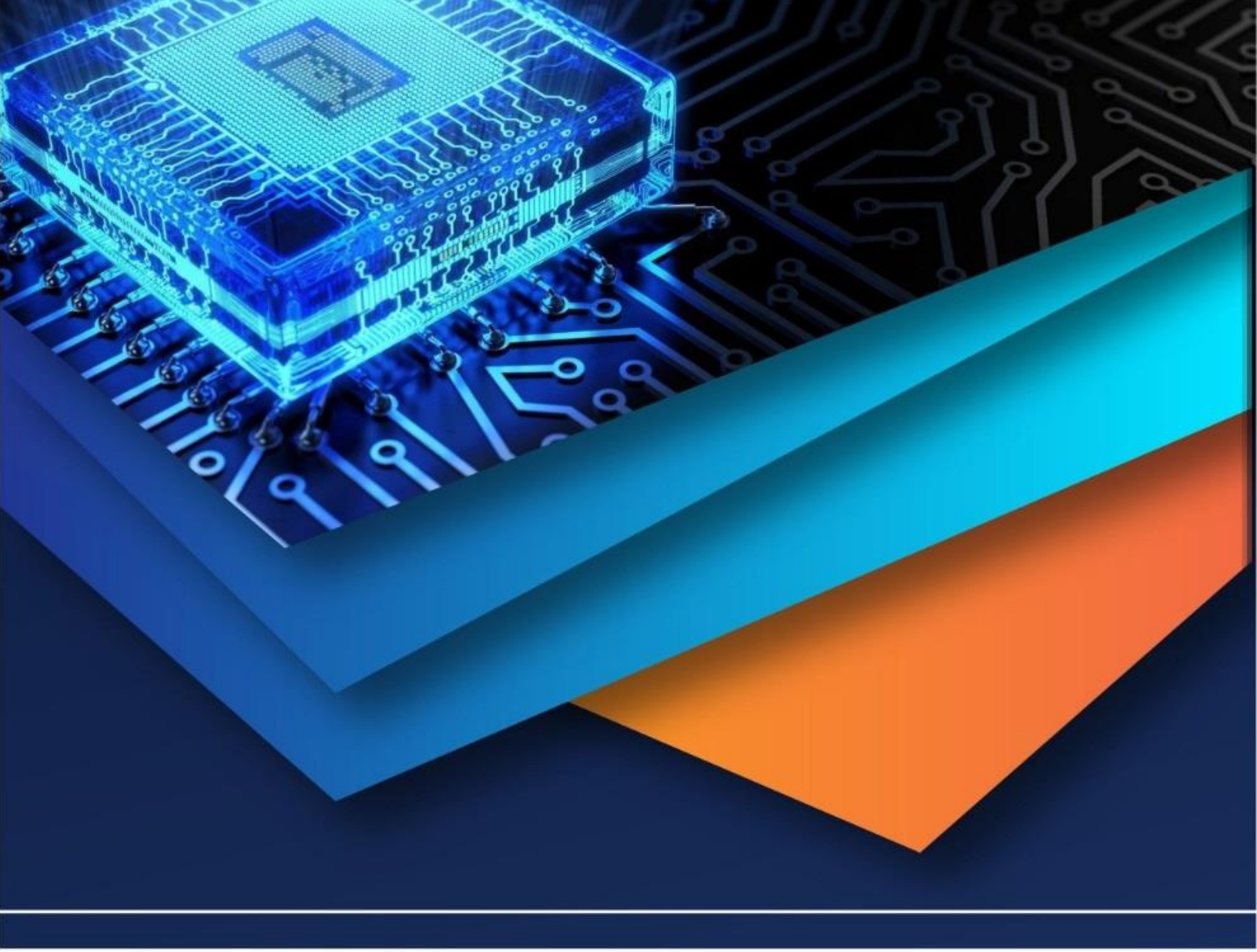

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