EXPERIMENTAL AND NUMERICAL STUDY OF RIGID THREE-PILE CAPS SUBJECTED TO CENTRED FORCES

Miriam Gonçalves Miguel[1], *João Batista de Paiva[2], Toshiaki Takeya[2] & José Samuel Giongo[2]

[1]*Campinas State University School of Civil Engineering, Architecture and Urban Design, Department of Geotechnics and Transport,* ***mgmiguel@fec.unicamp.br***
Rua Albert Einstein, 951 PO Box: 6.021, Zip Code: 13083-852 – Campinas – São Paulo - Brazil

[2]*University of São Paulo School of Engineering at São Carlos, Departament of Structural Engineering* ***paiva@sc.usp.br***, ***totakeya@sc.usp.br***, ***jsgiongo@sc.usp.br***
Avenida Trabalhador Sãocarlense, 400 ***Zip Code: 13566 - 590 – São Carlos – São Paulo - Brazil***

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ABSTRACT

This research presents a qualitative study on the behaviour of rigid pile caps, with an emphasis on the effects of reducing the diameter of the piles. Pile caps in which the distance between the vertical faces of column and cap is no more than 1.5-2.0 times the height of the cap are considered rigid. Strut and tie models have been employed in the scaled design of rigid pile caps loaded at the centre through a column, in which the stresses in the concrete are limited, to ensure that the bars composing the reinforcing ties yield under stress before the concrete breaks.

In this research, the caps were supported on three piles arranged in an equilateral triangle and the dimensions were chosen by applying the Blévot & Frémy Method [1] to rigid caps. The caps were designed with STRAUSS-type piles, of nominal diameter 32 cm, and a column in the shape of a cube of edge 35 cm. The reinforcement consisted of only the main sets of 3 bars (ϕ 12.5 mm) tying the piles together. Design details were calculated for caps with 32 cm piles (B32) and the same values were adopted for those

with 20 cm piles (B20), without introducing safety factors to augment stresses or reduce the strength of the material.

The numerical part of this investigation consisted of building 3D computer models of three-pile caps in the finite element analysis environment LUSAS, and endeavouring to simulate the conditions under which the corresponding physical models were tested in the laboratory, to allow subsequent comparison of numerical and experimental results. Two different 3-pile caps were analysed, each defined in terms of a mesh of 3D hexagonal elements (HX8M). To simulate the rheological properties of the concrete, the VON MISES model was used in a modified form in which the material was defined as elastoplastic with positive hardening, under compression, and perfectly elastoplastic under tension.

In the experimental part, specimens were load with increased stepwise until destruction. The aim was to discover the mode of rupture and to measure the deformation of the struts and the stresses and strains in the superior and inferior nodal zones, during the working cycle. The piles and columns were built of high-strength concrete, f_{cm} = 70 MPa. The strut zones were equipped with strain gauges affixed on 6.3 mm steel bars inclined at the same angle as the struts, so as to measure compressive and tensile strains in these zones, as well as compressive strains in the superior and inferior nodal zones.

When submitted to the characteristic force, the numerical and experimental models behaved fairly similarly with regard to calculate and measure stresses and strains in the regions under study, namely the struts and the superior and inferior nodal zones. In models with piles of diameter 20 cm, the compressive strains in the struts were smaller, while the tensile strains were larger, than in the models with 32 cm piles (B32). In the B20 caps, more thickening was observed in the struts and the zone of stress lines was more extensive of tension was stronger than in the B32 caps. Both in the experimental and the numerical models, the stresses developed in the inferior nodal zones were higher in B20 than in B32, whereas in the superior nodal zones the stresses were slightly higher in B32.

REFERENCES

[1] Blévot, J. & Frémy, R. "Pile Caps". *Annales, Institut Technique du Bâtiment et des Travaux Publics*. (Paris), v. 20, n. 230, February, pp 223-295, 1967. (in French).