INVESTIGATION ON ORIENTATION OF PILES IN PILE CAPS

[1]K.V.R.KARTHIKEYAN, [2]M. RAVINDRA KRISHNA, [3]P. BABU

[1]Assistant Professor, Department of Civil Engineering,
[2]Professor and HOD, Department of Civil Engineering,
[3]Professor in civil engineering and Principal
KKR and KSR Institute of Technology and Sciences, Guntur, A.P, India.

Abstract— Piles constitute the most extensively used deep foundation for various kinds of structures. A column is supported by 1,2,3,4 or many piles to resist forces coming from the column. The important structural member, pile cap, between the column and the piles, transfers forces coming from the column to the piles. Of the various forces acting on the pile cap, flexural shear constitutes most involved force. Indian national code IS 456 : 2000 specifies, when flexural shear force occurs on the pile cap for the given forces on the column and developing reactions from the piles and their orientation. Two pile caps were tested in the current experimental study to investigate the validity of the codal provisions relative to occurrence of shear force on pile cap. One pile cap had four piles at the four corners of a square. For comparison, second pile cap had four piles at the four corners of a rhombus. Comparisons were made between the orientations of pile arrangement. Both the pile caps failed in flexure, validating the codal provisions. The experimental research validates the provisions of IS 456 : 2000 code relative to occurrence of shear force on pile cap. Piles in rhombus orientation resulted in higher ultimate load and lesser deformations than the piles in square orientation.

Keywords— Pile cap, Column

I. INTRODUCTION

Pile caps:

Most frequently used deep foundations for various kinds of structures is piles. Piles and pile foundations have been in use since prehistoric times. If the bearing capacity of the upper soil layers are insufficient for a spread foundation, but firmer strata are available at greater depth, piles are used to transfer the loads from the super structure to the deeper strata. Piles constitute deep foundation that extends several metres into the soil. Piles are arranged in groups or clusters under each column. Generally two or more than two piles are provided in a foundation to resist the column loads.

Piles are arranged in a tight pattern. But closeness of piles cannot violate geotechnical considerations relative to specific minimum spacing distance of piles. The pile caps are tied at their top or capped by a spread footing or a cap that distributes column load to all the piles in the group. Pile cap helps the piles to act as a single integral unit. To spread the column loads evenly to all piles, it is in any event advisable to provide ample rigidity i.e., depth to the pile caps. A pile cap is essentially a thick slab supporting point loads of columns with point load reactions of piles. Pile cap should be deep enough not only to sustain loads coming on it, but also to allow for the necessary anchorage for the column and pile reinforcement bars into the cap.

Receiving the forces from the column, pile cap transfers them to the supporting piles. A single pile can resist only axial load from the column. Two pile cap foundation resists moment and horizontal force in one direction only besides axial force. A three pile cap and four pile cap and a multiple pile cap are capable of resisting not only axial loads but are capable of resisting moments, horizontal forces in two mutually orthogonal directions.

Traditional Sectional approach and Strut and Tie Model approach constitute the two main design procedures. In the present experimental study, sectional approach is followed.

II. OBJECTIVE OF WORK

The objective of the work is to test two numbers of four pile caps, and compare their performance. The variation between the two pile caps was different orientation of piles. In the first pile cap, piles were at the four corners of a square, while in the other at the four corners of a rhombus. In the current experimental study, two numbers of four pile caps were tested with design by sectional method. The experimental program was planned to compare the performance of two identical four pile caps with different orientation of piles.

III. EXPERIMENTAL INVESTIGATION

The current investigation is undertaken to test two identical pile caps. The only variable is location of piles. In one pile cap, piles were located at the four corners of a square. In the second one, piles were located at the four corners of a rhombus. The test results of the two pile caps were compared. Two numbers of identical four pile caps were taken for investigation in the present work. The piles are designated as PC 44 and PC 45. The moulds for the four pile caps are made with brick masonry and plastered smooth. The four pile cap PC 44 was designed to examine whether it fails in flexure, by placing the piles in such a position, shown in Figure 3.1(a). The depth of pile cap PC 44 was 250mm. As per the code, both the pile caps were designed to fail in bending. Pile cap PC 45 orientation is shown in Figure 3.1(b). The concrete for the pile caps was prepared in the laboratory with a concrete mixer. The concrete was placed in the pile cap mould and was compacted with a needle vibrator. The control specimen cubes and cylinders were compacted in a standard way. Curing of specimens was done with wet gunny bags in the lab environment. At the termination of curing, pile caps were made ready for testing. The pile caps were tested in a load frame shown in Figure 3.2.

The test specimens were instrumented to obtain the measurements of transverse load, deflection at the centre of pile cap and crack widths. A dial gauge with a least count of 0.01mm positioned, at the centre of pile cap, was employed to capture the load deflection response. A hand held microscope, capable of measuring a minimum value of 0.05mm was used to record crack growth development. A hydraulic jack of 1000kN and a proving ring of 1000kN capacity were used for load application and load measurement respectively.

The properties of test specimens are provided in Table 3.1.The properties of reinforcement used in the pile caps are tabulated in Table 3.2.The details of test specimens are illustrated in Figures 3.1(a) and 3.1(b).

The pile caps were tested to failure in several load increments. As the ultimate load approached, load increment was reduced. The time for testing to failure took about two hours. At each load stage, load applied, the resulting deflection and maximum crack width were measured.

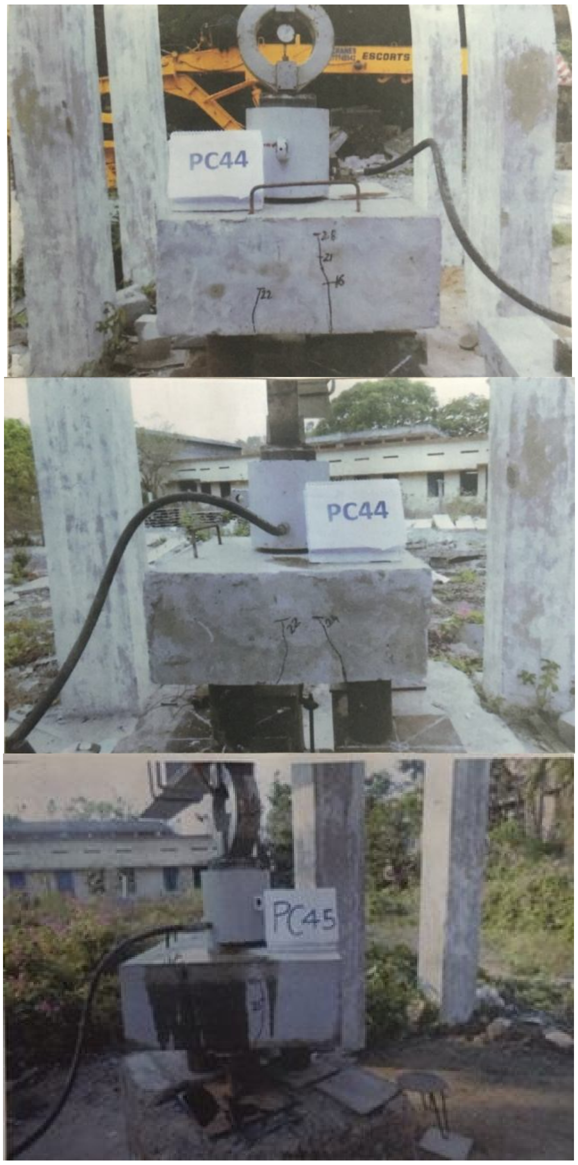
IV. PRESENTATION AND DISCUSSION OF TEST RESULTS

4.1 Pile cap PC 44:

Pile cap PC 44 developed initial crack at a shear force of 130.20 kN. At initial crack, the shear stress was 0.97 MPa. Initial cracks developed were flexural. As the loading progressed, several flexural cracks appeared on four faces of pile cap. At service load, the shear force was 145.3 kN and shear stress was 1.09 MPa. The crack width and deflection at service load were 0.3mm and 2.03mm respectively. As the loading approached ultimate load, flexural cracks on the two faces extended to the top face from the bottom. The shear stress at that load was 1.63 MPa. The pile cap finally failed in flexure. At ultimate load, shear force was 218.75 kN and shear stress was 1.63 MPa. The crack width and deflection at ultimate load were 1.2mm and 3.80mm respectively.

4.2 Pile cap PC 45:

Pile cap PC 45 which had change in position of piles, developed initial crack at a shear force of 86.28 kN. At initial crack, the shear stress was 0.64 MPa. The cracks developed were flexural. As the loading increased, several flexural cracks appeared on four faces of pile cap. The shear force at service load was 83.68 kN; the shear stress was 0.62 MPa. The deflection at service load was 1.53mm. No crack width developed at service load. With further loading, the flexural cracks extended to the top face. The pile cap failed in flexure at an ultimate load of 502.00 kN and a shear force of 125.50 kN and shear stress of 0.93 MPa. The crack width and deflection at ultimate load were 1.5mm and 2.38mm respectively. The change in position of piles from square to rhombus pattern did not interfere with the mode of failure. At service load, while PC 44 recorded crack width of 0.3mm, PC 45 recorded zero crack width. Relative to deflections, PC 44 recorded 2.03mm and PC 45 recorded 1.53mm. It is evident that rhombus orientation of piles recorded lesser deformations than square orientation of piles. Column load at ultimate recorded by PC 44 was 437.5 kN, while load recorded by PC 45 was 502 kN. Rhombus orientation pile cap failed in flexure at 15% higher load than the square orientation pile cap.



V. CONCLUSIONS

Based on the test results, the following conclusions are drawn

1) Two numbers of identical four pile caps were tested. Pile cap PC 44 had piles in plan in square orientation; while PC 45 had piles in rhombus orientation.
2) As per IS 456 : 2000 specifications, both the piles did not fail in shear but failed in flexure.
3) The pile cap with rhombus orientation piles recorded lesser deformations and more ultimate load than the companion square orientation piles. PC 45 recorded 15% higher ultimate load than PC 44.

REFERENCES

[1] Indian Standard Plain and Reinforcement Concrete – Code of Practice IS 456-2000, Bureau of Indian Standards, New Delhi.

[2] Indian Standard Code of Practice for a Design and Construction of Pile Foundations IS 2911 Part 1 / Section 4, 2010.

[3] Building code requirements for structural concrete, ACI 318-05, American Concrete Institute, Michigan, USA.

[4] Cement Concrete (Plain and Reinforced), IRC 21, Indian Road Congress code, New Delhi.

[5] Practical design of structural concrete, 1999, FIP Recommendations.

[6] Schlaich,J., Shaefer, K, and Jennewein, M., towards a consistent design for structural concrete, Journal of PCI, 1987, No.3(32).

★★★