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CHAPTER VII

CONCLUSIONS AND SUGGESTIONS FOR FUTURE STUDY

7.1 Conclusions

The following conclusions may be drawn on the basis of the analysis of test results:

1. From the analysis by Finite Element Method the principal stress trajectories were plotted to illustrate the internal force system in pile caps. It was observed that the compressive thrust in concrete, within elastic range, is in the form of a cone which must be supported along the edges of the pile caps. The edge supports then transmit the load to the two adjacent piles. However, the compressive stresses are mostly concentrated in the direction along the corners of this cone. Tensile stress trajectories are divided into two components, one transmitted from the centroid of the cap to the supporting piles, and the other linked between two adjacent piles. These distribution of the principal stress trajectories in pile caps, rather than being conformed to the simple bending theory, is in the form of the truss analogy.

After the cracks have formed, it might be expected that the compressive thrust in concrete then being carried directly to the piles by concentrated inclined compressive struts, hence the greater efficiency of bunched steel based on truss analogy.

2. All of pile caps tested in this investigation exhibited

deep beam behaviour in terms of the crack patterns, mode of failures, and load-deflection curves. The vertical flexural cracks have formed on the center lines of all faces at the initial stages of loading and followed by the diagonal tension cracks near ultimate condition. With this mode of failure the deflection in all pile caps increased linearly with load up to the point of collapse.

3. It was considered important in practice to the design of pile caps that the working or design loads should be well exceeded before the appearance of the first crack. As the amount of steel content in each form of pile cap has been kept constant in this investigation, to select the optimum reinforcement arrangements in terms of the cracking load, conclusions are as follows;

a) In the three-pile caps group, the reinforcement arrangement in P3-2 model which is in form of bands parallel to the sides of the cap passing over the piles gives the maximum strength and lead to some 15% higher load when compared to the conventional type of reinforcement in P3-1 model.

b) For the four-pile caps group, P4-4, whose reinforcement arrangement is in the form of bands parallel to the sides of the cap and combined with diagonal bands passing over the piles, gives the maximum strength and lead to some 16% higher load than that of the corresponding cap with uniform grid layout.

4. Up to the ultimate condition, the stress in the reinforcement exceeded its yielding stress in most of the pile caps. Since the mode of failure in most of pile caps were found to be diagonal type, it was difficult to indicate the effect of rein-

forcement arrangement to the ultimate strength in each cap. The ultimate load obtained from the P3-2 and P4-2 models for which the reinforcement are arranged according to the concept of truss analogy was nearly the same as those corresponding conventional type of reinforcement arrangement. In the three-pile caps group, P3-4 gives the maximum ultimate strength at 86.3 tons, about 13% higher load than P3-1 because of the vertical anchorage along the sides of the cap resisting shear stress in the critical plane. This indicates that, in the case of pile cap design with low span-depth ratio, the horizontal web reinforcement must be provided.

5. It is suggested and recommended for practical purposed that the method of design, whether beam analogy or truss analogy should be applied corresponding to the correct pattern of the reinforcement. The beam analogy can be used to predict the cracking load better than the truss analogy but it will lead to more complicated analysis in the case of irregular shaped pile caps. For truss analogy, yielding of reinforcement beyond cracking load can be well predicted.

In case of the cap spanning large numbers of piles, it was recommended to use the reinforcement arrangement with the combination of the banded diagonal from the centroid of the cap passing over the piles and the secondary peripheral bars along the sides of the cap which corresponding to truss analogy.

7.2 Suggestions for Future Study

The following list represents interesting discussion for future study ;

1) According to the results obtained from three-pile cap and four-pile cap, it is doubtful whether they could be applied directly to the caps spanning large numbers of piles, since the flexibility of the pile would then influences the load distribution.

2) The reduction in steel reinforcement due to the lateral rigidity of piles should be investigated.

3) The shear strength due to punching and diagonal tension in pile caps need further clarification.

4) A number of test specimen should be used in each particular investigation, instead of one specimen, to allow for averaging of material dispersion in concrete test results.