CHAPTER VI

ANALYSIS OF TEST RESULTS

Analysis of test results is summarized in Table 4-9. Samples of calculation shown in Appendix B. Reference will be made to these tables and other figures throughout the following analysis and discussion of test results.

6.1 Load-Deflection Relationship

The load-deflection curves are illustrated in Fig. 6.3 and Fig. 6.4 at all load levels obtained from the three-pile caps and four-pile caps test respectively.

The results indicate that the deflection of each pile cap behaved in two major stages,i.e., the elastic stage up to the formation of the first crack and the inelastic stage after yielding up to the ultimate condition.

In the elastic stage, the load-deflection curve is approximately linear corresponding to the early stages of loading up to the formation of the first crack where the slope of the curve was changed by a relatively sharp dip. The load at this change was observed and would be taken as the cracking load. Since the specimens in the test were multi-pile caps, the observed cracking load is not easily discernible from the load-deflection curve as in the simple beam. Thus, information from steel-strain readouts would provide such indication.

In the inelastic stage, as cracks were formed, tensile stress in concrete then transferred to the steel reinforcements. The load-deflection curve would be non-linear. The maximum load corresponding to the peak of the load-deflection curve would be taken as the ultimate load capacity of each pile cap. The deflection of each pile cap with various reinforcement arrangements varied in accordance with the patterns of tensile stress redistribution to the reinforcement previously described in Chapter 3. Comparison of load-deflection curves between pile cap models in normalized form are shown in Fig. 6.5-6.6 .

6.2 Crack Patterns and Modes of Failure

The cracking patterns of the specimens after failure are shown in Fig. 6.15-6.16 . At the initial stage of loading all pile caps behaved in a similar manner, with vertical cracks forming approximately at center of bottom edges for all faces. These cracks extended across the soffit of the cap in the form of a vertical cross. Towards ultimate the cracks had progressed to the top surface of the cap which was thus effectively split into three or four blocks. These blocks hinged about the loading point with the steel yielding.

Since the test specimens were under-reinforced, the same flexural mode of failure was observed at earlier stage of loading up to yielding of the reinforcements. In most cases the final failure was by shear near the ultimate load where the diagonal cracks formed vary suddenly on two or more faces and the loaded area punched into the top of the cap. Two different forms of mode of failure were observed as follow;

a) Flexure-Shear failure;

For the specimen P3-2, P3-3, P4-1, and P4-4, even after the steel had shown signs of considerable yielding, the secondary compression failure of the compression zone was delayed. Before the pile cap could fail in flexure, suddenly diagonal tension cracks developed and caused the collapse of the pile cap. The failure of these pile caps has been designed as flexure-shear failure. It appears that the behaviour of these pile caps has been influenced by biaxial compression existing in the compression zone near the loading point.

b) Diagonal tension failure;

Most of the tested specimens in this investigation failed by this mode. Failure of this type occured by a clean and sudden fracture along a joining between supporting piles and the loading point .

6.3 Load-Strain Relationship

The load-strain curves for steel and concrete in each specimen are shown in Fig. 6.7-6.14 . Each curve is identified by a number corresponding to the gage location shown in the figures.

The strain gage no.5 used in P3-3, no.1 used in P3-4, and no.3 used in P4-3 were found damaged and, the curves for these strain are not shown.

The concrete strain were plotted on tension side in all the test specimens.

6.3.1 Steel strain

The load-strain relationship for the tensile reinforcement was linear up to the cracking load. It was observed that for the initial stage of loading the load-strain curves conformed to the stress distribution of the simple bending theory. After the cracks were formed, the steel strains increased rapidly. Large strains were observed in most of the test specimens, greater than the yielding strain of the steel used.

6.3.2 Concrete strain

The load-strain relationship for the extreme compressive fiber of concrete was observed to conform to the stress-strain relationship for concrete under axial compression in accordance with the distribution of the bending moment stress. As the cracking load was obtained, the compressive strain increased at considerable rate. In all of the test specimens, the strain in concrete never reach the ultimate strain of the concrete used. This might due to the change from the flexural to diagonal tension types of failure.

6.4 Prediction for Strength of Full-Scale Caps from Model Test Results

Since full scale tests of large structural elements are prohibitively expensive and time consuming, the prediction of full-scale strength may be evaluated by multiplying the force scale, 9.0, to the model test results. The results are summarized in Table 10.