CHAPTER V

DISCUSSION AND CONCLUSION

5.1 Discussion of the test result

From the load-deflection curves as shown in Fig 23 to Fig 30, it is seen that the load-deflection curves were still straight line eventhough live load was over the anticipated ultimate live load (2520 kgs.) . This indicate that the model still behaved elastically up to this stage of loading. The vertical deflection profile along the center line of step were also shown in Fig 33. The maximum vertical deflection occurred at mid point of center line of step and reduced to zero at both the upper and lower support. The vertical deflections at live load 994.3 kg. which was slightly larger than the working load (900 kg.) were then plotted to compare with the experimental deflections. It is found that the analytical vertical deflections were greater than the experimental deflections. However, the deflection shape from the analysis conformed to that from the experiment.

The horizontal displacements in the radial direction which were measured at the outer side of the staircase showed that there were an inward movement at the upper half and outward movement at the lower half of the staircase. In Fig 31 the horizontal displacements measured at mid point of center line of step showed fluctuated values at each increment of load. However, the angle horizontal displacement curve in Fig 32 showed that it should be no movement at this location.

The illustration of the load deflection curves in Fig 34 to Fig 36 showed that the measured strain were erratic at small load. It is believed that discrepancies resulted mainly from the difficulty in measuring accurately the small changes in strain that resulted from an increment of load. Therefore, the measured strains at the begining stage of loading were disregarded and at large load the measured strains were compared to the analytical strains as shown in Table 15. It is found that the measured strains were greater than the analytical strains.

At a live load 5313 kg., many hair cracks were seen and uniformly distributed along the length of the helical stair. Since the helical stair was tapered so that its resisting capacity at each section closely agreed to the variation of the internal forces. Hence, the cracks were found to occur at the same time. If dead load of the model was included with live load, the load factor obtained at this stage of loading was 1.58 time the anticipated ultimate load which was equal 5000 kg (1.4 D.L. + 1.7 L.L.) . When the load was further increased to 7054.6 kg., the cracks only spreaded wider and no critical cracks occurred on the staircase. The model did not collapse eventhough the load was large. The load factor obtained at this final stage of loading was 1.9 time the anticipated ultimate load. In Fig 22, the cracks at the top face of the stair ocurred in diagonal direction and joined the diagonal cracks at the outer side of the stair. At the outer side, the cracks were widened visibly at the top face and propagated downward to or close to the location near the bottom face as shown in Fig 21. At this bottom face, cracks were not seen. It is seen from the pattern of cracks that failure of the structure in this manner should be caused by combined torsion and negative bending moment which torsion was dominant. In this test, tosional cracked occured on whole the staircase and found symmetrically about mid point of center line of step. At mid point of center line of step, flexural vertical crack was found at the joint of the thread and riser as shown in Fig 20. The crack indicated that negative bending moment was dominant at this location since the crack started at the top face. It is found that the type of failure of the model ocurred corresponding to the analytical internal forces which were dominant at any sections. From these reasons it is indicated that the behavior of the helical stair was closely agreed to the analytical assumptions. However, the load factor obtained from this test was high. This may resulted from the following factors :-

1. actual compressive stress was higher than that used in the design.

2. resisting capacity at any sections were increased since the capacity reduction factors were applied in the design in order to conform the ACI Code of practice.

3. the effect of the step of the stairs.

5.2 Conclusion

The following conclusions may be drawn from this study

1. From the experiment of a 720 degrees helical stair fixed at both ends, it shows that an analysis of helicoidal girder is satisfactory and give a conservative result.

2. The helicoidal girder can be analysed as a structure which is statically indeterminate to the sixth degree or using the principle of symmetry. Both methods of analysis yield the same results and can be applied to the helical stair with any central angle.

3. Bending moments, torsion and shear forces can be separately designed the same way as in straight beam.

4. Analytical deflections are greater than the actual deflec-tions.