# CHAPTER V

# SUMMARY AND CONCLUSIONS

## 5.1 Summary

This study presents a procedure for investigating the behavior of reinforced concrete columns and the global behavior of a reinforced concrete plane frame considering the interaction of core concrete, longitudinal bars and transverse steels. A confinement model is first proposed which is applicable to both normal-strength and high-strength concrete columns confined with normal- or high-strength transverse steel. The interaction between the concrete core-transverse steel system and the variation of the confining stress along the column height were realistically accounted for, considering flexural flexibility of the rectilinear ties. Compatibility of the concrete core and steel hoop is imposed at the hoop level using the area compatibility concept. An iterative procedure is used to obtain the effective confinement pressure at the peak compressive strength.

The buckling model of the longitudinal reinforcement inside a reinforced concrete column as proposed by Dhakal (2000) is used together with the proposed confinement model to obtain the envelope moment-curvature relationships of columns under cyclic lateral loadings. However, due to time constraint, only the proposed confinement model is implemented in the existing nonlinear finite element analysis program FINITE, without consideration of buckling. The modified finite element analysis program is used to study the behavior of selected reinforced concrete columns and plane frames. The effectiveness of a simplified finite element modeling is explored by comparing the result of a frame fully modeled by 2-D plane stress elements with that of a simplified model with part of the structure represented by an elastic beam element.

## 5.2 Conclusions

The following conclusions can be drawn from this study:

1. The influence of the tie flexibility, tie configuration and degree of confinement which governs the peak strength of the confined concrete can be captured by the proposed confinement model.

2. Application of the method proposed to columns with various tie configurations and confinement reinforcement under uniaxial loading yields satisfactory predictions of confined strengths compared with experimental results. In general, the discrepancy is within 10% and the maximum error is about 15%.

3. Comparison of the analytical envelope moment-curvature relationships with the experimental results reveals that the confinement and buckling models used in this study cannot reflect the significant strength reduction in the column at large axial strains, especially for columns with heavy confinement reinforcements. At large axial strains, crushing (or near crushing) of concrete leads to rapid loss of confinement, leading to a very complex confinement mechanism which cannot be captured by the proposed confinement model.

4. With the proposed confinement model incorporated into the finite element program FINITE without consideration of rebar buckling, the program can satisfactorily predict the cyclic behavior of the reinforced concrete columns studied prior to the sudden degradation of the load carrying capacity caused by reinforcing bar buckling and excessive deformation of concrete. After that the finite element model fails to predict the load-displacement relationship of the columns.

5. Although the computational time can be reduced when performing finite element analyses of the reinforced concrete frame using a simplified model with part of the bending member modeled as beam elements, difficulties arise in the selection of the properties of the transfer beam assemblage to reproduce the actual behavior of the structure. Improper selection of the properties of the transfer beam assemblage can also lead to premature numerical instability. Moreover, for the frame investigated, the solution failed to converge to the correct one after a few cycles of deformation.