CHAPTER 8

CONCLUSIONS

8.1 OVERVIEW

The main objective of this research was to identify a suitable joint detail for connecting steel beams to CFT columns in seismic regions. To fulfill this objective, a research program that included an extensive literature review, design of connections, experimental testing, and finite element analysis, was undertaken. Four subassemblies of steel beam to CFT column connections as shown in Figure 3.2, were designed according to AISC (2011). Square and circular steel tubular columns were considered with two different types of connections: (i) End-plate type connection, where flat and curved extended end-plates were bolted to the CFT column with steel rods passing through the column, and (ii) Through beam type connection, where the beam passing through the joint, and was connected with additional bolted bracket, without using any welding between the beam and the column.

This chapter presents the conclusions, followed by suggestions for further research in this area.

8.2 CONCLUSIONS

Based on the experimental and analytical investigations on the two types of connections between the steel beams and CFT columns (i) End-plate type connection and (ii) Through beam type connection, the following conclusions were drawn:
The through beam type connection was found to perform better compared to the end-plate type connection in terms of energy dissipation capacity.

In terms of the flexural moment capacity, the end-plate type connection was found to have slightly higher (8-12%) values compared to that of through beam type connection.

8.2.1 End-Plate Type Connections

I. The flat and curved extended end-plate connections to the square and circular CFT columns respectively had a drift ratio of more than 5% and the beams had an inelastic rotational angle of more than 0.054 radians at their end, which is in excess of 0.04 radians as recommended by AISC (2002) for high seismic areas. The proposed connections, both flat and curved extended end-plate for square and circular CFT columns respectively, are suitable for usage in high seismic regions which can result in ductile failure pattern.

II. Both curved and flat end-plate connections showed similar performance and exhibited good ductility and energy-dissipation capacity and the moment-rotation curves for the test specimens remained stable.

III. Using the stiffeners, the plastic hinges were relocated away from the end-plate face, reducing the stress concentration at the welds. As a result, the tube wall showed no apparent signs of local distress.

IV. The largest benefit of using the rods passing through the column was that localized outward stress was not applied on the inside of the tube, but rather in compression on the far side of the
column, resulting in a stiff load path. In addition, the proposed curved end-plate type connection with rods passing through the column in “×” shape was effective.

V. The mechanism of the bolted beam-to-column connection failure is influenced by the relative strength of the beam, the column and the panel zone. If the panel zone is relatively weak, the energy dissipation concentrates on the panel zone and the plastic hinge cannot be generated in the beams to dissipate energy. In these proposed connections with pre-stress applied to the rods at the beam end-plate, a confining force was generated between the column tube, and the surrounding concrete. This confining force helped to eliminate the outward buckling experienced by the column flange, as well as increased the concrete stiffness and strength, resulting in the better seismic resistance of the bolted connection.

VI. The numerical results of the analytical model for the end-plate type connections using RUUMOKO-2D Software were found to be in good qualitative agreement with the actual connection behaviour, which shows that the finite element model proposed in this study works well, and this model can be incorporated for the nonlinear dynamic analysis of the moment resisting frames with the proposed end-plate type connections.
be avoided for through beam type connections for both circular and square CFT columns, and the location of the yielding can be moved away from the column face.

II. The results presented in this study showed the capability of the proposed bolted bracket to develop the full plastic flexural capacity of the beam when the strong column-weak beam criterion is followed. The connection exhibited very ductile behaviour as the beam failure took place by the plastic hinge formation in the beam outside the joint.

III. The through beam type connections to the square and circular CFT columns respectively had a drift ratio of more than 6% and the beams had inelastic rotational angles of 0.077 and 0.059 radians for the connection with square and circular CFT columns respectively, at their end, which were in excess of 0.04 radians as recommended by AISC (2002) for high seismic areas. The proposed, through beam type connection can be used in high seismic regions.

IV. The test specimens showed a stable behaviour to drift ratio greater than 6%; the panel zone is subjected to very high shear forces. If the joint panel is not capable of transferring such forces, failure will take place by joint shear failure; therefore, it is very important to calculate the joint nominal shear force capacity. The results of this study indicate that the equations used for calculating the panel zone capacity are conservative.

V. The simulation results match well with the test results, and this demonstrates the ability of models developed using RUAUMOKO Software to simulate the cyclic behaviour of the through beam connection, very well.
SUGGESTIONS FOR FUTURE RESEARCH

Two different types of connection that develop the flexural strength of the connected beam were investigated in this study. This section suggests future topics of research, which can explore new areas of CFT behaviour or expand upon the results presented herein.

1. The composite behaviour of a beam-column with floor slab will benefit the performance of moment resisting frames. Therefore experimental investigations on both types of connections with floor slab can be carried out.

2. Testing on specimens with different connection details is required to be studied, in order to understand the seismic behaviour of the different connection details.

3. Experimental investigation of the through beam type connections, with different bolting arrangements is required to establish a data set, for qualifying other configurations that were not tested during this study.