Chapter V
Summary, Conclusions, and Recommendations

5.1 Summary

The purpose of this study was to evaluate the stability of castellated beams during erection. During erection a castellated beam is not braced in the same manner as it will be once the structure is complete. As a result its stability is based only on the resistance of the member to lateral-torsional buckling. Lateral-torsional buckling is directly related to the out-of-plane bending stiffness, warping torsional resistance, and pure torsional resistance, which are all dependent on the section geometry. Various approaches to calculating these cross-sectional properties were analyzed in an attempt to capture the unique geometry of the section and evaluate the contributions of the various components of a castellated beam on the overall stability. The classical lateral-torsional buckling solution, addition of the load location term, and the Galambos formula were evaluated to determine the critical unbraced length based on self-weight of the beam and a 300 lb concentrated load at midspan. The 300 lb concentrated load simulates the weight of an erector at midspan, a loading that is unique to the erection process.

Two specimens were tested to evaluate the results of the critical unbraced length determination procedures. Failure due to stability in addition to the erection load requirement was observed during the testing procedure. The test results were used to better model the contribution of a web to column flange double angle connection on the lateral stiffness and torsional rigidity of castellated beams. The contributions of the connection are expressed in the effective length factors, k_y and k_ϕ. Various effective length factor assumptions were compared to the test results to better model castellated beams during erection. Evaluating castellated beams using the classical lateral-torsional buckling solution with k_y equal to 0.8 and k_ϕ equal to 0.5 produced critical unbraced lengths closest to the experimental lengths determined through testing.

5.2 Conclusions

From the analytical and experimental results, the following conclusions can be reasonably drawn:

1. When analyzing deep castellated beams, the gross cross-sectional properties should be used when considering lateral-torsional buckling beam stability due to erecting loading.
2. The classical lateral-torsional buckling solution presented in the AISC specification (1999) with the addition of the effective length factors should be used to assure a safe and efficient design when checking for lateral-torsional buckling.
3. Castellated beam construction utilizing web to column flange double angle connection receive lateral and torsional stiffness from the connection. Use $k_y = 0.8$ and $k_\phi = 0.5$ in the classical lateral-torsional buckling solution.

5.3 Recommendations for Further Research

Through the analysis of the test data and a comparison with analytical results, the following are areas that would benefit from further investigation:

1. The stiffness characteristics of the castellated beams tested in this research proved to be closer to those of the gross cross-sectional properties. The beams tested in this research are considered deep beams. This relation should be examined for different size castellated beams, especially shallower sections and sections where the top and bottom flanges have different sizes.
2. The contribution of the web to column flange double angle connection was estimated. This connection when used in construction utilizing castellated beams needs to be examined to determine the actual contribution to torsional and lateral rigidity. The depth of the connection should also be varied to investigate the effect on beam stability.
3. The contributions of other connections, such as single plate connections or bottom flange bearing connections, should be investigated to determine what contribution, if any, they have on the stability of castellated beams.