EXECUTIVE SUMMARY

The purpose of this research is to discuss and resolve several issues pertaining to composite steel-concrete flexural members. The resulting solutions are proposed in three manuscripts. Objectives accomplished within each of the manuscript and short descriptions of the issues involved are provided below. The target publication for the first two manuscripts is ASCE Journal of Structural Engineering. The target publication for the third manuscript is the Journal of Steel and Composite Construction.

Manuscript 1 (Chapter H): New Means of Shear Connection in Composite Steel-Concrete Joists – Drilled Standoff Screws

For nearly a decade, the Virginia Tech structures program has been a site where an innovative system for shear connection in composite steel-concrete short-span joists was evaluated. It consists of standoff screws, ductile self-drilling fasteners, mechanically attached to the top chord of the steel member. The study performed by Mujagic et al. (2001) proposed a strength calculation model compatible with LRFD. As a part of the same study, several issues of concern were identified. Those primarily concern the lack of slip capacity of standoff screws in certain configurations and methods of reliability evaluation in composite joists and composite flexural members in general. Mason et al. (2002) supplemented the project with additional push-out tests, aimed at providing an experimental basis for extending the range of the model proposed by Mujagic et al (2001).

The objective of this study was to provide an updated and improved strength calculation model. The strength calculation model was generalized to where it can be applicable to other drilled connectors with similar geometries and properties, and the range of considered parameters was extended. Further, a method for easy assessment of the ductility of shear connection within design process, given readily available design parameters, was proposed. A reliability study was performed and the appropriate strength reduction factors were determined. A complete design procedure was proposed considering both strength and ductility criteria in the format that can be easily included in relevant design specifications and guides. The numerical example complements the manuscript to illustrate the application of the proposed procedure.

Manuscript 2 (Chapter I): Reliability Assessment of Composite Beams

The study presented in this manuscript evaluates the reliability of composite beams and proposes revised resistance factors based on provisions of the current 1999 AISC Specification. Resistance factors were also found based on newly proposed models to calculate the strength of shear connection: Roddenberry et al. model (R-method), and Simplified Roddenberry model (RS-method). It was found that the resistance factor for solid slab beams of 0.90 could be used. If 1999 AISC Specification provisions are used, and ribbed-slab beams are considered, the resistance factor ranges from 0.79 to 0.86, with an average of about 0.80, showing that combining the statistics from the two types of tests and a uniform resistance factor is not justified with this method. The situation is appreciably improved with the RS-method, by which the currently stipulated resistance factor of 0.85 for ribbed slabs is actually achieved. If the R-method was used, a uniform resistance factor of 0.90 is appropriate for all types of slabs.

Finally, it was shown that degree of shear connection has significant impact on the resistance factor. Functions were proposed that could be used to calculate the resistance factor based on degree of shear connection in a beam. Alternatively, it was proposed that the minimum degree of shear connection be raised to 50% and a uniform resistance factor of 0.90 be used provided that either R- or RS-method is adopted.

Manuscript 3 (Chapter J): Strength Requirements Comparison of 1999 AISC LRFD Specification and Eurocode 4, Part 1.1

This manuscript provides an insight into significant differences between ENV 1994-1-1 (EC4) and 1999 AISC Specification (1999 AISCS) rules for design of composite steel-concrete beams. The goal of this comparison was to identify the areas in which 1999 AISCS may be improved, taking advantage of available body of knowledge and experimental results about behavior of composite steel-concrete beams. Many if these aspects were already recognized and addressed in EC4.

Several modifications to 1999 AISCS are recommended. First, it is necessary to revise, or replace the stud strength computational model. The current modified version of the model by Grant et al. (1977) still has significant shortcomings. A possible solution is to implement the new model proposed by Rambo-Roddenberry et al. (2002a). Second, the minimum required percentage of degree of shear connection should be raised to 40 or 50%. Better yet, a member length dependant function can be established, based on which the minimum degree of shear connection should vary. In absence of such requirements, the design of shear connection could be significantly unconservative, even if the strength of shear connection is computed fairly accurately. The reason for this is the inability of horizontal shear to be progressively transferred towards interior studs due to lack of slip capacity in excessively long members. Third, 1999 AISCS should establish a required check for longitudinal slab splitting. Such a check is stipulated by EC4 and can be of significance, especially in members with high beam depth to slab thickness, d/t_s, ratios. Finally, a check for combined shear and bending can be significant. The example presented in this paper shows that this check can result in reduction of load carrying capacity of 11%, which is significant. Implementation of this check into the AISC Specification is recommended, as its use represents a good design practice. Also, the effect can have a significant impact on calculated strength, especially when beams with moment joints and continuous beams are considered.