The 1993 T. R. Higgins Lecture: Semi-Rigid Composite Construction

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Roberto T. Leon is an associate professor in the Department of Civil and Mineral Engineering at the University of Minnesota. He received a Ph.D. from the University of Texas at Austin in 1983. He is chairman of the American Society of Civil Engineers LRFD Committee, the Structural Stability Research Council TG 20 - Composite Structures, a member of the American Society of Civil Engineers Committee on Composite Construction, and a member of the American Institute of Steel Construction TC 107 - Composite Structures.

Over the past ten years Dr. Leon has been engaged in research on steel and composite structures, both for ultimate strength and serviceability conditions. He has conducted extensive research on bolted, riveted, and composite connection behavior under gravity and cyclic lateral loads, and on long-term deflections of composite floors.

In addition to laboratory studies, Dr. Leon has conducted extensive field instrumentation of structures, including composite columns, composite bridges, and illumination towers.

Summary

Over the past ten years Dr. Leon and his colleagues at the University of Minnesota have been involved in developing the concept of semi-rigid composite frames (SRCF). These structures utilize the contribution of continuous slab reinforcement across column lines to turn simple connections into semi-rigid, composite ones. The original premise for this work was that composite floors are by far the most common structural system to carry vertical loads in multi-story structures, and that the beneficial action of the floor continuity should be included in the calculations for both gravity and lateral loads. Another important consideration was the need to develop additional lateral resistance and structural integrity for structures in newly upgraded seismic regions without requiring extensive changes from current construction practice.

This work has been divided into three basic areas: experimentation, development of analytical tools, and design utilization. In the experimental part, four types of connections, ranging from very flexible to very stiff, have been tested under both monotonic and cyclic loads. One type of connection, the bottom seat and web angle type, was selected for further studies. Its performance has been verified by a test on a large two-bay, one-story subassemblage subjected to a combination of gravity and lateral loads. The analytical studies centered on developing both a finite element model for the connection area based on behavioral models derived from the experimental data, and stiffness method computer codes capable of carrying out the non-linear analysis of these structures efficiently. The finite element models were then utilized in parametric studies to derive simplified moment-rotation expressions for a wide variety of connection geometries. The third part, on design applications, has concentrated on the development of simple design procedures to make semi-rigid composite design accessible to the average designer. Two areas have been emphasized on the latter part: unbraced frame design and connection detailing.

All the studies conducted indicate that composite semi-rigid frames are a very competitive system up to ten stories in areas of low to moderate seismicity. This implies that fully rigid (FR) construction may not be required for low-rise buildings in these areas, with substantial savings in the design and construction of the connections. Non-linear dynamic analysis indicate that SRCF perform better than FR frames because the connections can be

utilized as fuses, with predictable strength, ductility, and hysteretic characteristics. These fuses prevent the excessive accumulation of moments in the columns as the structure sways, delaying or preventing the buckling of lower story columns that seem to dominate the design of FR frames.

The last major hurdle in this work is the technology transfer aspect. While the research results are available, much work needs to be done in both educating structural designers on semi-rigid frame behavior and developing design aids. Dr. Leon will strive to fill this gap through a forthcoming American Institute of Steel Construction design publication on semi-rigid composite frames and with nation-wide presentations to interested construction specialists.