First Interstate Bank Fire

structural design

The Structural Engineer and Fire Protection

By John L. Ruddy, P.E.

Life safety design involves the integration of many provisions which may include passive fire protection, active fire protection, detection and alarm, egress systems, smoke management systems, firefighter access and smoke control. Traditionally, the architect has maintained primary responsibility for satisfying building code mandated life safety provisions while relying on input from structural, mechanical, electrical and, in some instances, a fire protection engineer. The structural engineer has typically assumed a limited role in the life safety design regarding fire. The architect confirms the building classification based on size and occupancy. The classification allows the determination of the required passive fire resistance rating of the structural elements. Tested fire assemblies based on ASTM E-119 are referenced and listed on the architectural construction documents.

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This prescriptive approach has resulted in good structural performance under fire conditions for commercial buildings and, under the philosophy of "if it ain't broke don't fix it", little attention had been directed toward improvements. However, under these current prescriptive practices there is no measure of the level of fire safety. We are not sure if the provisions are overly conservative, marginally acceptable or inadequate.

"…it is prudent for the structural engineer to understand the fire provisions…"

Improvements are inevitable, but the prescriptive approach will remain the common approach to fire safety design for the immediate future. The responsibility for fire safe design remains with the architect. Nonetheless, it is prudent for the structural engineer to understand the fire provisions of the building code to avoid unnecessary conservatisms. The traditional role of the structural engineer has been one of support as demonstrated by several examples.

Fire Walls

A fire wall can often be used to divide a building into segments. Through the use of fire walls, height and area limitations associated with a construction type can be applied to the segments rather than the entire floor area. The segment area may permit the use of a construction type having less stringent fire resistance rating requirements than those for the entire building. In some cases, the need for structural fire protection can be completely eliminated. A requirement of a fire wall is that it shall have sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall. Providing lateral support for the wall and the assuring independent structures on either side can be challenging. The structural engineer's input to alternative wall locations can have a significant impact on construction cost. The support role of the structural engineer in confirming fire wall locations is vital.

Fire Partitions

A fire partition is a barrier to restrict the spread of fire and is used to separate dwelling units, guestrooms, tenant spaces in covered malls and corridor walls. Fire partitions are often required to provide a 1-hour fire resistance rating. Generally, the structure supporting fire partitions needs to have a fire resistance rating equal to the rating of the fire resistive construction supported. However, the need to provide a 1-hour fire resistance rating for structures supporting a fire partition in unprotected noncombustible construction (Type II B) is exempted in IBC Section 708.4. This exception had not been included in all the previous model building codes. A structural engineer can provide a valuable service by being cognizant of and identifying this provision.

Thermal Restraint

Section 703.3.3 of IBC 2000 states *"Fire resistance rated assemblies tested under ASTM E 119 shall not be considered to be restrained unless evidence satisfactory to the building official is furnished by the registered design professional showing that the construction qualifies for a restrained classification in accordance with ASTM E 119. Restrained construction shall be identified on the plans."* Classifying a steel structure

Deformed Floor (One Meridian Plaza)

unrestrained versus restrained can cause the thickness of Spray-applied Fire Resistance Material to double. Yet, sufficient information to enable the design professional to justify that steel beam floor and roof systems are to be based on restrained assembly ratings is contained in a paper by Richard G. Gewain and Emile W. J. Troup, "Restrained Fire Resistance Rating in Structural Steel."(1) The structural engineer provides an important service to the design team simply by having knowledge of the reference.

Performance Approach

A performance-based method for predicting structural performance under fire conditions is being pursued. Evidence is abundant that an increased structural engineer role in fire safety is likely.

Early in 2004 the American Institute of Steel Construction (AISC) will release Design Guide 20 - Fire Resistance of Structural Steel Framing. This guide consolidates information on fire protection for structural steel framing. It contains examples of application of building code prescriptive provisions, and is a resource for the correct application of the prescriptive provisions of the building codes. A series of seminars presenting the material contained in Design Guide 20 will commence in 2004. This publication and the seminars are in the interest of improving the structural engineer's knowledge of prescriptive fire safety provisions.

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AISC has commissioned a study designated "Strategy for Integrating Structural and Fire Engineering of Steel Structures". The study is certain to suggest an increased role for the structural engineer, as well as more interaction with fire protection engineers.

The next AISC Design Specification, Standard for the Design of Structural Steel Buildings will supersede the LRFD and ASD Specifications and is planned for release in 2005. Appendix V of the 2005 AISC Standard is titled *Structural Design for Fire Conditions.* Language will be included to prevent an inadvertent transfer of responsibility/liability for fire safety due to the inclusion of this addition to the standard.

In 1999, SEI/ASCE/SFPE 29-99 - Standard Calculation Methods for Structural Fire Protection was published to document methods for calculating the fire resistance of selected structural members and barrier assemblies using structural steel, plain concrete, reinforced concrete, timber and wood, concrete masonry, and clay masonry. The stated purpose of the publication is to provide architects, engineers, building officials, and others with calculation methods that give fire resistance results equivalent to those in ASTM E119. As an ASCE Standard, a degree of responsibility is implied.

Floor, Full-Scale Fire Test (Cardington, UK)

The National Institute of Standards and Technology (NIST) has been funded to investigate the mechanism of the collapse of the World Trade Center, and the influence of fire on the structure is one focus. NIST has looked to stakeholders for input in developing a roadmap that will identify research and development needs so that standards, tools and practical guidance can be provided to the design community. A workshop attended by structural engineers, academics, researchers, trade association representatives, architects and building officials occurred in October of this year. The need for data and design tools was confirmed. Design provisions do not consider fire a design condition for purposes of evaluating structural performance. Yet, under a performance approach to fire safety, the evaluation of structural

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performance in a fire condition is essential. As data on real fires and structural performance is confirmed, a significant increase in the structural engineer's role should be expected.

Responsibility

Technical activities directed toward collecting data and developing tools for evaluating structural performance in fire conditions have accelerated. A parallel effort must be made to address business practices and fee structures which may be appropriate for a shift in responsibility/liability. If fire is made a load condition, a transfer of responsibility and a degree of liability will occur. If that responsibility shift happens, an appropriate shift in compensation for the structural engineer is essential.■

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(1) Gewain, R.G., Troup, E.W.J., "Restrained Fire Resistance Ratings in Structural Steel Buildings", *Engineering Journal*, Vol. 38, No. 2, American Institute of Steel Construction, Chicago, IL, 2001.

UL Assembly after Fire Test

Photos provided by Charles J. Carter, Chief Structural Engineer, AISC