Fire Protection Systems

Existing System

Background

In the event of a fire in a large high-rise building such as the River Tower, a number of factors need to be considered in both the design and operation of such a large public space. Extinguishing the fire is only part of the story as three major objectives of the system dominate system design and operation: protection of life, protection of property, and continuity of operation. Within these objectives, evacuation, smoke control, structural protection, fire spread control, and electronic detection systems are all major issues to consider.

The general building classification for River Tower is mostly light hazard, and rated ordinary hazard (Group 1) for the storage and mechanical rooms, based on the BOCA 1999 Building Code. Most of the areas of River Tower are protected by an automatic sprinkler system. In addition, there are fire hose valves located at each level of the major stairwells. A fire pump room is located on the first level to service the fire protection system. Each stairwell has access to a standpipe for immediate access to water. The concrete slabs, beams, and columns provide passive fire protection by their very nature in the parking garage and loading dock areas. Strobes, fire alarms, smoke detectors, and standard equipment are located throughout the building, concentrated mainly in means of egress areas such as stairwells and corridors.

The post-tensioned concrete flooring and cast-in-place concrete columns of the original structural design provide more than enough inherent fire protection for this type of building. The River Tower falls under a Type 1A construction category, as it rises taller than the 160 ft height requirement of the code. The code provides reductions in fire ratings due to additional fire protective systems, such as automatic sprinkler systems that the River Tower does have, but the amount of floors is simply too great. The River Tower is required to have a two hour fire rating, which indicates that the protective system must sustain the fire for a minimum of two hours to

allow for proper evacuation. It is crucial that the structural system be properly protected, to ensure structurally stability during this evacuation process. The main goal is to extend the time it takes for the heat transfer from the fire to the steel member, thereby reducing its strength and potentially resulting in structural collapse.

Evacuation and Means of Egress

The main residential tower has two main stairwells, in addition to its main elevator core which consists of three elevator shafts. The easternmost stairwell, next to the elevator core, reaches all 25 floors of the building, but experiences a shift in axis as the tower interfaces with the parking garage levels from the eighth floor down to the ground floor. The westernmost stairwell which protrudes out of the western exterior wall rises from the first floor upward to the penthouse level on the 23rd floor, but does not service the upper two floors. The parking garage that abuts the residential tower contains two stairwells, one in the northeastern corner, and the other on the extreme opposite of the garage in the southwestern corner. This southwestern stair also services the outdoor terrace on the eighth level that rests above the parking garage. Two elevators service the parking garage in the southeastern corner of the garage.

Based on the *NFPA Fire Protection Handbook*, the occupant load for a typical residential building consists of one person per gross 200 ft^2 of floor square footage. The typical residential tower square footage per floor of the River Tower is approximately 12,000 ft^2, which yields population per floor of approximately 60 people. With a flow rate of approximately 35 people per minute per 22 in width of stair, and 23 main occupied floors, and two main stairwells, the River Tower has approximately a 10 minute evacuation procedure.

Standpipe and Sprinkler System

The River Tower utilizes a wet pipe, combined standpipe/sprinkler system. This means that water is constantly flowing through the standpipe riser and sprinkler branch system. This

type of system is standard practice for high-rise systems. Fire department hoses only have the ability to reach approximately 75 feet above their water source level with their truck-mounted ladders. Buildings above this height are classified by code as "high-rise" buildings, and the River Tower certainly falls under this distinction. The condominium tower has a standpipe in each major stairwell of its condominium tower to provide instant access to fire hoses on the taller floors.

Smoke and Fire Control

In taller structures, stairwells become the primary means of egress in a fire or similar evacuative event. Elevators are not reliable and should not be used, as smoke especially has the ability to travel upward vertically through the shaft. The River Tower has air pressurization capabilities in these stairwells to ensure that smoke will not penetrate these critical areas and spread throughout the building. When evacuees or fire personnel open the fire doors to the stairwells, clear air is forced out into the floors, keeping smoke and carbon dioxide out. This is an additional fire protection system which helps control the spread of fire and smoke and confines it to the very minimum spaces necessary. Smoke control holds the same significance as fire control, as smoke damage to property and smoke inhalation of evacuees can prove just as devastating in the event of a fire.

Proposed Fire Protection System

Additional Needs for Fire Protection

Because only the structural members of the main residential tower have been changed, the existing fire rating of two hours for the River Tower will still apply. The 8" thick precast plank flooring with 2" concrete coating, provides this two hour rated fire protection in the floor system. The existing combined sprinkler and standpipe system will suffice since the architectural changes will be relatively minor. Therefore, these sprinklers will serve roughly the same square footage and will not need to be resized. The same applies to the standpipe dimensions, as it services the same areas as the previous structural system. The key change in this new building system is the introduction of structural steel members, which can lose up to 40% of its yield strength in fires reaching temperatures of 1000-1300 degrees F. The current active fire protection system of detectors, sprinklers, and other mechanical equipment should be sufficient even after the proposed structural changes. The proposed steel members will require an additional passive (i.e. no activation required) system to maintain structural stability and integrity in such high temperatures. A three hour fire rating requirement of interior bearing walls, columns, and trusses is required by BOCA 1999 for this structure.

Steel Column Fire Protection

Columns are able to retain their structural integrity "as long as the fire exposure does not cause the average temperature at any cross section to elevate above 1,000 degrees F."[3] The amount, or more specifically, the thickness, of fire protection needed for a column is related to the W/D ratio of the individual structural member. The amount of surface area exposed to the fire, along with the mass of the object, affects its ability to retain its current sectional properties when heated to such high temperatures. Several options exist to properly protect a column. Relative to the River Tower, prefabricated fireproof columns, gypsum wallboard, lath and plaster

[3] Ruddy, John, et al. *AISC Design Guide 19: Fire Resistance of Structural Steel Framing.* American Institute of Steel Construction, 2003.

enclosures, concrete enclosures, or the popular spray-applied fire resistive materials are all viable options. The new passive fire protective system must maintain a healthy balance of system thickness, cost, and aesthetic appeal.

Please consult Appendix E for calculations for a sample column chosen for comparative purposes between three common protective types: concrete encasement, spray-on fire resistive materials, and gypsum wallboard. With the sample W12×72 member, some interesting results occurred. The concrete encasement provided the thinnest thickness required, but has the most difficult installation. The gypsum wallboard provides the thickest protection needed, but has the most aesthetic benefits for an interior column. The spray-applied fire resistive material, found to be Isolatek 800, requires a thickness of approximately 1.75" inches, but would be the easiest and quickest application. Considering all of these factors, the gypsum board provides a flat and easily painted surface for an interior space, so that would be the most design-friendly protective surface.

Steel Beam Fire Protection

Similar passive fire protection needs exist for the proposed steel beams. Once again, system thickness, so as not to infringe on the architectural spaces of the tower's units, cost, constructability, and aesthetics are all controlling factors for the use of the various systems available. The steel beams have the added benefit of the inherent two-hour fire rating of the hollow-core slabs that they support. However, this flooring system only rests on top of the structure, and sufficient protection is needed on all four sides of these critical members. Architecturally, these beams will not be exposed to public view, and most likely hidden by drop ceilings or similar low-weight interior solutions. The ease of application and relatively minimum thickness requirements of spray-on fire treatment would be an efficient application on the undersides of this flooring system.

Staggered Truss Fire Protection

The placement of the staggered trusswork in existing infill walls between most condominium units simplifies the fire protective requirements. These infill walls are required to have a minimum one hour fire rating, which reduces the threat of fire spread between individual units. The three hour fire rating requirement of interior bearing walls, columns, and trusses from the code supersedes this requirement, and effectively satisfies both needs. The aesthetic nature of this type of fire protection is perhaps the most crucial of all the fire protective needs, as these walls will form the interior of the luxury condo units. With this in mind, gypsum wallboard should provide sufficient protection while maintaining a smooth, easily painted surface. In places where thickness is at a premium, such as the door opening cutouts running through the trusses in specific units, the use of intumescent coatings may prove more beneficial. These coatings do not have the ease of application of spray-applied materials, or the aesthetic appeal of gypsum. But the thickness of the coating in these potentially tight spaces outweighs the qualities of these other systems. A combination of these systems, used in specific applications, will result in the most cost-efficient fire protective system that best maintains the existing architectural spaces.