PROCEEDINGS, Fire and Evacuation Modeling Technical Conference 2011
Baltimore, Maryland, August 15-16, 2011

CASE STUDY TO EVALUATE EFFECTS OF BUILDING CODE VIOLATIONS ON THE OUTCOME OF A FATALITY FIRE

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ABSTRACT

Modeling with FDS 4.07 was done to evaluate the effects of building code violations, construction features and wind on a multiple fatality fire.

Several unique construction features of the two story, eight unit structure included a common covered and enclosed exit pathway. The effects of combustible siding, carpeted stairs and door closers were modeled to show that the code violations significantly affected the growth of the fire and the ability of the occupants to exit the building in the fire. Smoke detectors and pressure sensors were used to evaluate the effectiveness of smoke detectors in this situation and the ability of the doors to be closed when opened into a wind driven flashover situation.

INTRODUCTION

On a warm late summer evening a fire was noted in the common entry to an apartment structure. The fire was noted by several people at the front of the structure. Efforts were made to alert the occupants of the apartment structure. Emergency services were called and responded but the structure's common entry was fully involved on the fire department's arrival and had already spread to a nearby identical structure.

The fire size stunned the arriving fire crews. The flames were extending more than 20 feet above the opening to the central entry. They were informed that people were still inside by radio and bystanders.

Occupants that survived the fire escaped from bedroom windows, sliding glass door patios and balconies. Some jumped from second story windows, one person jumped from a second floor balcony to the limbs of a nearby tree.

The fire destroyed six (6) of the eight (8) apartment units as well as 50% of an adjacent apartment structure exposed to fire by wind. Three fatalities were found within the first building.

The cause of the fire was probably an intentional ignition of a small pile of clothes on the ground floor at the rear of the entryway.

The investigation determined that various code violations prevented egress from the structure, did not provide required fire separation, had combustible surfaces in a required exit path and therefore, contributed to the fatalities.

The defense's arguments were that:

- This was common construction in the area.
- It was approved by the building department.
- It was an incendiary fire; how can the building be responsible?
- The upstairs occupants could easily jump down from the balconies to escape.
- Fire doors were installed and the occupants opened the door to #6.

BUILDING DESCRIPTION

Constructed in 1977-78, this apartment house layout had four apartments on the 1st floor and four apartments on the 2nd floor. All units had main entries into a central covered corridor. Each unit had a sliding glass door to porches on the 1st floor and balconies on the 2nd floor. There were two one-bedroom and two two-bedroom units on each floor (Figure 1).

The covered central entry served as the /exit pathway for the main entry of each unit on both floors. A stairway in the central corridor provided access to the second floor with a washer, dryer and supporting water heater located in a closet under the stairs (Figures 2 and 3). This laundry area under the stairs was covered with gypsum wall board.

Figure 1: Exemplar apartment structure front.

The type V-NR frame construction had painted wood T1-11 exterior with 2x4 studs. The central corridor had 5/8" Type X sheetrock over the studs and under the T1-11.

The concrete pad of the corridor, the stairs and the 2nd floor exterior walkway were carpeted at time of the fire.

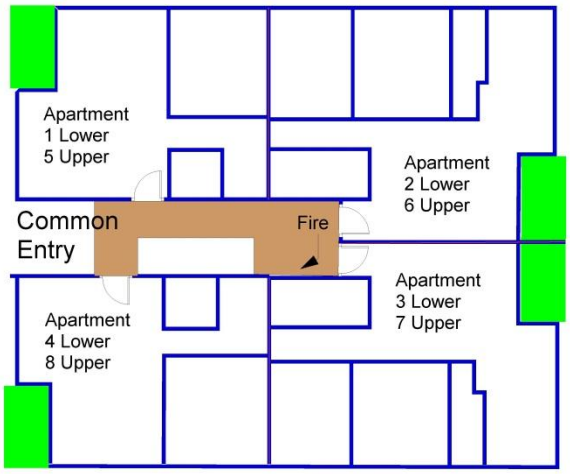

Figure 2: Central Corridor in brown, walls in blue and balconies in green

Structures

It was evident at the scene that the buildings adjacent to and across the street had the same exterior and interior layout. Since the subject structure was largely destroyed, the exemplar structures were evaluated to reconstruct the subject structure. Measurements of the internal walls and wiring from the closest adjacent unit were used to approximate the dimensions of the subject unit.

Figure 3: Exemplar structure central corridor and stair. Laundry door under stair.

Events

On the Sunday morning shortly after midnight there had been an altercation between an unknown person and a person within unit #3. The fire probably began on some bags of clothing between unit #3 and the laundry room wall.

The fire was initially observed by a local bystander who called emergency services. The fire rapidly grew and there were multiple calls to 911 while the fire department was en-route. The occupants of an upstairs unit, #6, were not aware of the fire and heard the yelling and commotion outside. The front door was opened by the mother and father into a fully involved fire area. They were immediately driven back and to their knees and were not able to close the door which allowed fire and hot gases into the apartment. The wind was blowing from the front of the building to the rear which caused the fire gasses to be driven into the apartment and out the balcony door when it was opened for egress.

The older son and daughter of #6 egressed through bedroom windows while the mother and father are able to jump from the balcony. A young son and grandfather sleeping in the living room within 10 feet of the balcony were lost in the smoke during the evacuation and did not exit.

THE INVESTIGATION

The building was thoroughly documented and some samples taken including:

- Evidence of smoke detectors and power supply in each unit
- Building construction and wiring
- Evidence of ignitable liquids

- Terrain level at the perimeter of the structure
- Electrical supply into the building
- Carpet and flooring material
- Exterior wall construction
- Main entry door construction and hardware
- Window size and locations
- Balcony locations and distance above terrain

BUILDING PLAN REVIEW

Following the scene investigation the original building plans where obtained. The building codes in effect at the time of permitting were researched and compared to the plans. The plans also confirmed that several other buildings were identical and built at the same time under the same set of approved plans.

On the plans filed with the county two hand drawn correction items were found:

1. Within the main entry corridor "1 hr fire resistive construction Section 3308 UBC" written in for the 1st floor and 2nd floor plans (Figure 4).
2. Within the arc of each main entry door an "*" was draw. Below the diagram was written "* 1 hour rated door assemblies" (Figure 5).

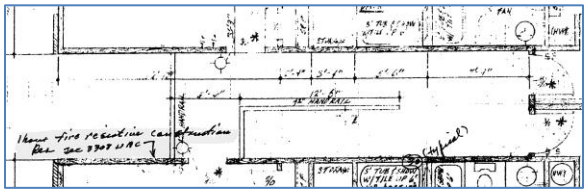

Figure 4: hand written note in corridor " 1 hour fire resistive construction Rec. Section 3308 UBC"

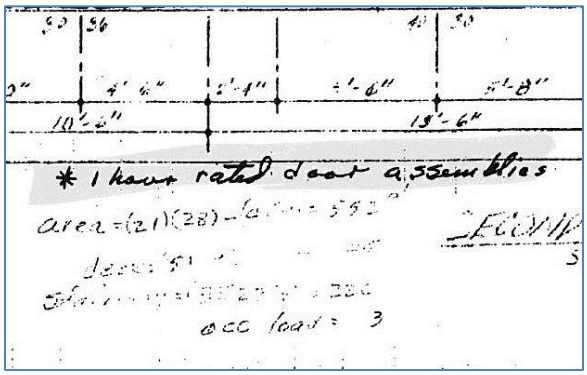

Figure 5: hand written note in margin with asterisk. " 1 hour rated door assemblies" Each door had an asterisk within the door arc.

Code Review

The building constructed in 1977 was evaluated for compliance to the 1973 Uniform Building Code (UBC).

Section 4306 (A) Where required by this code for the protection of openings, fire-resistive assemblies shall meet the requirements of this chapter.
(b) Definitions. FIRE ASSEMBLY is the assembly of a fire door, fire window, or fire damper, including all required hardware, anchorage, frames and sills…

The building was also evaluated for the 1976 Uniform Building Code (UBC).

Sec. 4306 (e) Hardware … Every fire assembly required to have a one and on-half hour, one hour, or three-fourths-hour fire-protection rating shall be of an automatic or self-closing type as specified in Section 4306 (b).

Sec 3308 Openings into Enclosures … exit doors shall be protected by a fire assembly having a fire-protection rating of not less than one hour…Doors shall be maintained self-closing…

OCCUPANCY AND EGRESS ROUTES

The building occupancy was calculated to be 28 with 14 on each floor. This was documented on the plans by the reviewing code official based on the actual square foot area. There was evidence that more than 28 people occupied the building at the time of the fire.

The 1973 code required a second exit when there are more than 10 people on a floor. The primary entry/exit pathway was via the central corridor. All main entry doors opened into this covered main entry way.

An exit is defined as a continuous and unobstructed means of egress to a public way. Therefore, to be considered an exit, the second floor balconies would require a stairway to ground level. The second floor balconies did not meet the description of an exit. The ground floor units did have a second route through the patio sliding glass door.

Code Evaluation of Central Corridor/Exit Pathway

The covered entry way was the focus of the investigation for the following reasons:

1. The initial fire was identified in this area
2. The fire spread quickly within the central corridor

3. All main doors from the apartments opened into the corridor
4. The fire blocked the only exit pathway from the second floor units
5. Laundry facilities closet under the stair

The exterior of the building had painted T1-11 exterior paneling. T1-11 is exterior plywood with a textured surface. This construction was continued around into the central corridor. The wall layered profile from the exterior surface to the inside was: T1-11, asphalt building paper, wood studs and insulation and 1/2" sheetrock on the interior wall.

Combustible construction is allowed on exterior exit balconies. An exterior exit balcony is a construction feature where the balcony runs along the side of a building and individual apartment doors open onto the balcony. The difference is that the outside of the balcony is open and should not become involved early in a fire. If the distance from an apartment door is greater than 20' to the stairs, a second exit from the balcony is required.

Once the "exterior exit balcony" was located in a covered common area facing each other, it no longer met the definition of "exterior" and became an exit pathway with required wall ratings. The T1-11 did not meet the flame spread rating and was not acceptable.

Door Examination

During the code review, it was determined that one hour doors and self-closing hardware were required. An examination of the remaining doors in the subject and exemplar building resulted in the following (Figure 6):

- Smoke control fire door
- UL classified
- Wood core fire door
- Fire Rating 20 minutes
- No evidence of door closure hardware or attachment points.

Figure 6: Door plate, fire rating 20 minute particleboard core

Floor Covering

The concrete pad of the first floor, the stairs and the second floor walkway was carpeted with a short nap commercial carpet adhered to the concrete and stair.

As an improvement to the apartment, the carpet would have reduced sound levels within central corridor. The original plans had no indication of carpet. In the fire that occurred; the carpet resulted in an additional fuel load increasing the size of the fire.

BUILDING THE CASE

With information obtained, MDE was able to develop a list of hypotheticals to allow testing the individual effects of:

Building Code Violations

The covered three sided exit corridor had combustible siding on all walls and the ceiling of the lower level was lined with plywood. The central corridor is considered to be an interior exit enclosure and the finish material is limited to class II with a flame spread rating of 26-75. T1-11 had a class III flame spread rating of 76-200. The test method to determine class rating is the ASTM E84 tunnel.

The doors from the central corridor to the individual apartments did not have self-closers. Per the hand written note on the plans "3308 One hour rated" They were required to be maintained as self-closing by the county. The average door closer swing force range is 5-20 pounds or more (when measured at the knob).

Two independent exits were required by the code. The occupant load was 14 for the upper floor requiring two exits. To make a second exit from each apartment possible, it was determined that there was room for a set of stairs from each second floor balcony. However, the hypothetical back set of stairs would not fully achieve a code compliant path to the public way because the back yard did not abut a developed alley.

Automatic fire sprinklers were not required per sec. 3802(b) 1.

The owner of the building was responsible for the maintenance of the building including maintaining the door closures.

The fire was thought to have been small and originated on a pile of cloths in the corner of the space between apartment #3 and the laundry. No evidence of an accelerant was found.

Based on the very rapid spread noted by the initial 911 caller and the witness from unit 1, the initial stages of a "hidden" ignition were evaluated (Figure 7). The location of the initial fire was behind the stairway and was not visible from the street or parking lot. This allowed the fire to develop and spread up the siding to the second story landing before being noticed. There were no lights to show any developing smoke.

Door Closures

Door closing mechanisms were required by the building plans and code, however, no evidence of the closing hardware was found at the subject apartment or the exemplar structures. To demonstrate that the closing mechanism would function in the pressure of a fire plume and wind, FDS modeling was employed and compared with the force measurements of door closing mechanisms.

The hypothetical was that even with a fire plume pressure on an open door, the door closing mechanism would close or at least reduce the opened area by closing the door partially. Seconds would have made a difference in the survival of the two individuals in this fire.

Figure 7: Estimated size of pile of bagged clothes placed in front of door #3 in an exemplar building.

FDS Modeling

The geometry of the models included the central corridor, external and the internal walls of the apartments. FDS modeling was completed and shared by both plaintiff and defense experts through agreement by counsel at a later stage of the project.

Material properties from the T1-11 were developed by testing exemplar specimens in the Cone Calorimeter at MDE.

Geometry was prepared using Chief Architect and using the DXF converter to prepare the input file for FDS.

Wind effects were integrated into the model to estimate the pressures on the doors. FDS allows the boundary vents to have a flow rate associated to the vent allowing the effects of a wind to be modeled.

Numerous modeling runs were performed by both MDE and defense teams. A portion of the models included the whole building. The remaining models encompassed the two story covered entry including apartment doors and stairway. MDE used several initial fuel packages to develop timelines for the spread and visibility for the witnesses in the front parking lot.

The modeling indicated that the combustible material that lined the covered exit passage quickly provided an untenable environment within the covered corridor (Figure 8).

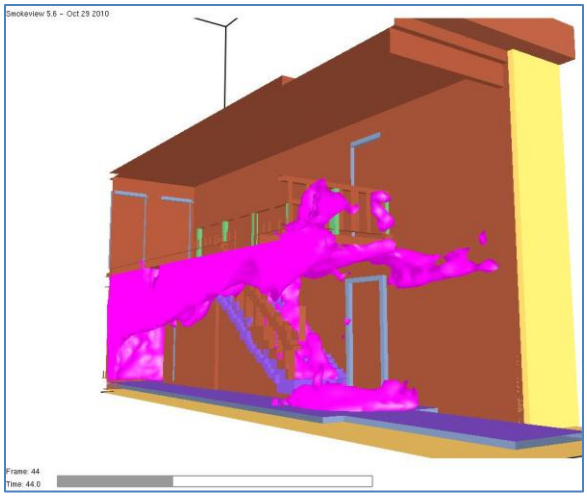

Figure 8: FDS 4.07 Corridor model with T1-11 walls and ceiling and carpeted flooring

The modeling indicated that wind and draft pressure levels at the second story doors #6 & #7 were low enough that an average door closure hardware with 5 pounds of force would have been able to overcome the wind and fire plume pressures during the initial and middle stages of the fire growth (Figure 9).

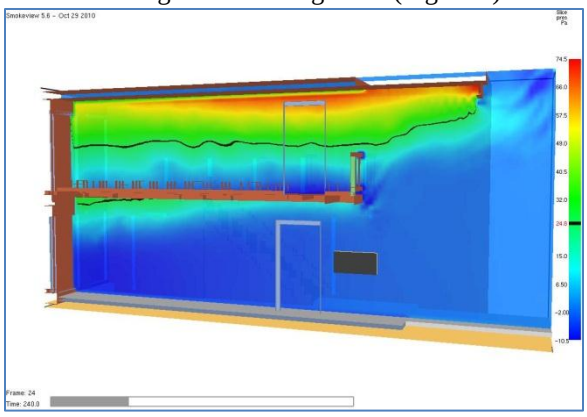

Figure 9: FDS 4.07 Model with Pressure slice through doors 2 and 6.

During the post flashover stages, the door closures would probably not fully latch the door closed, however; it would have reduced the flow of hot gases by closing the door part way adding seconds to the egress time.

Models conducted with gypsum sheetrock walls, concrete flooring did not produce flashover conditions or untenable conditions outside #6 & #7 within the central corridor even for initiating fires at 500 kW.

DISCUSSION AND SUMMARY

People are often creatures of habit. When there is a disturbance around their residence, people will often open doors to investigate. Opening a door onto a raging fire with a face full of heat and smoke will cause most people to panic and they may not shut the door. Closures probably would have reduced the amount of smoke and gasses into the apartment enough to allow everyone to escape.

Improvements such as carpet to the entry corridor are often not subject to permitting and inspection. However, in some situations the addition of carpet can add several hundred pounds of fuel load to a building space during a fire. Carpet of a commercial grade that passed the ASTM E 648 with a critical heat flux of Class I (0.45 watts per square centimeter), would have been ignited based on the FDS Modeling because of the radiant heat flux from the combustible siding and overhead wood deck and roof.

The fire occurred in a public access area. The size of the fire was not any larger than could be expected from a small garbage can, beauty bark fire or other accidental fire nor would it be different if a fire occurred in an individual apartment and the door was opened and left open into the common corridor.

Combustible siding is commonly used and is allowed in some kinds of exiting but it is not acceptable when the construction is changed such that it becomes “inside” and encloses the only exit for more than 10 people. Without the plywood siding, the fatalities would not have happened.

The lack of a second exit pathway to the public right of way for all units was a factor to the units on the second level.

A sprinkler system would have stopped the fire and is required for the rebuilt apartment building.

Two features of modeling that would be helpful would be developing a common material database of normal materials, especially for the newer versions of FDS. Second, the ability to show realistic flames at the appropriate location would be helpful to show to witnesses for validation of the model.

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