Woodward Willis Building

Fire & Life Safety Analysis
June 15, 2017
Overview

- Project Building Description
- Occupancy Evaluation
- Egress Analysis
- Construction Review
- Fire Protection Systems
- Fire Alarm System
- Performance Based Design Review
- Conclusions & Recommendations
Building Description

Location: Detroit Michigan

Multi Function Building:
- Technical College
- Mercantile
- Parking Garage
Applicable Codes & Standards

- 2015 International Bldg. Code (IBC)
- NFPA 10, Standard for Fire Extinguishers
- NFPA 72, National Fire Alarm and Signaling Code, (2016 Ed.)
Construction Review

Occupancies/Uses of Building
- E - Education
- M - Mercantile
- S-2 - Parking Garage

Building Notes
- Construction Type: IIB
- Area: 40,704 Sq. Ft.
- Height: 42’-0” (3 Levels)
- Total Occ. Load: 610 ppl.
- 100% Sprinklered
Occupancy Evaluation

1st Floor
- Parking Garage
- Stores

2nd & 3rd Floor
- Classrooms & Labs

<table>
<thead>
<tr>
<th>Function</th>
<th>Floor Area per person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>50 net</td>
</tr>
<tr>
<td>Mercantile</td>
<td>30</td>
</tr>
<tr>
<td>Parking Garage</td>
<td>200</td>
</tr>
<tr>
<td>Lobby</td>
<td>15</td>
</tr>
<tr>
<td>Mechanical</td>
<td>300</td>
</tr>
</tbody>
</table>
1st Floor Occupancy Layout

Space Designations
- PARKING GARAGE
- MERCANTILE
- MECHANICAL
- LOBBY

1st FLOOR

PARKING GARAGE
8152 Sq. Ft.
40 People

LOBBY
388 Sq. Ft.
25 People

STORE 12
1082 Sq. Ft.
36 People

STORE 11
2168 Sq. Ft.
72 People

MECHANICAL
364 Sq. Ft.
1 Person
Occupancy Evaluation

2nd & 3rd Floor Occupancy Layout

Space Designations
- EDUCATIONAL
- RESTROOMS

CLASSROOM 21
2726 Sq. Ft.
54 People

CLASSROOM 22
2774 Sq. Ft.
55 People

CLASSROOM 23
3726 Sq. Ft.
74 People

STAIRS
ELEVATOR
CORRIDOR

2nd & 3rd FLOOR
# Occupancy Evaluation

## 1st Floor

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>LOAD FACTOR</th>
<th>AREA (SQ FT)</th>
<th>OCC. LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARKING GARAGE</td>
<td>200 sq. ft. per person</td>
<td>8152</td>
<td>40 People</td>
</tr>
<tr>
<td>MERCANTILE</td>
<td>30 sq. ft. per person</td>
<td>N/A</td>
<td>108 People</td>
</tr>
<tr>
<td>MECHANICAL</td>
<td>300 sq. ft. per person</td>
<td>364</td>
<td>1 Person</td>
</tr>
<tr>
<td>LOBBY</td>
<td>15 sq. ft. per person</td>
<td>388</td>
<td>25 People</td>
</tr>
</tbody>
</table>

Total Occupancy = 174 People Total

## 2nd & 3rd Floor

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>LOAD FACTOR</th>
<th>AREA (SQ FT)</th>
<th>OCC. LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATIONAL</td>
<td>50 sq. ft. per person</td>
<td>11,180</td>
<td>222 People Per Floor</td>
</tr>
</tbody>
</table>

Total Occupancy = 618 people
Egress Evaluation

**Egress Widths**

- **Stairways** (IBC 1005.3.1)
  - .3” per Occupant
  - Min. 44” Wide
  - 306 Occ. Max per Floor (2 Installed @ 46” Wide)

- **Doorways** (IBC 1005.3.2)
  - .2” per Occupant
  - 360 Occ. Max per Floor (Installed 36” Doors)

- **Corridors** (IBC 1020)
  - Min. Width of 6’-0”
  - Dead Ends < 50’-0”
  - Required: 72”
  - Provided: 72”
  - Required: 23”
  - Provided: 36”
  - Required: 34”
  - Provided: 46”
Egress Evaluation

Obstructions

- 3rd Floor Corridor
  - Parked Bike
Egress Evaluation

Exit Arrangements

- IBC Table 1006.2.1
  - 2 exits required for rooms exceeding 49 occupants for Groups E & M.

- IBC Table 1006.3.1
  - 2 exits required per floor for 1-500 occupants.

- IBC 1007.1.1
  - Where 2 exits are required, they must be at least 1/3 the diagonal of the room apart.
Egress Evaluation

Exit Arrangements

2nd & 3rd FLOOR

CLASSROOM 21/31
2,726 Sq. Ft.
54 People

CLASSROOM 22/32
2,774 Sq. Ft.
55 People

CLASSROOM 23/33
3,726 Sq. Ft.
74 People

CLASSROOM 24
1,954 Sq. Ft.
39 People
Egress Evaluation

Travel Distance Requirements

- Travel Distances per IBC Table 1017.2

- Fully Covered by Sprinklers
  - Education: 250’-0”
  - Mercantile: 250’-0”
  - Parking Garage (S-2): 400’-0”
Egress Evaluation

Exit Signage

- **IBC 1013.1**
  - Minimum Distance: 100’-0

- **IBC 1013.3**
  - Exit Signs Shall Be Internally or Externally Illuminated

- **Exceptions:**
  - No Sign required in rooms with one exit
Egress Evaluation

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174 People Total
### Egress Evaluation

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**2nd & 3rd FLOOR**

- CLASSROOM 21: 54 People
- CLASSROOM 22: 55 People
- CLASSROOM 23: 74 People
- CLASSROOM 24: 39 People

- Illuminated Exit Sign
- Travel Distance: 124'
- Travel Distance: 152'
Structural Evaluation

- **IBC 1023.7**
  - Exit Stairwells must be 1 Hr. Fire Rated.

- **IBC Table 508.4**
  - 1 Hour Fire Rating Between S-2 & E/M

- **IBC 713.4**
  - 1 Hour Fire Rating for Shaft Enclosures

- **IBC 707.3.10**
  - 2 Hour Fire Rating horizontal separation between S-2 and E.
Structural Evaluation

Structural Fire Ratings

- 1 Hour Rating
- 2 Hour Rating
- 2 Hour Rating (Horizontal Separation)

1st Floor Fire Rating Layout

PARKING GARAGE
8152 Sq. Ft.

STORE 11
2168 Sq. Ft.

STORE 12
1082 Sq. Ft.

LOBBY
388 Sq. Ft.
Structural Evaluation

Structural Fire Ratings

- 1 Hour Rating
- 2 Hour Rating

2nd & 3rd Floor Fire Rating Layout
Fire Sprinkler System

Sprinkler System Overview

- Water Supply
- Type of System
- Riser Room Detail
- Design Criteria
- Sprinkler System Layout
- Hydraulic Calculation Overview
Fire Sprinkler System

Water Supply

Supply Flow Test Data

<table>
<thead>
<tr>
<th>Test Conducted By</th>
<th>Detroit Water &amp; Sewage Department</th>
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<tbody>
<tr>
<td>Test Witnessed By</td>
<td>N/A</td>
</tr>
<tr>
<td>Date of Test</td>
<td>4/1/2014</td>
</tr>
<tr>
<td>Time of Test</td>
<td>0900</td>
</tr>
<tr>
<td>Location</td>
<td>Woodward - Willis - NW Corner</td>
</tr>
<tr>
<td>Static Pressure</td>
<td>40.000</td>
</tr>
<tr>
<td>Residual Pressure:</td>
<td>36.000</td>
</tr>
<tr>
<td>Flow</td>
<td>1701.00</td>
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<tr>
<td>Outside Hose Flow</td>
<td>250.00</td>
</tr>
</tbody>
</table>
Fire Sprinkler System

Type of Sprinkler System

- Wet System
  - Wet Sprinklers For Enclosed Building
  - Dry Pendants for Exposed Parking Garage

- No Hose Valve Standpipe
  - 3rd Floor < 30’-0” above ground.
  - Less than 1,000 Occupants
  - Per, IBC Section 905

Dry Barrel Sprinkler
Fire Sprinkler System

Riser Room Detail

Floor Control Detail

Slide 23
Fire Sprinkler System

Hydraulic Design Criteria

- **Light Hazard**
  - Density = 0.10 / 1500
  - Design Area = 225 Sq.Ft.

- **Ord. Hazard Grp. I**
  - Density = 0.15 / 1500
  - Design Area = 130 Sq.Ft.

- **Ord. Hazard Grp. II**
  - Density = 0.20 / 1500
  - Design Area = 130 Sq.Ft.

- Classrooms
  - Parking Garage
  - Mechanical Room
  - Retail Stores
Fire Sprinkler System

1st Floor Sprinkler Layout
Fire Sprinkler System

2nd & 3rd Floor Sprinkler Layout
Fire Sprinkler System

- NFPA 13: 11.2.3.2.3
  Area Reduction

### Hydraulic Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Remote Area - 3rd Floor Classroom</td>
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<tr>
<td>OCCUPANCY CLASSIFICATION</td>
<td>Light Hazard</td>
</tr>
<tr>
<td>DENSITY</td>
<td>0.100gpm/ft² for 939.40ft² (Actual 1006.92ft²)</td>
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<tr>
<td>TOTAL HOSE STREAMS</td>
<td>100.00</td>
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<tr>
<td>TOTAL HEADS FLOWING</td>
<td>7</td>
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<tr>
<td>K-FACTOR</td>
<td>5.6</td>
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<tr>
<td>TOTAL WATER REQUIRED</td>
<td>208.76</td>
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<tr>
<td>TOTAL PRESSURE REQUIRED</td>
<td>29.785</td>
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<tr>
<td>SAFETY MARGIN (psi)</td>
<td>+10.133 (25.4%)</td>
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</table>
Fire Sprinkler System

### Hydraulic Information

<table>
<thead>
<tr>
<th>Remote Area - Parking Garage</th>
<th>Remote Area - Retail Space</th>
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<tbody>
<tr>
<td>OCCUPANCY CLASSIFICATION</td>
<td>Extra Hazard Group I</td>
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<tr>
<td>DENSITY</td>
<td>0.150gpm/ft² for 967.50ft² (Actual 1117.18ft²)</td>
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<tr>
<td>TOTAL HOSE STREAMS</td>
<td>250.00</td>
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<tr>
<td>TOTAL HEADS FLOWING</td>
<td>11</td>
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<tr>
<td>K-FACTOR</td>
<td>5.6</td>
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<tr>
<td>TOTAL WATER REQUIRED</td>
<td>424.67</td>
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<tr>
<td>TOTAL PRESSURE REQUIRED</td>
<td>20.157</td>
</tr>
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<td>SAFETY MARGIN (psi)</td>
<td>+19.536 (49.2%)</td>
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<tr>
<td>OCCUPANCY CLASSIFICATION</td>
<td>Extra Hazard Group II</td>
</tr>
<tr>
<td>DENSITY</td>
<td>0.200gpm/ft² for 1025.75ft² (Actual 1210.01ft²)</td>
</tr>
<tr>
<td>TOTAL HOSE STREAMS</td>
<td>250.00</td>
</tr>
<tr>
<td>TOTAL HEADS FLOWING</td>
<td>11</td>
</tr>
<tr>
<td>K-FACTOR</td>
<td>5.6</td>
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<tr>
<td>TOTAL WATER REQUIRED</td>
<td>428.68</td>
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<tr>
<td>TOTAL PRESSURE REQUIRED</td>
<td>27.423</td>
</tr>
<tr>
<td>SAFETY MARGIN (psi)</td>
<td>+12.264 (30.9%)</td>
</tr>
</tbody>
</table>

![Diagram of Fire Sprinkler System]
Fire Sprinkler System

- **Ps =** 40 psi
- **Pr =** 39.5 psi @ 250 gpm
- **SD =** 108.8 gpm @ 29.8 psi
- **SD+Hose =** 208.8 gpm @ 29.8 psi
Fire Sprinkler System

Fire Sprinkler Deficiencies
Portable Fire Protection

Fire Extinguishers (NFPA 10)

- Education & Mercantile
  - Design to “Class A” Restrictions
  - Extra Hazard – *Heavy Wood Projects*
    - Maximum Travel Distance: 75’-0”
  - Minimum Rating: **4A:10B:C**

- Parking Garage
  - Design to “Class B” Restrictions
  - Extra Hazard – *Liquid Fuel Fire*
  - Maximum Travel Distance: 50’-0”
  - Minimum Rating: **4A:80B:C**

Amerex Model B456
10# ABC Dry Chem
4A:80B:C Rating
Portable Fire Protection
1st Floor Fire Extinguisher Layout

Fire Extinguisher

Travel Distance = 75'-0 MAX (Stores)
Travel Distance = 50'-0 MAX (Parking Garage)

1st FLOOR
Portable Fire Protection
2nd & 3rd Floor Fire Extinguisher Layout

Travel Distance = 75'-0" MAX

F.E. Fire Extinguisher

2nd & 3rd FLOOR

CLASSROOM 21
2726 Sq. Ft.

CLASSROOM 22
2774 Sq. Ft.

CLASSROOM 23
3726 Sq. Ft.

CLASSROOM 24
1954 Sq. Ft.

Travel Distance = 46'-0"
Portable Fire Protection

Fire Extinguisher Issues

![Extinguisher in corner](image1)

![Extinguisher in corner](image2)
Fire Alarm System

Detection Devices

Water Flow Switch
- Sprinkler Activation

Duct Detector

Smoke Detector
- Photoelectric Type

Pull Station
- Manually Operated
Fire Alarm System

Fire Alarm Control Panel

- Notifier Addressable FACP
Fire Alarm System

Fire Alarm Notification Devices

Audio/Visual Alarm
135 cd
105 dBA

Visual Alarm
60 cd
Fire Alarm System

Fire Alarm Drawing 1st Floor
Fire Alarm System

Fire Alarm Drawing 2nd & 3rd Floors

- VISUAL DEVICE
- AV AUDIBLE / VISUAL DEVICE
- MF MANUAL PULL STATION
- $ SMOKE DETECTOR

CLASSROOM 21
CLASSROOM 22
CLASSROOM 23
CLASSROOM 24
ELEV
CORRIDOR
STAIRS

Slide 39
Smoke Damper System

Dampers to close upon smoke detector activation.

Reduce smoke movement throughout building.

Duct Damper
Performance Based Analysis

Goals
- Survivability and protection of occupants
- Safe emergency crowd movement

Objectives
- System Effectiveness

Design Criteria
- Design Fire Scenario 1 per NFPA 101 (2015 ed.)
- Building is at full occupant capacity
- Assume sprinkler system is inoperable
Performance Based Analysis

Fire Scenarios

- Scenario 1
  - Cardboard Desk

- Scenario 2
  - Wooden Models
Performance Based Analysis

Selected Design Fire Scenario

- Scenario 1: Cardboard Desk
- Fuel Load: 20 Cardboard Boxes
- Location: 3rd Floor Classroom
- Ignition Source: Electrical Malfunction
Performance Based Analysis

Fire Growth Parameters

- HRR: 1200 kW
- Burn Time: 10 Minutes

Proven: ~800 kW
SFPE Hdbk: Fig. 36.29

Proven: ~1600 kW
Suppression of Wood Cribs with Sprinkler Sprays: Test Results
William D. Walton (1988)

Proposed: 1200 kW
Performance Based Analysis

3rd Floor Cardboard Desk: HRR Curve

Time (sec)

HRR (kW)
Performance Based Analysis

Tenability Criteria

Method 1:
- Maintain 10 meter Visibility
- Maintain a Temperature below 60°C
- Maintain CO concentration below 1400 ppm

Method 2:
- Required Safe Egress Time
Performance Based Analysis

Location of Fire

3rd FLOOR

CLASSROOM 31
CLASSROOM 32
CORRIDOR
CLASSROOM 33
CLASSROOM 34

Fire Location
Performance Based Analysis

Pyrosim Model
Performance Based Analysis

Pyrosim Model: 3rd Floor
Performance Based Analysis

Visibility

- Visibility is lost in Room at 335 seconds
Performance Based Analysis

Visibility

- Visibility is lost in West Hall at 425 seconds
Performance Based Analysis

Temperature

- Room Temp exceeds 60°C at 345 seconds
Performance Based Analysis

Carbon Monoxide

- CO never exceeds 150 ppm.
Performance Based Analysis

Performance Summary

- Times where conditions are no longer tenable to occupants.

<table>
<thead>
<tr>
<th>Tenability Exceeded (sec)</th>
<th>Classroom 32</th>
<th>3rd Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility</td>
<td>335</td>
<td>425</td>
</tr>
<tr>
<td>Temperature</td>
<td>345</td>
<td>-</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Room ASET: 335 seconds
Performance Based Analysis

Performance Summary

- Room ASET: 335 seconds
- 3rd Floor ASET: 425 seconds
Performance Based Analysis

RSET

- Required Safe Egress Time
  - $T_w = 138$ seconds (Detector Activation Time)
  - $T_r = 5$ seconds (Delay until alarm)
  - $T_d = 40$ seconds (SFPE Hndb Table 64.9)
  - $T_m$ (3rd Floor) = 240 seconds (Path Finder)
    - $T_m$ (Room) = 135 seconds (Path Finder)

\[ t_e = t_w + t_r + t_d + t_m \]

where
- $t_e$ = Evacuation time (s)
- $t_w$ = Time of receiving warning (s)
- $t_r$ = Time to respond to warning (s)
- $t_d$ = Delay time, preparing to evacuate (s)
- $t_m$ = Movement time (s)

From SFPE Hnbk: Chapter 38
Performance Based Analysis

RSET

- Required Safe Egress Time
  - Room RSET: 318 seconds
  - 3rd Floor RSET: 423 seconds

From SFPE Hnbk: Chapter 38
Performance Based Analysis

Evacuation Conclusion

- RSET vs ASET

<table>
<thead>
<tr>
<th></th>
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<th>3rd Floor</th>
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<tr>
<td>RSET</td>
<td>318</td>
<td>423</td>
</tr>
<tr>
<td>ASET</td>
<td>335</td>
<td>425</td>
</tr>
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Performance Based Analysis

Recommendations

- Reduce Fire hazards by implementing fire resistive materials.
- Reduce Occupant loads for rooms with One Exit.
- Have Fire Extinguishers available and hung properly.
- Install Ceiling tiles in Parking Garage to maintain fire rating/Insulation.
- Maintain clear egress paths in corridors and exit stairways.
Questions & Comments