Warren J Baker Center for Science and Mathematics
Fire & Life Safety Analysis

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Applicable Codes & Resources

• Life Safety Code 2015
• International Building Code 2015
• NFPA 13 2013
• NFPA 72 2013
• SFPE Handbook 5th Edition
General Building Outline

- Finished Construction 2013
- Type 1-B Fire Resistive Construction
- Actual Building Height 108’
- Defined Building Height 64’ Non-High rise
- 188,400 G.S.F
- 6 Floors, 5 Story Atrium
Structural Fire Protection

• Steel Frame
  • Moment Frame
  • W-Flange Beams, Girders, and Columns
  • Light Weight Concrete Decking
  • Hollow Steel Sections
# Structural Fire Protection

## Occupancy Separation
- B to A-3: 1-hour
- B to H-3: 1-hour
- B to S-1: No Requirement
- S-1 to H-3: 1-hour
- S-1 to S-2: 1-hour

## Building Elements
- Steel Structure Frame: 2-hour
- Exterior Bearing Walls: 2-hour
- Interior Bearing Walls: 2-hour
- Interior Nonbearing Walls: 0-hour
- Floor Construction: 2-hour
- Roof Construction: 1-hour
Occupancy Classification, Load, and Egress Capacity Floor 1

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Floor 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Number of Exits: 3</td>
</tr>
<tr>
<td>Seminar Rooms, Terraces, Lecture Rooms</td>
<td>Occupant Load: 394</td>
</tr>
<tr>
<td>Business</td>
<td>Exit Capacity: 1530</td>
</tr>
<tr>
<td>Offices, Lecture Rooms, Labs</td>
<td>Travel Distance (ft.): 166</td>
</tr>
<tr>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td>Storage Areas, Mechanical Rooms, Electrical Rooms</td>
<td></td>
</tr>
<tr>
<td>Hazardous</td>
<td></td>
</tr>
<tr>
<td>Hazardous Material Storage</td>
<td></td>
</tr>
</tbody>
</table>
Occupancy Classification, Load, and Egress Capacity Floor 2

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Assembly</th>
<th>Seminar Rooms, Terraces, Lecture Rooms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Business</td>
<td>Offices, Lecture Rooms, Labs</td>
</tr>
<tr>
<td></td>
<td>Storage</td>
<td>Storage Areas, Mechanical Rooms, Electrical Rooms</td>
</tr>
<tr>
<td></td>
<td>Hazardous</td>
<td>Hazardous Material Storage</td>
</tr>
</tbody>
</table>

Floor 2

- Number of Exits: 9
- Occupant Load: 693
- Exit Capacity: 2894
- Travel Distance (ft.): 180
## Occupancy Classification, Load, and Egress Capacity Floor 3

### Occupancy Type

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Seminar Rooms, Terraces, Lecture Rooms</td>
</tr>
<tr>
<td>Business</td>
<td>Offices, Lecture Rooms, Labs</td>
</tr>
<tr>
<td>Storage</td>
<td>Storage Areas, Mechanical Rooms, Electrical Rooms</td>
</tr>
<tr>
<td>Hazardous</td>
<td>Hazardous Material Storage</td>
</tr>
<tr>
<td></td>
<td><strong>EXITS</strong></td>
</tr>
</tbody>
</table>

### Floor 3

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Number of Exits</td>
<td>6</td>
</tr>
<tr>
<td>Occupant Load</td>
<td>623</td>
</tr>
<tr>
<td>Exit Capacity</td>
<td>1600</td>
</tr>
<tr>
<td>Travel Distance (ft.)</td>
<td>211</td>
</tr>
</tbody>
</table>

![Floor Plan](image)
**Occupancy Classification, Load, and Egress Capacity Floor 4**

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Seminar Rooms, Terraces, Lecture Rooms</td>
</tr>
<tr>
<td>Business</td>
<td>Offices, Lecture Rooms, Labs</td>
</tr>
<tr>
<td>Storage</td>
<td>Storage Areas, Mechanical Rooms, Electrical Rooms</td>
</tr>
<tr>
<td>Hazardous</td>
<td>Hazardous Material Storage</td>
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</table>

**Floor 4**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Number of Exits</td>
<td>5</td>
</tr>
<tr>
<td>Occupant Load</td>
<td>476</td>
</tr>
<tr>
<td>Exit Capacity</td>
<td>1506</td>
</tr>
<tr>
<td>Travel Distance (ft.)</td>
<td>203</td>
</tr>
</tbody>
</table>
Occupancy Classification, Load, and Egress Capacity Floor 5

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Floor Type</th>
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</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Seminar Rooms, Terraces, Lecture Rooms</td>
</tr>
<tr>
<td>Business</td>
<td>Offices, Lecture Rooms, Labs</td>
</tr>
<tr>
<td>Storage</td>
<td>Storage Areas, Mechanical Rooms, Electrical Rooms</td>
</tr>
<tr>
<td>Hazardous</td>
<td>Hazardous Material Storage</td>
</tr>
</tbody>
</table>

### Floor 5
- **Number of Exits**: 3
- **Occupant Load**: 352
- **Exit Capacity**: 870
- **Travel Distance (ft.)**: 205

10
Occupancy Classification, Load, and Egress Capacity Floor 6

<table>
<thead>
<tr>
<th>Occupancy Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Seminar Rooms, Terraces, Lecture Rooms</td>
</tr>
<tr>
<td>Business</td>
<td>Offices, Lecture Rooms, Labs</td>
</tr>
<tr>
<td>Storage</td>
<td>Storage Areas, Mechanical Rooms, Electrical Rooms</td>
</tr>
<tr>
<td>Hazardous</td>
<td>Hazardous Material Storage</td>
</tr>
</tbody>
</table>

**Floor 6**

- Number of Exits: 3
- Occupant Load: 249
- Exit Capacity: 870
- Travel Distance (ft.): 197
## Occupancy Classification, Load, and Egress Capacity Floor 7

### Occupancy Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly</td>
<td>Seminar Rooms, Terraces, Lecture Rooms</td>
</tr>
<tr>
<td>Business</td>
<td>Offices, Lecture Rooms, Labs</td>
</tr>
<tr>
<td>Storage</td>
<td>Storage Areas, Mechanical Rooms, Electrical Rooms</td>
</tr>
<tr>
<td>Hazardous</td>
<td>Hazardous Material Storage</td>
</tr>
<tr>
<td>EXITS</td>
<td></td>
</tr>
</tbody>
</table>

### Diagram

The diagram shows the layout of Floor 7 with the various occupancy types color-coded for easy identification. The EXITS are marked with red circles on the map.
Fire Alarm and Detection Systems

• Emergency Voice Alarm Communication System (EVACS)
• No Mass Notification System (MNS)
• Fire Alarm Control Panel located Level 1 (Room 122)
• Automatic Smoke Detection System not required (CBC)
• Beam Detectors for Atrium
• Spot Type Smoke Detectors located at Atrium Horizontal Exits & Elevators
Fire Alarm and Detection

- Detection Device Types
  - Smoke Detectors
  - Beam Detectors
  - Duct Detectors
  - Heat Detectors
  - Pull Stations
  - Water Flow Switches

- Notification Devices
  - Speaker Strobes
  - Strobes
  - Speakers
Fire Suppression System

- Fully Sprinkled Building
- Class 1 standpipe system
- Quick Response Sprinklers
- Upright and Pendant used

Light Hazard
- K=5.6, 155 Deg. F
- Density- 0.10gpm/ft^2
- Max Design Area- 1500ft^2
- Max Coverage per sprinkler- 225ft^2

Ordinary Hazard Group 1
- K=5.6, 155 Deg. F
- Density- 0.15gpm/ft^2
- Max Design Area- 1500ft^2
- Max Coverage per sprinkler- 130ft^2
Fire Suppression System

- **Flow**
  - Static 60psi
  - Residual 55psi
  - 914gpm

- **10% Reduction**
  - Static 54psi
  - Residual 49psi
  - 914gpm

- **Fire Pump**
  - Located on Floor 1 (Room 122)
  - 60 Horsepower
  - 113psi
  - 750gpm
Fire Suppression System

- Hydraulic Calculations
  - 6th Floor most remote area to base of riser
  - 103psi at 275gpm
  - 150gpm hose stream required
  - 425gpm at 103psi
Interior Finishes Requirements

• The interior finish requirements are on Table A.10.2.2 of the LSC.

• Business occupancies: Exits and Exit Corridors require Class A or B

• Other spaces require Class A, B, or C

(1) Class A interior wall and ceiling finish — flame spread index, 0–25 (new applications); smoke developed index, 0–450.
(2) Class B interior wall and ceiling finish — flame spread index, 26–75 (new applications); smoke developed index, 0–450.
(3) Class C interior wall and ceiling finish — flame spread index, 76–200 (new applications); smoke developed index, 0–450.
(4) Class I interior floor finish — critical radiant flux, not less than 0.45 W/cm².
(5) Class II interior floor finish — critical radiant flux, not more than 0.22 W/cm², but less than 0.45 W/cm².
(6) Automatic sprinklers — where a complete standard system of automatic sprinklers is installed, interior wall and ceiling finish with a flame spread rating not exceeding Class C is permitted to be used in any location where Class B is required, and Class B interior wall and ceiling finish is permitted to be used in any location where Class A is required; similarly, Class II interior floor finish is permitted to be used in any location where Class I is required, and no interior floor finish classification is required where Class II is required. These provisions do not apply to new detention and correctional occupancies.
(7) Exposed portions of structural members complying with the requirements for heavy timber construction are permitted.

See corresponding chapters for details.
Smoke Management System

- 5 Story Atrium
- Floors 2 though 6
- Passive System
- Naturally Ventilated
- Fully Sprinkled and Smoke Detection Systems
Smoke Management System

- Activation within the Atrium
  - Smoke Detector
  - Beam Detector
  - Sprinkler Activation
- Actions
  - Deactivate Magnetic Door Holders
  - Activate Motorized Door Openers
  - Activate Alarm
  - Activate Alarm Dialer to Notify Police
Performance Based Analysis

• Life Safety Code 2015
  • Method 1
    • set detailed performance criteria
    • ensure that occupants are not incapacitated by fire effects.
    • establishing tenability limits

• Design Fire Scenarios
  • Scenario 6
    • most severe fire resulting from the largest possible fuel load characteristic of the normal operation of the building
  • Scenario 8
    • is a fire origination in ordinary combustibles in a room or area with each passive or active fire protection system independently rendered ineffective.
Performance Based Analysis

• Egress Analysis
  • Occupant Characteristics
    • Awake, Alert, and Oriented
    • Ages 18 – 60
    • 3.9 ft./sec
  • Limitations
    • Handicaps
    • Assistance
Performance Based Analysis

• RSET
  • Sum
    • $td = \text{time to detection (52 sec)}$
    • $tn = \text{time to notification (10 sec)}$
    • $tp-e = \text{pre- movement time (60 sec)}$
    • $te = \text{time to evacuate (60 sec)}$
  • Total RSET 182 sec

• Table 64.5 SFPE Handbook 5th Edition
  • Sharma
  • 6 story business occupancy
  • Mean of 28 seconds

• Time to Notification
  • 10.12.1 NFPA 72
Performance Based Analysis

- Tenability Criteria
  - Visibility 10m
  - Temperature 60℃
  - Toxicity (1000 ppm)

### Table 61.3
Allowable smoke densities and visibility that permits safe escape

<table>
<thead>
<tr>
<th>Degree of familiarity with inside of building</th>
<th>Smoke density (extinction coefficient)</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfamiliar</td>
<td>0.15 l/m</td>
<td>13 m</td>
</tr>
<tr>
<td>Familiar</td>
<td>0.5 l/m</td>
<td>4 m</td>
</tr>
</tbody>
</table>

### Table 63.9
$C \cdot t$ product exposure doses for incapacitation and death by CO for different species at rest and during light activity

<table>
<thead>
<tr>
<th>Species</th>
<th>Incapacitation</th>
<th>CO at rest ppm \cdot min</th>
<th>CO light activity ppm \cdot min</th>
<th>Fatal</th>
<th>CO at rest ppm \cdot min</th>
<th>CO light activity ppm \cdot min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human 70 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baboon ~20 kg</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Macaque 3-4 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rat ~ 300 g</td>
<td></td>
<td></td>
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</tbody>
</table>
Performance Based Analysis

- Design Fire 1
  - Sprinkler Controlled
  - Common Area in Atrium
  - Couch

- Design Fire 2
  - No Sprinkler
  - Couch
  - In the Atrium
Performance Based Analysis

• Design Fire Criteria
  • $Q = 1400\text{kW}$
  • $\alpha = 0.012 \text{ kW/s}^2$
  • $Q = \alpha t^2$
  • $\tau = 342\text{s}$
  • Soot yield 0.227 g/g
  • CO yield 0.031 g/g
Performance Based Analysis

- Scenario 1 Results
  - CO concentration 25 ppm
  - Temperature 30°C
  - Visibility 10m (170 sec)
  - Sprinkler Activation (157 sec)
Performance Based Analysis

• Scenario 2 Results
  • CO concentration 28 ppm
  • Temperature 33°C
  • Visibility 10m (170 sec)
Recommendations

- Use a Mechanical Smoke Management System instead of Naturally Ventilated Smoke Management System.
  - Due to loss of visibility criteria

<table>
<thead>
<tr>
<th>Floor</th>
<th>Visibility (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>170</td>
</tr>
<tr>
<td>4</td>
<td>205</td>
</tr>
<tr>
<td>5</td>
<td>230</td>
</tr>
<tr>
<td>6</td>
<td>250</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floor</th>
<th>Visibility (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>430</td>
</tr>
<tr>
<td>5</td>
<td>330</td>
</tr>
<tr>
<td>6</td>
<td>170</td>
</tr>
</tbody>
</table>
Recommendations

- Do a phased evacuation plan utilizing the EVACS system
  - East wing 2min 40sec
  - Atrium 40 sec
  - West wing 2 min 50 sec
Conclusion

• Compliant
  • Egress compliant with NFPA 101 LSC 2015
  • Sprinkler wet pipe system compliment with NFPA 13
  • Alarm systems comply with NFPA 72
  • Structural fire protection elements comply IBC and UL listings
  • Performance criteria met
    • CO concentration
    • Temperature

• Non-compliant
  • Heat detectors not located in elevator shafts
  • Visibility Criteria within Space
Questions?