Henderson Engineers, Inc. Building

Alex Ataiyan
FPE 596
Spring 2016
Building Description

• Located in Lenexa, KS (Kansas City)
• Construction completed in 2000
• Designed in accordance with the 1994 UBC or 1997 UBC
  - Will be evaluated against 2012 IBC
• Four story office building owned by Henderson Engineers, Inc. (HEI)
• 131,528 Square Feet
• 52’-6” above grade
Occupancy Classification – IBC Chapter 3

<table>
<thead>
<tr>
<th>Use</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Space</td>
<td>Group B</td>
</tr>
<tr>
<td>Conference Rooms</td>
<td>Group A-3^a</td>
</tr>
<tr>
<td></td>
<td>Group B^b</td>
</tr>
<tr>
<td>Kitchens (Bistros)</td>
<td>Group A-3^a</td>
</tr>
<tr>
<td>Fitness Area (The Pit)</td>
<td>Group B^a</td>
</tr>
</tbody>
</table>

^aAccessory Occupancy (IBC 508.2)
^bAssembly rooms that serve less than 50 occupants or are less than 750 square feet are to be considered as Group B. (IBC 303.1.2)

HEI:
- Open office design
  - Some enclosed offices
- Conference rooms and “Bistros” on each floor
  - Company meetings, happy hours
- Daily group workouts in “The PIT”
  - 10 per class

Other Tenants:
- University of Phoenix (Offices)
- Accounting Office
Construction Type – IBC Chapter 5

TYPE II-A, Group B (IBC Table 503)

Limited to:
- 65’ in height – 52’-6”
- 5 stories – 4 stories
- 37,500 square feet per floor

Floor 1: 34,235 square feet
Floor 2: 32,431 square feet
Floor 3: 32,431 square feet
Floor 4: 32,431 square feet

Maximum allowable area: 37,500 ft² x 3 = 112,500 ft² – 131,528 ft²

Height and Area Modifications Required

Allowable area per floor: 140,625 ft²
Total building allowable area: 421,875 ft²
# Rating Requirements – IBC Chapters 6 & 7

<table>
<thead>
<tr>
<th>Building Element</th>
<th>Type II-A* (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Structural Frame</td>
<td>1</td>
</tr>
<tr>
<td>Bearing Walls:</td>
<td></td>
</tr>
<tr>
<td>Exterior</td>
<td>1</td>
</tr>
<tr>
<td>Interior</td>
<td>1</td>
</tr>
<tr>
<td>Non-bearing Walls:</td>
<td>0</td>
</tr>
<tr>
<td>Interior</td>
<td>1</td>
</tr>
<tr>
<td>Exterior</td>
<td>1</td>
</tr>
<tr>
<td>Floor Construction and Secondary Members</td>
<td>1</td>
</tr>
<tr>
<td>Roof Construction and Secondary Members</td>
<td>1</td>
</tr>
</tbody>
</table>

### Other Rating Requirements

- **Elevator Shafts and Interior Exit Stairs**
  - Constructed as a 2-hour fire-rated barrier when connecting 4 or more stories (IBC 713.4).
  - Exit passageways require same rating as stairs (IBC 1023.3).

- **Horizontal Assemblies**
  - Require same rating as shafts that are supported (IBC 707.5.1).

- **Fire Riser Room**
  - Constructed as a 1-hour fire-rated barrier (IBC 913.2.1).
Fire Separation Distance—IBC Chapters 6 & 7

• Greater than 30’ to center of public way on all sides
  o Exterior fire-resistance ratings not required (IBC Table 602)
  o Unlimited openings (IBC Table 705.8)
Fire Separation Distance– IBC Chapters 6 & 7
Ratings – 1st Floor
Ratings – 2nd Floor

OVERALL 2ND FLOOR PLAN

1/8" = 1'-0"
Ratings – 3rd Floor
Ratings – 4th Floor
Fire Suppression System– IBC Chapter 9

- Light Hazard Occupancy
- Wet system
  - Tree system
  - 1”-1.5” branchlines, 4” mains
  - 5.6K ordinary temperature sprinklers
- Standpipes present in stairwells
- No fire pump
REMOTE AREA 1
4TH FLOOR - NORTH CORNER

9 SPRINKLERS

DENSITY: .10 GPM/SQFT
DESIGN AREA OF DISCHARGE: 1561 SQFT
GPM DISCHARGE 151 GPM
RESIDUAL PRESSURE AT BOR: 51.74 PSI
HOSE STREAM ALLOWANCE: 250 GPM
Fire Suppression System– IBC Chapter 9

WATER SUPPLY ANALYSIS
Static: 67.00 psi Resid: 55.00 psi Flow: 850.0 gpm

1. Available pressure
   64.01 psi @ 401.0 gpm
2. Required pressure
   51.74 psi @ 401.0 gpm
   A. Source Supply Curve
   B. System Demand Curve
   C. Available at Source
### Fire Alarm System– IBC Chapter 9

<table>
<thead>
<tr>
<th>Devices</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Alarm Control Panel</td>
<td>SW Entrance</td>
</tr>
<tr>
<td>Smoke/Heat Detectors</td>
<td>Elevator Lobbies</td>
</tr>
<tr>
<td>Water Flow Switch</td>
<td>Risers</td>
</tr>
<tr>
<td>Duct Detectors</td>
<td>HVAC</td>
</tr>
<tr>
<td>Manual Pull Stations</td>
<td>Exits and stair entrances</td>
</tr>
<tr>
<td>Horn/Strobe Notification Devices</td>
<td>Throughout</td>
</tr>
</tbody>
</table>

- **Emergency Voice capability**
  - Not utilized
- **Emergency Facilitators**
Fire Alarm System– IBC Chapter 9

Notification devices missing, or over-spaced on each floor
Occupant Load & Egress Capacity – 1st Floor

OVERALL 1ST FLOOR PLAN
1/30" = 1'-0"

TOTAL OCCUPANT LOAD: 427 PERSONS
TOTAL EGRESS CAPACITY: 1800 PERSONS

KEY
- 100% OCCUPANT LOAD
- 75% OCCUPANT LOAD
- 50% OCCUPANT LOAD
- 25% OCCUPANT LOAD

CAL POLY
Fire Protection Engineering
Occupant Load & Egress Capacity – 2nd Floor

OVERALL 2ND FLOOR PLAN
TOTAL OCCUPANT LOAD: 342 PERSONS
TOTAL EGRESS CAPACITY: 478 PERSONS

STAIR 1 DOOR
2
34"
170

STAIR 1
.2
.3
50"
166

STAIR 2 DOOR
.2
34"
170
146

STAIR 2
.3
44"

STAIR 2 DOOR
.2
3

STAIR 3 DOOR
2
34"
170
166

STAIR 3
.3
50"

KEY
EXIT
EGRESS CAPACITY
FACTOR
OFFICE SPACE (1:100)
CONFERENCE ROOMS (1:10)
MEP (1:900)
 OCCUPANT LOAD

CAL POLY
Fire Protection Engineering
Occupant Load & Egress Capacity – 3rd Floor

OVERALL 3RD FLOOR PLAN

TOTAL OCCUPANT LOAD: 600 PERSONS
TOTAL EGRESS CAPACITY: 478 PERSONS

STAIR 1 DOOR
.2
.3
34"
50"
170
166

STAIR 1

STAIR 2 DOOR
2
34"
170

STAIR 2
.3
44"
146

STAIR 3
.2
34"
170

STAIR 3 DOOR
.3
50"
166

KEY
EXIT
EGRESS CAPACITY FACTOR
WIDTH
BISTRO (1/15)
CONFERENCE ROOMS (1/15)
OFFICE SPACE (1/10)
STAIR 1
STAIR 2
STAIR 3
STAIR 3 DOOR

CAL POLY
Fire Protection Engineering
Occupant Load & Egress Capacity – 4th Floor

OVERALL 4TH FLOOR PLAN
TOTAL OCCUPANT LOAD: 463 PERSONS
TOTAL EGRESS CAPACITY: 476 PERSONS

CAL POLY
Fire Protection Engineering
Egress Analysis – IBC Chapter 10

Occupant load exceeds egress capacity on 4th Floor
Overall egress capacity on 1st Floor is exceeded
Reduce from 0.3 & 0.2 to 0.2 & 0.15 (907.5.2.2)

<table>
<thead>
<tr>
<th>Floor</th>
<th>Occupant Load</th>
<th>Total Egress Capacity (No Emergency Voice/Alarm)</th>
<th>Total Egress Capacity (With Emergency Voice/Alarm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>427</td>
<td>1800</td>
<td>2400</td>
</tr>
<tr>
<td>2</td>
<td>342</td>
<td>478</td>
<td>672</td>
</tr>
<tr>
<td>3</td>
<td>600</td>
<td>478</td>
<td>672</td>
</tr>
<tr>
<td>4</td>
<td>463</td>
<td>478</td>
<td>672</td>
</tr>
</tbody>
</table>
Egress Analysis – IBC Chapter 10

• Assumed max unimpeded speeds
• Max distance to stair – 95’
• Travel distance on the stairs – 18.5’/flight
• Landing distance – 10’/landing
• Additional travel to an exit – 60’
• Pre-action & Action time – 36 seconds, 30 seconds (Table 4.2.1 of the 20th edition of the NFPA Fire Protection Handbook – Mid-rise office building, mean pre-movement time)
• Travel Time – 5 minutes, 23 seconds

RSET – 6 minutes, 29 seconds
Egress Analysis – IBC Chapter 10

RSET – 7 minutes, 27 seconds
Prescriptive Conclusion and Recommendations

Prescriptive deficiencies
- As-builts indicate improper rating of horizontal assemblies
- Notification devices are missing or over-spaced
- Occupant load exceeds egress capacity

Recommendations:
- Install new notification devices in identified locations
- Install speakers throughout and utilize FACP emergency voice capabilities
Performance Based Analysis

Worst Case Scenario – Company Meeting/Happy Hour

• Occupant load is increased on 4th floor to 600 occupants (137 more occupants than max occupant load)

• Fire starts in “Quiet Room”
  o Fuel load consists of an upholstered sofa
  o No smoke detection in room
  o One sprinkler in room
  o Door is open

• Fire spreads, exposes occupants to heat and smoke

• Stair 2 is affected
Performance Based Analysis
Performance Based Analysis

Start of a happy hour on 4th Floor
Pathfinder simulation calculated egress at 8 minutes, 7 seconds
NFPA method calculated egress at 8 minutes, 20 seconds
Performance Based Analysis

Occupants are queued at exits at 160 seconds
Performance Based Analysis

- “Fast” Fire: $\alpha = 0.0469\ kW/s^2$
- Peak HRR 3100 kW
- Sprinkler activation will limit HRR
  - 80s to activation
  - HRR of 300 kW maintained upon sprinkler activation
Performance Based Analysis

- Modeled in FDS
- FDS results will determine:
  - Visibility: >10m
  - Toxicity: <1400ppm CO
  - Thermal effects: <120°C

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum Visibility within Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a small room</td>
<td>2 m</td>
</tr>
<tr>
<td>Other rooms</td>
<td>10 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical Products</th>
<th>5 Minutes Exposure</th>
<th>30 Minutes Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Incapacitation</td>
<td>Death</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>6000 ppm</td>
<td>12000 ppm</td>
</tr>
<tr>
<td>Low Oxygen</td>
<td>&lt; 13 %</td>
<td>&lt; 5 %</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>&gt; 7 %</td>
<td>&gt; 10 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode of Heat Transfer</th>
<th>Symptom</th>
<th>Exposure Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation</td>
<td>Severe skin pain</td>
<td>2.5 (kW/m²)</td>
</tr>
<tr>
<td>Conduction</td>
<td>Skin burns 1 s of contact (metal)</td>
<td>60°C</td>
</tr>
<tr>
<td>Convection</td>
<td>Skin/lungs affected by hot gas in &gt; 60 s</td>
<td>120°C</td>
</tr>
<tr>
<td>Convection</td>
<td>Skin/lungs affected by hot gas in &lt; 60 s</td>
<td>190°C</td>
</tr>
</tbody>
</table>

Tenability data from
“Literature Review of Performance-Based Fire Codes and Design Environment” Hadjisophocleous, et al.
Performance Based Analysis
Performance Based Analysis
Performance Based Analysis – Results

Temperature is 21.3 C at exit after 500 seconds
Performance Based Analysis – Results

CO concentration is 66ppm at exit after 500 seconds
Performance Based Analysis – Results

Visibility is less than 10m at exit after 160 seconds
Performance Based Analysis – Conclusion

- ASET < RSET at 160 seconds
- Occupants are already near exit after 160 seconds
- AHJ makes final decision