FPE 596 Culminating Project
Prescriptive and Performance Analysis of Husky Place
Prescriptive and Performance Analysis

Objectives

1. To demonstrate that the Project Building Fire and Life Safety Systems satisfy applicable prescriptive code requirements

2. To describe how the Fire and Life Safety Systems perform when challenged by two credible fire scenarios
Codes and Standards Applied

- National Building Code of Canada*
Project Building

Site Plan
Building Occupancy

Basement

- Assembly (Fitness)
  - $A = 180 \text{ m}^2$
  - Off-Load Factor (OLF) = 4.6
  - Occupants = 39

- Assembly (less conc)
  - $A = 175 \text{ m}^2$
  - OLF = 4.6
  - Occupants = 125

- Storage
  - $A = 191 \text{ m}^2$
  - OLF = 46.5
  - Occupants = 4

Exit up to Main Floor discharge

Exit up to grade level discharge

1 hr FRR
## Structural Fire Protection

### Fire Rating

<table>
<thead>
<tr>
<th>Building Elements</th>
<th>Type II A</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>Nonbearing walls and partitions</td>
<td></td>
</tr>
<tr>
<td>Interior</td>
<td>0</td>
</tr>
<tr>
<td>Floor construction and associated secondary members</td>
<td>1</td>
</tr>
<tr>
<td>Roof construction and associated secondary members</td>
<td>1</td>
</tr>
</tbody>
</table>
Fire Suppression Systems

Hydrant Test
Static = 79 psig
Residual = 63 psig
@ 1835 gpm

Connection to Municipal Water Supply

Fire Department Connection
Fire Suppression Systems

Building Riser Diagram
Fire Suppression Systems

Sprinkler System Design Basis

<table>
<thead>
<tr>
<th>Location</th>
<th>Hazard</th>
<th>Design Density (gpm/sq ft)</th>
<th>Design Area (sq ft)</th>
<th>Coverage per Sprinkler (sq ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main, 2nd and 3rd Floors</td>
<td>Light Hazard</td>
<td>0.07</td>
<td>3075</td>
<td>225</td>
</tr>
<tr>
<td>Basement and Penthouse</td>
<td>Ordinary Hazard</td>
<td>0.15</td>
<td>1500</td>
<td>116</td>
</tr>
</tbody>
</table>

CAL POLY
Fire Protection Engineering
Fire Suppression Systems

*Special Features*

- Pre-action, double interlocked, sprinkler system in Server Room
- Glycol system in shipping/receiving where high risk of freezing
Fire Suppression Systems

Water Supply and Demand

Municipal Water Supply
\[ P_{\text{static}} = 79 \text{ psi}; \]
1836 gpm @ 63 psi

System Demand
226 gpm @ 48 psi
plus 250 gpm hose allowance
Fire Detection and Alarm System

Building Fire Alarm System

Fire Alarm Panel (Main Entrance)

Fire Alarm Annunciator Panel (Building Manager’s Office)
Fire Detection and Alarm System

Detection and Notification Devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Type</th>
<th>Manufacturer</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoke Detector</td>
<td>Photoelectric – Light Scattering</td>
<td>Edwards</td>
<td>SIGA-PS Photo</td>
</tr>
<tr>
<td>Duct Smoke Detector</td>
<td>Photoelectric – Light Scattering</td>
<td>Edwards</td>
<td>SIGA-SD</td>
</tr>
<tr>
<td>Heat Detector</td>
<td>Fixed Temperature (57 °C)</td>
<td>GE – Edwards</td>
<td>SIGA-HFS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Device</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Operating Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horn/Strobe combination</td>
<td>Edwards</td>
<td>G1-HDVM</td>
<td>101.4 dBA 75 cd</td>
</tr>
<tr>
<td>Horn/Strobe combination</td>
<td>Edwards</td>
<td>GE 757 WP</td>
<td>98 dBA at 10 ft</td>
</tr>
</tbody>
</table>
Fire Detection and Alarm System

Smoke Detection and Control

Four duct smoke detectors are located in the west and east Penthouse Mechanical rooms in the inlet and return air ducts.
### Building Egress Capacity

<table>
<thead>
<tr>
<th>Floor</th>
<th>Egress Element</th>
<th>Egress Element Capacity (persons)</th>
<th>Total Available/Required (persons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basement</td>
<td>Exit Stairway Door (West)</td>
<td>171</td>
<td>300/168</td>
</tr>
<tr>
<td></td>
<td>Exit Stair (West)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exit Stairway Door (East)</td>
<td>171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exit Stair (East)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double Doors off Atrium</td>
<td>355</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double Doors off Cafeteria</td>
<td>355</td>
<td></td>
</tr>
<tr>
<td></td>
<td>East</td>
<td>211</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Main Entrance</td>
<td>211</td>
<td>1825/220</td>
</tr>
<tr>
<td></td>
<td>South Adjacent to Main</td>
<td>351</td>
<td></td>
</tr>
<tr>
<td></td>
<td>South East</td>
<td>171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shipping and Receiving</td>
<td>171</td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>Exit Stairway Door (West)</td>
<td>171</td>
<td>300/176</td>
</tr>
<tr>
<td></td>
<td>Exit Stair (West)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exit Stairway Door (East)</td>
<td>171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exit Stair (East)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>Exit Stairway Door (West)</td>
<td>171</td>
<td>300/140</td>
</tr>
<tr>
<td></td>
<td>Exit Stair (West)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exit Stairway Door (East)</td>
<td>171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exit Stair (East)</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

*Capacity Factor (mm/person)  Door = 5, Stair = 7.6 (LSC)*
## Building Egress

### Life Safety Code Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Path Limit</td>
<td>Common path of travel limited to 23 m in Assembly and 30 m in Business. Longest = 15 m on the east side of the Atrium</td>
<td>LSC Table A 7.6</td>
</tr>
<tr>
<td>Corridor Dead Ends</td>
<td>Dead Ends in Assembly limited to 6.1 m and Business 15 m; Longest dead end found in Business ≈ 8.5 m</td>
<td>(LSC Table A 7.6)</td>
</tr>
<tr>
<td>Number and Location of Exits</td>
<td>Occupant Load ≥ 50 more than one exit is required. All area of Assembly and Business meet the requirement. There are two separate exits per story.</td>
<td>LSC 7.4.1.2, LSC 7.4.1.2</td>
</tr>
<tr>
<td>Exit Access Travel Distance</td>
<td>Assembly limited to 76 m and Business to 91 m. Maximum travel distance found ≈ 25 m</td>
<td>LSC 7.6 Table A.7.6</td>
</tr>
<tr>
<td>Corridor Width</td>
<td>Business minimum clear width of corridors shall be 1120 mm. Some encroachment open office space</td>
<td>LSC 12.2.3.8 and 39.2.3.2</td>
</tr>
<tr>
<td>Distance Between Exits</td>
<td>Half the diagonal 105.3 m/2 = 52.7 m</td>
<td>LSC 7.5.4</td>
</tr>
</tbody>
</table>

*Fully protected by automatic sprinklers*
Building Evacuation Time

**Calculated and Simulated**

- **Flow Capacity Stairs**
  - 69 persons/min

- **Flow Capacity Doors**
  - 43 persons/min
  *Exit door is most restrictive egress component

- **Movement Speed**
  - 0.54 m/s

- **Travel Distance Between Floors**
  - 10.4 m

- **Travel Time Between floors**
  \[
  \frac{10.4 \text{ m}}{0.54 \text{ m/s}} = 19.6 \text{ s (0.3 min)}
  \]

- **Population Above the Main Floor**
  - 316 persons

- **Estimated Building Evacuation Time**
  \[
  \left( \frac{316 \text{ persons}}{43 \text{ person/min}} \right) \div 2 \text{ exits} + 0.3 \text{ min} = 4 \text{ minutes}
  \]

- \[
  T_{\text{evacuation}} = T_{\text{delay}} + T_{\text{movement}}
  \]

- \[
  T_{\text{evacuation}} = 1 + 4.4
  \]

- \[
  T_{\text{evacuation}} = 5.4 \text{ minutes}
  \]

---

**Simulation:** Egress April 9 v1
**Version:** 2016.1.0229
**Mode:** Steering (Flow-limited)
**Total Occupants:** 491
**Exit Times (s):**
- **Min:** 1.6
- **Max:** 431.4
- **Average:** 153.6
- **StdDev:** 136.0
Performance Based Analysis

Tenability Criteria

1. Thermal Effects – 60 °C
2. Toxicity – carbon monoxide concentration <1000 ppm
3. Visibility – 10 m at elevation of 1.8 m

Goal $ASET > RSET$
Fire Scenario 1

Fire Inside East Exit Stairway Enclosure
Fire Inside East Exit Stairway Enclosure

*Design Fire Growth and Heat Release Rate*

- **Fire Growth Rate**
  - $t^2$ model
  - $\alpha = 0.1 \text{ kW/s}$
  - Maximum HRR = 275 kW

- **Assumptions**
  - Exit doors closed
Fire Inside East Exit Stairway Enclosure

Assessing Sprinkler Response
Fire Inside East Exit Stairway Enclosure

Sprinkler Response

![Temperature Graph]

![3D Image]
Fire Inside East Exit Stairway Enclosure

Temperature

t = 60 s

120 C

60 C

120 C

60 C

t = 100 s

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Fire Inside East Exit Stairway Enclosure

Oxygen Limited Conditions

\[ t = 100 \text{ s} \]
Fire Inside East Exit Stairway Enclosure

Summary and Conclusion

Conclusion

1. The building water-based fire protection and fire detection and alarm systems work effectively when challenged by the trash bag fire

2. ASET > RSET
Fire Scenario 2
Chair Fire in the Third Floor Open-Plan Office Area

Rational for Selection
1. The high frequency of fires caused by electric space heaters (NFPA)
2. An office safety policy which is generally disregarded
Chair Fire

Design Fire

Calculated HRR

Heat Release Rate (kW)

Time (second)

HRR (kW)

Time (s)
Chair Fire

Location
Chair Fire

*FDS Model - Detector Locations*

- Horizontal Axis of the Beam Detector
- Vertical Axis of the Layered Zoning Device
- Three-Panel Workstation Fire
- TOP Ceiling, Layer A
- Third Floor
- Exit Door
Chair Fire

Sprinkler Response (FDS Device and DETACT Model)

T_{act} = 57 \, ^\circ C
Chair Fire

Temperature ($t = 160$ s; x plane slice view)
Chair Fire
Carbon Monoxide \((t = 160 \text{ s}; \text{x plane slice view})\)
Chair Fire

Smoke Level and % Obscuration

Distance Above Floor (m)

Time (s)

% Obscuration

40 s

1.8 m
Chair Fire

Smoke Detector Activation (DETACT Model)

![Graph showing Chair Fire with Smoke Detector Activation (DETACT Model)]
Chair Fire

Summary

Smoke Level Descends to 1.8 m
Smoke Obscuration 100%
Evacuation Delay Time
Sprinkler Activation Center Plume (FDS)
Smoke Detector $r = 3$ m (DETACT)
Sprinkler Activation $r = 3$ m (FDS)

Time (s)
Chair Fire

Conclusion and Recommendation

It can be concluded that:
• HRR of the chair fire may be insufficient to activate detection systems before untenable smoke conditions develop in the egress path
• ASET < RSET and occupants may not be able to safely evacuate from the building

It is recommended that:
• the hazards associated with the use of electric space heaters are reinforced with the building occupants
Conclusion and Recommendations

*Prescriptive Analysis*

- Fire Detection and Alarms Systems ✓
- Egress Components ✓
- Water-Based Fire Protection Systems ✓
- Structural Fire Protections Systems ✓

*Performance Analysis*

- Trash Bag Fire in the East Exit Stairway Enclosure ✓
- Chair Fire Third Floor, Open Office Area ✗
END