Presentation Overview

• Introduction
  • Applicable Codes & Standards
• Prescriptive-Based Design Review
  • Egress
  • Fire Protection
• Performance-Based Design Review
  • Egress Modeling
  • Fire Modeling
• Recommendations
Introduction

- Lawrence Berkeley National Laboratory (LBNL)
  - Operated by the University of California
  - Contracted to the Department of Energy
  - One of 10 Office of Science laboratories
- Department of Energy is Authority Having Jurisdiction (AHJ)
  - AHJ is delegated to LBNL staff
Location Overview

General Vicinity Map

San Francisco Bay

Oakland Airport

San Francisco

Oakland

Cal Berkeley

Wang Hall

LBNL Site Map

Chamberlain Road

McMillan Road

Segre Road

Chu Road

Seaborg Road

Cyclotron Road

Centennial Drive

Glaser Road

Calvin Road

Lee Road

Strawberry Gate

ACCESS TO ROAD

10 km

10 miles

N

Fire Protection Engineering
Building Overview

- High performance computers, offices, assembly and mechanical space
- Four stories built on a hill
- Construction completed in 2015
- Hayward Fault
- Significant wildland fire threat
Applicable Codes & Standards

• Department of Energy (DOE)
  • DOE Order 420.1B
  • DOE Standard 1066
  • 2010 NFPA 13, *Standard for the Installation of Sprinkler Systems*
  • 2007 NFPA 72, *National Fire Alarm Code*
  • 2009 NFPA 75, *Electronic Equipment*

• State of California
  • 2007 California Building Code
Building Details

• Building Construction
  • Type II-B (CBC)

• Building Height
  • Allowable: 55 feet; 75 feet AS
  • Actual: 71 feet

• Building Area
  • Allowable: 23,000 sq. ft.
    (69,000 sq. ft. AS)
  • Actual: 34,431 sq. ft. per floor

• Group B Occupancy
Occupancy

• Total Occupant Load = 1,140
• Actual number of people on Mechanical & Computing Level is lower
• Use of “classroom” load factor is questionable

<table>
<thead>
<tr>
<th>Floor</th>
<th>Occupancy</th>
<th>Factor</th>
<th>Occupant Load</th>
</tr>
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<tbody>
<tr>
<td>Roof</td>
<td>Mechanical</td>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>Second</td>
<td>Assembly</td>
<td>15</td>
<td>185</td>
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<tr>
<td>Second</td>
<td>Office</td>
<td>100</td>
<td>259</td>
</tr>
<tr>
<td>Second</td>
<td>Mechanical</td>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>First</td>
<td>Assembly</td>
<td>15</td>
<td>138</td>
</tr>
<tr>
<td>First</td>
<td>Office</td>
<td>100</td>
<td>256</td>
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<tr>
<td>First</td>
<td>Classroom</td>
<td>20</td>
<td>63</td>
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<tr>
<td>First</td>
<td>Mechanical</td>
<td>300</td>
<td>3</td>
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<tr>
<td>Computing</td>
<td>Office</td>
<td>100</td>
<td>16</td>
</tr>
<tr>
<td>Computing</td>
<td>Mechanical</td>
<td>300</td>
<td>131</td>
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<tr>
<td>Mechanical</td>
<td>Mechanical</td>
<td>300</td>
<td>81</td>
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</table>
Mechanical Level
Second Floor
Roof Level
Means of Egress

- Two remote exits on each floor
  - Roof Level has one exit
- Travel distance, common path, dead end corridors acceptable
- Central stair and main entry doors are not considered an exit
  - Convenience opening per NFPA 101
  - “Escalator exception” equivalency approved by AHJ
Structural Fire Protection

• Structural frame, exterior walls not fire-resistance rated
• North, south stairways are one-hour rated
• Floor/ceiling assemblies two-hour rated on Mechanical, Computing, First floors
• Roof meets Class A construction
Interior Finish

• Group B Building
  • Exit enclosures: Type B
  • Corridors: Type C
  • Rooms: Type C

• Computing Level
  • Hot Aisle plastic airflow shields
Smoke Control

- Fire alarm will shut down HVAC
  - This includes exhaust fans on Computing Level
- Building does not have any smoke exhaust
Fire Detection & Alarm

- Siemens XLS FACU
- Initiating Devices
  - Smoke detection, waterfall, manual
- Notification Appliances
  - Strobes, speaker strobes
- Installation is compliant with NFPA 72
- Mass notification/ EVACS not required at time of construction
  - System is capable of mass notification
Fire Suppression

• Fire Sprinklers
  • Wet-pipe 0.20 gpm/ft² over 3,000 ft²
  • Pre-action 0.20 gpm/ft² over 3,900 ft²
  • Wet-pipe 0.30 gpm/ft² over 1,350 ft²
  • Pre-action system is single interlock installed at ceiling and underfloor

• Standpipes
  • Combination automatic wet Class 3

• Special Hazard
  • No gaseous fire suppression
Water Supply

Pressure [psi]

Sprinkler demand with hose allowance: 1,076 gpm at 86.7 psi
Extra Hazard Group 1 (Wet)

Sprinkler demand: 576 gpm at 86.7 psi
Extra Hazard Group 1 (Wet)

1,400 gpm at 79 psi residual

Sprinkler demand with hose allowance: 1,130 gpm at 60 psi
Ordinary Hazard Group 1 (Preaction)

Sprinkler demand: 880 gpm at 60 psi
Ordinary Hazard Group 1 (Preaction)

Flow [gpm]
Performance-Based Analysis

• Compare RSET vs. ASET
  • How long does it take to evacuate the building?
  • Show that available time is greater than required time
• Fire Modeling
• Egress Modeling
Pathfinder Egress Model

- Evacuation time: 5 minutes 32 seconds
- Assume 1,140 occupants
- All exits available

- Central stair and main lobby doors are not used
Egress Hand Calculations

• Occupant characteristics will vary
• Pre-movement time may be several minutes
  • Office levels are not equipped with detection
  • Building Emergency Team will assist

<table>
<thead>
<tr>
<th>Floor</th>
<th>Controlling Element</th>
<th>Population</th>
<th>Time to Exit [min]</th>
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<tbody>
<tr>
<td>First North</td>
<td>North Stair Door</td>
<td>230</td>
<td>3.59</td>
</tr>
<tr>
<td>First South</td>
<td>South Stair Door</td>
<td>230</td>
<td>3.59</td>
</tr>
<tr>
<td>Second North</td>
<td>North Stair Door</td>
<td>224</td>
<td>3.50</td>
</tr>
<tr>
<td>Second South</td>
<td>South Stair Door</td>
<td>224</td>
<td>3.50</td>
</tr>
</tbody>
</table>
Tenability Criteria

- Carbon monoxide below 1,000 ppm
  - Allows for 28 minutes of egress
- Visibility
  - Above 10 meters
- Temperature below 60°C
- Radiant heat flux below 2.5 kW/m²
Design Fire

• First Floor adjacent to south exit
• Effectively blocks one of two exits
• RSET = 11 minutes
  • 1.5 Safety Factor
  • Pathfinder results
FDS Model

- Individual offices are modeled as obstructions
- Ceiling-level beams included near chair
- $D^*/dx = 4.16$
FDS Model: Design Fire

- One chair is modeled
  - Chair meets TB-117
- Max heat release rate is 2000 kW
- Model based on polyurethane foam

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<tbody>
<tr>
<td>Heat of Combustion</td>
<td>24.4 kJ/g</td>
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<tr>
<td>Heat Capacity ($c_p$)</td>
<td>1.4 kJ/kg-K</td>
</tr>
<tr>
<td>Density ($\rho$)</td>
<td>20 kg/m³</td>
</tr>
<tr>
<td>Thermal Conductivity ($k$)</td>
<td>0.034 W/m-K</td>
</tr>
<tr>
<td>Heat of Reaction</td>
<td>1,960 KJ/kg</td>
</tr>
<tr>
<td>CO Yield</td>
<td>0.03 g/g</td>
</tr>
<tr>
<td>Soot Yield</td>
<td>0.23 g/g</td>
</tr>
</tbody>
</table>

Babrauskas, Chapter 26
SFPE Handbook, 5th Ed.
FDS Model: Design Fire

• Actual FDS Heat Release Rate Curve
  • Does not reach expected maximum heat release rate
Analysis: Design Fire

• DETACT: 142 seconds for sprinkler activation (Approximate)
• FDS: 162 seconds for sprinkler activation (Approximate)
• Occupant movement may not begin until fire alarm activates
  • Alarm will activate upon waterflow
  • Approximately 210 seconds after fire ignition
• Visibility will drop below tenability limit near the fire source after activation of the sprinkler
Analysis: Design Fire

Smoke View Visibility

- Measured at 1.83 meters
- Does drop below 10 meters
Recommendations

• Verify sufficient water supply
• Detail BET responsibilities in fire safety plan
• Further evaluation needed for Central Stair
  • Shaft protection would provide for greater fire safety
• Determine impact of storage in computing area
• Determine if area smoke detection on office levels would be appropriate
Conclusion

- Overall design is code compliant and acceptable
- The time of day of the fire may impact outcome
- Smaller computers provides more space
- Questions?