JENSEN HUGHES/Cal Poly Fire Protection Engineering Department

Energy Storage Systems Design Challenge

SUPDET 2018

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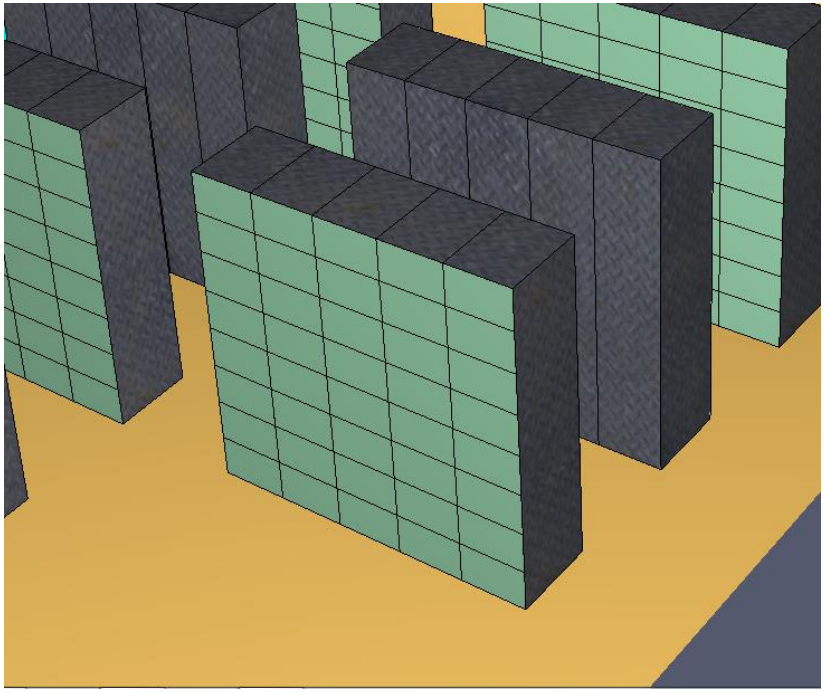
Presentation Outline

- Project Introduction
- Fire Scenarios
- FDS Analysis
- Building Fire Safety Strategy
  - Building Structural Performance
  - Occupant Evacuation
  - Fire Suppression/Detection Systems
    - Aqueous Vermiculite Dispersion
    - Early Warning Aspirating Smoke Detection
  - Fire Fighter Operations
- Future Research
- Conclusion
- Questions and Answers

Fire Scenarios

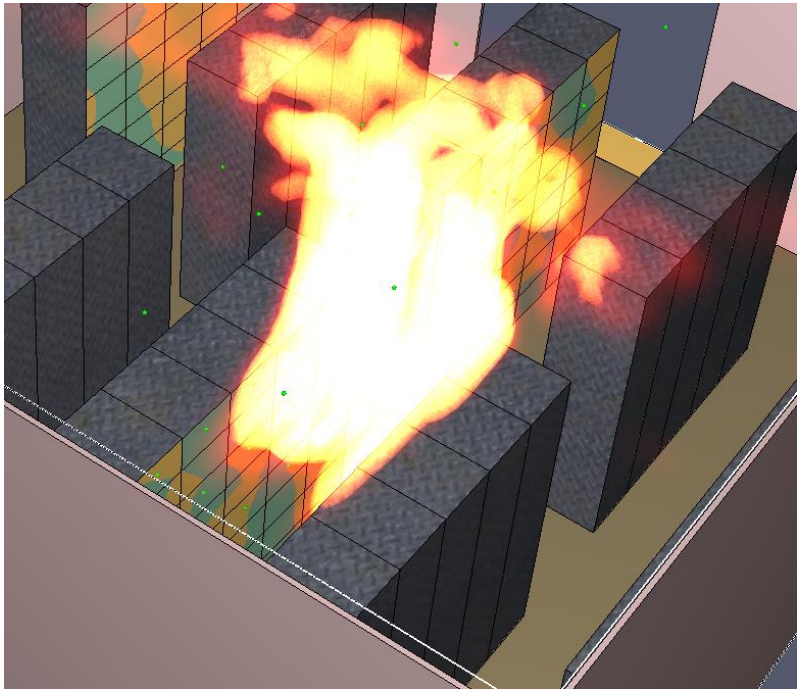
- 3 configurations modeled:
  - Doors closed
  - Double doors open
  - Floor to Ceiling Window open on the North side wall
- FDS Modeling:
  - Each scenario assumes suppression methods fail
  - Goal - to illustrate long term structural effects
  - Simple models

FDS Modeling



- Each rack split into 8 trays
- Represented as a surface burner
- Ignition assumed from thermal runaway occurrence in one tray
- Additional trays ignite at 100˚ C

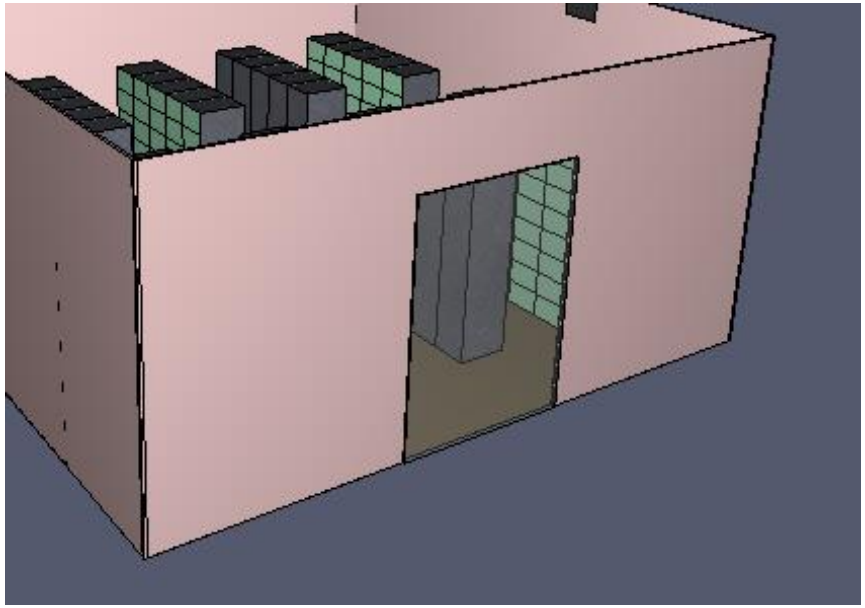
FDS Modeling

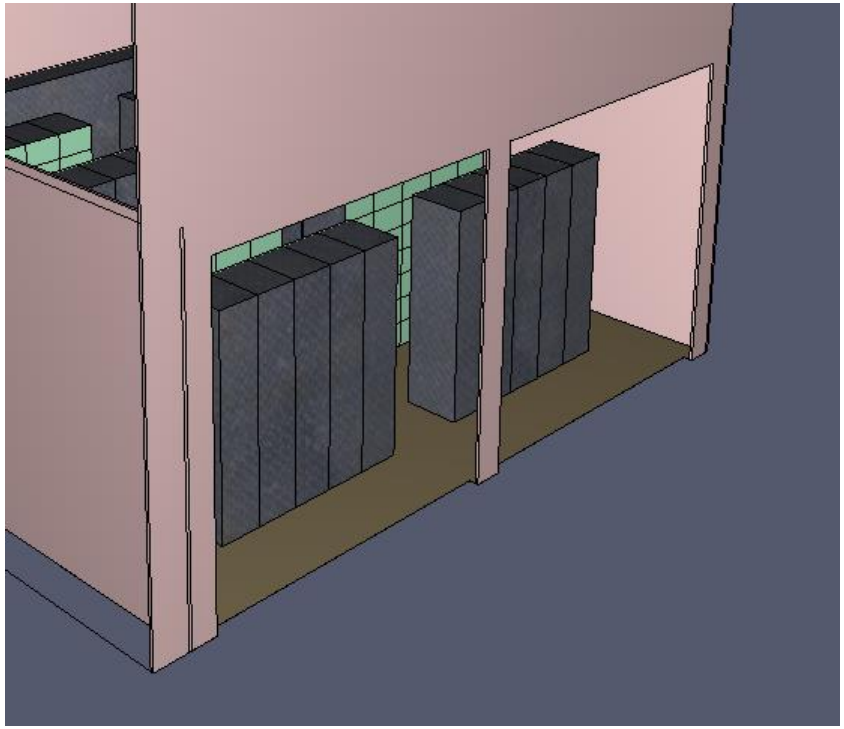


- HRR data per shelf: [1]
  - PHRR - 220 kW
  - Time to max – 18 min
  - THR – 225 MJ
- Goal: evaluate long-exposure effects on structure
  - Finite difference model for ceiling slab

[1] C. Grant, “Responding to Electric Vehicle Battery Fires.” Third international Conference on Fire in Vehicles, 2014.

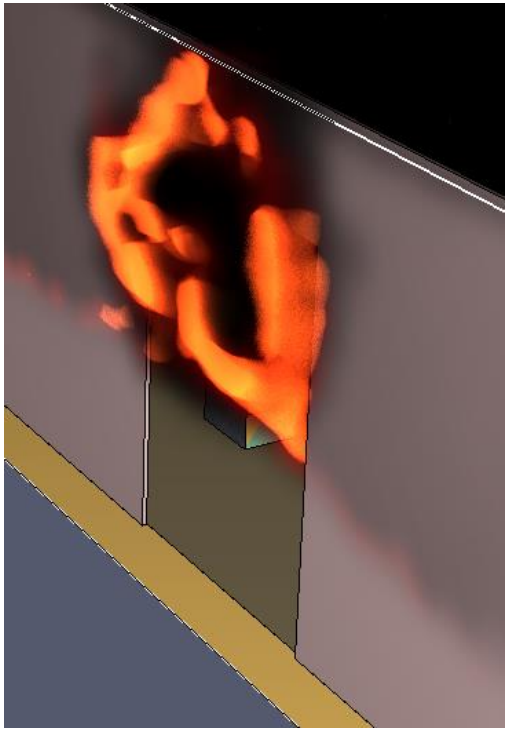
Scenario Configurations





Case 1 – Doors Open

- Room has a set of double doors
- Assume doors left open
- Resulting Fire:
  - 11 MW (24 min)
  - Burnout → 2.1 hours

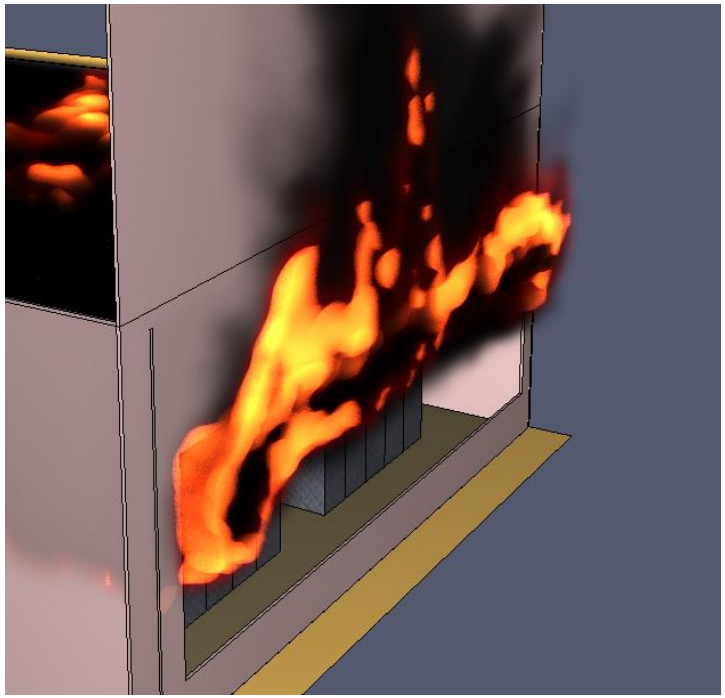


Case 2 – Window Ventilation

- Floor to ceiling windows on North face of building

- Assumed open from the start of the model

- Resulting Fire:
  - 36 MW (40 min)
  - Burnout → 52 min



Considerations for window ventilation

Pros

- Products of combustion vent out of the building
- Allows fire fighters flexibility
  - Break windows for controlled ventilation
  - Open doors without backdraft
- Significantly increases the HRR of the fire (ie. time to burnout decreases)

Cons

- Window Plume out to exterior of the building
  - Assuming no façade issues
  - Jeopardize vertical compartmentation
- Harder to starve the fire of oxygen

Building Fire Safety Strategy

- Building Structural Performance
  - $U^*_{fire} \leq \phi R_{fire}$
    - Applied Load ≤ Capacity of the Structural Element
    - First Order Analysis; Finite Difference Method
    - $M_u \leq \phi M_n$
    - $\phi = 0.90$
    - IBC Dead and Live Loads used
  - Assumptions
    - Concrete Reinforced Slab Thickness = 9 inches
    - Steel Reinforcing Area= 5 in^2
    - Slab span = 28 ft.

Building Fire Safety Strategy

- Building Structural Analysis Results

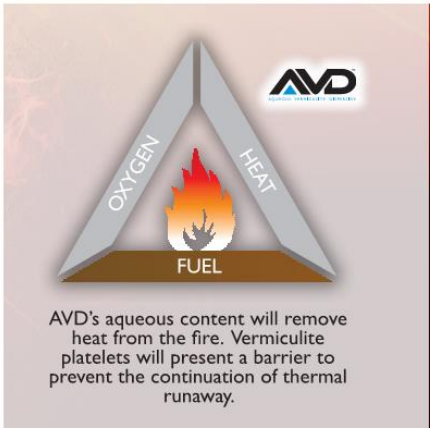
Scenario Number	Applied Load Mu (k-ft)	Load Capacity ΦMn(k-ft)
Door Open	19.90	109.17
Window Open	19.90	45.86

Building Fire Safety Strategy

- Occupant Evacuation
  - Prompt notification of occupants
  - Maintain primary exit route tenability

Building Fire Safety Strategy

- Fire Suppression/Detection Systems
  - Aqueous Vermiculate Dispersion (AVD) System
    - Vermiculite- Aluminum-iron-magnesium silicates
    - Water content cools fire
    - Vermiculite creates fire proof high insulation oxygen barrier
    - Prevents continuation of thermal runaway
    - Smaller volume of agent required



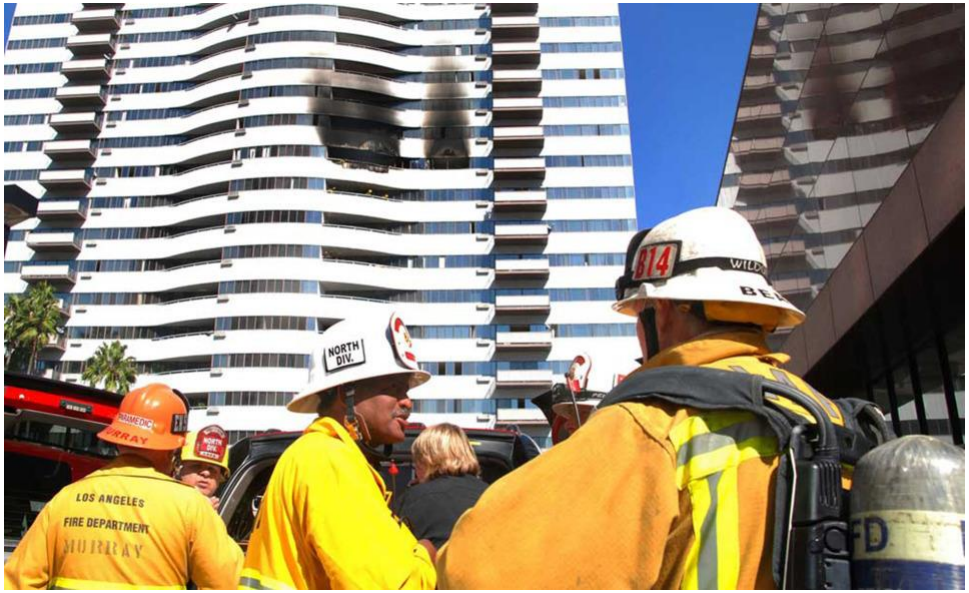
Building Fire Safety Strategy

- AVD System Challenges
  - Local application system
  - Application within battery enclosures

- Fire Detection System
  - Early warning aspirating smoke detection
  - Throughout space and within battery enclosures
    - » Additional challenges could arise in the enclosures

Building Fire Safety Strategy

- Fire Fighter Operations
  - Pre-fire Planning Critical



Future Research

- Application of AVD
- Detection System Design
- Closed Door Scenario
- Modifications to the FDS Models

Conclusion

- ESS are a unique hazard and should be addresses as such
- Preplanning of fire fighting operations is critical
- Other important aspects:
  - Room configuration
  - Fire suppression and detection system
  - Exposure of structural system should be considered

Questions and Answers

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