Design and Protection of High-Rise Building ER&R Systems for Explosive Event

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Presentation Outline

• Blast Load Primer
• Introduction to ER&R Systems
• Best Practices for ER&R System Layout
• Hardening Strategies
Explosive Event

• Size and location of DBTs determined from TARA or similar risk assessment.
  – DBTs often around building perimeter where a VBIED can be located.
  – Smaller DBTs can be located inside the building.
  – Other site-specific locations are possible.
Blast Load Parameters

• Loading functions are typically:
  – Dynamically applied;
  – Have an instantaneous rise to a peak pressure;
  – Have a small duration (on order of msec).

• Impulse (area under curve) is important.

• Other Factors
Exterior Explosions

• Pressure and impulse generally decrease as:
  – DBT size decreases;
  – standoff distance increases;
  – angle of incidence increases (normal = 0°).

• For exterior DBTs, urban environments provide relatively small standoffs.
  – Very high loads at first few floors close to DBT.
  – Load dissipates going up/around the building.
  – Canyon effects.

• **Note that interior components are subject to effects from exterior explosions.**
Interior Explosions

• Interior DBTs would generally be significantly smaller than exterior DBTs.
  – PBIED or screened VBIED vs. unscreened VBIED
  – Public areas vs. screened areas

• However, blast loads may still be high for interior DBTs due to:
  – Small standoffs;
  – Potential for multiple reflections (impulse increases);
  – Potential for gas build-up (impulse increases).
Introduction to ER&R Systems

• ER&R = Emergency, Response, and Rescue
  – Definition may vary.
• In case of an emergency evacuation, these systems allow for:
  – Building tenant egress;
  – First responder access.
• Primary concern is life safety, not continuity of operations.
• Note that protection of these systems is not necessarily required by typical building codes.
ER&R Systems

• Fire Alarm System
• Emergency Voice Communication System
• Vertical Transportation Utilized for ER&R
  – Stairwells
  – Fireman’s Elevator
• Stair and Exit Emergency Lighting
• Stair Pressurization System
• Fire Suppression System
• Additional Supporting Components
ER&R System Notes

- ER&R systems generally maintained with conduits running up height of building.
  - Normal power feeds;
  - Emergency power feeds via generator.
- Some systems may use a panel to control function on a set number of floors.
- Stair Pressurization System also relies on ductwork being functional.
- Tenants may have their own specific area(s) of concerns.
- Ultimately want to implement measures that are not cost-prohibitive.
Representative ER&R System Layout

- Stair A
- Pressurization Shaft A (SP A)
- Other Elevators
- FM Lift
- Normal ER&R Power Feeds
- Emergency ER&R Power Feeds
- Other Shafts or Closets

N1 N2
N3 E3
E1 E2
B
C
D
FCC
Best Practices for ER&R System Layout

• Goals for larger exterior DBTs:
  – Full building evacuation may be required.
  – Maintain functionality of at least XX% of ER&R systems.

• Goals for smaller interior DBTs:
  – Full building evacuation likely not required.
  – Lose no more than XX floors of ER&R systems.

• Consider loss scenarios early in design process.
  – Coordinate as needed with different disciplines.
  – Each discipline may have different objectives.
  – Make layout that works for everybody.

• Be conscious of expected egress times.
Best Practices for ER&R System Layout

• Restrict/Control Access
  – Particularly to mechanical floors and critical equipment rooms on non-mechanical floors.
  – Screening by itself may not be adequate to limit DBT size.

• Diversification and Multiple Pathways
  – Locate and route ER&R systems such that a loss of a portion of the system will not result in a disproportionate loss of that system.
  – Example: If one run serves north side and another serves south side, potentially lose one run, but not both.
  – Increase stairwell widths if feasible.
Diversification and Multiple Pathways

Other Elevators

Stair A

FM Lift

(north side run controls half floor)

(north side run controls half floor)

(north side run controls half floor)

(north side run controls other half floor)

(north side run controls half floor)
Best Practices for ER&R System Layout

• Add Distance (on top of diversification)
  – Do not locate normal and emergency power feed for any given ER&R system within same closet/shaft or otherwise proximately to one another if possible.
  – This ensures one event will not take out an entire ER&R system.
  – Keep stairwells as far apart as possible.
  – Locate generator on higher floors if possible.

• Redundancy
  – Consider providing a redundant power feed for any system that cannot otherwise meet goals.
  – Consider incorporating a redundant FCC.
    • Coordinate with local first responders.
Adding Distance & Redundancy

Other Elevators

Stair A

FCC
C
E1 E2

FM Lift

RFCC

(B FCC located on different floor)
Hardening Strategies

• Generally only use hardening when other strategies are impractical or insufficient.
• Locate ER&R system components within concrete core whenever possible.
  – May not apply to all buildings.
• Hardened walls for high load cases.
  – Provide adequate connections.
• Minimize use of blast doors, if possible.
  – Harden shaft housing normal or emergency power feed to meet goals vs. harden an electrical closet.
  – Shaft construction issues may control.
Conclusions

• Coordinate ER&R protection items with different disciplines early in design to avoid issues down the road.
  – Ensure everyone on design team understands ER&R protection goals.
• Separate systems whenever possible.
• Make use of concrete core when available.
• Use a combination of strategies as needed to economically meet design objectives.
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