Critical Issues in Achieving a Resilient Transportation Infrastructure

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Resilient Infrastructure

- Nature of Terror and Hazard Damage and Focus on Infrastructure Resiliency
- Traditional versus Broader Focus of Engineers
- Extreme Events - Anticipating the Unexpected
- Engineer’s Expanded Role
- Multi-Hazard/Multi-Disciplinary Mitigations
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Human Casualties
- Protect
- Respond
- Recover

Environmental Damage
- Protect
- Respond
- Recover

Psychological Damage
- Protect
- Respond
- Recover

Infrastructure Damage
- Protect
- Respond
- Recover

Terrorist Attack or Natural Hazard

Traditional Engineer’s Role

Word Bank
- Protect – Prevent Harm or Damage
- Respond (Physical) – Prevent Collapse or Limit Damage
- Respond (Human/Ecological) - Incident Management/Rescue
- Recover – Use Redundancy or Restore Operations

Engineer’s Multi-Disciplinary Role in Infrastructure Resiliency
Primary Objectives of Threat and Hazard Mitigation

- Focus resources ($, people, equipment, and time) on mitigating the number of casualties
- Focus resources ($, people, equipment, and time) on shortening the recovery period (Resiliency)
Focus resources on mitigating the number of casualties

- Limit propagation of collapse beyond point of attack/hazard
- Facilitate Evacuation, Rescue and Incidence Management
  Harden egress routes
  Provide incident feedback and protocols for first responders
  Harden life safety systems (alarms, lighting, communications)
  Improve egress way-finding (signage, fluorescent path markings for self evacuation)
Focus resources on shortening the recovery period

- **Pre-disaster Implementation**
  
  Harden, shield, armor, and/or insulate critical elements to prevent catastrophic failure
  
  Provide redundancy to prevent local failure from progressing
  
  Provide redundancy to maintain function of the system at reduced level

- **Post-disaster Implementation**
  
  Make provisions to isolate or limit damage in the response mode
  
  Prepare disaster recovery plans and procedures and arrange for resources to carry them out in an emergency recovery mode
Example of Extreme Event: Fire on a Bridge

Legend: Explosives - *  Fire - *  Collision - *

(Example: Generic Bridge)
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Incendiary Threats

Tanker Truck Fire at I-80 in Wisconsin (3.28.07)

Tanker Truck Fire at I-275 & I-375 in St. Petersburg (3.28.07)
• Overturned tanker truck
  – April 29, 2007
  – 8,600 gallons of gasoline
  – Temperatures > 2,500 °F (1,371 °C)
  – 2 hours for firefighters to get fire under control (using water)
- **Timeline**
  - **3:41am** – tanker overturns
  - **3:55am** – Oakland FD arrives at scene
    - 14 minutes
  - **4:02am** – I-580 overpass collapses
    - 21 minutes
  - Approx. **5:30am** – fire under control

**Oakland Tanker Fire**

Clifford Live Fire and Collapse Video (ABC)
Infrastructure Resiliency
Designing For Extreme Events

- Design Standards
  - Extreme Events
    - Seismic, Vessel Collision
    - Wind (Long Span Bridges Only)
    - Hydrocarbon Fire?
    - Terrorist Attack (Man-Made)?
    - Vehicular Impact?
    - Flooding?
  - Progressive Collapse
  - Life Safety
  - Rapid Recovery
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Terrorism Man-Made Hazards

- Targeted Infrastructure
  - Single Point Vulnerability
  - Multiple Soft Targets
  - Open Access

- Conventional Explosives

- Precision Demolition
  - Emerging Threats
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Vehicle Impact
Vehicle Impact
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Flooding Katrina Infrastructure Damage
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Bridges – Progressive / Disproportionate Collapse History

Silver Bridge (1967)

Mianus River (1983)

SFOBB – East Bay Spans (1989)

Queen Isabella Causeway (2001)

Bridge Demolition
- Baghdad, Iraq
  - April 12, 2007
  - Al-Sarafiyah Bridge over Tigris River
  - Six wheel truck packed with explosives
Expanded Engineer’s Role

Pre-event

• Assessment (Pre and Post Disaster)
  – Progressive Collapse
  – Extreme Events
• Design Strategies (New and Retrofit)
  – Protective Measures / Standoff
• Emergency Response
  – Damage Mitigation & Rescue
  – Tabletop Exercises with First Responders

Post-event

• Rapid Recovery
  – Preparedness, Temporary Bridging
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Pre-calculate Scenarios for Incident Management

- Approach path for emergency response vehicles
- Path and elapsed time for evacuation and response
- Standpipe system and AFF equipment and foam storage
Multi-Disciplinary/Multi-Hazard Mitigations

Shielding and Plating
- Blast Effects
- Fragmentation
- Standoff for Contact Charges
- Shielding from Hydrocarbon Fire

Situational Awareness
- CCTV Video Analytics
- Infrared Camera
- Thermocouples
- Strain Gauges

Potential Countermeasures

- Technology to improve situational awareness:
  - IR Camera: Thermal Sensing of a large field of view
  - IR Thermometer: Temperature readings at a single point on the structure
  - Thermocouple: placed in direct contact with structure for a single point temperature reading
Multi-Disciplinary/Multi-Hazard Mitigations

Rapid Recovery Preparedness

- Independent of Nature of Hazard
- Identify Resources in Advance
- Prepare Reconstruction Plans
- Table Top Exercises with Incident Commander and First Responders
- Crime Scene Investigation