Histogram of Documented Worldwide Terrorist Attacks against Public Transportation Infrastructure

Increasing Trend
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Introduction

- History of Terrorist Events Involving Transportation Infrastructure

Terrorist Attack Statistics between 1980 and 2006 Involving Highway Bridges Located in Industrialized Nations
SECURITY PLANNING FOR HIGHWAY BRIDGES

• Improved lighting
• Clearing overgrown vegetation
• Using creative landscaping to increase vehicular standoff distance
• Elimination of access to critical areas
• Elimination of parking spaces beneath bridges
• Providing gates in concrete median barriers to reroute traffic and access for emergency vehicles
• Planning redundancy in individual future bridges
• Avoiding architectural features that magnify blast effects
MATERIALS PERFORMANCE

- Explosives
- High Explosives
- Types of Explosive Charges
- Charge Shape
- Reinforced Concrete
  - Effect of Strain Rate on Material Response
  - Strength Values for Design
  - Thermal Effects
- Structural Steel
  - Effects of Strain Rate on Material Response
  - Strength Values for Design
  - Thermal Effects
Blast Phenomenology

Influence of Standoff to Height Ratio on Blast Load Resulting from Spherical Surface Burst: (a) Free-Field Detonation, (b) Near-Field Detonation
Blast Phenomenology

Effect of Section Shape on Physical Standoff and Angle of Incidence
MECHANICS OF STRUCTURAL ELEMENTS

- Conventional Reinforced Concrete Elements

Spall and Breach Behavior of Blast-Loaded RC Panels (adapted from [1]):
(a) Spall Damage, (b) Crater and Spall Damage, (c) Section Breach
MECHANICS OF STRUCTURAL ELEMENTS

- Structural Steel Elements

Local Breaching Failure of Steel Bridge Tower
DYNAMIC RESPONSE OF STRUCTURES

Dynamic Analysis Process

Illustration of Local Response versus Global Response
DESIGN GUIDANCE FOR REINFORCED CONCRETE COLUMNS

Bent
Standoff, \( R = 15 \text{ ft} \)
Column

Charge Weight, \( W = 2,800 \text{ lb TNT} \)
Height of Burst, \( H = 30 \text{ in.} \)

Deck Width, \( W = 25 \text{ ft} \)

Boundary Conditions: Propped Cantilever
Concrete Strength: 4000 psi
Concrete Unit Weight: normal
Concrete Age: 2 months
Longitudinal Reinf.: 10 #9 bars evenly spaced
Transverse Reinf.: #6 hoops spaced 6 in. OC
Rebar Type: Grade 60
Clear Cover, \( d_c = 1.5 \text{ in.} \)

Column Diameter, \( D = 36 \text{ in.} \)

Results for 36-in. Diameter Column
DESIGN GUIDANCE FOR STEEL CELLULAR TOWERS
DESIGN GUIDANCE FOR REINFORCED CONCRETE TOWERS

Progressive Collapse of Cable-Stayed Bridge due to Close-In Detonation near RC Tower Base
DESIGN GUIDANCE FOR HIGH-STRENGTH STEEL CABLES

Flexible Linear Shaped Charge about Pipe Circumference, Before Detonation and After Detonation

Cable and Flexible Linear Shaped Charge Input Screens
DESIGN GUIDANCE FOR OTHER BRIDGE COMPONENTS

• Flexural Members
  – Member Types
  – Failure Modes and Performance Criteria
  – Design Considerations

• Bridge Decks
  – Deck Types
  – Failure Modes and Performance Criteria
  – Design Considerations

• Design Considerations for Other Components
  – Bridge Bearings
  – Abutments and Riprap Walls
  – Bridges over Navigable Waterways
  – Horizontally Curved Bridges
  – Truss Bridges
  – Built-Up and Laced Members

Example of Steel Laced Column
ANTI-TERRORIST PLANNER FOR BRIDGES (ATP-BRIDGE) SOFTWARE

• Anti-Terrorist Planner for Bridges (ATP-Bridge) Software
• Software Operation
• Overview of Analysis Methodology
• Blast Load Computation
• Dynamic Response Algorithm for Reinforced Concrete Columns
• Dynamic Response Algorithm for Steel Cellular Tower Panels
• Dynamic Response Algorithm for Reinforced Concrete Tower Panels
• Dynamic Response Algorithm for High-Strength Steel Cable
• ATP-Bridge Design Examples
  – Reinforced Concrete Bridge Columns
  – Steel Cellular Bridge Towers
  – Reinforced Concrete Bridge Tower
  – High-Strength Steel Cables
Example

Boundary Conditions: Propped Cantilever
Concrete Strength: 4000 psi
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Who/When

• Who?
  – The manual will be distributed
  – AT Planner available to Feds, DOT’s, Contractors, & need to know basis.

• When?
  – Early 2017

• Questions?