Design and Construction of Recent Bridge Pier Protection Systems

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Outline

- Historical Developments
- Lessons from Past Collisions
- Current AASHTO Criteria
- Bridge Pier Protection Projects:
  - I-210 Prien Lake Bridge
  - I-10 Mississippi River Bridge
  - LA 27 Ellender Ferry Bridge
Historical Developments

**Prior to 1980:** Criteria was limited to special projects, movable bridge fenders

**1980 – 1984:** Increase in awareness and increased research efforts

**1984 – 1991:** LADOTD Criteria for Vessel Collision Design

**After 1991:** AASHTO Guide Specifications
                AASHTO LRFD Bridge Design
                AASHTO LRFD Movable Br. Design
Lessons from Past Collisions

May 26, 2002 M/V Robert Y. Love Tow Collision with the I-40 Bridge, OK
May 26, 2002 M/V Robert Y. Love Tow Collision with the I-40 Bridge, OK
February 2, 2007 4 - Barge Tow Collision with the US 80 Bridge, Vicksburg
May 9, 1980 Summit Venture Collision with the Sunshine Skyway Bridge
May 9, 1980 Summit Venture Collision with the Sunshine Skyway Bridge
September 27, 1996 Collision of the Julie N Tanker with the Million Dollar Bridge
Current AASHTO Criteria

AASHTO Method I

AASHTO Method II

\[ AF = (N) \times (PA) \times (PG) \times (PC) \]

- AF = Annual Frequency of Collapse
- N = Annual Number of Vessels
- PA = Probability of Vessel Aberrancy
- PG = Geometric Probability
- PC = Probability of Collapse

AF acceptable:
- < 0.0001 for Critical Bridges
- < 0.001 for Regular Bridges
Vessel Collision Loads

Ships

Barge Tows

- Ship Size
  - 160,000 DWT
  - 100,000 DWT
  - 60,000 DWT
  - 40,000 DWT
  - 20,000 DWT
  - 10,000 DWT
  - 2,000 DWT

- Tow Length
  - 4 Barges
  - 3 Barges
  - 2 Barges
  - 1 Barge

Graphs showing the relationship between impact speed (knots) and impact force (1,000 kips) for different ship sizes and barge tows.
Ship Collision Loads

February 19, 1981 Collision of Tanker Gerd Maersk with Newport Bridge, RI.
Barge Collision Loads
Approach to Bridge Pier Protection Design

- BRIDGE CHARACTERISTICS
- WATERWAY CHARACTERISTICS
- VESSEL TRAFFIC CHARACTERISTICS
- NAVIGATION CHARACTERISTICS

PERFORMANCE CRITERIA

PROTECTION ALTERNATIVES
I-210 Prien Lake Bridge Project
Original Fender
Vessel Traffic Characteristics
Navigation Conditions
Performance Criteria

Unusual Challenges:

• Large vessel sizes carrying chemicals
• Difficult navigation conditions
• Low global and local pier capacities
• Limited space for a protection system
Pier Protection Performance Requirements:

- *Longitudinal capacity* - large impact loads; may deform or share resistance with the pier
- *Transverse capacity* - less impact loads; must be rigid enough to prevent contact with the pier columns
- *Size* - improve navigation, prevent contact with pier columns and shaft
- *Facing* - smooth, low friction, prevent sparks
Concrete cap
Concrete walls
Micropiles
Design and Construction
Subcontractor: Nicholson Construction Company, Inc. (Micropiles)
I-10 Mississippi River Bridge Project

Pier 5
Feb 2007 M/T Kition Allision
DWT = 96,315 Tonnes
L = 798 Feet, B = 137 Feet
Bridge and Existing Fender Characteristics

Pier 5

Pier 6
Original Fender Characteristics
Vessel Traffic Characteristics

Ship Traffic: 25,000 to 125,000 DWT

Common Barge Tows:
- Hopper barge tows: 7 wide x 5 long
- Tanker barge tows: 2 wide x 3 long
Navigation Conditions

High volume of through traffic combined with local traffic

Docks and vessel anchorages near the bridge

Cross currents
Performance Criteria

Unusual Challenges:

- Large size ships and barge tows
- Vessel maneuvering operations near bridge
- Frequent accidents
- Low local pier capacities
- Protruding underwater pier ledge
- Deep water and high currents
- Limited space for a protection system
Pier Protection Performance Requirements:

- **Capacity** -
  - strong and rigid enough to prevent contact with the pier columns
  - deformable / crushable to limit load levels on the bridge pier

- **Size** - prevent contact with pier columns and underwater ledge

- **Facing** - smooth, low friction, prevent sparks
Pier Protection Solutions
Contractor: Weeks Marine, Inc., Houston, TX
Precaster: Standard Concrete Products, Theodore, AL
LA 27 Ellender Ferry Bridge Project
Vessel Traffic and Navigation Conditions

Common Barge Tows:  
- Hopper barge tows: 2 wide x 4 long
- Tanker barge tows: 2 wide x 2 long
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Summary

• Today’s design requirements specify vessel collision loads that are significantly higher than those considered in the past.

• New bridge piers are typically placed outside the channel or designed for collision loads.

• Providing protection to existing bridges presents design, construction and economical challenges.

• The cost of providing protection to existing bridges based on current criteria can be as high as the cost of the bridge.
Thank you!