Passing Vessel Analysis in Design and Engineering

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Passing Vessel Analysis in Port Engineering and Design

- Passing Vessel Effects
- Data Sources
- Passing Vessel Analyses
  - Planning and Siting Studies
  - Design Loads and Operational Criteria
  - Forensic Investigations
- Management Methods
PASSING VESSEL EFFECTS
Passing Vessel Issues in Ports

- Vessel berths adjacent to navigation channels
- Increasing size of vessels
- Passing vessels create long-period wave forms with so-called “draw down” and current
- Effects induce forces and yaw moments on moored ships.
- Dynamic mooring models are required for analysis of passing effects (NOT static)
Vessel Hydrodynamic Effect
Passing Vessel Forces

From NAVFAC TR-6056-OCN “Mooring Loads Due to Parallel Passing Ships
Passing Vessel Forces

- Primarily surge/sway forcing
- Acts to pull vessels from mooring
Defining Passing Vessel Problem and Risks

- More common in congested and busy ports
- May occur with right combination of speed, distance, mooring configuration, and tide
- Broken mooring lines
- Excessive movement
- Damaged mooring hardware/fenders
- Damage vessel hulls, loading equipment
- Environmental risk: fuel spills
- **PERSONNEL SAFETY**
  - Mooring line snapback
  - Broken mooring components
Passing Vessel Mooring Analysis

- Passing Vessel Loads
- Terminal Configuration
- Environmental Forces: Wind, Wave, Current
- Vessel Characteristics: Hydrodynamics

Dynamic Mooring Model

Loads to Structures and Vessel Motions
Example Passing Vessel Models

- Empirical/Theoretical
  - PASS-MOOR (US Navy)

- Three Dimensional Potential Flow
  - DELPASS (Pinkster Marine Hydrodynamics)
  - ROPES (Pinkster Marine Hydrodynamics)

- Computational Fluid Dynamics (future?)
Sources of Passing Vessel Data

- Port Pilots
- Simulator Studies
- AIS Data
  - fleet monitoring websites
  - data aggregators
  - USCG
Passing Vessel Analysis Examples

PLANNING AND SITING STUDIES
Planning and Siting Studies

- ‘Greenfield’ Terminals
- Berth Orientation
- Set Back from Traffic Areas
- Dredging Limits
- Effects on Existing Navigation
- Safety
- Cargo Handling Efficiency and Throughput
Craney Island Eastward Expansion

- Expansion of dredge disposal area
- Planned containment dikes within 500 ft (150 m) of channel
- Planned future container port
- Determine effect of passing vessels and establish berth offset
Passing Vessels

- DELPASS – foundation of ROPES
- Basic scenario: inbound loaded containership with moored containership
  - 3 passing distances
  - Passing speeds of 6-12 knots

Inbound 6-12 knots

185-338m
Surge Loads at 12 knots Passing

- 152 m
- 229 m
- 305 m
Mooring Model and Criteria

Dynamic Time Domain Simulations – Super Post-Panamax Ship

1. Line Loads $\leq 50\%$ of Minimum Breaking Load (MBL)
2. Fender Load $\leq$ Rated Reaction
3. Vessel Motion per PIANC 1995
   - For 100% Efficiency
     - Surge $\leq 1.0m$  Sway $\leq 0.6m$
   - For 50% Efficiency
Offset from Channel vs. Passing Speed

- Line Tension
- Surge
- Sway

Passing Speed Limit (knots)
Wharf Distance from Navigation Channel (m)
Final Recommended Alignment
Passing Vessel Analysis Examples

OPERATIONAL LIMITS AND DESIGN LOADS
Design Loads and Operational Criteria

• Terminals Exposed to Larger Ships
• Contribution to Structural Loading
  • Mooring Loads
  • Fender Loads
• Configuration of Bollards/Hooks
• Safe Passing Speeds and Distance
• Protective Structures
• Navigation Markers
Passing Vessel AIS Data: Lake Charles, LA

- AIS Data:
  - Speed
  - Track
  - Size
  - Loading condition
Passing Vessels at Example Terminal

- Identical vessel passing in channel
- 5, 6, 8 knots
- Look at coincident winds
- Passing on center and inside quarter
- Full/ballast draft
Passing Vessel: Mooring Line Tension Response

Dynamic Mooring Response
- Mooring Lines
- Fender Forces
- Motions

Graph showing load in tons over time (seconds) for different components of the mooring system.
Passing Vessel Results
Example: Mooring Analysis Results

- Vessels deploy 12 PP/PE mooring lines
- Wind limit 46 knots (30-sec gust)
- Quadruple hooks on mooring dolphins
- Mooring dolphin service load 150 tons
- Passing vessel speeds 5 knots or less
Passing Vessel Analysis Examples

POST INCIDENT ANALYSIS
Post Incident Analysis

- Gather Recorded Information and Anecdotal Accounts
  - AIS Data
  - Evidence of Damage
- Set Up Passing and Mooring Models to Recreate Incident
- Sensitivity on Unknown Parameters
- Attempt to Model Incident Conditions
- Recommendations for Infrastructure or Operation Improvements
Post Incident AIS Data
Passing Vessel Effects

MANAGING
Managing Passing Effects

- Navigation Management (pilots)
  - Reduce Passing Speed
  - Increase Passing Distance

- Mooring Management (ports)
  - Additional or Stronger Mooring Lines
  - Line Tending
  - Upgraded Mooring Hardware

- Technologies
  - Vacuum Pad Systems
  - Constant Tension Systems
Thank You

...Discussion