Modification and Relocation of Container Handling Cranes

A presentation & case study by Portek International Ltd
Scope of our Presentation

- Introduction
  - (Who is Portek/Experience List/Key Customers)

- Crane Modification
  - (General introduction; FE simulation; Real world; Simulation vs design)

- Crane/RTGs Relocation
  - (General introduction; FE simulation; Real world; Simulation vs design)

- Accident Repairs
  - (Case Studies)

- Conclusions
Crane vs. Ship

The First Ship Crane
1958 (Matson Navigation)
is capable of handling
feeder vessels only

Today’s Post-Panamax
Container Ship – 15/16 rows
across

Today’s
Container Crane must
be capable of handling
22 rows wide vessels
Brief Introduction of PORTEK

• Established in 1988.
• Leading Provider of Equipment, Services, and Solutions to the Global Port Industry.

Company’s competencies shall include:

✓ Technical Services - Design and Engineering Services
✓ Crane Modification & Modernization
✓ Crane Drive System Integration & Automation
✓ Crane Mobilization & Relocation
✓ Crane/Equipment Sale & Leasing
✓ Knowledge of Crane Components
✓ Crane Maintenance/Diagnostic Services
Portek’s core business includes:

- Crane & Equipment Sale & Leasing
- Crane Mobilization & Relocation
- Crane Modification - Span change
- Crane Repair & Diagnostic Services
Portek Experience List

**Crane Relocation**

1988 to present – moved more than 200 cranes

**Crane Modification – geometry changes**

1988 to present – modified more than 70 cranes

**Crane Modernization – Drive retrofit/CMS/PLC etc…**

1993 to present – upgraded more than 150 cranes
OUR CUSTOMERS ARE MAINLY PORT & TERMINAL OPERATORS

- PSA Corporation Ltd (Singapore) & PSA Sical Terminals Ltd (India)
- P. T. (Persero) Pelabuhan Indonesia 1, 2 & 3 (Indonesia)
- Hutchison Ports in (H K, Myanmar, Panama, Mexico)
- PT. Jakarta International Container Terminal (Indonesia)
- Kelang Multi Terminals Sdn. Bhd. (Malaysia)
- P & O ports (Botany Bay Sydney, Australia)
- Thai Laemchabang Terminal Ltd. (A2, Thailand)
- Modern Terminals Ltd. (Hong Kong)
- Vietnam Intl Container Terminal (Vietnam)
- PT Riau Andalan Pulp & Paper (Indonesia)
- Penang Port Sdn Bhd (Malaysia)
- PT. Terminal Petikimas Surabaya (Indonesia)
Crane Modification

- Geometry changes
- Performance changes
- Operational changes
- Retrofits
Crane Modification

- Geometry changes
  1. Increase outreach
  2. Increase lift height
  3. Rail gage change
  4. Miscellaneous changes
Case 1 ==== Increase Outreach

Aims:

1. Extend boom 4.5 m
2. Strength & Fatigue
3. Design method
FE Simulation

Solver: ANSYS/Mechanical

Elements: Plate  
Beam  
Bar  
Joint

Models:
1. Original boom  
2. Extended boom without moving lug  
3. Extended boom by moving lug
## Loading conditions and load combinations (BS)

<table>
<thead>
<tr>
<th>Load name</th>
<th>Operating</th>
<th>Overload</th>
<th>Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OP-1</td>
<td>OP-2</td>
<td>OL-1</td>
</tr>
<tr>
<td>Dead load</td>
<td>DL</td>
<td>DL</td>
<td>DL</td>
</tr>
<tr>
<td>Trolley load</td>
<td>TL</td>
<td>TL</td>
<td>TL</td>
</tr>
<tr>
<td>Lifting system</td>
<td>LS</td>
<td>LS</td>
<td>LS</td>
</tr>
<tr>
<td>Lifted load</td>
<td>LLE</td>
<td>LLE</td>
<td>LL'</td>
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<tr>
<td>Impact</td>
<td>-</td>
<td>IMP</td>
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<tr>
<td>List</td>
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<tr>
<td>Trim</td>
<td>TRIM</td>
<td>TRIM</td>
<td>TRIM</td>
</tr>
<tr>
<td>Trolley lateral load</td>
<td>-</td>
<td>LATT</td>
<td>-</td>
</tr>
<tr>
<td>Gantry lateral load</td>
<td>LATG</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trolley skew load</td>
<td>-</td>
<td>SKT</td>
<td>-</td>
</tr>
<tr>
<td>Operating wind load</td>
<td>-</td>
<td>WLO</td>
<td>WLO</td>
</tr>
<tr>
<td>Earthquake load</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

For example: \( \text{OP1} = \text{DL} + \text{TL} + \text{LS} + \text{LLE} + \text{LIST} + \text{TRIM} + \text{LATG} \)
**Simulation results**  
Von-Mises stresses for all cases (Unit: MPa)

<table>
<thead>
<tr>
<th>Loading Position</th>
<th>Load Case</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Position</td>
<td>OP-1</td>
<td>182</td>
<td>272</td>
<td>193</td>
</tr>
<tr>
<td></td>
<td>OP-2</td>
<td>203</td>
<td>304</td>
<td>214</td>
</tr>
<tr>
<td></td>
<td>OL-1</td>
<td>171</td>
<td>257</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td>OL-2</td>
<td>156</td>
<td>236</td>
<td>165</td>
</tr>
<tr>
<td></td>
<td>FL-1</td>
<td>86</td>
<td>130</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>FL-2</td>
<td>135</td>
<td>204</td>
<td>143</td>
</tr>
<tr>
<td>Normal Position</td>
<td>OP-1</td>
<td>66 (106/79)</td>
<td>74 (104/74)</td>
<td>78 (128/86)</td>
</tr>
<tr>
<td></td>
<td>OP-2</td>
<td>74 (116/92)</td>
<td>73 (113/84)</td>
<td>92 (136/107)</td>
</tr>
<tr>
<td></td>
<td>OL-1</td>
<td>63 (102/77)</td>
<td>67 (100/72)</td>
<td>78 (121/91)</td>
</tr>
<tr>
<td></td>
<td>OL-2</td>
<td>62 (106/78)</td>
<td>69 (105/75)</td>
<td>74 (127/92)</td>
</tr>
<tr>
<td></td>
<td>FL-1</td>
<td>40 (60/40)</td>
<td>48 (58/37)</td>
<td>44 (73/49)</td>
</tr>
<tr>
<td></td>
<td>FL-2</td>
<td>51 (86/64)</td>
<td>59 (84/59)</td>
<td>76 (103/63)</td>
</tr>
</tbody>
</table>
Simulation results & Comparison
FE Analysis of lifting Lug at Mast Top
Real World
**Simulation vs. Design**

- Extending the boom by moving the lug with the same length is a good scheme;
- A certain reinforced component attached the lug is suggested.
Case 2 === Height Increase

Aims:

1. Increase height 5.0 m
2. Strength & stability of jacking tower
3. Design method
FE Simulation

Solver: LS_DYNA

Model: Inner tower & Jacking component

Key point: Multi-surface contact

Loads:
1. Overall crane weight
2. Lateral wind
Simulation results
Simulation results
Facing the Real World

Jack up 1 m
&
Insert new leg

Components to equipment

Jack up 5 m

Jack up 1 m
Simulation vs. Design

- The jacking procedure is safe despite contact stresses are high;
- The stress on the pin is quite low;
- Local modification of the jacking section is suggested.
Crane Relocation

Principal Points of Consideration:

- Ship motions and accelerations
- Wind force
- Ship & Crane stability
- Crane strength
- Lashing design
Case 1 ==== Crane’s Relocation
Case 1 === Crane’s Relocation
Case 2 === RTGs’ Relocation
Case 2 === RTGs’ Relocation
Simulation vs. Design

- To make sure that the relocation process is reliable:
  1. Strength of Crane/RTGs is permissible;
  2. No stability problem;
  3. Deck has sufficient strength.
- To suggest a more reasonable lashing scheme.
1 unit Quay Crane moved from PSA to Banten
A Modified QC at Banten
2 Quay Cranes & 2 RTG moved from PSA to VICT
2 Quay Cranes in operation at VICT
2 RTG Cranes in operation at VICT
Relocation of 2 QCs in PSA from KT to BT
3 Unloaders moved from Hong Kong to Indonesia
2 QCs moved from Thailand to Indonesia
Span Modification of cranes in Indonesia
Relocation of 7 QCs & 32 at MTL
Relocation of 2 QCs from PSA to Dubai
Span Change of 9 RTGC in Dubai
1 IHI QC moved from Taiwan to Tuticorin, India
Span Change

Skidding
Extended boom by moving lug with same length (severe loading position)
Outreach Extension
Accident Damage
Survey & Repair
Crane Collapsed in Surabaya due to Wind
Hitachi container crane boom destroyed by vessel collision
Manufacture & transport of new boom
Installation of replacement boom designed by Portek
Another Incident of Boom Damaged
Dismantling of Boom for Repair
850T ship unloader crane & conveyor damaged by vessel collision
850T ship unloader crane & conveyor damaged by vessel collision
850T ship unloader crane after repair
Panamax Quay crane damaged by vessel collision in Dunkirk
Panamax Quay crane damaged by vessel collision
Survey & Repair
Survey & Repair
Survey & Repair
• Modification and relocation of cranes are a part of the core businesses of PORTEK.

• A reasonable design & accurate simulation methods are required for a successful modification project.

• In the real world it is often complicated to do the works, so we believe that simplification is the key to carrying out the numerical simulations.

• Techniques can often be improved through research & time but experience to do the work is critical to ensure successful completion & customer satisfaction.
Questions & Answers