Port and Terminal Risks

Quay Container Cranes

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Quay Container Cranes

Risks & Loss Prevention Actions

Laurence Jones – Director Global Risk Assessment

2022

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Agenda

1. **Claims analysis**
2. **Top risks and trends**
3. **Loss prevention actions**
4. **Summary**

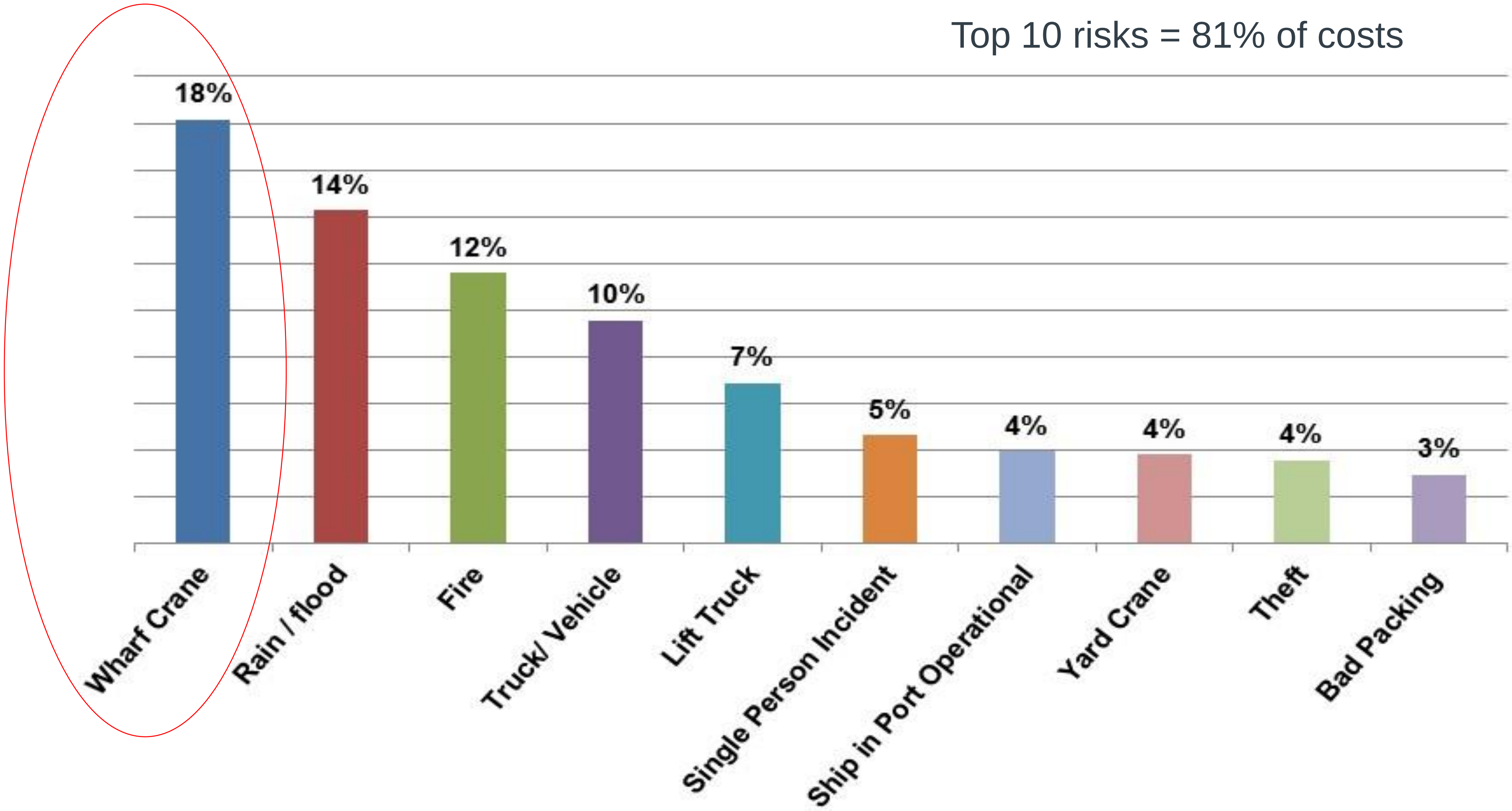
Analysis of the main causes of claims:

- Includes last 5 years data (2017-2021)
- Rolling 5 year analysis
- All claims over US$6,000
- 9,323 claims
- Includes all claim types:
  - Property
  - Liability
  - Bodily injury

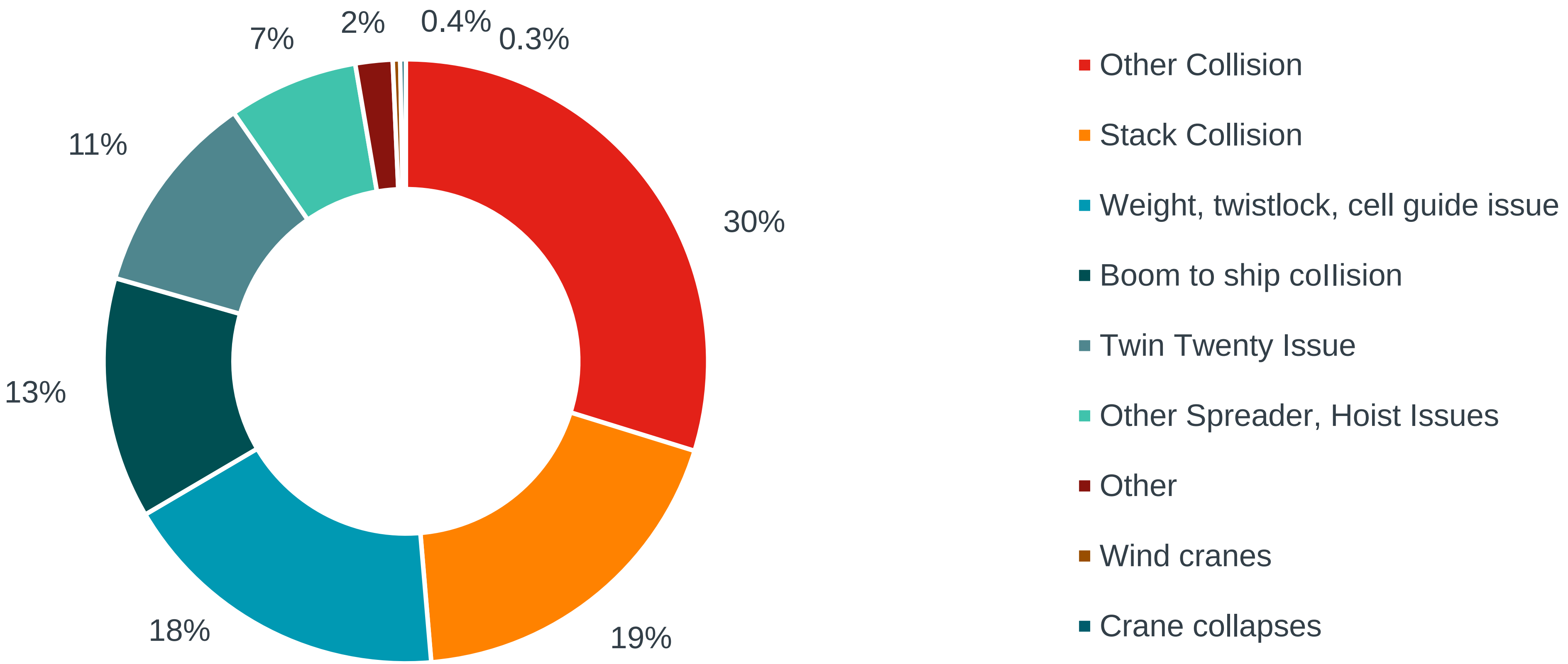
TT

Port & Terminal members
All claims top risk costs

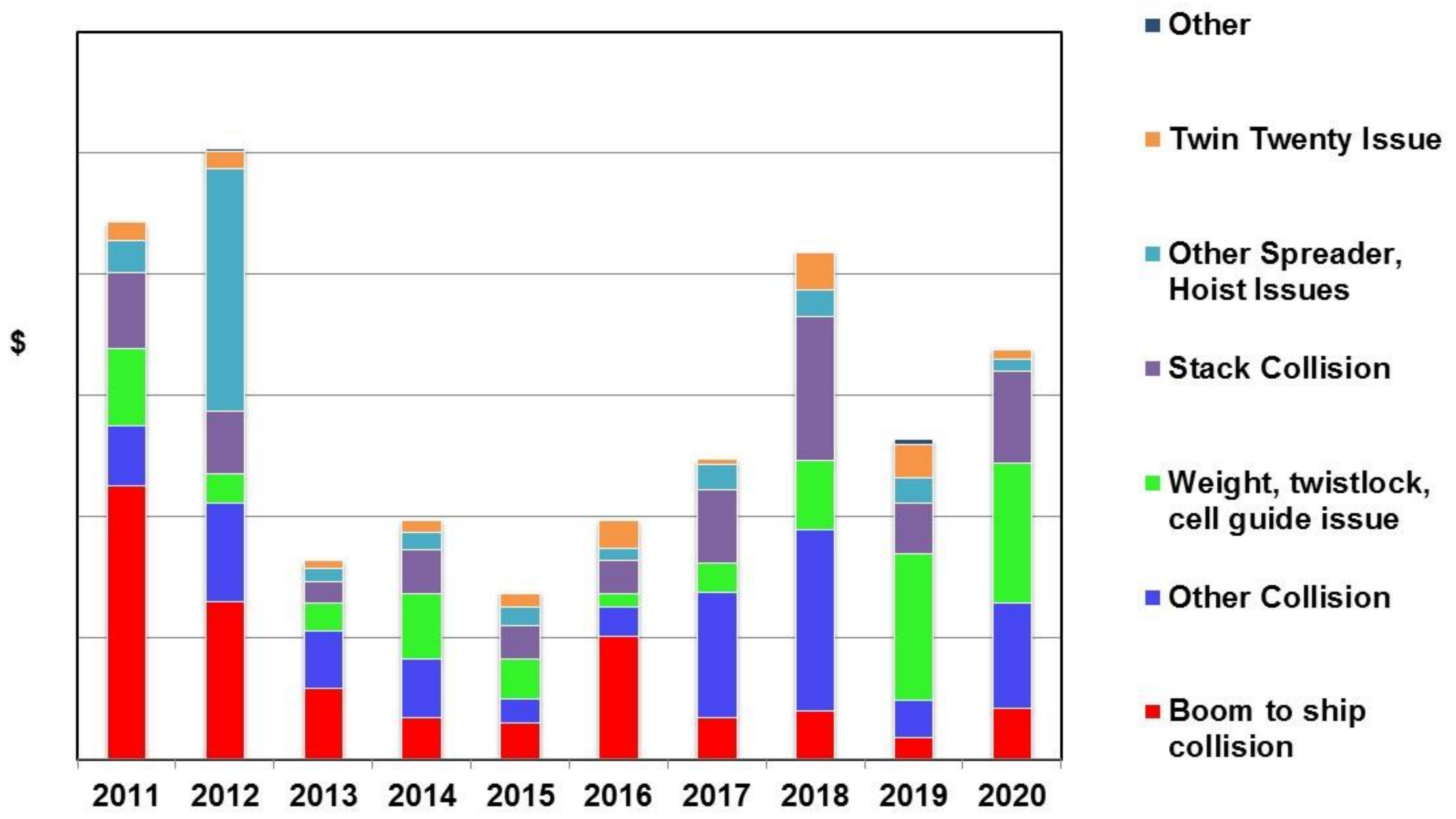
Top 10 risks = 81% of costs



Port & Terminal Members – Quay crane all claims costs



Port & Terminal members - Quay crane claims costs trend



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Other collisions

Examples:

- Gantry collisions
- Hatch cover hits ship
- Hatch cover hits crane legs
- Container hits lasher

Prevention:

- Anti-collision sensors for travel
- Crane to crane anti-collision sensors
- Crane driver training (simulator training)
- Lasher training.

Ship stack collision

Prevention:

- Stack profiling

Container Got Stuck in cell guides

Prevention:

- Twistlock load sensing system

Not all twistlocks engaged

Prevention:

- Twistlock load sensing system

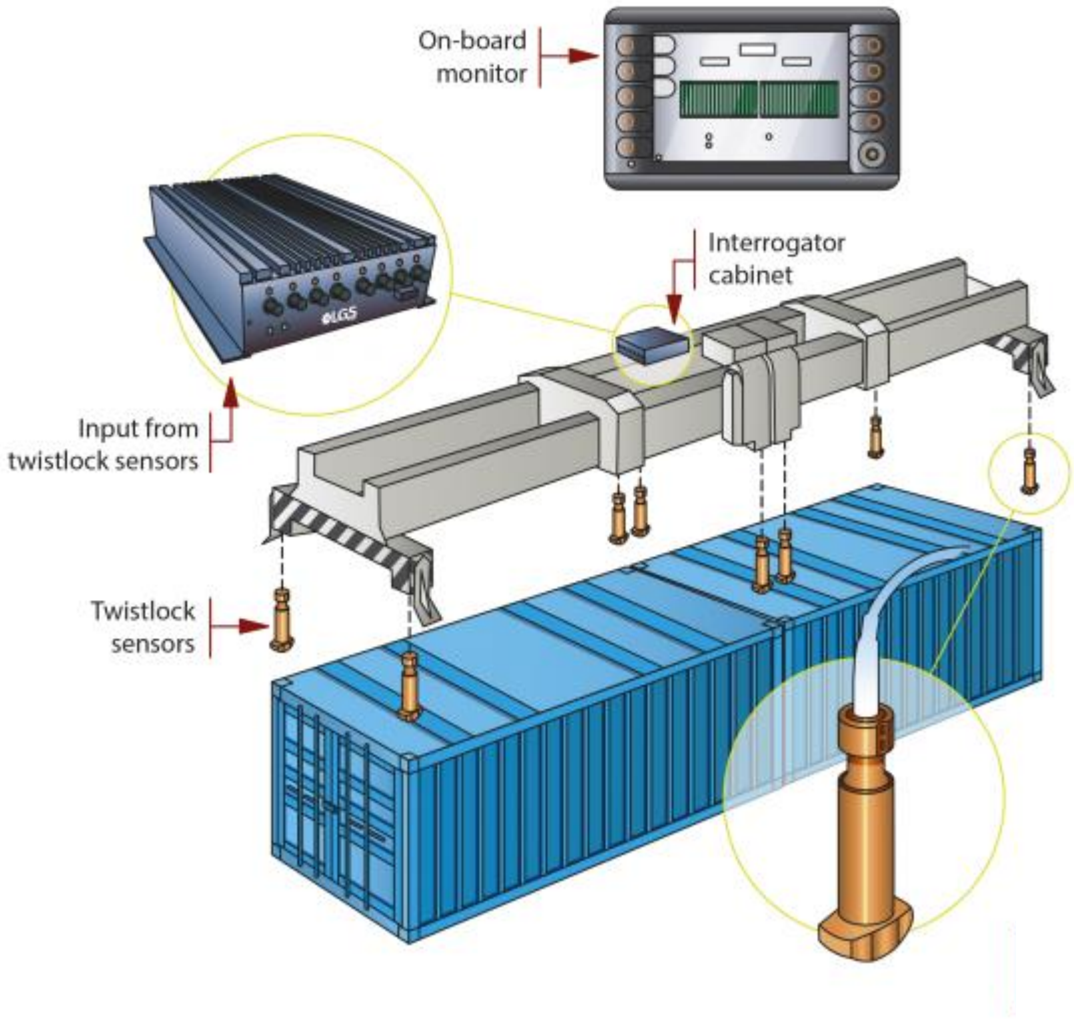
Twistlock load sensing

Detects & prevents:

- Lifting if not all twistlocks engaged

Measures and records:

- Each twistlock & total container weight
  - VGM
  - Safer handling of containers
  - Better ship planning to ensure trim and stability
- Load eccentricity in single & twin lift
  - Help prevent trucks overturning
  - Can side shift spreader before exiting ship cell guides
- Twistlock load cycles
  - Optimise twistlock replacement intervals
  - Spreader & crane life cycle management & overload tracking



Boom collisions

Boom collisions

Boom collisions

Boom to ship collisions

Prevention:

- Totally preventable with electronic quay crane boom anti-collision system using laser sensors
- Install correctly

Note:

Trip wire systems provide collision detection not collision protection.

Twin Twenty issue

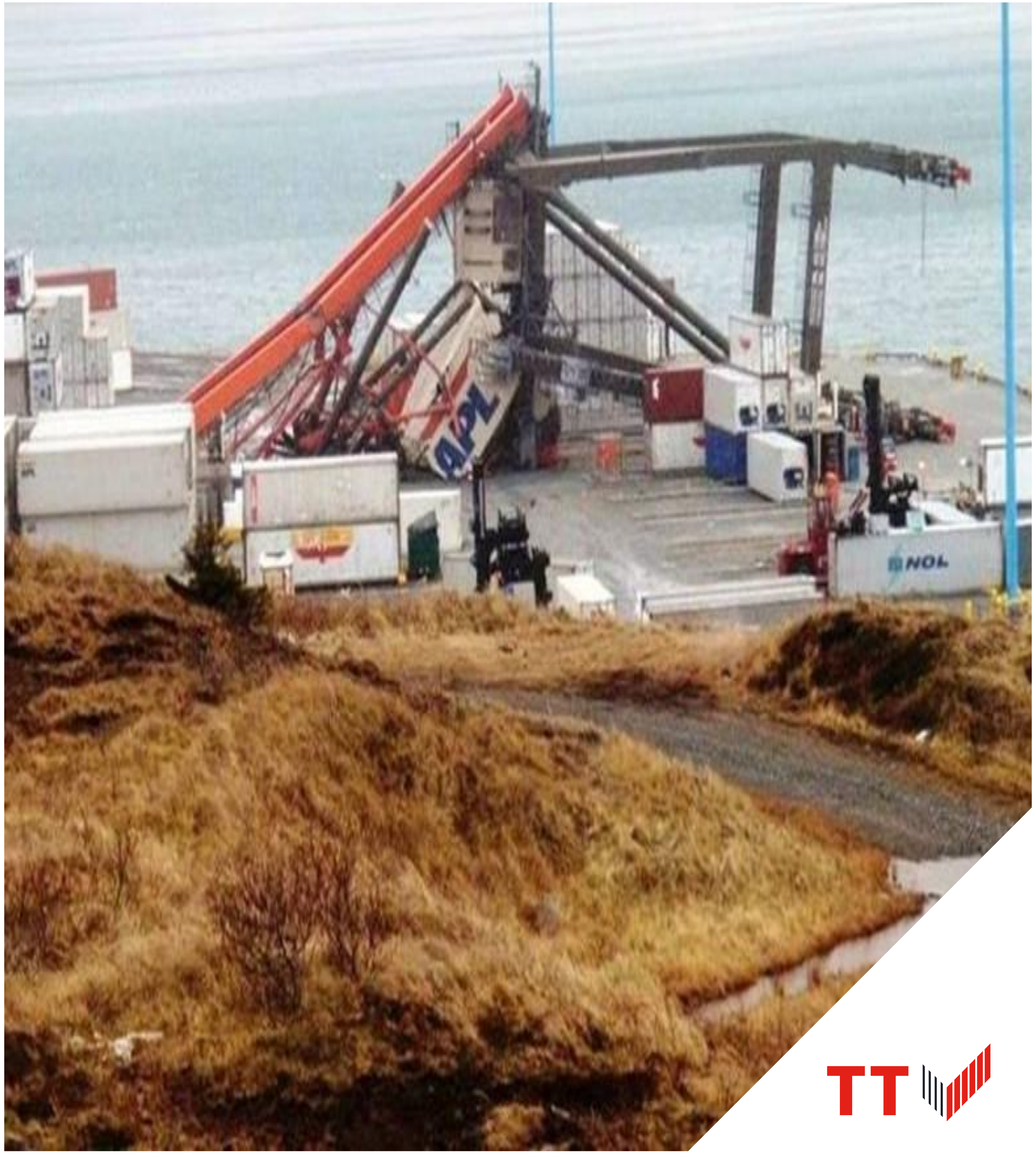
Prevention:

- twin-twenty laser sensors to detect the gap between containers

Severe weather can happen anywhere today

Crane blown over

Forecast windstorm

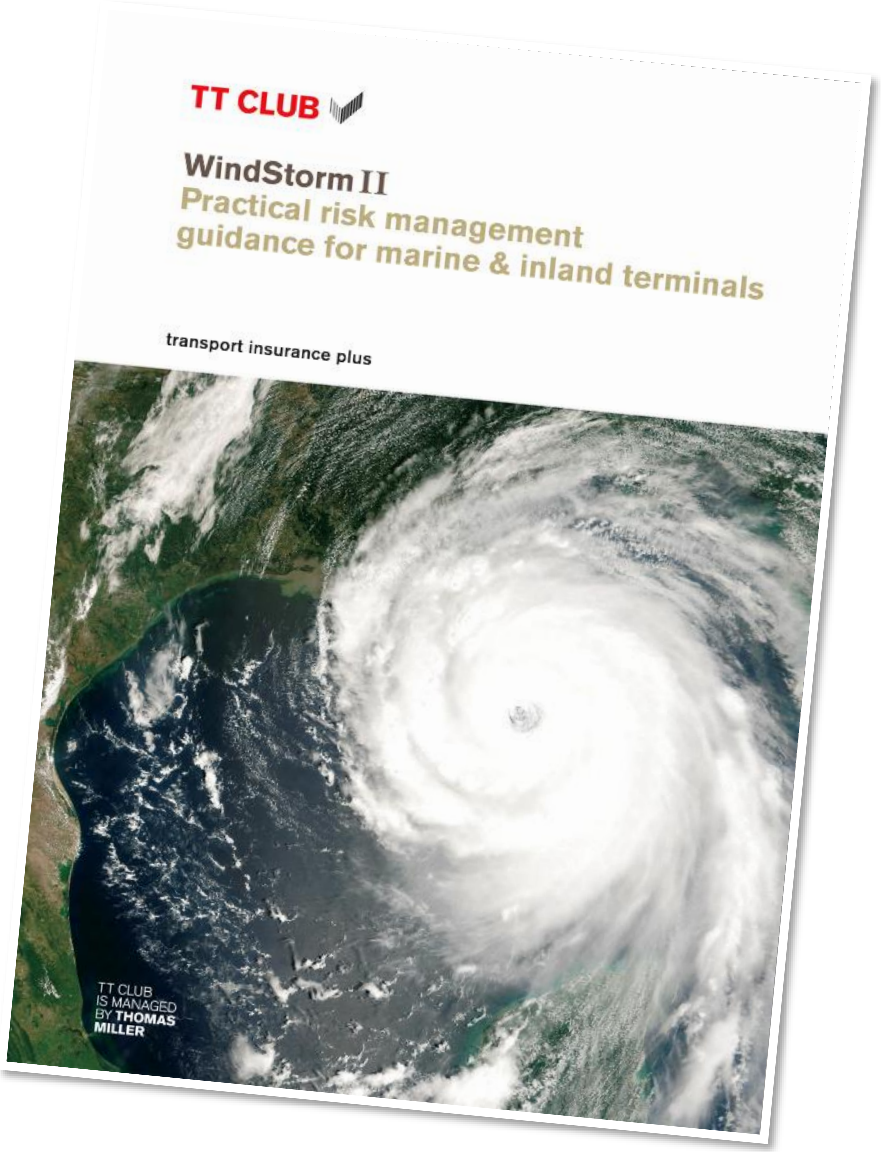


Crane blown along wharf

Sudden windstorm

Wind damaged cranes

- **Forecast storms:**
  - Procedures to secure cranes
  - Storm pins & tie-downs on all quay cranes
- **Sudden windstorms:**
  - All motors and brakes working at all times



Refer to TT Club Windstorm II booklet

- Available at www.ttclub.com

Boom collapses

Prevention:

- Structural inspections annually
- Using qualified structural engineers

Summary

Loss prevention actions for quay cranes

- Ensure structural integrity of cranes – annual inspections
- Ensure all cranes are pinned and tied-down during storms
- Ensure all gantry brakes are always working 100%
- Install boom anti-collision sensors
- Install travel anti-collision sensors
- Install stack profiling system
- Install twistlock load sensing system
- Install twin-twenty detection system
- Consider automation and remote control

- TT Club, ICHCA and PEMA joint publication
  - “Recommended minimum safety features for quay cranes”
  - https://www.ttclub.com/news-and-resources/publications/crane-safety-recommendations/

Do not be complacent about safety

Plan ahead and be prepared.

Thank you
Any questions?

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Director Global Risk Assessment
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Shoreside Cranes – Post Incident Investigations

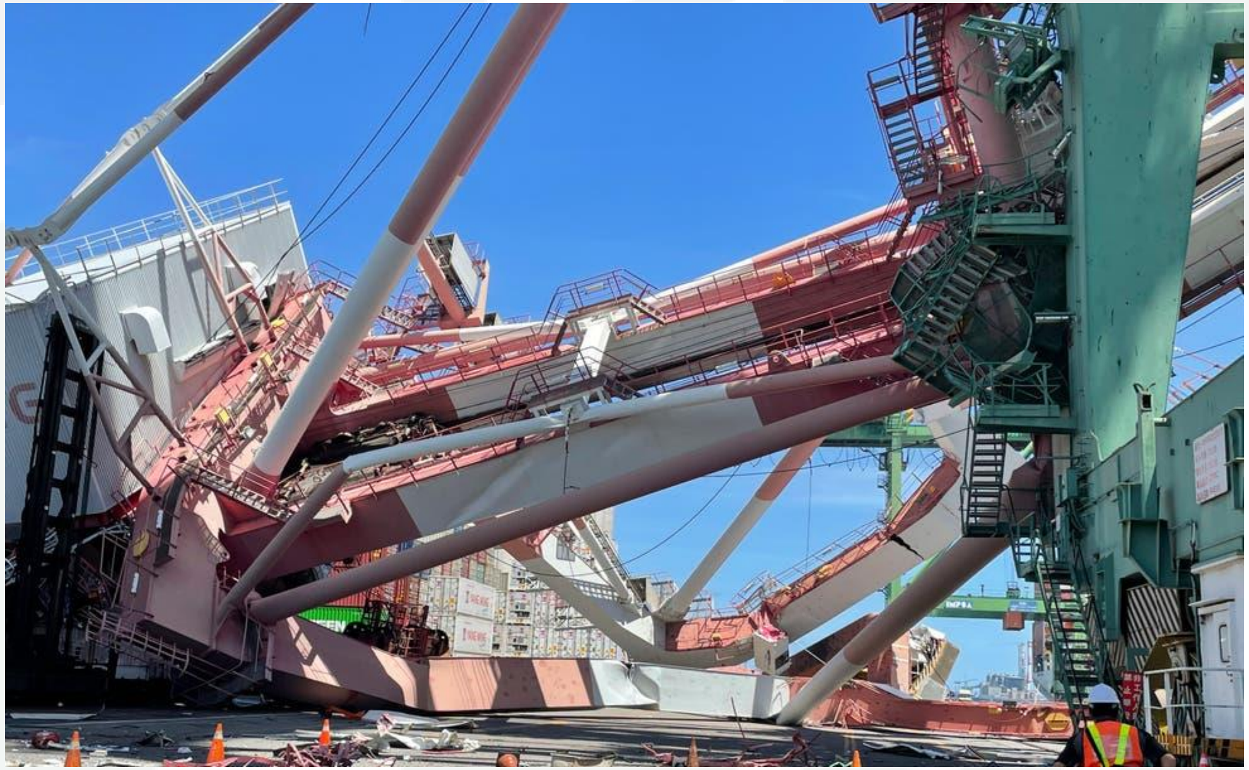
Ray Luukas – Chief Technical Officer – May 2022

Investigation Process

1) Study the incident reports and evidence to date, including, importantly, CCTV footage
2) Advise on evidence preservation whilst we mobilise
3) Arrange joint surveys, inspections, Non-destructive Testing (NDT), and liaise with manufacturers, contractors and other involved parties
4) Reach WP agreement on nature and extent of incident damage and identify any pre-existent defects
5) Investigate any relevant and causative operational matters (controls, safety devices, pre-incident structural integrity, etc.), equipment certification checks, maintenance records, etc.

Gantry Crane Accidents and Failures

1. Vessel contact during berthing;
2. Snagged loads;
3. Runaway cranes in heavy weather and winds; contact with vessel
4. Wire Failures;
5. Weld Defects;
6. Lack of maintenance;
7. Operator error.



Case Study 1 - Vessel Contact During Berthing

Case Study 1 – Repairs

The repairs were effected insitu on the quayside and in the vicinity of the running rails. Crane supported by temporary erected structures and jacks. Note also three floating jacks (coloured yellow) below the jacking beam and constrained in their glide tray.

Case Study 1 – Repairs

Multiple structural components were repaired with inserts such as the left and right portals, and sea side legs:

Case Study 1 – Repairs

The crane was hydraulically jacked up in order to replace all the bogies, drive motors and brake components:

Final repair cost was in the order of US 3 Million

Case Study 2 - Vessel Contact During Berthing

Case Study 2 - Vessel Contact During Berthing

Case Study 2 – Repair Costs

Cost of Stabilisation and Repairs in USD (Millions – Approx.)

- Crane 82 - No Damage
- Crane 83 - 1.8
- Crane 84 - 2.7
- Other Costs - 1.5

- Total - 6.0 (including stabilisation and transport cost)

- Crane 81 - Total Loss - Demolished
- Crane 85 - Total Loss - Demolished

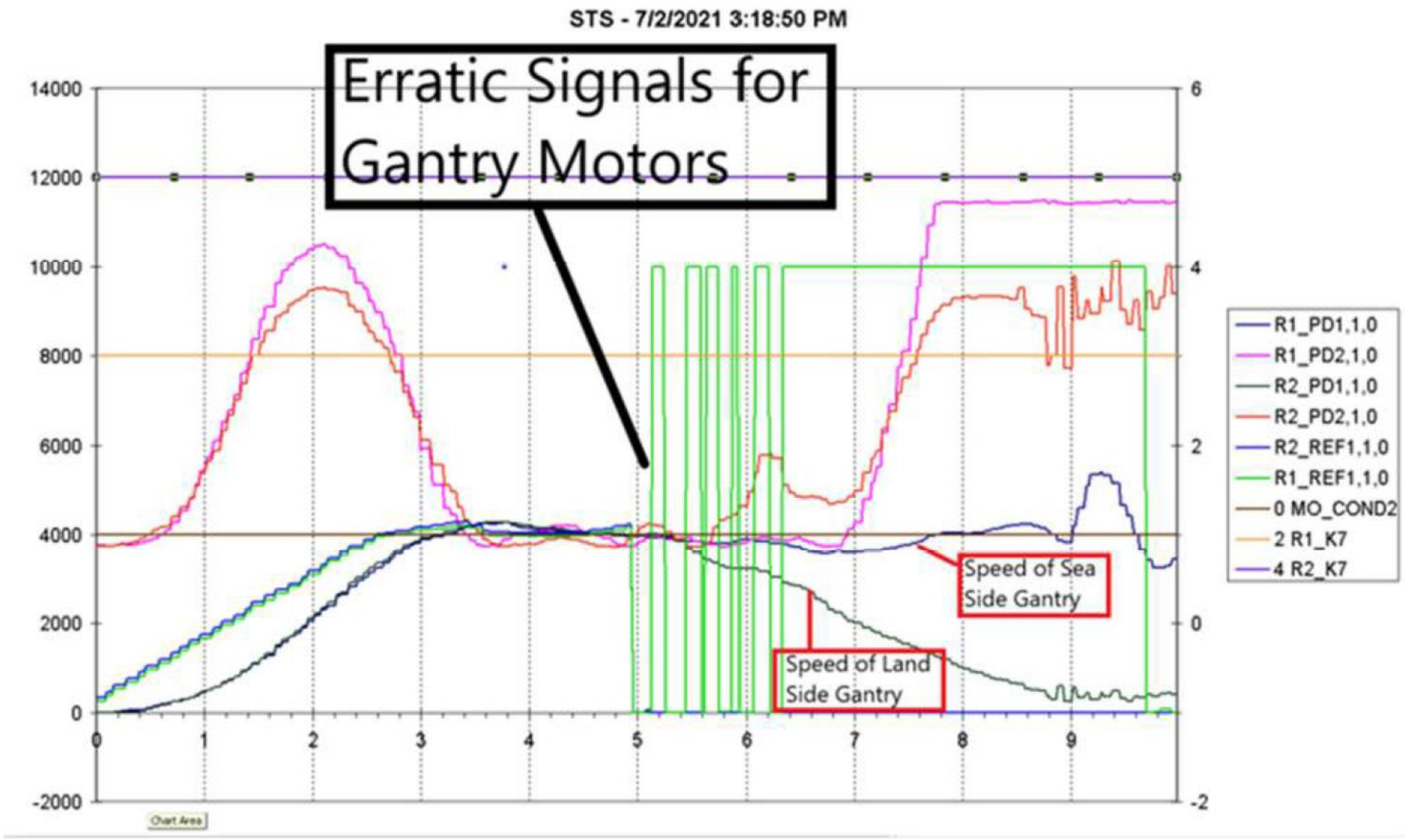
Case Study 3 – Control System Fault

- Wide-span gantry crane

Case Study 3 – Control System Fault

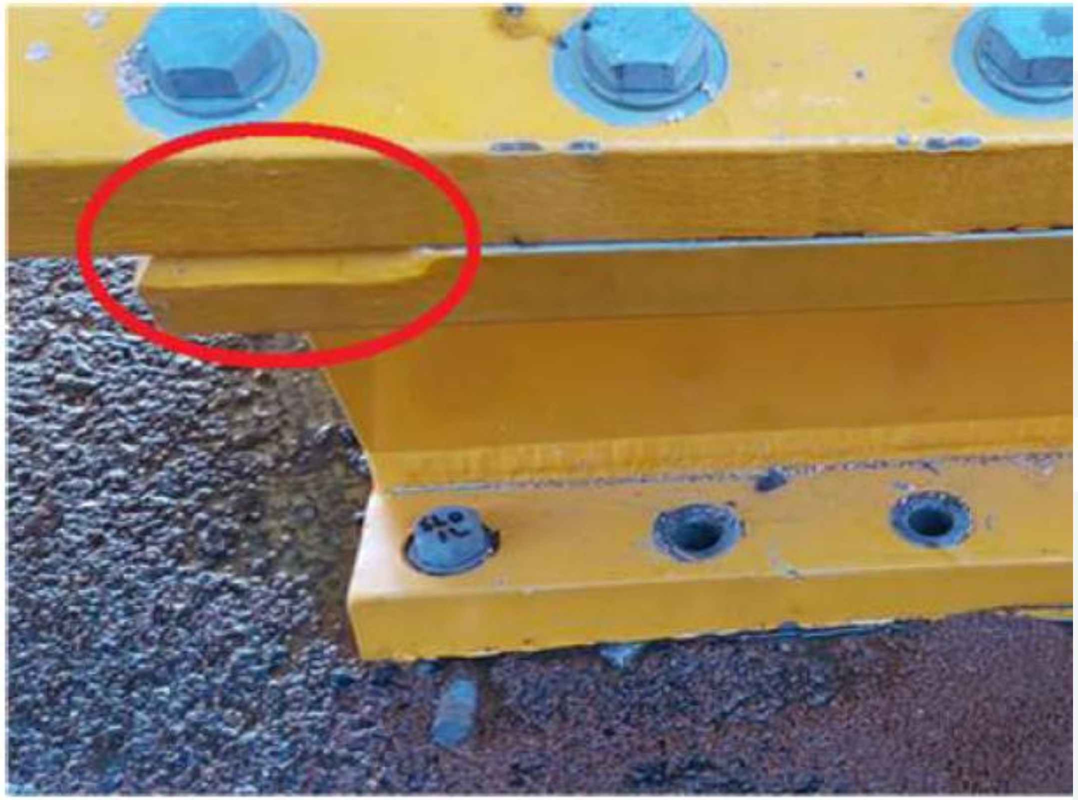
Case Study 3 – Control System Fault

The crane software data was interrogated. It was discovered that the recently updated software conflicted with the existing system causing a communication error and erratic signals being sent to the motor drives for the land side and sea side legs of the crane.



Case Study 3 – Control System Fault

In addition, we noted that the bogie connection pieces had not been correctly fitted when the crane was installed.



Case Study 3 – Control System Fault

Our metallurgical inspection of the bogie connection bolts confirmed their failure mode.

The recovered bolts fitted to the left-hand connection piece had failed in shear whilst those fitted to the right-hand connection piece, had failed in overload.

Case Study 4 – Snagged Load

Case Study 4 – Snagged Load

Case Study 5 – Mishandling

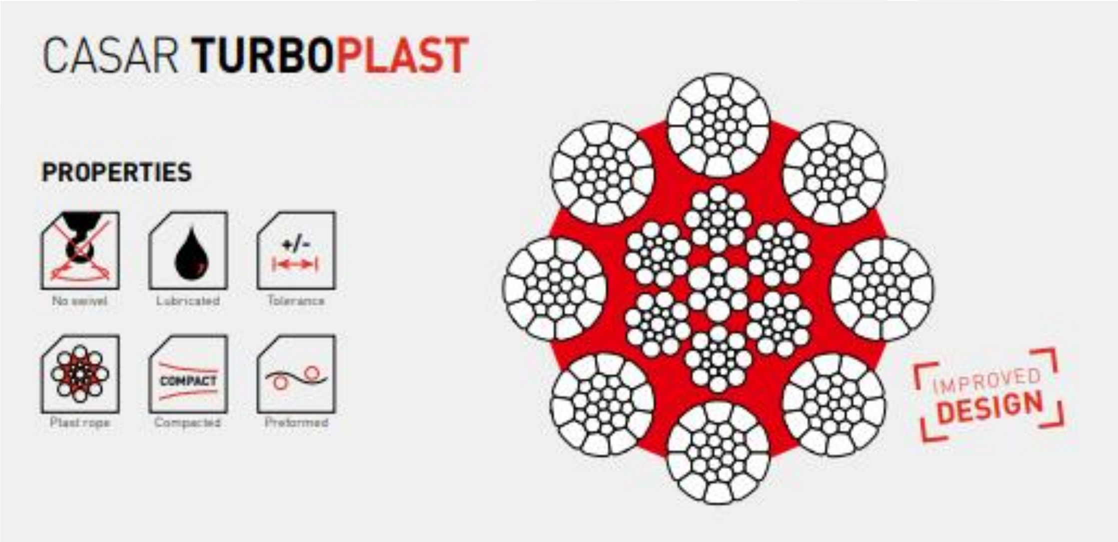
Case Study 5 – Mishandling

Case Study 5 – Mishandling

Case Study 6 – Hoist Wire Failure

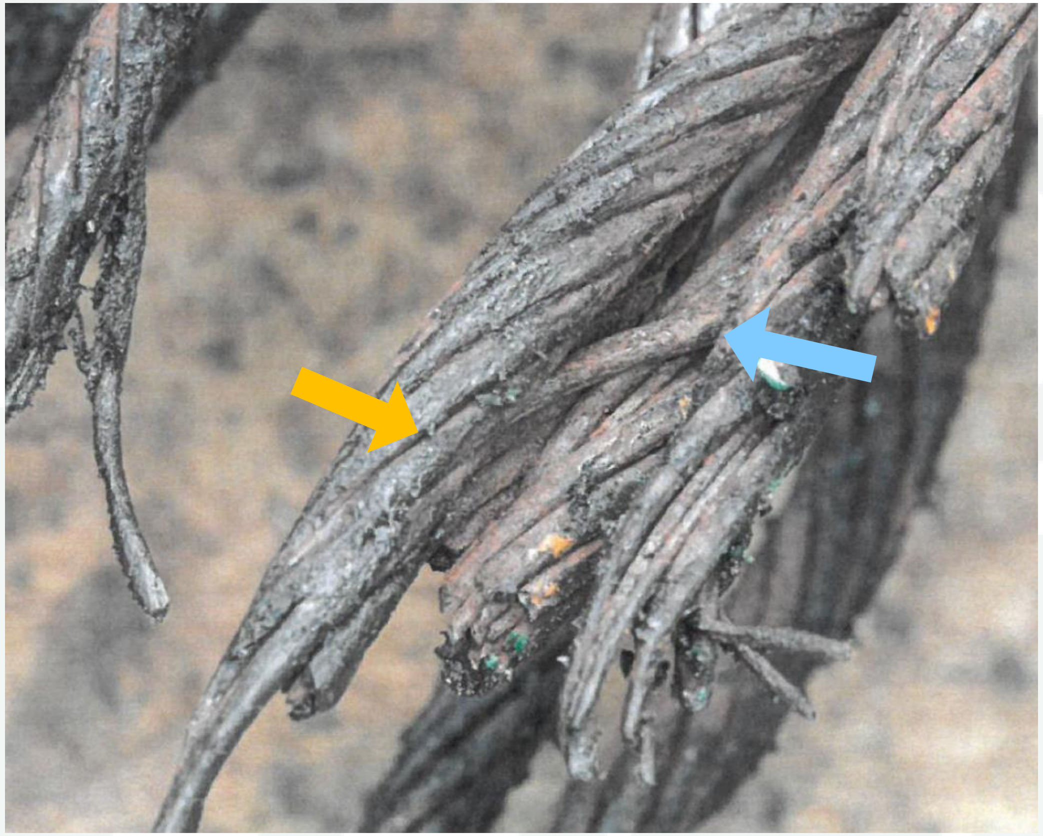
Case Study 6 – Hoist Wire Rope Failure

CASAR ROPES IN PORTAL CRANES RTG AND RMG

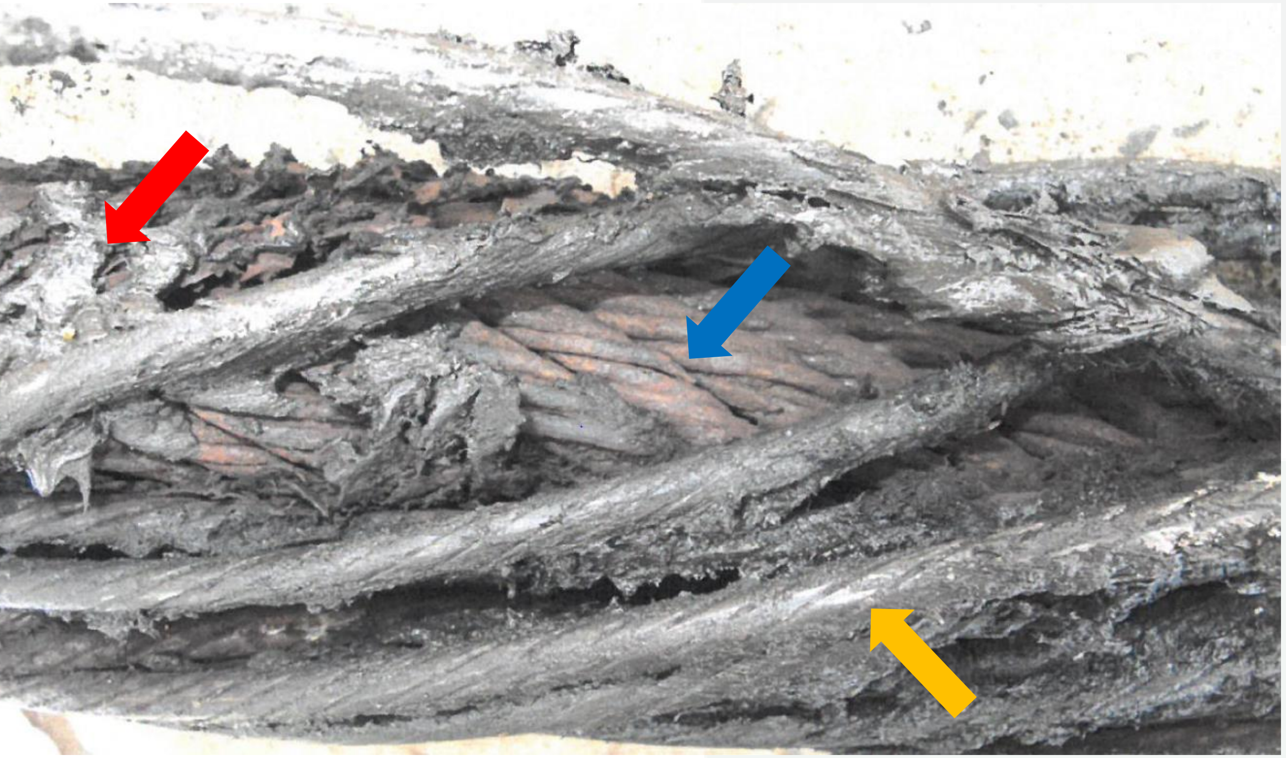


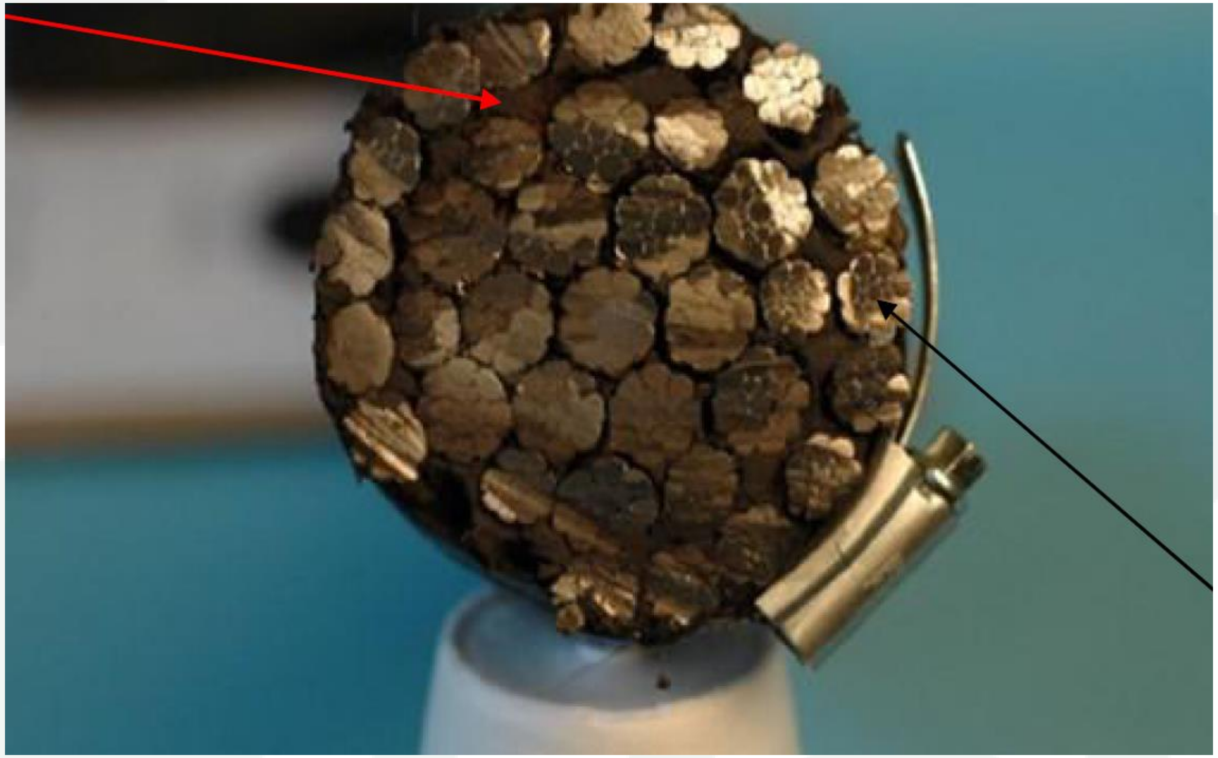
Case Study 6 – Hoist Wire Rope Failure

Casar Powerplast Wire Rope



Case Study 6 – Hoist Wire Rope Failure





Rules & Standards

European materials handling federation

FEM

RULES FOR THE DESIGN OF HOISTING APPLIANCES (8 BOOKLETS – 1998)

POSTED 9TH MARCH 2016

INTERNATIONAL STANDARD **ISO 4309:2017(E)**

Cranes — Wire ropes — Care and maintenance, inspection and discard

1 Scope

This document establishes general principles for the care and maintenance, and inspection and discard of steel wire ropes used on cranes and hoists.

AGREED SCOPE OF INSPECTION/TESTING

Agreed inspection/testing protocol of the two sections of the No. 2 crane hoist wire rope with frayed ends:

1. The inspections should be made in accordance with ISO 4309 – this includes determining if the discard criteria has been exceeded on the outer wires with referenced to corrosion, wear and fatigue.

2. The wire rope(s) sample should be measured as per ISO 4309 (i.e. two measurements made at right angles) to determine if there has been excessive reduction or increase in diameter. Any areas affected by significant change in diameter (we will refer to these as areas of interest) should be inspected in way of the core of that region. "Areas of interest" will be determined by a change in nominal diameter by more than 4%. The core should be inspected to determine the following:

   (a) Condition of the polypropylene sheath.

   (b) Condition of the lubrication of the inner strands in that region.

   (c) Determination of condition as per ISO 4309 – i.e. determine extent of corrosion, fatigue and wear.

   (d) Regions of interest should be compared with an area which appears sound and this should be done before and after cleaning. Examination for external corrosion of the sample will be done before cleaning; all other examination will be done after cleaning of the rope; cleaning will be carried out using kerosene or acetone – MSDS for both products are attached.

   The parties acknowledge that it will not be possible to examine the polypropylene sheath and internal strands of the wire rope without dismantling it.

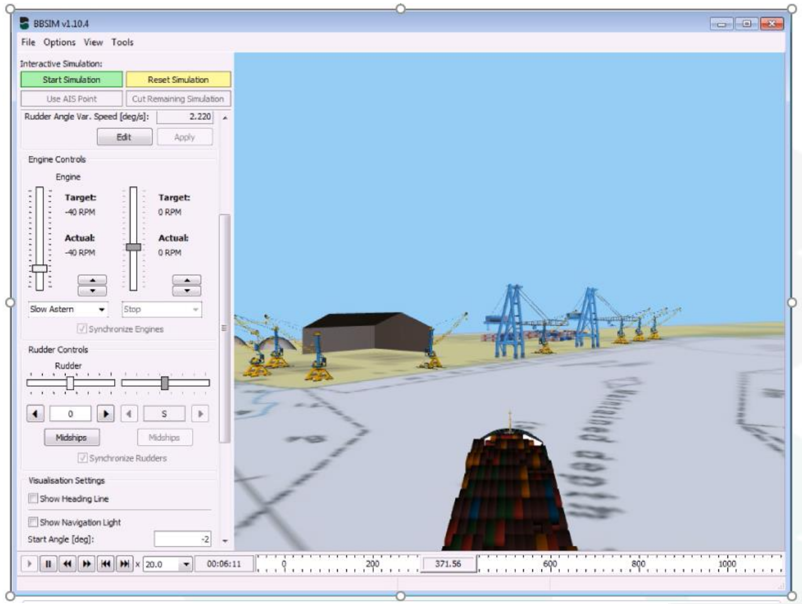
3. The condition of the wire rope in way of the failure and immediately adjacent to it should be investigated. In addition to characterising the mechanism of failure of the individual wires, the general condition should be determined in terms of corrosion, wear and number of fatigue breaks.

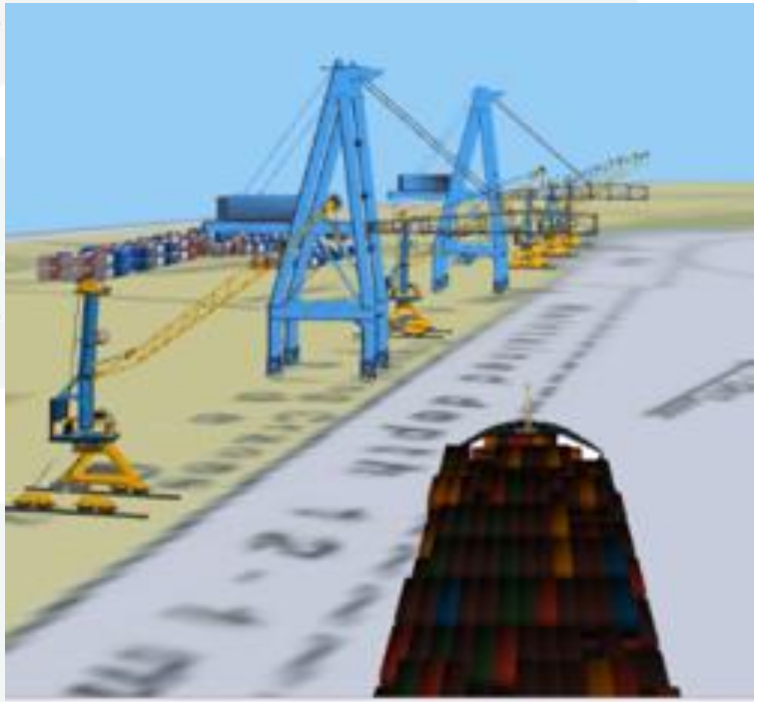
4. Stereomicroscope examination of individual failed strands to ascertain condition of fracture in terms of extent of corrosion since failure – the condition for both the core strands and outer strands should be compared.

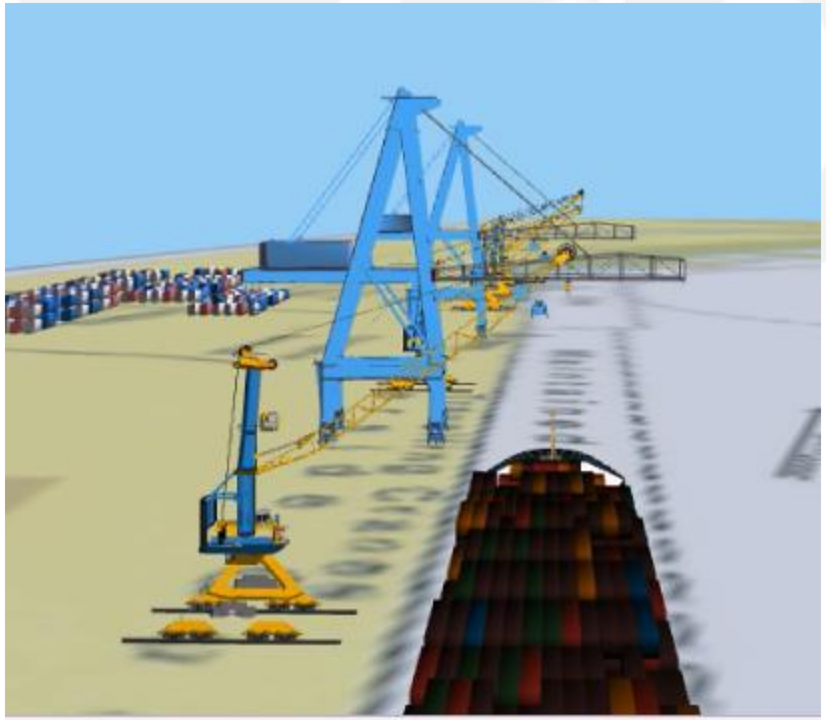
Forensic Analysis Tools

- Computer Modelling
- Finite Element Analysis
- Metallurgy
- Advanced Non-destructive Testing (NDT)

Modelling – BBSIM - Reconstruction of Incident



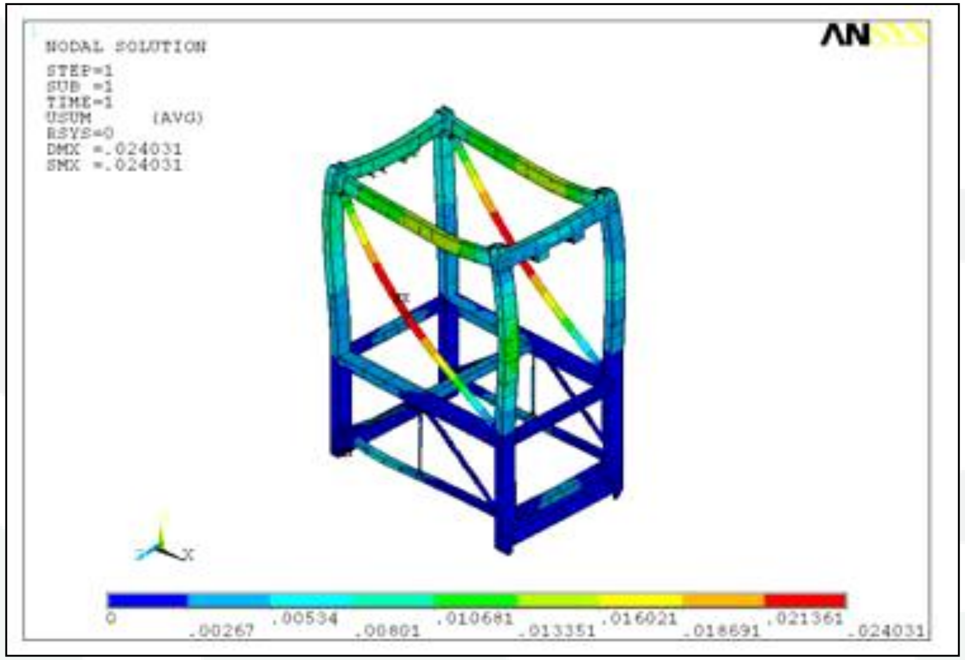




Gantry Crane Design

Cranes are not designed to absorb horizontal impact loads from ships or adjacent cranes. Therefore, to understand the behaviour of a crane damaged, in a major allision, it is frequently necessary to carry out a Finite Element Stress Analysis (FEA). This is to identify the extent of the structure that has been affected.

- Crane structure designed to lift vertical loads



- Cranes can only tolerate certain limited horizontal loads from wind and earthquake conditions

Modelling & Finite Element Analysis (FEA)

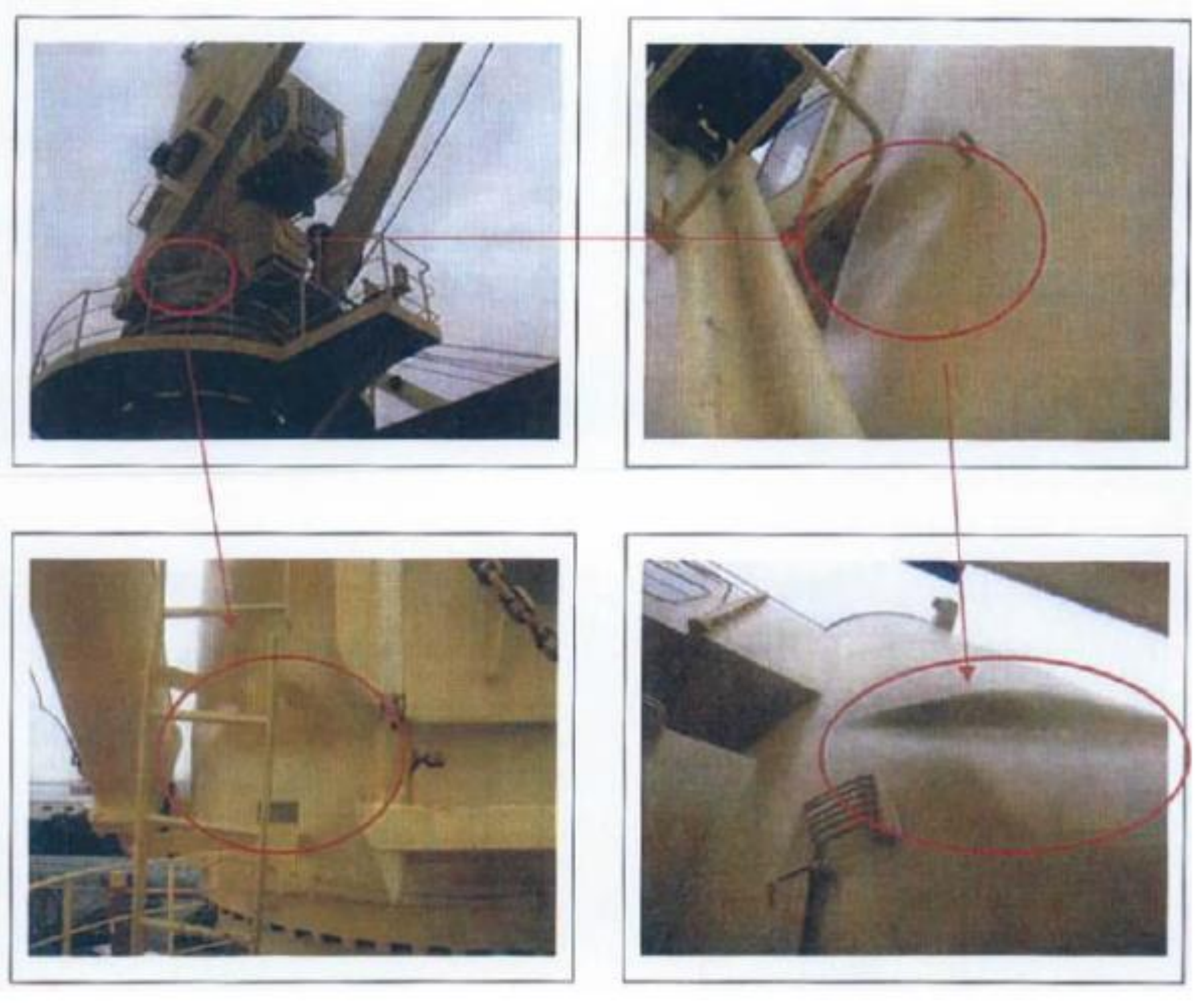
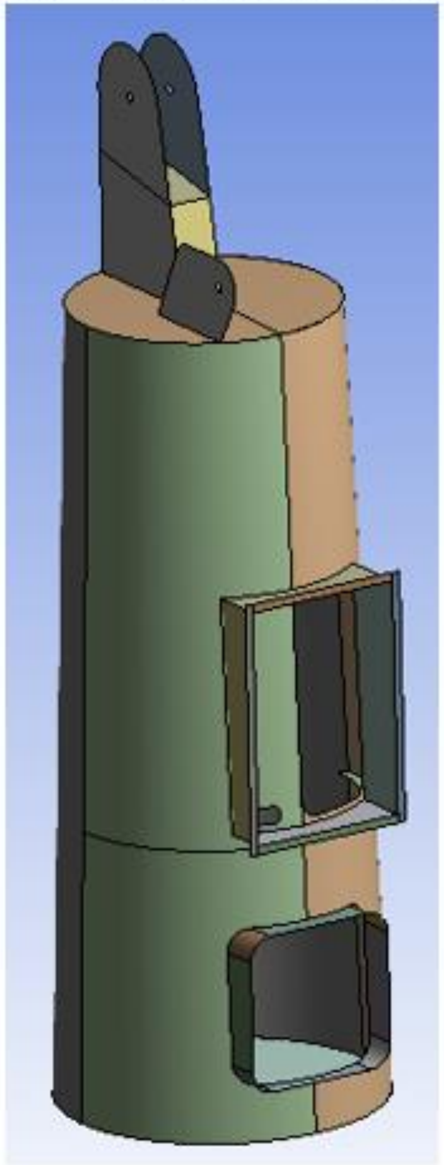


Figure 3 – Geometry of FEA Model



Modelling & Finite Element Analysis (FEA)

Figure 5 – Stress in Slew Post under 30 tonne Load at 26 metres

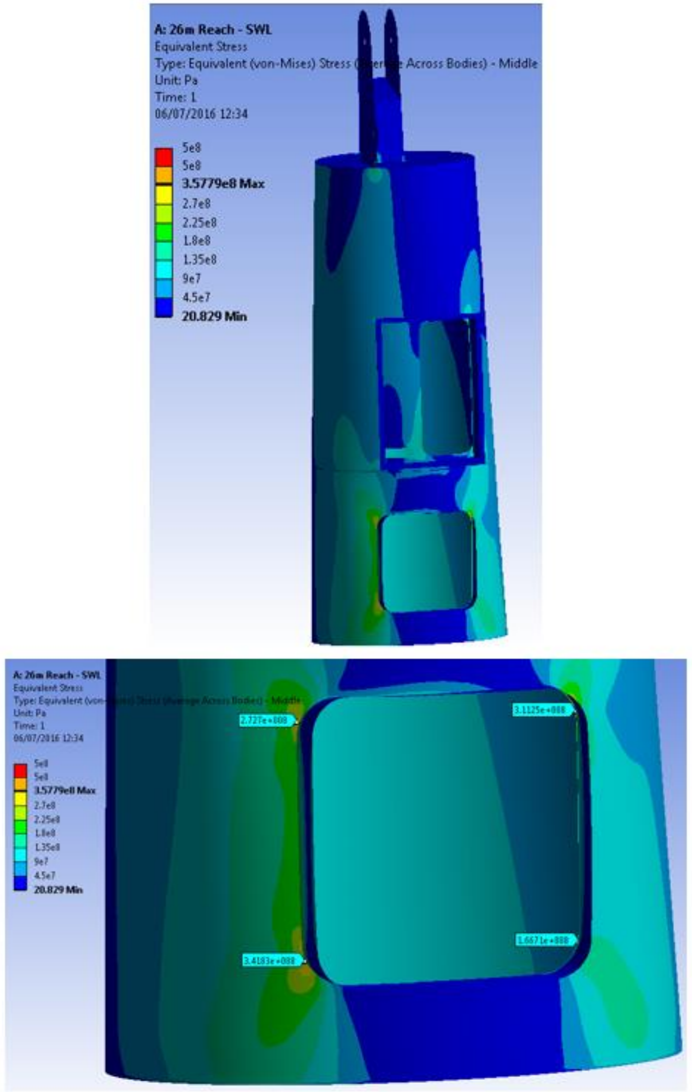
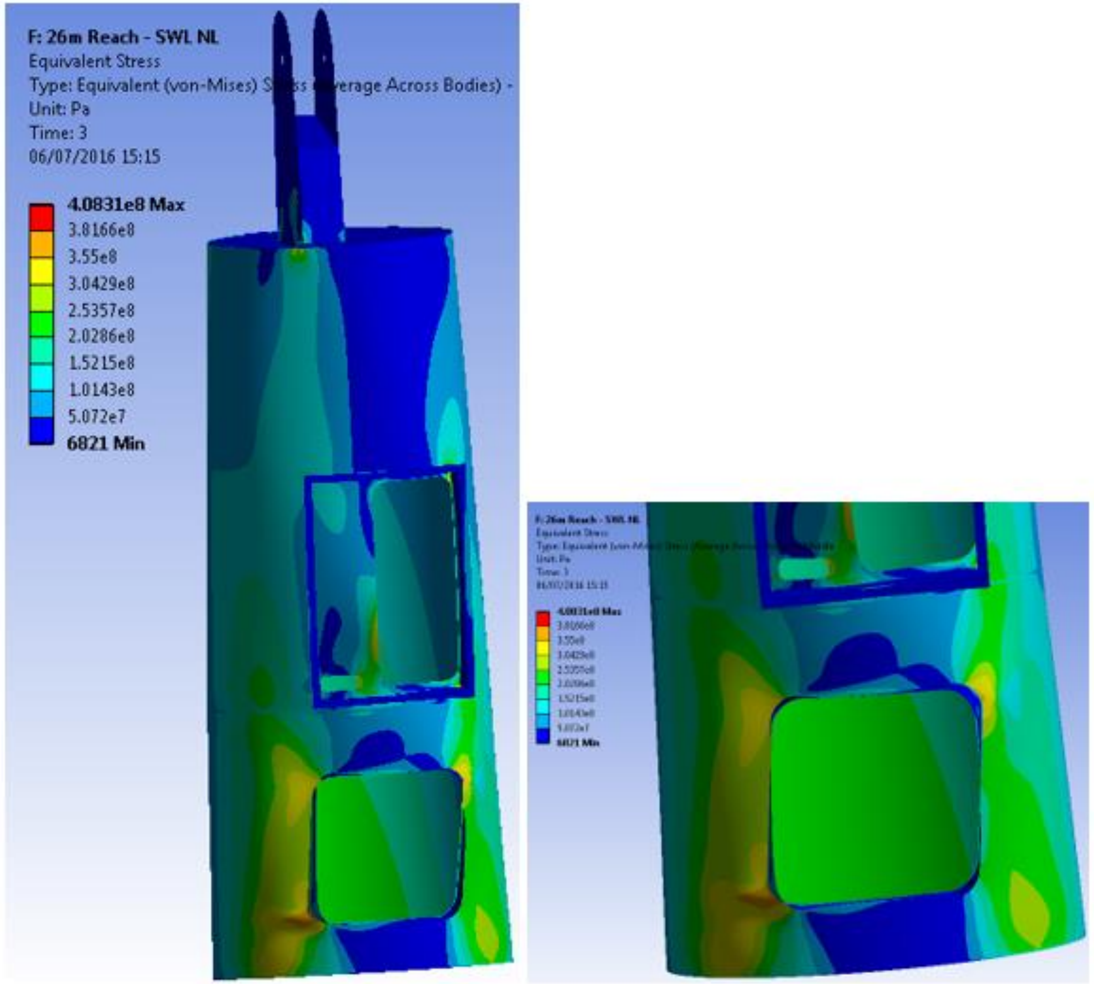
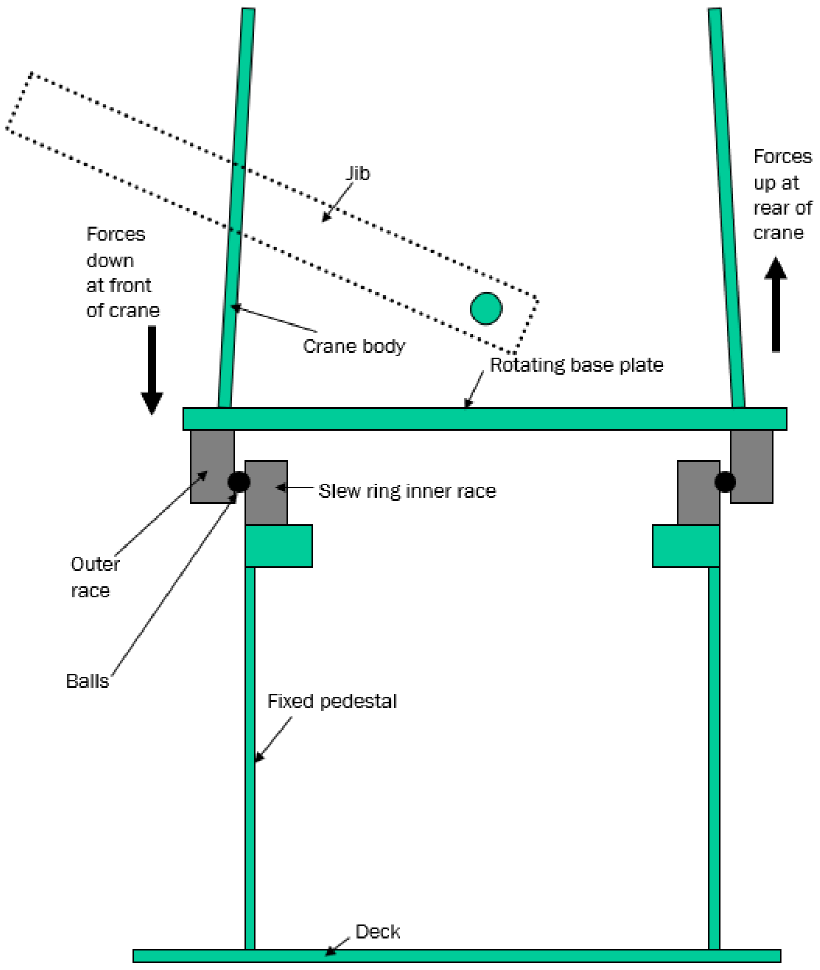


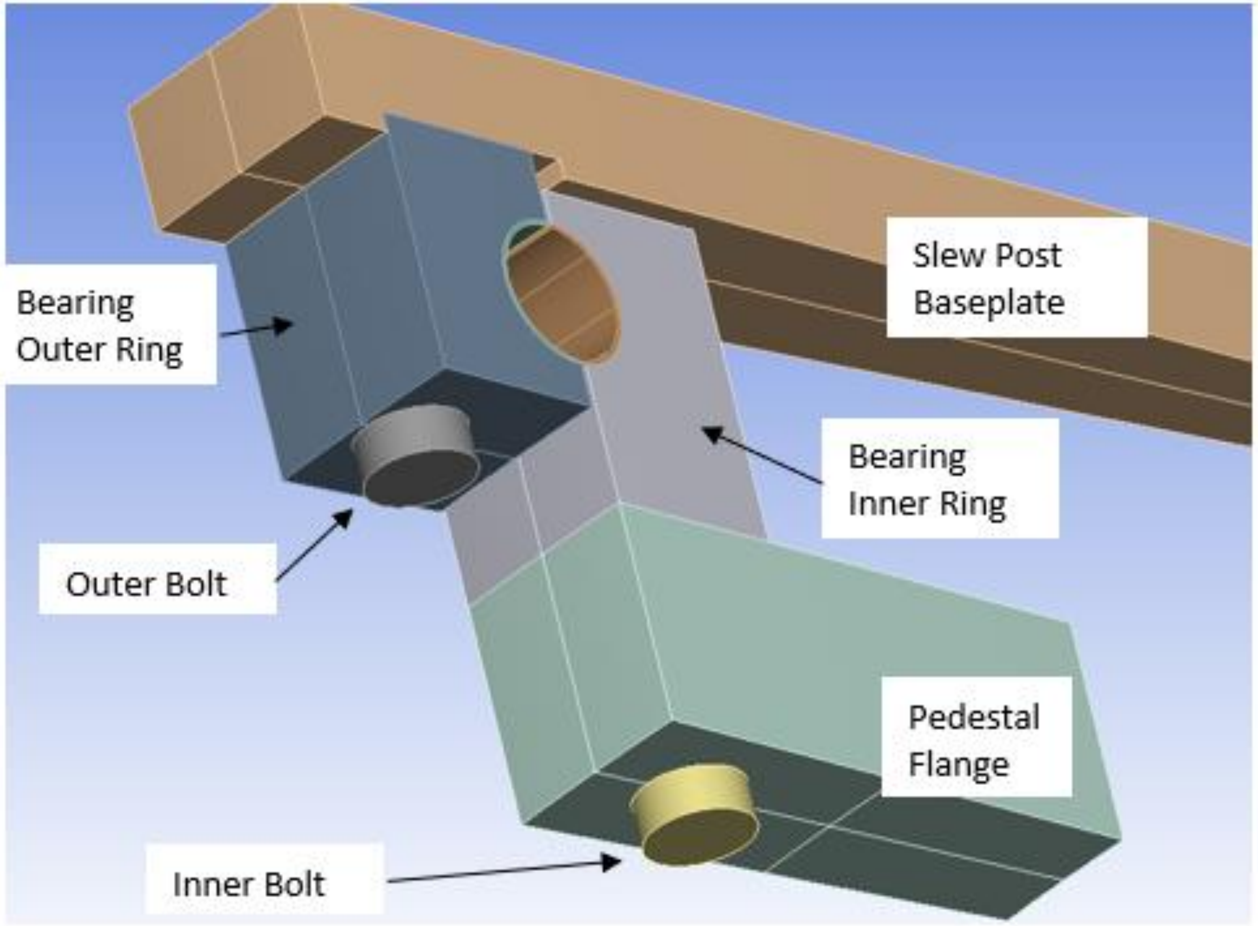
Figure 14 – Slew Post Stresses with 60 tonne Hook Load at 26 metres



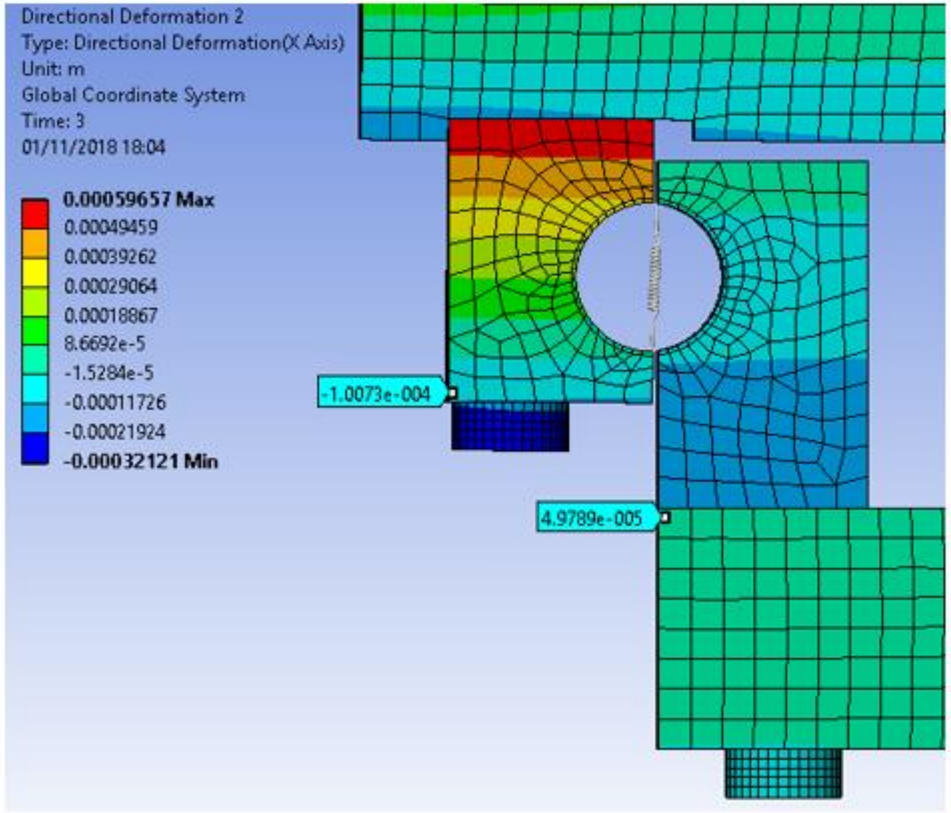
Modelling & Finite Element Analysis (FEA)

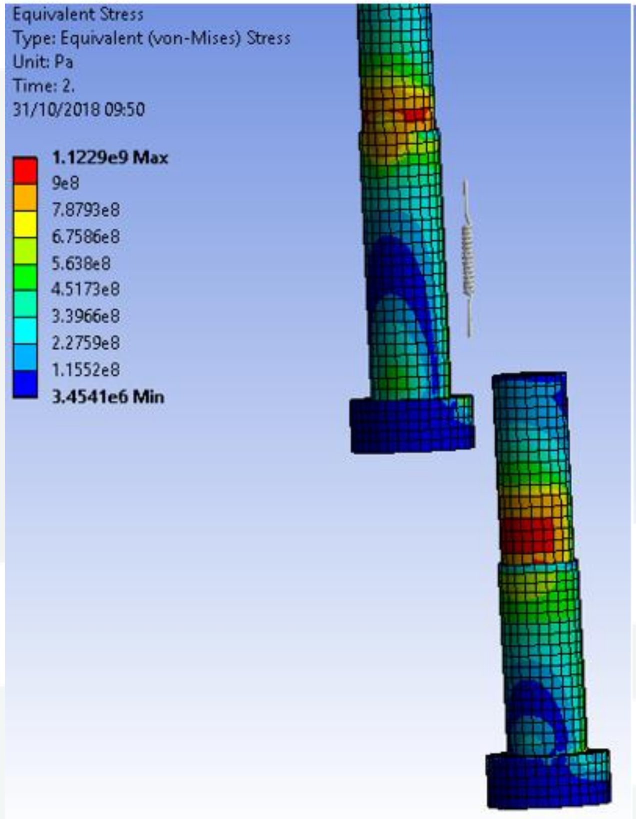


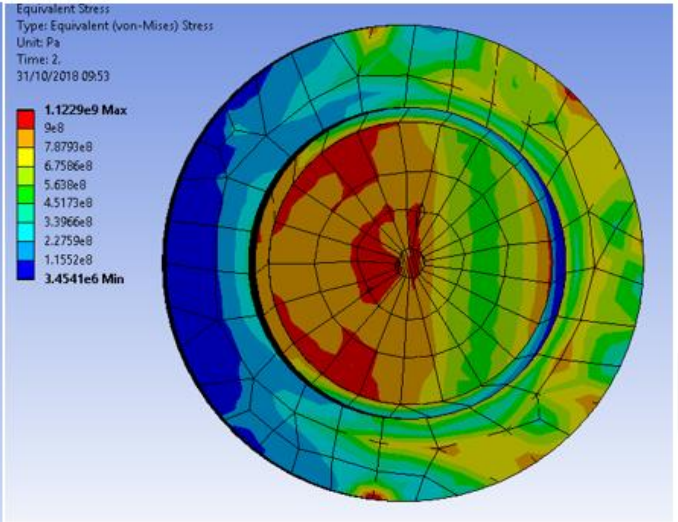
Schematic diagram of deck crane structure and slew bearing arrangement



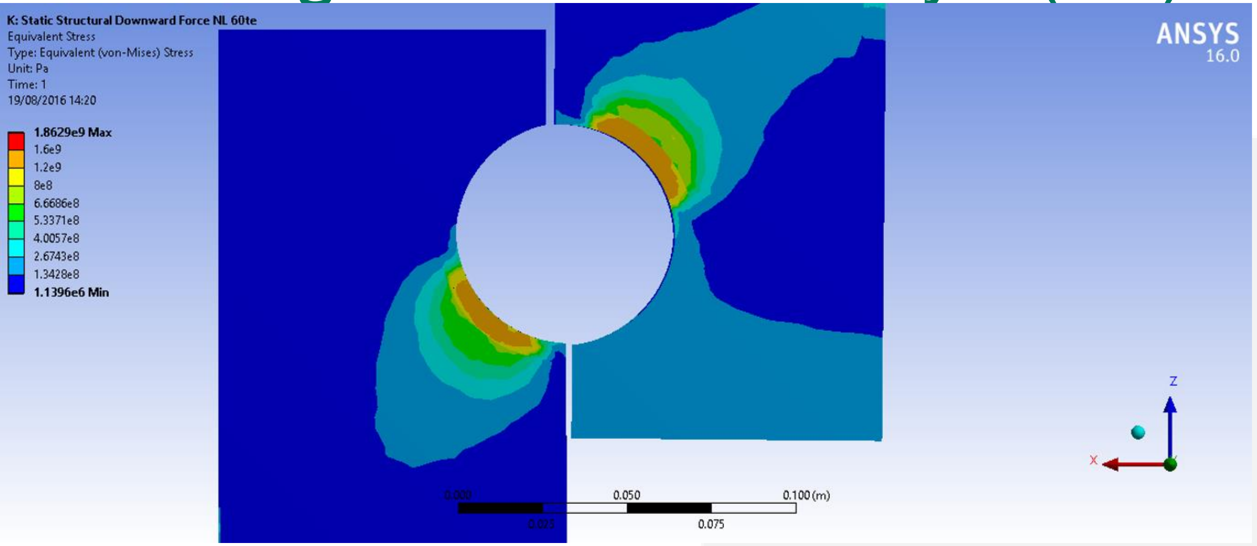
Modelling & Finite Element Analysis (FEA)

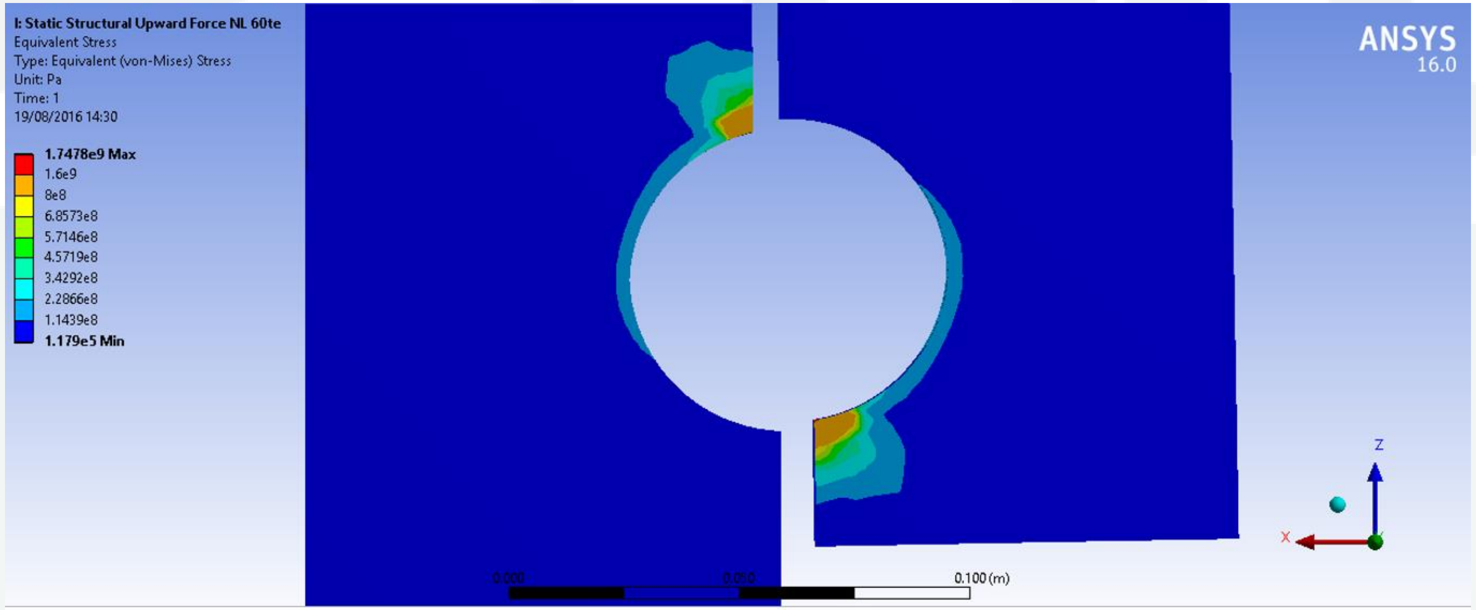




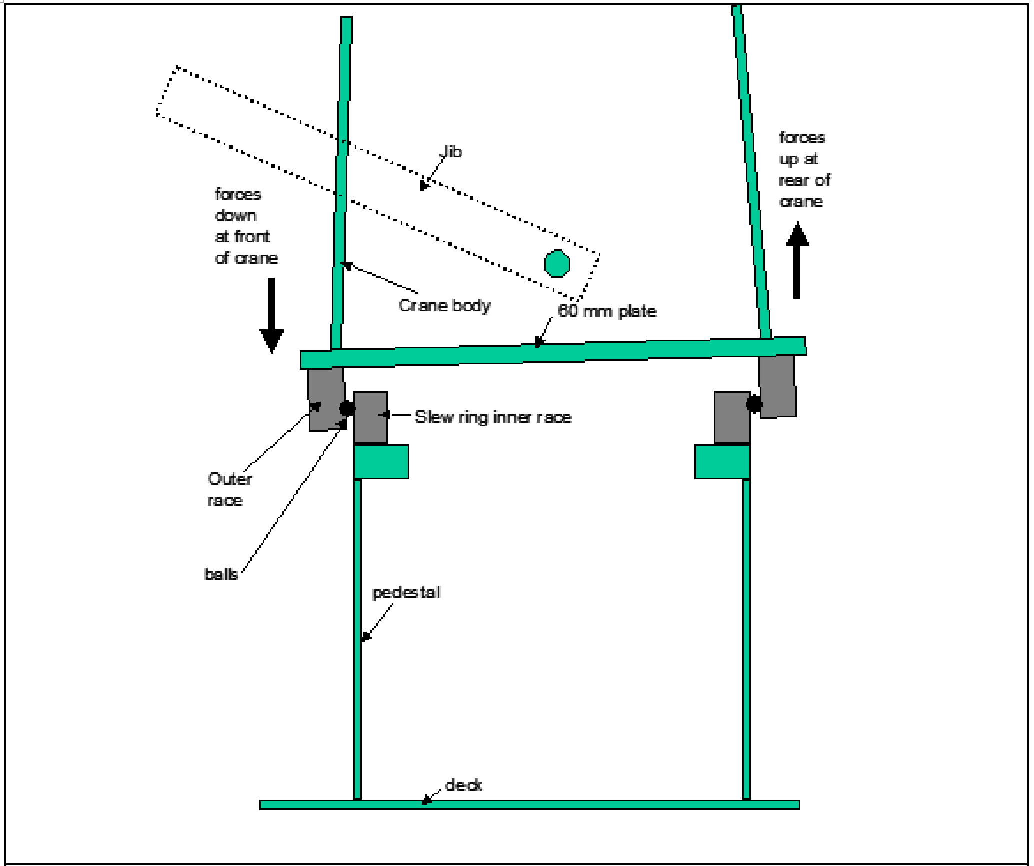


Modelling & Finite Element Analysis (FEA)



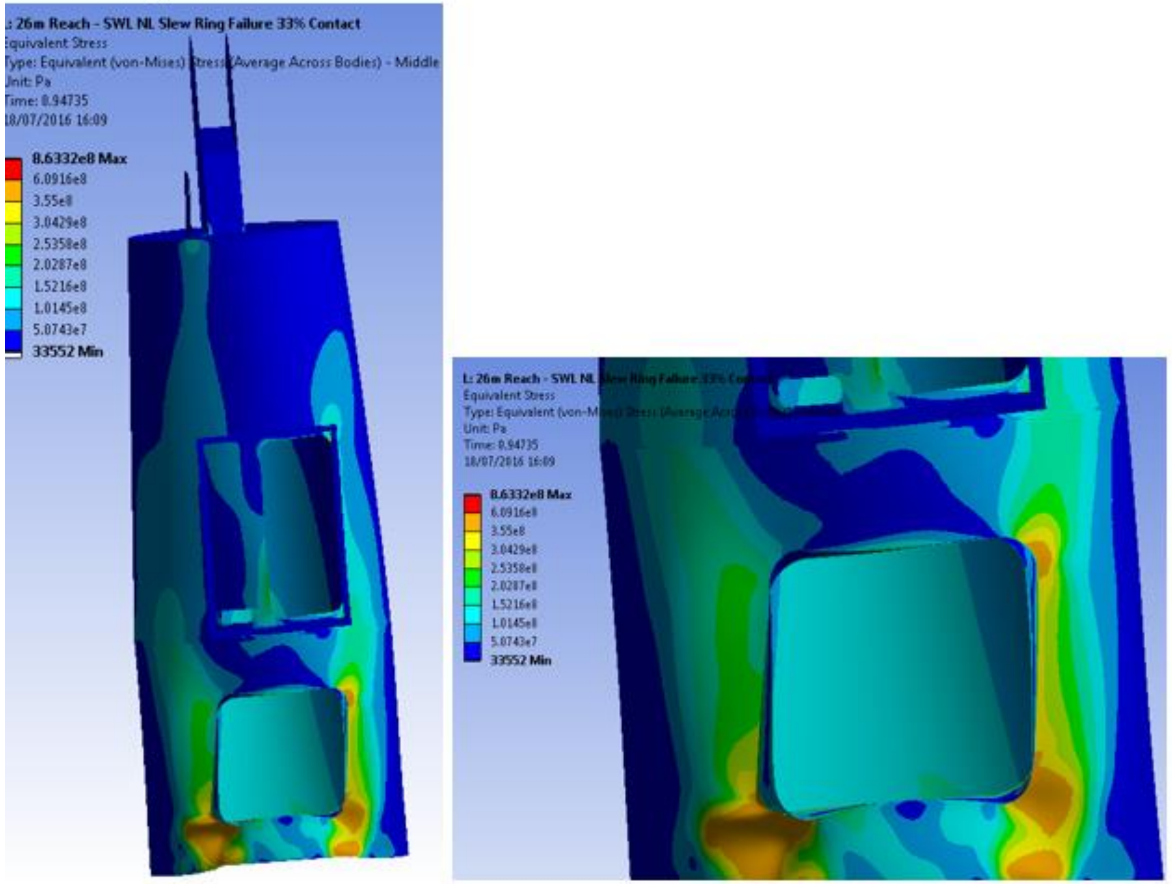


Modelling & Finite Element Analysis (FEA)



Crane slew post now tilts as a result of progressive bearing wear, which results in the load at the front being concentrated on a relatively small number of balls, leading to increased local stresses in structure.

Figure 19 – Slew Post Stresses with 28.4 tonne Hook Load at 26 metres

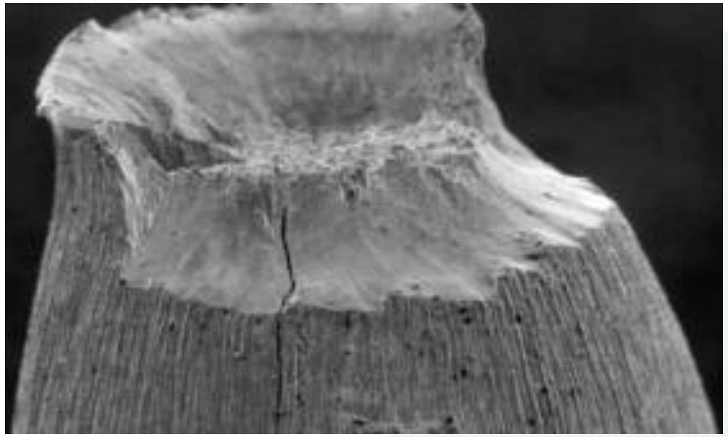


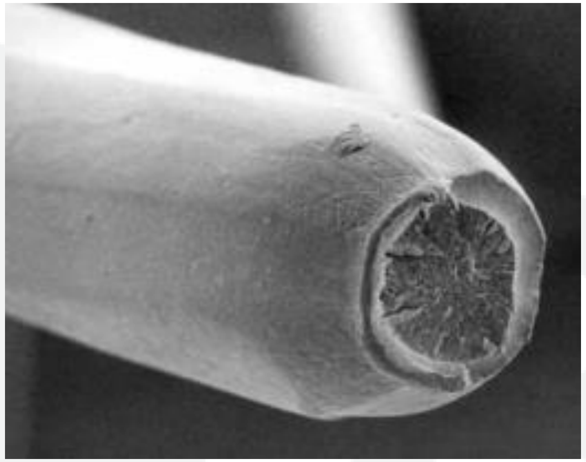
Wire Failures - Microscopy

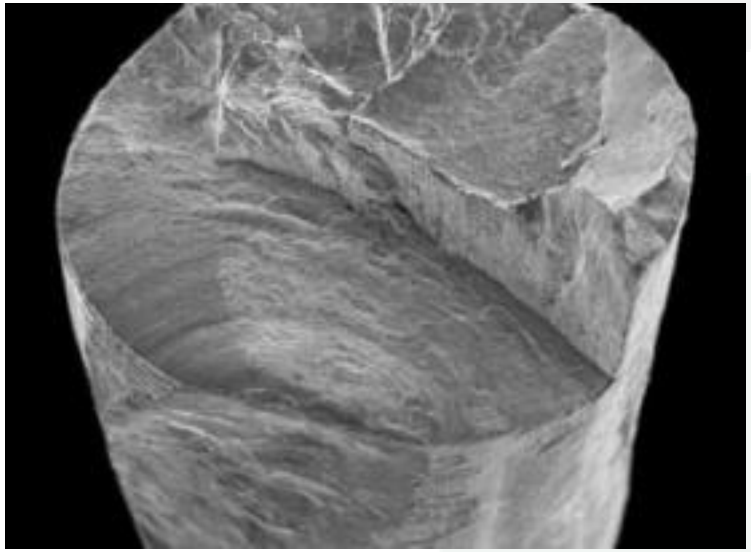


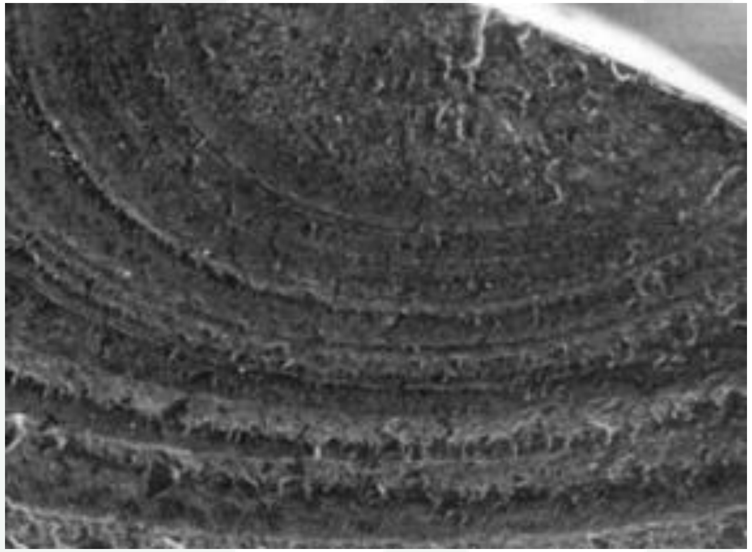


Scanning Electron Microscopy – Images Courtesy of Casar Ropes



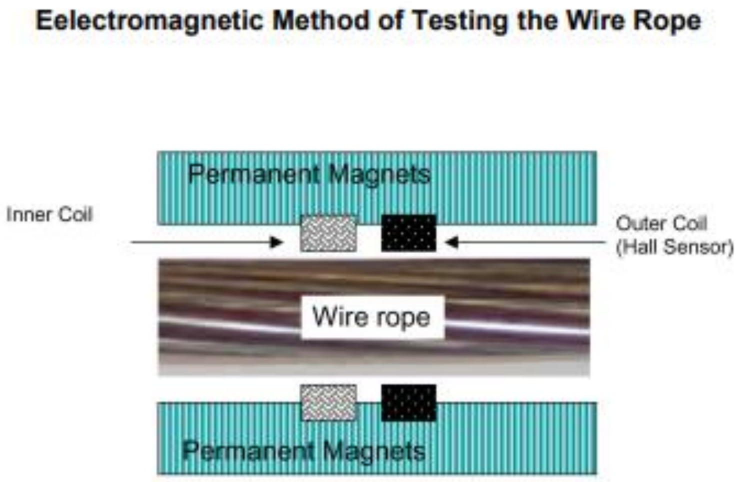


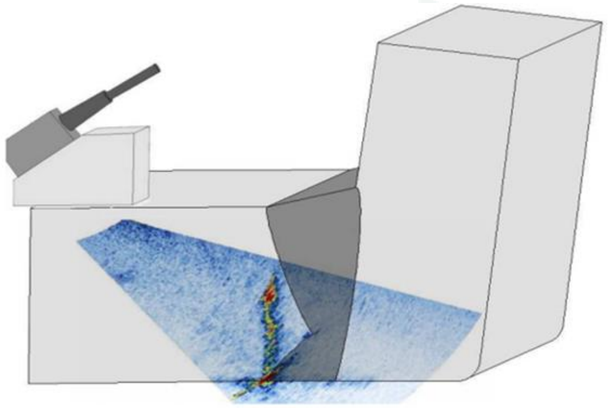


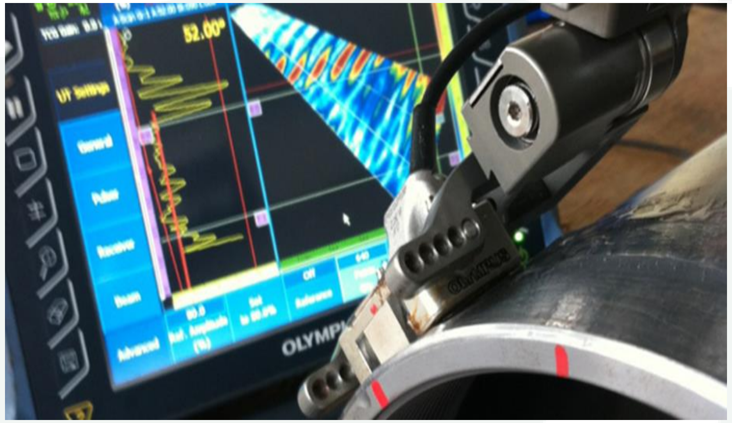


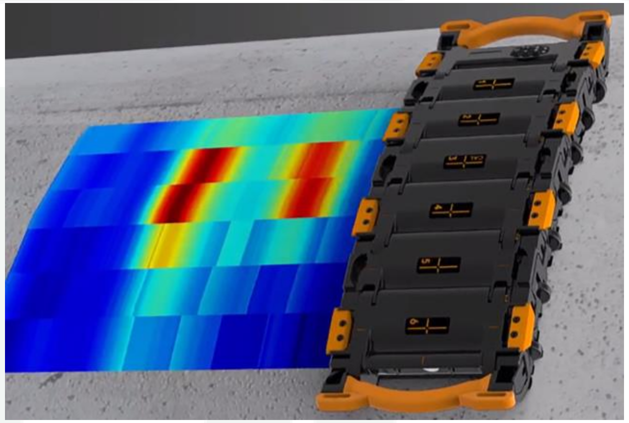
Loss Prevention – Asset Integrity Checks

1) Advanced NDT Inspection and Test Plan
   i. Dimensional checks
   ii. Critical welds for testing
   iii. Phased Array Ultrasonic Testing (PAUT)
   iv. Magnetic Particle Inspection (MPI)
   v. Electro-magnetic Testing (ET/PEC)

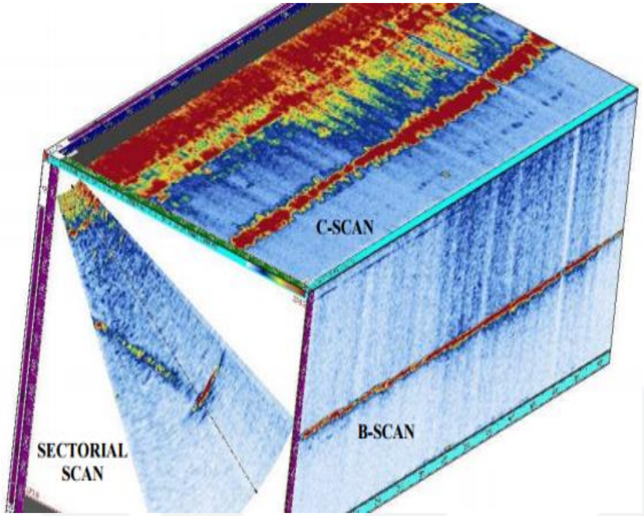




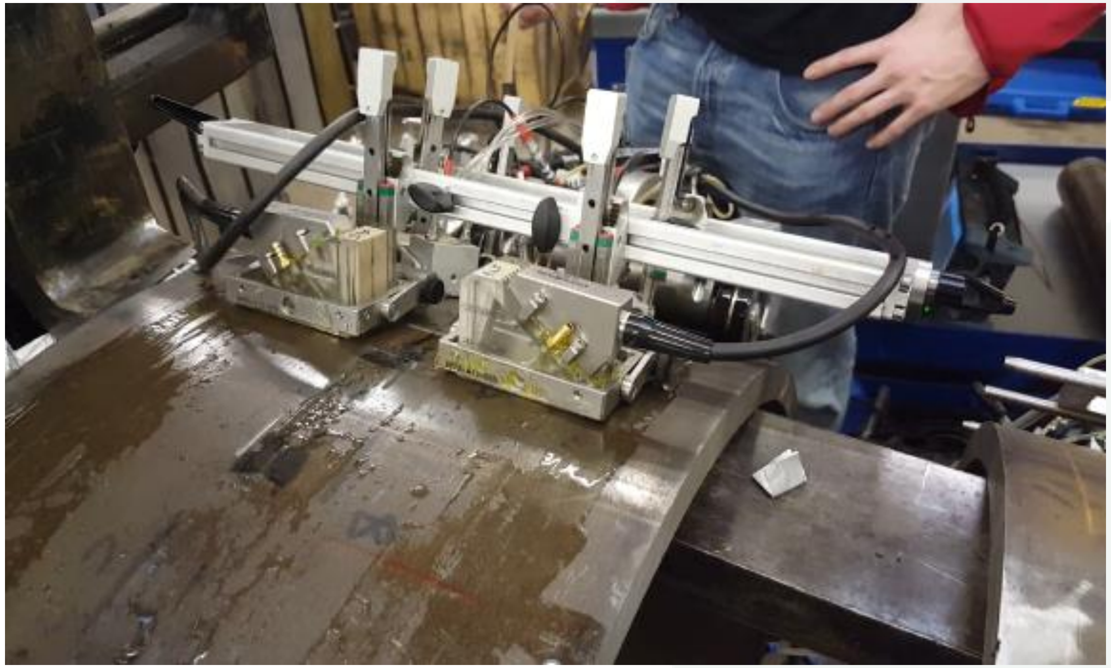




Loss Prevention – Regular Visual Inspection and Structural NDT Testing



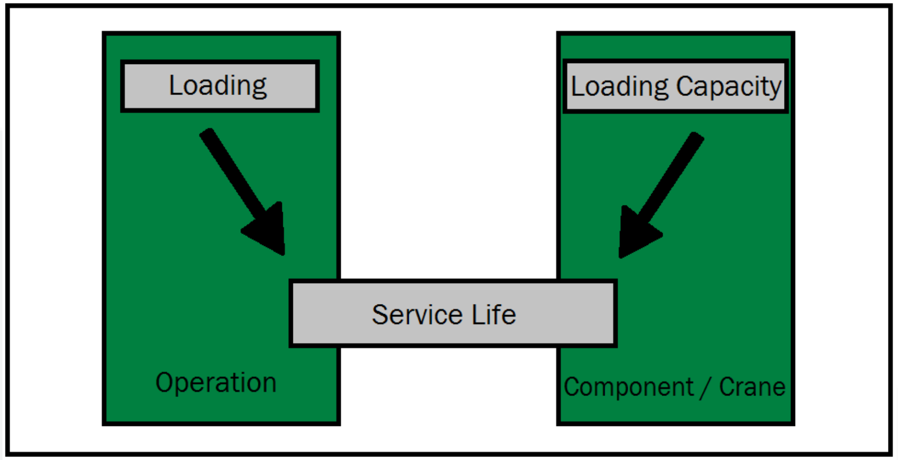
Performing visual inspections can highlight structural defects, such as cracks and indentations on box beams before failure occurs.

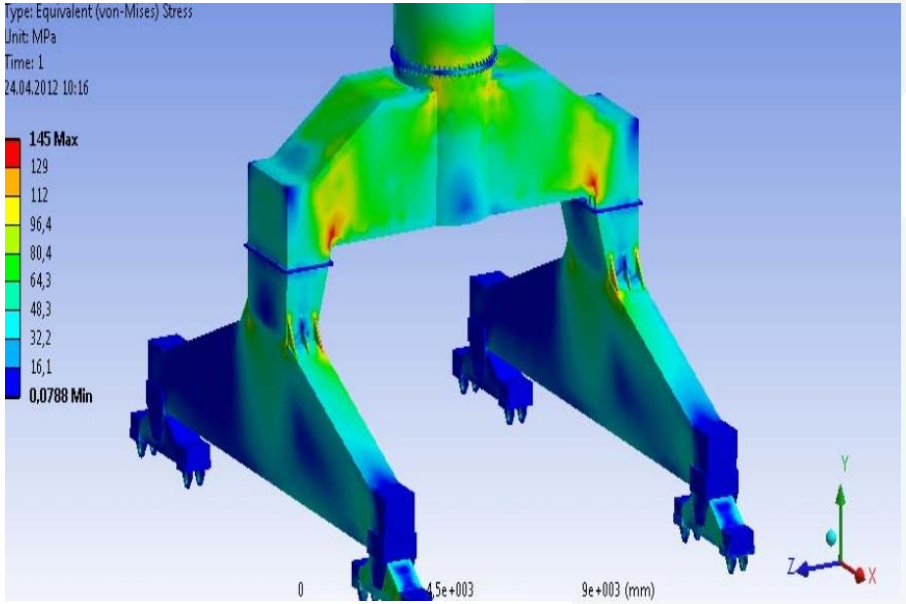


Regularly performing NDT tests, such as Ultrasonic Thickness Measurement (UTM) and Magnetic Particle Inspections can reveal hidden defects and confirm the structural integrity of the asset.

Loss Prevention - FEA

Proper application of rules, such as FEM, at the design stage to establish safe working limits on both load and lifespan of the crane





Finite Element Analysis carried out to determine stress concentrations and enable for adequate structural modifications/repairs

Image Courtesy of Casar Ropes

The evidence is there, you just have to look in the right places !

Many Thanks for Your Attention

brookesbell.com