



Learning Report

**Fatal Accident Involving Failure of a Tower Crane
At Kajima Overseas Asia (Singapore) Pte Ltd's Worksite Located
At Tan Tock Seng Link**

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1. About the Incident

- 1.1 On 4 November 2019, the jib of a Luffing Jib Tower Crane failed during a lifting operation at a construction worksite along Tan Tock Seng Link, near central Singapore. The occupier of the worksite was Kajima Overseas Asia (Singapore) Pte Ltd.
- 1.2 On the said morning, the Luffing Jib Tower Crane ("the TC") was lifting a bundle of scaffolding material when the jib of the TC suddenly buckled. This resulted in the load and the hook block of the TC plummeting down to the ground. The accident resulted in one fatality and an injury to another worker. A photograph of the TC post-accident, with its deformed jib, is shown in Figure 1 & Figure 2.



Figure 1 – General view of the TC after the accident



Figure 2 - Side view of the TC after the accident

2. Luffing Jib Tower Cranes

2.1 Operating Principle

- 2.1.1 Luffing Jib Tower Cranes are a type of tower crane that vary their working radius by raising or lowering their jib through a luffing jib system. The upper portion of a Luffing Jib Tower Crane is shown in [Figure 3](#).

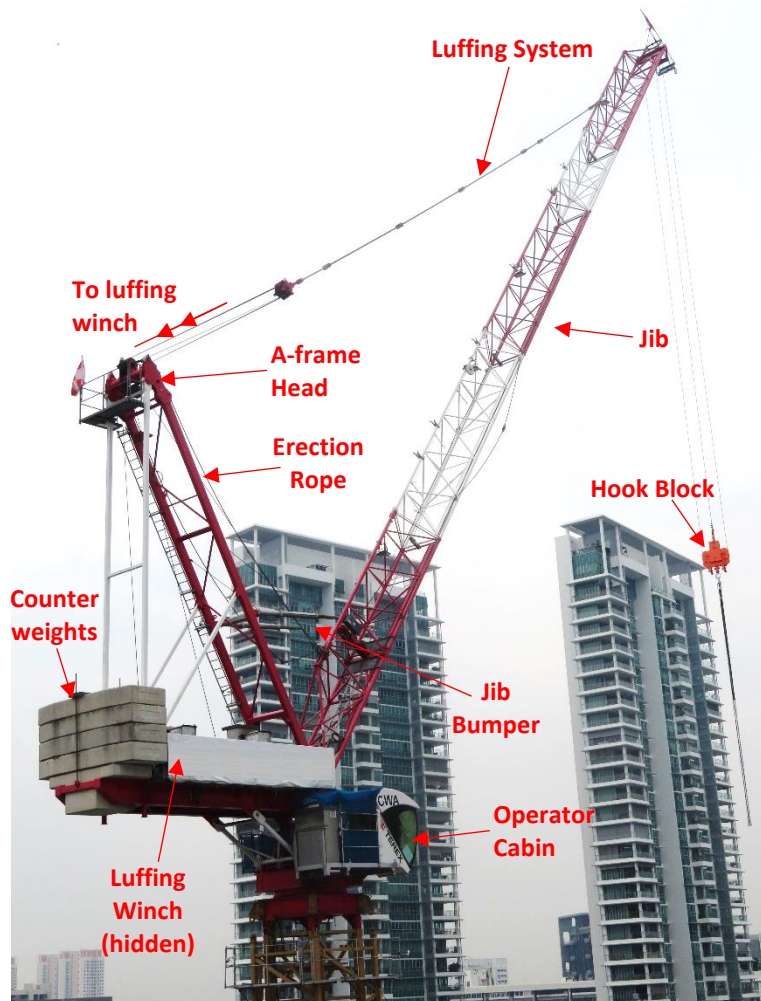


Figure 3 - Upper Portion of the TC

2.2 Installation of a Luffing Jib Tower Crane and Erection Ropes

- 2.2.1 Luffing Jib Tower Cranes are installed on-site. The installation process begins with the casting of a strong concrete foundation for the tower crane to be sited on. This is followed by the installation and assembly of the various components, including the mast sections, slew ring, operator cabin, counter-jib, counter-weights, A-frame and jib sections.

Erection Ropes

- 2.2.2 During the jib installation process, Erection Ropes are typically used to hold and balance the jib in position for the crane erectors to install and secure the jib onto the A-frame head (please see [Figure 4](#) and [Figure 5](#)).

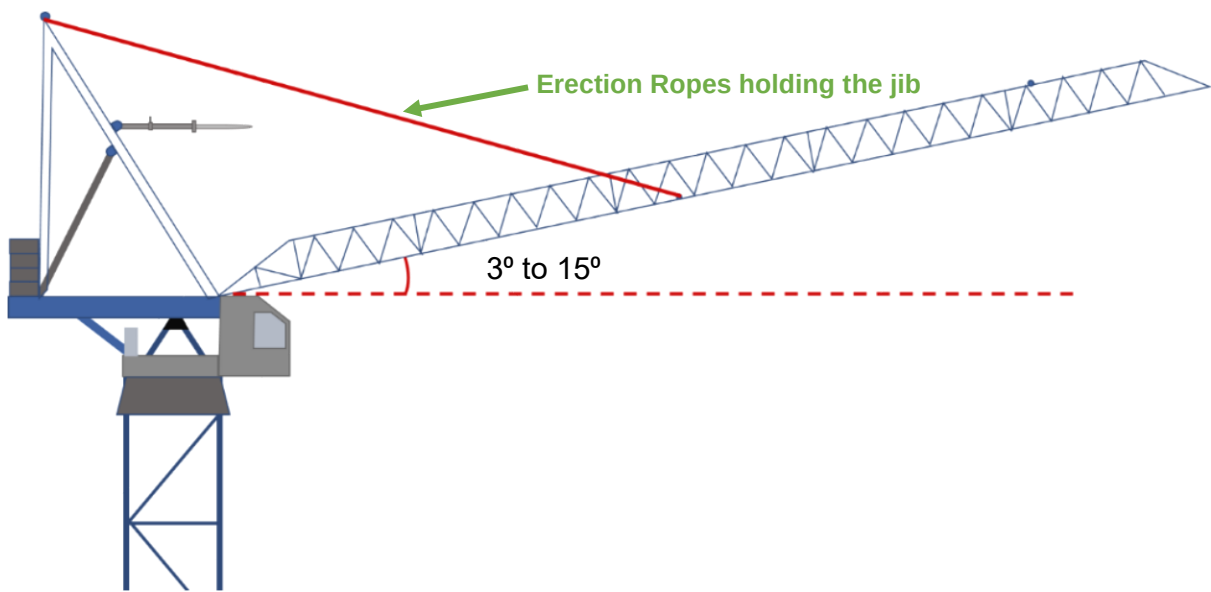


Figure 4 - Function of Erection Ropes of a Luffing Jib Tower Crane

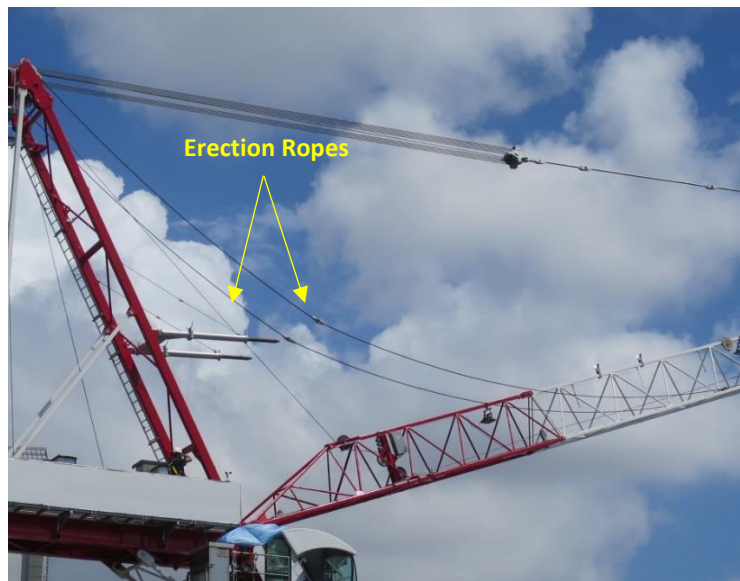


Figure 5 - Erection Ropes of luffing jib when the jib is lowered

- 2.2.3 Erection Ropes usually come in a pair, with one end of each rope secured to the A-frame head and the other end secured to one of the jib sections (please see [Figure 4](#)). Erection Ropes can come in a single length or as an assembly comprising of shorter lengths of ropes. The length of the jib determines the length of the Erection Ropes used and the location on the jib they are secured to. This ensures that the Erection Ropes used are of optimal length (not excessively long or short). The specific length and position of installation of the Erection Ropes are prescribed in the tower crane manual.
- 2.2.4 After the luffing system of the jib has been installed, the Erection Ropes play no further role in the function and operation of the tower crane.

Management of Erection Ropes

- 2.2.5 Some tower crane manufacturers recommend for the Erection Ropes to be removed after the jib installation. In such cases, the Erection Ropes are required to be reinstalled back onto the cranes before any jib maintenance or dismantling of the cranes can occur.
- 2.2.6 However, there are other tower crane manufacturers who allow for the Erection Ropes to be left on the tower cranes after the jib installation (as in the case for this TC). This eases subsequent jib maintenance and dismantling of the cranes, as the Erection Ropes need not be reinstalled back onto the cranes. Some manufacturers also recommend leaving the Erection Ropes on the tower cranes to support the jib in the event of troubleshooting or repair of a defective jib mechanism. Leaving the Erection Ropes on the tower cranes also eliminate working at height risks during its re-installation.
- 2.2.7 For Erection Ropes that are left on the tower cranes after the jib installation, the amount of slack in the Erection Ropes will vary during operation - they will have more slack when the jib is raised and less slack when the jib is lowered. As such, support brackets are often provided on the tower crane to contain and guide the Erection Ropes into its proper resting position and prevent excessive dangling of the Erection Ropes when the jib is raised (please see Figure 6).



Figure 6 - Erection Ropes rest in the support bracket when the jib is raised

3. Findings from Accident Investigation

3.1 Sequence of Events

3.1.1 The sequence of events that led to the accident was:

- a) The TC was operated to lift a load at the time of the accident.
- b) The TC's jib was raised to reach the load which was positioned near to the TC's mast. During the process, the Erection Ropes slackened and the right Erection Rope likely slipped out of its support bracket instead of resting within it, as shown in [Figure 7](#).
- c) After the load was picked up, the TC's jib was lowered to reach the intended unloading position. During the process, as the Erection Ropes straightened, **the right Erection Rope became entangled with the outer pivot joint on the right side of the A-frame**, (please see [Figure 8](#)).
- d) The entanglement of the right Erection Rope caused a mechanical restriction to the luffing function of the jib of the TC i.e. the jib was prevented from being lowered further.
- e) The attempt to continue luffing down the TC's jib resulted in the luffing winch continuing to unspool and thereby releasing the luffing wire rope from the drum. As the luffing wire rope became slackened, the entangled right Erection Rope began to take on the weight of the jib and the suspended load. Under continual stress, the right Erection Rope eventually failed at the entanglement point, and the jib jerked downwards in free-fall.
- f) As the jib was held back by the luffing wire rope, it buckled at jib section #3 as it fell. The buckling of the jib occurred after the jib started to fall and was not the cause of the accident.
- g) Consequently, the hook block and load also plummeted down to the ground, hitting the deceased and another worker who were working in the vicinity.
- h) The TC was not overloaded at the time of the accident.
- i) The full sequence of events is illustrated in [Figure 9](#).

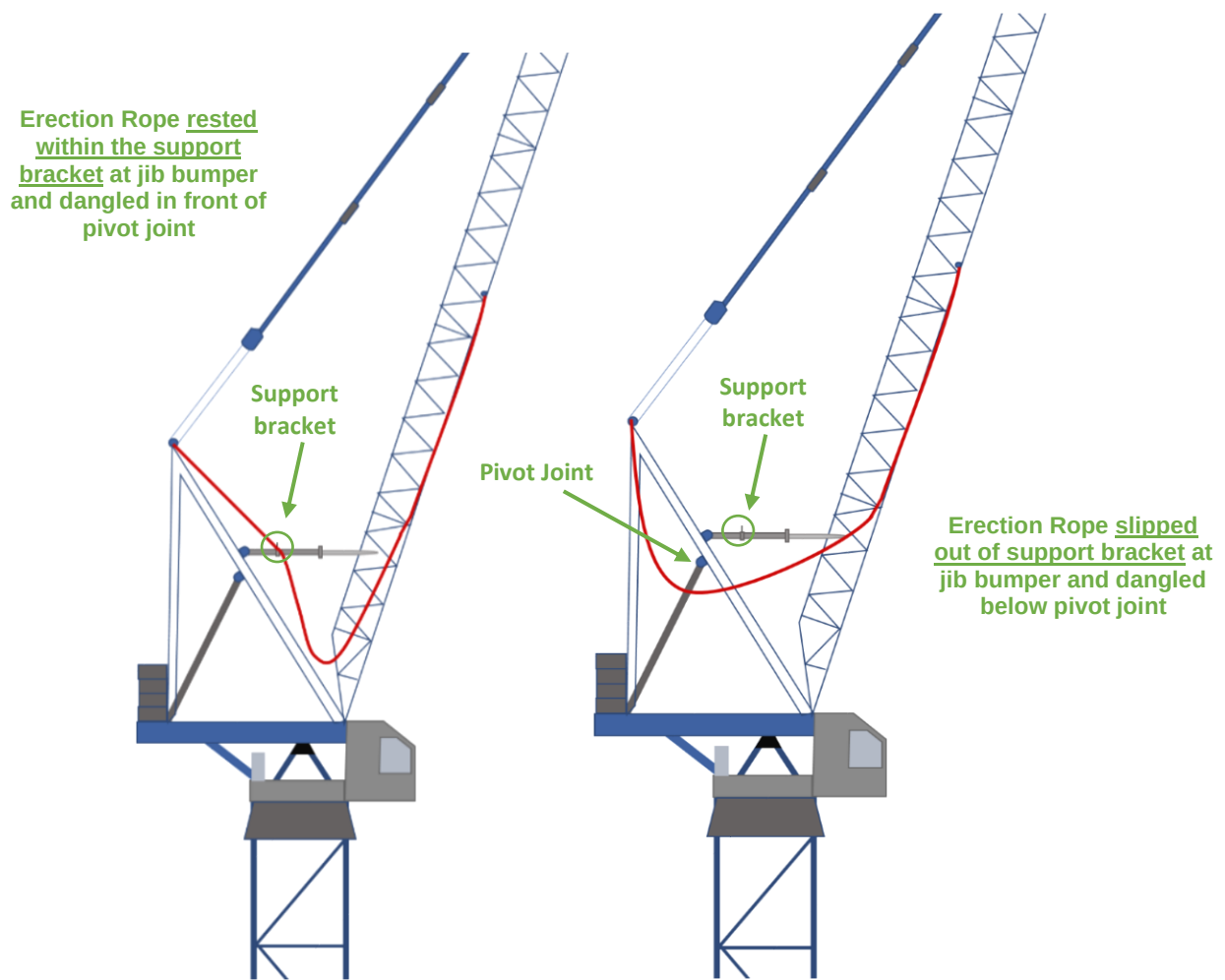


Figure 7 - Schematic views of Erection Rope in and out of the support bracket

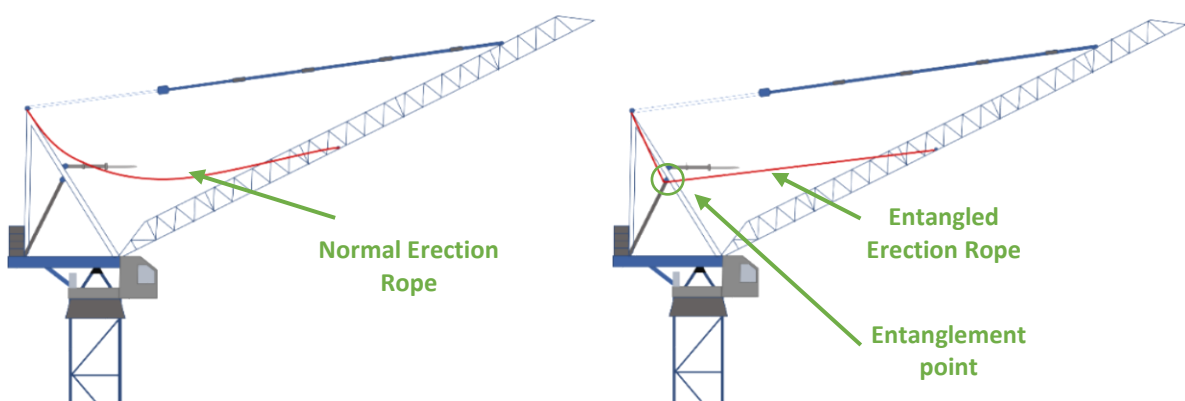


Figure 8 - Schematic views of the TC showing conditions with normal and entangled Erection Rope

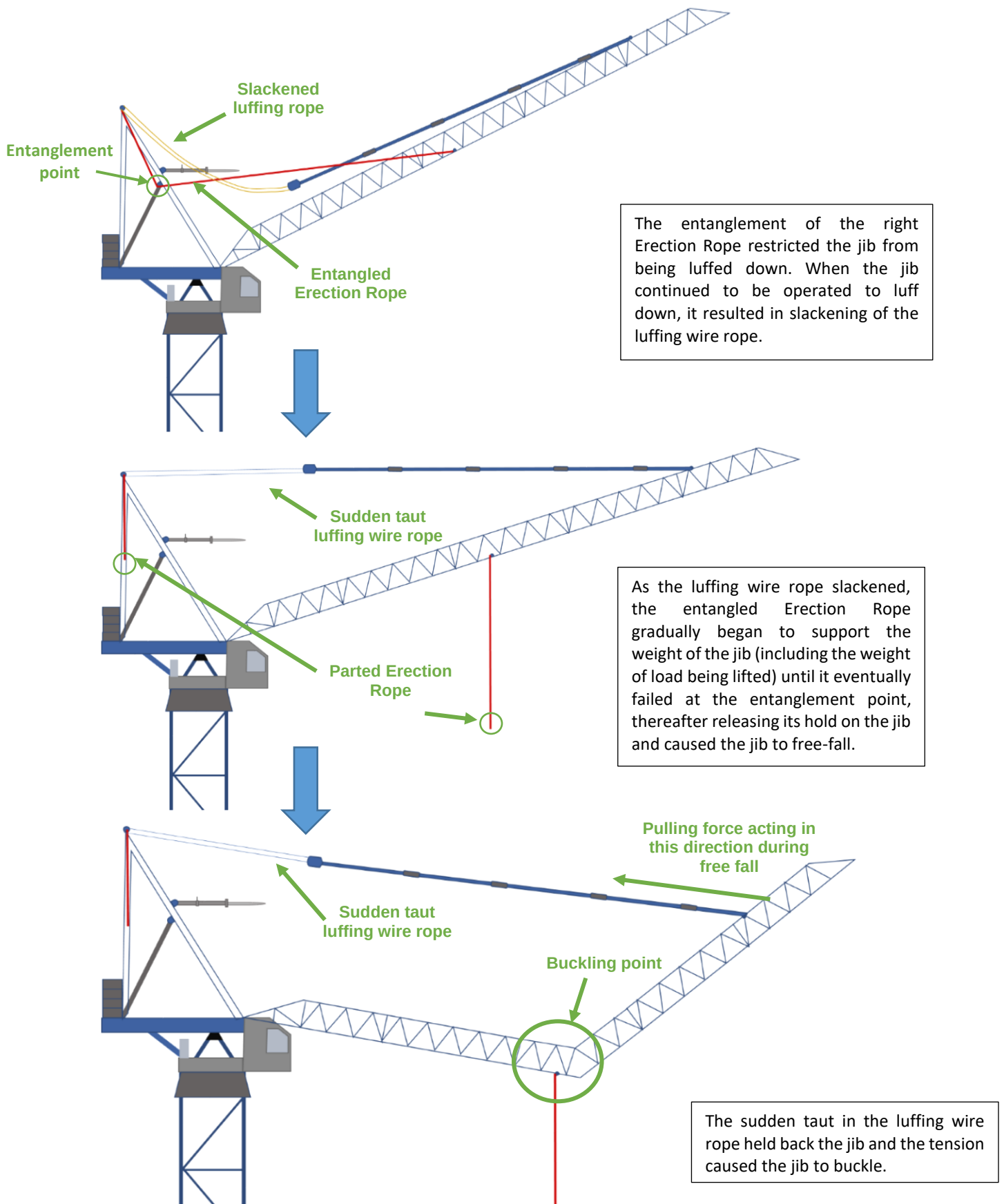


Figure 9 – Sequence of events on the buckling of luffing jib of the TC

3.2 Contributing Factors

Design of Supporting Brackets

- 3.2.1 The design of the support brackets (to contain and guide the Erection Ropes) was open and shallow – in a widened “U” shape (please see [Figure 6](#)). This was deliberate so that the Erection Ropes could move freely as it slackened or tightened depending on whether the jib was raised or lowered. The support brackets were not meant to be load bearing.
- 3.2.2 When the Erection Ropes were not positioned within the support brackets, they would dangle below the A-frame (please see [Figure 7](#)), resulting in the possibility of them being entangled with other parts of the crane. As the jib was subsequently lowered, any entanglement would cause mechanical restriction to the luffing of the jib of the tower crane and could impact the operation of the crane.

Entanglement Risks

- 3.2.3 There was a groove/gap at the connection between the main and supporting frame of the A-frame at the pivot joint (please see [Figure 10](#)). The size of the gap was about the size of the diameter of the Erection Rope. This created an entanglement risk when the Erection Rope glided past the pivot joint while the jib was being lowered.

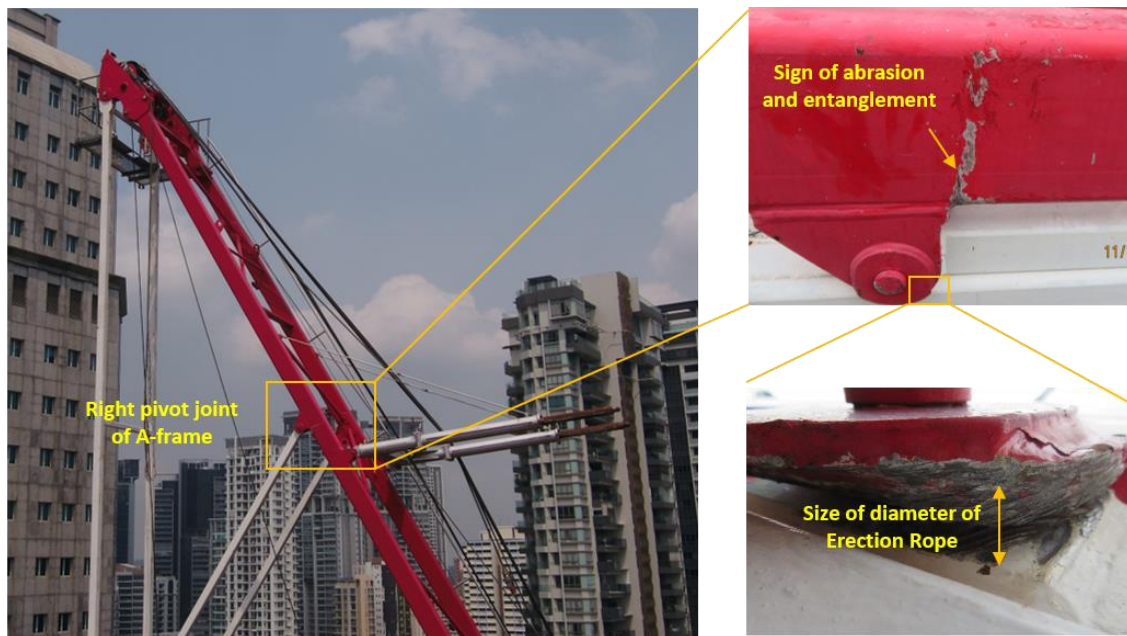


Figure 10 - Close-up view of the right pivot joint of the A-frame

4. Learning Points

MOM has checked with industry stakeholders and could not find any similar incident of tower crane failure involving Erection Ropes globally. Hence, it is critical to establish the learning points from the incident to prevent recurrence.

Based on the findings gathered from this incident, **two** learning points were derived.

4.1 Eliminate Risk of Entanglement between Erection Ropes and other Structures

- 4.1.1 Whenever the jib is being raised or lowered, the Erection Ropes will progressively shift from a more slackened to a less slackened configuration, and the lengths of the Erection Ropes will glide past fixed structures of the upper body of the tower crane. While some manufacturers recommend that it is acceptable for the Erection Ropes to be left on the tower cranes during the operation phase, **MOM has consulted industry stakeholders and recommend that, notwithstanding manufacturers' recommendation, Erection Ropes should be removed or disconnected and stowed securely on the crane after the jib installation.** This is to eliminate any risk of accidental entanglement of the Erection Ropes with any fixed structure of the tower crane as the Erection Ropes will not be in tension even when the jib is being lowered.
- 4.1.2 If the removal or disconnection of the Erection Ropes is not practicable or it introduces additional risks, crane manufacturers and suppliers will need to review and identify any potential entanglement points and mitigate the risks of accidental entanglement of the Erection Ropes at these points. For the TC involved in the accident, this could be done by way of reviewing the design of the pivot joint to eliminate the presence of the groove/gap or installing a purpose-built protective guard to cover the entanglement points, to reduce the risk of entanglement.

4.2 Ensure Erection Ropes return to their Resting Position

- 4.2.1 Erection Ropes are secured at their ends. Hence, their lengths are free to progressively slacken to correspond to the movement (raising or lowering) of the jib. For cases where the Erection Ropes are not removed or disconnected, any support brackets to contain and guide the Erection Ropes in position, should be adequately designed to prevent unintended slippage during the repeated raising and lowering of the jib. To ensure that the Erection Ropes will return to their resting position within the support brackets, regular testing (without load) by repeated raising and lowering of the jib should be carried out to check if there is any unintended or excessive slippage of the Erection Ropes.

5. Relevant Industry Practices

In addition to the learning points discussed in Section 4, the following practices should also be adopted for the use of Luffing Jib Tower Cranes:

5.1 Conduct Regular Examination and Inspection of Tower Cranes

- 5.1.1 To ensure the safe operation of tower cranes, it is imperative to conduct regular examination, inspection and testing to detect any deviations from safe operating conditions. This will ensure that defects or anomalies are rectified promptly, and that the tower cranes are in good working condition and safe for its intended use.
- 5.1.2 Inspections should include checks on Erection Ropes and support brackets to ensure that they are in good working condition. Although the Erection Ropes are not required for the function and operation of the Luffing Jib Tower Crane, any anomaly found on the Erection Ropes, such as wear features and abrasion marks, could suggest likelihood of unidentified hazards, such as possible entanglement or abrasion of Erection Ropes.

5.2 Ensure Installation, Dismantling and Repair of Tower Cranes are done in accordance to Manufacturer's Recommendations

- 5.2.1 Installation, dismantling and repair of tower cranes shall only be conducted by Approved Crane Contractors¹ (ACC) with the relevant scope. The ACC shall plan the installation thoroughly to ensure that the operation is proceeded safely, efficiently and without incident.
- 5.2.2 The ACC shall ensure that the installation of the tower cranes is done in accordance to the crane manufacturer's instructions. Any deviation from the specified procedure should be approved by the crane manufacturers to ensure that the safe operation of the tower cranes will not be compromised after the installation. The ACC should also ensure that all the crane components are inspected prior to installation to ensure they are of good construction, sound material, adequate strength and free from patent defects.
- 5.2.3 The length and position of the Erection Ropes installed on the jib sections must conform to the crane manufacturers' recommendation. While having Erection Ropes of an excessive length may increase the stresses on the crane during installation of the luffing system, a shorter length may restrict the reach of the jib and cause undue loads on the Erection Ropes. Hence, Erection Ropes of an optimal length shall be used in

¹ Approved Crane Contractor is any firm or company which is the holder of a valid certificate of approval issued by the Commissioner under the Workplace Safety and Health Act to conduct installation, repair, alteration or dismantling of mobile or tower crane.

accordance to manufacturer's recommendations, specific to the length of the luffing jib of the tower crane.

- 5.2.4 It is also critical to ensure that the pair of Erection Ropes installed on the tower crane are of the same length to prevent imbalanced loadings on the ropes.

5.3 Implement proper Lifting Plans to ensure Safe Lifting Operations

- 5.3.1 All lifting operations shall be accompanied by a Lifting Plan and supported by a risk assessment, permit-to-work system, safe work procedures and method statements. The Lifting Plan shall be developed in accordance to generally accepted principles of safe and sound practice and shall include critical information that must be considered in a lifting operation such as safe working load of tower crane, rigging details, communication of lifting crew and demarcation of lifting and exclusion zones.

6. Conclusion

Workplaces utilising the use of Luffing Jib Tower Cranes are reminded to take heed of the learning points and implement effective risk control measures to prevent any similar recurrences. In summary, the two key learning points from this incident are:

- 1) Eliminate Risk of Entanglement between Erection Ropes and other Structures; and
- 2) Ensure Erection Ropes return to their Resting Position.