Lessons Learnt Case Report

COLLAPSE OF CRANE: NOT JUST ANOTHER DANGEROUS OCCURRENCE BUT A FATAL INCIDENT

May 2009
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Introduction

1 On the incident day in April 2006, during the lifting of a 182 ton load, the crane suddenly collapsed, taking 3 workers’ lives instantly and injuring 3 others. This case study report analyses the cause of this major incident using the 5M (Machine, Man, Management, Medium and Mission) model. Recommendations to prevent such incidents from happening had also been included.

Summary of Events

2 On the incident day, at about 0900 hrs, the lifting of an approximately 182 ton “spun can” (a movable structure or a “shoe” that is connected to the leg of an oil rig) by a crawler ringer crane commenced. The mission was to lift the load from the ground and to place it into the forward leg well of the oil rig which was still under construction.

3 The crane operator lifted the load and slewed the boom of the crane gradually to about 45 degree to his right and held the load at about 4 metres above the main deck of the oil rig. During the lifting process, one of the 3 tag lines that served as a guide rope to control the swaying movement of the lifted load came into contact with the scaffolds that were erected next to the oil rig. A rigger managed to clear the tag line from the scaffold.

4 After the tag line was cleared from the scaffold, the operator continued to slew the boom slowly toward the forward leg well, within the designated working radius of 30 metres. The same tag line once again came into contact with the scaffold and had to be cleared again by the rigger before operation could continue.

5 During the lifting operation, other shipyard activities went on as usual. Scaffolders and workers on the main deck resumed their work once the load had been lifted a distance away from their working area. Other workers and vehicles were free to move within the lifting zone and an excavator was moving around the vicinity during the lifting operation.

6 At about 0915hrs, during the slewing of the boom, the operators experienced a resistance that prevented the boom from being slewed any further. Attempts were made to slew the boom by progressively easing back and powering up the boom.
At about 0935hrs, after operator had rotated the boom by 90 degrees, he held it there within the designated operating radius of 30 metres. The operator heard a “metallic cracking sound”, and the boom collapsed to the ground. This caused the “spun can” that was being lifted to fall onto the main deck of the oil rig and subsequently fall onto the collapsed boom on the ground.

As the crane collapsed, the “spun can” struck some gas cylinders within the lifting zone which resulted in a fire.

3 workers were killed instantly and 3 other workers were injured as a result of the collapsed.

- A scaffolder who was staging materials on the main deck was killed instantly after being struck by the “spun can”.
- An operator of the excavator was crushed and killed after being struck by the collapsed boom and “spun can”.
- A worker walking toward the toilet was killed after being struck by the collapsed boom tip.
- A worker was injured by the fallen “spun can” while aligning some of the measurement on the main deck.
- A worker cycling to the workshop was struck by the collapsed boom and fractured his left arm.
- Lastly, a worker who was ensuring that the load did not swivel during the lifting operation was thrown backward into the ring of the crane and was injured.
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Findings

Machine

10 Erection and installation of crane: The crawler ringer crane was erected and installed by qualified personnel under the supervision of the crane section head. Erection and installation took about 10 working days. Steel plates of different thickness were placed on the ground where the crane was erected. During installation, the crane was checked for alignment, levelled using a 900mm level ruler gauge, and fitted with fly jib and counterweight. To level the ring of the crane, shims of different thickness and sizes were placed either between the ring and the steel keel block or the ground.

Figure 1: Schematic diagram of accident site (Not drawn to scale and not in sequence)
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11 Absence of necessary equipment: Theodolite or manometer was not installed on the crane. According to the Assembly and Erection Manual, a manometer is required to be installed to monitor that the crane is still level after every heavy lift.

12 Reliability of crane: The collapsed crawler ringer crane had been in service for many years and was taken over by the occupier 9 years ago. The crane had a Lifting Equipment Registration Number, and the Certificate of Test by an authorized examiner was still valid at that time of the incident. There were no records of major repairs other than general servicing and minor repairs.

13 Wire ropes: The wire ropes used in the operation had a Lifting Equipment Registration Number. Although the wire ropes were in good condition, the Certificate of Test had expired.

14 Boom of the crane: After the incident, the boom was badly damaged. Trusses of the boom showed signs of ductile overload fracture. Failure analysis has shown that there were numerous internal weld imperfections at the lugs section of the boom carrier assembly, which eventually fractured through crack propagation originated from the welded zone of the hinges.

Man

15 Workers failed to take reasonable care of their own safety: Scaffolders and workers were working at the main deck before “spun can” collapsed and landed onto one of the scaffolder and killed him instantly. The collapsed “spun can” also injured one of the workers working at the main deck. Although they were informed to stop work by the lifting supervisor prior to the lifting operation, they resumed their work as soon as the load was lifted a distance away without receiving any instruction from lifting supervisor to do so.

16 Due diligence of crane operator: Despite feeling resistance during the slewing of crane, the operator continued the operation. The operator failed to perform his due diligence to stop the lifting operation whenever any abnormalities arise, which could have prevented this accident from happening.

Management

17 Test conducted prior to commencement of work: A day before the commencement of the said work, several test lifts were conducted. The “spun can” was also lifted from the ground and placed in an upright seated position on the concrete blocks ready to be deployed.

Please note that the information provided is intended to enhance workplace safety and health so that a similar recurrence may be prevented, and is not exhaustive. The information provided should not to be construed as implying any liability to any party nor should it be taken to encapsulate all the responsibilities and obligations of the reader of Lessons Learnt Case Report under the law.
Personnel and objects in the lifting zone: Gas cylinders located within the lifting zone were not removed by the Management. Thus when it was struck by the fallen load, a fire broke out. In addition, the Management failed to prevent other workers and vehicles from moving in and out of the lifting zone during the lifting operation. The Management also failed to perform their due diligence to ensure that works on the oil rig during the lifting operation were completely stopped. It was reasoned that in normal yard practice, the lifting personnel would have cleared workers away from the lifting zone by sounding the horn and the whistles.

Absence of Barricade in the lifting zone: No physical barriers were erected to keep other workers or vehicles from entering into the lifting zone.

Absence of safety assessment by safety personnel prior to work: The Crane Section consisted of a team of personnel who would self regulate the works being carried out for the lifting operation and was not normally required to seek approval from the Safety Department of the shipyard to perform heavy lifting. For this lifting operation, the crane section head had made the necessary preparation and put in place safety measures prior to the commencement of work. Hence prior to the lifting operation that lead to the incident, safety personnel was not deployed to check that safety requirements were in place before the commencement of work.

Compacted ground: According to the crane section head, prior to the installation of the crane on site, the ground was compacted using a bulldozer followed by moving the 200 ton mobile crawler crane over it. The ground on which the crane positioned was tested to have sufficient capacity to withstand the entire lifting operation.

Inclined ground: The ground was found to be inclined at 1.7 degrees, which exceeded the crane’s tolerance limit of 0.09 degree by 18 times. This could have accounted for the difficulty that the operator had faced in slewing the load to his right and caused the stresses on the hook roller to exceed its rated load by 2 to 8 times.

Frequency of lifting operation: Such lifting operations were carried out routinely, around 5 to 10 times per month. Hence, such operations were a norm in the shipyard.

Load being lifted: According to the crane operator, the operating radius of the crane was 30 metres. In addition, the “spun can” which was 182 tons, was within the
lifting capacity of the crane. Based on the lifting capacities chart, the safe working load for 30 metres was about 218 ton.

Analysis

Primary Causal Factors

25  Man:

a. Crane operator continued to operate the crane despite facing resistance during slewing of the boom. This added unnecessary stress on the boom and coupled with the internal weld imperfections on the lugs section of the boom, the boom failed. The operator could have performed his due diligence to stop the lifting operation whenever any abnormalities arise.

b. The scaffolders and workers on the main deck had failed to take reasonable care of their own safety by resuming their work without receiving instruction from the lifting supervisor to do so. Thus contributing to their death and injuries.

All these may be due to the absence of safety culture being inculcated into the workers’ mindset. If they have strong safety culture, workers would take more responsibility of their own safety by not resuming their work before proper instruction was given to do so. In addition, the crane operator would be more cautious and alert when faced with difficulty during the operation.

Contributory Causal Factors

26  Management:

a. Management was unable to ensure that the crane was levelled, within the tolerance limit, throughout the lifting operation as theodolite or manometers were not installed.

b. Management failed to effectively prevent workers from resuming their work before the area was declared to be safe, or to stop other works in the lifting zone during the lifting operation. By condoning bad practices of the workers, the Management failed to keep the workers safe and away from dangers.
c. Management failed to thoroughly identify the hazards involved in the heavy lifting operation. Such hazards include mechanical failure, operation failure, entry of unauthorized personnel and vehicles, and risk of workers being crushed by fallen structure.

d. Adequate safe work procedure was also not in place to keep the workers safe in the worksite. Even though Management did inform the workers involved in the lifting operation to keep clear from the lifting zone, no further action was taken to effectively clear the workers and equipment from the site. This refers to the absences of barricade to keep clear of other personnel, vehicles and dangerous objects (such as gas cylinders) from the lifting zone.

e. The Management failed to ensure equipment used were properly maintained and maintenance records were properly kept.

All these may be seen as the failure of having a proper safety management system in the company.

**Other Considerable Factors**

27 Method of ground compaction:

A 200 ton mobile crawler crane should not be used to further compact the ground after the ground was compacted using a bulldozer. This was deem unsafe as if the ground was not well compacted by the bulldozer, an incident could have resulted when the mobile crawler crane was moving on it.

28 Tag lines:

The tag lines that served as guide to control the swaying movement of the load should be cleared of any obstruction. Situation where the tag lines come into contact with surrounding obstruction (in this case, the scaffold) and requires personnel to clear the tag line is not acceptable. Adequate planning of work should be carried out before commencement of work to ensure that there is sufficient space for the operation.

29 Movement of workers and vehicles in the lifting zone:

During the lifting operation, workers and vehicles were found to be moving in and out of the lifting zone. Even though they may not be injured or killed in this incident, such situation should still be prevented and eliminated.

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Conclusion

30 The incident was primarily due to the failure of Man with Management being the contributory factor, taking into consideration of Medium and Machine.

31 Failure of Man mainly referred to the crane operator who continued to operate the crane despite facing difficulty in slewing the crane. In addition, the failure of the scaffolders and workers working on the main deck to take reasonable care on their own safety could further increased the severity of the incident.

32 If safety culture is inculcated into the mindset of the workers, they are more likely to take ownership of their (and their co-workers’) safety. The following can greatly reduced the severity of such incidents:
   a. Be competent in the work they do, especially when dealing with situations.
   b. Stop work when lifting operation is being carried out.
   c. Alert and inform others when a lifting operation is taking place.

33 Management contributed to this incident by:
   a. Not installing equipment to ensure that the crane was levelled throughout the lifting operation;
   b. Not putting in place a reasonable safety management system (SMS) that took into consideration of hazard identification, maintenance regime and safe work procedure (Physical barrier to cordon off lifting zone, safe working environment, equipment to ensure that the crane was levelled at all times)

34 As such, Man and Management each played a significant role in this incident. By addressing issues arising out from them, the severity and likelihood of such incident can be greatly reduced.
Recommendations

35 Adequate knowledge through training: It is important for the workers to have adequate knowledge in handling different work situations and emergencies in order to reduce the risks involved. Management should provide workers with the necessary training.

36 Safety Culture: Management should endeavour to inculcate appropriate safety culture into the mindset of workers to reduce the probability of workers putting their (and their co-workers’) lives in danger.

37 Check on the level of the crane: The ground condition in which the crane is placed is crucial to the stability of the crane. Significant change in the angle will lead to catastrophic events. Hence Management should ensure that the crane is levelled within the tolerance limit, throughout the lifting operation. Else measure should be taken.

38 Strict supervision: Management should provide strict supervision during lifting operation and not to condone any bad practices. All works in the lifting zone during lifting operation must be stopped without exception.

39 Risk assessment and Safe Work Procedure: Risk assessment should be carried out prior to start of any work in order to identify potential hazards so as to eliminate or reduce the risk involved. This could be done by having a safe work procedure to help the workers to handle the hazard and to work safely.

40 Barricade for lifting zone and communication of lifting operations: In addition to verbal instructions, physical barricade should be installed to prevent unauthorized personnel or vehicles from entering into the lifting zone during lifting operation. Commencement of lifting operations should also be communicated clearly to the affected workers.

41 Safety Management System: Effective safety management system and comprehensive record keeping will help to reduce the probability and severity of incidents from happening.

42 Maintenance of equipment: The condition of the equipment also plays a crucial role in assessing the reliability of the equipment. Management should ensure that equipments used are properly maintenance with good record keeping.
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43 **Usage of wire ropes:** Wire ropes that do not comply with the mandatory statutory requirement of annual examination and test by authorized examiner should not be used.

44 **Ground compaction:** Special attention should be taken when the mobile crawler crane is used to further compact the ground. There should be additional measures to ensure that the ground is safe for the crane to travel without facing the risk of collapsing. One such measure would be placing adequate steel plates over the ground to prevent the collapse of crane if the ground is still soft.

45 **Proper planning of site:** Proper planning of site should be carried out prior to the start of work. This is to ensure that surrounding obstructions is brought down to the minimum during lifting operation or any other operation.
Annex A

5M Model

*Man* refers to the specific individual(s) directly involved in the operation’s execution, taking into account his/her reliability (attitude, discipline, psychological factors and physical health) and proficiency (knowledge, judgement and hands-on skills).

*Mission* relates to the task that has to be achieved, including the objectives and the aspects of planning, preparation, operating area and contingencies.

*Management* refers to all those who can influence the control of the operations. It involves the supervision, control and scheduling of the operations. It also concerns with the provision of training and management of the risks associated with the operation.

*Machine* refers to the tools for the operation and its reliability (failure rate, accuracy and dependability) and capabilities (its suitability to the tasks, degree of automation, and ability to provide for the needs of the human).

*Medium* refers to the physical environment of an operation. It includes visibility, weather conditions, density of events, the degree of real-time supervision or control and support and the nature of terrain.
Annex B

Pictures of a typical crane similar to the incident crane