TO: Director, National Institute for Occupational Safety and Health

FROM: Iowa FACE Program

SUBJECT: Mobile tower crane falls 180 feet to the ground killing the crane operator.

SUMMARY

During the summer of 1997 a 36-year-old employee for a crane service company was killed while working on top of a portable tower crane. The crane was set up at a large wind farm, to assemble a large wind turbine. The crane was positioned adjacent to the metal column for the windmill and the outriggers were extended. The two-man crew from the crane company was preparing to place a 20-ton generator on top of the 140-foot windmill column while installation workers from the windmill company were inside the column ready to attach the generator with large bolts. The victim was working on top of the crane platform charging a battery for the winch engine on the crane, which had recently stalled. Suddenly, in a shower of hydraulic oil from the base of the crane, the right outrigger slid off its footing and the entire tower crane, extended to its maximum height of ~180 feet, fell to the north, away from the windmill tower, and crashed to the ground, carrying the wind generator and the victim with it. The victim rode with the crane to the ground and was killed instantly when he hit the ground. There was no wind that day, for other windmills were not operating. The farmer who owned the wind farm was standing at a safe distance, perpendicular from the line of the fall, and witnessed the entire event. The outrigger that failed was setting on fresh, packed dirt immediately adjacent to the new footing for the windmill column. It is assumed that this dirt caved in allowing the outrigger to slide off its base.

RECOMMENDATIONS based on our investigation are as follows:

1. *Portable tower cranes must be set up with extreme care to ensure that all outriggers are on solid ground with no potential for shifting or settling.*

2. *Workers must be diligent to regularly check and re-check alignment of crane equipment according to manufacturer's guidelines.*

3. *Additional means to anchor or secure tower cranes should be considered.*

4. *Employers should ensure that all equipment is in good operating condition.*

5. *Further safety engineering research should be conducted to determine whether this type of crane is adequately stable.*

INTRODUCTION

In July, 1997 a 36-year-old crane operator was killed while attempting to erect a large windmill on a wind farm in Iowa. The Iowa FACE program became aware of the incident through an article in a newspaper and began an investigation. Contact was made with the manager of the crane company and a site visit was scheduled immediately because of plans to cut up the wreckage the next day. One investigator conducted the site visit, meeting with the farmer who owned the property and was an eyewitness to the event. Photographs and measurements were taken at the scene, which had not been altered since the event four days earlier.

The employer was a crane service company who offered various types of heavy cranes for construction purposes. The company had 16 employees and had been in business for 12 years. Both the victim and his partner were experienced crane operators, very familiar with mobile tower crane operation. This was their second day on the job at this windmill site. The victim had worked for this company for more than five months.

Both men from this company had received operational and safety training specific for mobile tower cranes and were equally competent in crane operation. They were certified union operators. The company had written safety handbooks for each type of crane and conducted monthly safety meetings appropriate for the type of work hazards encountered. This was the first time a crane had fallen for this company, and their first fatality.

INVESTIGATION

Four men from the windmill company and two men from the crane company comprised the crew that were assembling the large windmill. The three-bladed prop had fiberglass blades 68 feet in length. It was assembled on the ground, waiting to be lifted into position onto the new generator. The round windmill tower stood 140 feet in the air and was anchored into the ground with a substantial concrete base approximately 12 feet in diameter. This round base extended into a larger rectangular concrete footing. The mobile crane was positioned to the east of the base and slightly south of center (see diagram), so that the left outrigger was on solid, undisturbed ground, while the right outrigger was on backfilled soil immediately adjacent to the new tower foundation.

The crane was built in 1979, one of three mobile tower cranes used by this company. It had a 30 ton capacity. It had two separate power systems, each with their own hydraulic systems. The gasoline-powered engine on the trailer section of the crane powered hydraulic movements of the retracted tower, the four outriggers, and the main central hydraulic column which raised the winch platform and tower section in the air. On the platform itself was a diesel-powered winch engine with hydraulics that controlled movements of the platform and the 50-foot boom.

The crane had two extendable hydraulic outriggers to the right and left of the tower, and two non-extended stationary hydraulic pads on both sides of the trailer at the opposite end. The 2½ foot square pad of each outrigger was placed on railroad ties which were on top of other 4x4 timbers on the ground. The crew had carried out a compaction procedure to hydraulically compress the dirt under each outrigger, then inserted heavy timbers. This process was repeated until a solid surface was obtained. By report from the farmer who was present, workers from

the crane company were very methodical and careful with this compaction procedure, frequently using levels to ensure the crane was perfectly plumb. The length of each extended outrigger was 9½ feet, making the distance from one outrigger to the next ~27 feet.

By report, the crane operators were not able to lift the generator to a sufficient height the day before, stating that the hydraulic oil was too hot. Then sometime after 8 P.M., the farmer and his wife heard sounds of electrical arcing, and looked up to see sparks coming from the winch engine area of the crane. The crane operators repaired the shorted wire, lowered the generator to the ground and quit for the evening, hoping for better performance when the oil was cool in the morning.

The next morning the men started work at ~7:00 A.M., going through their normal procedures to assure that the crane was level. Once this was accomplished, they started the winch engine and lifted the generator to the top of the windmill column, trying to align it up perfectly with the windmill column. The generator section weighed 20 tons and was compact containing all electronic controls and communication / monitoring equipment for the windmill. The crew was very close to attaching this generator section prior to the crash, holding it within a few inches of the top of the tower, however it was aligned incorrectly.

The engine for the boom winch stalled at this time, and the battery was not sufficient to start it up again. The victim asked for a battery charger, which was attached to a rope, and the victim pulled it up the tower. The winch had a hydraulic release brake, which requires power to lower any load, so there was no danger of the generator falling from its position due to the stalled engine.

Just seconds later, the tower began to fall to the north side of the windmill column. The farmer saw oil shoot up 50-60 feet from the base of the hydraulic column inside the tower. The soil under the right outrigger apparently caved in on the side nearest the foundation causing the pad to slide in that direction until it completely failed leaving no support for that side of the tower. The outrigger pad slid off its wooden base into the dirt causing the entire crane, with the generator, to come crashing down into an adjacent cornfield. The victim, who was working on the winch engine, was not wearing any type of fall-protective gear and fell with the tower crane landing on the ground next to the cornfield. He was killed instantly. His co-worker was standing on the ground next to the trailer section of the crane and narrowly escaped with his life when the trailer section crashed on top of a backhoe positioned next to him.

The farmer states the crane tower appeared to be leaning 2-3 degrees off-plumb that morning, in the direction of the fall. However this was after the men had started working, and the tower may have shifted after it was checked before work began. The farmer was positioned perpendicular to the line of fall and had an excellent view of the scene, however the exact timing of events cannot be determined. The farmer reported seeing hydraulic oil shooting upward for 50-60 feet immediately prior to the fall, the oil hitting the underside of the tower platform. This oil came from the base of the telescoping hydraulic column which was inside the tower crane, which was used to lift the tower and winch engine platform.

The exact sequence of events that led to the crane falling are not clear. Photographs reveal that

the right outrigger pad slid to the northwest, toward the windmill foundation, and fell into a depression at the edge of the area covered by the 4x4 timbers. It appears the tower fell in the exact direction that the extended right outrigger faced. The hydraulic cylinder for this outrigger shows no sign of retraction or failure, yet is covered with clay where it jammed into the ground after breaking away from its socket on top the outrigger pad.

There is no evidence that hydraulic failure elsewhere on the machine contributed to failure of the outrigger. It appears that the soil under the right outrigger simply gave way. The dirt adjacent to the foundation may have been capable of supporting the machine during compaction procedures, but gave way when the added weight of the generator was applied. This caused the inside timbers to fall into a loose pocket of soil, dislodging the hydraulic cylinder from the outrigger, causing the outrigger to forfeit any support for that side of the crane. The tower crane then fell over, snapping hydraulic fittings as it fell, causing extensive spray of hydraulic oil.

In the United States, lesser numbers of portable tower cranes are now being used, in favor of "hammer head" type cranes, which are considered much more stable, and therefore safer to operate. By report from a crane industry expert, many portable tower cranes of this type are still being used worldwide. The Canadian company that manufactured the tower crane involved in this fatality is no longer in business.

CAUSE OF DEATH

The official cause of death was listed as multiple head and internal injuries due to crush injury from a falling crane. An autopsy was performed.

RECOMMENDATIONS / DISCUSSION

Recommendation #1 *Portable tower cranes must be set up with extreme care to ensure that all outriggers are on solid ground with no potential for shifting or settling.*

Discussion: According to crane experts, improper setup of mobile tower cranes results in >50% of crane accidents. Sudden ground subsidence can lead to disastrous results, as in this case. Both adjustable crane outriggers should have been placed on solid, undisturbed soil. There was sufficient room around the base of the windmill to avoid setting an outrigger directly on loose dirt. The exact position was chosen considering the slope of the land, available access, and the position of the assembled fiberglass prop and other equipment already present at the site. Significantly changing the position of the outriggers may have been difficult, considering these factors, however, even a small change away from the foundation may have been enough to prevent this fatality.

Recommendation #2 *Workers must be diligent to regularly check and re-check alignment of crane equipment according to manufacturer's guidelines.*

Discussion: It appears that proper procedures were followed to check the alignment of

the crane on the morning it fell over. As work progressed the additional weight of the generator may have slightly shifted the crane. An eyewitness reported the crane appeared to be leaning prior to the fall, which occurred suddenly and without warning. Checking the alignment more frequently may have alerted workers to an unstable condition and prevented this fatality.

Recommendation #3 *Additional means to anchor or secure tower cranes should be considered.*

Discussion: This crane was used at its maximum height and had a payload which was B of its rated capacity. In this situation simple guy wires could provide significant additional lateral stability to the crane. In certain situations, however, it may be impossible to maneuver around guy wires, and they may create additional hazards on the worksite.

Recommendation #4 *Employers should ensure that all equipment is in good operating condition.*

Discussion: This tower crane appeared to be in fair operating condition, however the presence of sparks and battery failure on the platform indicate an immediate need for maintenance. The failure of the crane to perform adequately the night before indicates a problem with the winch engine or its hydraulics. Failure of the winch engine that morning required the victim to climb to the top of the platform to charge the battery.

Recommendation #5 *Further safety engineering research should be conducted to determine whether this type of crane is adequately stable.*

Discussion: The span between the left and right outriggers was ~27 feet. Considering the crane is ~140 feet tall, with a 50 foot boom on top of this, the rig may be inherently unstable, especially with a load, high winds, or other factors. Since this crane company is no longer in business, improvements to cranes currently in operation may be difficult. However, engineering information would be useful for designing new cranes or determining the safety of cranes currently in use.

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Fatality Assessment
&
Control Evaluation Program
(FACE)

The University of Iowa, in conjunction with the Iowa Department of Public Health is investigating the causes of work-related fatalities in the State of Iowa. FACE is a surveillance program funded by the National Institute for Occupational Safety and Health (NIOSH), that identifies all occupational fatalities, conducts in-depth, on-site investigations on specific types of fatalities, and makes recommendations for employers, employees, farmers, and others to help prevent similar fatal accidents in the future.

Iowa is a major farming state, and therefore the Iowa FACE Program deals with many occupational deaths on the farm. It is a very hazardous profession that claims hundreds of lives nationally every year. We publish detailed reports that are disseminated to key agricultural leaders in Iowa who share our concern for the safety of farmers. To reach and effectively communicate with this independent and vulnerable group is a worthy challenge here in Iowa.

NIOSH funded state-based FACE Programs include: Alaska, California, Iowa, Kentucky, Maryland, Massachusetts, Minnesota, Missouri, Nebraska, New Jersey, Ohio, Oklahoma, Texas, Wisconsin, Washington, and Wyoming.

Additional information regarding this report or the Iowa Face Program is available from:

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