NEW YORK State FACE Program
Fatality Assessment & Control Evaluation

New York State Department of Health • Bureau of Occupational Health and Injury Prevention
Empire State Plaza-Corning Tower, Room 1325 • Albany, NY 12237 • 866-807-2130
www.health.ny.gov/environmental/investigations/face/index.htm

**REPORT#:** 15NY032 **REPORT DATE:** 04/19/22

# Construction Worker Fatally Struck by Steel Sheet Pile Falling from a Vibratory Pile Driver

## INCIDENT HIGHLIGHTS

**DATE:**
May 29, 2015

**TIME:**
12:04 p.m.

**VICTIM:**
50-year old female employee of a construction company

**INDUSTRY/NAICS CODE:**
Bridge and road construction/237310

**EMPLOYER:**
Construction company

**SAFETY & TRAINING:**
Not trained on how to safely operate the vibratory pile driver

**SCENE:**
Bridge construction site

**LOCATION:**
New York

**EVENT TYPE:**
Struck and killed by a steel sheet pile

## SUMMARY

On May 29, 2015, at 12:04 p.m., a 50-year-old female employee of a construction company was struck and killed by a steel sheet pile that broke off from a vibratory pile driver at a bridge construction site. At the time of the incident, the decedent was directing traffic while a crew consisting of a foreman, a crane operator, an excavator operator, and an assistant iron worker were conducting a pile driving operation. A vibratory pile driver was used to install sheet piles at the existing bridge abutments… READ THE FULL REPORT> (p.3)

## CONTRIBUTING FACTORS

**Key contributing factors identified in this investigation include:**

- There was only one main hoist line holding the pile driver because the crane's auxiliary hoist was not assembled and rigged
- The sheet pile was not rigged to the crane through a safety line
- Workers were not trained on how to safely operate the vibratory pile driver LEARN MORE> (p.16)

## RECOMMENDATIONS

**New York FACE investigators concluded that, to help prevent similar occurrences, employers should:**

- Ensure that piles are always secured to the crane via a safety line for as long as the piles are being held by the crane.
- Ensure that all workers are protected from being struck by the load of a crane during pile driving.
- Ensure that the hydraulic clamp bolts are inspected and evenly tightened to the appropriate torque as specified by the manufacturer. LEARN MORE> (p.17)

New York FACE Program

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The New York State Fatality Assessment and Control Evaluation (NY FACE) is a research program funded by the National Institute for Occupational Safety and Health and administered by the New York State Department of Health. NY FACE collects information on work-related fatalities, investigates the incidents to identify the causes and contributing factors, proposes prevention measures, and shares the injury prevention information with employers, workers, and other organizations interested in promoting workplace safety. NY FACE does not determine fault or legal liability associated with a fatal incident. Names of employers, victims and/or witnesses are kept confidential. Additional information regarding the NY FACE program can be obtained from:

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## SUMMARY

On May 29, 2015, at 12:04 p.m., a 50-year-old female employee of a construction company was struck and killed by a steel sheet pile that broke off from a vibratory pile driver at a bridge construction site. At the time of the incident, the decedent was directing traffic while a crew consisting of a foreman, a crane operator, an excavator operator, and an assistant iron worker were conducting a pile driving operation. A vibratory pile driver was used to install sheet piles at the existing bridge abutments. Each sheet pile consisted of two 32-inch wide, 40-foot-long Z-shaped steel sheet piles interlocked to form a "paired" or "double sheet" pile that weighed approximately 4,000 pounds. The sheet pile was not secured to the crane; it was only held by the hydraulic clamp on the pile driver. When the sheet pile was being driven between 18 and 24 inches below grade, the foreman observed a hydraulic clamp bolt falling off the pile driver. The foreman immediately hit the emergency stop. At the same time the sheet pile broke from the hydraulic clamp and started to topple over. The sheet pile landed on a concrete jersey barrier and started to slide on top of it. The jersey barrier was parallel to the roadway. The sheet pile was sliding horizontally on top of the jersey barrier with its length spanning the width of the bridge. Meanwhile, the decedent was running south from the center of the bridge where she was directing traffic, trying to avoid being struck by the sliding sheet pile. The sheet pile struck the decedent from behind near the south end of the bridge before it slid and fell off the jersey barrier and landed on the west side of the bridge. The victim suffered injuries on the head, neck, and back. The foreman immediately reached the victim and started CPR, and 911 was called at the same time. Emergency medical technicians and New York State troopers responded to the site within minutes. The county coroner was on scene and pronounced the death of the worker at 1:00 p.m. The post incident analysis determined that the sheet pile fractured and broke at the point where it was being gripped by the hydraulic clamp. The hydraulic clamp did not fail: It was holding the broken sheet pile piece. The root cause of this fatal incident was that the sheet pile was not rigged to the crane, allowing it to fall and strike the decedent.

## INTRODUCTION

On May 29, 2015, at 12:04 p.m., a 50-year-old female employee of a construction company was struck and killed by a steel sheet pile that broke off from a vibratory pile driver at a bridge construction site. New York State Fatality Assessment and Control Evaluation (NY FACE) staff learned of the incident from news media reports and contacted the employer to initiate an investigation. The employer, however, decided not to allow an on-site NY FACE investigation. The Occupational Safety and Health Administration (OSHA) investigated the incident. The NY FACE investigator obtained the case information from OSHA, visited the incident site (after the bridge construction was completed), consulted engineers of a third-party construction firm that specialized in pile driving, and discussed the case with a field representative of the pile driver manufacturer. During the investigation, the NY FACE investigator reviewed the OSHA report, pile driver manual, police report, and death certificate. This report summarizes the findings of the NY FACE investigation.

## EMPLOYER

The construction company involved in the incident has been in business for over 75 years. It started as a paving contractor and later expanded its business into bridge, road, and highway construction, repair, and replacement including steel structure fabrication and rehabilitation. It conducts business in both New York and Pennsylvania. At the time of the incident, the company employed approximately 175 workers who were represented by two labor unions.

## WRITTEN SAFETY PROGRAMS and TRAINING

The company had developed written safety and health programs including an accident prevention and investigation program and provided employees with construction safety training and other OSHA required training. Union-represented workers also received safety trainings provided by the unions. Workers were required to wear high visibility orange vests or T-shirts, hard hats, safety glasses, gloves, and steel-toed boots at job sites.

This was the company's second fatal incident. In May 2005, three employees of the company were killed after being struck by a passenger bus inside a highway work zone. NY FACE investigated the case, and the case report is available at https://www.health.ny.gov/environmental/investigations/face/docs/05ny039.pdf.

## WORKER INFORMATION

The deceased worker was represented by a labor union. She started as an apprentice in 2001 and became a journeyperson. She worked for different contractors at job sites ranging from road and bridge construction to pipeline installation. She was an experienced worker and was the foreman on a couple of job sites.

## EQUIPMENT

The vibratory pile driver was an ICE 14-23 model with a power pack manufactured in 2010. It was designed to drive or extract sheet, pipe, piles, caissons, and beams to provide structural foundation support. The pile driver was powered by a 220-horsepower diesel engine (Caterpillar 3116DITA). The unit, which weighed approximately 5525 pounds, operated in a frequency range of 900 to 1900 vibrations per minute and generated an eccentric moment of 1100 inch-pound with a centrifugal force of 80 tons and a maximum amplitude (vertical travel distance of pile per vibration) of 0.94 inch.

The pile driver consisted of three major components: The vibrator, the vibration suppressor, and the hydraulic clamp (Figure 1 and Photo 1). Vibration was created in the vibrator gear case by a pair of rotating eccentric weights powered by hydraulic motors. Only vertical vibration was created as horizontal vibration being canceled by the paired eccentrics. The vertical vibration was transmitted into the pile being driven by the hydraulic clamp which was attached to the bottom of the gear case. The pile driver was held by a crane during pile driving. To prevent the vibration created in the gear case from affecting the crane, a vibration suppressor absorbed and dampened the vibrations reaching the crane.

The hydraulic clamp consisted of two gripping jaws with teeth: one was fixed, and the other was movable. The movable jaw was connected to a hydraulic cylinder. The hydraulic circuit could maintain a clamping pressure at 4500 psi when the jaws were in "CLOSE" position. A clamp relief valve ensured a clamping pressure not exceeding 4800 psi.

The hydraulic clamp was attached to the gear case by 14 socket-head cap bolts (1.5"- 6), with eight bolts securing the fixed jaw and six bolts securing the movable jaw. The clamp bolts are critical in pile driving: If they are loose or not evenly torqued, the hydraulic clamp would not be able to transmit the correct vibration energy into the piles being driven. Damage to the equipment, as well as serious worker injury could occur. The manufacturer required that each clamp bolt be torqued 2800 ft-lbs (3.79 kN-m) with a torque wrench.

The manufacturer emphasized in the Operating and Maintenance Manual that the only reason clamp bolts break is because they are not tightened to the correct specified torque. An operator is required to check the bolts at least daily since vibration could loosen them. If one is broken, then they all need to be replaced. The operator should never drive piles if one or more bolts are loose or broken.

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To prevent serious worker injuries, the manufacturer required that a safety line must be attached to a pile when the pile was being extracted or hoisted into position, and the safety line is rigged to the crane. In other words, the pile should be secured to the crane through the safety line, and it should not be held solely by the jaws of the hydraulic clamp when extracting or hoisting into position.

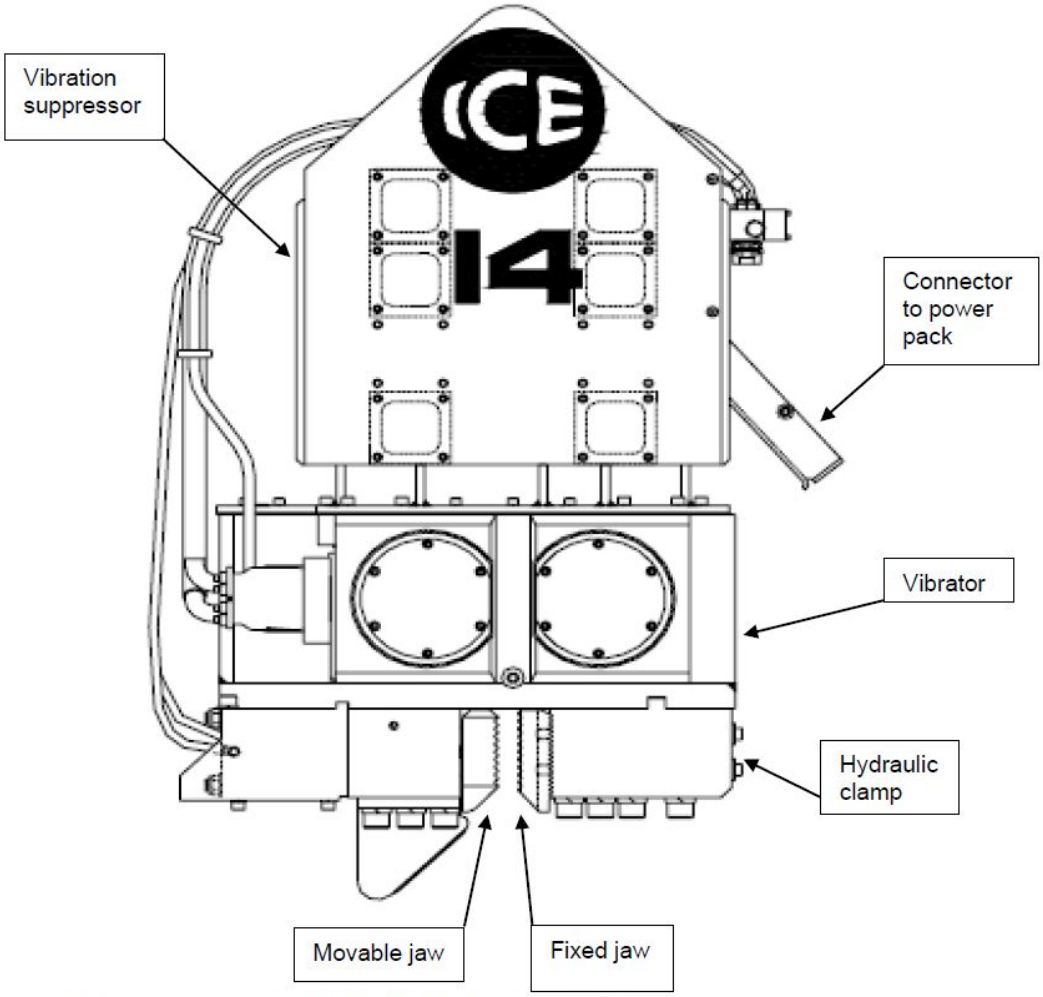


Figure 1. Major components of ICE 14-23 vibratory pile driver/extractor.

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*Photo 1. The International Construction Equipment, Inc (ICE) Model 14-23 vibratory driver/extractor that was involved in the incident (photo courtesy of OSHA).*

*Photo 2. The Link-Belt crane had two winding drums, one for the main hoist rope and the other for the auxiliary hoist rope (photo courtesy of OSHA).*

*Photo 3. The crane had only one load line that was holding the pile driver. The auxiliary hoist was never rigged (photo courtesy of OSHA).*

## INVESTIGATION

The construction company was contracted by the New York State Department of Transportation (NYSDOT) to demolish and reconstruct a two-lane bridge on a state route in central NY. The bridge, oriented in a north/south direction, was approximately 47 feet wide and 52 feet long spanning a creek in an east/west orientation. The construction plan was to first demolish one lane of the bridge while keeping the other lane open to traffic. The company was to install steel sheet piles at the existing bridge abutments to reinforce and maintain their structural integrity before excavating and installing new abutments. The project started on May 11, 2015, and the incident occurred on Friday, May 29, 2015, when the pile driving started.

***Photo 4. Two piles were interlocked to form a "pair" or "double sheet". The double-sheet pile were approximately 40 feet long and 4000 pounds in weight (photo courtesy of OSHA).***

The project was overseen by a superintendent, who was in charge of another job site at the same time. When the superintendent visited the other site, a foreman was put in charge. The foreman had been with the company for seven years and had been a foreman for six years at the time of the incident.

The company had its own pile driving equipment and a designated crew that was trained and experienced in pile driving. However, the pile driving crew was not available for this project since they were working at another job site. The company had to rent the ICE pile driver and use a crew that was neither familiar with the equipment nor trained for the pile driving operation. None of the crew members including the foreman had received specific training on safety hazards associated with the pile driving and how to properly operate the pile driver.

On Monday, four days prior to starting the pile driving operation, a crew lead by the foreman set up supporting cables and a debris net over the creek. The crew then demolished one (west) lane of the bridge. A lattice boom crawler crane

(Link-Belt 218 Hylab HSL) with a maximum lift capacity of 110 tons and maximum boom length of 230 feet was delivered to the site on Tuesday afternoon. The crane was assembled and erected on Thursday. The vibratory pile driver along with the power pack were delivered to the site on Thursday. The Operating and Maintenance Manual did not come with the pile driver.

For a typical pile driving operation, at least two crane hoist lines are needed: The main hoist line to hold the pile driver and the auxiliary line to hold the pile. In addition, the pile must be rigged to the auxiliary hoist through a safety line. The Link-Belt crane had two winding drums, one for the main hoist rope and the other for the auxiliary hoist rope (Photo 2). However, the crew only rigged the main hoist on Thursday. The auxiliary hoist was never rigged (Photo 3).

On the day of the incident, Friday, the workers started working at around 7:00 a.m. The crew consisted of the superintendent, the foreman, a crane operator, an excavator operator, an assistant iron worker, and the decedent, who all wore hard hats and high visibility vests. A NYSDOT transportation construction inspector was at the site. The decedent was assigned to direct traffic. The traffic control plan, that was designed by NYSDOT, consisted of a stop light system on each end of the bridge with appropriate signage.

The foreman first set up the vibratory pile driver. He reportedly checked the fuel and the engine oil in the power pack, rigged the vibratory pile driver to the crane's main hoist line, and connected the hydraulic lines to the pile driver and the power pack. He conducted a visual inspection of the pile driver looking for "things that were out of the ordinary". According to the OSHA investigation, the foreman did not know what torque the clamp bolts had to be set at, and he was not sure if he even had a torque wrench on site. However, he indicated that he did check the clamp bolts with a regular wrench.

The crane operator was hired approximately two months prior to the incident. He had worked for a pile driving company prior to his employment with this company. He did a visual inspection of the crane, and he relied on the foreman to rig and inspect the pile driving equipment.

The piles were stacked at a staging area. Each consisted of two 32-inch wide, 40-foot-long Z-shaped steel sheet piles interlocked together to form a "pair" or "double sheet" (Photo 4). The double-sheet pile weighed approximately 4000 pounds. The piles were reportedly used previously on another project. The grade of steel was unknown.

At the staging area, the crew attached a pair of sheet pile shackles to a double-sheet pile (Photo 5). The shackles had a ground release mechanism with a release line, which could be used to remove the shackles from the sheet pile from the ground. The crane picked up the sheet pile by the pile shackle wire with the pile driver's hydraulic clamp and placed it in driving position. Once in position, the shackles were removed from the pile. With the help of an excavator, the foreman used a level to make sure that the sheet pile was plumb and aligned. The pile driver then was aligned, and the hydraulic clamp was set in the "close" position, grabbing the pile. The sheet pile from then on was only 11 held by the hydraulic clamp, and there was no safety line to secure the sheet pile to the crane. At approximately 10:30 a.m., the foreman turned the power on at the power pack and started pile driving. The superintendent left to visit the other job site before pile driving started.

***Photo 5. Pile shackles with ground release attached to a pair of sheet pile (photo courtesy of OSHA).***

At approximately 11:00 a.m. the traffic lights at both ends malfunctioned. Instead of alternating in red or green cycles, both lights went to flashing yellow simultaneously. The decedent was first directing the traffic at the north end of the bridge. Once the traffic lights malfunctioned, the traffic kept encroaching into the work zone. The foreman sent the decedent to the center of the bridge so that she could better control the traffic (Figure 2. Incident site sketch).

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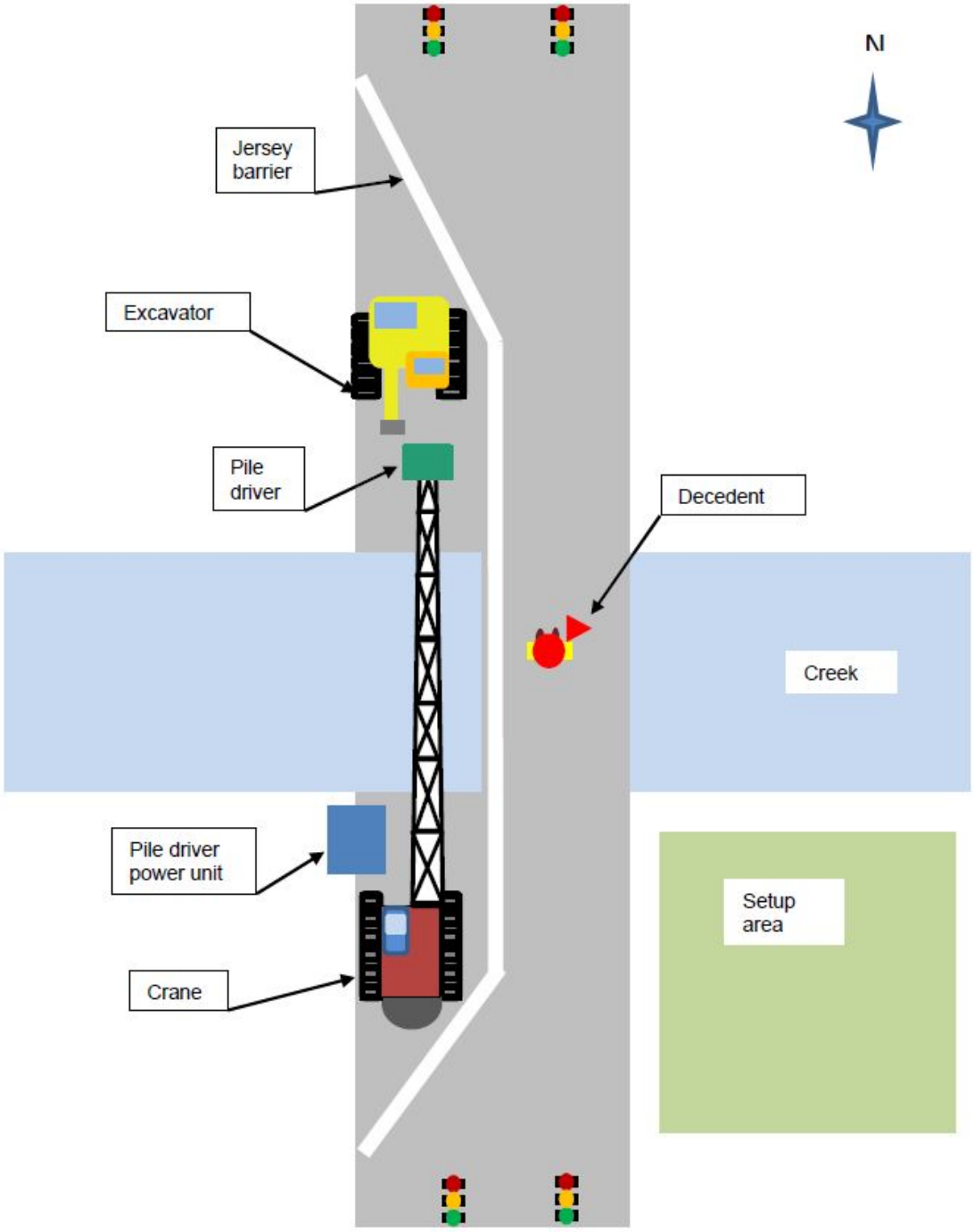


Figure 2. Incident site sketch showing locations of the decedent and the pile driving operation.

At the power pack, the foreman put the pump to maximum pressure. The hydraulic clamp was clamped to the center of the double-sheet pile (first grip), with one set of teeth gripping each sheet pile (Photo 9). The vibratory driver started driving the sheet pile into the ground. The soil was rocky, and the pile reportedly went down seven feet and stopped. The crew continued to drive for another minute but was unable to drive any deeper. When the crew pulled the pile out, they noticed that the pile was ripped around the clamped area. They repositioned the clamp (second grip on Photo 9) and drove the sheet pile again in the original location but made no progress.

The crew started extracting the sheet pile when the foreman noticed that the sheet pile ripped around the second grip area. He had the excavator steady the pile with its bucket while he switched to a third grip location on the intact sheet pile (Photo 9). With this grip the crew extracted the pile, placed it in a second location, and drove it. This time the pile only went down four feet before it stopped. During this attempt the interlocked sheet piles started to shift. The foreman tack welded the two sheet piles together. The crew took a short break at approximately 11:45 a.m.

The crew resumed the operation after the break and began driving the sheet pile in a new location (the third location) at approximately 12 p.m. While the assistant iron worker worked with the excavator operator to position the pile in the third location, the foreman started the pile driver. The crane operator was operating the crane, and the decedent was in the middle of the bridge directing traffic.

The incident occurred at 12:04 p.m. when the sheet pile was being driven down between 18 and 24 inches below grade. According to the foreman, he observed a large bolt falling off the pile driver and immediately hit the emergency stop. At the same time the sheet pile, which was not secured to the crane, broke from the pile driver and started to topple over. The sheet pile landed on a concrete jersey barrier and started to slide on top of it. The jersey barrier was parallel to the roadway. The sheet pile was sliding horizontally on top of the jersey barrier with its length spanning the width of the bridge. Meanwhile, the decedent was running south from the center of the bridge where she was directing traffic, trying to avoid being struck by the sliding sheet pile. The sheet pile struck the decedent from behind near the south end of the bridge before it slid and fell off the jersey barrier and landed on the west side of the bridge (Photo 10). The victim suffered injuries on the head, neck, and back.

The foreman immediately reached the victim and started CPR while the NYSDOT inspector called 911. Emergency medical technicians and NYS Troopers responded to the site within minutes. The county coroner was on scene and pronounced the death of the worker at 1:00 p.m.

Two broken bolts were found at the site after the incident. Each bolt had metal failures, leaving a portion of the threaded end in the pile driver (Photo 6). One bolt piece was found on the north side of the bridge, this was the one observed by the crew. The other piece was found on the south side of the bridge, on the debris netting. Both pieces were $1\ ^{1/2}$ inches in diameter, and one was $11^{5/8}$ inches long, and the other was $12\ ^{1/8}$ inches long. They were the clamp bolts that secured the fixed jaw to the gear case.

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***Photo 6. The clamp bolt broken from the vibratory pile driver had metal failure (photo courtesy of OSHA).***

Both fixed and movable jaws had two clamp areas with teeth: Each clamp area was approximately 1 inch wide and 7 3/4 inches long with 10 teeth (Photos 7 and 8). All four clamping surfaces had worn or broken teeth: The peaks were either broken off or worn flat. The sections that had worn or broken peaks were approximately 4 inches long from the end of the jaws where they gripped the piles. The jaws were mis-aligned in all three dimensions resulting in unparallel gripping surfaces and mis-aligned and partially engaged teeth.

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***Photo 7. The bolt holes of the broken bolts and clamp areas of fixed and movable jaws of the hydraulic clamp. Both the fixed and movable jaws have two clamp areas with teeth. The jaws were mis-aligned (photo courtesy of OSHA).***

***Photo 8: The jaws had worn or broken teeth: the peaks were broken off or worn flat especially in the lower end of the jaws. Part of the sheet pile was still being held by the jaws (photo courtesy of OSHA).***

The failures on three clamped areas on the interlocked sheet piles were examined (Photo 9). Each clamped area had two grip marks (left and right). All clamped areas had tooth imprints indicating unevenly worn and partially engaged teeth. For example, the left gripping mark of the first grip showed that the top part of the sheet pile was being crushed and the lower part was ripped or torn off, indicating uneven pressure distribution among gripping teeth.

The post incident analysis determined that the sheet pile fractured and broke at the point where it was being gripped by the hydraulic clamp. The hydraulic clamp did not fail: It was holding the broken sheet pile piece. The root cause of this fatal incident was that the sheet pile was not rigged to the crane, allowing it to fall and strike the decedent. The untightened or unevenly torqued bolts, mis-aligned clamp jaws, and broken or unengaged teeth in the clamp area exposed the pile driver to excessive forces and vibrations and contributed to the failure of the sheet piles and the clamp bolts.

***Photo 9. All three gripping areas on the sheet pile had tooth imprints indicating unevenly worn and partially engaged teeth and uneven distribution of pressure (photo courtesy of OSHA).***

***Photo 10. The sheet pile broke from the pile driver, fell and landed on the west side of the bridge (photo courtesy of OSHA).***

## CAUSE OF DEATH

According to the death certificate, the cause of death was multiple blunt force injuries.

## CONTRIBUTING FACTORS

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events. The NY FACE investigation identified the following key contributing factors in this incident:

- *There was only one main hoist line holding the pile driver because the crane's auxiliary hoist was not assembled and rigged.*
- *The sheet pile was not rigged to the crane through a safety line.*
- *Workers were not trained on how to safely operate the vibratory pile driver.*
- *The pile driver operation/maintenance manual was not available to the crew.*
- *Clamp bolt torques were not checked.*
- *The jaws of the hydraulic clamp were mis-aligned, and the teeth were unevenly worn or broken.*

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## RECOMMENDATIONS/DISCUSSION

***Recommendation #1: Employers should ensure that piles are always secured to the crane via a safety line for as long as the piles are being held by the crane.***

Discussion: A pile driver exerts tremendous forces on piles being driven. Piles may fracture or break, and equipment may malfunction or fail causing the piles to topple over or fall. To prevent serious worker injuries, employers should ensure that piles are always secured to the crane via safety lines for as long as the piles are being held by the crane. If a safety line becomes detached, the operation should be halted immediately until the safety line is reattached, and the pile secured.

The crew in this case never rigged the crane's auxiliary hoist which should have been used to hoist and secure the sheet pile through a safety line. Employers should ensure that the pile driving crew and the crane operators strictly follow the manufacturer's safety requirement.

***Recommendation #2: Employers should ensure that all workers are protected from being struck by the load of the crane during pile driving.***

Discussion: During pile driving, overhead cranes suspend heavy equipment including pile drivers and piles, presenting potentials for fatal crushing injuries. Parts may fall from pile driving equipment, and piles may break or shatter creating additional hazards. A fall zone or danger zone should be established to protect workers from suffering serious injuries caused by falling objects. All workers except the essential crew must stay outside of the fall zone when piles are being positioned, driven, or extracted. 19

When replacing infrastructure, one major challenge is the tight work zones. The crane swing radius in this case extended beyond the actual width of the bridge. The decedent who was directing traffic in the middle of the bridge was exposed to the fatal struck-by hazard. Employers should consider using two flaggers, one at each end of the construction zone, to ensure that flaggers can work safely outside the fall zone.

***Recommendation #3: Employers should ensure that the hydraulic clamp bolts are inspected and evenly tightened to appropriate torque as specified by the manufacturer.***

Discussion: The hydraulic clamp transmits vibrations generated in the vibrator gear case into the piles being driven, and the clamp bolts secure the hydraulic clamps to the gear case. The clamp bolts are critical in pile driving: If they were loose or not evenly tightened, the hydraulic clamp would not be able to transmit the vibration energy efficiently to the piles. Loose jaws can expose both the pile driver and the piles to excessive non-centric forces and vibrations which can cause equipment and pile damage as well as serious worker injuries or deaths.

The manufacturer in this case required that the clamp bolts be torqued to 2800 ft-lbs (3.79 kN-m) with a torque wrench. The crew did not have a torque wrench on site, and the foreman did not know the correct torque. Employers should ensure that all clamp bolts are evenly tightened to the specified torque, and all clamp bolts are inspected at the beginning of each shift. Since vibration loosens bolts, workers should check the bolts periodically during their shifts depending on driving conditions. If one bolt breaks, all bolts must be immediately replaced since others may be damaged. Never drive piles if one or more bolts are broken.

***Recommendation #4: Employers should ensure that the hydraulic clamp teeth are in good working condition and the fixed and movable jaws are aligned properly.***

Discussion: Both the fixed and movable jaws had broken, unevenly worn, or partially engaged teeth, and the jaws were mis-aligned in this case. To ensure that the clamp transmits the vibrations efficiently to the piles, manufacturers require that all teeth must engage the work evenly and the fixed and movable jaws must be aligned properly.

Employers should ensure that operators inspect the hydraulic clamp teeth and the gripping jaws to ensure that they are properly aligned and in good working condition before starting the pile driver. A jaw with cracked, broken, unevenly worn, or non-engaging teeth should be replaced immediately.

***Recommendation #5: Employers should conduct a hazard assessment and a job hazard analysis when there is a change in the construction plan to ensure worker safety.***

Discussion: The company used workers who were not trained to conduct pile driving operations because the trained crew was at another job site. Pile driving is a high-risk operation. Using an untrained crew can lead to serious worker injury including death.

Whenever there is a change in the construction plan, employers should conduct a hazard assessment to identify the hazards and risks associated with the new plan. A job hazard analysis (JHA) should be conducted since the new plan may require changes in operation procedures as well as job assignments. A JHA focuses on the relationship between the worker, the task, the tools, and the work environment so that the hazards associated with each component and each step of the task can be identified before they occur. It is critical that one conducts a JHA on new or complex jobs, jobs with high injury or illness rates, jobs with the potential to cause severe or disabling injuries or illness, or jobs in which one simple human error could lead to a severe accident or injury. Based on the hazards identified through a JHA, employers can then develop and implement appropriate control and prevention measures and standard safe work procedures for workers to follow.

***Recommendation #6: Employers should provide specific training to workers on pile driving equipment, hazards, and safety measures before assigning them to pile driving operations.***

Discussion: The employer in this case did not provide specific training to the workers before assigning them to pile driving. Pile driving is a high-risk operation: One single human error could lead to severe injuries or deaths, or costly equipment or property damage. It is critical for employers to provide workers with training so that they fully understand the hazards, the risk factors, the protection measures, and the consequences for not following safe operating procedures.

***Recommendation #7: Employers should ensure that the pile driving equipment operating and maintenance manual is available, and the crew read and understand the manual.***

Discussion: The manufacturer in this case required that users of the vibratory pile driver read and understand the information in the Operating and Maintenance Manual before operating, lubricating, repairing, or performing maintenance on the equipment.

The manufacturer warned that improper operation of the pile driver can be dangerous and could result in injury or death. The Operating & Maintenance Manual was not delivered to the site with the vibratory pile driver. Employers

should ensure that the operating and maintenance manual is available for the pile driving crew, and the crew read and understand the manual.

***Recommendation #8: Manufacturers, pile driving companies, and trade associations should require that the piles be secured to the crane via a safety line for as long as the piles are being held by the crane.***

Discussion: The current requirement for rigging a pile to a crane through a safety line is not consistent among major manufacturers, pile driving companies, and trade groups. Some required only rigging the pile to the crane when extracting or hoisting into position, while others only required it if there is a danger of injury or property damage.

Piles can shatter and break free from the pile driver when they are being driven into the ground as it happened in this case. Therefore, it is critical that a safety line be attached to the pile during pile driving. Manufacturers should clearly emphasize in their operating manuals that the pile should be secured to the crane via a safety line for as long as it is suspended by the crane including when hoisting a pile into position, or positioning, driving, or extracting a pile. All driving operations shall be suspended immediately if the safety line becomes detached. The operations should not be resumed until the safety line is reattached and pile secured. All construction companies and trade groups should include this requirement in their standard operating procedure and adopt that as the best industry practice.

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## REFERENCES

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## INVESTIGATOR INFORMATION

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