CRANE & HOIST SIDE PULLS
Hazards, Risks & Alternative Methods

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IN 1996, OSHA OFFERED that approximately 120,000 cranes were in operation and more than 250,000 crane operators were at risk of serious and often fatal injury due to incidents involving cranes, derricks, hoists and hoisting accessories (OSHA, 1996). Numerous regulatory and consensus standards, industry safe practice documents, and equipment manufacturers' technical manuals and user guides caution against or prohibit using a crane or hoist to move an object when the crane and hoisting cables are not directly above the object being moved. These regulations, consensus standards and other documents have provided this prohibition since at least 1971 based on OSHA's adoption of ANSI B30.2-1967 and ANSI B30.5-1968 for the crane standards. This lifting or placing when the load is not plumb with the hoist is referred to as a side pull or side loading. Side pulls place additional tension on the equipment involved in the lift and can lead to the deterioration or breakage of equipment, causing other complications and workplace hazards. Their highly dangerous maneuvers can lead to serious death or injury as well as property and equipment damage.

According to OSHA 29 CFR 1910.179(a)(54), "Side pull means that portion of the hoist pull acting horizontally when the hoist lines are not operated vertically." The amount of weight that a crane can lift is specific to its capacity when the load is lifted vertically and centered as "a crane's capacity is greater when the load is closer to its mast (center of rotation) and less when the load is further away from its mast" (ILO, 1983; 1998). If an operator attempts to perform a side pull, the load will begin to center itself under the hoist when lifted from the ground. This pendulum effect created by the side pull causes the load to swing and can cause damage to nearby personnel or equipment in the facility (Runyon, 2020).

A pendulum, "an object hung from a fixed point that swings back and forth under the action of gravity," takes time to return to its original position when swung (Science Buddies, 2012). The amount of time a pendulum takes to return to its original position is dependent on the length of the pendulum and the force of gravity.

To prevent side pulls, it is critical that the load line is plumb prior to the lift. Even 2° out of plumb is excessive and introduces stress in the crane or hoist that was not accounted for in its

KEY TAKEAWAYS

- Despite the abundance of regulatory standards prohibiting side pulls, they continue to be a common cause of crane and hoist failure, accounting for about 175 injuries and 45 fatalities in the U.S. each year (Ankerich, 2020).
- OSHA has prohibited the practice of using cranes and hoists to pull or drag a load sideways since 1971; ANSI crane and hoist standards have had the same prohibitions since at least 1967 for overhead and gantry cranes and since 1968 for crawler, locomotive and truck cranes.
- Side pull warning systems and limiting systems are available for some types of hoists and cranes.
- This article examines these prohibited practices including circumstances under which they are permitted. It also explores alternative materials handling methods such as the use of a portable gantry crane or an engine hoist to avoid the hazards associated with side pulls.

FIGURE 1
DEMONSTRATED SIDE PULLS

Note. Adapted from "Swinging (and Dropping) Wrecking Ball, McDonald's HQ Demolition" [Video], by D. DeBruler, 2019, https://youtu.be/XDdzktnyxoQ.

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design (U.S. DOE, 2002). Figure 1 shows video stills depicting the demolition of the former McDonald's headquarters in Oak Brook, IL, with side pulls of 7° and 11°, respectively. If the criteria of ANSI and OSHA that address the permitted use of side pulls are met, then these practices are acceptable. Using a wrecking ball (also known as "balling") as shown in Figure 1 is a practice still employed.

In discussing other causes of side loading during a conference presentation, Davis (2014) observed that crane use in windy environments can lead to side loading. He noted:

> Wind on the front decreases the load radius, which tries to push the boom over backward and may push the load into the boom. Wind from the side could be a major issue. Sidewind pushes the boom and load sideways, introducing side loading on the crane. Most cranes can tolerate only minimal side loading from suspended loads hung from level cranes. A few models have special attachments to increase the crane's tolerance of wind. These are often found in applications such as erecting towers and windmills.

When wind causes side loading, it places more force on the crane than when the load is plumb with the crane. This increased force on the crane can lead to failure and may put the workers and passersby at risk of injury or death.

Despite being a prohibited practice by regulatory and consensus standards, side pulls are still performed in a variety of industrial and construction settings and are a cause of crane and hoist failures (Runyon, 2020). Following are several examples of incidents generated from side pulls.

•In a fatal incident at a scrap metal yard in which a crane's boom collapsed, the causes were attributed to both shock loading and side pulls (NIOSH, 2009).

•In another fatal incident, a groundsperson was electrocuted when the boom of a crane came into contact with a power line while the crane was side pulling a pipe (Shapo, 2016).

•A fatal incident occurred when the pulley on a rough-terrain telescopic boom crane, which had previously been used for side pulls (as evident by the visible damage caused by the cable tearing through the sheave's metal exterior) gave way (Crane Tech LLC, n.d.).

•In the telecommunications industry, a transformer was being raised by a gin-pole type derrick (a single pole held by guys in a nearly vertical position that supports a block and tackle used for lifting loads) when the gin pole came free and fell into the electrical wires, electrocuting the lineperson (Clarke, 2004).

•In 2010, two large triple-axle, 12-tire wreckers in Raleigh, NC, were employed to remove a trailer that had been detached from the tractor and was on its side on a highway bridge. When the trailer was lifted, one of the wreckers was pulled onto its side from the forces generated as the trailer swung toward the downgrade side of the bridge (Cox, 2010).

Tandem Loading

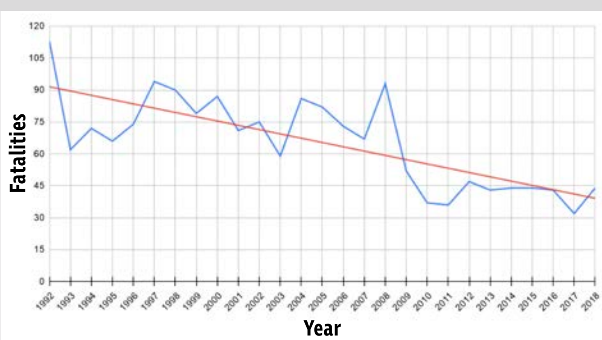
While side pulls are traditionally caused by swinging a load or by a group of workers pulling a load using chain falls, they can also be caused by tandem loading. Tandem loading uses two cranes in tandem to transfer large loads or lift long components from horizontal to vertical positions. It is critical that the center of gravity of the load be known so that the load is correctly distributed between the cranes. Tandem loads have the potential to be extremely dangerous because of misalignment of the center of gravity and the dangerous hazards of sideloading (SPANCO, 2018). Since 1991, OSHA has stated that tandem lifting is considered to be a hazardous practice and that one must be able to demonstrate that the practice complies with the crane manufacturer's specifications and limitations (OSHA, 1991). It is an unsafe practice to allow horizontal loads or off-center lifts, and these should be prevented by ensuring that the lifting plan provides ways to avoid side loading, such as positioning the cranes parallel to reduce the side loading risk (SPANCO, 2018).

Transferring the load from one crane to another crane or to some other lifting or hoisting mechanism such as a come-along is a form of tandem loading, also referred to as "stealing the load." In the authors' consulting practice, this was encountered in an industrial environment in which a truck crane lifted a 3-ton industrial fan approximately 35 ft above ground level through a building opening where contractors attempted to steal the load from the crane using two come-alongs. The come-alongs were attached to an overhead I-beam that was supporting the roof, adding more stress to that structural member and causing it to break. Unfortunately, the beam landed on one worker's leg, breaking it in several places, while bits of debris hit the other worker's head, causing serious head, neck and spinal injuries.

If an overhead structural member within a facility is to be used as an attachment point for a hoist, it is critical that an appropriate review with requisite calculations be made to determine whether the structure is capable of supporting the load. If it is determined that the overhead structure is capable of supporting the load and doing so is not a violative condition of local or state codes or guidelines, then it is imperative that the load be applied without introducing a side pull to the structural member. One source for this determination is the Steel Construction Manual produced by the American Institute of Steel Construction (AISC, 2011).

FIGURE 2

FATAL OCCUPATIONAL INJURIES INVOLVING CRANES, 1992-2018



Note. Data from "Census of Fatal Occupational Injuries," by BLS, n.d., www.bls.gov/iif/oshcfoi1.htm.

FIGURE 3

PULLEY WEAR CAUSED BY SIDE PULLS

Side pulls can cause lasting damage to pulleys and cables, even if they do not result in an injury or incident. Three examples of wear to the cables and pulleys that can be caused or exacerbated by side pulls include:

Injury & Property Damage Statistics Associated With Cranes & Overhead Hoists

In 2010, OSHA revised the 29 CFR 1926 Cranes and Derricks in Construction standard after receiving concerns from industry stakeholders "that accidents involving cranes and derricks continued to be a significant cause of fatal and other serious injuries on construction sites" (OSHA, 2010a, p. 47907). Some of the revisions made to the standard include new guidance for electrocution hazards caused by cranes, new training requirements for crane operators and crews, new rules surrounding assembly and disassembly of cranes, regulations surrounding fall protection and the creation of a "safe work area," which was intended to prevent incidents from falling equipment and loads striking workers. According to OSHA (2010a) estimates, 89 crane-related fatalities on average occurred at construction sites each year between 1997 and 2003. When compared to the data from 2011 to 2015, after the revisions made to the OSHA standard, an average of 44 crane fatalities occurred per year—a 51% reduction in fatalities compared to the data from 1997 to 2003 (BLS, 2017; n.d.). This may be due, in part, to the changes made in 2010 to 29 CFR 1926 Subpart CC, Cranes and Derricks in Construction. Figure 2 shows the total number of fatal injuries involving cranes for the 27-year period of 1992 to 2018 from Census of Fatal Occupational Injuries (CFOI) data supplied by the Bureau of Labor Statistics (BLS, n.d.).

From this database, OSHA noted that side pulls accounted for 1% of fatal crane incidents where the crane tipping over was the proximal cause and the contributing factor was the side pull. Contributing physical factors include "overload, loss of center of gravity control, outrigger failure, high winds, side pull and improper maintenance." In a secondary analysis on crane-related fatalities between the years 1997 and 2003, 125 case files were used that consisted of 126 cranes and 127 deaths (Beavers et al., 2006).

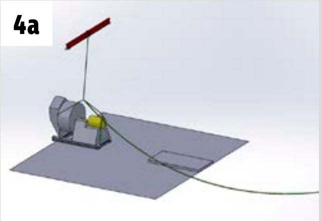
In 1980, data were recorded on crane failure by David MacCollum, a recognized authority on crane hazards. The analysis found that side pulls were one of the top 13 modes of failure for cranes. However, no deaths were caused by side pulls in 1980 (MacCollum, 1980).

Side pulls do not always result in property damage or injury; they can also cause irreversible damage to cables, sheaves and pulleys. ASME B30.5-2018 prescribes a ratio of outer diameter pulley size to cable diameter of 18:1. In the illustration in Figure 3, the pulley with a 9-in. outer diameter is able to encompass a cable diameter of up to 0.5 in. A side pull can lead to pulley wear from misalignment, cable misalignment and other potentially dangerous wear; performing a side pull with a cable that is too large for the pulley can exacerbate the damage (Flight Mechanic, n.d.).

OSHA standard 1926.1414 addresses the rope pitch diameter and specifies that it not be less than 18 times the nominal diameter of the rope used. This requirement is also noted in ASME B30.5-2014. If a rope with a 0.5-in. diameter is used, then the outside diameter of the sheave must be 10.25 in. to satisfy a pitch diameter ratio of 18:1. The pitch diameter is less than the outside diameter as it is the distance from the center of the rope to the center of the rope on the opposite side of the pulley. In addition, the depth of a sheave groove is typically at least 1.75 times the rope diameter, which also assists in keeping the rope riding in the groove of the sheave.

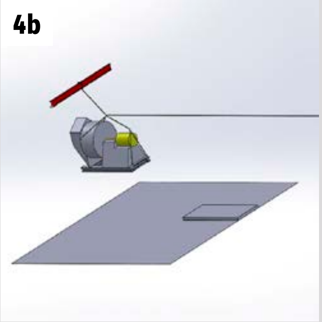
FIGURE 4
ILLUSTRATIONS OF A SIDE PULL

4a



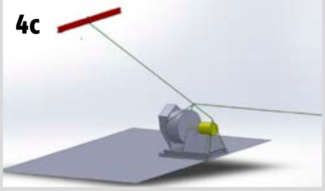
In Figure 4a, the fan is resting on the ground and has a cable attached to an I-beam and a cable for applying a horizontal pulling load. At this point, no horizontal load has been applied to the horizontal cable, but it is included for illustration purposes.

4b



In Figure 4b, the fan has been lifted vertically and pulled slightly out from below the I-beam. The magnitude of the vertical force is unchanged (equal to the weight of the fan), but a small horizontal force has been added. Force is transmitted through the cable and the direction of the resultant horizontal and vertical forces is the same as the axis of the cable attached to the I-beam.

4c



In Figure 4c, the fan has been lowered to rest on the concrete pad and the horizontal and vertical loads applied by the cables are no longer present.

TABLE 1
SIDE PULL ILLUSTRATIVE EXAMPLE CALCULATIONS

Example: A fan and motor assembly are being lifted by a hoist attached to an overhead I-beam in an industrial setting. The force on the I-beam increases as the angle of the cable from the vertical is increased. The horizontal force (HF) is calculated by multiplying the fan weight (F) by the tangent of the angle (α). The angle increases as the object is pulled out further from beneath the boom, as does the tangent of the angle and, therefore, the horizontal force. The resultant force (RF) is calculated by taking the square root of the fan weight squared plus the horizontal force squared.

$$HF = (F) \cdot \tan(\alpha)$$

$$RF = (F^2 + HF^2)^{1/2}$$

Fan weight (lbf)	Angle of cable from vertical	Horizontal force (lbf)	Resultant force on I-beam (lbf)
5,800	0°	0	5,800
5,800	15°	1,554	6,005
5,800	30°	3,349	6,697
5,800	45°	5,800	8,202

Side Pull Illustrative Example

If a hoist attached to an I-beam is used to lift an object, then a single vertical force (the weight of the object being lifted) is applied to the I-beam. If a side pull is also used to move the object, then a vertical force is applied to the beam (the weight of the object being lifted) and a horizontal force is also applied to the beam. The horizontal force is used to pull the lifted object off to the side so that it is no longer directly below the I-beam. The further the object is pulled away from hanging directly beneath the I-beam, the greater the horizontal force. These two forces can be resolved into a single greater diagonal force applied to the I-beam. The example shown in Figure 4 serves to illustrate the change of forces when a side pull is performed. For the purpose of this illustrative example, a fan and motor assembly are being lifted by a hoist attached to an overhead I-beam in an industrial setting.

Table 1 demonstrates how the force on the I-beam increases as the angle of the cable from the vertical is increased. The horizontal force is calculated by multiplying the fan weight by the tangent of the angle. As the object is pulled out further from underneath the boom, the angle increases, as does the tangent of the angle and therefore the horizontal force. The resultant force is calculated by taking the square root of the fan weight squared plus the horizontal force squared.

$$HF = (F) \cdot \tan(\alpha)$$

$$RF = (F^2 + HF^2)^{1/2}$$

where:
HF = horizontal force
F = fan weight
α = cable angle
RF = resultant force on I-beam

Regulatory & Consensus Standard Prohibitions on Side Pulls

Crane and hoist side pulls are a known industry hazard and are prohibited by a multitude of regulatory and consensus standards. Since 1971, the OSHA construction standard 29 CFR 1926.1417(q), which provides standards for cranes and derricks, has required that "the equipment [cranes] shall not be used to drag or pull loads sideways." In the revisions and additions to the OSHA (2010a) construction standard for cranes and derricks, the final rule notes that "side loading can buckle the boom, damage the swing mechanism or overturn the crane (such as when the boom is at a high angle)" (p. 47993). An operator who performs a side pull also places additional stress on the equipment that could damage the chain, drums or sheaves. The load chain could break, causing the load to drop and potentially causing damage to the equipment (Runyon, 2020).

The National Safety Council's (NSC) *Accident Prevention Manual* lists the rules for crane operators from the Crane Manufacturers Association of America Inc., which includes centering the crane over the load before starting the hoist to avoid swinging the load (Hagan et al., 2015). It also emphasizes that the crane hoisting ropes should be kept vertical and that cranes are not to be used for side pulls. NSC's data sheet on demolition balls states that:

> An operator must never attempt to check the swing of the weight nor to add impetus to it by reversing the boom before the swinging weight has reached the top of the arc. Either act will cause unnecessary torsion and could possibly result in the collapse of the boom.

Table 2 (p. 26) presents key regulatory, industry and consensus standards from 1967 through 2014 that address the prohibition of crane and hoist side pulls. The standards listed in Table 2 note some exceptions to the outright prohibition on side pulls. These exceptions to permit side pulls are based on allowances given by appointed persons, responsible persons, qualified engineers, qualified persons and authorized persons as set forth in the standard requirements. These terms are defined in some but not all of the standards.

TABLE 2

SIDE PULL PROHIBITIONS OR RESTRICTIONS FROM REGULATORY & CONSENSUS STANDARDS

Regulatory body	Standards
U.S. Department of Energy (selected standards date from 2004 to 2011)	• Standard 1090-2011, Hoisting and Rigging • Standard 1090-2004, Hoisting and Rigging
International Labor Office	• *Encyclopedia of Occupational Health and Safety (Volume I): Cranes and Lifting Appliances*
OSHA (selected standards date from 1971 to 2010)	• 29 CFR 1910.179, Overhead and Gantry Cranes • 29 CFR 1910.180, Crawler Locomotive and Truck Cranes • 29 CFR 1910.181, Derricks • 29 CFR 1926, Cranes and Derricks in Construction: Final Rule • 29 CFR 1926 Subpart CC, Cranes and Derricks in Construction
American Society of Mechanical Engineers (selected standards date from 2014 to 2018)	• ASME B30.2-2016, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist) • ASME B30.5-2018, Mobile and Locomotive Cranes: Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks and Slings • ASME B30.16-2017, Overhead Underhung and Stationary Hoists • ASME B30.17-2015, Cranes and Monorails (With Underhung Trolly or Bridge) • ASME B30.20-2018, Below-the-Hook Lifting Devices • ASME B30.21-2014, Lever Hoists
American National Standards Institute (selected standards date from 1967 to 2016)	• USAS B30.2.0-1967, Overhead and Gantry Cranes (ANSI) • ANSI/ASSP A10.48-2016, Criteria for Safety Practices with the Construction Demolition, Modification and Maintenance of Communication Structures

In those instances where an overhead hoist is being bumped to create a side load as a means to allow the lifted piece to be positioned, it is critical that the persons directing or authorizing this activity meet one or more of the following five criteria.

1. The qualified engineer as specified in ANSI/ASSP A10.48 is a professional engineer who is knowledgeable and experienced in the communication structures industry and this standard, capable of understanding the contractor's rigging plan and the scope of work impact upon the structure, and responsible for analyzing the structure's strength and stability while accounting for construction loads in accordance with the ANSI/TIA-322 standard.

2. OSHA standards 29 CFR 1926.32(m) and 29 CFR 1926.1401 define a qualified person as one "who, by possession of a recognized degree, certificate or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter, the work or the project."

3. In the ASME B30 standards, a qualified person is defined as:

> . . . a person who, by possession of a recognized degree in an applicable field or a certificate of professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated, the ability to solve or resolve problems relating to the subject matter and work.

4. An appointed person in lifting operations is defined as the "person responsible for the execution and safety of a lifting operation" (Essential Site Skills Ltd., 2021).

5. A competent person is defined in OSHA standard 29 CFR 1926.32(f) as:

> . . . one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Technology to Detect Loads & Side Pulls

The data noted demonstrate that side pulls have produced serious injuries and deaths. The persons authorizing and allowing side pulls to be made must, therefore, be aware of these data and have the appropriate background to safely authorize side pulls by either hoists or cranes. If a side pull is authorized, NIOSH (2009) recommends that load moment indicators (LMIs) be installed on the crane. An LMI alerts the crane operator of the load conditions to prevent overloading or over-hoisting during operations. LMIs typically monitor the overturning moment of the equipment, which is the load multiplied by the radius. The equipment's rated capacity is impacted by factors that increase load moments. These parameters include movements being made by the crane and its operator including the hoist downward movement, the boom telescoping outward and the boom moving downward. Many of the monitors have key data for the crane stored in a central processing unit and generally include dimensional data, capacities, the weight of the boom and the crane's center of gravity, all used to determine whether the crane is being operated safely. Some LMIs have the capability also of limiting the actions of the crane and its operator by shutting down the power if further actions will increase the load on the equipment beyond a safe condition. Functions that might be shut down include hoisting, telescoping out or "luffing out," where a crane operator moves the jib of the crane vertically to lift the load. Generally, the functions that decrease the load severity are not restricted.

LMIs are different from boom angle indicators, which show the angle of the lift from the x-axis of the crane. Photo 1 shows a boom angle indicator, which includes a scale that generally goes from 0° to 90° from horizontal and a plumb bob that is fixed at the top of the scale so that it remains fixed as the scale moves up or down, allowing the operator to read the degrees at the intersection of the plumb bob and the scale. In a New Jersey case report on a crane failure, NIOSH (2009) advised that "LMI devices allow for the operator to estimate the load weight being pulled by the crane during its operation and therefore greatly enhance the operator's ability to avoid exceeding the maximum critical load of the crane."

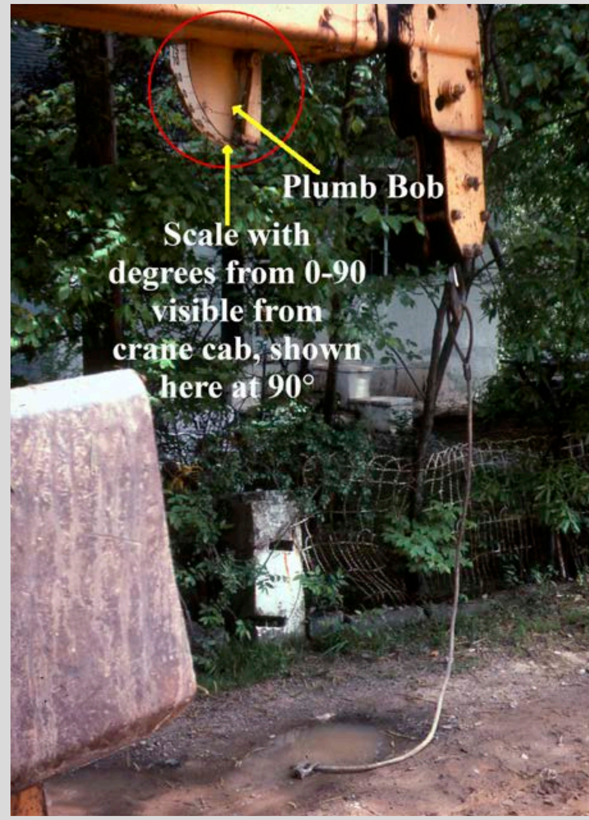
Photo 2 shows a cable-mounted LMI measurement unit and Photo 3 shows an LMI display panel with alarms and lift-stopping mechanisms. An LMI typically displays the load maximum and the current load. It continuously tracks the crane's rated capacity and compares the current condition of the lift to the rated capacity to show the percentage of capacity that the crane is working. If the load is at 3.1 tons and the maximum capacity is 3.8 tons, then the display will show the percentage of the rated capacity at 81.6%. Alarms, lights or other alerts warn the crane operator when the risk of overloading or overturning are high (BTS Crane, n.d.; 2014).

Although many hoists and cranes do not have any form of side pull protection installed, the core idea of monitoring the angle of the rope is not new. One available option is a solid-state side pull detection system that mounts to the wire rope and allows the operator to set limits and timing (Laser-View Technologies, n.d.). A tilt sensor can be mounted on a bracket clamped to the dead end of the wire rope to detect side pulling, measure the angle of wire rope and apply sensor-based limits. Some detectors also have the option to select the maximum deviation from the vertical position. Mechanical limits can also serve as an option to detect and limit side pulling. Limit bars or mechanical limit boxes can be installed that shut down or momentarily reverse lifting and travel motions when the mechanical bars sense a side load (Crane 1 Services, n.d.; Laser-View Technologies, n.d.). If a side pull is being performed on a hoist or crane, it is imperative that the requisite provisions of the OSHA and ANSI standards are met and that the lift is authorized by an appointed, competent, qualified or other designated person, as noted.

Alternative Material Handling Methods

Portable Gantry Cranes

Rather than performing a side pull using another crane, hoist or come-along, or by having a group of workers move the crane horizontally into its final position, a portable gantry crane can instead be used to lift and move an object into position. Portable gantry cranes are a readily available material handling method available for rent or purchase and are available in sizes and weight capacities sufficient to move a variety of different objects (portable gantry cranes are readily available that can lift from 2,000 to 10,000 lb). Many of these cranes have an adjustable height and can be assembled and disassembled on site to accommodate placement in limited spaces. They typically feature four swivel caster wheels so that they can be easily moved into place to hoist or move objects and can be moved in a 360° circle as well as raise or lower the object being lifted or moved. After hoisting is performed, gantry cranes with casters can then be used to move heavy objects laterally. With a gantry crane, the lifting can be performed while the operator is at a safer distance from the hoisted object, which also reduces the operator's exposure in the event of an equipment failure or malfunction. Photo 4 (p. 28) shows a shop-built 10,000-lb portable gantry



(From top) Photo 1: Boom angle indicator. Photo 2: Cable-mounted load moment indicator measurement unit. Photo 3: Load moment indicator display panel with alarms and lift-stopping mechanisms.

(From top) Photo 4: A 10,000-lb capacity portable gantry crane with hoist. Photo 5: 5,000-lb engine hoist.

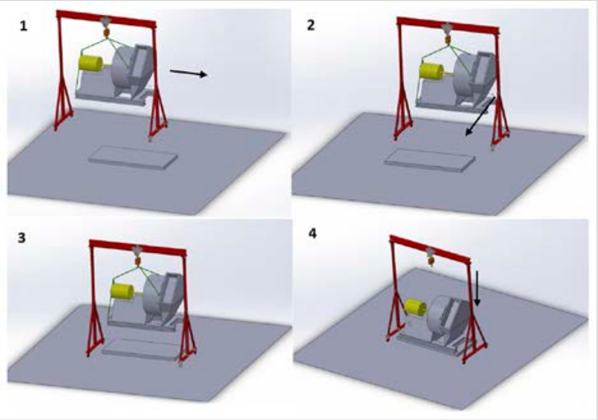
crane designed by a licensed professional engineer with a 12-ft beam-to-floor clearance and 12-ft span in the equipment repair and maintenance shop of a construction contractor.

In Figure 5, a portable gantry crane is shown being used to pick up a fan and motor assembly and place it onto a concrete pad. The portable gantry crane's ability to be assembled in tight quarters and moved into place can also eliminate attaching the load to an overhead object or structural member and possibly then creating a side pull if the hoist is not directly below the hoist. The portable gantry crane can move laterally in a 360° arc while maintaining a plumb relationship between the object being lifted and the hoist. With this disassembly feature, the portable gantry crane could be transported to tight or hard to access spaces or assembled at ground level and lifted into place. As depicted in Figure 5, the casters on the bottom of the portable gantry crane allow for horizontal movement of the unit.

Most portable gantry cranes are supplied with either steel or phenolic-resin casters or wheels. Unlike cushioned tires, these casters or wheels have little or no shock absorbency; when rolled across anything other than a smooth surface, the load being transported can create a dynamic rather than a static loading condition. When used as they frequently are in construction applications for both initial construction and alteration or repair, for safe use it is critical that the user be aware of the surface conditions on which the portable gantry crane is to be used. Most industrial suppliers of portable gantry cranes for lease or purchase typically have 8-in. diameter tires or smaller. Portable gantry cranes are usually supplied with a swivel hook where the hoist is attached to the I-beam to keep the load plumb.

FIGURE 5

PORTABLE GANTRY CRANE USED TO MOVE A LOAD



A 2010 incident exemplifies the forces that can occur when hoists or cranes are engaged in side pulls. When attempting to right a semi-truck trailer that had overturned on an interstate highway in Raleigh, NC, two large triple-axle, 12-tire wreckers were employed to remove the trailer. The two wrecker trucks were positioned on either end of the overturned semi-truck trailer, which was partially resting on the guardrail for the highway. The highway had an 8.0% (4.6°) cross slope. When an attempt was made to lift the trailer off the guardrail, the trailer fell and rolled down the bridge, which pulled and overturned one of the wreckers (Cox, 2010). Therefore, it is important to ensure that the portable gantry crane is used on level surfaces to avoid changing the load from a static to a dynamic load. Dynamic loading can be sufficient to generate forces capable of overturning cranes and damaging hoists.

Portable gantry cranes have been used for more than 100 years. For the purposes of this article, patents and patent applications are used as a primary measure of establishing the technology's earliest usage. Table 3 compiles selected patents for portable gantry cranes, demonstrating the extensive history of this technology. As shown in Table 3, the first portable gantry crane patent was applied for in 1916 and granted in 1920 to a German inventor with intended use in the railway industry (Krupp Stahl AG, 1920).

Engine Hoist

Photo 5 shows a 5,000-lb engine hoist. This particular type of machinery has a wide range of applications for lifting, lowering and relocating needs. Engine hoists can be used in various industrial settings such as food production factories, auto garages, construction sites, power plants, warehouses and others. Similar to the 360° rotation provided by the portable gantry crane, the casters on an engine hoist allow it to move in any desired direction for easy placement or removal of objects. Engine hoists can be easily disassembled and stored when not in use. They are a useful combination of reach and power that comes in varying sizes and weight capacities.

Table 4 compiles selected patents for engine hoists, demonstrating the extensive history of this technology. As shown in Table 4, the first engine hoist patent was granted in 1891 to transmit the motion of the motor-armature to a hoisting drum (Baxter, 1891).

Conclusion

•Side pulls should not be performed in the workplace unless approval to do so has been given by an entity authorized by a consensus or regulatory standard.

•In addition to the OSHA standards governing the use of side pulls, at least four other U.S.-based regulatory bodies have similar standards prohibiting said practices.

•Where side pulling or side loading is being performed in accordance with the allowances to do so by OSHA or another consensus standard, the hoisting equipment should be equipped with side pull monitors, also known as LMIs, as well as boom angle indicators.

•The use of a portable gantry crane, an engine hoist or another alternative material handling method may be preferable to performing a side pull.

•Where portable gantry cranes are used, it is critical that the user is aware of the surface conditions on which the portable gantry crane is to be used; portable gantry cranes should only be used on a level and smooth surface.

•Construction equipment is usually equipped with much larger tires than similar equipment used in industrial environments. Many of the portable gantry cranes and engine hoist models are not equipped with tires suitable for use in a construction environment. In all construction instances, however, both boom angle indicators and LMIs should be used on cranes and hoists. **PSJ**

TABLE 3

PORTABLE GANTRY CRANE PATENTS

Patent name; no.	Date	Description
Mobile gantry crane; DE325812C	Applied Jan. 18, 1916; granted Sept. 21, 1920	"Moveable and collapsible gantry crane"
Portable gantry crane; US2034920A	Applied Mar. 16, 1934; granted Mar. 24, 1936	"A portable bridge crane of sturdy construction, which can be cheaply manufactured, and which will provide a clear unobstructed space between the side supports and overhead member to give the workmen ample room for the hoisting operations."
Portable gantry crane; GB728472A	Applied May 29, 1952; granted Apr. 20, 1955	"A portable and collapsible gantry crane comprises an elongated horizontally disposed bridge beam supported by a pair of towers and means pivotally connected to the opposite ends of the bridge beam and engaged with the towers for movement lengthwise thereof."
Portable gantry crane; US2772004A	Applied May 29, 1952; granted Nov. 27, 1956	"A portable and collapsible gantry crane, comprising a horizontal bridge beam; a pair of positioning guide members horizontally pivoted to said bridge beam."

TABLE 4

ENGINE HOIST PATENTS

Patent name; no.	Date	Description
Electrical hoisting-machine; US449661A	Granted July 4, 1891	This invention relates to an electrical hoisting-machine arranged to transmit the motion of the motor-armature to a hoisting drum.
Hoist for motor vehicle parts; US2522267A	Applied Aug. 4, 1948; granted Sept. 12, 1950	Hoist that is adapted to be supported by portions of the chassis or framework of a motor vehicle for supporting and moving heavy assemblies
Adjustable engine lift; US3751097A	Applied Apr. 12, 1971; granted Aug. 7, 1973	An adjustable engine lift adapted for use by mechanics and the like, wherein a means for removing and installing an automobile engine is simplified by being able to adjust engine angle while the engine weight is suspended.
Portable hydraulic hoist for vehicular engines; US4090625A	Applied Jan. 10, 1977; granted May 23, 1978	A portable vehicle engine handling hydraulic hoist including a wheeled base for mounting a vertically and swingable base boom with a tiltable and longitudinally movable horizontal boom pivoted to the upper end thereof.
Portable foldable hoist; US4334668A	Applied Feb. 17, 1980; granted June 15, 1982	A portable hoist is provided and is adapted to be used for lifting and moving heavy objects or loads such as automobile engines, etc. The hoist is designed such that it is portable, in that it is fully foldable into a small, compact unit for storage or transport. The hoist is further mounted on rollable wheels, thereby permitting movement when loaded.

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