National Safety Council
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Tower cranes

Progress takes on many forms and innovations. One piece of equipment that has helped the building and heavy construction industries is the tower crane. These cranes, first introduced in the United States in 1957, have become an integral part of the changing skylines in many cities throughout the country and elsewhere.

2. This data sheet describes the operation of tower cranes and delineates the possible hazards that may be encountered before and during erection, operation and dismantling procedures. In addition, the various measures concerning the avoidance of these hazards also will be explained and illustrated. A 138-entry glossary is included.

Description

3. The primary feature of the tower crane is its elevated boom or jib. It can assume various configurations as described in the Glossary of Terms, under "Tower Cranes," and also in paragraph 13.

4. There are many design variations, depending upon the manufacturer and the intended use. The tower crane can be erected on a minimum of ground area or within a building; for example, within the elevator shaft or other floor opening. To increase their range and versatility, some tower cranes are mounted on under-carriages running on rails, rather than on a fixed base; there also is a truck-mounted type.

5. A turntable, which permits swinging (slewing) the jib, is mounted near the top of the tower. The operator's cab also may be on the turntable. Swinging, hoisting, trolleying and traveling motions are powered by electrical hydraulic or diesel machinery placed at a convenient location on the crane.

6. Some of these cranes are of the "climbing" type; they use several ingenious arrangements to increase the height of the tower and to elevate the jibs (Figure 1). Although the climbing crane can rise within the building as it is erected, it is also a common practice to erect the crane to its full

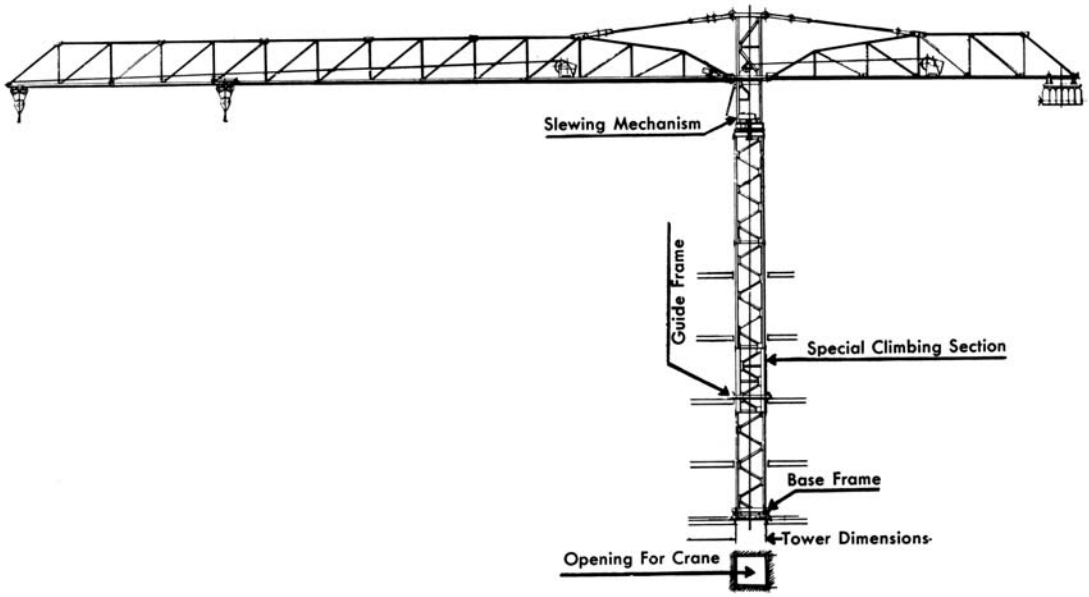

Figure 1

working height before it is put into operation. Some climbing-type designs use hydraulic jacks at the base to raise the entire tower; tower sections are then added underneath. There is also a type that has a similar jack attached to the yokes, which engages the frame under the turntable. This permits the turntable and jibs to be raised so sections may be added under the turntable.

7. Another type uses a hoisting winch; this will add a tower section to the top of the tower (which extends through the turntable). A hydraulic ram then uses two climbing ladders, attached to a support frame on the upper floor of the building, to raise the turntable around the new tower section.

8. The tower may be freestanding, or guy wires may be used to provide additional stability. Towers erected inside of buildings may be wedged or bolted at various floor levels for support. In such cases it should be determined that the floors are sufficiently strong enough to accept the load and stresses imposed by the crane. It is important that the manufacturer's specifications be strictly adhered to regarding the minimum vertical distance between supports.

9. Because relatively few of the mechanical features of tower cranes correspond to the design of the conventional crawler or truck cranes, current safety standards and requirements are most often not directly applicable to this type of equipment. Therefore, definite safety standards should be set applying to all types of tower cranes.

10. There are a variety of distinctive problems presented, in addition to those commonly associated with material hoisting equipment.

a. Even though this type of crane consists primarily of a network of angle iron or tubing, there is sufficient surface exposed to wind pressure to cause considerable stress.
b. The location of the operator within the cab of the crane may limit the view of hooking-on or unloading, requiring the presence of a well-trained signalperson.
c. The manner of tower assembly, with pins or nuts and bolts, requires regular inspection and tightening of all connections.
d. The detection of structural weakness requires specialized detailed inspection methods.

11. The impact of these tower cranes on the construction industry is being felt by all organizations concerned with the safe installation and use of this equipment. Those accidents already reported as resulting from the use of tower cranes indicates immediate attention should be given to the setting up of suitable safety standards for this equipment.

Common causes of failure

12. The following procedures have been established as significant among the more common causes of failure:

a. Improper erection of the crane
b. The lifting of loads above the rated capacity of the crane, or the lifting of eccentric loads
c. Improper bracing of the crane
d. Bracing, or attachment to material or structural members that are insecure or unable to provide the needed support
e. Erection within a building, the design of which has not provided the necessary allowances for the crane weight, or support at the application point of the crane weight
f. Operators not being fully cognizant of the limitations or operating characteristics of tower cranes
g. Tampering with limit switches or other safety devices
h. Failure to have instructions spelled out in plain English

i. Failures resulting from use during high winds

Design and fabrication

13. There are three general types of tower cranes:

Climbing. When climbing within a building, using its climbing frames and hydraulic climbing mechanism, the crane's lifting limitation is governed only by the height of the building. As the building goes up, climbing frames are brought up to the new stories and the crane can continue to climb (Figure 2). Prior to its installation within a building, the basic unit can be used as a static-mounted crane for the first stage of the project.

Stationary. A stationary (static or fixed) crane, either freestanding or supported by the building, can be erected on a suitable concrete base or other substantial mount (Figures 3a and 3b). Increases in the height of the crane are made possible through the use of the telescoping mechanism of the crane, permitting the addition of sections.

Traveling. The addition of a rail-mounted undercarriage to the stationary crane allows free traveling under load on either straight or curved tracks. This is particularly useful when the application requires a larger area than the working radius the crane permits. There is also a truck-mounted tower crane,

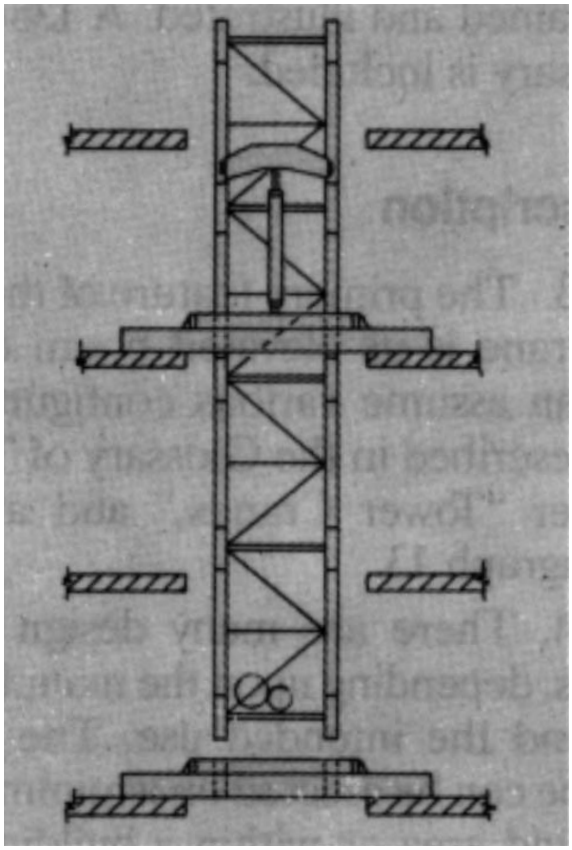

Figure 2

and attachments that convert conventional crawler or truck cranes to tower cranes (Figure 4).

14. Every crane should have a descriptive booklet – written in plain English – giving comprehensive and easily understood design characteristics, installation prepara-

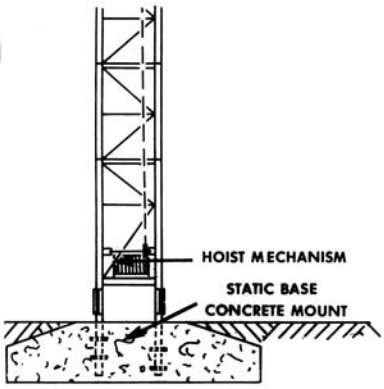

Figure 3a

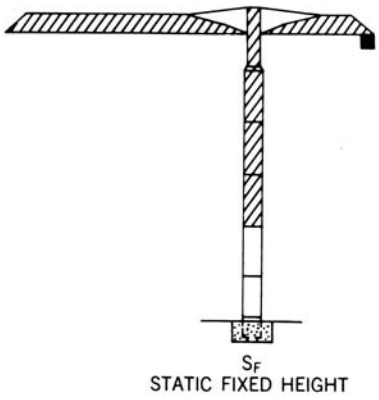

Figure 3b

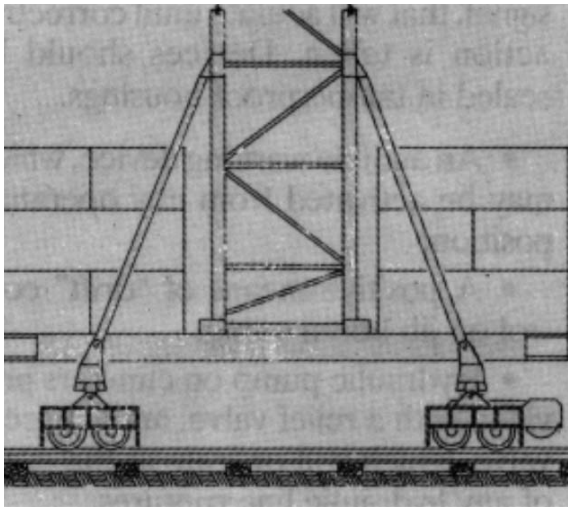

Figure 4

tion requirements, erection procedures, operation techniques, repair and maintenance recommendations, and general and specific safety precautions. This booklet should always be easily accessible on every jobsite.

15. The equipment should be properly designed and constructed to perform in accordance with the ratings placed upon it.

16. Important accident prevention items are included in the following sections.

General

- Stresses for steel used for fabrication and construction conforming to American Institute of Steel Construction specifications. (If special materials, such as high-tensile steel or aluminum alloys have been used in the crane structure, the crane should bear a notice to this effect.) All parts of the crane and supports should be designed and constructed to withstand maximum stresses resulting from intended use. (The design and construction should provide the safety factors specified by the authority having jurisdiction.)
- A secure attachment of counterweights – and safety ropes, rods or chains to hold the counterweights – in addition to the basic attachment
- The strength of the system used to anchor the rope on a winding drum with an ample safety factor exceeding the normal working load of the rope
- Flanges of winding drums projected well above the height of the highest layer of rope wound on the drum in normal operation
- Non-rotating hoist rope (except on receiving systems that do not require it)
- Guarding of all moving parts including pulley block and sheave guards

Cabs

- Cabs built of fire-retardant materials and large enough to allow ample ventilation and space for the operator to safely perform all duties
- Cabs equipped with a roof to protect the operator (Figure 5). This is especially important if the cab is located at the foot of the mast.
- Heated operator's cab
- Air conditioning of cab. Temperatures are 95º - 120º in many locations
- Adequate lighting inside the cab

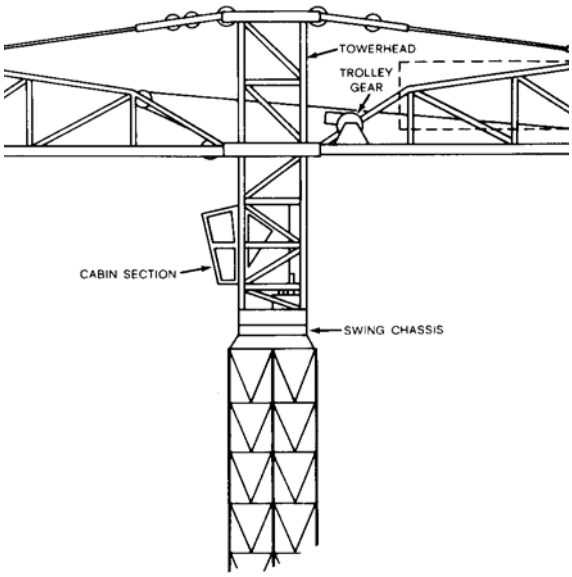

Figure 5

- Cab window frames designed so the panes can be cleaned
- Safety glass in the cabs
- Proper type and size fire extinguisher placed within easy reach inside the cab
- A comfortable operator's seat, in proper proximity to the controls

Brakes

- All cranes equipped with brakes or an equivalent device capable of stopping the full-rated load or the jib in any position. There should be an adequate factor of safety.
- Stopping devices to be either automatic or operable by the crane operator immediately and directly from his or her working position, even in the event of a total or partial interruption of the crane's power supply
- A device to control acceleration and deceleration rates, and to prevent damage to the mast section from torsion effects
- Slewing brakes with electrical controls that regulate the rate of deceleration, designed and wired so that the built-in safety mechanism cannot be altered to manual, or other controls that could bring about a sudden application of the slewing brake

Controls

- Crane controls designed and located so the operator can manage the crane efficiently
- "Dead man" control that will completely immobilize every part of the machine if the operator removes his hands from the controls
- Plates clearly indicating the rated (safe working) loads and with the radii located in the operator's cab on the tower, and if necessary, on the jib
- Operating instructions and safety procedures posted in the operator's cab, and elsewhere if necessary
- All controls clearly marked in plain English indicating their purposes and modes of operation
- When the control panel is located on the counterweight jib, the power cable connecting it to the control box should be long enough to permit safe operation without damaging the cable
- Remote control panels designed to be portable, for maximum visibility

Safety devices

- Height limit switches, moment limit switches, and variable and maximum load limiters equipped with a signal that will actuate until corrective action is taken. Devices should be sealed in tamper-proof housings.
- An audible warning device, which may be activated from any operating position
- A positive means of "drift" control on jib boom swing
- Hydraulic pump on climbers provided with a relief valve, and a check valve, which will operate in the event of any hydraulic line ruptures
- The use of hooks of adequate strength, designed or equipped to prevent accidental dislodging of loads, such as by having safety latches
- Installation of appropriate retentive devices to prevent objects from falling from the crane. (Be sure locknuts or similar protection is used on all sectional connections.)
- Safe access ladder or catwalk, both in the tower and on the jibs with standard ladders (with hoop guards), landing platforms, toe boards, handrails, etc., should be included where required. All masts should be equipped with a standard interior fixed-ladder, which should be used for climbing the tower.

- Resilient buffers located at both ends of the trolley

Internal combustion engines

- Exhaust from the engine (when power source is other than electrical) vented so as not to obscure the view of the operator, or subject him to fumes
- An effective means for allowing the operator to shut off the fuel on equipment powered by an internal combustion engine

Rail cranes

- Design attachments to prevent derailment on a correctly laid track under normal usage
- Fender supports or similar devices capable of supporting the crane on the track in the event of derailment, or if a wheel or axle breaks
- A rail crane's running wheels should be fitted with wheel guards, unless their position provides equivalent safety.
- The ends of all tracks should be equipped with buffers to prevent derailment or overturning of the crane.

Electrical aspects

17. Electrical wiring should not be subjected to tensile, bending or torsion stresses, other than those produced by its own weight or by the operation of a winding device.

18. A slip-ring or similar device should be provided to convey electric current from a stationary part to a rotating part of the machine, except where rotation can be limited to a few turns, the number of which would depend upon the height of the tower.

19. The manufacturer or supplier should provide the user with all the necessary information concerning power requirements to properly operate the crane (Figure 6).

20. The operator's cab should be equipped with a master switch permitting the operator to stop all movement of the crane, except any electromagnetic lifting device, in the event of any abnormal functioning. (The switch should be fail-safe).

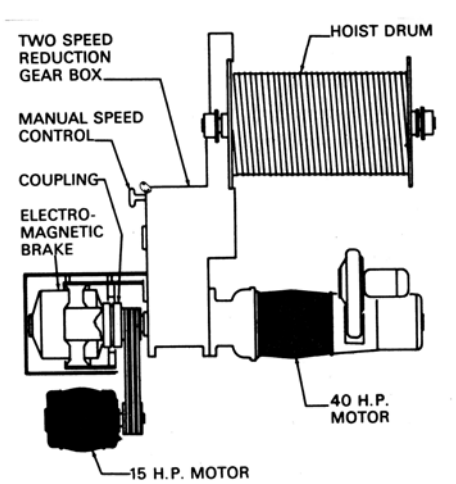

Figure 6

21. Electric motors should be protected separately against current overloads.

22. Switch boxes should be padlocked or otherwise made inaccessible to unauthorized persons.

23. Where a remote control is used, all circuits that terminate at a hand-operated control should be supplied by an isolating transformer. The remote control box should be made of non-conductive material, and the control levers insulated from any inside metallic frame (this frame should be grounded).

24. The crane hoist mechanism and supplementary equipment should be effectively grounded to comply with any applicable standards and codes (include lightning protection).

25. The track on rail-mounted cranes should be grounded to comply with applicable standards or codes.

26. All electrical wiring, repairs or other work should be done only by qualified personnel, in accordance with the requirements of the National Electrical Code, or the

applicable enforcing authority. All electrical wiring and switches should be waterproof.

Procedures

Preparation for installation

27. Planning and the acquisition of all necessary materials and data are imperative elements in preparing for the erection of a tower crane. These include:

a. Providing a means for securing the crane (jacks, rail clamps, chocks, bracing, guys, etc.), for applying brakes and, where necessary, for allowing it to swing freely should be provided to permit immobilization of the crane when it is out of service, or to reduce loads due to the force of the wind. These devices also should be provided whether the machine is mounted on wheels or not. The manufacturer should supply detailed instructions.

b. Providing the ballast at the foot of the tower as well as the counterweight to be hung from the counterweight jib. Manufacturers' instructions also should include, in particular, the exact weights and sizes for the ballast. The ballast and counterweight support should be designed to make sure it can neither move nor fall.

c. Thoroughly checking the ground that is to support the crane. Choose the location carefully. Take any necessary corrective action to prevent any deflection tendency of the crane. In the case of a traveling crane, the tracks should be erected upon solid supports.

d. Determining that structural support is adequate.

e. Preparing the slab support for a static crane in conformance with the manufacturer's recommendations.

28. In summary, two major salient safety requirements stand out as imperative on behalf of accident prevention:

- All specifications for installation preparation should be provided by the manufacturer.
- The provided specifications should be adhered to, with no deviation to any degree whatever without the permission of the manufacturer.

Initial erection

29. The original erection and subsequent jacking and climbing of a tower crane should comply with all applicable safety precautions, standards and codes. The manufacturer's specifications, recommendations and instructions for the erection of these cranes should be adhered to in every detail. Any deviation from the established norms can invite a catastrophe. Among those details to observed in these operations are:

- Only those who are properly trained and qualified should be assigned to erecting the crane.
- Erect the crane only during favorable weather.
- The sequence of the mounting should be done only as prescribed by the manufacturer's specifications.
- Crane foundations must be adequate to support the overturning moment of the crane, in compliance with manufacturer's specifications and a structural engineer's recommendations.
- The stability of the crane (whether stationary or mobile, and whether in service or only being subjected to the force of the wind) should at all times be safeguarded by ensuring the ground and the base beneath it is absolutely firm; and by using any necessary mooring and staying devices such as bracing struts, guy wires, ballast and freeswinging jib.
- For wheel-mounted cranes, in order to prevent movement by the force of the wind, adequate chocking, mooring and braking devices should be provided.

These should be capable of withstanding the strongest wind forces that might normally be expected under local conditions.

- Ballast and counterweights must conform to the manufacturer's specifications and instructions regarding their weight, density, size and other characteristics. The counter jib ballast and counterweight may be of reinforced concrete or in bulk form. If in bulk form, the material used for the ballast should be securely contained in a closed metal casing; the total weight of the material so used should be checked each time the crane is reassembled.
- Safety chain, wire rope or a similar device is recommended to hold the counterweight in the event that bolts or other methods of securing it should fail.
- Where the stability of the crane is achieved by use of ballast weights, affix a diagram or notice showing the position and amounts of such weights to the crane at a point where it can be easily seen.
- Do not support the vertical and horizontal load of a crane assembly by a permanent structure without first making an engineering determination of the anticipated forces. When guy lines are used to support the mast, "dead man" anchors must be able to withstand the stresses imposed.
- Make all connections of the structural components of the crane with bolts or pins of proper size.
- Secure all bolted connections according to manufacturer's requirements.
- The crane tower mast must be erected plumb.
- For either exterior or interior erection, wedging and bracing should be located in accordance with manufacturer's recommendations only. (Additional wedging not specified by the manufacturer can actually be harmful).
- Mast wedges should be tapered to provide proper bearing surface so they will fit evenly.
- Rig power cables with care to prevent damage, and in accordance with manufacturer's specifications.
- The operator should be located where he or she can control the crane most efficiently, and have maximum visibility of the load block. Normally, positioning of the operator in the frame of the crane is the most expeditious, particularly with very high-speed cranes. (In effect, use direct, rather than remote control, whenever possible).
- If the operator's cab is attached to the jib, it should be installed in such a manner that the strength of the boom is not reduced, and the safety of the unit not impaired.
- A safe climbing device or ladder should lead to the top of the crane, with intermediate doors or landings at standard distances from each other (check compliance with any applicable code).
- After erection, all cranes should be tested before being put into service. Ensure the weights are accurate.
- After the testing of the machine is complete, set the overload devices as specified by the manufacturer.

Jacking and climbing

30. Jacking and climbing should be done only as prescribed by the manufacturer's recommendations, and by properly trained and qualified personnel assigned to this task.

31. Climbing should not be done when wind speeds are above those specified by the manufacturer.

32. A check should be made of all telescoping safety devices prior to jacking and climbing.

33. All working ropes and/or climbing systems should be inspected prior to climbing operations.

34. Maintaining the balance of the crane during climbing operations should follow manufacturer's recommendations.
35. Beams supporting the crane should be leveled to make sure the mast is supported on both beams, and at both sides of the mast.
36. On those cranes so equipped, the steps of each climbing ladder should be at the proper level for both pawls to engage the ladder steps at the same time during climbing.
37. After each climbing operation is completed, all crane functions should be tested.
38. The vertical load of the crane assembly should not be supported by the edges of a floor opening without an engineering determination that the edges will support the intended load.
39. When the tower is supported by a permanent structure, the support should not transmit harmful vibrations.
40. For either interior or exterior jacking or climbing operations, any wedging or bracing to be used should be in accordance with the manufacturer's recommendations. (Additional wedging not specified can be dangerous).
41. Floors to be used for support should have developed sufficient strength before climbing starts. The nature and extent of bracing necessary will have to be determined by a structural engineer.
42. When guy lines are used to support the mast, "dead man" anchors should be able to withstand the stresses imposed.
43. Following each climb, all fastenings should be checked.

Operation

44. Only personnel of recognized ability should operate a tower crane. The operator should be mature in attitude, have quick responses and be in good health. His or her background should include both training and experience in the operation of this type of equipment. The operator should possess a general knowledge of the crane's construction; and the necessary knowledge of electricity, hydraulics, trade terms, parts identification and of maintenance needs for this work. The operator also should have a knowledge of safety codes and standards applicable to crane operation, and of any special safety recommendations of the crane manufacturer. Operators should be CCCO, or equivalent, certified.
45. The storing of rags, waste, oil or other combustible materials in the operator's cab should be prohibited. Approved closed metal containers should be provided.
46. The warning horn should be tested at the beginning of each shift.
47. Procedures that should be followed include:

Visibility and signaling

- Full visibility should be provided for the crane operator during the operation of the crane or movement of a load. When this is not possible, the recommendations applying to the use of signalers should be observed.
- Where a crane is not controlled from the ground but from an elevated cab, hand signaling or voice communications should be established between the operator and a competent signaler on the ground. The operator should respond only to signals given by the official signaler (except for emergency stops).
- Only standard, approved signals should be used (Figure 7). It is a good safety practice to post these signals at the operator's position signal-control points, and any other locations necessary.

Lifting and lowering

- The weights of materials to be lifted

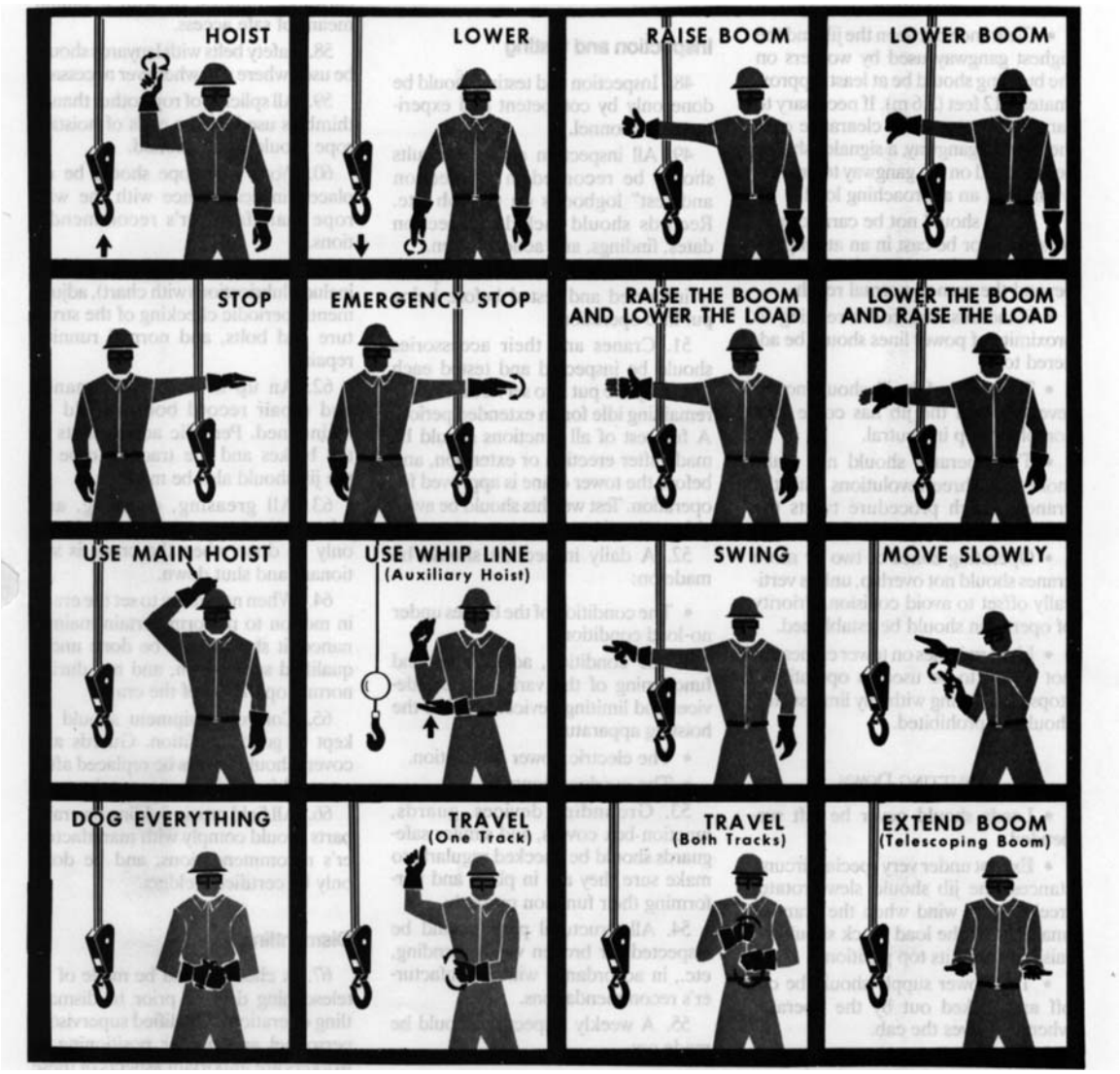

Figure 7

should be specified, and responsibility assigned for checking loads. Loads of greater weight than the permissible limit of the machine should not be lifted.

- Special precautionary plans should be established and practiced for exceptional lifting operations such as lifting large panels, which may be blown about by the wind, or combined lifting by two or more cranes.
- The crane should not be used to pull vehicles of any type, remove piling, loosen formwork, or pull away loads that are attached to the ground or walls or for any operation other than the proper handling of freely suspended loads.
- The maximum safe load rating of hooks should be clearly marked.
- Hooks should be maintained in good condition and equipped with safety latches.
- Stop gradually. The hook should never be too low to cause the hoist rope to become slack on the drum. Standard or code requirements for extra rope wraps on drums should be maintained (usually 4).
- Start gradually. Before the load is actually raised, tension should be placed on the hoist rope while in the first position.

- Check all pulleys in each block for correct positioning of the rope in the pulley grooves immediately after a pulley-block is placed under load and before it is required to perform any operation.
- Riding a load, hook, sling, etc., should be prohibited.
- Free-fall lowering of loads should be prohibited. The lowering of loads solely under the control of a brake should be permissible only if the machine is equipped with a speed limiter (a device that limits the speed that can be attained by the load when the brake is released), and only if such brakes require continuous action by the operator throughout the descent, i.e., only if the brake is of the type which is automatically applied as soon as such action by the operator ceases (brake with controlled release).

Swinging

- Clearance between the jib and the highest gangway used by workers on the building should be at least 12 feet. If necessary to carry loads at a lesser clearance over the highest gangway, a signaler should be stationed on the gangway to provide warning of an approaching load.
- Loads should not be carried over personnel, or be cast in an attempt to get them down at a point beyond the crane's normal reach.
- Standards and codes relating to proximity of power lines should be adhered to.
- The swing of the jib should not be reversed until the jib has come to a complete stop in neutral.
- The operator should not make more than three revolutions with the crane, if such procedure twists the hoisting ropes or electrical cables.
- Operating zones of two or more cranes offset to avoid collision. Priority of operation should be established.
- Limit switches on tower cranes are not meant to be used as operational stops. Tampering with any limit switch should be prohibited.

Shutting down

- Loads never should be left suspended.
- Except under very special circumstances, the jib should rotate freely in the wind when the crane is unattended; the load block should be raised to near its top position.
- The power supply should be cut off and locked out by the operator when he leaves the cab.
- Test weights should be placed so they cannot be frozen in place or stuck in mud.

Other precautions

- The crane operator never should stand on, or climb upon, the framework outside the cab while the crane is in operation.
- Climbing to the end of the jib should be prohibited except when necessary, for which prescribed special precautions and equipment should be used.
- Safety harnesses and other necessary personal protective equipment should be available, and used when necessary.

Inspection and testing

48. Inspection and testing should be done only by competent and experienced personnel.

49. All inspection and test results should be recorded in "inspection and test" logbooks on the jobsite. Records should include inspection dates, findings and actions taken.

50. The crane should be completely inspected and tested before being put into operation.

51. Cranes and their accessories should be inspected and tested each time they are

put into service and after remaining idle for an extended period. A full test of all functions should be made after erection or extension, and before the tower crane is approved for operation. Test weights should be available at the site.

52. A daily inspection should be made on:

- The condition of the brakes under no-load conditions
- The condition, adjustment, and functioning of the various safety devices and limiting devices fitted to the hoisting apparatus
- The electric power installation
- The overload controls

53. Grounding devices, guards, junction box covers and similar safeguards should be checked regularly to make sure they are in place and performing their function properly.

54. All structural parts should be inspected for broken welds, bending, etc., in accordance with manufacturer's recommendations.

55. A weekly inspection should be made on:

- Wire ropes on hoist and trolley
- Guys
- Electric power cables
- Jib and counterweight jib guy
- Lines
- Hoist rope anchorage on winding
- Drum
- Foundations
- Bolts and pins

Maintenance and repair

56. Maintenance and repairs should be performed only by qualified personnel and in compliance with the manufacturer's recommendations.

57. Jibs should be equipped with catwalks, railings or with a similar means of safe access.

58. Safety belts with lanyards should be used where and whenever necessary.

59. All splicing of rope other than at thimbles used on the ends of hoisting rope should be prohibited.

60. Worn wire rope should be replaced in accordance with the wire rope manufacturer's recommendations.

61. Maintenance procedures should include lubrication (with chart), adjustments, periodic checking of the structure and bolts, and normal running repairs.

62. An up-to-date maintenance and repair record book should be maintained. Periodic adjustments to the brakes and the traction rope of the jib also should be made.

63. All greasing, cleaning, and other maintenance and repair should only be performed when the crane is stationary and shut down.

64. When necessary to set the crane in motion to perform certain maintenance, it should only be done under qualified supervision, and not during normal operation of the crane.

65. Control equipment should be kept in good condition. Guards and covers should always be replaced after removal for maintenance work.

66. All field repair welding on crane parts should comply with manufacturers' recommendations, and should be performed only by certified welders.

Dismantling

67. A check should be made of all telescoping devices prior to dismantling operations. Qualified supervisory personnel and proper positioning of workers are important aspects of these operations. Dismantling procedures should follow the manufacturer's specifications.

Glossary of terms

The following terms apply to tower cranes and are listed as an aid in determining the correct definition for words used in this text.

Accessory. A secondary part of an assembly of parts that contributes to the overall functions and usefulness of a machine.

Anchor bolt. Bolts embedded in a foundation to support the base of a tower crane. One of the methods used to stabilize the tower crane to resist overturning moments. Designed to provide maximum resistance to being accidentally pulled out.

Anchoring. Supports for tower cranes that could include guys, clamps, anchor bolts, or suitable devices to maintain stability of crane. Type of device is dependent on varying operating conditions.

Angle indicator (boom). An accessory that measures the angle of the boom to the horizontal.

Auto stable. Refers to a tower crane that is self-supporting above its base anchorage, thereby requiring no guy supports.

Auxiliary hoist. see "Whip line"

Axis of rotation. The vertical axis around which the crane superstructure rotates.

Axle. The shaft or spindle with which, or about which, a wheel rotates. On rubber wheel-mounted cranes, refers to an automotive type of axle assembly, including housing, gearing, differential, bearings and mounting appurtenances.

Ballast. (a) Weight used to supplement the weight of the crane for purposes of stability. Contrary to counterweight, ballast is placed so its center of gravity falls within the center of the tower. Can be positioned on the traveling platform or directly on the tower above the platform. (b) When term is used for rails or tracks, it refers to the material that holds track in line, provides drainage and distribution of load uniformly to the sub-grade. Stone, gravel, slag and cinders are a few local materials used for ballast.

Base (mounting). The base, or carrier, on which a rotating superstructure is mounted.

Bogie. Two or more automotive-type axles mounted in tandem in a frame to divide the load between the axles and permit vertical oscillation of the wheels. This type is used on traveling tower cranes.

Boom. Term usually applied to the luffing erecting member of a conventional crane. The heel (lower end) is affixed to a base, carriage or support; and the upper end supports a sheave and cable where the load is lifted by means of wire rope and a hook. (See "Jib.")

Boom angle. The angle between the longitudinal center of the boom and the horizontal. The boom longitudinal centerline is a straight line between the boom foot pin (heel pin) centerline and boom point sheave pin centerline.

Boom hoist. A hoist drum and rope reeving system used to raise and lower the boom.

Boom point. The outward end of the top section of the boom.

Brake. A device used for retarding or stopping motion by friction or power means.

Drag brake – A brake that provides retarding force without external controls. Holding brake – A brake that automatically prevents motion when power is off.

Bridle. Another term for guy rope and pendant. (See "Floating boom harness.")

Bumper (buffer). An energy-absorbing device for reducing impact when a moving crane or trolley reaches the end of its permitted travel, or when two moving cranes or trolleys come into contact.

Cab. A housing that covers the rotating superstructure and/or operator's station.

Cable reel. A device usually used on traveling version of tower cranes that permits automatic, power-controlled winding or unwinding of electric feeder cables from bogie platform to a stationary power source. Tensioning device eliminates hazard of slack cable being cut by wheels, or becoming tangled and breaking.

Capacity chart. A sign or plate giving the

maximum load capacity and other determining circumstances.

Castellated nut (castle nut). A special nut with notches to permit cotter pins to be inserted in matching bolt holes to prevent nut from working loose. Used for making splice connections of sections in tower cranes.

Cathead. A material lifting device usually designed as a horizontal cantilever having a single load sheave at its unsupported end, extending over the structure on which it is supported. A load line from a winch is reeved over the sheave to provide load lifting power.

Catwalk. A walkway with handrail or hand rope, mounted on a horizontal jib for access purposes.

Chord member. The corner member of a structural jib tower or boom.

Clearance. Distance of any part of the crane to a point of the nearest obstruction.

Climbing. The act of raising a crane within a structure as the structure height progresses.

Climbing frame. A structural platform assembled to the floor of a permanent structure around an opening through which the tower crane climbs. May be further described as a horse collar. Usually furnished in pairs and serves a dual purpose: (a) For providing support for the tower crane resisting vertical forces and in some designs also horizontal forces. (b) Aid in the climbing function by supporting climbing ladders. These climbing frames either rest or are bolted directly onto floor slabs or steel building framing.

Climbing frequency. In a climbing tower crane it provides an indication of a number of floors that can be poured or erected before climbing.

Climbing ladder. A ladder suspended from a climbing frame used in conjunction with a jacking mechanism to permit a tower crane to climb within a structure. Spacing of ladder steps controls height of incremental jump.

Clutch. A friction, electro-magnetic, hydraulic, pneumatic or positive mechanical device for engagement or disengagement of mechanical power.

Collectors (current). Contact devices for taking up current from runway or bridge conductors or from static to rotating component.

Conversion tower. Refers to a tower section that can telescope within an outer tower extension. Usually fitted with a jacking mechanism to permit telescoping operation.

Counterweight. Weight used to supplement the weight of the machine or structure. Contrary to ballast, counterweight is positioned so its center of gravity falls outside the centerline of the tower. On tower cranes it is usually placed on the outer end of a counter-weight arm known as the counterweight jib.

Counterweight trolley. A wheeled carriage, supporting counterweight, mounted on the rails of a counterweight jib of a tower crane to permit varying the radial position of the counterweight to provide variable counter-balancing effects. Especially useful in positioning the counterweight to ensure the plumbness of the tower during a climbing operation.

Crane. A power-operated machine for lifting or lowering a load and moving it horizontally, which uses wire rope and in which the hoisting mechanism is an integral part of the machine.

Crawler crane. A crane consisting of rotating superstructure with power plant, operating machinery and boom, mounted on a base, equipped with crawler treads for travel.

Deadman control. A device built into operating levers (usually spring-operated) that

when released, will return automatically to a neutral position.

Derrick. An apparatus consisting of a mast or equivalent members held at the top by guys or braces with or without a boom, for use with a hoisting mechanism and operating rope, for lifting or lowering a load and moving it horizontally.

Dismantling. Describes operations required for disassembly of a tower crane.

Self-dismantling – Ability of a tower crane to dismantle itself without use of auxiliary equipment.

Dog. Terms used for a hinged latch. When mounted on a climbing frame, its prime function is to engage openings in the tower crane base to transfer vertical loads to the climbing frame resting on the permanent structure floor. It is further used to support climbing ladders from the climbing frame.

Dual control. Portable control box with control levers (joysticks) for controlling crane motions from either the operator's cabin or remotely from the building.

Drum. The cylindrical members around which ropes are wound for raising and lowering the load or boom.

Dynamic loading. Loads introduced into the machine or its components by acceleration or deceleration of a load.

Eddy current control. Electrical speed and brake regulating device that permits a soft and smooth operation of all crane motions. Acting directly on the motor axle, the eddy current brake exercises a variable counter torque according to the intensity of current automatically fed to it. This braking torque is opposed to the motor torque.

Equalizer. A device that compensates for unequal length or stretch of a rope.

Expendable base. A section partially embedded in a concrete foundation to serve as convenient anchorage for installation of a statically mounted tower crane. Eliminates the need for the use of anchor bolts.

Extension. Refers to tower crane sections that are built up with four individual panels bolted together. Lengths vary from approximately 10-20 feet. They are used on static or traveler-mounted extendable type tower cranes to increase tower height. Through the extensions an inner-telescoping jacking section climbs, permitting increased heights.

Factor of safety. Term used in engineering design to indicate the magnitude of the actual working stresses compared with the yield point or tensile (ultimate) strength of the material. These factors vary and are dependent on materials, job conditions and regulating codes.

Fail-safe. A provision designed to automatically stop or safely control any motion in which a malfunction occurs.

Fish plating. Refers to splice plates or splice angle used to connect tower extension panels and elements of tower sections.

Floating boom harness (sometimes called bridle.) A floating frame or spreader equipped with sheaves and connected to the boom head by stationary cables usually called pendants. The boom hoist cable or cables then lead from the gantry to the floating frame. To change the boom length, it is necessary only to change the pendants.

Gantry (A-frame). (a) Structure mounted on a revolving superstructure of a machine to which the boom (or jib) supporting cables are attached. (b) Portal shaped undercarriage with tower crane mounted on top permitting storage or traffic below tower crane.

Guy rope. Cables with both ends deadended. Usually used in connection with stabilizing guy derricks or tower cranes with cables from the crane structure to the ground or to an adjoining structure or deck.

Hog rod. Rigid boom supports used instead of luffing cables.

Jack. A device, mechanically or hydraulically actuated, whose function is to provide the

means for the climbing and telescopic motions of the tower crane. Usually mounted at the base of the tower, and may or may not be an integral part of the tower base section.

Jib. (a) When used with tower cranes: A horizontal arm for supporting a trolley or fall block, which does not change its inclination. (b) When used with conventional cranes: An extension added to the head of a boom for increasing the reach.

Joystick. Single lever used for controlling several motions and speeds of the machine.

Kip. Short notation standing for 1,000 pounds. For example: 5 kips = 5,000 lb or 100 kip ft = 100,000 ft-lb.

Knee brace frame. A structural platform used as an alternate method for supporting and stabilizing static-mounted tower cranes (see "Expendable base"). Consists of a frame constructed of beams resting on a foundation and tied down by means of anchor bolts. Diagonal braces extend from each of four corners of the platform to connect to the main angles of the tower base section. Dimensions vary with design requirements.

Lacing. Structural truss members angled to and supporting the corner members of a structural tower, jib or boom.

Laggings. Removable and interchangeable drum spool shells for changing hoist drum diameter to provide variation in rope speeds and line pulls.

Lateral (side loading). A load applied at an angle to the vertical plane of the boom or jib.

Latticed boom. Boom of open construction with angular lacing between main cord members in the form of a truss.

Load (working). The external load applied to the crane, including the weight of auxiliary load attaching equipment such as load blocks, shackles and slings.

Load block (lower). The assembly of hook or shackle, swivel, sheave, pins or frames suspended by the hoisting ropes.

Load block (upper). The assembly of hook or shackle, swivel, sheave, pins or frames suspended from the boom point.

Load hoist. A hoist drum and rope reeving system used for hoisting and lowering loads.

Load ratings. Maximum loads that may be lifted by a crane at various angles of the boom, or positions of trolley block on a jib.

Limit switch. A device designed to cut off the power automatically at or near the limit of travel of a crane, trolley, hoist or similar mechanism, independently of the operating device.

Line pull. Maximum pull at the drum at full speed, with specified pitch diameter of drum or lagging for the first layer of rope.

Line speed. Speed in feet per minute at the drum at full speed, with a specified pitch diameter of drum or lagging for the first layer of rope.

Luffing. Operation of changing boom angle, or hoisting or lowering of boom.

Main switch. A switch controlling the entire power supply to the crane.

Master switch. A switch that dominates the operation of contractors, relays or other remotely operated devices.

Mast. see "Tower"

Moment (torque). A term used to measure the tendency to produce motion about a point or axis. Dimensions are usually in foot-pounds or inch-pounds. Typical related terms are as follows:

Overturning –Tendency for machine to overturn.

- **Wind moment** – Tendency for machine to overturn as a result of a wind force.
- **Swing moment** – Tendency for structure to rotate about longitudinal axis of tower.
- **Restricting moment (Stabilizing moment)** – Resistance of a machine against overturning or tipping.

Outriggers. Members attached to the carrier frame that may be blocked up to relieve

suspensions. When expendable, can further increase stability by increasing the size of the supporting base. Term usually used with conventional cranes.

Overhaul. Ability of a weight on end of hoist line to unwind cable from drum when brake is released.

Panic button. Stop button at operator's control panel that provides for simultaneous mechanical braking of all tower crane motions when actuated by operator.

Pendant. Term for bridle or guy rope.

Radius of load. Horizontal distance from the axis of rotation and of the machine to a vertical line through the center of the hook or load.

Rated load. The maximum load for which a crane or individual hoist is designed and built by the manufacturer, and shown on the equipment nameplate.

Reeving. A rope system in which the rope travels around drum and sheaves.

Remote control. Provides control of the crane from a position outside of the usual operator's cab position.

Rope. Refers to wire rope, unless otherwise specified.

Running sheave. A sheave that rotates as the load block is raised or lowered.

Safety devices. Electrical and/or mechanical devices whose prime function is to automatically prevent accidents due to mishandling of tower crane equipment. Limit switches and automatic brakes are some of the devices used to perform this function.

Section. The structural elements of a crane used in making up jibs, towers or booms. Are completely prefabricated and do not require building up with loose panels, such as extensions. To vary the length of the jib, tower or boom, sections are spliced together with bolts and/or shear pins.

Shear bolt (shear pin). Used in conjunction with the assembly of crane sections. Its function in a splice is to resist tendency of sections to shear off from the mating section.

Signals. A system of hand signals or bells used by personnel operating or supervising operations of cranes to transmit crane operating instructions where direct vision or voice contact.

Slewing. see "Swing"

Splice connection. For assembly of sections of basic crane booms, tower or jib and intermediate sections; may be of the splice plate type, pin type or butt type.

Stability. Refers to the design characteristics of a tower crane as a measure of its rigidity, flexibility and ability to safely resist forces tending to overstress the crane structural members.

Static loading. Loads produced by a suspended load when not moving in any direction.

Stop. A device to limit a motion.

Stresses. Defined as the force per unit area. Typical units are in lb/sq in. lb/sq ft, and kg/sq cm. Related importance terms are:

- **Working stress** – Safe stress for the material based on proper factor of safety code regulations, etc.
- **Yield point (yield strength)** – That stress (in structural steel and other elastic materials) which will cause the member to permanently deform.
- **Ultimate (tensile strength)** – That stress in a member that causes rupture.

Structural competence. The ability of the machine and its components to withstand the stresses imposed by applied loads.

Superstructure. Rotating upper frame structure of the machine.

Swing (or slewing). Rotation of the superstructure for movement of loads in a horizontal direction about the axis of rotation.

Swing brake – a control device to retard the swing of the revolving superstructure and/or to hold it from swinging.

Swing lock – is a mechanical device to lock the revolving superstructure rigidly to the mounting in selected positions.

Swing (or slewing mechanism.) The machinery involved in providing rotation of the superstructure.

Swing speed. Speed in RPM at which the revolving superstructure rotates with engine operating at full load speed.

Switch. A device for opening or closing of an electric circuit.

Stop switch (emergency). A manually or automatically operated electric switch to cut off electric power independently of the regular operating controls.

Tackle. An assembly of ropes and sheaves arranged for hoisting and pulling.

Tandem control. Double operator's control at two stations permitting simultaneous operation. Particularly valuable on buildings higher than 25 stories.

Telescoping. Describes the action of sections of a structure to slide or pass within another. In extendable type tower crane, it describes the action of an inner jacking section to climb or lower within an outer extension to permit increasing or decreasing tower crane heights. Telescoping action is usually achieved by use of hydraulic jacking mechanisms or use of a reeving cable system.

Topping lift. Block and sheave arrangement or wire ropes affixed to the tip of the boom for raising and lowering the boom (luffing).

Tower. The vertical supporting structure upon which are mounted the crane components.

Tower cranes. A crane that uses a tower to support a jib and occasionally a boom. Adapted to hoist and swing loads over high obstructions. There are several forms of tower cranes:

Truck- or crawler-mounted – These are mounted on a conventional truck or crawler crane body with the crane operating mechanism rotating on the frame of the truck. The tower is mounted on the front end of the rotating crane body. A boom is hinged at the top, or near the top of the tower. Through a means of falls, and a gantry on the rear end of the truck or crawler crane body, the tower is supported in its upright working position. A separate set of boom holding falls permit the boom to be rotated up or down (luffing type boom). Loads are lifted or lowered by a set of load falls attached to the tip of the boom.

Static or fixed – Consists of a stationary vertical tower mounted on a fixed foundation. The tower can be self-supporting or guyed, depending on height and manufacturer's design. The tower is usually at a fixed height, or can be telescoped for variable heights by adding additional elements. The upper portion of the tower supports usually two arms maintained in a horizontal position (known as jibs) with wire ropes, pendants or links; and is designed to permit horizontal rotation through a minimum of 360 degrees. These arms, generally triangular in cross-section, are built-up members and are pinned to the rotating portion of the tower. On the longer arm (known as the main jib), the lifting tackle mechanism or trolley rolls on the underside of this erection arm. A second shorter arm, called a counterweight jib, extends horizontally from the tower in the opposite direction to the longer arm. Counterweight is placed at the outer end of this arm. On some models the operating equipment also is placed on this arm. The operator cab is usually placed on the rotating section just below the main jib to provide maximum visibility.

Climbing – Tower mounted to climb vertically in the permanent structure. Usually the tower is of a fixed height

and, by means of a jacking mechanism climbing frames and ladders or falls, is jumped to a new level. In either case, supporting beams are placed under the bottom of tower resting on the floor members of the permanent structure at the new level. This tower should be braced securely to the permanent structure at various floors. The horizontal main and counterweight jibs are similar in construction to that described in previous paragraphs.

Traveling – Tower mounted on a ballasted bogie platform to roll directly on rails laid on the ground. The tower and jibs are similar to the construction of the fixed or telescopic type tower described in previous paragraphs.

In some models of tower cranes, the main jib (long arm) is of a luffing type permitting rotation in the vertical plane similar to the operation of the boom in the conventional type crane (with the erecting member luffes it is referred to as a boom). Another special type of tower crane uses the same basic tower. As described earlier, but the rotating (slewing) portion of the tower is replaced with a conventional crane body that rotates on a turntable mounted on top of the tower equipped with a luffing boom.

Traction bolt. Used in conjunction with the assembly of crane sections, its function is to resist the tendency of sections to pull apart at the splice due to tensile loads.

Travel. The function of the machine moving from one location to another on the jobsite.

Trolley. A truck or carriage to which the load blocks are suspended. The trolley is movable on the jib runway.

Trolleying. The motion of the trolley on the jib to locate the load hoisting mechanism at its working position.

Truck crane. A crane mounted on an automotive truck. (see "Tower crane")

Turntable. Another term for revolving superstructure of the machine.

Weather cocking (or weathervaning). Refers to motion of tower crane job when not under operator's control during off hours, to swing freely with the wind. This prevents possible accidents that could result if the jib was in a fixed position and subjected to intense winds.

Wedge. A tapered wood or steel device used to provide stability to tower cranes during its operation as a climber. Wedges are used at a minimum of two floor openings spaced at a minimum floor height, depending on the manufacturer's recommendations. When the wedges are securely tightened against the four main angles of the tower, they convert overturning moments into horizontal forces that are resisted by the floor framing or slab. Wedges are either of the loose type (usually wood that is hammered to achieve tightness) or special wedge assemblies that are tightened by means of adjusting bolts.

Whip line (auxiliary hoist). A separate hoist rope system of lighter load capacity and higher speed than provided by the main hoist.

Winch head. A power-driven spool for handling of loads by means of friction between fiber or wire rope and spool.

Working height. Refers to the maximum effective working height under the hook of the crane block measured above the crane base.

Wrap. The amount of rope that wraps on a drum in one turn.

Acknowledgment

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