

## SECTION 27

# CONCRETE AND MASONRY CONSTRUCTION AND STEEL ERECTION

### 27.A CONCRETE AND MASONRY CONSTRUCTION-GENERAL

27.A.01 Construction loads shall not be placed on a concrete or masonry structure or portion of a concrete or masonry structure unless the employer determines, based on information from a person who is qualified in structural design, that the structure or portion of the structure is capable of supporting the loads.

27.A.02 Employees shall not be permitted to work above or in positions exposed to protruding reinforcing steel or other impalement hazards unless provisions have been made to control the hazard.

27.A.03 Post-tensioning operations.

- a. No employee (except those essential to the post-tensioning operations) shall be permitted to be behind jacks or end anchorages during post-tensioning operations.
- b. Signs and barriers shall be erected to limit employee access to the post-tensioning area during tensioning operations.

27.A.04 Equipment.

- a. Bulk storage bins, containers, or silos shall have conical or tapered bottoms with mechanical or pneumatic means of starting the flow of material.
- b. Concrete mixers equipped with 1-yard or larger loading skips shall be equipped with a mechanical device to clear the skip of material and shall have guardrails installed on each side of the skip.

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- c. Handles on bull floats used where they may contact energized electrical conductors shall be constructed of nonconductive material or insulated with a nonconductive sheath whose electrical and mechanical characteristics provide equivalent protection.
- d. Powered and rotating concrete troweling machines that are manually guided shall be equipped with a control switch that will automatically shut off the power whenever the operator removes his/her hands from the equipment handles.
- e. Concrete pumping systems using discharge pipes shall be provided with pipe supports designed for 100% overload.
- f. Handles of concrete buggies shall not extend beyond the wheels on either side of the buggy.
- g. Concrete buckets equipped with hydraulic or pneumatically operated gates shall have positive safety latches or similar safety devices installed to prevent premature or accidental dumping. The buckets shall be designed to prevent material from accumulating on the top and sides of the bucket.
- h. Sections of tremies and similar concrete conveyances shall be secured with wire rope (or equivalent material) in addition to the regular couplings or connections.

27.A.05 Riding on concrete buckets shall be prohibited.

27.A.06 Elevated concrete buckets shall be routed, to the extent practical, to minimize the exposure of workers to hazards associated with falling buckets or concrete. Vibrator crews shall be kept out from under concrete buckets suspended from cranes or cableways.

27.A.07 Structural and reinforcing steel for walls, piers, columns, and similar vertical structures shall be supported and/or guyed to prevent overturning or collapse. Support systems for reinforcing

steel that are independent of other form or shoring support systems shall be designed by a registered engineer.

- a. Connections of equipment used in plumbing-up shall be secured.
- b. The turnbuckles shall be secured to prevent unwinding while under stress.
- c. Plumbing-up guys and related equipment shall be placed so that employees can get at the connection points.
- d. Plumbing-up guys shall be removed only under the supervision of a competent person.

27.A.08 Measures shall be taken to prevent unrolled wire mesh from recoiling.

## **27.B FORMWORK AND SHORING**

27.B.01 All formwork, shoring, and bracing shall be designed, fabricated, erected, supported, braced, and maintained so that it will safely support all vertical and lateral loads that might be applied until such loads can be supported by the structure.

27.B.02 Planning and design.

- a. The planning and design of formwork and shoring shall be in accordance with provisions of American Concrete Institute (ACI) Publication 347.
- b. The design and the erection and removal plans for formwork and shoring shall be submitted for review to the GDA.
- c. The manufacturer's specifications for fabricated shoring systems shall be available at the job site during job planning and execution.

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27.B.03 Base support.

- a. Supporting ground or completed construction upon which formwork and shoring is to be placed shall be of adequate strength to carry the vertical and lateral loads to be imposed.
- b. Sills for shoring shall be sound, rigid, and capable of carrying the maximum intended load.
- c. Base plates, shore heads, extension devices, or adjustment screws shall be in firm contact with the footing sill and form material and, as applicable, shall be snug against the posts.

27.B.04 Splices shall be designed and constructed to prevent buckling and bending.

27.B.05 Diagonal bracing shall be provided in vertical and horizontal planes to provide stiffness and to prevent buckling of individual members.

27.B.06 Inspection.

- a. All shoring equipment shall be inspected prior to erection to determine that it is as specified in the shoring design. Any equipment found to be damaged shall not be used.
- b. Erected shoring equipment shall be inspected immediately prior to, during, and immediately after the placement of concrete. Any shoring equipment that is found to be damaged, displaced, or weakened shall be immediately reinforced or re-shored.

27.B.07 Re-shoring shall be provided to safely support slabs and beams after stripping or where such members are subjected to superimposed loads due to construction.

27.B.08 Fabricated shoring shall not be loaded beyond the safe working load recommended by the manufacturer.

27.B.09 Single post shores.

- a. Wherever single post shores are used in more than one tier, the layout shall be designed and inspected by an engineer qualified in structural design.
- b. Single post shores shall be vertically aligned and spliced to prevent misalignment.
- c. When shoring is at an angle, sloping, or when the surface shored is sloping, the shoring shall be designed for such loading.
- d. Adjustment of single post shores to raise formwork shall not be made after concrete is in place.
- e. Fabricated single post shores and adjusting devices shall not be used if heavily rusted, bent, dented, rewelded, or have broken weldments or other defects; if they contain timber, they shall not be used if timber is split, cut, has sections removed, is rotted, or otherwise structurally damaged.
- f. All timber and adjusting devices to be used for adjustable timber single post shores shall be inspected before erection.
- g. All nails used to secure bracing or adjustable timber single post shores shall be driven home and the point of the nail bent over if possible.
- h. For stability, single post shores shall be horizontally braced in both the longitudinal and transverse directions.
  - (1) Single-post shores shall be adequately braced in two mutually perpendicular directions at the splice level.
  - (2) Each tier shall also be diagonally braced in the same two directions.

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(3) Bracing shall be installed as the shores are erected.

27.B.10 Tube and coupler shoring.

- a. The material used for the couplers shall be of a structural type such as drop-forged steel, malleable iron, or structural grade aluminum. Gray cast iron shall not be used. No dissimilar metals shall be used together.
- b. Couplers shall not be used if they are deformed, broken, or have defective or missing threads on bolts, or other defects.
- c. When checking the erected shoring towers with the shoring design, the spacing between posts shall not exceed that shown on the layout and all interlocking of tubular members and tightness of couplings shall be checked.

27.B.11 Tubular welded-frame shoring.

- a. All locking devices on frames and braces shall be in good working order, coupling pins shall align the frame or panel legs, pivoted cross braces shall have their center pivot in place, and all components shall be in a condition similar to that of original manufacture.
- b. When checking the erected shoring frames with the shoring design, the spacing between towers and cross brace spacing shall not exceed that shown in the design and all locking devices shall be closed.
- c. Devices for attaching external lateral stability bracing shall be fastened to the legs of the shoring frames.

27.B.12 Vertical slip forms.

- a. The steel rods or pipe on which the jacks climb or by which the forms are lifted shall be designed specifically for that

purpose. Such rods shall be braced where not encased in concrete.

b. Jacks and vertical supports shall be positioned in such a manner that the vertical loads are distributed equally and do not exceed the capacity of the jacks.

c. The jacks or other lifting devices shall be provided with mechanical dogs or other automatic holding devices to provide protection in case of failure of the power supply or the lifting mechanism.

d. Lifting shall proceed steadily and uniformly and shall not exceed the predetermined safe rate of lift.

e. Lateral and diagonal bracing of the forms shall be provided to prevent excessive distortion of the structure during the jacking operation.

f. During jacking operations, the form structure shall be maintained in line and plumb.

g. All vertical lift forms shall be provided with scaffolding or work platforms completely encircling the area of placement.

#### 27.B.13 Removal of formwork.

a. Forms and shores (except those on slab or grade and slip forms) shall not be removed until the individual responsible for forming and/or shoring determines that the concrete has gained sufficient strength to support its weight and all superimposed loads. Such determination shall be based on one of the following:

(1) Satisfaction of conditions stipulated in the plans and specifications for removal of forms and shores, or

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(2) Concrete testing (in accordance with ASTM standard test methods) indicates that the concrete has achieved sufficient strength to support its weight and superimposed loads.

b. Re-shoring shall not be removed until the concrete being supported has attained adequate strength to support its weight and all loads placed on it.

## **27.C PRECAST CONCRETE OPERATIONS**

27.C.01 Precast concrete members shall be adequately supported to prevent overturning or collapse until permanent connections are complete.

27.C.02 Lifting inserts and hardware.

a. Lifting inserts which are embedded or otherwise attached to tilt-up precast concrete members shall be capable of supporting at least two times the maximum intended load applied or transmitted to them.

b. Lifting inserts which are embedded or otherwise attached to precast concrete members, other than tilt-up members, shall be capable of supporting at least four times the maximum intended load applied or transmitted to them.

c. Lifting hardware shall be capable of supporting at least five times the maximum intended load applied or transmitted to the lifting device.

27.C.03 No employee shall be permitted under precast concrete members being lifted or tilted into position except employees required for the erection of those members.



## 27.D LIFT-SLAB OPERATIONS

27.D.01 Lift-slab operations shall be planned and designed by a registered engineer or architect. Such plans and designs shall include detailed instructions and sketches indicating the prescribed method of erection and shall be submitted to the GDA for review.

27.D.02 Jacking equipment.

- a. The manufacturer's rated capacity shall be legibly marked on all jacks and shall not be exceeded.
- b. Threaded rods and other members that transmit loads to the jacks shall have a minimum safety factor of 2.5
- c. Jacks shall be designed and installed so that they will not continue to lift when overloaded.
- d. All jacks shall have a positive stop to prevent overtravel.
- e. Hydraulic jacks used in lift slab construction shall have a safety device that will cause the jacks to support the load in any position if the jack malfunctions.

27.D.03 Jacking operations.

- a. When it is necessary to provide a firm foundation, the base of the jack shall be blocked or cribbed. Where there is a possibility of slippage of the metal cap of the jack, a wood block shall be placed between the cap and the load.
- b. The maximum number of manually-controlled jacks on one slab shall be limited to 14, and in no event shall the number be too great to permit the operator to maintain the slab level within specific tolerances.
- c. Jacking operations shall be synchronized to ensure even and uniform lifting of the slab.

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d. During lifting, all points of the slab support shall be kept within 1/2 in (1.2 cm) of that needed to maintain the slab in a level position.

(1) If leveling is automatically controlled, a device shall be installed which will stop the operation when the 1/2 in (1.2 cm) leveling tolerance is exceeded.

(2) If leveling is manually controlled, such controls shall be located in a central location and attended by a trained operator while lifting is in progress.

e. No one shall be permitted under the slab during jacking operations.

## **27.E STRUCTURAL STEEL ASSEMBLY**

27.E.01. Prior to beginning the erection of any structural steel, a steel erection plan shall be submitted to the GDA for review and acceptance.

27.E.02. Steel erection activities include:

a. Hoisting, laying out, placing, connecting, welding, burning, guying, bracing, bolting, plumbing, and rigging structural steel, steel joists and metal buildings;

b. Installing metal decking, curtain walls, window walls, siding systems, miscellaneous metals, ornamental iron, and similar materials; and

c. Moving point-to-point while performing these activities.

27.E.03 The following activities are covered by this Section when they occur during and are a part of steel erection activities: rigging, hoisting, laying out, placing, connecting, guying, bracing, dismantling, burning, welding, bolting, grinding, sealing, caulking, and all related activities for construction, alteration and/or repair of

materials and assemblies such as structural steel; ferrous metals and alloys; non-ferrous metals and alloys; glass; plastics and synthetic composite materials; structural metal framing and related bracing and assemblies; anchoring devices; structural cabling; cable stays; permanent and temporary bents and towers; false work for temporary supports of permanent steel members; stone and other non-precast concrete architectural materials mounted on steel frames; safety systems for steel erection; steel and metal joists; metal decking and raceway systems and accessories; metal roofing and accessories; metal siding; bridge flooring; cold formed steel framing; elevator beams; grillage; shelf racks; multi-purpose supports; crane rails and accessories; miscellaneous, architectural and ornamental metals and metal work; ladders; railings; handrails; fences and gates; gratings; trench covers; floor plates; castings; sheet metal fabrications; metal panels and panel wall systems; louvers; column covers; enclosures and pockets; stairs; perforated metals; ornamental iron work, expansion control including bridge expansion joint assemblies; slide bearings; hydraulic structures; fascias; soffit panels; penthouse enclosures; skylights; joint fillers; gaskets; sealants and seals; doors; windows; hardware; detention/security equipment and doors, windows and hardware; conveying systems; building specialties; building equipment; machinery and plant equipment, furnishings and special construction.

27.E.04 Written notifications. Before authorizing the commencement of steel erection, the controlling Contractor shall ensure that the steel erector is provided with the following written notifications:

- a. The concrete in the footings, piers, and walls and the mortar in the masonry piers and walls has attained, on the basis of an appropriate ASTM standard test method of field-cured samples, either 75% of the intended minimum compressive design strength or sufficient strength to support the loads imposed during steel erection.

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b. Any repairs, replacements, and modifications to the anchor bolts were conducted in accordance with contract specifications and/or the design engineer.

c. A steel erection Contractor shall not erect steel unless it has received written notification that the concrete in the footings, piers and walls or the mortar in the masonry piers and walls has attained, on the basis of an appropriate ASTM standard test method of field-cured samples, either 75% of the intended minimum compressive design strength or sufficient strength to support the loads imposed during steel erection.

d. Both Contractors will keep a copy of this written notification on-site.

27.E.05 Site layout. The controlling Contractor shall ensure that the following is provided and maintained:

a. Adequate access roads into and through the site for the safe delivery and movement of derricks, cranes, trucks, other necessary equipment, and the material to be erected; and means and methods for pedestrian and vehicular control. Exception: This requirement does not apply to roads outside of the construction site.

b. A firm, properly graded, drained area readily accessible to the work with adequate space for the safe storage of materials and the safe operation of the erector's equipment.

c. Pre-planning of overhead hoisting operations. All hoisting operations in steel erection shall be pre-planned.

27.E.06 Site-specific erection plan. Where employers elect, due to conditions specific to the site, to develop alternate means and methods that provide employee protection, a site-specific erection plan shall be developed by a qualified person and be available at the work site.

27.E.07 Hoisting and rigging. All the applicable requirements of Sections 15 and 16 apply to this Section.

27.E.08 Visual inspection of cranes. A competent person shall visually inspect cranes being used in steel erection activities prior to each shift. The inspection shall include observation for deficiencies during operation. At a minimum, this inspection shall include the following:

- a. All control mechanisms for maladjustments;
- b. Control and drive mechanism for excessive wear of components and contamination by lubricants, water, or other foreign matter;
- c. Safety devices including, but not limited to, boom angle indicators, boom stops, boom kick out devices, A2B devices, and LMI where required;
- d. Air, hydraulic, and other pressurized lines for deterioration or leakage, particularly those that flex in normal operation;
- e. Hooks and latches for deformation, chemical damage, cracks, or wear;
- f. Wire rope reeving for compliance with hoisting equipment manufacturer's specifications;
- g. Electrical apparatus for malfunctioning, signs of excessive deterioration, dirt, or moisture accumulation;
- h. Hydraulic system for proper fluid level;
- i. Tires for proper inflation and condition;
- j. Ground conditions around the hoisting equipment for proper support, including ground settling under and around outriggers, ground water accumulation, or similar conditions;

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k. The hoisting equipment for level position; and

l. The hoisting equipment for level position after each move and setup.

27.E.09 Deficiencies. If any deficiency is identified, an immediate determination shall be made by the competent person as to whether the deficiency constitutes a hazard.

a. If the deficiency is determined to constitute a hazard, the hoisting equipment shall be removed from service until the deficiency has been corrected.

b. The operator shall be responsible for those operations under the operator's direct control. Whenever there is any doubt as to safety, the operator shall have the authority to stop and refuse to handle loads until safety has been assured.

27.E.10 A qualified rigger (a rigger who is also a qualified person) shall inspect the rigging prior to each shift.

27.E.11 The headache ball, hook, or load shall not be used to transport personnel.

27.E.12 Cranes or derricks may be used to hoist employees on a personnel platform when all applicable provisions of 22.F have been met.

27.E.13 Safety latches on hooks shall not be deactivated or made inoperable.

27.E.14 Structural stability.

a. Structural stability shall be maintained at all times during the erection process.

b. The following additional requirements shall apply for multi-story structures:

(1) The permanent floors shall be installed as the erection of structural members progresses, and there shall be not more than eight stories between the erection floor and the uppermost permanent floor, except where the structural integrity is maintained as a result of the design.

(2) At no time shall there be more than four floors or 48 ft (14.6 m), whichever is less, of unfinished bolting or welding above the foundation or uppermost permanently secured floor, except where the structural integrity is maintained as a result of the design.

(3) A fully planked or decked floor or nets shall be maintained within two stories or 30 ft (9.1 m), whichever is less, directly under any erection work being performed.

27.E.15 Walking/working surfaces.

a. Shear connectors and other similar devices.

(1) Tripping hazards. Shear connectors (such as headed steel studs, steel bars, or steel lugs), reinforcing bars, deformed anchors or threaded studs shall not be attached to the top flanges of beams, joists, or beam attachments so that they project vertically from or horizontally across the top flange of the member until after the metal decking, or other walking/working surface, has been installed.

(2) Installation of shear connectors on composite floors, roofs, and bridge decks. When shear connectors are used in construction of composite floors, roofs, and bridge decks, employees shall lay out and install the shear connectors after the metal decking has been installed, using the metal decking as a working platform.

b. Slip resistance of metal decking.

c. Slip resistance of skeletal structural steel. Workers shall not be permitted to walk the top surface of any structural steel

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member that has been coated with paint or similar material unless documentation or certification that the coating has achieved a minimum average slip resistance of 0.50 when measured with an English XL tribometer or equivalent tester on a wetted surface at a testing laboratory is provided. Such documentation or certification shall be based on the appropriate ASTM standard test method conducted by a laboratory capable of performing the test. The results shall be available at the site and to the steel erector.

d. Plumbing-up.

(1) When deemed necessary by a competent person, plumbing-up equipment shall be installed in conjunction with the steel erection process to ensure the stability of the structure.

(2) When used, plumbing-up equipment shall be in place and properly installed before the structure is loaded with construction material such as loads of joists, bundles of decking, or bundles of bridging.

(3) Plumbing-up equipment shall be removed only with the approval of a competent person.

e. Metal decking - Hoisting, landing, and placing of metal decking bundles.

(1) Bundle packaging and strapping shall not be used for hoisting unless specifically designed for that purpose.

(2) If loose items such as dunnage, flashing, or other materials are placed on the top of metal decking bundles to be hoisted, such items shall be secured to the bundles.

(3) Bundles of metal decking on joists shall be landed in accordance with 27.E.29.



(4) Metal decking bundles shall be landed on framing members so that enough support is provided to allow the bundles to be unbanded without dislodging the bundles from the supports.

(5) At the end of the shift or when environmental or jobsite conditions require, metal decking shall be secured against displacement.

(6) Roof and floor holes and openings. Metal decking at roof and floor holes and openings shall be installed as follows:

(a) Framed metal deck openings shall have structural members turned down to allow continuous deck installation except where not allowed by structural design constraints or constructibility.

(b) Roof and floor holes and openings shall be decked over. Where large size, configuration, or other structural design does not allow openings to be decked over, employees shall be protected from falls.

(c) Metal decking holes and openings shall not be cut until immediately prior to being permanently filled with the equipment or structure needed or intended to fulfill its specific use and that meets the strength requirements of 27.E.16, or shall be immediately covered.

27.E.16 Covering roof and floor openings.

a. Covers for roof and floor openings shall be capable of supporting, without failure, twice the weight of the employees, equipment, and materials that may be imposed on the cover at any one time.

b. All covers shall be secured when installed to prevent accidental displacement by the wind, equipment, or employees.

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c. All covers shall be painted with high-visibility paint or shall be marked with the word "HOLE" or "COVER" to provide warning of the hazard.

d. Smoke dome or skylight fixtures that have been installed, are not considered covers for the purpose of this Section unless they meet the strength requirements of 27.E.16a and 27.H.09.

e. Decking gaps around columns. Wire mesh, exterior plywood, or equivalent, shall be installed around columns where planks or metal decking do not fit tightly. The materials used must be of sufficient strength to provide fall protection for personnel and prevent objects from falling through.

#### 27.E.17 Installation of metal decking

a. Metal decking shall be laid tightly and immediately secured upon placement to prevent accidental movement or displacement.

b. During initial placement metal-decking panels shall be placed to ensure full support by structural members.

#### 27.E.18 Derrick floors.

a. A derrick floor shall be fully decked and/or planked and the steel member connections completed to support the intended floor loading.

b. Temporary loads placed on a derrick floor shall be distributed over the underlying support members so as to prevent local overloading of the deck material.

#### 27.E.19 Column anchorage

a. General requirements for erection stability.

(1) All columns shall be anchored by a minimum of four anchor rods (anchor bolts).

(2) Each column anchor rod (anchor bolt) assembly, including the column-to-base plate weld and the column foundation, shall be designed to resist a minimum eccentric gravity load of 300 lbs (136.2 kg) located 18 in (45.7 cm) from the extreme outer face of the column in each direction at the top of the column shaft.

(3) Columns shall be set on level finished floors, pre-grouted leveling plates, leveling nuts, or shim packs that are adequate to transfer the construction loads.

(4) All columns shall be evaluated by a competent person to determine whether guying or bracing is needed; if guying or bracing is needed, it shall be installed.

b. Repair, replacement or field modification of anchor rods (anchor bolts).

(1) Anchor rods (anchor bolts) shall not be repaired, replaced, or field-modified without the approval of the project structural engineer of record.

(2) Prior to the erection of a column, the controlling Contractor shall provide written notification to the steel erector if there has been any repair, replacement, or modification of the anchor rods (anchor bolts) of that column.

#### 27.E.20 Beams and columns

a. During the final placing of solid web structural members, the load shall not be released from the hoisting line until the members are secured with at least two bolts per connection (of the same size and strength as shown in the erection drawings) drawn up wrench-tight or the equivalent as specified by the project structural engineer of record, except as specified in 27.E.21.

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b. A competent person shall determine if more than two bolts are necessary to ensure the stability of cantilevered members; if additional bolts are needed, they shall be installed.

27.E.21 Diagonal bracing. Solid web structural members used as diagonal bracing shall be secured by at least one bolt per connection drawn up wrench-tight or the equivalent as specified by the project structural engineer of record.

27.E.22 Double connections

a. Double connections at columns and/or at beam webs over a column. When two structural members on opposite sides of a column web, or a beam web over a column, are connected sharing common connection holes, at least one bolt with its wrench-tight nut shall remain connected to the first member unless a shop-attached or field-attached seat or equivalent connection device is supplied with the member to secure the first member and prevent the column from being displaced.

b. If a seat or equivalent device is used, the seat (or device) shall be designed to support the load during the double connection process. It shall be adequately bolted or welded to both a supporting member and the first member before the nuts on the shared bolts are removed to make the double connection.

27.E.23 Column splices. Each column splice shall be designed to resist a minimum eccentric gravity load of 300 lbs (136.2 kg) located 18 in (45.7 cm) from the extreme outer face of the column in each direction at the top of the column shaft.

27.E.24 Perimeter columns. Perimeter columns shall not be erected unless:

a. The perimeter columns extend a minimum of 48 in (121.9 cm) above the finished floor to permit installation of perimeter safety cables prior to erection of the next tier, except where constructibility does not allow.

b. The perimeter columns have holes or other devices in or attached to perimeter columns at 42-45 in (106.6-114.3 cm) above the finished floor and the midpoint between the finished floor and the top cable to permit installation of perimeter safety cables except where constructibility does not allow.

27.E.25 Open web steel joists.

a. Except as provided in paragraph (b)(2) below, where steel joists are used and columns are not framed in at least two directions with solid web structural steel members, a steel joist shall be field-bolted at the column to provide lateral stability to the column during erection. For the installation of this joist:

(1) A vertical stabilizer plate shall be provided on each column for steel joists. The plate shall be a minimum of 6 in by 6 in (15.2 cm by 15.2 cm) and shall extend at least 3 in (7.6 cm) below the bottom chord of the joist with a 13/16-in (2.1-cm) hole to provide an attachment point for guying or plumbing cables.

(2) The bottom chords of steel joists at columns shall be stabilized to prevent rotation during erection.

(3) Hoisting cables shall not be released until the seat at each end of the steel joist is field-bolted, and each end of the bottom chord is restrained by the column stabilizer plate.

b. Where constructibility does not allow a steel joist to be installed at the column:

(1) An alternate means of stabilizing joists shall be installed on both sides near the column and shall:

(a) Provide stability equivalent to paragraph a(1) above,

(b) Be designed by a qualified person,

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(c) Be shop installed, and

(d) Be included in the erection drawings.

(2) Hoisting cables shall not be released until the seat at each end of the steel joist is field-bolted and the joist is stabilized.

c. Where steel joists at or near columns span 60 ft (18.3 m) or less, the joist shall be designed with sufficient strength to allow one employee to release the hoisting cable without the need for erection bridging.

d. Where steel joists at or near columns span more than 60 ft (18.3 m), the joists shall be set in tandem with all bridging installed unless an alternative method of erection, which provides equivalent stability to the steel joist, is designed by a qualified person and is included in the site-specific erection plan.

e. A steel joist or steel joist girder shall not be placed on any support structure unless such structure is stabilized.

f. When steel joist(s) are landed on a structure, they shall be secured to prevent unintentional displacement prior to installation.

g. No modification that affects the strength of a steel joist or steel joist girder shall be made without the approval of the project structural engineer of record.

h. Field-bolted joists.

(1) Except for steel joists that have been pre-assembled into panels, connections of individual steel joists to steel structures in bays of 40 ft (12.1 m) or more shall be fabricated to allow for field bolting during erection.

(2) These connections shall be field-bolted unless constructibility does not allow.

i. Steel joists and steel joist girders shall not be used as anchorage points for a fall arrest system unless written approval to do so is obtained from a qualified person.

j. A bridging terminus point shall be established before bridging is installed.

27.E.26 Attachment of steel joists and steel joist girders.

a. Each end of "K" series steel joists shall be attached to the support structure with a minimum of two 1/8-in (0.3-cm) fillet welds 1 in (2.5 cm) long or with two 1/2-in (1.2-cm) bolts, or the equivalent.

b. Each end of "LH" and "DLH" series steel joists and steel joist girders shall be attached to the support structure with a minimum of two 1/4-inch (0.6-cm) fillet welds 2 in (5 cm) long, or with two 3/4-in (1.9-cm) bolts, or the equivalent.

c. Except as provided in paragraph d below, each steel joist shall be attached to the support structure, at least at one end on both sides of the seat, immediately upon placement in the final erection position and before additional joists are placed.

d. Panels that have been pre-assembled from steel joists with bridging shall be attached to the structure at each corner before the hoisting cables are released.

27.E.27 Erection of steel joists.

a. Both sides of the seat of one end of each steel joist that requires bridging under Tables 27-1 and 27-2 shall be attached to the support structure before hoisting cables are released.

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**TABLE 27-1**

**ERECTION BRIDGING FOR SHORT SPAN JOISTS**

<b>JOIST</b>	<b>SPAN</b>	<b>JOIST</b>	<b>SPAN</b>
8L1	NM	22K6	36-0
10K1	NM	22K7	40-0
12K1	23-0	22K9	40-0
12K3	NM	22K10	40-0
12K5	NM	22K11	40-0
14K1	27-0	24K4	36-0
14K3	NM	24K5	38-0
14K4	NM	24K6	39-0
14K6	NM	24K7	43-0
16K2	29-0	24K8	43-0
16K3	30-0	24K9	44-0
16K4	32-0	24K10	NM
16K5	32-0	24K12	NM
16K6	NM	26K5	38-0
16K7	NM	26K6	39-0
16K9	NM	26K7	43-0
18K3	31-0	26K8	44-0
18K4	32-0	26K9	45-0
18K5	33-0	26K10	49-0
18K6	35-0	26K12	NM
18K7	NM	28K6	40-0
18K9	NM	28K7	43-0
18K10	NM	28K8	44-0
20K3	32-0	28K9	45-0
20K4	34-0	28K10	49-0
20K5	34-0	28K12	53-0
20K6	36-0	30K7	44-0
20K7	39-0	30K8	45-0
20K9	39-0	30K9	45-0
20K10	NM	30K10	50-0
22K4	34-0	30K11	52-0
22K5	35-0	30K12	54-0



**TABLE 27-1 (CONTINUED)**

**ERECTION BRIDGING FOR SHORT SPAN JOISTS**

<b>JOIST</b>	<b>SPAN</b>	<b>JOIST</b>	<b>SPAN</b>
10KCS1	NM	20KCS2	36-0
10KCS2	NM	20KCS3	39-0
12KCS1	NM	20KCS4	NM
12KCS2	NM	24KCS5	NM
12KCS3	NM	26KCS2	39-0
14KCS1	NM	26KCS3	44-0
14KCS2	NM	26KCS4	NM
14KCS3	NM	26KCS5	NM
16KCS2	NM	28KCS2	40-0
16KCS3	NM	28KCS3	45-0
16KCS4	NM	28KCS4	53-0
16KCS5	NM	28KCS5	53-0
18KCS2	35-0	30KCS3	45-0
18KCS3	NM	30KCS4	54-0
18KCS4	NM	30KCS5	54-0
18KCS5	NM		

NM=diagonal bolted bridging not mandatory for joists under 40 ft (12.1 m).

**TABLE 27-2**

**ERECTION BRIDGING FOR LONG SPAN JOISTS**

<b>JOIST</b>	<b>SPAN</b>	<b>JOIST</b>	<b>SPAN</b>
18LH02	33-0	28LH06	42-0
18LH03	NM	28LH07	NM
18LH04	NM	28LH08	NM
18LH05	NM	28LH09	NM
18LH06	NM	28LH10	NM
18LH07	NM	28LH11	NM
18LH08	NM	28LH12	NM
18LH09	NM	28LH13	NM
20LH02	33-0	32LH06	47-0 through 60-0
20LH03	38-0	32LH07	47-0 through 60-0
20LH04	NM	32LH08	55-0 through 60-0
20LH05	NM	32LH09	NM through 60-0
20LH06	NM	32LH10	NM through 60-0
20LH07	NM	32LH11	NM through 60-0
20LH08	NM	32LH12	NM through 60-0
20LH09	NM	32LH13	NM through 60-0
20LH10	NM	32LH14	NM through 60-0
24LH03	35-0	32LH15	NM through 60-0
24LH04	39-0	36LH07	47-0 through 60-0
24LH05	40-0	36LH08	47-0 through 60-0
24LH06	45-0	36LH09	57-0 through 60-0
24LH07	NM	36LH10	NM through 60-0
24LH08	NM	36LH11	NM through 60-0
24LH09	NM	36LH12	NM through 60-0
24LH10	NM	36LH13	NM through 60-0
24LH11	NM	36LH14	NM through 60-0
28LH05	42-0	36LH15	NM through 60-0

NM = diagonal bolted bridging not mandatory for joists under 40 feet (12.1 m).

- b. For joists over 60 ft (18.2 m), both ends of the joist shall be attached as specified in 27.E.26 and the provisions of 27.E.28 are met before the hoisting cables are released.
- c. On steel joists that do not require erection bridging under Tables 27-1 and 27-2, only one employee shall be allowed on the joist until all bridging is installed and anchored.
- d. Employees shall not be allowed on steel joists where the span of the steel joist is equal to or greater than the span shown in Tables 27-1 and 27-2 in accordance with 27.E.28.
- e. When permanent bridging terminus points cannot be used during erection, additional temporary bridging terminus points are required to provide stability.

27.E.28 Erection bridging.

- a. Where the span of the steel joist is equal to or greater than the span shown in Tables 27-1 and 27-2, the following shall apply:
  - (1) A row of bolted diagonal erection bridging shall be installed near the mid-span of the steel joist.
  - (2) Hoisting cables shall not be released until this bolted diagonal erection bridging is installed and anchored, and
  - (3) No more than one employee shall be allowed on these spans until all other bridging is installed and anchored.
- b. Where the span of the steel joist is over 60 ft (18.2 m) through 100 ft (30.4 m), the following shall apply:
  - (1) All rows of bridging shall be bolted diagonal bridging.
  - (2) Two rows of bolted diagonal erection bridging shall be installed near the third points of the steel joist.

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(3) Hoisting cables shall not be released until this bolted diagonal erection bridging is installed and anchored, and

(4) No more than two employees shall be allowed on these spans until all other bridging is installed and anchored.

c. Where the span of the steel joist is over 100 ft (30.4 m) through 144 ft (43.9 m), the following shall apply:

(1) All rows of bridging shall be bolted diagonal bridging.

(2) Hoisting cables shall not be released until all bridging is installed and anchored, and

(3) No more than two employees shall be allowed on these spans until all bridging is installed and anchored.

d. For steel members spanning over 144 ft (43.9 m), the erection methods used shall be in accordance with 27.E.20 through 27.E.24.

e. Where any steel joist specified in paragraphs b above and 27.E.29a, b, and c is a bottom chord-bearing joist, a row of bolted diagonal bridging shall be provided near the support(s). This bridging shall be installed and anchored before the hoisting cable(s) is released.

f. When bolted diagonal erection bridging is required by this section, the following shall apply:

(1) The bridging shall be indicated on the erection drawing;

(2) The erection drawing shall be the exclusive indicator of the proper placement of this bridging;

(3) Shop-installed bridging clips, or functional equivalents, shall be used where the bridging bolts to the steel joists;

(4) When two pieces of bridging are attached to the steel joist by a common bolt, the nut that secures the first piece of bridging shall not be removed from the bolt for the attachment of the second; and

(5) Bridging attachments shall not protrude above the top chord of the steel joist.

27.E.29 Landing and placing loads.

a. During the construction period, the employer placing a load on steel joists shall ensure that the load is distributed so as not to exceed the carrying capacity of any steel joist.

b. Except for paragraph d below, no construction loads are allowed on the steel joists until all bridging is installed and anchored and all joist-bearing ends are attached.

c. The weight of a bundle of joist bridging shall not exceed a total of 1,000 lbs (454 kg). A bundle of joist bridging shall be placed on a minimum of three steel joists that are secured at one end. The edge of the bridging bundle shall be positioned within 1 ft (0.3 m) of the secured end.

d. No bundle of decking may be placed on steel joists until all bridging has been installed and anchored and all joist bearing ends attached, unless all of the following conditions are met:

(1) The employer has first determined from a qualified person and documented in a site-specific erection plan that the structure or portion of the structure is capable of supporting the load,

(2) The bundle of decking is placed on a minimum of three steel joists,

(3) The joists supporting the bundle of decking are attached at both ends,

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(4) At least one row of bridging is installed and anchored.

(5) The total weight of the bundle of decking does not exceed 4,000 lbs (1816 kg), and

(6) Placement of the bundle of decking shall follow paragraph e below.

e. The edge of the construction load shall be placed within 1 ft (0.3 m) of the bearing surface of the joist end.

## **27.F SYSTEMS-ENGINEERED METAL BUILDINGS.**

27.F.01 All of the requirements of the previous section apply to the erection of systems-engineered metal except 27.E.19 (column anchorage) and 27.E.25 (open web steel joists).

a. Each structural column shall be anchored by a minimum of four anchor rods (anchor bolts).

b. Rigid frames shall have 50% of their bolts or the number of bolts specified by the manufacturer (whichever is greater) installed and tightened on both sides of the web adjacent to each flange before the hoisting equipment is released.

c. Construction loads shall not be placed on any structural steel framework unless such framework is safely bolted, welded, or otherwise adequately secured.

d. In girt and eave strut-to-frame connections, when girts or eave struts share common connection holes, at least one bolt with its wrench-tight nut shall remain connected to the first member unless a manufacturer-supplied, field-attached seat or similar connection device is present to secure the first member so that the girt or eave strut is always secured against displacement.

(1) Releasing the hoisting cables.

(2) Allowing an employee on the joists, or

(3) Allowing any construction loads on the joists.

e. Purlins and girts shall not be used as an anchorage point for a fall arrest system unless written approval is obtained from a qualified person.

f. Purlins may only be used as a walking/working surface when installing safety systems, after all permanent bridging has been installed and fall protection is provided.

g. Construction loads may be placed only within a zone that is within 8 ft (2.4 m) of the centerline of the primary support member.

h. Both ends of all steel joists or cold-formed joists shall be fully bolted and/or welded to the support structure before:

#### 27.F.02 Falling object protection.

a. Securing loose items aloft. All materials, equipment, and tools, which are not in use while aloft, shall be secured against accidental displacement.

b. Protection from falling objects other than materials being hoisted. The controlling Contractor shall bar other construction processes below steel erection unless overhead protection for the employees below is provided.

#### 27.F.03 Fall protection.

a. Each employee engaged in a steel erection activity who is on a walking/working surface with an unprotected side or edge more than 6 ft (1.8 m) above a lower level shall be protected from fall hazards by guardrail systems, safety net systems, personal fall arrest systems, positioning device systems, or fall restraint systems.

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b. Perimeter safety cables. On multi-story structures, perimeter safety cables shall be installed at the final interior and exterior perimeters of the floors as soon as the metal decking has been installed.

27.F.04 Each connector shall:

a. Be protected, in accordance with 27.F.03, from fall hazards of more than 6 feet (1.8 m) above a lower level.

b. Have completed connector training in accordance with 27.F.10 and 27.F.11

c. Be provided, at heights over 6 ft (1.8 m) above a lower level, with a personal fall arrest system, positioning device system or fall restraint system and wear the equipment necessary to be able to be tied off; or be provided with other means of protection from fall hazards in accordance with Sections 5 and 21.

27.F.05 Controlled decking zones (CDZ) are not permitted.

27.F.06 Guardrail systems, safety net systems, personal fall arrest systems, positioning device systems, and their components shall conform to Sections 5 and 21.

27.F.07 Fall arrest system components shall be used in fall restraint systems and shall conform to the requirements in this manual.

27.F.08 Perimeter safety cables shall meet the criteria for guardrail systems.

27.F.09 Custody of fall protection. Fall protection provided by the steel erector shall remain in the area where steel erection activity has been completed, to be used by other trades, only if the controlling Contractor or its authorized representative:

a. Has directed the steel erector to leave the fall protection in place, and



b. Has inspected and accepted control and responsibility of the fall protection prior to authorizing persons other than steel erectors to work in the area.

27.F.10 Training personnel. Training required by this Section shall be provided by a qualified person(s).

27.F.11 Fall hazard training. The employer shall provide a training program for all employees exposed to fall hazards. The program shall include training and instruction in the following areas:

a. The recognition and identification of fall hazards in the work area;

b. The use and operation of guardrail systems (including perimeter safety cable systems), personal fall arrest systems, positioning device systems, fall restraint systems, safety net systems, and other protection to be used;

c. The correct procedures for erecting, maintaining, disassembling, and inspecting the fall protection systems to be used;

d. The procedures to be followed to prevent falls to lower levels and through or into holes and openings in walking/working surfaces and walls to meet requirements of 27.E.

27.F.12 Special training programs. In addition to the training required above, the employer shall provide special training to employees engaged in connector procedures. The employer shall ensure that each connector has been provided training in the following areas:

a. The nature of the hazards associated with connecting; and

b. The establishment, access, and proper connecting techniques.

## **27.G MASONRY CONSTRUCTION**

27.G.01 A limited access zone shall be established whenever a masonry wall is being constructed. The limited access zone shall conform to the following:

- a. The limited access zone shall be established prior to the start of construction on the wall.
- b. The limited access zone shall be equal to the height of the wall to be constructed plus 4 ft (1.2 m), and shall run the entire length of the wall.
- c. The limited access zone shall be established on the side of the wall that will be unscaffolded.
- d. The limited access zone shall be restricted to entry by employees actively engaged in constructing the wall; no other employees shall be permitted to enter the zone.
- e. The limited access zone shall remain in place until the wall is adequately supported to prevent overturning and to prevent collapse unless the height of the wall is over 8 ft (2.4 m), in which case the limited access zone shall remain in place until the requirements of 27.G.02 have been met.

27.G.02 All masonry walls over 8 ft (2.4 m) in height shall be adequately braced to prevent overturning and to prevent collapse unless the wall is adequately supported so that it will not overturn or collapse. The bracing shall remain in place until permanent supporting elements of the structure are in place.

27.G.03 Scaffolds for masonry construction workers shall not be used to provide temporary lateral support of masonry walls.

27.G.04 Cleanouts shall be on the side of the masonry wall opposite to the scaffolding.

27.G.05 Fall protection shall be provided to masonry workers exposed to falls of 6 ft (1.8 m) or more. > **See Section 21**

## **27.H ROOFING**

27.H.01 Before work begins, a competent person shall complete a daily inspection of each job site. This individual, designated by management, shall be capable of identifying existing predictable hazards and has the authority to take prompt corrective action to eliminate them. Hazards shall be eliminated by engineering and if this cannot be accomplished, guarding to isolate the hazard from the exposed employees shall be implemented. In no case shall warnings or instructions be used as a substitute for elimination of hazards by engineering means or guarding.

27.H.02 Prior to the start of work, a structural analysis of the roof shall be conducted by a qualified person to assure that the load capacity of the rood deck will not be exceeded.

27.H.03 Where the work presents a potential hazard to the public, the Contractor shall set up barricades with proper postings to alert public to the hazards. Visible signs and barricades for the information, protection, and safety of the public shall be provided and properly maintained. They shall be set up in accordance with ANSI D6.1. Applicable statutes and local regulations shall be examined and the more restrictive requirements shall be followed.

27.H.04 Work on the roof shall be halted during severe weather such as strong winds, electrical storms, icing conditions, heavy rain, or snow as soon as practical.

27.H.05 The employer shall establish emergency plans and fire prevention plans. All employees shall be trained in accordance with these plans.

27.H.06 Roof openings and holes shall be provided with covers or guardrail systems on all exposed sides.

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27.H.07 Roofing material, such as roofing membrane, insulation or felts, covering or partly covering openings or holes, shall be immediately cut out. No hole or opening shall be left unattended unless covered.

27.H.08 All covers for openings shall be provided with a sign stating "**Danger Roof Opening--Do Not Remove.**" The message on the sign shall state that there is an opening beneath the cover and that the cover is not to be removed without specific authorization of the competent person. The sign shall be visible from all sides of the cover and shall comply with provisions of danger signs as specified in ANSI Z535.2-1991, "C".

27.H.09 Skylights warning lines, screens or covers, shall guard skylights, together with guardrails. Skylight screens are acceptable if they are of such construction and mounting that they are capable of withstanding a static load of at least 250 lb (113.4 kg) applied perpendicularly at any one area on the screen. They shall also be of sufficient construction and mounting that when a load of 250 lb (113.4 kg) or more falls against the screen, the glass or lens below will not break. The construction shall be of grillwork with openings not more than 4 in (10.1 cm) long or of slats with openings not more than 2 in (5 cm) wide with an unrestricted length.

27.H.10 Fall protection requirements.

a. In the construction, maintenance, repair, and demolition, of roofs, fall protection systems shall be provided which will prevent personnel from slipping and falling from the roof and prevent personnel on lower levels from being struck by falling objects. > **See Section 21**

b. Employees engaged in the construction, maintenance, or repair of built-up roofing (but not construction of the roof deck) on low-slope roofs with unprotected sides and edges 6 ft (1.8 m) or more above lower levels, shall be protected from falling by guardrail systems, safety net systems, personnel fall arrest systems, or a combination of warning line system and guardrail system, warning line system and safety net system, or warning

line system and personal fall arrest system, or a warning line system and a safety monitoring system. Or on roofs 50 ft (15.2 m) or less in width, the use of a safety monitoring system alone without a warning line system is permitted. > Each of the above systems is presented in their order of hierarchy and shall be considered as such in their application. A competent person shall evaluate each situation and determine which level of protection is necessary beginning with the use of guardrails. The competent person shall develop a fall protection plan and submit it to the GDA for review and acceptance prior to the start of work.

c. Steep sloped roofs with unprotected sides and edges 6 ft (1.8 m) or more above a lower surface shall be protected from falling by guardrail systems with toe boards, safety net systems, or personal fall arrest systems.

27.H.11 On all roofs greater than 16 ft (4.8 m) in height, a hoisting device, stairways, or progressive platforms shall be furnished for supplying materials and equipment.

27.H.12 Roofing materials and accessories that could be moved by the wind, including metal roofing panels, which are on the roof and unattached, shall be secured when wind speeds are greater than, or are anticipated to exceed, 10 mph (16.1 km/h).

27.H.13 Level, guarded platforms shall be provided at the landing area on the roof.

27.H.14 Crawling boards.

a. Crawling boards shall be not less than 10 in (25.4 cm) wide and 1 in (2.5 cm) thick, having cleats 1 in x 1-1/2 in (2.5 cm x 3.8 cm).

b. Cleats shall be equal in length to the width of the board and spaced at equal intervals not to exceed 24 in (60.9 cm).

c. Nails shall be driven through and clinched on the underside.

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d. Crawling boards shall be secured and extend from the ridge pole to the eaves when used with roof construction, repairs, or maintenance.

e. A firmly fastened lifeline of at least  $\frac{3}{4}$  in (1.9 cm) diameter rope, or equivalent, shall be strung beside each crawling board for a handhold.

27.H.15 Roofing brackets.

a. Roofing brackets shall be secured by nailing in addition to the pointed metal projections.

b. When it is impractical to nail brackets, rope supports shall be used. When rope supports are used, they shall consist of first-grade manila rope,  $\frac{3}{4}$  in (1.9 cm) diameter or equivalent.

27.H.16 When their use is permitted, warning line systems shall comply with the following:

a. Warning lines shall be erected around all sides of the work area.

(1) When mechanical equipment is not being used, the warning line shall be erected not less than 6 ft (1.8 m) from the roof edge.

(2) When mechanical equipment is being used, the warning line shall be erected not less than 6 ft (1.8 m) from the roof edge that is parallel to the direction of mechanical equipment operation and not less than 10 ft (3.0 m) from the roof edge that is perpendicular to the direction of mechanical equipment operation.

b. Warning lines shall consist of ropes, wires, or chains, and supporting stanchions erected as follows:

- (1) The rope, wire, or chain shall be flagged at not more than 6 ft (1.8 m) intervals with high visibility material.
- (2) The rope, chain, or wire shall be rigged and supported in such a way that its lowest point (including sag) is no less than 34 in (86.4 cm) from the roof surface and its highest point no more than 39 in (99 cm) from the roof surface.
- (3) After being erected, with the rope, wire, or chain attached, stanchions shall be capable of resisting, without tipping over, a force of at least 16 lb (7.3 kg) applied horizontally against the stanchion 30 in (76.2 cm) above the walking/working surface, perpendicular to the warning line, and in the direction of the roof, floor, or platform edge.
- (4) The rope, wire, or chain shall have a minimum tensile strength of 500 lb (226.8 kg), and after being attached to the stanchions shall be capable of supporting, without breaking, the loads applied to the stanchions (as described in (3) above).
- (5) The lines shall be attached at each stanchion in such a way that pulling on one section of the line between stanchions will not result in slack being taken up in adjacent sections before the stanchion tips over.
- (6) No employee shall be allowed in the area between a roof edge and a warning line unless the employee is performing work in that area and is protected by a motion stopping safety (MSS) system.
- (7) Mechanical equipment on roofs shall be used or stored only in areas where employees are protected by a warning line, guardrail, or personnel fall arrest system.

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c. Access paths shall be erected as follows:

(1) Points of access, materials handling areas, and storage areas shall be connected to the work area by a clear access path formed by two warning lines.

(2) When the path to a point of access is not in use, a rope, wire, or chain, equal in strength and height to the warning line, shall be placed across the path at the point where the path intersects the warning line erected around the work area, or the path shall be offset such that a person cannot walk directly into the work area.

27.H.17 Employees working in a roof-edge materials handling or storage area located on a roof having a slope less than or equal to 4 vertical to 12 horizontal and with edges 6 ft (1.8 m) or more above lower levels shall be protected by the use of a guardrail, safety net, or personal fall arrest system along all unprotected roof sides and edges of the area.

a. When guardrails are used at hoisting areas, a minimum of 4 ft (1.2 m) of guardrail shall be erected on each side of the access point through which materials are hoisted.

b. A chain or gate shall be placed across the opening between the guardrail sections when hoisting operations are not taking place.

c. When guardrails are used at bitumen pipe outlets, a minimum of 4 ft (1.2 m) of guardrail shall be erected on each side of the pipe.

d. When personal fall arrest systems are used, they shall not be attached to the hoist.

e. When personal fall arrest systems are used, they shall be rigged to allow the movement of employees only as far as the roof edge.



- f. Materials may not be stored within 6 ft (1.8 m) of the roof edge unless guardrails are erected at the roof edge.
- g. Materials that are to be piled, stacked, or grouped shall be stable and self-supporting.

