

CONCRETE AND MASONRY CONSTRUCTION CONSTRUCTION AND STEEL ERECTION

27.A CONCRETE AND MASONRY CONSTRUCTION AND STEEL ERECTION

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.
- 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 of 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 Publication ACI 347R, *Guide to Formwork for Concrete*.
- b. The design and the erection and removal plans for formwork and shoring shall be submitted for review to the Designated Authority.
- c. The manufacturer's specifications for fabricated shoring systems shall be available at the job site during job planning and execution.

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. Baseplates, 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 reshored.

27.B.07 Reshoring 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.

(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
 - (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. Reshoring 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 to 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 Designated Authority 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 which 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 fourteen, 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.

d. During lifting, all points of the slab support shall be kept within 1.25 cm (0.5 in) 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 1.25 cm (0.5 in) 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 Material and equipment.

a. Impact wrenches shall have a locking device for retaining the socket.

b. Containers shall be provided for storing or carrying rivets, bolts, and drift pins, and secured against accidental displacement when aloft.

c. A safety wire shall be properly installed on the snap and on the handle of the pneumatic riveting hammer and shall be used at all times: the wire size shall be not less than No. 9 (B&S gauge), leaving the handle and annealed No. 14 on the snap or equivalent.

27.E.02 Structural and reinforcing steel for walls, piers, columns, and similar vertical structures shall be guyed and supported to prevent collapse.

27.E.03 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 not less than two bolts or 10% of the bolts, whichever is greater, at each connection, drawn up wrench tight.

27.E.04 Open web steel joists shall not be placed on any structural steel framework until the framework is permanently bolted or welded.

a. No loading shall be placed upon steel joists until all bridging is completely and permanently installed.

b. For individual joists, the hoisting cables shall not be removed until sufficient top and bottom chord bridging is attached to provide lateral restraint.

27.E.05 Lateral bracing.

a. In steel framing, where bar joists are used and columns are not framed in at least two directions with structural steel members, a bar joist shall be field-bolted at columns to provide lateral stability during construction.

b. Where longspan joists or trusses, 12 m (40 ft) or longer, are used, a center row of bolted bridging shall be installed to provide lateral stability during construction prior to slacking of hoisting line.

c. No load shall be placed on open web steel joists until the stability requirements

of 27.E.03 are met.

27.E.06 Workers shall be provided fall protection whenever they are exposed to falls of 1.8 m (6 ft) or more. > **See Section 21**

27.E.07 Riveting shall not be done near combustible material unless precautions are taken to prevent fire.

27.E.08 When bolts, drift pins, or rivets are being knocked out, they shall be kept from falling.

27.F FLOORING

27.F.01 Temporary flooring - skeleton steel erection.

- a. Derrick or erection floors shall be planked or decked over their entire surface except for access openings.
- b. On structures not adaptable to temporary floors, and where scaffolds or personnel lifting platforms are not used, safety nets shall be installed and maintained whenever the potential fall distance exceeds two stories or 7.5 m (25 ft). > **See Section 21.C**
- c. Temporary flooring shall be maintained within two stories or 9 m (30 ft), whichever is less, below and directly under that portion of each tier of beams on which any work is being performed, except:
 - (1) when removing temporary flooring on a lower floor in preparation for transfer to an upper floor, or
 - (2) where such a floor is not practical, in which case safety nets shall be used.
- d. The design of temporary flooring shall be approved by a registered engineer.
- e. Planking or metal decking shall be of sufficient strength and thickness to carry the working load: planking shall be not less than 5 cm (2 in) thick (full size undressed).
- f. Planking and metal decking shall be laid tight and secured to prevent displacement.
- g. A fall protection system, delineated in an activity hazard analysis and accepted by the designated authority, shall be provided for employees placing and removing temporary flooring.

27.F.02 Permanent flooring - skeleton steel erection.

- a. Permanent floors shall be installed as the erection of structural members progresses.
- b. There shall be not more than eight stories between the erection floor and the

uppermost permanent floor, except where the structural integrity is maintained by design.

c. At no time shall there be more than two floors or 9 m (30 ft) of unfinished bolting or welding above the foundation or uppermost permanently secured floor unless the column is one continuous member and approval has been obtained from the designated authority: in no case shall 4 floors or 15 m (48 ft) be exceeded.

27.F.03 Flooring - other construction.

a. In the erection of a building having double wood floor construction, the rough flooring shall be completed as the building progresses, including the tier below the one on which floor joists are being installed.

b. In the erection of a building having a single wood floor or other flooring systems, the floor immediately below the story where the floor joists are being installed shall be kept planked or decked over.

27.F.04 After a temporary working floor is provided, a safety line of 1.25 cm (0.5 in) wire rope or the equivalent shall be installed around the periphery of all temporary-planked or metal-decked floors with a fall potential of 1.8 m (6 ft) or more.

a. The line shall be installed approximately 105 cm (42 in) above the working floor and shall be flagged to provide visibility.

b. The line shall be attached to all perimeter columns and kept taut by use of a turnbuckle or other means.

c. The line shall remain in place until it is replaced by walls or standard guardrails.

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 1.2 m (4 ft), and shall run the entire length of the wall.

c. The limited access zone shall be established on the side of the wall which 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 2.4 m (8 ft), 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 2.4 m (8 ft) 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 feet or more. > **See Section 21**

27.H ROOFING

27.H.01 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 roofs having a slope less than or equal to four vertical to twelve horizontal and edges 1.8 m (6 ft) or more above lower levels, shall be protected from falling by one of the following: guardrail systems; safety net systems; personnel fall arrest systems; or warning line system combined with guardrail, safety net, personnel fall arrest, or safety monitoring system.

27.H.02 On all roofs greater than 4.8 m (16 ft) in height, a hoisting device, stairways, or progressive platforms shall be furnished for supplying materials and equipment.

27.H.03 Roofing materials and accessories which 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, 15 km/h (10 mph).

27.H.04 Level, guarded platforms shall be provided at the landing area on the roof.

27.H.05 Crawling boards

a. Crawling boards shall be not less than 25 cm (10 in) wide and 2.5 cm (1 in) thick, having cleats 2.5 cm x 3.75 cm (1 in x 1.5 in).

- b. Cleats shall be equal in length to the width of the board and spaced at equal intervals not to exceed 60 cm (24 in).
- c. Nails shall be driven through and clinched on the underside.
- 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 2 cm (0.75 in) diameter rope, or equivalent, shall be strung beside each crawling board for a handhold.

27.H.06 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, 2 cm (0.75 in) diameter or equivalent.

27.H.07 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 1.8 m (6 ft) from the roof edge.
 - (2) When mechanical equipment is being used the warning line shall be erected not less than 1.8 m (6 ft) from the roof edge which is parallel to the direction of mechanical equipment operation and not less than 3 m (10 ft) from the roof edge which 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 1.8 m (6 ft) 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 85 cm (34 in) from the roof surface and its highest point no more than 100 cm (39 in) 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 7 kg (16 lb) applied horizontally against the stanchion 75 cm (30 in) 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 230 kg (500

lb), and after being attached to the stanchions shall be capable of supporting, without breaking, the loads applied to the stanchions (as described in (3)).

(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.

(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.

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.08 Employees working in a roof-edge materials handling or storage area located on a roof having a slope less than or equal to four vertical to twelve horizontal and with edges 1.8 m (6 ft) 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 1.2 m (4 ft) 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 1.2 m (4 ft) 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 1.8 m (6 ft) of the roof edge unless guardrails are erected at the roof edge.

g. Materials which are to be piled, stacked, or grouped shall be stable and self-supporting.

DEFINITIONS

Built-up roofing: a weather-proofing cover, applied over roof decks, consisting of either a liquid-applied system, a single-ply system, or a multiple-ply system.

Bull float: a tool comprising a large, flat, rectangular piece of wood, aluminum, or magnesium, with a handle, used to smooth uniform surfaces of freshly placed concrete.

Double-wood floor construction: a system in which a second layer of wooden flooring is placed upon a layer of rough wooden flooring.

Eaves: the bottom edges of a sloping roof.

Formwork: the total system of support for freshly placed or partially cured concrete, including the mold or sheathing (form) that contacts the concrete and all supporting members, including shores, reshores, hardware, and bracing.

Lift-slab: a method of concrete construction in which floor and roof slabs are cast at or on the ground level and, using jacks, lifted into position.

Limited access zone: an area alongside a masonry wall which is clearly demarcated to limit access by employees.

Post-tensioning: a method of pre-stressing concrete with tendons that are tensioned after the concrete has hardened.

Precast concrete: concrete members (such as walls, panels, slabs, columns, and beams) which have been formed, cast, and cured prior to final placement in a structure.

Reshoring: the construction operation in which shoring equipment (also called reshores or reshoring equipment) is placed, as the original forms and shores are removed, in order to support partially cured concrete and construction loads.

Ridge pole: the longitudinal board, set on end, which is tied to the upper ends of roof trusses.

Roofing bracket: a bracket fastened to the roof or supported by ropes fastened over the ridge of the roof and secured to a suitable structural member,

Safety monitoring system: a safety system in which a competent person monitors the safety of all employees in a roofing crew and warns them when it appears to the monitor that they are unaware of the hazard or are acting in an unsafe manner. This competent person must be on the same roof as and within visual sighting distance of the employees and must be close enough to verbally communicate with the workers.

Shoring: a supporting member that resists a compressive force imposed by a load.

Shore head: a horizontal member fastened atop vertical shoring.

Sill: a horizontal member placed on the foundation and upon which shores are supported.

Tremie: a pipe or tube through which concrete is placed under water.

Troweling machine: a device utilizing rotating trowels on radial arms and used in concrete finishing operations.

Vertical slip forms: forms which are jacked vertically during the placement of concrete.

