dioxide) are near the detection limitations of commercially available instrumentation. This makes them more prone to statistical fluctuations and cross sensitivities that could cause false alarms if the TWA OEL were used as the alarm set points. It is permissible to use the short-term exposure limit or ceiling limits as alarm set points in lieu of the TWA limits, as long as compliance with the TWA is assured and personnel are trained to promptly evacuate when these levels are reached.

26-9. Figures and Tables.
Not Applicable.

26-10. Checklists and Forms.
Not Applicable.

Chapter 27
Concrete, Masonry, Roofing, and Wood Construction

27-1. References.

a. American Concrete Institute (ACI) 347R-14, Guide to Formwork for Concrete (https://www.concrete.org) (27-1.a)

b. ANSI/ASSP A10.34, Protection of the Public on or Adjacent to Construction Sites (https://webstore.ansi.org/) (27-1.b)

c. Department of Transportation (DOT) Federal Highway Administration's "Manual on Uniform Traffic Control Devices" (MUTCD) (https://mutcd.fhwa.dot.gov) (27-1.v)

d. Mason Contractors Association of America (MCAA), Standard Practice for Bracing Masonry Walls Under Construction (https://www.masoncontractors.org) (27-1.d)

e. OSHA Technical Manual (OTM) Section V: Chapter 2, Excavations: Hazard Recognition in Trenching and Shoring (https://www.osha.gov/otm/section-5-construction-operations/chapter-2) (27-1.e)

f. 29 CFR 1926 Subpart Q, Concrete and Masonry Construction (https://www.govinfo.gov/content/pkg/CFR-2020-title29-vol8/pdf/CFR-2020-title29-vol8-part1926-subpartQ.pdf) (27-1.f)

27-2. Definitions.

a. Construction Loads. Those loads imposed on a partially completed or temporary structure during and as a result of the construction process. Construction loads include, but are not limited to, materials, personnel, and equipment imposed on the temporary or permanent structure during the construction process. (27-2.a)

b. Limited Access Zone. An area alongside a masonry wall, which is under construction, and which is clearly demarcated to limit access by employees. (27-2.b)

c. Reshoring. The construction operation in which shoring equipment (that is, reshores or reshoring equipment) is placed as the original forms and shores are removed. The reshoring supports partially cured concrete and construction loads. (27-2.c)

d. Restricted Zone. The area on each side of a wall subject to the effect of a masonry wall collapse, measured by a horizontal distance equal to the height of the constructed wall plus 4 feet, measured at right angles to the wall, and continuing for the length of the wall plus a minimum of 4 feet beyond the ends of the wall. (27-2.d)

e. Shore. A supporting member (for example, false work to support an elevated concrete deck pour) that resists a compressive force imposed by a load. See OSHA Technical Manual (OTM) Section V: Chapter 2, Section VII Shoring Types for examples of shore types. (27-2.e)

f. Tremies. Pipe through which concrete may be deposited under water. (27-2.f)

g. Vertical Slip Forms. Forms which are jacked or hoisted vertically during the placement of concrete. (27-2.g)

27-3. Personnel Required Qualification/Training.
Not Applicable.

27-4. Roles and Responsibilities.

a. Competent Person (CP). (27-4.a)

(1) Oversee the removal of plumb-up guys for structural and reinforcing steel according to paragraph 27-8.c.

(2) Determine if concrete has gained sufficient strength prior to removal of formwork and shoring according to paragraph 27-8.e.

(3) Supervise the repairs of any damaged or weakened masonry bracing elements according to paragraph 27-8.g.

(4) Inspect unsupported masonry walls according to paragraph 27-5.b.

b. Qualified Person (QP). (27-4.b)

(1) Prepare plans according to paragraph 27-7.

(2) Determine restricted zone for multi-story structures according to paragraph 27-8.g.

(3) Conduct a structural analysis of the roofs according to paragraph 27-8.h(1).

c. Registered Professional Engineer (RPE). (27-4.c)

(1) Plan and design vertical slip forms according to paragraph 27-8.e(8).

(2) Design independent reinforcing steel support systems according to paragraph 27-8.c.

(3) Design single post shores according to paragraph 27-8.e(5).

(4) Inspect erected shoring systems according to paragraph 27-5.

(5) Design repairs do damaged masonry walls according to paragraph 27-8.g.

(6) Design wood type construction according to paragraph 27-8.i.

27-5. Inspection Requirements.

a. Formwork and Shoring. (27-5.a)

(1) An RPE qualified in structural design must inspect shoring equipment prior to erection to determine that it is as specified in the shoring design. Do not use any damaged equipment.

(2) Inspect erected shoring equipment immediately prior to, during, and immediately after the placement of concrete. Immediately reinforce or re-shore any shoring equipment that is found to be damaged, displaced, or weakened.

(3) Whenever single post shores are used in more than one tier, the layout must be inspected by a structural engineer.

b. Masonry Construction. Unsupported masonry walls, including the wall bracing system, must be inspected by a CP at the beginning of each shift and after any occurrence that could affect the structural integrity of the wall or wall bracing system. (27-5.b)

27-6. Activity Hazard Analysis (AHA) Requirements.
Develop AHAs according to paragraphs 1-6 or 2-6, as applicable.

27-7. Minimum Plan Requirements.

a. Erection and Removal Plan for Formwork and Shoring. An erection and removal plan for formwork and shoring is required for all formwork other than slab on grade. The plan must be developed by a QP from the approved formwork and shoring design, updated as conditions change, and submitted to the USACE supervisor for approval or to the KO or COR for acceptance. The plan must include the following: (27-7.a)

(1) Detailed description of the work being performed to include the sequence of erection and removal activities and site preparation and control.

(2) Description of the anticipated hazards or concerns and the control measures that will be implemented to control to an acceptable level.

(3) Procedures for material deliveries, storage, staging and removal.

(4) Procedures for determining if concrete has reach sufficient strength to begin removal of formwork and shoring.

(5) A list of the QPs and CPs to include their roles and responsibilities under the plan.

(6) Inspection and oversight methods to ensure adherence to the plan.

b. Precast Concrete Plan. A precast concrete plan is required prior to the erection of any precast concrete. The plan must be developed and signed by a QP, updated as conditions change, and submitted to the USACE supervisor for approval or to the KO or COR for acceptance. The plan must include the following: (27-7.b)

(1) Detailed description of the work being performed to include the sequence of erection activity and site preparation and control.

(2) Description of the anticipated hazards or concerns and the control measures that will be implemented to control to an acceptable level.

(3) A description of required bracing and placement procedures according to approved fabrication drawings.

(4) Procedures for material deliveries, storage, and staging.

(5) Process for coordination with other trades and ongoing construction activities.

(6) A list of the QPs and CPs to include their roles and responsibilities under the plan.

(7) Inspection and oversight methods to ensure adherence to the plan.

c. Masonry Erection Plan. A masonry erection plan is required prior to the erection of any structural masonry. The plan must be developed and signed by a QP, updated as conditions change, and submitted to the USACE supervisor for approval or to the KO or COR for acceptance. The plan must include the following: (27-7.c)

(1) Detailed description of the work being performed to include the sequence of erection activity and site preparation.

(2) Description of the anticipated hazards or concerns and the control measures that will be implemented to control to an acceptable level to include limited access and restricted zone perimeters.

(3) A description of required bracing selection and placement procedures to include supportive calculation; Stability considerations requiring temporary bracing; Terminus point; and Connections. If bracing is determined to be not required, provide justification.

(4) Procedures for material deliveries, storage, and staging.

(5) Process for coordination with other trades and ongoing construction activities.

(6) A list of the QPs and CPs to include their roles and responsibilities under the plan.

(7) Inspection and oversight methods to ensure adherence to the plan.

27-8. General Requirements.

a. General. (27-8.a)

(1) For all work covered by this chapter, the fall protection threshold height requirement is 6 feet (1.8 m) (see chapter 21).

(2) Do not place construction loads on a structure or portion of a 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.

(3) Do not allow employees to work above or in positions exposed to protruding reinforcing steel, fasteners, or other impalement hazards unless provisions have been made to control the hazard.

(4) Working Under Loads.

(a) Do not allow employees to work under concrete buckets, bundled material loads, or other suspended loads.

(b) To the extent practical, route elevated concrete buckets and loads to minimize the exposure of workers to hazards associated with falling loads or materials from the loads. Keep vibrator crews out from under concrete buckets suspended from cranes or cableways.

(c) Do not allow anyone to ride on concrete buckets or other suspended loads.

(5) Select and use PPE (as necessary for the work activity being performed according to chapter 5.

(6) Where the work activities performed present a potential hazard to the public, set up and maintain barricades with proper postings to alert the public to the hazards according to the MUTCD and ANSI/ASSP A10.34, and any other state or local requirements.

b. Concrete. (27-8.b)

(1) Equipment.

(a) Bulk storage bins, containers, or silos must have conical or tapered bottoms with mechanical or pneumatic means of starting the flow of material.

(b) Equip concrete mixers having a 1 yd^3 (0.8 m^3) or larger loading skip with a mechanical device to clear the skip of material. Also install guardrails on each side of the skip. (See chapter 21)

(c) Construct the handles on bull floats used where they may contact energized electrical conductors of nonconductive material or insulate them with a nonconductive sheath that provides equivalent protection.

(d) Equip powered and rotating concrete troweling machines that are manually guided with a control switch that will automatically shut off the power whenever the operator removes their hands from the equipment handles.

(e) Concrete buckets equipped with hydraulic or pneumatically operated gates must have positive safety latches or similar safety devices installed to prevent premature or accidental dumping. Design the buckets to prevent material from accumulating on the top and sides of the bucket.

(f) Provide concrete pumping systems using discharge pipes with pipe supports designed for 100% overload.

(g) Concrete buggy handles must not extend beyond the wheels on either side of the buggy.

(h) Secure the sections of tremies and similar concrete conveyances with wire rope or equivalent material in addition to the regular couplings or connections.

c. Structural and Reinforcing Steel. (27-8.c)

(1) Brace, guy, weld, or otherwise support structural and reinforcing steel for walls, piers, columns, and similar vertical structures to prevent overturning or collapse. An RPE must design any support systems for reinforcing steel that are independent of other forms of shoring support systems.

(2) Properly secure all equipment connections used in plumbing-up.

(3) Secure turnbuckles to prevent unwinding while under stress.

(4) Place plumbing-up guys and related equipment so that employees can get at the connection points.

(5) Prevent unrolled wire mesh from recoiling.

d. Post Tension Operations. (27-8.d)

(1) Do not allow employees, except those essential to the post-tensioning operations, to be behind jacks or end anchorages during post-tensioning operations.

(2) Erect signs and barriers to identify and limit employee access to the post-tensioning area during tensioning operations.

e. Formwork and Shoring. (27-8.e)

(1) Formwork and shoring will be designed and planned according to ACI 347R-14 (see para 27-7.a).

(2) Design, fabricate, erect, support, brace, and maintain formwork, shoring, and bracing so that it will safely support all vertical and lateral loads that might be applied until such loads can be supported by the structure.

(3) When fabricated shoring systems are used, keep a copy of the manufacturer’s specifications for the system available at the work site during job planning and execution.

(4) Do not use fabricated single post shores or adjusting devices if heavily rusted, bent, dented, re-welded, or have broken welds or other defects. If they contain timber,

they may not be used if the timber is split, cut, has sections removed, is rotted, or is otherwise structurally damaged.

(5) Base Support.

(a) Ensure supporting ground or completed construction upon which formwork and shoring is placed has adequate strength to carry the applied vertical and lateral loads.

(b) Ensure sills for shoring are sound, rigid, and capable of carrying the maximum intended load.

(c) Ensure base plates, shore heads, extension devices, or adjustment screws are in firm contact with the footing sill and form material and when necessary, are secured to them.

(d) Design and construct splices to prevent buckling and bending.

(e) Provide diagonal bracing in vertical and horizontal planes to provide stiffness and to prevent buckling of individual members.

(f) Provide reshoring to safely support slabs and beams after stripping or where such members are subjected to superimposed loads due to construction.

(g) Do not load fabricated shoring beyond the safe working load recommended by the manufacturer.

(6) Single Post Shores.

(a) A structural engineer must design and inspect the layout wherever single post shores are used in more than one tier.

(b) Vertically align single post shores and splice them to prevent misalignment.

(c) When shoring is at an angle, sloping, or when the shored surface is sloping, design the shoring for such loading.

(d) Do not adjust single post shores to raise formwork after the concrete is in place.

(e) Drive home all nails used to secure bracing or adjustable timber single post shores and bend the point of the nail over, if possible (that is, clinch the nails).

(f) For stability, brace single post shores in both the longitudinal and transverse directions.

(f-1) Adequately brace single-post shores in two mutually perpendicular directions at the splice level.

(f-2) Diagonally brace each tier in the same two directions.

(f-3) Install bracing as the shores are erected.

(f-4) Secure posts located near the slab perimeter during assembly and dismantling or reshoring to prevent the post from “fall out”.

(7) Tube and Coupler Shoring.

(a) Use structural type material (for example, drop-forged steel, malleable iron, structural grade aluminum) for the couplers. Do not use gray cast iron or dissimilar metals.

(b) Do not use couplers if they are deformed, broken, or have defective or missing threads on bolts, or have other defects.

(c) When inspecting the erected shoring towers, do not exceed the spacing between posts from that shown on the designed layout drawings. Inspect the interlocking of all tubular members and the tightness of the couplings.

(8) Tubular Welded Frame Shoring.

(a) All locking devices on frames and braces must be in good working order and all components must be in a condition similar to that of original manufacture. Coupling pins must align the frame or panel legs and pivoted cross braces must have their center pivot in place.

(b) Do not exceed the spacing between towers and cross brace spacing from that shown in the design. Ensure all locking devices are closed.

(c) Fasten devices for attaching external lateral stability bracing to the legs of the shoring frames.

(9) Vertical Slip Forms.

(a) Design the steel rods or pipe on which the jacks climb or by which the forms are lifted specifically for that purpose. Brace the rods and pipes where not encased in concrete.

(b) Position jacks and vertical supports so that the vertical loads are distributed equally and do not exceed the capacity of the jacks.

(c) Provide jacks or other lifting devices with mechanical dogs or other automatic holding devices to provide protection in case of failure of the power supply or the lifting mechanism.

(d) Perform lifting steadily and uniformly. Do not exceed the predetermined safe rate of lift.

(e) Provide lateral and diagonal bracing of the forms to prevent excessive distortion of the structure during the jacking operation.

(f) During jacking operations, maintain the form structure in line and plumb.

(g) Provide all vertical lift forms with scaffolding or work platforms completely encircling the area of placement.

(10) Removal of Formwork and Shoring. Do not remove forms or shores, except those on slab on grade and slip forms, until the CP for forming or shoring determines that the concrete has gained sufficient strength to support its weight and all superimposed loads. The CP must base the determination on one of the following:

(a) Satisfaction of conditions stipulated in the plans and specifications for removal of forms and shores.

(b) Concrete testing indicates that the concrete has achieved sufficient strength to support its weight and superimposed loads.

f. Precast Concrete Operations. (27-8.f)

(1) Develop a precast concrete plan prior to beginning any precast placement activities (see para 27-7.b).

(2) Adequately support precast concrete members to prevent overturning or collapse until permanent connections are complete.

(3) Lifting Inserts and Hardware.

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

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

(4) Do not allow employee under precast concrete members being lifted or tilted into position except employees required for the erection of those members.

g. Masonry Construction. See MCAA Standard Practice for Bracing Masonry Walls Under Construction. (27-8.g)

(1) Develop a masonry erection plan prior to beginning any structural masonry activities (see para 27-7.c).

(2) Establish a limited access zone whenever a masonry wall is being constructed. The limited access zone must:

(a) Equal the height of the wall plus four feet and run the entire length of the wall.

(b) Be established on the side of the wall which will be unscaffolded.

(c) Be restricted to entry by employees actively engaged in constructing the wall.

(d) Remain in place until the wall is adequately supported to prevent overturning and to prevent collapse unless the height of wall is over eight feet, in which case, a restricted access zone must be established according to paragraph 27-8.g.

(3) Establish a restricted zone whenever a masonry wall over 8’ is being constructed. The restricted zone is created to keep masons and other tradesmen away from a wall under construction when winds exceed critical velocities until the wall is completely tied into the rest of the structure. The restricted zone must:

(a) Be established on both sides of wall prior to the start of wall construction.

(b) Be equal to the height of the wall being constructed plus 4 feet (1.2 m) and must run the entire length of the wall plus 4 feet (1.2 m) beyond the ends of the wall.

(c) Be restricted to entry by individuals who have been trained to recognize the hazards associated with working inside the restricted zone and are actively engaged in constructing the wall.

(d) Be evacuated during the initial period of wall construction when wind speeds exceed 20 mph (32.1 km/h).

Note. The initial period is considered the period of time, not to exceed 24 hours, during which the masonry is being laid above its base or highest line of bracing, and at the end of which required bracing is installed.

(e) Be evacuated during the intermediate period of wall construction when wind speeds exceed 35 mph (56.3 km/h).

Note. The intermediate period is considered the period of time following the initial period but before the wall is connected to the elements that provide its final lateral support.

(f) Remain in place until the wall has obtained its final lateral support.

(g) For multi-story structures, a QP must determine the restricted zone.

(4) Adequately brace all masonry walls over 8 feet (2.4 m) in height to prevent overturning and to prevent collapse unless the wall is adequately supported so that it will not overturn or collapse. The bracing must remain in place until permanent supporting elements of the structure are in place.

(5) Repair or replace any damaged or weakened brace elements before work is permitted in the restricted zone in the vicinity of the damaged brace or weakened brace element.

(6) Repairs to damaged walls must be designed by a structural engineer, familiar with the work being performed, and approved by the designer of record before starting the repairs.

(7) Each employer having workers in the restricted zone must monitor the wind speed continuously while the work is in progress and evacuate employees when wind speeds exceed the requirements of paragraphs 27-8.g(3)(d) and 27-8.g(3)(e).

(a) Wind speeds must be 3-second gust speeds.

(b) Instrument methods must accurately measure wind speed to +/- 2 mph (+/- 3.2 km/h). Properly maintain the instruments.

(8) Do not use scaffolds intended for masonry construction workers to provide temporary lateral support of masonry walls.

(9) Locate cleanouts on the side of the masonry wall opposite to the scaffolding.

h. Roofing. (27-8.h)

(1) A QP must conduct a structural analysis of the roof to assure that the load capacity of the roof deck will not be exceeded prior to the start of work.

(2) Stop roof work during severe weather (for example, strong winds, electrical storms, icing conditions, heavy rain, snow) as soon as practical.

(3) Protect roof openings and holes according to chapters 21 and 24.

(4) On all roofs greater than 16 feet (4.9 m) in height, provide a hoisting device, stairways, or progressive platforms when supplying materials and equipment.

(5) Secure all roofing materials and accessories when wind speeds are greater than, or are anticipated to exceed, 10 mph (16.1 km/h). This includes unattached metal roofing panels stored on the roof.

(6) Provide access and egress to and on roofs or roof sections according to chapters 22 and 24, as applicable.

(7) Do not store materials within 6 feet (1.8 m) of the roof edge unless guardrails are erected at the roof edge. Materials that are to be piled, stacked, or grouped must be stable and self-supporting. (See chapters 14 and 19)

(8) Personnel working with hot roofing materials (for example, hot mop roofing bitumen, torch applied roofing membranes) must wear the proper PPE (see chapter 5).

i. Wood Construction. (27-8.i)

(1) All wood used for construction must meet applicable building codes and design criteria. Inspect wood used for temporary work platforms or fall protection for compliance with chapters 21 and 22, since structural lumber from the site may not meet the requirements for protective systems.

(2) Raising Walls.

(a) Before manually raising framed walls that are 10 feet (3 m) or higher, install temporary restraints (for example, cleats on the foundation or floor system, straps on the wall bottom plate) to prevent inadvertent horizontal sliding or uplift of the framed wall bottom plate.

(b) Do not use only anchor bolts for blocking or bracing when raising framed walls 10 feet (3 m) or higher.

(3) Do not allow employees to work from or walk on top plates, joists, rafters, trusses, beams, or other structural members until they are securely braced and supported.

(4) For wood type construction, an RPE must design the truss support plates, required spacing, temporary bracing, and connection details.

27-9. Figures and Tables.
Not Applicable.