1. **DESCRIPTION**

Fabricate precast prestressed and precast nonstressed concrete members. This Item, in conjunction with DMS-7300, “Precast Concrete Fabrication Plants,” applies to both multi-project and project-specific fabrication plants. For this Item, the following definitions apply:

- **Prestressing.** The introduction of internal stresses (pre-tensioning or post-tensioning) into a structural member by tensioning and anchoring strands, bars, or wires to counteract the stresses resulting from the applied load.
- **Pre-Tensioning.** The application of prestressing force to the tensioning devices before casting concrete.
- **Post-Tensioning.** The application of prestressing force to the tensioning devices after concrete has hardened.
- **Tendon.** Any single unit used to apply prestressing force to the member. For post-tensioned units, a tendon is a bar, group of wires, or group of strands with common end anchorage.
- **Multi-Project Fabrication Plant.** A facility at an offsite location that fabricates precast prestressed or precast nonstressed members. This definition also applies to single Contract offsite facilities.
- **Project-Specific Fabrication Plant.** A temporary facility at or near the project location that fabricates precast prestressed or precast nonstressed members for only one Contract. This definition may be applied to temporary facilities that fabricate for multiple Contracts, if approved.
- **Nonstressed Members.** Precast concrete members that have not been pre-tensioned or post-tensioned.
- **Prestressed Members.** Precast concrete members fabricated by the process of pre-tensioning, post-tensioning, or a combination of both methods.
- **Minor Prestressed Members.** Includes piling, bridge deck panels, and sound wall panels.
- **Major Prestressed Members.** Includes all other prestressed members not listed as minor prestressed members.
- **I-Beams.** For this specification all I-girders and bulb-tee beams are referred to as I-beams.
- **Self-Consolidating Concrete (SCC).** A highly workable concrete that can flow through densely reinforced or complex structural elements under its own weight and adequately fill voids without segregation or excessive bleeding without the need for vibration.
- **Temperature Probe.** Thermocouple for measuring concrete temperature or air temperature.
- **Temperature Recording Device.** Data logger for recording temperatures from the temperature probes.

2. **EQUIPMENT**

2.1. **Field Office and Inspection Laboratory.** Provide a field office and inspection laboratory for multi-project and project-specific fabrication plants in accordance with DMS-7300, “Precast Concrete Fabrication Plants.”

2.2. **Furnishings and Laboratory Equipment.** Provide furnishings and laboratory equipment for multi-project and project-specific fabrication plants in accordance with DMS-7300, “Precast Concrete Fabrication Plants.”

2.3. **Plant Facilities.** Provide plant facilities for multi-project and project-specific fabrication plants that produce prestressed members in accordance with DMS-7300, “Precast Concrete Fabrication Plants.”
2.4. **Batch Plant.** Provide batch plant onsite for SCC construction unless otherwise approved. Do not use volumetric mixers for SCC.

3. **MATERIALS**

Furnish materials in accordance with Item 425, “Precast Prestressed Concrete Structural Members,” and other pertinent Items.

4. **CONSTRUCTION**

4.1. **General Requirements.**

4.1.1. **Shop Drawings.** Prepare and electronically submit shop drawings before fabrication as documented in the *Guide to Electronic Shop Drawing Submittal* available on the Bridge Division website. Provide one complete approved 11 × 17-in. set in hardcopy to the Department inspector at the fabrication plant. Stamp it “For Construction Division Inspector.” The Engineer may require additional complete hardcopy sets.

Provide a title block on each sheet in the lower right corner with the following information:
- sheet index data shown on lower right corner of the project plans,
- sheet numbering for shop drawings,
- name of structure or stream,
- name of owner or developer,
- name of fabricator or supplier, and
- name of Contractor.

4.1.1.1. **Prestressed Members.** Furnish shop drawings for prestressed members unless otherwise shown on the plans or in other Items. Submit the proposed designs on forms furnished by the Department when optional designs are permitted by the plans. Obtain approval of these designs before casting. Approval of optional designs does not relieve the Contractor from the responsibility of furnishing a satisfactory completed structure. Provide submittals for precast post-tensioned members in accordance with this specification and Item 426, “Post-Tensioning.”

4.1.1.2. **Nonstressed Members.** Furnish shop drawings for nonstressed members when required by the plans or pertinent Items.

4.1.2. **Plant Approval.**

4.1.2.1. **Plant Submittals.** Provide submittals in accordance with DMS-7300, “Precast Concrete Fabrication Plants,” for each particular plant operation. This requirement does not apply to project-specific nonstressed member fabrication plants.

4.1.2.2. **Plant Audits.** Multi-project and project-specific fabrication plants must pass initial and periodic Department-directed plant audits in accordance with DMS-7300, “Precast Concrete Fabrication Plants.”

4.1.3. **Notice of Beginning Work.** Give adequate notice before beginning work as specified in Table 1. Include a schedule for all fabrication processes and dates when inspections are to occur.

<table>
<thead>
<tr>
<th>Plant Location</th>
<th>Notice Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Texas</td>
<td>7 days</td>
</tr>
<tr>
<td>In the contiguous United States</td>
<td>21 days</td>
</tr>
<tr>
<td>Outside the contiguous United States</td>
<td>60 days</td>
</tr>
</tbody>
</table>

Perform no Department work in the plant before the Engineer authorizes fabrication. The Contractor must bear all Department travel costs when changes to their fabrication or inspection schedules are not
adequately conveyed to the Department. When fabrication is performed outside of the contiguous 48 states, the additional cost of inspection will be in accordance with Article 6.4., “Sampling, Testing, and Inspection.”

4.1.4. **Personnel Qualifications.** Provide qualified personnel in accordance with DMS-7300, “Precast Concrete Fabrication Plants,” for each particular plant operation.

4.1.5. **Quality Responsibilities.** The quality responsibilities for the Contractor for each particular plant operation will be in accordance with DMS-7300, “Precast Concrete Fabrication Plants.”

4.2. **Fabrication.** Prepare a casting schedule on Department-approved forms per DMS-7300, “Precast Concrete Fabrication Plants,” and submit it daily to the Department before fabrication. This requirement does not apply to project-specific minor prestressed member or project-specific nonstressed member fabrication plants. Perform fabrication during daylight hours unless the production site has an approved lighting system. Submit lighting details electronically to the Engineer for review before installing lighting system. Allow for plant and Department inspection in accordance with Item 6, “Control of Materials.”

4.2.1. **Forms.** Design forms to prevent damage to the concrete from restraint as the concrete shrinks, from form expansion and contraction from thermal changes, from stripping operations, and from dimensional changes due to pre-tensioning. Forms, regardless of material, must conform to the profiles, dimensions, and tolerances of the finished product as specified on the plans and in this Item. Maintain forms free from dents, grease, or other foreign materials that may affect the appearance of the member, and clean forms thoroughly before each casting operation and immediately before applying a form-release agent.

4.2.1.1. **External Forms.** Construct side and bottom forms of steel unless otherwise approved or noted on the plans. Timber forms, when permitted, must meet the requirements of Section 420.4.4., “Forms.” End headers may be of other material as approved.

Construct forms with sufficient thickness, external bracing and stiffeners, and anchorage to withstand the forces generated during concrete placement and consolidation. Do not stabilize forms with bracing and holding devices that will remain in the finished member.

Provide corners with a chamfer or radius where shown on the plans.

Maintain forms sufficiently mortar-tight to prevent damage that requires repair to the finished product. Where sections of forms will be joined, an offset of 1/16 in. for flat surfaces and 1/8 in. for corners and bends is permitted. Longitudinal form joints in prestressed concrete beams are not permitted except for in the side forms of slab beams, decked slab beams, box beams, and X-beams or as shown on the plans. Do not allow vertical or horizontal gaps or offsets to exceed 1/4 in. between adjacent sections of built-up end headers.

Check the grade and alignment of forms each time they are set, and maintain them during placement of concrete.

Apply a form-release agent, in accordance with the manufacturer’s recommendations, to the facing of forms before placing concrete. Use a form-release agent that facilitates form removal and does not affect any required coating, painting, or color-staining operations. Do not use materials that appreciably stain or react with the concrete. Remove excess form-release agent from the form surface before casting, and ensure it does not contaminate strands, reinforcing steel, and embedments. Use a clear form-release agent of the same brand throughout the casting of retaining wall panels per structure, unless it can be shown that a different form-release agent does not change the appearance of the concrete.

Construct the forms to facilitate removal of members without damage to the concrete.

Construct and maintain the soffit (liner) to provide a maximum 1/4 in. variation from the theoretical plane, and do not allow the soffit to vary more than 1/4 in. between any 2 points in any 50-ft. length.
At the Contractor’s option, construct side forms for bridge deck panels and prestressed piling with a draft for ease of product removal. Maintain product dimensional tolerances per Table 3. A maximum 1/4 in. draft is allowed for bridge deck panels.

4.2.1.2. Internal Forms. Use solid expanded polystyrene conforming to ASTM C578 Type I for forming internal voids. The form material must be inert, non-biodegradable, non-absorptive, and strong enough to maintain sufficient rigidity to withstand the forces generated during concrete placement and consolidation without damage. Other materials for forming internal voids may be used when approved. Provide certification of conformance for void forms. The Engineer may require samples to be submitted when needed.

Anchor internal void forms to prevent movement or misalignment while placing concrete. Provide hold-down devices for all types of void forms at 30-in. maximum spacing unless otherwise approved. Do not use internal hold-down or lateral bracing devices that will remain in the finished member unless approved. Provide enough bearing area on the void form to prevent penetration of hold-down devices into the void form. Splice void form sections to prevent separation or misalignment during concrete placement and consolidation operations.

During casting, verify and document void form placement at 10-ft. maximum spacing using an approved method.

Vent void forms without solid cores to eliminate high air pressure caused by heat of hydration. Insert a 3/4-in. diameter plastic tube into the top of the void before placing concrete, and leave it in place until there is no possibility of damage from pressure. Remove the plastic tube afterwards and seal the hole with an approved repair material and procedure.

Drain prestressed concrete box beams and U-beams through the bottom flange by forming holes in each voided area as shown on the plans.

4.2.2. Prestressing. Perform pre-tensioning in accordance with this Item and post-tensioning in accordance with Item 426, “Post-Tensioning.”

4.2.2.1. Prestressing Equipment. Furnish hydraulic jacks with sufficient capacity for pre stressing the steel. Equip the jacks with instruments for monitoring the hydraulic pressure. Provide gauges at least 6 in. in diameter and with means to prevent the gauge pointer from fluctuating. Electronic pressure transducers with digital indicators may be used. Pressure gauges or electronic pressure indicators must indicate the load directly to 1% of the maximum gauge or sensor/indicator capacity or 2% of the maximum load applied, whichever is smaller.

Calibrate each jack and its gauge with the cylinder extension in the approximate position at final jacking force. Jacks and gauges for post-tensioning and single-strand pre-tensioning must be calibrated as a unit. Have certified calibration charts furnished by an independent laboratory and with each jack and gauge used on the project. Provide certified calibration of each ram before starting stressing operations on the project and:

- every 6 mo. thereafter for post-tensioning operations,
- every 12 mo. thereafter for pre-tensioning operations, and as requested by the Engineer.

The calibration frequency for multiple-strand pre-tensioning equipment may be extended to every 24 mo. thereafter if an approved master gauge system monitors it. The master gauge must check this equipment when suspect results occur and at least every 6 mo. Calibrate the master gauge per the manufacturer’s recommendations and at least every 12 mo.

Recalibrate jacks and gauges when a malfunction occurs, when repairs such as replacing the seals, changing the length of the hydraulic lines, or changing the pump occur, or when using gauges that have not been calibrated with the jack. Extra compensation will not be allowed for the initial or subsequent calibrations.
Post-tensioning jacks must have provisions for measuring tendon elongation directly on the strand, bar, or wire. The jacks must be capable of slow release of force to properly seat the tendon anchors.

Single-strand stressing jacks for pre-tensioning must have provisions for measuring the elongation directly on the strand.

Multi-strand detensioning jacks must have sufficient capacity and throw to permit simultaneous release of the entire load in the strands. Use an approved single-strand flame-release procedure to release the remaining load if there is not enough throw in the multi-strand jacks to release all load in the strands.

4.2.2.2. Pre-Tensioning. Pre-tension all strands to a uniform initial load between 5% and 25% of the final load unless otherwise approved. Apply the load within a tolerance of:

- ±100 lb. per strand if the designated initial load is less than or equal to 10% of the final load, or
- ±200 lb. per strand if the designated initial load is greater than 10% of the final load.

Measure the initial load with a calibrated dynamometer or other suitable equipment.

Do not allow the modulus of elasticity of individual strands to vary more than 1% from each other when multiple-strand tensioned. Use a weighted average modulus of elasticity of strands to calculate elongation for multiple-strand tensioning operations.

Establish reference marks on the strand for measuring elongation after initial tensioning. Provide means for measuring the elongation of the strand to an accuracy of 1% of the theoretical elongation or 1/8 in., whichever is smaller. Establish independent references on the strand adjacent to each anchorage, to indicate slippage that may occur between the time of initial stressing and final release of the strands.

Do not allow the stress in the strand to exceed 80% of the specified ultimate tensile strength of the strand at any time.

Do not use any portion of the strand that has been previously gripped with chucks in the length of strand to be tensioned, except where gripped with chucks during initial tensioning. Do not drive over prestressing strand.

Strand chucks designed with spring caps must be used with the spring caps. Visually inspect strand chucks that are not equipped with spring caps to ensure all wedges are evenly seated after applying initial load. Correct unevenly seated wedges by releasing the stress, repositioning wedges, and reapplying the initial load.

Failure of individual wires in a 7-wire strand is acceptable if the total area of wire failure is not more than 2% of the total cross-sectional area of all strands in the member, and if no more than 1 wire fails in any single strand. Any setup with one or more broken wires must be examined by a licensed professional engineer or Quality Control Supervisor (as defined in DMS-7300, "Precast Concrete Fabrication Plants," to determine the cause before continuing stressing operations on the particular casting line.

4.2.2.2.1. Strand Splicing. Do not splice draped strands. One splice per straight strand will be permitted subject to the following:

- Locate splices outside the members.
- Splice strands with the lay or twist in the same direction to avoid unraveling.
- Splice all straight strands in a multiple-strand tensioning operation so an adjustment can be made for the average seating loss.
- Cut strand ends to be spliced with shears, abrasive saws, or grinders to remove regions where chucks were previously seated. Cut in the same manner at least 12 in. from strand ends to be spliced that were previously flame cut.
4.2.2.2. **Single and Multiple Straight Strand Tensioning.** After initial tensioning, apply the required load to the strands as shown on the plans by means of single-strand or multiple-strand hydraulic jacks equipped with calibrated gauges. Verify the final load in the strands by observing either the gauge pressure or elongation and independently checking the other. The final load and elongation must agree within 5% of the computed theoretical values. Additionally, the final load and elongation must agree algebraically with each other within 5%. Suspend tensioning operations until the problem has been identified and corrected in the event of discrepancies greater than these tolerances.

Verify uniform application of load to strands for multiple-strand-tensioning systems by measuring the movement on opposite sides of the anchorage.

4.2.2.3. **Draped Strand Tensioning.** Verify the intermediate load by observing either the gauge pressure or elongation and independently checking the other when draped strands are tensioned in a straight or partially-draped position before application of final load. The intermediate or final load, if strands are tensioned in the final position and elongation must agree within 5% of the computed theoretical values. Additionally, the intermediate or final load and elongation must agree algebraically with each other within 5%. Suspend tensioning operations until the problem has been identified and corrected in the event of discrepancies greater than these tolerances.

After application of final load, measurements on individual draped strands to establish differential stresses at selected points on the member will be averaged at a cross-section of the member, and the averages must be within 5% of the theoretical elongation. The measured elongation of any individual draped strand must not vary from the theoretical elongation by more than 10% at any measured cross-section. Suspend tensioning operations until the problem has been identified and corrected in the event of discrepancies greater than these tolerances.

Other methods to measure the intermediate load and final load in the draped strands may be submitted for approval.

4.2.2.4. **Strand Debonding.** Encase strands in plastic sheathing along the entire debonded length, and seal the ends with waterproof tape when shown on the plans. Use split plastic sheathing only if the seam is sufficiently sealed with waterproof tape to prohibit grout infiltration. Do not use sheathing that will permanently alter the physical or chemical properties of the surrounding concrete.

Full-length debonding of straight strands will be approved on an individual basis. Full-length debonding, when permitted, must be symmetrical about the vertical centerline of the beam and limited to 10% of the total number of straight strands or 6 straight strands, whichever is less. Do not debond draped strands full length. When using a concrete anchor block to combined strand patterns the same criteria applies.

4.2.3. **Combined Pre-Tensioning and Post-Tensioning.** When the plans call for a combination of pre-tensioning and post-tensioning, all of the requirements for pre-tensioning in this specification and for post-tensioning in Item 426, “Post-Tensioning,” apply.

4.2.4. **Placing Reinforcing Steel.** Place reinforcing steel in accordance with Item 440, "Reinforcement for Concrete." Reinforcing steel projection outside of the member must not be more than 1/2 in. or less than 3/4 in. from plan dimension unless otherwise approved. Do not damage sheathing for strand debonding. Do not tie reinforcing steel to debonded strand regions.

Weld steel components in accordance with Item 448, “Structural Field Welding.” Provide welding procedure specifications (WPSs) for approval, and welding personnel certifications per the applicable AWS code.

4.2.4. **Quality of Concrete.** Provide concrete in accordance with Item 421, “Hydraulic Cement Concrete.” Use the class of concrete shown on the plans or in the pertinent Item for each type of structure or unit. Provide concrete meeting the approved mix design water-cement ratio. SCC is not allowed for project-specific fabrication plants unless approved by the Engineer. Mix concrete for a period of 1 min. for 1 cu. yd. and 15 sec. for each additional cu. yd. of rated capacity of the mixer. Count the mixing time from the time all materials are in the drum. Increase mixing time if necessary to achieve a uniform mix. Control concrete by
compressive strength tests of cylinders or other pertinent performance tests detailed on the plans or pertinent Items. Concrete compressive-strength test cylinders will be made, cured, and tested in accordance with Tex-704-I. Cure release-of-tension strength cylinders in accordance with Tex-715-I when match-cure technology is used.

High-strength concrete (f’c > 9,000 psi) is accepted based on 56-day compressive strength testing. Concrete design-strength test cylinders for high-strength concrete will be made, cured, and tested in accordance with Tex-704-I.

Product with concrete that fails to meet minimum design compressive strength requirements will be reviewed. Concrete that has been determined to be structurally adequate may be accepted at an adjusted price based on the formula in Article 421.6., “Measurement and Payment.” If the Engineer requires cores be taken to determine the strength of the in-situ concrete, the coring will be at the Contractor’s expense and in accordance with Tex-424-A. All cores from precast members must meet 100% of the minimum design compressive strength requirements. For concrete that has been determined to be structurally adequate, coring of the in-situ concrete will not be allowed for the purpose of avoiding the price adjustment. The Department may require reimbursement for testing of cores. Testing by an approved commercial testing laboratory will be at the Contractor’s expense. Test results from a commercial laboratory must be sealed by a licensed professional engineer.

SCC used for prestressed beams must have a Modulus of Elasticity of 5,000 ksi at 28 days. Test the concrete mix design before use in accordance with ASTM C469.

4.2.5. Placing Concrete. Place concrete only when its temperature at time of placement is between 50°F and 95°F.

Take responsibility for producing quality concrete under any weather condition and ensure adequate weather protection provisions are on-site and available for immediate use.

Provide immediate protective measures without compromising the quality of the product if rainfall occurs after concrete placing operations have started. Failure to immediately provide adequate weather protection may be cause for rejection of the affected product.

Maintain concrete transporting equipment clean and free from hardened concrete coatings.

At the time of concrete placement, reinforcing steel, strands, and embedments must be free of dirt, oil, or other bond-breaking substances.

Place and adequately consolidate concrete while all lifts are in a plastic state. Concrete must not exhibit segregation or excessive bleeding. Minimize concrete flow lines and displacement of the reinforcing steel, strands, embedments, and ducts during concrete placement. Concrete must not exhibit segregation or excessive bleeding.

Place concrete as near as possible to its final position in the forms except when using SCC. Do not deposit large quantities of concrete at one location and run or work it along the forms to other locations except for SCC. Place SCC in a manner to avoid segregation.

Do not allow fresh concrete to free-fall more than 8 ft. unless approved.

Work the coarse aggregate back from the face of the concrete, and force the concrete under and around the reinforcing steel, strands, embedments, and ducts. If prestressed concrete I-beams are cast in multiple lifts, the thickness of the first lift must be slightly above the juncture of the bottom flange and web.

Cast prestressed concrete box beams monolithically in 2 stages, maintaining the concrete in the previously placed bottom slab in a plastic state until the web (side wall) concrete is placed and vibrated into the bottom slab unless approved by the Engineer.
The maximum time between the addition of mixing water or cement to the concrete batch and the placing of concrete in the forms is 30 min. for concrete delivered in non-agitated delivery equipment and 60 min. for concrete delivered in agitated delivery equipment. If conditions of wind, humidity, and temperature cause quick stiffening of the concrete, the required placement times may be reduced and an approved retarder may be required, or increased if currently in use. Submit a plan for approval, if necessary, to demonstrate the concrete can be properly placed, consolidated, and finished without reducing placement time limits.

The maximum acceptable placement slump will be in accordance with Item 421, “Hydraulic Cement Concrete,” unless otherwise specified. When the maximum acceptable placement slump or slumpflow is exceeded, the affected concrete will be rejected and retesting for slump or slumpflow will not be allowed regardless of the concrete placement times.

Additional requirements for precast mass placements will be in accordance with Item 420, “Concrete Substructures.” In the case of a conflict between the 2 Items the more stringent requirements apply.

4.2.5.1. Placing Concrete in Cold Weather. Maintain concrete temperature between 50°F and 95°F at time of placement as specified in Section 424.4.2.5., “Placing Concrete,” and maintain the concrete temperature of precast members at or above 50°F during the specified curing period as specified in Section 424.4.2.7., “Curing of Concrete.” Do not place concrete when the atmospheric temperature in the shade is below 40°F and falling unless approved. Concrete may be placed when the atmospheric temperature in the shade is at least 35°F and rising or above 40°F, provided adequate cold-weather protection provisions are on-site and available for immediate use before placing concrete when weather conditions indicate a possible need for temperature protection. When required, provide necessary covering material or an approved accelerated curing system in accordance with Section 424.4.2.7.4., “Accelerated Curing,” and do not allow any concrete to remain unprotected for longer than 1 hr. after placement. Do not place concrete in contact with any material coated with frost or with material at a temperature of 32°F or lower. Do not apply heat directly to concrete surfaces if accelerated curing is used. Take protective measures to ensure the difference between air temperature and concrete surface temperature does not cause thermal cracking.

Maintain aggregates free from ice, frost, and frozen lumps. Heat the aggregate and the water when needed to produce the minimum concrete placement temperature of 50°F, but:

- do not allow the water temperature to exceed 180°F or the aggregate temperature to exceed 150°F,
- heat the aggregate uniformly to eliminate overheated areas in the stockpile that might cause flash set of the cement, and
- provide an aggregate and water mixture temperature between 50°F and 85°F before introduction of the cement.

4.2.5.2. Placing Concrete in Hot Weather. Keep concrete at or below 95°F at time of placement in accordance with Section 424.4.2.5., “Placing Concrete.” Use any of the following methods, as needed, to control the concrete placement temperature:

- Cool the aggregate by sprinkling or fogging (fine mist) with water, shading, or using an approved liquid nitrogen system and procedure.
- Cool the fresh concrete by using chilled mixing water, partially replacing mixing water with shaved or crushed ice, or using an approved system and procedure to discharge liquid nitrogen into concrete during batching.

Apply a fog spray (fine mist) of water to this steel just before placing concrete when the temperature of steel forms, strand, or reinforcing steel is greater than 120°F. Water droplets left on the form surfaces must not adversely affect surface finishes.

When field conditions are such that evaporation of water from the concrete makes the surface finishing operation difficult, a fog spray (fine mist) of water may be applied above the concrete surface. Do not fog directly toward the concrete or in any manner that will wash cement paste from the fresh concrete surface or cause water to puddle. Do not fog as a means to add finishing water and do not work moisture from the fog spray into the fresh concrete. An approved evaporation retardant conforming to DMS-4650, “Hydraulic
Cement Concrete Curing Materials and Evaporation Retardants, is also acceptable if used in accordance with the manufacturer’s recommendations. Do not apply the evaporation retardant when floating and troweling concrete. Do not allow it to puddle or be worked into the concrete surface immediately after application. Misuse of fog spray or evaporation retardant will be cause for disallowing its use. Shade the concrete during casting if necessary.

Use an approved retarder, in accordance with the manufacturer’s recommendations, when the air temperature is above 85°F if necessary to control concrete slump loss and lengthen the time for placing, consolidating, and finishing operations.

4.2.5.3. **Consolidation of Concrete.** Consolidate concrete thoroughly with high-frequency vibration immediately after placement. For prestressed concrete beams and piling, internal vibration is required and may be supplemented with external vibration.

Provide at least 1 on-site standby vibrator of the type being used for emergency use.

Perform concrete vibration using trained personnel and proper timing and spacing to ensure adequate consolidation. Revise the concrete placement and consolidation procedures, and review the concrete mix design and batching procedures, if necessary, when unacceptable defects such as excessive honeycombing, aggregate or mortar pockets or surface air voids (bugholes) are present. Provide supplemental vibrators or modify the vibration system when required to accomplish thorough consolidation of the concrete and complete embedment of the strands, reinforcing steel, embedments, or ducts. Avoid segregation or excessive bleeding of the concrete during vibration.

4.2.5.3.1. **Internal Vibration.** Insert vibrators into the concrete immediately after concrete placement at points spaced to ensure uniform vibration of the entire concrete mass. Limit the insertion spacing to within the radius where the vibrators are visibly effective. Allow the vibrators to sink into the concrete by their own weight and penetrate into previously placed lifts that are still in a plastic state to thoroughly consolidate the layers together and prevent cold joints. Withdraw the vibrators slowly to avoid forming holes after the concrete is thoroughly consolidated.

Do not allow prolonged contact of vibrators with forms so vibrator marks on concrete surfaces are minimal. Do not use vibrators to move concrete to other locations in the forms.

Use vibrators with nonmetallic vibrating heads to prevent damage to the epoxy coating when epoxy coated reinforcing steel is used. Increase the consolidation time and decrease the insertion spacing, if necessary, when using these vibrators.

4.2.5.3.2. **External Vibration.**

4.2.5.3.2.1. **Form Vibrators.** Form vibrators may be used to consolidate thin members, supplement internal vibration, or consolidate members with highly congested reinforcing steel.

Determine the size, number, and location of external vibrators to provide enough intensity of vibration to the desired area of the form. Adjust the spacing, frequency, amplitude, and duration of vibration according to the concrete mix and size of member to produce uniform consolidation of the concrete.

4.2.5.3.2.2. **Surface Vibrators.** Use vibratory screeds to consolidate thin sections. Move vibratory screeds at a rate that will bring enough mortar to the surface to embed and cover the coarse aggregate. Do not over vibrate by causing an excessive amount of mortar to be brought to the surface.

4.2.5.3.2.3. **Vibrating Tables.** Determine the size, number, and location of external vibrators to provide enough intensity of vibration to the desired area of the form. Adjust the spacing, frequency, amplitude, and duration of vibration according to the concrete mix and size of member to produce uniform consolidation of the concrete.
Vibration of Self-Consolidating Concrete (SCC). Vibrate SCC only when approved by the Engineer. Provide an adequate amount of viscosity modifying admixture (VMA) in SCC mix when internal vibration is allowed by the Engineer.

**Finishing of Concrete.** Finished, unformed surfaces must not have distortions greater than 1/4 in. Screed or rough-float unformed surfaces of members, bringing enough mortar to the surface to embed and cover the coarse aggregate. Provide a uniform rough wood float finish to the surface of the member unless otherwise shown on the plans. Do not loosen aggregate when roughening the surface with a broom or when providing a tine finish.

Provide a smooth metal trowel finish for surfaces at anchor bolt locations.

**Curing of Concrete.** Cure concrete to promote early cement hydration by providing adequate moisture on exposed surfaces and by maintaining the concrete temperature or curing enclosure air temperature at the concrete surface within the limits specified in this Section. Provide uniform temperature and moisture on the surfaces to prevent differential shrinkage that may cause warping or cracking. Prevent temperature differentials within the concrete that cause thermal cracking.

Begin curing after the finishing operation, before the formation of plastic shrinkage cracks, and as soon as damage to the surface finish will not occur. Provide fog spray or an evaporation retardant after finishing and before curing if needed to prevent plastic shrinkage cracks. Apply fog spray or evaporation retardant in accordance with Section 424.2.5.2., “Placing Concrete in Hot Weather.” Keep exposed concrete surfaces continuously wet for the duration of the specified curing period, unless an approved liquid membrane-forming curing compound is used. Membrane curing compound is only permitted as noted in this Section or in the pertinent Item.

Approved equipment and materials for curing must be on-site and available for immediate use before placing concrete. Provide temperature probes to monitor the concrete temperature or curing enclosure air temperature as specified in Table 2.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Major Prestressed Members</th>
<th>Minor Prestressed Members</th>
<th>Nonstressed Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecasted atmospheric temperature ( \geq 50^\circ F ) during specified curing period</td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions(^5)</td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions(^1,5)</td>
<td>N/A</td>
</tr>
<tr>
<td>Forecasted atmospheric temperature (&lt; 50^\circ F ) during specified curing period</td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions,(^5) and 2 concrete temperature probes per casting line to monitor low concrete temperature regions(^2,5)</td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions,(^1,5) and 2 concrete temperature probes per casting line to monitor low concrete temperature regions(^2,5)</td>
<td>1 concrete temperature probe per 100 cubic yards of concrete or fraction thereof to monitor low concrete temperature regions(^2)</td>
</tr>
<tr>
<td>Forecasted atmospheric temperature (&lt; 40^\circ F ) during additional 3-day curing period(^2)</td>
<td>N/A</td>
<td>1 concrete temperature probe per similar curing condition for prestressed piling only</td>
<td>N/A</td>
</tr>
<tr>
<td>When accelerated curing is used</td>
<td>2 temperature probes per casting line to monitor curing enclosure air temperature at concrete surfaces(^4,5)</td>
<td>2 temperature probes per casting line to monitor curing enclosure air temperature at concrete surfaces(^5)</td>
<td>1 temperature probe per 100 cubic yards of concrete or fraction thereof to monitor curing enclosure air temperature at concrete surfaces</td>
</tr>
</tbody>
</table>

1. Excluding prestressed bridge deck panels and prestressed retaining wall panels.
2. When accelerated curing is used, concrete temperature probes to monitor low concrete temperature regions are not required.
3. After attaining specified release-of-tension strength.
4. These probes are in addition to the concrete temperature probes required for monitoring high concrete temperature regions.
5. Place probes at the beginning and end of casting line.
Attach each temperature probe to a separate temperature recording device unless multi-channel temperature recording devices are used, in which case 1 high concrete temperature probe and 1 low concrete temperature probe may be attached to the same recording device. When accelerated curing is used, 1 curing enclosure air temperature probe may also be attached to this multi-channel temperature recording device.

Inadequate curing facilities or lack of attention to the proper curing of concrete will be cause for the Engineer to stop concrete placement until approved curing is provided. Inadequate curing may be cause for rejection of the affected product.

Forms may be removed at the discretion of the Contractor at any time after the concrete has reached sufficient strength to prevent physical damage to the member. Do not interrupt curing for more than 60 min. during form removal.

The following curing requirements apply for prestressed members:

- Cure concrete continuously, except as allowed during form removal, until the compressive strength of the concrete has reached the specified release-of-tension strength and until detensioning has been performed.
- Maintain concrete temperatures between 50°F and 150°F during the curing period. The maximum allowable concrete temperature may be increased to 170°F if the Contractor uses one of the concrete mix design options listed in Section 421.4.2.6., “Mix Design Options,” other than options 6, 7, and 8. The Engineer may require lowering of the total cementitious content in the concrete mix design to the limits specified in Item 421, “Hydraulic Cement Concrete,” for repeated violations of the maximum curing temperature.
- Membrane curing is permitted only for unformed surfaces of prestressed wall panels and interim curing on unformed surfaces of prestressed piling. Use Type 1-D or Type 2 curing compound conforming to DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants,” for this application.
- Water cure prestressed piling an additional 3 days after attaining the specified release-of-tension strength. Do not interrupt curing for more than 4 hr. when moving piling to the storage area. Maintain the concrete temperature of piling at 50°F or above during this additional curing period.

The following curing requirements apply for nonstressed members:

- Cure concrete continuously, except as allowed during form removal, for 4 days or until the compressive strength of the concrete has reached the design strength.
- Maintain concrete temperatures between 50°F and 150°F during the curing period. The maximum allowable concrete temperature may be increased to 170°F if the Contractor uses one of the concrete mix design options listed in Section 421.4.2.6., “Mix Design Options,” other than options 6, 7, and 8.
- Membrane curing is permitted on nonstressed members, except for surfaces to be painted or color-stained.

Cure members for an additional 24 hr. beginning immediately after the normal curing period if they are out of cure at any time other than during the allowable 60 min. for form removal or during the allowable 4 hr. for moving piling to storage.

Members failing to meet the concrete temperature requirements or curing enclosure air temperature requirements during curing will be reviewed. Repeated failure to maintain proper concrete temperatures may be cause for rejection of the affected product.

**Water Curing.** Water curing provides additional moisture to concrete and prevents moisture loss. Water used for curing must meet the requirements for concrete mixing and curing water specified in Section 421.2.5., “Water.” Do not use seawater or water that stains or leaves an unsightly residue that cannot be removed. Monitor and maintain a temperature differential between curing water and concrete surface temperature that prevents thermal cracking.
4.2.7.1.1. **Wet Mat Method.** Use water-saturated cotton mats, burlap, burlap-polyethylene sheeting, or other approved moisture-retaining materials. Anchor the wet mats adequately to provide continuous contact with exposed concrete surfaces.

4.2.7.1.2. **Water Spray Method.** Use overlapping sprays, sprinklers, or soil-soaker hoses so concrete surfaces are kept continuously wet.

4.2.7.1.3. **Ponding Method.** Use an approved retarder when the air temperature is above 85°F in accordance with the manufacturer’s recommendations if necessary to control concrete slump loss and lengthen the time for placing, consolidating, and finishing operations.

4.2.7.2. **Moisture Retention Curing.** Moisture retention curing prevents moisture loss from the concrete.

4.2.7.2.1. **Form Curing Method.** Concrete surfaces in direct contact with forms that are left in place will not require additional curing methods unless cold-weather protection is necessary.

4.2.7.2.2. **Impermeable Cover Method.** Cover exposed concrete surfaces with polyethylene sheeting, burlap-polyethylene sheeting, impervious paper, or other approved impermeable materials placed in close contact with concrete surfaces to keep them continuously wet. Provide additional moisture inside the enclosure in accordance with Section 424.4.2.7.1., “Water Curing,” if this is not enough to keep exposed concrete surfaces continuously wet.

4.2.7.3. **Membrane Curing.** Liquid membrane-forming curing compound is a moisture retention covering that is applied as a liquid. It is only permitted as noted in Section 424.4.2.7.7., “Curing of Concrete.”

Use Type 1-D or Type 2 membrane curing compound in accordance with DMS-4650, *Hydraulic Cement Concrete Curing Materials and Evaporation Retardants.* Apply membrane curing compound with equipment and in a manner specified in Section 420.3.5., “Spraying Equipment,” and Section 420.4.10.3., “Membrane Curing,” respectively.

Do not contaminate reinforcing steel, embedments, or concrete surfaces that will later be in direct contact with cast-in-place concrete unless the curing compound can be completely removed to the satisfaction of the Engineer when applying membrane curing compound.

Use membrane curing compounds that do not appreciably stain the concrete.

4.2.7.4. **Accelerated Curing.** Accelerated curing is defined as curing with artificial heat provided to the curing enclosure or forms.

Test accelerated-curing facilities for a minimum of 48 hr. to demonstrate temperature variations do not exceed 20°F between any points in the curing enclosure. Submit accelerated curing facility drawings and test results, and obtain approval before using these facilities for Department work. The test may be performed on the entire casting line with either freshly cast concrete inside the forms or with empty forms. Provide 1 curing enclosure air temperature probe per 100 feet of casting line when accelerated curing facilities are being tested.

Maintain the air temperature in the curing enclosure between 50°F and 85°F until initial set of the concrete (as determined in accordance with Tex-440-A when establishing mix designs under representative temperature conditions) and for at least 3 hr. after concrete placement. The concrete temperature may then be raised uniformly at a maximum rate of 36°F per hour. Provide an unobstructed air space of at least 6 in. between surfaces of the concrete and the curing jacket.

Monitor and maintain the curing enclosure air temperature between 50°F and 160°F during accelerated curing for prestressed and nonstressed concrete members. Do not allow the air temperature to exceed 160°F for more than 1 cumulative hour during the entire curing period. Do not allow the air temperature to exceed 170°F at any time during the specified curing period. Arrange the location of the heat discharge into
the curing enclosure so temperature variations do not exceed 20°F between any points in the curing enclosure.

Provide curing enclosure air temperature probes to monitor the temperature at the concrete surface as specified in Table 2.

Provide enough moisture inside the curing enclosure to keep exposed concrete surfaces continuously wet for the specified curing period.

Provide other acceptable curing methods for the remaining curing period if accelerated curing is terminated before the specified curing period has elapsed.

4.2.7.4.1. **Steam Curing.** Steam cure in accordance with the requirements of accelerated curing. Position steam outlets so live steam is not applied directly on the concrete, forms, or test cylinders.

4.2.7.4.2. **Alternate Methods.** Other methods of accelerated curing, such as the use of radiant heaters or portable heater, may be permitted if they meet the requirements of accelerated curing. The use of any alternate method requires written approval.

4.2.8. **Detensioning.** Release the tension in the strands after concrete strength requirements are met using a sequence to minimize premature wire breakage or shock and damage to the concrete members. Release strands by multiple-strand detensioning or single-strand flame detensioning. Ensure strands are not released individually with single-strand jacks.

Flame-release each strand simultaneously at both ends of the casting bed, using a symmetrical sequence prepared by a licensed professional engineer if strands are released individually. Heat the strands over an approved strand length and duration when flame detensioning so that the metal slowly elongates and gradually loses strength. Do not abruptly flame-cut strand by holding the heat source in a concentrated location on the strand. Submit the flame-release procedures and sequences for approval. Approval of flame-release sequences does not relieve the Contractor from responsibility for meeting the product workmanship requirements of Section 424.4.3., “Workmanship.”

Release the tension in the strand hold-down anchor slowly to minimize shock and damage to the concrete member when draped strands are used. Heat the anchor until the metal slowly elongates and gradually loses strength if heat is used to release the hold-down anchor. Provide positive external hold-downs to offset the vertical forces in the members when the sum of the hold-down forces is greater than half the weight of the member or for any amount of vertical force that has previously caused cracking. External hold-downs are to remain on each member until detensioning has been complete.

4.3. **Workmanship.** Formed surfaces must not have excessive surface honeycombing, aggregate or mortar pockets, air voids, lift lines, stains, or vibrator marks. Remove form-joint-offset marks in excess of the tolerances specified in Section 424.4.2.1.1., “External Forms,” and fins and rough edges along chamfer lines, in a manner that will not damage the member. Repair fabrication holes, except box beam and U-beam drain holes, with an approved repair material and procedure.

Recess strands in accordance with the *Concrete Repair Manual* unless otherwise shown on the plans. Submit for approval any other moisture-barrier systems for protecting strands.

Before shipment of members, remove:
- concrete, paste, dirt, oil, or other bond-breaking substances from exposed reinforcing steel, and
- laitance, dirt, oil, or other bond-breaking substances from concrete surfaces to be in contact with cast-in-place concrete.

4.3.1. **Defects and Breakage.** Members that sustain damage or surface defects during fabrication, handling, storage, hauling, or erection are subject to review. Evaluate and repair members in accordance with the *Concrete Repair Manual*. Submit proposed deficiencies in accordance with the Department’s NCR guidelines.
and obtain approval before performing repairs. Repair work must reestablish the member’s structural integrity, durability, and aesthetics to the satisfaction of the Engineer.

When deficiencies occur, determine the cause and take immediate corrective action. Failure to take corrective action, leading to similar repetitive deficiencies, could be cause for rejection of members.

Cracks that extend to the nearest reinforcement plane and fine surface cracks that do not extend to the nearest reinforcement plane, but are numerous or extensive, are subject to review.

Cracks in prestressed members that tend to close upon transfer of stress to the concrete are acceptable. Cracks that do not tend to close are subject to review.

Seal cracks in I-beam ends exceeding 0.005 in. in width as directed. The fabricator must decrease the spacing of Bars R and S in I-beam by providing additional bars to help limit crack width. No less than 1 in. clearance between bars will be permitted. The fabricator must take approved corrective actions if cracks greater than 0.005 in. form. All work, material, and engineering related to these cracks will be at the Contractor’s expense.

Prestressed bridge deck panels will be rejected for any of the following conditions:

- any crack extending to the reinforcing plane and running parallel and within 1 in. of a strand for at least 1/3 of the embedded strand length; or
- any transverse or diagonal crack, including corner cracks and breaks, intersecting at least 2 adjacent strands and extending to the reinforcing plane.

Prestressed bridge deck panels that sustain damage, cracks not listed above, or surface defects during fabrication, handling, storage, hauling, or erection are subject to review.

4.3.2. Tolerances.

4.3.2.1. Prestressed Members. Allowable tolerances for the dimensions and configurations shown on the plans or approved shop drawings are shown in Table 3.

Variations greater than those specified in Table 3 are subject to review. However, these tolerances do not relieve the Contractor from the responsibility of furnishing a completed structure that is in reasonably close conformity with the lines, grades, cross-sections, dimensions, and details specified. Correct members not meeting these tolerances at no additional expense to the Department, to achieve a satisfactory completed structure. This also includes costs for correction due to variations in vertical beam camber. Correction may require replacement of the member.

Horizontal misalignment (sweep) in beams, which may increase at a later time and exceed the tolerance shown in Table 3, may be acceptable if the members can be hauled, erected, and aligned to within the allowable tolerance without being damaged. Store these members in a manner that will minimize the sweep.

Embedments must be firmly held in proper position to avoid movement during concrete placement. Place embedments in accordance with the manufacturer’s recommendations. Place weld clip inserts for permanent metal deck forming no more than 1/16 in. from the beam edge.
## Table 3
### Allowable Tolerances for Prestressed Members

<table>
<thead>
<tr>
<th>Dimension</th>
<th>I-beams</th>
<th>U-beams</th>
<th>Box and Slab</th>
<th>Double-T Beams</th>
<th>Bridge Deck Panels</th>
<th>Piling</th>
<th>Wall Panels¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (perpendicular to strands for bridge deck panels)</td>
<td>±1&quot;</td>
<td>±1&quot;</td>
<td>±1&quot;</td>
<td>±3/4&quot;</td>
<td>±1/2&quot;</td>
<td>−1&quot;</td>
<td>±3/16&quot;</td>
</tr>
<tr>
<td>Width (parallel to strands for bridge deck panels)</td>
<td>+3/4&quot;−1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±3/16&quot;</td>
</tr>
<tr>
<td>Nominal depth (thickness in case of panels)</td>
<td>+1/2&quot;−1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>+1/4&quot;−1/8&quot;</td>
<td>±1/4&quot;</td>
<td>±3/16&quot;</td>
</tr>
<tr>
<td>Thickness: top slab or flange</td>
<td>+1/2&quot;−1/4&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Thickness: bottom slab or flange</td>
<td>+1/2&quot;−1/4&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Thickness: web or wall</td>
<td>+3/4&quot;−1/4&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±1/4&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Horizontal alignment (deviation from straightness of all panel edges)</td>
<td>±1/8&quot; per 10' of length</td>
<td>±1/8&quot; per 10' of length, 3/4&quot; Max</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/8&quot;</td>
<td>±1/8&quot; per 10' of length, 1/2&quot; Max</td>
<td>NA</td>
</tr>
<tr>
<td>Deviation of ends (horizontal batter)</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±1/8&quot;</td>
<td>±1/4&quot; per 5&quot; of width, 1/2&quot; Max</td>
</tr>
<tr>
<td>Deviation of ends (vertical batter)</td>
<td>±1/2&quot;±1/4&quot;</td>
<td>±1/2&quot;±1/4&quot;</td>
<td>±1/2&quot;</td>
<td>NA</td>
<td>±1/8&quot;</td>
<td>NA</td>
<td>±1/4&quot;</td>
</tr>
<tr>
<td>Notched end areas (for diaphragms): depth</td>
<td>±1/4&quot;</td>
<td>NA</td>
<td>±1/4&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Notched end areas (for diaphragms): length</td>
<td>±2&quot;−1&quot;</td>
<td>NA</td>
<td>±2&quot;−1&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Bearing surfaces: perpendicular to vertical axis</td>
<td>±1/8&quot;</td>
<td>NA</td>
<td>NA</td>
<td>±1/16&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Bearing surfaces: deviation from plane</td>
<td>±1/16&quot;</td>
<td>±1/8&quot;</td>
<td>±1/8&quot;</td>
<td>±1/16&quot;</td>
<td>NA</td>
<td>NA</td>
<td>±1/16&quot;</td>
</tr>
<tr>
<td>Anchor hole location: from end of member</td>
<td>+3/4&quot;−1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±3/4&quot;−1/4&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Anchor hole location: longitudinal spacing</td>
<td>±3/4&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>±3/4&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Anchor hole location: transverse location</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Diaphragm or lateral tie location</td>
<td>±1/2&quot;</td>
<td>NA</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Position of internal void form (longitudinal for box beams and U-beams)</td>
<td>NA</td>
<td>±1&quot;</td>
<td>±1&quot;±1/4&quot;</td>
<td>NA</td>
<td>NA</td>
<td>±1/2&quot;</td>
<td>NA</td>
</tr>
<tr>
<td>Projection of reinforcing steel outside of member</td>
<td>+1/2&quot;−3/4&quot;</td>
<td>+1/2&quot;−3/4&quot;</td>
<td>+1/2&quot;−3/4&quot;</td>
<td>+1/2&quot;−3/4&quot;</td>
<td>NA</td>
<td>±1/2&quot;−3/4&quot;</td>
<td>NA</td>
</tr>
<tr>
<td>Position of strands: vertical</td>
<td>±1/4&quot;±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/8&quot;−1/4&quot;</td>
<td>NA</td>
<td>±1/4&quot;</td>
<td>±1/8&quot;</td>
</tr>
<tr>
<td>Position of strands: horizontal</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/2&quot;</td>
<td>±1/2&quot;</td>
</tr>
<tr>
<td>Debonded length of strands</td>
<td>±3&quot;</td>
<td>±3&quot;</td>
<td>±3&quot;</td>
<td>±3&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Position of strand hold-down points</td>
<td>±6&quot;</td>
<td>±6&quot;</td>
<td>±6&quot;</td>
<td>±6&quot;</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Position of handling devices: parallel to length</td>
<td>±6&quot;</td>
<td>±6&quot;</td>
<td>±6&quot;</td>
<td>±6&quot;</td>
<td>As shown on the plans</td>
<td>±6&quot;</td>
<td>±6&quot;</td>
</tr>
<tr>
<td>Position of handling devices: transverse to length</td>
<td>±1&quot;</td>
<td>±1&quot;</td>
<td>±1&quot;</td>
<td>±1&quot;</td>
<td>As shown on the plans</td>
<td>±1&quot;</td>
<td>±1&quot;</td>
</tr>
<tr>
<td>Local flatness of formed surfaces (excluding bearing surface)</td>
<td>±1/4&quot; in 10'</td>
<td>±1/4&quot; in 10'</td>
<td>±1/4&quot; in 10'</td>
<td>±1/4&quot; in 10'</td>
<td>±1/4&quot; in 10'</td>
<td>±1/4&quot; in 10'</td>
<td>±1/4&quot; in 10'</td>
</tr>
<tr>
<td>Bow (length and width)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>±1/4&quot; per 10'</td>
</tr>
</tbody>
</table>

1. Prestressed and nonstressed wall panels (tie back, C-wall, sound wall, etc.) except MSE wall panels.
2. Maximum length as approved.
3. Measured along the panel depth at the top and bottom panel sides.
4. Voided box beams only.
5. Length of box beam internal void form +1 in. to −6 in.
6. For draped strands, the tolerance for vertical position of strands at the end of the beam may be increased to ±1/2 in. provided the tested concrete compressive strength, before release of tension into the member, is at least 5% greater than the release-of-tension strength shown on the plans.
7. Measured from bottom of panel.
8. 3/4 in. maximum for beams exceeding a height of 54 in.
4.3.2.2. **Nonstressed Members.** The allowable tolerances for nonstressed members are as specified in Table 4 unless otherwise shown on the plans. The allowable tolerances for nonstressed wall panels, except MSE wall panels, are as specified in Table 3.

<table>
<thead>
<tr>
<th>Member</th>
<th>Dimension</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE wall panels and wall components (coping, posts, etc.)</td>
<td>All dimensions (including deviation from edge straightness)</td>
<td>±3/16 in.</td>
</tr>
<tr>
<td></td>
<td>Deviation of ends (horizontal skew)</td>
<td>±1/4 in. in 5 ft., ±1/2 in. Max</td>
</tr>
<tr>
<td></td>
<td>Local flatness of formed surfaces</td>
<td>±1/8 in. in 5 ft.</td>
</tr>
<tr>
<td></td>
<td>Connection hardware</td>
<td>±1/2 in.</td>
</tr>
</tbody>
</table>

1. Includes wall components for tie-back walls, C-walls, sound walls, etc.

4.4. **Storage and Handling.** Mark members for identification immediately after form removal as shown on approved shop drawings in accordance with the requirements of the pertinent Items or as required. Do not change any identification markings or transfer material to other projects without approval from the Engineer. Inspect members immediately before shipping to the jobsite for damage that may have occurred in storage. Store and handle prestressed and nonstressed members in accordance with Item 425, “Precast Prestressed Concrete Structural Members.”

5. **MEASUREMENT AND PAYMENT**

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to bid items of the Contract.