424.1. 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:

- **Prestressed Members.** Precast concrete members fabricated by the process of pretensioning or post-tensioning or a combination of both methods.
- **Nonstressed Members.** Precast concrete members that have not been pretensioned or post-tensioned.
- **Multi-Project Fabrication Plant.** A facility at an offsite location that fabricates precast prestressed or precast nonstressed members for more than one Contract.
- **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.
- **Major Prestressed Members.** Includes I-beams, bulb-tee beams, U-beams, and box beams (voided).
- **Minor Prestressed Members.** Includes all other prestressed members not listed as major prestressed members.
- **Temperature Probe.** Thermocouple for measuring concrete temperature or air temperature.
- **Temperature Recording Device.** Data logger for recording temperatures from the temperature probes.

424.2. Equipment.

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

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

C. **Plant Facilities.** For multi-project and project-specific fabrication plants that produce prestressed members, provide plant facilities in accordance with DMS-7300, “Precast Concrete Fabrication Plants.”

424.3. Construction.

A. **General Requirements.**

1. **Shop Drawings.**
   a. **Prestressed Members.** When optional designs are permitted by the plans, submit the proposed designs on forms furnished by the Department. 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.

      Unless otherwise shown on the plans or in other Items, furnish shop drawings for prestressed members. Prepare clear and legible shop drawings on 11 × 17 in. sheets. At the left end, provide a 1-in. margin, with the other margins 1/2-in. wide. 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 fabricator, and
      - name of Contractor.

      Submit 7 complete sets of shop drawings to the Engineer. Submit 1 additional copy of each sheet if the owner is a non-Department entity such as a railroad or a municipal or turnpike authority, and another copy if the designer is a private consultant. The Engineer may require
additional sets. Provide submittals for precast post-tensioned members in accordance with Section 426.4.A, “Required Submittals.”

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

2. **Plant Approval.**
   a. **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.
   b. **Plant Audits.** Multi-project and project-specific fabrication plants that produce major prestressed members must pass initial and periodic Department-directed plant audits in accordance with DMS-7300, “Precast Concrete Fabrication Plants.”

3. **Notice of Beginning Work.** Give adequate notice before beginning work as specified in Table 1.

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

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.”

B. **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.

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 pretensioning. 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.
   a. **External Forms.** Construct side and bottom forms of steel unless otherwise approved or noted on the plans. Wood forms, when permitted, must meet the requirements of Section 420.4.D, “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. 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 that 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 prestressed bridge deck panels with a 1/8-in. draft for ease of product removal.

b. **Internal Forms.** Use solid expanded polystyrene conforming to ASTM C 578 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.

2. **Prestressing.** Perform prestressing in accordance with Item 426, “Prestressing.” Place post-tensioning ducts in accordance with Item 426 and keep ducts free of obstructions.

3. **Placing Reinforcing Steel.** Place reinforcing steel in accordance with Item 440, “Reinforcing Steel.” 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.

4. **Quality of Concrete.** Provide concrete in accordance with Item 421, “Hydraulic Cement Concrete,” except that air-entrained concrete will not be required in precast concrete members unless otherwise shown on the plans. For each type of structure or unit, use the class of concrete shown on the plans or in the pertinent Item. When optional designs are permitted, the minimum concrete strength is as shown on the approved shop drawings.

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 ($f_{c'} > 9000$ 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. However, a maximum of 10 design-strength cylinders are permitted.

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 420.6, “Payment.” If the Engineer requires that cores be taken to determine the strength of the in-situ concrete, the coring will be at the Contractor’s expense and will be in accordance with Tex-424-A. 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.

5. Placing Concrete. Place concrete during daylight hours unless the production site has an approved lighting system.

Place concrete only when its temperature at time of placement is between 50°F and 95°F. Under any weather condition, the Contractor is responsible for producing quality concrete and must have adequate weather protection provisions on-site and available for immediate use. If rainfall occurs after concrete placing operations have started, immediately provide protective measures without compromising the quality of the product. 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 it is in a plastic state, which is before the concrete attains initial set as determined in accordance with Tex-440-A. When it is necessary to determine initial set time, including for concrete mix design trial batches per the Department work plan guidelines, perform the test in a manner representative of the concrete temperature at the time of placement.

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.

Place concrete as near as possible to its final position in the forms. Do not deposit large quantities of concrete at one location and run or work it along the forms to other locations. Do not allow fresh concrete to free-fall more than 5 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.

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 minutes for concrete delivered in non-agitated delivery equipment and 60 minutes 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. Submit a plan for approval, if necessary, to demonstrate that the concrete can be properly placed, consolidated, and finished without reducing placement time limits.

Unless otherwise specified, the maximum acceptable placement slump will be in accordance with Section 421.4-A.5, “Slump.” When the maximum acceptable placement slump is exceeded, the
affected concrete will be rejected and re-slumping will not be allowed regardless of the concrete placement times.

Requirements for precast mass placements will be in accordance with Section 420.4.G.14, “Mass Placements.”

a. **Placing Concrete in Cold Weather.** Maintain concrete temperature between 50°F and 95°F at time of placement as specified in Section 424.3.B.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 424.3.B.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 that 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 424.3.B.7.d, “Accelerated Curing,” and do not allow any concrete to remain unprotected for longer than 1 hour 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. If accelerated curing is used, do not apply heat directly to concrete surfaces. Take protective measures to ensure that the difference between air temperature and concrete surface temperature does not cause thermal cracking. Maintain aggregates free from ice, frost, and frozen lumps. When needed to produce the minimum concrete placement temperature of 50°F, heat the aggregate and the water, 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.

b. **Placing Concrete in Hot Weather.** Keep concrete at or below 95°F at time of placement in accordance with Section 424.3.B.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.

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

Place concrete without exceeding the design water-cement ratio. 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. If necessary, shade the concrete during casting.

When the air temperature is above 85°F, use an approved retarder, in accordance with the manufacturer’s recommendations, if necessary to control concrete slump loss and lengthen the time for placing, consolidating, and finishing operations.
c. **Consolidation of Concrete.** Thoroughly consolidate concrete with high-frequency vibration immediately after placement. For prestressed concrete beams and piling, internal vibration is required and may be supplemented with external vibration.

For emergency use, provide at least 1 on-site standby vibrator of the type being used. 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.

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 to penetrate into previously placed lifts that are still in a plastic state in order to thoroughly consolidate the layers together and prevent cold joints. After the concrete is thoroughly consolidated, withdraw the vibrators slowly to avoid forming holes.

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

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

2. **External Vibration.**
   
   a. **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.

   b. **Surface Vibrators.** Vibratory screeds may be used 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 overvibrate by causing an excessive amount of mortar to be brought to the surface.

   c. **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.

6. **Finishing of Concrete.** Finished, unformed surfaces must not have distortions greater than 1/4 in.

   a. **Prestressed Members.** Screed or rough-float unformed surfaces of prestressed members and bridge deck panels by bringing enough mortar to the surface to embed and cover the coarse aggregate.

   Provide a uniform rough wood float finish for the top surface of box beams and slab beams with exposed reinforcing steel, I-beams, bulb-tee beams, and U-beams.

   Provide tine finish of approximately 1/16-in. amplitude or a stiff broom finish for the top surface of box beams and slab beams without exposed reinforcing steel, bridge deck panels, and double-T beams.

   Do not loosen aggregate when roughening the surface with a broom or tine finish.
Provide a smooth metal trowel finish for surfaces at anchor bolt locations.

Strike off the top surface of prestressed concrete piling, and finish it with a wood or magnesium float by bringing enough mortar to the surface to cover the aggregate and providing a reasonably smooth appearance.

b. Nonstressed Members. Screed or rough-float unformed surfaces by bringing enough mortar to the surface to embed and cover the coarse aggregate. Provide a uniform rough wood float finish to the surface unless otherwise shown on the plans.

7. Curing of Concrete. To promote early cement hydration, cure concrete 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. If needed to prevent plastic shrinkage cracks, provide fog spray or an evaporation retardant after finishing and before curing. Apply fog spray or evaporation retardant in accordance with Section 424.3.B.5.b, “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.

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 30 minutes 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.A.6, “Mix Design Options,” other than options 6, 7, and 8.
- Membrane curing is permitted only for unformed surfaces of prestressed wall panels and for 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 hours when moving piling to the

<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 ≥ 50°F during specified curing period</td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions</td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions, and 2 concrete temperature probes per casting line to monitor low concrete temperature regions</td>
<td>2 concrete temperature probes per casting line to monitor high concrete temperature regions, and 2 concrete temperature probes per casting line to monitor low concrete temperature regions</td>
<td>1 concrete temperature probe per 100 cu. yd. of concrete or fraction thereof to monitor low concrete temperature regions</td>
</tr>
<tr>
<td>Forecasted atmospheric temperature &lt; 50°F during specified curing period</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>Forecasted atmospheric temperature &lt; 40°F during additional 3-day curing period</td>
<td>2 temperature probes per casting line to monitor curing enclosure air temperature at concrete surfaces</td>
<td>2 temperature probes per casting line to monitor curing enclosure air temperature at concrete surfaces</td>
<td>1 temperature probe per 100 cu. yd. 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.
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.A.6, other than options 6, 7, and 8.
- Membrane curing is permitted on nonstressed members, except for surfaces to be painted or color-stained.

Cure precast prestressed and precast nonstressed substructure members, excluding piling, in accordance with Section 420.4.J, “Curing Concrete.”

Cure members immediately for an additional 24 hours if they are out of cure at any time other than during the allowable 30 minutes for form removal or during the allowable 4 hours 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.

**a. 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.D, “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.

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.

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

3. **Ponding Method.** Continuously cover the exposed concrete surfaces with standing water.

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

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.

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. If this is not enough to keep exposed concrete surfaces continuously wet, then provide additional moisture inside the enclosure in accordance with Section 424.3.B.7.a, “Water Curing.”

**c. 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 424.3.B.7, “Curing of Concrete.”

Use Type 1-D or Type 2 membrane curing compound conforming to 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.H, “Spraying Equipment,” and Section 420.4.J.3, “Membrane Curing,” respectively.

When applying membrane curing compound, 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.

Do not use membrane curing compounds that appreciably stain the concrete.

d. **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 hours to demonstrate that 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 ft. 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 hours 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.

For prestressed and nonstressed concrete members, monitor and maintain the curing enclosure air temperature between 50°F and 160°F during accelerated curing. 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 that 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.

If accelerated curing is terminated before the specified curing period has elapsed, provide other acceptable curing methods for the remaining curing period.

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

(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.

C. **Workmanship.** Formed surfaces must not have excessive surface honeycombing, aggregate or mortar pockets, air voids, lift lines, or vibrator marks. Remove form-joint-offset marks in excess of the tolerances specified in Section 424.3.B.1.a, “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.

Unless otherwise shown on the plans, recess strands approximately 3/8 in. without overheating or damaging the surrounding concrete. Clean and coat the inside of each 3/8-in. recess and strand end with approximately 10 mils of Type VIII neat epoxy conforming to DMS-6100, “Epoxies and Adhesives,” and fill with epoxy grout while the neat epoxy is still tacky. Furnish epoxy grout with the same type of epoxy and dry, clean sand. 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.

1. **Defects and Breakage.**
**a. Prestressed and Nonstressed Members.** Members that sustain damage or surface defects during fabrication, handling, storage, hauling, or erection are subject to review. Submit proposed written repair procedures 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 damage occurs, determine the cause and take corrective action. Failure to take corrective action, leading to similar repetitive damage, could be cause for rejection of the damaged 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.

**b. Prestressed Members.** 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.

Vertical or horizontal cracks 1/16 in. or less in width that tend to close upon transfer of stress to the concrete are acceptable. Cracks that do not tend to close are subject to review. 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 or surface defects during fabrication, handling, storage, hauling, or erection are subject to review.

2. **Tolerances.**

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

<table>
<thead>
<tr>
<th>Dimension</th>
<th>T-Beams and Bulb-Tee Beams</th>
<th>U-Beams</th>
<th>Box and Slab Beams</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>±3/4”</td>
<td>±1”</td>
<td>±1”</td>
<td>±3/4”</td>
<td>±1/2”</td>
<td>−1/2”</td>
<td>±3/16”</td>
</tr>
<tr>
<td>Width (parallel to strands for bridge deck panels)</td>
<td>+3/4” −1/4”</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>±3/16”</td>
</tr>
<tr>
<td>Nominal depth (thickness in case of panels)</td>
<td>+1/2” −1/4”</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>−1/8”</td>
<td>±1/4”</td>
</tr>
<tr>
<td>Thickness: top slab or flange</td>
<td>+1/2” −1/4”</td>
<td>±1/2”</td>
<td>±1/2”</td>
<td>±1/4”</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Thickness: bottom slab or flange</td>
<td>+1/2” −1/4”</td>
<td>±1/2”</td>
<td>±1/2”</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Thickness: web or wall</td>
<td>+3/4” −1/4”</td>
<td>±1/2”</td>
<td>±1/2”</td>
<td>±1/4”</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” per 10’ of length, 3/4” max.</td>
<td>±1/4”</td>
<td>±1/4”</td>
<td>±1/8”</td>
<td>±1/8” per 10’ of length, 1/2” max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deviation of ends (horizontal skew)</td>
<td>±1/4”</td>
<td>±1/8” per 1’ of width, 1/2” max.</td>
<td>±1/8” per 1’ of width, 1/2” max.</td>
<td>±1/8” per 1’ of width, 1/2” max.</td>
<td>±1/2”</td>
<td>±1/8”</td>
<td>±1/4” per 5’ of width, 1/2” max.</td>
</tr>
<tr>
<td>Deviation of ends (vertical batter)</td>
<td>±1/8” per 1’ of depth, 1/2” max.</td>
<td>±1/8” per 1’ of depth, 1/2” max.</td>
<td>±1/8” per 1’ of depth, 1/2” max.</td>
<td>±1/8” per 1’ of depth, 1/2” max.</td>
<td>NA</td>
<td>±1/8”</td>
<td>±1/4”</td>
</tr>
</tbody>
</table>
### Table 3 (continued)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>T-Beams and Bulb-Tee Beams</th>
<th>U-Beams</th>
<th>Box and Slab Beams</th>
<th>Double-T Beams</th>
<th>Bridge Deck Panels</th>
<th>Piling</th>
<th>Wall Panels¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notched end areas (for diaphragms): depth</td>
<td>±1/4&quot;</td>
<td>NA</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</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>+2&quot; −1&quot;</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>±1/16¹</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;¹⁴</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;</td>
<td>+1/2&quot; −3/4&quot;</td>
<td>+1/2&quot; −3/4&quot;</td>
<td>NA</td>
<td>+1/2&quot;</td>
<td>−3/4&quot;</td>
</tr>
<tr>
<td>Position of strands: vertical</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/4&quot;</td>
<td>±1/8&quot;</td>
<td>±1/4&quot;</td>
<td>±1/8&quot;</td>
</tr>
</tbody>
</table>
Table 3 (continued)  
Allowable Tolerances for Prestressed Members

<table>
<thead>
<tr>
<th>Dimension</th>
<th>I-Beams and Bulb-Tee Beams</th>
<th>U-Beams</th>
<th>Box and Slab Beams</th>
<th>Double-T Beams</th>
<th>Bridge Deck Panels</th>
<th>Piling</th>
<th>Wall Panels¹</th>
</tr>
</thead>
<tbody>
<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>±1/2&quot;</td>
<td>±1/4&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 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 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;</td>
<td>±1/4&quot; in 10'</td>
<td>±1/4&quot; per 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", −6".
6. For draped strands, the tolerance for vertical position of strands at the end of the beam may be increased to ±1/2" 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.

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.

b. **Nonstressed Members.** Unless otherwise shown on the plans, the allowable tolerances for nonstressed members are as specified in Table 4. The allowable tolerances for nonstressed wall panels, except MSE wall panels, are as specified in Table 3.

Table 4  
Allowable Tolerances for Nonstressed Members

<table>
<thead>
<tr>
<th>Member</th>
<th>Dimension</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE wall panels and wall components¹ (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.

D. **Storage and Handling.** Immediately after form removal, mark members for identification as shown on approved shop drawings in accordance with the requirements of the pertinent Items or as required.
Inspect members immediately before shipping to the job site for damage that may have occurred in storage.

1. **Prestressed Members.** Store and handle prestressed members in accordance with Item 425, “Precast Prestressed Concrete Structural Members.”

2. **Nonstressed Members.** Store and handle nonstressed members in a manner to avoid excessive bending stresses and damage.
   
   The storage area must be clean and well drained. Prevent excessive or differential settlement of members by storing them on stable ground and on dunnage of sufficient size, shape, and strength, to prevent crushing.

   When members are stacked, separate them with blocking, arranged in vertical planes, that does not crush under load. Stack members so that lifting devices are accessible and undamaged.

   Rearrange improperly stored members and inspect them for damage. Members that are improperly stored and become cracked, warped, or otherwise damaged in storage may be cause for rejection.

   Dunnage and blocking material must not cause damage or stains that are unacceptable for the required finish.

**424.4. 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.