

SECTION 453 EPOXY JOINTING OF PRECAST SEGMENTS

453-1 Description.

Furnish, mix and apply a two-component epoxy bonding system to the match cast faces of joints between precast concrete superstructure and/or substructure segments in accordance with the Contract Documents.

In its workable state, or open time, the epoxy bonding agent must function as a lubricant for joining the segments. In its hardened state, the epoxy bonding agent must provide a watertight seal between the precast concrete segments. The hardened epoxy bonding agent must provide intimate contact for stress transfer by completely filling all interstitial space between the match cast segment faces.

This Section applies to precast segmental structures with multiple shear joints in webs and joints with suitable shear keys in precast substructure segments.

453-2 Acceptance of Epoxy Bonding System.

Use only epoxy systems that are on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products must submit an application conforming to the requirements of Section 6.

~~Provide~~**Submit** to the Engineer a manufacturer's certification conforming to the requirements of Section 6, which confirms that each manufactured lot meets the requirements of this Section and is the same as the material listed on the APL.

453-3 Qualifications of Contractor's Personnel.

For mixing, handling and applying the epoxy bonding agent, provide direct supervision by a person with knowledge and experience, or trained by a technical representative of the manufacturer in the use of this material. Arrange for a technical representative of the manufacturer to be at the site as an advisor at the beginning of this work.

Ensure that all personnel who will be working with the epoxy bonding agent are thoroughly familiar with the safety precautions necessary for use of this material.

453-4 Material.

453-4.1 General: Use only epoxy bonding agents for match-cast joints between precast segments which are thermosetting 100% solid compositions that do not contain solvent or any non-reactive organic ingredient except for pigment required for coloring and meet the requirements of ASTM C881, Type VI Grade 3 as modified below. Use epoxy bonding agents composed of two components, a resin and a hardener, with each component distinctly pigmented so that mixing produces a third color similar to the concrete in the segments.

Epoxy bonding agents must be insensitive to damp conditions during application and, after curing, must exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics and tensile strength greater than the concrete.

453-4.2 Packaging, Identification and Use: Use only components packaged in two parts, in sealed containers, proportioned in the proper reacting ratio, ready for combining and mixing in accordance with the manufacturer's instructions. Each container must bear a label and/or stamp designating the manufacturer's name, brand name, the component type (resin or hardener), the range of substrate (surface of concrete) temperature over which the application is

suitable, material classification, the date of formulation, the shelf life of the material, and the manufacturer's lot number.

Provide ~~Submit~~ instructions, ~~furnished by~~ from the manufacturer, for the safe storage, handling, mixing and application of the material.

Do not use any material from containers which are damaged or have been previously opened. Combining of epoxy bonding components from bulk supplies will not be permitted. Only full packets of components will be mixed.

453-4.3 Classification of Epoxy Material: Epoxy bonding agents which remain workable for a short open time (about one hour) are referred to herein as "normal set epoxy". Epoxy bonding agents which remain workable over an extended open time (about eight hours) are referred to herein as "slow set epoxy".

453-4.4 Formulation for Temperature Range: Epoxy bonding agents must be formulated to provide application temperature ranges which are suitable for the erection of match cast segments with substrate temperatures between 40°F and 115°F with a minimum of at least two, but preferably three, formulations dividing the range into approximately equal subranges which overlap by at least 5°F.

453-4.5 Physical Requirements:

453-4.5.1 General: Epoxy bonding agents proportioned as designated by the manufacturer and mixed in accordance with the manufacturer's recommendations shall meet the requirements of ASTM C881. For the properties listed below, modify the ASTM test procedures as noted. The components of the epoxy-bonding agent shall be conditioned to the temperature at which testing is to be done prior to mixing the test specimen.

453-4.5.2 Contact Time (Open Time) and Contact Strength: The contact time (open time) of the mixed epoxy-bonding agent shall be:

Normal-Set Epoxy 60 minutes, minimum

Slow-Set Epoxy 6 hours, minimum

The above contact time (open time) will be deemed acceptable if a slant cylinder test specimen, prepared and tested in accordance with the conditions below, sustains the following stress (contact strength) on the slant plane calculated as the axial (vertical) load divided by the area of the slant ellipse:

Normal-Set Epoxy 1,000 psi at 48 hours after joining

Slow-Set Epoxy 1,000 psi at 14 days after joining

The cement mortar/concrete material for the slant-cylinder test shall have a compressive strength of at least 4,500 psi at 28 days when tested to ASTM C39. The slant-cylinder test procedure must be in accordance with ASTM C882 with the following modifications:

1. Delay joining of the sloped surfaces for the following period of time, measured from the time the epoxy was mixed:

Normal-Set Epoxy 60 minutes

Slow-Set Epoxy 6 hours

2. During the period between mixing of the epoxy and joining of the sloped surfaces, the specimens will be uncovered and maintained at the maximum temperature of the application range for the formulation tested.

3. After joining, cure at the maximum temperature of the formulation range at the time periods specified above prior to testing.

For slow-set epoxy, prepare an additional test specimen and test it to failure at 36 hours. The formulation of the slow-set epoxy is acceptable only if the epoxy-bonding agent exhibits a brittle break.

453-4.5.3 Compressive Yield Strength: The compressive yield strength of the epoxy-bonding agent shall be:

Normal-Set Epoxy	2,000 psi at 24 hours
.....	6,000 psi at 48 hours
Slow-Set Epoxy	2,000 psi at 7 days
.....	6,000 psi at 14 days

Determine compressive yield strength in accordance with ASTM D695 with the following conditions:

1. Pour the epoxy-bonding agent into the mold for forming specimens within ten minutes after starting mixing of the components.
2. Prior to testing, cure the specimens at the minimum temperature of the formulation range for the time periods specified above.

453-4.5.4 Bond Strength: Bond strength shall be:

Normal-Set Epoxy	1,000 psi at 48 hours after joining
Slow-Set Epoxy	1,000 psi at 14 days after joining

Determine the bond strength in accordance with ASTM C882 with the following modifications:

1. The test cylinder of concrete shall have a compressive strength of at least 6,000 psi at seven days age.
2. Delay joining of the sloped surfaces for the following period of time, measured from the time the epoxy was mixed:

Normal-Set Epoxy	60 minutes
Slow-Set Epoxy	6 hours
3. During the period between mixing of the epoxy and joining of the sloped surfaces, the specimens will be uncovered and maintained at the minimum temperature of the application range for the formulation tested.
4. After joining, cure at the minimum temperature of the formulation range for the time periods specified above prior to testing.

453-5 Construction Requirements.

453-5.1 General: Apply an epoxy bonding agent meeting the requirements of this Section to mating surfaces of all match-cast precast concrete segments.

Prior to the manufacture of epoxy for the project, a site meeting will be held with representatives from the Engineer, Contractor and epoxy manufacturer, to discuss the selection of the proper formulations, storage and handling, mixing and application of the epoxy.

Have the necessary cleaning materials immediately available at the location of the segment joining, in the event that the segments must be separated and cleaned or epoxy reapplied.

Include in the erection manual required by Section 452, details of erection and post-tensioning operations which assure that the time elapsing between mixing components of the first batch of epoxy bonding agent applied to the joining surfaces of precast concrete segments and the application of a compressive contact pressure across the joint does not exceed

70% of the open time for the particular formulation of epoxy bonding agent used. Also, include details of how the minimum, closing, contact pressure of approximately 40 psi will be applied uniformly to each joint to which epoxy is applied during the epoxy curing period. Contact pressure may be attained through combinations of weight and temporary and/or permanent post-tensioning.

453-5.2 Cleanliness of Surfaces to be Joined: Ensure that the application surfaces are free from oil, form release agent, laitance or any other deleterious material that would prevent the epoxy bonding agent from bonding to the concrete surface. Remove laitance by light sandblasting, wire brushing. Do not destroy the surface shape and profile of the mating surfaces.

Ensure that the surfaces have no free moisture on them at the time the epoxy bonding agent is applied. Free moisture will be considered present if a dry rag, after being wiped over the surface, becomes damp.

453-5.3 Substrate Temperatures and Epoxy Formulation: Apply the epoxy bonding agent only when the substrate temperature of both surfaces to be joined is between 40°F and 115°F. The formulation of the epoxy bonding agent must have an application temperature range that conforms to the substrate temperature of the surfaces being joined. If the mating surfaces have different substrate temperatures, then use the formulation for the higher temperature in hot weather periods. In cold weather periods, use the formulation for the lower temperature. Thermal control precautions may be taken in accordance with 453-5.7 below.

453-5.4 Mixing of Epoxy Bonding Agent: Mix the two components of the epoxy bonding agent in strict accordance with the manufacturer's instructions, using only full and undamaged containers. Only open the containers immediately before being combined and do not use any which have an expired shelf life. Thoroughly stir each container of component before combining the components. Combine the two components and thoroughly mix until a uniform color is achieved. Mix with a properly sized mechanical mixer operating at no more than 600 rpm and/or in accordance with the recommendations of the epoxy manufacturer.

Do not mix until the segments to be joined are within approximately 18 inches of their final position. Schedule mixing of the epoxy bonding agent so that the material in a batch is applied to the face of a joint within a maximum of 20 minutes after combining the components.

The Engineer, at his discretion, may require a dry run to check the fit of two surfaces before applying the epoxy.

453-5.5 Application and Amount of Epoxy: Begin application immediately after a batch has been mixed. Uniformly apply the epoxy bonding agent in accordance with the manufacturer's recommendations by spatula or gloved hand a nominal thickness of 1/16 inches. Apply the epoxy to all areas of both faces to be joined. Do not exclude epoxy from around holes formed by ducts. Apply additional epoxy thickness, equal to the shim thickness, to segment faces when shims are placed in a joint.

The amount of epoxy may be adjusted provided that a sufficient amount is applied to completely fill all interstitial space in the joint and to extrude a small bead from the joint after application of the compressive contact pressure.

If a bead of epoxy is not extruded all around the joint, then determine the reason why before proceeding.

Do not use an epoxy bonding agent from a batch for which the time since combining the components has exceeded 20 minutes.

453-5.6 Mating of Segments: Immediately after each mating surface is covered with epoxy bonding agent, bring the segments together and apply the specified compressive contact

pressure in accordance with the approved erection procedures. The contact pressure may be increased at any time after the epoxy has taken an initial set. Do not reduce the contact pressure until the epoxy in the joint has properly hardened and cured. If the contact pressure is reduced, do not subject the joint to tensile stress.

A discernable bead line of extruded epoxy bonding agent must be apparent along the exposed edges of the joint. Fill all areas of the joint which do not show a bead of epoxy by dispensing additional epoxy, meeting the requirements of this specification, into the joint using a pneumatic gun with epoxy cartridges. Inject epoxy to a minimum depth of 1 inch.

Catch and retain epoxy which is squeezed out of the joint in areas over waterways, roadways, buildings, etc.

Clean all extruded epoxy bonding agent from external visible surfaces in a way not to damage or stain the concrete surface. Do not smear surplus extruded epoxy bonding agent over large areas (areas more than 1 inch from each side of the joint), visible surfaces or surfaces to which a cover coat, Class 5 applied finish coat or similar or texturing is to be applied later.

Immediately after the segments are joined, swab all embedded (internal) post-tensioning ducts or conduits passing through the joints to smooth out any extruded epoxy bonding agent.

If the time between combining the components of the epoxy bonding agent and applying the compressive contact pressure exceeds 70% of the minimum open time, immediately separate the segments and clean in accordance with 453-5.8.

453-5.7 Thermal Controls:

453-5.7.1 Cooling in Hot Weather: If the substrate temperature exceeds 115°F, do not proceed with epoxy jointing. The Contractor may take precautions to keep the mating substrate surfaces cool by shading and/or wetting with clean water except that the above requirements for no moisture at the time of application must be strictly adhered to.

453-5.7.2 Artificial Heating in Cold Weather: If electing to erect segments in cold weather when the substrate temperature of the mating concrete surfaces is below 40°F, an artificial environment may be used to increase the substrate temperature subject to the following:

1. Make the artificial environment by an enclosure surrounding the joint through which warm air is circulated, or heating is provided by radiant heaters.
2. Raise the temperature of the concrete substrate across the entire joint surface to at least 40°F.
3. Prevent localized heating and the temperature of the substrate exceeding 95°F at any point on the surface. Direct flame heating of the concrete is not allowed.
4. Maintain the temperature of the substrate surfaces between 40°F and 95°F for at least 24 hours after joining the surfaces.
5. The Contractor may propose, for review by the Engineer, an optional method of raising and maintaining the substrate temperature of the mating surfaces. Any optional method must meet the thermal restrictions above.

Epoxy jointing operations may proceed if the air temperature is above 45°F and rising and the limitations above are met.

453-5.8 Failure to comply with Time Limits or Incomplete Jointing: If the time limit between mixing of the epoxy-bonding agent and the application of the contact pressure is exceeded, or if the joint is incompletely filled and sealed, separate the segments and remove all epoxy from the faces using spatulas and approved solvent. Do not re-apply epoxy until the faces have been properly cleaned and solvents dispersed, for a period of 24 hours.

453-6 Removal of Support to Segments.

453-6.1 Span-by-Span Erection: Ensure that precast concrete segments remain fully supported by the erection truss or system until at least 20 hours after mixing of the last batch of epoxy bonding agent applied to any joint in the span.

453-6.2 Cantilever Erection: Independent support to a newly erected cantilever segment may be removed when the epoxy bonding agent in the third previous mating joint has set. It is not necessary for the epoxy bonding agent in the new joint or the immediately previous joint to be set prior to removing the independent support of the new segment provided that the temporary and/or permanent post-tensioning has been installed to carry the load of the new and previous segment along with any applied construction loading as per the requirements of the erection system.

453-7 Record of Jointing.

Record and submit to the Engineer on a weekly basis the following information:

1. General:
 - a. Date and time of jointing,
 - b. Segment numbers or spans jointed,
 - c. Weather conditions
2. For each joint (identified by location or segment numbers):
 - a. manufacturer's lot number of epoxy bonding agent components.
 - b. Temperature of the concrete on the joint surface at the middle of each segment when application of the epoxy bonding agent began.
 - c. Time of mixing first batch of epoxy bonding agent applied to the joint and completion of application.
 - d. Time of applying the required compressive contact pressure.
3. Details of any repairs performed including reason for repair, joint location, volume of epoxy used, method of application, etc.

453-8 Basis of Payment.

No separate payment will be made for the work of epoxy jointing of precast concrete segments. The cost of this work will be included in payment for the various precast concrete items.