453 EPOXY JOINTING OF PRECAST SEGMENTS.

(REV 12-11-00) (FA 2-5-01) (2-01)

PAGE 524. The following new Section is added after Section 451.

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 Material.

453-2.1 General: Epoxy bonding agents for match-cast joints between precast segments shall be thermosetting 100% solid compositions that do not contain solvent or any non-reactive organic ingredient except for pigment required for coloring. Epoxy bonding agents shall be two components, a resin and a hardener. The two components shall be distinctly pigmented so that mixing produces a third color similar to the concrete in the segments.

Epoxy bonding agents shall be insensitive to damp conditions during application and, after curing, shall exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics and tensile strength greater than the concrete. They will be deemed acceptable if they meet the requirements of this Section.

453-2.2 Packaging, Identification and Use: The components shall be 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 shall bear a label designating the Manufacturer's name, the component type (resin or hardener), the range of substrate (surface of concrete) temperature over which the application is suitable, the date of formulation, the shelf life of the material and the Manufacturer's Lot Number.

Instructions shall be furnished by the Manufacturer for the safe storage, handling, mixing and application of the material.

Material from containers which are damaged or have been previously opened shall not be used. Combining of epoxy bonding components from bulk supplies will not be permitted. Only full packets of components will be mixed.

453-2.3 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".

453-2.4 Formulation for Temperature Range: Epoxy bonding agents shall be formulated to provide application temperature ranges which are suitable for the erection of match cast segments with substrate temperatures between 40 and 115ºF [4 and 46ºC]. There shall be a minimum of at least two, preferably three, formulations dividing the range into approximately equal subranges which overlap by at least 5ºF [3ºC].

453-2.5 Tests:

453-2.5.1 Samples for Testing and Certified Test Reports: For quality control purposes, the Contractor shall furnish to the Engineer certified test reports from an approved testing laboratory indicating that the epoxy bonding agent material has passed all required tests for each manufactured lot. Upon request, the Contractor shall also furnish to the Engineer, samples of the epoxy bonding agent material for independent quality assurance testing.

453-2.5.2 Physical Requirements:

453-2.5.2.1 General: Epoxy bonding agents proportioned as designated by the Manufacturer and mixed in accordance with the Manufacturer's recommendations, as modified herein for a specific test, shall meet the physical requirements set out below. The epoxy bonding agents shall be conditioned to the temperature at which testing is to be done prior to mixing the test specimen.

453-2.5.2.2 Sag Flow: Mixed epoxy bonding agent when tested in accordance with ASTM D 2730 at the maximum temperature of the temperature range for the formulation shall not sag flow at 1/8 inch [3 mm] minimum thickness.

453-2.5.2.3 Gel-Time: The test shall be performed in accordance with ASTM D 2471 as modified herein. The gel-time shall be a minimum of 30 minutes.

The following modifications apply to ASTM D 2471:

1. The quantity in the test sample shall be 1 gallon [4 L].
2. The components shall be conditioned to, mixed and tested at the maximum temperature of the temperature range for the formulation.

453-2.5.2.4 Open Time: Open time is defined as the allowable period of time between mixing components of the epoxy bonding agent, application of the epoxy to the joint face(s), and the joining of the segments by the application of an approximately uniform closure pressure.

The open time of the mixed epoxy bonding agent shall be:

Normal Set Epoxy..... 60 minutes, minimum
Slow Set Epoxy..... 8 hours, minimum

The open time and formulation of the epoxy bonding agent will be deemed acceptable if a slant cylinder test specimen, prepared and tested according to the conditions set out below, sustains the following compressive stress on a section perpendicular to the direction of the applied load:

Normal Set Epoxy.....1,000 psi [7 MPa]
at 48 hours after joining

Slow Set Epoxy.....1,000 psi [7 MPa]
at 14 days after joining

NOTE: For slow set epoxy, an additional test specimen shall be made and tested to failure at 24 hours after joining. The formulation of the slow set epoxy is acceptable only if the epoxy bonding agent exhibits a brittle break.

The slant cylinder test shall be carried out in accordance with the procedure in 453-2.5.2.7 below, except that the specimens shall be prepared according to the following conditions:

1. The concrete specimens shall be soaked in water at the maximum temperature of the temperature range for the formulation for a period of 72 hours prior to the application of the epoxy bonding agent.

2. The two components of the epoxy bonding agent shall be brought to the maximum temperature of the application temperature range for the formulation being tested before being mixed and applied to the specimens.

3. The sloped surfaces of the concrete specimens shall be dried by placing them on an absorbent material for ten minutes. Immediately after drying, the epoxy bonding agent shall be applied to one of the sloped surfaces of the concrete test specimens to a thickness of 1/16 inch [1.6 mm].

4. Joining of the sloped surfaces shall be delayed for the following period of time, measured from the time the epoxy was mixed:

Normal Set Epoxy.....60 minutes
Slow Set Epoxy.....8 hours

5. During the delay period between mixing the epoxy and joining of the sloped surfaces, the specimens shall be uncovered and maintain at the maximum temperature of the application range for the formulation being tested.

6. The specimens shall then be pressed together and held in position for 24 hours. Then the assembly shall be wrapped in a damp cloth which shall be kept wet during an additional 24 hours at the minimum temperature of the application range for the formulation being tested.

7. The joined specimen shall then be tested in accordance with ASTM C 39.

453-2.5.2.5 Compressive Yield Strength: The compressive yield strength of the epoxy bonding agent, determined in accordance with ASTM D 695 [ASTM D 695M] as modified herein, when tested at 77ºF [25ºC], shall be at least:

Normal Set Epoxy.....2,000 psi [14 MPa] at 24 hours
and 6,000 psi [41 MPa] at 48 hours
Slow Set Epoxy.....2,000 psi [14 MPa] at 36 hours
and 4,000 psi [28 MPa] at 72 hours

The following modifications shall apply to ASTM D 695 [ASTM D 695M]:

1. The epoxy bonding agent shall be poured into the mold for forming the specimens within ten minutes after beginning of mixing of the components.

2. The specimens shall be cured at the minimum temperature of the temperature range for the formulation being tested for a period of 24 hours.

453-2.5.2.6 Compressive and Shear Strength:

The compressive and shear strength will be deemed acceptable if a slant cylinder test specimen, prepared and tested according to the conditions set out below, sustains the following compressive stress on a section perpendicular to the direction of the applied load:

Normal Set Epoxy....6,000 psi [41 MPa] at 48 hours
Slow Set Epoxy..... 6,000 psi [41 MPa] at 14 days

NOTE: For slow set epoxy, an additional test specimen shall be made and tested to failure at 24 hours after joining. The formulation of the slow set epoxy is acceptable only if the epoxy bonding agent exhibits a brittle break.

The slant cylinder test shall be carried out in accordance with the procedure in 453-2.5.2.7 below, except that the specimens shall be prepared according to the following conditions:

1. The concrete specimens shall be soaked in water at the minimum temperature of the temperature range for the formulation for at least 72 hours prior to the application of the epoxy bonding agent.

2. The two components of the epoxy bonding agent shall be mixed in accordance with the manufacturer's recommendations.

3. The sloped surfaces of the test specimens shall be dried by placing them on an absorbent material for ten minutes. Immediately after drying, one of the sloped surfaces shall be coated with epoxy bonding agent to a thickness of 1/16 inch [1.6 mm].

4. Joining of the sloped surfaces shall be delayed for the following period of time, measured from the time the epoxy was mixed:

Normal Set Epoxy.....60 minutes
Slow Set Epoxy.....8 hours

5. During the delay period between mixing of the epoxy and joining of the sloped surfaces, the specimens shall be uncovered and maintained in an air environment at the minimum temperature of the application range for the formulation being tested.

6. The specimens shall then be pressed together and held in position for 24 hours. Then the assembly shall be wrapped in a damp cloth which shall be kept wet during an additional 24 hours at the minimum temperature of the application range for the formulation being tested.

7. The joined specimen shall then be tested in accordance with ASTMC 39.

453-2.5.2.7 Slant Cylinder Test Method: A test specimen of concrete is prepared in a standard 6 by 12 inch [152 by 305 mm] cylinder mold to have a height at midpoint of 6 inches [152 mm] and an upper surface with a slope at 30 degrees (±1 degree) with the vertical. The upper and lower portions of the specimen with the slant surfaces may be formed through the use of an elliptical insert or by sawing a full sized 6 by 12 inch [152 by 305 mm] cylinder. If desired, 3 by 6 inch [76 by 152 mm] or 4 by 8 inch [102 by 203 mm] specimens may be used.

The sloped surfaces shall be free from bumps, edges or high spots over 1/32 inch [0.8 mm] in magnitude and the sloped surfaces shall not deviate from plane by more than 1/8 inch [3 mm]. After the specimens have been moist cured for 14 days and the

concrete has reached a compressive strength in excess of 6,000 psi [41 MPa], the slant surfaces shall be prepared by light sandblasting or stoning and washing with clean water.

After the concrete halves have been joined with epoxy bonding agent according to the required conditions for the property being tested, the joined specimen shall be tested in accordance with ASTM C 39.

453-2.5.2.8 Temperature Deflection of Epoxy Bonding Agent: When tested in accordance with ASTM D 648, the minimum deflection temperature at fiber stress loading of 264 psi [1.8 MPa] on test specimens cured for 7 days at 77ºF [25ºC], shall be 122ºF [50ºC].

453-2.5.3 Frequency of Quality Assurance Laboratory Tests, Certification of Delivered Shipments and Reporting: Quality Assurance Tests for Sag-Flow, Gel-Time, Open Time, Compressive Yield Strength, Compressive and Shear Strength (Slant Cylinder) and Temperature Deflection of Epoxy Bonding Agent in accordance with the above procedures shall be performed by an independent laboratory engaged by the Contractor and approved by the Department. These tests shall be performed at the following frequencies on randomly selected samples of resin and hardener taken from shipments to the site:

(a) before any segments are erected,

(b) after approximately one-third of the segments have been erected and

(c) after approximately two-third of the segments have been erected,

(d) or at intervals not to exceed nine months.

All three series (a, b and c) of tests shall be required for epoxy bonding agents from different manufacturers or if the manufacturer is changed during the course of the project. In the latter case, the one-third intervals between tests shall apply to the remainder of the segments yet to be erected.

Unless the Engineer has reason to suspect the quality of epoxy bonding agent and notifies the Contractor accordingly, erection of segments may proceed without interruption while awaiting the results of the next required test providing these results are furnished within 45 days.

All tests shall be performed by a reputable testing laboratory engaged and paid for by the Contractor and approved by the Department. Two sets of certified test results showing compliance with the test requirements shall be submitted to the Engineer.

With each shipment of all or part of a manufactured lot of epoxy bonding agent delivered to the site, the Contractor shall provide the Engineer with certification as required in 453-2.5.1.

453-2.5.4 On-Site Gel-Time Tests: During the progress of the work, the Contractor shall perform tests for gel-time as prescribed below on a periodic basis not to exceed two weeks during segment erection operations. A gel-time test shall also be performed when a new shipment of material (which may be from the same manufactured lot as previous shipments) is opened, if the source of material is changed or if, in the opinion of the Engineer, the material exhibits unanticipated behavior during normal erection operations. The test shall be performed at ambient air temperature and shall meet the 30 minute minimum requirement.

1. The sample shall be 1 gallon [4 L].

2. Agitate each component slowly and separately with a mechanical mixing paddle for at least three minutes avoiding the entrapment of air.

3. Combine the components in the recommended ratio and stand the container on a poor heat conducting surface. (To avoid heat transfer, do not hold container.)

4. Using a suitable stop-watch or similar, record the time at the start of mixing the components. Mix the components thoroughly for three minutes avoiding air entrapment by slow agitation with a mechanical stirring paddle.

5. Approximately five minutes before the anticipated gel-time, begin probing the center of the reacting with a clean probe or applicator stick perpendicular to the surface and at approximately 15 second intervals.

6. When the reacting material no longer adheres to the end of a clean probe, record the time elapsed from the start of mixing; this is the gel-time.

In the event that a gel-time test conducted in this manner by the Contractor indicates a gel-time less than 30 minutes, the test shall be repeated with a second sample from the same shipment of epoxy materials. The shipment shall be deemed acceptable if the second test passes the three minute requirement. However, when two successive tests on the same shipment fail to meet the 30 minute requirement, that shipment of epoxy materials shall be rejected and removed from the site.

A replacement shipment of epoxy materials shall be furnished by the Contractor and the on-site gel-time test shall be repeated for the shipment prior to use in construction all at no additional cost.

453-3 Construction Requirements.

453-3.1 General: Apply an epoxy bonding agent meeting the requirements of this Section to mating surfaces of all match-cast precast concrete segments unless otherwise specified on the plans.

453-3.1.1 Substrate Temperatures and Epoxy Formulation: Apply the epoxy bonding agent only when the substrate temperature of both surfaces to be joined is between 40 and 115ºF [4 and 46ºC]. The formulation of the epoxy bonding agent shall have an application temperature range between 40 and 115ºF [4 and 46ºC]. If the mating surfaces have different substrate temperatures, then use the formulation for the higher temperature in hot weather periods and in cold weather periods, use the formulation for the lower temperature. Thermal control precautions may be taken in accordance with 453-3.7 below.

453-3.1.2 Closing Joint within Open Time: Plan erection and post-tensioning operations so 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.

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, move the concrete segments apart and remove all epoxy bonding agent from both surfaces using spatulas and/or approved solvent. If solvent is used, do not reapply epoxy bonding agent to the mating surfaces for at least 24 hours.

Before beginning erection operations, submit details to the Engineer explaining how operations will be arranged to meet the 70% of the open time limit, including removal procedures and materials.

453-3.1.3 Closure Pressures Across Joints: For superstructure segments, the compressive contact pressure across a joint may be accomplished through temporary and/or permanent post-tensioning. For precast pier column segments, the contact pressure may be

applied by temporary post-tensioning, permanent post-tensioning and/or the weight of the segments. Continuously maintain the contact pressure across a joint, as uniformly as possible. Regardless of minimum stresses for any other structural requirements specified elsewhere, maintain contact pressure of at least 40 psi [275 kPa] at all points.

453-3.2 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.

453-3.3 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 or light use of high pressure water blasting. 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.

453-3.4 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 [450 mm] 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.

453-3.5 Application and Amount of Epoxy: Begin application immediately after a batch has been mixed. Apply the epoxy bonding agent in accordance with the Manufacturer's recommendations by spatula or gloved hand to completely and uniformly cover the faces of both surfaces to be joined to a nominal thickness of 1/16 inch [1.6 mm] on each surface.

The amount of epoxy may be adjusted providing 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.

The Engineer may require that joints which show lack of epoxy extrusion or incomplete filling be pressure injected with epoxy or other remedial measures taken after all internal tendons have been grouted, at no additional cost to the Department.

When epoxy is applied in conjunction with layers of woven fiberglass matting for the purpose of shimming a joint to correct alignment, submit a proposal detailing the areas and

layers of matting, amounts of epoxy and operational procedures to the Engineer for review and approval before implementing.

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

453-3.6 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. A discernable bead line of extruded epoxy bonding agent must be apparent along the exposed edges of the joint or the segments shall be parted and the joint cleaned with spatulas and approved solvent. Do not reapply epoxy to the joint until 24 hours after any solvent has been used. Have cleaning materials available on hand before the start of each mating operation.

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 [25 mm] 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.

453-3.7 Thermal Controls:

453-3.7.1 Cooling in Hot Weather: If the substrate temperature exceeds 115ºF [46ºC], 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 shall be strictly adhered to.

453-3.7.2 Artificial Heating in Cold Weather: If electing to erect segments in cold weather when the substrate temperature of the mating concrete surfaces is below 40ºF [4ºC], 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 to at least 40ºF [4ºC] to a depth of approximately 3 inches [75 mm] beneath all portions of the mating surfaces.
3. Prevent localized heating and the temperature of the substrate exceeding 95ºF [35ºC] 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 and 95ºF [4 and 35ºC] 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 45ºF [7ºC] and rising.

453-4 Removal of Support to Segments.

453-4.1 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. The Engineer may waive this time limitation if it is positively demonstrated that the epoxy bonding agent has set sufficiently to establish an adequate intimate contact mechanism for the transfer of stresses in the joints.

453-4.2 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 sufficiently to establish an adequate intimate contact mechanism for the transfer of stresses in that joint. 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.

453-5 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. Results of any laboratory or on-site tests performed that week.

453-6 Acceptance.

The Engineer will base acceptance of the epoxy bonding system on certified results, quality assurance testing, satisfactory results for periodic on-site gel-time tests and continuing satisfactory on-site performance.

453-7 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.