

Approval & Reception Procedure

DMC – Departamento de Materiais de Construção	
Epoxy Bonding Agent for Segmental Construction	Document no. ARP/DMC/21
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1 Reference Standards

FIP publication FIP/9/2 March 1978 “Proposal for a standard for acceptance tests and verification of epoxy bonding agents for segmental construction”.

2 Approval Procedures

2.1 General

The manufacture, testing, storage and application of the epoxy bonding agent shall generally be in accordance with the recommendations set out in the FIP publication FIP/9/2 March 1978 “Proposal for a standard for acceptance tests and verification of epoxy bonding agents for segmental construction” except that the requirements of this Specification shall take precedence.

Manufacturer’s information, such as production catalogue, accredited quality system certificates, and test certificates should be submitted for compliance verification before any delivery.

2.2 Application Temperature Range

Different formulations of adhesive shall be supplied to cover the maximum range of temperature pertaining during the construction of the precast concrete deck. The application temperature ranges appropriate to the different formulations shall overlap by at least 5°C.

2.3 Colour

The epoxy resin and hardener shall possess clearly contrasting colours. When properly mixed the bonding agent shall be of homogeneous greyish colour, matching the colour of the precast concrete units to be bonded.

2.4 Properties

2.4.1 General

Apart from the above, compliance verification includes the following:

- Minimum Pot Life (FIP 5.1)

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- Minimum Open Time (FIP 5.2)
- Thixotropy (FIP 5.3)
- Angle of Internal Friction (Squeezability) (FIP 5.4)
- Bonding of Cured Epoxy Adhesive to the Concrete Surfaces to be Jointed (FIP 5.5 and 5.14)
- Curing Rate (FIP 5.6) and Compressive Stress (FIP 5.12)
- Shrinkage (FIP 5.7)
- Creep (FIP 5.8)
- Water Absorption and Solubility in Water (FIP 5.9)
- Heat Resistance (FIP 5.10)
- Instantaneous and Deferred Modulus in Compression (FIP 5.13)
- Tensile Bending Strength (FIP 5.14)
- Shear Strength (FIP 5.15)
- Shear Modulus

A material sample should be submitted at the same time as the above mentioned information is submitted.

2.4.2 Minimum Pot Life (FIP 5.1)

At upper limit of specified application temperature range: 20 minutes.

2.4.3 Minimum Open Time (FIP 5.2)

At upper limit of specified application temperature range, measured from the start of the Pot Life: 60 minutes.

2.4.4 Thixotropy (FIP 5.3)

No sag flow at minimum thickness of 3mm when tested according to ASTM D2730 at the upper limit of the specified application temperature range.

2.4.5 Angle of Internal Friction (Squeezability) (FIP 5.4)

At the lower limit of the specified application temperature range the area of the epoxy adhesive to be tested shall have the following minimum values, at the given squeezing loads:

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Squeezing Load	Surface Area
0.15 kN	3,000 mm ²
2.0 kN	7,500 mm ²
4.0 kN	10,000 mm ²

2.4.6 Bonding of Cured Epoxy Adhesive to the Concrete Surfaces to be Jointed (FIP 5.5 and 5.14)

The characteristic of the bond between the adhesive and the concrete surfaces to be jointed shall be such that in the bond tension tests specified, total fracture of the concrete paste and aggregate occurs with no evidence of the bonding agent failure.

2.4.7 Curing Rate (FIP 5.6) and Compressive Stress (FIP 5.12)

Trials in accordance with FIP 6.5 shall be carried out to predict the rate of curing. The compressive strength of the epoxy adhesive shall attain the following values at the specified times after jointing has occurred at the lower limit of the specified application temperature range:

12 hours	20 MPa
24 hours	60 MPa
7 days	75 MPa

2.4.8 Shrinkage (FIP 5.7)

The shrinkage of the epoxy adhesive shall not exceed 0.4% after 7 days at the upper limit of the specified application temperature range.

2.4.9 Creep (FIP 5.8)

At the upper limit of the specified application temperature ranges the following values shall be attained:

- Pure compression for an instantaneous modulus of elasticity, E, of 8000 MPa, the deferred modulus at 1 hr shall not be less than 6000 MPa.
- Pure shear for an instantaneous modulus of shear G, of 1500 MPa, the deferred modulus of 28 days shall not be less than 1000 MPa.

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2.4.10 Water Absorption and Solubility in Water (FIP 5.9)

When subject to the specified tests the quantity of bonding agent dissolved in water shall be less than 0.1% and the water absorption shall be less than 0.5%.

2.4.11 Heat Resistance (FIP 5.10)

The heat resistance of the cured adhesive determined according to DIN 53458 (Martens) on the rods of the mixed epoxy bonding agent with dimensions of 10mm x 15mm x 120mm when cured for 7 days at the upper limit of the specified application temperature range shall be 50°C.

2.4.12 Instantaneous and Deferred Modulus in Compression (FIP 5.13)

The instantaneous modulus in compression (E_i) shall not be less than 8000MPa and the deferred modulus in compression at 1 hour ($E_{d.1}$) not less than 6000MPa.

2.4.13 Tensile Bending Strength (FIP 5.14)

After 24 hours at 100% humidity and at the lower limit of the specified application temperature range subject to a tensile bending strength test, total fracture of concrete paste and aggregate shall occur, with no evidence of epoxy bonding agent failure.

2.4.14 Shear Strength (FIP 5.15)

The shear (bond) strength of the epoxy bonding agent at failure, at the lower limit of the specified application temperature range when subject to the slant test with a rectangular prism or cylinder is to be at least 12MPa.

2.4.15 Shear Modulus

At the lower limit of the specified application temperature range if the epoxy bonding agent the instantaneous shear modulus (G); shall be a minimum of 1500MPa, the shear modulus at 1 hours ($G_{d.1h}$) 1200MPa.

3 Reception Procedure

3.1 Lot

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A lot of epoxy bonding agent is any set of epoxy and hardener components of the same type, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

3.2 Packaging

The epoxy component of the adhesive shall be packed by the supplier in containers which are different and distinct from those in which the hardener is packed. The label on each container shall clearly indicate the component it contains, the net weight, the words "Epoxy Resin" or "Epoxy Hardener" according to the container, the application temperature range of the formulation, the storage temperature range and the date of packaging.

The contents of one container of resin and one container of hardener shall be so proportioned as to form a mix of fixed net weight of epoxy bonding agent.

The container for the resin shall be large enough for it to accommodate the hardener during mixing.

3.3 Storage of the packaged components

The materials shall be stored in accordance with the recommendations as stated by the manufacturer. The Contractor shall maintain the temperature of the packaged components within the specified storage temperature range at all times until the containers are opened for mixing and application. The Contractor shall submit for approval his proposals for maintaining and controlling the storage temperature range, at all times.

The packaged components (resin and hardener) shall be stored in a cool place and not be kept for a longer period than one year or that recommended by the manufacturer if shorter. After a storage period of more than three months, it is important to check that epoxy resin shows no sign of having become crystalline.

This check shall be made approximately three days before use. If evidence of crystallisation is established, the resin container be placed in a hot water bath of 70°C for three to four hours, and stirred every 15 to 20 minutes, until the white crystals have been dissolved. After

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cooling of the resin, the pot life, the thixotropy (sag flow) and the desired curing rate shall all be checked.

If the crystals have not dissolved after this treatment or, if the pot life found is not sufficient, and the thixotropy (sag flow) or the rate of curing is not acceptable, the epoxy resin component shall not be used and shall be replaced by a fresh supply.

3.4 Information to be submitted

The manufacturer shall carry out sufficient testing to the satisfaction of the Project Manager to verify that each manufacturer's production batch of epoxy bonding agent supplied to the site complies with the requirements of sub-clause (6) "Properties" of this clause. The Contractor shall present the results of such testing, and a manufacturer's certificate of compliance with the requirements of this ARP. The certificate will state the manufacturer's production batch reference, storage temperature range, if different from the requirements of sub-clause 3.3 of this ARP, and the application temperature range.

3.5 Joint preparation

Match cast faces of units shall be prepared by wire-brushing or water jetting to remove all traces of mould oil, hydraulic oil, grease or any other substance that may impair the bond between the epoxy bonding agent and the concrete surface. The surface must be free from dust and loose particles.

The joints between the precast concrete segmental units shall be filled with an approved epoxy bonding agent. It shall be applied to the mating surfaces of the unit, within the "pot life" and in accordance with the manufacturer's recommendations.

Major contamination of the mating surfaces should be referred to the Project Manager. The condition of each joint shall be checked before the epoxy bonding agent is applied.

The epoxy bonding agent shall not be applied if the surface to which it is applied is subject to running water. If during the application of the epoxy bonding agent, running water commences to pass over the surface, placement of the epoxy bonding agent must cease,

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the applied epoxy bonding agent removed in accordance with the manufacturer's recommendations and the operation repeated under dry or acceptable damp conditions. If rain falls on applied bonding agent before the faces are brought together, the epoxy bonding agent shall be removed and the joint re-made. Before the joint is re-made, the joint surfaces shall be prepared to a satisfactory condition.

3.6 Mixing and application of epoxy bonding agent

Mixing shall be carried out as close as possible to the site of application.

The epoxy bonding agent shall be thoroughly mixed in accordance with the manufacturer's instructions, in the resin container supplied by the manufacturer. Mixing shall continue until the whole of the contents of the container achieves a uniform colour. Resin and hardener shall be taken only from full and undamaged containers which provide the correct proportion of each constituent. The whole contents of each container shall be used, even if this produces more adhesive than required. Part packs shall not be used. The method of mixing shall be approved by the Project Manager before the first joint is made. The batch shall be considered as not complying with the specified requirements for the property if the result of any additional test does not comply with the specified requirements for the property.

All the operations of mixing and applying the epoxy bonding agent and completing the joints shall be carried out under the supervision of an engineer and a foreman trained in the use of epoxy bonding agents. The foremen so trained shall be named to the Project Manager before commencing epoxy bonding agent application. No epoxy bonding agent application shall take place unless one of the named foremen is present.

The Contractor shall ensure that the operatives and other personnel who may handle or otherwise come into contact with the epoxy bonding agent are fully aware of the manufacturers' recommendations on handling procedures and the use of protective clothing, barrier creams and cleansing agents.

Waste epoxy and empty or part full containers used for mixing of the epoxy bonding agent or containing materials shall be disposed of at a tip approved for the disposal of dangerous chemicals. The Contractor shall ensure that all such materials, contaminated containers and

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disposable implements, used in the mixing and application of the epoxy bonding agent are so disposed and shall inform the Project Manager of the location and the Approval Authority of the tip to be used.

All excessive epoxy bonding agent applied to the matching surfaces of precast segment units shall be removed such that the follow-on activities will not be affected.

The epoxy bonding agent shall be applied with a uniform thickness of approximately 1mm to all parts of one face of the joint. Epoxy bonding agent shall be applied by gloved hand, or other approved method. Sufficient epoxy bonding agent shall be used to completely fill the joint. Care should be taken during the application of the epoxy bonding agent to prevent its entry into the tendon ducts.

To ensure proper curing, the epoxy bonding agent shall not be applied to joint surfaces when the ambient air temperature falls outside the manufacturer's recommended temperature range.

Immediately following the application of the epoxy bonding agent and within the specified "open time" at the ambient temperature, the joint shall be closed and temporary prestress applied. If for any reason the joint is not closed and the temporary prestress not applied within the "open time", the epoxy bonding agent shall be removed. Before the joint is re-made, joint surfaces shall be prepared to a satisfaction condition.

The Contractor shall keep a record of each joint with the following details:

- (a) Joint number
- (b) Date and time of jointing
- (c) Batch numbers of resin and hardener
- (d) Weather conditions
- (e) Air temperature
- (f) Name of engineer and foreman supervising mixing and application of bonding agent.

3.7 Testing

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For each lot of material delivered to the Site, one set of the following tests is to be performed:

- Serviceability of the component
- Pot life of the mixed bonding agent
- Open time of the applied bonding agent
- Colour of the bonding agent
- Rate of curing
- Compressive Strength
- Shear Strength

The methods of testing shall be in accordance with FIP/9/2.

4 Acceptance Criteria

- Serviceability of the component
 - Epoxy resin should not show any sign of having become crystalline
- Pot life of the mixed bonding agent
 - Pot life measured must be a minimum of 20 minutes at the ambient temperature at the site
- Open time of the applied bonding agent
 - Open time should not be less than 60 minutes
- Colour of the bonding agent
 - Should be similar to the colour of the concrete segments to be bonded
- Rate of curing (compressive strength test)
 - After 24 hours, the compressive strength should not be less than 60 MPa
 - After 7 days, the compressive strength should not be less than 75 MPa
- Compressive Strength
 - After 7 days, the compressive strength should not be less than 75 N/mm². The speed of loading should be approximately 25 N/mm²/min.
- Shear Strength
 - The lower limit of the specified application temperature range of the bonding agent formulation tested, is to be at least 12 N/mm².

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The lot shall be considered as not complying with the specified requirements for the property if the result of any of the above tests does not comply with the specified requirements for the property.