B16 Repair of Concrete Cracks
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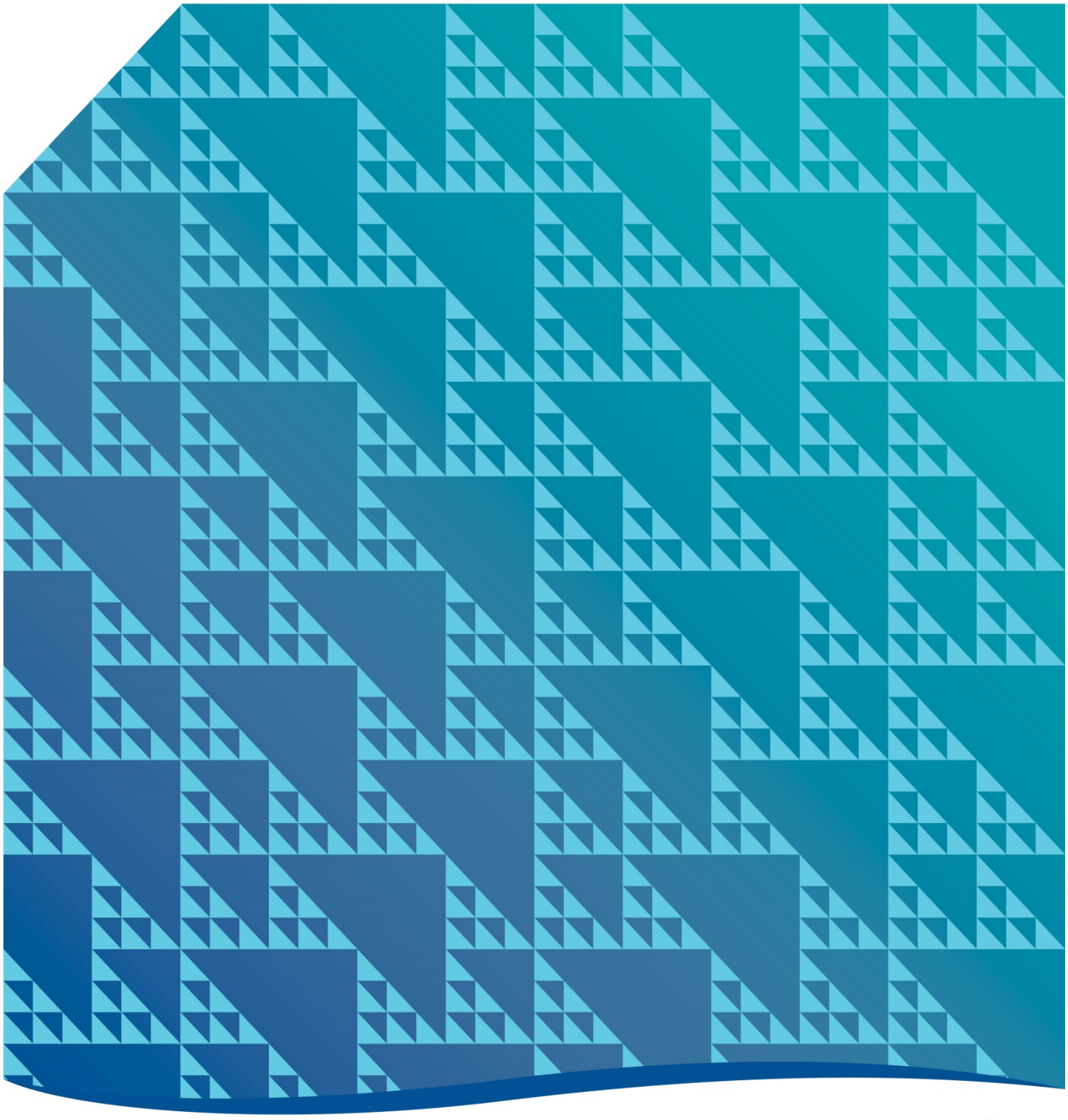
Bridgeworks Specification



Department of State Growth

Tasmanian Government

REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1 / Rev 0	All	*'Department of State Growth'* replaces *'DIER'*	VT (MBA)	07.07.14
	Title	Specification Title renamed from "*Concrete Crack Injection*"		
	B16.1	Clause reworded		
	B16.3–B16.8	New clauses added		
	B16.9	Replaces previous B16.4 clause, clause reworded		
	B16.10	New clause, replaces previous B16.3, B16.5 & B16.6 clauses		
	B16.11-B16.14	New clauses added		
	B16.15	Replaces previous B16.7 clause, clause reworded		
	B16.16-B16.17	New clause added		
	B16.18	Replaces previous B16.8 clause, wording added to clause		
	B16.19	New clause added		

Index **Page**

B16.1 SCOPE

This Specification sets out the requirements for the supply and quality of materials, surface preparation, application, relevant testing and acceptance criteria for the repair of cracks in concrete.

Repair of cracks shall not be undertaken unless the cracked concrete structure has been assessed and the influence of cracks on load bearing capacity, serviceability and durability has been evaluated by the Contractor, and reviewed by the Superintendent.

A crack repair method shall be selected based on the assessment of the cause(s) of the crack, crack width, the moisture condition of the crack and whether a crack is active or inactive prior to any repair works taking place. The crack repair method shall also include details of the crack filling material properties, location, local environment, likely crack behaviour, effect on load capacity, serviceability and durability, surface preparation and method of application.

Crack repair methods and crack filling materials other than those specified in this specification shall not be used unless their suitability has been demonstrated by the Contractor and reviewed by the Superintendent.

B16.2 EXTENT OF WORKS

The extent of works shall be as defined in the drawings, in the Specification, or by the Superintendent on site.

B16.3 REFERENCES AND STANDARDS

The repair of cracks in concrete shall be compatible with the provisions of all Department of State Growth Standard Specifications, Austroads Guides & Test Methods and Australian Standards in particular:

Department of State Growth Standard Specifications

- B15 – Cementitious Patch Repair of Concrete
- B23 – Penetrating Sealers and Coatings for Concrete

Other Relevant Standards

- BS 6319 Testing of resin and polymer/cement compositions for use in construction.

B16.4 DEFINITIONS

Further to the documents referred to in *Clause B16.3* the following definitions shall apply:

Active cracks – Live cracks, which are subject to further movement (i.e. opening up).

Coating over cracks – Application of coatings with a crack bridging capability.

Crack filling material – A resin (or resin adhesive or adhesive) or sealant applied into a crack for the purpose of filling and closing the crack.

Entry port – A device or passageway in the surface seal through which the resin adhesive is introduced into a crack.

Flexible sealing – Use of suitable flexible sealants to seal active cracks in the same manner as flexible joints.

Gravity feed – Filling and sealing of horizontally positioned cracks using low viscosity resins by pouring and spreading onto surface or placing into purposely formed reservoirs.

Inactive cracks – Dormant or dead cracks , which do not open, close or extend further.

Resin (or resin adhesive or adhesive) – The crack filling material that is injected or introduced into a crack for the purpose of re-bonding the separated edges to allow the transfer of tensile stress across the crack and/or water-tightness.

Resin injection – Crack filling under pressure using a selected polymer resin adhesive such as epoxy or polyurethane to restore structural soundness and/or penetrability of concrete where cracks are inactive or can be prevented from moving further.

Routing and sealing – Enlarging the crack along its exposed face and filling with a suitable joint sealant to produce a repair method for cracks that are inactive and not structurally significant.

Sealant – The crack filling material that has adhesive and cohesive properties that forms a seal to prevent the ingress of liquid or gases into the concrete.

Surface Seal – Material used to confine the injection adhesive in the fissure during injection and cure.

B16.5 MAXIMUM ACCEPTABLE CRACK WIDTHS

B16.5.1 General

The concrete shall have no cracks at any stage after construction measured at the concrete surface of width greater than the relevant value given in *Table B16.1 – Maximum Acceptable Crack Widths* for the corresponding exposure classification. Where such cracks exist, they shall be identified as defects.

Notwithstanding the requirements of this clause the acceptable crack width at the concrete surface of pre-cast pre-stressed concrete elements shall not exceed 0.1 mm.

Table B16.1 – Maximum Acceptable Crack Widths

Exposure Classification	Maximum Acceptable Crack Widths (mm)
A	0.20
B1	0.20
B2	0.15
C, U	0.10

B16.5.2 Repair of Inactive Cracks

Repair of inactive cracks shall be as follows:

(i) Cracks up to 1 mm wide shall be repaired by pressure injection of low viscosity epoxy resin, unless otherwise approved.

(ii) Vertical cracks 1–2 mm wide shall be repaired by pressure injection of low viscosity epoxy resin, unless otherwise approved. Horizontal cracks 1–2 mm wide shall be repaired either by pressure injection of epoxy resin or other repair methods which comply with the requirements of this specification, provided a supporting assessment and evaluation by an appropriately experienced consultant has been submitted to the Superintendent for review.

(iii) Cracks over 2-3 mm shall be repaired with filling materials and methods in accordance with the requirements of this specification. Where the repair of such cracks is likely to result in the complete detachment of fractured pieces of concrete away from the main concrete component, such fractures shall be treated as patch repairs and repaired with polymer modified cementitious repair materials in accordance with the requirements of this specification.

B16.5.3 Repair of Active Cracks

Live/active cracks which are non-structural shall be repaired using flexible filler materials and methods in accordance with the requirements of this specification. Live/active cracks which are of structural significance shall be assessed separately and the method of repair approved by the Superintendent.

Any cracks wider than 3.0mm shall be further investigated.

B16.6 CRACK FILLING MATERIALS

The properties of the crack filling material and the characteristics of the equipment to be used shall be specifically allowed for by the Contractor when assessing crack repair methods.

The crack filling material shall possess the following properties:

(a) Resin Injection

(i) Viscosity @ 20°C – Maximum 300 centipoise
(ii) Compressive strength (*BS 6319*) @ minimum at 7 days – 60 MPa
(iii) Tensile strength (*BS 6319*) @ minimum at 7 days – 25 MPa
(iv) Flexural strength (*BS 6319*) @ minimum at 7 days – 50 MPa
(v) Adhesive strength at the crack edges @ minimum at 7 days – 2.5 MPa or failure in concrete whichever occurs first.

(b) Routing or Sealing, Nipple Placement, Gravity Feed or Stitching

(i) Compressive strength (*BS 6319*) @ minimum at 7 days – 60 MPa
(ii) Tensile strength (*BS 6319*) @ minimum at 7 days – 25 MPa
(iii) Flexural strength (*BS 6319*) @ minimum at 7 days – 30 MPa.

(c) Flexible Sealing for Live or Active Non Structural Cracks

The flexible sealant shall provide for a minimum expectant movement of ± 25%.

Materials shall not be used when the ambient temperature is below 5°C or is 5°C on a falling thermometer or is above 35°C. The crack filling material shall be compatible with all materials with which it is intended to come into contact.

B16.7 EQUIPMENT

B16.7.1 General

Equipment used for the filling of cracks shall ensure an adequate, uninterrupted flow of the crack filling material until capillary suction has ceased, and shall be capable of filling the cracks as detailed in the manufacturer's requirements.

B16.7.2 Equipment for Injection

Equipment for injection shall have the following characteristics:

- easy to handle with simple function checking
- pressure regulation or limitation in the operating range of the injection equipment
- simple cleaning and maintenance.

Equipment for multi-component injection such as special purpose twin-metering pumps shall also satisfy the requirements detailed in *Clause B16.7.3*.

B16.7.3 Multi-component Injection Equipment

B16.7.3.1 Type

The equipment used to meter and mix the two injection adhesive components and inject the mixed adhesive into the crack shall be portable, with positive displacement type pumps with interlock to provide positive ratio control of exact proportions of the two components at the nozzle. The pumps shall be electrically powered and shall provide in-line metering and mixing. The equipment shall have high dosing accuracy throughout all temperature ranges.

B16.7.3.2 Discharge Pressure

The injection equipment shall have automatic pressure control capable of discharging the mixed adhesive at any pre-set pressure up to 550 ±5 kPa and shall be equipped with a manual pressure control override.

B16.7.3.3 Ratio Tolerance

The equipment shall have the capability of maintaining the volume ratio for the injection adhesive prescribed by the manufacturer of the adhesive within a tolerance of ±5% by volume at any discharge pressure up to 550 kPa.

B16.7.3.4 Automatic Shut-Off Control

The injection equipment shall be equipped with sensors on both component reservoirs that will automatically stop the machine when one component is being pumped to the mixing head.

B16.7.4 Injection Fittings and Surface Seal

Bonded-on injection fittings or injection fittings placed in drilled holes in conjunction with V-grooving of the cracks may be used. Where hole drilling is undertaken care shall be taken to ensure that the reinforcement is not damaged. Parts of injection fittings remaining in the structure shall be made of rustproof materials.

The surface seal material shall have adequate strength to hold injection fittings firmly in place and to resist injection pressure adequately to prevent leakage during injection. Suitable rapid-curing repair materials for after-sealing shall be kept ready for use where poor sealing is identified.

B16.8 MATERIAL MIXING AND APPLICATION

All materials shall be mixed and applied in accordance with the directions for use issued by the manufacturer.

B16.9 SURFACE PREPARATION

Cracks and surfaces located a minimum of 50 mm either side of cracks on all areas of application shall be cleaned of all loose particles, dirt, dust, grease, oil, paints, curing compounds or efflorescence using appropriate methods (i.e. oil-free compressed air, industrial vacuum cleaners or flushing with high pressure water). Impurities, which inhibit wetting and adhesion or penetration by the crack filling material, shall be removed.

Cracks and crack zones shall be allowed to dry thoroughly for a minimum of 24 hours or dried out by accelerated means prior to the application of materials, unless such materials are water tolerant.

Where cracks exist in a coated area, remove the coating for 100 mm each side of the crack and prepare the surface in accordance with *Standard Specification B23 Penetrating Sealers and Coatings for Concrete*. Reinstate the coating after the repair, lapping the old coating by at least 50 mm.

B16.10 RESIN INJECTION OF CRACKS

B16.10.1 General

The Contractor shall submit all details of crack filling procedure for review by the Superintendent 14 days prior to commencement of the Works.

B16.10.2 Materials

Cold curing, two component, solvent free, unfilled epoxy or polyurethane resin adhesives may be used to seal cracks.

With reference to *Clause B16.1*, the Superintendent shall determine whether the cracks are of any structural significance. Only epoxy resin adhesives approved by the Superintendent shall be used for structural repairs.

B16.10.3 Execution of the Works

B16.10.3.1 General

Each crack shall be treated in a single continuous operation and shall be filled completely. The Contractor shall comply with the temperature ranges for application and any other material specific constraints specified in the directions for use by the manufacturer.

Where water-bearing cracks are to be sealed, rapid-foaming polyurethane shall, where necessary, be injected to provide temporary sealing prior to injection of the cold-curing resin. Where cement paste is used, dry or moist crack edges shall be wetted thoroughly.

Where re-injection is required, this shall be carried out within the temperature-dependent period of the crack filling material given in the directions for use by the manufacturer. At high ambient temperatures, the use of cooling to influence the workability time of materials in containers is permissible.

The injection pressure used shall be commensurate with the equipment and materials used, to ensure that cracks are completely filled without leaving voids. Use crack injection pressures < 400 kPa for crack widths ≥ 2.0 mm and between 400 kPa and 2000 kPa for crack widths < 2.0mm. Use higher pressures only as required by the crack configuration.

B16.10.3.2 Preparation

(1) Surface preparation shall be undertaken in accordance with *Clause B16.9*.

(2) Injection entry ports shall be provided along the crack at intervals of not greater than 200 mm.

Unless otherwise approved by the Superintendent, where a concrete component such as a wall or slab is cracked all the way through, the injection entry ports shall be located on both sides where access is possible. The injection entry ports at the reverse face shall be placed midway between those at the front.

Where cracks can only be sealed on one side only, injection entry ports shall be placed at intervals which are 50% of the depth to which the resin is required to penetrate or not greater than 200 mm, whichever is the lesser.

Use only surface mounted injection ports to avoid drilling concrete. Drill into decks only where a suitable surface for mounting the ports does not exist, and/or where crack widths are smaller than 1 mm.

(3) Apply surface seal material to the face of the crack between the entry ports. Surface seal material shall also be applied to the reverse face of cracks where accessible.

(4) Resin injection shall not proceed until the surface seal material has achieved adequate strength in accordance with the manufacturer's directions for use.

B16.10.3.3 Resin Injection

(1) For vertical cracks injection of resin adhesive shall begin at the lowest entry port and continue until there is an appearance of resin adhesive at the next entry port adjacent to the entry port being pumped. Where resin adhesive drains out of vertical cracks in retaining walls or foundation walls due to the inability to seal the earth backfill side or the bottom of slabs, such cracks shall be re-injected until they are full and remain full.

For horizontal cracks, the injection shall proceed from one end of the crack to the other. For horizontal cracks, which are on grade, the crack shall be re-injected until the crack is full to compensate for any resin adhesive which may drain away due to the grade.

Where a concrete component such as a wall or slab is cracked all the way through, the resin shall be injected through alternate entry ports on both sides where access is possible. For slabs, injection from the underside shall precede injection from the top.

(2) When resin adhesive travel is indicated by appearance at the next adjacent port, injection shall be discontinued and the entry port capped, and the resin injection shall be transferred to the next adjacent port where the resin adhesive has appeared.

(3) Resin adhesive injection shall be performed continuously until cracks are completely filled.

(4) If port to port travel of resin adhesive is not indicated, the work shall cease immediately and the Superintendent notified.

B16.11 ROUTING AND SEALING

B16.11.1 Materials

Cold curing, two component, solvent free, epoxy or polyurethane sealants or silicones, polysulphides or asphaltic materials may be used to seal cracks. Cement grouts shall not be used for this type of crack repair. Sealants shall be able to withstand cyclic deformations and shall not be brittle. Flexible sealants used for the repair of active cracks shall be capable of accommodating the anticipated movement.

With reference to *Clause B16.1*, the Superintendent shall determine whether the cracks are of any structural significance. Only epoxy or polymer modified cementitious repair materials approved by the Superintendent shall be used for structural repairs.

B16.11.2 Execution of the Works

B16.11.2.1 Inactive or Dormant Cracks

The crack shall be chased and a V-shaped groove with a minimum surface width of 10 mm and depth of 10 mm shall be formed to act as the sealant reservoir. The groove shall be prepared and cleaned in accordance with *Clause B16.9*. The sealant shall be placed into the dry groove and allowed to cure in accordance with the material manufacturer's specified directions.

B16.11.2.2 Flexible Sealing for Live or Active Non Structural Cracks

A rectangular reservoir with a minimum width to depth ratio of 2:1 or as required by the material manufacturer's directions shall be cut out on top of the active crack and prepared in accordance with *Clause B16.9*. A bond-breaking polyethylene tape or equivalent shall be placed over the crack at the bottom of the reservoir prior to the application of the flexible sealant.

Live/active cracks which are of structural significance shall be assessed separately and the method of repair approved by the Superintendent.

B16.12 GRAVITY FEED

B16.12.1 Materials

Cold curing, two component, solvent free, unfilled epoxy resin adhesives may be used to close cracks by gravity feed.

B16.12.2 Execution of the works

B16.12.2.1 General

Filling and sealing of horizontally positioned cracks shall be executed by pouring and spreading suitable crack filling material onto the surface or placing into purposely formed reservoirs.

B16.12.2.2 Pouring and Spreading onto Surface

The crack filling material shall be poured onto the surface and spread with brooms rollers or squeegees. The material shall be worked back and forth over the cracks to obtain maximum filling. Excess material shall be broomed off the surface to prevent slick, shining areas after curing. The feeding of material to the crack shall be uninterrupted, throughout the temperature-dependent workability of the crack filling material, until no more material can be absorbed.

B16.12.2.3 Purposely Formed Reservoir

A reservoir shall be formed by running a bead of silicone or acrylic sealant along both sides of the crack. The ends of both beads shall be formed together at the termination of the crack to form a reservoir. The edge of the sealant shall be a minimum of 5 mm away from the crack and its height shall be a minimum of 10 mm above the substrate. The crack filling material shall be poured into the reservoir and be topped up as its level drops. When the crack filling material in the reservoir starts to gel, both the excess resin and the sealant reservoir shall be scraped off.

B16.13 COATING OVER OF SHALLOW CRACKS

Except for pre-cast pre-stress concrete elements where the limit is 0.1mm, inactive cracks with a width of less than 0.2 mm may be coated over with an acceptable protective coating system as required by the Superintendent, provided such cracks are not associated with earth or water retaining concrete components. Protective coating systems including their mixing and application shall satisfy all requirements of *Standard Specification B23 Penetrating Sealers and Coatings for Concrete*.

Active or live cracks of width equal to or greater than 0.2 mm shall be repaired in accordance with *Clause B16.11* prior to coating over.

Inactive or dormant cracks of width equal to or greater than 0.2 mm shall be repaired in accordance with *Clauses B16.10 and B16.11* prior to coating over.

Protective coatings shall be compatible with any previously applied crack fillers or sealers.

B16.14 QUALITY CONTROL FOR RESIN INJECTION

B16.14.1 Low Pressure Injection

Resin injection, which utilises proprietary injection kits, modified grease guns or sealant guns shall continue until firm and sustained hand pressure on the gun trigger signifies that no further resin can be accepted in the crack.

B16.14.2 Multi-component Injection

B16.14.2.1 Pressure Test

The mixing head of the injection equipment shall be disconnected and the two-adhesive component delivery lines shall be attached to the pressure check device. The pressure check

device shall consist of two independent valved nozzles capable of controlling flow rate and pressure by opening or closing the valve. There shall be a pressure gauge capable of sensing the pressure build-up behind each valve. The valves on the pressure check device shall be closed and the equipment operated until the gauge pressure on each line reads 550 kPa. The pumps shall be stopped and the gauge pressure shall not drop below 515 kPa within three minutes.

The pressure test shall be undertaken twice a day for each injection unit, at the beginning and half way mark when the unit is used in the crack repair work.

B16.14.2.2 Ratio Test

The mixing head of the injection equipment shall be disconnected and the two-adhesive components shall be pumped simultaneously through the ratio check device. The ratio check device shall consist of two independent valved nozzles capable of controlling backpressure by opening or closing the valve. There shall be a pressure gauge capable of sensing the backpressure behind each valve. The discharge pressure shall be adjusted to 550 kPa for both adhesive components. Both adhesive components shall be simultaneously discharged into separate calibrated containers. The amounts discharged into the calibrated containers during the same time period shall be compared to determine that the volume discharged conforms to the manufacturers specified directions.

B16.14.2.3 Proof of Ratio and Pressure Test

The Contractor shall maintain complete and accurate records of the pressure and ratio tests for review by the Superintendent.

B16.15 CURING AND FINISHING

When cracks are completely filled, resin adhesive shall be cured for sufficient time in accordance with the material manufacturer specified directions, to allow removal of surface seal without any draining or runback of resin material from cracks.

Surface seal material and injection adhesive runs or spills shall be removed from concrete surfaces.

The face of the crack shall be finished flush to the adjacent concrete showing no indentations or protrusions caused by the placement of surface sealant or entry ports.

Where protective or decorative coating systems are required these shall satisfy all requirements of *Standard Specification B23 Penetrating Sealers and Coatings for Concrete*.

B16.16 VERIFICATION OF DEPTH OF PENETRATION OF CRACK FILLING MATERIAL

Where nominated in the specification or directed by the Superintendent, the Contractor shall extract at a minimum of seven days after completion of crack repair works a sample of two 75 mm diameter cores from the first 25 m of crack repair works and thereafter for every 50 m or part thereof, to verify the depth of penetration of the crack filling material. The core samples shall be extracted at locations jointly determined by the Contractor and the Superintendent and shall be inspected by the Superintendent, to verify that the crack filling material has penetrated to the full depth of the crack.

Core samples shall be located with a calibrated cover meter capable of detecting the presence of steel reinforcement with an accuracy of ±1 mm at a depth of 25 mm, to avoid cutting through the reinforcing steel. Drilling cores in areas of high stress, or creating core holes below the waterline shall be avoided.

The Contractor shall obtain the approval of the Superintendent prior to undertaking any extraction of core samples.

If the Contractor fails to adequately verify the depth of penetration of the crack filling material it shall extract additional 75 mm diameter cores at its own expense. Alternatively, the Contractor may at its own expense use non-destructive test (NDT) methods such as Ultrasonic Pulse Velocity (UPV), Impact Echo (IE) or Spectral Analysis of Surface Waves (SASW) to establish the extent of penetration of resin adhesive into the cracks.

The Contractor shall supply for review by the Superintendent a copy of all depth of penetration testing including photographic records within one week of undertaking such verification testing.

The cored holes shall be cleaned and repaired with a suitable shrinkage compensating cementitious repair material in accordance with the requirements of *Standard Specification B15 Cementitious Patch Repair of Concrete*. The exposed surface of the repaired hole shall be similar in texture and colour to the surrounding concrete.

Should the crack filling material not penetrate the full depth of the crack, the Contractor shall carry out rectification works. These works shall achieve the specified level of durability, otherwise the concrete works represented by that sample may be rejected.

B16.17 CONTRACTOR COMPETENCY

Personnel, sub-contractors and suppliers used in repair of concrete cracks shall have a minimum of five years experience in the repair and rehabilitation of reinforced concrete structures and a demonstrated competency for surface preparation and application of the crack filling material to be applied.

The concrete crack repair supervisor shall be trained and qualified on all aspects of application techniques and shall be present at all times during repair work. Application personnel shall be trained and skilled in the application procedures of the crack repair material to be applied.

Documented evidence shall be available to demonstrate experience, qualification, skills and training of personnel, sub-contractors and suppliers.

B16.18 PAYMENT

Payment for concrete crack injection repairs shall be at the items as listed in the Schedule of Rates.

Payment shall include the provision of all plant, labour and materials required for access, preparation of the area, supply and placement of repair material and the disposal of any debris.

B16.19 HOLD POINTS

The following hold points have been identified in this specification:

Hold Points identified in this Specification are listed in *Table B16.2 – Hold Points.*

Table B16.2 – Hold Points

Clause Ref	Description	Nominated work not to proceed	Evidence of Compliance
B16.10.1	Resin Injection	Resin Injection of cracks	The Contractor shall submit all details of crack filling procedure for review by the Superintendent 14 days prior to commencement of the Works.

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