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| AUSTROADS TECHNICAL SPECIFICATION ATS 5341Repair of Concrete Cracks | A close up of a flag  Description automatically generated |

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| Contents[1. Scope 2](#_Toc133600936)[2. Referenced Documents 2](#_Toc133600937)[3. Definitions 2](#_Toc133600938)[4. Quality System Requirements 3](#_Toc133600939)[5. Materials 4](#_Toc133600940)[6. Contractor and Personnel Competency 4](#_Toc133600941)[7. Crack Repair Method 4](#_Toc133600942)[8. Equipment 5](#_Toc133600943)[General 5](#_Toc133600944)[Equipment for injection 5](#_Toc133600945)[Injection fittings and surface seal 6](#_Toc133600946)[9. Surface Preparation 6](#_Toc133600947)[10. Pressure Injection 7](#_Toc133600948)[Materials 7](#_Toc133600949)[General 7](#_Toc133600950)[Preparation 7](#_Toc133600951)[Low pressure injection 7](#_Toc133600952)[Resin injection 8](#_Toc133600953)[Multi-component injection – Pressure test 8](#_Toc133600954)[Multi-component injection – Ratio test 8](#_Toc133600955)[Records 9](#_Toc133600956)[11. Routing and Sealing 9](#_Toc133600957)[General 9](#_Toc133600958)[Inactive cracks 9](#_Toc133600959)[Active cracks 9](#_Toc133600960)[12. Gravity Feed 9](#_Toc133600961)[Materials 9](#_Toc133600962)[General 10](#_Toc133600963)[Pouring and spreading onto surface 10](#_Toc133600964)[Purposely formed reservoir 10](#_Toc133600965)[13. Coating over Cracks 10](#_Toc133600966)[14. Stitching of Cracks 10](#_Toc133600967)[15. Curing and Finishing 10](#_Toc133600968)[16. Verification of Penetration Depth 11](#_Toc133600969)[Annexure A: Summary of Hold Points, Witness Points and Records 12](#_Toc133600970) |

# Scope

Austroads Technical Specification ATS 5341 sets out the requirements for the repair of cracks in concrete, including supply and quality of materials, surface preparation, application, relevant testing and acceptance criteria.

Unless specified otherwise in the Contract documents, it only applies to Inactive Cracks in concrete.

# Referenced Documents

The following documents are referenced in this Specification:

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| **Australian / New Zealand Standards**AS 1012.24 Determination of the Tensile Bond Strength of Concrete – Repairs and Strengthening SystemsAS 5100.8 Bridge design Part 8: Rehabilitation and strengthening of existing bridgesHB 84 Guide to concrete repair and protection |
| **Austroads**ATS 5340 Cementitious Patch Repair of Concrete |
| **International / European Standards**EN 1504 Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity – Part 5 Concrete injection and Part 9 General principles for the use of products and systems |

# Definitions

The following definitions apply to this Specification.

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| **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. |
| **Resin injection:**  | Crack filling under pressure using a selected polymer resin adhesive such as epoxy or polyurethane to restore structural soundness and impenetrability of concrete where cracks are inactive or can be prevented from moving further. |
| **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. |
| **Stitching of cracks:**  | Anchoring of U-shaped metal legs in predrilled holes on both sides of cracks to restore the tensile strength of the crack affected concrete. |
| **Surface Seal:**  | Material used to confine the injection adhesive in the fissure during injection and cure. |

# Quality System Requirements

The Contractor must prepare and implement a Quality Plan that includes the documentation in Table 4.1.

Table 4.1 Quality Plan

| Clause | Description of document |
| --- | --- |
| 5.1 | Details of the cracking filling material, |
| 7.2 | Details, work method statements / procedures for undertaking the crack repair. |

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| **HOLD POINT 1.** |
| Process Held | Commencement of concrete crack repairs. |
| Submission Details | The Quality Plan must be provided to the Principal at least 10 working days prior to the commencement of the concrete repair work. |

Where a Principal’s Registration Scheme is in place for the supply of crack repair material, the crack repair material must be approved under that scheme.

For work undertaken in Queensland, the crack repair material must be a Transport and Main Roads registered product and the manufacturer must be a Registered Supplier. Further details are available from <https://www.tmr.qld.gov.au/business-industry/Business-with-us/Approved-products-and-suppliers>.

# Materials

The Quality Plan must include details of the cracking filling material, including its properties and the manufacturer’s instructions. The Contractor must ensure that the properties of the crack filling material and the characteristics of the equipment to be used are suitable for the successful repair of the crack.

All materials must be mixed and applied in accordance with the manufacturer’s instructions.

The crack filling material must comply with Clause 3.5.2.2.2 *Materials properties* of AS 5100.8.

# Contractor and Personnel Competency

The Contractor warrants that it (or the subcontractor, if the repair work is being undertaken by a subcontractor) is:

1. suitably skilled and experienced in undertaking the undertaking the repair of concrete cracks; and
2. holds all approvals from the materials manufacturer that are necessary to ensure that the manufacturer’s warranties are not voided.

The concrete crack repair supervisor must be suitably trained and qualified on all aspects of application techniques and must be present at all times during repair work.

Personnel undertaking the repair must be suitably trained and skilled in the application procedures of the crack repair material to be applied.

If requested by the Principal, the Contractor must provide evidence of the experience, qualification, skills and training of personnel, sub-contractors and suppliers.

# Crack Repair Method

Unless the Principal has specified the crack repair method, the Contractor must:

1. assess of the cause(s) of the crack, crack dimensions (width, depth and length), the moisture condition of the crack and whether a crack is active or inactive; and
2. select the crack repair method, in accordance with EN 1504-9 and HB 84.

The Quality Pan must include a description of the crack repair method, including details of the crack filling material properties, location, local environment, likely crack behaviour, effect on load capacity, serviceability and durability, surface preparation, method of application and method of verifying conformance with this Specification.

Crack repair methods and crack filling materials other than those specified in this Specification must not be used unless their suitability has been demonstrated by the Contractor and included in the Quality Plan accepted by the Principal.

If the concrete adjacent to the crack has deteriorated, the concrete must be treated in accordance with ATS-5340-20 Cementitious Patch Repair of Concrete,

The repair of concrete cracks must be undertaken by one of the following methods:

1. Pressure injection: Crack filling under pressure using a selected polymer resin (such as epoxy or polyurethane) or cementitious grout to restore structural soundness and impenetrability of concrete. The procedure must be either:
2. Low pressure injection; using proprietary injection kits, based on firm and sustained hand pressure until no further resin can be accepted in the crack; or
3. Multi-component injection; based on proof of ratio and pressure tests relating to the discharge pressure and ratio of adhesive components.
4. Routing and sealing: Enlarging the crack along its exposed face and filling with a suitable joint sealant.
5. 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.
6. Coating over cracks: Application of coatings with a crack-bridging capability or impregnation ability (such as silanes) for cracks of width of 0.2 mm or less. The method must be used only for cracks that are compatible with the functional requirements of the structure but are not associated with earth-retaining or water-retaining concrete components.
7. Flexible sealing: Use of suitable flexible sealants to seal cracks in the same manner as flexible joint (if permitted in the Contract documents).
8. Crack stitching: Anchoring of U-shaped metal legs in predrilled holes on both sides of cracks to restore the tensile strength of the crack affected concrete.

The crack repair must comply with EN 1504-5.

Pressure injection or routing must not be used for active cracks.

# Equipment

## General

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

## Equipment for injection

Equipment for pressure injection must have the following characteristics:

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

Equipment for multi-component injection such as special purpose twin-metering pumps must also satisfy the following requirements:

1. Type

The equipment used to meter and mix the two injection adhesive components and inject the mixed adhesive into the crack must 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 must be electrically powered and must provide in-line metering and mixing, unless the Contractor can demonstrate that alternative equipment will perform satisfactorily. The equipment must have high dosing accuracy throughout all temperature ranges.

1. Discharge Pressure

The injection equipment must have automatic pressure control and must be equipped with a manual pressure control override. Unless the Contractor can demonstrate that a lesser pressure will be satisfactory, the equipment must be capable of discharging the mixed adhesive at any pre-set pressure up to 550 ±5 kPa.

1. Ratio Tolerance

The equipment must 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 up to the maximum discharge pressure of the equipment.

1. Automatic Shut-Off Control

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

## Injection fittings and surface seal

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

The surface seal material must 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 must be kept ready for use where poor sealing is identified.

# Surface Preparation

Prior to the commencement of crack repair and during crack repair, cracks, grooves and surfaces located a minimum of 50 mm either side of a crack to be repaired must be clean and free of anything which inhibit wetting and adhesion or penetration by the crack filling material. This including loose particles, dirt, dust, grease, oil, paints, curing compounds, efflorescence or other impurities.

The cleaning method must not push dirt or dust particles further into the crack. The use of industrial vacuum cleaners is permitted.

Cracks and crack zones must 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.

# Pressure Injection

## Materials

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

## General

Each crack must be treated in a single continuous operation and must be filled completely. The Contractor must 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 must, 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 must be wetted thoroughly.

Where re-injection is required, this must 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 must be commensurate with the equipment and materials used, to ensure that cracks are completely filled without leaving voids.

## Preparation

Surface preparation must be undertaken in accordance with Clause 9.

Injection entry ports must be provided along the crack at intervals of not greater than 200 mm.

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

Where cracks can only be sealed on one side only, injection entry ports must 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.

Surface seal material must be applied to the face of the crack between the entry ports. Surface seal material must also be applied to the reverse face of cracks where accessible.

Resin injection must not proceed until the surface seal material has achieved adequate strength in accordance with the manufacturer’s directions for use.

## Low pressure injection

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

## Resin injection

For vertical cracks injection of resin adhesive must 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 must be re-injected until they are full and remain full.

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

Unless the Contractor can demonstrate that an alternative system will meet the requirements of this Specification, a balloon injection port system must be used for overhead and vertical cracks.

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

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

Resin adhesive injection must be performed continuously until cracks are completely filled.

If port to port travel of resin adhesive is not indicated, the work must cease immediately and the Contractor must develop a proposal to ensure port to port travel of resin adhesive is achieved.

| **HOLD POINT 2.** |
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| Process Held | Resin injection of cracks where port to port travel of resin adhesive is not indicated. |
| Submission Details | A proposal to ensure port to port travel of resin adhesive is achieved must be submitted to the Principal prior to the re-commencement of the resin injection |

## Multi-component injection – Pressure test

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

The pressure test must 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.

## Multi-component injection – Ratio test

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

## Records

The Contractor must maintain complete and accurate records of:

1. the quantity of materials used; and
2. the pressure and ratio tests.

# Routing and Sealing

## General

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

Routing of cracks must not be undertaken on prestressed concrete components unless the depth of concrete cover has been established.

## Inactive cracks

Unless repaired using pressure injection or gravity feed, Inactive cracks must be repaired in a manner which ensures that the alkalinity around reinforcement is restored. At a minimum, the repair method must include the following:

1. route the crack to 10 – 15 mm wide and 15 – 20 mm and clean in accordance with Clause 9;
2. ensure the concrete is saturated surface dry;
3. apply a coat of crystalline growth promoting primer;
4. apply a 5 – 10 mm bead of dry pack crystalline growth promoting mortar;
5. fill the crack with non-shrink plug mortar;
6. apply a cap coat with crystalline growth promoting slurry; and
7. curing in accordance with the manufacturer’s instructions.

## Active cracks

If the sealing of an Active Crack is specified in the Contract documents, at a minimum, a rectangular reservoir with a minimum width to depth ratio of 2:1 or as required by the material manufacturer’s directions must be cut out on top of the Active Crack and prepared in accordance with Clause 9.

A bond-breaking polyethylene tape or equivalent must be placed over the crack at the bottom of the reservoir prior to the application of the flexible sealant.

# Gravity Feed

## Materials

Cold curing, two component, solvent free, unfilled epoxy resin adhesives may be used to close cracks by gravity feed. The viscosity of the resin must be less than 100 mPa s.

## General

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

## Pouring and spreading onto surface

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

## Purposely formed reservoir

A reservoir must be formed by running a bead of silicone or acrylic sealant along both sides of the crack. The ends of both beads must be formed together at the termination of the crack to form a reservoir. The edge of the sealant must be a minimum of 5 mm away from the crack and its height must be a minimum of 10 mm above the substrate. The crack filling material must 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 must be scraped off.

# Coating over Cracks

Inactive cracks with a width of less than 0.2 mm may be coated over with an approved protective coating system, provided such cracks are not associated with earth or water retaining concrete components.

If the crack width is equal to or greater than 0.2 mm, it must be repaired in accordance with this Specification prior to coating over.

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

# Stitching of Cracks

This crack repair method must be used where restoration of the tensile strength is required across major cracks. Holes must be drilled on both sides of the crack, cleaned in accordance with Clause 9**.** and U shaped metal legs (stitching) anchored in the holes with an epoxy resin based bonding system. The stitching metal legs must be variable in length and orientation, and they must be located such that the tension across the crack is distributed over an area in the concrete and not concentrated on a single plane within a section. Such cracks must also be sealed in accordance with this Specification.

# Curing and Finishing

When cracks are completely filled, resin adhesive must 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 must be removed from concrete surfaces.

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

# Verification of Penetration Depth

The Contractor must 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.

Core samples must 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 must be avoided.

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| **HOLD POINT 3.** |
| Process Held | Extraction of core samples. |
| Submission Details | The proposed position of core samples must be submitted to the Principal at least 48 hours prior to the commencement of the coring |

The core samples must be extracted to verify that the crack filling material has penetrated to the full depth of the crack.

If the Contractor fails to adequately verify the depth of penetration of the crack filling material it must extract additional 75 mm diameter cores. Alternatively, the Contractor may 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 must maintain complete and accurate records of all depth of penetration testing including photographic records and provide to the Principal a copy within one week of undertaking the testing.

The cored holes must be cleaned and repaired with a suitable shrinkage compensating cementitious repair material in accordance with the requirements of ATS-5340-20. The exposed surface of the repaired hole must 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 must carry out rectification works. The rectification works must achieve the specified level of durability.

Annexure A: Summary of Hold Points, Witness Points and Records

The following is a summary of the Witness Points/Hold Points that apply to this Specification and the Records that the Contractor must submit to the Principal to demonstrate compliance with this specification.

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| **Clause** | **Hold point** | **Witness point** | **Record** |
| 4.1 | Commencement of concrete crack repairs. |  | Quality Plan |
| 10.19 | Resin injection of cracks where port to port travel of resin adhesive is not indicated |  | Proposal to ensure port to port travel of resin adhesive is achieved |
| 10.23 |  |  | Materials qualities and results of the pressure and ratio tests |
| 16.2 | Extraction of Core Samples |  | The proposed position of core samples |
| 16.5 |  |  | Photographs and observed depth of crack filling material. |

Amendment Record

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| --- | --- | --- | --- |
| **Amendment no.** | **Clauses amended** | **Action** | **Date** |
| - | New specification | New | January 2020 |
| 1 | 1.2 – ATS 5341 only applies to inactive cracks, unless specified otherwise | New | May 2023 |
| 7.5 e) – added (if permitted in the Contract documents) | New |
| 11.4 – The clause only applies if specified in the contract documents | Substitution  |

|  |  |
| --- | --- |
| **Key** |  |
| Format | Change in format |
| Substitution | Old clause removed and replaced with new clause |
| New | Insertion of new clause |
| Removed | Old clauses removed |