|  |  |
| --- | --- |
| AUSTROADS TECHNICAL SPECIFICATION ATS5340 Cementitious Patch Repair of Concrete  | A close up of a flag  Description automatically generated |

|  |
| --- |
| Contents[1. Scope 2](#_Toc29386440)[2. Definitions 2](#_Toc29386441)[3. Referenced Documents 3](#_Toc29386442)[4. Quality System Requirements 4](#_Toc29386443)[5. Materials Properties 4](#_Toc29386444)[6. Handling and Storage of Materials 5](#_Toc29386445)[7. Surface Preparation 5](#_Toc29386446)[Removal of Defective Concrete 5](#_Toc29386447)[Steel Reinforcement 6](#_Toc29386448)[8. Application of Repair Mortar 7](#_Toc29386449)[Reinforcement Protection and Substrate-Bonding Coat 7](#_Toc29386450)[Application 7](#_Toc29386451)[Blowholes and Surface Imperfections 8](#_Toc29386452)[9. Curing and Protection 8](#_Toc29386453)[10. Finishing and Surface Condition 9](#_Toc29386454)[11. Tolerances 9](#_Toc29386455)[12. Quality Control Testing 9](#_Toc29386456)[Compressive Strength of Cementitious Repair Material 9](#_Toc29386457)[Bond Strength (Pull-Off) Testing 9](#_Toc29386458)[Testing for Drummy Areas 10](#_Toc29386459)[Test Results 10](#_Toc29386460)[Non-conformances 10](#_Toc29386461)[Annexure A: Summary of Hold Points, Witness Points and Records 11](#_Toc29386462) |

# Scope

This Austroads Technical Specification sets out the requirements for the patch repair of Defective concrete using cementitious materials.

The process of restoring existing concrete typically includes:

1. breaking back to sound and dense concrete to receive repair material;
2. preparation of steel reinforcement (including possible replacement of steel reinforcement) and concrete substrate;
3. application of an appropriate steel primer and substrate bonding coat; and
4. placement of cementitious repair material

# Definitions

The following definitions apply to this specification:

**Blowholes:** Small regular or irregular cavities, usually not exceeding 15 mm in diameter or 5 mm in depth, resulting from entrapment of air bubbles in the surface of formed concrete during placement and consolidation.

**Bond:** The adherence between the repair material and the existing concrete substrate.

**Bond strength (or pull-off strength):**
The resistance to separation of a repair material from the existing concrete substrate.

**Defective Concrete:** Concrete with Blowholes, cracking, deterioration, Delamination, excessive cracking, impact damage, Spalling, honeycombing or Surfacing Imperfections resulting from:

1. contamination by deleterious substances such as chlorides and carbon dioxide associated with the overall mechanism of corrosion of steel reinforcement;
2. overloading or impact;
3. excessive early shrinkage; or
4. deficient compaction, placement or finishing.

**Delamination:** The separation of a section of concrete from solid concrete usually along the plane of steel reinforcement which is identified by a drummy or hollow sound instead of a clear ringing sound when metal hits the concrete.

**Fairing coat:** A thin layer of cementitious material used to render large surface areas and cover, fill or smooth blowholes and surface imperfections flush with the finished concrete surface.

**Featheredging:** Cementitious material applied to the edge of the restoration in a very thin layer instead of a thicker layer which is contained at the edge with a square cut.

**Professional Engineer:** has the meaning defined in AS 5100.

**Surface Imperfections:** Surface voids or cavities not exceeding 5 mm in depth left on the concrete surface (in the form of surface honeycomb), due to failure of the mortar to effectively fill the spaces among coarse aggregate particles during placement and consolidation.

**Spall:** A fragment of concrete broken off or detached from the edge of solid concrete due to the corrosion of steel reinforcement or due to accidental, physical or mechanical damage.

# Referenced Documents

The following documents are referenced in this specification:

**Australian Standards**

AS 1012.8.3 Methods of testing concrete - Methods of making and curing concrete – Mortar and grout specimens

AS 1012.5 Methods of testing concrete - Determination of mass per unit volume of freshly mixed concrete

AS 1012.9 Methods of testing concrete – Compressive strength tests –Concrete, mortar and grout specimens

AS 1012.20.2 Determination of water-soluble chloride in aggregates and hardened concrete

AS 1012.24 Determination of the Tensile Bond Strength of Concrete – Repairs and Strengthening Systems

AS 1478 Chemical admixtures for concrete, mortar and grout

AS 1627 Metal finishing – Preparation and pretreatment of surfaces

AS 2350.13 Methods of testing portland, blended and masonry cements – Determination of drying shrinkage of cement mortars

AS 3799 Liquid membrane‑forming curing compounds for concrete

AS 5100 Bridge design

**Other Standards**

EN 1504 Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity.

EN 13057 Products and systems for the protection and repair of concrete structures. Test methods. Determination of resistance of capillary absorption

EN 1267-4 Products and systems for the protection and repair of concrete structures. Test methods. Determination of shrinkage and expansion

EN 13412 Products and systems for the protection and repair of concrete structures. Test methods. Determination of modulus of elasticity in compression

EN 1770 Products and systems for the protection and repair of concrete structures. Test methods. Determination of the Coefficient of Thermal Expansion

**Austroads**

ATS 5210 Supply and Placement of Reinforcing Steel

#  Quality System Requirements

The Contractor must prepare and implement a Quality Plan that includes:

1. the manufacturer’s specifications / instructions;
2. detailed work method statement (WMS); and
3. inspection and test plans (ITPs) for the specific concrete restoration works that will verify conformance with this Specification.

The WMS and ITPs must:

1. cross reference all applicable Specification clauses; and
2. identify all performance requirements and Hold Points.

|  |
| --- |
| **HOLD POINT 1** |
| Process Held | Commencement of concrete restoration. |
| Submission Details | The Quality Plan must be provided at least 14 days prior to the commencement of the concrete restoration work. |

|  |
| --- |
| **For Works constructed in Queensland, the following additional requirements apply:**The cementitious repair material must be registered by the Queensland Department of Transport and Main Roads.Refer to: <https://www.tmr.qld.gov.au/business-industry/Business-with-us/Approved-products-and-suppliers> |

# Materials Properties

Materials used for reinstatement of concrete must be single component cementitious restoration mortar or be part of a complete proprietary cementitious restoration system. Only whole bags of material are to be used. Material data sheets and health and safety data sheets must be available for all materials.

The repair material must:

1. be suitable for application in the geometric orientation of the restoration (ie horizonal, vertical and / or overhead);
2. possess a coefficient of thermal expansion which is compatible with the parent concrete;
3. be tested in accordance with Clause 11.1; and
4. comply with *Table 3 Performance Requirements for Structural and Non-structural Repair Products* of EN 1504-3.

Steel reinforcement primer and substrate-bonding coat must be compatible with the repair material and be part of the same range of proprietary repair system as the repair material and be from the same supplier.

Any cementitious coating material used to fill blowholes and imperfections on concrete structures must be:

1. a single component material;
2. capable of application at 0 – 3 mm thick and fill blowholes and imperfections flush with the finished concrete surface; and
3. capable of application without being subject to shrinkage cracking.

#  Handling and Storage of Materials

The repair material must be stored in accordance with the material manufacturer’s instructions, including storage:

1. in dry conditions not exposed to direct sunlight;
2. within the specified maximum and minimum temperature range; and
3. in the original, sealed moisture resistant bags or containers.

All material must be brought to site in the original sealed bags or unopened containers clearly labelled with the appropriate manufacturer’s name, product type, reference number and batch number. Materials stored beyond the manufacturers recommended shelf life must be discarded.

The following information must be provided for each batch of repair material:

1. manufacturer’s name and address;
2. product reference;
3. batch number / identification;
4. quantity manufactured in the batch; and
5. certificate of date of manufacture and the date that the material must be used by.

# Surface Preparation

## Removal of Defective Concrete

Prior to commencement of any patch repair of an existing concrete structure, the Contractor must assess the Defective concrete and prepare an Assessment Report which includes the following at a minimum:

1. extent of Defective concrete; and
2. effect of the Defective concrete on load bearing capacity, serviceability and durability.

|  |
| --- |
| **HOLD** POINT**2** |
| Process Held | Concrete repair work  |
| Submission Details | The Assessment Report, submitted at least 14 days prior to the commencement of the repairs. |

If requested by the Principal, before the removal of the concrete, the Contractor must undertake a trial of the concrete removal method to verify the competence of the operator and suitability of the proposed technique.

All Defective concrete (including any material used in a previous concrete repair) must be removed to expose a sound and dense concrete surface, which is free of loose and unsound materials and surface laitance. The position and depth of reinforcement must be determined prior to the concrete removal to ensure that there is no unnecessary over break.

Defective concrete must be removed using light handheld percussive equipment or high-pressure water jetting. Care must be taken to ensure that:

1. any steel reinforcement exposed is not cut or damaged;
2. micro-bruising of the substrate does not occur; and
3. dust which has the potential to be a hazard or nuisance is not created.

If high-pressure water jetting is used, the water pressure must be greater than 18 MPa and less than 60 MPa.

Where rusted reinforcement is present:

1. existing concrete must be removed for a minimum of 25 mm behind and around the rusted steel reinforcement; and
2. concrete must be removed along the length of visibly corroding steel reinforcement until at least 100 mm of sound, rust free metal is exposed at each end of the rusted section

Hammer sounding must be conducted on completion of breakout to ensure that all delamination has been removed.

A perpendicular saw cut of at least 20 mm must be provided around the perimeter of the area to be repaired to prevent featheredging of the repair material. Concrete must be removed to the saw cut edge of the repair area, including the minimum necessary removal of sound concrete to achieve the saw cut edge depth. The saw cut surface must be roughened by removing the surface layer to expose small particles of well bound aggregate.

All concrete surfaces clean and free from dust, oils, and grease and surface contaminants. When using cement based repair products, the concrete substrate shall be thoroughly soaked with water to obtain a Saturated Surface Dry (SSD) condition for at least 24 hours prior to concreting. Any surplus water shall be removed before reinstatement begins.

If a bonding agent is used, the bonding agent must be applied strictly in accordance with the manufacturer's recommendation and must remain green or tacky during the placement of restoration material.

|  |
| --- |
| **HOLD POINT 3** |
| Process Held | Application of repair material  |
| Submission Details | Notification that the structure has been prepared for the application of the repair material and evidence that the preparation of the repair area conforms to the requirements of this Specification, at least 24 hours prior to the commencement of the repairs. |

## Steel Reinforcement

Any corrosion products must be removed from the exposed steel reinforcement. Steel reinforcement must be cleaned to a bright metal to achieve a surface preparation equivalent to AS1627 Part 4 Class 2.5.

If the reinforcing steel in an existing structure is exhibiting a loss of its original cross-sectional area in excess of 20% due to corrosion, the following applies:

1. the reinforcement section loss must be measured and assessed for structural adequacy;
2. new reinforcing steel must be incorporated into the structure to compensate for the loss of cross sectional area;
3. the augmentation of reinforcement must be assessed by a Professional Engineer; and
4. the supply and placement of the reinforcing steel must comply with ATS 5210.

|  |
| --- |
| **HOLD POINT 4**  |
| Process Held | Insertion of new reinforcing steel into the structure. |
| Submission Details | Details of proposed new reinforcing steel must be provided at least 3 days prior to the commencement of the concrete repair work. |

# Application of Repair Mortar

## Reinforcement Protection and Substrate-Bonding Coat

Immediately following preparation and cleaning, all exposed steel reinforcement must be coated with a primer. Only the following types of primer are permitted:

1. zinc-rich epoxy primer;
2. epoxy; or
3. epoxy modified-cementitious.

If an electrochemical corrosion protection system is in place, the Contractor must verify that the coating is compatible with the electrochemical system, which may involve consultation with the manufacturer of the system or an electrochemical specialist.

A substrate-bonding coat which also forms part of the proprietary repair system must be worked into the concrete substrate using a short bristle brush to enhance the bond at the repair interface.

The materials must be thoroughly mixed to achieve a uniform colour and consistency. Materials must not be thinned and the whole container contents must be mixed without split mixing between mixes.

##  Application

The repair work must be undertaken in accordance with the manufacturer’s instructions.

The repair materials must be mixed in whole bags with potable water prior to commencement of application. Mixing of repair materials must be undertaken in a forced action mixer or in a suitably sized drum using a spiral paddle fitted to a low speed heavy-duty drill. Free-fall mixers must not be used.

“Repair material must be applied “wet on wet” when using a bonding aid or primer unless the manufacturer of the repair system specifies that the bonding aid or primer must dry out before the repair material is applied. If at any time the primer or bonding aid completely dries out before over-laying, except as permitted above, the repair surface must be re-prepared, generally by complete removal of the dried primer or bonding aid or as specified by the manufacturer of the materials”.

Where the depth of a vertical or overhead patch repair exceeds 50 mm, the repair must incorporate stainless steel or non-metallic mechanical shear connectors, installed at a suitable spacing.

Concrete must be rebuilt to the original surface profile. However, if the existing concrete cover to steel reinforcement is less than the design requirements, the concrete repair must be profiled to ensure compliance with AS 5100.5 Table 4.12.3.2. For overhead patch repairs, the repairs must be proud and held in place by formwork for at least 3 days to develop a strong bond.

Where formwork is used to facilitate the patch repair, it must be pre-treated such that it prevents moisture absorption from the repair mortar and positioned such that it does not inhibit effective compaction of the repair material.

Repair material must not be applied unless the concrete substrate temperature and the air temperature measured at the point of application is

1. above 5°C or 5°C and rising; and
2. below 35°C.

Where the ambient temperature at the point of application of material is above 30°C and the area to be treated is subject to direct sunlight, protective shading must be used and equipment that comes into direct contact with the repair material must be kept cool and not exposed to direct sunlight.

The repair material must be applied in layers not exceeding the thickness specified by the manufacturer of the material.

Each layer must be thoroughly worked and compacted into the repair zone and around or between reinforcing bars. The technique employed must ensure that no air is entrapped and that full contact with the primed substrate is achieved.

Successive layers must be applied as soon as the preceding layer has become sufficiently stiff to support the weight of the additional build-up layer but is still adequately tacky to provide bonding. The time between layers must be in accordance with the manufacturer’s recommendations. If sagging occurs, the material must be completely removed and replaced at a reduced thickness.

If at any time the last layer applied completely dries out before over-layering, the surface must be prepared in accordance to the manufacturer's recommendations.

The final build-up layer within a repair must not be less than 10mm thick and must be levelled off or profiled using trowelling techniques to produce the specified finish.

Curing to retain moisture must be implemented immediately on completion of the repair. The surface of the repair material must be protected by strong sunlight and drying winds.

##  Blowholes and Surface Imperfections

Any blowholes and surface imperfections must be filled with a scrape coat application of a single component cementitious fairing coat repair mortar.

A cementitious fairing coat repair mortar may also be used in a thin layer where a uniform concrete surface is required prior to the application of a protective or decorative coating.

Any fairing coat must be applied in accordance with the manufacturer’s instructions, including preparation of the substrate. The quality control testing requirements of Clause 12 Quality Control Testing do not apply to cementitious fairing coat repair mortars.

#  Curing and Protection

Immediately after placement and for seven days thereafter, the repair material must be cured and protected from drying out and against the harmful effects of water movement and weather, including rain and rapid temperature changes.

Cementitious material must be cured with the application of two coats of a curing compound in accordance with the material manufacturer's specification. In addition to a curing compound, heavy duty polyethylene sheeting fastened and sealed at the edges must also be provided for concrete patch repairs greater than 500 mm x 500 mm in size and for all concrete repairs to chloride affected concrete structures or components.

Curing compounds must comply with AS 3799. Curing compounds must be removed prior to the application of any protective or decorative coatings.

#  Finishing and Surface Condition

All surfaces must match surrounding surface finish, which may require the use of steel forms or steel trowel finish.

The surface of the concrete repair must not have cracks of width greater than 0.10 mm measured at the concrete surface nor craze cracking covering more than 20% of the area of the repair at the completion of the curing period.

Any cracks in the repair material must be rectified in accordance with ATS 5131 Repair of Concrete Cracks.

The interface of the concrete repair with the existing concrete must not be debonded.

The following applies to the insitu repair of an existing structure:

1. At 12 months after completion of the repair works, or prior to the end of the defects liability period (whichever is earlier):
2. the Contractor and Principal must jointly inspect all concrete repaired areas; and
3. at this time, the repaired concrete must not exhibit any cracks or craze cracking.
4. Any necessary rectification works must be undertaken within two weeks of the date of inspection.

#  Tolerances

The tolerance on edges and surfaces in plan and level is ± 3 mm.

The maximum allowance for irregularities when measured with a 2.0 metre straightedge is 3 mm. In addition, evenness must not deviate by more than 1 mm when checked with a 300 mm straightedge.

#  Quality Control Testing

## Compressive Strength of Cementitious Repair Material

Test cubes must be made and cured in accordance with AS 1012.8.3 and tested in accordance with AS 1012.9.

Three 75 mm test cubes must be taken from the first batch of material mixed, then three 75 mm cubes for every further 100 kg of material. The cubes must be cured for 7 days under conditions which match that used for the repair. Two cubes must be tested at 7 days and the third cube at 28 days to confirm that the minimum compressive strength complies with this Specification.

##  Bond Strength (Pull-Off) Testing

The Contractor must conduct partially cored direct pull-off tests of the fully cured in situ repair material to verify the tensile bond strength between the in situ repair material and the existing concrete substrate, 7 days after the completion of application. The pull-off testing must be undertaken in accordance with AS 1012.24.

The test locations must be jointly determined by the Contractor and the Principal.

Testing must be carried out at a frequency of three tests per 10 m2 at representative test locations of a completed repair area.

The mode of failure must be determined by visual inspection of the test specimens and categorised as follows:

Mode 1: Tensile failure within the existing concrete substrate.

Mode 2: Tensile failure within the repair material.

Mode 3: Bond failure at the interface between the existing concrete substrate and the repair material.

Mode 4: Bond failure between the adhesive layer and the dolly.

Mode 5: Partial bond failure at the interface between the existing concrete substrate and the repair material and partial tensile failure within the repair material.

Mode 6: Partial bond failure at the interface between the existing concrete substrate and the repair material and partial tensile failure within the existing concrete substrate.

Where a combination of modes of failure exist the percentage of each mode of failure must be recorded to the nearest 10% based on the surface area of the failure face.

The mean bond strength at 7 days must not be less than 0.75 MPa, with no individual result less than 0.65 MPa.

The mode of failure of the pull-off test must be in accordance with Mode 1, with tensile failure within the existing concrete substrate.

Mean bond strengths less than 0.75 MPa or failure modes 2, 3, 4, 5 and 6 must be raised as a non-conformance.

##  Testing for Drummy Areas

A visual inspection of all concrete repair areas must be conducted immediately prior to the application of any decorative / anti-carbonation coating for delamination and any defects recorded.

|  |
| --- |
| **WITNESS POINT 1** |
| Process  | Testing for Drummy Areas |
| Notification | Notification of the testing must be submitted at least 48 hours prior to the commencement of the testing. |

The test for drummy areas must be conducted using a small (0.8 kg) hand-held hammer along the whole surface area of the concrete patch repairs and delaminated areas are be characterised by a ‘drummy’ or hollow sound.

Any delaminated repair patches must be removed and repaired in accordance with the requirements of this Specification.

##  Test Results

The Contractor must provide a copy of all quality control testing, including photographic records, within one week of undertaking such testing.

##  Non-conformances

For any test batch that fails to meet the specified standards, all repairs to which the test batch relates must be removed and the repairs repeated in accordance with the requirements of this Specification.

 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 supply to the Principal to demonstrate compliance with this specification.

|  |  |  |  |
| --- | --- | --- | --- |
| Clause | Hold Point | Witness Point | Record |
| 4.2 | 1. Commencement of concrete repairs.
 |  | Quality Plan |
| 6.3 |  |  | Information for each batch of repair material |
| 7.1 | 1. Assessment of the affected concrete structure or component
 |  | Assessment report |
| 7.7 | 1. The concrete has been prepared in readiness for application of repair material
 |  | Notification |
| 7.9 | 1. Insertion of new reinforcing steel into the structure
 |  | Details of proposed new reinforcing steel |
| 12.2 |  |  | Compressive Strength test results |
| 12.3 |  |  | Pull-off tests results |
| 12.11 |  | 1. Testing for Drummy Areas |  |
| 12.14 |  |  | All quality control testing, including photographic records |

Amendment Record

|  |  |  |  |
| --- | --- | --- | --- |
| Amendment no. | Clauses amended | Action | Date |
| - | New specification | New  | January 2020 |
|  |  |  |  |

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