SECTION 689 ‑ CEMENTITIOUS PATCH REPAIR OF CONCRETE‑

##This section cross-references Sections 168, 176, 611, 685, 686 and 687.

If any of the above sections are relevant, they should be included in the specification.

If any of the above sections are not included in the specification, all references to those sections should be struck out, ensuring that the remaining text is still coherent:

689.01 GENERAL

This section specifies the requirements for the supply of materials, surface preparation, application, relevant inspection and testing and acceptance criteria for the patch repair of concrete structures using cementitious repair materials.

689.02 TYPES AND SELECTION OF PATCH REPAIR METHODS

This section includes the following types of patch repair of concrete structures using cementitious repair materials:

• corrosion deteriorated concrete repair;

• non-corrosion deteriorated concrete repair; and

• filling of blowholes and surface imperfections.

Repair of concrete shall include:

• breaking back to sound and dense concrete to receive repair material;

• preparation of steel reinforcement and concrete substrate;

• application of an appropriate steel primer and substrate bonding coat; and

• rebuilding to the original surface profile.

**HP Prior to commencement of any patch repair of concrete, the Contractor shall assess the affected concrete structure or component to determine the influence of spalled, deteriorated, damaged or honeycombed concrete on load bearing capacity, serviceability and durability, and submit the assessment to the Superintendent for review.**

A cementitious patch repair method shall be selected based on:

• an assessment of the cause(s) and extent of the spalled, deteriorated, damaged or defective concrete;

• the location of the patch repair on the concrete structure or component;

• the proposed repair material properties, likely patch behaviour and the effect on load capacity and structural safety, serviceability and durability.

A patch repair method shall be submitted which includes requirements for surface preparation, method of application, curing and surface finish, to ensure the longevity of the repair solution.

**Any proposal to use patch repair methods and repair materials other than those specified in this section shall be submitted to the Superintendent for review.**

The application of anti-graffiti and decorative/anti-carbonation coatings and crack repairs which may be required as part of the concrete repair work shall be undertaken in accordance with the requirements of Sections 685, 686 and 687.

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689.03 STANDARDS

(a) Australian Standards

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

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

AS 1012.24 Method 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

(b) Other Standards

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

689.04 DEFINITIONS

**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.

**Corrosion Deteriorated Concrete:** Concrete with deterioration, delamination, cracking or spalling due to contamination by deleterious substances such as chlorides and carbon dioxide associated with the overall mechanism of corrosion of steel reinforcement.

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

**Exposure Classifications:** Designation indicative of the most severe environment to which a concrete member is to be subjected during its design life, in accordance with the exposure classifications A, B1, B2, C1, C2 and U, as stated in Table 4.3 of AS 5100.5, and which are used to determine the concrete quality requirements.

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

**Non-corrosion Deteriorated or Defective Concrete:** Concrete with deterioration, damage or defects due to accidental or physical loadings, temporary overloading, impact and other mechanical or uncontaminated damage, excessive early shrinkage or thermal stresses and low quality honeycombed or off form voided concrete.

**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.

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689.05 CONTRACTOR COMPETENCY

Personnel, sub-contractors and suppliers utilised in cementitious patch repair of concrete shall have a minimum of 5 years experience in the repair and rehabilitation of reinforced concrete structures and a demonstrated competency for surface preparation and application of the repair material to be applied.

The concrete 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 repair material to be applied.

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

689.06 MATERIAL PROPERTIES

(a) General

 Materials used for reinstatement of concrete shall be single component polymer modified cementitious non-shrink repair mortars, or be part of a complete polymer modified cementitious repair system. Only whole bags of material shall be used. Test certificates, material data sheets and health and safety data sheets shall be available for all materials.

(b) Repair Material

 The proposed repair material shall:

 (i) be capable of being hand applied in vertical and overhead sections up to 30 mm thick in one application with no slumping;

 (ii) achieve strength conforming to the requirements in Table 689.061;

 **Table 689.061 Repair Material Minimum Strength Requirements**

|  |  |
| --- | --- |
| **In situ strength of structural element** | **Repair Material Minimum Strength** |
| **At 1 day** | **At 7 days** | **At 28 days** |
| **COMPRESSIVE STRENGTH** (in accordance with BS 6319 Pt 2:1983 – dry cure) |
| 15 MPa to 30 MPa | 5 MPa | 19 MPa | 23 MPa |
| Greater than 30 MPa to 50 MPa  | 10 MPa | 25 MPa | 35 MPa |
| Greater than 50 MPa | 15 MPa | 40 MPa | 60 MPa |
| **FLEXURAL STRENGTH** (in accordance with BS 6319 Pt 3:1990) |
| 15 MPa to 30 MPa |  |  | 4 MPa |
| Greater than 30 MPa to 50 MPa  |  |  | 6 MPa |
| Greater than 50 MPa |  |  | 10 MPa |
| **TENSILE STRENGTH** (in accordance with BS 6319 Pt 7:1985) |
| 15 MPa to 30 MPa |  |  | 1.8 MPa |
| Greater than 30 MPa to 50 MPa  |  |  | 2.8 MPa |
| Greater than 50 MPa |  |  | 3.8 MPa |
| **BOND OR PULL-OFF STRENGTH TO CONCRETE SUBSTRATE AT 7 days**(in accordance with AS 1012.24) |
| All Concrete Structure Strengths |  | 0.75 MPa |  |

 (iii) achieve a drying shrinkage of less than 600 microstrain at 28 days in accordance with AS 2350.13;

 (iv) minimum wet density of 1600 kg/m3;

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 (v) maximum water/powder ratio of 0.17;

 (vi) resistant to alkaline solutions;

 (vii) possess an acid soluble chloride-ion content expressed as the percentage of the total mass of cementitious material of not greater than 0.05%; and

 (viii) be compatible with the properties of the parent concrete, including coefficient of thermal expansion.

 Steel reinforcement primer and substrate-bonding coat shall be compatible with the repair mortar and be part of the same range of proprietary repair system.

(c) Fairing Coat

 Fairing coat cementitious repair material required to fill blowholes and imperfections on concrete structures shall be:

 (i) a single component polymer modified material;

 (ii) capable of application at 0 – 3 mm thick and fill blowholes and imperfections flush with the finished concrete surface;

 (iii) capable of application over a large area without being subject to shrinkage cracking.

689.07 HANDLING AND STORAGE OF MATERIALS

Repair materials shall be stored in accordance with the material manufacturer’s requirements, including:

• in dry conditions not exposed to direct sunlight;

• within the specified maximum and minimum temperature range;

• in their original, sealed moisture resistant bags or containers.

All material shall 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 shall be discarded.

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

(a) manufacturer’s name and address;

(b) product reference;

(c) batch number of identification;

(d) quantity manufactured in the batch; and

(e) certificate of date of manufacture.

689.08 PREPARATION AND APPLICATION

(a) General

 The Contractor shall perform concrete repair work in conformity with the manufacturer’s specification.

**HP** **Any deviations from the manufacturer’s specification and the requirements of this specification shall be submitted to the Superintendent for review accompanied by certification from the manufacturer, prior to commencement of repairs.**

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(b) Steel Reinforcement

 Where the existing concrete cover to steel reinforcement is less than the design requirements, the concrete repair shall be profiled to ensure that the following minimum cover of polymer modified repair material is achieved:

 (i) Exposure Classification A and B1 20 mm minimum cover

 (ii) Exposure Classification B2, C1 and C2 50 mm minimum cover

 For a corrosion deteriorated concrete repair new reinforcing steel shall be incorporated into the structure to compensate for any existing reinforcing steel which is exhibiting loss in excess of 25% of its original cross-sectional area. Steel reinforcement incorporated into the structure shall comply with the requirements of Section 611.

(c) Surface Preparation

 (i) General

 For all types of patch repair all defective and delaminated concrete and existing repair materials shall be broken back to a sound and dense concrete surface. Defective concrete shall be removed using light hand held percussive equipment or high pressure water jetting. Care shall be taken to ensure that any steel reinforcement exposed is not cut or damaged. The method of breaking back or scabbling shall ensure that excess dust does not form a hazard in the surrounding area.

 Hammer sounding shall be conducted on completion of breakout to ensure that all delamination has been removed. A perpendicular saw cut of at least 15 mm shall be provided around the perimeter of the area to be repaired to prevent featheredging of the repair material. The saw cut surface shall be roughened by removing the surface layer to expose small particles of well bound aggregate.

 All concrete surfaces and mortar substrates shall be sound, clean and free from dust, oils, and grease and surface contaminants. All loose and unsound materials and surface laitance shall be removed.

 The concrete substrate and any exposed steel reinforcement shall be cleaned by a final wash down or by blowing down with oil free compressed air to ensure removal of all residual contamination. The prepared concrete substrate shall be thoroughly pre-wetted with clean fresh water and shall be surface dry prior to application of repair material.

 (ii) Corrosion Deteriorated Concrete Repair

 In addition to other requirements, for repair of corrosion deteriorated concrete repair all defective and delaminated concrete and existing repair materials shall be broken back to a sound and dense concrete surface to a minimum of 20 mm behind and around the rusted steel reinforcement.

 Concrete shall be removed along the length of visibly corroding steel reinforcement until at least 50 mm of sound, rust free metal is exposed at each end of the rusted section.

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

 (iii) Non-corrosion Deteriorated or Defective Concrete Repair

**HP The Superintendent shall review the depth of removal of concrete for non-corrosion deteriorated or defective concrete repair and the amount of exposure of steel reinforcement prior to commencement of application of repair material.**

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(d) Application of Reinforcement Protection and Substrate-Bonding Coat

 All exposed steel reinforcement shall be coated immediately following preparation and cleaning with a primer which forms part of the proprietary repair system to provide immediate protection against corrosion. The steel primer shall be adequately applied to the back of the steel reinforcement where it is fully exposed and where steel bars are tied together. Over-coating of the concrete substrate with the steel primer shall be avoided unless it is a requirement of the overall repair system.

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

 The steel primer and substrate bonding coat shall be thoroughly mixed to achieve a uniform colour and consistency. Materials shall not be thinned and the whole container contents shall be mixed without split mixing between mixes.

(e) Application of Repair Mortar

 The Contractor shall include within its quality procedures the manufacturer’s specifications for use of the repair materials, and test plans that meet the requirements of the standards and this section.

**HP Reinstatement of prepared areas shall not commence until:**

 **(i) a joint measurement of the repair area by the Superintendent and the Contractor has taken place;**

 **(ii) evidence that the preparation of the repair area conforms to the requirements of this Specification; and**

 **(iii) the Contractor’s quality procedures has been sighted by the Superintendent.**

 All materials shall be applied in accordance with the manufacturer’s specifications or instructions for use in a continuous process.

 The repair mortar shall be thoroughly mixed in whole bags with potable water prior to commencement of application. Mixing of repair materials shall 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 shall not be used.

 Repair material shall be applied while the substrate bonding coat is still tacky.

 Concrete shall be rebuilt to the original surface profile using a cementitious repair material. Where the existing concrete cover to the steel reinforcement is less than the design requirements, the new repair shall be profiled as required to ensure that a minimum cover of polymer modified repair material to the steel reinforcement is achieved as specified in clause 689.08(b).

 Where formwork is used to facilitate the patch repair, it shall 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 shall only be applied when the concrete substrate temperature and the air temperature measured at the point of application is above 5°C or 5°C and rising. No material shall be applied when the air temperature measured at the point of application is above 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 shall be used and equipment that comes into direct contact with the repair material shall be kept cool and not exposed to direct sunlight.

(f) Blowholes and Surface Imperfections

 Blowholes and surface imperfections shall 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.

 The quality control testing requirements of clause 689.12 shall not apply to cementitious fairing coat repair mortars.

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689.09 CURING AND PROTECTION

Immediately after placement and for seven days thereafter, the repair material shall 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 shall 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 shall 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 shall comply with AS 3799. Curing compounds shall be removed prior to the application of any protective or decorative coatings, unless documented evidence is provided to the satisfaction of the Superintendent that the applied curing compound is compatible with any proposed coatings.

689.10 FINISHING AND SURFACE CONDITION

All surfaces shall match surrounding surface finish by use of steel forms or steel trowel finish.

The surface of the concrete repair shall not have cracks of width greater than 0.10 mm measured at the concrete surface nor craze cracking covering a significant area of the repair at the completion of the curing period.

Cracks in repair material shall be repaired in accordance with Section 687.

There shall be no cracking at the interface of the concrete repair with the existing concrete.

**A joint inspection of all concrete repaired areas with the Contractor and Superintendent shall be undertaken 12 months after completion of the repair works, or prior to the end of the defects liability period (whichever is earlier).**

The surface of the concrete repair shall not have cracks of width greater than 0.10 mm measured at the concrete surface nor craze cracking covering a significant area of the repair 12 months after completion of the repair works, or at the end of the defects liability period (whichever is earlier).

Any necessary remedial works shall be undertaken within two weeks of the date of inspection.

689.11 TOLERANCES

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

Maximum allowance for irregularities when measured with a 2.0 metre straightedge shall be 3 mm. In addition, evenness shall not deviate by more than 1 mm when checked with a 300 mm straightedge.

689.12 QUALITY CONTROL TESTING

(a) Compressive Strength of Cementitious Repair Material

 Three 75 mm test cubes shall be taken from the first batch of material mixed, then three 75 mm cubes for every 100 kg of material used thereafter to test for compressive strength. The cubes shall be cured for 7 days under laboratory-controlled conditions. Two cubes shall be tested at 7 days and the third cube at 28 days to confirm compliance with the minimum compressive strength requirements as specified in Table 689.061. Test cubes shall be made and cured in accordance with AS 1012.8.3 and tested in accordance with AS 1012.9.

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(b) Bond Strength (Pull-Off) Testing

 The Contractor shall 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 shall be undertaken in accordance with AS 1012.24.

 **The test locations shall be jointly determined by the Contractor and the Superintendent.**

 Testing shall 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 shall 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 shall be recorded to the nearest 10% based on the surface area of the failure face.

 The mean bond strength at 7 days shall 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 shall 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 shall be raised as a non-conformance.

(c) Testing for Drummy Areas

 A visual inspection of all concrete repair areas shall be conducted immediately prior to the application of any decorative/anticarbonation coating for delaminations and any defects recorded.

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

 Delaminated patch repairs shall be removed and repaired in accordance with the requirements of this section.

 **Testing for drummy areas shall be conducted in the presence of the Superintendent.**

(d) Test Results

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

(e) Non-conformances

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

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689.13 WORK METHOD STATEMENT AND INSPECTION AND TEST PLANS

The Contractor shall submit a detailed work method statement (WMS) and inspection and test plans (ITPs) for the specific concrete patch repair works. The WMS and ITPs shall reference all specification clauses and identify all performance requirements and hold points. Generic or incomplete WMSs and ITPs shall not be allowed.

The Contractor shall provide documented evidence of conducting tool box meetings of all concrete patch repair personnel on all aspects of the WMS, the ITPs and specification requirements, including sampling and testing, immediately prior to the commencement of the concrete patch repair works.

**HP The Contractor shall not proceed with concrete patch repair works until the WMS and ITPs have been reviewed and approved by the Superintendent.**

689.14 OCCUPATIONAL HEALTH AND SAFETY AND ENVIRONMENTAL MANAGEMENT

(a) Occupational Health and Safety Requirements

 Further to the requirements of Section 168, the Contractor shall include within its Health and Safety Co‑ordination Plan, specific provisions for the material manufacturer’s occupational health and safety directions and the Occupational Health and Safety Act standards. All material safety data sheets (MSDS) shall be kept on site at all times and be readily available.

(b) Environmental Management Requirements

 Further to the requirements of Section 176, the Contractor shall include within its Environmental Management Plan, specific provisions regarding the collection, segregation, handling, control and disposal of waste generated during concrete patch repair works, and clean up.

 Waste materials including liquid wastes shall be deposited in suitable containers and disposed of at sites to be located by the Contractor that are acceptable to the EPA and other relevant authorities.

 Liquid or other waste material shall not be disposed of in creeks, waterways or the stormwater drainage systems.

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