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Transport Infrastructure Ireland

## TII Publications



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# Specification for Road Works Series 5500 – Structural Concrete Repairs

CC-SPW-05500

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Transport Infrastructure Ireland (TII) is responsible for managing and improving the country's national road and light rail networks.

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## Document Attributes

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## NRA DMRB and MCDRW References

For all documents that existed within the NRA DMRB or the NRA MCDRW prior to the launch of TII Publications, the NRA document reference used previously is listed above under 'historical reference'. The TII Publication Number also shown above now supersedes this historical reference. All historical references within this document are deemed to be replaced by the TII Publication Number. For the equivalent TII Publication Number for all other historical references contained within this document, please refer to the TII Publications website.

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# ***STRUCTURAL CONCRETE REPAIRS***

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# Structural Concrete Repairs

## 5501 Concrete Repairs - Introduction

- 1 This Specification defines the methods and materials for rehabilitation or partial reconstruction of existing road structures which are wholly or partially constructed of reinforced, prestressed, post-tensioned or mass concrete.
- 2 For the purposes of this Specification, the terms and definitions are as stated in IS EN 1504-1 with the following addition.

### Repair Material

Repair product which has been mixed with water or reactive binder, but before setting has occurred.

- 3 Products and methods shall conform generally to IS EN 1504 and additional requirements in this Specification.
- 4 This Specification is intended to cover IS EN 1504-9 Table 1 repair methods 1.5, 3.1, 3.2, 3.3, 4.1, 4.5, 4.6, 6.3, 7.1, 7.2 and 10.1.
- 5 Lightweight repair concretes and mortars are not covered by this Specification.
- 6 Repairs to concrete carriageways are not covered by this Specification.

## 5502 Concrete Repairs – General Requirements

- 1 Assumed repair methods for each construction activity and each element shall be tabulated in Appendix 55/1.
- 2 The method of concrete repairs shall be specified in accordance with IS EN 1504-9 and shall be carried out in accordance with IS EN 1504-10, refer to NRA BD27 for further information.
- 3 Any cabling, suspended drainage, ducts, adjacent painted steelwork, bearings, electrical boxes and any other parts of the existing structure shall be protected against damage during the repair Works.
- 4 Concrete repairs is a specialist activity that shall only be carried out by a Contractor with a proven track record in this discipline of repairs and who can demonstrate suitable qualifications, training, expertise and experience for the particular element of work being undertaken. The Contractor shall only use operatives trained in the techniques that are to be used and shall be subject to the approval of the Employer's Representative. The Contractor must be IS EN ISO 9001 and IS EN 14001 accredited.
- 5 The Contractor should be a member of a Concrete Repair Association or an equivalent trade regulating organisation approved by the Employers Representative.
- 6 The Contractor shall submit a Quality Plan for acceptance or approval by the Employers Representative prior to commencement of work.

The Quality Plan shall describe the proposed management strategy setting clear and sustainable performance objectives, delegation of responsibility, and describing lines of communication.

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- 7 The Contractor shall assign overall responsibility for execution of concrete repairs to a Concrete Repairs Supervisor, and the Quality Plan must include a named individual for this role. The Concrete Repairs Supervisor should be able to demonstrate a minimum of 5 years experience of concrete repair work.
- 8 The Quality Plan should also contain the following information:

**General Information**

Name and contact details of the Engineer responsible for the design, detail and specification of the concrete repair.

Definition of the products to be provided

Management strategy including performance objectives

Structure of the organisation, describing delegations and naming key individuals

**Control, maintenance and selection of equipment**

Process of communication with the Employers Representative

Proposed date of commencing concrete repair activities

Contract Specific Information

Name and contact details of Customer/Client

Details of communications required

Names of specialist contractors, details of work gangs

Work programme, risk assessments, method statements

Evidence that proposed operatives are suitably competent, including experience and qualifications

Details and control of quality records

Outline of proposed action to be taken in the event of product non-conformances during the Works.

**5503 Concrete Repairs - Concrete Removal**

- 1 The extent of concrete removal shall be as indicated on the Drawings and shall be confirmed by the Employer's Representative prior to commencement of concrete removal. If further hollow areas are detected behind the specified breakout, the Employer Representative shall be consulted for further instruction.
- 2 If the Contractor is required to investigate the condition of existing concrete, detailed requirements shall be specified in Appendix 55/6. Locations for sampling and testing of the existing structure shall be as shown on the Drawings or agreed by the Employer's Representative.
- 3 The Contractor shall supply the results of the existing condition testing for each structure no less than 28 days before intended commencement of concrete removal.

- 4** The Contractor shall not commence concrete removal without the written approval of the Employer's Representative. Approval shall be requested in writing no less than 24 hours prior to the intended breakout. The Contractor's Quality Assurance system shall include appropriate Hold Points to ensure compliance with this Clause.
- 5** Concrete shall be removed from the existing structure in accordance with the sequence and criteria shown on the Drawings. The Contractor shall prepare detailed method statements and programmes for concrete removal and shall submit the same to the Employer's Representative for approval.
- 6** Where the Contract requires temporary support to be provided, the Contractor shall not commence any repair Works until the temporary supports are fully in place and written approval to proceed has been given in accordance with Clause 5503.4.
- 7** Further removal may be instructed by the Employer's Representative. The Contractor shall not damage concrete to be retained adjacent to, above or below repair or replacement areas. Any concrete damaged by the Contractor shall be rectified as directed by the Employer's Representative.
- 8** The Contractor shall take precautions to avoid damaging the steel reinforcement during removal of concrete. Any damage caused by the Contractor shall be rectified as directed by the Employer's Representative.
- 9** The concrete substrate in each breakout area shall be profiled to encourage flowable repair material to flow freely into all voids and be continuously in contact with the existing concrete. When soffits are being repaired and the repair patch does not extend to the free edge of the soffit, additional concrete shall be removed locally to force trapped air to a central point (i.e. domed) from which it shall be vented to avoid air pockets in the completed repair.
- 10** The defective concrete shall be removed to an accuracy of -5mm to + 15mm of the specified depth of concrete removal.
- 11** When existing reinforcement is corroded at the perimeter of the area shown on the Drawings as requiring repair, further concrete shall be removed until a continuous length of not less than 100mm of uncorroded bar is exposed. The extent and sequence of removal of the additional concrete shall be as instructed by the Engineer responsible for the Design. The load bearing capacity of the element being repaired shall also be reviewed.
- 12** The perimeter of each concrete repair area shall be prepared to prevent feather edging or overbreak. Existing concrete shall be removed at the perimeter to a depth of not less than 15mm or to within 10mm of the reinforcement, whichever is the lesser. The depth of the existing reinforcement along the perimeter of the repair shall be measured by the Contractor using a cover meter or similar device.
- 13** Permitted methods of concrete removal shall include either or both of the following methods unless shown otherwise on the Drawings. The hazards and risks associated with each method shall be considered before the choice is made:

  - a) high pressure water jetting;
  - b) electric demolition hammer or lightweight pneumatic picks.

Concrete around prestressing strand and post-tensioning tendons and anchorages shall be removed by method a) only.

Care shall be taken to prevent overbreak beyond the line of the saw cut.

- 14** Any proposal for use of a different method of removal shall be subject to approval by the Employer's Representative through the Departure from Standards procedure.

### **High Pressure Water Jetting**

- 15** High pressure water jetting shall be carried out by operatives qualified to at least a standard equal or equivalent to Level 2 NVQ Certificate in Associated Industrial Services Occupations - Water Jetting. Safety measures shall comply with the Code of Practice for the Use of High Pressure and Ultra High Pressure Water Jetting Equipment, produced by the Water Jetting Association. A lightweight electric demolition hammer may be used for final trimming of the area broken out.
- 16** Water for high pressure water jetting shall be clean and fresh and obtained from a Public Utility Undertaking. The Contractor shall not add anti-freeze or any other chemical.
- 17** The Contractor shall take appropriate measures to keep the Site, immediate work areas and staging free of standing water and concrete debris arising from high pressure water jetting operations. Where standing water is to be pumped to a surface water drain, the Contractor shall obtain the consent of the relevant authority and provide details of such consent to the Employer's Representative.

### **Mechanical Breakout**

- 18** Mechanical breakout shall only be permitted by operatives qualified to at least a standard equal or equivalent to Level 2 NVQ Diploma in Specialist Concrete Occupations - Specialist Concrete Occupations (Construction) QCF.
- 19** The Contractor shall take appropriate measures to keep the Site, immediate work areas and staging free of concrete debris arising from concrete removal operations.

### **Concrete Breakout Trial**

- 20** Where a trial of the Contractor's proposed method of concrete breakout is required, details shall be included in Appendix 55/3.

### **Breakout Inspection**

- 21** When defective concrete has been removed in a repair area to the depth and extent required by the design, the entire substrate in the repair area shall be hammer tested. If there are any areas of hollow sounding concrete they shall be marked out. Results shall be provided to the Employer's Representative. The Contractor shall request in writing an inspection by the Employer's Representative and provide suitable access to the area.
- 22** Following the inspection, the Designer's Site Representative shall then confirm in writing either that:
- the extent of breakout is acceptable and work may proceed or
  - further work is required to satisfy the design prior to another breakout inspection or
  - additional breakout is required prior to a further breakout inspection

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- 23** The Contractor shall notify the Employer's Representative at least 4 hours before requiring the inspection and allow a period of 4 hours for the recording and inspection described in Clause 5503.21.
- 24** When the existing concrete from a specified repair area has been removed in accordance with the design, additional breakout has been carried out, the substrate has been hammer tested again, and the reinforcement has been cleaned in accordance with Clause 5505.1, the Contractor shall notify the Employer's Representative of an intention to proceed to the next stage of repair.

#### **5504 Concrete Repairs - Substrate Preparation**

- 1** The existing concrete substrate within a repair area shall be prepared to concrete surface profile grade CSP6 or higher in accordance with the Guideline for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion, 310.1R-2008 published by the International Concrete Repair Institute.
- 2** The concrete substrate exposed by mechanical percussive breaking Clause 5503.13(b) shall be further prepared as described in Clause 5504.1
- 3** The surface of the exposed concrete in the repair area shall be cleaned of all dust and grit using a mains pressure water jet, properly filtered oil-free airline or other approved method. Any loose aggregate shall be removed.
- 4** The prepared surface shall be continuously wetted with potable water for a minimum period of four hours. Any surface water remaining on the concrete breakout surface or reinforcement shall be removed prior to placement of the repair material. Placement of the repair material shall commence within one hour of completion of wetting.
- 5** The use of bonding agents shall not be permitted for use with chemical type CC and PCC, as defined in IS EN 1504-1. For PC chemical types, as defined in IS EN 1504-1, a bonding agent may be proposed for approval by the Employer's Representative. If approved for use, bonding agents shall be applied strictly in accordance with manufacturer's instructions.

#### **5505 Concrete Repairs - Reinforcement**

##### **Treatment of Reinforcement**

- 1** The exposed reinforcement shall be cleaned by wet grit blasting, or other approved method, to remove all scale, any loose rust, and all visible contaminants in accordance with IS EN ISO 8501-1, preparation standard Sa 2½. The exposed surface of the steel reinforcement shall be cleaned immediately prior to concreting and only light flash rusting on the reinforcement shall be permitted. Holding primers shall not be used on the cleaned reinforcement.
- 2** Where existing reinforcement exposed within a repair patch is excessively corroded as defined in Appendix 55/2, or where otherwise directed by the Employer's Representative, the Contractor shall provide, bend and fix additional or replacement reinforcement, complying with the requirements for reinforcement specified in IS EN 13670. The Contractor shall, for this purpose, maintain on site a stock of reinforcement bars comprising at least the bars shown in Appendix 55/2.
- 3** All additional or replacement reinforcement bars and reinforcement mesh shall comply with Clause 1712. Tying wire shall comply with Clause 1714.



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- 4** Where required by Appendix 55/2 or shown on the drawings, reinforcement shall be treated with a reinforcement coating complying with the requirements of IS EN 1504-7.

### **Welding of Reinforcement**

- 5** Welding of reinforcement shall only be used where permitted in Appendix 55/2, and shall comply with the requirements of Clause 1717 and IS EN 13670.
- 6** Testing of welded joints shall be in accordance with Appendix 1/5, which shall include any testing requirements from IS EN ISO 17660-1.

### **5506 Concrete Repairs - Galvanic Anodes (for control of incipient anode effect)**

#### **General**

- 1** This Clause refers to proprietary galvanic anodes used within a concrete repair area and connected to existing steel reinforcement. The anodes may be either:
- Type 1 - embedded within the new concrete repair
  - Type 2 - installed within holes drilled into the existing concrete substrate
- 2** This Specification does not cover galvanic anodes installed in areas where the concrete is not delaminated.
- 3** The use of galvanic anodes within a concrete repair shall have prior written approval from the Structures Section of the NRA.

#### **Quality**

- 4** Galvanic anodes shall be manufactured under a quality plan such as IS EN ISO 9001 or equivalent and shall be delivered to the site with a Certification of Conformity.
- 5** Galvanic anodes and associated components shall be compatible. The anodes shall have a proven successful performance in service of at least five years on similar structures, in comparable environments, to the satisfaction of the Employer's Representative.
- 6** Details of the anodes selected by the Contractor shall be submitted to the Employer's Representative for acceptance. Where requested by the Employer's Representative, the Contractor shall provide details of the owners and operators of similar anode systems.
- 7** Galvanic anodes shall have a declared maintenance-free service life expectancy of at least 10 years in ambient weather conditions similar to those experienced in Ireland.
- 8** The Contractor shall provide the Employer's Representative with the following details, where applicable, for the anode units:
- a) manufacturers or suppliers;
  - b) technical specifications;
  - c) health & safety and risk assessment data;
  - d) details of previous successful installations;
  - e) grade and reference standard of galvanic anode metal;

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- f) anode core activation method;
  - g) life expectancy;
  - h) efficiency/utilisation of anode material;
  - i) confirm electrical connector linking anode to reinforcement is corrosion resistant.
- 9** The galvanic anode system, including the galvanic metal element, the activating agent and the backfill where needed, shall not present a corrosion risk to the steel throughout the service life of the system.
- 10** The chemical reaction products of a galvanic anode shall not expand and cause cracking or spalling of the concrete cover.

### **Design**

- 11** All galvanic anodes and anode systems shall be designed to deliver sufficient current to the steel to arrest steel corrosion and/or prevent corrosion initiation. They shall include sufficient galvanic metal and activating agent to deliver this protection for the maintenance-free service life specified.
- 12** If the Contractor is required to design and install the galvanic anode system, qualifications and experience of the Contractor's design consultant should be in accordance with IS EN 15257. The Employer's Representative shall supply appropriate information to the Contractor to support the design e.g. reinforcement density, free chloride content of the adjacent existing concrete etc. Contractor design requirements should be included in Appendix 55/7.

### **Materials**

- 13** Galvanic anodes shall have a core of high purity zinc or high-purity zinc alloy embedded within a medium compatible with the parent or repair concrete. The medium shall not contain any chemical that may cause deterioration of the surrounding concrete or reinforcement.
- 14** One or more connector wires attached to the zinc core shall extend to the outside of the anode and be long enough to facilitate connection to the existing steel reinforcement.
- 15** If a mortar is required for embedding the anode unit, it shall have a resistivity rating no greater than 15 KΩcm. Repair concrete or mortar surrounding the anodes in a patch repair shall comply with Clause 5518.
- 16** The manufacturer supplying the anodes shall be a corporate member of the Corrosion Prevention Association or equivalent and shall employ professional members of the Institute of Corrosion or National Association of Corrosion Engineers or equivalent organisations.

### **Installation of Galvanic Anodes**

- 17** The Contractor shall propose to the Employer's Representative for approval, a specialist Contractor for installing the galvanic anodes after consultation with the anode manufacturer. The choice of specialist Contractor, if satisfactory, shall be approved by the Employer's Representative.
- 18** Cathodic Protection operatives shall be qualified to a level appropriate to the task being undertaken, in accordance with IS EN 15257.

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- 19 Prior to installation of the galvanic anode system, continuity of the steel reinforcement shall be checked. Any loss of continuity shall be restored by a method approved by the Employer's Representative.
  - 20 The spacing of galvanic anodes shall be in accordance with the drawings, or Appendix 55/7.
  - 21 The anodes shall be located close to the edge of the broken out repair zone, subject to a minimum 25mm offset to the broken out edge. Anodes shall be connected to the steel reinforcement using wire attachments on the anode.
  - 22 Electrical contact between the wire attachments and the steel reinforcement shall be checked by measuring the resistance which shall be  $\leq 0.3 \Omega$ .
  - 23 Junction boxes shall be installed where monitoring is required as described in Appendix 55/7. Electrical connection shall not be made directly to the reinforcement, but wires from the anodes shall be chased to a junction box and back to the reinforcement, which shall allow measurement and disconnection of either individual anodes or a group of anodes as specified.
  - 24 The anode units shall be handled using gloves and other personal protective equipment, as per standard procedures for handling cementitious materials.
  - 25 Electrical continuity between the wire ties and the reinforcement bar shall be confirmed by use of a direct current (dc) resistance meter or a dc potential meter. The dc resistance shall be stable, less than 1ohm, and be confirmed with the leads reversed or the dc potential shall be stable, less than 1mV and be confirmed with the leads reversed.
  - 26 The anodes shall be prepared in accordance with the manufacturer's data sheet or specification. Prior to application of concrete repair material, the anodes shall be soaked with water complying with IS EN 1008, unless stated otherwise by the manufacturer's data sheet.
  - 27 The depth from the external surface of the repair patch to the galvanic anode shall not be less than 20mm for deck repairs or 15mm for vertical and overhead repairs.
  - 28 As-built Drawings shall be provided on completion of the Works detailing the positions of individual galvanic anodes, and any wires or junction boxes provided where monitoring is required.

#### **Particular Requirements for Type 1 Galvanic Anodes**

- 29 The anodes shall be installed immediately following preparation and cleaning of the steel reinforcement and in accordance with the manufacturer's instructions.
- 30 The anodes shall be positioned to ensure all round contact with the reinstatement material and be attached using wire in accordance with Clause 1714. Tie wires shall be tightened so that no free movement is possible, to ensure good electrical continuity.
- 31 Concrete repair material for repair areas including galvanic anodes shall comply with Clause 5518.

#### **Particular Requirements for Type 2 Galvanic Anodes**

- 32 The anodes shall be installed immediately following preparation and cleaning of the steel reinforcement and in accordance with the manufacturer's instructions.

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- 33** The sides of the hole drilled into the existing concrete shall be pre-wetted before installation of the anodes. Standing water within the holes shall be removed before anode installation.
- 34** An approved shrinkage-compensated low-resistivity repair slurry shall be inserted in the drilled holes before anodes are fitted. When the anodes are fitted, the repair material shall surround the units and completely fill the annular cylindrical void, connecting the anode with the existing concrete.
- 35** A wire shall be used to connect either a single anode or an array of anodes to the steel reinforcement.

**5507 Concrete Repairs – Falsework and Formwork**

- 1** Details and further requirements of any temporary support necessary as part of the concrete repair work shall be stated in Appendix 55/3.
- 2** Formwork shall comply with the requirements of Clause 1710 and IS EN 13670. Formwork shall impart the class of surface finish listed in Appendix 55/3 and in accordance with Clause 1708. The finish shall be at least F4 or better.
- 3** Where shown on the Drawings and indicated in Appendix 55/3, formwork shall incorporate clear panels to enable the compaction of concrete during placing of concrete to be observed.
- 4** The Contractor shall take particular care with sealing of the formwork against existing concrete surfaces. Where the existing concrete surface is irregular, the Contractor shall submit his proposed method of sealing to the Employer's Representative for approval. The Contractor shall carry out such trials of its proposed method of sealing as may be required by the Employer's Representative.
- 5** Where appropriate to the method of placing the concrete, formwork for flowable concrete repairs shall be arranged and constructed so that it is possible to lightly tap the surface to achieve full compaction.
- 6** Before the next repair in the repair sequence is commenced, the Contractor shall provide the Employer's Representative with access to each completed repair area for inspection after the formwork has been struck and any integrity cores have been drilled in accordance with Clause 5512.33.

**5508 Repair Product - General**

- 1** The proprietary material shall be supplied by a manufacturer who either:
- a) holds a current certificate of registration as a registered firm of assessed capability in accordance with IS EN ISO 9001, or
  - b) operates quality assurance procedures of an equivalent standard to a) above and which meet the approval of the Employer's Representative.
- 2** The manufacturer's quality control procedures shall comply with the requirements of IS EN 1504-8.
- 3** Assumed repair methods for each construction activity and each element to be repaired shall be tabulated in Appendix 55/1.

- 4 The required class or classes of repair product referred to in IS EN 1504-3, Table 3 shall be specified in Appendix 55/1 for each structural element to be repaired and shall also be shown on the drawings. If no class is specified in Appendix 55/1 the required class shall be deemed to be R4. Class R2 repair products shall only be used for non-structural repairs. Class R1 shall not be used.
- 5 Proprietary repair products shall only be used in accordance with its data sheet and the manufacturer's instructions.

## **5509 Repair Product – Constituent Materials**

### **Cement-Based Products - General**

- 1 Cement-based products shall be hydraulic or polymer hydraulic type - IS EN 1504-1 chemical types CC and PCC.
- 2 Repair products shall contain proprietary shrinkage-compensated materials, except for sprayed concrete/mortar when Clause 5516 applies.
- 3 A repair product or material shall contain components in suitable proportions to ensure that it does not segregate, bleed or be prone to cracking in either the plastic or hardened state.
- 4 Flowable products shall be of such composition and grading that when mixed with water the resulting material will flow freely into the space to be filled, without the need for compaction. IS EN 1504-1 chemical types are CC and PCC.
- 5 Unless otherwise described in Appendix 55/1, the constituent materials of the repair concrete shall comply with the following:

#### **Cement**

- 6 Cement shall be in accordance with Clause 1702.1 of the Specification.
- 7 Minimum cement content shall be in accordance with the requirements of IS EN 206-1 and NRA BD57.

#### **Water/Cement Ratio**

- 8 Water/cement ratio shall be in accordance with Clause 1704.2 of the Specification.

#### **Water**

- 9 Water used in the production of concrete shall conform to IS EN 1008.

#### **Aggregates**

- 10 Only natural aggregates which comply with the requirements of Clause 1702.2 shall be used. Aggregates shall be well graded.

#### **Admixtures**

- 11 The Contractor shall demonstrate by means of trial mixes, the action of the admixture he proposes to use to the Employers Representative's approval.

#### **Proprietary Repair Materials**

- 12** All proprietary repair materials shall have a BBA or IAB certificate or equivalent and shall be used for the correct purpose. These shall be applied in accordance with their associated data sheet.

### **Control of Alkali-Silica Reaction**

- 13** Measures to control alkali-silica reaction shall be in accordance with Clause 1704.5, except that the mix shall contain low reactivity aggregates (as defined in BRE Digest 330). The equivalent sodium oxide content shall not exceed 3.0kg in any cubic metre of concrete.

For Portland Cement (CEM 1), the acid-soluble alkali content shall be used and for ground granulated blastfurnace slag (GGBS) and pulverised fuel ash (PFA), the water-soluble alkali content shall be used.

The equivalent sodium oxide content and alkali content shall be determined in accordance with IS EN 196-2.

The Contractor shall submit to the Employer's Representative test certificates giving, in terms of the sodium oxide equivalent, the water-soluble alkali content of any GGBS or PFA which is intended for use in the concrete mixes.

### **Silica Fume**

- 14** Silica Fume may be used in the mix, unless prohibited by Appendix 55/1. The Silica Fume content shall not exceed 10% of the mass of the cement or such other value specified in Appendix 55/1. If used, the Silica Fume shall be Class 1 complying with EN 13263.

### **Fibres**

- 15** The use of fibres in repair products is not covered by this Specification. Any proposal for use of fibres shall be subject to the approval of the Employer's Representative through its Departure from Standard process.

### **Resin-Based Products – General**

- 16** Resin mortars shall be polymer type - IS EN 1504-1 chemical type PC.
- 17** Resin mortars shall contain fine aggregates, grading category GF85, conforming to IS EN 12620.

### **5510 Repair Product - Approval**

#### **Provisional Approval**

- 1** The Contractor shall submit details of the proposed repair product to the Employer's Representative for approval. These details shall include:
- a) Threshold values of performance characteristics described in Table 3 of IS EN 1504-3;
  - b) Declaration of performance;
  - c) Instructions for use and safety information;
  - d) Details of factory production control testing, including range of tests and frequency;
  - e) Cement content or cementitious material content;

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- f) Water/cement ratio;
  - g) Equivalent sodium oxide content and alkali content.
- 2 All repair products require an attestation of conformity system of 2+ in accordance with the relevant Table ZA.2 of IS EN 1504-3.
  - 3 If the Contractor proposes to modify the repair product for use in an application which requires modified properties, e.g. workability, then a separate departure from standard approval submission shall be made for each application. The details provided for each submission shall be appropriate to the mix proposed for that application, including the quantity of water to be added.
  - 4 Once approval for the repair concrete has been given, no changes shall be made to the type of repair concrete or its formulation without the prior approval of the Employer's Representative.

### **Firm Approval**

- 5 When Provisional approval has been granted for the Contractor's proposed products, the products shall be tested to determine whether they are suitable for the project specific applications. Testing required is described in Clause 5512.

### **5511 Repair Product - Supply and Storage of Material**

#### **Packaging**

- 1 The components of proprietary repair products shall be pre-weighed and pre-mixed under factory conditions and shall be packed into sealed containers immediately after mixing. The containers shall be damp proof and made so they can be readily emptied of their contents. The weight of the contained material shall be correct to within 2% of that marked on the container.

#### **Delivery data**

- 2 The containers shall be clearly marked with the information indicated in IS EN 1504-8, section 6; CE marking in accordance with Clause ZA.3 of Annex ZA in IS EN 1504-3. The following additional information shall also be supplied if not indicated elsewhere on the marking:
  - a) Date of manufacture;
  - b) Weight of container and contents;
  - c) Net weight of contents;
  - d) Type of binder;
  - e) Quantity of water to be added (cementitious-based material only);
  - f) Sodium oxide and alkali content.
- 3 The following information indicated in IS EN 1504-8, section 6; Table 3 of IS EN 1504-3 and CE marking in accordance with Clause ZA.3 of Annex ZA in IS EN 1504-3 shall be provided with each bulk consignment of proprietary repair product delivered to site:

- a) Date of manufacture;
- b) Details of the predominant rock types contained in the aggregates (IS EN 932-3, Annex A);
- c) Type of binder (if not included elsewhere on the delivery note).

### **Storage**

- 4 The repair product shall be stored in a controlled environment in accordance with the manufacturer's recommendations. The materials shall not be removed from the store for use in the Works until immediately prior to mixing.

### **Use of Repair Product**

- 5 CC or PCC repair products, as defined in IS EN 1504-1, shall not be older than 3 months, or lesser period described by the manufacturer's product marking. PC products, as defined in IS EN 1504-1, shall not be older than 6 months.
- 6 Resin mortars shall only be used for superficial concrete repairs, and shall not be used where carbon steel reinforcement is exposed in the prepared repair void. See Clauses 5517.2 and 5518.2 for further restrictions.

### **5512 Repair Product - Testing**

#### **Quality Control Tests**

##### **Tests for Suitability of Products -General**

- 1 Before concrete repairs commence on site, the Contractor shall arrange for an independent testing laboratory to carry out the following suitability tests on samples of the proposed and provisionally approved concrete repair products, as supplied by the manufacturer. Tests shall comprise those tests specified in the sub-Clauses below. Test results shall be deemed to be satisfactory if they comply with the performance requirements in Table 3 of IS EN 1504-3.
- 2 Testing laboratories accredited by the Irish National Accreditation Board (INAB) or equivalent shall be employed for tests on concrete repair materials.
- 3 The sources of constituent materials, composition of the concrete, the mix proportions and the equipment used for mixing shall be the same as that proposed for use in the Works. The composition shall not be varied throughout the course of the suitability tests.
- 4 At the discretion of the Employer's Representative, evidence of performance tests, identification tests or factory production control test results carried out on the formulation of repair concrete proposed for the Works may be accepted in place of the relevant approvals test. Tests offered for approval shall have been undertaken or verified by an independent testing laboratory complying with Clause 5512.2



### **Tests for Suitability of Products – Compressive Strength**

- 5 Compressive strength shall be determined in accordance with IS EN 12190. Compressive strength shall comply with performance required for the class of repair product specified and any other early strength gain performance characteristic specified in Appendix 55/1.

### **Tests for Suitability of Products – Elastic Modulus**

- 6 The static elastic modulus or secant modulus shall comply with performance required for the class of repair product specified and any other range of modulus values specified in Appendix 55/1. Static elastic modulus or secant modulus shall be determined in accordance with IS EN 13412 or IS EN 12390-13.

### **Tests for Suitability of Products – Air Content**

- 7 Air content of a high or normal flow repair material determined in accordance with IS EN 12350-7, shall not exceed 7% when measured at an ambient temperature between 5 °C and 20 °C. During the test the concrete and apparatus shall be maintained at a constant temperature.

### **Tests for Suitability of Products – Cementitious Material Content**

- 8 Cementitious material content shall be determined in accordance with BS 1881-124. Values shall be in the range of Min. 400 kg/m<sup>3</sup> - Max. 550 kg/m<sup>3</sup>, in accordance with NRA BD57.

### **Tests for Suitability of Products – Chloride Ion Content**

- 9 Chloride ion content shall be determined in accordance with IS EN 1015-17.

### **Tests for Suitability of Products – Equivalent Sodium Oxide Content**

- 10 The equivalent sodium oxide content shall be determined in accordance with IS EN 196-2. Values shall be  $\leq 3\text{kg/m}^3$ .

### **Tests for Suitability of Products - Flowability**

- 11 The flow characteristics of the concrete shall be determined in accordance with IS EN 13395-3. Values shall be 750mm in 30 seconds (High Flow) and 450mm in 30 seconds (Normal Flow).

### **Tests for Suitability of Products – Restrained Shrinkage**

- 12 Restrained shrinkage shall be determined in accordance with IS EN 12617-4.

### **Tests for Suitability of Products – Carbonation Resistance**

- 13 Carbonation resistance shall be determined in accordance with IS EN 13295.

### **Tests for Suitability of Products – Electrical Resistivity**

- 14 When repair products are required for repairs to concrete patches containing galvanic anodes, or repairs below proposed impressed current cathodic protection, tests for electrical resistivity shall be carried out in accordance with Clause 5517.8 or Clause 5518.8.

### **Tests for Suitability of Products – Additional Tests**

- 15 The Contractor shall carry out any additional approval tests specified in Appendix 1/5.

### **Batch Acceptance Tests**

- 16** Following firm approval of repair products, each batch of approved proprietary repair material (defined in IS EN 1504-8) delivered to the Site shall be tested in an approved independent laboratory as specified in the following sub-Clauses. Where continuous production methods are used by the manufacturer, the frequency of sampling shall be determined by the Employer's Representative.
- 17** Samples for the Batch Acceptance Tests shall be taken at random from one or more containers in the same batch under the supervision of the Employer's Representative. The equipment used for mixing the material shall be the same as that used for the Works.
- 18** At the discretion of the Employer's Representative, evidence of performance tests, identification tests or factory production control tests results carried out on that batch of repair concrete may be accepted in place of the relevant batch acceptance test.

### **Batch Acceptance Tests – Compressive Strength**

- 19** Compressive strength shall be determined in accordance with IS EN 12190, for cast prisms and IS EN 12390-3 for cored cylinders.

### **Batch Acceptance Tests - Flowability**

- 20** The flow characteristics of the concrete shall be determined in accordance with IS EN 13395-3.

### **Batch Acceptance Tests – Additional Tests**

- 21** The Contractor shall carry out any additional batch acceptance tests specified in Appendix 1/5.

### **Contract Compliance Tests - General**

- 22** For each repair area the Contractor shall carry out the Works tests specified in the following sub-Clauses. Tests for compressive strength shall also be carried out on samples cored from hardened sprayed concrete.
- 23** An independent testing laboratory shall be employed by the Contractor for each test. The laboratory employed for each test shall hold an accreditation by the INAB, for each test proposed.

### **Contract Compliance Tests – Compressive Strength**

- 24** Compressive strength shall be determined in accordance with IS EN 12190.
- 25** Unless agreed otherwise by the Employer's Representative, the rate of gain of strength of the repair shall be monitored by testing cubes cured alongside the repair area at ambient temperature.
- 26** From each concrete mix a minimum of six 40mm specimens shall be made. The specimens shall be cured for 24 hours in the moulds with the top surfaces covered by polythene sheets. After 24 hours the specimens shall be stripped and placed in polythene bags for a further 48 hours. The specimens shall continue to be stored alongside repaired areas until required for testing.

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- 27 The specimens shall be crushed in sets of two, at times determined by the Contractor, until the compressive strength of both specimens in a set is not less than the minimum value specified on the Drawings.

#### **Contract Compliance Tests - Flowability**

- 28 The flow characteristics of high or normal flow material shall be determined in accordance with IS EN 13395-3. Samples shall be taken and tested on a daily basis. Values shall be 750mm in 30 seconds (High Flow) and 450mm in 30 seconds (Normal Flow).

#### **Contract Compliance Tests - Inspection by the Employer's Representative**

- 29 When the concrete from an area has been removed and the reinforcement cleaned in accordance with Clause 5505, access to the area shall be provided for the Employer's Representative to inspect and record details of the concrete and reinforcement prior to any further work being carried out.
- 30 Before the next repair in the repair sequence is commenced, the Contractor shall provide the Employer's Representative with access to each complete repair area for inspection after the formwork has been struck and any cores have been drilled in accordance with Clause 5512.35.
- 31 The Contractor shall allow a period of 4 hours, for each inspection detailed in Clause 5512.29 and 30, for each repair area.

#### **Contract Compliance Tests – Air Content**

- 32 The air content of the high or normal flow repair material determined in accordance with IS EN 12350-7, shall not exceed 7% when measured at an ambient temperature between 5 °C and 20 °C.

During the test the concrete and apparatus shall be maintained at a constant temperature. Samples shall be taken and tested on a daily basis.

#### **Contract Compliance Tests – Cores (Integrity of Repair)**

- 33 The Contractor shall demonstrate the integrity of repair work by drilling cores through completed repairs as detailed on the Drawings, or at positions directed by the Employer's Representative. The frequency and distribution of cores shall be described in Appendix 55/3, or as directed by the Employer's Representative.
- 34 The drilling of cores to demonstrate integrity in each repaired area shall be carried out as soon as practicable after the removal of formwork (if present), or when the repair concrete strength is at least 10 MPa. Cores shall be drilled in accordance with IS EN 12504-1.
- 35 The positions of cores directed by the Employer's Representative shall be regarded as a guide only. The exact location of each core shall be determined on site by the Contractor so as to avoid reinforcement and shall be agreed with the Employer's Representative prior to the commencement of the drilling operations. Drilling shall be stopped immediately if a reinforcing bar is encountered and the Contractor shall agree an alternative location for the core with the Employer's Representative.
- 36 The Contractor shall provide access for the Employer's Representative to carry out an examination of the cores and the core holes. The Contractor shall allow a period of 4 hours

for such an inspection. The Contractor shall also make the concrete cores available for inspection.

- 37** The drilling of cores in each repaired area shall be carried out as soon as practicable after the removal of formwork.
- 38** Cores shall be compared with photographs in IS EN 15054-1 and assessed for percentage voids. Voidage shall not exceed 2.5%.

#### **Contract Compliance Tests– Cores (Adhesion to Substrate)**

- 39** The Contractor shall demonstrate that repaired areas have adequate adhesion to the substrate by coring through completed repairs as detailed on the drawings, or at positions directed by the Employer's Representative. The frequency and distribution of cores shall be described in Appendix 55/3, or as directed by the Employer's Representative.
- 40** Each core shall be drilled normal to the surface of the concrete as described in IS EN 12504-1 (sprayed concrete) or IS EN 1542 (high flow concrete or repair mortar).
- 41** Cores shall not be taken until the repair has gained sufficient strength to ensure that when the base of the core is cross cut and removed, the adhesion at the interface between existing and new concrete has not been adversely affected. Testing shall be in accordance with IS EN 14488-4 (sprayed concrete) or IS EN 1542 (high flow concrete or repair mortar).
- 42** The testing of cores removed to determine adhesion in each repaired area shall generally be carried out at least 28 days after placement of repair material.
- 43** Each core shall be 50mm in diameter, to a depth not less than 20 mm beyond the interface of the repaired area and existing concrete and drilled normal to the surface of the concrete. Each core shall be located so as to provide the maximum possible clearance between the core and reinforcing bars. Drilling shall be stopped immediately if a reinforcing bar is encountered and the Contractor shall agree an alternative location for the core with the Employer's Representative.
- 44** Results shall be reported to the Employers Representative. Target adhesion strength shall be in accordance with Appendix 55/3. Any tested cores where failure is fully within the concrete substrate shall not count as part of the results from which the average is calculated. Additional cores and tests shall be undertaken until a satisfactory set of results has been obtained

#### **Contract Compliance Tests – Reinstatement of Cores**

- 45** The next group of repairs in the repair sequence shall not be commenced and any temporary support system shall remain in place until the holes have been drilled and the examination of each repaired area has been carried out and found satisfactory.
- 46** On completion of drilling, all dust and debris shall be removed from each hole using a mains pressure water jet.
- 47** Any core hole in which reinforcement is encountered shall be filled as soon as practicable with repair mortar complying with the requirements of Clause 5515.
- 48** Following the examination, unless otherwise directed by the Employer's Representative, the Contractor shall fill the holes with repair mortar complying with the requirements of Clause 5515.

## **Contract Compliance Tests – Additional Tests**

**49** The Contractor shall carry out any additional Works tests specified in Appendix 1/5.

### **5513 Repair Product - Site mixing, placing and curing**

#### **General**

- 1** Repair products shall not be older than 3 months, or 6 months as indicated in Clause 5511.5, or lesser period described by the manufacturer's product marking, when used for concrete repairs.
- 2** Repair products shall not be removed from the store until immediately prior to mixing.
- 3** Site mixing, placing and curing shall be carried out in accordance with the requirements of IS EN 1504-10 and the following clauses.
- 4** Immediately before mixing and placing the repair product, the existing concrete substrate within the repair area and the existing unbroken concrete immediately surrounding the repair area shall be hammer tested to detect any remaining loose, or hollow sounding concrete which has occurred since the main concrete breakout activities. Any defective concrete shall be removed in accordance with Clause 5503.
- 5** Before placing the mixed repair material, the prepared concrete substrate shall be free of laitance and cleaned of all dust and grit by a water jet at mains pressure, filtered oil-free air or other equivalent method, and shall be pre-wetted in accordance with Clause 5504.4.

#### **Mixing**

- 6** The site mix shall be produced by the addition of the appropriate quantity of water complying with Clause 5509.9 to a given weight of the proprietary material.

The quantity of water shall be within 2% of that recommended by the manufacturer's data sheet for the material approved by the Employer's Representative. Water shall not be added after the original mixing.

- 7** Only full containers of the proprietary material as presented by the supplier shall be used. On-site proportioning shall not be permitted.
- 8** Site mixing shall be carried out strictly in accordance with the manufacturer's written instructions, as approved by the Employer's Representative. Mixing shall be carried out in a forced action paddle mixer of appropriate capacity. Hand mixing shall not be permitted.

#### **Placing of Repair Product**

- 9** Placing of mixed repair material shall be carried out strictly in accordance with the manufacturer's written instructions, as approved by the Employer's Representative.
- 10** The repair material shall be placed into the repair void within 20 minutes of completion of site mixing or such lesser period stated by the manufacturer. The repair material shall be continuously agitated between site mixing and placing.
- 11** Repair material shall not be placed or continue to be placed if either the shade air temperature in the immediate environment of the repair or the surface temperature of the repair material in the repair void are less than the following:

| Temperature   | Location                            | Requirement  |
|---|-------------------------------------|--|
| Shade air temperature in the immediate environment of the repair    | Immediate environment of the repair | The higher of the manufacturer's minimum recommended temperature and 5°C |
| Surface temperature of the existing concrete within the repair void | Within the repair void              | The higher of the manufacturer's minimum recommended temperature and 4°C |

- 12** The temperature of the repair material when deposited shall not be less than 5°C and not more than 20°C.
- 13** The Contractor shall provide all necessary artificial heating or cooling of types approved by the Employer's Representative to ensure compliance with the above temperature requirements. Heat shall not be applied directly to any repair material or completed repair.
- 14** Fresh material shall not be placed against in-situ repair material that has been in position for more than 30 minutes or against hardened concrete which has been in position for less than 20 hours unless a construction joint is formed as described in Clause 1710.1 In addition, the joint surface shall be saturated for a minimum of 2 hours before concrete is placed against it.
- 15** Repair material shall not be dropped into place from a height exceeding 500mm. When trunking or chutes are used they shall be kept clean and be used in such a way to avoid segregation.
- 16** For soffit repairs or other areas defined on the Drawings, repair material shall be placed into position by pumping or gravity feed. The supply points shall be located in the horizontal shutter or at the locations shown on the Drawings. Material shall be placed until the level reaches at least 100mm above the prepared concrete surface.
- 17** The method of compaction of repair materials other than flowable materials shall be in accordance with the manufacturer's instruction and subject to the approval of the Employer's Representative.

### **Curing of Completed Repair**

- 18** Once the repair material is placed, its surface temperature shall not be allowed to fall below 2°C for the period required by the manufacturer.
- 19** Immediately after placing and for 14 days thereafter the completed repair shall be protected against harmful effects of weather including rain, rapid temperature changes, frost and from drying out. The method of curing shall be in accordance with the manufacturer's instructions to provide a suitable environment for the repair material to mature and prevent harmful loss of moisture and shall be subject to the approval of the Employer's Representative.
- 20** The surface profile of a completed repair shall be the same as the existing profile. The tolerance on a finished surface shall be in accordance with IS EN 13670, Annex G.10.7

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#### **5514 Flowable Concrete or Mortar**

- 1** Flowable concrete or mortar shall comply with the requirements of Clauses 5501, 5502 and 5508 to 5512.
- 2** When making cubes for the determination of density of compressive strength of flowable concrete materials, no compaction shall be applied.
- 3** The use of Self Compacting Concrete (SCC) is not covered by this Specification. Where the use of SCC is proposed, it shall be subject to the approval of the Employer's Representative through its Departure from Standards process.
- 4** Aggregates for flowable concrete shall be natural well graded with designation 0/8mm complying with IS EN 12620.
- 5** When making cubes for the determination of density or compressive strength of flowable concrete or mortar, no compaction shall be applied.
- 6** Unless specified otherwise in Appendix 55/1, the minimum "flowability" of high flow concrete shall be 750mm, and the minimum "flowability" of normal flow concrete shall be 450mm when measured in accordance with IS EN 13395-3.
- 7** Where a less flowable mix is required, the repair material shall be capable of being mixed with a reduced water content to produce a stiffer mix. Such adjustment shall be in accordance with the manufacturer's recommendations and subject to approval of the Employer's Representative.
- 8** 28 day characteristic compressive strength of the flowable product shall comply with the specified IS EN 1504-3 class. Early strength gain requirements should be specified in Appendix 55/1.
- 9** When a trial of the Contractor's method of concrete/mortar placement is required, details shall be included in Appendix 55/3.
- 10** Flowable repair products shall flow freely into the repair void to be filled and shall not be compacted using internal vibration. Formwork may be tapped lightly with a hammer to expel trapped air.
- 11** Adhesive bond pull-off tests shall be carried out in-situ on 50mm cores in accordance with Clauses 5512.39 to 5512.44. The target adhesive bond strength shall be specified in Appendix 55/3.

#### **5515 Repair Concrete or Mortar**

- 1** Repair concrete shall be a proprietary shrinkage compensated structural concrete complying with IS EN 1504-3.
- 2** Repair mortar shall be polymer modified, IS EN 1504-1, Type PCC and suitable for small repairs (less than 1m<sup>2</sup> in area), such as a render for low cover build-up, replacing small areas of damaged concrete, filling test holes and the like, using hand placing techniques and elsewhere as specified on the Drawings.
- 3** Repair mortar shall comply with the requirements of Clauses 5501, 5502 and 5508 to 5512 except that the product shall contain natural fine aggregates with designation 0/2mm, complying with IS EN 12620

- 4 The composition of the proprietary material shall be such that, when mixed with water in accordance with the manufacturer's recommendations, a mortar is produced that can be worked easily into the tight irregularly-shaped spaces to be filled and not be prone to cracking in either the plastic or hardened state.
- 5 Where repair mortar is applied in more than one layer, the maximum layer thickness shall be in accordance with the manufacturer's instructions. The underlying surface of mortar shall be prepared in accordance with the manufacturer's instructions.
- 6 Finish on the completed surface of a repair patch using repair mortar shall be as stated in Appendix 55/3 or a minimum of U2 in accordance with Clause 1708.
- 7 Adhesive bond pull-off tests shall be carried out in-situ on 50mm cores in accordance with Clauses 5512.39 to 5512.44. The target adhesive bond strength shall be specified in Appendix 55/3.

#### **Treatment of Areas with Low Cover to Reinforcement**

- 8 Chemical type PC products, as defined in IS EN 1504-1, shall not be used.
- 9 Small areas requiring treatment for low cover to reinforcement shall be treated as follows:
  - a) The perimeter of the treatment area shall be saw cut in accordance with Clause 5503.12 and trimmed back;
  - b) The whole surface, including the cut edges of the area to be built up, shall be prepared in accordance with Clause 5504;
  - c) The prepared area shall then be built-up with repair mortar to achieve the required minimum cover indicated on the drawings.

#### **5516 Sprayed Concrete or Mortar**

##### **Products**

- 1 The use of sprayed concrete within a concrete repair shall have prior written approval from the Structures Section of the NRA. Sprayed concrete if approved shall be either:
  - a) Proprietary material, IS EN 1504-1 Type CC or PCC and complying with the requirements of Clauses 5501, 5502 and 5508 to 5512, IS EN 14487-1 as modified below or
  - b) Designed concrete as defined in Clause 1701 of the Specification complying with the requirements of the 1700 Series of the Specification, IS EN 14487-1 as modified below.
- 2 Sprayed mortar shall be a proprietary repair product complying with the requirements of Clauses 5501, 5502 and 5508 to 5512, Section 8.2.3 of IS EN 1504-10, IS EN 14487-1 and as modified below
- 3 Expansive agents shall not be used in the formulation of sprayed concretes or mortar.
- 4 The provisions of Clause 5509.6 shall apply except sulfate resisting cement shall not be used.
- 5 The water / cement ratio or water/(cement + k x addition) ratio for wet spray mixes shall not exceed 0.45.



- 6 The maximum total chloride content of the concrete constituent materials shall not exceed 0.1% of chloride ion by weight of cementitious material determined by the testing methods given in the Table below:

| Constituent  | Method Specified in  |
|--|--|
| Cement, PFA, GGBS, limestone fines, metakaolin   | IS EN 196-2  |
| Aggregate excluding RCA and filler aggregate made from fly ash   | IS EN 1744-1   |
| Admixture  | IS EN 480-10   |
| Water <sup>(a)</sup>   | IS EN 196-2 <sup>(b)</sup> or BS 6068-2.37 <sup>(b)</sup> (ISO 9297) |
| <p><sup>(a)</sup> Testing is not required if the water is from a potable supply</p> <p><sup>(b)</sup> IS EN 1008 cites “the relevant clauses of IS EN 196-21” for the determination of chloride ion content. This standard has been superseded by IS EN 196-2:2005. The chemical procedure is the same as that given in BS 6068-2.37 and in this case the starting point is a sample of water. When the chloride ion content is outside the recommended range for the test procedure, dilution and factoring is necessary.</p> |  |

- 7 Aggregates shall comply with Clause 1702 of the Specification, and IS EN 14487-1, Table 4 and Table 5. The maximum size shall be 10mm for sprayed concrete and 3mm for sprayed mortar.

### Fibre Reinforced Sprayed Concrete

- 8 The use of fibres shall be in accordance with Clause 5509.16. Fibres, where approved, shall be the 25mm stainless steel melt extract type.
- 9 The weight of fibres shall not exceed 5 per cent by weight of the combined weights of cement and aggregate.
- 10 Unless provided for otherwise a final 5 to 13mm thick coat of unreinforced sprayed concrete shall be applied to cover exposed fibres.
- 11 Fibres shall be added to the mix in such a manner that the fibres are evenly distributed and not bent.
- 12 The gun and the nozzle shall be electrically earthed.

### Performance Requirements

- 13 The sprayed material shall comply with the requirements of Clause 5510 as modified by Appendix 55/4 and the following.
- 14 The tensile splitting strength at 28 days, determined in accordance with IS EN 12390-6, shall be greater than 2.4 N/mm<sup>2</sup>.
- 15 The secant modulus of elasticity, determined in accordance with IS EN 13412, shall not exceed 34 GPa.

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- 16** Percentage shrinkage determined in accordance IS EN 12617-4 shall be less than 0.07%.
- 17** The coefficient of thermal expansion shall be between  $8 \times 10^{-6} /^{\circ}\text{C}$  and  $12 \times 10^{-6} /^{\circ}\text{C}$ .
- 18** The coefficient of chloride ion diffusion shall be determined in accordance with the method in IS EN 13396, and shall be less than  $700 \times 10^{-15} \text{ m}^2/\text{s}$ .

### Quality Control Tests

#### Pre Works Competency Testing

- 19** The Contractor shall demonstrate by procedure trials the suitability of the proposed mix, the method of working and the competence of the operatives.
- 20** Before concrete repairs commence on site, the Contractor shall carry out approval tests on test panels as described below.
- 21** The test panels shall be produced in moulds approved by the Employer's Representative using the materials and equipment proposed for use in the Works. The minimum dimensions of the moulds shall be 750mm x 750mm x 100mm deep. The moulds shall not be coated with release agent.
- 22** Two test panels shall be produced for each proposed mix at each inclination described in the Contract by each spray-gun operator the Contractor proposes for the work. Categories of inclination shall be as follows:
- a) Horizontal soffit (inclination to horizontal,  $0^{\circ}\text{C} - 5^{\circ}\text{C}$ );
  - b) Horizontal upper surface (inclination to horizontal,  $0^{\circ}\text{C} - 5^{\circ}\text{C}$ );
  - c) Vertical (inclination to horizontal,  $80^{\circ}\text{C} - 90^{\circ}\text{C}$ );
  - d) Inclined (inclination to horizontal,  $5^{\circ}\text{C} - 80^{\circ}\text{C}$ ).
- 23** A minimum of four sprayed concrete test panels will be required for each structure being repaired. At least one test panel should contain reinforcement bars of similar diameter spacing and orientation to a typical section of reinforced concrete member to be repaired as part of the contract.
- 24** Tests for adhesive bond, tensile splitting strength, elastic modulus, shrinkage, coefficient of thermal expansion and coefficient of chloride ion diffusion shall be carried out on three of the panels selected by the Employer's Representative.
- 25** Tests shall be carried out by a testing laboratory accredited by the INAB or equivalent.
- 26** One 100mm diameter core shall be taken through the full depth from each quarter of the test panel at not less than two days of age.
- 27** The cores shall not reveal voids or laminations and the Employer's Representative may require further cores to be taken from the remainder of the panel to confirm the performance of the material and application.
- 28** Two of the four cores taken from each panel shall be selected by the Employer's Representative for testing for compressive strength.

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- 29** The cores shall be taken, prepared, tested and the results expressed as estimated in-situ cube strengths in accordance with IS EN 12504-1 and IS EN 12390-3 at an INAB laboratory approved for this test.
- 30** The 28 day minimum compressive strength and tensile splitting strength requirement will be satisfied if, for each panel, the average of the three strengths is greater than the specified value and the difference between the strengths is not more than 20% of their average strength.
- 31** Studs or screws shall be used to measure shrinkage cracking and the coefficient of thermal expansion in the concrete test panels. Monitoring points shall be installed at a spacing of 200 mm at three places in a triangular arrangement on three of the test panels selected by the Employer's Representative and the test panels left for 102 days. The above measurements and readings of air temperature and surface temperature of the concrete shall be taken at regular intervals to monitor movement in the concrete. The percentage of shrinkage in the concrete and the coefficient of thermal expansion shall be calculated from these readings.
- 32** The competence of the sprayed concrete operative shall be deemed to be acceptable for shrinkage, if measured shrinkage is less than 0.07% at 28 days.

### **Contract Compliance Tests**

- 33** The Contractor shall carry out compressive strength tests and adhesive bond tests on cores taken from the sprayed area in accordance with Appendix 1/5.
- 34** Compressive strength tests shall be carried out on 100mm cores with a height/diameter ratio of between 1.0 and 2.0 in accordance with Clauses 5516.29 and 30.
- 35** Adhesive bond pull-off tests shall be carried out in-situ on 50mm cores in accordance with Clauses 5512.39 to 5512.44. The target adhesive bond strength shall be specified in Appendix 55/4.
- 36** Unless directed otherwise by the Employer's Representative the core holes shall be reinstated with repair mortar complying with the requirements of Clause 5515 as soon as reasonably practical after completion of the core sampling.

### **Workmanships**

- 37** The inspection category for sprayed concrete repairs to concrete road structures shall be Category 3 in accordance with IS EN 14487-1.
- 38** The Contractor should be a member of a Sprayed Concrete Association (or equivalent).

### **Qualification of Sprayed Concrete Operative**

- 39** The Contractor should employ a specialist nozzle operator who should have one of the following qualifications:
- a) Be certified to a minimum of Level 2 NVQ Diploma in Specialist Concrete Occupations (Construction) for sprayed concrete activities, and have 2 year's post qualification experience;
  - b) 10 years experience with spraying concrete may be acceptable subject to evidence of experience with suitable references being provided to the Employer's Representative;

- c) Holds a current Certificate of Competence in Sprayed Concrete Practice obtained from the Sprayed Concrete Association or an equivalent organisation.

A copy of the certificate and details of their experience should be submitted to the Employer's Representative for approval before commencement of the work.

- 40** The Contractor shall use a dry-spray process if using a proprietary product, and a dry-spray or wet-spray process if using a designed concrete. Spraying shall be interrupted at each layer of reinforcement to permit visual examination of the deposited concrete.

### **General Construction Requirements**

- 41** Execution shall be in accordance with IS EN 14487-2 for sprayed concrete.
- 42** Sprayed concrete shall be applied with sufficient velocity so as to give a dense and homogeneous covering to the surface in one layer of a thickness compatible with the mix design, constituents, position of reinforcement and place of application, to ensure the placed concrete does not slump or sag.
- 43** Adequate precautions shall be taken to ensure that sprayed concrete rebound is not incorporated in the finished work. Hardened rebound deposits on reinforcement which may prevent a proper bond or encasement shall be removed from reinforcement before spraying.
- 44** Adequate shielding shall be provided around the nozzle and application surface during high winds.
- 45** No concrete or mortar shall be sprayed when the air temperature is less than 5°C or the surface temperature of the concrete is less than 2°C. Surfaces shall be clean and damp but free of standing water before the application of sprayed concrete or mortar.
- 46** Proprietary sprayed mortar shall be applied strictly in accordance with the manufacturer's instructions where these do not conflict with this Specification.
- 47** The thickness of sprayed concrete applied in each pass shall not exceed manufacturer's recommendation. Subsequent passes of sprayed concrete shall be applied in accordance with manufacturer's recommendations.
- 48** The sprayed concrete material shall be incorporated in the Works within the time limits specified by the manufacturer.
- 49** The outline of the finished sprayed concrete shall be as defined by screed boards, guide strips, guide wires or other means approved by the Employer's Representative. The Contractor shall ensure that all oversprayed materials are removed from the surrounding area. The placed material shall be capable of being profiled and trowel finished (to the equivalent of class F2) without detrimental effects, if required and specified.
- 50** Guide wires shall be installed tight and true to line and in such a manner that they may be easily re-tightened.
- 51** Construction tolerances on the finished surface shall be in accordance with IS EN 14487-2, Section 10.
- 52** The Contractor shall ensure that all oversprayed materials are removed from the surrounding area. The placed material shall be capable of being profiled and trowel finished (to the equivalent of class U2) without detrimental effects, if required and specified.

## **Construction Joints**

- 53** Unless specified otherwise by the Employer's Representative, construction joints in a sprayed area shall be tapered at approximately 30° or cut back square to the reinforcement and then tapered to 30°. The construction joint shall be thoroughly cleaned, all laitance and loose material removed and the surface pre-wetted as required in Clause 5504 prior to the placement of adjacent sprayed concrete.

## **Curing**

- 54** Sprayed concrete shall be cured and protected in accordance with IS EN 14487-2 Clause 9.3, except that IS EN 13670 Curing Class 4 shall apply.

## **Surface Finishes**

- 55** The surface finish of sprayed concrete shall be in accordance with IS EN 14487-2, Clause 9.2 and shall normally be left as sprayed from the nozzle. Any exception to this should be as described in Appendix 55/4.
- 56** Geometric surface tolerance for an as-sprayed concrete surface shall be in accordance with IS EN 13670 Annex G10.7 for a non-moulded surface.

## **5517 Repairs to Structures to Receive Impressed Current Cathodic Protection**

### **General**

- 1** Concrete repairs being carried out in preparation for the application of cathodic protection systems shall be carried out in accordance with the general requirements of this series as modified by the following.
- 2** Cement or cementitious based materials shall be used. Resin based repair mortars or repair materials containing steel or carbon fibres shall not be permitted.

### **Removal of detrimental objects**

- 3** The Contractor shall identify and mark all visible objects embedded within the concrete surface and likely to cause an electrical short circuit between the system negative and the cathodic protection anode. All identified objects shall be removed and the concrete surface be reinstated to its former profile.

### **Materials**

- 4** The electrical resistivity of the repair material shall be not less than 5000  $\Omega\cdot\text{cm}$  and not greater than 15000  $\Omega\cdot\text{cm}$  when samples are tested after 28 days. If electrical resistivity of proposed repair material is greater than 15000  $\Omega\cdot\text{cm}$ , a conductive bridging material shall be provided around each anode after it is attached to reinforcement.

### **Approval**

- 5** In addition to the details submitted in accordance with Clause 5510, the Contractor shall provide details of the resistivity of the repair material.

### **Quality Control Tests**

- 6** In addition to the Approvals Tests described in Clause 5512, the Contractor shall carry out Approvals Tests to confirm the resistivity of the material.

- 7 The resistivity shall be measured on three 150mm cubes stored at 20°C under saturated conditions. A probe shall be cast into each cube. The probe shall consist of four pins of stainless steel, spaced at 20mm centres. Each pin shall have a diameter of 5mm, with a 10mm length embedded into the cube to a depth of 40mm. Resistivity shall be measured by the 4 – point Wenner system using a resistance meter with an AC frequency of 105 to 495 Hz. Measurements shall be taken at 14, 21 and 28 days, immediately after removing the cube from the water bath and drying off the surface with absorbent paper. The resistivity shall be calculated from the following formula:

$$\text{Resistivity} = 2 \pi a (V/I)$$

Where: a = pin spacing  
V = voltage measured on inner pins  
I = current flowing between outer pins

### Batch Acceptance Tests

- 8 In addition to the Batch Acceptance Tests described in Clause 5512, the Contractor shall carry out Batch Acceptance Tests in accordance with Clause 5517.8 to confirm the resistivity of the material.

### Treatment of Areas with Low Cover to Reinforcement

- 9 Where the Contract requires substandard concrete cover to reinforcement to be increased prior to application of a cathodic protection system contained within an overlay, the areas shall be treated in accordance with Clause 5515.8 and 5515.9. The minimum cover shall be 15mm.

### Treatment of Reinforcement

- 10 Where concrete repairs are being carried out prior to the application of cathodic protection, continuity of the existing reinforcement shall be ensured. Tying wire used to restore continuity of reinforcement shall comply with Clause 1714.

## 5518 Repairs to Structures using Galvanic Anodes for Control of Incipient Anode Effect

### General

- 1 Concrete repairs to structures including the use of galvanic anodes placed within the repair patch or installed in holes drilled in the existing concrete adjacent to the repair patch, shall be carried out in accordance with the general requirements of this series as modified by the following.
- 2 Cement or cementitious based materials shall be used. Resin based repair mortars or repair materials containing steel or carbon fibres shall not be permitted.

### Materials

- 3 The electrical resistivity of the repair material used in repair patches shall be not less than 5000  $\Omega \cdot \text{cm}$  and not greater than 15000  $\Omega \cdot \text{cm}$  when samples are tested after 28 days, as described in Clauses 5518.7 and 8.
- 4 Electrical resistivity of proposed repair material may be greater than 15000  $\Omega \cdot \text{cm}$ , if a conductive bridging material is provided locally around each anode after it is attached to reinforcement.

- 5 For anodes placed in holes drilled into the existing concrete, the surrounding material shall be flowable and shrinkage compensated.

### Approval

- 6 In addition to the details submitted in accordance with Clause 5510, the Contractor shall provide details of the resistivity of the repair material.

### Quality Control Tests

- 7 In addition to the Approvals Tests described in Clause 5512, the Contractor shall carry out Approvals Tests to confirm the resistivity of the material.
- 8 The resistivity shall be measured on three 150mm cubes stored at 20°C under saturated conditions. A probe shall be cast into each cube. The probe shall consist of four pins of stainless steel, spaced at 20mm centres. Each pin shall have a diameter of 5mm, with a 10mm length embedded into the cube to a depth of 40mm. Resistivity shall be measured by the 4 – point Wenner system using a resistance meter with an AC frequency of 105 to 495 Hz. Measurements shall be taken at 14, 21 and 28 days, immediately after removing the cube from the water bath and drying off the surface with absorbent paper. The resistivity shall be calculated from the following formula:

$$\begin{aligned} \text{Resistivity} &= 2 \pi a (V/I) \\ \text{Where } a &= \text{pin spacing} \\ V &= \text{voltage measured on inner pins} \\ I &= \text{current flowing between outer pins} \end{aligned}$$

### Batch Acceptance Tests

- 9 In addition to the Batch Acceptance Tests described in Clause 5512, the Contractor shall carry out Batch Acceptance Tests in accordance with Clause 5517.8 to confirm the resistivity of the material.

### Treatment of Reinforcement

- 10 Where concrete repairs are being carried out prior to the application of cathodic protection, continuity of the existing reinforcement shall be ensured. Tying wire used to restore continuity shall comply with Clause 1714.

## 5519 Concrete Injection

### Introduction

- 1 Injecting and filling of cracks in concrete satisfying Principles 1 and 4 of IS EN 1504-9 shall comply with IS EN 1504-5.
- 2 This Specification does not cover special applications as defined in IS EN 1504-5, Section 5.3

### General Requirements

- 3 Classification of the injection product shall be in accordance with Annex A of IS EN 1504-5. Details shall be described in Appendix 55/5 and be referenced on the Contract Drawings.
- 4 The proprietary injection product shall be supplied by a manufacturer who either:

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- a) Holds a current Certificate of Registration as a registered Firm of Assessed Capability in Accordance with IS EN ISO 9001, or
  - b) Operates quality assurance procedures of an equivalent standard to a) above and which meet the approval of the Employer's Representative.
- 5** The manufacturer's quality control procedures shall comply with the requirements of IS EN 1504-8.
- 6** All personnel proposed for concrete injection shall be trained operatives experienced in the use of injection equipment and shall be familiar with or have received instruction in the use of the specified injection product.

### **Products for Crack Injection**

- 7** Products for crack injection of cracks in concrete shall comply in general with the requirements of IS EN 1504-5. Performance characteristics shall be confirmed for all intended uses in Tables 1, 2 and 3 of IS EN 1504-5.
- 8** The injection material shall not pose a corrosion risk to the existing reinforcement either in its fluid or cured state.
- 9** Unless described otherwise in Appendix 55/5, the performance characteristics of injection product shall comply with the requirements of Tables 6, 7 and 8 of IS EN 1504-5 as appropriate to the required class of injection product and the following:
- a) The injection product shall achieve a minimum characteristic compressive strength of 25N/mm<sup>2</sup> within 10 hours of injection;
  - b) The volumetric shrinkage of unrestrained filled injection product shall not exceed 3 %;
  - c) 'Gel time' of injection materials under working conditions shall not be less than 30 minutes.
- 10** Additional performance characteristics for certain intended uses shall be specified in Appendix 55/5
- 11** Workable time of injection product under ambient conditions at the time of use shall not be less than 30 minutes.

### **Inspection**

- 12** As soon as practical after commencement of the Contract, the Contractor shall provide access to enable a joint inspection of the structure to be undertaken with the Employer's Representative to determine which cracks require treatment. Light grit blasting of the concrete surface shall be carried out prior to inspection of the cracks.

### **Product Approval**

- 13** Before Works commence on site, the Contractor shall provide the Employer's Representative with documentary evidence of the performance characteristics of the proposed injection product in accordance with Table 3 of IS EN 1504-5 as appropriate to the specified U and W classification of the injection product. Once approved for use in the Works, no changes to the type of material or its formulation may be made without the prior approval of the Employer's Representative.



### **Supply and Storage of Approved Product**

- 14** The containers shall be marked with the information indicated in IS EN 1504-8, Section 6 and the following:
- a) Date of manufacture;
  - b) Weight of container and contents;
  - c) Net weight of contents;
  - d) CE marking in accordance with Clause ZA.3 of Annex ZA in IS EN 1504-5.
- 15** The following information indicated in IS EN 1504-8, Section 6 shall be provided with each consignment of proprietary injection product delivered to site:
- a) Batch reference numbers, size of each batch and number of containers in the consignment;
  - b) Date of manufacture;
  - c) CE marking in accordance with Clause ZA.3 of Annex ZA in IS EN 1504-5.
- 16** The injection product shall be stored in a controlled environment in accordance with the manufacturer's recommendations, and IS EN 1504-10, Clause 8.1

### **Testing**

#### **Suitability Tests**

- 17** Provided that satisfactory data is provided in accordance with Clause 5519.13, approvals tests shall only be required where detailed in Appendix 1/5.

#### **Batch Acceptance Tests**

- 18** Unless specified otherwise in Appendix 1/5, batch acceptance tests shall comprise the factory production control tests carried out by the manufacturer in accordance with IS EN 1504-8. Copies of all relevant test certificates shall be supplied to the Employer's Representative for approval.
- 19** The Contractor shall carry out random tests to confirm workable time of each injection material at an average rate of seven tests per week. Test curing shall be representative of working conditions.

#### **Contact Compliance Tests**

- 20** The Contractor shall carry out the following Works tests together with any further Works tests described in Appendix 1/5.
- 21** The Contractor shall carry out random 'gel tests' at an average rate of seven tests per week. Test curing shall be representative of working conditions.
- 22** Core samples shall be inspected by the Employer's Representative to confirm that the penetration requirements are met. The percentage extent of crack filling shall be at least 80% or other higher value specified in Appendix 55/5. If they have not, the core filling shall be

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declared to be presently unsatisfactory. The cores shall then be loaded under compression to destruction. If no fracture occurs on a glue line, the core is acceptable.

- 23** If following compression loading, the break occurs on a glue line, the core fragment shall be examined further to determine if improper metering/mixing of the injection material has occurred. In this case, the Contractor shall be required to provide further remedial proposals in conjunction with the resin manufacturer.
- 24** The specialist injection Contractor shall take core samples through filled cracks to confirm the extent of filling at locations agreed with the Employer's Representative and as indicated on the Drawings. Cores shall generally be 50mm diameter x 100mm long, however the specialist injection Contractor shall also make provision for taking 25mm diameter x 100mm long cores in place of the 50mm diameter cores where directed by the Employer's Representative.
- 25** Core holes shall be reinstated using polymer modified repair mortar complying with Clause 5515

### **Workmanship**

- 26** Crack injection shall be carried out by a specialist injection Contractor experienced in the use of the material and equipment proposed for the Works.
- 27** The specialist injection Contractor shall either:
- a) Hold a current Certificate of Registration as a registered Firm of Assessed Capability in Accordance with IS EN ISO 9001, or
  - b) Operate quality assurance procedures of an equivalent standard to i) above and which meet the approval of the Employer's Representative.
- 28** All personnel used in the injection Works shall be trained operatives experienced in the use of injection equipment
- 29** The specialist injection Contractor shall prepare and submit to the Employer's Representative an outline method statement covering the following points relating to the injection Works:
- a) Details of methods and materials (including suppliers) to be employed for each item of work. Details of materials shall include viscosity ranges for various crack widths, strength characteristics, gel times, the percentage volumetric shrinkage and expansion characteristics, and water tolerance levels;
  - b) Details of the drying out process to be employed where appropriate.
- 30** Unless specified otherwise on the Contract Drawings, crack injection shall be carried out by a method using combined vacuum and pressure. Grouting pressures shall not exceed a positive pressure of 1.5 bar combined with a negative pressure of -0.75 bar.
- 31** The mixing and injection of all material shall be strictly in accordance with the manufacturer's recommendations.
- 32** Debris lodged within the cracks and unacceptable contamination of the crack sides shall be removed before filling. Where moisture within the crack or soaked into the sides of the concrete within the crack is greater than recommended by the proposed injection product, moisture shall be removed by an approved method prior to crack filling.

- 33 The procedure for crack injection shall ensure all cracks and voids interconnected with surface cracks are completely filled.
- 34 The injection method and materials shall be sufficient to ensure a bond strength between resin grout and existing substrate of not less than 1N/mm<sup>2</sup> (or the strength of the substrate if less than 1N/mm<sup>2</sup> is achieved) when tested in accordance with IS EN 1542.
- 35 Injection products spilled onto concrete surfaces shall be removed.

## **5520 Surface Protection Systems**

### **General Requirements**

- 1 The surface protection system shall be an impregnant that achieves the values for hydrophobic impregnation of concrete for Class II in Table 3 of IS EN 1504-2 and shall be in accordance with Clause 1709 of the Specification. The minimum depth of penetration shall be >5mm.


### **5521 Structural Bonding**

- 1 Structural bonding shall be in accordance with IS EN 1504-4.

### **5522 Anchoring of Reinforcing Steel**

- 1 Anchoring of reinforcing bars shall be in accordance with IS EN 1504-6
- 2 The design of the anchor shall be conducted by a suitably qualified Chartered Engineer who will need to design the bond length of the anchor and the diameter of the hole, taking due consideration of the strength of the existing concrete, the type of anchor grout to be used and the maximum load to which the anchor will be subjected.
- 3 The Contractor shall install the reinforcement anchor in accordance with the material manufacturers recommendations.
- 4 Diamond-cored holes are to be avoided. Holes shall be thoroughly cleaned out prior to installation and that the anchors are not disturbed, or subjected to loading, until the grout has achieved the design strength.



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