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COTO

Committee of Transport
Officials

Standard Specifications for Road and Bridge Works for State Road Authorities

Committee Draft Final (CDF)

CHAPTER 14: REPAIR AND REHABILITATION OF STRUCTURES

August 2019

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Comments

Comments on the Chapters must be provided in writing as per the format provided on the SANRAL website www.nra.co.za and e-mailed to cotorevision@nra.co.za no later than **04 October 2019**.

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CHAPTER 14: REPAIR AND REHABILITATION OF STRUCTURES

A14.1 ACCESS FOR BRIDGE REHABILITATION

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PART A: SPECIFICATIONS

A14.1.1 SCOPE

This Section covers the requirements for the provision of suitable and safe access to all areas requiring concrete demolition, repair work or rehabilitation of structures in accordance with the contract, and for inspections by the Engineer. It shall also include for the protection of passing persons, animals and vehicles against injury or damage and prevention of damage and contamination of the environment.

A14.1.2 DEFINITIONS

Temporary works - shall be necessary for access to the work area and includes all foundations, scaffolding and support structures, working platforms, cradles, fixtures to existing structural members, etc. required for the safe access to and execution of the work.

Mobile access unit - consists of a vehicle-mounted access gantry and work platform, including mobile crane type units.

Location - means a specific structure as a whole where rehabilitation work has to be carried out.

Structural element - shall be that particular part or parts of a structure, bridge, culvert, retaining wall, traffic barrier, gantry or light mast as specified or indicated on drawings.

- Bridge elements consist of abutments, piers, foundations, piles, decks, parapets, bearings and joints.
- Culvert elements consist of floors, walls and decks.
- Retaining wall elements consist of foundations and walls.
- Median barriers consist of foundations and barrier walls.
- Gantries consist of foundations, stub column and masts.

Setting up at each structural element shall include all movement required from point to point on a particular element.

Screening the work - suitable metallic or non-metallic grids, boarding or fabric membranes shall be used to screen the work area and to prevent falling debris from endangering the persons in the work area.

A14.1.3 GENERAL

The Contractor shall provide and will be responsible for safe access structures and work platforms to all areas or structural elements requiring remedial work. The access and temporary works shall be designed, constructed and maintained in accordance with the current relevant safety regulations, all in compliance with the Occupational Health and Safety Act and its applicable Regulations, and shall remain in place until removal is authorised by the Engineer. Appropriate allowances shall be made for screening of the work and other protective measures required by the various work activities.

Access and work platforms may be provided from overhead mobile access gantries or vehicles, or from temporary works supported from the ground or fixed to structural elements.

Notwithstanding approval given by the Engineer for the design and drawings prepared by the Contractor and the acceptance of temporary works including the working platform(s) and access structure(s) as constructed, the Contractor shall be solely responsible for the safety and adequacy of the temporary works in terms of the occupation health and safety Act and shall indemnify and keep indemnified the Employer and Engineer against any losses, damage to persons or property, all claims, demands, proceedings, damages, costs, charges and expenses whatsoever, which may arise out of or in consequence of the design, construction, use and maintenance of the temporary works.

For works on, over, under or adjacent to any railway line which is controlled by Rail Authorities, the Contractor shall comply, inter alia, with the requirements for the preparation and submission of drawings for falsework and formwork, and the submission of certificates for the proper construction thereof, all in accordance with the latest Rail Authority Specifications. The Contractor shall submit to the Engineer the relevant design details and drawings of the working platform(s) and access structures for comment and/or record purposes.

Roped access techniques shall not be permitted unless specified in the Contract Documentation. Where roped access is used, only persons who are specialists in roped access may be used in accordance with (Section18) of the applicable construction regulations.

Complete method statements including Occupation Health and Safety, Environmental and risk assessments, shall be submitted to the Engineer of techniques to be adopted for execution of the work before any work commences.

The Contractor shall comply with any additional imposed or physical restraints upon the means of access to and from the structure as stated in the project specification and the drawings.

The Contractor shall provide access facilities for inspection and testing by the Engineer, including the inspection at the end of the defects liability period. Any specific access facility required for the inspection at the end of the defects liability period shall be as indicated in the pricing schedule.

Traffic control and safety measures shall be erected to protect the access structures as required and specified on the drawings.

These special traffic control measures are required to protect the working platforms these shall consist of gantries across the road with attached flashing lights. In addition, the gantries shall be fitted with alarm systems to warn the workman on scaffolds working on the bridge to evacuate to positions of safety. Sirens set off from the impacted gantry are the preferred warning system. The Contractor shall however put in place all other measures deemed necessary to minimise his risk.

A14.1.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.1.4.1 General

The Contractor's design and drawings of the falsework for access shall comply with all requirements of the Construction Regulations.

The Contractor's design of all falsework for access shall be carried out by an ECSA Registered Professional Engineer or Technologist with relevant experience and shall be in accordance with but not limited to the loadings of the latest version of TMH7. The drawings and calculations shall be submitted to the Engineer for approval at least 14 days prior to the commencement of the work. The design, erection and construction of such temporary works shall be certified by an ECSA Registered Professional Engineer or Technologist on behalf of the Contractor shall comply with the relevant safety regulations regarding strength and stability for all imposed loads that can be anticipated to arise from the specified work activities.

The Contractor shall submit to the Engineer at least 14 days before work on the existing structure is scheduled for construction a detailed analysis showing the effect of the stresses that will be induced on the permanent works by the Contractor's chosen method of construction. The cost of any additional work or material required as a result of the Contractor's chosen method of construction shall be to the Contractor's account. No construction shall commence until the Engineer has given his written approval.

The Contractors registered professional shall monitor at regular intervals and also sign off on the erection of the falsework and formwork after the erection thereof before the Engineer permits the work to proceed.

A14.1.4.2 Falsework

The Contractor shall make his own assessment of the allowable bearing pressure on the foundation material and shall design the footings and falsework to prevent overloading, differential settlement and unacceptable overall settlement. In assessing the allowable bearing pressure, due account shall be taken of the effect of wetting on the foundation material.

The Contractor's falsework designer shall take account of the location of the structure and the possible ingress of water from sources such as watercourses, water table and saturation due to rainfall and assess the resulting effects in bearing capacity.

In designing the falsework, cognizance shall also be taken of the redistribution of load which may occur on account of the effect of temperature, wind force, flooding and debris.

Cognizance shall also be taken of the lateral forces which may be induced by earth platforms, required for the support of falsework on the substructures resulting in temporary or permanent stresses for which the existing sub-structures have not been designed.

Particular attention shall be given to providing transverse and diagonal bracing as well as rib stiffeners on cross bearers.

A14.1.5 MATERIALS

All timber, structural steel and scaffolding used shall be free from defects that may prejudice the stability of the working platform(s) and access structures. All materials used for temporary access shall be certified and approved by the designer and copied to the Engineer. The jacks, devices, clamps and fittings shall all be in good working order and of adequate design and strength.

The type, grade and condition of the material shall be subject to the designer's approval and submitted to the Engineer for the record.

A14.1.6 CONSTRUCTION EQUIPMENT

A14.1.6.1 Mobile access units

Access structures and work platforms mounted and operated from a mobile support base shall be of an approved type and capacity for the intended use. The unit shall at all times be operated within the recommended limits in terms of reach and capacity and within all their limitations as stated by the manufacturer or the authority responsible for the operation and maintenance of the access unit. The unit shall be maintained and serviced by the Contractor up to completion of the works. The operator of the vehicle shall be suitably qualified and certified to operate the unit.

A14.1.6.2 Scaffolds, platforms and cradles

Temporary works entailing scaffolds, platforms and cradles providing access to the work area shall be assembled and constructed from materials and structural sections complying with the relevant material specifications. The temporary works shall be designed, erected, operated, maintained and dismantled so as to ensure safe working conditions for all site personnel, and where necessary the safety of the general public having access to the site. Traffic safety measures shall be in place before the work commences.

A14.1.7 EXECUTION OF THE WORKS

All temporary access structures and work platforms and associated works shall be erected, modified, maintained and dismantled under the direction of an experienced and competent supervisor and safety officer.

Prior to using any temporary access structure or facility, and at regular intervals thereafter, or following unforeseen circumstances, the temporary works shall be inspected and certified by a suitably experienced and qualified person on behalf of the Contractor.

To ensure the safety of, and to prevent injury or damage to passing persons, vehicles, animals, etc. the temporary works shall be enclosed with a suitable screening membrane or boarding where necessary to contain material or work equipment within the limits of the restricted work area.

Suitable debris containers and chutes shall be provided to assist in the removal of debris and unusable or rejected materials.

Where temporary works are to be fixed to, or supported from an existing permanent structure, the location shall be subject to the approval by the Engineer. Such temporary works shall be removed when the work is completed and any holes, surface damage or blemishes arising from the fixture thereof to the inspected structure shall be repaired to the surface finish of the adjacent surface to the satisfaction of the Engineer.

The Contractor shall submit a Method Statement including Risk Assessments required in terms of the Occupation Health and Safety Act and also provide for all requirements required in terms of the Environmental Management Plan.

A14.1.8 WORKMANSHIP

The Contractor shall, prior to dispatching the mobile access unit to the site, provide certification from the manufacturer or the operating authority that the unit has been thoroughly inspected and serviced, that the unit is functioning properly and that it complies with the relevant safety regulations and that the operator has been certified to operate the unit. After the erection for access purposes and before usage by the workmen the works shall be certified by the designer in terms with compliance with the specifications and is suitable for its intended use. A copy of the certification shall be delivered to the Engineer.

B14.1 ACCESS FOR BRIDGE REHABILITATION

PART B: LABOUR ENHANCEMENT

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B14.1.7 EXECUTION OF THE WORKS

B14.1.8 WORKMANSHIP

B14.1.1 SCOPE

Access for bridge rehabilitation through mechanised means, is deemed to be specialised activity and generally not suitable for labour enhanced work, however the traffic accommodation related to access requirements can be considered to be a labour enhanced activity and is covered under Section B1.1 of Chapter 1. The temporary works associated with scaffolding and platform erection is executed by labour with the relevant skills set and is deemed to be a labour enhanced activity.

B14.1.2 DEFINITIONS

The provisions of Part A, shall apply.

B14.1.3 GENERAL

The provisions of Part A, shall apply.

B14.1.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A, shall apply.

B14.1.5 MATERIALS

The provisions of Part A, shall apply.

B14.1.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.1.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply.

B14.1.8 WORKMANSHIP

The provisions of Part A, shall apply.

C14.1 ACCESS FOR BRIDGE REHABILITATION

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

None

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

The following payment items shall include full compensation for all the works items associated with the provision of suitable safe access to all areas on site.

Item	Description	Unit
C14.1.1	Temporary access structures and work platforms (by element)	
C14.1.1.1	Access and platforms to locations as described as well as dismantling and removal at completion (heights assessed by Contractor)	
(a)	(Description of bridge or structures given)	
(i)	(Element of work requiring access described)	number (No)
(ii)	(Etc. for other elements of work)	number (No)
(b)	Etc. for other bridges or structures)	
(i)	(Element of work requiring access described)	number (No)
(ii)	(Etc. for other elements of work)	number (No)

The unit of measurement for each item shall be the lump sum.

The height of the required access platforms can be estimated from the drawings but must be confirmed on site. The heights must be assessed by the Contractor at the time of tender.

The tendered amount shall include full compensation for design, supply, fabrication, erection, dismantling, movement and for all labour, materials, and equipment required for the above works including the inspections, supervision by the safety officer and the maintenance of the temporary access structure and work platform.

Payment shall be made on the following basis: - 70 % of the lump sum on erection of access structures
- 30 % of the lump sum on removal of access structures

Payment shall not be made for re-erection of access structures.

Item	Description	Unit
C14.1.2	Mobile access units	
C14.1.2.1	Establishment of mobile access unit on site (description of type of unit)	lump sum
C14.1.2.2	Setting up of mobile access unit at each structure location and removal after completion	number (No)
C14.1.2.3	Operation of mobile access unit during repair work at each location (structure)	days
C14.1.2.4	Operation of mobile access unit during inspections by the Engineer	hours (h)
C14.1.2.5	De-establishing and removal of mobile access unit from site after completion of work	lump sum

The unit of measurement for each item shall be the lump sum, number, days or hours as indicated and shall be paid proportionately as the work progresses.

The tendered amounts and rates shall include full compensation for all labour, plant and equipment required to procure, transport to site and to establish the mobile access unit including all costs related to inspection, operation and maintenance of the unit on site.

The tendered rate for items C14.1.2.1 to C14.1.2.5 shall cover all costs necessary for establishing and de-establishing of the mobile access unit on site.

The tendered rate for item C14.1.2.2 shall cover the cost for setting up of the mobile unit at each of the number of locations scheduled, and removal after completion of the work at the location.

The tendered sum for item C14.1.2.3 shall cover all costs for operating the mobile access unit on location for the full time required to complete the repairs.

The tendered rate for item C14.1.2.4 shall cover the cost of operation of the mobile access unit as required by the Engineer. No payment shall be considered for this item if the Engineer requires the use of the mobile access unit while it is on location for the normal work to be done under the contract and not specially re-established on the location for the purpose of inspection only.

Item C14.1.2.1 and C14.1.2.5 shall not apply to times when the mobile access unit is in operation on site for the repair works when it is possible to be simultaneously also be used for inspection by the Engineer. The Contractor is to co-ordinate with the Engineer to ensure no unnecessary establishment or de-establishments.

Item	Description	Unit
C14.1.3	Access at end of defects liability period (Description of location)	lump sum

The unit of measurement shall be the lump sum for access to each site or structural elements at the end of the Defects Liability Period as ordered by the Engineer.

The tendered amount shall include full compensation for all labour, material, plant or equipment including plant operators required to provide suitable and safe access for the Engineer to carry out the necessary inspections as measured in the pricing schedule.

Item	Description	Unit
C14.1.4	Attendance by (relevant authority)	
C14.1.4.1	Prime cost sum to allow for attendance by relevant authority to obtain access near electrified railway lines or other relevant authorities as required (give description of bridge)	prime cost sum
C14.1.4.2	Percentage on prime cost sum for charges and profits	Percentage (%)

A prime cost sum is provided in the pricing schedule to cover the cost of the attendance as required and approved by the Engineer.

Payment for obtaining this service shall be in accordance with the provisions of the General Conditions of Contract.

Item	Description	Unit
C14.1.5	Provision of designs and drawings of access structures and platforms by an ECSA Registered Professional Engineer or Technologist (description of member to which applicable)	Lump Sum

The unit of measurement shall be the lump sum and shall be paid in two payments of 50 % on submission of the access structures and platform designs and the second 50 % on complete removal of all the access structures and platforms.

The tendered rates shall include full compensation for procuring and provision of all drawings for the access structures and platforms designs by an ECSA Registered Professional Engineer or Technologist, including inspections, supervision and certification where applicable, all labour, material, travelling and incidentals, and the signing off on the erection of the access structures and platforms including submission of all certificates as specified.

Item	Description	Unit
C14.1.6	Provision of a safety gantry with warning system (description of type of gantry, size and location)	Number (No)

The unit of measurement shall be the lump sum for each complete safety gantry erected.

The tender amount shall include full compensation for design supply, fabrication, erection, dismantling and for all labour materials and plant or equipment required fabricate, supply, erect and dismantle the safety gantry in its location as specified.

Item	Description	Unit
C14.1.7	Accommodation of Vehicular and Pedestrian Traffic at Access Structures	Lump Sum

The unit of measurement shall be the lump sum and shall be paid in three payments of 50 % on setting up of the accommodation of traffic measures and the second 20 % on complete removal of all the traffic accommodation measures and the final 30 % at the end of the defects liability period.

The tendered rates shall include full compensation for procuring and provision of all road signs and other measures required in accordance with Chapter 1 for accommodation of vehicular and pedestrian traffic during the works and the accommodation of traffic measures required for the defects liability inspection. The tendered rate shall also include all labour, material, travelling and incidentals, and the removal the road signs and other measures after the completion of the works to the satisfaction of the Engineer.

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D14.1 ACCESS FOR BRIDGE REHABILITATION

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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D14.1.9 NOTIFICATION OF REMEDIAL WORK

D14.1.10 REMEDIAL WORK

D14.1.1 SCOPE

The scope of this Section covers the following:

- Product conformance specifications
- Warranties for product or element design and installation of proprietary systems
- Performance specifications

Note that the requirements for performance specifications are not limited to that given in Part A only but includes all of the requirements in the Contract Documentation.

D14.1.2 GENERAL

D14.1.2.1 Product conformance specifications

The Contractor shall, within 28 days of entering into the contract with the Employer, submit to the Engineer conformance documentation related to the specifications.

Conformance documentation shall be provided for:

- a. Scaffolding members.
- b. Timber scaffolding members.
- c. Jacks, devices, clamps and fitting.
- d. Mobile Platform / Hanging Access Platform Certificates.

D14.1.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.1.3.1 Warranties for product or element design and installation of proprietary systems

Certification for all falsework for access by a suitable experienced ECSA Registered Professional Engineer or Technologist shall be required.

D14.1.3.2 Performance specifications

Performance based specifications shall be contained in the Contract Documentation for the project if applicable. Method Statements shall be drawn up by the Contractor's designer and submitted to the Engineer for approval.

The Contractor shall accept full responsibility for the design, erection, usage and removal of the plant and equipment from site after completion.

A14.2 CORROSION SURVEY METHODS AND TESTING OF NEAR SURFACE CONCRETE PROPERTIES

CONTENTS

PART A: SPECIFICATIONS

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PART B: LABOUR ENHANCEMENT

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PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.2.1 SCOPE

This Section covers the test methods and requirements to determine cover over reinforcement and to evaluate specific concrete properties, such as compressive strength, ingress of aggressive chemicals and environmental agents, and common reinforcement corrosion methodologies, that are generally assessed from the surface of an existing structural member. Specialised techniques not included in this specification, such as petrographic tests, Alkali-silica reaction (ASR) tests, thermography, radiography, ground penetrating radar and vibration- or acoustic-based structural assessments, shall be provided in the Contract Documentation.

A14.2.2 DEFINITIONS

A14.2.3 GENERAL

The Engineer will specify what provision must be made to inspect and survey exposed concrete surfaces via a sampling plan. The Contractor shall carry out appropriate in situ or laboratory tests as stipulated in the sampling plan to determine appropriate remedial work. The Contractor shall make allowance in his programme for the time required to carry out surveys, laboratory tests and the reporting of results prior to commencing with repairs.

The Contractor shall provide suitable and safe access to enable the Engineer to carry out a close inspection of all specified concrete surfaces.

General access requirements shall be measured and paid for under Section A14.1.

A14.2.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.2.5 MATERIALS

All materials utilised to repair any survey or testing locations, shall comply with the requirements of Section A14.4 or as directed by the Engineer.

The following chemicals shall be standards for testing concrete according to the standard methods presented in this Section:

A14.2.5.1 Reference pH indicator solutions used to determine carbonation depth

The pH indicator solution shall consist of either:

- a) Phenolphthalein indicator solution comprising 1 gram phenolphthalein dissolved in 50 to 70 millilitres ethyl alcohol and diluted to 100 millilitres with neutral distilled or deionised water; or
- b) Thymolphthalein indicator solution comprising 1 gram thymolphthalein dissolved in 50 to 70 millilitres ethyl alcohol and diluted to 100 millilitres with neutral distilled or deionised water.

A14.2.5.2 Laboratory chemicals used to determine chloride content

The chemicals used to determine chloride content shall consist of:

- a) Deionised water with an electrical conductivity less than 2 $\mu\text{S}/\text{cm}$;
- b) Nitric Acid (5 mol/l);
- c) Silver Nitrate solution (0,02 mol/l);
- d) Ammonium thiocyanate (NH_4SCN) solution (0,1 mol/l);
- e) Ammonium ferric sulfate indicator solution (100 millilitres of a cold saturated solution of $\text{NH}_4\text{Fe}(\text{SO}_4)_2$ and 10 millilitre diluted nitric acid); and
- f) 3,5,5-triethylexanol; or
- g) Additional reagents as may be required when using the potentiometric method (refer Clause A14.2.7.4b).

A14.2.6 CONSTRUCTION EQUIPMENT

All cover meter devices shall comply with BS 1881 Part 204 or SS – EN206.

All equipment, tools and devices used to obtain concrete samples from structures shall be based on proven and accepted technology within the industry. The Contractor shall note the particular requirements of safely obtaining samples from the surface of soffit, i.e. working upside down, and shall select for use the appropriate equipment for the intended purpose. The plant, equipment, tools and accessories shall be inspected and maintained on a regular basis to ensure that they remain in good working order, function efficiently, and that safety is not compromised.

A14.2.7 EXECUTION OF THE WORKS

Sampling shall be carried out according to the plan prepared for the assessment or repair works, with due cognisance of the particular requirements for each test. The sampling plan shall specify the approximate number, location and depth of samples, including depth increments for specific tests. The Contractor shall be responsible to perform on site checking to ensure:

- a) that concrete to be sampled is representative of the elements under investigation;
- b) to confirm the location of reinforcement;
- c) to avoid damage to reinforcement during sampling; and
- d) to ensure that the load bearing capacity of the structure is maintained at all times.

The generally accepted concrete test methods and corrosion survey techniques are presented below.

A14.2.7.1 Delamination survey

Physical delamination surveys, comprising of hammer tapping (by hand for vertical, overhead and small areas) or chain drag (using a robust steel chain for large flat areas), are commonly used to quantify and locate general areas of delamination in concrete. Skilled operators are required to perform the surveys and to identify hollow sounding areas, but the methods may under-estimate the full extent of internal damage. Physical delamination surveys may be supplemented with other techniques, such as radar or ultrasonic measurements or coring and specimen extraction, on a case-by-case basis.

Hammer tapping shall be carried out by striking the concrete with a hammer with mass of at least 1,0 kg and recording the location of hollow sounding areas. For plane concrete surfaces, the concrete face shall be sounded at approximately 300 mm centres in each direction. For columns, beams or similar members with faces less than 300 mm wide, each face shall be sounded near each edge or corner at approximately 300 mm centres along the members. Where a hollow sounding area is detected, its extent shall be determined by local tapping and its periphery marked clearly on the face of the member.

A14.2.7.2 Cover over reinforcement

The cover survey shall be conducted using the manual, grid or block survey method using approved cover meter devices. The cover meter shall be sufficient to record and mark the position of reinforcement, including the cover depth and bar diameter, in the vicinity of all tests identified in the sampling plan. Should another cover survey method be proposed, for example linear or quick scan method, a calibration procedure shall be conducted strictly according to Clause A20.1.5.1h) of Chapter 20 and shall be submitted to the Engineer for approval prior to use.

A14.2.7.3 Compressive strength determined from cores

Concrete core specimens shall be drilled, prepared and tested for compressive strength in accordance with SANS 3001-CO2-3. The correction for embedded reinforcement transversely in the sample, if required, shall be permitted. The correction for excessive voids shall not be permitted.

- a) When compressive strength is evaluated relative to the specified characteristic cylinder strength, the desirable core sample length to diameter ratio shall be 2:1. The correction for length to diameter shall not be permitted.
- b) When compressive strength is evaluated relative to the specified characteristic cube strength, the desirable core sample length to diameter ratio shall be 1:1 and the correction for length to diameter ratio shall be permitted.

The average compressive strength determined from cored specimens shall be calculated from a sample comprising a minimum of three core specimens.

A14.2.7.4 Ingress of aggressive chemicals or environmental agents

a) Carbonation depth

The depth of carbonation shall be determined in accordance with EN 14630, as a general method to determine the loss of alkalinity caused by carbonation or exposure to other acidic agents. Where other acidic causes may be present, further laboratory testing shall be required to establish the mechanism of loss of alkalinity.

(i) Extraction of core sample

Core samples shall be drilled at locations, to the depths, indicated on the sampling plan. The core sample shall be dislodged from the parent concrete with due care, such that the sample length is maximised. Blunt force, such as hitting the sample with a chisel, shall not be utilised to dislodge the sample from the substrate. All core holes shall be repaired to the satisfaction of the Engineer.

(ii) Preparation of core sample for carbonation depth measurement along the outer drilled core surface

The core sample shall be cleaned with a nylon bristle scrubbing brush and clean potable water within 24 hours of extracting the core from the structure and the prepared surface shall be kept damp.

(iii) Preparation of core sample for carbonation depth measurement on the inner fractured core surface

The core sample shall be split along its drilled axis up to 7 days after extracting the core from the structure and cleaned with a nylon bristle scrubbing brush and clean potable water and the prepared surface shall be kept damp.

(iv) Reference pH indicator solution

Core surfaces prepared for testing shall be maintained in a surface damp condition prior to the application of a pH indicator solution. The pH indicator solution shall be applied within 1 hour after preparation of the core sample.

The pH indicator solution shall be stored in a sealed airtight container prior to, and after, use. Where phenolphthalein pH indicator solution is used, the colourless depth from the exposed surface to the interface at which the concrete turns fuchsia-coloured (colour variations from pink to deep red are common) shall be recorded as the carbonation depth. Where thymolphthalein pH indicator is used, the colourless depth from the exposed surface to the interface at which the concrete turns blue-coloured shall be recorded as the carbonation depth.

(v) Measurement, calculation and reporting of carbonation depth

The carbonation depth shall be measured and recorded within 30 seconds of spraying with an indicator solution. Both the arithmetic mean and maximum carbonation depth shall be measured and reported to the nearest mm.

1. Carbonation depth measurement along the outer drilled core surface.

Where core sample outer diameter exceeds 25 mm but less than 50 mm, the carbonation depth shall be measured at four discrete locations equally distributed around the perimeter of the core sample, and the arithmetic mean calculated and reported as the mean carbonation depth. Where core sample outer diameter, exceeds 50 mm, the carbonation depth shall be measured at eight discrete locations equally distributed around the perimeter of the core sample and the arithmetic mean calculated and reported as the mean carbonation depth.

2. Carbonation depth measurement on the inner fractured core surface or fragment removed from the structure.

Where a fragment or core sample outer diameter exceeds 25 mm, but less than 50 mm, the carbonation depth shall be measured at three discrete locations equally distributed along the fractured surface of one portion of the sample, and the arithmetic mean calculated and reported as the mean carbonation depth. Where a fragment or core sample outer diameter exceeds 50 mm, the carbonation depth shall be measured at four discrete locations equally distributed along the fractured surface of one portion of the sample and the arithmetic mean calculated and reported as the mean carbonation depth.

(vi) Reuse of core sample for further testing

1. After carbonation depth measurement along the outer drilled core surface.

The core may not be reused to perform any chemical, electro-chemical or corrosion-survey measurements due to probable contamination of the sample and shall be discarded. However, the core sample may be reused to determine compressive strength, if required and of suitable dimensions.

2. After carbonation depth measurement on the inner fractured core surface

The portion of core used for carbonation testing may not be reused to perform any chemical, electro-chemical or corrosion-survey measurements due to probable contamination of the sample and shall be discarded. The untested portion of core may be used for other chemical tests.

b) Chloride content

The total acid soluble chloride content of hardened concrete or mortar shall be determined in accordance with EN 14629. This method may be used on samples of powder obtained from either by drilling or from cores or fragments removed from concrete structures using nominal dry processes.

(i) Taking core samples, or fragments removed from the structure, and processing into powder

The determination of chloride profiles related to the distance from the concrete surface, core samples or fragments removed from the structure, may be cut into slices as specified in the sampling plan, using dry processes, or may be ground in increments to obtain powder samples.

The slices of concrete shall be ground to a fine powder to pass a 1,0 mm sieve, and then homogenised for the particular depth increment and sample under investigation. The ground sample shall be dried in an oven to constant weight at $105 \pm 5^\circ\text{C}$ and then allowed to cool to room temperature, for example in a desiccator.

(ii) *Collecting powder samples*

Powder samples shall be collected using a hand-held rotary drill, and the diameter of the drilling tool along with the number of drill holes shall ensure that a suitable sample size is determined. The minimum total sample size of collected powder is 20 grams to ensure that it is representative of all the concrete constituents at the sampling location. For concrete containing aggregates of a maximum size of 20 mm, a 20 mm drill should be used. Typically a drill diameter of 20 mm and two holes is normally sufficient to provide 1 gram of powder per mm depth of increment. For larger aggregate sizes a larger drill diameter and sample size should be used.

(iii) *Determining and reporting the chloride content*

The chloride content shall be determined using either Volhard's method or potentiometric titration in accordance with EN 14629. The chloride content shall be reported for each depth increment in accordance with the sampling plan.

A14.2.7.5 Corrosion risk assessment

The corrosion risk assessment techniques should be interpreted in the context of complementary data from the reinforced concrete structure, i.e. cover and ingress of aggressive chemicals or environmental agents, by specialists or skilled Engineers experienced in the field of corrosion testing and structural evaluation.

a) Half-cell potential measurements

Half-cell potentials shall be carried out in accordance with recommendations published by RILEM TC 154-EMC "Half-cell potential measurements – Potential mapping on reinforced concrete structures". The saturated copper-copper sulfate electrode (CSE) is recommended for all atmospheric measurements, and the silver chloride electrode (SSCE) for damp or wet elements. All half-cell potential measurements shall be reported as CSE-equivalence.

b) Surface resistivity measurements

The surface resistivity shall be carried out in accordance with recommendations published by RILEM TC 154-EMC "Test methods for on-site measurement of resistivity of concrete". A four-probe arrangement, with the ability to geometrically vary the spacing of the probes, is desirable. The resistivity device shall be used in locations where no or minimum reinforcement is present in the concrete and shall preferably not be used in an orientation parallel to the reinforcement, i.e. the four-probe arrangement shall be used diagonally inside the reinforcement mesh wherever possible.

c) Corrosion rate measurements

The corrosion rate measurement shall be carried out in accordance with recommendations published by RILEM TC 154-EMC "Test methods for on-site corrosion rate measurement of steel reinforcement in concrete by means of the polarization resistance method". The corrosion rate equipment shall utilise either a galvanostat or potentiostat as a means of controlling and measuring potential and current.

A14.2.7.6 Repair of sample and test locations

The concrete surfaces of sampling and test locations shall be prepared in accordance with Clause A14.4.7.1a), and then cleaned with minimum 250-bar high-pressure water jet as a final preparation. All reinforcement shall be prepared in accordance with Clause A14.4.7.1b). The concrete surface should present as dark matt, without glistening or shiny water films and should not be allowed to dry out before the application of the repair system.

a) For repairs up to 50 mm deep

The repair shall be executed in accordance with Section A14.4. Structural (Class R3 or R4) or non-structural (Class R2) repair mortar in accordance with EN 1504-3 including concrete restoration in accordance with Principle 3 – Methods 3.1 and 3.2. The concrete restoration system shall include all bonding agents, treatments and curing measures in accordance with the manufacturer's instructions.

b) For repairs greater than 50 mm deep

The repair shall be executed in two stages in accordance with Section A14.4. The first stage shall include the application of structural (Class R3 or R4) or non-structural (Class R2) repair mortar to fill the void up to 30 mm to 50 mm from the outer surface. Once the first stage repair mortar has hardened, the second stage may be completed using a structural (Class R3 or R4) or non-structural (Class R2) repair mortar in accordance with EN 1504-3 Principle 3 – Methods 3.1 and 3.2. The concrete restoration system shall include all adhesion promoting treatments, reinforcement protection treatments and curing measures in accordance with the manufacturer's instructions.

A14.2.8 WORKMANSHIP

The Contractor shall prepare an agreed reference grid of lines on the concrete surface to be tested and the Engineer will supply the design sampling plan. The location of each test, as amended by the Contractor, shall be recorded on an approved reference drawing along with the processed test result. All standard areas or areas of potential contamination or corrosion risk shall be agreed with the Engineer and marked on the structure by the Contractor.

B14.2 CORROSION SURVEY METHODS AND TESTING OF NEAR SURFACE CONCRETE PROPERTIES

PART B: LABOUR ENHANCEMENT

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- B14.2.2 DEFINITIONS**
- B14.2.3 GENERAL**
- B14.2.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS**
- B14.2.5 MATERIALS**
- B14.2.6 CONSTRUCTION EQUIPMENT**
- B14.2.7 EXECUTION OF THE WORKS**
- B14.2.8 WORKMANSHIP**

B14.2.1 SCOPE

This chapter covers the test methods and requirements to determine cover over reinforcement and to evaluate specific concrete properties. Due to the specialised nature of the activities it is not suitable for labour enhanced work.

B14.2.2 DEFINITIONS

The provisions of Part A shall apply with no additional requirements.

B14.2.3 GENERAL

The provisions of Part A shall apply with no additional requirements.

B14.2.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply with no additional requirements.

B14.2.5 MATERIALS

The provisions of Part A shall apply with no additional requirements.

B14.2.6 CONSTRUCTION EQUIPMENT

The provisions of Part A shall apply with no additional requirements.

B14.2.7 EXECUTION OF THE WORKS

The provisions of Part A shall apply with no additional requirements.

B14.2.8 WORKMANSHIP

The provisions of Part A shall apply with no additional requirements.

C14.2 CORROSION SURVEY METHODS AND TESTING OF NEAR SURFACE CONCRETE PROPERTIES

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

None

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
5. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

The following payment items shall include full compensation for all the works items associated with the provision of suitable safe access to all areas on site.

Item	Description	Unit
C14.2.1	Delamination Survey:	
C14.2.1.1	using hammer tapping technique to (description)	square metre (m ²)
C14.2.1.2	using chain drag technique to (description)	square metre (m ²)
C14.2.1.3	using extracted core samples (description of location, core size and length)	number (No.)
C14.2.1.4	using extracted core samples (description of location, core size and length)	metre (m)

The unit of measurement shall be the square meter area of delamination tests carried out in accordance with Clause A14.2.7.1 or the number or metre length of concrete core.

The tendered rate shall include full compensation for all labour, material and testing equipment, transport to a laboratory, preparation of the sample and testing, data capturing and data processing required to execute the work and the recording and presentation of results, including furnishing of record drawings, and the repair of all specimen and test locations.

Item	Description	Unit
C14.2.2	Concrete cover survey	
C14.2.2.1	(description of location on structure)	square metre (m ²)

The unit of measurement shall be the square metre of concrete surface surveyed by means of an approved covermeter using the block or grid survey method, in accordance with Clause A14.2.7.2.

The tendered rate shall include full compensation for all labour, material and testing equipment required to execute the work and the recording of results, including furnishing of record drawings, and the repair of all specimen and test locations.

Item	Description	Unit
C14.2.3	Concrete compressive strength	
C14.2.3.1	using extracted core samples (description of location, core size and length)	number (No.)
C14.2.3.2	using extracted core samples (description of location, core size and length)	metre (m)

The unit of measurement shall be the number or metre length of concrete core, transport to a laboratory, preparation of the specimen and testing, in accordance with Clause A14.2.7.3. The tendered rate shall include full compensation for all labour, material and testing equipment required to execute the work, the recording and reporting of results, including furnishing of record drawings, and the repair of all specimen and test locations.

Item	Description	Unit
C14.2.4	Carbonation depth testing	
C14.2.4.1	using extracted core samples or fragment removed for (description of location on structure)	number (No)

The unit of measurement shall be the number of carbonation tests carried out in accordance with Clause A14.2.7.4a).

The tendered rate shall include full compensation for all labour, material and testing equipment required to execute the work, the recording of results, including furnishing of record drawings, and the repair of all specimen and test locations.

Item	Description	Unit
C14.2.5	Chloride profile testing	
C14.2.5.1	using extracted core samples or fragment removed for (description of location on structure)	number (No)

The unit of measurement shall be the number of chloride tests carried out in accordance with Clause A14.2.7.4b).

The tendered rate shall include full compensation for all labour, material and equipment required to execute the work including all testing and reporting by an approved laboratory, including furnishing of record drawings, and the repair of all specimen and test locations.

Item	Description	Unit
C14.2.6	Half-cell potential measurements	
C14.2.6.1	(description of location on structure)	square metre (m ²)

The unit of measurement shall be the square metre of concrete surface where half-cell potentials are determined in accordance with Clause A14.2.7.5a).

The tendered rate shall include full compensation for all labour, material and equipment required to execute the work including all connections to the reinforcement, testing and reporting by an approved specialist or laboratory, including furnishing of record drawings, and the repair of all specimen, reinforcement connections and test locations.

Item	Description	Unit
C14.2.7	Surface resistivity measurements	
C14.2.7.1	(description of location on structure)	square metre (m ²)

The unit of measurement shall be the square metre of concrete surface where surface resistivity is determined in accordance with Clause A14.2.7.5b).

The tendered rate shall include full compensation for all labour, material and equipment required to execute the work including all testing and reporting by an approved specialist or laboratory, including furnishing of record drawings.

Item	Description	Unit
C14.2.8	Corrosion rate measurements	
C14.2.8.1	(description of location on structure)	square metre (m ²)

The unit of measurement shall be the square metre of concrete surface where corrosion rates are determined in accordance with Clause A14.2.7.5c).

The tendered rate shall include full compensation for all labour, material and equipment required to execute the work including all connections to the reinforcement, testing and reporting by an approved specialist or laboratory, including furnishing of record drawings, and the repair of all specimen, reinforcement connections and test locations.

D14.2 CORROSION SURVEY METHODS AND TESTING OF NEAR SURFACE CONCRETE PROPERTIES

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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No specific items in this Section.

Where applicable, details must be provided in the Contract Documentation.

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A14.3 DEMOLITION AND REMOVAL OF STRUCTURAL CONCRETE AND STEELWORK

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PART A: SPECIFICATIONS

A14.3.1 SCOPE

This Section covers the work in connection with the demolition of entire members of a concrete structure as well as cutting back concrete to expose reinforcement and the initial preparation of the exposed surface. Surface and structural repair of concrete members is covered in Section A14.4. This Section also covers the demolition and removal of steel structures and members.

A14.3.2 DEFINITIONS

Concrete and steel members or elements:

- a) All references to concrete members shall include mass concrete, un-reinforced, reinforced and prestressed concrete members.
- b) References to steel members shall include all structural steel members in structures.

Demolition of concrete and steel members or elements:

Demolition means the breaking up and removal of an entire concrete member or portion of a member or demolition and removal of an entire structural steel member or element.

Removal of concrete and steel members or elements:

- a) Removal of concrete means cutting back into the surface or end of a concrete element and the removal of unsound, damaged or contaminated concrete, or the partial removal of concrete sections, to expose a sound surface for bonding new material for the repair or extension of the concrete element.
- b) Removal of steel members or elements means the cutting out of a steel member or element out of a steel structure.

A14.3.3 GENERAL

A14.3.3.1 Concrete members and elements

The work in this chapter includes the demolition of concrete members or elements either completely or partially. Complete demolition is usually carried out for the replacement of a member or element of a structure in its entirety and partial demolition of member or element is carried out for alterations or extensions to a structure.

Removal of small areas of concrete in partial demolitions is carried out for repairs of concrete members or elements.

A14.3.3.2 Structural steel

The demolition of structural steel members or elements can also be full demolition of a structure, member or element and is also carried out for alterations, extensions or repairs on structural steel structures.

A14.3.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Where concrete members or elements are demolished or where concrete is removed from concrete sections, or where steel members or elements are removed, the Contractor shall submit complete method statements for the method of execution of the works. These method statements shall be submitted for approval by the Engineer at least 14 days prior to works being carried out.

A14.3.5 MATERIALS

All materials used in the demolition and removal of concrete elements, shall be handled, stored and used strictly in accordance with the manufacturer's instructions and the current Occupation Health and Safety Act and its regulations.

A14.3.6 CONSTRUCTION EQUIPMENT

A14.3.6.1 General

All plant, equipment and tools used for the demolition of concrete elements or the removal of portions of existing concrete or the removal of steel members or elements shall be based on proven and accepted technology within the industry. The plant, equipment, tools and accessories shall be inspected and maintained on a regular basis to ensure that they remain in good working order, function efficiently, and that safety is not compromised. All cutting and breaking tools shall be kept sharp to reduce the force required to break out concrete to a minimum.

The plant, equipment and tools used for the demolition or removal process shall be of the accepted type and capacity for the relevant application. The suitability of the chosen method shall be demonstrated on a representative test section identified by the Engineer prior to the execution of any programmed work.

A14.3.6.2 Access structures and working platforms

Where necessary, the Contractor shall provide suitable and safe temporary access structures, working platforms, debris collection and removal chutes and bins, including protection screens where required, at each location where concrete has to be demolished or removed.

The temporary structures, platforms, chutes, etc. must be stable and of sufficient strength and rigidity to safely carry the imposed temporary loads arising from the work activity, all as described in Section A14.1.

A14.3.7 EXECUTION OF THE WORKS

A14.3.7.1 Sequence of execution

The method and sequence of demolition or removal of concrete and structural steel shall be in accordance with the drawings or the approved method statement submitted by the Contractor to the Engineer for approval.

Any temporary propping specified in the approved method statement and the drawings shall be securely positioned in accordance with each stage of the demolition or removal sequence prior to commencement of the following stage.

Areas to be demolished shall be indicated by the Engineer or shown on the drawings.

A14.3.7.2 Site preparation and access

The necessary access and temporary support structures shall be in place prior to the commencement of demolition or removal of concrete or structural steel. Screening and protective measures shall be established around the work area as necessary to ensure acceptable Environmental, Occupation, Health and Safety conditions.

A14.3.7.3 Demolition of entire structural members

a) Concrete members

The demolition of entire concrete structures or major members of a structure shall employ techniques that do not damage the existing structure, adjacent structures or structural members or elements the roadway below, nor contaminate the surrounding environment. The Contractor shall ensure that any nuisance associated with his work activity is minimised by implementing appropriate precautions and measures to the approval of the Engineer. Common nuisances associated with demolition and concrete removal include fumes, noise, dust, flying fragments, heat and vibration.

Concrete members which are to be demolished completely shall be broken into suitably sized fragments to allow easy removal from site to an approved disposal site.

Recommended demolition techniques include the use of concrete cutting equipment, percussion breakers, chisels or other approved mechanical equipment, the use of thermal or hydraulic cutting techniques or by non-explosive chemical means, to ensure minimal damage (e.g. micro-cracking) to the existing concrete. Demolition by explosive means shall normally not be acceptable and shall only be permitted subject to the Engineer's written approval. Water jet removal of concrete is preferred wherever this method is feasible.

b) Steel structures or members

The removal of entire structural steel structures or members shall be carried out using techniques which do not damage adjacent structures or members. The Structural members to be demolished or removed completely shall be cut up into suitably sized sections and removed to suitable scrap metal yards for re-cycling.

A14.3.7.4 Removal of concrete from structural elements

a) Cutting back concrete to a new finished surface

The concrete and reinforcement shall be cut back adequately to provide the prescribed concrete cover to the new finished surface as indicated on the drawings or as directed by the Engineer. The technique used shall be suited to its intended purpose and shall not cause damage to the remaining concrete member.

Only techniques that do not damage the inherent structure, bond or strength of the remaining sound concrete shall be used. Heavy duty demolition equipment or thermal cutting techniques shall not be used closer than 100 mm from the final surface of the cut back as indicated on the drawings. The remaining concrete shall be removed using approved mechanical equipment or preferably hydro demolition.

The fixed exposed contact surface shall be bounded by straight line edges cut at least 10 mm deep by a diamond cutting saw, angle grinder or other approved equipment.

b) Cutting back concrete to expose reinforcement

Where a concrete member has to be joined or extended or replaced by new concrete, the concrete shall be carefully cut or broken from the reinforcement bars to expose the bars to the dimensions and outline as shown on the drawings or as directed by the Engineer. Care shall be taken not to damage or reduce the strength of the exposed bars or concrete member thereby making them unfit for use. The remaining concrete contact surface shall be cut to a plane and even surface with exposed faces perpendicular to the horizontal face or side faces as applicable.

The bounding lines of the cut concrete shall be straight and neatly cut to at least a depth of 10 mm using a diamond cutting saw, angle grinder or other approved concrete cutting equipment.

A14.3.7.5 Removal of structural steel elements from existing structures

Where structural steel elements or members are removed from structures special cutting techniques shall be used to ensure the integrity of the remaining steel structure. Temporary bracing and or members shall be welded or bolted into place as indicated on the drawings before such a structural member or element is removed from the structure.

No work shall be carried out unless a complete method statement is submitted to the Engineer for approval and which shall include all Occupational Health and Safety requirements and a Risk Assessment.

A14.3.7.6 Removal of metal sections embedded in concrete

Metal sections including steel reinforcement that are embedded in concrete members by means of grout pockets shall be removed by carefully chipping out the embedment grout filling the pocket. Care shall be taken not to damage the structural concrete surrounding the pocket. Suitable tools such as hand-held power tools with chisel bits or hand tools shall be used to carry out this work.

Following the removal of the metal section or steel reinforcement, all remaining grout shall be removed and the pocket cleaned out to expose only solid concrete surfaces. The pocket shall be finally cleaned using high-pressure water jetting or oil-free compressed air to remove all loose fragments of grout, or concrete aggregate before further work is carried out.

A14.3.7.7 Preparation of exposed contact surfaces (for extension of existing concrete elements or construction of new concrete members)

All loose and shattered concrete, as well as foreign material such as oil, paint, grease, etc. shall be removed from the contact surface of old concrete before new concrete is placed. The aggregate must be exposed to provide a good bonding surface.

The mechanically prepared concrete surface shall be cleaned by means of grit blasting or water jetting.

The breaking out and preparation of damaged, spalled and/or cracked concrete surfaces is described and measured under Sections A14.3 and A14.4.

A14.3.7.8 Disposal of waste material

All waste materials, rubble, scrap and rubbish arising from the Contractor's presence on site and/or the execution of the works shall be disposed of weekly to a disposal site or scrap metal yard identified by the Contractor and approved by the Engineer in accordance with the EMP requirements.

A14.3.8 WORKMANSHIP

A14.3.8.1 Tolerances

The Contractor shall remove concrete to a planar, uniform surface with 25 mm maximum deviation from the level or dimension indicated on the drawings unless otherwise approved by the Engineer. The outer edge of the contact surface shall consist of straight lines with maximum deviation of 5,0 mm from straight, measured with a 1,0 m long straight edge, and shall be within 5,0 mm of the position indicated on the drawings, or as instructed by the Engineer. Steel members to be removed shall be cut out and replaced to a tolerance of 2,0 mm and then be welded or bolted into position.

A14.3.8.2 Trials

The Contractor shall carry out pre-construction trials with the proposed equipment to determine the suitability of the technique for the envisaged application. The results shall be reported to the Engineer and shall be subject to the Engineer's approval before the inclusion of such equipment into the method statement for the execution of the works.

B14.3 DEMOLITION AND REMOVAL OF STRUCTURAL CONCRETE AND STEELWORK

PART B: LABOUR ENHANCEMENT

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- B14.3.1 SCOPE**
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- B14.3.6 CONSTRUCTION EQUIPMENT**
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- B14.3.8 WORKMANSHIP**

B14.3.1 SCOPE

This Section covers the work in connection with the demolition of entire members of a concrete structure as well as cutting back concrete to expose reinforcement and the initial preparation of the exposed surface. Surface and structural repair of concrete members is covered in Section A14.4. This Section also covers the demolition and removal of steel structures and members. It is suitable for labour enhanced work. This part covers additional specifications to optimise the labour component of construction activities.

The removal of concrete for labour enhanced activities is limited to a surface area of 2,0 m².

B14.3.2 DEFINITIONS

The provisions of Part A, shall apply.

B14.3.3 GENERAL

The provisions of Part A, shall apply, in addition to the following:

All concrete shall conform to the requirements of Section A13.4 Concrete for Structures.

The demolition of discrete structural elements shall employ techniques that do not damage adjacent structures or structural components, nor contaminate the surrounding environment.

The Contractor shall ensure that any nuisance associated with his work activity is minimized by implementing appropriate precautions and measures. Common nuisances associated with demolition and concrete removal include fumes, noise, dust, flying fragments, heat and vibration.

Water jet removal of concrete is preferred wherever possible. Demolition using explosives is not permitted.

B14.3.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Add to the provisions of Clause A14.3.4 the following:

For labour optimised construction, a separate method statement shall be prepared for every structure that is to be taken down or removed. These method statements shall be drawn up by competent Contractor's Representative with relevant experience and shall be submitted to the Engineer for approval. The method statements shall be accompanied by drawings and calculations as needed for clarity.

B14.3.5 MATERIALS

The provisions of Part A, shall apply.

B14.3.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.3.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply.

B14.3.8 WORKMANSHIP

The provisions of Part A, shall apply.

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C14.3 DEMOLITION AND REMOVAL OF STRUCTURAL CONCRETE AND STEELWORK

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the Contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

None

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

The following pay items shall include full compensation for all work associated with the demolition and removal of concrete structural elements including initial preparation of concrete surfaces or portions thereof. General access, work platforms and associated temporary works are covered in Section A14.1.

The quantities indicated in the pricing schedule are based on the dimensions shown on the drawings and on inspections carried out and increased to allow for the quantity of work. It must, however, be accepted that the quantities of work actually done may vary significantly from the scheduled quantities, and that the Contractor shall be deemed to have allowed in his tendered rates for such variations in quantities which can be reasonably expected.

Item	Description	Unit
C14.3.1	Demolition of concrete members or elements	
C14.3.1.1	Full member or element (location and description)	cubic metre (m ³)
C14.3.1.2	Partial member or element (location and description)	cubic metre (m ³)
Item	Description	Unit
C14.3.2	Demolition of concrete members or elements by labour enhanced construction	
C14.3.2.1	Full member or element (location and description)	cubic metre (m ³)
C14.3.2.1	Partial member or element (location and description)	cubic metre (m ³)

The unit of measurement for items C14.3.1 and C14.3.2 is the cubic metre of concrete demolished, measured in its original position and shape based on either full or partial demolition.

The tendered rate shall include full compensation for all labour, material, screening of the structure for safety and environmental protective measures, equipment and plant as well as for all work and incidentals required to complete the work as specified and required to demolish the concrete member and to load, transport and dispose the concrete segments and rubble at the nearest approved disposal site including overhaul and any fees applicable at the site. Refer to Clause A14.3.7.3.

Item	Description	Unit
C14.3.3	Demolition of structural steel structures, members or elements (location and description)	
C14.3.3.1	Full member or element (location and description)	ton
C14.3.3.2	Partial member or element (location and description)	ton

Item	Description	Unit
C14.3.4	Demolition of structural steel structures, members or elements by labour optimised construction (location and description)	
C14.3.4.1	Full member or element (location and description)	ton
C14.3.4.2	Partial member or element (location and description)	ton

The unit of measurement for items C14.3.3 and C14.3.4 is the ton of structural steel removed measured in its original position based on either full or partial demolition of a structure, structural member or element.

The tender rate shall include full compensation for all labour, material, screening of the structure and protective measures, equipment and plant as well as for all work and incidentals required to remove the structural steel structure, member or element and to load, transport and dispose the steel elements and rubble to the nearest approved disposal site or scrap metal yard including overhaul and any fees applicable at the site.

Item	Description	Unit
C14.3.5	Removal of metal sections embedded in concrete (description)	number (No)

The unit of measurement shall be the number of metal sections removed.

The tendered rate shall include full compensation for all labour, materials, equipment, screening of the structure and protective measures, required for the removal of the metal sections as described in Clause A14.3.7.6 and disposal of all rubble at an approved waste disposal site including overhaul and any fees applicable at the site, and the cleaning of the pocket as specified in Clause A14.3.7.6.

Item	Description	Unit
C14.3.6	Establishment on site for hydro-demolition equipment	lump sum

The tendered lump sum shall include full compensation for establishment on the site and the subsequent removal of all special equipment and plant for the high pressure water demolition of defective concrete, the cost of which does not vary with the actual amount of work to be done.

This work will be paid for by way of a lump sum, 75 % of which will become payable when all the equipment is on the site. The remaining 25 % will become payable after all the water demolition of concrete has been completed and the equipment has been removed from the site.

D14.3 DEMOLITION AND REMOVAL OF STRUCTURAL CONCRETE AND STEELWORK

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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- D14.3.5 VISUALLY ASSESSED PROPERTIES**
- D14.3.6 INSTRUMENTALLY ASSESSED PROPERTIES**
- D14.3.7 EVALUATION FOR ACCEPTANCE**
- D14.3.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE**
- D14.3.9 NOTIFICATION OF REMEDIAL WORK**
- D14.3.10 REMEDIAL WORK**

No specific items in this Section.

Where applicable, details must be provided in the Contract Documentation.

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A14.4 SURFACE AND STRUCTURAL REPAIR OF CONCRETE MEMBERS

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PART A: SPECIFICATIONS

A14.4.1 SCOPE

A14.4.2 DEFINITIONS

A14.4.3 GENERAL

A14.4.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.4.5 MATERIALS

A14.4.6 CONSTRUCTION EQUIPMENT

A14.4.7 EXECUTION OF THE WORKS

A14.4.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.4.1 SCOPE

This Section covers the requirements for the surface and structural repair of structural concrete members. It covers the preparation of the exposed concrete surface and reinforcement for the rehabilitation of the member, and the repair or replacement of concrete with cementitious mortars, epoxy systems and proprietary concrete repair compounds.

The method for removal of defective or contaminated concrete, partial removal of concrete sections and the initial preparation of contact surfaces are covered in Section A14.3.

A14.4.2 DEFINITIONS

Bonding agent - the component of a repair system used to promote adhesion of a repair mortar or concrete to a concrete substrate for the purpose of achieving a permanent bond, which is not affected by moisture and strong alkalis in service.

Cementitious repair products and systems - hydraulic or polymer mortars, concretes and grouts.

High flow mortar or concrete - a repair product formulated to exhibit extremely high flow characteristics, outside the limits of normal methods of test, and which flows through narrow gaps and around areas of congested reinforcement, without bleeding or segregation.

Smoothering coat - a fine mortar coating applied to a surface to fill voids, cracks, and cavities or to level an uneven surface. The purpose is to prepare the surface for the application of protection systems (refer Section A14.7).

A14.4.3 GENERAL

This Section includes all the work and materials required to carry out the surface and structural repair of concrete members. The proprietary repair materials which are specified are based on the EN 1504-3 specification which shall be used in conjunction with this specification.

A14.4.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Where the repair system comprises, in part, of a cementitious mortar or concrete, the material design and preconstruction laboratory results shall be recorded and submitted to the Engineer for approval prior to the commencement of the repair activities. The surface and structural repair activities shall only commence after the approval of the material design. The Contractor shall allow sufficient time in his programme for the material design, EN 1504 compliance verification and approval of the repair system.

A14.4.5 MATERIALS

A14.4.5.1 General

Both cementitious-based and epoxy-based repair systems are described in this specification. In particular, cementitious repair systems may comprise either of a proprietary system conforming to the specification or a site-based formulation and performance tested with the relevant requirements of this Section.

A14.4.5.2 Cementitious mortar or concrete

The cementitious repair mortar shall comply with the strength requirements of the concrete in the structural member to be repaired. The water/cement (w/c) ratio shall not exceed 0,5 and guidelines for the composition of mortars and concretes consisting of different aggregate sizes shall be in accordance with the requirement of Section A14.4.

The Contractor shall be responsible for the final design of the repair mix and shall submit a test report by an approved testing laboratory to the Engineer for approval prior to its use in the permanent works. All the test results shall be incorporated in the standard concrete mix design approval form.

Materials used in the cementitious mortar or concrete shall comply with the following requirements:

a) Cement

Cement shall comply with SANS 50197-1 (EN 197-1) with a strength class of 32,5 or greater, and a rate of strength gain N or greater. Cement shall hold valid certification in the form of a Letter of Authority issued as certified approval pursuant to the Compulsory Specification for cement published by Government Notice R.544. Masonry cement shall not be used.

b) Aggregates

Aggregates shall comply with the requirements of SANS 1083, subject to all amendments and additional project requirements described in Clause A13.4.5.2 of Chapter 13 aggregates.

c) Admixtures

Admixtures shall comply with the requirements of SANS 50934 and shall be of an approved brand and type.

d) Performance requirements for cementitious mortar or concrete

Unless otherwise specified, the cementitious mortar or concrete shall conform to the performance requirements stipulated in Table A14.4.5-1 for class R3 for structural repairs or class R2 for non-structural repairs.

A14.4.5.3 Water

The Contractor shall prove by way of laboratory test that all water used for mixing and curing repair materials complies with SANS 51008.

A14.4.5.4 Epoxy systems

Epoxy systems shall consist of a solvent-free, two-part adhesive consisting of a resin and hardener curing at ambient temperatures. The hardener shall be amine based with a high resistance to moisture. The epoxy shall be supplied and used in accordance with the manufacturer's instructions and recommendations regarding the intended use thereof. Aggregate for epoxy mortars shall be kiln-dry when mixed with the epoxy system. The proprietary epoxy system used shall be approved by the Engineer and shall have a minimum compressive strength after 7 days of 50 Mpa.

The suitability of the epoxy mortar for a particular application shall be proved by testing or submission of an approved industry track record of usage under similar circumstances.

The epoxy mortar shall have a compressive strength equal to or greater than the adjacent concrete and it shall exhibit similar temperature expansion characteristics. The elastic modulus, Ee, shall not exceed that of the parent concrete. Aggregate (fine and coarse) shall be clean and dry and the size shall not exceed one third of the minimum patch thickness.

The Contractor shall be responsible for the final mix design and shall submit details to the Engineer for approval prior to its use in the permanent works.

A14.4.5.5 Proprietary cementitious repair systems

The suitability of the repair compound for a particular application shall be proved by testing or submission of an approved industry track record of usage under similar circumstances.

The Contractor shall submit details of the proprietary cementitious compounds to the Engineer for approval prior to its use in the permanent works.

The repair systems shall consist of the following to be approved by the Engineer:

a) Primer for Steel Surfaces

The primer shall consist of a single component zinc rich primer as per Clause A14.4.5.7 or cementitious epoxy resin compensated three component coating material with active corrosion inhibitor

b) Adhesion promoter for concrete surfaces

The products and measures deemed suitable for use as adhesion promoters in accordance with the proprietary repair compound and site conditions shall conform to the requirements stipulated in Clause A14.4.5.6.

c) Concrete Repair products

For structural repairs, only Class R3 and R4 repair products conforming to EN 1504 as specified shall be used. For non-structural repairs, Class R1, R2, or R3 repair products conforming to EN 1504 as specified shall be used.

Typical generic descriptions of suitable repair products may include:

- (i) High strength, expansive cementitious grout
- (ii) Free flowing structural repair concrete
- (iii) Fibre reinforced, polymer modified repair mortar
- (iv) High build, polymer modified repair mortar

- (v) Polymer modified pore sealer
- (vi) Very rapid setting repair mortar
- (vii) Non-sag patching and repair mortar

d) Curing of repaired surface

The repaired surface shall be cured using a liquid membrane – forming compound as per Clause A13.4.5.9 of Chapter 13, covering with clear polythene sheeting or water-absorbent material.

The type and application of the curing compound shall be to the Engineer’s approval.

Proprietary cementitious repair systems shall include all components and materials necessary to complete both non-structural and structural repair of concrete structures. The proprietary repair systems shall comply with EN 1504-3. The repair system shall be suitable for the following protective and remedial principles in accordance with EN 1504-9 as set out in Table A14.4.5-1.

- (i) Applying mortar by hand (Principle 3 – Method 3.1)
- (ii) Recasting concrete (Principle 3 – Method 3.2)
- (iii) Adding Mortar or concrete (Principle 4 – Method 4.4)
- (iv) Increasing cover to reinforcement with mortar or concrete (Principle 7 - Method 7.1)
- (v) Replacing contaminated concrete (Principle 7 – Method 7.2)

The materials for proprietary cementitious repair products shall be supplied as a factory pre-packed dry premix of cements, aggregate and other proprietary products requiring only the addition of pre-packed liquid or a prescribed volume of water of an approved quality to produce the satisfactory repair product. The proprietary repair products shall compensate for shrinkage in both the plastic and hardened states and shall be suitable for use in the proposed mix and placing techniques. These products are suitable for both structural and non-structural applications.

Proprietary concrete shall be highly workable and self-compacting without the use of vibrators. The aggregate grading shall be designed to prevent segregation during transportation and placing. The concrete system shall have a low alkali content to ensure minimal risk of alkali-silica reaction and shall contain no chlorides. The proprietary concrete shall comply with the material properties as indicated on the detail drawings, alternatively the performance requirements defined in Table A14.4.5-1 shall apply:

Table A14.4.5-1: Performance requirements for structural and non-structural repair products (Extract from Table 3, EN 1504-3)

Item No.	Performance Requirements	Reference substrate (EN 1766)	Test Method	Requirement			
				Structural		Non-structural	
				Class R4	Class R3	Class R2	Class R1
1	Compressive strength	None	EN 12190	≥ 45 MPa	≥ 25 MPa	≥ 15 MPa	≥ 10 MPa
2	Chloride ion content	None	EN 1015-17	≤0,05%			
3	Adhesive bond	MC(0,40)	EN 1542	≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,80 MPa	
4	Restrained shrinkage / expansion	MC(0,40)	EN 12617-4	Bond strength after test			No requirement
				≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,80 MPa	
5	Carbonation resistance	None	EN 13295	Dk ≤ control concrete (MC(0,45))			No requirement
6	Elastic Modulus	None	EN 13412	≥ 20 GPa	≥ 15 GPa	No requirement	
7	Thermal compatibility Part 1: Freeze-thaw	MC(0,40)	EN 13687-1	Bond strength after 50 cycles			Visual inspection after 50 cycles
				≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa	
8	Thermal compatibility Part 2: Thunder shower	MC(0,40)	EN 13687-2	Bond strength after 30 cycles			Visual inspection after 30 cycles
				≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa	
9	Thermal compatibility Part 4: Dry cycling	MC(0,40)	EN 13687-4	Bond strength after 30 cycles			Bond strength after 30 cycles
				≥ 2,0 MPa	≥ 2,0 MPa	≥ 2,0 MPa	
10	Skid resistance	None	EN 13036-4	Class I: >40 units wet tested Class II: >40 units dry tested Class III: >55 units wet tested		Class I: >40 units wet tested Class II: >40 units dry tested Class III: >55 units wet tested	
11	Coefficient of thermal expansion	None	EN 1770	Not required if tests 7, 8, or9 are carried out, otherwise 9,0E-6 mm/mm/°C.		Not required if tests 7, 8, or 9 are carried out, otherwise 9,0E-6 mm/mm/°C.	
12	Capillary absorption	None	EN 13057	≤ 0,5 kg.m ⁻² .h ^{-0.5}		≤ 0,5 kg.m ⁻² .h ^{-0.5}	No requirement

In addition to the general occupation health and safety requirements of the works all the necessary health, safety and fire precautions stated by the manufacturer shall be complied with.

Only material of which the shelf life has not expired shall be used.

A14.4.5.6 Adhesion promoting techniques

Adhesion of the repair material to the substrate is a priority requirement for all repair systems. Adhesion can be assisted by the use of bonding agents, prewetting the substrate, or sealing of the substrate, as appropriate to the particular requirements of the repair system.

Bonding agents shall be supplied, pre-packaged and ready for on-site mixing and application. Typical cementitious materials may include either a one component cementitious, polymer modified primer; or a cementitious, epoxy resin compensated three component coating material. The Contractor shall note the limitations given by the manufacturer to pot life, workable life and open time related to the materials used.

Where appropriate to the cementitious repair system, the concrete shall be well pre-wetted but free from water on the surface at the time of application. The surface should achieve a dark matt appearance without glistening and surface pores and pits should not contain water.

Some repair systems recommend the use of a substrate sealing compounds, this technique shall comply with the adhesion requirements of EN 1504. Typical materials include single-component emulsion based on modified acrylic type resins, but the use of wet-to-dry type epoxy materials shall not be permitted.

A14.4.5.7 Anti-corrosion primer for reinforcement

The anti-corrosion primer shall be a single component zinc rich primer with a minimum volume solids of 30 % complying to a 700 hour salt spray resistance to exposure as per ASTM B-117 or a cementitious, epoxy resin compensated three component coating material with an active corrosion inhibitor meeting the requirement of EN 1504-7.

The primer shall be supplied and used in accordance with the manufacturer's instructions and recommendations regarding the intended application. All necessary health, safety and fire precautions stated by the manufacturer shall be complied with.

A14.4.6 CONSTRUCTION EQUIPMENT

All plant and equipment used for the preparation of concrete surfaces, batching of material and mixing operations shall be in good working order and suited for the intended use. The plant shall be inspected, serviced and calibrated at regular intervals and tested to ensure proper functioning, all to the satisfaction of the Engineer.

A14.4.7 EXECUTION OF THE WORKS

A14.4.7.1 Preparation of repair surfaces

a) Preparation of concrete contact surface

All surface laitance and damaged, loose and soft concrete, concrete containing aggressive ions e.g. chloride, as well as all foreign materials such as oil, paint, grease, etc. shall be removed from the contact surface using pneumatic chisels or other approved mechanical equipment or thermal/hydraulic techniques. The contact surface shall be treated to expose the aggregate by means of grit blasting or high-pressure water-jetting or where it can be shown to produce the required aggregate exposure, a hard brush may be used subject to the Engineer's approval.

The mechanically prepared concrete surface shall be cleaned of dust by means of oil-free compressed air or water-jetting.

The area to be repaired shall be bounded by straight line edges cut to the required depth using a diamond cutting saw, angle grinder or other approved equipment. The edges shall be recessed such that the patch has a thickness at the edge of at least twice the maximum aggregate size of the patching material, but in no case less than 10 mm.

b) Preparation and protection of embedded reinforcement

All visible or embedded reinforcement bars showing signs of corrosion shall be exposed by cutting back the concrete around the bar with pneumatic chisels or other approved method. The corrosion shall be removed by grit blasting, or where this is not warranted, by wire-brushing with power tools to an acceptable surface. The treated steel surface shall be clean of all corrosion and foreign material likely to impair the bond of the anti-corrosion primer to the reinforcement. No chemical solvents shall be used without the approval of the Engineer.

Reinforcement that has experienced significant pitting or reduction in diameter shall be referred to the Engineer for acceptance. All rejected reinforcement shall be cut out and replaced with new bars of the same type and size, allowing for a minimum overlap of 45 diameters with the in situ bars.

All exposed and cleaned reinforcement shall receive one coat of a single-component anti-corrosion primer based on zinc and epoxy resins, which shall be evenly applied to achieve a minimum 40 µm dry film thickness. The primer shall contain at least 30 % zinc solids by volume. The primed surface shall not be exposed to the atmosphere longer than specified by the manufacturer primer before the application of the repair mortar, but at least until the coating is fully dry.

Alternative proprietary anti-corrosion coatings shall be subject to the approval of the Engineer, based on submitted test documentation and proven performance within the industry.

In cases where the final concrete cover is deemed by the Engineer to be inadequate the following protection shall be applied at the Engineer's instruction:

- Cover 0 – 5,0 mm

The reinforcement shall receive two coats of anti-corrosion zinc-based epoxy primer as described previously. In order to improve the bond to the covering epoxy mortar, kiln-dry quartzitic sand shall be applied onto the final wet coat.

- Cover >5,0 mm

The outer surface mortar patch shall receive a surface coating based on an approved hydrophobic impregnants, sealers and pore blockers, or coatings complying with Clause A14.7.5. Where an epoxy mortar is used as repair material, the reinforcement shall be coated as for the 0 – 5,0 mm case.

A14.4.7.2 Bonding layer

a) Cementitious mortar or concrete repair

Concrete surfaces that exhibit a high moisture absorption shall be wetted prior to patching, the mortar being applied only when the surface has dried sufficiently to have a matt moist appearance, preferably saturated surface dry.

Generally, the cement paste shall consist of one part cement (same type as for patching mortar) and one part sand (<2,0 mm) mixed with water to a thick, but fluid consistency.

The use of polymer dispersive additives to improve workability and bond characteristics shall be subject to the approval of the Engineer.

Alternatively, an approved adhesive or bonding agent may be applied to the prepared surface so as to enhance the bond of the fresh mortar to the dry concrete in accordance with the manufacturer's instructions. Only compatible materials shall be used.

b) Epoxy mortar repair

The repair surfaces shall be covered with a thin compatible bonding layer of epoxy resin. Should the time interval between resin and mortar application exceed 24 hours, the wet bonding layer shall be sprayed with a kiln-dry quartzitic sand to achieve a sandpaper-like covering. All loose sand shall be brushed off before applying the epoxy mortar to the bonding layer.

c) Proprietary cementitious repair compounds

The contact surfaces shall be prepared and treated with a compatible bonding layer in accordance with the manufacturer's specification.

A14.4.7.3 Batching and mixing

a) Cementitious mortar or concrete

The constituent parts of the mortar or concrete, i.e. the cement, aggregate and water, shall be weigh-batched.

Mixing of mortar shall be done with plant or equipment suited to the amount of mortar to be mixed.

The batched materials shall be mixed continuously for at least five minutes in a mechanical drum or table type mixer, or, for small amounts, with an electric drill with a mixing paddle.

b) Epoxy mortar

The epoxy base and activator shall be mixed strictly in accordance with the manufacturer's instructions.

The epoxy and aggregate shall be weigh-batched. The base and activator shall first be mixed thoroughly for at least 3 minutes and until a consistent uniform colour is maintained, whereafter the aggregate shall be added and mixed to a uniform consistency. The manufacturer's instructions shall be strictly adhered to.

c) Proprietary cementitious repair compounds

The repair compound shall be mixed strictly in accordance with the manufacturer's specifications. Unless otherwise specified the product shall be thoroughly mixed in a forced-action mixer of adequate capacity. Alternatively, a suitably sized drum may be used with a slow speed (400/500 rpm) high-torque rotary drill fitted with an approved mixing paddle. The contents shall be properly mixed to ensure a smooth, uniform mix.

The mixing capacity and placing capacity of equipment and labour shall be adequate and matched to enable placing operations to be carried out continuously within the recommended placement time of the product, or within 20 minutes of mixing ensuring a smooth, uniform mix.

Tools and equipment shall be cleaned after each batch and all previously mixed material shall be removed from tools and equipment prior to charging and mixing a new batch of repair compound.

A14.4.7.4 Formwork for structural concrete repair

All formwork shall conform to the Specifications contained in Section A13.2 of Chapter 13 and shall be used when the area to be patched will not allow for a trowelled finish.

Formwork shall be fixed in place as soon as possible after the substrate has been prepared as specified. Openings in the formwork shall be protected to prevent entry of debris or contaminants.

When casting high flow concrete or mortar, the formwork shall be water-tight and shall be free from obstructions to the free flow of cementitious repair product. Where required, a suitable provision for the drainage of pre-soaking water or access for the application of a surface bonding layer immediately prior to placing the repair concrete shall be provided.

All formwork surfaces which will be in contact with proprietary concrete repair compounds shall be treated with a suitable mould release agent. The formwork surfaces shall match the existing surface textures.

A14.4.7.5 Application of the repair material

a) Cementitious mortar

After the defective concrete surface and the embedded reinforcement have been prepared, the bonding layer shall be worked onto the concrete contact surface followed directly by the freshly mixed repair mortar. The mortar application shall follow the technique of plastering.

The mortar surface shall be trowelled when the mortar exhibits initial set to obtain a uniform plain surface true to line, matching the boundaries of the repair area, and shall then be finished to match the adjacent existing surface finish.

Local areas, where deep recesses have been cut out, or where concrete has been removed around reinforcement bars, shall be built up in layers as required.

b) Concrete

After the defective concrete surface or member has been prepared, an approved bonding layer shall be worked onto the concrete contact surface followed directly by the freshly mixed concrete. The concrete shall be properly compacted and where possible, vibrators shall be used.

c) Epoxy mortar

The epoxy mortar shall be applied in accordance with the manufacturer's recommendations and specifications.

Each layer of epoxy mortar shall be trowelled onto the prepared and primed surface in one work session. The rate at which the epoxy mortar can be applied shall determine the batch quantity such that the pot life of the epoxy is not exceeded. Unused mortar for which the pot life has been exceeded shall be discarded.

d) Proprietary cementitious repair compound

The proprietary compound shall be applied in accordance with the manufacturer's recommendations and specifications.

The minimum and maximum layer thickness shall be as specified by the manufacturer, depending on the orientation of the application.

Each layer of repair compound shall be thoroughly worked and compacted into the repair zone ensuring that full contact with the primed contact surface is achieved and no air entrapment occurs. All sagging or slumping material shall be removed and the contact surface cleaned prior to re-application using a reduced layer thickness.

A14.4.7.6 Protection and curing

a) Cementitious mortar or concrete

The finished mortar surface shall be protected from drying out due to wind, direct sunlight or frost. The Contractor shall arrange such protection to the Engineer's approval who will assess each case on its merits.

The surfaces shall be cured over a period of at least 7 days by spraying a uniform, full coat of an approved resin-based curing membrane not later than 2 hours after placement of the mortar, but within 20 minutes after stripping the formwork, or by any other approved procedure.

b) Epoxy mortar

The mortar shall be protected from rain and frost for at least 24 hours and shall be cured in accordance with the epoxy supplier's recommendations, or as directed by the Engineer.

c) Proprietary cementitious repair compounds

Immediately after the proprietary compound has been applied or after formwork has been removed cure the compound as per the manufacturer's detailed instructions.

A14.4.7.7 Reinstatement of concrete cover

a) Cementitious mortar

The mortar shall consist of one part cement and two parts sand (0-2,0 mm) by mass with a water/cement ratio not exceeding 0,42. Additives approved by the Engineer may be used to improve workability and durability of the mortar.

The mortar shall be applied to minimum thickness of 10 mm and the finished surface shall be treated with an approved curing compound in accordance with Clause A13.4.5.8 of Chapter 13.

b) Epoxy Mortar

Epoxy mortars shall not be applied to structural concrete surfaces with temperatures below +10°C.

The concrete and reinforcement shall be prepared as described in Clause A4.3.7.2b) of Chapter 4 and primed with the bonding layer before applying the approved epoxy mortar based on the size and depth of repair.

A14.4.7.8 Partial removal of concrete to expose reinforcement

Where a structural element contains embedded reinforcement which will be re-used in the rehabilitation process, the concrete shall be carefully chipped away without damaging the reinforcing bars. Damaged bars shall be replaced with new reinforcement of similar type and size, subject to the Engineer's approval.

A14.4.7.9 Sounding survey

On instruction from the Engineer a sounding survey shall be carried out by striking the concrete with a hammer of approximately 500 g mass and recording the location of hollow sounding areas. On plane areas of concrete the surface shall be sounded at approximately 300 mm centres in each direction. On columns, beams or other similar members with faces less than 300 mm wide, each face shall be sounded near each edge or corner at approximately 300 mm centres along the member. Where a hollow sounding area is detected its extent shall be determined by local sounding and its periphery marked on the surface of the member for repair.

A14.4.8 WORKMANSHIP

A14.4.8.1 Tolerances

The Contractor shall apply the patching mortar or concrete and finish the surface to the line and level of the existing concrete and within the tolerances specified on the drawings, or if none is specified, to the tolerances specified in the Section A13.2 of Chapter 13.

A14.4.8.2 Testing

The Contractor shall ensure that only compatible materials are used for surface and structural repair of concrete members. All test results shall be reported to the Engineer and will be subject to the Engineer's approval.

The site weather conditions during the application of surface and structural repair of concrete members shall be monitored and recorded as follows:

- a) Ambient temperature shall be recorded using thermometers with accuracy of 1°C, in the direct vicinity of the Works, but not subject to direct solar radiation.
- b) Precipitation shall be recorded daily during product application.

The following tests for the substrate and repair material are required:

- The cleanliness of the substrate shall be visually inspected, after preparation and immediately before the application of repair materials.
- The temperature of the substrate shall be recorded using thermometers with accuracy of 1°C, but not subject to direct solar radiation.
- The consistency of repair materials shall be recorded for each batch: for concrete slump measured according to SANS 3001-CO1-3, or flow according to SANS 3001-CO1-6 and consistency for mortar determined in accordance with EN 13395 – parts 1, 2 or 4.
- Colour, uniformity and texture of finished surfaces shall be assessed visually to ensure consistent aesthetic appearance.

c) Material

The Contractor shall ensure that only compatible materials are used as ingredients for the repair mixes.

The Contractor shall carry out pre-construction compatibility tests on the proposed repair system in accordance with EN 1504 to ensure that the strength and serviceability requirements of the structural rehabilitation are met. The test results shall be reported to the Engineer and shall be subject to the Engineer's approval.

Any patch material exhibiting signs of cracking at its perimeter shall be deemed to have failed and shall be removed and replaced.

d) Acceptance testing

The Engineer will assess cast repair concrete or proprietary cementitious compounds according to SANS 3001-C02-03 and the relevant sub-clauses and any applicable Contract Documentation.

Repair material for surface repair will be assessed for compliance based on the 28-day mean strength test result compared to the specified 28-day compressive strength for each class of repair material.

The criteria for compliance with the strength requirements shall be the mean strength result of three test cubes made from the repair material mix used, which are then prepared and tested in accordance with SANS 3001-C02-03.

Test cubes shall be stored and cured in a manner appropriate to the materials to be tested in accordance with the manufacturer's specifications and shall be properly identified.

The strength results shall represent the section of work executed in the period as agreed to by the Contractor and the Engineer in advance of sampling and the mean strength must be higher than the specified strength with no single value less than 90% of the specified value.

The work at risk due to non-compliance shall be that executed during the agreed period represented by the strength results that failed to achieve the specified strength.

As a consequence of non-compliance in terms of the acceptance criteria, the Contractor shall take such remedial action as the Engineer may consider necessary. Such action may include removal and replacement of material in repairs at risk and further testing. All such costs shall be borne by the Contractor.

B14.4 SURFACE AND STRUCTURAL REPAIR OF CONCRETE MEMBERS

PART B: LABOUR ENHANCEMENT

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B14.4.7 EXECUTION OF THE WORKS

B14.4.8 WORKMANSHIP

B14.4.1 SCOPE

This Part covers items to optimise the labour component of construction activities

This Section covers the requirements for the surface and structural repair of structural concrete members. It covers the preparation of the exposed concrete surface and reinforcement for the rehabilitation of the member, and the repair or replacement of concrete with cementitious mortars, epoxy systems and proprietary concrete repair compounds. This work is deemed to be labour enhanced activities, but of a specialised skills level.

B14.4.2 DEFINITIONS

The definitions given in Part A, shall apply.

B14.4.3 GENERAL

Hydro-demolition (or water jet removal) of concrete is preferred wherever possible. Demolition using explosives will not be permitted.

B14.4.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A, shall apply.

B14.4.5 MATERIALS

The provisions of Part A, shall apply.

B14.4.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.4.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply

B14.4.8 WORKMANSHIP

The provisions of Part A, shall apply.

C14.4 SURFACE AND STRUCTURAL REPAIR OF CONCRETE MEMBERS

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

The following payment items shall include full compensation for all work associated with the repair of concrete structures such as procurement, transport, additional access and temporary works, plant and equipment required to undertake the work as specified. General access and work platforms and associated temporary works are covered in Section A14.1.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

New reinforcement will be measured separately.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.4.1	Cementitious mortar or concrete (Class) to (description)	litre (ℓ)

The unit of measurement is the litre of mortar or concrete measured in place, of specified class, used for the repair of specified concrete defects.

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to break out, prepare, prime all surfaces, apply repair mortars and cure the designated areas (include for wastage) all in accordance with the project specification and the repair material manufacture's procedures, methods and specifications.

In addition the tendered rates shall make full provision for all efforts to remove existing concrete behind the reinforcement with inadequate cover, and to force the reinforcement deeper into the exiting member. The tendered rates shall cover all the cleaning and preparation of all surfaces in accordance with the supplier specifications, inclusive of the cleaning and treatment of existing reinforcement steel.

Item	Description	Unit
C14.4.2	Epoxy mortar	litre (ℓ)

The unit of measurement is the litre of epoxy mortar measured in place, of specified type used for the repair of specified concrete defects.

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to break out, prepare, prime all surfaces, repair and cure the designated areas all in accordance with the Contract Documentation and the repair material manufacture's procedures, methods and specifications.

In addition the tendered rates shall make full provision for all efforts to remove existing concrete behind the reinforcement with inadequate cover, and to force the reinforcement deeper into the exiting member. The tendered rates shall cover all the cleaning and preparation of all surfaces in accordance with the supplier specifications, inclusive of the cleaning and treatment of existing reinforcement steel.

Item	Description	Unit
C14.4.3	Proprietary cementitious repair system (Class and generic description) in positions as indicated in accordance with Table A14.4.5-1.	
C14.4.3.1	Class R4 – (Generic description)	
(a)	(Position indicated)	litre (ℓ)

- (b) (Etc. for other positions)
- C14.4.3.2 **Class R3** – (Generic description)
 - (a) (Position indicated) litre (ℓ)
 - (b) (Etc. for other positions)
- C14.4.3.3 **Class R2** – (Generic description)
 - (a) (Position indicated) litre (ℓ)
 - (b) (Etc. for other positions)
- C14.4.3.4 **Class R1** – (Generic description)
 - (a) (Position indicated) litre (ℓ)
 - (b) (Etc. for other positions)

The unit of measurement is the litre of proprietary repair compound measured in place used for the repair of specified concrete defects.

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to break out, prepare, prime all concrete and reinforcement surfaces, repair and cure the designated areas (including for wastage) all in accordance with the Contract Documentation and the repair material manufacture's procedures, methods and specifications.

In addition, the tendered rates shall make full provision for all efforts to remove existing concrete behind the reinforcement with inadequate cover, and to force the reinforcement deeper into the exiting member. The tendered rates shall cover all the cleaning and preparation of all surfaces in accordance with the supplier specifications, inclusive of the cleaning and treatment of existing reinforcement steel.

Item	Description	Unit
C14.4.4	Curing of repair surfaces	
C14.4.4.1	By coating the surface with (type indicated) to (description)	square metre (m ²)
C14.4.4.2	Curing by (method indicated) to (description)	square metre (m ²)

The unit of measurement is the square metre of concrete repair surface treated or coated by the method and curing compound indicated and accepted by the Engineer.

The tendered rates shall include full compensation for all labour, materials, plant, equipment and safety measures required to cure the repair work to the satisfaction of the Engineer.

In addition, the tendered rates shall make full provision for all efforts to remove existing concrete behind the reinforcement with inadequate cover, and to force the reinforcement deeper into the exiting member. The tendered rates shall cover all the cleaning and preparation of all surfaces in accordance with the supplier specifications, inclusive of the cleaning and treatment of existing reinforcement steel.

Item	Description	Unit
C14.4.5	Sounding survey (Prior to repair of the surface)	square metre (m ²)

The unit of measurement for the sounding survey shall be the square metre of area tested prior to repair of the surfaces.

The tendered rate shall include full compensation for everything that is necessary to carry out the survey as specified or instructed, mark out repair limits on the concrete surfaces and accompany the Engineer's representative during subsequent inspection to confirm the extent of concrete that is to be repaired on the basis of the sounding survey. The sounding survey conducted after the surface repair has been carried out is deemed to be included in cost of the repair of the surface using a hammer with a mass of at least 500 g.

D14.4 SURFACE AND STRUCTURAL REPAIR OF CONCRETE MEMBERS

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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D14.4.9 NOTIFICATION OF REMEDIAL WORK

D14.4.10 REMEDIAL WORK

D14.4.1 SCOPE

The scope of this Section covers the following:

- Product conformance specifications
- Warranties for product or element design and installation of proprietary systems
- Performance specifications

Note that the requirements for performance specifications are not limited to that given in Part C only but includes all of the requirements in the contract documentation.

D14.4.2 GENERAL

D14.4.2.1 Product conformance specifications

The Contractor shall, within 28 days before the work commences, submit to the Engineer conformance documentation related to the specifications.

Conformance documentation shall be provided for:

- a) Cements CEM I or CEM II and Admixtures.
- b) Primer for steel surfaces.
- c) Adhesion promoter for concrete surfaces.
- d) Epoxy adhesives and Repair Mortars.
- e) Structural Repair Products types R1, R2, R3 and R4 (conforming to EN 1504-3)

D14.4.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.4.3.1 Warranties for product or element design and installation of proprietary systems

No additional requirements.

D14.4.3.2 Performance specifications

The guarantee for proprietary products shall be 10 years or as contained in the contract documentation for the project.

A14.5 ANCHORING OF REINFORCEMENT, GROUTING AND CRACK INJECTION

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PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.5.1 SCOPE

This specification covers the requirements for the anchoring of reinforcing bars, the filling of gaps, holes and pockets with grout systems and the injection of cracks and cavities with adhesive systems.

A14.5.2 DEFINITIONS

Anchoring - the process of forming or drilling holes into hardened concrete, cleaning and preparation of the hole surface, and bonding of reinforcement steel into the holes using proprietary products based on Portland cement binder or synthetic adhesives, for example vinylester or epoxy. Anchoring is generally used for structural strengthening applications to ensure the continuity of reinforced concrete structures by resisting shear, tension and vibration loadings; to hold various structural members or embedments in the concrete; or to prevent dislodging of repairs from concrete substrate.

Grouting - grouting means the filling of gaps between structural elements by using gravity techniques to fill holes or pockets in concrete members including the embedment of steel sections or other components. Grouting is generally done with a proprietary high-strength, non-shrink, cementitious compound or epoxy system.

Crack injection - crack injection means the filling of cracks and internal cavities in concrete members with low-viscosity liquid epoxy adhesive by a low-pressure injection procedure.

Epoxy adhesive - epoxy adhesive means the compound that serves to bond together two separate materials or contact faces resisting the interfacial stresses to ensure structural composite action of the joined materials.

A14.5.3 GENERAL

A14.5.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.5.5 MATERIALS

A14.5.5.1 Anchoring adhesive

The materials selected shall be suitable for anchoring reinforcement into concrete surfaces in accordance with EN 1504-9 Principle 4-Method 4.2. All anchoring adhesives shall have certified fire resistance and hold European Technical Approval for use in non-cracked concrete, or if specified on the drawings, certified approval for cracked concrete or seismic zones. All anchoring products shall be styrene-free and shall be compatible with European Technical Approval ETAG 001-5.

A14.5.5.2 Grout

The materials selected shall be suitable as structural repair products for concrete in accordance with EN 1504-9 Principle 3-Method 3.2, Principle 4-Method 4.4 and Principle 7-Method 7.2.

a) Cementitious grout

Cementitious grout shall comply with the requirements of ASTM C1107 or EN 1504. The materials for the grout shall be supplied as a factory pre-packed dry premix of Portland cement powder, graded fillers and other proprietary products requiring only the addition of water to produce the required consistency ranging from a plastic to flowable. The proprietary grout shall compensate for shrinkage in both the plastic and hardened states whilst hardening free of bleeding, segregation and settlement, without gas-generating and air-releasing agents.

Flowable grouts shall be suitable for use by pumping and mix-and-pour placing techniques, and shall be highly workable, self-compacting and self-levelling without the use of vibrators. The cementitious grout shall have no deleterious effects on the reinforcement or embedments, and shall not contain harmful quantities of chloride, nitrate, nitrite, sulphide or sulphate.

b) Epoxy resin grout

The materials for the grout shall consist of a factory pre-packed, solvent-free, two-part epoxy adhesive consisting of resin and hardener components and specially prepared and graded aggregate. The epoxy shall be low viscosity modified aliphatics or amidoamines with a high resistance to moisture and low creep values under sustained loads. Polyester-based products shall not be permitted for grouting purposes.

The mixed adhesive shall have a smooth, free-flowing liquid consistency which, when mixed with the aggregate, will not separate or settle out prior to curing.

The epoxy resin grout shall be suited to the intended application and the toxicity of the chemicals in the components shall be low enough to enable safe usage in confined areas of the construction site and in a normal workshop environment.

c) Working characteristics of grout

(i) Application

The grout system shall be suitable for application by pouring into gaps, holes, pockets or formwork depending on the particular circumstances.

(ii) Strength development, cure time and environmental conditions

The grout shall be capable of curing to the required strength at ambient temperatures between 10°C and 40°C in relative humidity up to 95 %.

The grout must cure sufficiently within 24 hours, to the compressive strength specified on the drawings, with negligible shrinkage on curing.

A14.5.5.3 Crack injection and crack filling

The materials selected shall be suitable for crack injection filling and sealing in accordance with EN 1504-9 Principle 1-Method 1.5 and Principle 4-Methods 4.5 and 4.6.

a) Adhesive

(i) Surface sealing for vertical and overhead surfaces

The surface sealant shall be suitable for bonding the injection ports to the concrete substrate and for sealing the surface of the crack. The surface sealing adhesive shall be grey in colour, shall be compatible with the injectable adhesive and shall have sufficient strength and adhesion to contain the injectable adhesive at the maximum injection pressure within the crack during the injection and curing processes. The hardened surface sealant adhesive shall be capable of being easily removed without damage to the concrete surface and shall not leave a residue.

Acrylic compounds or car body repair-type compounds shall not be permitted.

(ii) Surface sealing for horizontal, top surfaces

The surface sealant shall be suitable for use in creating a ponding area along the crack for the filling by pouring method. The sealant shall be applied as a bead or dam onto the concrete surface, be capable of retaining the epoxy adhesive and maintain the sealant properties until the epoxy adhesive has hardened. The surface sealant shall be easily removed after hardening of the epoxy adhesive. Surface applied beads of thixotropic acrylic- or polyurethane-sealants are commonly used, but compliance with the epoxy adhesive manufacturer's instructions shall be enforced.

b) Injection ports

Injection ports shall consist of short lengths 75 mm to 130 mm of small diameter 3,0 mm to 5,0 mm ID, flexible, high-pressure tubing each fitted with a locating pin at the base for bonding in the crack sealant. The locating pin shall be supplied with a length of wire flattened at the end for accurate positioning of the tube over a crack.

Grease nipples or similar self-closing injection nipples shall not be used unless authorized by the Engineer. Sufficient field testing to demonstrate the satisfactory operation of such injection port shall precede any approval application.

c) Injectable and pourable epoxy adhesive products

The adhesive used for epoxy injection into cracks in concrete shall consist of an unfilled, solvent-free, two-part epoxy consisting of resin and hardener components. The epoxy shall be low viscosity modified aliphatics or amidoamines with a high resistance to moisture and low creep values under sustained loads. The injectable adhesive shall meet the requirements for force transmitting structural filling of cracks in accordance with EN 1504-5.

The adhesive components shall be supplied in liquid form and in separate sealed containers. Each component shall have a different identifiable colour which results in a distinctive homogeneous colour when thoroughly mixed.

The adhesive shall mix readily to a smooth liquid consistency of low to medium viscosity and shall be suitable for injection into cracks on surfaces ranging from horizontal top to vertical, as well as inverted overhead, surfaces.

The mixed adhesive shall be free of lumps and the components shall not separate or settle out during the pot life of the adhesive.

d) Working characteristics of adhesive

(i) Surface sealing application

The surface sealing adhesive shall be suitable for trowelling application, shall be non-slump and shall have excellent gap filling properties.

(ii) Injectable and pourable application

The adhesive shall be suitable for injection into cracks and voids under low pressure and shall meet the requirements for Injectability Class P3 (as defined in EN 1504-5) when determined in accordance with EN 1771.

The viscosity of the epoxy shall be matched to the crack width and material macroporosity surrounding the crack, generally between 200 cP and 400 cP at 25°C.

The adhesive shall be capable of bonding to dry and moist surfaces where the injected adhesive displaces moisture present in cracks and cavities.

(iii) Pot life

The workable time or pot life of the mixed adhesive shall be determined according to EN ISO 9514. The mixed adhesive shall exceed 60 minutes at 25°C and a relatively high humidity, unless special circumstances dictate a fast-setting adhesive.

(iv) Storage life

The storage life, or shelf life, in the original sealed containers of both the resin and hardener shall not be less than six months stored at temperatures between 5°C and 25°C. Only batches of material of which the shelf life has not expired shall be used.

(v) Cure time and temperature

The adhesive shall be capable of curing to the required strength at temperatures between 10°C and 40°C in relative humidity of up to 95 %.

The adhesive must cure sufficiently to develop the specified mechanical properties within 7 days, with negligible shrinkage on curing.

e) Mechanical properties of cured injectable adhesive

(i) Moisture resistance

The adhesive shall comply with "Adhesion by tensile bond strength" Class F2 (as defined in EN 1504-5) when tested in accordance with EN 12618-2 for "Adhesion by tensile bond strength after thermal and wet-drying cycles". If specified on the drawings, the adhesive shall comply with "Adhesion by tensile bond strength after thermal and wet-drying cycles" Class F1 (as defined in EN 1504-5).

(ii) Temperature resistance

The glass transition temperature of the adhesive, measured in accordance with EN 12614, shall exceed 40°C and the adhesive shall have a heat distortion temperature (HDT) of at least 50°C measured in accordance with ISO 75.

(iii) Flexural modulus

The modulus of elasticity in flexure of the adhesive, determined in accordance with EN ISO 178, shall be between 2,0 GPa and 10,0 GPa at 20°C. The adhesive must have a consistent static behaviour for temperatures ranging between -20°C to 40°C under cyclic loading.

(iv) Modulus of elasticity in compression

The modulus of elasticity in compression of the adhesive, determined in accordance with EN 13412, shall be minimum 2,0 GPa.

(v) Shear strength

The bulk shear strength of the adhesive, determined in accordance with EN 12188, shall exceed 12 MPa at 20°C.

(vi) Tensile strength

The adhesion capacity shall be determined in accordance with EN 12188. The tensile stress carried by the bonded joint in a pull-off test shall not be less than 14 MPa. The slant shear strength of scarf-jointed prisms tested in compression at various interface angles:

1. for an interface angle of 50°, the minimum adhesion stress shall be 50 MPa
2. for an interface angle of 60°, the minimum adhesion stress shall be 60 MPa
3. for an interface angle of 70°, the minimum adhesion stress shall be 70 MPa.

(vii) Double lap shear strength

The average lap shear strength of a double overlap joint at failure using steel plates shall exceed 8 MPa at 20°C.

A14.5.5.4 Packaging and handling

All adhesive components shall be supplied in separate sealed containers of suitable sizes to obtain a mixed quantity that can be fully utilized within the pot life of the adhesive. The components shall be packaged in the correct portions so that the entire contents of each container

mixed together shall produce a mix of the correct proportions. The adhesive properties shall not vary significantly with minor variations in the mix proportions resulting from the container emptying process.

Each container shall be durably and legibly marked and complete records of stock acquired and issued for use, shall be kept. The containers shall be clearly marked with the following information:

- a) name of manufacturer;
- b) manufacturer's product identification;
- c) batch number and date of manufacture;
- d) date of expiry or shelf life;
- e) manufacturer's instructions for mixing; and
- f) detailed health and safety information, including precautionary physical, toxicological and environmental requirements.

A14.5.5.5 Storage

The Contractor shall provide a lockable store with ventilation and observe all storage requirements and safety precautions recommended by the manufacturer's instructions and applicable Regulations.

A14.5.5.6 Manufacturer's instructions and documentary proof of compliance

The material manufacturer's quality control conformance certificates and test results relevant for each batch of material supplied to site shall be made available to the Engineer upon request. The manufacturer shall provide a dated, coded and titled instruction sheet with each delivery of adhesive. The following information shall be contained on the sheet in a clear and unambiguous manner:

- a) the general chemical type of each component used in the adhesive;
- b) recommended storage conditions and shelf life when stored under these conditions;
- c) preparation instructions for steel and concrete surfaces;
- d) instructions for use of primers, including optimum dry film thickness and permissible ranges;
- e) mixing instructions, including allowable variations in mix ratio and any temperature control requirements during the mixing process;
- f) application instructions, including limits on pressure, temperature, open time and relative humidity before injection;
- g) safety precautions for all components of the adhesive; and
- h) curing conditions and temperature-related precautions.

A14.5.6 CONSTRUCTION EQUIPMENT

A14.5.6.1 General

All plant and equipment used for anchoring of reinforcing bar, grouting operations and pressure- and gravity- injection of epoxy resins shall be based on proven and accepted technology and practice within the industry. The plant, equipment, tools and accessories shall be inspected and maintained on a regular basis to ensure that they remain in good working order, are clean, function efficiently, and that safety is not compromised - all to the approval of the Engineer.

A14.5.6.2 Temporary access structures and working platforms

Where necessary the Contractor shall provide temporary access structures and working platforms in accordance with Section A14.1 at each location for anchoring, grouting or crack preparation and injection procedures.

A14.5.6.3 Forming holes for anchoring

The Contractor shall form holes for anchoring utilizing equipment based on rotary drilling or wet coring techniques, appropriate to the size of the hole and the anchoring material utilized.

A14.5.6.4 Pressure injection equipment

The type and capacity of the pressure injection equipment, delivery hoses and nozzles shall be such as to ensure the uniform supply of separate components to the mixing nozzle, thereby obtaining the correct consistency and a uniform discharge rate from the nozzle.

The pressure injection equipment shall be capable of continuously supplying the freshly mixed epoxy resin on demand. The equipment shall be fitted with properly calibrated positive displacement pumps and a pressure gauge capable of recording correct pressures applied up to 2,0 MPa with 0,1 MPa divisions.

The two components of the epoxy injection compound shall be fed separately to the extrusion gun and shall only be mixed together within the pressure chamber of the gun at the time of injection. On no account shall ready-mixed epoxy be fed to the extrusion gun.

A14.5.7 EXECUTION OF THE WORKS

A14.5.7.1 Anchoring

Prior to forming holes for anchoring, the Contractor shall ensure that the position of existing embedded reinforcement is determined by covermeter tests performed according to Clause A14.2.7.2 and marked on the structure. Anchors shall not be installed in unsound concrete. Anchors shall not reduce the structural or electrochemical performance of other reinforcement.

a) Preparation of contact surfaces

The texture and cleanliness of the surface of anchor holes shall be appropriate to the anchoring adhesive. The hole surfaces shall be free from dust, loose material, surface contamination and all materials that reduce the bond of anchoring adhesive. Unless cleaning is carried out immediately before the application of the anchoring adhesive, the cleaned substrate shall be protected from further contamination.

b) Installation of anchoring adhesive and reinforcing bar

The anchoring adhesive shall be inserted into the prepared hole, starting at the bottom while slowly drawing back the delivery system. The anchoring adhesive delivery system shall be in accordance with the manufacturer's instructions, and suitable extension tubing may be used for deep holes. The reinforcing bar shall be inserted with a gentle rotary motion into the filled hole within the open time of the anchoring adhesive. Correctly filled holes will usually show evidence of the outward displacement of some adhesive. During the adhesive hardening time, the reinforcement must not be moved or loaded.

A14.5.7.2 Grouting

a) Preparation of contact surfaces

Concrete contact surfaces shall be prepared by removing all surface laitance and damaged, loose and soft concrete, concrete containing aggressive ions, e.g. chloride, as well as cleaning the surfaces of all foreign adherents and impregnants such as oil, paint, grease, curing compounds, dirt, etc. The contact surface shall be treated to expose the sound substrate by means of chiselling, grit blasting or high-pressure water-jetting. Where concrete removal is achieved by mechanical means (for example, chiselling), the surface shall receive treatment using high-pressure water-jetting to remove concrete layer potentially containing micro-cracking.

The prepared contact surfaces shall be finally cleaned of loose dirt and dust by means of oil-free compressed air, water-jetting or vacuum cleaning, as appropriate for the grouting material.

b) Holes, recesses and pockets for grouting.

Holes, recesses and pockets that are formed in concrete must be cleaned of all foreign material and prepared as for the contact surfaces in Clause A14.5.7.2a).

c) Pre-soaking

Cementitious grout usually requires the pre-soaking of the concrete substrate with water several hours prior to grouting. All surface pores and local depressions formed due to roughening should not contain standing water when the grouting takes place. All free water shall however be removed from the surface and holes or pockets immediately prior to grouting. The contact surface should present as dark matt, without glistening or shiny water films. A site test may be performed by introducing drops of water applied to the contact surface that must be soaked up, leaving the surface matt again after a short time. The surface should not be allowed to dry before the application of the grouting products.

The use of an epoxy resin grout usually requires a clean and substantially dry contact surface. No pre-soaking is required unless specified by the grout manufacturer.

d) Formwork

Temporary formwork may be required to place and contain the fluid grout. Reference shall be made to the manufacturer's instructions regarding flow distance based on the gap width and the fluid head at the pouring side. The formwork shall be constructed to be leakproof to prevent wastage and loss of material. For grouting applied proud of existing concrete surfaces, 45 degree chamfers may be used around the grout perimeter, if instructed by the Engineer. The Contractor shall apply suitable care in the selection of formwork release agents appropriate to the grouting product used.

e) Batching and mixing

The proprietary grout shall be batched and mixed strictly in accordance with the manufacturer's instructions.

Unless otherwise specified, the product shall be mixed thoroughly in a forced action mixer of adequate capacity. Alternatively a suitably sized container equipped with a slow-speed (typically 400-500 rpm), high-torque rotary drill fitted with an approved paddle may be used. The liquid components shall be properly mixed to ensure a smooth uniform mix prior to adding the aggregate.

The premixed aggregate shall be added slowly to the liquid binder and mixed until an evenly coated and wet mix is obtained.

The mixing and placing capacity of equipment and labour shall be adequate and matched to enable placing operations to be carried out continuously within the recommended workable time, or pot life, of the product, generally within 15 minutes of mixing for cementitious grouts. The mixed product shall be passed through a suitable coarse metal screen prior to placing or pumping to remove any lumps of unmixed product.

The mixed product shall not be used after expiry of the pot life and all material unused after the workable time limit, shall be discarded at the Contractor's expense. All previously mixed material shall be removed from tools and equipment prior to charging and mixing a new batch of grout.

f) Placement of grout for bedding or gap filling

The mixed grout shall be placed within the workable life or pot life of the material in accordance with the manufacturer's instructions.

In general, continuous grout flow is essential, hence sufficient mixed grout shall be available prior to commencing placement, and the rate of placing a batch shall be matched to the time taken to batch and mix a new batch.

Placement shall take place at one end of a gap to ensure continuous flow through the gap expelling all air from the exit opening. A sufficient grout head shall be maintained at the inlet end to ensure a continuous grout front through the gap.

For an epoxy grout a single batch shall not exceed 30 litres of mixed material.

For large batches of cementitious grout, placing by pump may be considered.

g) Protection and curing

The exposed cementitious grout surfaces shall be protected from wind, rain and low or high ambient temperatures that may lead to cracks caused by plastic or drying shrinkage. While the cementitious grout hardens and cures, the temperature gradient throughout the structure shall be managed to ensure it remains as uniform as possible to avoid thermal cracking.

Cementitious grouts shall be thoroughly cured by supplying excess water over the grout surface, the application of water using continuous mist sprays, or using saturated absorbent material covered with transparent plastic sheeting. In cold weather, grout may be cured by means of an approved curing compound.

A14.5.7.3 Crack injection

All work related to the injection of cracks with epoxy shall be executed in accordance with the approved method statement as confirmed by site tests according to Clause A14.5.7.3a).

a) Extent and sequence of work

The extent of work will be indicated by the Engineer and no work may commence unless instructed by the Engineer. The extent of the actual work may vary very significantly from that indicated in the pricing schedule and the Contractor is advised to discuss the extent of the work with the Engineer at the outset of the contract before establishing the necessary personnel, equipment or plant on site.

Following the erection of the necessary temporary access and working platforms at the work location and, if required, cleaning of the surface, the Engineer, assisted by the Contractor, shall undertake a detailed inspection of the existing concrete surfaces to identify cracks requiring epoxy injection. The Engineer shall then issue an instruction to the Contractor detailing the extent and nature of the work. In general, only cracks exhibiting a surface crack width of 0,4 mm or greater shall be injected unless instructed to the contrary by the Engineer.

b) Crack preparation

All surfaces within 50 mm of a crack line shall be thoroughly cleaned of all foreign material likely to impair the bond of the surface sealant to the concrete by high-pressure water-jetting, wet grit blasting or other approved chemical and mechanical means. All loose spalls and foreign materials within the crack shall be similarly removed followed by final cleaning with clean, oil-free compressed air. The concrete surface and crack shall be allowed to dry out completely and finally cleaned before commencing with crack sealing and injection.

c) Surface sealing and injection port installation

The whole surface of the crack shall be temporarily sealed with a sag resistant fast setting epoxy surface sealant cured with a modified aliphatic amine. The type of temporary sealant used shall be such that it can be removed without causing damage to, or defacement of, the concrete surface.

All minor cracks branching out from the identified cracks by more than 50 mm shall be cut perpendicularly across the crack using an angle grinder to a depth of at least 25 mm and filled with epoxy surface sealant.

Approved injection ports shall be properly spaced along cracks, but shall not be drilled and fixed directly into the crack. The first and last injection ports must be established at either end of a crack in a member. The injection ports shall be located over the cracks using the locating wire and the locating end shall be firmly sealed and bonded to the concrete surface with a generous amount of epoxy sealant. Thereafter the crack surface between injection ports shall be sealed with an approved epoxy surface sealant band at least 3 mm thick and 30 mm wide.

While guidelines can be given for proper spacing, good judgement must be the final criterion.

(i) Guidelines for injection port spacing in partial depth cracks are as follows:

1. Spacing between injection ports should be equal to the desired depth of penetration since the resin generally travels as far into the crack as along the face of the crack. If port-to-port travel at this spacing is not obtained, intermediate injection ports must be established.
2. If the cracks are less than 0,4 mm wide, injection ports should not be spaced more than 150 mm apart.
3. If the cracks are more than 600 mm in depth, full penetration may be difficult to achieve because of equipment limitations. Intermediate ports should be established to monitor the flow of epoxy.

(ii) Guidelines for injection port spacing in cracks extending the full depth of the member are as follows:

1. Members up to 300 mm thick

For members 300 mm or less in thickness, injection ports should be placed in the crack on one side only and spaced at the thickness of the member.

2. Members 300 mm to 600 mm thick

For members 300 mm to 600 mm in thickness, injection ports should be placed in the crack on all available sides and spaced no more than the thickness of the member.

3. Members over 600 mm thick

For members greater than 600 mm in thickness, injection ports should be placed in the crack on all available sides and spaced according to the guidelines set forth for the partial depth cracks in Clause A14.5.7.3c)(i).

d) Epoxy resin injection

Either the pressure injection or vacuum impregnation technique of crack injection shall be used.

The epoxy surface sealant shall have cured fully before commencing with any crack injection.

All traces of cleaning solvent and air shall be expelled from the injection gun prior to commencing with crack injection.

Using an automatic epoxy mixing gun, the epoxy resin shall be injected in such a way that there is a steady displacement of air and moisture from within the crack. Starting from the lowest injection port at one end, the epoxy resin shall be injected until resin flows out of

the next injection port. The upper injection port is closed and the process of injecting the epoxy resin is continued briefly. A steady injection pressure shall be maintained, however at no stage shall the pressure exceed 1,0 MPa.

The gun shall then be moved to the injection port where the resin has flowed out and the procedure is repeated for the length of the crack. After the crack is filled, and not longer than 30 minutes after the work has begun, another attempt shall be made to inject more resin, starting at the first port.

Before injection work starts, a rough calculation shall have been made as to the amount of resin required to fill the crack. If consumption exceeds the estimated quantity by more than three times, the matter shall be referred back to the Engineer for investigation.

At all cracks, contact surface or repaired cavities, epoxy injection shall commence at the lowest injection point and at one end, and shall in all cases be executed such that there is a steady displacement of air, residual moisture and fine material from the void being injected.

During the entire injection operation, the sealing lines (on both sides in the case of full depth cracks) and adjacent concrete surfaces shall be inspected for any signs of leakage of epoxy and, if observed, the injection shall be stopped and the leaking region sealed or resealed.

Further injection shall recommence only once the epoxy sealant repair has cured sufficiently. Accurate and complete records shall be kept of the amount of epoxy injected into each crack, contact surface or repaired cavity together with any leakage that may have occurred during the injection operation.

After satisfactory completion of the pressure injection at any particular location and the full curing period of the epoxy injection material, the injection points and all epoxy sealant shall be removed and the concrete surfaces and crack lines, as applicable, made good. Where the aesthetic appearance of the concrete surface is important, the surface sealant epoxy may be removed by careful heating using a propane torch, allowing the epoxy to soften, i.e. above 130°C in combination with gentle scraping. Alternatively, for non-aesthetic surfaces and those that may receive protective coatings, grinding down the areas as necessary and finishing to a smooth and clean surface will be required.

Where the crack is chased out, the chase should be filled with an approved repair material and finished flush with the concrete surface.

e) Crack filling

(i) Extent and sequence of work

The extent of the work will be indicated by the Engineer and no work may commence unless instructed by the Engineer. The extent of the actual work may vary very significantly from that indicated in the pricing schedule and the Contractor is advised to discuss the extent of the work with the Engineer at the outset of the contract before establishing the necessary personnel, equipment or plant on site.

Following the erection of the necessary temporary access and working platforms at the work location, the Engineer, assisted by the Contractor shall undertake a detailed inspection of the existing concrete surfaces to identify cracks requiring filling. The Engineer shall then issue an instruction to the Contractor detailing the extent and nature of the work. In general, only cracks exhibiting a surface crack width exceeding 0,2 mm shall be filled unless instructed to the contrary.

(ii) Surface preparation

All surfaces within 50 mm of a crack line shall be thoroughly cleaned of all foreign material likely to impair the bond of the surface sealant to the concrete by high pressure water jetting, wet grit blasting or other approved mechanical means. All loose spalls and foreign materials within the crack shall be similarly removed followed by final cleaning with clean, oil free compressed air. The concrete surface and crack shall be allowed to dry out completely and finally cleaned before commencing with crack filling.

(iii) Crack preparation

Create a vee notch in the concrete approximately 20 mm wide over the crack using a hammer and chisel or small power tools. Clear all debris, loose concrete and dust and prime the surface with the specialised materials.

(iv) Crack filling

Fill the vee notch with specified material and grind smooth with the surrounding surface when cured.

A14.5.7.4 Manufacturer's guidelines, and health and safety requirements

Compliance with all health, safety, storage and fire precautions shall be in accordance with the manufacturer's instructions. The toxicity of the chemicals in the components shall be low enough to enable safe usage in confined areas on the construction site and in a normal workshop environment, including special ventilation if required. Wherever toxicity of the chemicals in the components is declared by the manufacturer, suitable personal protective equipment shall be utilized by all persons working with, transporting or storing that product.

A14.5.8 WORKMANSHIP

A14.5.8.1 Anchoring

The Contractor shall ensure that the position of embedded reinforcement is determined by covermeter tests, or alternatively confirmed visually if an appropriate method of concrete removal is specified.

Where instructed by the Engineer, the Contractor shall ensure that the bond of reinforcement is determined using pull out tests in accordance with EN 1881.

A14.5.8.2 Grouting

The Contractor shall through the application of careful methodology, ensure that the grouting has minimal entrapped air. Wherever possible, tapping or sounding on a grouted surface can be carried out with a light hammer or other impact echo equipment. The purpose of the sounding shall be to detect delaminated areas of the grout.

The compressive strength of grouting products shall be verified in accordance with EN 12190.

The consistency of concrete mortar and grouts shall be determined in accordance with EN 13395-Parts 1 to 4.

A14.5.8.3 Crack injection

a) Site tests

The Contractor shall ensure that only approved materials for the proposed crack injection process are used. Preconstruction site tests to confirm proposed work procedures shall be undertaken in accordance with this specification and the approved preliminary method statement. Any variation to procedures or material usage arising from site test results shall be incorporated into the approved final method statement. Further site tests to confirm revised procedures or material use, and test coring to confirm crack penetration and sealing quality shall be at the discretion of the Engineer.

b) Core tests

Test coring from the actual crack injection areas shall be done at positions and at intervals as instructed by the Engineer to confirm satisfactory crack penetration and sealing quality. The core size shall be 30 mm to 60 mm nominal diameter and shall extend at least to the full depth of the crack or other dimension as instructed by the Engineer. Where conformance in accordance with EN1504-10 is verified, the degree of crack filling shall be minimum 80 %. Acceptance of the core results will be at the discretion of the Engineer.

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B14.5 ANCHORING OF REINFORCEMENT, GROUTING AND CRACK INJECTION

PART B: LABOUR ENHANCEMENT

CONTENTS

B14.5.1 SCOPE

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B14.5.8 WORKMANSHIP

B14.5.1 SCOPE

This specification covers the requirements for the anchoring of reinforcing bars, the filling of gaps, holes and pockets with grout systems and the injection of cracks and cavities with adhesive systems. The work activities have a high labour competent of a specialist nature and is deemed to be ideal for labour enhanced construction.

B14.5.2 DEFINITIONS

The provisions of Part A, shall apply.

B14.5.3 GENERAL

The provisions of Part A, shall apply.

B14.5.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A, shall apply.

B14.5.5 MATERIALS

The provisions of Part A, shall apply.

B14.5.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.5.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply.

B14.5.8 WORKMANSHIP

The provisions of Part A, shall apply.

C14.5 ANCHORING OF REINFORCEMENT, GROUTING AND CRACK INJECTION

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

Payment for items in this Section shall include full compensation for all works associated with any additional temporary works, execution of the work and quality assurance procedures which are not separately covered by the measurement and payment items of the specification. All costs associated with general access, work platforms and temporary works not included under Section A14.1, shall be included in the tendered rates.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.5.1	Anchoring of reinforcing steel:	
C14.5.1.1	Reinforcing (type, bar diameter) into formed holes (hole diameter and depth stated) in (description of member)	number (No.)
C14.5.1.2	Reinforcing (type, bar diameter) into pockets (pocket size and depth stated) in (description of member)	number (No.)

The unit of measurement shall be the number of reinforcing steel bars installed into holes or pockets as specified.

The tendered rate shall include full compensation for all labour, material, plant and equipment as well as for all work and incidentals required to form the holes or pockets, install each item as detailed on the drawings including cleaning of holes, preparation of concrete surfaces, supplying, placing and curing of anchoring adhesive and the installation, support and treatment of each item as indicated.

Reinforcing steel bars and specified corrosion protection shall be measured separately in Section A14.3.

Item	Description	Unit
C14.5.2	Preparation of contact surfaces for grouting (type, position and size indicated)	number (No)

The unit of measurement shall be the number of surfaces of type, position and size that have been prepared for grouting.

The tendered rate shall include full compensation for all labour, materials, plant and equipment as well as all work and incidentals required to adequately prepare the concrete surfaces, including any pre-soaking where required.

Item	Description	Unit
C14.5.3	Grouting for:	
C14.5.3.1	Bedding (type, thickness and size indicated) to (description)	litre (ℓ)

C14.5.3.2 Gap filling (type, thickness and size indicated) to (description) litre (ℓ)

The unit of measurement shall be the volume of grout used measured in situ according to the sizes indicated on the drawings.

The tendered rate shall include full compensation for all labour, material, plant and equipment as well as all work and incidentals required to supply, mix, place, protect and cure the grout in position including any temporary formwork, support and control measures as necessary to assist the placement procedure.

Item	Description	Unit
C14.5.4	Establishment on site for crack injection	lump sum

The unit of measurement shall be the lump sum.

The tendered sum shall include full compensation for the establishment on site and the subsequent removal of all special plant and equipment required for the pressure injection of epoxy resin into cracks and any additional plant, specialist access structures and work platforms required for the execution of the work.

The lump sum shall be paid as follows:

- i. 75 % when all equipment is established on site and the first crack injection work has been satisfactorily completed according to the approved method statement, and
- ii. 25 % after all crack injection work has been satisfactorily completed and the equipment is removed from site.

Item	Description	Unit
C14.5.5	Surface preparation and surface sealing for crack injection to (location on structure)	metre (m)

The unit of measurement shall be the metre (m) of crack prepared for crack injection by pressure or gravity means.

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to prepare, clean and prime all surfaces, seal and cure the designated cracks (including for wastage), and install and operate injection ports, all in accordance with the project specification and the repair material manufacturer's instructions.

Item	Description	Unit
C14.5.6	Crack injection adhesive to (location on structure)	litre (ℓ)

The unit of measurement shall be the litre of adhesive used as approved by the Engineer. The volume shall be determined from the dimensions indicated on the drawings or as authorized by the Engineer following the detailed inspection of the prepared surfaces. Any overcut or excessive preparation resulting in additional adhesive quantities shall not be measured.

The tendered rate shall include full compensation for all labour, materials, equipment, plant and incidentals required for the supply, mixing and application of the adhesive to the prepared concrete surface. It shall also include the certification testing and quality assurance monitoring and testing by the Contractor, as well as any wastage of the mixed or spilled materials and the disposal thereof. The tendered rate shall also include all costs arising from any clean-up and finishing actions required due to spillage or poor workmanship.

Item	Description	Unit
C14.5.7	Crack filling	

C14.5.7.1 Repair system to (location on structure) metre (m)

The unit of measurement shall be the metre (m).

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to, prepare, clean and prime all surfaces, repair and cure the designated cracks (including for wastage), and finish the repaired surface all in accordance with the project specification and the manufacturer's instructions.

Item	Description	Unit
C14.5.8	Site and core tests	
C14.5.8.1	Drilling of cores (specify diameter of cores)	metre (m)
C14.5.8.2	Site testing and testing of cores	provisional sum
C14.5.8.3	Percentage on provisional sum for charges and profit	percent (%)

The unit of measurement for drilling of cores shall be the metre length of cores drilled and extracted. The tendered rate shall include full compensation for all labour, plant, equipment and material as necessary to drill and extract the cores, submit the cores to the Engineer and to fill the hole with repair material and finish the drilled holes to the approval of the Engineer.

The stated provisional sum for site and core testing shall be employed to cover the cost of specific tests to be carried out as ordered by the Engineer.

D14.5 ANCHORING OF REINFORCEMENT, GROUTING AND CRACK INJECTION

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

CONTENTS

- D14.5.1 SCOPE**
- D14.5.2 GENERAL**
- D14.5.3 PERFORMANCE GUARANTEE REQUIREMENTS**
- D14.5.4 FUNCTIONAL PERFORMANCE ASSESSMENTS**
- D14.5.5 VISUALLY ASSESSED PROPERTIES**
- D14.5.6 INSTRUMENTALLY ASSESSED PROPERTIES**
- D14.5.7 EVALUATION FOR ACCEPTANCE**
- D14.5.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE**
- D14.5.9 NOTIFICATION OF REMEDIAL WORK**
- D14.5.10 REMEDIAL WORK**

D14.5.1 SCOPE

The scope of this Section covers the following:

- Product conformance specification
- Performance specifications

D14.5.2 GENERAL

D14.5.2.1 Product conformance specifications

The Contractor shall within 28 days of entering into the contract with the Employer submit to the Engineer conformance documentation related to the specifications. All products used to anchor reinforcement, in grouting and in crack injection of Bridge elements shall be in compliance with the specifications continued in Section A14.5.

Compliance documentation shall be provided for:

- a) Anchoring adhesive (Clause A14.5.5.1)
- b) Grout (Clause A14.5.5.2)
- c) Crack injection and crack filling (Clause A14.5.5.3)

D14.5.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.5.3.1 Performance specifications

Performance based specifications shall be contained in the Contract Documentation for the project.

A14.6 SPRAYED CONCRETE FOR STRUCTURES

CONTENTS

PART A:	SPECIFICATIONS
A14.6.1	SCOPE
A14.6.2	DEFINITIONS
A14.6.3	GENERAL
A14.6.4	DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS
A14.6.5	MATERIALS
A14.6.6	CONSTRUCTION EQUIPMENT
A14.6.7	EXECUTION OF THE WORKS
A14.6.8	WORKMANSHIP
PART B:	LABOUR ENHANCEMENT
PART C:	MEASUREMENT AND PAYMENT
PART D:	GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.6.1 SCOPE

This Section covers the supply and application of sprayed concrete in the rehabilitation of structures and miscellaneous work requiring cast concrete-like finish as shown on the drawings. It shall include the supply and application of the sprayed concrete by either the dry-mix or wet-mix method or the preparation required prior to- and post-spraying, protection and treatment of the sprayed concrete. Sprayed concrete (Shotcrete) applied onto rock or soil faces shall be covered in Section A12.5 of Chapter 12.

A14.6.2 DEFINITIONS

Sprayed concrete (Shotcrete) - sprayed concrete means mortar or concrete pneumatically projected at high velocity onto a surface.

Dry-mix sprayed concrete - the constituent materials, comprising a mixture of cementitious binder and aggregates, are mixed and delivered to the application nozzle in dry form. Water and admixtures are added at the delivery nozzle under high pressure while being sprayed to the receiving surface.

Wet-mix sprayed concrete - the constituent materials, comprising a mixture of cementitious binder, aggregates, water and admixtures, are premixed and delivered to the application nozzle as a wet-mix before being sprayed to the receiving surface.

A14.6.3 GENERAL

A14.6.3.1 Method Statements

The method statements and typical drawings submitted by the Contractor with his tender submission, describing key facets such as method, key plant, materials, personnel and programme constraints of the envisaged construction process, shall form the basis for the detailed method statements required for the works to be executed on the project.

These method statements shall be prepared and submitted to the Engineer for approval for each facet of the work at the start of construction, within time scales specified. The onus lies with the Contractor to ensure that the information is gathered and associated activities are completed expeditiously so as to avoid any delays in the commencement, continuation and completion of the required works. Unless otherwise specified or provided for in the Contract Documentation no permanent works shall be commenced until the Engineer's approval has been obtained. Due allowance shall be made for obtaining alternative materials, resubmissions and redesigns, all to the required/approved standards, methods and practices in attending to these requirements. Particular attention shall be paid to the early submission of materials-, concrete- and grout mix designs where parameters at various ages may be specified. No consideration for extension of the contract period will be entertained for delays incurred in meeting these requirements.

Trials, if applicable, shall be conducted and based on outcomes thereof, may require that changes be made to the relevant method statements. Once approved in writing by the Engineer, these shall become the method statements in accordance whereby the relevant portion of the works shall henceforth be executed. Notwithstanding, the Engineer may require revision from time to time if circumstances during construction arise which warrants change.

The Contractor shall, however, remain responsible for all work-methods, materials, plant and equipment used, notwithstanding acceptance by the Engineer.

A14.6.3.2 Hold points and approvals

The Contractor shall comply with the specified hold points relating to approvals required from the Engineer. A hold point is a stage of the work, where the Engineer's approval is required, before commencement or continuance of that particular activity by the Contractor, is

permitted. Project specific requirements will be included in the Contract Documentation or agreed upon between the Engineer and the Contractor.

A14.6.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.6.4.1 General

Where design by the Contractor for any technique or aspect or segment or portion of the works to be carried out, is, in terms of the Contract Documentation, responsibility of the Contractor, all aspects given below shall be taken into consideration in carrying out these obligations.

The following shall be specified (where applicable) by the Engineer and reflected in the Contract Documentation:

- Techniques and methods to be followed
- Site specific requirements
- Limits of the area and thickness/ cover
- sprayed concrete mix composition
- sprayed concrete pigmentation
- sprayed concrete strengths, post treatment properties, durability and any other deliverables as may be appropriate
- Layout of treatment positions
- Sequence of sprayed concrete applications
- Ancillary items such as reinforcing and drainage
- Quantities of sprayed concrete to be used
- Monitoring of works
- Measureable properties to be achieved over the life span of the project
- Environmental and safety requirements specific to the techniques to be executed
- Monitoring and record keeping requirements.

The following information will be generally provided in the Contract Documentation:

- A definition of the objectives and the control criteria
- Investigation data including subsurface geological information, hydrological data and geotechnical parameters
- Test data, borehole logs and recovered core samples

The following additional aspects, shall also be addressed where applicable

- Finishing off of treatment area to specified lines and levels, whether materials are to be removed, removed and replaced by other materials, processing of materials and all other measure to be carried out in meeting requirements as specified in the Contract Documentation.
- The Contractor shall provide a quality management plan indicating his proposed quality assurance testing program which shall allow for testing at each treatment position. Testing methods to be employed shall be as specified in the Contract Documentation.

A14.6.4.2 Sprayed concrete

Where so specified the Contractor shall prepare a detailed construction proposal/design detailing all plant, equipment and materials to be employed in meeting the structural sprayed concrete objectives and performance requirements detailed in the Contract Documentation. In compliance herewith the Contractor shall address all the aspects given in Clause A14.6.4.1 above.

The Contractor shall be responsible for the design of a suitable cementitious mix for sprayed concrete which shall be presented for approval by the Engineer with due consideration of the following:

- Availability of cementitious products in the quantities required for production
- Achievement of specified characteristic strength in the mix
- Consistency and pump-ability of the sprayed concrete

The following procedure shall be applicable:

- Obtaining samples of mix constituents with verification of required properties through laboratory testing
- Carrying out mix designs
- Production of trial mixes in the laboratory to allow for sampling and testing of sprayed concrete
- Production of trial mixes by production plant to allow for the sampling and testing of the sprayed concrete
- Carrying out adjustments to mix designs as may be needed and repeating laboratory and production plant trial mixes to allow for sampling and testing of sprayed concrete
- Obtaining the Engineer's approval of the mix.

Note that the above design shall be carried out by competent personnel following the relevant approved/ specified mix design procedures. Slump of various mixes shall be determined to provide a basis for ongoing quality assurance during production sprayed concrete.

The Contractor shall submit his proposed cementitious sprayed concrete mix design for sprayed concrete accompanied by all relevant information for approval by the Engineer. Lead time as per Table A12.5.3-1 is required for this information. It should be noted that sprayed concrete will only be permitted to proceed if the Engineer is satisfied that the mix meets the minimum performance criteria specified including 28 day characteristic strength of the sprayed concrete as specified in the Contract Documentation.

Any changes to the mix after the Engineer's approval shall only be permitted if approved in writing by the Engineer.

A14.6.5 MATERIALS

A14.6.5.1 Cementitious binder

Refer to Clause A13.4.5.1 of Chapter 13.

a) Cement

Refer to Clause A13.4.5.1a) of Chapter 13.

b) Supplementary cementitious materials

Refer to Clause A13.4.5.1b) of Chapter 13.

A14.6.5.2 Aggregate

- Aggregates shall fully comply with SANS 1083, subject to the following amendments:
- Where the maximum aggregate size equals or exceeds 5,0 mm, the 10 % FACT value as determined by SANS 3001-AG10 shall be minimum 130 kN when tested dry or minimum 110 kN when tested wet;
- The flakiness index as determined by SANS 3001-AG4 shall be maximum 20 %;
- The fine aggregate shall be uniformly graded and shall comply with the following limits:

Table A14.6.5-1: Aggregate grading limits for sprayed concrete

Sieve size (mm, complying with SANS 3001-AG1))	Percentage Passing (by mass)
10	100
5	95 - 100
2	80 - 90
1	50 - 85
0,6	25 - 60
0,3	10 - 30
0,15	2 - 10

- The fine aggregate shall contain no soft particles shall present by means of visual inspection as clean and sharp good particle shape.
- The fineness modulus shall be restricted to the range between minimum 2,5 and maximum 3,2; and
- The optimum moisture content shall be maximum 8 % by mass.

A14.6.5.3 Water

The Contractor shall prove by way of laboratory test that water used for mixing and curing complies with SANS 51008.

The supply of water to the mixing nozzle shall be such that a pressure of at least 400 kPa can be maintained.

A14.6.5.4 Admixtures

Sprayed concrete admixtures shall comply with SANS 50934 (EN 934) and shall be submitted to the Engineer for approval prior to the commencement of work. Admixtures shall have no deleterious effects on the reinforcement or sprayed concrete, and shall not contain levels of chlorides, nitrates, sulphides or sulphites, which may be detrimental to the reinforcement. Where combinations of two or more admixtures are utilized, they shall be tested for compatibility. The approval of the sprayed concrete admixture shall be subject to the satisfactory demonstration of the suitability of the proposed sprayed concrete mixture through the construction of trial panels and acceptable quality assessments conducted on a minimum of three test panels representing three independently-batched sprayed concrete mixes.

A14.6.5.5 Integral permeability reducing technology

Refer to Clause A13.4.5.5 of Chapter 13.

A14.6.5.6 Pigments and colouring agents

All pigments and colouring agents for concrete shall comply with ASTM C979 or EN 12878, in particular only Category B pigments shall be used for reinforced or prestressed concrete.

A14.6.5.7 Fibres

All steel fibres for concrete shall comply with EN 14889-1 or ASTM A820 and all polymer fibres shall comply with EN 14889-2 or ASTM D7508. All fibres shall be submitted to the Engineer for approval prior to the commencement of work.

It is common practice to utilise fibre lengths up to 30 mm for the dry process and up to 40 mm for the wet process and the length of fibres shall not exceed 70 per cent of the minimum internal diameter of the pipes and hoses used, unless it has been proven that longer fibres can be used without blockages.

A14.6.5.8 Reinforcement

All reinforcement shall comply with Section A14.3 of the specification. The reinforcement type and description shall be shown on the drawings. Where chemical anchoring of the reinforcement is required, it shall be shown on the drawings and shall comply with Section A14.5 of the specification.

A14.6.5.9 Compressive strength, tensile splitting strength, flexural strength, or energy absorption capacity

The Contractor shall be responsible for the design of the sprayed concrete mix and for the proportions of the constituent materials necessary for producing sprayed concrete that complies with the requirements for each class of sprayed concrete.

The class of sprayed concrete is indicated by the designated code SP, the characteristic cylinder strength in MPa at 28 days, and the characteristic cube compressive strength in MPa at 28 days. For example, SP25/30 means sprayed concrete with a characteristic cylinder strength of 25 MPa after 28 days or characteristic cube strength of 30 MPa after 28 days.

Where required, the minimum tensile splitting strength, flexural strength or energy absorption capacity requirements shall be specified on the drawings.

A14.6.5.10 Drainage and weepholes

All weephole material shall be unplasticised PVC pipes and shall comply with SANS 966-1.

All water collection pipes shall be perforated or slotted unplasticised PVC pipes that shall comply with SANS 791 or perforated pitch-fibre pipes that shall comply with SANS 921. The size of perforations in perforated pipes shall in all cases be 8,0 mm in diameter plus or minus 1,5 mm, and the number of perforations per metre shall not be fewer than twenty-six for 100 mm pipes and fifty-two for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and in four rows for 150 mm pipes. Slotted pipes shall have a slot width of 8,0 mm with a tolerance of 1,5 mm in width. The arrangement of slots shall be subject to the Engineer's approval, but the total slot area shall not be less than that specified for perforations.

Pipes without slots or perforations required for transporting water from the drainage system to the point of discharge shall be unplasticised PVC or unperforated pitch-fibre pipes of the types specified above.

All geocomposite band drains, geotextile and geosynthetic filter fabric shall be of the type and grade specified on the drawings. These materials shall be protected against sunlight and mechanical damage during storage and installation. All geotextiles and geosynthetic filter fabric shall be a non-woven, spun or thermic-bonded continuous filament fabric consisting of at least 85 per cent by mass of polypropylene, polyester or other approved material and manufactured for civil-Engineering applications by a recognized manufacturer.

A14.6.5.11 Embedded instrumentation

All specified instrumentation shall be installed prior to the application of sprayed concrete and protected until the sprayed concrete has reached its specified characteristic strength.

A14.6.5.12 Curing compound

Refer to Clause A13.4.5.9 of Chapter 13.

A14.6.5.13 Storing the materials

a) General

Constituent materials shall be stored and handled so that their properties do not change significantly, for example by action of climates, intermingling or contamination, and that their conformity with the respective standard is maintained.

b) Cement and supplementary cementitious materials

Cementitious binder materials stored on the site shall be kept separately under cover which provides adequate protection against moisture and other factors which may promote deterioration of the cement or supplementary cementitious material.

Cementitious binder may only be used if stored and maintained at a temperature less than 45°C. In hot weather concreting conditions, the cementitious binder storage facilities shall be painted with white high solar reflectance paint and insulated to reduce any temperature rise in the stored cement or supplementary cementitious material.

Cement or supplementary cementitious material supplied in bags shall be closely and neatly stacked to a height not exceeding twelve bags and arranged so that they will not be in contact with the ground, the floor or the walls, and can be used in the order in which they were delivered to the site.

Cement or supplementary cementitious material supplied in bulk shall be stored in waterproof containers so designed as to prevent any dead spots from forming, and the cement drawn for use shall be measured by mass.

Cementitious binder shall not be kept in storage for longer than eight weeks without the Engineer's permission, and different brands or types of the same brand of cement or supplementary cementitious material shall be stored separately.

c) Prebagged sprayed concrete mixture

Dry prebagged sprayed concrete mixtures shall comply with EN 1504-3 and shall be stored on site according to the requirements for storing cement or supplementary cementitious material. The prebagged sprayed concrete mixture shall not exceed the shelf life determined by the manufacturer and shall not be kept in storage for longer than 8 weeks without the Engineer's permission.

d) Aggregates

Aggregates of different nominal sizes shall be stored separately and in such a manner as to avoid segregation from occurring. Intermixing of different materials and contamination by foreign matter shall be avoided. Aggregates exposed to a marine (XS) environment (refer Table A13.4.7-2 of Chapter 13 shall be covered to protect them from salt contamination.

Fine aggregate shall be stored in such a manner that the moisture content is kept constant at all times. The moisture content of fine aggregate stockpile shall not exceed 8 % by mass when a dry mix sprayed concrete is used.

In hot weather concreting conditions, both the coarse- and fine-aggregate stockpiles shall be shaded from the sun.

Where concrete is batched on site, the aggregates shall be stored in covered bins with minimum 150 mm thick concrete floor slab constructed below the aggregate stockpile area to prevent contamination during the storing and handling the aggregate. An additional 3,0 m wide concrete apron slab, minimum 150 mm thick, shall be constructed at the outer mouth of the stockpile. This slab shall be sloped for drainage away from the main stockpile area. The aggregates shall be tipped on the concrete apron slab at the mouth of the stockpile to prevent contamination during the tipping and hoisting the aggregate.

(e) Storage capacity

The storage capacity provided and the quantity of material stored, whether cement, supplementary cementitious materials, aggregates, admixture or water, shall be sufficient to ensure that no interruptions to the progress of the work will be occasioned by any lack of materials.

(f) Deteriorated material

Deteriorated, contaminated or otherwise damaged material shall not be used in sprayed concrete. Rebound material shall be deemed to be contaminated material. Such material shall be removed from the site without delay.

A14.6.6 CONSTRUCTION EQUIPMENT

A14.6.6.1 General

Plant used for the sprayed concrete application shall be based on proven technology within the industry, and shall be in good working order. The plant shall be inspected, serviced and calibrated at regular intervals and tested to ensure that the system functions efficiently and accurately, all to the satisfaction of the Engineer.

A14.6.6.2 Mixing and batching

Cement, supplementary cementitious materials, aggregates, integral permeability reducing technology, fibres, pigment and colouring agents, admixtures and additions in the form of powders shall be batched by mass to an accuracy of 3 %. Where permitted by the Engineer, volume batching may be permitted on the basis of an acceptable quality assurance procedure. The quality assurance procedure shall include, but not be limited to, the use of accurate gauge boxes of an approved design that acceptably takes account of the bulking factors of the fine aggregates. Cementitious binder shall be measured by mass where volume batching is permitted.

For wet- and dry-mix spraying methods, the mixer shall be capable of achieving a uniform distribution of the constituent materials. Mixing shall continue until the mix has a homogenous appearance, ensuring the complete coating of the fine aggregate particles with cementitious binder, and for a period of at least 90 seconds thereafter. Special care shall be taken when adding integral permeability reducing technology, fibres, and pigments and colouring agents to the mix in order to ensure a uniform dispersion in the mix.

Any mix split during handling or ejected from the spraying equipment shall not be re-used. The mix shall be screened prior to loading the gun to prevent the inclusion of stones, cement bag scraps or other foreign materials in the mix. Prepared batches shall be discharged through the nozzle within 60 minutes of mixing.

A14.6.6.3 Delivery and spraying equipment

The type and capacity of the delivery hoses and nozzles shall be such as to ensure a uniform mix and supply of the mix ingredients to the mixing nozzle, thereby obtaining the correct consistency and a uniform discharge rate from the nozzle.

The Contractor shall provide on-site a standby hose of capacity similar to the one in use to maintain continuity of work in case of a hose blockage. Hoses shall be blown clean before any work is stopped.

a) Dry-mix process

The air operating pressure supply at the gun outlet shall not be less than 240 kPa, and in any case such as to maintain a discharge nozzle velocity of between 90 to 120 metre per second. Water which is added at the nozzle shall be supplied at a uniform pressure of not less than 100 kPa greater than the air pressure at the nozzle.

The sprayed concrete shall be applied as dry as practicable to prevent shrinkage cracking, while ensuring a compacted dense homogeneous mass. Appropriate measures shall be taken to ensure that the fresh concrete remains sufficiently workable until the end of spraying.

Dry mix compositions with moist aggregate shall normally be applied within 60 minutes after mixing and shall be discarded after such elapsed period. If more than 60 minutes is required until the end of the spraying of a batch, the open time provided by the chosen measures shall be demonstrated and verified in advance to the satisfaction of the Engineer.

Dry mix composition with oven or kiln dried aggregate may be stored for a limited time but shall be applied immediately after mixing with water. Oven or kiln dried material should be pre-dampened before the nozzle or before it is loaded in the spraying machine. When adverse weather conditions require the use of quickset cement, the procedure shall be adjusted to allow for the limited open time of the mix.

Detrimental changes in the dry mix, such as segregation, or other changes shall be minimized during loading, transporting and unloading as well as during conveying on site. The plant shall be chosen, screened off and suitably controlled in a manner that prevents excessive cement dust generation and aggregate separation.

b) Wet-mix process

The air compressor and delivery hose lines shall be of adequate capacity and size to provide a minimum pressure of 240 kPa at the nozzle for 25 mm nozzles and proportionally greater for larger nozzles. Appropriate measures shall be taken to ensure that the mixed constituents remain sufficiently workable until the end of spraying. The normal workability time shall be determined by pre-construction tests on test panels. If the work requires longer workability times it shall be verified by additional tests. Wet mix compositions shall be applied within 60 minutes after mixing and shall be discarded after such elapsed period. Detrimental changes to the base mix, such as segregation, bleeding, paste loss or other changes shall be minimized during loading, transporting and unloading as well as when being conveyed on site.

A14.6.7 EXECUTION OF THE WORKS

A14.6.7.1 Mix design

The Contractor shall submit for approval details of the proposed sprayed concrete mix proportions prior to the commencement of sprayed concrete activities. The sprayed concrete operations shall only commence with the approval of the mix design. The Contractor shall adequately allow sufficient time in his programme for the design and approval of the concrete mix design. The mix ingredients and material source shall not be altered during the course of the construction without prior approval of the Engineer. The sprayed concrete shall be designed to yield a 28-day characteristic compressive strength as shown on the drawings for the different application areas.

A14.6.7.2 Certification of skilled operators

Only experienced foremen, gunmen, nozzle men and rodmen shall be employed, and satisfactory evidence of such experience shall be furnished when requested by the Engineer. Nozzle men shall be highly skilled craftsmen with demonstrable personal project history exceeding 4,000 hours of spraying concrete as the responsible nozzle man or minimum 5 years' referenced experience as the responsible nozzle man. With the qualifying exception of demonstrable practical experience specified above, the nozzle man shall be trained and certified as a nozzle man for the proposed sprayed concrete process and proposed spraying orientation by the Sprayed Concrete Association (UK), American Shotcrete Association, American Concrete Institute or other relevant certification authority approved by the Engineer.

A14.6.7.3 Preconstruction trial panels

The Contractor shall provide trial panel formers made of nominal 20 mm thick shutter ply, to form sprayed concrete panels with approximate size 700 mm by 700 mm at the front face, and 400 mm by 400 mm at the back face. The sprayed concrete panel shall be 150 mm thick and all forms around the perimeter of the sample shall be tapered inwards at depth to horizontal offset ratio of 1:1. Where instructed by the Engineer, a light expanded metal mesh may be used to line the formwork prior to spraying the trial panel. The expanded metal mesh shall stand at least 150 mm proud of the front face of the panel. Core samples obtained from the trial panels shall be used to determine the compressive strength.

Where tensile splitting strength requirements are specified, additional samples will be required

Where ultimate flexural strength requirements are specified, additional trial panels will be required.

Where energy absorption capacity is specified, specimen slabs constructed in accordance with EN 14488 shall be required.

A14.6.7.4 Surface preparation

a) Concrete surfaces

Concrete surfaces that are to receive a layer of sprayed concrete shall be mechanically prepared to expose the aggregate in a rough but generally uniform surface with amplitude of approximately 5,0 mm. All loose, spalling and soft concrete shall be removed to expose only sound concrete.

The treated surface shall be cleaned with minimum 250-bar high-pressure water jet as a final preparation. The concrete substrate shall be wetted immediately prior to the application of sprayed concrete.

The area to be repaired shall be bounded by straight line edges cut to the required depth using a diamond cutting saw, angle grinder or other approved equipment. The edges shall be recessed such that the patch has a thickness at the edge of at least twice the maximum aggregate size of the sprayed concrete mix, but not less than 20 mm.

b) Embedded reinforcement

Exposed reinforcement shall be cleaned of all corroded material by wire brushing using power tools or sandblasting to a clean metal finish. Concrete around corroded reinforcing bars shall be chiselled away with a minimum clearance of three times the maximum sprayed concrete aggregate size between concrete and reinforcement, such that the bars can be cleaned satisfactorily. Where specified on the drawings, the cleaned reinforcement shall be coated with an active anti-corrosion coating complying with EN 1504-7 and approved by the Engineer.

A14.6.7.5 Formwork

Formwork shall be selected to ensure that the appearance and finish of the sprayed concrete is consistent with the existing structural member. Formwork and shooting strips for sprayed concrete shall be employed to ensure square corners, straight lines, and a plane surface of sprayed concrete, except as otherwise permitted by the drawings or approved by the Engineer. Chamfer and fillets shall be aligned and sized to suit the appearance of the existing structure. Formwork and shooting strips shall be designed and placed to avoid pockets of rebound

A14.6.7.6 Fixing of reinforcement

At the time of application of the sprayed concrete, the reinforcing steel shall be free from loose or powdery rust, mill-scale, hardened rebound or any other coating which may reduce the bond strength or have a deleterious effect on the steel or sprayed concrete.

The reinforcement shall be fixed and positioned in accordance with the requirements of the Section A14.3 of the specification and as indicated on the drawings.

A14.6.7.7 Weather limitations

Sprayed concrete shall not be placed on a frozen surface or when the ambient temperature is less than 5°C; nor shall it be placed when it is anticipated that temperature during the following 24 hours will drop below 1°C. The application of sprayed concrete shall be suspended if high winds prevent proper application, or rain occurs which would wash out the sprayed concrete mortar.

A14.6.7.8 Application of sprayed concrete

Before spraying concrete, the mix temperature and consistence of the concrete on site shall be monitored and controlled to ensure conformity. All adjustments of the concrete stream through the nozzle, whether air pressure, accelerator or concrete stream, shall only be

performed when the nozzle has been turned away from the substrate. Sprayed concrete shall be composed and sprayed in a manner to limit rebound. Important factors influencing rebound, such as concrete composition, nozzle angle and distance to the substrate, accelerator dosage, particular area of application, etc shall be carefully controlled and monitored on a continuous basis during the application by competent supervisory staff of the Contractor.

The nozzle shall be directed, wherever possible, normally to the application surface, to produce a layer of optimum density and thickness, with full encasement of the reinforcement and minimum rebound. The distance between the nozzle and the surface is determined according to the site conditions and the possibility to obtain good compaction, full encasement of the reinforcement and minimum rebound. Generally, a distance of 1,0 m to 2,0 m is recommended, although site conditions may dictate an application distance outside the suggested range.

The thickness of each sprayed concrete layer depends on several parameters and shall be based on site conditions and composition of the mix. The specified nominal sprayed concrete thickness may necessitate the application of two or more layers in order to avoid sagging and sloughing, particularly with overhead work. The thickness of the layer may be increased by the use of admixtures such as accelerators, additions such as silica fume, or the use of quick-setting cements.

A subsequent layer shall not be applied before the preceding layer is able to support it. Should considerable time elapse between the placement of the different layers to obtain the specified nominal thickness, the previously sprayed concrete shall be cleaned either by blowing with compressed air, high pressure washing, brushing or sand blasting and prewetted until the suction of the substrate and the consequent risk of an adverse influence on the subsequent sprayed concrete layer is mitigated and approved by the Engineer.

All sprayed concrete shall be of a homogenous composition without any inclusion of rebound. Overspray and loose rebound material shall be removed from surrounding areas and from the substrate before sprayed concrete is applied to the new or subsequent section. Prewetted substrates shall be free from standing or running water.

When spraying on or through reinforcement, the consequence of rebound and shadow effects shall be carefully taken into account and particular attention given to minimize all possible negative effects. Mitigation measures may include ensuring that the air stream velocity around the reinforcement is sufficient, and ensuring the encapsulation of reinforcement is completed as soon as practical with adequate cover over the reinforcement and preventing poor compaction, if spraying with fibres onto other types of reinforcement.

A14.6.7.9 Surface finish

The finished surface shall have a neat, smooth, even and uniform finish free from rebound pockets or other defects. The types of finish are designated on the drawings by the following:

- (i) GU : Undisturbed nozzle finish
- (ii) GT : Trowelled finish
- (ii)(1) GTB : Trowelled and brushed
- (ii)(2) GTF : Trowelled and flash-coated
- (ii)(3) GTW : Trowelled and wood-floated.

The general procedure for achieving the required finishes shall be as follows:

(i) *Undisturbed nozzle finish (GU)*

The sprayed surface shall be brushed with a soft plasterer's brush approximately one hour after placement to remove adhering rebound dust and to prevent surface crazing.

(ii) *Preparation for final treatment*

Wherever a trowelled finish is required, the primary sprayed concrete layer shall receive a typical GU finish and shall fully encapsulate all embedded reinforcement and instrumentation. After curing the primary sprayed concrete layer, the exterior surface shall be lightly sandblasted to remove surface laitance and sprayed with water and kept wet for at least 1 hour and then allowed to dry to a surface dry condition prior to application of the final sprayed concrete layer.

(iii) *Trowelled finish (GT)*

Wherever a trowelled finish is required, a thin layer of sprayed concrete approximately 25 mm thick shall be applied as a final layer. Any high points from the preceding layer shall be trimmed to ensure that the final layer thickness has uniform thickness. The Contractor shall exercise special care to ensure a uniform appearance on all exposed surfaces consistent with the finish of the remaining portions of the structure.

The surface of the final sprayed concrete layer shall be trowelled when the sprayed concrete exhibits initial set to obtain a uniform curved or plain surface true to line. On vertical surfaces all additional treatments shall be worked in an upward direction. All surfaces that require a trowelled finish shall then receive one of the following additional treatments as specified on the drawings:

1) Brush-coated (GTB)

Coating of the trowelled surface with a cement mortar slurry using a soft broom or brush to give a soft "brushed effect".

2) Flash-coated (GTF)

Coating the trowelled surface with a thin uniform layer approximately 3,0 mm thick of sprayed concrete at least four hours after trowelling but not later than eight hours.

3) Wood-floated (GTW)

Floating the trowelled surface with a wood float to produce a smooth even surface free from trowel marks.

A14.6.7.10 Rebound material

Rebound material shall not be re-used. Rebound material shall be removed from all future working areas and may not be covered up by subsequent applications of sprayed concrete. Rebound material shall also be cleaned from the surface of any finished work.

Where large coarse aggregate in excess of 10 mm is used, higher rebound volumes are anticipated.

When fibres are used, there is the possibility of increased proportion of fibres in the rebound and the appropriate corrections to the mix design process shall be taken into account.

A14.6.7.11 Properties of hardened sprayed concrete

a) Compressive strength

For the purposes of determining compressive strength, the characteristic cylinder strength shall be determined using 75 mm diameter, 150 mm high cylinders drilled from either test panels or the structure, prepared strictly in accordance with SANS 3001-CO2-2 and tested in accordance with SANS 3001-CO2-3 at 28 days taking due cognisance of clause A20.1.5.1a) and b) of Chapter 20.

Table A14.6.7-1: Compressive strength classes for sprayed concrete

Compressive strength class	Minimum characteristic cylinder strength, MPa
SP12	12
SP16	16
SP20	20
SP25	25
SP28	28
SP32	32
SP35	35
SP40	40

For particular uses, it may be necessary to specify the compressive strength at ages earlier or later than 28 days, or after storage under special conditions. In assessing the strength, other sizes of specimens and other curing regimes may be used provided that the relationship to those standardized has been established and documented.

b) Tensile splitting strength

The tensile splitting strength shall be determined at 28 days in accordance with SANS 3001-CO2-6.

c) Flexural strength

The flexural strength shall be determined from beam specimens cut from test panels, tested at 28 days in accordance with SANS 3001-CO2-5.

d) Energy absorption capacity

The energy absorption capacity shall be determined from a slab specimen, tested at 28 days, in accordance with EN 14488-5, and shall conform to the specified energy absorption class defined in Table A14.6.7-2.

Table A14.6.7-2: Energy absorption classes and values

Energy absorption class	Energy absorption for deflection up to 25 mm (J)
E500	500 to 690
E700	700 to 990
E1000	1000 and greater

A14.6.7.12 Construction joints

Once a section of work has commenced the application of the sprayed concrete shall be continuous up to the construction joints shown on the drawings or up to approved locations. All construction joints shall be wet and cleaned with compressed air or minimum 250-bar high pressure water jetting before joining the next day's work.

Irregular edges shall be cut back to straight lines before commencing with further work.

A14.6.7.13 Weepholes

New and additional weepholes comprising nominal 50 mm diameter unplasticised PVC piping shall be installed at those positions indicated on the drawings or otherwise instructed by the Engineer. The pipe shall protrude minimum 25 mm beyond the final sprayed concrete layer and have its inner end wrapped with a single layer of geotextile. It is required that weepholes be positioned to intersect seepage anticipated from soft zones and the weepholes shall be positioned prior to the application of the initial sprayed concrete layer with the geotextile end hard against the substrate face.

Where existing weepholes are extended, unplasticised PVC piping with nominal diameter selected so as not to impede the internal drainage capacity and fit snugly around the existing weepholes outlet shall be selected. The overlap of existing and new weephole shall be at least 30 mm for nominal 50 mm and smaller diameter pipes, or proportionately more for larger diameter pipes, to ensure a stable and reliable connection. Any annular gap between new and existing weephole pipes shall be sealed using a thixotropic, epoxy-based putty or similar material. The outer ends of the weephole pipes shall be adequately protected during the application of sprayed concrete.

A14.6.7.14 Test panels

The Contractor shall produce a test panel, fully complying with the requirements for a preconstruction trial panel, alongside every new stage of the work, minimum one panel required per lot of sprayed concrete, and at least one per day. At the start of, or during the work, the nozzle operator shall produce test panels alongside and in similar orientation to the work. These test panels shall be protected and cured in the same manner as the work. Sufficient test panels shall be produced by the Contractor to ensure that all compressive strength, tensile splitting and where required flexural strength tests, are routinely performed.

A14.6.7.15 Protection of adjacent work

During the progress of the work, adjacent facilities which may be permanently discoloured, stained, or otherwise damaged by overspray, dust or rebound, shall be adequately protected and, if contacted, shall be cleaned at the cost of the Contractor by early scraping, brushing, or washing, as surroundings permit.

A14.6.7.16 Blasting restriction and demolition limitation

In order to reduce possible damage to the sprayed concrete, no blasting shall be carried out within 50 m of a sprayed concrete section within 72 hours of application of the sprayed concrete. No demolition activities may take place on structural elements where sprayed concrete has been sprayed within 48 hours of application.

A14.6.7.17 Protection and curing

a) Protection from adverse environmental conditions

The finished sprayed concrete surface, including all intermediate layers, shall be protected from drying out and direct sunlight by all suitable means subject to the approval of the Engineer. The ambient temperature, the relative humidity, sprayed concrete temperature and wind speed shall be actively monitored to ensure that the rate of evaporation is minimised and at all times limited to maximum 1,0 kg per square metre per hour in accordance with ACI 305R or the Concrete Society of Southern Africa technical report on Concrete Curing (November 1991, ISBN 0-620-16248-1).

Where the ambient temperature exceeds 30°C, the formwork, reinforcement, and all surfaces that will come into contact with the sprayed concrete shall be shaded and cooled to below 30°C to the satisfaction of the Engineer.

Measures shall be taken to protect against frost when spraying in cold weather, or when spraying against frozen concrete, rock and soil surfaces. Such protection shall be in place until the sprayed concrete has developed a compressive strength of at least 5 MPa.

b) Curing

Intermediate layers of sprayed concrete shall be cured by spraying with a continuous uniform water spray commencing maximum 8 hours after application and remain in place for a continuous period of 24 hours. Alternatively, the sprayed concrete surface can be covered with two layers of 340 gram per square metre hessian commencing maximum 6 hours after application and maintaining the saturation of the hessian layers for 30 continuous hours.

The final layer of sprayed concrete, including all specified surface finishes, shall be cured by an approved curing compound sprayed onto the completed surface at a minimum application rate approved by the Engineer, applied within one hour after application, or alternatively cured using the same methods indicated for intermediate layers except that curing measures be continuously maintained for 5 days after spraying.

Rapid drying of the sprayed concrete at the end of the curing period must be prevented.

A14.6.8 WORKMANSHIP

A14.6.8.1 Tolerances

The Contractor shall apply the sprayed concrete and finish the surface to the tolerances specified on the drawings, or if none is specified, to the tolerances contained in Section A14.2, except that the following additional requirements shall be required:

a) Thickness:

- *Mean depth per sample:*
Minimum 100 % of specified layer thickness;
Maximum thickness not specified.
- *Individual depth at any location:*
Minimum 80 % of specified layer thickness;
Maximum thickness not specified.

b) Surface regularity:

The maximum value of any individual irregularity measured with a 3,0 m straight edge, or custom template for curved surfaces, that ensures the specified layer thickness is achieved, shall not exceed 20 mm.

A14.6.8.2 Criteria for compliance with the requirements

Routine inspection and quality control shall be performed by the Engineer. Compressive strength shall be determined using cored cylinder specimens prepared in accordance with SANS 3001-CO2-2 and tested in accordance with SANS 3001-CO2-3 at the age of 28 days. The tensile splitting strength shall be determined in accordance with SANS 3001-CO2-6 at 28 days. The flexural strength shall be determined from beam specimens prepared from test panels and tested at 28 days in accordance with SANS 3001-CO2-5.

The criteria for compliance with the requirements specified for 28-day characteristic compressive, strength shall be as specified in Section A20.24 and Clause A20.2.5 of Chapter 20 for full acceptance, and as specified in Clause A20.2.6 of Chapter 20 for conditional acceptance. If the Engineer is satisfied that the requirements of the Contractor's process control have been met, the Engineer may decide at his discretion to use the Contractor's test results in the evaluation of the concrete.

A14.6.8.3 Procedure in the event of non-compliance with the requirements

Any lot represented by test samples failing to comply with the criteria specified above for the characteristic strength shall be rejected.

The Engineer may at his discretion allow the following tests to be conducted in order to decide whether the concrete may be left in position at further reduced payment:

The Engineer may allow the elements or units concerned to be cured for an additional period not exceeding 56 days. Thereafter the Contractor shall drill samples from the structure and test core samples in accordance with SANS 3001-CO2-2 and the Engineer may evaluate these cores in accordance with SANS 10100-2.

In all cases where sprayed concrete has been supplied which fails to comply with the requirements, the Contractor shall immediately take the required remedial action by changing the mix proportions to obtain the required strength.

A14.6.8.4 Tests ordered by the Engineer

The Engineer may order the Contractor to have concrete cores, flexural beams, or energy absorption slabs, which have been prepared under the direction of the Engineer, tested at an approved testing laboratory, in which case payment will be made for such tests in accordance with the provisions of Section C20.1 of Chapter 20.

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B14.6 SPRAYED CONCRETE FOR STRUCTURES

PART B: LABOUR ENHANCEMENT

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- B14.6.1 SCOPE**
- B14.6.2 DEFINITIONS**
- B14.6.3 GENERAL**
- B14.6.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS**
- B14.6.5 MATERIALS**
- B14.6.6 CONSTRUCTION EQUIPMENT**
- B14.6.7 EXECUTION OF THE WORKS**
- B14.6.8 WORKMANSHIP**

B14.6.1 SCOPE

This Section covers the supply and application of sprayed concrete in the rehabilitation of structures and miscellaneous work requiring cast concrete-like finish as shown on the drawings. It shall include the supply and application of the sprayed concrete by either the dry-mix or wet-mix method and the preparation required prior to- and post-spraying, protection and treatment of the sprayed concrete. This specification is deemed to be activities associated with specialist skills level, and is suitable for labour enhanced work.

B14.6.2 DEFINITIONS

The provisions of Part A, shall apply.

B14.6.3 GENERAL

The provisions of Part A, shall apply.

B14.6.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A, shall apply.

B14.6.5 MATERIALS

The provisions of Part A, shall apply.

B14.6.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.6.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply.

B14.6.8 WORKMANSHIP

The provisions of Part A, shall apply.

C14.6 SPRAYED CONCRETE FOR STRUCTURES

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

Payment for items in this section shall include full compensation for all works associated with any additional temporary works, execution of the work and quality assurance procedures which are not separately covered by the measurement and payment items of the specification. All costs associated with general access, work platforms and temporary works not included under Section A14.1, shall be included in the tendered rates.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.6.1	Establishment on site for sprayed concrete work	Lump Sum

The unit of measurement shall be the lump sum and payable in two instalments as follows:

- (i) 50 % of the sum in the interim payment certificate following the establishment of the necessary equipment on site to the satisfaction of the Engineer; and
- (ii) the remaining 50 % of the sum after the work has been accepted and the installation team has left the site.

The tendered rate shall include full compensation for the establishment and subsequent removal from site of all the equipment, transport, plant, access platforms, scaffolding, materials and labour necessary to carry out the specified work.

Item	Description	Unit
C14.6.2	Preparation of concrete surface	square metre (m ²)

The unit of measurement shall be the square metre surface area that is prepared for application of sprayed concrete.

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to adequately prepare the concrete surface. It shall also include the cleaning and treating of embedded and exposed reinforcement.

Item	Description	Unit
C14.6.3	Sprayed concrete of specified strength class, thickness and finish applied in one or multiple layers as necessary:	
C14.6.3.1	Indicate strength, thickness, finish of sprayed concrete to portion of structure or use	square metre (m ²)
C14.6.3.2	Etc. for other strength, thickness, finish of sprayed concrete to other portions of structure or uses	square metre (m ²)

The unit of measurement is the square metre of sprayed concrete, of specified class and thickness in position as indicated on the drawings.

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to supply, mix, apply, finish and protect the sprayed concrete layer in position. The tendered rate shall include for everything necessary to carry out the specified work to the satisfaction of the Engineer and shall include the following:

- (i) Supplying all materials, including admixtures, pigments and colouring agents, fibres, and other additives, mixing and applying sprayed concrete including test sections as ordered by the Engineer, either to prove the adequacy of the various additives or the sprayed concrete methods and materials;
- (ii) Cleaning down the prepared bonding face with minimum 250-bar high pressure water jetting as ordered, and the removal of all resulting concrete demolition products, soil and rock debris from the site to an approved spoil site, including all loading and transport;
- (iii) Taking appropriate precautions for applying and protecting sprayed concrete in adverse weather;
- (iv) Applying the sprayed concrete in one, or more layers as directed by the Engineer;
- (v) Checking the thickness in the manner specified;
- (vi) Cleaning off all rebound material and overspray and the disposal of same at an approved spoil site;
- (vii) Making test specimens as specified; and
- (viii) Laboratory testing and reporting of relevant material properties

No separate or additional payment shall be made for sprayed concrete applied to a thickness greater than specified and required, nor shall any additional payment be made for sprayed concrete whether applied in one or more layers. Any formwork, reinforcement and prestressing work shall be measured separately according to the relevant sections of the specifications.

Item	Description	Unit
C14.6.4	Curing of sprayed concrete surface	square metre (m ²)

The unit of measurement shall be the square metre of completed sprayed concrete element cured using an approved method as described in the specification irrespective of the number of layers used.

The tendered rate shall include full compensation for all labour, materials, equipment and plant as well as for all work and incidentals required to adequately cure the sprayed concrete surface. It shall also include the supply and application of curing compounds in accordance with the product manufacturer's specified nominal rates of application satisfying ASTM C309 as amended in the specification.

Item	Description	Unit
C14.6.5	Special tests ordered by the Engineer	Provisional Sum

The provisional sum provided to cover the cost of special tests as requested by the Engineer in terms of Clause A20.1.16 of Chapter 20 shall be expended in accordance with the provision of the general conditions of contract. Payment will not be made for any special test should the test indicate that the specifications have not been complied with.

D14.6 SPRAYED CONCRETE FOR STRUCTURES

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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D14.6.9 NOTIFICATION OF REMEDIAL WORK

D14.6.10 REMEDIAL WORK

D14.6.1 SCOPE

The scope of this Section covers the following:

- Product conformance specifications
- Performance specifications

D14.6.2 GENERAL

D14.6.2.1 Product conformance specifications

The Contractor shall within 28 days of entering into the contract with the Employer submit to the Engineer conformance documentation related to the specifications. All products used in the manufacture and installation of sprayed concrete for structures shall be in compliance with the specifications continued in Section A14.6.

Compliance documentation shall be provided for:

- (a) Cement (Clause A14.6.5.1a))
- (b) Supplementary cementitious materials (Clause A14.6.5.1b))
- (c) Aggregate (Clause A14.6.5.2)
- (d) Water (Clause A14.6.5.3)
- (e) Admixtures (Clause A14.6.5.4)
- (f) Integral permeability reducing technology (Clause A14.6.5.5)
- (g) Pigments and colouring agents (Clause A14.6.5.6)
- (h) Fibres (Clause A14.6.5.7)
- (i) Reinforcement (Clause A14.6.5.8)
- (j) Drainage and weepholes (Clause A14.6.5.10)
- (k) Curing compound (Clause A14.6.5.14)
- (l) Testing necessary to prove the satisfactory execution of the works (Clause A14.6.7)
- (m) Certification of skilled operators (Clause A14.6.7b))

D14.6.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.6.3.1 Performance specifications

Performance based specifications shall be contained in the Contract Documentation for the project.

A14.7 PROTECTIVE COATINGS AND TREATMENTS FOR CONCRETE

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PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.7.1 SCOPE

This Section covers the material, equipment and work required for applying protective coatings and treatments to concrete surfaces.

A14.7.2 DEFINITIONS

Hydrophobic impregnation - involves the surface treatment of concrete to produce a water-repellent surface. The pores and capillaries are internally coated, but they are not filled. There is no film on the surface of the concrete and there is little or no change in its appearance. Active compounds may be, for example, silanes or siloxanes.

Sealers and pore blockers - involve the treatment of concrete to reduce the surface porosity and to strengthen the surface. The pores and capillaries are partially or totally filled. This treatment usually leads to a discontinuous film on the concrete surface. Binders for sealer and pore blockers may be, for example, organic polymers. Typical pore blocker materials react with the concrete substrate, for example calcium hydroxide present in hydrated cement, to form crystals. Other fluids such as resins and drying oils penetrate and harden by chemical reaction. Characteristic examples are silicates, silicon fluorides, methacrylates and epoxy resins. Sealers are more viscous fluids which both penetrate the concrete and form a thin film on its surface. They are most often utilized as sealing coats or primers to a coating. The thin film of the sealer is vulnerable to weathering. Characteristic examples are epoxy resins, polyurethanes, and acrylics.

Coatings - result in a continuous protective layer on the surface of concrete. Binders for coating may be, for example, organic polymers, organic polymers with cement as a filler or hydraulic cement modified with polymer dispersion that produce a typical layer thickness from 0,1 mm to 5,0 mm.

Renderings - are thick film coatings, generally applied by trowel rather than by brush or spray. They work in a similar way as coatings, by providing a physical barrier but with mean layer thickness of at least 5,0 mm. Typical examples are cement mortar with various polymer additions or crystal growth systems.

Corrosion inhibitor - are emulsion type impregnating fluids that are applied to the outer surface of existing concrete members. Inhibitors migrate into concrete and are absorbed onto the surface of embedded reinforcing steel thus delaying the onset of corrosion and reducing the rate of corrosion that is in progress.

A14.7.3 GENERAL

A14.7.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.7.5 MATERIALS

A14.7.5.1 Hydrophobic impregnants

Concrete surfaces shall be impregnated with silane in liquid form containing minimum 99 % active ingredient. When silane is used in cream form, it shall contain minimum 80 % active ingredient and the manufacturer's application rate shall be proportionally increased to account

for the reduction in the active ingredient from 99 %. Silane impregnants shall comply with EN 1504-2. The hydrophobic impregnants shall be suitable for the following protective and remedial principles in accordance with EN 1504-9:

- a) Protection against ingress (Principle 1-Method 1.1),
- b) Moisture control (Principle 2-Method 2.1), or
- c) Increasing resistivity (Principle 8-Method 8.1).

Materials incorporating siloxane shall not be used on concrete surfaces. Plastered and masonry surfaces may be impregnated with siloxane and blended materials incorporating siloxane.

A14.7.5.2 Sealers and pore blockers

Concrete surfaces shall be treated with impregnation materials that comply with EN 1504-2. The surface impregnants shall be suitable for the following protective and remedial principles in accordance with EN 1504-9:

- a) Protection against ingress (Principle 1-Method 1.2),
- b) Moisture control (Principle 2-Method 2.1),
- c) Increasing physical resistance (Principle 5-Method 5.2),
- d) Resistance to chemicals (Principle 6-Method 6.2),
- e) Increasing resistivity (Principle 8-Method 8.2).

A14.7.5.3 Coatings

Coatings shall be applied to concrete surfaces according to EN 1504-2. Coatings shall be suitable for the following protective and remedial principles in accordance with EN 1504-9:

- a) Protection against ingress (Principle 1-Method 1.3),
- b) Moisture control (Principle 2-Method 2.3),
- c) Increasing physical resistance (Principle 5-Method 5.1),
- d) Resistance to chemicals (Principle 6-Method 6.1), or
- e) Increasing resistivity (Principle 8-Method 8.3).

A14.7.5.4 Renderings

Renderings shall be applied to concrete surfaces according to EN 1504-2. Rendering shall be suitable for the following protective and remedial principles in accordance with EN 1504-9:

- a) Protection against ingress (Principle 1-Method 1.3),
- b) Moisture control (Principle 2-Method 2.3),
- c) Increasing physical resistance (Principle 5-Methods 5.1 or 5.3),
- d) Resistance to chemicals (Principle 6-Methods 6.1 or 6.3),
- e) Preserving or restoring passivity (Principle 7-Method 7.1) or
- f) Increasing resistivity (Principle 8-Method 8.3).

A14.7.5.5 Corrosion inhibitor

Corrosion inhibitors shall consist of an aqueous solution of amino alcohols and salts of amino alcohols. Corrosion inhibitors that are applied to the concrete surface shall be capable of penetrating the concrete down to the depth of reinforcement. The effective migration of the inhibitor shall be assessed based on the manufacturer's standard qualitative or quantitative test method to confirm the depth and rate of penetration of the corrosion inhibitor.

The corrosion inhibitor shall be suitable to control anodic areas according to EN 1504-9 Principle 11-Method 11.3.

A14.7.5.6 Anti-graffiti protection

Anti-graffiti protective treatments shall be based on polyorganosiloxane polymers and solvent. Anti-graffiti protection shall provide permanent anti-graffiti and anti-fly poster protection to concrete, sprayed concrete and masonry surfaces. There shall be no requirement for additional application of the anti-graffiti protection after the cleaning operation. The anti-graffiti protection shall also provide excellent performance against exterior elements such as rain, sun, and temperature extremes. The anti-graffiti protection shall be diluted up to 30 % with white spirits, to enable application by long haired roller or brush.

The anti-graffiti protection shall ensure the removal of graffiti is effective by cold water or water jetting up to 100-bar pressure and rubbing the surface with clean, absorbent cloth or brush, and completely without the use of additional chemical agents.

The anti-graffiti protection shall be suitable for the following protective and remedial principles in accordance with EN 1504-9:

- a) Protection against ingress (Principle 1-Method 1.3)
- b) Resistance to chemicals (Principle 6-Method 6.2)"

A14.7.6 CONSTRUCTION EQUIPMENT

A14.7.6.1 General

All plant and equipment used for cleaning, surface preparation and application of protective treatment shall be based on proven technology and practice, and shall be maintained in a clean and good working order. The equipment shall be inspected, serviced and calibrated at regular intervals and tested to ensure that the system functions efficiently and accurately, all to the satisfaction of the Engineer. All work shall be carried out in accordance with the EMP.

A14.7.6.2 High-pressure water-jetting equipment

The type and capacity of the water-jetting equipment, delivery hoses and nozzles shall be capable of delivering up to 35 MPa, or 350-bar, water pressure and maintaining a minimum flow rate of 300 litres per hour through nozzles.

A14.7.6.3 Abrasive blasting equipment

Abrasive methods are required when the removal of a significant amount of concrete surface is required.

a) Water blasting with abrasives

Water blasting with abrasives is a cleaning system using a stream of water at pressure up to 35 MPa, or 350-bar, with an abrasive such as sand, aluminium oxide, garnet or other approved blast media, introduced into the stream.

b) Dry grit blasting

In dry grit blasting, abrasive particles are propelled at concrete and or steel surfaces in a stream of compressed air at a minimum pressure of 0,7 MPa, or 7-bar. The compressor size will vary to suit the size of the gritblasting pot. The abrasive medium typically consists of angular particles with a maximum particle size of 4,0 mm.

The dry grit blasting technique is associated with many common nuisances and shall only be permitted if appropriate method statement is approved by the Engineer.

c) Wet sandblasting

In wet sandblasting, the free particulate rebound that results from the sand being projected at the concrete surface, similar to dry grit blasting, is confined within a shroud of water.

A14.7.6.4 Low-pressure airless sprayer

Low-pressure airless sprayers consist of knapsack sprayers which shall be capable of providing a uniform discharge rate and even spread over the spray area.

A14.7.6.5 Access structures and working platforms

Where necessary the Contractor shall provide suitable and safe measures at each location for pressure cleaning and surface coating. These provisions shall be deemed to form part of the access for bridge rehabilitation as specified in Section A14.1.

A14.7.7 EXECUTION OF THE WORKS

A14.7.7.1 Storing of materials

The Contractor shall provide a lockable store for the repair materials and observe all storage requirements and safety precautions recommended by the manufacturer's instructions and applicable Regulations.

A14.7.7.2 Surface preparation

a) Procedures

All concrete surfaces that are to receive protective coatings or treatments shall be prepared strictly in accordance with the material manufacturer's instructions. The preparation shall include for everything that is necessary to prepare the surface to receive the protective coatings or treatments. In particular, all traces of curing compounds and formwork release agents shall be removed.

b) Permitted techniques

(i) High-pressure water-jetting

This technique shall be utilized to remove curing compounds or membranes, shutter release compounds and water-soluble contaminants without inadvertently damaging the concrete appearance and without producing an exposed aggregate finish. This method generally should not produce any significant increase in texture, profile, or pattern in the concrete.

(ii) Abrasive blasting

Abrasive methods shall be required when the removal of a significant amount of concrete surface is required.

Water blasting with abrasives can be used to remove dirt or other foreign matter and concrete laitance, typically exposing the fine aggregates.

Where permitted by the Engineer, dry gritblasting has the ability to remove the concrete surface. This technique may produce large quantities of airborne particulates, such as dust, and suitable precautions should be taken to protect labour, equipment and the environment.

Wet sandblasting generally produces less airborne particulates than dry sandblasting, however some inefficiency results from the interaction of the water shroud with some of the abrasive agents. The process is generally limited to cleaning the concrete surface.

c) Evaluation, inspection and approval of concrete surface

Weak, micro-cracked, damaged, delaminated and deteriorated concrete, including that caused by the selection of inappropriate techniques of cleaning, roughening or removal that reduces bond or structural integrity, shall be subsequently removed or remedied. The finished surface shall be visually inspected and tested by tapping with a hammer to detect loose concrete. Concrete removal shall be kept to a minimum and shall not reduce the structural integrity beyond the structure's ability to perform its function. Acceptable surfaces shall be free of oil, grease, loosely adhering concrete, and other contamination. Where required, projections or voids in the concrete surface shall be corrected prior to surface preparation.

The Contractor shall ensure that technical representatives, appointed or employed by the material suppliers, carry out regular inspections of the preparation work and provide written confirmation that the work is in accordance with the material supplier's instructions. The reports shall be specific and definitive, and generalised statements will not be acceptable.

Where surface preparation is found by the technical representatives to be inadequate the report shall contain specific advice to enable the Contractor to attain a required standard.

The Contractor shall provide the Engineer with copies of all technical inspection reports before any surface treatment or protective coating is applied to a structural element.

Where the time between surface preparation and treatment exceeds two days, during windy and or wet weather the prepared surfaces shall be reinspected and approved by the technical representative prior to application of the surface treatment or protective coating.

The moisture content of patch repair areas must be specifically checked by the technical representative to ensure that coatings are not applied over surfaces that contain excessive moisture.

A14.7.7.3 Batching and mixing

Mixing equipment, mixing times, working life and overcoating times shall conform to the manufacturer's instructions taking into account the ambient temperature, relative humidity, dew point and wind speed at time of application.

Treatment materials shall be mixed, if applicable, and applied strictly in accordance with the manufacturer's instructions. Thinning or diluting shall not be permitted without the approval of the Engineer.

A14.7.7.4 Protective surface treatment

Surface treatment or coatings may consist of a system of several coats of more than one type of coating. Where such a system is applied, the various components shall be compatible and sourced from one manufacturer.

Anti-graffiti and protective treatments shall be applied to the entire exposed concrete surface as indicated. Items or areas which are not to be coated shall be suitably protected or masked before application of the treatment.

a) Application of surface coatings

All protective coatings and treatments for concrete shall be stored, mixed and applied strictly in accordance with the product manufacturer's instructions and the specifications.

All surface coating materials shall be handled, mixed and applied strictly in accordance with the manufacturer's instructions.

b) Application rate records

Records of application rates shall be submitted by the Contractor to the Engineer on a daily basis indicating batch numbers, the area covered by each coat and the quantity of coating material used. Only material from the same batch shall be used for any continuous, visible, unbroken surface to attain uniformity of colour, appearance and texture on the concrete surface.

c) Trial sample panels

Protective treatment shall not be applied until trial sample panels of the protective treatment have been prepared by the Contractor and approved by the Engineer and the material supplier's technical representative.

The Contractor shall prepare the sample panels using the same surface preparation mixing and batching equipment, application technique, application rate and under the same climatic conditions he intends to treat the whole structure. The position of the trial sample panels are subject to the Engineer's approval.

Product manufacturers of coating products are required to inspect, assist and finally approve all aspects of surface preparation and product application employed on the trial sample panel.

The trial sample shall be used as a standard against which the rest of the work will be judged and shall be maintained intact until all other coating work is complete.

(i) Establishment of quality benchmarks

Trial panels shall be utilised to establish benchmarks for the evaluation of quality assurance parameters. The Engineer shall approve the set of relevant quality assurance indicators for the particular protective coating and treatment system, where no values are provided the values stated in Clause A14.7.5 shall apply. The quality assurance parameters may, amongst others, include:

- Permeability to water vapour according to EN ISO 7783-1 and 2.
- Permeability of carbon dioxide according to EN 1062-6.
- Capillary absorption and permeability to water according to EN 1062-3, or EN 13580 or ASTM D6489 for hydrophobic impregnants.
- Adhesion strength by pull-off test according to ASTM D7234 or EN 1542.

- Determination of film thickness according to ISO 2808.
- Crack bridging ability according to EN 1062-7.
- Depth of penetration according to EN 14630.
- Soundness and cleanliness of substrate according to ASTM D4258.

d) Proprietary protective surface coatings

The suitability of the protective surface coating for a particular application shall be proved by testing and submission of an approved industry track record of usage under similar circumstances. All proprietary protective surface treatments and coatings shall be subject to the requirements of performance based systems and shall conform to the requirements of Clause A14.7.7.

The Contractor shall submit details of proprietary protective surface coatings and proposed performance guarantee documentation to the Engineer for approval prior to its use in the permanent works.

A14.7.8 WORKMANSHIP

The Contractor shall ensure that only compatible materials are used for the surface treatment or protective coatings. All test results shall be reported to the Engineer and will be subject to the Engineer's approval.

The site weather conditions during the application of coatings and surface treatments shall be monitored and recorded as follows:

- Ambient temperature shall be recorded using thermometers with an accuracy of 1°C, in the direct vicinity of the works, but not subject to direct solar radiation.
- Ambient humidity shall be measured according to ISO 4677-1 and 2.
- Wind velocity shall be recorded using anemometers to record maximum values during application.
- Dew point shall be calculated according to ISO 4467-1 and 2, and the coating application for dew point affected materials shall proceed when the ambient dry temperature is at least 3°C above the dew point.

The permeability to water vapour of a protective coating system shall be evaluated in accordance with EN ISO 7783-1 and EN ISO 7783-2. Where breathability of the coating is required, the permeability to water vapour shall meet the requirements of $H_2O S_d < 5$ m (Class 1).

The permeability to carbon dioxide of a protective coating system shall be evaluated in accordance with EN 1062-6. Where the requirement for protection of the coating is required, the permeability to carbon dioxide shall meet the requirements of $CO_2 S_d \geq 50$ m.

The capillary absorption and permeability to water shall be evaluated in accordance with EN 1062-3, except that hydrophobic impregnating compounds shall be assessed in accordance with EN 13580 or ASTM D6489. Where the requirement for resistance to capillary absorption and permeability to water is essential, the water uptake shall be limited to less than 0,1 kg per square metre per $h^{0.5}$ in accordance with EN 1062-3, or less than 7,5 % in accordance with EN 13580 or ASTM D6489.

The adhesion strength by pull-off test shall be evaluated in accordance with ASTM D7234 or EN 1542. The test report shall include details on the particular failure mode for each individual reported pull-off test result and evaluation shall take cognisance of particular coating system properties, in particular highly elastomeric coatings.

The dry film thickness of coatings shall be evaluated in accordance with ISO 2808. The average film thickness shall exceed that stated by the manufacturer to ensure adequate protection of the concrete. Individual readings shall everywhere exceed 75 percent of the dry film thickness stated by manufacturer and all non-conforming areas shall be overcoated to increase the total dry film thickness to the desired levels. The wedge cut method (ISO 2808, method 5B) shall be the preferred test method, and the test location, including an additional 30 mm around the perimeter of the test location, shall be treated or coated with sufficient product to ensure equivalent protection as specified. Alternatively, a profilometer method and determining the quantity of product used (Method 2) in accordance with ISO 2808 may be used.

The wet film thickness of coatings shall be evaluated during the application of the product in accordance with ISO 2808. The comb gauge (ISO 2808, Method 1) shall be used and minimum three readings are taken in different locations per member in a similar manner, but normal to the plane of the surface, to obtain representative results over the coated area.

The crack bridging ability of protective coatings shall be evaluated in accordance with EN 1062-7. All protective coating materials suitable for crack bridging shall meet the minimum requirement for Class A1.

The depth of penetration for hydrophobic impregnation materials shall be evaluated in accordance with EN 14630, except that water is substituted in place of the phenolphthalein indicator solution. All hydrophobic impregnation materials shall meet the requirement for Class 2, which means the dry zone is more than 10 mm.

Surface cleanliness for coating system that does not require alteration of the surface profile of the concrete shall conform to the requirements of EN 1504-9 and ASTM D4258. Soundness shall be verified by hammer test or visual inspection conducted by the manufacturer's technical representative, all to the satisfaction of the Engineer.

B14.7 PROTECTIVE COATINGS AND TREATMENTS FOR CONCRETE

PART B: LABOUR ENHANCEMENT

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B14.7.1 SCOPE

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B14.7.5 MATERIALS

B14.7.6 CONSTRUCTION EQUIPMENT

B14.7.7 EXECUTION OF THE WORKS

B14.7.8 WORKMANSHIP

B14.7.1 SCOPE

This Section covers the material, equipment and work required for applying protective coatings and treatments to concrete surfaces. It is deemed to require specialised skills level and is suitable to labour enhanced construction.

B14.7.2 DEFINITIONS

The provisions of Part A, shall apply.

B14.7.3 GENERAL

The provisions of Part A, shall apply.

B14.7.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A, shall apply.

B14.7.5 MATERIALS

The provisions of Part A, shall apply.

B14.7.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.7.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply.

B14.7.8 WORKMANSHIP

The provisions of Part A, shall apply.

C14.7 PROTECTIVE COATINGS AND TREATMENTS FOR CONCRETE

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

1. Payment for items in this Section shall include full compensation for all works associated with the execution of the work and quality assurance procedures. General access and work platforms and associated temporary works are covered in Section A14.1.
2. All work and material for which no specific pay item is defined shall be deemed to be covered by the items in this Section.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.7.1	Cleaning and preparation of concrete surface (method and surface finish indicated)	square metre (m ²)

This item covers concrete areas that will not be treated with protective coatings and treatments.

The unit of measurement shall be the square metre of surface area cleaned by the method indicated.

The tendered rate shall include full compensation for all material, plant and equipment, all labour and incidentals required to execute the work as specified.

Item	Description	Unit
C14.7.2	Application of protective coatings and treatments (type and application rate indicated)	square metre (m ²)

The unit of measurement shall be the square metre of surface area to be protected or treated as specified. For payment purposes, the surface area shall be measured once only irrespective of the number of layers of protective coatings or applications of surface treatment is required to achieve the specified application rate.

The tendered rate shall include full compensation for all surface preparations, labour, materials, equipment, additional safety measures, storage, mixing and applications of the protective coatings and treatments, cleaning and disposal of unused or rejected material and all incidentals necessary to execute the work, including wastage, as specified, all to the satisfaction of the Engineer.

Item	Description	Unit
C14.7.3	On site monitoring and supply of written product performance guarantee	Lump Sum

The unit of measurement shall be the lump sum. The lump sum shall be paid as follows:

- (i) 50 % shall be paid pro rata as the application of protective coatings and treatments progress, and
- (ii) the remaining 50 % shall be paid on the receipt and acceptance by the Engineer of written product performance guarantee documentation.

The tendered rate shall include full compensation for all verification and testing of the protective coatings and treatments, site inspections, approval and reporting of all work concerning protective coatings and treatments, and the issuing of product performance guarantee in accordance with the requirements stipulated in item C14.7.3.

Item	Description	Unit
C14.7.4	Trial sample panels	square metre (m ²)

The unit of measurement shall be the square metre surface area of successful and accepted trial sample panels to be treated. For payment purposes, the surface area shall be measured once only, irrespective of the number of applications of material and attempts required to achieve an acceptable sample with the specified application rate.

The tendered rate shall include full compensation for everything that is necessary to prepare an acceptable sample panel.

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D14.7 PROTECTIVE COATINGS AND TREATMENTS FOR CONCRETE

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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D14.7.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE

D14.7.9 NOTIFICATION OF REMEDIAL WORK

D14.7.10 REMEDIAL WORK

D14.7.1 SCOPE

The scope of this Section covers the following:

- Product conformance specifications
- Warranties for product or element design and installation of proprietary systems
- Performance specifications

D14.7.2 GENERAL

D14.7.2.1 Product conformance specifications

The Contractor shall within 28 days of entering into the contract with the Employer submit to the Engineer conformance documentation related to the specifications. All products used in the manufacture and application of protective coatings and treatments for concrete shall be in compliance with the specifications continued in Section A14.7.

Compliance documentation shall be provided for:

- a) Hydrophobic impregnants (Clause A14.7.5a))
- b) Sealers and pore blockers (Clause A14.7.5b))
- c) Coatings (Clause A14.7.5c))
- d) Renderings (Clause A14.7.5d))
- e) Corrosion inhibitor (Clause A14.7.5e))
- f) Testing necessary to prove the satisfactory execution of the works (Clause A14.7.6)

D14.7.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.7.3.1 Warranties for product or element design and application of protective coatings

The design and application of protective coatings shall require a warranty of 10 years to be supplied by the Contractor. The format of this warranty shall be as per Form D14.7.1 hereafter. A full set of specifications for the protective coatings shall be submitted together with certificates of all tests carried out in accordance with the requirements of EN 1504. Certification of the application by a suitably experienced representative of the protective coating manufacturer is also required together with the warranty.

D14.7.3.2 Performance specifications

The Contractor shall ensure that all material and construction requirements are fully satisfied such that enable the issuing of a performance guarantee on the protective coating and treatments without any reservation. The performance guarantee shall include the continuous functioning of the protective coating system and treatments for a period of 10 years, of which the first 9 years shall be wholly free from any reductions in the protection afforded by the surface treatment or protective coatings. The subsequent maintenance, surface preparation and over coating requirements of the protective coating system shall form part of the performance guarantee documentation.

Form D14.7.1

WARRANTY FOR DESIGN, MANUFACTURE AND APPLICATION OF PROPRIETARY PROTECTIVE COATINGS AND TREATMENTS FOR CONCRETE SURFACES ON (CONTRACT NUMBER AND DESCRIPTION)	
DESCRIPTION	DETAILS
Structure Name or Location	
Name and Address of Contractor	
Name of Contact Person	
Name and Address of Manufacturer	
Name of Contact Person	
Name and Address of Applicator	
Name of Contact Person	
Date of Manufacture	
Date of Application	
Duration of Warranty	
Start date of Warranty	
End date of Warranty	

The Contractor, Manufacturer and Applicator hereby warrant that the above protective coating will perform satisfactorily in terms of workmanship and durability, and that the protective coating has been applied in accordance with the patent holders requirements and as set out in the specifications and on the drawings for each particular protective coating.

This warranty is for 10 years from the completion date of the Main Contract for the project.

In the event that the performance of the coating is not in accordance with this warranty due to materials or workmanship defects, the Contractor undertakes to rectify the coating within 90 days of receiving the instruction to do so by the Employer.

The coating shall be completely replaced including, supply and application including all other costs associated thereto (i.e. Traffic Accommodation, jacking, closure of the road and bridge as agreed to by the Employer) to the satisfaction of the Engineer.

SIGNED ON BEHALF OF CONTRACTOR: _____

SIGNED ON THIS THE _____ DAY OF _____ IN THE YEAR _____

on behalf of: _____

Address: _____

Telephone No: _____

SIGNED ON BEHALF OF MANUFACTURER: _____

SIGNED ON THIS THE _____ DAY OF _____ IN THE YEAR _____

on behalf of: _____

Address: _____

Telephone No: _____

SIGNED ON BEHALF OF APPLICATOR: _____

SIGNED ON THIS THE _____ DAY OF _____ IN THE YEAR _____

on behalf of: _____

Address: _____

Telephone No: _____

WITNESS:

Signature: _____

Name: _____

Address: _____

Telephone No: _____

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A14.8 EXTERNAL BONDING OF STEEL AND CARBON FIBRE

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A14.8.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.8.1 SCOPE

This Section covers the external bonding of steel plates, carbon fibre plates, carbon fibre fabric, structural steel sections, reinforcement bars and carbon fibre bars to structural concrete surfaces with adhesive. Aramid-carbon fibre composites and other composites are not covered,

A14.8.2 DEFINITIONS

The following definitions shall apply to these specifications:

Adhesive - serves to bond together two separate materials, and resists the interfacial stresses necessary to ensure structural composite action between the two materials.

Epoxy primer - is a very low viscosity resin, specifically designed for improving the bond to surfaces as part of a compatible, load transferring, bonded system.

Saturant for fibre fabric material - the saturant epoxy material is a low viscosity resin, specifically designed for bonding the fibre fabric materials, as part of a compatible, load transferring, bonded system.

Carbon fibre plate - is a pre-fabricated (pultruded) section, specifically designed for adding tensile strength as part of a compatible, load transferring, bonded system.

Fibre fabric material - is pre-woven into sheets, specifically designed to protect the underlying carbon fibre plates, for wrapping structural elements or for shear or torsional strengthening, as part of a compatible, load transferring, bonded system.

Workable life for structural bonding products - the period of time the mixed bonding agent remains workable in the batch quantities used and at the limit of conditions that the material is fit for the purpose of use.

A14.8.3 GENERAL

The products and systems employed in the external bonding of steel and carbon fibre shall comply with EN 1504: Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity.

Part 4 of EN 1504 covers structural bonding.

A14.8.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.8.5 MATERIALS

A14.8.5.1 Adhesive

The adhesive shall be a cured epoxy resin complying with EN1504-4. The adhesive shall be a thixotropic paste, specifically designed as part of a compatible load transferring bonded system. The adhesive shall be a solvent-free, two-part epoxy. The epoxy shall have high resistance to moisture and low creep values under sustained loads.

The adhesive components shall be supplied in liquid form and in separate sealed containers. Each component shall have a different identifiable colour, which results in a distinctive homogenous colour when thoroughly mixed.

The adhesive shall mix readily to a smooth paste-like (thixotropic) consistency and it shall be suitable for spreading on surfaces ranging from horizontal to vertical and on inverted overhead surfaces.

The mixed adhesive shall be free of lumps and the components shall not separate or settle out during the workable life of the adhesive.

The toxicity of the chemicals in the components shall be low enough to enable safe usage on the construction site and in a normal workshop environment. If special ventilation is necessary such requirements shall be clearly stated on the containers.

The adhesive shall be suitable for application to prepared steel, carbon fibre and concrete surfaces in a layer thickness of between 1,0 mm and 20 mm.

The bond stress to concrete surfaces shall exceed 3,5 MPa with failure through the concrete.

Workable life shall not be less than 20 minutes at temperatures up to 20°C.

The storage life (shelf life) in the original sealed containers of both the resin and hardener shall not be less than 6 months at temperatures between 5° and 25°C.

The adhesives shall be capable of curing to the required strength at temperatures between 10°C and 30°C in relative humidities of up to 95 %. The adhesive shall cure sufficiently within three days to confer the specified mechanical properties at 20°C and shall undergo a negligible shrinkage on curing (maximum linear shrinkage of 0,1 %).

The adhesive shall be formulated to minimize moisture transport through the adhesive itself. Water absorption shall not exceed 2 % by mass after immersion for 24 hours in distilled water at 20°C.

The instantaneous flexural modulus of the adhesive shall be between 2,0 GPa and 10,0 GPa at 20°C.

A14.8.5.2 Epoxy Primer

The epoxy primer shall have the following properties:

- a) A viscosity of no more than 600 cps @ 25°C
- b) Bond to damp concrete surfaces of no less than 3,5 MPa (with concrete failure)
- c) A tensile strength of no less than 60 MPa
- d) A flexural strength of no less than 40 MPa
- e) A compressive strength of no less than 95 MPa
- f) Solvent free

A14.8.5.3 Saturant for fibre fabric materials

The epoxy saturant shall have the following properties:

- a) A viscosity of no more than 2000 cps @ 25°C
- b) Bond to damp concrete surfaces of no less than 3,5 MPa (with concrete failure)
- c) A tensile strength of no less than 60 MPa
- d) A flexural strength of no less than 40 MPa
- e) A compressive strength of no less than 95 MPa
- f) Solvent free

A14.8.5.4 Carbon fibre fabric materials

The fibre fabric material to be used shall consist of Carbon fibres and shall have the following properties:

- a) Be woven in a unidirectional sheet
- b) Manufactured to ISO quality standard
- c) Weighs not less than 290 g/m²
- d) A fibre density of not less than 1,45 g/cm³
- e) A modulus of elasticity of no less than 120 GPa
- f) An ultimate tensile strength of no less than 2900 MPa

A14.8.5.5 Carbon fibre plate

The carbon fibre Plate shall have the following properties:

- a) A volumetric fibre fraction of no less than 70 %
- b) A modulus of elasticity for design of no less than 205 GPa
- c) An ultimate tensile strength of no less than 2400 MPa
- d) A tensile strength at 0,8% elongation of no less than 1600 kN

- e) Manufactured to an ISO quality standard

A14.8.5.6 Structural steel

Structural steel plates and sections shall comply with the following requirements:

Mild steel: SANS 50025 (EN 10025) Grade S275JR

High-yield steel: SANS 50025 (EN 10025) Grade S355JR

The dimensions and properties of the rolled steel plate and sections shall conform to the structural steel tables as issued by the SA Institute of Steel Construction, as amended.

A14.8.5.7 Anchors, nuts and washers

Anchors shall consist of proprietary embedment type studs or bolts utilizing a chemical adhesive or mechanical expansion and locking systems to set the anchor in a concrete member. Certification and test results from a recognised approval authority or laboratory shall be made available at the request of the Engineer.

A14.8.5.8 Quality control

The adhesive manufacturer's quality control and conformance certificates and test results for each batch of adhesive supplied on site shall be made available to the Engineer upon request.

The average test results shall meet the specification requirements and no single result shall deviate by more than 15 % from the specified criteria.

A14.8.5.9 Packaging, handling and storage

All adhesive components shall be supplied in separate sealed containers of suitable sizes to obtain a workable quantity within the workable life of the adhesive. The components shall be packaged in the correct proportions so that the entire contents of each container mixed together shall produce a mix of the correct proportions. The adhesive properties shall not vary significantly with minor variations in the mix proportions resulting from the container emptying process.

Each container shall be durably and legibly marked and complete records of stock acquired and issued for use, shall be kept. The containers shall be clearly marked with the following information:

- a) name of manufacturer
- b) manufacturer's product identification
- c) batch number and date of manufacture
- d) date of expiry and shelf life
- e) manufacturer's instructions for mixing
- f) safety precautions, warnings for handling and toxicity
- g) manufacturer's recommendations for storage

A14.8.5.10 Manufacturer's instructions

The manufacturer shall provide a dated, coded and titled instruction sheet with each delivery of adhesive. The following information shall be contained on the sheet in a clear and unambiguous manner.

- a) the general chemical type of each component used in the adhesive;
- b) recommended storage conditions and shelf life when stored under these conditions;
- c) preparation instructions for the adherent and concrete surfaces;
- d) Instructions for use of primers, including optimum film thickness and permissible ranges;
- e) mixing instructions, including allowable variations in mix ratio and any temperature control requirements during the mixing process;
- f) application instructions, including limits on pressure, temperature, open time and relative humidity before mating the surfaces to be joined. It shall also be stated whether adhesive shall be applied to one or both of the surfaces to be bonded;
- g) maximum allowable interval between application of primer to coated steel or concrete, and application of adhesive and any primer reactivation procedure if applicable;
- h) safety precautions for all components of the adhesive and primer;
- i) curing conditions, including the amount of pressure to be applied, the period under pressure and the temperature of the assembly when under pressure. It shall be stated whether this temperature is that of the adhesive layer or of the atmosphere in which the assembly is to be maintained or both. A graph of cure time against temperature shall be supplied; and
- j) condition procedure before testing or use of the assembled product, including the time, temperature and relative humidity.

A14.8.6 CONSTRUCTION EQUIPMENT

A14.8.7 EXECUTION OF THE WORKS

A14.8.7.1 Sequence of execution

The sequence of execution for the bonding of plates or reinforcement to the concrete surface shall be in accordance with the drawings and the method statement, as approved by the Engineer.

A14.8.7.2 Site preparation and access

The necessary access and temporary support structures shall be in place prior to the commencement of surface preparation. If deemed necessary to ensure acceptable environmental conditions and public safety, screening of the work area shall be established.

A14.8.7.3 Preparation of concrete surfaces

a) Concrete surface for steel and carbon fibre plate bonding

The outline positions of the steel or carbon fibre plates shall be clearly marked on the receiving concrete surface. For steel plates, a covermeter survey shall be carried out in all regions where anchor studs are to be installed in order to accurately locate the existing form reinforcement. The located bar positions shall be clearly marked which the stud positions can be determined.

The anchor stud positions shall be carefully measured up and transferred to the steel plate fabrication drawings. Particular care shall be taken with regard to the orientations and plate references during the survey and preparation of fabrication drawings.

Once the survey is completed the concrete surface shall be prepared.

Any cracks wider than 0,4 mm shall be pressure injected using a low viscosity epoxy resin system in accordance with the procedures specified in Section A14.4.

Any concrete surface defects or deeper reinforcement corrosion within the plate outline and other areas considered defective shall be removed and repaired with suitable and compatible repair systems in accordance with Section A14.4.

The marked concrete areas to be plated shall be grit-blasted to remove all concrete laitance, surface coatings and impregnants, organic growth, bituminous residues, oil, dirt and any other surface contamination. The surface shall be sound and shall exhibit the coarse sand and aggregate texture to present a rough key to the adhesive.

The prepared surface profile shall be checked using a 1,0 m long profile edge and any areas deviating by more than 4,0 mm from the profile edge shall be marked.

Any high areas shall be removed with light scabbling or grinding equipment and low areas can be filled with the adhesive to be used for the plate bonding. Normal grit-blasting preparation shall not remove more than 1,0 mm of the concrete surface.

The Engineer will inspect the prepared surface to identify areas that are defective or substandard which may require additional preparation or remedial work. Repairs shall not weaken the load transfer to the concrete.

b) Preparation for fibre fabric material

The requirements in Clause A14.8.7.3a) shall apply with the additions:

Differences in adjacent concrete surface levels shall be no more than 1,0 mm. Concrete surface protrusions such as small projections, grouting lines etc. shall be ground flat using concrete planes, disc sanders etc.

Sharp corners shall be rounded with a radius of at least 10 mm.

c) Concrete surfaces for bonding reinforcement or rods in slots

The positions of the slots for reinforcement shall be clearly marked on the receiving concrete surface. A covermeter survey shall be carried out along each slot position to determine the position of existing reinforcement bars and the concrete cover thickness. The located bar positions shall be clearly marked and the depth of the slots shall be adjusted if necessary to avoid cutting reinforcement transverse to the direction of the slots. Where possible the slots shall be located midway between existing reinforcement bars.

A covermeter capable of measuring concrete cover to reinforcement within 3,0 mm accuracy shall be used.

Once the survey is completed, the slots can be cut into the concrete surface. Any cracks wider than 0,4 mm and concrete surface defects and deeper reinforcement corrosion shall be treated as required in Clause A14.8.7.3a).

The slots for bonding the reinforcement shall be cut into the member at the positions and to the dimensions as indicated on the drawing or as directed by the Engineer following the covermeter survey. The sides of the slots shall be neatly cut along the required profile using a diamond saw or angle grinder to the required depth. Holes within a slot shall be carefully drilled using a diamond drill. Equipment that may damage the adjacent material structure, soundness or integrity shall not be used.

The surfaces of the slots shall be free of loose or unsound material, and any contaminant that may react with or impair the bond of the adhesive to the concrete surface, shall be cleaned off.

The cut surfaces shall be prepared to exhibit a coarse sandpaper-like texture by grit-blasting, water-jetting or other approved means.

The Engineer will inspect the concrete surface with prepared slots to identify areas that are defective or substandard and which may require additional preparation or remedial work.

A14.8.7.4 Preparation of steel plates for bonding

After the plates for bonding have been fabricated to size with all the required holes, the plate surface preparation shall be done. The plates

shall be handled with care to ensure that the flatness tolerances of BS 4360 are maintained in the final prepared plate.

a) Corrosion protection using paint system

All physically adhering contaminants and residues shall be removed and the bond surface shall be grit-blasted to SA 2 ½ surface finish in accordance with EN ISO 8501 – 1 to a surface profile of between 50 to 100 microns.

The steel surfaces shall be prepared under factory conditions to ensure complete removal of rust, millscale, grease, dirt, etc. using grit-blasting techniques with a clean, angular, hard metal grit free from contaminants.

Mechanical abrasion techniques such as wire brushing or emery cloth that polish rather than remove oxide layers are not acceptable.

No abrasive blasting shall be done outside factory conditions during rainy weather or where corrosive air conditions prevail.

Prepared steel surfaces shall be primed within four hours of blast-cleaning to prevent re-oxidation of the steel surface. Immediately prior to the primer application the surface shall be degreased and vacuum-cleaned to remove all dust and debris. The prime shall be applied to a dry film thickness (DFT) of 50 µm to 75 µm allowing for the full cure of the primer. The primer shall consist of a single-component, anti-corrosion compound based on zinc and epoxy resins compatible with the bonding adhesive.

The primed plates shall be allowed to cure for at least 24 hours before further handling or transportation is undertaken. Suitable precautions shall be taken to protect the primed plates against handling, transportation and storage damage. Plates with defective bond surfaces or out of tolerance flatness at the time of adhesive application of the adhesive shall be rejected.

b) Corrosion protection using hot-dip galvanizing

The surface preparation of steel plates for hot-dip galvanizing shall entail the mechanical removal of all millscale, rust and other adhering debris to achieve a minimum grade SA 3 surface finish to EN ISO 8501 – 1. All galvanizing shall be done in accordance with SANS 121, heavy-duty coating.

After the steel plates have been galvanized, the surface to be bonded shall be abrasive-blasted as in Clause A14.8.7.4a) to remove the galvanizing layer and then primed and protected against damage during handling, transportation and storage.

The surrounding galvanized surface shall be suitably protected against the abrasive blasting to ensure that the galvanizing is not damaged.

c) Corrosion protection using zinc-metal spraying

The surface preparation of steel plates for zinc-metal spraying shall entail the mechanical removal of all millscale, rust and other adhering debris to achieve a minimum grade SA 3 medium profile surface finish to EN ISO 8501 – 1. All metal spraying shall be done in accordance with EN 22063 and Section A14.12.

After the steel plates have been metal-sprayed, the surface to be bonded shall be abrasive-blasted as in Clause A14.8.7.4a) to prepare the surface for the adhesive, and then primed and protected against damage during handling, transportation and storage.

The surrounding metal-sprayed surface shall be suitably protected against the abrasive blasting to ensure that the metal-sprayed surface is not damaged.

d) Preparation of carbon fibre plates for bonding

The carbon fibre plates shall be cleaned with a supplier-approved solvent before applying the adhesive.

e) Preparation of fibre fabric materials

The fibre fabric materials shall be cut into prescribed sizes using scissors or cutters before application of low viscosity saturants. The number of sheets cut shall be limited to those that can be used within a day. The largest dimension of any sheet shall be less than 2,0 m to facilitate flat wrinkle free application and to ensure no air is trapped under the fibre sheet during application.

A14.8.7.5 Preparation of reinforced steel bars

The steel bar surface shall preferably be cleaned and grit-blasted immediately before bonding into the prepared slots in the concrete surface. Alternatively, approved measures shall be taken to prevent surface corrosion and maintain the clean surfaces free from dirt, oil, or any other deleterious contaminants.

The steel surface shall be prepared by removing all physically adhering contaminants and by grit-blasting to grade Sa 2 ½ medium profile surface finish to EN ISO 8501 – 1. No grit-blasting shall be done on site during rainy weather or when corrosive environmental conditions prevail.

A14.8.7.6 Inspection of concrete surface prior to adhesive bonding

The prepared concrete surfaces or slots shall be carefully inspected immediately prior to application of the adhesive to ensure that the requirements of Clause A14.8.7.3 are maintained. All bond surfaces shall be dry or have a moisture content less than that recommended by the manufacturer of the selected adhesive. Should the moisture content be excessive, the concrete surface shall be allowed to dry sufficiently to prevent the possibility of a moisture barrier forming between the concrete substrate and the adhesive. The surface temperature of the concrete shall be between the temperature limits recommended by the adhesive manufacturer.

Where carbon fibre plates are attached to repair mortar, the adhesive shall only be applied after the repair mortar has cured for at least 7 days and the moisture content of the repair mortar is below 6 %. The Contractor shall prove the moisture content by means of a test method that has been approved by the Engineer.

Where fibre fabric sheets are placed over other plates, the sheets can only be applied once the plate adhesive has cured sufficiently.

A14.8.7.7 Mixing of adhesive system components

The entire contents of the containers of a multi-component adhesive system shall be mixed together as recommended by the manufacturer and shall be used within the workable life of the adhesive.

The adhesive components shall be mixed in a clean container, free of harmful residue or foreign particles. The adhesive shall be carefully and

thoroughly mixed to a uniform colour and a homogenous mixture. The temperature of the adhesive components shall be between 10°C to 30°C before mixing, unless specified otherwise by the manufacturer in writing.

Sufficient adhesive shall be mixed to cover the necessary bonding surfaces which can be comfortably handled within the available period to ensure the necessary quality and workmanship.

Once the adhesive has been thoroughly mixed, no re-mixing will be allowed.

In order to monitor the quality of the mixing process, flexural modulus tests on prisms made from the adhesive shall be undertaken prior to installation and at intervals during installation. The results shall be submitted to the Engineer for approval.

A14.8.7.8 Application of epoxy primer

The work site shall be thoroughly ventilated. The primer shall not be applied if ambient temperature is less than dew-point plus 5°C. Only mix as much primer as can be applied within its workable life.

Mixed primer shall be applied with a roller or brush. Where required, a second coat can be applied when the surface is very porous. The primer shall be allowed to cure until tack-free

A14.8.7.9 Application of adhesive to bond surfaces

Immediately before the application of the adhesive to the prepared concrete surface, the receiving surface shall be vacuum-cleaned to remove all dust, debris, etc.

The mixed adhesive shall be trowelled onto the receiving concrete surface using plastering techniques. The adhesive shall be well worked into the grit-blasted surface to a layer thickness of approximately 2,0 mm. Skilled operators are essential due to the speed and care demanded by this phase of the work.

The adhesive shall be applied to the steel or carbon fibre bonding plates preferably with a specially profiled trowel to ensure a uniform thickness and profile across the plate width. The profile shall be such that when the plate is pushed into contact with the concrete surface the adhesive is squeezed out towards the free edges to reduce the risk of air entrapment. The minimum thickness of adhesive applied to the plate shall be 1,0 mm at the edges while the average thickness shall be 3,0 mm.

The actual thickness applied to the plate and concrete surface shall be carefully controlled to ensure that sufficient quantity is used to achieve the required final layer thickness with minimal wastage.

In order to ensure a uniform adhesive layer thickness, suitable 3,0 mm thick inert spacers may be placed along the plate at regular intervals suited to the plate stiffness.

For steel plates: Once the adhesive is applied to the bond surfaces, the plate shall be positioned with a suitable and adjustable support system to within 5,0 mm of the required location. The position and alignment shall be checked against markers or guides and if correct, the plate shall be pushed into its final position relative to the concrete surface, applying pressure to the adhesive layer.

For carbon fibre plates: Apply the carbon fibre plate and, using a roller, exert a constant pressure by moving the tool both ways in the direction of the fibres.

The pressure applied shall be sufficient to just squeeze out the adhesive along the full plate perimeter. Care shall be taken to apply the pressure evenly without distortion of the plate.

Once the plate is in position, the edges must be neatly finished with a fillet of adhesive to protect the interface of the plate, the adhesive layer, the edge of the plate and the concrete against the ingress of moisture.

The support system shall be left undisturbed for a minimum period of 24 hours and the temperature variation shall be monitored during this period. Where low temperatures have resulted in insufficient strength gain, this period shall be extended.

A14.8.7.10 Application of saturant

The fully mixed saturant shall be applied to the fibre fabric material using a roller brush. Place the resin saturated fibre fabric material, saturant-side against the concrete, onto the concrete surface on which the primer has been applied.

The fibre reinforcement system shall be strongly squeezed in the direction of the fibres two or three times using a de-foaming roller and rubber spatula in order to impregnate the resin into the fibres and to de-foam the resin coat.

For joining strips of fibre sheets, a 150 mm overlap is required in the direction of the fibres and a 20 mm overlap in the direction transverse to the fibres. Additional resin shall be applied at the overlap location on top of the outer layer of fibre sheet to be overlapped. Any lifting or dislocation that occurs within the first 30 minutes shall be corrected using the roller and spatula.

The second coat of mixed saturant shall then be applied onto the surface of the fibre sheet. The coated surface shall be strongly squeezed in the fibre direction two or three times with the roller and spatula in order to impregnate the fibre sheets in the same manner as above.

The impregnated fibre reinforcement shall be left until fully cured before applying a protective top coat.

A14.8.7.11 Application of adhesive and placing of reinforcement bars to be bonded

The concrete slot and reinforcing steel surfaces receiving the adhesive shall be primed with a compatible primer approved by the Engineer. While the primer is still tacky the slot shall be filled with adhesive to a thickness sufficient to fill, with a slight excess, the gap between the concrete substrate and the reinforcement bar.

The reinforcement bar shall be placed and fixed into position within the slot using an approved method. The minimum thickness of adhesive shall be 1,0 mm.

The remainder of the slot depth shall then be filled with adhesive to a slightly convex surface with respect to the surrounding concrete surface.

The elements being bonded shall not be disturbed during the curing period of the adhesive.

A14.8.7.12 Fixing and anchors

Anchor studs shall normally be installed after the plate-bonding adhesive has cured and the support system is removed.

The holes in the concrete are drilled through the holes in the steel plate using hand-held power drills with rotary hammer action.

The anchor studs shall be installed and set to the depth and detail as indicated on the drawings or the approved alternative anchor setting procedure approved by the Engineer.

The annular space between the stud and the plate shall be filled with the same adhesive as used for the plate bonding. Before the adhesive enters the curing phase, the hole shall be covered with a suitable washer and the nut torqued to the specified value.

A14.8.7.13 Finishing

Excess hardened adhesive shall be carefully ground away to the required surface profile. Where the adhesive colour does not match the colour of the surrounding concrete surface, a compatible finishing paint of matching colour shall be applied to the area.

After installation, the steel plate system shall be finished off with a protective paint system consisting of a primer, two coats of MIO and a polyurethane final coat in accordance with Section A14.10. The final coat shall be of a colour similar to that of the surrounding concrete.

Carbon fibre shall be painted with a compatible primer and polyurethane final coat in accordance with Section A14.10.

A14.8.7.14 Environmental protection and cleaning-up

Care shall be taken during any work with adhesive components to avoid contamination of the subsoil and the environment. Any spillage, wastage and clean-up residues shall be collected, removed and disposed of in suitable containers at an approved waste disposal site. All work shall be carried out strictly in accordance with the EMP.

The concrete surface adjacent to the prepared surfaces receiving adhesive shall be protected against spillage where necessary. Any adhesive applied or spilled on unwanted areas shall immediately be removed and cleaned with an approved clean-up agent and procedure recommended by the manufacturer for the required purpose.

A14.8.7.15 Tolerances

The positional and level tolerances of the bonded steel and carbon fibre elements shall comply with those specified on the detail drawings, or if none is specified, as follows:

Position & Alignment:	± 5,0 mm with maximum 1° angular deviation
Level:	± 2,0 mm
Flatness:	± 5,0 mm deviation over a 2,0 m long straight-edge

A14.8.8 WORKMANSHIP

The Contractor shall submit the following to the Engineer for approval:

- a) The adhesive manufacturer's certification verifying conformance to the specification of the material in Clause A14.8.5 for each batch of product delivered on site. The certification shall include the relevant laboratory test results.
- b) A detailed method statement for the execution of the work covered in this section, including details of temporary works, work procedures and equipment to be used for mixing and placement of adhesive and bonding elements, as well as quality assurance procedures and tests that have to be followed to ensure that the correct quality of workmanship is achieved as part of his quality control testing procedure.

The Engineer may instruct that the on-site monitoring, sampling and testing be carried out by an independent test laboratory to ensure that the required standard of surface preparation, adhesive mixing, application and performance is achieved.

Detailed records of all operations and inspections carried out and materials received, issued and tested shall be kept by the Contractor and submitted to the Engineer for record purposes.

B14.8 EXTERNAL BONDING OF STEEL AND CARBON FIBRE

PART B: LABOUR ENHANCEMENT

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B14.8.7 EXECUTION OF THE WORKS

B14.8.8 WORKMANSHIP

B14.8.1 SCOPE

The specification covers the external bonding of steel plates, carbon fibre plates, carbon fibre fabric, structural steel sections, reinforcement bars and carbon fibre bars to structural concrete surfaces with adhesive. Due to the specialised nature of these applications, the work activities are deemed to be not focused at labour enhanced construction.

B14.8.2 DEFINITIONS

B14.8.3 GENERAL

The provisions of Part A shall apply with no additional requirements.

B14.8.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply with no additional requirements.

B14.8.5 MATERIALS

The provisions of Part A shall apply with no additional requirements.

B14.8.6 CONSTRUCTION EQUIPMENT

The provisions of Part A shall apply with no additional requirements.

B14.8.7 EXECUTION OF THE WORKS

The provisions of Part A shall apply with no additional requirements.

B14.8.8 WORKMANSHIP

The provisions of Part A shall apply with no additional requirements.

C14.8 EXTERNAL BONDING OF STEEL AND CARBON FIBRE

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

None

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.8.1	Moving to and setting up the equipment at each work site (description of location)	number (No)

The unit of measurement shall be the number of sites where equipment had been set up for the preparation of surfaces and placement of bonded plates and bars.

The tendered rate shall include full compensation for all costs involved in moving to each location, setting up the equipment and later dismantling thereof, extra over the general access and work platform covered in Section A14.1.

Item	Description	Unit
C14.8.2	Preparation of concrete surfaces	
C14.8.2.1	Concrete surfaces for plate bonding (position, size and material indicated)	square metre (m ²)
C14.8.2.2	Slots in concrete for steel or carbon fibre bonding (position, size and material indicated)	metre (m)

The unit of measurement shall be the square metre of concrete surface area repaired, and the metre of slots of the size specified.

The tendered rate shall include full compensation for all labour, materials, plant and equipment required for the cover and position survey of existing reinforcement, the measurement, recording and working on the concrete member, preparation of steel fabrication drawings, the surface preparation of the concrete surface and cutting of slots as required.

It shall also include the supply and application of an adhesive compatible primer to the prepared concrete surfaced if required for the type of adhesive being used.

Item	Description	Unit
C14.8.3	Adhesive and saturant	
C14.8.3.1	Adhesive (description or type to location)	litre (ℓ)
C14.8.3.2	Saturant (description or type to location)	kilogram (kg)

The unit of measurement shall be the litre of adhesive or kilogram of saturant used as approved by the Engineer. The volume shall be determined from the dimensions indicated on the detail drawings or as authorized by the Engineer following the detailed inspection of the

prepared surfaces. Any overcut or excessive preparation resulting in additional adhesive quantities shall not be measured.

The tendered rate shall include full compensation for all labour, material, equipment, etc., required for the supply, mixing and application of the adhesive to the prepared concrete and steel or carbon fibre surfaces, slots and holes. It shall also include the certification testing and quality assurance monitoring and testing by the Contractor, as well as any wastage of mixed or spilled materials and the disposal thereof.

The rate shall also include all costs arising from any clean-up and finishing actions required due to spillage or poor workmanship.

Item	Description	Unit
C14.8.4	Bonded plates, bars or sections	
C14.8.4.1	Plates (description of material, unit, size and mass)	number (No)
C14.8.4.2	Bars (material, type and size indicated)	kilogram (kg)
C14.8.4.3	Sections (material, type and size indicated)	number (No)
C14.8.4.4	Elements (material, description)	number (No)
C14.8.4.5	Fibre fabric material (material and type indicated)	square metre (m ²)

The unit of measurement shall be the mass of steel bars or number of identified steel or carbon fibre plates or described items or square metre of fibre fabric bonded to the concrete member.

The tendered rate shall include full compensation for all labour, materials, plant, equipment etc., required for the fabrication and supply of the steel items on site, the placing and fixing of the steel items into position including all ties, fasteners, waste, etc. complete as per details on the drawings. Fixing studs and bolts are measured separately.

It shall also include all costs arising from the surface preparation, corrosion protection and primer application to the steel or carbon fibre bonding surface, as well as temporary support required during installation.

Item	Description	Unit
C14.8.5	Fixing studs and bolts (type and size indicated)	number (No)

The unit of measurement shall be the number of units installed.

The tendered rate shall include full compensation for all labour, materials, plant and equipment required to supply and install the described fixing studs or bolts in accordance with the detail drawings, including the drilling and preparation of holes, the application of adhesive and the installation and tightening of the fixings with washers and nuts.

Item	Description	Unit
C14.8.6	Protective paint coatings (type and film thickness indicated)	square metre (m ²)

The unit of measurement shall be the square metre of surface area covered by the paint coating measured in place.

The tendered rate shall include full compensation for all labour, materials, plant and equipment required to prepare the surfaces and to supply and apply the protective coating and primer to the required film thickness.

D14.8 EXTERNAL BONDING OF STEEL AND CARBON FIBRE

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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D14.8.9 NOTIFICATION OF REMEDIAL WORK

D14.8.10 REMEDIAL WORK

D14.8.1 SCOPE

The scope of this Section covers the following:

- Product conformance specifications
- Warranties for product or element design and installation of proprietary systems
- Performance specifications

Note that the requirements for performance specifications are not limited to that given in part C only but includes all of the requirements in the contract documentation.

D14.8.2 GENERAL

D14.8.2.1 Product conformance specifications

The Contractor shall, within 28 days of entering into the contract with the Employer, submit to the Engineer conformance documentation related to the specifications.

Conformance documentation shall be provided for:

- a) Adhesives;
- b) Saturants and epoxy primers;
- c) Structural steel plate;
- d) Carbon fibre plate;
- e) Carbon fibre fabric;

D14.8.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.8.3.1 Warranties for product or element design and installation of proprietary systems.

No additional requirements.

D14.8.3.2 Performance specifications

Performance based specifications shall be contained in the Contract Documentation for the project.

A14.9 REPAIR AND REPLACEMENT OF ANCILLARY STRUCTURAL ELEMENTS

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PART A: SPECIFICATIONS

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PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.9.1 SCOPE

This Section covers the requirements for the removal of debris from expansion gaps, clearing of drainage elements, repair of expansion joints, repair of handrails, removal and rebuilding of brickwork on bridges, provision of drainage to deck void formers and the refurbishment or replacement of bridge bearings.

A14.9.2 DEFINITIONS

Elements are defined elsewhere in these specifications.

A14.9.3 GENERAL

Work requiring accommodation of traffic shall be carried out in stages and widths approved by the Engineer. Traffic accommodation shall be provided in accordance with the SADC Road Traffic Signs Manual Volume 2 Chapter 13 or indicated on the drawings.

A14.9.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.9.5 MATERIALS

All materials referred to in this section shall be in accordance with relevant sections Chapter 13 or the Contract Documentation.

A14.9.6 CONSTRUCTION EQUIPMENT

The Contractor shall before the construction commence, provide comprehensive details of all plant and equipment, which shall be appropriate for the intended use and in good working order.

A14.9.7 EXECUTION OF THE WORKS

A14.9.7.1 Removal of debris from expansion gaps

All debris in the expansion gaps and expansion joints between deck ends, walls and girder beds shall be removed and the gaps shall be cleaned out with high-pressure water or air jets or other suitable means. Solvents or fire shall not be used.

Protective measures such as screening shall be provided to contain flying debris, dust and water spray to ensure that passing traffic is not endangered and that the environment is not contaminated.

A14.9.7.2 Clearing of bridge drains

All drains, in the deck and substructure, including drain inlets, outlets and channels shall be cleared of all debris and all organic material, sand etc. Where drain inlets have been covered or clogged with concrete or asphalt pavement materials, the material shall be carefully removed without damaging the inlet or the surrounding concrete.

Drain pipes shall be cleared and flushed to attain a free flowing drainage system.

Damage to inlets, outlets or pipe components shall be repaired or replaced as instructed by the Engineer.

A14.9.7.3 Repair of expansion joints

Remedial work on bridge expansion joints and repairs to joint nosings shall be in accordance with the drawings. Refurbishment of proprietary joint systems shall entail the servicing of the joint in situ, or the removal and replacement of joint components.

Damaged portions of concrete in joint nosings, or concrete nosings that are to be replaced shall be carefully removed and replaced with new concrete in accordance with Sections A14.3 and A14.4 as applicable.

The joint terminations as specified in Section A13.7 of Chapter 13 shall be constructed if these are not existing in the joint being repaired.

Debonded or damaged sealants shall be removed and the bonding surfaces cleaned to receive replacement sealant in accordance with Section A13.7 of Chapter 13.

The installation of new replacement joints shall be executed in accordance with Section A13.7 of Chapter 13 and relevant sections of Section A14.3 of these specifications.

Traffic shall not be permitted directly on concrete nosings before the concrete has attained a cube strength of 30 MPa. If the nosings are required to carry traffic before a strength of 30 MPa is attained, steel bridging plates held down on both sides with scope for horizontal movement shall be provided over the concrete nosings, and shall remain in place until the concrete has attained the required strength.

A14.9.7.4 Repair of handrails

a) Metallic Handrails

Remedial work shall be carried out on metal handrails that have been damaged or require maintenance work.

All painting shall be in accordance with Section A13.11 of Chapter 13 with the requirement that previously painted handrails shall be cleaned and prepared for over-coating in accordance with the recommendations of the paint or protective coating manufacturer.

Damaged components of handrails shall be repaired where possible or replaced as instructed by the Engineer.

The removal of sections embedded in concrete shall be done in accordance with Section A14.3.

b) Non-metallic handrails

Remedial work shall be carried out on non-metallic handrails which have been damaged or require maintenance work.

Damaged non-metallic handrails shall be removed from their concrete embankment and replaced in accordance with Section A14.3. The handrail stanchions and railing shall be replaced as indicated on the drawings or as instructed by the Engineer.

A14.9.7.5 Removal and rebuilding of brickwork

Brickwork that needs to be rebuilt, shall be broken down and removed as instructed by the Engineer.

Care shall be taken not to damage brickwork or concrete adjacent to the section to be removed.

New brickwork shall be joined to existing brickwork using a stepped-back or keyed joint. Joints shall only be provided where shown on the drawings or as instructed by the Engineer.

Rebuilt walls shall be plastered if instructed and the surfaces shall be treated as specified to provide a uniform texture and colour to match the existing work.

A14.9.7.6 Drainage to deck void formers

The provision of drainage to deck void formers covers the drilling of holes and installation of drainage pipes through deck soffits into void formers in the deck to facilitate drainage.

The Contractor shall ensure that the equipment used is suitable to the application.

The Contractor shall determine the positions of void formers accurately from the drawings.

Prior to drilling the Contractor shall use a cover meter to determine the location of reinforcement bars and to position the drainage holes between such bars maintaining at least 40 mm concrete cover to the existing steel reinforcement.

Drainage holes of 20 mm diameter shall be drilled into the lowest end of the void former, and a PVC pipe with a minimum protrusion of 10 mm from the deck soffit. The Contractor shall take care not to damage the surrounding concrete during the drilling of holes. A 20 mm diameter PVC pipe, 100 mm long must be inserted and epoxied 50 mm deep into each drainage hole.

A14.9.7.7 Refurbishment and replacement of bridge bearings

The maintenance or replacement of bearings which involves jacking of the deck, shall be performed as specified in Section A14.10: Jacking of Bridge Structures.

The refurbishment of existing bearings which are to be reinstalled shall be carried out using the same materials and to the standards as specified in Section A13.6 of Chapter 13 or replaced where deemed necessary. Where existing bearings are refurbished this shall be carried out to current standards for materials and manufacture. If bearings cannot be refurbished they shall be replaced as specified in Section A13.6 of Chapter 13.

A14.9.7.8 Replacement and refurbishment of ancillary elements

The replacement or refurbishment of ancillary bridge elements such as drainage pipes, catch pits, gratings and bridge number plates shall be carried out as specified on the drawings or directed by the Engineer. This work shall also be carried out in all respects in accordance with Section A13.8 of Chapter 13.

A14.9.7.9 Disposal of waste material

All waste materials, rubble, scrap and rubbish arising from the Contractors work on site and the execution of the works shall be disposed of to a disposal site identified by the Contractor and approved by the Engineer. All work shall be carried out in accordance with the EMP.

A14.9.8 WORKMANSHIP

The quality of materials and workmanship used for the replacement and repair of bridge elements shall be to the equivalent standard as the new elements as specified in Chapter 13: Structures.

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B14.9 REPAIR AND REPLACEMENT OF ANCILLARY STRUCTURAL ELEMENTS

PART B: LABOUR ENHANCEMENT

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B14.9.1 SCOPE

This Section covers the requirements for the removal of debris from expansion gaps, clearing of drainage elements, repair of expansion joints, repair of handrails, removal and rebuilding of brickwork on bridges, provision of drainage to deck void formers and the refurbishment or replacement of bridge bearings. All elements of the scope is suited to labour enhanced construction with the exception of bridge bearings repair and replacement, which is deemed to be specialised work.

B14.9.2 DEFINITIONS

The provisions of Part A, shall apply.

B14.9.3 GENERAL

The provisions of Part A, shall apply.

B14.9.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A, shall apply.

B14.9.5 MATERIALS

The provisions of Part A, shall apply.

B14.9.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.9.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply.

B14.9.8 WORKMANSHIP

The provisions of Part A, shall apply.

C14.9 REPAIR AND REPLACEMENT OF ANCILLARY STRUCTURAL ELEMENTS

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

None

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.9.1	Removal of debris from expansion gaps (description)	metre (m)

The unit of measurement shall be the metre (m) of expansion gaps cleaned.

The tendered rate shall include full compensation for all labour, material, plant and equipment required to execute the work including any additional protective measures and disposal of debris to an approved disposal site including overhaul and any fees payable at the disposal site.

Item	Description	Unit
C14.9.2	Clear bridge drainage system (description of elements)	number (No)

The unit of measurement shall be the number of drainage elements cleaned.

The tendered rate shall allow full compensation for all labour, material, plant and equipment required to execute the work including any special protective measures and disposal of debris to an approved disposal site including overhaul and any fees payable at the disposal site.

Item	Description	Unit
C14.9.3	Service and repair of existing joint system	
C14.9.3.1	Service and repair of bridge joints (description)	metre (m)

The unit of measurement shall be the metre of specified expansion joint removed or serviced and repaired as detailed.

The tendered rate shall include full compensation for all plant, equipment, labour and material required to service and replace, or to remove and dispose of the existing joint system and the preparation and installation of the new system as detailed. The rate shall also allow for the provision of special protective measures specified during each stage of the installation.

New replacement joints shall be provided in accordance with Section A13.7 of Chapter 13.

Item	Description	Unit
C14.9.4	Joint terminations as specified on the drawings in:	
C14.9.4.1	Barriers and Parapets (type of joint indicated)	number (No)
C14.9.4.2	Sidewalks (type of joint indicated)	number (No)

The unit of measurement shall be the number of each type of joint termination installed.

The tendered rate shall include full compensation for all supplying materials transporting, handling and storing, and all labour, plant and equipment to form the recesses and install the joint terminations as specified and indicated on the drawings.

Item	Description	Unit
C14.9.5	Cover plates (nonmetallic) in barriers, parapets and sidewalks as specified on the drawings in:	
C14.9.5.1	Barriers and parapets (type of joint indicated)	number (No)
C14.9.5.2	Sidewalks (type of joint indicated)	number (No)

The unit of measurement shall be the number of each type and size of cover plates installed.

The tendered rate shall include full compensation for the supply and installation of the cover plate and box outs as detailed on the drawings. The tendered rate shall also include for all stainless steel bolts and fixing anchors' and incidentals as specified.

The unit of measurement shall be the metre of specified expansion joint removed or serviced, repaired and replaced as detailed.

The tendered rate shall include full compensation for all plant, equipment, labour and material required to service and replace, or to remove and dispose of the existing joint system and the preparation and installation of the new system as detailed. The rate shall also allow for the provision of special protective measures specified during each stage of the installation.

In addition, the tendered rates shall include full provision for trimming the expansion gap of the concrete nosings, if required by the Engineer. This cutting shall be executed with a multi-blade cutting machine.

Item	Description	Unit
C14.9.6	Repair of handrails (description of work)	metre (m)

The unit of measurement shall be the metre of handrail repaired.

The tendered rate shall include full compensation for the fabrication, supply and installation of handrail components complete as specified to repair the railings.

Item	Description	Unit
C14.9.7	Removal and reinstatement of brickwork on bridges (description and wall thickness)	square metre (m ²)

The unit of measurement shall be the square metre of brickwork removed and disposed of, and subsequently rebuilt.

The tendered rate shall include full compensation for all labour, material, plant and equipment required for the removal of brickwork and subsequent rebuilding the brickwork complete with plaster finish.

Item	Description	Unit
C14.9.8	Drilling of drainage holes into void formers from deck soffit (size of hole indicated)	number (No)

The unit of measurement shall be the number of holes drilled into void formers, and the installation of PVC drainage pipes.

The tendered rate shall include full compensation for all labour, material and equipment required for the location of reinforcement bar positions and to drill holes into void formers from the soffit of the deck, and fixing of PVC drainage pipes into the concrete with a 10 mm free overhang. Access required for this operation shall be deemed to be included in the amounts tendered under Section A14.1.

Item	Description	Unit
C14.9.9	Refurbishment of bearings (type and size described)	
C14.9.9.1	Removal and inspection	number (No)
C14.9.9.2	Refurbish and reinstall	number (No.)

The unit of measurement shall be the number of specified bearings to be removed, inspected, refurbished and reinstalled.

The tendered rate shall include full compensation for all labour, materials and equipment required for the removal, inspected, refurbishment and re-installation of bearing components.

New replacement bearings shall be provided in accordance with Section A13.6 of Chapter 13.

Item	Description	Unit
C14.9.10	Replace PVC junctions in deck (type and size described)	number (No)

The unit of measurement shall be the number of junctions replaced.

The tendered rate shall include full compensation for all labour, materials and equipment required for the removal and replacement of the junction components.

Item	Description	Unit
C14.9.11	Reseal PVC junctions in deck drainage network (type and size described)	number (No)

The unit of measurement shall be the number of junctions resealed.

The tendered rate shall include full compensation for all labour, materials and equipment required for the resealing of the junction components.

Item	Description	Unit
C14.9.12	Inlet gratings	
C14.9.12.1	Inlet grating in kerb (size)	number (No)
C14.9.12.2	Other types of gratings (<i>indicate details</i>)	number (No)

The unit of measurement shall be the number of gratings installed.

The tendered rate shall include full compensation for the materials, fabrication, transport, handling and installation of the complete assembly, for the corrosion protection as well as for the equipment, tools, incidentals and labour required to complete the work.

Item	Description	Unit
C14.9.13	Seal deck drainage outlets at deck level (size)	number (No)

The unit of measurement shall be the number of outlets sealed.

The tendered rate shall include everything that is necessary to clean out the existing outlet/deck interface and reseal with a suitable sealant.

Item	Description	Unit
C14.9.14	Bridge number plates	
C14.9.14.1	Refurbishment of existing plates	number (No)
C14.9.14.2	New number plate	number (No)

The unit of measurement shall be the number of plates replaced or refurbished.

The tendered rate shall make full provision for the provision and installation of new bridge number plates, manufactured from non-ferrous and non-aluminium material and installed in recesses as shown on the drawings. For existing number plates, the tendered rate shall cover the cost of labour, equipment and material to remove, clean, repaint and re-install the number plates.

Item	Description	Unit
C14.9.15	Fix or re-fix ancillary elements	
C14.9.15.1	(Description of element)	metre (m)
C14.9.15.2	(Description of element)	number (No)
C14.9.15.3	(Description of element)	square meter (m ²)

The unit of measurement shall be the linear meter, square meter of ancillary element or the number of individual elements as the case may be.

The tendered rate shall include full compensation for all labour, material and equipment required to re-attach the relevant ancillary element to the concrete surfaces.

Item	Description	Unit
C14.9.16	Supply new ancillary elements	
C14.9.16.1	(Description of element)	metre (m)
C14.9.16.2	(Description of element)	square meter (m ²)

The unit of measurement shall be the linear meter of ancillary element or the number of individual elements as the case may be.

The tendered rate shall include full compensation for all labour, material and equipment required to supply and install the relevant ancillary element on the bridge. All corrosion protection shall be to the specification for paintwork or galvanising of ancillary elements as the case may be as specified in Section A13.11 of Chapter 13.

Item	Description	Unit
C14.9.17	Light fittings (description of element)	provisional sum

A provisional sum is provided in the pricing schedule to cover the cost of this work. The work authorised by the Engineer shall be paid for in accordance with the provisions of the General Conditions of Contract.

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D14.9 REPAIR AND REPLACEMENT OF ANCILLARY STRUCTURAL ELEMENTS

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No specific items in this Section.

Where applicable, details must be provided in the Contract Documentation.

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A14.10 JACKING OF BRIDGE STRUCTURES

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PART B: LABOUR ENHANCEMENT

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PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.10.1 SCOPE

This Section covers the requirements for the jacking of structural elements in both the vertical and horizontal directions.

A14.10.2 DEFINITIONS

Temporary works - the temporary works for jacking operations include all foundations, scaffolding and support structures, working platforms, temporary props and jacking equipment, control measures etc. required for the safe raising, lowering or moving of the structural members, which will be removed after completion of the jacking operations.

Jacking equipment - includes the mechanical and hydraulic equipment, plant, tools and systems required for the jacking of the specified members and, where necessary, includes the jacks for bearing replacement.

A14.10.3 GENERAL

A14.10.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

A14.10.4.1 Design of temporary works

The Contractor shall provide the Engineer with a method statement of the jacking procedures, compiled by an ECSA registered professional Engineer or Technologist with sufficient experience of jacking operations to design the temporary works and jacking procedures and to supervise the installation and operation thereof.

The Contractor shall also be responsible for the horizontal stability of the structural member during vertical jacking operations.

Jacking procedures shall be so designed that the effect on the member due to differential displacements shall not exceed 70 % of the effect of the bridge design loadings.

All temporary works shall be certified by an ECSA registered professional Engineer or Technologist on behalf of the Contractor to comply with all applicable safety regulations regarding strength and stability for all imposed loads that are anticipated to arise from the specified jacking operations as well as the load carrying capacity and suitability of the proposed jacking equipment and procedures.

The jacking positions shall be as indicated on the Contractor's drawings. Any deviation from those positions shall be subject to the Engineer's approval. The capacities of the jacks shall be at least 50 percent higher than the anticipated jacking load. Once locked off, the jacks shall be capable of carrying full dead load and live load.

A14.10.4.2 Design and detail amendments to the permanent works

Any amendments to the original design requested by the Contractor to suit his proposed jacking equipment or procedure or his proposed construction procedure, which require extra work, material or other costs shall be at the expense of the Contractor and subject to the Engineer's approval.

Such approval shall further be subject to the condition that the costs are covered by the Contractor's tender rates and amounts and shall be measured and paid in accordance with the original drawings and tendered pricing schedule.

A14.10.5 MATERIALS

A14.10.6 CONSTRUCTION EQUIPMENT

A14.10.6.1 Jacking Equipment

a) General requirements

All hydraulic hoses and connections shall be capable of withstanding at least 150 % of the rated load capacity.

The jacking equipment shall be supplied with tested hoses and connections which shall be exchanged in accordance with the manufacturer's planned maintenance programme.

The jack system shall be provided with a positive means of arresting the dropping of the deck onto the temporary support in the event of a sudden failure of any element in the jack system.

The Contractor is responsible for the design and supply of all the jacking equipment to suit his proposed jacking procedure. Jacking lifts shall not exceed 100 mm unless approved by the Engineer.

The jacking forces for the various jacking procedures will be provided on the working drawings. Structural elements shall be checked dimensionally for the suitability of the proposed jacking equipment.

b) Vertical alignment of members

The jacks are required to carefully facilitate the alignment of the jacked members according to the levels stated on the drawings. Once the members have been jacked to the required alignment, the jacks must be mechanically locked or the dead load must be transferred to the temporary support via packers and wedges.

All jacking points of the jacking equipment acting on the member to be raised or lowered shall be jacked simultaneously and at the same rate.

The jacking system must be capable of gradually adjusting the vertical position of the member to within 0,1 mm of the design levels, and must be capable of the lifting forces and strokes as specified on the working drawings.

These requirements also apply where jacks are used to support the deck during the removal of the existing bearings and the installation of the new bearings and plinths.

c) Raising or lowering of bridge decks

Where the distance by which a bridge is raised or lowered exceeds the stroke of the jack, steel packers may be used to increase the height. The packer plates shall be flat with a gap of less than 0,2 mm under a straight-edge.

A4.10.7 EXECUTION OF THE WORKS

A14.10.7.1 Founding of temporary supports

The temporary supports shall be supported on a stable and adequate founding system which will ensure compliance with the required tolerances during the deck jacking operation.

The Contractor is responsible for the design of the foundations for the temporary works and must provide details to the satisfaction of the Engineer indicating the ability of the proposed foundations to maintain the required tolerances under the construction loads.

The design shall be certified by an ECSA Registered Professional Engineer or Technologist on behalf of the Contractor.

All temporary works above a level 0,5 m below ground level shall be removed from site unless otherwise instructed by the Engineer.

A14.10.7.2 Temporary supports

The temporary supports shall be capable of transferring the loads from the jacks to the foundations. The support system shall be suitably braced, stable and of sufficient rigidity and strength to safely carry all imposed temporary primary and foreseeable secondary loads from the deck to the foundation during the construction activity. The temporary supports shall also be designed to carry all horizontal and vertical superimposed loads which may be applied to the member being jacked up. Bracing shall also consider longitudinal, transverse and twisting effects so that sway of the temporary supports is eliminated.

Where temporary supports are fixed to, or supported from the permanent structure, any temporary holes or other blemishes arising from the fixing of such temporary support shall be repaired to match the surface finish of the adjacent surface to the satisfaction of the Engineer.

The design and construction of the temporary supports shall allow for protective measures, such as guardrails or barriers, around supports which may endanger the structure, or compromise its safety, if these are damaged by passing traffic. These measures are intended to ensure the safety of the jacked structure and will not be paid for separately.

This safeguarding of the structure is in addition to the Accommodation of Traffic measures that are paid for under Chapter 1 which are primarily intended to ensure the safety of workmen, traffic and the travelling public.

A14.10.7.3 Jacking of continuous structures

Where a continuous bridge deck is jacked up or lowered via jacking, the levels between adjacent supports shall be carefully controlled. The difference in the amount lifted or lowered shall not exceed 10 mm between adjacent supports, or as shown on the drawings.

Only one support shall be jacked at a time to a maximum of 10 mm. The support shall then be locked off and made stable, and jacking continue on an adjacent support. If the Contractor wishes to deviate from this, such as jacking several supports at a time, he shall submit

a detailed method statement to the Engineer for approval. The method statement shall include details of the sequence of jacking, as well as stability and safety of the structure during jacking.

A14.10.7.4 Removal of restraints to jacking

All restraints to jacking shall be removed prior to the jacking operation. The restraints include dowels, vertical anchors, joints which may have closed up or become blocked, and other forms of ties or restraint.

Where joints or expansion joints at the ends of deck sections may have closed up or become blocked, these shall be cleaned out such that they will not impede the jacking operation.

A14.10.7.5 Installation of permanent bearings

Permanent bearings shall be installed after the deck has been jacked into its final position. Details of installation, bearing seats, rehabilitation work required to re-use bearings and protective measures to be applied, are indicated on the drawings.

Any excess height between the bearing assembly and the top of the substructure element shall be taken up by a high strength concrete plinth, structural steel stub column or epoxy mortar as applicable. The bearing shall be installed horizontally at the prescribed level in accordance with Section A14.6.

All mortar and grout used to bed the plinths, bearing assembly and the deck shall be of an approved high strength, non-shrink type achieving minimum compressive strengths of 20 MPa at 24 hours and 50 MPa at 48 hours.

The Contractor shall take adequate measures to ensure that the deck cannot move from its position during the bearing replacement and shall submit details of the proposed procedure to the Engineer for comment and approval.

A14.10.7.6 Loads on deck during jacking

No equipment, material or plant may be placed or stored on or in a bridge deck during the lifting of the deck and until the permanent bearings have been installed, except such equipment, material or plant that is approved and forms an essential part of the temporary works and jacking operations.

Temporary closure of the bridge to vehicular traffic will be required during each jacking operation. Only once the jacks have been locked off and the deck can withstand any vertical or horizontal imposed action, will the bridge be re-opened to traffic.

A14.10.8 WORKMANSHIP

The quality of materials and workmanship used during the jacking of bridge structures shall be equivalent to new works as specified in Chapter 13.

During the jacking operation and at regular intervals, the structure shall be inspected for any unexpected behaviour. This shall include movement and deflections which should not be occurring, settlement of temporary foundations, cracks opening in the structure and any other signs of distress.

A14.10.8.1 Alignment, deflection and jacking control

The Contractor shall establish at least two coordinated reference benchmarks at each support where jacking will take place. These benchmarks shall be of such description that they will be suitably protected against accidental damage for the duration of the jacking operations. No separate payment shall be made for these benchmarks and the costs of establishing and protecting the benchmarks will be deemed to be covered by the rates tendered for the other items.

The deck alignment and levels at each deck end and at each support shall be monitored continuously during the jacking operation. Any deviation from the design alignment must be corrected immediately.

Adjacent level differences shall not differ relatively by more than 1,0 mm, or as specified on the drawings, from the original value unless approved in writing by the Engineer. Level measurement during jacking shall include a dial gauge with an accuracy of 0,01 mm.

The Contractor shall record and submit all results within 24 hours to the Engineer for record purposes.

The jacking operation shall be controlled by a person with extensive and appropriate experience in the jacking procedure.

B14.10 JACKING OF BRIDGE STRUCTURES

PART B: LABOUR ENHANCEMENT

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B14.10.1 SCOPE

This Section covers the requirements for the jacking of structural elements in both the vertical and horizontal directions. This is deemed to be specialised activities and hence not suitable for labour enhanced construction.

B14.10.2 DEFINITIONS

The provisions of Part A shall apply with no additional requirements.

B14.10.3 GENERAL

The provisions of Part A shall apply with no additional requirements.

B14.10.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A shall apply with no additional requirements.

B14.10.5 MATERIALS

The provisions of Part A shall apply with no additional requirements.

B14.10.6 CONSTRUCTION EQUIPMENT

The provisions of Part A shall apply with no additional requirements.

B14.10.7 EXECUTION OF THE WORKS

The provisions of Part A shall apply with no additional requirements.

B14.10.8 WORKMANSHIP

The provisions of Part A shall apply with no additional requirements.

C14.10 JACKING OF BRIDGE STRUCTURES

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

1. The pay items in this Section shall include full compensation for all works associated with the jacking procedure which are not already covered by the measurement and payment items elsewhere in the specifications e.g. all temporary works and associated plant and equipment required for the successful raising, lowering or moving of structural members of a bridge to its final position.
2. All work and material associated with the jacking operations for which no specific pay item is defined shall be deemed to be covered by the items in this Section.

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for the hauling of any materials where the material is moved over a distance of less than, and up to 1,0 km and for labour enhanced construction, less than and up to 50 m.
6. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
7. No separate payment will be made for the removal or any surplus material imported to complete the works.
8. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.10.1	Temporary support and foundations	
C14.10.1.1	Design, construct and erect temporary supports for the jacking of (bridge deck)	lump sum
C14.10.1.2	Dismantle and remove from site	lump sum

The unit of measurement for each item shall be the lump sum.

The tendered amount shall include full compensation for all labour, material and equipment required for the design, fabrication, supply and erection of the temporary supports and foundations or the dismantling and removal from site, as well as the operation and maintenance of the supports. The amount shall include protective measures such as safety nets, screens, guard rails or barriers around the temporary support structures which shall be installed such that it does not constitute a traffic hazard.

Payment shall be made on completion of each pay item.

Item	Description	Unit
C14.10.2	Jacking equipment	
C14.10.2.1	Design, supply and install equipment for the jacking of (bridge deck)	lump sum
C14.10.2.2	Dismantle and remove all jacking equipment from site	lump sum

The unit of measurement for each pay item shall be the lump sum.

The tendered amount shall include full compensation for the work related to the design, supply and erection of the jacking equipment and all costs related to the maintenance of the equipment during the jacking operations. The equipment must include all mechanical and hydraulic units and the associated equipment and control units necessary for the jacking procedures.

The capacities of the jacking equipment shall be at least 50 percent higher than the anticipated jacking load.

Item	Description	Unit
C14.10.3	Vertical jacking of the bridge deck (site details)	number (No)

The unit of measurement shall be the number of structural members of specified mass (including superimposed loads) relocated vertically to the specified position by jacking.

The tendered rate shall include full compensation for all labour, materials, equipment and plant required for the execution of jacking operation, the alignment and deflection control during the operation and the recording and submission of results of the jacking operation and the alignment control.

Payment shall be made after the successful jacking and positioning of each specified member in the required location.

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D14.10 JACKING OF BRIDGE STRUCTURES

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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D14.10.10 REMEDIAL WORK

D14.10.1 SCOPE

The scope of this Section covers the following:

- Product conformance specifications
- Warranties for product or element design and installation of proprietary systems
- Performance specifications

Note that the requirements for performance specifications are not limited to that given in part C only but includes all of the requirements in the contract documentation.

D14.10.2 GENERAL

D14.10.2.1 Product conformance specifications

The Contractor shall, within 28 days of entering into the contract with the Employer, submit to the Engineer conformance documentation related to the specifications.

D14.10.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.10.3.1 Warranties for product or element design and installation of proprietary systems.

No additional requirements.

D14.10.3.2 Performance specifications

Performance based specifications shall be contained in the Contract Documentation the project.

A14.11 REPAIR OF STEEL ELEMENTS

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PART A: SPECIFICATIONS

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A14.11.6 CONSTRUCTION EQUIPMENT

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A14.11.8 WORKMANSHIP

PART B: LABOUR ENHANCEMENT

PART C: MEASUREMENT AND PAYMENT

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

PART A: SPECIFICATIONS

A14.11.1 SCOPE

This Section covers the requirements for removal, refurbishment and re-attachment of corroded or damaged steel items on bridges.

A14.11.2 DEFINITIONS

Ancillary items: Non-structural items such as street lighting, guardrail, electrical and similar connections.

Structural items: Load bearing structural items contributing to the strength of the structure.

A14.11.3 GENERAL

Steel items shall be refurbished such that they fulfill their original design intent in terms of strength, safety and durability. Structural items especially shall meet the requirements of Sections A13.9 and A13.11 of Chapter 13 in terms of fabrication, weld quality, straightness and corrosion protection.

A14.11.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

Where a damaged or corroded steel item, or where the removal of a steel item may compromise the safety or stability of part of a structure, the Contractor shall design and install appropriate temporary works certified by an ECSA registered professional Engineer or Technologist. Details shall be submitted to the Engineer for approval.

A14.11.5 MATERIALS

A14.11.6 CONSTRUCTION EQUIPMENT

Corroded or badly fitting steel ancillary items shall be refurbished when instructed by the Engineer.

The items to be refurbished shall be carefully removed from their installed positions without damaging the surrounding concrete or other steel items, removed from site and refurbished. Where a section of steel is cut out and replaced, the new steel shall be connected using full strength welds. The welds shall be ground flush with the steel surface.

Where steel members require straightening, this shall be done using jacking equipment.

Items will then be prepared for painting or hot dip galvanising in accordance with Clause A13.12.7.8a) of Chapter 13.

Steel ancillary items will be returned to site and re-installed in their original positions, utilizing new galvanised mild steel bolts to suit their application if necessary.

For structural items being refurbished, bolts and rivets removed shall not be reused but replaced with Class 10.9 HSFGB bolts torqued using the method of turn.

Where items cannot be removed from site for refurbishment such as refurbishment of local damage to a major welded steel item, the work shall be carried out on site in near-factory conditions.

All items shall be painted as specified on the drawings or instructed by the Engineer. Painting shall be done immediately after refurbishment in near-factory conditions. All paint damaged during installation shall be repaired after installation. Site welds, bolts and nuts shall be painted to the full paint specification after installation.

All works, including fabrication and painting shall be done in accordance with Section A9, A10, A11 and A12 of Chapter 13.

A14.11.7 EXECUTION OF THE WORKS

All hot dip galvanising shall be done in accordance with SANS 121, and the minimum coating thickness for all elements shall be 85 microns. All items shall be sand blasted to ST2½ to remove all existing corrosion protection and corrosion.

The correct shape and size of ill-fitting items shall be requested from the Engineer who shall either issue drawings from which the dimensions shall be derived, or provide such general dimensions in writing as are appropriate to the structure concerned. The Contractor shall then be fully responsible for ensuring that the item removed for refurbishment will fit to generally accepted tolerances onto the structure once it is reinstalled.

The Contractor shall ensure that the structure from which the steel element was removed, remains in a safe condition, specifically where the removal of the item may have a negative impact on the safety of the public. In this regard, any and all necessary supports, signage, danger tape etc. shall be utilised by the Contractor.

A14.11.8 WORKMANSHIP

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B14.11 REPAIR OF STEEL ELEMENTS

PART B: LABOUR ENHANCEMENT

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B14.11.1 SCOPE

B14.11.2 DEFINITIONS

B14.11.3 GENERAL

B14.11.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

B14.11.5 MATERIALS

B14.11.6 CONSTRUCTION EQUIPMENT

B14.11.7 EXECUTION OF THE WORKS

B14.11.8 WORKMANSHIP

B14.11.1 SCOPE

This Section covers the requirements for removal, refurbishment and re-attachment of corroded or damaged steel items on bridges. It is suitable for labour enhanced construction.

B14.11.2 DEFINITIONS

The provisions of Part A, shall apply.

B14.11.3 GENERAL

The provisions of Part A, shall apply.

B14.11.4 DESIGN BY CONTRACTOR / PERFORMANCE BASED SYSTEMS

The provisions of Part A, shall apply.

B14.11.5 MATERIALS

The provisions of Part A, shall apply.

B14.11.6 CONSTRUCTION EQUIPMENT

The provisions of Part A, shall apply.

B14.11.7 EXECUTION OF THE WORKS

The provisions of Part A, shall apply.

B14.11.8 WORKMANSHIP

The provisions of Part A, shall apply.

C14.11 REPAIR OF STEEL ELEMENTS

PART C: MEASUREMENT AND PAYMENT

(i) Preamble

The tendered rate for each item shall include full compensation for providing, maintaining and decommissioning upon completion, of all the plant, equipment, labour, tools, incidentals and supervision to carry out the activity or construct the works in the item, unless otherwise stated.

Any prime cost or provisional sums shall be paid in accordance with the provisions of the conditions of contract. The charge or mark-up tendered or allowed for is a percentage of the amount actually paid under the prime cost or provisional sum. This percentage shall cover all the contractor's handling, supervision, profit and liability costs to provide the services in the prime cost or provisional sum item.

The requirements of Section C1.1 of Chapter 1 shall apply.

Where pay item descriptions include any wording in brackets it is an indication that contract specific information is to be inserted in the Pricing Schedule included in the Contract Documentation.

(ii) Notes on measurement and pay items

None

(iii) Items that will not be measured separately

The following activities, whether required to complete the specified work or not, will not be measured and paid for separately and the Contractor shall include the cost thereof in other pay items as he deems appropriate:

1. No separate payment will be made for setting out the works.
2. No separate payment will be made for the protection or repair as required of any existing or new road furniture, structures, buildings, infrastructure or services damaged by the Contractor's activities.
3. No additional payment shall be made, nor shall any claim for additional payment be considered, for any specified work in confined or restricted areas. Any additional costs associated with working in confined or restricted areas shall be deemed to be included in the standard applicable pay items.
4. No separate payment will be made for the loading of any materials.
5. No separate payment will be made for transporting materials from commercial sources irrespective of the haul distance.
6. No separate payment will be made for the removal or any surplus material imported to complete the works.
7. For all Works performed, precautionary measures required in terms of the Occupational Health and Safety Act (Act 85 of 1993) and the latest amendments thereof as well as the latest Construction Regulations shall be deemed included in the rates tendered for the relevant products.

(iv) Items specifically for this Section of the specifications

Item	Description	Unit
C14.11.1	Refurbishment of (describe item)	number (No)

The unit of measurement shall be the number of whole items as described which are removed, refurbished and re-installed on the bridge or element.

The tendered rate shall include full compensation for all labour and equipment required to remove the item, to refurbish the item including replacement of steel sections, all fabrication, transport, hot dip galvanising, and to re-install the item using new bolts where required. HSFG bolts and nuts are paid for under the next pay-item.

The tendered rate shall include all temporary works required to make the structure safe during refurbishment, and the making good of any damage that may have occurred to the structure during refurbishment.

Item	Description	Unit
C14.11.2	Replacement of rivets or bolts with HSFG bolts (diameter and class indicated)	number (No)

The unit of measurement shall be the number of rivets or bolts removed and replaced with new HSFG bolts.

The tendered rate shall include full compensation for removing the rivet or bolt, reaming the hole to the correct size to receive the HSFG bolt, supplying the bolt, nut and washer and installing the bolt to the correct tension.

D14.11 REPAIR OF STEEL ELEMENTS

PART D: GUARANTEES AND COMPLIANCE CERTIFICATES

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D14.11.1 SCOPE

D14.11.2 GENERAL

D14.11.3 PERFORMANCE GUARANTEE REQUIREMENTS

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D14.11.8 ADDITIONAL PROCEDURES TO BE ADOPTED IN THE EVENT OF FAILURE

D14.11.9 NOTIFICATION OF REMEDIAL WORK

D14.11.10 REMEDIAL WORK

D14.11.1 SCOPE

The scope of this Section covers the following:

- Product conformance specifications
- Warranties for product or element design and installation of proprietary systems
- Performance specifications

Note that the requirements for performance specifications are not limited to that given in part C only but includes all of the requirements in the contract documentation.

D14.11.2 GENERAL

D14.11.2.1 Product conformance specifications

The Contractor shall, within 28 days of entering into the contract with the Employer, submit to the Engineer conformance documentation related to the specifications.

D14.11.3 PERFORMANCE GUARANTEE REQUIREMENTS

D14.11.3.1 Warranties for product or element design and installation of proprietary systems

No additional requirements.

D14.11.3.2 Performance specifications

Performance based specifications shall be contained in the Contract Documentation for the project.