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REVISION REGISTER

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SHOTCRETE WORK

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IC-DC-B82

VERSION FOR:
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FOREWORD

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BASE SPECIFICATION

This document is based on Specification RMS B82 Edition 2 Revision 4.
RMS SPECIFICATION D&C B82
SHOTCRETE WORK

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the supply and application of structural shotcrete for permanent works, excluding wearing surfaces, with total thickness equal to or greater than 75 mm. Its main use is intended to be for tunnel linings, but the specification may be used for other works such as retaining walls as appropriate.

Shotcrete supplied and applied under this Specification must:
(a) be wet-mix shotcrete; and
(b) contain steel fibre reinforcement.

The scope of this Specification does not include provisions for the structural design of the shotcrete, the supply and installation of rockbolts or the supply and installation of waterproofing and drainage elements.

1.2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

1.2.1 Details of Work

Project specific requirements are shown in Annexure B82/A.

1.2.2 Schedules of HOLD POINTS and Identified Records

The schedules in Annexure B82/C list the HOLD POINTS that must be observed. Refer to Specification RMS D&C Q6 for the definition of HOLD POINTS.

The records listed in Annexure B82/C are Identified Records for the purposes of RMS D&C Q6 Annexure Q/E.

1.2.3 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure B82/D and must be implemented.

1.2.4 Testing Procedures

The Inspection and Test Plan must nominate the proposed testing frequency to verify conformity of the item and it must not be less than that specified in Annexure B82/L. Where a minimum frequency is not specified, nominate an appropriate frequency.
1.2.5 Referenced Documents and Abbreviations

Codes, standards, specifications and test methods are referred to in abbreviated form (e.g., AS 1234). For convenience, the full titles are given in Annexure B82/M. Whenever a part of a standard is referenced, the common title of the standard is mentioned in Annexure B82/M as a separate entry with that part of the standard referred to only by its particular title.

1.3 Definitions

The terms “you” and “your” mean “the Contractor” and “the Contractor’s” respectively.

The following definitions apply to this Specification:

(a) **Cement**: Material conforming to Specification RMS D&C 3211 Clause 6. It comprises cements, blended cements, supplementary and other cementitious materials.

(b) **Concrete**: A thoroughly mixed combination of cement, aggregates and water, with or without the addition of fibres, chemical admixtures or other materials, all of which separately and when combined conform to the requirements of this Specification.

(c) **Cover**: The distance between the outside of the reinforcement other than fibres and the nearest permanent surface of the shotcrete, or between the outside of the reinforcement other than fibres and the nearest point on the receiving surface.

(d) **Curing**: The control of temperature and moisture in the concrete until the concrete has developed required properties.

   (i) **Sealed Curing**: Curing at ambient temperature in which the concrete surface is sealed by at least two coats of a curing compound conforming to this Specification.

   (ii) **Standard Moist Curing**: Standard Moist Curing as defined in AS 1012.8.1.

   (iii) **Wet Curing**: Curing at ambient temperature in which the concrete surface is effectively covered with water or placed in a fog room/chamber with a relative humidity exceeding 98%.

(e) **Exposure Classification**: The exposure classification for the surface of a member as determined in accordance with Clause 4.3 of AS 5100.5.

(f) **Nozzle**: Attachment at end of delivery hose from which shotcrete is projected.

(g) **Overspray**: Material projected outside the intended receiving surface.

(h) **Rebound**: Shotcrete material that bounces off the receiving surface.

(i) **Shotcrete**: 

   (i) **Shotcrete (generic)**: Concrete pneumatically projected onto a surface at high velocity.

   (ii) **Wet-mix Shotcrete**: Shotcrete in which cement, aggregate, and water are first mixed together before introduction as concrete into the delivery hose.

(j) **Shotcrete Mix**: 

   (i) **Base Mix**: Concrete designed, tested and supplied independent from the shotcreting process, equipment and personnel.
Shotcrete Work

(ii) **Shotcrete Mix:** The base mix after it is applied to the Project Works, or to test panels.

(k) **Sloughing:** Subsidence of fresh shotcrete.

(l) **Water / Cement Ratio (w/c):** The ratio, by mass, of total free water, including water contained in admixture solutions, to total cement including all supplementary cementitious materials, in the concrete mix.

## 2 MATERIALS FOR CONCRETE

### 2.1 GENERAL

Materials for concrete must conform to Section 2 of AS 1379 and with the additional requirements of Clause 2 of this Specification.

### 2.2 CEMENT

Cement used in the Project Works must be Shrinkage Limited Type SL or General Purpose Blended cement Type GB in accordance with this Specification and RMS D&C 3211.

Blending of cement must be achieved either at the cement manufacturer's facilities and/or at the concrete batching plant, unless otherwise specified.

Supplementary cementitious materials (SCM) such as Fly Ash, Slag and Amorphous Silica and their proportions must conform to RMS D&C 3211.

### 2.3 ADMIXTURES

#### 2.3.1 General

Chemical admixtures, including corrosion inhibitors, and their use must conform to AS 1478.1. Admixtures must not contain calcium chloride. Where two or more admixtures are proposed for incorporation into a concrete mix, get their compatibility certified by the manufacturers. Submit details of the requirements for storage, preparation and mixing the admixtures.

Dispense accelerators and other admixtures that are added to concrete at the nozzle or at the delivery hose by calibrated mechanical means at dosage rates not exceeding the maximum recommended by the manufacturer.

Hydration control admixtures that suspend the hydration of shotcrete until the addition of the activator must not cause a decrease in concrete strength with age.

#### 2.3.2 Corrosion Inhibitors

Corrosion inhibitors must contain a minimum of 30% of calcium nitrite solids. Where retarders additional to those already present in the corrosion inhibitor admixture are used to further modify the acceleration characteristics of the admixture, they must be added to the concrete before or with the admixture.

Where corrosion inhibitors are specified, the admixture application rate must be such that the concrete contains a minimum of 9 kg of calcium nitrite solids per cubic metre.
2.4 AGGREGATES

2.4.1 General

All aggregates used in the Project Works must conform to AS 2758.1 and the requirements of Clauses 2.4 and 2.5 of this Specification.

The combined particle size distribution of all coarse and fine aggregates in the base mix and concrete must be in accordance with Table B82.1.

Table B82.1 – Combined Coarse and Fine Aggregate Particle Size Distribution Requirements

<table>
<thead>
<tr>
<th>Sieve aperture</th>
<th>Mass of sample passing, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2 mm</td>
<td>100</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>90 – 100</td>
</tr>
<tr>
<td>6.7 mm</td>
<td>–</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>70 – 85</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>50 – 70</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>35 – 55</td>
</tr>
<tr>
<td>600 µm</td>
<td>20 – 40</td>
</tr>
<tr>
<td>300 µm</td>
<td>8 – 20</td>
</tr>
<tr>
<td>150 µm</td>
<td>2 – 10</td>
</tr>
</tbody>
</table>

2.4.2 Additional Requirements for Coarse Aggregate

(a) Do not use lightweight coarse aggregate;

(b) Only use coarse aggregate with maximum nominal size of 10 mm;

(c) Limit water absorption to a maximum of 2.5% except for slag aggregate where the maximum limit is 6%; and

(d) Use wet strength and wet/dry strength variation tests for aggregate durability assessment in accordance with AS 2758.1 with ‘duplicate testing’ being carried out in accordance with AS 1141.22

2.4.3 Additional Requirements for Fine Aggregate

(a) Limit water absorption to a maximum of 2.5%; and

(b) Any manufactured sand used as a fine aggregate must be crushed from rock from which is produced aggregate conforming to the requirements of Clause 2.4, and must be non-plastic when tested in accordance with AS 1289.3.

The requirements of Clause 8.2.2 of AS 2758.1 do not apply for manufactured sand. The water absorption of the combined fine aggregate must not exceed 2.5%.
2.5 ALKALI-AGGREGATE REACTION (AAR)

2.5.1 Alkali - Reactive Materials

All aggregate used in the concrete to be incorporated into the Project Works must be:
(a) petrographically examined in accordance with Clause 2.5.2; and
(b) assessed and classified for AAR using either the accelerated mortar bar test method or the concrete prism test method, in accordance with RMS T363 and RMS T364, respectively.

2.5.2 Petrographic Examination

Petrographic examination must be in accordance with ASTM C295. Those aggregates containing obviously reactive components such as:
(a) Opaline material;
(b) Unstable silica minerals such as moderate amounts of tridymite and cristobalite; or
(c) Sheared rock containing moderate amounts of strained quartz and microcrystalline quartz,
may be eliminated without further testing.

Do not rely on petrographic examination alone to determine that an aggregate is non-reactive. Testing of the aggregate to RMS T363 is also required.

2.5.3 Actions Required for Control of AAR

For aggregates classified as non-reactive by either RMS T363 or RMS T364, no action is required.

For aggregates classified by RMS T363 as having potential for mild/slow or substantial AAR, actions required for control of potential AAR must be in accordance with Table B82.2.

Blended cements used for control of potential AAR must be in accordance with RMS 3211.

Aggregates classified as reactive by RMS T364 in a particular concrete mix design, must not be used. Alternative aggregates and/or alternative concrete mix designs must be used which conform to the requirements of this Specification.

Table B82.2 – Actions Required for Control of Potential AAR

<table>
<thead>
<tr>
<th>Mortar bar expansion (%) in 1M NaOH (80°C) at 21 days</th>
<th>Actions Required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coarse aggregate</strong></td>
<td><strong>Fine aggregate</strong></td>
</tr>
<tr>
<td>≥ 0.10, &lt; 0.40</td>
<td>≥ 0.15, &lt; 0.45</td>
</tr>
<tr>
<td>≥ 0.40</td>
<td>≥ 0.45</td>
</tr>
</tbody>
</table>

* based on RMS T363
2.6  FIBRES

2.6.1  Steel Fibres

Use deformed steel fibres at a dosage rate that does not result in balling during addition or use of the mix. The inclusion of the fibres in the shotcrete mix must not lead to a significant reduction in workability, pumpability, or sprayability.

Assess the suitability of steel fibre type and dosage using toughness testing during the design and trial of the shotcrete mix in accordance with Clause 3.

Store fibres in dry sealed containers until ready for use. Fibres must be free from corrosion, oil, grease, chlorides and deleterious materials which may reduce the efficiency of mixing or spray process, or which may reduce the bond between the fibres and the shotcrete.

2.6.2  Synthetic Fibres

Include synthetic fibres in the shotcrete mix to mitigate the effects of explosive spalling of shotcrete when subjected to high intensity hydrocarbon-fuelled fires. Add between 1 and 2 kg/m³ of fine micro polypropylene monofilament fibres to the concrete.

2.7  SOLUBLE SALTS

Determine the chloride ion content by testing ground samples of hardened concrete in accordance with AS 1012.20.

Take the samples from a minimum 1.2 kg portion of the hardened concrete. Crush and grind the 1.2 kg of hardened concrete to a maximum size of 150 microns and then oven dry at 110°C ± 5°C for a minimum of one hour before taking the samples for analysis.

Analyse five (5) randomly selected samples of 20 ± 0.1 grams of the ground concrete for chloride ion content.

Use the Volhard method calibrated against a concrete with known chloride content for the tests. Modify the procedure of AS 1012.20 and use standard solutions for the analysis that bracket the expected chloride ion concentration.

Report the chloride ion content of each of the five samples and calculate and report the average chloride content and the standard deviation of the five samples.

The average mass of acid-soluble chloride ion per unit volume of concrete as placed must not exceed the values given in Table R68.3.

The sulfate content of concrete as placed, determined by calculation and expressed as the percentage by mass of acid-soluble SO₃ to cement, must not be greater than 5.0%.
Table B82.3 - Maximum Values of Acid-Soluble Chloride-Ion Content in Concrete

<table>
<thead>
<tr>
<th>Exposure classification *</th>
<th>Maximum acid-soluble chloride ion content (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fibre Reinforced Concrete without Conventional Reinforcement</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B1</td>
<td>0.8</td>
</tr>
<tr>
<td>B2</td>
<td>0.8</td>
</tr>
<tr>
<td>C</td>
<td>0.8</td>
</tr>
<tr>
<td>U</td>
<td>In accordance with Annexure B82/A Clause A1</td>
</tr>
</tbody>
</table>

Note: Chloride ion content may be expressed in percentage weight of oven dried concrete (0.1 kg/m³ ion content is approximately equivalent to 0.004% by weight of oven dried concrete).

* For information on exposure classifications, see AS 5100.5.

3 DESIGN OF SHOTCRETE MIX

3.1 GENERAL

Base the design and trial of the shotcrete mix on the anticipated conditions which will prevail on site so that, under these conditions and with the nominated application method and nozzle operators, the shotcrete meets all the requirements of this Specification.

Carry out the design of the shotcrete mix in two stages. The first stage is the design of a base mix. The second stage is the trial of the shotcrete mix.

Where the shotcrete mix, during its trial stage, is found to require significant alteration to the base mix exceeding the variations specified in Clause 3.13, design and trial a modified base mix and assess for conformity.

Test results must be the average of a minimum of two specimens, unless otherwise specified in the applicable test method.

3.2 BASE MIX

3.2.1 Target Compressive Strength for Mix Design

Design the base mix to achieve a target strength $f_{c,md}$ such that:

$$f_{c,md} \geq f_{c,min} + M_{control}$$

where $M_{control}$ is the margin nominated for variations in strength as defined in Clause 6.1 and $f_{c,min}$ is the specified minimum 28 day compressive strength as stated in the Design Documentation, or elsewhere in the Specification.

The target strength $f_{c,md}$ must not exceed 45 MPa.
3.2.2 Proportioning for Durability

For the exposure classifications specified in the Design Documentation, the minimum cement content and maximum water/cement ratio of the base mix must be in accordance with Table B82.4.

Table B82.4 - Minimum Cement Content and Maximum Water/Cement Ratio

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Minimum cement content (kg/m³)</th>
<th>Maximum water/cement ratio (by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>320</td>
<td>0.45</td>
</tr>
<tr>
<td>B1</td>
<td>320</td>
<td>0.45</td>
</tr>
<tr>
<td>B2</td>
<td>370</td>
<td>0.40</td>
</tr>
<tr>
<td>C</td>
<td>420</td>
<td>0.40</td>
</tr>
<tr>
<td>U</td>
<td>In accordance with Annexure B82/A Clause A1</td>
<td></td>
</tr>
</tbody>
</table>

3.2.3 Trial Base Mix, Sampling and Testing

Prepare a trial base mix in accordance with AS 1012.2 using:

(a) the proposed materials and mix proportions;

(b) all admixtures including nozzle-added admixtures added at the highest dosages proposed by you; and

(c) the proposed fibres at proposed dosage.

Batch the trial base mix at the highest water/cement ratio conforming to the allowable slump range which must allow for batching tolerances specified for the nominated base mix.

Carry out sampling and testing for:

(i) slump;

(ii) shrinkage;

(iii) density; and

(iv) compressive strength.

3.3 Slump

The base mix must have a slump between 75 mm and 120 mm.

3.4 Shrinkage

Prepare and measure shrinkage of specimens from the base mix in accordance with AS 1012.13.

Shrinkage of the specimens after either 3 or 8 week’s drying must conform to Table B82.5. Where no exposure classification is stated in the Design Documentation or elsewhere in the Specification, apply exposure classification B1.
Table B82.5 - Maximum Shrinkage Strain of the Nominated Base Mix Specimens

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Maximum shrinkage strain (microstrain)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drying period</td>
</tr>
<tr>
<td></td>
<td>3 Weeks</td>
</tr>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>B1, B2</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td></td>
</tr>
</tbody>
</table>

3.5 STEEL FIBRE CONTENT

Steel fibre content of base mix or fresh concrete taken from the mixer must not be less than the limits required to meet the toughness requirements of Clause 3.9.

Base determination of steel fibre content of shotcrete as placed on a sample of a known volume not less than 6 litres. Wash the sample, separate and weigh the steel fibre content and report the results to the nearest 2 grams.

3.6 COMPRRESSIVE STRENGTH

The 28 day compressive strength of concrete determined in accordance with Annexure B82/L Clause L2 must not be less than 32 MPa.

3.7 PERMEABILITY

For the exposure classifications specified in the Design Documentation the maximum permeability penetration depth, determined in accordance with DIN 1048, of concrete included in the Project Works must be in accordance with Table B82.6.

Table B82.6 - Permeability Requirements - Penetration Depth

<table>
<thead>
<tr>
<th>Exposure classification</th>
<th>Maximum Penetration Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>30</td>
</tr>
<tr>
<td>B1</td>
<td>30</td>
</tr>
<tr>
<td>B2</td>
<td>25</td>
</tr>
<tr>
<td>C</td>
<td>25</td>
</tr>
<tr>
<td>U</td>
<td>In accordance with Annexure B82/A Clause A1</td>
</tr>
</tbody>
</table>

3.8 DENSITY OF HARDENED CONCRETE

The density, at 28 days, of hardened concrete included in the Project Works, determined in accordance with AS 1012.12 on representative samples cut from the Project Works in accordance with AS 1012.14, must not be less than 98% of:
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Shotcrete Work

a) that of the corresponding samples taken from the transit mixer in accordance with AS 1012.8.1; and
b) the nominated base mix.

Core diameters of less than 75 mm are acceptable.

3.9 **TOUGHNESS**

Toughness must be determined in accordance with ASTM C 1550.

The toughness as measured by energy absorbed in causing central deflections of 5 mm and 40 mm must be equal to or exceed 100 Joules and 500 Joules respectively.

If two panels are tested from the same day work, the mean performance should be used and the lower performing specimen should be discarded if the results differ by more than 20% of the higher result.

3.10 **TRIAL OF SHOTCRETE MIX**

Prior to commencing construction, construct test panels using each proposed base mix and for each nominated nozzle operator. Apply shotcrete normal to the surface of horizontal and vertical test panels. The test panels must be at least 750 mm x 750 mm and constructed to the same thickness as the Project Works or 115 mm, whichever is the greater. Where reinforcement in the form of steel fabric or bars is used, provide the same reinforcement in at least half of the panel.

Make separate test specimens using 75 mm thick round forms 800 mm in diameter in accordance with Clause 3.9 for toughness.

Carry out sampling and testing for:

(a) compressive strength;
(b) density;
(c) permeability; and
(d) toughness.

3.11 **ASSESSMENT FOR CONFORMITY**

Assess the nominated shotcrete mix for conformity including assessment of the base mix, the curing regime and application method based on:

(a) the average result, for slump, shrinkage and steel fibre contents of specimens sampled from the trial mix;
(b) the average result, for compressive strength and permeability of specimens cut from test panels;
(c) the average result for concrete density and relative concrete density;
(d) the result of toughness testing;
(e) thickness of panels, quality of its external surfaces and internal cut surfaces; and
(f) the degree of control required to achieve dense and homogeneous shotcrete without segregation, sloughing, collapsing, excessive rebound or other visible imperfections.
3.12 NOMINATED SHOTCRETE MIX

3.12.1 General

Submit to the Project Verifier details of each nominated shotcrete mix, together with a certificate stating that the nominated shotcrete mix, its constituents, the proposed application and the proposed curing regime meet the requirements of this Specification.

HOLD POINT

Process Held: Use of each nominated shotcrete mix in the Project Works
Submission Details: All details in Clause 3.12 and certification, at least 5 working days prior to the proposed usage of each shotcrete mix.
Release of Hold Point: The Nominated Authority will consider submitted documents and may carry out surveillance and audits, prior to authorising the release of the Hold Point.

3.12.2 Submission Details for Base Mix

(a) Material Constituents
   (i) Source;
   (ii) Current test results not more than 12 months old providing evidence of conformity to Clause 2; and
   (iii) Method of controlling alkali-aggregate reaction specified in Clause 2.5.

(b) Mix Design
   (i) Constituent quantities;
   (ii) Trial mix water/cement ratio and corresponding nominated water/cement ratio;
   (iii) Condition of constituents used in the mix design eg moisture condition of aggregates;
   (iv) \( f_{c,\text{min}} \) (refer Clause 3.2.1);
   (v) Slump of the trial base mix and corresponding nominated slump;
   (vi) Slump of the trial base mix with the proposed fibre dosage and corresponding nominated slump; and
   (vii) Maximum time for shotcrete application, where hydration-control admixtures are used.

(c) Batching, Mixing and Transport
   (i) Methods;
   (ii) Level of control and accuracy of batching;
   (iii) Level of control and accuracy of determination of the aggregate moisture content;
   (iv) Method of determination of \( M_{\text{control}} \); and
   (v) Minimum mixing time.

(e) Test Results of Hardened Concrete
   (i) 28 day compressive strength in accordance with AS 1012.9;
(f) Trial mix “Report” in accordance with AS 1012.2

3.12.3 Submission Details for Shotcrete Mix

(a) Test Panel Construction
   (i) Number and sizes of test panels;
   (ii) Base mix used in each test panel;
   (iii) Type and dosage of fibres;
   (iv) Type and dosages of nozzle-added admixtures;
   (v) Required and actual thickness;
   (vi) Description of finished product;
   (vii) Description of internal cut surfaces; and
   (viii) Degree of control required to achieve uniform shotcrete without excessive rebound, sloughing, partial or total collapsing during shotcreting.

(b) Hardened Shotcrete Characteristics

Test reports for:
   (i) Compressive strength;
   (ii) Toughness in terms of energy absorption of the round panel specimens;
   (iii) Density; and
   (iv) Permeability.

3.12.4 Submission Details for Application Method and Curing Regime

(a) Application Method
   (i) Procedures for shotcreting;
   (ii) Equipment used for shotcreting;
   (iii) Position of shotcreting; and
   (iv) Names and experience of nozzle operators.

(b) Curing regime
   (i) Method and duration of curing; and
   (ii) Anticipated minimum ambient temperatures during the curing period.

If you propose to vary the curing regime, submit a new nominated base mix in accordance with Clause 3.12.
3.13 **VARIATION TO NOMINATED MIXES**

The quantities of the constituents in a nominated mix may be varied to improve the quality of the concrete. Variations to the quantities of constituents in the nominated mix must not exceed the following:

(a) Cement: 3% by mass of each constituent.
(b) Aggregates: 5% by mass of each constituent.
(c) Water: 3% by mass and/or volume of water.
(d) Fibres: 10% by mass of fibres.

Notify the Project Verifier in writing and submit written details of such variations to a nominated mix before commencing production with the varied quantities.

Notwithstanding the above provisions, the varied mix must:

(i) not have a water/cement ratio exceeding that nominated for the concrete mix (refer to Clause 3.12);
(ii) conform to the requirements of Clause 3.2.2 for minimum cement content and maximum water/cement ratio; and
(iii) conform to the requirements of RMS D&C 3211 for the range of SCM in Blended cement.

If you wish to vary the quantities of the constituents in excess of the above amounts, or wish to change the type or source of supply of any constituent, or vary the curing regime, submit a new nominated mix for approval in accordance with Clause 3.12.

### 4 SURFACE PREPARATION

#### HOLD POINT

<table>
<thead>
<tr>
<th>Process Held:</th>
<th>Surface preparation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission Details:</td>
<td>Notification of each intention to commence surface preparation with details of the method to be used at least two working days prior to commencing.</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
<td>The Project Verifier will consider the submitted documents and may carry out surveillance and audits, prior to release of the Hold Point.</td>
</tr>
</tbody>
</table>

#### 4.1 GENERAL

Prepare all surfaces to be shotcreted prior to application of shotcrete.

Prevent wash-out of freshly placed shotcrete due to water seepage by using conduits to channel the water away. On completion of shotcreting, plug the conduits using flash setting cement.

#### 4.2 EARTH SURFACES

Prior to shotcreting, compact and trim the earth surface to line and grade to enable the designed shotcrete thickness to be achieved. Remove all loose soil or other material from the trimmed surface.
Prevent excessive absorption of mixing water from the shotcrete by:

(a) Prewetting all earth surfaces to be shotcreted (but keeping the surface drained of free water); or

(b) Installing a moisture barrier system to stop the movement of moisture from the newly placed shotcrete into the earth. When sheet materials are used, prevent wrinkling or folding to stop voids being formed behind the moisture barrier. Take extra care in the sequence of application or apply a flashcoat to prevent shotcrete slippage.

4.3 ROCK SURFACES

Clear all rock surfaces to be shotcreted of loose material, debris, chips, mud, dirt, or other foreign matter prior to shotcreting.

After the loose material has been removed, wash the surface as required with a high-pressure air / water jet or by other means.

After the above preparation is carried out, prewet the rock surface prior to the application of shotcrete.

Remove any excess free water by blowing with oil-free dry compressed air.

4.4 CONCRETE SURFACES

Clear existing concrete surfaces to be shotcreted of any spalled, cracked, deteriorated, loose, unsound and/or chemically contaminated concrete until a sound and uncontaminated concrete is reached.

Where shotcrete is to be placed against a smooth concrete surface, roughen the surface by mechanical methods.

After the above preparation is carried out, prewet the concrete surface prior to the application of shotcrete.

Remove any excess free water by blowing with oil-free dry compressed air.

5 SUPPLY AND FIXING OF STEEL REINFORCEMENT (OTHER THAN STEEL FIBRES) AND EMBEDMENTS

5.1 QUALITY MANAGEMENT SYSTEM

The reinforcement material supplier must be certified by the Australian Certification Authority for Reinforcing Steels (ACRS) for the supply of reinforcement material.

The reinforcement fabricator must be certified by ACRS for fabricating reinforcement and implement and maintain a quality management system in accordance with AS/NZS ISO 9001, as a means of ensuring that the product conforms to the Specification requirements.
5.2 MATERIALS

5.2.1 Reinforcement

Reinforcement must be deformed bars or welded wire fabric except that plain bars or wire may be used for fitments (a fitment is a unit of reinforcement commonly known as a tie, stirrup, ligature or helix). All reinforcement must conform to AS/NZS 4671.

5.2.2 Protective Coatings

Unless specified otherwise, do not use reinforcement with protective coating, including epoxy coating.

5.3 STORAGE

Support reinforcement above the surface of the ground, and protect it from damage and from deterioration due to exposure.

5.4 SURFACE CONDITION

At the time concrete is placed, the surface condition of reinforcement must be such as not to impair its bond to the concrete or its performance in the member.

5.5 PLACING AND FIXING OF REINFORCEMENT AND EMBEDMENTS

Support reinforcement and hold clear of surface to be shotcreted with the cover as stated on the Design Documentation drawings. Where no cover is shown on the Design Documentation drawings, maintain a minimum cover of 30 mm.

5.6 EMBEDMENTS FOR DRAINAGE

Relieve water pressure behind the completed Project Works by installation of a permanent pressure-relief drainage system where stated in the Design Documentation.

6 SUPPLY AND DELIVERY OF CONCRETE

6.1 GENERAL

Produce and deliver concrete to the site of the Project Works in accordance with the requirements of AS 1379 and the additional requirements of this Specification.

Classify all concrete for use in the Project Works as Special Class and designate "S" in accordance with Clause 1.6.4 of AS 1379. Nominate the method of production assessment relevant to the plant in accordance with the criteria of AS 1379.

Nominate a margin for strength which is consistent with the nominated method of production assessment under which the plant operates. This margin for strength, referred to in this Specification as $M_{control}$, is the measure of the level of control for the nominated plant producing the nominated mix.
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Dispose of water, contaminants, debris, excess concrete and other materials from concrete supply operations in accordance with Specification RMS D&C G36.

6.2 MOISTURE CONTENT OF AGGREGATES

Determine the moisture content of the fine and coarse aggregates prior to concrete production for the day and whenever conditions change, either by a moisture meter or by other equivalent devices or methods. Make corrections to the mass of all aggregates and the volume of water used in the mix commensurate with the moisture content determined.

6.3 ADDITION OF STEEL FIBRES

Add steel fibres to the concrete or concrete-making ingredients in such a way that balling does not occur and the concrete mix remains workable and sprayable.

6.4 ADDITIONAL REQUIREMENTS FOR MIXING

6.4.1 Equipment

Do not use continuous mixers.

6.4.2 Discharging of Mixer

Discharge the entire contents of the mixer before charging it with a new batch.

6.4.3 Maximum Mixing Time

Where by reason of delay it is necessary to hold a batch in the mixer, mixing may be continued, for a maximum of ten successive minutes, except for split drum mixers where the maximum must be five minutes.

For longer periods, the batch may be held in the mixer and turned over at regular intervals, subject to the time limits specified for incorporation of the concrete into the work not being exceeded.

6.4.4 Delivery

Transport concrete produced at a remote central batching plant to the point of discharge by truck-mounted drum mixers conforming to the requirements of AS 1379 and this Specification. On completion of batching, continuously agitate the concrete until it is thoroughly mixed. On completion of mixing, continuously agitate the concrete until it is fully discharged. The agitation speed and duration to achieve thorough mixing must be as specified by the manufacturer of the equipment.

6.4.5 Period for Completion of Discharge

Place the shotcrete within 1.5 hours from the addition of the cement to the aggregates, unless hydration-control admixtures are used.

Do not incorporate concrete into the Project Works if its slump is outside the specified limits.
6.5 **SLUMP**

Check the slump of the concrete with steel fibres incorporated in accordance with AS 1379 except that the frequency of sampling must be in accordance with Annexure B82/L.

If the measured slump is not within the specified limits, immediately make one repeat test from another portion of the same sample. If the value obtained from the repeat test falls within the specified limits, the concrete represented by the sample is deemed to conform; otherwise reject it.

Check and record the slump of the concrete within 30 minutes of adding cement to the aggregate. Also check and record the slump immediately prior to discharge when the actual haul time exceeds 45 minutes and/or when water is added to a mixed batch.

6.6 **ADDITION OF WATER TO A MIXED BATCH**

You may add water to a mixed batch of concrete prior to the commencement of discharge subject to the following:

(a) Less than 45 minutes have elapsed since cement was added to the aggregate.

(b) Immediately after the addition of any water, operate the mixing mechanism at mixing speed for a time equivalent to at least 30 revolutions of the mechanism, and for such additional time as may be necessary to re-establish uniformity of the mix.

(c) The total quantity of water added is not more than 9 kg/m³ and is such that the nominated water/cement ratio is not exceeded.

(d) The quantity of water added is measured and recorded.

(e) The slump is checked after the water has been added.

Once discharge of a batch has commenced, do not add further water to that batch.

6.7 **TEMPERATURE AT POINT OF DELIVERY**

Do not use concrete if its temperature at any time up to the time of discharge from transport vehicles is less than 10°C or more than 32°C.

7 **APPLICATION OF SHOTCRETE AND CURING**

7.1 **EQUIPMENT**

The type and capacity of the proposed shotcrete equipment must have performance records of successful application.

Equipment must be capable of allowing the shotcrete to leave the nozzle in a continuous uninterrupted stream. Equipment must be capable of maximising compaction and quality while minimising rebound and overspray.

Delivery hoses must have an internal diameter of at least 1.33 times the maximum length of steel fibres to be used or five times the maximum size of the aggregate, whichever is greater.
Dispensing devices for admixtures added at the nozzle must be mechanically regulated and have calibrated meters.

7.2 PROVISION FOR MONITORING SHOTCRETE THICKNESS

Utilise probes during application of shotcrete to enable monitoring of shotcrete thickness.

7.3 SHOTCRETING

**HOLD POINT**

<table>
<thead>
<tr>
<th>Process Held:</th>
<th>Each application of Shotcrete in the Project Works.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission Details:</td>
<td>At least 2 working days notice of each intention to shotcrete.</td>
</tr>
<tr>
<td></td>
<td>At least 4 working hours prior to the proposed commencement of application, submit a Certificate of Conformity in respect of surface preparation, reinforcement and embedments. Verification checklists and other details showing conformity to this Specification must accompany this certificate.</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
<td>The Nominated Authority will consider the submitted documents and may carry out surveillance and audit, prior to authorising the release of the Hold Point.</td>
</tr>
</tbody>
</table>

The procedure, equipment and personnel involved in shotcreting must produce an end product which is dense, homogeneous, without segregation of aggregate or fibres, and without sloughing, collapsing, excessive rebound or other visible imperfections.

The nozzle operator carrying out the shotcreting for the Project Works must be the same person as the operator who performed the shotcreting of the conforming test panels specified in Clause 3.10.

Apply shotcrete in layers not exceeding 150 mm in thickness and with adequate adhesion to the surface or previous layers of shotcrete to prevent sagging or slumping.

Stop shotcreting in situations which may adversely affect the end product. Before shotcreting is resumed, prepare the hardened concrete surface in accordance with Clause 4.4.

Remove shotcrete that is segregated, loose, porous or otherwise uncompacted prior to the application of additional shotcrete. Do not incorporate rebound into the Project Works.

Regulate the concrete pump to evenly deliver the wet mix shotcrete at the rate required for the particular shotcrete application.

The shotcrete must emerge from the nozzle in a steady, uninterrupted flow. Where the flow becomes intermittent for any reason, direct it away from the Work until it becomes constant.

The distance of manually held nozzles from the receiving surface must be between 0.5 m and 1.0 m. Hold the nozzle perpendicular to the receiving surface except that where necessary use an angle of 0° to 30° to the perpendicular.
Where a succeeding layer is to cover a layer of shotcrete, sharply taper the first layer at joints and do not feather the tapered joints. Prepare the first layer in accordance with Clause 4.4 and then place the second layer on the tapered surface.

Do not apply curing compounds and bond breaking materials to surfaces that will be covered by an additional layer of shotcrete.

For vertical and near vertical surfaces of a tunnel lining, commence application of shotcrete at the bottom of the surface with the full thickness applied before applying any shotcrete to overhead surfaces.

### 7.4 Surface Finish

Unless specified otherwise, all completed shotcrete surfaces must be the undisturbed natural finish as applied from nozzle. Where specified in the Design Documentation, steel float the shotcrete surface.

### 7.5 Tolerances

The maximum variation in alignment, grade, and dimensions of the structures from the established alignment, grade and dimensions (excluding thickness) shown on the Design Documentation is ± 50 mm, unless specified otherwise in the Design Documentation. The tolerance in thickness is as shown in the Design Documentation.

### 7.6 Temperature and Rain

Unless adequate protection is provided, do not place shotcrete during rain or when rain appears imminent. Do not apply shotcrete when the air temperature in the shade is below 5°C or above 38°C unless special precautions, approved by the Project Verifier, are taken. Any shotcrete which is exposed to rain, other precipitation or dripping water within the period from application to curing must be deemed nonconforming.

### 7.7 Placing Outside Daylight Hours

Do not place shotcrete outside daylight hours or underground unless adequate lighting is provided.

### 7.8 Curing

#### 7.8.1 General

Cure all shotcrete surfaces by one, or more, of the following methods,

- (a) wet curing, in accordance with Clause 7.8.2;
- (b) use of curing compounds, in accordance with Clause 7.8.3; and/or
- (c) using internal curing admixtures in accordance with Clause 7.8.4.

For all types of curing regimes, maintain the concrete surface at a temperature not less than 5°C throughout the curing period.
7.8.2 Wet Curing

Apply wet curing to surfaces immediately after the completion of the application and finishing operations.

You may cover shotcrete by canvas, hessian or plastic sheets or other suitable materials provided it is kept continually wet. Water used for curing must conform to AS 1379.

7.8.3 Curing Compounds

Do not use spray-on curing compounds when additional layers of shotcrete or surface materials are to be applied to a shotcrete surface.

Curing compounds must conform to the requirements of AS 3799 for the classes and types specified in Table B82.7. No curing compound must remain on any shotcrete surface exposed to view within a period of six (6) months after the date of application of the compound.

### Table B82.7 - Classes and Types of Curing Compounds

<table>
<thead>
<tr>
<th>Description of curing compound</th>
<th>Class (to AS 3799)</th>
<th>Type (to AS 3799)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wax-based compounds (Wax emulsion)</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>
| Resin-based compounds (Hydrocarbon resin) | B | 1-D  
| Water-borne compounds | Z |  

The curing compound supplier must implement and maintain a quality management system in accordance with AS/NZS ISO 9001, as a means of ensuring that the product conforms to the Specification requirements.

For each curing compound proposed for use in the Project Works obtain a Certificate of Conformity from the supplier, supported by test certificates from a laboratory with appropriate NATA registration, certifying that the curing compound conforms to this Specification.

This Certificate of Conformity must relate only to the formulation on which the tests were made and must be valid for not more than three years from the date of issue. The test certificates must report the non-volatile content, the efficiency index and the density and must provide a reference for the infrared spectrum as determined in accordance with Test Method RMS T1005. The non-volatile content of each curing compound proposed for use must be a minimum of 30%.

For each batch delivered, obtain a Certificate of Uniformity from the supplier, supported by uniformity testing on both non-volatile content and density in accordance with AS 3799 Clause 3.2, and on viscosity in accordance with AS 3799 Clause 3.1.5. Additionally, provide an infrared spectrum and it must match the above mentioned reference infrared spectrum. The Certificate of Uniformity must state that the same formulation has been used for the batch as is represented by the Certificate of Conformity.

Sample and test at a rate of not less than one test per 3000 litres, or part thereof, supplied.

Apply the curing compound by a pressurised sprayer to give a uniform cover. The sprayer must incorporate a device for continuous agitation and mixing of the compound in its container during spraying.
Apply the curing compound using a fine spray at the rate stated on the certificate of conformity, or at a rate of 0.2 litres/m² per coat, whichever is the greater. Check the application rate by calculating the amount of curing compound falling on felt mats, each approximately 0.25 m² in area, placed on the concrete surface.

Apply two coats at the full rate.

The time between the first and second coat must be in accordance with the manufacturer's recommendation, or on the basis of a trial application.

Apply the curing compound to surfaces immediately after completion of all finishing operations.

Maintain the curing membrane intact after its initial application, for a minimum period of seven days. Make good any damage to the curing membrane due to your or others’ activities by respraying of the affected areas.

7.8.4 Internal Curing Admixtures

Use internal curing admixtures in accordance with Clause 2.3. The admixture must not cause a decrease in concrete strength with age.

7.9 SHOTCRETE CRACKING

At the completion of the curing period, the shotcrete must have no cracks of width greater than 0.15 mm, measured at the shotcrete surface. Where such cracks exist, identify them as nonconforming.

7.10 QUALITY OF SHOTCRETE

Sample and test the shotcrete for conformity with the Specification and the Design Documentation drawings during the progress of the work in accordance with Annexure B82/L for:

(a) thickness (Clause 7.2);
(b) compressive strength (Clause 3.6);
(c) permeability (Clause 3.7);
(d) density (Clause 3.8); and
(e) toughness in terms of the energy absorption of an ASTM C 1550 round panel specimen (Clause 3.9).

Sample and test production test panels constructed with the Project Works in accordance with Clause 3.10 and, where specified in Annexure B82/L, from the completed Project Works.

7.10.1 Thickness and Visual Inspection

Determine the shotcrete thickness by coring specimens of 25 mm diameter in randomly located positions within a representative area in accordance with Annexure B82/L.

Where production test panels are used for this purpose, saw each test panel into four parts for examination and evaluation of the internal cut surfaces, as well as the external surfaces, and total thickness.
In addition to the above requirement, visual inspection of all completed shotcrete work must ensure the conformity to compaction and finish requirements.
ANNEXURE B82/A – PROJECT SPECIFIC REQUIREMENTS

Refer to Clause 1.2.1.

A1 MEMBERS IN EXPOSURE CLASSIFICATION U

A1.1 General

Shotcrete in exposure classification U must conform to the requirements of Specification RMS D&C B82 for the “Base Exposure Classification” and the additional requirements contained in this Annexure.

A1.2 Nominated Classification

The Base Exposure Classification, Nature of Exposure and shotcrete isolation requirements are contained in Table B82/A.1 or as specified on the Design Documentation Drawings.

Shotcrete quality, cover and other durability requirements for the Base Exposure Classification must conform to those specified for the corresponding exposure classification of AS 5100.5.

Where full isolation of shotcrete surface from the aggressive environment is mandatory, include details of the proposed isolation method with the shotcrete mix design submission.

Table B82/A.1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Project Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Exposure Classification:</td>
<td></td>
</tr>
<tr>
<td>1 B1</td>
<td>2 B2</td>
</tr>
<tr>
<td>Nature of Exposure:</td>
<td></td>
</tr>
<tr>
<td>1 Acid sulfate soil</td>
<td>2 Soft or running water</td>
</tr>
<tr>
<td>Full Isolation of Shotcrete Surface from Aggressive Environment:</td>
<td></td>
</tr>
<tr>
<td>1 Not required</td>
<td>2 Optional</td>
</tr>
</tbody>
</table>

A1.3 Additional Requirements

Cement: .................................................................................................................................

Aggregate: ............................................................................................................................

Admixtures: ..........................................................................................................................

Curing Regime: ....................................................................................................................

Others: ...............................................................................................................................
C1 SCHEDULE OF HOLD POINTS

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.12.1</td>
<td>Submission of nominated shotcrete mix details and certification</td>
</tr>
<tr>
<td>4</td>
<td>Submission of method of surface preparation and a notice of intention to commence surface preparation.</td>
</tr>
<tr>
<td>7.3</td>
<td>Submission of Certificate of Conformity in respect of surface preparation, reinforcement and embedments and notice of intention to commence shotcreting.</td>
</tr>
</tbody>
</table>

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of RMS D&C Q6 Annexure Q/E.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description of Identified Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>Details of the effect of hydration control admixtures</td>
</tr>
<tr>
<td>6.3</td>
<td>Methods for controlling fibre distribution</td>
</tr>
<tr>
<td>3.12</td>
<td>Details and verification of each nominated shotcreting mix</td>
</tr>
<tr>
<td>7.3</td>
<td>Certificate of Conformity of surface preparation, reinforcement and embedment</td>
</tr>
<tr>
<td>7.8.3</td>
<td>Certificate of Conformity of curing compound.</td>
</tr>
<tr>
<td>7.8.4</td>
<td>Details of the effect of internal curing admixtures</td>
</tr>
</tbody>
</table>
ANNEXURE B82/D – PLANNING DOCUMENTS

Refer to Clause 1.2.3.

The following documents are a summary of documents that must be included in the PROJECT QUALITY PLAN. Review the requirements of this Specification and others included in the deed to determine additional documentation requirements.

The information to be submitted as part of the PROJECT QUALITY PLAN must include the following:-

(a) Details of the methods to be used in determining the effect of hydration control admixtures on the properties of shotcrete in the Project Works over time (refer to Clause 2.3).

(b) Technical Procedures in accordance with RMS D&C Q6 for the surface preparation processes in Clause 4. Include details of the personnel required to carry out the operations together with proof of their relevant training and experience.

(c) Technical Procedures in accordance with RMS D&C Q6 for the shotcreting processes in Clause 7. Include details of the nozzle operators and other personnel required to carry out the operations together with proof of their relevant training and experience.

(d) Methods for controlling and monitoring fibre distribution in the mix.

ANNEXURES B82/E TO B82/K – (NOT USED)
ANNEXURE B82/L – TESTING PROCEDURES

Refer to Clause 1.2.4.

L1 MINIMUM FREQUENCY OF TESTING

<table>
<thead>
<tr>
<th>Clause</th>
<th>Property Tested</th>
<th>Test Method</th>
<th>Minimum Frequency of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supply and Delivery of Concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4.1</td>
<td>Combined particle size distribution of coarse and fine aggregates - deviation from nominated particle size distribution</td>
<td>AS 1141.11</td>
<td>One per week</td>
</tr>
<tr>
<td>6.5</td>
<td>Slump</td>
<td>AS 1012.3.1</td>
<td>One per batch of concrete</td>
</tr>
<tr>
<td>6.3</td>
<td>Steel fibre content</td>
<td>Clause 3.5</td>
<td>One per 5 batches of concrete</td>
</tr>
<tr>
<td></td>
<td>Production of Test Panels</td>
<td></td>
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<tr>
<td>3.10</td>
<td>Construction of production test panels</td>
<td>Clause 3.10</td>
<td>As required by the RMS Representative</td>
</tr>
<tr>
<td></td>
<td>Thickness and Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.10.1</td>
<td>From production test panels</td>
<td>Clause 7.10.1</td>
<td>Each production test panel</td>
</tr>
<tr>
<td></td>
<td>Frequency of sawing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From the Works</td>
<td>Clause 7.10.1</td>
<td>Random core for each 50 m² or part thereof</td>
</tr>
<tr>
<td></td>
<td>Frequency of drilling</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determination of 28 Day Compressive Strength, Density and Relative Density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6 &amp; 3.8</td>
<td>From concrete supply</td>
<td>AS 1012.8.1, AS 1012.9</td>
<td>One pair per 25 m³ or part thereof</td>
</tr>
<tr>
<td></td>
<td>Frequency of moulding specimens and testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>From the Works</td>
<td>AS 1012.14</td>
<td>One pair per one day’s production</td>
</tr>
<tr>
<td></td>
<td>Frequency of drilling test specimens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determination of Permeability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>From the Works</td>
<td>AS 1012.14, DIN 1048</td>
<td>One pair per one day’s production</td>
</tr>
<tr>
<td></td>
<td>Frequency of drilling test specimens</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determination of Toughness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>From production shotcrete</td>
<td>ASTM C 1550</td>
<td>One pair per one day’s production</td>
</tr>
<tr>
<td></td>
<td>Frequency of making round panel test specimens</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**L2 COMPRRESSIVE STRENGTH**

**L2.1 Moulding of Samples**

Mould concrete specimens in standard cylinders in accordance with the requirements and procedure of AS 1012.8.1 using rodding only.

**L2.2 Specimens Cut from the Project Works (Cores)**

Where required by the design, cut 75mm diameter core specimens by means of a core drill, wet-condition and test in accordance with AS 1012.14. Adjust the corrected (for length to diameter ratio) strength so determined for age by dividing the result by the factors shown in Table B82/L.1.

Do not test cores containing reinforcement, but cut replacement cores at new locations.

Clean and restore core holes using concrete mix designed to produce the same shotcrete quality as the material from which the core was cut. Design the repair concrete mix, and place the concrete in such a manner, so as to produce no shrinkage and no visible cracks. The surface of the restored hole must be similar to the surrounding surface in texture and colour.

**L2.3 Testing**

The compressive strength of the concrete represented by a pair of specimens made and cured in accordance with AS 1012.8.1 and tested in accordance with AS 1012.9, is the average strength of the two specimens unless the two results differ by more than 10% of their average, in which case take the higher result as the strength of the concrete.

**L2.4 Adjustment for Age of Specimen**

Should any specimen be tested more than 28 days after moulding, the equivalent 28 day strength is the test strength divided by the age factor given in Table B82/L.1. Age adjustment factors are given for concrete made with Portland cement and Blended cement. For intermediate ages determine the factor on a pro-rata basis.

<table>
<thead>
<tr>
<th>Age of specimen at time of test (days)</th>
<th>Age factor</th>
<th>Age factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Portland cement</td>
<td>Blended cement</td>
</tr>
<tr>
<td>28</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>56</td>
<td>1.08</td>
<td>1.19</td>
</tr>
<tr>
<td>112</td>
<td>1.14</td>
<td>1.33</td>
</tr>
<tr>
<td>224</td>
<td>1.22</td>
<td>1.42</td>
</tr>
<tr>
<td>365 or greater</td>
<td>1.25</td>
<td>1.45</td>
</tr>
</tbody>
</table>
ANNEXURE B82/M – REFERENCED DOCUMENTS AND ABBREVIATIONS

Refer to Clause 1.2.5.

M1 REFERENCES

RMS Specifications

RMS D&C G36   Environmental Protection
RMS D&C Q6    Quality Management System (Type 6)
RMS D&C 3211  Cements, Binders and Fillers

RMS Test Methods

RMS T363     Accelerated Mortar Bar Test for AAR Assessment
RMS T364     Concrete Prism Test for AAR Assessment
RMS T1005    Quantitative Analysis Using the Infrared Spectrophotometer

Australian Standards

AS 1012     Methods of testing concrete
AS 1012.2   Method 2: Preparation of concrete mixes in the laboratory
AS 1012.3.1 Method 3.1: Determination of properties related to the consistency of concrete – slump test
AS 1012.8.1 Method 8.1: Method for making and curing concrete – compression and indirect tensile test specimens
AS 1012.9   Method 9: Determination of the compressive strength of concrete specimens
AS 1012.12.1 Method 12.1: Determination of mass per unit volume of hardened concrete – rapid measuring method
AS 1012.12.2 Method 12.2: Determination of mass per unit volume of hardened concrete – water displacement method
AS 1012.13  Method 13: Determination of the drying shrinkage of concrete for samples prepared in the field or in the laboratory
AS 1012.14  Method 14: Method for securing and testing cores from hardened concrete for compressive strength
AS 1012.20  Method 20: Determination of chloride and sulfate in hardened concrete and concrete aggregates
AS 1141     Methods for sampling and testing aggregates
AS 1141.11  Method 11: Particle size distribution by sieving
AS 1141.22  Method 22: Wet/dry strength variation
AS 1289     Methods of testing soils for engineering purposes
AS 1289.3   Soil classification tests
### Shotcrete Work

**D&C B82**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>AS 1379</td>
<td>Specification and supply of concrete</td>
</tr>
<tr>
<td>AS 1478</td>
<td>Chemical admixtures for concrete, mortar and Grout</td>
</tr>
<tr>
<td>AS 1478.1</td>
<td>Admixtures for concrete</td>
</tr>
<tr>
<td>AS 2349</td>
<td>Method of sampling Portland and blended cements</td>
</tr>
<tr>
<td>AS 2758</td>
<td>Aggregates and rock for engineering purposes</td>
</tr>
<tr>
<td>AS 2758.1</td>
<td>Concrete aggregates</td>
</tr>
<tr>
<td>AS 3799</td>
<td>Liquid membrane - forming curing compounds for concrete</td>
</tr>
<tr>
<td>AS/NZS 4671</td>
<td>Steel reinforcing materials</td>
</tr>
<tr>
<td>AS 5100</td>
<td>Bridge design</td>
</tr>
<tr>
<td>AS 5100.5</td>
<td>Concrete</td>
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<tr>
<td>AS/NZS ISO 9001</td>
<td>Quality management systems - requirements</td>
</tr>
</tbody>
</table>

### ASTM Standards

- **ASTM C 295** Standard Practice for Petrographic Examination of Aggregates for Concrete
- **ASTM C 1550** Standard Test Method for Flexural Toughness of Fibre Reinforced Concrete (Using Centrally Loaded Round Panel)

### DIN Standards

- **DIN 1048 Part 5** Testing Methods for Concrete - Permeability

### M2 ABBREVIATIONS

- **RMS** Roads and Maritime Services