

Specification for the Manufacture
of Glassfibre Reinforced Concrete (GRC)
Planters and Street Furniture.

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■ INTRODUCTION

Glass Reinforced Concrete (GRC) is essentially concrete but differs from traditional concrete through the addition of alkaline resistant glass fibres that provide significantly enhanced flexural and tensile strength. Due to these enhanced strengthening properties, the walls of GRC planters and GRC street furniture products can be made significantly thinner, hence lighter, than what is required for traditional cast concrete planters to achieve the same or greater strength.

This Specification is designed for Suppliers and covers all aspects of GRC production as it relates to planters and street furniture including raw materials, manufacture, curing, storage, packaging, product identification, quality assurance, and testing.

The Grades of GRC covered in this Specification are: -

- Simultaneously sprayed GRC Grade 18, and Grade 18P.
- Premix Grades 8, 8P, 10, and 10P.

(Where 'P' refers to the use of Polymer in the GRC mix design.)

This Specification is a material and manufacturing specification. A Structural Engineer should be consulted to ensure that the material grade selected is consistent with the structural engineering design of the products being produced.

Definitions

- **Aggregate/cement ratio:** The ratio of the mass of total dry aggregate to the mass of dry cement in the GRC.
- **Alkali resistant Glassfibre:** Alkali resistant glass fibres, or AR (Alkali Resistant) glass fibres, are glass fibres suitable for use in concrete that have a minimum zirconium dioxide (ZrO₂) content of 16%. AR glass fibres for use in GRC will conform to the requirements of EN 15422, EN 14649 category B, or other equivalent national standards.
- **AS:** This prefix to any number in this Specification refers to a standard that has been adopted by the Standards Association of Australia.
- **Bag and bucket' tests:** Methods for the calibration of GRC spray equipment. Refer to EN 1170-3.
- **Concentric GRC Spray gun:** A GRC spray gun whereby both the AR glass fibres and cementitious slurry are emitted from one nozzle and sprayed onto a mould.
- **Dry curing:** A method of curing by adding an appropriate quantity of polymer to the GRC mix which prevents early loss of moisture and allows curing to take place without keeping the GRC damp.
- **EN:** This prefix to any number in this Specification refers to a standard that has been adopted by a regional European standardizing body.
- **Extremes of dimensional variations:** The maximum dimensional variations (residual hydraulic shrinkage and reversible expansion) of a GRC composition attributable to variations in the water content to which products exposed to the elements may be subjected. Refer to EN 1170-7.
- **Facing coat:** An initial layer without fibres but containing decorative sands or aggregates and/or pigments.
- **Glassfibre content by weight (WF):** The ratio (expressed as a percentage) of the mass of AR glassfibre to the mass of GRC in the Uncured (wet mix) state.
- **Grade:** The strength Grade of the GRC, based on the Characteristic MOR of the product.
- **GRC Consultant:** A person who is experienced in relevant aspects of GRC.
- **GRCA:** The International Glassfibre Reinforced Concrete Association in the UK.
- **High shear mixer:** A mixer with a high shear action used for the preparation of the fine sand/cement slurries required for the GRC spray process.
- **Limit of proportionality (LOP):** Also known as elastic limit. The stress in a flexural bending test where the stress/strain plot deviates from a straight line.
- **"Methods of testing":** "Methods of testing", or MOT, refers to the GRCA "Methods of Testing Glassfibre Reinforced Concrete (GRC) Material" document noted in the REFERENCES section of this specification.
- **Mist coat:** An initial cementitious sprayed coating without glass fibres.
- **Modulus of rupture (MOR):** The highest stress on a stress/strain plot during a flexural bending test.
- **Polymer:** For the purposes of this Specification, refers to an aqueous acrylic thermoplastic co-polymer dispersion.
- **Polymer-modified GRC:** GRC which has been modified by the addition of polymer for "dry curing" and property enhancement.
- **Premix GRC:** A method of manufacture in which pre-cut AR glass fibres and cementitious slurry are blended during mixing.
- **Premix GRC mixer:** A two stage mixer which has the capability to mix a base cement/sand slurry at a high speed with a high shear mixing action and then to blend in the cut AR glass fibres with a slower, low shear mixing action.
- **Producer:** The person or authority entering a contract to manufacture a GRC product.

- **Purchaser:** The person or authority entering a contract to buy a GRC product.
- **Simultaneous sprayed GRC:** A method of manufacture in which a GRC product is produced by simultaneously spraying cementitious slurry and AR glassfibre, which is chopped from a roving by a cutter mechanism inside a Concentric GRC Spray gun to the length required. Both cementitious slurry and the chopped AR glass fibres are emitted from the same nozzle.
- **Slump test:** A test for checking the consistency of the cementitious slurry. Refer to EN 1170-1.
- **Specification:** Refers to this document.
- **Sprayed GRC:** A method of manufacture in which a GRC product is produced by spraying a cementitious slurry and AR glassfibre mix with a GRC Spray gun.
- **Structural Engineer:** A person or authority responsible for the structural design of a GRC component. A Structural Engineer must hold formal qualifications in the discipline of Structural Engineering and hold Professional Indemnity insurance cover.
- **Supplier:** In respect to this Specification, refers to the person or authority entering a contract to supply goods and/or raw materials to the Producer.
- **Test board:** A sheet of GRC manufactured during production for the purpose of assessing the quality of the GRC products being made. A test board will be made in the same way and at the same time as the GRC products being tested are being made so that it is representative of the quality of the GRC incorporated in the products.
- **Test board mean:** The arithmetic mean value for a property calculated from all the individual test coupon results from one test board. For statistical analysis, this arithmetic mean is regarded as one result.
- **Test coupons:** Several specimens taken from a single test board for the purpose of determining a property.
- **Uncured state:** The stage in the manufacture of GRC when all physical processes that could alter the composition of the material are complete, but the fibre can still be separated from the matrix by the action of running water.
- **'Wash out' test:** A method for determining the glass fibre content of Uncured GRC. Refer to EN 1170-2.
- **Water/cement ratio:** The ratio of the mass of total water to the mass of dry cement in GRC in the Uncured State. When pozzolanic fillers are used they can be considered as cementitious and the water/cement ratio can be expressed as a water/total binder ratio; examples of such pozzolanic fillers are fly ash, silica fume and metakaolin.

■ CONSTITUENT MATERIALS

Alkali resistant glass fibres

Glass fibres will be an alkali resistant continuous filament glass fibre developed and formulated to have high strength retention in hydraulic cement environments. The Producer will provide certification from the Supplier to show that the AR glass fibres conform to the requirements of EN 15422, EN 14649 category B, or other equivalent national standards.

Cement

Cement will be supplied by a manufacturer of assessed capability, made to recognised standards such as EN 197, AS3972, or other equivalent national standards and supported by suitable certification. Cement will be correctly stored and kept dry to avoid deterioration.

Fine aggregates

Fine aggregate or sand will be washed to remove soluble matter and dried to permit accurate control of the water/cement ratio. Sands with moisture content may be used provided the moisture content is known and the mix design is altered accordingly.

Fine aggregates will comply with any applicable national standards. In all cases the fine fraction, i.e., sand passing a 150-micron sieve, will be less than 10% of the total weight of sand.

The particle shape will be round or irregular and will have a smooth surface without honeycombing.

Silica sands are widely used and have proven to be acceptable in the manufacture of GRC. Sands other than silica sands may be used but the Producer will provide evidence of their suitability. Soft building sand will not be used.

Water

Water will be clean and free from deleterious matter that may substantially interfere with the colour, curing, or strength of the GRC.

Admixtures

Admixtures are permitted and their use is encouraged as they can enhance the properties of GRC. They will always be used strictly in accordance with the Suppliers' recommendations and the Producer will ensure that their use has no adverse effect on the product.

Admixtures will comply with the requirements of EN 934, AS 1478, or other equivalent national standards.

Calcium chloride-based admixtures will not be used if the GRC component contains steel reinforcement, fixing sockets or other cast-in devices.

Acrylic Thermoplastic Co-Polymer Dispersions

Acrylic thermoplastic co-polymer dispersions are permitted and will be used in accordance with the manufacturers' instructions and will conform to the material characteristics: -

- *Polymer type:* Acrylic based
- *Solids:* 45-55%
- *pH:* 4-10
- *Appearance:* Milky white creamy, free from lumps
- *Minimum film-formation temperature (MFFT):* 7 °C
- *Ultraviolet resistance:* Good
- *Alkali resistance:* Good

Polymers with properties outside the above specification may be used provided adequate data based on research can be produced to support manufacturers' claims.

Pigments

Powder pigments or dispersions may be used to produce coloured GRC. The pigments will conform to BS 1014 or any other applicable national standards.

The Purchaser should recognise that colour variation may occur and must agree an acceptable range of variation with the Producer.

Other component materials

Other component materials (e.g., silica fume, metakaolin, fly ash, reinforcing fillers, admixtures, meshes), may be added to modify the properties of the GRC mix. They will conform to any applicable national standards and must be used in accordance with the Suppliers' instruction. The Producer must be able to demonstrate that their use will not adversely affect the properties of the GRC.

Storage of raw materials

All raw materials will be stored in a manner which protects against deterioration and contamination.

■ COMPOSITION OF GRC

Mix design

It is the responsibility of the Producer to agree a suitable mix design for the product. The mix-design must be such that the mechanical properties of the GRC in the COMPLIANCE Section of this Specification are achieved and that these requirements are consistent with the engineering design of the product.

The mix-designs in the following tables are intended as a guide, indicating typical figures. However, mix-designs falling outside these guidelines may be acceptable but must be fully scrutinised and tested before use.

General Purpose Premix Grade Table

	Grade 8	Grade 8P
Aggregate/cement ratio	0.5 -1.50	0.5 -1.50
Water/cement ratio	0.30 - 0.40	0.30 - 0.40
AR Glassfibre content (% by weight of total mix)	2.0 - 3.0%	2.0 - 3.0%
Polymer solids content (% by weight of cement)	Nil	4-7%
Extreme dimensional variations mm/m	0.6 – 1.2	0.6 – 1.2

Water Absorption	5 – 11%	5 – 11%
Minimum bulk dry density kg/m ³	1800	1800
Minimum bulk wet density kg/m ³	2000	2000

Sprayed Premix or High-Quality Cast Premix Grade Table

	Grade 10	Grade 10P
Aggregate/cement ratio	0.5 -1.50	0.5 -1.50
Water/cement ratio	0.30 - 0.38	0.30 - 0.38
AR Glassfibre content (% by weight of total mix)	2.0 - 3.5%	2.0 - 3.5%
Polymer solids content (% by weight of cement)	Nil	4-7%
Extreme dimensional variations mm/m	0.6 – 1.2	0.6 – 1.2
Water Absorption	5 – 11%	5 – 11%
Minimum bulk dry density kg/m ³	1800	1800
Minimum bulk wet density kg/m ³	2000	2000

Direct Sprayed Grade Table

	Grade 18	Grade 18P
Aggregate/cement ratio	0.5 -1.5	0.5 -1.5
Water/cement ratio	0.30 - 0.38	0.30 - 0.38
AR Glassfibre content (% by weight of total mix)	4.0 - 5.5%	4.0 - 5.5%
Polymer solids content (% by weight of cement)	Nil	4-7%
Extreme dimensional variations mm/m	0.6 – 1.2	0.6 – 1.2
Water Absorption	5 – 11%	5 – 11%
Minimum bulk dry density kg/m ³	1800	1800
Minimum bulk wet density kg/m ³	2000	2000

■ MANUFACTURE

Shop Drawings

Prior to the commencement of manufacturing: -

- The Producer will provide the Purchaser with shop drawings showing detailed section and elevation plans for each product being ordered.
- The Producer will obtain formal approval of the shop drawings by the Purchaser.

Manufacture by Simultaneous spray

• **Weighing/batching**

Dry ingredients will be measured by weight using calibrated weighing equipment capable of an accuracy of ± 2% of the stated batch weight. Liquids will be weighed, volume batched or automatically dispensed. The Producer will be able to demonstrate that the method employed will give an accuracy of ± 2%.

• **Mixing**

The cementitious slurry will be mixed in a high speed, high shear type mixer or equivalent designed for the purpose of preparing mixes for GRC manufacture. Standard concrete mixers or cement/sand mortar mixers as used on construction sites and elsewhere are not suitable. The Producer must be able to demonstrate that the mixing system used is suitable for producing batches of “lump-free” slurry with good consistency.

• **Simultaneous Spraying**

Simultaneous spraying will be carried out using specialist equipment that allows the simultaneous deposition of known quantities of cementitious slurry and chopped AR glassfibre.

The spray equipment will be calibrated to measure the deposition rates of the AR glassfibre and cementitious slurry and ensure that the specified glassfibre percentage is achieved. The calibration will be carried out for each spray machine at the beginning of each shift, after any alteration of the equipment controls, and after any unsatisfactory 'Wash out' test results. Calibration will be carried out using the 'bag and bucket' tests in accordance with EN 1170-3, or equivalent national standards.

A mist coat without fibre may be sprayed. However, this coat will be as thin as practicable (~ 1 mm) and will be followed immediately by the first GRC spray.

When a facing coat is used, this may be sprayed or poured. This coat may be allowed to stiffen but the first GRC coat must be applied before initial set takes place. Typical thickness is 3-5 mm depending on subsequent treatment e.g., grit blasting or acid etching.

The GRC materials will be sprayed and built up in thin layers of 3-4 mm until the required thickness is achieved. The sprayed GRC will be compacted using a flexible hand roller before spraying the next layer. After the final layer has been sprayed the thickness of the GRC will be checked using a template or depth gauge and compared to the design thickness. Unless specifically stated in the agreed product manufacturing specification, the design thickness will be considered as a minimum and no part of the component will be below this thickness.

Over-thickness will be permitted and is to be expected particularly at corners or areas with a deep profile. It will not be permitted if: -

- Any flat areas exceed the design thickness by 4 mm, or
- The weight of the component exceeds the maximum design weight as specified by the Structural Engineer.

After checking the thickness, any areas of under- thickness will be re-sprayed, areas of over-thickness removed, and the excess material discarded.

Manufacture by Premix

- **Weighing/batching**

Dry ingredients will be measured by weight using calibrated weighing equipment capable of an accuracy of $\pm 2\%$ of the stated batch weight. Liquids will be weighed, volume batched or automatically dispensed. The GRC manufacturer will be able to demonstrate that the method employed will give an accuracy of $\pm 2\%$.

- **Mixing**

The GRC will be mixed in a two-stage or other suitable mixer. The Producer will be able to demonstrate that the equipment is suitable for manufacturing premix GRC.

First the cementitious slurry will be mixed at high speed in an intensive shear mixer or other approved mixer. The slurry will then be transferred to a second mixer, or the mixing action of the shear mixer adapted so that the AR glassfibre is blended uniformly into the slurry. The AR glassfibre may be added manually or automatically as chopped fibres or automatically as AR glassfibre roving using a fibre chopper.

- **Cast Premix**

The premixed GRC material will be pumped or carried in a holding vessel to the filling station. The material will then be poured or pumped into the mould ensuring that the method of filling expels the air from the product and planes of weakness are avoided. Compaction may be by internal or external vibration or by the use of a self-compacting mix. The Producer must ensure that the method chosen is consistent with the required surface finish and mechanical properties.

- **Sprayed Premix**

The premixed GRC material may also be sprayed onto or into moulds using specialist sprayed premix equipment. A facing coat or a mist coat may be sprayed first. The GRC material will be sprayed in layers 3-4 mm and compacted using a flexible hand roller before spraying the next layer. The thickness will be checked in the same way as specified for the Simultaneous Spraying method described above.

Storage before demoulding

Filled moulds will be stored at temperatures between 5° C and 40° C. 'P' grades will be stored at a temperature higher than the MFFT (Minimum film-formation temperature) but below 40° C.

Moulds will be stored on a level surface and supported in such a manner that they will not bow or twist.

Once the initial set has taken place the mould will be covered with a sheet of polythene, or other suitable material, and will not be moved until demoulding.

Demoulding (including lifting and fixing)

The GRC component will not be demoulded until it has gained sufficient strength to be removed from the mould and transported without being over-stressed. The time required will be temperature dependent.

Demoulding will be carried out in such a manner that no damage occurs to the component. Unique demoulding, lifting and fixings sockets must be suitably embedded in the component.

All embedded items will be of a suitable non-corrosive material and encapsulated in a block of GRC. Depending on the intended purpose of the embedded items, the Purchaser should consider requiring the Supplier to obtain appropriate certification from a Structural Engineer before starting production.

Curing

• **Moist curing (for non-polymer grades)**

GRC components should be cured at controlled temperature and humidity. Ideally this should be for seven days at 20 °C and 95% RH. This is not always practical and alternative curing regimes are satisfactory providing the Producer can demonstrate that the procedure: -

- Enables the component to achieve the physical properties given in the section of this Specification below entitled "COMPLIANCE".
- Ensures that excess shrinkage does not occur by the product drying too quickly.

• **Curing of polymer grades**

Components produced using polymer grades of GRC will be loosely covered overnight and will be dry cured after demoulding. Components will not be exposed to drying winds or temperatures above 35 °C or below 5 °C for a minimum of two days after production.

Storage, handling, and transport

GRC components will be stored, handled, and transported in such a way that: -

- No part of the component is overstressed.
- Bowing or twisting is not induced in the component.
- No damage is caused to any part of the component, particularly edges and corners.
- No permanent staining or discoloration is caused either by the storage conditions, stacking, or by the use of any protection material.

Sealing (Waterproofing & Graffiti Protection)

There are three key issues to address in the sealing of GRC planters and street furniture: -

- **External sealing**
Unless otherwise requested by the Purchaser, an external penetrative sealant will be applied to the outside GRC surfaces of the products. Upon request, the Producer must be able to show the Purchaser proof that the external sealant has been manufactured to be resistant to UV degradation.
- **Graffiti protection sealing**
If requested by the Purchaser, the external sealant will be replaced by an anti-graffiti sealant. Upon request, the Producer must be able to show the Purchaser proof that the graffiti protection sealant has been manufactured to be resistant to graffiti.
- **Internal planter sealing**
Unless otherwise requested by the Purchaser, a high-quality bitumen-based sealant will be applied to the inside surfaces and the bottom of GRC planters for waterproofing purposes. Upon request, the Producer must be able to show the Purchaser proof that the bitumen-based sealant has been specifically manufactured to waterproof concrete surfaces that may be subject to water ponding.

Manufacturing tolerances

In general, manufacturing tolerances should be within the following limits.

- a) **Linear Dimensions** (i.e., Length and Height): ± 6 mm.
- b) **Thicknesses:**
 - i) Architectural facing thickness (min 3 m: $+2$ mm - 0 mm
 - ii) backing mix: $+5$ mm - 0 mm
- c) **Angular variation of side moulds:** ± 1.5 mm.
- d) **Variations from square** (i.e., The difference in lengths of diagonals): 6 mm.
- f) **Bowing:** $\leq L / 250$.
- g) **Openings within panel face:** ± 5 mm.
- h) **Location of opening within a wall:** ± 3 mm.
- i) **Warping:** Maximum permissible warp of one corner out of the other three should not be more than 5 mm/m distance from the nearest adjacent corner.

■ QUALITY CONTROL AND ASSURANCE

Quality management system

The Producer will be able to demonstrate that a quality assurance system is operated in compliance with ISO 9001, or equivalent national standard.

■ SAMPLING

Sampling and Test Boards

Tests may be carried out on coupons cut from GRC components or from a Test Board specifically produced for testing. This will be manufactured, demoulded and cured in the same manner as the component it represents. Its quality should be the same as the component, as far as possible and Test Boards will be large enough for sufficient coupons to be cut to meet the testing requirements.

Frequency

The frequency of production of Test Boards will be not less than one board per day per mixer/pump, for both spray and premix processes. Spray process Test Boards not tested will be kept for a minimum of one year for any future testing requirements.

■ TESTING

The following tests will be carried out and the required properties will be as shown in the above "Characteristics Values Table" and the above "Minimum Strengths Table", and, unless alternative requirements are agreed, will be as shown in the above Tables: "General Purpose Premix Grade Table", "Sprayed Premix or High-Quality Cast Premix Grade Table" or "Direct Sprayed Grade Table".

• AR glassfibre content

With Simultaneous sprayed processes, the AR glassfibre content will be determined at the frequency set out in the above section on MANUFACTURE. Testing will be carried out in accordance with either the GRCA "Methods of Testing GRC Material Part 4", or EN 1170-3, or "Methods of Testing GRC Material Part 1" or EN 1170-2. Testing to equivalent national standards is permitted in countries outside Australia where appropriate.

• Limit of proportionality [LOP] and modulus of rupture [MOR]

The LOP and MOR will be determined at 7 and/or 14 and/or 28 days in accordance with either the "GRCA Methods of Testing Glassfibre Reinforced Concrete (GRC) Material Part 3" or EN 1170-5 or equivalent national standards. 7- and 14-day results will only be acceptable if they already exceed design requirements.

The minimum LOP and MOR testing frequency will be: -

Spray: Twice per week per spray station or every 10 tons of GRC produced, whichever is greater.

Premix: Once per week per mixer or every 10 tons of GRC produced, whichever is greater.

Table of Characteristics Values by Grade

	Grades 8 or 8P	Grades 10 or 10P	Grades 18 or 18P
Characteristic LOP*	5	6	7
Characteristic MOR*	8	10	18

Bulk density, water absorption and apparent porosity

These properties will be determined in accordance with either the “GRCA Methods of Testing Glassfibre Reinforced Concrete (GRC) Material Part 2” or EN 1170-6 or equivalent national standards. All these tests will be carried out a minimum of once per month.

Other tests

An extremes of dimensional variations test, to EN 1170-7, or suitable alternative, will be carried out when setting up a new mix design. Other tests of GRC may be carried out as required by the Purchaser, including full-scale load tests of products and components, fire tests, performance testing of cast-in fixings etc.

■ COMPLIANCE

General

The constituent materials: -

- Will comply with the requirements of the above section on CONSITUENT MATERIALS.
- The composition of the GRC will comply with above section on COMPOSITION OF GRC.
- The GRC will be produced and cured in accordance with the above section on MANUFACTURE.
- The GRC will be sampled at a frequency in compliance with the above section on SAMPLING.
- The GRC will be tested in accordance with the above section on MANUFACTURE.
- The GRC will meet the requirements of this section on COMPLIANCE.

Minimum values for compliance

To conform to this Specification, the manufacturer will be able to demonstrate via their testing regime and documentation that analysis shows Characteristic Values as shown in the above “Table of Characteristics Values”. This analysis will form part of their Quality Assurance procedures to be allowable.

If other properties, e.g., density or porosity, are critical for an application, compliance values and testing frequency will be agreed between the Purchaser and the Producer.

The following “Minimum Strengths Table” indicates minimum LOP and MOR values using in-process inspection results as a guideline for initial compliance only.

Minimum Strengths Table by Grade

	Grades 8 or 8P	Grades 10 or 10P	Grades 18 or 18P
LOP MPa			
Mean of 4 consecutive test board means	7.25	8.00	8.00
Minimum for individual test board mean	5.75	6.00	6.00
MOR MPa			
Mean of 4 consecutive test board means	9.50	12.00	21.00
Minimum for individual test board mean	7.50	8.50	15.00

■ NON-COMPLIANCE

Failure to comply

If any single test board fails to meet any of the compliance requirements, the GRC at risk will be that produced between the previous complying test board and the next complying test board.

Where testing is not carried out daily retained sample boards may be tested to determine the extent of the non-compliant product.

Action in the event of non-compliance

The action to be taken over GRC products that do not comply with this Specification will be determined with due regard to the technical consequences of adopting remedial measures or replacing the rejected products.

In estimating the quality of the sub-standard GRC and in determining the action to be taken, the following should be established, wherever possible: -

- That the raw materials and mix proportions used in the GRC under investigation comply with this Specification and/or with those agreed between the Purchaser and the Producer.
- That the curing regime adopted before testing complies with the requirements in this Specification. Re-testing of test boards may be appropriate when it is considered that the storage conditions of the product might result in improved properties because of extended curing.
- The effect of any reduction in GRC properties on the strength and durability of the product by taking the following points into consideration: -
 - The safety factors adopted in the design.
 - The thickness of GRC produced compared to the design thickness.
 - LOP/MOR strengths required by engineering calculations.

■ REFERENCES

- **GRCA Publications: -**
 - GRCA Specification: “Specifiers Guide to Glassfibre Reinforced Concrete (GRC)”.
 - GRCA MOT: “Methods of Testing Glassfibre Reinforced Concrete (GRC) Material”.
 - GRCA Design Guide: “Practical Design Guide for Glassfibre Reinforced Concrete (GRC)”.
 - GRCA Fixing Guide: “Practical Fixing Guide for Glassfibre Reinforced Concrete (GRC)”.
 - GRCA Publications: See www.grca.online for an up-to-date list of GRCA Publications.
- **European Standards.**
 - EN 197: Parts 1 & 2: Cement.
 - EN 480: Various Parts: Admixtures for concrete, mortar, and grout. Test methods.
 - EN 934: Various Parts: Admixtures for concrete, mortar, and grout. Requirements.
 - EN 1008: Mixing water for concrete.
 - EN 1170: Parts 1-8 Precast concrete products: Test methods for glass-fibre reinforced cement.
 - Part 1: Measuring the plasticity of the mortar— 'Slump test' method.
 - Part 2: Measuring the fibre content in fresh GRC, Wash out test'.
 - Part 3: Measuring the fibre content of sprayed GRC.
 - Part 5: Measuring bending strength — 'Complete bending test' method.
 - Part 6: Determination of the absorption of water by immersion and determination the dry density
 - Part 7: Measurement of extremes of dimensional variations due to moisture content.
 - EN 14649: Precast concrete products — Test method for strength retention of glass fibres in cement and concrete (SIC TEST).
 - EN 15191: Precast concrete products. Classification of glassfibre reinforced concrete performance.
- **GRCA (Glass Fibre Reinforced Concrete Association - UK) documents** (See www.grca.online for an up-to-date list of GRCA Publications).
 - GRCA Specification: “Specifiers Guide to Glassfibre Reinforced Concrete (GRC)”.
 - GRCA MOT: “Methods of Testing Glassfibre Reinforced Concrete (GRC) Material”.
 - GRCA Design Guide: “Practical Design Guide for Glassfibre Reinforced Concrete (GRC)”.
 - GRCA Fixing Guide: “Practical Fixing Guide for Glassfibre Reinforced Concrete (GRC)”.
 - GRCA techNOTES: A series of technical notes are available on most aspects of GRC.
- **National Precast Concrete Association Australia (NPCAA).**
 - Recommended Practice – Design, Manufacture, and Installation of Glass Reinforced Concrete (GRC).
 - Recommended Specification for Manufacture, Curing, and Testing of Glassfibre Reinforced Concrete (GRC) Products.