Polymers for GRC

This techNOTE from The International Glassfibre Reinforced Concrete Association (GRCA) explains the benefits of using pure acrylic ester co-polymers in the production of Glassfibre Reinforced Concrete (GRC / GFRC).

GRCA Technical Working Group

This is the twelfth in a series of technical notes covering aspects of glassfibre reinforced concrete (GRC / GFRC) technology.

Pure Acrylic Polymers in the Production of GRC / GFRC

Glassfibre Reinforced Concrete (GRC / GFRC) made with AR glassfibre was first introduced to the construction industry in the early 1970's. It was originally "wet cured" in a similar manner to normal concrete. As in the case of all Ordinary Portland Cement (OPC) based concretes, the reason for wet curing GRC is to hydrate the cement as fully as possible to maximise the strength of the cement/sand matrix. Today, there are not many GRC products which are still wet cured.

Wet curing has several disadvantages, not least the fact that the GRC products must be kept in high humidity for at least 7 days. Small products are not a problem but larger units, such as stud-frame panels, can be. Furthermore, the surfaces of wet cured GRC panels can easily be spoiled by water droplets tracking down the panels' surfaces leaving "run lines".

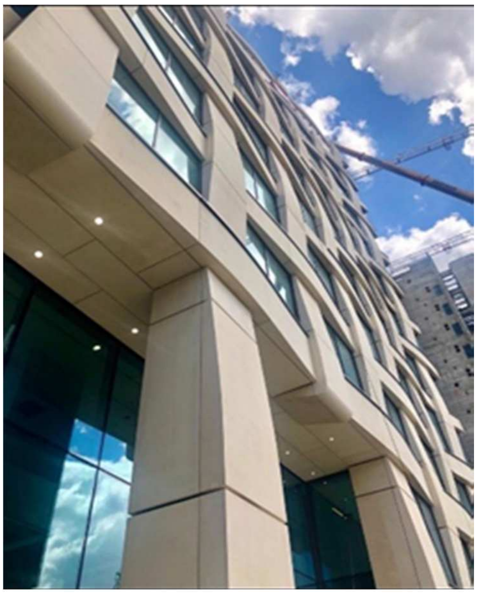
"Dry curing" was investigated and manufacturers found that adding an aqueous thermoplastic pure acrylic ester co-polymer dispersion (hereafter referred to as "acrylic polymer") to the GRC matrix in the range of 4-7% polymer solids on the weight of cement yielded similar, if not superior and certainly more consistent, properties to those obtained via wet curing.

Specification for Acrylic Polymers	
Compound Type	Aqueous Thermoplastic Co-polymer Dispersion
Polymer Type	Acrylic based
Solids Content	45 - 55%
pH	4 - 10*
Appearance	Milky White
Minimum Film Formation Temperature	7 - 12 °C
Ultra Violet Resistance	Good
Alkali Resistance	Good
* acrylic polymers can be acidic or alkali due to differences in the manufacturing processes	

Table 1: Specification for Acrylic Polymers [1]

Subsequently, it was observed that adding an acrylic polymer to the GRC matrix imparted other benefits, for example:

- A reduction in moisture absorption which in turn can reduce the tendency for GRC to effloresce (this is a complex issue and will be the subject of another GRCA techNOTE).
- An improvement in the workability of a GRC mix. The plasticising effect of the acrylic polymer improves the mix workability and allows the use of lower water:cement ratios.
- A positive effect on the thixotropic properties of the base slurry mix which can assist the spraying of vertical sides to moulds and the underside of complex, difficult shapes.
- Perceived better appearance with cleaner edges and corners and a reduced risk of surface crazing.



Acrylic polymers for use in GRC / GFRC are aqueous dispersions containing approximately 50% water and 50% active solid content.

The acrylic polymer must be used at the recommended dosage level of 4-7% polymer solids by weight of cement. In effect, for an acrylic polymer with a 50% solids content the addition rate of the liquid dispersion is 8-14% by weight of cement.

Typical mix requirements can be found in the GRCA "Specification for the Manufacture, Curing & Testing of Glassfibre Reinforced Concrete (GRC) Products" [1]. When polymer is used the resulting material is referred to as a "P Grade" GRC (e.g. Grade 18P).

An explanation of how acrylic polymers effect a "dry cure" is as follows:

Once spraying or casting is complete, the cement continues to hydrate taking mix water and water from the acrylic polymer emulsion. As this occurs, microscopic polymer particles from the emulsion act in two ways to reduce the evaporation of moisture.

1. They combine to form a continuous film on the outside of the GRC. This process is called coalescence and is similar to wrapping the GRC product in a thin sheet of plastic.
2. They fill the pores formed in concrete that allow water to move around. This results in both reduced water loss by evaporation during cure as well as reduced moisture absorption when the GRC product is in use. During the initial stages of cement hydration, the film formation process is not complete and some water can be still lost by evaporation. Therefore, it is important that the GRC products are covered by polythene sheets immediately after spraying or casting which are only removed at the demoulding stage.

The rate of film formation increases with increased temperature as does the rate of evaporation of water. Factory temperatures should be above 5 ^{o}C and covering the moulds during the initial setting period is essential.

After demoulding it is further recommended that panels are not moved to outside storage and exposed to direct sunlight for at least 1-3 days.

The effectiveness of the "Dry Curing" regime should be demonstrated by individual manufacturers by reference to the 7 and 28-day flexural bending test results carried out in accordance with the GRCA "Methods of Testing Glassfibre Reinforced Concrete (GRC) Material" [2] Part 3 or European Standard EN 1170 Part 5 – the "Full Bending Test".

Different types of acrylic polymers may be used for different mixes and these should also be tested by the GRC producer according to the GRCA's "Methods of Testing" [2] Part 3 or EN 1170 Part 5, and results should be compared for conformity. Compatibility with other additives used in the GRC mixes should also be assessed.

There are many acrylic polymers and not all are suitable for GRC. Some reduce the workability of the mix. Others will not coalesce and form the required film to ensure proper hydration. The reason that thermoplastic pure acrylic ester co-polymers are used in preference to other types of polymer is because some (e.g. styrene/butadiene-based polymers) "yellow" under the natural ultraviolet component of sunlight. At the effective dosage levels (i.e. 4% or more), this can result in an otherwise brilliant white GRC surface developing a "nicotine" stained appearance after a few years.

Furthermore, there is little research on other types of polymers in conjunction with GRC whereas there is a large amount of historical data which supports the benefits of adding acrylic polymer dispersions to GRC matrices. Much of this has been reported at the GRCA Congresses over the last 40 years [3][4].

It is recommended that the acrylic polymer used is in accordance with Table 1, <0.2% of free monomer and free from lumps. The recommended dosage rate is 4-7% polymer solids by weight of cement although the accepted level is typically 5% in the case of most mix designs.

Suppliers of acrylic polymers should be able to demonstrate the suitability of their polymers for the production of GRC and be proven to yield good mechanical and physical properties as set out in the GRCA "Specification" [1] and "Methods of Testing" [2].

techNOTE 12 References:

1. The International Glassfibre Reinforced Concrete Association (GRCA): "Specification for the Manufacture, Curing & Testing of Glassfibre Reinforced Concrete (GRC) Products".
2. The International Glassfibre Reinforced Concrete Association (GRCA) "Methods of Testing Glassfibre Reinforced Concrete (GRC) Material".
3. H. Ball, Ball Consulting Ltd: GRCA Congress 2005: "25 years of Forton polymer modified GRC: Reasons for its use."
4. B. R. Crenshaw, Engineered Polymer Solutions: GRCA Congress 2015: "Performance of polymer modified GRC compared to GRC produced with plasticizer only."

The International Glassfibre Reinforced Concrete Association t: +44 (0) 330 111 (GRCA) w: grca.org.uk
PO Box 1454, Northampton, NN2 1DZ, United Kingdom t: +44 (0) 330 111 4722 e: info@grca.org.uk