

The use of admixtures in GRC production

The use of chemical admixtures for Portland cement-based mixes have grown steadily over the last 20-30 years, with a number of new generation types developed during this period. Admixture types and their applications are well documented, with The Concrete Society's Technical Report 18⁽¹⁾ being a good reference source.

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The most common admixtures are those that reduce the water demand and/or improve fluidity. These aid the dispersion of cement and are generically referred to as plasticisers with the early forms being based on lignosulfonates. They were improved with the introduction of super-plasticisers based on sulfonated melamine or naphthalene formaldehyde. Recently, mainly for the self-compacting concrete market, a new range of products has been launched based on polycarboxylate ether chemistry. However, all three types of plasticisers are still freely available.

Increasingly, plasticisers are used with VMAs (viscosity modifying admixtures), which improve cohesion. They are added mainly to prevent segregation and bleeding when a highly fluid mix is required.

In addition to the above, there are a number of other admixtures that are frequently used for concrete such as set retarders for hot weather, accelerators for cold weather and water-repellent/anti-efflorescence chemicals.

Plasticisers

For GRC to flow more easily for a given water:cement ratio it is necessary to reduce the yield point (force needed to start the mix moving) of the mix. Plasticisers do this by adsorbing onto the surface of the cement particles, reducing flocculation, thus aiding dispersion and reducing drag, which increases fluidity. They have become quite sophisticated: some will give a high degree of fluidity quickly but are short-lived, while others give less dramatic fluidity but last over a longer period of time. Sometimes rapid filling and early demoulding is the key issue but in other cases it is better to accept a lower fluidity so as to have a longer time to fill moulds.

The original and still the cheapest plasticisers are based on lignosulfonate. They have a limited use with fibrous mixes such as GRC because the fibres severely inhibit flow so they are less effective. Nonetheless, they can be cost-effective in some cases. They can only be used at low dose levels since at high levels (>0.5% by weight of cement) they may cause retardation and entrainment of air.

Plasticisers based on sulfonated melamine as well as naphthalene formaldehyde are much more effective at increasing flow or reducing the water content (to increase strength) for a given flow. They were originally given the name superplasticisers, becoming widely available in the 1970s and are still extensively used today by GRC manufacturers. They are custom-manufactured so as to give better early strengths, by reducing the water for a given fluidity or longer fluidity retention for rapid mould filling. Dosage is usually in the range 0.7-1.5% by weight of cement, allowing for water reduction from 15 to 25% with

resulting increase in strength. In addition, they are less likely to retard the set of the mix if used within this range. They can also be combined with other admixtures, eg, accelerators or retarders, for secondary effects.

The latest range of plasticisers is based on polycarboxylate ethers (PCEs) and they have dramatically improved the ease of producing GRC, particularly premix GRC. They are the most expensive plasticisers but are also very efficient so lower dose rates are possible. They are typically used in the range 0.1-2%, which will give a very fluid mix and would probably need to be used in conjunction with a VMA to avoid segregation. At the higher levels higher fibre content premix can be achieved. They also reduce mixing problems, with excellent results being obtained with even the simplest of mixers. PCEs are readily modified by the manufacturers to produce specific properties such as workability retention, cohesion or early strengths. Lowering the water:cement ratio will increase the strength of the GRC as well as improving its resistance to water and chloride ingress. Surface finishes are also usually improved with reduced number of blemishes.

Viscosity modifying admixtures

Most VMAs are based on high molecular weight polymers with a high affinity for water and build up a sort of three-dimensional structure in the liquid phase. In this way, VMAs modify the rheological properties of the cement paste in the GRC mix. Typically, they are used at the rate of 0.1-1.5% by weight of cement.

Basically, the flow (rheology) of a fresh cement-based matrix depends on two properties: the yield point, which is the force needed to start it moving; and the plastic viscosity, which is the resistance of the mix to flow due to the internal friction of its ingredients. Slump tests mainly measure the yield point and the V-funnel test will measure the plastic viscosity (although this is not part of any current recommended GRC testing programme).

Plasticisers decrease the yield point and therefore increase flow. VMAs, on the other hand, increase the plastic viscosity without affecting the yield point. This helps to hold the constituents together, thus reducing any tendency to segregate, especially in highly fluid mixes. They also help to reduce friction during pumping and reduce bleeding. In this way, VMAs complement plasticisers in GRC mixes and are especially useful for pumped mixes and/or highly fluid mixes.



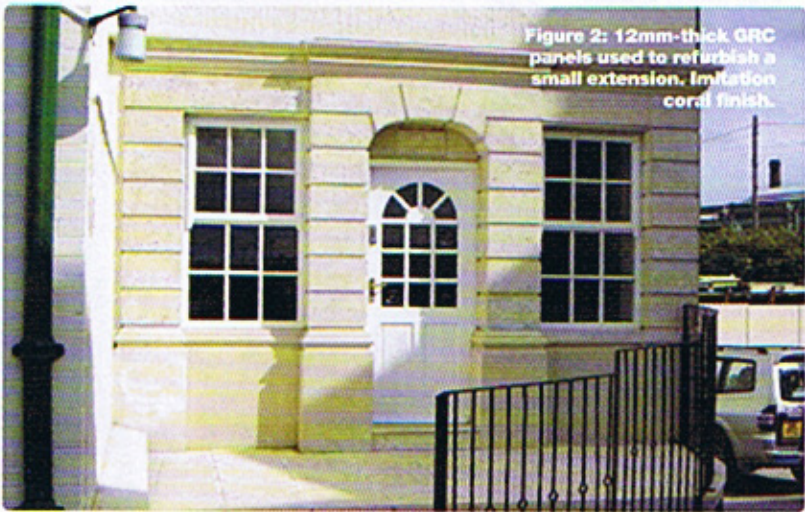
This is the third in a series of technical notes covering aspects of glass-fibre-reinforced concrete (GRC) technology.

The Glassfibre Reinforced Concrete Association (GRCA) is a Special Sector Group of The Concrete Society.

Figure 1 below: 10mm-thick GRC promenade tiles for flat roofs.



Figure 2: 12mm-thick GRC panels used to refurbish a small extension. Imitation coral finish.



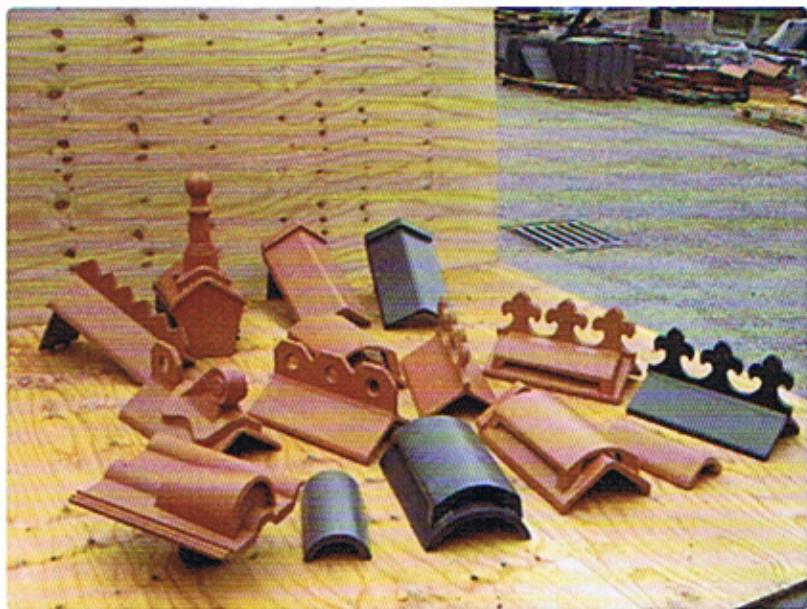
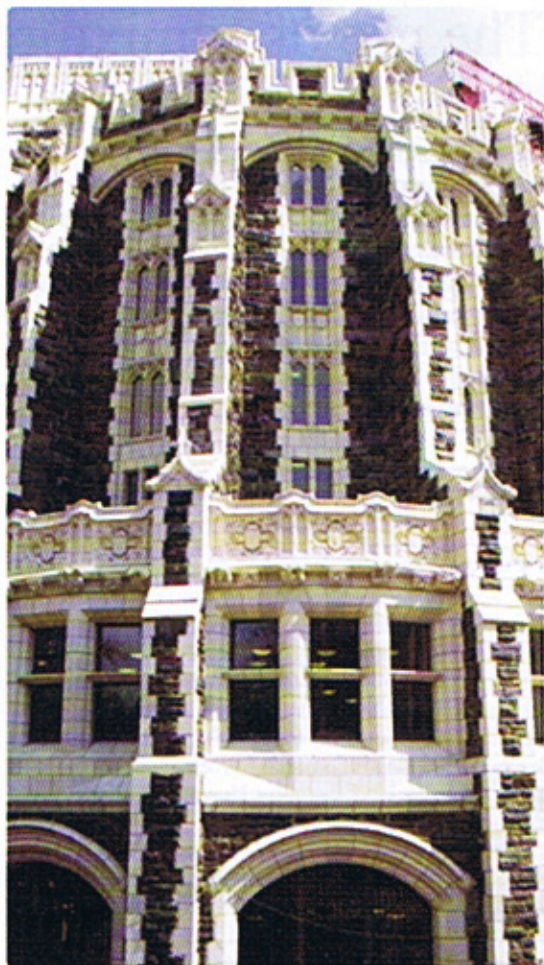


Figure 3 above: Miscellaneous roofing products in GRC.

Figure 4 right: Some 75,000 GRC replacement units, most with complex shapes, were used to renovate this building in New York (architect - C Stein).



Accelerating admixtures

For GRC, accelerating admixtures are generally not required. GRC is cement-rich, so it has a natural exothermic (heat developing) reaction and is made under factory conditions, therefore setting in 12–16 hours is not normally a problem. However, in factories that are not heated overnight in very cold climates, they can help to ensure that the product sets hard enough to demould the next morning. If GRC is being left under these cold, overnight conditions, it would be better to consult with the suppliers of plasticisers so as to find one that has an accelerator preblended in.

The most common accelerators are based on calcium chloride but care must be taken when using this product if there is any steel (eg. fixings parts) embedded in the GRC. A number of chloride-free accelerators are available. One use of these could be of interest if sprayed GRC is being produced, since it is added at the nozzle head of wet sprayed concrete in tunnels to increase the strength development. Perhaps this is a way to increase mould turnaround?

Retarding admixtures

In hot weather, manufacturing GRC can become problem-

atic because of its high cement content and resulting exothermic heat development. In hot weather, it is also best to keep all ingredients cool and use iced water but when this is not possible chemical retarders can be used.

The majority of retarders are sugar-based and are most effective if they are added a few minutes after mixing is complete. They should be used in addition to other admixtures, such as plasticisers, so as to have a fluid mix to start with. Retarders do not normally affect long-term strengths but they can affect 24-hour properties.

Figure 5: A total of 11,945 window surrounds, each using approximately 4m² of GRC, plus 15,898 decorative elements on 1742 flats in Istanbul.



Air-entraining admixtures

Air-entraining admixtures are not usually used with GRC since it is already relatively lightweight and such admixtures generally reduce the mechanical strength of the finished product. However, if the weight of a product on-site is a problem – and, even for GRC, this is increasingly the case – then there are a large number of proprietary admixtures available that can easily reduce the density of GRC. If air entrainers (or low-density aggregates) are used, then the mechanical properties of the GRC should be verified.

Polymers

For the past 30 years polymers have been used with GRC and their use in all forms of concrete and cement-based blends is growing. For GRC, the following are some of the reasons:

- the elimination of wet curing while still achieving good seven- and 28-day strengths
- greatly improved workability and application even without the use of other admixtures
- to improve the long-term mechanical properties of GRC, particularly the aged flexural strain to failure
- harder, denser surface with no 'dusting' and less crazing.

The polymers used are white latex, usually acrylic, emulsions with approximately 50% solids content. The recommended dosage is 5–6% solids (10–12% latex) by weight of cement with lower levels also being used (accepting lower benefits). The polymer must be resistant to alkali and UV stable. They function by forming a network of flexible polymer bridges between the brittle mineral ingredients, helping to bind them together. The polymer film

forms, which traps in the water preventing premature evaporation and sealing the surface. This results in a harder surface, which also reduces moisture ingress especially the rate of water penetration.

Anti-efflorescence and water-repellent admixtures

GRC has a high cement content so produces more lime during setting. This makes it prone to efflorescence since lime is the primary cause of efflorescence. Replacing some of the cement with a high-reactivity pozzolanic material will drastically reduce the amount of lime generated and almost eliminate efflorescence. However, pozzolans are added at 15–20% dose levels and, therefore, fall into the category of additives, so are not discussed here.

By reducing the water content and curing the GRC correctly, efflorescence is kept to a minimum. The use of polymers is beneficial since it ensures good cure and also helps to seal the surface of the product, preventing or reducing the evaporation of water from the surface, which leads to efflorescence.

There are also a number of compounds that can be added into the mix to increase the water-repellent nature of the surface after setting, including the more recent integral crystalline compounds. Anything that helps reduce evaporation of water from the surface will automatically reduce efflorescence. ■

Reference:

1. CONCRETE SOCIETY. *A guide to the selection of admixtures for concrete*. Technical Report 18, The Concrete Society, Camberley, 2002.