GRC TECHNOTES 7

This is the seventh 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.

Self-compacting premix GRC

The use of self-compacting concrete (SCC) has revolutionised the way both precast and in-situ concrete is placed. As the term implies, SCC is a concrete that can be compacted into every corner of a formwork/mould, purely by means of its own weight and without the need for vibration compacting. It was first developed in Japan in 1988 and has gained world popularity in the last 20 years.

Yanfei Che, Power-Sprays and
Iain D Peter, Fibre Technologies International

The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure.

The advantages in the precast concrete factory are a much more pleasant, and more importantly, a safer working environment. The moulds can be of lighter construction and last longer.

There are perceived disadvantages in that the mix design has to be adapted to reduce the quantity of large aggregate while increasing the quantity of the fine aggregate. Additionally there must also be an increase in the fines content, which can be achieved either by increasing the cement content or by the addition of cement replacements such as ground-granulated blast-furnace slag (GGBS) or fly ash.

Figure 1: Fluidity test apparatus.

Table 1 – Typical mix designs

Material	Non-polymer mix	Polymer mix
Cement	25	25
Silica sand	25	25
Water	9.0	6.75
Acrylic polymer	0	2.5
Flowaid SCC	0.25	0.25

Cast premix GRC

Cast premix GRC has always relied on vibration to fill moulds and to remove entrapped air. This has never been particularly satisfactory and as the fibre content has increased it has become increasingly difficult to get the concrete to flow sufficiently to completely fill the mould and to give a satisfactory finish without air holes. This problem is exacerbated when rubber moulds are used, which tend to absorb rather than transmit the vibration. Moving empty moulds to the vibrating table and full ones away is another added complication.

Many GRC products require a facing mix that is sprayed into the mould first, which is not possible when vibration is used.

Self-compacting premix GRC mix design

The mix must have the following properties:

- does not require vibration
- is suitably fluid to completely fill the mould but does not segregate
- gives a surface finish free from voids and air holes
- gives satisfactory mechanical properties, particularly flexural strength and density.

With premix GRC, the dry mix comprises exclusively 'fines', ie, cement and fine sand used in the ratio 1:1. The only parameter to vary is the type and quantity of the concrete additives. The use of a rheology modifier is essential since adding a high-dosage superplasticiser is prone to cause segregation in the GRC mix. The solution is to optimise the dosage of each of the additives as they have opposite effects on GRC workability. This is not easy and getting the right balance proved elusive until superplasticisers based on polycarboxylic polymers with integral stabilisers became available.

Another important factor is the selection of chopped glass strands. High-integrity fibres must be used to minimise the filamentation during mixing. Strand length is normally limited to 13/19mm as longer fibres lead to an excessive reduction in workability. The fibre percentage does not need to exceed 3% and the water/cement ratio is optimised between 0.35 and 0.38. Both polymer and non-polymer mixes can be used.

Measuring workability

The standard slump test (BS EN 1170-1[1]) is not appropriate, as concretes with a suitable flow would all show the maximum number of rings, although this slump test can be useful in assessing segregation. An additional flow test was developed, which proved to be very accurate and gave

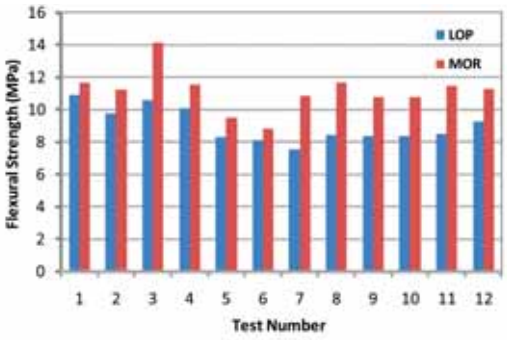
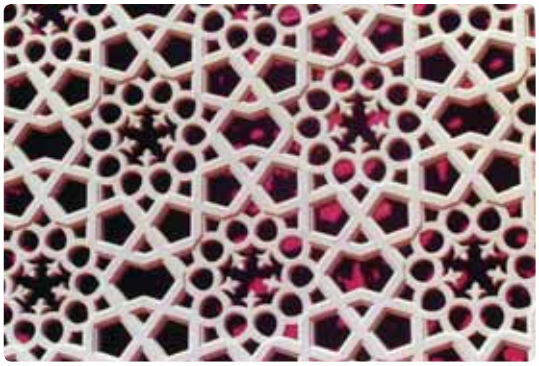
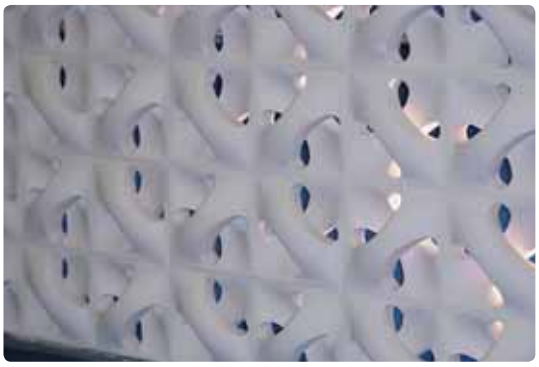


Figure 2: Typical flexural strengths (non-polymer) from daily QC tests.

Self-compacting premix has been shown to be not only a viable alternative to vibration casting but also to have positive advantages.





Figures 3–7: Typical products made with self-compacting premix GRC.

reproducible results. A stainless-steel funnel with a 19mm spout was held vertically in a frame and filled with the test mix (see Figure 1). The time taken for the concrete to completely empty was recorded. It was found that GRC mixes with a flow time of less than 30 seconds could be considered self-compacting.

Mechanical properties

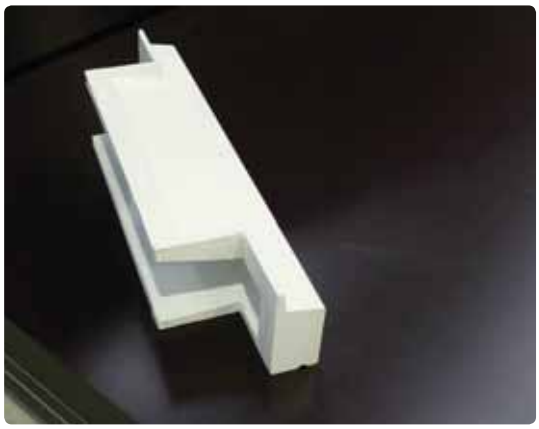
Self-compacting premix GRC has been shown to achieve the required mechanical properties to comply with Grade 8 (GRCA Specification). This is the grade appropriate to most premix applications. Figure 2 and Table 2 show the test results of some typical mixes. Figures 3–7 show some typical products made with self-compacting premix GRC.

Concluding remarks

Self-compacting premix has been shown to be not only a viable alternative to vibration casting but also to have positive advantages:

- a special additive is required that will give the required flow properties without segregation
- typical mechanical properties for premix are achieved
- facing mixes can be used
- provided a high-integrity fibre is used then the required mechanical and flow properties can be achieved with a range of fibre types and percentages
- a more pleasant and safer working environment.
- lighter mould construction and longer mould life
- self-compacting premix can be poured or pumped into moulds directly.

These advantages have been recognised by the leading UK and international GRC producers. ■



■ **Acknowledgement:** The authors would like to thank Dave Bratton of BCM GRC, Bob Faulding of GRC UK and Mohammed Marasli and Numan Ugur of Fibrobeton Turkey for their assistance.

Table 2 – Typical results for polymer mixes with various glass-fibre additions

Fibre (%)	Filaments per strand	Filament diameter (μ)	Fibre length (mm)	Strand integrity	Time (s)	LOP (MPa)	MOR (MPa)
2.5	100	13/14	12/13	High	27.03	10.69	12.21
3.0	200	13/14	12/13	High	28.38	9.54	11.81
3.5	200	18	12/13	High	21.78	7.74	9.63
3.0	200	18	19	High	31.06	7.96	11.01

Reference:

1. BRITISH STANDARDS INSTITUTION, BS EN 1170. *Precast concrete products. Test method for glass-fibre reinforced cement. Part 1 – Measuring the consistency of the matrix. 'Slump test' method.* BSI, 1998.