THE MAGAZINE OF THE CONCRETE SOCIETY

CONCRETE

Volume 58, Issue 5 June 2024

STEPS TO SUCCESS

Industry collaboration needed to support industry's next generation

PERMEABLE PAVING

How SuDS will be a central solution to prevent flooding

ON THE FACE OF IT

Factors to consider when using GRC facing coats

GRC FACING COATS

Bob Faulding of **The GRC Centre** looks at what specifiers, users and manufacturers need to consider when using GRC facing coats on construction projects.

Many people assume that architectural products manufactured from glass-fibre-reinforced concrete (GRC) are homogeneous, featuring the same design mix throughout the full thickness of the unit.

While some products such as small architectural dressings etc can be made this way, the majority of GRC in use will have a separate layer of unreinforced cementitious material applied to the mould surface before the GRC composite. This is necessary to ensure that the reinforcing fibres are not visible on the architectural surface.

Small elements, manufactured by the premix method as defined in BS EN 1169:1999[1], will contain approximately 2–3% of alkali-resistant fibres, typically 13mm in length. With careful consolidation, these are seldom visible on the surface of the finished item.

Larger products such as cladding panels will almost certainly be produced using the spray process, again as defined in BS EN 1169. This method typically has 5% fibre with lengths generally 25–32mm, which would be impossible to avoid being visible on the surface.

ABOVE:
Application of facing coat: hopper gun.

Traditionally with this type of production, 'mist coats' have been used to prevent the appearance of visible fibres. This is a layer of the same cementitious material as the structural GRC but without the alkali-resistant fibres. Products manufactured in this way would typically result in finishes comparable with cast and natural stones. Mist coats are generally 1–3mm in thickness.

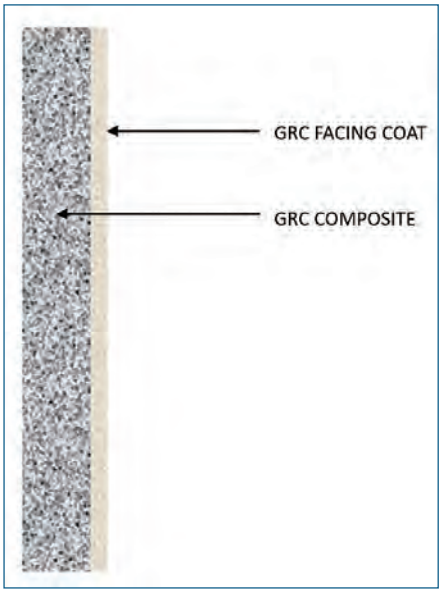
However, in recent years there has been a tendency to move towards more individual finishes, featuring decorative aggregates such as quartz, mica, dolomite, granites, etc. These are commonly referred to as either face or facing coats. While these finishes add to the appeal of GRC products, very careful consideration must be given not only to their visual appearance but also to their in-use performance.

ABOVE:
Cracking in over-thick or non-compatible facing coat.

FACING COAT DEVELOPMENT

The development of a facing coat mix needs to be carefully considered at an early stage in the design process. The importance of allowing sufficient time for the matrix to be fully designed and validated by the manufacturer and/or third-party assessment body cannot be overemphasised. Specifiers and users should allow approximately 12–16 weeks for the full development and testing of a bespoke facing coat, although the manufacturer should clarify this at the outset.

The starting point is to have a clear understanding of the design intent and this can often be the most complex part of the entire process.



ABOVE:
Section showing the build-up of a GRC panel.

ABOVE:
Surface sealant applied to facing coat.

Primary colour, aggregate size, distribution and exposure are the key factors that need to be explored. Often, this is achieved through the presentation of a selection of small samples developed by the manufacturer or specialist facing-coat supplier.

Once a preliminary choice has been made, it is usual to progress to a larger representation. Typically, this would be a 300 × 300mm sample developed from the initial consultations.

In producing all the samples presented, the supplier must have considered all the factors that govern the development of durable and long-lasting facing coats.

RAW MATERIALS

The cement should be of the same type and colour as that of the GRC structural matrix. This is usually a white cement, which is far more controllable in regard to colour consistency. In our experience of manufacturing GRC over the past 20 years, we have always found it is easier to control colour consistency, even in dark shades, using white cement.

Wherever possible the cement:aggregate ratio should be as close to that of the GRC backing mix to avoid differential movement. Aggregate size and grading should ideally be close to the silica sand generally used in the GRC matrix. While this isn't always possible, the larger the deviation the greater the potential for differential movement.

The collective global GRC industry has various thoughts on what should be the largest aggregate size. As a company, we would always recommend an ideal size of 1mm, with a maximum size of 3mm. PCI MNL 130-09[2] recommends a maximum of 6mm, as larger sizes can not only cause production difficulties but also make units more likely to display differential shrinkage/expansion characteristics leading to bowing and cracking. We are aware of some manufacturers using aggregates up to 10mm; however, the use of this size aggregate significantly increases the necessity for a comprehensive programme of proof testing, including weathering testing of full-size panels.

Whichever aggregate is chosen, excessive quantities of fine aggregates defined as those passing a no.200 sieve (75µm) could act as undesirable colouring agent. These can also increase water requirements, decrease strength and induce higher drying shrinkages. PCI MNL 130-09 recommends content does not exceed 1% of the total aggregate weight.

The chosen aggregate size will affect the facing coat thickness, which is generally 1–3mm thicker than the largest aggregate size. As such, a 6mm aggregate may have a facing coat up to 9mm thick. Given the potential for crazing/cracking when the unreinforced layer increases with thickness, consideration may be given to including 6mm fibres designed to reduce cracking. It should also be understood that the design engineering ignores the facing coat and is based purely on the thickness of the GRC backing, which remains constant irrespective of facing coat thickness. It follows that a larger aggregate selection can increase panel weight.

Pigments will generally be used to produce all shades other than white. Dosage rates of less than 1% by weight of cement should be avoided, as colour sensitivity increases at lower concentrations. Given that facing coat mixes are generally prepared in relatively low quantities due to their working time, it is preferable to increase the pigment dosing to 1–5%. Pigment content above 5% makes little difference to colour intensity.

To maintain close compatibility with the GRC backing, admixture, additive and water:cement ratios should be as similar as possible.

TESTING

The specific mix design should be comprehensively tested before approval:

- Differential movement – whatever steps are taken to ensure compatibility with the GRC, the facing coat is by

ABOVE:
Dimensional movement testing.

LEFT:
Applied facing coat.

definition a different material. As such, it is important to measure both thermal contraction and volume-induced expansion of both the facing and backing mixes. In the event of deviations, an analysis of the imposed internal matrix stresses and subsequent effects should be carried out.

- Compressive strength – although GRC backing strength is determined by its flexural capacity, facing coats are non-ductile and performance should be measured through compressive strength testing. A 28-day strength in excess of 28MPa should be achieved.
- Freeze–thaw – the facing coat will be subject to freeze–thaw cycles in some environments. While GRC is known to be resistant to freeze–thaw cycles, the facing coat that is exposed to the elements should be tested for compliance. Freeze–thaw cycles may also induce widening of micro-cracking and, in worst cases, facing coat delamination.
- Water absorption – the material should display a water absorption similar to GRC (less than 10% by weight).
- Fire testing – given the facing coat sits on the outside of any construction and is a different formulation to the GRC backing, each mix type should be tested for fire classification.

FINAL APPROVAL

Once the facing coat has been developed and tested, larger samples should be produced for final approval by the relevant stakeholders. We would always recommend to clients a minimum of five samples be produced in a size similar to the finished product but not less than 1000 × 1000mm. These should be manufactured on different days, replicating actual production. Repairs should form part of the samples as a benchmark. Panels may also be incorporated into a visual mock-up constructed at the work site.

PRODUCTION CONTROL

Process control at the mixing stage is essential to avoid colour variations. Precise measuring equipment is required, especially for pigments etc. These should be regularly calibrated and have suitable readability and accuracy. Scales or balances that are accurate to 1% of the load being weighed are recommended. The slump value of every mix should be measured to ensure consistency.

The application of facing coats is a skilled operation undertaken in the factory. The slurry is sprayed onto the mould surface using either a special facing coat or hopper gun. It is not advisable to run facing mixes through the GRC concentric gun due to the sharper aggregates that are often used in facing coats. The higher operating pressures required for concentric guns can also contribute to blowholes on the surface of the facing coat.

The thickness of the applied facing coat must be thoroughly checked. If this process is not carried out diligently, the subsequent checking of the critical GRC thickness will be incorrect, as this is determined by thickness checking of the overall skin. In our experience, over-thick facing and indeed mist coats, and consequently lower GRC thicknesses, are the biggest challenges in quality control faced by the industry.

Once the facing coat has been applied, it must be left for a sufficient time before the backing is applied. This allows the mix to stiffen, preventing fibres from being pushed through. However, if the mix is left to stiffen too long, there is a real risk of delamination. Good quality-control systems will have methods for determining optimum timing.

It is good practice to apply the first layer of structural GRC thinly. This allows for minimal compaction and reduces further the risk of fibres being pushed through.

Facing mixes can be finished by a variety of methods including grit blasting, acid washing, retarders or high-pressure washing. The application of a suitably approved surface sealant will not only improve the weathering of the facing coat but also protect against ductility loss.

REPAIRS

Repairs are inevitable during the various handling operations to which GRC products are subjected. These should always be carried out using the same mix design as the facing coat. Such repairs are highly skilled operations and should only be carried out by factory personnel or specialist companies with experience in GRC manufacture.

CONCLUDING REMARKS

Facing coats can be used to expand the already versatile nature of GRC in manufacturing construction products, especially those used as façade cladding panels. They add to the appeal of the material, allowing architects and designers freedom of imagination in form, function, colour and finish. Very few precast concrete or composite products can rival GRC for its ability to translate architectural concepts into finished building components that are durable, environmentally friendly, long-lasting and maintenance-free.

As such, they are critical in both appearance and performance. Provided due care is taken in selection, development and application, facing coats can be as long-lasting as the GRC composite itself.

References:

1. BRITISH STANDARDS INSTITUTION, BS EN 1169. *Precast Concrete – General rules for factory production control of glass-fibre reinforced cement*. BSI, London, 1999.
2. PRECAST/PRESTRESSED CONCRETE INSTITUTE, MNL-130-09. *Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products*. 2nd Edition, PCI, Chicago USA, 2009.