3 SPRAYED PREMIX, THE NEW GRC

I. D. PETER
Power-Sprays Ltd., UK

SUMMARY: Although there have been many changes and improvements since the GRC industry started over 30 years ago, the main production techniques are still hand spray and vibration cast premix.

This paper investigates another production method that is becoming increasingly popular, namely sprayed premix. It compares this to traditional hand spray and vibration cast premix, looking at mechanical properties, consistency and ease of use. It has been found that, although hand spray is a very versatile technique, it relies on skilled, well-trained labour and it can be difficult to maintain consistent properties.

The range of products that can be made by vibration cast premix is limited by the type of moulds used. There are no such limitations with sprayed premix and the moulds can be much simpler, thus reducing the time taken to strip and reassemble them.

The essentials for producing good quality sprayed premix are considered and the paper concludes that this production technique will be widely used worldwide.
KEYWORDS: Alkali-resistant glassfibre, cast, mechanical properties, premix, sprayed.

HISTORICAL

The first commercial applications of GRC were in the 1970s following the development and commercialisation of high zirconia alkali-resistant (AR) glassfibre.

The GRC that was produced then would be difficult to recognise today. It started as a neat cement paste reinforced by 5–6% AR fibre. It was produced almost exclusively by the spray method. The industry did not understand how some properties changed with time, how to design with GRC and even how to fix it.

GRC products tended to be grey or white and if colour was required they were painted.

Products required wet curing for 7 days and the manufacturing equipment used was modified from other industries. Large panels had to be made of sandwich construction and often contained styropore concrete.

HAVE THINGS CHANGED?

The mix design has been improved with the increase in the sand content and the introduction of polymers and plasticisers. Dry curing is now possible and the matrix strength has been increased while at the same time reducing shrinkage.

The AR fibres have been developed and improved and there is now a range of fibres available to meet specific applications. It has been realised that there is nothing magical about 5% and the fibre content and type can be varied to suit the application.

A range of colours and textures can be produced and GRC products can now imitate many traditional building materials.

The ageing of GRC is much better understood and considered and allowed for at the design stage. There are more options when it comes to panel construction with stud frame panels finding favour in some areas and ribbed single-skin construction in others.

The machinery manufacturers have developed specialist pumping, mixing and spraying systems and, while the spray method of production still predominates, premix is becoming increasingly popular.

WHAT HAS BROUGHT ABOUT THESE CHANGES?

The fibre manufactures have improved their products and reduced costs.

Machinery manufacturers continue to develop and improve production machinery and improved acrylic polymers and other additives are available.

Designers have a better understanding of the material, and products that at one time couldn't be made are now commonplace.

The Glassfibre Reinforced Concrete Association (GRCA) also deserves recognition as a source of independent information. It has produced specifications, test methods, a design guide and a range of technical and marketing literature. The biannual congresses are the leading world events for the industry, allowing the exchange of ideas and information.

The main responsibility for change is with the GRC manufacturers themselves; it is they who have developed the new products, processes and finishes etc., and it will be the manufacturers who move GRC on into the 21st century.

ARE FURTHER DEVELOPMENTS REQUIRED?

Yes. GRC products are still produced mainly by the hand-spray process, which although very effective is still very labour intensive and dependent on the skill of the operator.

Vibration cast premix is much less labour intensive but the type of product that can be produced is limited.

New techniques, namely extrusion, pressing, rotational moulding and robotic spray have been considered but with a few exceptions these remain uncommercialised.

There is, however, one production method that has proved a commercial and technical success. This is sprayed premix and this paper will investigate this production technique and consider its benefits and disadvantages.

WHAT IS SPRAYED PREMIX?

The fibre is added to the matrix during the mixing process and the mixed fibre and matrix are pumped to a spray gun and sprayed onto the mould.

WHAT ARE THE ADVANTAGES?

Compared with vibration cast

Vibration cast premix requires complex moulds, which, as well as being expensive to produce, are also time consuming to strip and reassemble.

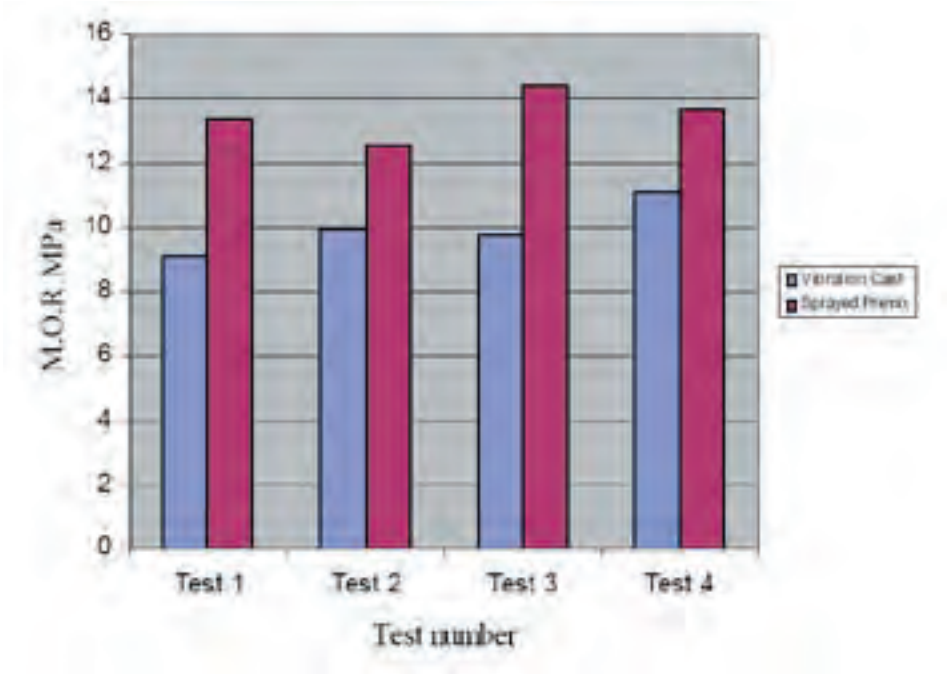
As premix GRC can be sprayed on vertical sides and mould returns, an inner mould as used in vibration cast premix is not necessary.

It is difficult to produce stone finishes with the vibration cast process and the range of products that can be produced is limited.

There are no such limitations with sprayed premix.

Using the same mix design and fibre content it has also been shown that higher flexural strengths are obtained compared with vibration cast premix. It is believed that this is because the spraying results in a more planar or two-dimensional fibre orientation compared with the random three-dimensional array with conventional premix.

Comparison sprayed premix/vibration cast premix



Compared with hand spray
Spraying premix is a much simpler process than conventional hand spray. It is less labour intensive and requires less skill. The spray gun is smaller and there are fewer hoses making the spraying of small products easier.

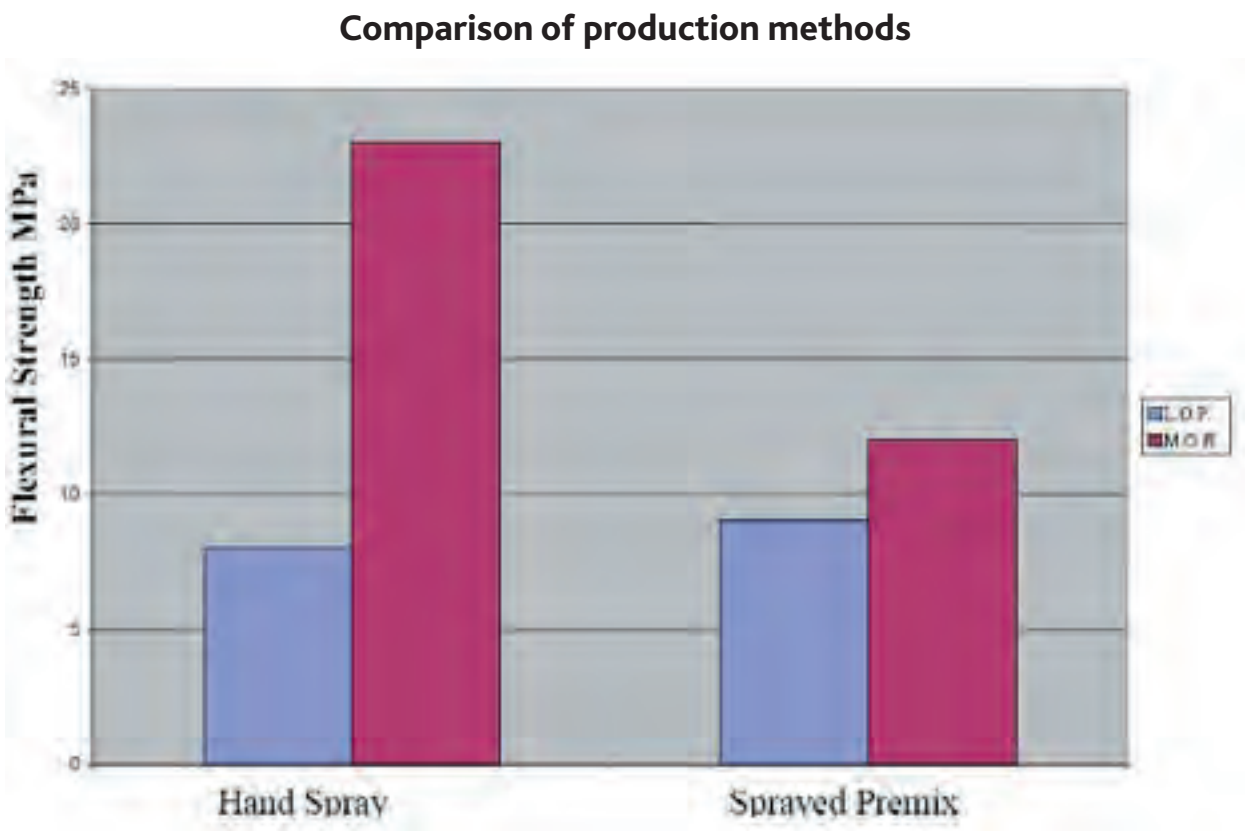
Although established manufacturers with trained staff are capable of producing high quality hand-sprayed products newcomers to the industry find the technique difficult.

Producing high quality hand-sprayed GRC also requires rigorous factory control and it is necessary to:

1. have a low water/cement ratio
2. have a glassfibre content in the range 4.0–5.5%
3. calibrate the spray equipment regularly (bag and bucket tests)
4. measure the glass content (wash-out test)
5. spray the GRC in two to three passes with compaction between every coat
6. cure the GRC while it is in the mould and after demoulding
7. spray daily sample boards and carry out flexural testing at 7 and/or 28 days.

If all the above is performed regularly then the anticipated properties can be achieved. If not, then material of indeterminate quality will be produced.

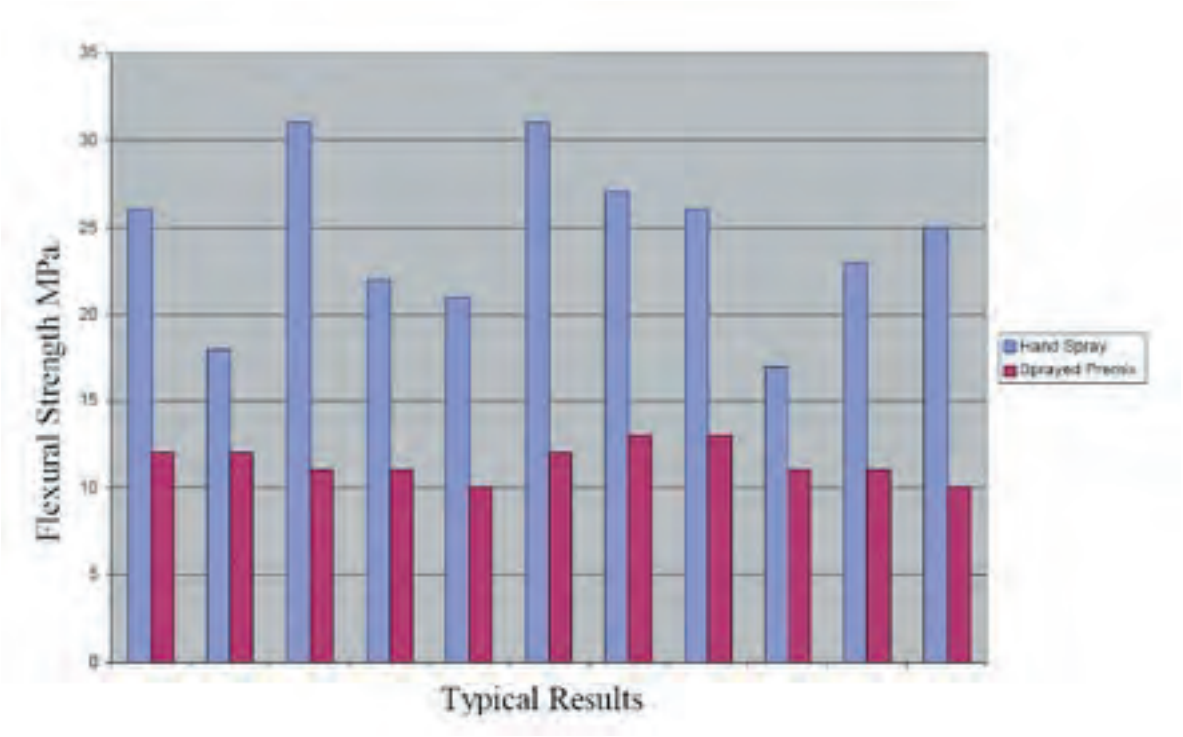
Compare this with sprayed premix
The flexural strength properties are lower.



However, it is much easier to achieve them consistently.

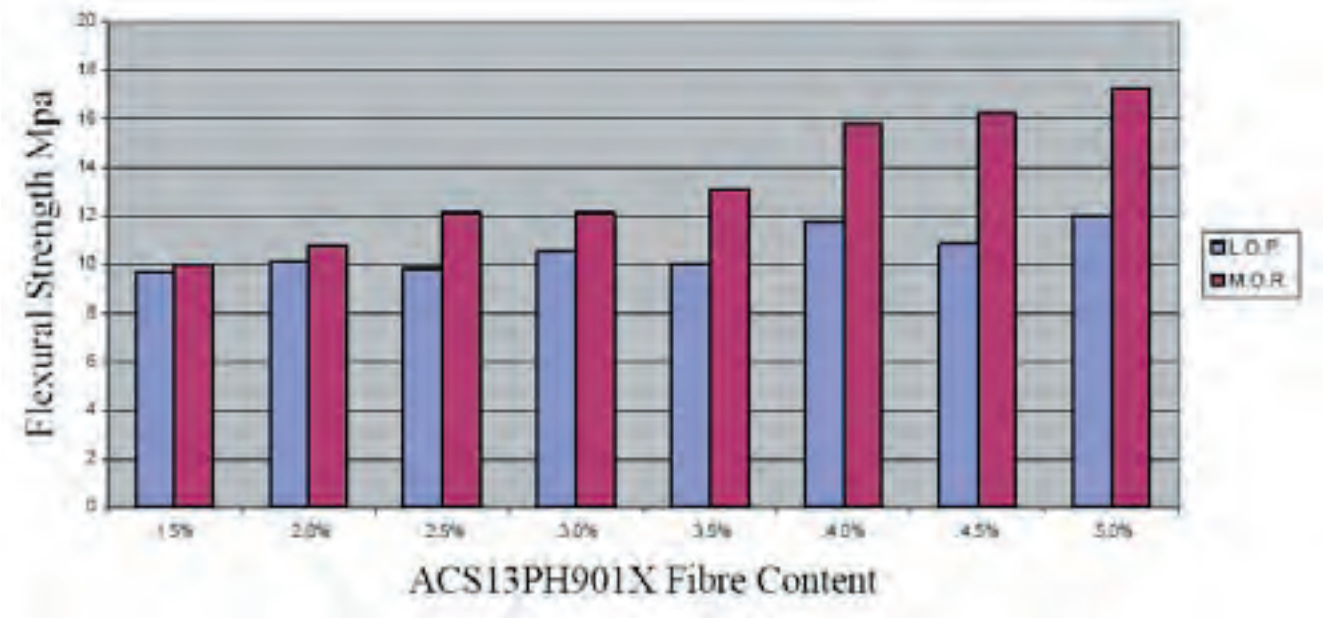
1. The fibre content is determined by weighing; there is no calibration or bag and bucket tests and wash-out tests are unnecessary.
2. The mix has to be strictly controlled; if the water/cement ratio is too high or too low then spraying is difficult or impossible.
3. Compaction is used to ensure a good surface finish but it is not required to ensure that the fibre is encapsulated by the cement.
4. The sprayed material is homogeneous and unlike hand spray, over-sprayed material can be used, thus reducing wastage.
5. Because the properties achieved are more consistent, fewer sample boards are required and this in turn reduces testing costs.
6. The equipment is much easier and quicker to clean and uses less water. Because the moving parts of the pump do not come into contact with the mix it can be used for faster-setting materials.

Consistency comparisons



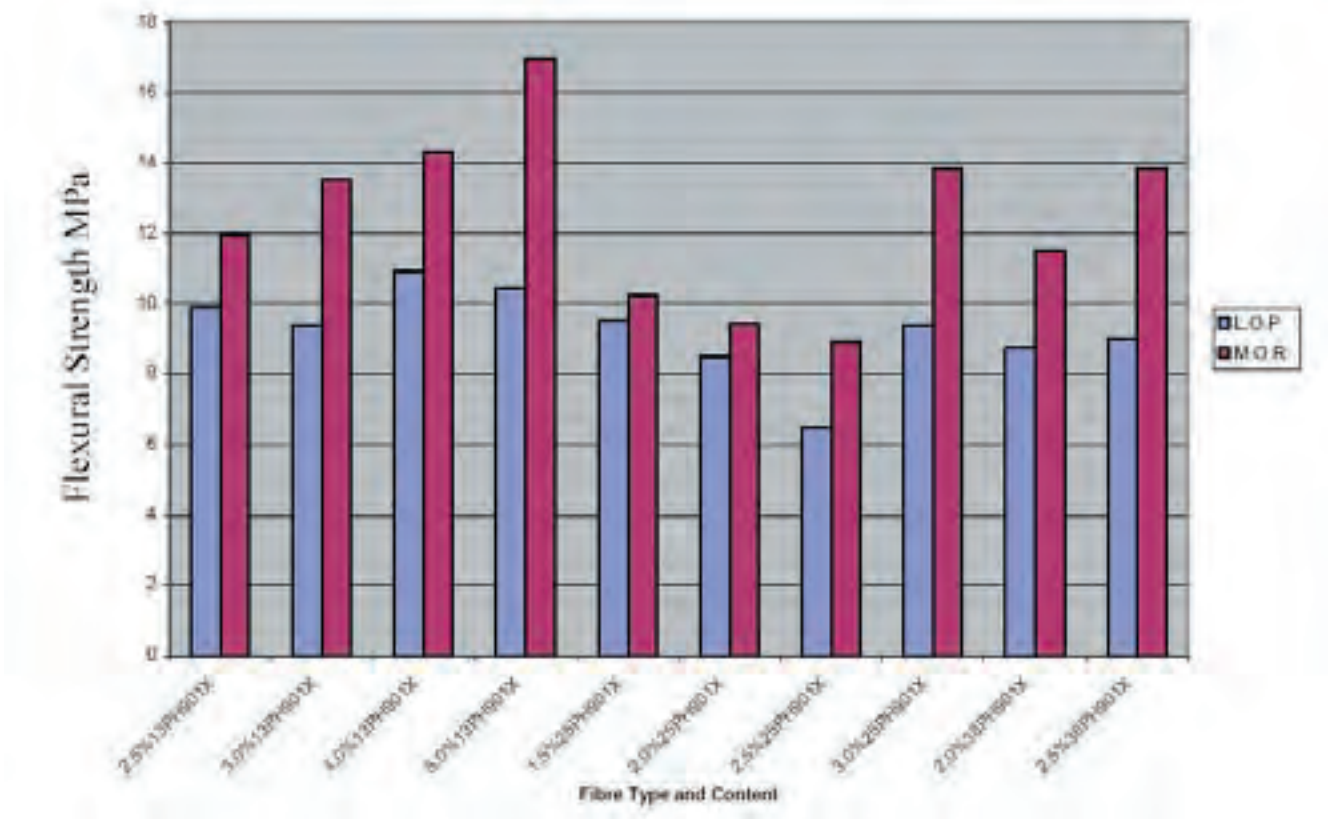
The above results show the variation in flexural results for the two production methods. The hand-spray results show considerably more variation and these results have been provided by a manufacturer that calibrates and tests on a daily basis.

Vibration cast premix influence of fibre content



With sprayed premix there is a gradual change in flexural strength with increasing fibre content that allows a factor of safety should, for any reason, the specified fibre content not be strictly adhered to. It is also possible to use a range of fibre lengths from 13mm to 38mm.

Typical properties with varying fibre length and content



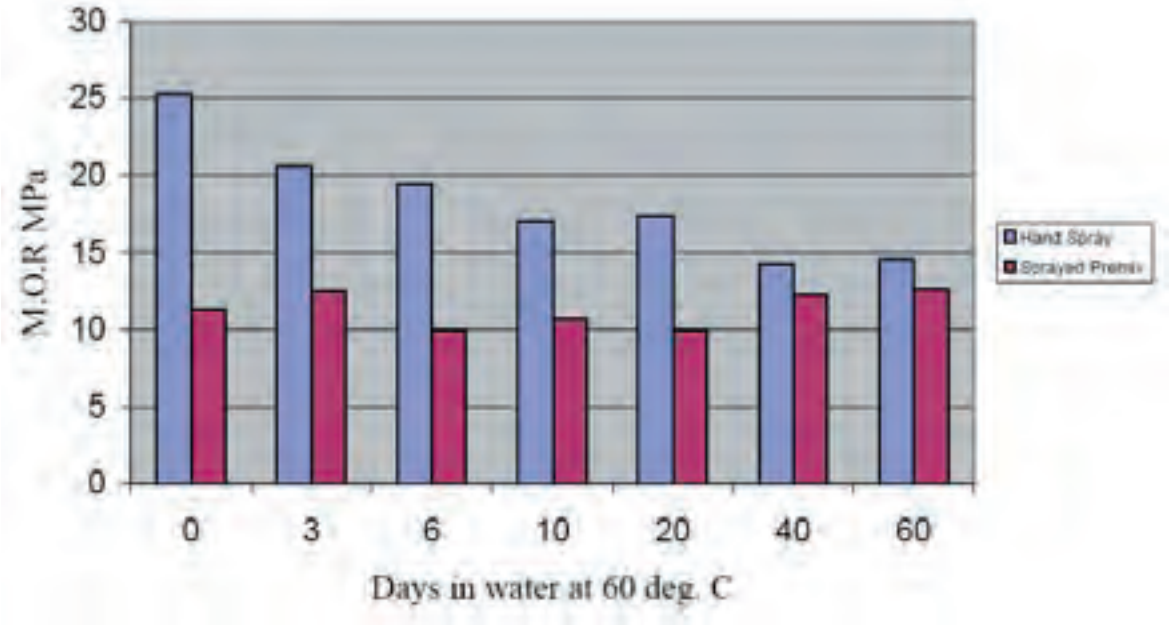
Aged properties

The change in time with certain fibre-dependent properties is well understood and is allowed for in conservative design rules. With hand spray the decline can look quite dramatic although in the fully aged state there remains a significant factor of safety.

With sprayed premix with lower initial strength properties the decline is very small and the 28-day properties are very similar to the fully aged properties.

In practice this can mean that the potential for an in-service failure is removed.

Ageing behaviour comparisons



ESSENTIALS TO PRODUCE A GOOD QUALITY PREMIX

1. High quality raw materials, particularly alkali-resistant fibre

Because the fibre is being added to the mixer it must have 'high integrity'; it must not filamentise, i.e. break down into individual filaments or groups of filaments during the mixing process. If this occurs then there is a loss of workability that makes subsequent pumping and spraying difficult or impossible.

The leading AR glassfibre manufacturers produce fibres that are specifically for the premix process and these must be used, e.g. ACS13PH901X manufactured by NEG.

2. Specific mix design

When a GRC mix is put under pressure during the pumping process there can be a tendency for the mix to segregate and to preferentially pump the liquids and cement leaving behind the sand and fibre. This can be overcome by selecting a specific mix design and rigidly adhering to it.

A common fault to overcome pumping problems is to add more liquids but this generally makes the problem worse by increasing the likelihood of segregation.

Specially formulated rheology modifiers or pumping aids are recommended.

Typical mix designs

Material	Polymer mix	Non-polymer mix
Cement	25.00kg	25.00kg
Silica sand	25.00kg	25.00kg
Water	6.75kg	8.00kg
Acrylic polymer	2.50kg	NIL
Pumping aid	0.0625	0.125
Superplasticiser	Nil	0.125
N.E.G. ACS13PH901X	1.80kg	1.80kg

3. Controlled batch weighing of materials

The specified mix design must be adhered to and it is therefore necessary to have accurate control of the raw materials.

This is made easier if the liquids are added to the mixer via automated measuring/dispensing systems. The sand and cement should be added using bags of known weight or via a weighing system fed from bulk silos. The sand should be dried or of known moisture content.

4. Two-stage or variable-speed mixer

As with all GRC production, the slurry (sand/cement/liquids) must be mixed in a high shear mixer. The benefit of the high shear mixing action is that it produces a slurry with the required workability but at a lower water/cement ratio than would be achieved with a conventional concrete/mortar mixer.

The high-shear mixing action is not suitable, however, for mixing in the fibres. Either a second mixer should be used or a mixer with a two-speed or variable-speed drive (see Figure 1).

5. Premix spray station comprising pump and spray gun

The progressive cavity (rotor/stator) pumps used for hand-sprayed GRC are not suitable for spraying premix. The best solution found to date is the peristaltic type pump that can pump mixes with fibre loadings up to 5% (see Figure 2).

The spray gun is much simpler than the hand-spray gun as there is no need to chop the fibre (see Figure 3).

Figure 1 - Variable-speed mixer with water, polymer and admixture dispensing systems

Figure 2 - Premix spray station

Figure 3 - Premix spray gun

CONCLUSIONS

- Sprayed premix produces GRC with consistent properties. This can reduce the frequency of testing.
- The fibre content is guaranteed.
- The process is much simpler than traditional hand spray and is less labour intensive.
- It is more versatile than cast premix and can use simpler moulds.
- Reliable and proven equipment is available.
- Stable long-term properties.
- As labour costs increase sprayed premix will become increasingly more popular and will soon rival hand spray as the main production technique.