Cem-FIL®
GRC Production

Guide to Premix Manufacture

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INTRODUCTION

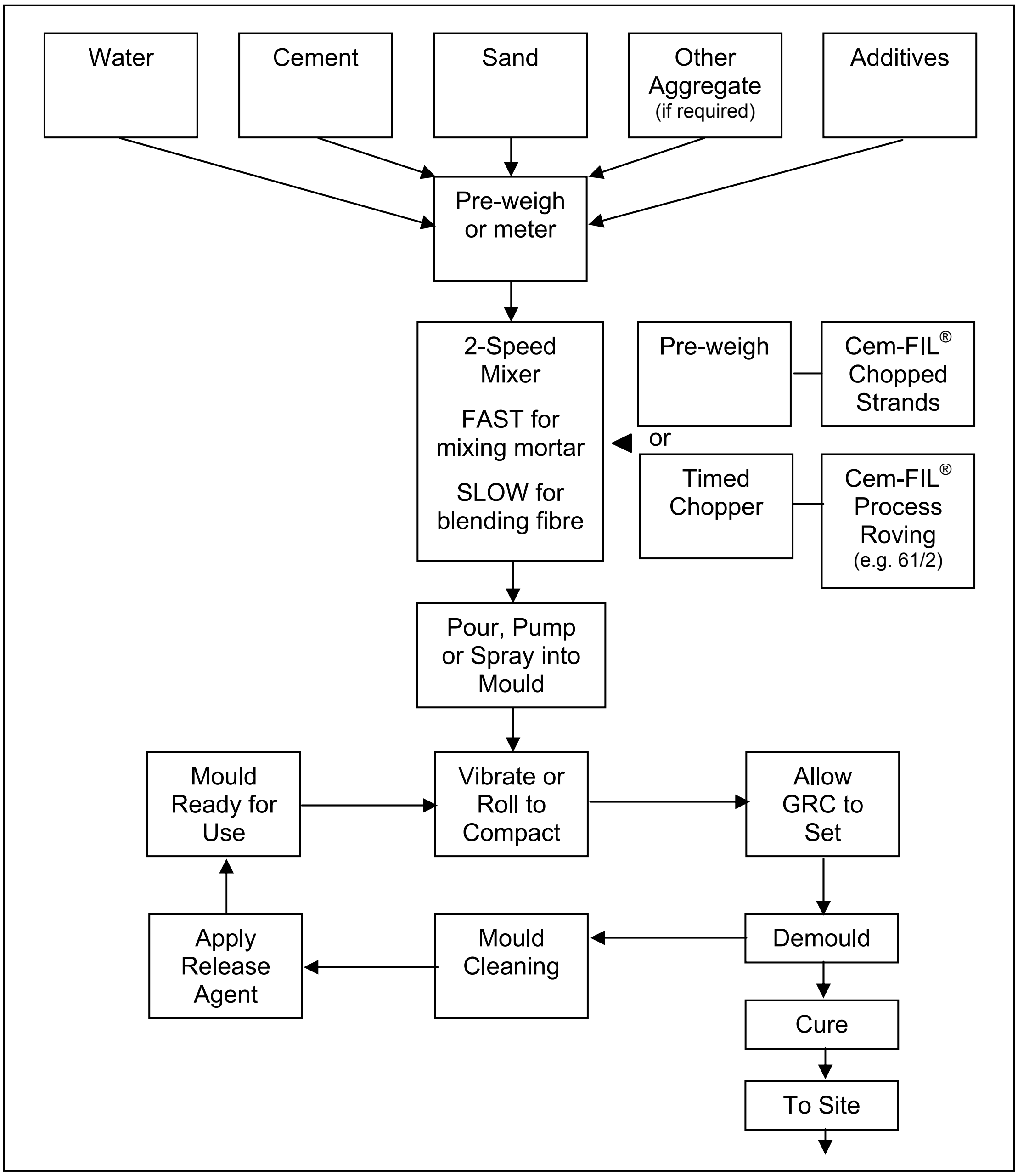
Premix GRC products are made from a mixture of cementitious mortar and chopped strands of Cem-FIL® AR glass fibre which is then poured into a mould under vibration, or sprayed.

The vibration casting process is relatively simple to control and mechanise. It can produce products with good dimensional control, and complex shaped components can be produced with relative ease. Sprayed premix has the advantage that moulds can be simpler to produce and strip, and products can be made with architectural finishes (e.g. simulated stone).

Premix processes have low material losses together with accurate control of product weight (particularly where vibration-casting is used).

This guide covers the basic techniques for manufacturing premix GRC products by the vibration casting and sprayed processes, and provides guidelines on mix and mould design.

PREMIX GRC MANUFACTURE



1. MIX DESIGN

1.1 Typical Mix Formulations

Since a wide range of raw materials are used for premix GRC, and each product has its own particular requirements, it is only possible to provide guideline mix designs.

There are general rules for mix design:

I) **Use a low water content.**
Use admixtures to improve workability. Adding more water reduces GRC strength.

2) **Use an adequate fibre content.**
Less than 3% may not provide adequate mechanical properties (depends on fibre type).

3) **Do not use sand/cement or filler/cement ratios less than 0.67**.
Too much cement causes shrinkage problems. Use as much sand or filler as is practicable.

There are a wide range of possible formulations for premix GRC

A particular GRC product or process may require:

- A superplasticiser for increased workability at low water-cement ratios
- Higher sand or filler content to reduce shrinkage
- Acrylic polymer for air-curing
- Pumping aids, to reduce segregation, (particularly for sprayed premix)

Experience can be quickly obtained and a separate formulation derived for each product type starting from a general purpose formulation.

A useful general purpose formulation is given below: it contains 3.5% fibre *(by weight)*.

GENERAL PURPOSE MIX	**Kg**	**%**
Cement	50 (1 bag of cement)	48.5
Sand	33	32.0
Water	16	15.5
Plasticiser	0.5	0.5
Cem-FIL Chopped Strands (12, 18 or 24mm)	3.61	3.5

A selection of different mix designs is given in Appendix 1

1.2 Secondary Processing

If the premix is being subjected to secondary processing such as pumping it is usually necessary to modify the mix to prevent segregation. One suitable material for this purpose is Hydroxy Propyl Methyl Cellulose (HPMC).

A suitable mix for preventing segregation during secondary processing is:

PUMPABLE MIX	Kg	%
Cement	50	47.8
Sand	33	31.5
Water	17.5	16.7
Plasticiser	0.5	0.5
Cellulose (HPMC)	0.02	Negligible
Cem-FIL Chopped Strands (12, 18 or 24mm)	3.66	3.5

In the Premix Spray process, where the product is both pumped and sprayed it is common practice to use an acrylic polymer in the mix, and in some cases Cem-Star metakalolin. Both products help to prevent segregation, and also minimise friction. Alternatively pumping aids are available from many of the admixture manufacturers.

1.3 Setting Time

Premix GRC products can usually be demoulded 4-16 hours after casting, depending on mix formulation, ambient temperature and product form.

Demoulding time can be reduced by using:

1.3.1 **Regulated set cements**. These can allow demoulding to take place within 30 minutes, but the workability time is short *(5 minutes)* and retarders are often added to ease production.

1.3.2 **Accelerators**: Calcium chloride accelerators may be used provided: 1) There are no embedded steel parts; 2) Unprotected steel moulds are not used; 3) It is not excluded by specification. This should allow demoulding to take place within two hours depending upon the product size and ambient temperature. Many accelerators are blended with a plasticiser. The water content of the mix should be adjusted to keep the water/cement ratio constant. The following is a typical example:

ACCELERATED MIX	Kg	%
Cement	50	41.3
Sand	50	41.3
Water	14.5	12
Accelerator *	2.25	1.9
Cem-FIL Chopped Strands (12, 18 or 24mm)	4.23	3.5

* A typical plasticised accelerator containing approx. 34% of calcium chloride, a specific gravity of 1.34, and a solids content of about 50%.

1.3.3 **Using heat:** Curing the cast or sprayed GRC in its mould at a temperature no higher than 50°C is allowable and will shorten the demould time. This may be combined with the use of accelerators.

The change in temperature at the start and end of the curing cycle should be gradual to minimise the thermal shock on the uncured product. It is also important that the GRC is not allowed to dry out during the curing cycle and steam or fog may be used for this purpose.

1.3.4 **New formulations** containing Cem-Star metakaolin or other pozzolanic additives have been made available. These offer greater long-term performance and may be suitable for use with white cement and pigments for specialist projects.

Further information will be provided on request.

2. MIXING PROCEDURE

2.1 Mixing Process

The mixing process is an extremely important aspect of premix and it is important to follow the recommendations. Even a small deviation can have a large influence on the workability of the wet GRC and on the properties and appearance of the final composite.

To ensure the best performance, the mixing of premix GRC should NOT be carried out in the same manner as the mixing of concrete.

To produce a premix of the correct quality it is necessary to mix in two stages. The first stage is designed to produce a high quality mortar, which is essential for the uniform incorporation of fibre and to achieve the necessary workability. The second stage is the blending of fibres into the mortar.

It is more convenient to carry out both stages in the same piece of equipment, if the mixer has adjustable speeds, but otherwise separate mixers can be used for each stage.

Stage 1

Preparation of a mortar. This should be creamy in consistency and free of lumps. The mortar is prepared at high speed using a High Shear mixer or alternatively using a specially designed two speed mixer on its high speed setting. The water and acrylic polymer (if used) would be added to mixer first, followed by the sand and then cement. Admixtures should be added towards the end of this mixing cycle. In some cases the polymer may cause the mix to stiffen (a false-set). If this occurs the mixer should be stopped for 30 seconds and then re-started. This should break the false-set.

When using a mixer where water is added to the previously blended dry solids, the best mortars are produced by adding the water in two portions. Approximately 75% of the water should be added first to produce a stiff mortar. After mixing for 45 seconds the remaining 25% of the water should be slowly added. The above operation is eased considerably by using a water meter. The water is normally added over periods of 30 seconds and 15 seconds. Admixtures are best dispensed in accordance with Cem-FIL Information Bulletin 45.

Stage 2

Adding the fibre. This stage of mixing is carried out at low speed if possible, and with a low shear action. The objective is to achieve a uniform fibre distribution with no fibre damage. The fibre is added to the mortar at a rate which is fast enough to avoid fibre damage due to over-mixing but not so fast that it causes poor distribution. Fibre is best introduced into the mix by cascading chopped strands from a vibratory feeder or by using a heavy-duty glass fibre chopper and chopping a specially developed roving (e.g. Cem-FIL® 61/2) directly into the mix.

In general, it is best to add the fibre to the mix in less than 1½ minutes. A typical fibre addition rate is 3 kg/min. *(See Section 2.2)*

After addition of the fibre the mixer should only be allowed to run for a sufficient time to fully incorporate the fibre, normally only a few seconds. A typical time to prepare a batch *(50-200 kg)* of premix is 6-10 minutes.

Notes on Mixing

1) Although it is possible to use a concrete-type mixer to produce both the mortar and blend the fibre it is likely to result in a mix of poor workability causing production difficulties and hence a product of reduced strength and inferior appearance

2) The fibre must be blended with the mortar in a mixer which gives a good distribution and minimum fibre damage (avoids splitting of strands into single filaments). Too much fibre damage reduces the workability of the mortar. Poor fibre distribution should be avoided: this is noticeable by fibres combining together to form dry clumps.

3) To minimise fibre damage it may be necessary to adjust the mixing blade position. This is particularly true with pan and paddle mixers where blades are normally in close proximity to the drum. This can be avoided by adjusting the blades to produce a 2-3 mm gap.

4) Superplasticisers are normally required. They allow the water-cement ratio to be reduced (improving strength and reducing shrinkage), whilst maintaining the workability of the mix.

5) If a high range water-reducing admixture is used for self-compacting GRC it may also be necessary to use a Viscosity Modifying Admixture to minimise bleeding. Anti-foaming agents can also be beneficial to assist the release of air by reducing surface tension.

6) In general the mortar should be mixed to a consistency which is self-levelling when it is poured. Small variations in the water content will be required to maintain this consistency with changes in raw materials.

7) Do not use old cement - this gives poor strengths.

8) Do not use sand/filler which contains an excess of fine particles - this increases the water demand of the mix, reduces strength and increases shrinkage.

9) It is very important that the mixer blades are kept clean. A build-up of hardened premix on the blades reduces the mixing efficiency and it is very difficult to remove.

10) If wet sand/fillers are being used remember to correct the amount of water being added to the mix. Too much water gives low product density and strength.

2.2 Blending the fibre into the mortar *(Fig. 1)*

Fibre feeding can be done in one of three ways:

2.2.1 Hand feeding:
Pre-weighed batches of fibre are sprinkled into the mixer as it turns. Handfuls of fibre must **not** be allowed to fall into the mix as these may cause clumps in the premix.

2.2.2 Vibration Feeder:
Pre-weighed batches of fibre are placed in the hopper of a vibrating feeder. The best results are obtained when two vibrators are used, with the second vibrator operating at a higher speed than the first. This reduces fibre clumping.

2.2.3 Direct Chopping:
Cem-FIL® 61/2 rovings can be used together with a heavy-duty chopper to feed chopped strands directly into the mix. An air-mover operating at about 0.7 bar *(10 psi)* enables the strands to be directed into the mix Since the roving has a known weight/unit length it is convenient to connect the chopper motor to a timer so that the batch weights of chopped strands are consistent.

Whatever method is chosen DO NOT OVER-MIX the fibre.

2.3 Chopped Strand Lengths

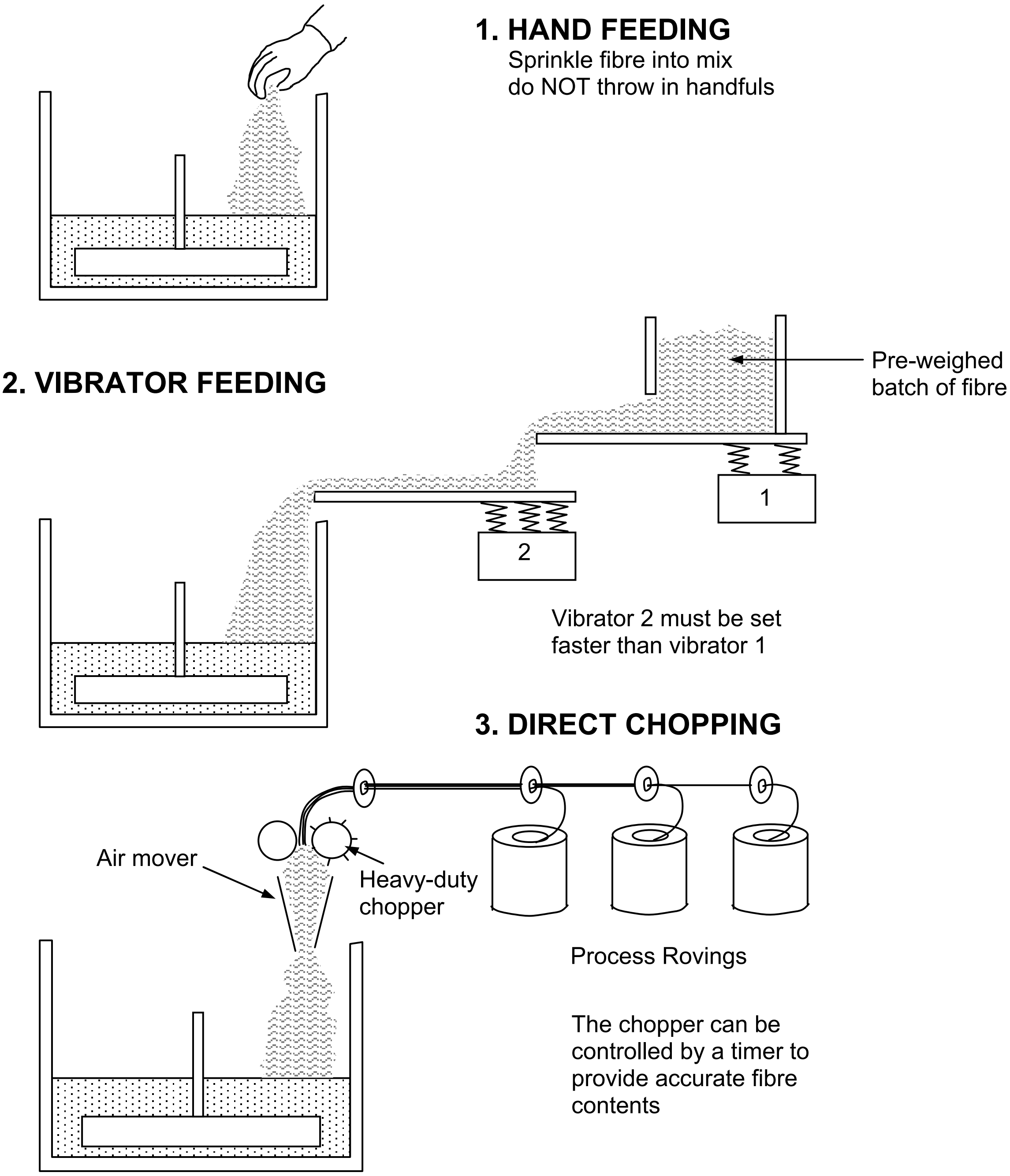
Cem-FIL® Chopped Strands are available in standard lengths of 6 mm to 24 mm depending on fibre type.

In theory longer strands should produce a stronger product, but this will depend on the thickness and complexity of the product.

In general 24 mm chopped strands are suitable for simple open or thick section products and 12 mm strands more suitable for complex shaped, narrow section products.

If a heavy duty chopper is being used, strands of length 12 mm, 18 mm or 24 mm can be produced by altering the blade configuration.

Fig 1 FIBRE FEEDING TECHNIQUES



3. VIBRATION CASTING

3.1 Vibration of Mould

In this process the mould is vibrated as the GRC premix is poured into it. The vibration has two functions:

1) It enables the premix to flow and fill the mould.

2) It releases air trapped in the premix and allows compaction.

There are three parameters which are important on vibration motors: frequency, amplitude and force.

Motors are normally available at frequencies from 3,000 rpm to 12,000 rpm. However, at high frequencies the amplitude is very low, and the amplitude needs to be as high as possible to obtain efficient flow and compaction. High frequency is desirable for consolidating small particles. The force is usually adjustable by varying the position of eccentric weights on the motor shafts.

Most general purpose vibrators and vibrating tables operate at 3,000 rpm.

The output force of the motor is dependent on the construction of the table and the moulds which are to be vibrated. As a general guide, about 500 kg of force per m2 of table should be sufficient for most work

It is necessary to clamp the mould securely to the vibrating table to ensure that the vibration is transmitted efficiently to mould and the premix mortar.

3.2 Filling the Mould *(Fig. 2)*

The procedure for filling the mould is very important and will affect the quality of the product.

Wherever possible the mould should be filled from one point only.

This method of filling pushes the air in front of the material and gives consistent product quality.

If filling is done from two points an interface is likely to be formed between the two flows of material. Fibres will not bridge this interface and a plane of weakness will be formed.

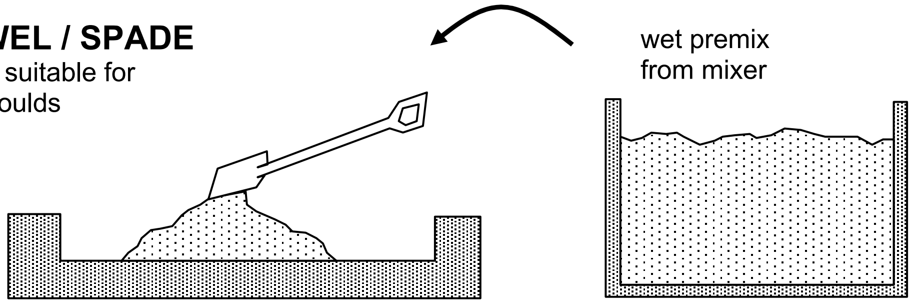
If the premix is poured rapidly into a deep mould air will be trapped which, on vibration, will only move to the surface of the mould, causing surface defects. One method of reducing this is to allow the premix to flow down an inclined plate mounted above the mould. "Degassing" of the premix can take place on this plate to produce a higher density product.

Another mould-filling technique is to pump the premix into the mould. A "Peristaltic" pump is suitable for this technique. Pumping a premix not only reduces the air content of the mix but also presents the opportunity for controlling material usage. For standard products a timed discharge can be used to produce constant product weights. When manufacturing difficult shaped units, such as a sunscreen, the premix can be pumped into the mould, reducing the physical effort in moving the wet premix from the mixer to the mould.

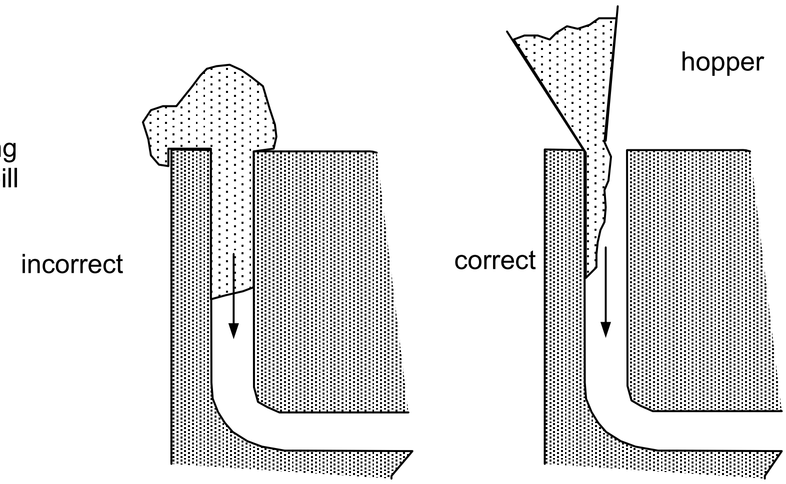
When filling deep, narrow moulds, it is often useful to use a secondary hopper above the mould. This provides a 'head' to push the GRC into the mould and reduces spillage over the lip of the mould.

Fig 2 MOULD FILLING

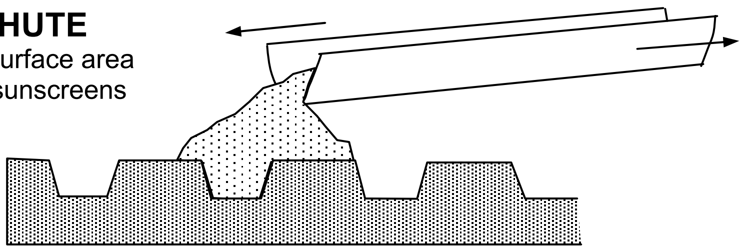
1. TROWEL / SPADE
Simple, suitable for
open moulds



2. HOPPER
Useful for moulds
with narrow entries
- speeds mould filling
and reduces overspill



3. MOVABLE CHUTE
Useful for large surface area
moulds such as sunscreens



4. STORAGE HOPPER
Useful for conveyor systems
when large quantities of premix
are to be cast and for controlling
the distribution of premix

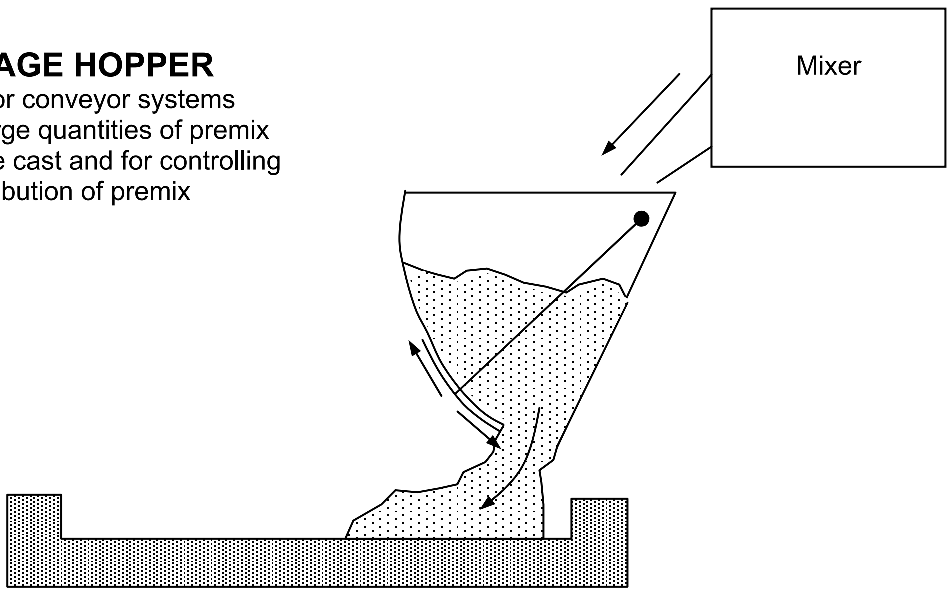
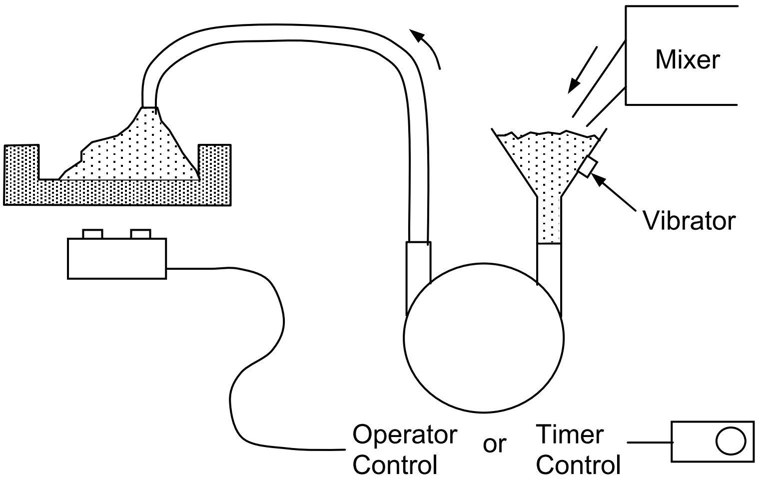


Fig 2 Continued

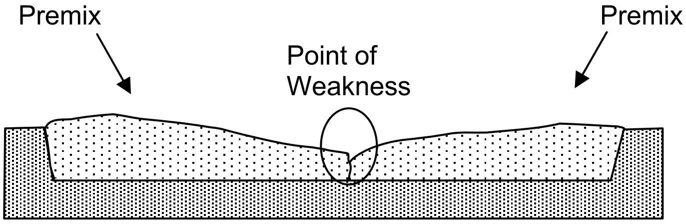
5. PERISTALTIC PUMPING

Useful for filling moulds remote from the mixer. Avoids use of barrows. Can be used to meter quantity of premix into mould if connected to timer.

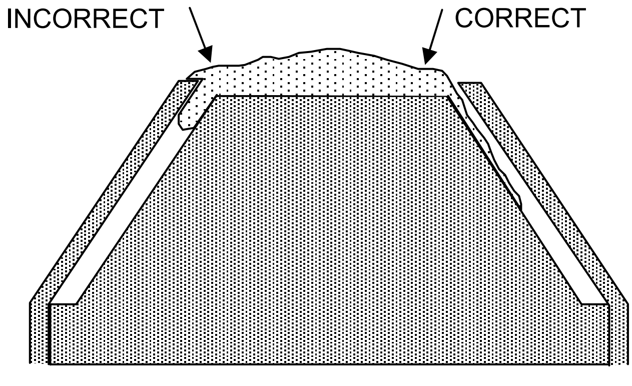


GENERAL POINTS

1. AVOID FILLING FROM MORE THAN ONE POINT



2. LET THE AIR ESCAPE



4. SPRAYING OF PREMIX

4.1 Equipment

The spraying of premix requires the use of a peristaltic pump and a premix spray gun. The peristaltic pump transports the premixed material effectively with minimum damage to the fibres.

The premix spray gun is fed with compressed air to atomise the premixed material, and also with a water line to flush out the gun to avoid blockages when spraying is stopped. In most systems the activation of the gun will automatically start and stop the pump to give control to the sprayer.

4.2 Spraying

Before spraying commences it is necessary to check:

- that the mould is clean and has been treated with appropriate mould release agent.
- that the brushes, rollers and trowels are clean and at hand with a bucket of water.
- that the correct mix is in the hopper.
- that spray pressures are correct.

If a mist coat or architectural face coat is being used this can be sprayed with the premix gun by increasing the atomising pressure, but better results can often be achieved by using a face coat gun or hopper gun, as these produce a finer spray. The mist or face coat can be compacted gently using a paint-brush to ensure good coverage of the mould. An architectural face coat will often contain acrylic polymer, which helps to prevent crazing as the surface dries, and may also be reinforced with a small addition of dispersible fibres (e.g. Cem-FIL 70/30) which should be invisible in the finished surface.

Once the mist or face coat has been evenly applied and compacted it may be left to stiffen for a few minutes before the premix is sprayed. This helps to prevent the face coat from being disturbed as the premix is sprayed and compacted.

The thickness of the sprayed material is built-up by spraying overlapping layers, and then repeating in a perpendicular direction. As the thickness is built-up the GRC should be periodically rolled for compaction, and the thickness checked using a pin-gauge (as for simultaneous spray). Care should be taken during rolling so that the face coat is not disturbed.

Once the correct thickness has been sprayed and compacted it may be trowelled if required.

5. MOULD DESIGN

5.1 Mould Requirements

Practical hints on mould design are illustrated in Fig 3. The design of the mould will affect:

a) the ease and speed of filling; b) the ease and speed of demoulding;
c) the quality of the product; d) the surface appearance.

A well-designed mould made from the correct material will produce good products easily and should have a long life.

Although each product will have specific mould requirements there are basic rules for designing moulds. Most of these are related to vibration-casting, as the moulds are in general more complex, but some may also apply to sprayed premix:

1) Avoid sharp corners. These can interfere with the filling of the mould and are vulnerable in the finished product. Whenever possible a minimum radius of 12mm should be used whenever vibration-casting, and approx. 3mm when spraying premix.

2) Moulds should be tapered to help demoulding. A minimum of 5° is usually satisfactory.

3) Moulds should be strong enough to withstand the vibration, and stiff enough to withstand the hydraulic pressure of the premix. This is very important with deep moulds. If the mould is too weak the sides will distort and this could make demoulding impossible.

4) The mould must be easy to dismantle, clean and reassemble. This increases the life of the mould and reduces labour and overall cycle time.

5) Attention should be paid to joints to prevent leaking during casting. This produces an unsightly flash mark on the moulded product and may make demoulding very difficult and require costly remedial work on the product.

6) Demoulding can be performed earlier by designing lifting points or location points for hydraulic rams into the mould itself.

7) Where a product has a large surface area demoulding can be made easier by including an air-release valve into the surface of the mould.

8) In components which may be stressed due to the restraint of shrinkage caused by the mould, the mould material should be selected to avoid these stresses. Rubber moulds are extremely useful because they flex to accommodate the shrinkage, i.e. as in the core members of a gully grid mould.

5.2 Mould Materials

5.2.1 Timber

Very useful for short production runs. This surface must be properly sanded and sealed otherwise demoulding may be difficult.

4.2.2 GRP/FRP

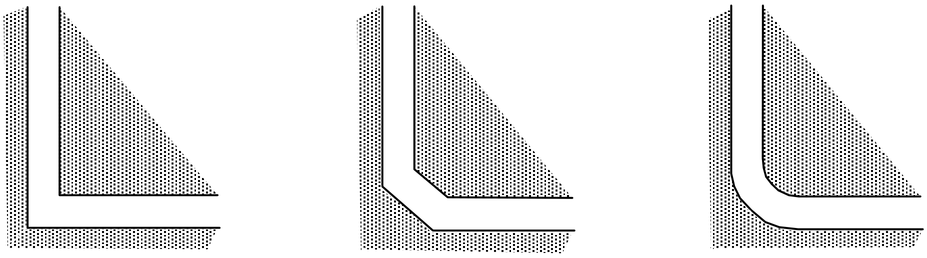
Suitable for long production runs and good for shaped products.
Note: The ‘gel coat’ must of an alkali resistant resin. General purpose resins deteriorate rapidly when used with cement causing a poor surface finish and very difficult demoulding.

4.2.3 Steel

Very good for standard products and large production runs.
The weight of the mould can cause handling problems and sometimes can damp vibrations on low-powered vibration tables.

Fig 3 HINTS ON MOULD DESIGN

1. AVOID SHARP CORNERS

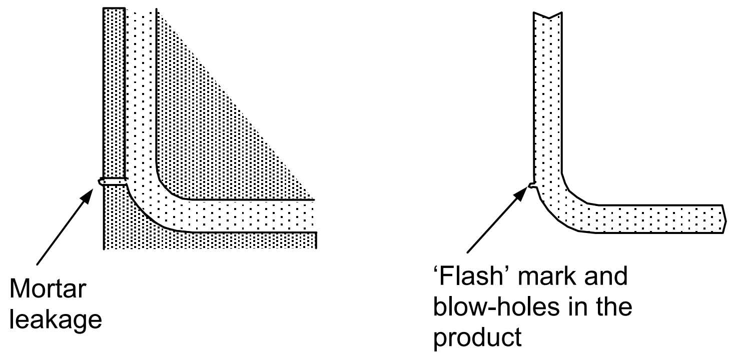


INCORRECT

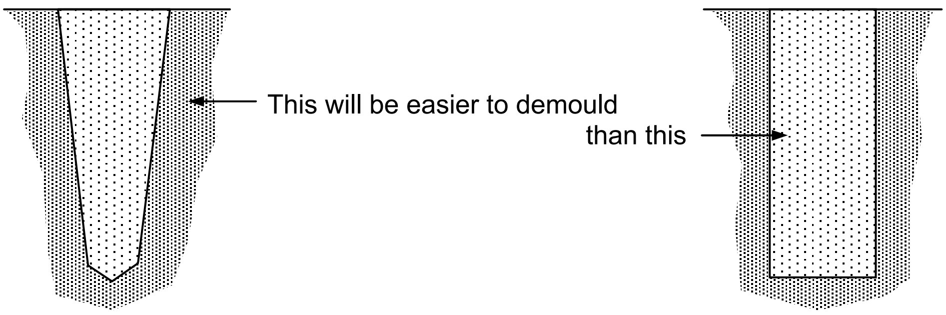
Radius or chamfer corners wherever possible

CORRECT

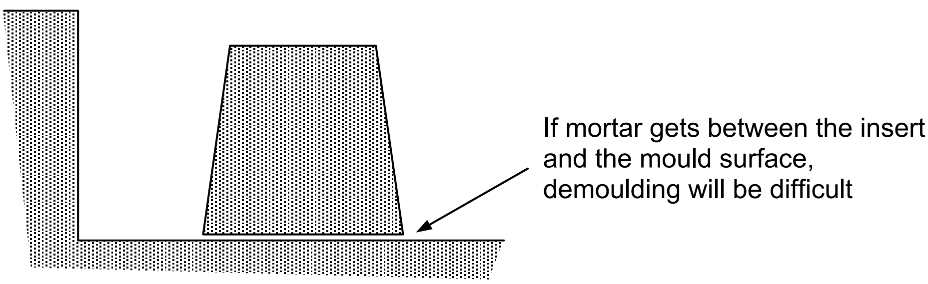
2. ENSURE THAT JOINTS DO NOT LEAK



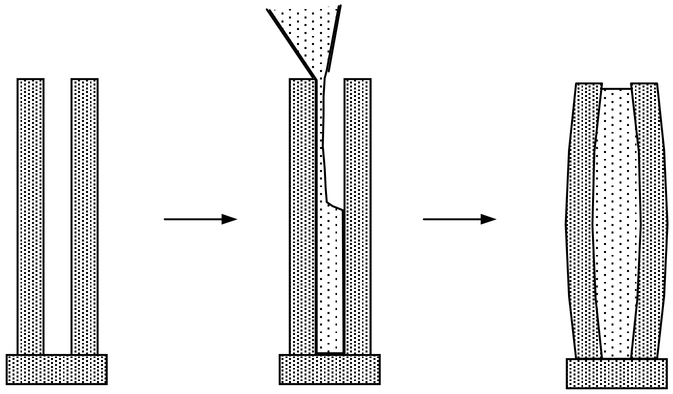
3. ALLOW AT LEAST 5° DRAW ANGLE



4. ENSURE INSERTS ARE SEALED AGAINST THE MOULD SURFACE



5. ENSURE MOULD SIDES ARE STIFF ENOUGH



Weak mould | The mould distorts as GRC is poured under vibration | This is impossible to demould without dismantling the mould, and the dimensions and weight are incorrect

5.2.4 Rubber Moulds

Rubber moulds can simplify the demoulding of certain products, as its flexibility allows it to be peeled from the product. Rubber moulds are essential if there are undercuts in the mould, otherwise, very complex interlocking moulds would be required.

The most suitable types of rubber for this application are either polyurethane or silicone. These are two-component cold cure systems which may be either poured or sprayed, and accurately replicate the fine surface details that they are in contact with.

The main advantages of using rubber moulds are: its ability to reproduce very fine detail; and the rubber does not unduly stress the product during demoulding, as it is simply peeled back from the product. If moulds are well-maintained, rubber moulds should have a life well in excess of 100 castings.

(Some guidelines for constructing rubber moulds are detailed in the Cem-FIL® Information Bulletin No. 46).

6. RELEASE AGENTS

Any release agent suitable for use with precast concrete will work with GRC. In general chemical release agents are preferred as they do not contaminate the product surface.

It is considered best to use as little release agent as possible. Only a thin film should be necessary, and an excess in the bottom of the mould will cause discolouration and pin-holing

Release agents can be applied by spray or by impregnated sponges/cloths.
(see Cem-FIL Information Bulletin No. 52).

7. AFTER MOULD-FILLING / SPRAYING

I) Remove any excess GRC which may interfere with demoulding when the GRC has set.

2) Perform any final trowelling before the GRC sets.

3) Cover the filled moulds with polythene to prevent water being lost from the GRC during initial hydration. This is important whether or not acrylic polymers are being used. Demoulding can normally be performed after 16 – 24 hours.

8. DEMOULDING

Remember: it takes more time to demould, clean and re-apply release agent than it does to fill the mould.

1) A steady force is quicker and more effective than hammering the mould. It also causes less damage.
2) In the case of a double-skin mould it is useful to extract the core as soon as possible after casting. This prevents the GRC from shrinking onto the core and making demoulding difficult.
3) If a product is overstressed during demoulding, it may crack at a later date. Therefore demoulding should be performed with care.
4) GRC products should not be allowed to dry-out after demoulding before being moved into a curing area.
5) **Clean** the mould as soon as possible after demoulding.

9. CURING

Two types of curing are used with GRC: moist cure and air cure.

9.1 Moist Cure

Thin section GRC products with low water/cement ratios can rapidly dry out. If this occurs before hydration is complete, the cement never achieves its full strength and the GRC properties are adversely affected.

To ensure complete hydration, it is essential that products are kept moist immediately after manufacture and during the curing period. Several methods of achieving this are currently in use, including storage in a humidity chamber or fog room, sealing in polythene bags, total immersion in water or steam curing.

As a guide to practical curing regimes, GRC products will achieve a substantial proportion of their ultimate strength when the main cure is performed for 7 days, in a humidity of greater than 95% RH and with a minimum temperature of 20°C. A suitable post-curing regime will allow the remainder of the strength to be achieved. *(For more information consult 'Cem-FIL Technical Data' Manual)*.

Steam curing at a temperature of up to 50°C can further increase the rate of strength gain, and may be necessary with some cements which are not rapid hardening. Care should be taken to ensure that the rate of temperature change at the beginning and end of the cycle is gradual, and does not cause thermal shock to the product.

9.2 Air Cure

The incorporation of acrylic-polymer into the GRC formulations provides the capability for air curing. The polymer formulation used must be capable of forming a film around the matrix particles, thus allowing the moisture in the GRC to be trapped and hydration to continue. The polymer materials are normally added at rates of between 3% - 10% of polymer solids to cement weight. After initial cure under polythene and demoulding, the GRC product can be allowed to cure in ambient air conditions, but care must be taken to ensure that the air temperature is above the minimum film-formation temperature of the polymer. The addition of polymer materials to GRC may affect the fire performance properties.

Further reading - GRCA Guide to the Use of Acrylic Polymers.

10. QUALITY CONTROL

The mechanical properties of premix GRC are highly dependent on the product density and glass fibre content.

They must be measured regularly. Test methods have been published by Cem-FIL, and European standards (EN 1170-1 to EN 1170-7) are also applicable.

1) Glass Content (Wash-out Test)
   Use Cem-FIL test method CEM/QC/004 or EN 1170-2.

2) Density
   Use Cem-FIL test method CEM/QC/009 or EN 1170-6.

3) Mechanical Properties
   These may be measured by testing samples in bending* or in the case of products with a performance requirement a direct test may be made by testing the product itself.

* Test methods available *(as applicable)*:

EN 1170-5 *("complete Bending Test")*
GRCA Methods of Testing GRC Material S0103
ASTM C 947-89 standard test method for flexural properties of thin-section GFRC

11. PROBLEM SOLVING

Mixing Problems

Problem:	Cause:	Solutions:
Poor mix workability	Over-mixing of fibre	Keep fibre mixing time to a minimum
	No plasticiser	Check use / type of plasticiser
	Insufficient water	Check water addition
	Sand grading too fine	Use correct grade / remove fines
	Mix left too long before use	As a guide, use within 20 minutes of mixing
	Mix too warm	Use ice in the mixing water to drop the temperature
	Acrylic polymer may be causing a false-set	Stop mixing for 30 seconds and then re-start
Clumps of fibre in mix	Poor fibre feeding	Use vibratory feeder or heavy duty chopper
Mix segregation	Old cement	Use fresh cement
	Too much water	Control water content
	Incorrect admixture use	Check dosage and adjust
	Bad mixing practice	Follow mixing recommendations

Product Problems

Problem:	Cause:	Solutions:
Blow-holes *(large)*	Mould filled too quickly / Incorrect mould filling technique / Inadequate vibration	See 'Filling the Mould'
Pin-holes	Poor mix workability	See 'Mix Design'
	Excess release agent /Poor quality release agent	See 'Mould Design'
	Air entrainment	Use anti-foaming agent
Cracks on de-moulding	Rigid mould / Bad mould design	See 'Mould Design'
	Filling from more than one point	See 'Filling the Mould'
	Insufficient fibre	See 'Mix Design'
	Water content too high	Use Superplasticiser and reduce water content
	De-moulding too early	Longer setting time, heat, accelerators
Non-uniform appearance	Segregation due to poor mixing / Bad mix formulation / Over-vibration	May be necessary to use cellulose additive to homogenise the mix

APPENDIX 1

GRC PREMIX - MIX DESIGNS

These formulations are for guidance only, and may need to be modified to suit particular product Requirements and local raw materials. This will relate mainly to water contents.

	Cement kg	Sand kg	PFA kg	Water kg	Polymer (1)* kg	Admix. 2 (2)* kg	Admix. 3 (3)* kg	Cem-FIL® Fibre Content kg	%	Length (mm)
General Purpose	50	33	-	16	-	0.5	-	3.61	3.5	12
Small Flat Products	50	33	-	16.5	-	0.5	-	3	3	24
Low Shrink	50	50	-	17.5	-	0.5	-	4.17	3.5	12
General Sunscreens	50	33	-	16	-	0.5	-	3.61	3.5	12
Polymer Mix	50	50	-	13	5	0.5	-	4.29	3.5	12
Accelerated	50	50	-	14.5	-	-	2.25 (3)*	4.23	3.5	12
Pumpable Mix	50	33	-	17.5	-	0.5	0.02 (4)*	3.66	3.5	12
Premix Spray	50	50	-	13.5	5	0.5		3.66	3	12
Mix Containing PFA	50	-	16.6	18.3	-	0.5	-	2.65	3	12

NOTES:
(1) Acrylic Polymer
(2) Superplasticiser
(3) Calcium Chloride Accelerating Plasticiser
(4) Hydroxy Propyl Methyl Cellulose

NOTES:

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