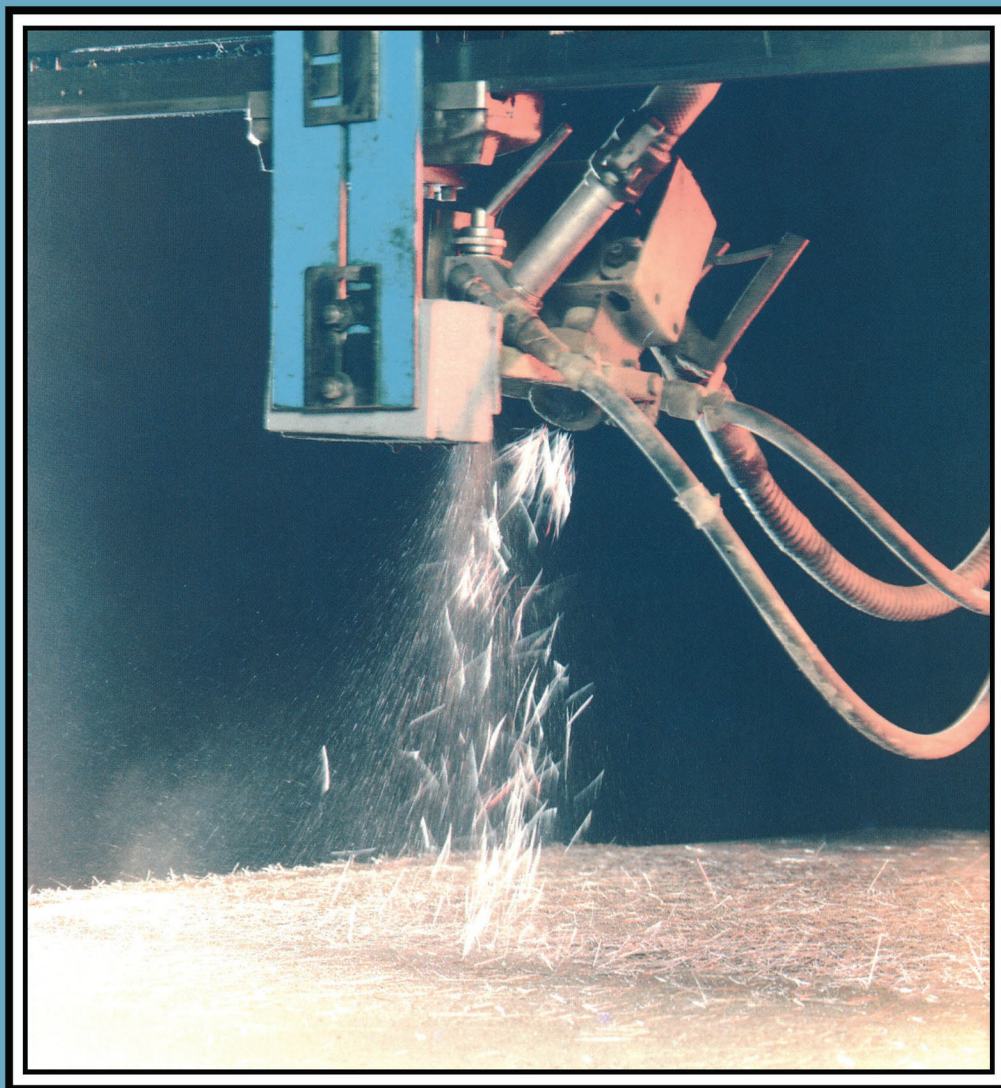


GRC

PRODUCTION & USES

Graham True



GRC PRODUCTION & USES

Graham True

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Author

Graham True was introduced to concrete technology while working at the Central Electricity Research Laboratories in Leatherhead, Surrey. His involvement included project work and experimentation to determine the performance of concrete used to form prestressed pressure vessels and radiation containment vessels for nuclear power plant operated by the C.E.G.B.

A more specific interest in glassfibre reinforced cement began with the author's employment by E H Bradley & Sons, Swindon. In 1973 they started investigating the properties and potential of this material in order to produce a successful range of products.

Similar investigations were initiated by Mr True's next employer Thyssen (GB) Ltd. Specialization in grc permanent formwork became the main stay of the operation bringing out all the product's potential.

This work was continued and expanded to include design and detailing aspects of grc permanent formwork while working for Velmac UK, a member of Tarmac Industrial Holdings Ltd.

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Preface

All new materials require a period of careful investigation in order to establish properties, product potential, design and manufacturing methods. On this basis market recognition and acceptance is achieved. Glassfibre reinforced cement has passed through this phase and is now treated as a material with significant inherent possibilities. Its potential has given rise to particular grc products such as cladding panels, asbestos replacement products, pipes and permanent formwork. The latter employs the properties of this material to such a degree that it warrants its placement in a special category — unequalled by current alternatives. Codes of Practice and British Standards are now including glassfibre reinforced cement and thereby giving full recognition to the material in its own right.

This book sets out the production of grc, exploring the various methods currently available. Basic 'run of the mill' together with some of the more specialized processes are included and the equipment available is described. Naturally, with a new material, innovation is continually bringing about new manufacturing processes, some of which are closely guarded by companies developing them into commercial propositions. Chapters are devoted to quality control, design, costing, curing and finishes. In addition, the final uses of the product are described focusing on both the general and the specific. This enables the reader to appreciate the possibilities of glassfibre reinforced cement to the full.

Glassfibre reinforced cement cannot be aligned with concrete or glassfibre plastic as so often is the case. It must be classed separately as a material with its own distinct properties. The author's intention, through this book, is to encourage further acceptance of this novel and useful material.

Graham True
1986

Background

In 1967, Dr A J Majumdar of the UK Building Research Establishment (BRE), Watford, began investigating the effect of zirconia additions to glass formulations. The overall aim was to achieve a glassfibre that had sufficient alkali resistance to withstand the environment found in hydrating Portland cement. Some of these formulations were successfully fiberized and their potential use for reinforcing Portland cement was demonstrated. The National Research and Development Corporation (N.R.D.C.) filed patent applications to cover these achievements.

Development work encouraged trials to determine whether the formulations could be produced economically on a commercial scale. BRE and N.R.D.C. set out, with Pilkington Brothers Ltd, to undertake further commercial exploration. As a result, an agreement was reached whereby Pilkington Brothers Ltd, through their subsidiary Fibreglass Ltd, was licensed exclusively to develop world-wide the commercial potential of this alkali resistant fibre.

By 1971 Pilkington Brothers Ltd had achieved:

1. The development of a viable, commercially fiberizable alkali resistant glassfibre, with the trade name of Cem-FIL
2. The furthering of the test programme set up by BRE to assess the long-term durability of composites containing Cem-FIL, when exposed to a range of environmental conditions
3. The development of further prototype products and processes employing Cem-FIL alkali resistant fibre.

The third stage followed on from earlier work carried out at BRE using non-alkali resistant 'E' glassfibres. While the alkali resistant fibre formulation was under development, production techniques were investigated using the non-alkali resistant 'E' glassfibre in ordinary Portland cement (oPc) and gypsum plaster. This search for a suitably resistant glassfibre for incorporation into oPc proceeded from earlier tests in the UK where 'E' glassfibre had been incorporated into high alumina cement mortar.

Research in Russia had also been in progress since 1941 when glassfibre rovings were used in an attempt to reinforce concrete. The experiment had, however, met with little success. Glassfibre rovings were therefore replaced by glassfibre reinforced plastic rods, but the presence of plastics caused very considerable creep. Finally, research culminated in a publication in

1965 which detailed the development of 'dispersed-stress' reinforcement and, consequently, a material with a completely new structure and completely new properties. This material, now referred to as gfr cement, has glassfibres dispersed over its entire section and orientated mainly along the line of action of the tensile forces. The resultant material is one in which the densely laid fibres reinforce thin layers of hardened cement paste.

Principal types of binder used to make gfr cement were high alumina cement, gypsum-aluminous cement and waterproof expanding cements. The Russian report notes that Portland cements lead to failure of the glassfibre reinforcement owing to the aggressive action on the glassfibre. It also goes on to state that protective films or high-alkali fibres exceeding 25 microns in diameter may be used with Portland cement.

Overall Russian research probably prompted many investigators to study the possibilities of grc and from this evolved the alkali resistant fibres mentioned earlier.

Pilkington Brothers Ltd have now produced a new fibre named Cem-FIL 2 which will replace Cem-FIL. This fibre is based on the original Cem-FIL but with the added benefit of a special surface coating that prolongs the ductile failure pattern previously achieved. Other companies, in particular Forton in Holland, have adopted the technique mentioned in the Russian Report – not only coating the surface of an 'E' glassfibre with a suitable polymer but additionally dispersing a polymer solution throughout the matrix. The extra cost of the polymer dispersion is offset by the lower cost of the 'E' glassfibre to achieve a similar overall cost for the composite at the 5% additional level.

Various incorporation techniques have been developed ranging from pre-mixing the fibres into the matrix to hand laying and rolling into the cement paste, from winding and pressing using nets and continuous aligned rovings to spraying simultaneously chopped fibres and cement mortar causing mixing in mid-stream before depositing onto the mould surface. The latter method of spraying has gained enormous popularity due to the ease with which it can be performed, the availability of production equipment from the glassfibre reinforced plastics (grp) industry and the superior properties that can be achieved by this method of production. Early work at BRE was based on this spray-up technique but was further assisted by vacuum dewatering of the composite in order to reduce the water content, increase the density and improve the physical bond between the fibre and the composite.

Requirements for production

When planning a factory lay-out, the inter-relationship of the various production stages and their individual function and scope must be clearly defined. In the following notes, which are intended to assist this preparation, the functions of a grc production facility are divided into three groups:

Administration — Production — Storage

These three groups have been further sub-divided:

Administration:	Office administration (costing, buying, marketing, management, design) Quality control testing and recording
Production:	Spraying and mixing Production quality control laboratory functions Mould manufacture Mould cleaning and oiling Overnight storage, demoulding and making good Curing
Storage:	Raw materials storage Mould storage Stockyard operations and despatch

2.1 ADMINISTRATION

This section highlights aspects particularly relevant in grc production. It is not felt necessary to cover 'pure' administration requirements which have a general application.

2.1.1 Office administration

The manufacturing unit should be closely associated with administrative personnel in order to produce a unified team that benefits from feed-back concerning shop-floor operations. This encourages a speedy eradication of production problems and ensures that errors and misjudgements at the design and planning stages of a contract do not carry forward into subsequent contracts.

2.1.2 Quality control testing and recording

This aspect of the quality assurance function is categorized under administration because its purpose is defined as:

1. To test grc test coupons for flexural strength, density and so on, at 7 and 28 days as specified
2. To analyze the results recorded from the above and keep a running account (graphical or otherwise) of the quality of the output. Thus an overall 'picture' concerning the standard reached is obtainable and this assists the design department in specifying, with confidence, new production requirements.

If a full statistical analysis of the type shown in *Chapter 11* is maintained then a good understanding of

production capabilities and the cost/effective use of fibre and other raw materials can be seen.

This department should also administer the functions of the production quality control laboratory.

2.2 PRODUCTION

Any discussion on this topic is directly related to the method or methods being used and varies accordingly. For this reason, only notes of a general kind are applicable.

Figure 2.1 shows the inter-relationship of typical production steps and these apply to most production set-ups including hand-spray, automated spray and specialized procedures. Consequently this diagram should also be seen as a guide to the physical lay-out of a production process. When considering every new grc production set-up a similar plan should be worked out taking account of the specific manufacturing process to be employed.

2.2.1 Spraying and mixing

Since almost all activities concerned with production relate to spraying and mixing, this particular stage should be considered as the focal point of the production process. A particular manufacturing facility may require a number of spraying and mixing set-ups in order to process concurrently a range of products. This could enable other stages in the production process to be shared but, nevertheless, the following aspects have to be considered in order to plan out the physical location of the equipment and the area required:

1. The type of spray rig to be used — either a simple hand-spray facility or a compact spraying/mixing set-up (refer to *Chapter 3, Figure 3.27*)
2. The area required to position and carry out mould spraying. Turntables, trestles and conveyors may be required
3. A location at hand for storing raw materials needed in the mixing and spraying operation and taken from the main storage area
4. Weighing scales, if batching is to be carried out alongside the mixer set-up (pre-bagged, pre-weighed quantities may be more effective)
5. Washing-down facilities including drainage and settlement pits
6. Easy access to and from the area for moving moulds before and after filling, as well as supplying raw materials. Consideration should be given to the best method of transporting mould and materials, whether by conveyors, fork-lift trucks, monorails or hand barrows.

From the above it becomes apparent that the mixing/spraying area is one of transition and requires careful planning in order to establish an efficient flow to the process.

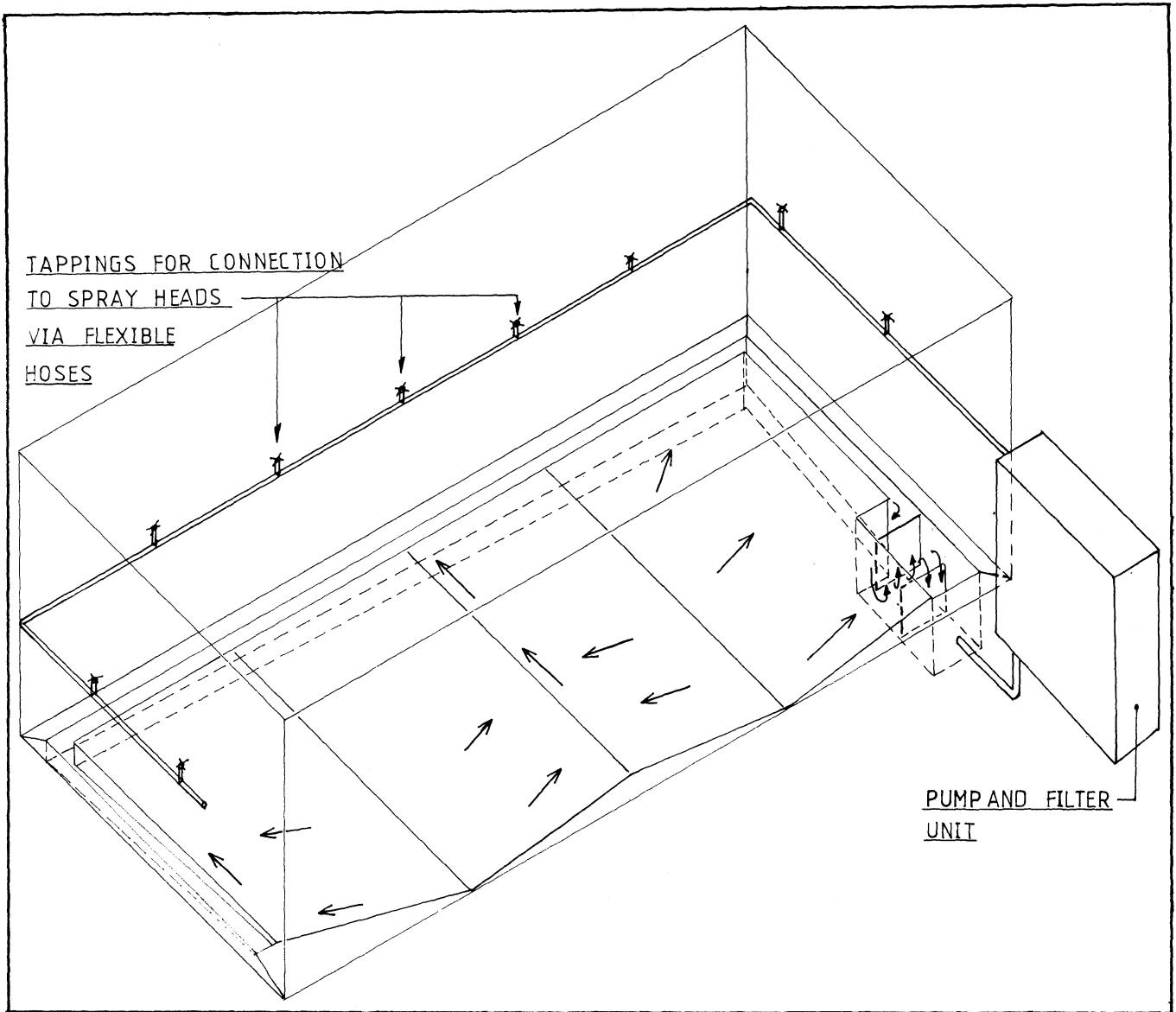


Figure 2.2 Lay-out of curing chamber.

2.3 STORAGE

Important aspects to be considered are:

- Raw materials storage
- Mould storage
- Stockyard operations and despatch.

2.3.1 Raw materials storage

Clearly a dry area is necessary for this and, if the scale of operation is sufficiently large, it is worth considering bulk silo storage of sand and cement. However, it must be noted that a precise and sensible method of extraction from the silos is required. This enables batch quantities to be drawn and placed into the mixer. It will, however, mean a large capital outlay.

2.3.2 Mould storage

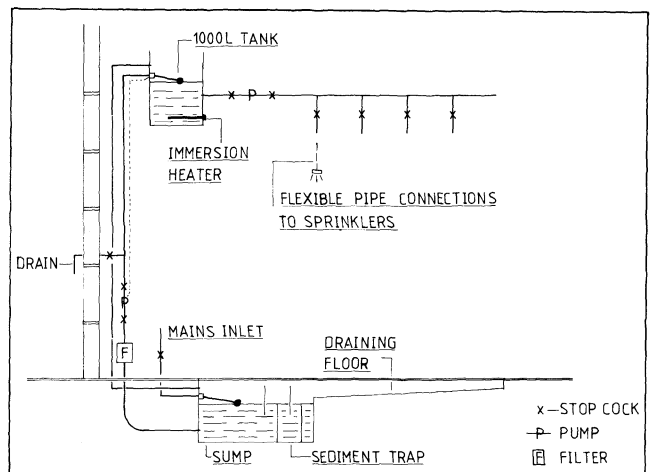
Ideally moulds should be stored away from the production area. Yard storage may suffice, but protection in the form of covering and pretreatment (i.e., oiling of steel moulds) is vital. Each one must be clearly labelled to provide a register of stock moulds. Moulds can often be adapted for future needs, unless improper storage renders them useless.

2.3.3 Stockyard operations and despatch

This function should be under the control of one super-

visor. Naturally sensible stocking of products in the yard, correctly labelled and in a fit state for despatch, is important and a suitable site should be chosen away from delivery or heavily trafficked areas. It simply requires careful planning of the available space location, with racking and stillages used to enable quick despatching.

Figure 2.3 Curing room plumbing lay-out.



Production equipment

In this Chapter it is intended to give a fairly broad guide to the equipment available for the production of grc. Since hand-spray work and 'mechanized' hand-spray work are at present the major volume production processes employed, most consideration is given to the equipment they require. Sections are included, however, to illustrate specially developed processes that are either now being brought into use or have at least been described as viable manufacturing techniques for the production of grc components.

3.1 PUMP UNITS

The pump unit is the piece of equipment that processes the matrix or mortar component of the grc composite. Freshly mixed mortar, or in some cases the raw materials, is transported by the pump unit at discrete set rates to the spray head or gun. The unit can therefore be regulated to produce a precisely maintained mortar output at the gun nozzle.

There are few machines available at present but nearly all employ the worm action pump, and the Mono Pump MT 420 wide-throat pump is common in UK manufactured units.

The *MT 420 Pump* is designed for mixes with difficult flow properties. It is essential that the speed of the pump is carefully selected to ensure the delivery rate conforms with the relative velocity at which mortar can pass through the pipeline. Very stiff mixes are directly influenced in their rate of output by the pipeline friction with only marginal relationship to static head. Consequently, when low water/cement ratio mixes are processed, admixtures may be required to assist the pumpability of the mix.

The components of a Mono Pump MT 420 are shown in Figure 3.1. The wide throat entry allows mortar to fall easily onto the auger-conveyor which transports it to the rotor/stator. The Mono pumping element consists essentially of an elastomeric stator (35) in the form of a double internal helix and a single helical rotor. The stator is a single component clamped to the pump and end cover by long bolts fitted with hand nuts for quick dismantling and therefore easy cleaning and maintenance. The rotor (39) maintains a constant seal across the stator and this seal travels continuously through the pump giving uniform positive displacement. The rotor is removed by disconnecting the rotor head from the connecting rod.

The pump must *never be run in dry condition as the stator will instantly be damaged*. It is crucial to ensure that the hopper is filled with mortar so that the auger-conveyor engages with the mortar to fill the pump immediately. A few turns of the rotor by hand will assist the initial lubrication of the stator until the pump primes itself. When the pump is stopped, sufficient mortar is trapped to provide lubrication on starting-up again. The pump is arranged for anti-clockwise rotation facing the driving end.

The drain plug may be replaced by a stop valve which, when connected to the water mains, provides a quick flushing-down at the end of the work shift. It also enables the stator to be fed with water at the beginning of the morning shift to prevent undue stator wear at start-up.

The ball bearings require periodic cleaning and it is advisable to establish the correct maintenance schedule by regular examination.

Mono Pumps Ltd are located at Arnfield Works, Audenshaw, Manchester M34 5JA.

3.1.1 Downland grc spray pump unit

The pump (Figure 3.2) is mounted on castor wheels and comprises a mortar hopper with sieve, safety guard and vibrator, feeding the mortar to a Mono Pump MT 420. The Mono Pump is driven by an enclosed fan cooled electric motor. To maintain the essential accuracy of slurry output, the pump is driven through a variable speed thyristor control linked to the drive motor. The thyristor control permits manual setting. An electronic speed indicator displays the rotor speed (Figure 3.3).

By thyristor speed control, transmission losses are minimized allowing the use of a 1.5 hp single phase 240 V motor. All the controls are grouped on one panel. They include air regulators and pressure gauges for each of the compressed air systems, electric switch gear for auto and hand control, pump speed regulator and speed indicator, and compressed air filter and lubricator. The control panel may also be supplied as a wall mounted unit, or as a separate console when it is necessary to group controls on automated plants.

The specification for this unit is given in Table 3.1.

The Downland grc spray pump unit is obtainable from K & C Mouldings (England) Ltd, Spa House, Shellanger, Diss, Norfolk IP22 2DF.

Table 3.1 Specification for the Downland grc spray pump unit.

Electric supply	240 V	
Motor	1.5 hp	
Main fuse	10 amp	
Thyristor fuse	20 amp	
Weight	325 kg	
Size	Height	1067 mm
	Length	1220 mm
	Width	991 mm
Maximum mortar output with standard pulley arrangement	15 kg/min.	

3.1.2 Power-Sprays grc spray pump

The Power-Sprays company has marketed grc spray units for a number of years using initially the narrow