Saint Gobain Vetrotex: *CEM-FIL* alkali-resistant glass fibres

The Building Research Establishment in the UK first developed *Cem-FIL* alkali resistant glass fibres more than 30 years ago. These fibres have a long service history, and have been used in more than 60 countries worldwide to create some of the world's most stunning architecture. As a part of the Saint-Gobain Reinforcements division (the world leader in glass fibre reinforcements), Vetrotex has developed a wide range of *Cem-FIL* products to satisfy the needs of the developing markets and the diverse processes used.

GRC is a material that is currently making a significant contribution to the economics, to the technology and to the aesthetics of the construction industry worldwide. This environmentally-friendly composite, with its low consumption of energy consisting of natural raw materials, is being formed into a wide variety of products and has become the product of choice among architects, engineers, designers and end users for its flexibility to meet performance, appearance and cost parameters.

As manufacturing processes have evolved, so have the fibres. A large range of fibres have been developed to satisfy the needs of the markets, and to provide optimum processing efficiency and performance in the chosen manufacturing methods.

Applications of GRC

These fall into many categories, but can be broadly classified into:

- Crack prevention
- Architectural
- Civil engineering

Crack prevention

It is a widely accepted fact that traditional concrete mixes are prone to plastic shrinkage during the setting phase and this can lead to cracking. *Cem-FIL Anti-Crak* fibres were developed by Saint Gobain specifically for the reinforcement of cementitious mortars and concrete mixes. These fibres, made of alkali-resistant glass are also resistant to acids and other chemicals and can be easily incorporated in the concrete mix.

(i) Alkali-resistant (AR) glass fibres have a density that is similar to that of concrete. This ensures uniform mixing in the matrix as well as low rebound losses, especially relevant in plastering applications.

(ii) AR glass fibres are superior to the conventional synthetic fibres even in the plastic stage since they provide around 200 million reinforcing points thereby ensuring a better bond between the concrete matrix and the reinforcement.

(iii) The fibres also have an elastic modulus which is significantly higher than concrete. This enables the fibres to provide an effective reinforcement during the hardened stage of concrete.

Independent studies conducted by Saint Gobain have shown the following key benefits in concrete at small dosage additions of 600 g/m^3 of *Anti Crak HD*:

- 85 percent reduction in plastic shrinkage cracking

Characteristics of GRC

Thin and light-weight

- Rapid erection without heavy lifting equipment
- Reduced load allows savings to foundation and structural costs
- Economical to transport

Durable

- GRC will not rot or corrode, and is resistant to biological attack
- No embedded steel, so no spalling or staining
- Advanced matrices can be used to further enhance long-term ductility, reduce shrinkage, etc.

High quality matrix

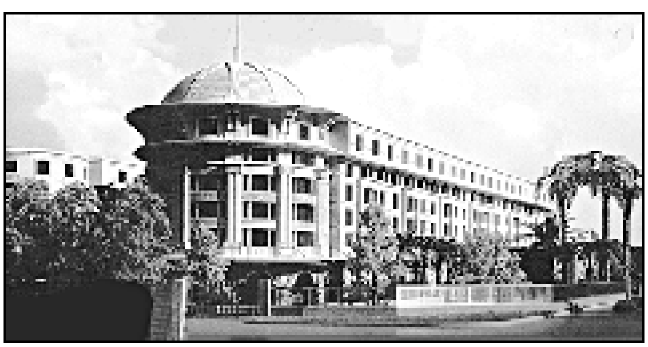
- Low permeability and a hard dense surface
- Carbonation 1/10th the rate of concrete
- High compressive and flexural strength
- Low maintenance

Attractive and versatile

- Can be formed with complex shapes, colours and textures
- Can be used to accurately simulate natural materials (timber, rock, stone, etc)
- Making aesthetic solutions possible

Non-combustible

Excellent acoustic performance



GRC Dome Cladding - ITC Grand Maratha Sheraton, Mumbai

Properties of AR glass fibre

Fibre	*Density, t/m^3*	*Elastic modulus, GPa*	*Tensile strength, MPa*	*No of fibres, million/kg*
AR –Glass	2.6	73	1700	220
Steel	7.8	200	400-1200	0.2
Polypropylene (PP)	0.9	3.5-5	400-600	15
High Mod.PP	0.9	5-15	500	15-35
Concrete	2.4	20-40	0-5	0

- Reduction in bleeding (water rising to the surface) - 25 percent
- Increase in compressive strength by 13 percent
- Increase in flexural strength by 15 percent
- Reduction in permeability by 50 percent
- Reduction in freeze/thaw expansion by 66 percent

Architectural applications

Facade cladding

GRC cladding, principally used for architectural purposes gives the architect a unique and unrivalled opportunity to express individuality, interpretation and creativity. Its unique blend of abilities and properties can be utilised for:

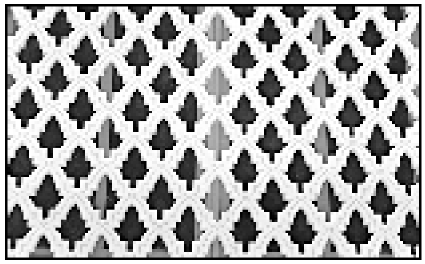
- custom-made units for a specific building
- in modular units for system building
- as over cladding to existing facades.

Carefully constructed moulds in metal, timber, plastics or synthetic rubbers can provide the means of achieving an almost limitless variety of surface textures.

With a white or gray cement base, a dash of inorganic pigment and selected sands and aggregates, a palette of colour is available to satisfy the most discerning architect.

Architectural components

Complementary to GRC cladding units are the many artefacts to finish off a detailed design or replicate an old feature for a re-



Sunscreens made of GRC

furbishment or renovation project.

The inherent properties of GRC make it an ideal material for such items as porticos, cornices and sunscreens. Since it is light and easy to handle, has minimal maintenance requirements and a huge capacity to reproduce shape and colour.

Landscaping

In building projects, leisure facilities, urban renewals and municipal schemes, even more attention is being given to the built environment and its need to integrate with and be sympathetic to its location and purpose.

GRC is being used for instance to create attractive water scapes and features in such places as shopping malls, leisure parks and golf courses. Seating planters, balustrades, kiosks, bollards, signs, statues, fountains etc., all benefit from being made in GRC with its ability to tailor shape, form and finish to be aesthetically pleasing in the chosen environment.

Civil engineering

Noise barriers

In addition to their primary function of reducing noise pollution in major traffic routes, GRC noise barriers can often be used to enhance the visual appearance of a highway. GRC noise barriers provide engineers and architects with an excellent surface appearance coupled with speed of erection.

Water ducts and channels

GRC's thin section and lightweightness allows it to be used for a range of channel and duct sections. GRC channels with their lower weight are well within the carrying capacity of one person and reduce installation time. Additionally, above ground channels and cable ducts give significant cost savings as a result of the reduced number of supports required. They can be used for a wide variety of applications including transporting water.

Tunnel lining

The needs of tunnel lining materials can be ideally matched by the material properties of GRC. It can be moulded to the required shape and its surface is hard and impermeable needing very little maintenance. It will accept a wide range of surface finishes, has excellent impact resistance and is totally incombustible. GRC also gives abrasion resistance and improved hydraulic characteristics resulting in high flow rates for these applications.

GRC has been used as tunnel lining panels both for road and rail projects.

Emerging applications

Arcotex

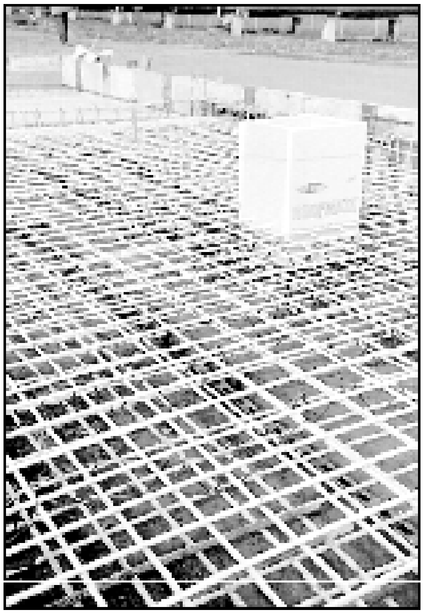
The durability of reinforced concrete in aggressive environments is a major problem worldwide. The use of fibre-reinforced plastics (FRP) in place of steel should be a viable solution, provided that its durability can be demonstrated. Trials have been carried out in *Eurocrete* project, both in the laboratory and in the field for use of fibre glass reinforced plastic rebars. These have

Properties of GRC : Typical mechanical properties of CEM-FIL GRC (at 28 days)

Property	*Unit*	*Premix*
Addition of CEM-FIL fibre	Weight percent	3
Bending		
Ultimate strength (MOR)	MPa	10-14
Elastic limit (BOP)	MPa	5-8
Tensile		
Ultimate strength (UTS)	MPa	4-7
Elastic limit (BOP)	MPa	4-6
Shear		
Inter laminar strength	MPa	N/A
In plane strength	MPa	4-7
Compressive strength	MPa	40-60
Impact strength	kJ/m^2	10-15
Elastic modulus	GPa	10-20
Strain to failure	percent	0.1-0.2
Dry density	t/m	1.8-2.0

Note : The above data is relevant to GRC formulations having sand : cement ratios between 0.5 and 1.00

Noise barriers made of GRC – Near Dusseldorf Airport, Germany



Rebar in concrete (structural pultruded elements)

demonstrated that the correct choice of both the resin and the fibre are important for the long term durability.

Conventional concrete structures are reinforced or pre-stressed with steel. While it is fully recognised that the steel will corrode in aggressive environments, all design codes work on the basis of assuming that the steel is durable and will not corrode during the life of the structure. The durability is "ensured" in the design process by the requirement to provide adequate protection to the steel in the form of a minimum thickness of concrete of a suitable quality. The cover requirements are dictated by the nature of the environment in which the structure will be situated. Over the years much developmental work has been carried out on the concrete itself, generally leading to material which has a lower permeability, thus delaying the onset of corrosion. However, this approach has proved to be inadequate in many situations. Hence, other forms of reinforcement have been developed which should be less susceptible to corrosion, such as epoxy coated rebars or stainless steel. FRP rebar is one of the advancements that has shown promise in the fight against corrosion.

There is a growing interest in the use of FRP materials, either for reinforcement or as prestressing tendons. The implicit assumption would appear to be that FRP materials are durable. However it is well known that glass fibres, and some resins, are degraded by alkalies in concrete. Hence the effective properties of the material will change with time. Alkali resistant fibres from *Vetrotex* have proved that they are effective in highly alkaline environments.

In *Eurocrete*, a major European collaborative research project, suitable design codes for reinforced concrete, were developed, when using FRP reinforcement.

Conclusions

Compared with steel fibres, the small diameter of *Anti-Crak Cem-FIL* fibres ensures better and more uniform dispersion, efficient load transfer, and their greater surface area provides better ability to bridge cracks.

Compared with polypropylene fibres, the bond between *Anti-CrakHD* fibres and the matrix is superior, giving increased reinforcing efficiency and limiting fibre pull-out.

Anti-CrakHD fibres have sufficient resilience and compliance that they can aligned randomly in the mix, and are therefore able to bridge micro-cracks before they can reach a critical size, giving a substantial increase in durability.

The above feature is based on the inputs given by Mr G. Prasanth, Sr Manager, Speciality Products, and Mr N.E. Surbramanian, Product Manager.

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