AR Glassfibre for GRC

This techNOTE from the GRCA explains why only Alkali Resistant Glassfibre must be used in OPC based composites such as Glassfibre Reinforced Concrete (GRC/GFRC), and traditional concretes.

GRCA Technical Working Group

This is the eleventh in a series of technical notes covering aspects of glassfibre reinforced concrete (GRC/GFRC) technology.

Glass fibres were first discovered in the 1930's but production on a commercial scale only started in the early 1950's when they were used to reinforce thermosetting polyester resins. It is estimated that the annual production today is over 10 million tonnes. This was originally a borosilicate glassfibre known as E-glass, but now incorporates a wide range of glass fibres including E, ECR, C, H, R and S-glass. These glass fibres all have particular benefits in resin systems, but cannot be used in Ordinary Portland Cement (OPC) because they degrade in the alkali environment.

The Development of the Glassfibre Reinforced Concrete Industry

Following the successful reinforcement of polyester resins with glass fibres it was hoped that similar techniques could be used to reinforce cement pastes and concretes. Unfortunately, it was soon discovered that E-glass fibres were quickly degraded by the high alkalinity of the cement matrix with a catastrophic reduction in tensile strength. Figure 1 shows the effect of cement on both Alkali Resistant glass fibres and on E-glass fibres [1].

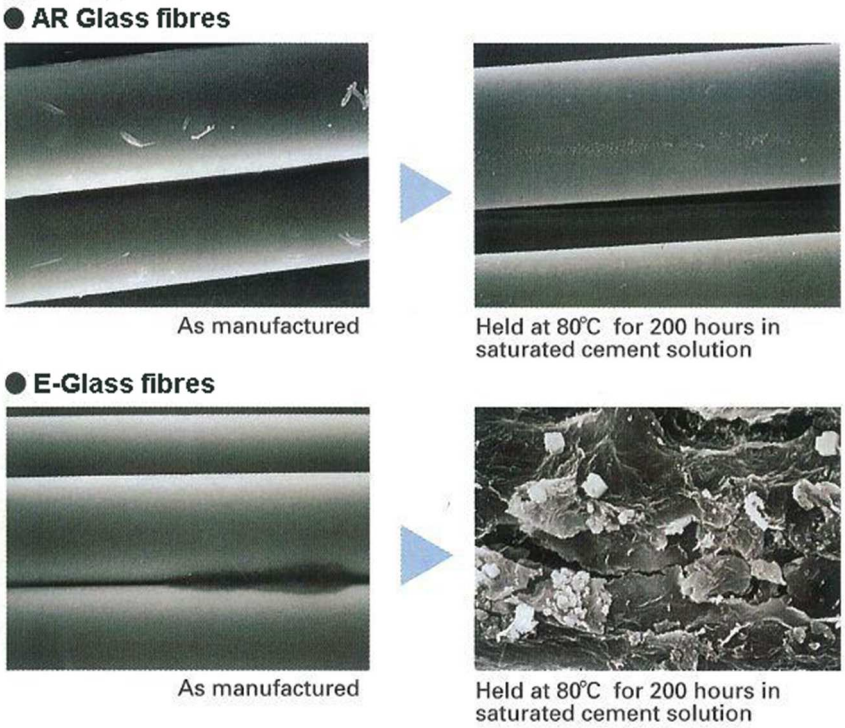

Figure 1: Comparison of Alkali Resistant Glass fibres (ARG) and E-Glass fibres in cement solution at 80 °C for 200 hours.

Early research in the Soviet Union investigated the use of special low alkali cement matrices. This showed potential but such low alkali cements were not generally available on a commercial basis.

The break- through came in the 1960's when a team from the UK Building Research Establishment led by Dr A. J. Majumdar produced the first Alkali Resistant (AR) Glassfibre. The key to this development was the addition of Zirconium Dioxide (ZrO_2) to the glass composite.

Commercial development quickly followed in the 1970's lead by Pilkington Brothers in the UK, Owens Corning in the USA and Nippon Electric Glass Co. in Japan. Others followed but some withdrew from the market due to slow growth. Changing the mind-set of the building industry is not an easy task, even for large companies with significant marketing budgets.

AR Glassfibre Production

AR Glassfibre is made by drawing multiple filaments of liquid glass through small holes in a special plate called a "bushing". As the liquid glass cools, the filaments are drawn together and a coating or "size" is applied to bind them into strands.

The diameter of the filaments is controlled by the diameter of the holes in the "bushing". Typically, the filament diameter is in the range 10-20 microns. For GRC production the number of filaments per strand can range from 50 to over 400, the most popular for GRC production being in the range 100 to 300.

The composition of the "size" is important and these have been developed to meet the demands of a wide range of applications.

Different specialist fibres are available for Sprayed GRC, Cast Premix GRC, Sprayed Premix GRC, glassfibre reinforced renders, screeds and concretes.

Figure 2: Rovings

In the case of glass fibres for the Spray GRC process, the strands are spun to form a cake which is then placed in a drier. After drying, the strands from several cakes are wound together to form a roving (Figure 2). The size which binds the filaments is designed to soften as the fibres come into contact with water.

Property	Approximate Value
Thermal Expansion	≈ 9 x 10^{-6} /°C
Softening Point	≈ 830 °C
Density	≈ 2.65-2.80 g/m^3
Tensile Strength	≈1000 – 1700 MPa
Young's Modulus	≈ 72-74 GPa
Strain to Failure	≈ 2 %

Table 1: Properties of Alkali Resistant Glass Fibres [2]

This assists the bond with the cement while allowing easy compaction of the GRC by rolling.

In the case of fibres for Premix GRC (Figure 3), the continuous strands are chopped into a variety of lengths. The size is designed to hold the filaments together as integral strands during the mixing process.

Dispersible fibres, as the description implies, are designed to separate into individual filaments as they are mixed with the wet cement-based composite. Applications include reinforcement of renders, floor screeds and in concretes to control plastic shrinkage cracks.

Other AR glass fibres have been developed to supplement or replace both the steel mesh reinforcement used in ground slabs and the reinforcement used in other reinforced concrete products.

Nets and Scrims are also manufactured by weaving the continuous glass strands in processes similar to those common in the textile industries. Glassfibre Reinforced Concrete made with these materials is often referred to as "TRC" – Textile Reinforced Concrete.

All Alkali Resistant Glassfibre used in cement composites are governed by international standards - in Europe EN 15422, and ASTM C1666 in the USA. Both specify a minimum zirconium dioxide ZrO_2 content of 16%.

The GRCA's recommended practice [2] for GRC production supports these standards as do most international architects and engineering practices.

Figure 3: Chopped Strands

How does a Specifier Ensure Alkali Resistant Glassfibre is Supplied with the correct Zirconia content?

Figure 1 shows the devastating results of using E-glass instead of AR Glass fibres with high zirconia content. As the test in a cement solution demonstrates, E-glass must never be used with cement and concrete.

The test for zirconia content is by X Ray fluorescence analysis and when this test is carried out repeatedly using properly calibrated equipment the results are accurate and consistent. These tests are conducted regularly by the AR Glass manufacturers with periodic 3rd party verification.

When purchasing AR glassfibre, a GRC manufacturer can ensure that they are being supplied with a compliant AR glassfibre by following these simple rules:

1. Choose a reputable manufacturer and brand.
2. Demand a Certificate of Conformity to the relevant standard. In Europe this is EN 15422, and in the USA it is ASTM C1666.
3. Ensure a Quality Certificate or Certificate of Analysis stating the zirconia content is provided with each batch received. The zirconium dioxide ZrO_2 content for glassfibres for use in GRC / GFRC should be a minimum of 16%.
4. Ensure the product ordered is the most suitable for the production process by discussing this with the glassfibre manufacturer or their local stockist.

techNOTE 11 References:

1. Image from Nippon Electric Glass Co. Ltd.
2. The International Glassfibre Reinforced Concrete Association (GRCA): “Specification for the Manufacture, Curing & Testing of Glassfibre Reinforced Concrete (GRC) Products”.