ZOHO STONE

Modern Precast Solutions™

INTRODUCTION TO ZOHO STONE'S GFRC.

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1. Introduction

Plain concrete processes a very low tensile strength, limited ductility, and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle failure of the concrete.

The most widely accepted remedy to this flexural weakness of concrete is the conventional reinforcement with high strength steel. Restraining techniques are also used to. Although these methods provide tensile strength to members, they however do not increase the inherent tensile strength of concrete itself. Also the reinforcement placing and efficient compaction of RCC is very difficult if the concrete is of low workable especially in the case of heavy concrete (M35-M60). I plain concrete and similar brittle materials, structural cracks (micro-cracks) develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these cracks seldom exceeds a few microns, but their two dimensions may be of higher magnitude.

When loaded, the micro cracks propagate and open up, and owing to the effects of stress concentration, additional cracks form in places of minor defects. The structural cracks proceed slowly or by tiny jumps because they are retarded by various obstacles, changes of direction in bypassing the more resistant grains in the matrix. The development of such micro crack is the main cause of inelastic deformation in concrete.

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as fiber reinforced concrete. Glass fibers do the same effect and perform better than any other fibers.

Glass Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed fibers. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibers.

2.Fiber reinforced concrete- in general

For improving the tensile properties of plain concrete many methods have been evolved. Many of the methods succeeded in making the concrete members resistant to tension, but none of them increased the inherent tensile properties of plain concrete. The dispersion of fibers in concrete matrix to improve its tensile properties has been practiced worldwide over 3 past decades. The addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as fiber reinforced concrete.

Fiber reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar, or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibers.

2.1 Fibers Used

Although every type of fiber has been tried out in cement and concrete, not all of them can be effectively and economically used. Each type of fiber has its characteristic properties and limitations. Some of that could be used are steel fibers, polypropylene, nylons, asbestos, coir, **glass** and carbon.

Fiber is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fiber is often described by a convenient parameter called “aspect ratio”. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

Steel fiber is one of the most commonly used fibers. Generally, round fibers are used. The diameter varies from 0.25 to 0.75mm. Rusting of steel fibers is a major problem when it is used and due to this some strength is lost. Polypropylene and nylon fibers are found to be suitable to increase the impact strength. They possess very high tensile strength, but their low modulus of elasticity and higher elongation do not contribute to the flexural strength.

Asbestos is a mineral fiber and has proved to be most successful of all fibers as it can be mixed with Portland cement. Tensile strength of asbestos varies between 560 N/mm^2 to 980N/mm^2. The composite product called asbestos cement has considerably higher flexural strength than the Portland cement paste.

1. **Application**

Fiber reinforced concrete is increasingly used on account of the advantages of increased static and dynamic tensile strength, energy absorbing characteristic and better fatigue strength. The uniform dispersion provide throughout the concrete provides isotropic properties not common to the conventionally reinforced concrete. Fiber reinforced concrete has been tried on

1. Overlays of air-field
2. Road pavements
3. Industrial floorings
4. Bridge decks
5. Canal lining
6. Explosive refractory lining etc...

2.2 Glass Fiber Reinforced Concrete:

Glass fiber is a recent introduction in making fiber concrete. It has very high tensile strength 1020 to 4080 N/mm^2. The alkali resistant glass fiber reinforcement in concrete shows considerable improvement in durability also. Glass-fiber-reinforced concrete (GFRC) has been used worldwide since the early 1970s. Over the last few years there has been a growing recognition of the material as a durable and lightweight alternative to the traditional natural and cast stone architectural dressings used in house building. Zoho Stone's GFRC uses glass fibers for reinforcement instead of steel. It is typically cast in a thin section of around 1/2" to 3/4". Since the fibers cannot rust like steel, there is no need for a protective concrete cover thickness to prevent rusting. With the thin, hollow construction of Zoho Stone's GFRC products, they can weigh a fraction of the weight of traditional precast concrete.

3.1 Components of Zoho Stone's GFRC:

Zoho Stone's GFRC is a composite of cement, glass fibers, aggregates and polymers. The main components of GFRC are:

1. **Cement: -** The cement used in the GFRC is ordinary Portland cement
2. **Aggregates: -** Usually in GFRC only fine aggregates are only used fine aggregates are of silica sand. If used, coarse aggregates may be of crushed stones.
3. **Glass fibers: -** glass fiber shall be an alkali resistant, continuous filament fiber developed and to have high strength retention in ordinary Portland cement environments.

4. **Polymers:** - Polymers are used in the GFRC mix to give toughness to the mix and give a curing effect to the mix after hardening due to its high water content. Acrylic polymers having low solid content is used usually
5. **Admixtures:** - Addition of glass fibers reduces the workability of the concrete mix to a great extend, for making the concrete workable plasticizers can be used in required dosage.

Alkali Resistant Glass Fibers For Zoho Stone's GFRC

The glass used in Zoho Stone's GFRC is of alkali resistant and the alkali resistance of AR glass fibers is a result of adding zirconia (zirconium oxide) to the glasses. The best fibers have zirconia contents of 19% or higher. More the amount of zirconia in glass more will be the alkali resistance. **Figure 1** shows the relationship between Zirconia content and the alkali resistance of glass fibers.

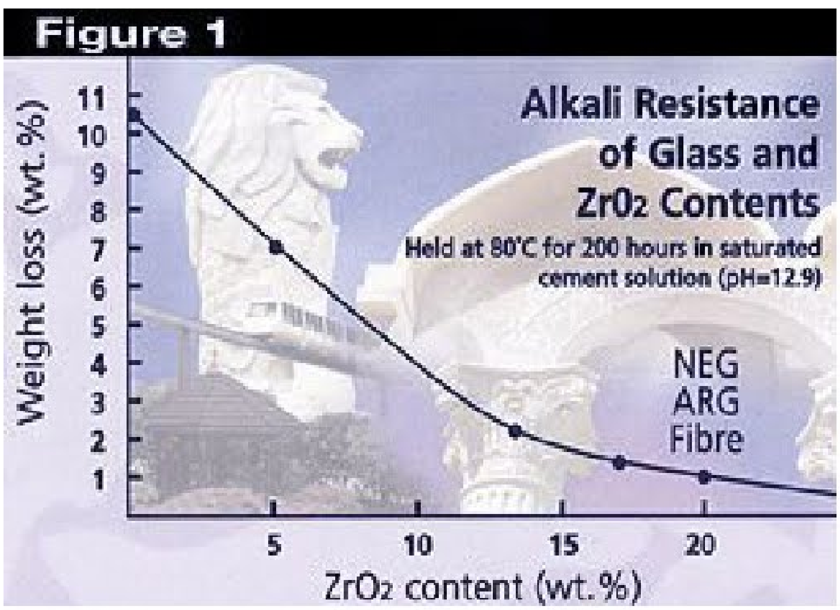

Figure 1: Alkali resistance of Glass and ZrO^2 Content

The fibers used for countertops, fireplace surrounds, and other decorative applications have high integrity (meaning the strands don't break down into individual filaments) and are usually ½-inch (13-mm) long or a combination of 13, 19, and 25 mm. AR-glass fibers are also available as roving, which is a spool of a continuous length of multiple strands of glass fiber twisted together (typically 28 strands in a roving with 200 filaments per strand). Glass fiber is also available as a scrim, which is a fiber fabric. This is placed into areas that might have a tendency to crack.

There are several manufacturers of AR glass fiber, including NEG America, Nycon, Rich Fibers & Systems, and Owens Corning. Owens Corning recently bought Saint-Gobain's Vortex glass fiber business (Cem-FIL) and has transferred sales and marketing of its concrete-reinforcing fibers (including AR glass fibers) to Continental Marketing's Rich Fibers & Systems.

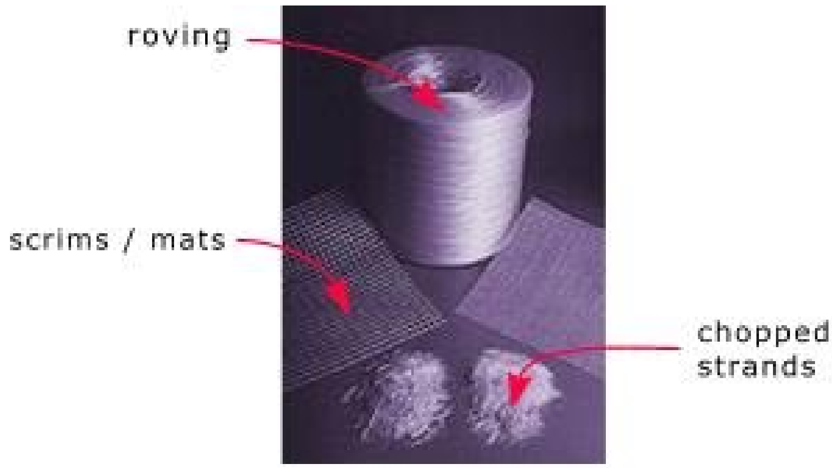

Figure 2: Different forms of AR glass fibers

3.2 Structural Properties of Zoho Stone's GFRC

Zoho Stone's GFRC derives its strength from a high dosage of AR glass fibers and a high dosage of acrylic polymer. While compressive strength of GFRC can be quite high (due to low water to cement ratios and high cement contents), it is the very high flexural and tensile strengths that make it superior to ordinary concrete. Essentially the high dose of fibers carries the tensile loads and the high polymer content makes the concrete flexible without cracking.

GFRC is analogous to the kind of chopped fiber glass used to form objects like boat hulls and other complex three-dimensional shapes. The manufacturing process is similar, but GFRC is far weaker than fiber glass.

While the structural properties of GFRC itself are superior to unreinforced concrete, properly designed steel reinforcing will significantly increase the strength of objects cast with either ordinary concrete or GFRC. This is important when dependable strength is required, such as with cantilever overhangs, and other critical members where visible cracks are not tolerable.

Zoho Stone's GFRC does not replace reinforced concrete when true load carrying capacity is required. It's best used for complex, three dimensional shells where loads are light. Applications where GFRC makes the most sense are fireplace surrounds, wall panels, vanity tops and other similar elements. GFRC's advantage is minimized when ordinary flat countertop-shaped pieces are being made. While the weight savings due to reduced thickness is maintained, the effort of forming, mixing and casting are similar or the same.

The table below shows various physical and structural properties of atypical GFRC mix.

Property	Hand or Machine Spray GRC	Vibration Cast Premix GRC
Glassfibre Content by Weight of Mix	**5%**	**3%**
Bending:		
Ultimate Strength (Modulus of Rupture – MOR) MPa	20–30	10–14
Elastic Limit (Limit of Proportionality – LOP) MPa	7–11	5–8
Tension:		
Ultimate Strength (Ultimate Tensile Strength – UTS) MPa	8–11	4–7
Elastic Limit (Bend Over Point – BOP) MPa	5–7	4–6
Shear:		
Interlaminar Shear Strength MPa	3–5	N.A.
In-plane Shear Strength MPa	8–11	4–7
Compressive Strength MPa	50–80	40–60
Impact Strength kJ/m²	10–25	10–15
Elastic Modulus GPa	10–20	10–20
Strain to Failure %	0.6–1.2	0.1–0.2
Dry Density Tonne/m³	1.9–2.1	1.8–2.0

Table 1: Properties of GFRC.

3.3 How The Fibers Work?

Zoho Stone's GFRC uses alkali resistant glass fibers as the principle tensile-load carrying member. The polymer and concrete matrix serves to bind the fibers together and transfer loads from one fiber to another via shear stresses through the matrix.

In order to resist tensile loads (and thus prevent the GFRC piece from breaking or cracking), there needs to be a sufficient amount of fiber present. Additionally, the orientation of the fiber determines how effective that fiber resists the load. Finally, the fiber needs to be stiff and strong enough to provide the necessary tensile strength. Glass fibers have long been the fiber of choice due to their physical properties and their relatively low cost.

Typical Zoho Stone's GFRC mix uses a high loading of glass fibers to provide sufficient material cross-sectional area to resist the anticipated tensile loads. Often a loading of 5% fiber by weight of cementitious material is used. So for every 100 Kg of cementitious material in the GFRC mix, 5 Kg of glass fibers are added.

Finally, the orientation of the fibers is important. The more random the orientation, the more fibers are needed to resist the load. That's because on average, only a small fraction of randomly oriented fibers are oriented in the right direction.

There are 3 levels of reinforcement that are used in general concrete, including GFRC. The first is random, three-dimensional (3D) reinforcing. This occurs when fibers are mixed into the concrete and the concrete is poured into forms. The fibers are distributed evenly throughout the concrete and point in all different directions. This describes ordinary concrete with fibers. Because of the random and 3D orientation, very few of the fibers actually are able to resist tensile loads that develop in a specific direction. This level of fiber reinforcing is very inefficient, requiring very high loads of fibers.

The second level is random, two-dimensional (2D) reinforcing. This is what is in spray-up GFRC. The fibers are oriented randomly within a thin plane. As the fibers are sprayed into the forms, they lay flat, conforming to the shape of the form.

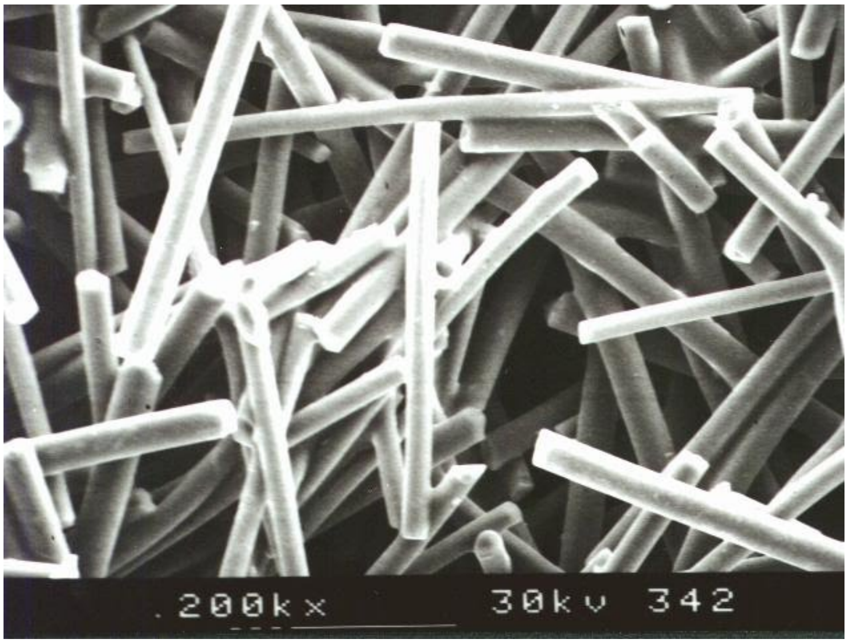

Figure 3 : 3D Fibers

Figure 4: 2D Fibers

This orients them in the plane that the tensile loads develop in. While more efficient than 3D, 2D reinforcing is still inefficient because of the highly variable fiber orientation within a horizontal plane. Additionally, most of the fibers lie outside the zone where the tensile loads are the greatest (which is the best location to place reinforcing so as to resist those tensile loads), this zone is always at the bottom surface of a beam (or at the top in the case of a cantilever).

The third level of reinforcement is one-dimensional (1D) reinforcing. This is how structural beams are designed using steel reinforcing. It is the most efficient form of reinforcing because it uses the least amount of material to resist the tensile loads. The reinforcing is placed entirely within the tensile zone, thereby maximizing the effectiveness without wasting reinforcing in areas that don't generate tensile loads. The middle of a countertop slab is such a zone.

3.4 Zoho Stone's GFRC Mix Design

Traditional spray-up GFRC is a low water-cement ratio mix. Most decorative GFRC products, other than artificial rocks, are made with a two-layer process with a very thin (1/8 to 3/16 inch) face coat and a thicker backing layer.

Sand and cement are typically used at a ratio of about 1:1, although some mix designs call for slightly higher cementitious materials content. With its high cement content and low water-cement ratio (0.33 to 0.38), GFRC can dry out quickly and not gain full strength. Traditionally, GFRC panels were cured in a moist-room for 7 days. Today, more commonly, this is overcome by using an **Acrylic Polymer** additive which serves as a curing compound to prevent the mix water from evaporating. The acrylic is typically in liquid form. Using 5% acrylic solids by weight of cement will result in the same strength you would get from a 7-day wet cure. The acrylic also gives you concrete that gains strength rapidly. GFRC panels and countertops are ready for use within 3 days. Acrylic used in the mix also gives water to the mix so that a typical mix we have to supply the water by taking into account, the water supplied by the polymer also. With a polymer solids content of 46%, 15 Kg of polymer plus 23 Kg of water are added for every 100 Kg of cement.

Fiber content varies, but is generally about 5% to 7% of the cementitious weight. Some mixes go up to 10% by weight of cement. Increased fiber content adds strength but decreases workability. Cem-Fil's Anti-Crack HP 12mm AR glass fiber is commonly used in premix applications.

In addition to the above components usually silica fume, metakaolin, or other Pozzolanas is also used in the mix, this reduces the permeability of the concrete, making it more water-resistant and also reduces the alkalinity of the concrete, which means it doesn't affect the glass fibers, and both of these factors mean increased concrete durability.

Typical GFRC mix may be as shown as below.

Table 2 –Typical GFRC mix

Chopped AR glass fibers	2 to 3% by weight for premixed; 4% to 6% for spray-up
Acrylic polymer emulsion	5% by weight of cement
Sand to cement ratio	1:1
Pozzolanas (silica fume, metakaolin)	10 to 25% cement replacement
Water cement ratio	0.30 to 0.38

3.5 Admixtures in Zoho Stone's GFRC

Now a day in all concrete construction admixtures is inevitable. In Zoho Stone's GFRC also admixtures are used to a greater extent. The high dosage of glass fibers in the GFRC makes the mix very stiff and less workable, thus the use of plasticizers and super plasticizers.

i. Plasticizers: - for GFRC to flow more easily for a given water-cement ratio it is necessary to reduce the yield point(force needed to start the mix moving) of the mix. Plasticizers do this by absorbing on to the surface of the cement particles, reducing the flocculation, thus aiding the dispersion and reducing the drag, which increases the fluidity.

ii. Viscosity modifying admixtures: - Most VMA's are based on high weight polymers with a high affinity for water and built up a sort of three-dimensional structure in the liquid phase. Typically these are used at the rate of 0.1-1.5%. VMA's affect the plastic viscosity of the concrete without affecting the yield point. This helps in holding the constituents together thereby reducing the chance of bleeding and segregation this helps in reducing the friction in pumped mixes.

iii. Polymers: - Polymers used are mainly white latex, usually acrylic emulsion with approximately 50% solid content. The recommended dosage is 5-6%(10-12% latex) by weight of cement. The polymer must be resistant to alkali and UV stable. They function by forming a network of flexible polymer bridges between the brittle mineral ingredients, helping them to bind together

iv. Anti efflorescence and water-repellent admixtures: - Zoho Stone's GFRC has high cement content and so produce more lime during setting. This make it prone to efflorescence since lime is the primary cause of efflorescence. Usually Pozzolanas added at a rate of 15-20% cement replacement level will take care of this lime production and almost eliminates efflorescence. But in some cases a little amount is added according to the situation.

3.6 GFRC Casting Method

Commercial GFRC commonly uses two different methods for casting GFRC. One is called spray-up, the other is called premix.

a) Spray-up:

Spray-up is similar to shortcrete, in that the fluid concrete mixture (minus fibers) is sprayed into the forms. The concrete is sprayed out of a gun-like nozzle that also chops and sprays a separate stream of long fibers. The concrete and fibers mix when they hit the form surface. Glass fiber is fed off of a spool in a continuous thread into the gun, where blades cut it just before it is sprayed. Chopped fiber lengths tend to be much longer (about 1.5") than fibers that get mixed in, since long fibers would ball up if they were mixed into the concrete before spraying.

Figure 5: Hand spraying Zoho Stone's GFRC

Typically Spray-up is applied in two layers. The first layer is the face coat, much like a gel-coat in fiberglass. This face coat usually has no fibers in it and is thin, often only about 1/8" thick. The second or backer layer has the fiber in it. The action of spraying on the fibers orients them in a thin layer, much like the layers in plywood.

Spray-up permits very high fiber loading using very long fiber length. Zoho Stone's GFRC made using the spray-up method the greatest strength. However, the equipment required to do spray-up is very expensive, often costing more than $20,000.

GFRC used for concrete countertops in large shops is made using the spray-up method. However, the high equipment cost puts this out of the reach of most people.

b) Premix:

Premix, on the other hand, involves mixing shorter fibers in lower doses into the fluid concrete. This mixture is either poured into molds or sprayed. While the spray guns used don't have a fiber chopper, they are nonetheless costly and require a pump to feed them (the same pump used with spray-up). Premix tends to be less strong than spray-up due to the shorter fibers and more random fiber orientation.

Figure 6: Premix Zoho Stone's GFRC pouring into a mold

c) Hybrid:

An alternative hybrid method uses an inexpensive hopper gun to spray the face coat. The fiber loaded backer mix is often poured or hand packed, just like ordinary concrete. Once the thin face mix is sprayed into the forms it is allowed to stiffen up before the backer mix is applied. This prevents the backer mix from being pushed through the thin face mix.

Hopper guns are often used to spray acoustic ceilings, cementitious overlays or other knock-down surfaces. They are inexpensive and run off of larger air compressors. A very effective combination of a hopper gun and a 60 gallon air compressor can cost as little as $400-$500.

The face mix and the backer mix are applied at different times, so the makeup and consistency can be different. It is always important to ensure the gross makeup is similar, and w/c ratios and polymer contents should be the same to prevent curling

Figure 7:Spraying the face coat

Figure 8: Hand packing backer on upright

3.7 Benefits of Zoho Stone's GFRC

There are many good reasons to use Zoho Stone's GFRC for thin sections of concrete:

- **Light weight**: With GFRC, concrete can be cast in thinner sections and is therefore as much as 75% lighter than similar pieces cast with traditional concrete. An artificial rock made with Zoho Stone's GFRC will weigh a small fraction of what a real rock of similar proportions would weigh, allowing for lighter foundations and reduced shipping cost.
- **High strength**: GFRC can have flexural strength as high as 4000 psi and it has a very high strength-to-weight ratio.
- **Reinforcement**: Since GFRC is reinforced internally, there is no need for other kinds of reinforcement, which can be difficult to place into complex shapes.
- **Consolidation**: For sprayed GFRC, no vibration is needed. For poured GFRC, vibration or rollers are easy to use to achieve consolidation.
- **Toughness:** GFRC doesn't crack easily—it can be cut without chipping.
- **Surface finish**: Because it is sprayed on, the surface has no bug holes or voids.

- **Adaptability**: Sprayed or poured into a mould, GFRC can adapt to nearly any complex shape, from rocks to fine ornamental details.
- **Sustainable**: Because it uses less cement than equivalent concrete and also often uses significant quantities of recycled materials (as a Pozzolanas), GFRC qualifies as sustainable.
- **Cost**: Zoho Stone's GFRC as a material, however, is more expensive than conventional concrete on a m^2 basis. But since the cross sections can be so much thinner, that cost is overcome in most decorative elements. Other factors to keep in mind with regards to the cost is that GFRC does not require the substrate to be fortified as much in order for it to handle the heavy weight that is associated with regular concrete. This therefore reduces the cost of material and construction. Due to its lighter weight more products can be shipped in a truckload than the conventional concrete, which will reduce transportation costs greatly.
- **Fire resistant**: Zoho Stone's GFRC structures are not only resistant to fire but also it insulates the heat from surroundings entering through it. It is an excellent heat insulator.

3.8 Application of Zoho Stone's GFRC

Since its introduction in 1970 GFRC has gained much popularity among civil engineers, particularly among architects due to its flexibility of casting it in any desired shape. Zoho Stone's GFRC presents architects and engineers with a material from which the most ambitious designs can be created. It can be molded to form modern futuristic designs or to replicate traditional historic features. Zoho Stone's GFRC can be painted, faced with fine aggregates, colored or simply left with a natural white or grey, smooth or textured finish. Zoho Stone's GFRC provides the designer with a complete technology that few other materials can match for versatility.

1. **GFRC Claddings: -** GFRC is one of the most popular materials used for creative prefabricated architectural cladding. GFRC's ability to be molded into thin, lightweight panels with a wide variety of shapes, forms and surface finishes make the materials suitable for making beautiful claddings for the buildings. Zoho Stone can design, engineer and supply **PCI Certified** GFRC exterior cladding systems for institutional and commercial buildings that are beautiful, durable, energy efficient and cost effective. Zoho Stone's GFRC cladding panels are generally manufactured by the 'Hand Spray' technique.
2. **Zoho Stone's GFRC Landscaping: -** Landscaping features such as Seating, planters, receptacles, kiosks, bollards, signs, statues and fountains are being made in Zoho Stone's GFRC with its ability to tailor shape, form and surface finish and to be aesthetically compatible with the chosen environment. GFRC is used to create rock spaces, replica buildings, simulated environments for animals, and much more.

3. **GFRC Roofing: -** GFRC is an ideal material to use on a variety of roofing structures. It is lightweight but tough, easy to fix and unaffected by environmental conditions. It can imitate traditional roofing materials such as slate, natural stone or clay products but unlike these materials it is neither heavy nor brittle. GFRC can be molded into complex shapes for roofing accessories such as finials, ridges and chimneys. It is non-combustible with a high impact strength and can be used on all types of roof.

Figure 9: Zoho Stone's GFRC Roofing's

4. **Zoho Stone's GFRC Renovation: -** Zoho Stone's GFRC is another ideal of one our materials for use in renovation. Thin lightweight panels are easy to fix and minimize the weight imposed on the existing structure. In many cases the opportunity is taken not only to improve the aesthetics of the building but also to improve the thermal and acoustic properties. Zoho Stone's GFRC's ability to be molded and finished with natural materials means that traditional architectural forms can be maintained when required.

5. **GFRC Flooring: -** GFRC can provide practical solutions in the construction of foundations and floors. As permanent formwork under suspended, in-situ concrete floors it can give economic benefits together with excellent appearance. In balcony slab construction, GFRC can provide a pre-finished molded edge while simplifying construction. On ground floor concrete slabs, insulated GFRC edge formwork can help in minimizing heat loss from the building in cold climates. Similarly, in wall construction insulated GFRC base course and sill units can be incorporated, which contribute to the overall wall insulation performance. On the construction site, forms of glass fiber-modified concrete can be used in floor screeding, both in relatively thick concrete screeds and in thin self-leveling overlays.

Figure 10: GFRC Flooring

6. **GFRC Modular buildings: -** The qualities of GFRC are shown to great advantage in the area of modular building. GFRC panels are light and easily transported but also resistant to damage. Small units such as modular bathrooms or telecommunications equipment housings can be shipped in one piece and rapidly lifted into position. The strength of GFRC is sufficient so that, even in thin skin construction, small modular buildings can be designed without heavy structural frames. GFRC walls can incorporate thermal insulation if required, while the absence of steel reinforcement can be a benefit in electrical or telecommunications applications.
7. **GFRC Permanent formwork: -** GFRC has been using for making permanent formwork for concrete construction for years. The most popular application is in bridge construction. Small (1-2 m span) GFRC panels are fitted between precast concrete beams before steel reinforcement and concrete are placed GFRC permanent formwork panels are not only fast to install, they also provide extra corrosion protection to the steel

reinforcement. GFRC carbonates very slowly and has low permeability providing a barrier to the ingress of de-icing salts. GFRC permanent formwork has also proved to be an efficient solution to the world's ageing sewers. In the UK, France, Holland and elsewhere thousands of kilometers of brick-built sewers have been lined with GFRC permanent formwork and grouted in place. Not only does this safeguard the structural integrity of the sewer but also the smooth surface of the GFRC enhances the hydraulic performance.

Figure 11: Zoho Stone's GFRC Permanent Form Work

8. **Zoho Stone's GFRC for earthquake resistant structures: -** In areas that receive earthquakes, Zoho Stone's GFRC can be effectively used in the construction to reduce the effect of earthquake. There are three main reasons why architectural concrete is particularly well suited for seismic design applications. First, Glass Fiber Reinforced Concrete is lighter than many other commonly used construction materials, including brick, stone, cast stone, terra cotta, and traditional precast concrete. Lighter weight means a reduced seismic load on the structure and simplified connection details. Second, Zoho Stone's GFRC is reinforced throughout. Because the glass fiber is integral to the product, there are no unreinforced areas in a Zoho Stone's GFRC panel or GFRC element. Since the reinforcing is continuous, there are no fragile, unreinforced sections in GFRC. Lastly, fiber reinforced concrete is capable of flexing without breaking, making it ideally suited for use in seismic zones. Unlike rigid masonry or precast concrete, Glass Fiber Reinforced Concrete can withstand a considerable amount of bending forces and shaking and still remain intact.

3.9 Zoho Stone's GFRC and the Environment

The main constituents of GFRC are based on the naturally occurring earth oxides that are used in the manufacture of cement and glass fibers. These are not generally regarded as pollutants. Wash water from the manufacturing process contains cement and this is alkaline. It is normal for factories to have settlement tanks so that solids do not enter the drainage system. The reduced weight of GFRC compared to steel reinforced concrete products does provide environmental benefits. An assessment carried out as part of a UK government DETR/Concrete Industry Alliance 'Partners in Technology' project compared two precast concrete and GFRC products that fulfill the same function. The results show that GFRC has a lower environmental impact. The main reasons for the reduced environmental impact of Zoho Stone's GFRC compared to traditional precast concrete are:

- ***Reduced cement usage per product***
- ***Reduced transport costs, therefore smaller carbon footprint.***

3.10 Durability of Zoho Stone's GFRC

GFRC has been tested both by accelerated aging tests in the laboratory and in real life installations. Zoho Stone's GFRC can be expected to last as long as pre-cast concrete. In many environments, as when exposed to salt spray or high moisture, Zoho Stone's GFRC can be expected to perform better, as there is no steel reinforcement to corrode. Since the surface of Zoho Stone's GFRC is a Portland concrete, it weathers much as a quality architectural pre-cast concrete would.

4. CONCLUSION

Zoho Stone's PCI Certified GFRC as an engineered material has excellent properties that can be conveniently used for many construction works and it is a suitable material for architects to give life to their imaginations as structures by properly using this flexible material. A properly designed, manufactured and installed Zoho Stone's GFRC system will provide an innovative and aesthetically pleasing appearance, while often reducing overall cost, onsite labor requirements and shortening construction schedules. Zoho Stone's Glass Fiber Reinforced Concrete (GFRC) offers an endless variety of decorative and ornamental shapes and forms at affordable prices. We have an in-house mold making shop where model making and tooling is taken to the highest level in this trade. Other services we offer include CADD-generated shop drawings, technical consultation, material safety data information and material testing.

For more information, please visit our website at www.ZohoStone.com, or find us on Facebook under "Zoho Stone". For any comments or questions please call :+1 727 230 6956 or email us at sales@zohostone.com. We look forward to working with you on your next exciting project.

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