Experimental Study on Strength Characteristics of Chopped Glass Fiber (CGF) Cement-Mortar Composites

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Chopped Glass Fiber (CGF) manufactured by a specification of materials in glass fiber diameter 9 to 25 micron its formed silica-based formulations of glass. Is flexible, lightweight and durability without oxidation, CGF adds enough material quantity to resist the anticipated tensile loads. The hardened CGF composite mortars are inflated ductility resistant and absorbed upper load energy. CGF fiber compound mix materials consist of top strength, glass fiber implant in a cementitious matrix. CGF is another admixtures and alkali resistance. In this research evaluating the different percentages CGF mix with the cement mortar and test in different casted specimens. Appraised the specimens is increased ductility individuality, through the direct compression, tensile, elastic modules strength test. CGF mix cement mortar its high improvements of a (tensile) strength of the better composites. CGF fiber mix is a high mechanical properties consequence outcome. Con-currently fiber cement mortar composites are more efficiency of tensile and compression strength.

Introduction

CGF consists of 300 are more individual filaments its bonded in order of improvements bonding strength in the concrete alkali-resistant fibers act as a principle tensile load [**1**]. It's greatly made in the field of high rise building and infrastructures. And supplementary necessities and high presentation of high ductility and durability, the strength of the concrete [**2**]. The CGF is individual however and disagreement of concrete. It's development of abrasion matrix bonding in cement and CGF in glass fibers in concrete [**3**]. The natural fiber is in rich in a mineral content its same silica mineral contents in a glass fiberits activated the better grips bindings in a cement and fine aggregates [**4**]. The chopped glass fiber reinforcement has been proven to be an effective and economical way to improve the strength properties of cement mortars [**5**]. It comprises the hydration process of cement+fine aggregate+glass fiber [**6**]. Regard as they were decayed through the unreasonable alkali Portland cement in the group of arrangements [**7**]. Consequently alkali silicafibers additional in concrete to makes the structural ability, strength for available of tunnel structure, precast blocks, railway sleepers, and seismic foundations or seismic structure in ductility resistant [**8**]. The CGF is used in some other industry in the form of fabricated products some other likes is wool cloths, carpets, bulletproof rests, bags and shoes [**9**]. In heat thermal process to produce in liquid filaments of glass fiber resins in use in an application for coated in a surface of RC steel bars and rupture old surfaces epoxy resins compounds have also been tried out to protect from alkaline attacked by Portland cement [**10**]. Various purposes and uses of glass fibred in concrete and very limited values and depend on the site and environmental conditions [**11**]. In partial replaced the cement and aggregate in glass fiber in concrete is 10 to 12 percentage of volume sizes, is increased and tensile strength roughly from 2, 4 times and 10 times more than impact resistance [**12**]. CGF reinforced concrete is a fatigue resistance to freezing and thawing effect for thermal, sudden changes and roughly comparable in another composites concrete [**13**]. If CGF mix concrete is applied to the more applications. Construction and repair work process, underwater constructions like dams and harbors, bridge constructions for precast slab decks, and tunnel chambering walls, Enduring variety work constructions is speedy constructions, especially down stand beams and provide high-quality finishes [**14**]. Its high workability of cementitious mixes its flow availability of guniting [**15**]. 1:3 ratios of mix cement guniting are used to force applied the surfaces under a pressure for 20 to 30 N/cm^2 it regularly provided the quantity of water and admixture [**16**].

Materials and methods

The uneven glass fiber is manufactured is easy and waste product collections to cuttings chip sizes. It will be produced quickly and tones of machine productions of factory waste glass fiber products. It is rapidly hardening and its category of plastic composites that specifically uses glass fiber materials to mechanically improve the strength and stiffness of glass silica [**17**]. The resins of molten glass fiber provide additional protections to the fiber due to the bonding between the materials [**18**].

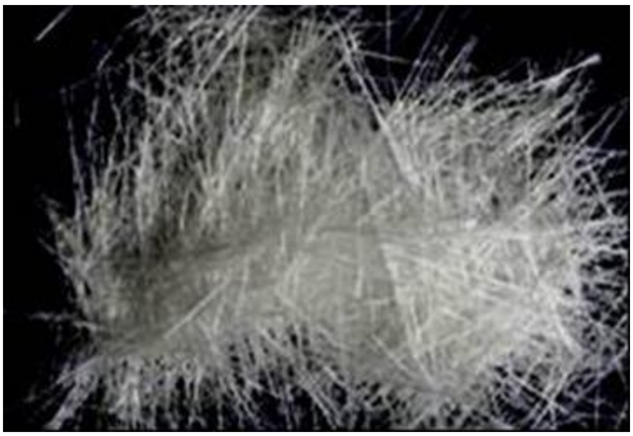

Fig. 1. Photos of chopped glass fibers.

As shown in **Fig. 1**, its irregular parts of chopped glass fiber are bonding with the matrix during were will disperse mixed in standard deviations of target strength. For mix proportions in (OPC), ordinary Portland cement in CGF added in 0.10, 0.20, 0.30 percentage of respectively in cement and sand content. For specimens is 1:1 mix proportion of cement and sand, percentage of CGF fibers add in total amount of content per volume likes (150mm^3).
0.10% fiber mix = 1215 grams (cement) + 1215 grams (sand) + 2.43 grams (CGF),
0.20% fiber mix = 1215 grams (cement) + 1215 grams (sand) + 4.86 grams (CGF),
0.30% fiber mix = 1215 grams (cement) + 1215 grams (sand) + 7.29 grams (CGF).

Table 1. Chemical compositions of OPC and CGF.

Oxides	OPC	CGF
SiO_2	21.2	35
Al_2O_3	4.52	12.5
Fe_2O_3	2.79	2
CaO	65	46
MgO	0.05	5.2
K_2O	0.01	0.5
TiO_2	0	1

The specific gravity of chopped glass fiber is 25 micron diameter is 2.58 to 2.68 and 72 to 76 GPa elastic modulus. The tensile strength is ≥1700 MPa and unequal length of CGF. Concurrently chemical composition for Ordinary Portland Cement (OPC) and CGF is given **Table 1**. In the mix of (cement + sand + CGF +w/c ratios + admixture) flow in a mortar is uniform and dispersed and added in an admixture in typical conditions because CGF is one of the mineral admixture its main core mineral of silica content's [**19**]. Their proportions admixtures are followed in (VMA) methods (Volume mixed admixtures) are added to the mix and to achieve better workability flows properties [**20**]. And then slump flows and mechanical test in 1:1 grade cement mortar, and then compressive, tensile and shear strength of measured in 28 days of curing of water and after 24 hours of hydration process for each curing days at room temperatures.

Measurements of slump test

The flow and mechanical characteristics of 1:1 grade fresh mortar. Partial mixes inCGF in cement content in 0.10, 0.20, and 0.30 %. And measure the consistency of concrete by using the slump cone [**21**]. Tamping rod and metallic sheets are the equipment are used in the experimental analyses them. The procedure of the test is the interior surface of the mold is cleaned and free from redundant moisture and devotion of any aged set concrete previous to beginning the test. The sizes of the mold are top ø100 × bottom ø200 × height 300mm [**22**]. CGF cement mix grade (1:1) fresh mortar is placed in the mold. The filling process is in the mold is layer forms, each layer is tamped in 25 times its well better compacted into the mold. Suddenly lifted from removed the mold in carefully in vertical directions. It's spreading range from 18 inches to 32 inches. The slump cone test is used for the traditional slump cone is majority consistency test is followed by the field test and is standardized in [**23**]. The test results in slump value of the mortar are given in **Table 2**.

Table 2. Slump values in CGF replacements of OPC mortars.

% of CGF replacements in OPC	Slump Flow Values in Spread metallic sheets
0.10%	635mm
0.20%	712mm
0.30%	762mm

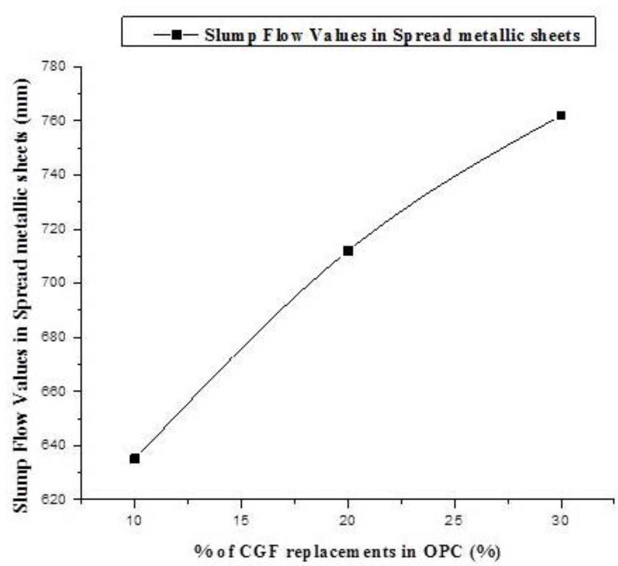

Fig. 2. Measured slump flow of CGF fibre % cementitious composites.

The slump flow mortar containing CGF fibre is identified proof by the given **Fig. 2** its some admixtures added in the relative proportions of the water-cement ratios. The 0.40 W/C ratios of water added in a total quantity of amount of OPC cement content. And plus 0.10 to 0.15 percentage of added in some chemical admixture [**24**]. Its added to the sulfonated melamine formaldehyde is a 1:1 mix proportions and w/c ratios are 0.40 and admixtures are 10-15% is added. This % of admixtures are added in a fresh concrete and its superior actions of self-compaction which low yield stress and high deformability action and good segregation resistance of the CGF mortars [**25**]. It prevents separations of the aggregates in mixes. And it's initially mix it reduced the moderate level of viscosity in after 5 minutes.

Target strength of CGF mortar mix proportions

$$f'_{ck}=f_{ck}+1.65s$$

where f'_{ck} is targeting average compressive strength at 28 days, f_{ck} is characteristics compressive strength at 28 days, and is a standard deviation is 5. Therefore, target strength is 25 + 1.65×5= 33.25 N/mm^2.

Selection of water cement ratios

W/C ratios are taken from the mortar mix is 0.40, based on the CGF mix. 0.40≤0.50. Calculations of cement and Chopped Glass Fibbers content W/C ratios 0.40 + 0.10 add in super plasticizers = 0.40, Cementitious material to OPC + CGF content = 140/0.40 = 350Kg/m^3. Determine the percentage of CGF to use in the requirements is based on the quality and quantity of the materials. The final judgment on increases in cementitious material content and % may be used in weight batching methods. There are choices to take in a manual batching is more experience desires. Cementitious, material 360Kg/m^3.

$$\text{Water content} = 0.50$$
$$= 360 \times 0.50$$
$$= 180 \text{ Kg/m}^3$$

Water cement ratios = 0.50, the % of chopped glass fibre at the total volume of material content is 144 Kg/m^3 and cement (OPC) = 360Kg/m^3, CGF is deployed in cement content.

Result and discussion

Test and discussions of compression strength characteristics

The Compressive strength of CGF cements mortar to determine the cubes (150 × 150 × 150mm). Cube mould and tamping rods are tested apparatus [**26**]. Fill up the CGF fresh mortar into the cube moulds. And after 24 hours, remove from the cube mould the CGF mortar hardened status and put down in curing tub. After 28 days curing to take place in woven 2 hours in 30 degree Celsius. And after scrupled in exterior faces and put it placed in a 2000KN Compression Testing Machines (CTM) [**27**]. The specimens are placed in the central location marks of the compression testing machines. The load is applied to continuously, uniformly and without shocks. The result of compressive strength CGF mortar cube is given in **Fig. 3**.

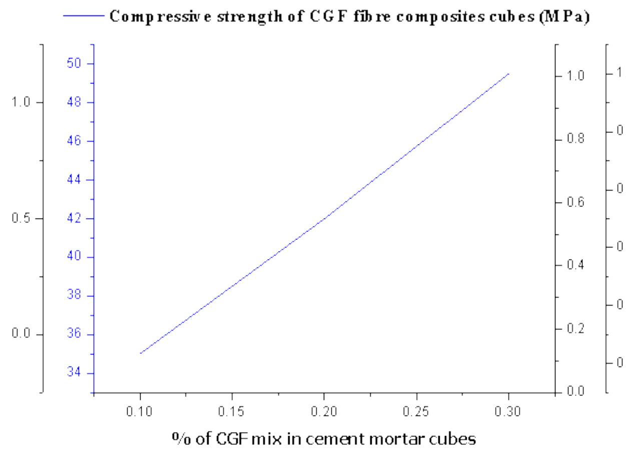

Fig. 3. Compressive strength of CGF fibre composites cubes.

It was proof that the CGF fibres mortar strength, it's not directed to induce the strength of the mortar its compressed composition's amorphous matter likes glass fibre are improvements of the ductility resistance of the concrete components. The load is gradually applied to the mortar cube in CTM machines to denote the yield tensile strength and the breaking points are cubes equal to the yield tensile strength or yield strength. The **Fig. 3** represents the blue colour single straight lines are intimated at the 28 days complete curing of cube strength. It results 35N/mm^{2}are the highest strength of the CGF mortar cubes mix content in 0.10 percentage. And 42 MPa is the strength of CGF content in 0.20 percentage its well fine results of breaking the mortar cubes. And third 0.30 percentage CGF mix content strength is twenty-eight days complete curing in 49.5MPa, its accepted ranges (30≥25) in strength ratios for 1:1 mix proportioned. In 7, 14- days curing CGF mortar cubes are 2 times better acceptable strength ratios for 28 days curing mortars cubes. So it's preferred for comparisons to other % of mix compositions. It's highly uniformly distributes settings and high load carrying capacity and its improvements of the strength in friction bonding.

Test and discussions on direct tensile strength characteristics

After 28-days curing CGF mortar beams (50×10×10cm) to determine the strength of the test by using flexural test [**28**]. Then after completing the 28- Days curing process in specimens to put into the woven in 24 degree Celsius to 30 degree Celsius for 48-hours in before testing and after taking the beam to 0.05mm coat to 4T oil on exterior surface. To place the Flexure testing machines the surface contacted the bearing surfaces of bearing rollers [**29**]. And these load applied to the top surfaces of the beam. The gradually applied the load without sudden impact shocks. It's analysed the reading in yield to the breaking point of surfaces. To causes sudden failure of the beam is stopped the hydraulic loads and to take the note the values of the fractures of failure of breaking points. The results CGF mortar beams strength is given in **Fig. 4**.

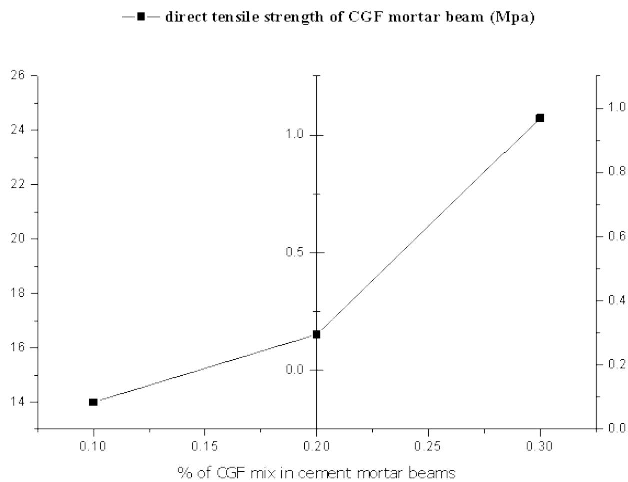

Fig. 4. Tensile strength of mortar containing Chopped glass fibre with together with a photo of tensile cracking in after the test specimens.

Fig. 5. Fracture of tensile failure of CGF fibre in cementitious composites.

Fig. 5, shown as ductility resistance materials are behaviour of breaking strength is the stress is limitations values of all recognized standards. It's followed by UTS – ultimate tensile yield strength, it's irreversible of limitations of high values of load controlling and deforms. Across the deformation limits formations of failure ruptures on the surfaces. CGF fibres reinforcement is a cementitious composite, its prevent post cracks for exposed durability of the external climatic conditions its performed best of specific results on the chemical test [**30**]. These types of a glass are performed the specific level and working same levels. E, C and AR glass its face corrosive environmental conditions its protective the exposed hardened climatic conditions example acid rains. FRP- Fiber Reinforced Polymer has corrosion barrier are the structural portions [**31**].

SCT - Stress Corrosion Test in Glass fibre its advantages of E-glass fibre in salt water it should be considered for the corrosion barrier of structural portions of FRP parts its exposed conditions high durability strength its resists acid solutions of acid rain. For FRP parts of the expected retained CGF are 44% and load carrying capacity of the matrix [**32**]. The CGF fibre cement composites are condescending chopped glass fibre reinforced concrete acrylic copolymer elements, glass fibre reinforcing additive. This is a copolymer form of steel fibre reinforced concrete, much feel the as high strength in tensile behaviour and better strength bonding, superior quality. CGF fibre reinforced cementitious composites could greatly enhance tensile strength. The final comparisons for all percentages especially 0.30 % of composites is better outcome flexural strength.

Test and discussions of modulus of elasticity

Modulus of elasticity is a relative proportion of composite cement matrix its constant themes of lower stress level to higher stress level are lower to decreases the higher stress the cracked are formed [**33**]. The elastic modulus of the CGF hardens mortar cylinder conducted the test. CGF cylinder is placed compressions machines and dial gauge wire wound the contacted the mortar cylinders it helps the intimated the ranges of stresses in the dial gauge. Its continuously loads are applied a rate 150Kg/cm^2 the loads is cylinder the stress is formed by deformed the failure of components. To take perfect deformations of analysed the dial gauge initial target range modulus reached for the CGF mortar cylinder. If 30Mpa the working stress of target modulus is 34Mpa the stress range from sapling on the exterior surface of the cylinder, the modulus of elasticity of giving concrete mean values of 40Mpa and 46.5Mpa divided by half of the range is 57Mpa. The load variations of CGF mortar in % of replacements in OPC are given **Fig. 6** and **Fig. 7**.

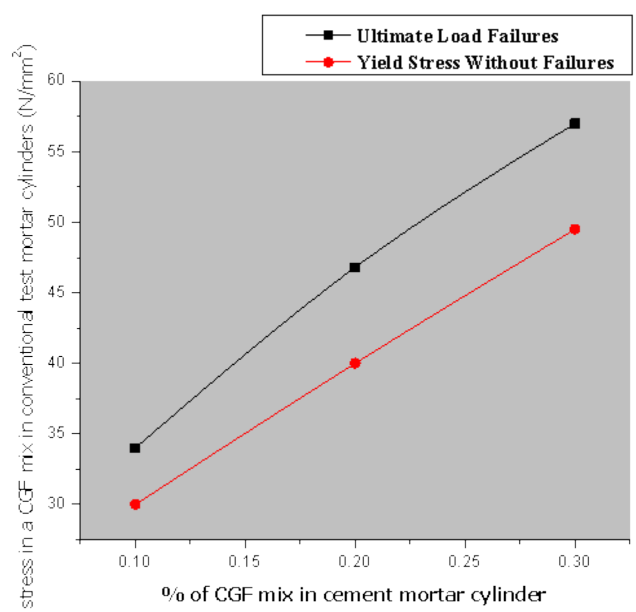

Fig. 6. Characteristics strength in modulus of elasticity stress and strain curves.

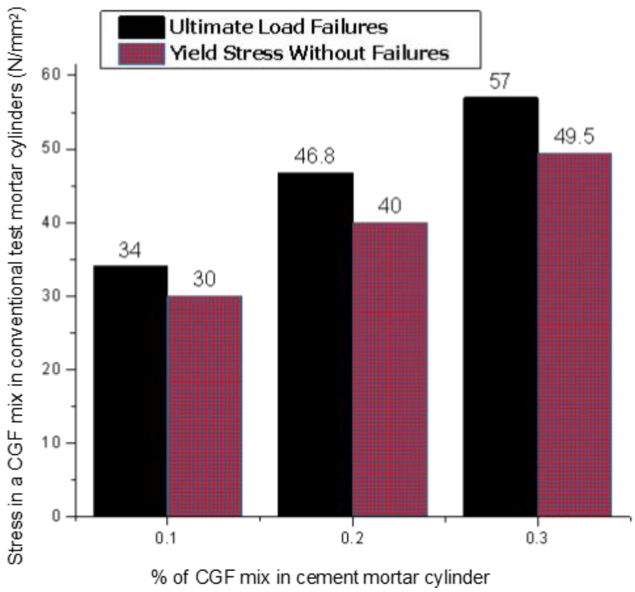

Fig. 7. Percentages variation of CGF fibre hardened mortar Cylinders. 0.10%, 0.20%, 0.30% of chopped glass fibre is replaced to the cement mortars chronic cylinders.

CGF fibre, mixed into the cement composites, it was high withstanding shear capacity its best choices of mix compositions in a cementitious material. It comparing the conventional concrete is 3 to 4 times are rapturous mean values of usually shear strength and compare normal mortar. The compositions of mixing 0.10% to 0.30% of the CGF are the improvement of matrix strength in cement mortar. And 0.50% is above the volume of CGF mixes is component members or test specimens are required range to increased bulging failure. So it consists of the mixing limiting (0.10 to 0.30%) proportions of the quantity of CGF fibre content. For the 1= ¼ ≤ ½ ranges of examples, 1.2 Kg cement contents and adding the limits is 4.8 grams to 8.400 grams of CGF fibre mix is better results for shear strength. And 144 gram< values are and cause of volumes loss and strength in a cementitious matrix are friction bonding is relieved. The CGF fibre reinforcements cement composites fibre dimensions is 20µm diameter and irregular length. The Mixes is (a) 0.10%, (b) 0.20%, (c) 0.30% fibre volume is should not exhaust sizes and excellent outstanding capacity of shear strength and load transfer capacity in concrete specimens.

Test and discussions of thermal expansion coefficients

The thermal expansion coefficients of the test are conducted in CGF hardened mortar cubes and after 28-Days [**34**]. They are followed by the 2- methods T1B and DT1 methods test on identified by the coefficients of thermal expansions. The T1B methods are placed the silent CGF mortar cube analysed the temperature range from 5 degree Celsius to 30 degree Celsius in the oven. And suddenly exposed them some changes in a laterally and longitudinally dimensions is deformed in expansions and contractions on the specimens. To calculate the expansions of the cube is thermal expansion coefficients (α) is equal to strain/change in degree temperature Celsius. These test methods determined the expansions and contractions of CGF mortar cube in an identified them of exposed conditions. CGF mortar cubes have analysed the 3-different temperature conditions its measured sensitivity in mm levels of dimensions varied for cubes with regard contraction of concrete specimens [**35**]. The temperature is adjusted the vice versa check in the dimensions of the CGF hardened mortar cubes at the range is 5-degree Celsius to 100-degree Celsius.

Each measuring the test specimens length and width wise in (mm). The thermal efficiency is balanced. Specimens are inside the electric oven and seal the outside the sudden increased the temperature 50°C at the initial temperature. And slowly reduced the temperatures in up to our coming 10°C then next increased the 60°C and maintains the temperature of 70°C and coming 100°C and taken the CGF mortar cube measuring the size variations expansions and contract behaviour of CGF mortar. It's used highly equipped the measuring in sample CGF specimens (SYLVAC measuring device model 100, accurate range of 0.005 to 0.2mm sometimes coming out the 2mm depend upon the conditions). Test specimens are available CGF mix mortar cubes for lab testing 50×50×50mm. These CGF mortar cubes are the fine seal in plastic bags into water tub the temperature range 20°C until the testing before the procedures. The test specimens carried out in water hot tub the thermally balanced at 4°C. But 1°C is removed from the water, dry status. And measure the dimensions of cubes, and again to put into the electric oven. Plastic bags covered the cube its better act isolation process in absorptions of water and take reading the latitude and longitudinal dimensions of the cubes. Takes the cubes into the oven and put the water tub and again heat 60°C the repeat the process is continuously termed. The test results for measuring in a vertical & horizontal dimensions of the cubes, in (100°C) approximate range from expansions and contraction action is 1 to 3mm and length latitude (lt) dimensions of the cubes, are (100 to 5°c) sudden cooling to the water approximate range of deformations in 0.07×10^{-5}mm.

Conclusions

The experimental study of the CGF is % of mix its OPC cement mixing mortar and amorphous micro chopped glass fibre with its high strength properties for comparing to conventional cement mortars sample cube specimens. And CGF induced high shear strength and ductility resistance of the cement mortars samples, its CGF improvements of more cementitious matrix frictions bond and high compressive strength more and have gradually load and % of CGF mix increased the tensile strength. CGF fibre reinforced cementitious composites that have prevented post cracked for the rigorous climatic conditions and this fibre is the superiority of ductility resistance structure. It's most have the high tensile strength of the

CGF fibre mortar flexural beams and fundamental progress of the study CGF is its high acid resistance of the exposed conditions.

Keywords

Chopped glass fiber, tensile strength, crack control, modulus of elasticity in CGF mortars.

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