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Study on Glass Fibre Added RC Beam with M-SAND – A Review

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Abstract *- The concrete generally comprises of Fine aggregate (F.A), Coarse Aggregate (C.A), Cement and Water as the constituent materials of which F.A are the naturally available River sand and C.A are the naturally available crushed stone aggregates. The main objective of this work is to proceed by the study of the effects of adding Glass fibres into the Concrete to study flexural behaviour of Glass Fibre Reinforced concrete (GFRC) beams with Manufactured sand (M-Sand) as replacement material for F.A at various percentages. Usage of M-Sand in concrete is an alternative way to reduce the depletion of Natural river sand and along with Glass Fibres in concrete which will enhance the properties of concrete and it was also evident that the important properties of GFRC is its superior resistance to cracking at ultimate load level, Alkali attack and heat resistance when compared with the Conventional Concretes.*

Keywords: glass fibre, concrete, manufactured sand, reinforced concrete

1. Introduction

In this study, the effect of fibres on the strength parameters of concrete of various authors are described. The study proceeded with usage of Alkali Resistant (AR) Glass fibres in concretes with increasing 0.2% up to 0.6% to total volume of concrete along with the usage of M-Sand in various replacement ratios ranging from 40% - 60% based on literature study. The cubes and cylinders will be casted with varying AR-Glass fibre & M-Sand ratios to obtain the optimizing mix ratio based on which the flexural beam member of sizes 1100mm×150mm×100mm will be casted and 2 point load test was conducted to study the behavior of GFRC & Conventional Concrete and compared.

2. Literature reviews

Alam et al. (2015) in this paper studied on the usage of Alkali resistant glass fibre of sizes 12mm in concrete with the mix grades of M 20 and M 30. With this mixes, the glass fibres were added in the ratio of 0.02%, 0.04% & 0.06% by the total volume of the concrete. The W/C ratio of 0.50 for M 20 mix and 0.42 for M 30 mix were maintained. The Compressive strength and Split tensile strength tests were conducted over casted specimens such as cubes and cylinders. The authors concluded with the obtained results that usage of Alkali resistant glass fibres significantly improved the compressive as well as the tensile strength of the concrete mixes and the results also illustrated that there was marginal increase in Compressive strength and Split Tensile strength strengths on the specimens up to approx. 25% when compared with the control specimens casted without glass fibres.

Mo et al. (2015) in this paper illustrated about the durable properties of concrete with oil palm shell (OPS) as coarse aggregate, manufactured sand as the replacement for fine aggregates and also with GGBS as partial replacement material to cement which results in the production of light weight concrete. In this study, the concrete were mixed with M – Sand of particle sizes between 300µm and 5mm as F.A, OPS of sizes 2.3 to 14mm as C.A and GGBS were used at the replacement ratio of 20%, 40% and 60% to the mixes. With the mixes, the cubes were casted and compressive strength and water absorption tests were conducted over the specimens. The results indicated that the usage of GGBS replacement level of 60% with OPS and M - Sand had most effects on minimizing the strength loss when compared to the nominal mixes.

Riad et al. (2015) in this paper studied on the experimental investigation of effects of glass fibres in RC beams exposed to fire. The type of glass fibre used were Alkali resistant Glass fibre (E glass) of 18mm length. The experiment was conducted over RC beam specimen of size 1650×120×250mm with varying Glass fibre ratios. The fibres were added in the ratios of 0%, 0.5% and 1.0% to the total volume of the concrete mixes. The High performance concrete mixes were produced with Silica fumes and super plasticizer which can yield strength upto 60 Mpa. The Flexural test results over the beams indicated that adding glass fibres, the strength of the beams increased and the crack density also decreased when compared to the control specimens and it was also particularly found that the glass fibre content equal to 0.5% the weight of the concrete was more effective than the higher usage of glass fibres in concrete.

Petersen et al. (2015) in this paper experimentally studied on the Mechanical properties of fire-retardant glass fiber-reinforced polymer materials with alumina tri-hydrate (ATH) filler as the main component material. The experiment investigation was conducted over a thin mortar panel with E glass fibre and alumina tri-hydrate and tests such as Compression, Tension, Flexural and Shear tests were conducted over the specimen. The test results illustrated that control specimen was the strongest for all of the tests except for flexure, which is 3% lower than the flexural strength of 25% ATH sample and for compression test, there is a 19% and 25% reduction from the control specimen to 25% and 50% ATH samples respectively while for tension, shear and flexure strengths the 25% ATH sample with fibres acted similarly to the control specimen and however, the 50% ATH sample had a significantly lower maximum stress when compared with all of the above.

Kelestemur et al. (2014) in this paper conducted experimental studies on the Statistical analysis for freeze–thaw resistance of cement mortars containing marble dust and glass fibre. The E glass fibres of 6mm and marble dust were mixed with the concrete and the prismatic specimens of size 40×40×160mm and cubes of sizes 50×50×50mm were casted with marble dust in the replacement ratios of 0%, 20%, 40% & 50% to the total volume by the replacement of river sand and glass fibres were added in the ratio of 0.25%, 0.50% & 0.75% to the total volume of concrete. The results indicated that the usage of marble dust increased the compressive and flexural strengths of the specimens when compared with the normal river sand FA's. The findings also indicated that the addition of glass fibres into cement mortars & concrete can increase the air voids thus providing an alternative to air entrainment as a method of freeze thaw protection over the specimens.

Wang et al. (2014) in this paper studied on the Flexural properties of epoxy syntactic foams reinforced by short glass fibres with concrete. The experiment was further processed with the usage of short glass fibres of 3mm in length with the addition ratio varying from 0% to 1.5% to the total weight percentage of the concrete and also with glass fibre mesh of 0.6mm covering over it with varying layers. The flexural test investigation was done over the beam specimen comprising of sizes 5x10x190mm^3. From the obtained results, the authors concluded that the concrete foams reinforced by 0.5% of weight glass fibre and 2 layers of glass fibre mesh enhanced the flexural properties and during flexure, the fibre glass mesh on the tensile side is also stopping the micro crack propagation.

Jayswal et al. (2014) in this paper studied on the Effects of replacing Natural Sand by M- Sand as fine aggregates in Concrete. M 25 grade of concrete mix were designed for both Natural sand mix and manufactured sand mix which was replaced by upto 100% of natural sand in the mix of concrete. Cubes were cast for the compression tests and the results were obtained. From the obtained results the authors suggested that even 100% replacement of F.A with M-Sand showed best results on compression tests over the cubes.

Tassew and Lubell (2014) experimentally studied on the mechanical properties of Glass fibre reinforced ceramic concrete. The experiment proceeded with the addition of Glass fibres of various size compositions in various volume fractions ranging from 0% to 2% with the concrete. The experiment was conducted over the cubes, cylinders and prisms to find the Compressive, Tensile & Flexural strength of the specimens with various glass fibre mixes. The obtained results suggested that the Compressive strength increased with increase in glass fibre volume fraction while the fibres had negligible effect on modulus of elasticity & the direct shear strength of concrete was also noticed to increase with the increase in the glass fibre volume not more than 0.5%.

Kamal et al. (2014) investigated on the Behavior and strength of beams cast with Ultra High Strength Concrete containing Steel & Polypropylene fibres. The Steel fibres comprised aspect ratio of 65 and polypropylene fibre comprised of 12.5 were used in the concrete mixes. The fibres were added to the concrete mixes by a desired volume fraction of 40kgs of Steel fibres and 1kg of Polypropylene fibres. 2 point flexural loading test was conducted over the beam specimen and the results illustrated that the use of steel and polypropylene fibres increased the 28th day compressive strength by 2.5% & 6% when compared to the normal mix concrete without fibres. It was also noticed that the increase in the ultimate load was also high as 48% & 15% when steel and polypropylene fibres were used in the concretes.

Jayaraman and Kumar (2013) investigated on the Optimization of full replacement of natural sand by M-sand in High Performance Concrete with nanosilica as constituent material. The concrete mixes was designed as such with 0.75% is replaced by Nanosilica with Cement and 100% replacement with M-Sand of F.A. The cubes were casted with different mixes and normal mix. From the obtained results the authors suggested that the addition of nano silica leads to significance increase in the characteristics strength and durability of the concrete & the self-weight of the mix with Nano silica is also much less when compared to the other mixes and even the penetration level of chlorides and acids are also less in Nano silica influenced concrete mixes when compared with the normal mixes.

Gowri and Mary (2013) in this paper investigated on the effects on mechanical properties of concrete with glass wool fibres. The experiment was conducted with various test specimens such as cubes & cylinders and for compressive & Split tensile strength tests. The concrete mixes were designed with the glass wool fibres of Aspect ratio 125 in the addition ratio of .025%, .05% and .075% by the total volume of the concrete. From the obtained results it was concluded that when fibre content increases from 0.025% to 0.075% the compressive strength also increases & the failure patterns were also studied and it illustrated that the formation of cracks is more in concrete without fibres than with the glass wool fibres.

Castro et al. (2013) in this paper investigated on the sustainable waste recycling solution for the glass fibre reinforced polymer composite materials. The investigation proceeded with recycled glass fibre aggregates induced in the concrete with various proportions of 4%, 8% & 12% of the total mass weight. The authors also initiated the tests with recycled glass fibres as partial replacement material to F.A up to 8% to the total weight of content over a prism of size $40x40x160mm^3$. The test results showed incremental effect on both compressive and flexural strengths of polymer mortars. Polymer mortars with coarse wastes showed improved mechanical behaviour over those with fine wastes both in bending and compression tests.

Joe et al. (2013) studied on experimental investigation on the effects of M-Sand in High Performance concrete. The investigation was proceeded with the various replacement levels of natural sand by M – Sand with various ratios varying of 30%, 40%, 50% & 60%on M 30 mix of concrete. The tests such as Compression, Tensile and flexural strength tests were conducted over Cubes, cylinder and prisms for the optimum results. Chemical admixtures such as Super plasticizers and Viscous modifying agents were also added to the concrete mix to reduce the segregation. The test results illustrated that that 50% replacement in F.A with M-sand gives maximum strength to the concrete which resulted in high compressive strength, higher split tensile strength, higher flexural strength and thus the extraction of River sand can be reduced.

Gobinath et al. (2013) experimentally studied on the strength of concrete by partially replacing the fine aggregate using M – Sand. The authors experimented with replacement of fine aggregates with M-Sand and cement with silica fumes at various percentages on the M 25 mix of concrete. The Compressive and Split Tensile tests over the cube and cylinder specimen were conducted to find the strength behaviour on 7th and 28th day respectively. The results concluded that M sand satisfies the requirements of fine aggregates such as strength, gradation, shape, angularity etc in the concrete. The authors also suggested that adoption of M- sand for replacement by 50% of natural sand is encouraging based on test results.

Jadhav et al. (2012) experimentally investigated on the properties of concrete containing manufactured Sand. The manufactured sand was replaced in place of natural sand in the ratio of 0% to 100% at the increment of 20% on the M 20 mixes of concrete and experiments were done over the specimens. The compressive, split tensile and flexural strength tests were conducted over the specimens of Cube, Cylinder & Prism respectively. The results illustrated that M – sand replacement ratio with 60% gave higher strength compared to the other nominal mixes. The overall strength of concrete also linearly increases from 0%, 20%, 40% and 60% replacement of natural sand by manufactured sand and has better workability when compared.

Nanthagopalan & Santhanam (2011) experimentally studied on the fresh and hardened properties of Self compacting concrete with manufactured sand as Fine aggregate material. The concrete was mixed using different volume of W/P (Water - Paste) ratio in the mix. Superplasticizers and Viscosity modifying agent were used for attaining the properties of Self compacting concrete with different W/P ratios. The experimental results indicated that crushing process of M – Sand affects the shape and grading of concrete when compared with the natural fine aggregates as material. The authors even stated that the w/p ratio had a good correlation with the compressive strength for the cement ratio used the M – Sand also presented numerous advantages when compared with the River sand including its contribution as filler content of the concrete, this also helps in achieving lower cost benefit ratio when compared with the River sand.

Kim et al. (2009) studied on the Finite element analysis of thin GFRC panels reinforced with FRP as reinforcing bars by both experimental & analytic analysis. The experiments are carried on both cylindrical and prism panels with pull out test being carried out. The results illustrated that tests on GFRP reinforced with GFRC shows GFRP bond characteristics are better than conventional concrete without fibre reinforcement. The authors also concluded that GFRP can be used in combination with GFRC to enhance the strength characteristics of thin GFRC panels.

Beixing et al. (2009) investigated on the effects of limestone fine content in manufactured sand on durability strengths of low and high strength concretes. The test studies were done for compressive and freeze thaw effects of the specimens. The experimental results showed that for low strength concretes, the increment of limestone fines from 0% to 20% improved the resistance to chloride ion penetration but decreased the freezing effect, whereas in case of high strength concretes, the increment of limestone fines from 0% - 15% did not affect the chloride permeability and freeze thaw effect. The authors also concluded that the durable concrete can be made from Manufactured Sand with at least 10% of limestone fines included in it, which doesn't influence the freeze-thaw effect.

Mingkai et al. (2008) studied on the experimental effects of manufactured sand on dry shrinkage and creep factors of high strength concrete. The study showed the influence of Natural sand, manufactured sand and stone dust with the properties such as Workability, Compressive strength, elastic modulus, dry shrinkage and creep effects on High strength concrete. The author's conclusion stated that, the reasonable content of Stone dust could improve the manufactured sand in High strength concrete. The influence of stone dust increased the compressive strength of the specimen for 7^{th} day and 28^{th} day tests while the creep is also influenced remarkably by aggregate characteristics and content of cement paste. The specific creep and creep coefficient of MS-HSC with 7% stone dust content were also close to that of Natural sand in HSC.

Kim et al. (2008) experimentally studied with the thin FRP/GFRC Structural elements for compression and pull out tests. The glass fibres used comprised of Alkali resistant chopped glass fibre of 15mm length in dimension and was added in different volume ratios of 2% & 3% respectively with different mixes along with glass fibre re-bars. With the arrived test results the authors concluded that by using GFRC and FRP re-bars the nominal size of the member was reduced from 20-50mm which would usually be up to 80mm in conventional members. The test results also showed that GFRC sections with FRP reinforcement had higher capacity to resistance than with plain GFRC sections.

Cortes et al. (2008) experimentally studied on the rheological and mechanical properties of mortars prepared with natural and manufactured sands as aggregates in the mix. The tests were conducted to study the properties of mortars behaviour which comprised of angular manufactured sand and natural river sand. The tests such as Flowability, stiffness and strength tests were conducted over the mortar mixes by the authors. The implementation of comprehensive experimental study for mortars prepared with two round natural sands and two round angular manufactured sands with various w/c ratios and fine aggregate to cement ratios were evaluated for the experiments. The loosest packing density of the fine aggregates depends on the aggregates particle size and therefore a large volume of paste was required to attain adequate flowability in the mortar mixes.

Purnell and Beddows (2005) studied about the durability and simulated ageing of new matrix reinforced concrete with glass fibre. Alkali resistant glass fibre were used for reinforcing concretes made of ordinary Portland cement mixes. The initial test results showed that OPC concrete with AR fibres gathered a co-relation between hot water accelerated ageing and natural weathering. The authors hence arrived at a conclusion that hot water ageing is not suitable for predicting the long term behaviour of polymer modified concrete in general.

Choi and Yuan (2005) arrived on the experimental relationship between splitting tensile strength and compressive strength of GFRC & PFRC in cube and cylinder specimens. The Fibres used dimensions are of 19mm in length and 0.0013mm in dia for glass fibre and 50mm in length and 0.90mm in dia for polypropylene fibres, which were added in the ratios ranging from 1% to 1.5% of total volume as only low content had some positive influence and more than 2% may end in un uniform distribution of the fibres. The test results suggested that split tensile strength of both GFRC & PFRC ranged from 9% to 13% of its compressive strength & the addition of fibres in concrete also increases the splitting tensile by approx. 20-50% in total comparatively with the conventional concrete specimens.

Avci et al. (2004) did experimental study to access the fracture behaviour of glass fibre reinforced polymer composites. The glass fibres used comprised of E-glass fibres of 10-12mm in length and was added in the ratios of 1% to 1.5% of total weight of the polymer system along with varying polyester resin content ranging from 13% to 19.5%. The fracture behaviour was studied by 3 point bending test over the beam specimen of 300x30x50mm in size. The test results illustrated that in Glass fibre reinforced polymer concrete with increasing polyester content increases the flexural strength and while the fibre content also increased both flexural strength and modulus of the beam specimen.

Donza et al. (2002) experimentally studied on the High strength concretes with different fine aggregates and natural sand with rounded and smooth grains. The crushed sand used were comprises of granite, limestone and Dolomite with similar grading of natural sand. The Cylinders & Prisms were casted for conducting Compression Tests & Elastic modulus tests and the authors found that HSC having crushed sand as aggregates has better mechanical properties than with the natural sand aggregates. The investigation also revealed that some higher dosage of admixtures is needed to overcome the adverse shape and texture of particles.

Griffiths and Ball (2000) assessed on the properties and degradation behaviour of glass-fibre reinforced polyester polymers in concrete with glass fibres of sizes 12.5mm & 18mm. The chopped glass fibre strand was added in the ratio of 1.5% to the total weight of the concrete for 3 point flexural load test. The results initiated that the use of glass fibre increased the modulus of rupture and the usage of glass fibre improves the strength of the material by increasing the force required for deformation.

3. Conclusion

Based on the literature study, conclusions such as need for the usage of Glass fibres and M – Sand in the Reinforced concrete members were studied and understood. The study illustrated that the usage of fibres in concrete influenced in attaining the higher strength for the members when compared with the conventional and traditional type of concrete members and the usage of M – Sand also enhanced the properties of concrete members which can be majorly used as a replacement material for natural sand as there is a huge depletion of river beds and natural sands, this in way also protects the natural resource and is cost effective. In general, behaviour of glass fibres in concrete increases the ultimate load carrying capacity, enhances stiffness properties and also acts as a major bonding material due to its micro structure. More over its resistance to Alkali agents and fire has a major impact for the stiffness and thermal properties of the members and the fibres can also recycled from waste glass particles.

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