Experimental Study on Steel Fibre Reinforced Rubberised GGBS Based Geopolymer Concrete

Ms.S.Sathya[1], Mrs.M.Saranya[2]
[1]Dept of Structural Engineering
[2]AP, Dept of Civil Engineering
[1, 2] NSN College of Engineering and Technology, Karur

Abstract- *The vehicle tyres which are disposed to landfills constitute one important part of solid waste. Stockpiled tyres also present many types of, health, environmental and economic risk through air, water and soil pollution. Investigation carried out so far reveal that tyre waste concrete is specially recommended for concrete structures located in areas of severe earthquake risk and for the applications submitted to severe dynamic actions like railway sleepers Waste material recycling through using in concrete manufacturing not only provides a promising resource to produce a high-quality concrete, but also helps to properly encounter the problem of waste disposal. Also, the cement industry is one of the primary industrial producers of carbon dioxide (CO2), creating up to 5 % of worldwide man-made emissions of this gas, of which 50% is from the chemical process and 40 % from burning fuel.*

I. INTRODUCTION

Waste material recycling through using in concrete manufacturing not only provides a promising resource to produce a high-quality concrete, but also helps to properly encounter the problem of waste disposal. Also, the cement industry is one of the primary industrial producers of carbon dioxide (CO_2), creating up to 5 % of worldwide man-made emissions of this gas, of which 50% is from the chemical process and 40 % from burning fuel. Hence mineral admixtures are used as partial replacement of cement in concrete, which reduces the amount of cement used, thereby reducing the environmental pollution. In most of the cases these mineral admixtures are the waste product obtained from various industries. Sothe problems caused due to the dumping of the waste are also tackled by using them as replacement for cement in concrete. It also proves to be cost effective as these admixtures are obtained as waste from the industries.

II. MATERIALS USED

Ground Granulated Blast Furnace Slag:

Ground Granulated Blast Furnace Slag (GGBS) is a by-product from the blast furnaces used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore is reduced toiron and the remaining materials from a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching optimises the cementitious properties and produces granules similar to coarse sand. This granulated slag is then dried and ground to a fine powder.

GGBS

Crumb Rubber:

The study on the use of recycled tyres as materials to be used in the concrete as partial or complete replacement of aggregate that there are four types of scrap tyre particles available which are classified in accordance to their particle size and the texture. These types consist ofslit tyre particles in the form of slit which are halved in two halves. Apart from the slit tyre particles, there are shredded tyre particles which are also utilized in concrete as a replacement of aggregate in the concrete. The particle size varies from 300 to 400 millimeters long and 100 to 200 millimeters wide. There is also ground type of rubber tyre available for the utility in the study work which is cut. Shredded rubber passing through 2.36mm and 1.18mm proportionately mixed was used for fine aggregate replacements.

Crumb Rubber

Super plasticizer (SP):

The use of super plasticizer has significant effect on overcoming the hitch in the reduction of workability of AASC when equipped with GGBS and early setting time has been significantly reduced with the use of super plasticizer resulting may improve the mechanical characteristics of GPC. The super plasticizers of conplast SP430 has been employed in this work with a pH of 6, relative density of 1.08 at 25 ^{0}C with less than 2% chloride content, asit may be well suited for sodium activated geopolymers with their best plasticizing effect comparing with other commercial types.

Steel Fiber : Steel Fiber is a Cost effective and innovative solution for enhancing concrete strength and performance. Glued Steel Fibres an alternate concrete reinforcing material are low carbon, high tensile steel wires with hooked ends, glued together for compactness and uniform dispersion in concrete. There are many types of steel fibres, here we have used hooked end steel fibres. The tensile strength and the Young's modulus of the used steel fibers were 1250 MPa and 210 GPa, respectively.

Alkaline solution*:* A combination of sodium hydroxide and sodium silicate solutions was used as the activator (the alkaline liquid). Sodium hydroxide in the form of flakes (NaOH with 98 % purity), and sodium silicate solution (Na_2O = 10.6 %, SiO_2 = 26.5 % and density = 1.39 g/ml at 25 ^{0}C) were used. Sodium silicate based activating solution, the sodium hydroxide solution (8 molarity concentration) was prepared by dissolving sodium hydroxide flakes in water and kept for at least 24 hr in ambient conditions. The sodium hydroxide and sodium silicate solution were then mixed together. The resulting solution was stored at ambient temperature for a period of at least
24 hr.

CASTING PROCEDURE:

The inner faces of the formwork were brushed with oil before placing concrete. Total five mixes were cast, which comprises of slab specimens for control and optimum mix. after casting the specimens, ambient curing is done for 28 days. The specimens' size are as follows 1. Cube (100 x 100 x 100 mm), 2. Cylinder (100 mm dia. & 200 mm height), 3.Impact (150 x 50 mm), 4. Impact Slab (500 x 500 x50 mm), 5. Sorptivity (100 mm dia. & 50 mm height), 6. Porosity (100 mm dia. & 50 mm height), 7. Acid curing (100 x 100 x 100 mm).

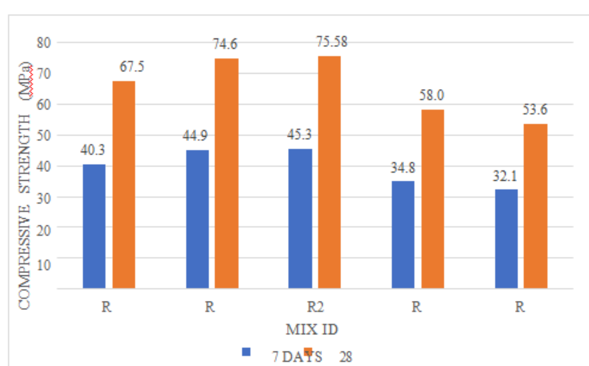
CURING:

The cubes were demoulded after 24 hours of casting. The cubes of Geopolymer concrete were kept for curing Under Ambient Curing at laboratory temperature 27 ± 2 ^{0}C for 7, 14 and 28 Days.

III. TESTING OF SPECIMEN

COMPRESSIVE STRENGTHTEST

Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analysed independently**.**



SPLITTENSILESTRENGTHTEST:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. After the curing period, the specimen is taken out from the curing tank and wipes it clean. Then the specimens are placed horizontally between the loading surface of the Compression testing machine and the load is applied till the specimens fails. The ultimate load at the time of the failure is noted down.

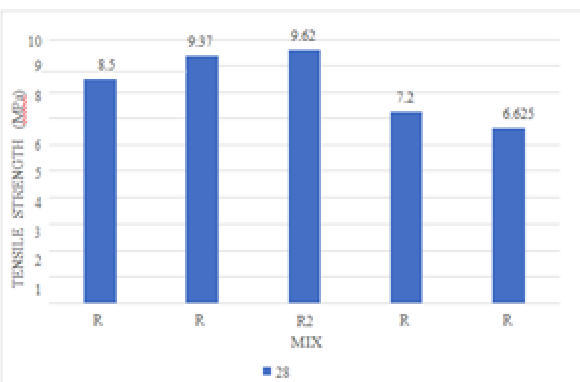
F=2P/LDinN/mm^2

Where,

P = Compressive load, D = Diameter of the cylinder.

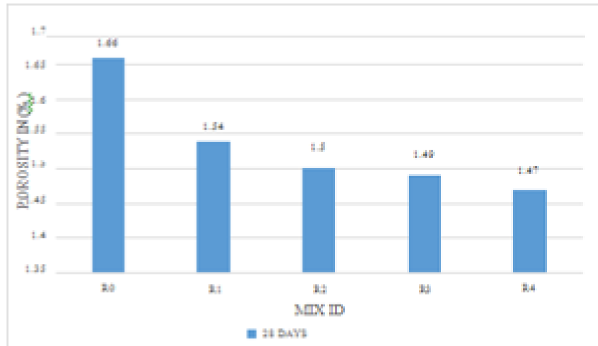
L = Length of the cylinder,

Split Tensile Strength testing



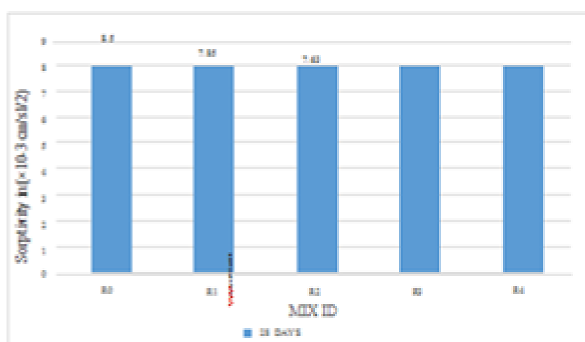
POROSITY TEST

Porosity is the number of pores in a material for instance pores in certain concrete. Porosity is usually expelled in volume percent. The porosity of concrete has influence on the properties in many aspects. Composition of concrete, casting in practice, maturing and hardening, cement reactions and risks at freezing, all are influenced by porosity. The possibilities to influence the type of porosity are important. Composition of concrete technology deals in very great extent about the porosity of concrete. Concrete consists of gravel, sand and cement, all particles, and water plus air and eventual additives. The firm substances give the concrete strength. Aggregates are cheap and therefore should fill up the space as much as possible. Therefore the particle size grading should be such that this is possible. The fine cement particles find room in spaces between the aggregate particles. More cement means that the spaces between aggregates are better filled. Consequently, more cement added, stronger concrete. Water fills the rest of the spaces.



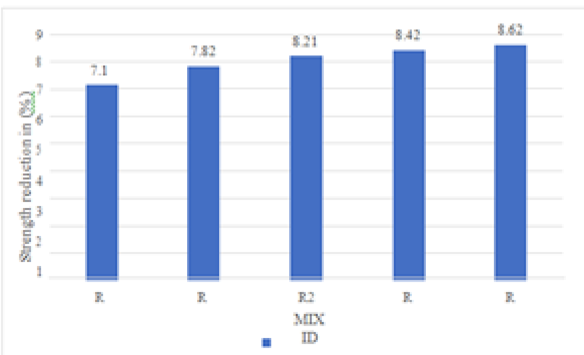
SORPTIVITY TEST

Sorptivity was used to assess the penetration of water through capillary pores from one side of the unsaturated concrete. The size of specimen tested was disc of 100 mm diameter and 50 mm thickness obtained from cylinder of size 100 mm x 50 mm by saw cutting machine. The samples were tested at the curing age of 28 days. Before testing, specimens were dried in the oven at the temperature of 105 ± 5 ^{0}C until constant mass of 0.1% was achieved between two successive readings after an interval of 24 hr. After attaining the constant mass, samples were kept in the desiccators to cool down over the period of 24 hr at temperature of 27 ± 2 ^{0}C.



ACID ATTACK TEST

After immersion in acid (H_2SO_4) solution for concrete specimens, after immersion in H_2SO_4 solution for 28 and 56 days the loss in compressive strength was determined as per ASTM standard. Fig 6.12 shows the compressive strength 5 %, 10 %, 15 %, 20 % respectively at the age of 28 and 56 days. The remaining mixes exhibited reduced compressive strength (difference) in the range of minimum 2 MPa to maximum 6 MPa indicating that 50% of strength was lost in acid solution at the age of 56- days. When acid reacts with concrete, the inter locking between the cement matrix and aggregate as C-S-H gel was broken down. The specimens kept under acid curing exhibited white patches on their surfaces. Honeycombing was also noticed on their surfaces due to acid attack.



Acid Attack

IV. CONCLUSION

Based on the study of the previous literatures regarding strength and durability properties of GGBS based geopolymer concrete with crumb rubber as a partial replacement of fine aggregate in concrete, the following conclusions can be arrived as inference.

1. Geopolymer concrete incorporating ground granulated blast furnace slag has better strength & durability performance than those incorporating flyash.
2. The acid attack test results reduction in strength between 6 to 8 % in geopolymer concrete. Geopolymer concrete performs well than normal cement concrete.
3. The highest value of the impact load resistance in concrete proved that mix R4 has increased 100% than nominal concrete mix. Due to good impact properties in steel fibre and rubber, the impact value increases with the percentage of rubber replacement.
4. The compressive strength of FR-RC is dependent on both the rubber content and steel fiber dosage, while the tensile strengths are dominated by the fiber dosage
5. The optimum percentage (R2) of replacement of rubber in fine aggregate is 10%. Further, addition of Crumb rubber above 15% in concrete, there is a decrease in strength.
6. Increase in the cumulative bleeding with the inclusion of rubber as natural sand replacement in concrete mixtures at levels of 5 %, 10 %, 15 % and 20 %, by volume. The cumulative bleeding increased as the amount of rubber replacement increased.

REFERENCES

[1] Alaa M. Rashad. (2015), A comprehensive overview about recycling rubber as fine aggregate replacement in traditional cementitious materials, *International Journal of Sustainable Built Environment*, 5, 46–82.
[2] Ali Heidari, Davoud Tavakoli. (2013), A study of the mechanical properties of ground ceramic powder concrete incorporating nano-SiO_2 particles, *Construction and Building Materials*, 38, 255–264.
[3] Ankur Mehta, Rafat Siddique (2017), Properties of low-calcium fly ash based geopolymer concrete incorporating OPC as partial replacement of fly ash, *Construction*