EXPERIMENTAL AND NUMERICAL INVESTIGATION ON RUBBERIZED GEOPOLYMER CONCRETE WITH STEEL FIBRE

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Abstract- **This project focuses on the study of sustainability to the cement – less geopolymer concrete by partially replacing fly ash by GGBS and fine aggregate with rubber crumb obtained from waste tyre. Geopolymer concrete is one of the building materials that has become more popular in recent years due to the fact that it is significantly more environmentally friendly than standard concrete. Geopolymer concrete usually includes the fly ash, fine aggregate and coarse aggregate activated by means of alkaline liquids like sodium silicate and sodium hydroxide which is effective in oven curing. For the purpose of utilizing Geopolymer concrete for the insitu applications, fly ash is partially replaced by means of Ground Granulated Blast Furnace slag which requires ambient curing conditions. Further, the rubber crumb is obtained by shredding the waste rubber tyre. By using rubber crumb in construction purpose, it reduces the exploitation of natural resources and environmental pollution. Geoploymer concrete of grade M40 with rubber crumb as a replacement of fine aggregate was studied for its strength and durability properties.**

In this study, the rubber crumb is used in various percentage such as 0%, 5%, 10% and 20% and found 10% was effective in terms of strength.

Key words: Rubberized geopolymerr concrete with steel fibre.

I. INTRODUCTION

Geopolymer concrete is an innovative and sustainable alternative to traditional Portland cement-based concrete. Traditional concrete production is a significant contributor to carbon dioxide emissions, as the manufacturing of Portland cement involves high energy consumption and releases substantial amounts of CO2. Geopolymer concrete, on the other hand, is produced by activating aluminosilicate materials with an alkaline solution, resulting in a lower carbon footprint.

For the alkaline liquid activator, potassium based or sodium based activators are used. In this study, sodium based activator was used. It is a combination of sodium hydroxide and sodium silicate solution. The sodium solution was prepared by dissolving the sodium hydroxide pellets in distilled water. After the solution reaches to the room temperature, the sodium silicate solution is added at a ratio of 1:2.5 and mixed all together. This solution was prepared a day before casting the specimens. At the end of this mixing, the alkaline solution was added to the aggregates and the mixing is continued for specified period of time. It is glossy in nature. Geopolymer are formed when various alumina and silica containing materials react under highly alkaline conditions and forms a three dimensional network of Si- O-Al-O bonds.

II.BINDER MATERIALS

In this study, 40% GGBS and 60% of Fly ash is used as a binder materials.

GGBS

Ground Granulated Blast Furnace Slag which is a by-product of iron manufacturing industry is an accepted mineral admixture for use in concrete. This granulated material when further ground to less than 45micron is called Ground Granulated Blast Furnace Slag (GGBS).

FLY ASH (CLASS F)

Low calcium fly ash (Class F) is one of the deposits produced in the burning of coal. In this work, Class F fly ash is to be used which was collected from Mettur Thermal Power Station, Salem. Generally, Class F fly ash providesgood pozzolanic activity and it contains less than 10% of lime (CaO).

III. RUBBER CRUMB

Rubber crumb are obtained from shredding the waste rubber tyres. Rubber tires after their lifespan, contain materials, which cannot be decomposed in an environment-friendly manner and lead to severe environmental problems. Rubber can be decomposed via burning, but it adversely affects the atmosphere. Alternatively, these scrap tires can be used in concrete as replacement of aggregates. The demand for tires continuously increases as the number of vehicles increases. As the scrap rubber tires are not easily biodegradable, therefore it is acute challenging for the industries to handle such waste. On the other hand, the natural aggregates used for making concrete are finite and are rapidly dwindling. The frequent use of conventional concrete also necessitates a careful selection of the constituent materials for avoiding undesirable consequences like alkali-silica or alkali carbonate reactions and many others.

FIG.1 RUBBER CRUMB

Usually, the rubber crumb is treated with the 1M NaOH solution to reduce its hydrophobic nature.

IV. ADVANTAGES OF RUBBER CRUMB

1. The use of rubber crumb can result in the production of lightweight concrete, which is advantageous in applications where weight is a critical factor, such as in precast concrete components.
2. Rubber crumb helps improve the thermal insulation properties of concrete. This can contribute to energy efficiency in buildings by reducing heat transfer through walls and floors.
3. Rubberized concrete exhibits excellent sound-absorbing properties, making it an effective material for noise reduction.
4. The inclusion of rubber crumb improves the impact resistance of concrete, making it more durable and less prone to damage from sudden impacts or heavy loads.
5. Rubberized concrete can show improved resistance to aging, reducing the likelihood of deterioration over time. This enhanced durability can contribute to longer service life for structures.

DISADVANTAGES OF RUBBER CRUMB

1. Rubber is much softer than traditional aggregates, and excessive substitution may compromise the load-bearing capacity of the concrete.
2. Rubber has a tendency to absorb moisture, which can lead to issues such as reduced freeze-thaw resistance and increased susceptibility to deterioration in wet conditions.
3. The color of rubber crumb is typically black, and incorporating it into concrete can result in a darker overall appearance.
4. The lightweight and elastic nature of rubber crumb can make it challenging to mix uniformly with concrete.

Application of rubber crumb

- High impact resistance
- Improve shock absorption
- Improve durability
- Improve flexibility and resilience

PROPERTIES OF RUBBER CRUMB

S.NO.	DESCRIPTION	VALUE
1	Specific gravity	0.54
2	Fineness modulus	2.36
3	Water absorption	-

V STEEL FIBRE

Steel Fibres are widely used in concrete based composite projects worldwide. Steel Fibres are made under strict quality control process and gives excellent strength and durability to the concrete eliminating cracking. Steel Fibre is available in stainless steel grades and also in carbon steel grades

PROPERTIES OF STEEL FIBRE

SI.NO	DESCRIPTION	VALUE
1	Length	30mm
2	Diameter	0.55 mm
3	Tensile strength	1150 Mpa
4	Aspect ratio	60
5	Specific gravity	7.85

FIG.2 STEEL FIBRE

VI. ALKALINE SOLUTION

Sodium hydroxide and sodium silicate is used in this study. Sodium hydroxide solution is prepared by dissolving sodium hydroxide pellets in distilled water.The molarity of the sodium hydroxide is taken as 12 Mol. The ratio between the sodium hydroxide and sodium silicate is taken as 1: 2.5.

VII. MIX RATIO

BINDER (Fly ash + GGBS)	FINE AGGREGATE	COARSE AGGREGATE	ALKALINITY SOLUTION (NaOH + Na2SiO3)	STEEL FIBER
Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3
408	554.4	1293.6	144	4.08
1	1.35	3.17	0.35	0.01

Reference: Fly ash based geopolymer concrete (2010)

Author: B V Rangan , Curtin university

VII. BATCHING AND MIXING

FIG.3. BATCHING

FIG.4. MIXING

VIII. CASTING

The cube and cylinder specimens where casted with different rubber crumb percentage such 5%, 10%, 15% and 20%. The steel fibre was maintained as 1% for all mix proportions. The specimens casted was tested under compression load and tensile load.

FIG.5. DEMOULDED BLOCKS

The specimens were demolded and allowed for ambient curing. The cubes and cylinders were tested on 7 and 28 days under compression and tensile load. The compression strength and tensile strength were analysed.

XI COMPRESSION AND TENSILE STRENGTH TEST

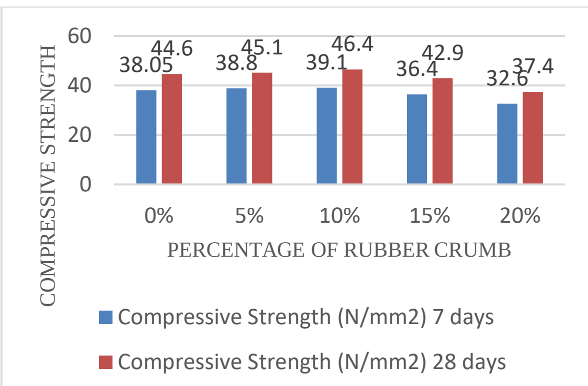

FIG.6. COMPRESSION STRENGTH

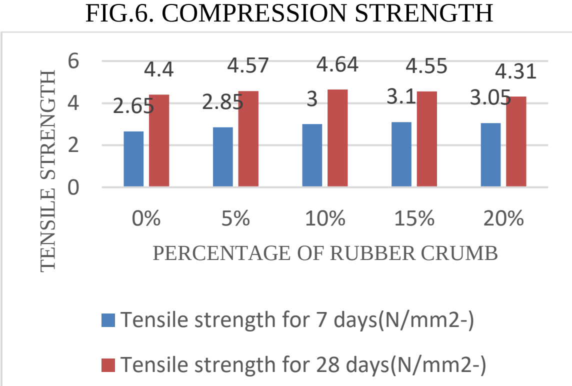

FIG.6.1. TENSILE STRENGTH TEST

XII ABAQUS MODELING

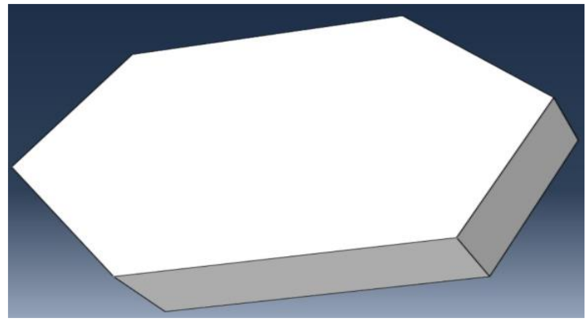

FIG.7. MODELING

The hexagonal pavement was modelled in the abaqus software with a dimension of 100 mm on all sides. The thickness of the pavement is 50 mm.

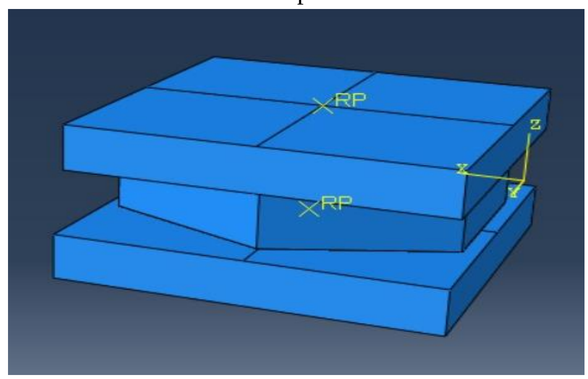

FIG.7.1. ASSEMBLING

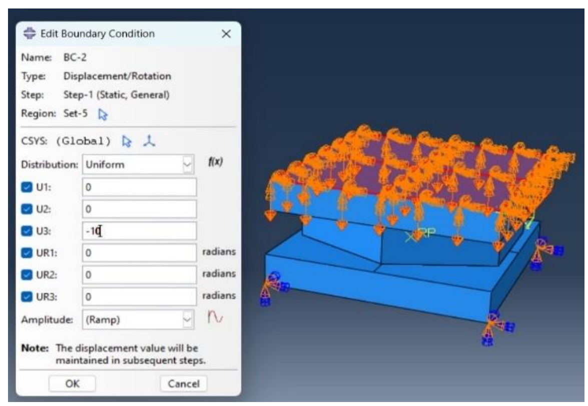

FIG.7.2. LOADING CONDITION

The pavement was placed between two plates. The bottom was fixed and the top was allowed to compressive the pavement while applying the loads.

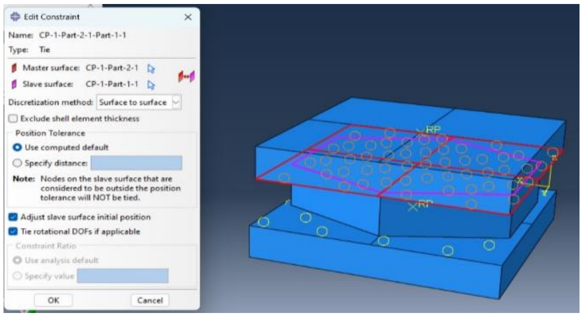

FIG.7. 3. INTERACTION PROPERTY

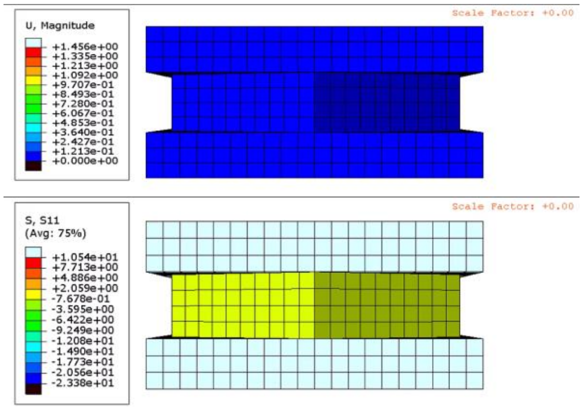

FIG.7. 4. STRESS DISTRIBUTION

CONCLUSION

The geopolymer concrete properties can be enhanced by considering the replacement of fine aggregate by 10% rubber crumb with 1% of steel fibre. From the test results, we can say that among various percentage of addition of rubber crumb by volume of fine aggregate, 10% addition of rubber crumb by volume of fine aggregate with 1% of steel fibre was found to be optimum value. The compressive strength of rubberized geopolymer concrete increased by 20% when compared to conventional geopolymer concrete. The tensile strength of rubberized geopolymer concrete increased by 6% when compared to conventional geopolymer concrete. This gives the scope that the geopolymer concrete with fine aggregate in proportion with rubber crumb can be employed in construction for better achievement of strength characteristics. The hexagonal pavement was analysed in Abaqus software.

Further work: The pavement specimens should be casted and analysed.

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