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RUBBERIZED GEOPOLYMER CONCRETE

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Abstract: **This experimental study deals with the optimization of rubberized geopolymer concrete replacing crumb rubber waste as replacement of course aggregate(CA) partially in varying proportions(5%, 10%, 15%, 20%, 25%).In this experimental study, properties of concrete like workability and mechanical properties of hardened geopolymer concrete such as compression strength,Tensile strength and flexural strength were analysed to determine the strength parameters of rubberized geopolymer concrete mix.Nowadays, the construction field is addressing the issue of integrating sustainability into the production processes for the past few years. This was done by using solid waste materials as aggregates in concrete or by looking for more environmentally friendly raw materials. Incorporating used tyre rubber into geopolymer concrete to replace natural aggregate is one of the potential uses for the material.To reduce the greenhouse gas emission caused by ordinary portlant cement,the cement is fully replaced by combination of cementitious materials like ggbs and pozzolanic materials such as flyash that have been alkali activated.To protect the construction field from the depletion of natural resources, natural sand is replaced by manufacturing sand.The paper focuses to develop a process to not only eliminates the binder like Ordinary Portland Cement, but also eliminates water curing and consumes diminished quantity of natural Sand - a product of restricted natural resources.The mix design is calculated, casted and tested at 7 days and 28 days. Obtained results were calculated and analyzed that there is a reduction in strength parameter by the increment in rubber crumb content. From 5%-25% , 15% of rubber crumbs in geopolymer shows the optimum mix when differentiate to conventional portlant cement concrete mix. Our project aims to bring out an advanced concrete material that is sustainable, economical, eco-friendly after all meeting the strength criterias for the construction industry.**

Keywords: Rubberized geopolymer concrete, Geopolymer concrete, Rubber tyre crumbs, Flyash, Ground Granulated Blast-furnace Slag (GGBS), Alkaline Activator solution.

I. INTRODUCTION

In field of construction, concrete are the most extensively utilized building material and the primary component of the concrete is Portland cement. Carbon dioxide (CO_2) emissions from cement manufacturing contributes considerably to atmosphere's green-house gases emission. A tonne of CO_2 is thought to be discharged into the surroundings for every tonne OPC production. The annual global cement output is 2.6 billion tonnes. It takes a lot of limestone to make cement, and that supply is now quickly running out. In addition, a significant amount of fossil fuel is used to the production of limestone. Alternatives to OPC are continually researched to address this issue.But a significant amount of it still poses a threat to the environment.

In order to preserve natural resources and work towards using substitute materials that don't consume a lot of energy as the leading future demands the use of sustainable and environmentally friendly construction materials and methods, while nevertheless supporting the same anticipated structure performances & constructional purposes. The main adhesive & binder in building combinations is often cement. Without sacrificing the necessary cementitious qualities, using wastes and substitute binder materials in the optimisation of materials like concrete will create reduction in greenhouse gas formation. These substitute binders emphasize combining basic components and fuel obtained from waste.The switch to employing geopolymer concrete as alternative to regular Portland-cement-concrete is one of the alternatives that has been offered that outperforms traditional concrete. Davidovits found that some primary calcinated kaolinite (flyash, ggbs, metakaolin etc), calcinated clays, may then used with alkaline solution to activated to produce products that are similar to hardened ceramics at temperatures below 100°C. Because of this finding, geopolymerization has advanced. J. Davidovits' development & research and leads for production of 1st geo-polymer cement in the 1980s, that were based on slag. Rockbased geopolymer mix, flyash-based geopolymer mix, ferrosialate based geopolymer cement mix, and Slag based geopolymer cement were the few models for the geo-polymer concrete kinds.To improve sustainability, this method was created to produce sustainabled concrete & less cement masonry utilising reprocessed resources, According to research, manufacturing geopolymer concrete creates CO_2 release which were 5x lesser than of normal cement concrete. Fly ash were among the top ingredients used to make geopolymer concrete. The advanced strength attaining property of fly-ash geo-polymer concretes showed delayed growth on addition to a reduction in the heat- of-hydration of concrete , by which it minimises thermal crack action. Fly ash configuration were particularly affluent in silicon & aluminium elements. Yet there are other techniques to accelerate the growth of strength, like employing high-temperature curing or using slag elements.The steam curing during the use of flyash can be partially substitute by adding slag content such as GGBS.

Ground-granulated blast-furnace-slag were the waste material produced from industry deals with steel. The use of hydroxides & nitrates of sodium solution by alkaline liquids retort with GGBS & fly ash for generating bonding gel polymer with aggregates for make GPC . Non-metallic substance known as "blast furnace slag" is described as mostly being composed by calcium silicates & some bases. GGBS helps to increase the compressive strength on concrete.Concrete uses sand as a fine aggregate. The most popular choice for a fine aggregate material is natural river sand. The natural weathering of rocks over millions of years produces river sand. Sand is extracted from riverbeds, and mining for it has terrible effects on the ecosystem.Sand demand grew globally as a result of the quickening urbanisation and rise of the world's population. Additionally, a higher level of living leads to more sand being consumed. It is a non-renewable material created by the breakdown of rock. An important and precious resource, sand is vital to the economics of all nations.As alternative for the natural sand introduced artificial sand called M- sand.The usage of M-sand improves and contributes to environmental sustainability by eradicating the global shortage of river sand and preventing related environmental issues like indiscriminate sand mining and soil erosion.

In present contemporary civilization, a significant growth in the automotive and industrial sectors has given rise to brand-new issues in the shape of rubber or scrap tyre waste. The rubber waste is a significant environmental issue that has a negative impact on ecosystems.Inorder to reduce the amount of waste tyres recycling methods should be practised in different ways. Utilisation of the waste recycled rubber by processing the tyres materials as a substitute in concrete has been the subject of several investigations.Our experimental study focuses on how to properly substitute waste rubber for coarse aggregate in concrete while using that material as little as possible.

Rubberized geopolymer concrete can plays an important role for the sustainable buildout of world.It not only eliminates the carbon footprints but also meet the strength parameters when compared to conventional concrete. Water usage can be minimized with contrast of normal concrete mixture. The use of rubber can reduce the dumping of waste tyres to a certain extent.By meeting all this criterias we can create a sustainable, eco-friendly,economical concrete at its best of its functionality.

II. MATERIALS AND ITS PROPERTIES

➢ *Flyash:*

The materials that include silica and aluminium are the source materials of components of geopolymer; examples include fly -ash, silica fume, GGBS, metakaolin, and ash of rice husk. Fly ash is employed as a source of data in the majority of research which act as a pozzolanic material. Fly as of, low calcium (ASTM class F) is employed as a origin material. The process of polymerization may be hampered by the high concentration of calcium present.

➢ *Ground - Granulated Blast Furnace Slag(GGBS)*

GGBS is a waste material obtained from blast furnaces used in iron industry. It have great usage in concrete as a cementitious material.They are non-metallic substance made mainly of calcium aluminates & silicates. GGBS in geopolymer concrete requires only ambient curing.It provides more compressive strength when compared to other binder materials like flyash, woodash etc.

TABLE I. CHEMICAL COMPOSITION OF FLYASH

Sl No.	Elements	Flyash(% mass)	GGBS(% mass)
1	Al_2O_3	23.40	13.8
2	SiO_2	50.00	29.2
3	K_2O	1.41	1
4	CaO	5.06	44.9
5	TiO_2	1.60	2.1
6	MnO	0.22	-
7	Fe_2O_3	17.29	5.5
8	Na_2O	-	0.3

➢ *Fine Aggregates*

Fine aggregate is defined as the material that completely retains on an IS Sieve 75 (75 microns) after passing through a 4.75 mm IS sieve. The experimental study aimed to use M sand instead of river sand.

➢ *Coarse Aggregates*

In this study 20 mm size aggregates are used as course aggregates .The course aggregates are partially substituted by rubber tyre crumbs in different proportions such as 5%, 10%, 15%, 20%. 25%.

➢ *Rubber Tyre crumbs*

Crumb rubber from automobile and truck trash tyres was used in this experiment to substitute course aggregates. When compared to mineral aggregates , unit weight of crumb rubber is low. The incorporation of crumb waste into the mixture decreased the geo-polymer concrete mixture's unit weight.The course aggregates are replaced by rubber tyre crumbs in different ratios.

➢ *Na_2SiO_3 - Sodium Hydroxide*

The solid form of sodium hydroxide is seen as flakes & pellet forms. The price of sodium hydroxide is mostly determined by the products purity. Because its primary procedure has to activate Na_2SiO_3. The least expensive were advised for use, i.e. in between 94 - 96 percentage purity. At a rate of 13 molar concentrations,ie, 623g water and 377g NaOH pellets per litre, the pellets are submerged into water. The preparation of this solution is advised to give 24 hrs of resting period and it will solidify if left more than 36 hrs.Because of this solution produced must be used before the time given.

➢ *NaOH - Sodium Silicate*

Sodium silicate is a liquid gel like substance that is accessible , also named as liquid glass/ water glass.

III. MIX PROPORTIONING

M30 Grade rubberized geopolymer concrete is designed here. Mix proportions for various mixes is designed below:

TABLE II. MIX DESIGN PROPORTION OF M30 GRADE RGPC FOR CUBE

Mix	Fly ash	GGBS	NaOH	Na_2SiO_3	FA	CA	Rubber
MIX 1	0.928	0.759	0.294	0.735	1.7	3.89	0.205
MIX 2	0.928	0.759	0.294	0.735	1.7	3.69	0.410
MIX 3	0.928	0.759	0.294	0.735	1.7	3.48	0.615
MIX 4	0.928	0.759	0.294	0.735	1.7	3.28	0.820
MIX 5	0.928	0.759	0.294	0.735	1.7	3.07	1.025

TABLE III. MIX DESIGN PROPORTION OF M30 GRADE RGPC FOR CYLINDER

Mix	Flyash	GGBS	NaOH	Na_2SiO_3	FA	CA	Rubber
MIX 1	1.45	1.192	0.461	1.154	2.7	6.12	0.322
MIX 2	1.45	1.192	0.461	1.154	2.7	5.79	0.644
MIX 3	1.45	1.192	0.461	1.154	2.7	5.47	0.966
MIX 4	1.45	1.192	0.461	1.154	2.7	5.15	1.288
MIX 5	1.45	1.192	0.461	1.154	2.7	4.83	1.610

IV. EXPERIMENTAL PROGRAM

➢ *Slump cone test for determine workabiility*

The slump value gives out the workability features for a given concrete mix. It reflects the ability of the concrete to flow and consolidate. The factor, such as aggregate shape, grading, and water content, can influence the concrete's workability & performance. Test were carried out on mould having dimensions 100mm 200mm 300mm and and analysed on different mixes having crumb rubber proportions from 5% to 25%.

Fig. 1. Slump cone test

➢ *Rebound Hammer Test*

To determine the hardness or compressive strength of rock or concrete,the rebound hammer testing is used as a non destructive method. To determine the cube strength and rebound number, a set of rubberized geopolymer cube concrete measuring 150mm dimensions were cast & ambient cured at 7 and 28 day. In this experiment, M30 concrete grade were used. The goal strength should be at least 30 MPa after 28 days.

Fig. 2. Rebound hammer test

➢ *Compressive Strength Test*

Concrete that has been casted on 150mm x 150mm x 150mm is subjected to compressive strength test on the UTM. The cubes of 7 days and 28 days of age are examined using compressive testing machine.

Fig. 3. Compressive strength Test

➢ *Tensile Test*

The test for tensile strength is carried out in cylinder measuring 150mm x 300mm dimension. The experiment is carried out on the UTM for determine split tensile strength for geopolymer concrete. The cylinders are evaluated at 7 and 28 days of age.

Fig. 4. Tensile strength Test

➢ *Flexural Strength Test*

A flexural strength test is assessed to determine the bending ability of a material.It is performed on a beam sample with the measurements 500mm x 100mm x 100 mm.This test is performed under 3 point loading conditions.

V. RESULTS AND DISCUSSION

➢ *Slump - Cone Test*

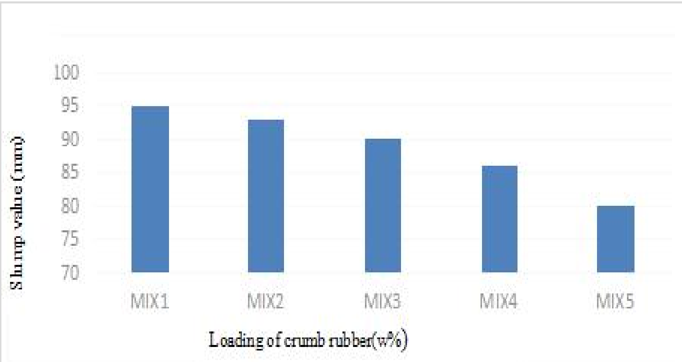

Fig. 5. Graph showing loading of crumb rubber v/s slump flow value

The workability of different mixes of rubberized geopolymer concrete is tested using slump cone test.The test is carried out using mould having dimension 300mm height,200mm bottom dia, and 100mm top dia. It is found out there have a decrease on slump value on concrete mix by the increase of rubber crumb ratio and thereby decrement of workability characteristics. The 15% partial replacing of CA with rubber crumbs have better workability when analysed with portland cement concrete of grade M30.

➢ *Compression - Strength Test*

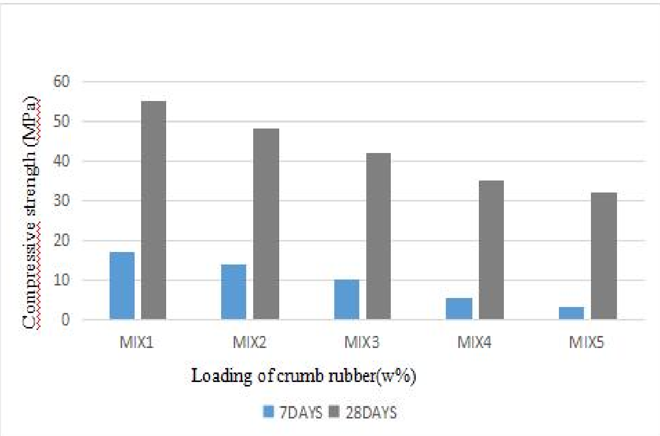

Fig. 6. Graph showing loading of crumb rubber v/s Compressive strength

The given graph shows the compressive strength for the 5 distinct mortar specimen mix cured at 7, 28 day at ambient temperature. These samples include varying amounts of rubber crumbs in geopolymer concrete. The rubber aggregate is utilised as substitute for course aggregate at 5%, 10%, 15%, and 20%, 25% respectively. Generally, the strength of geopolymer concrete decreases as there is an increase in rubber ratio. As the rubber proportion of rubberied geopolymer concrete increases, so does it's compressive strength gradually reduces.Although the addition of crumb rubber produces a reduction on compressive strength, geopolymer concrete still maintains strength criteria of concrete grade M30 when compared to the ordinary concrete mix.

➢ *Tensile - Strength Test*

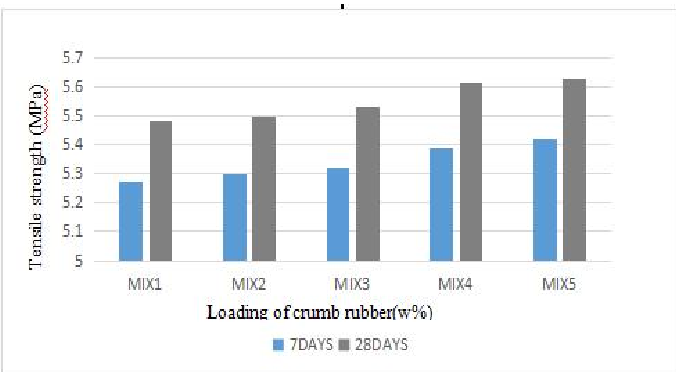

Fig.7. Graph showing crumb rubber v/s tensile strength

The tensile-strength test is used for determine ductility of concrete. Factors influencing crumb rubber inclusion in concrete include course aggregate replacement percentage and aggregate size.The test were carried out for rubber crumb ratio of 5% to 25% using universal testing machine. It is found out that the durability of rubberized geopolymer concrete rises with increment in the rubber amount. The split tensile strength steadily improves as the proportion of rubber fibre increases from 5% to 25%.

➢ *Flexural - Strength Test*

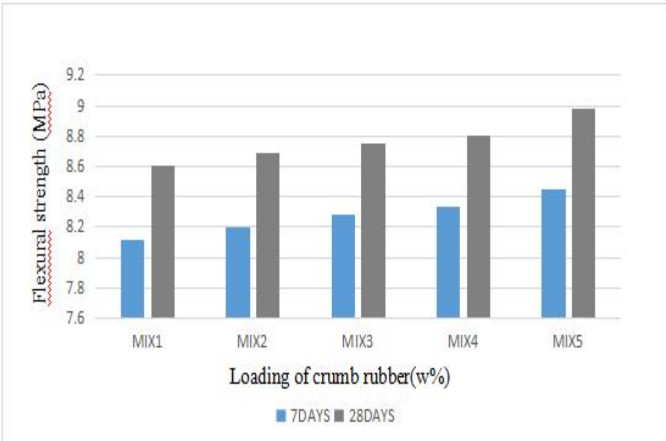

Fig.8. Graph showing loading of crumb rubber v/s Flexural strength

Flexural strength on the geopolymer concrete mix is executed on specimen having dimension 500mm × 100mm × 100mm. The specimen is tested in 7 and 28 day to findout its strength. It is found out that with increase in crumb rubber proportions, there is an flexural strength is gradually increasing for the geopolymer concrete mixes.

VI. CONCLUSION

- According to the result of this study, the aggregates on concrete made of rubberized geopolymer concrete is substituted by adding varied ratio of rubber tyre crumbs with , 5%, 10%, 15%, 20% and 25%.
- The workability of concrete mix reduced with increasing of the rubber ratio.
- It is found that varied amount of rubber content in concrete mix has an impact in compression strength. The results of this study shows that crumb rubber may be easily blended into geopolymer paste. But compressive strength of concrete reduced as there is an increase in the rubber ratio.
- When crumb rubber content increases, the split tensile strength increases. This is due to the high modulus of elasticity characteristics of crumb rubber.
- Partial usage GGBS as binder material helps to eliminate water and oven curing.It only require ambient air curing.
- The replacement of cement by GGBS and flyash helps to reduce the carbon footprint caused by construction purposes.
- The substitution of rubber tyre wastes as course aggregates results in the recycling of waste material rubber thereby reducing the environmental pollution.
- The use of rubber crumbs for enhancing compression strength of concrete is not feasible. This might be attributed to improper crumb rubber bond with the mix, as well as the existence of void spaces in the concrete.
- GGBS helps to increase compressive strength as distinguish to conventional concrete mix.
- Inspite of the fact that adding of rubber in the geopolymer concrete mix should not result in a considerable increase on its strength, it still can be used for a variety of other constructional applications
- As conclusion of this experimental study by comparing all the experiments, it is found out that, out of the 5 mixes,the combination with 15 % of rubber replacement made out the optimal mix for the construction purposes.

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