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Experimental on Partial Replacement of Cement with (GGBS) and Partial Replacement of course Agreement with Rubber Pallets.

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ABSTRACT

The high consumption rate of raw materials by the construction sector, results in chronic shortage of building material and the associated environmental damage. In the last decade, many research on the utilization of waste products in concrete in order to reduce the utilization of natural available resource have been undertaken. Thus, in this project we have tried to use those waste products and replace cement partially by ground granulated blast furnace slag (GGBFS) and coarse aggregate by rubber pallets. The aim is to experimentally determine how would GGBS & Rubber pallets would affect the compressive strength of concrete when used in different proportions of GGBS 20%, 30% & 50%, & Rubber pallets 5%, 10%, 15%. This experimental investigation supports the potential use of GGBFS and rubber pallets as partial replacement in concrete production, contributing to eco-friendly and resource efficient construction practice.

Keywords: - GGBFS and rubber pallets.

I. INTRODUCTION

In recent decades, worldwide growth of automobile industry and increasing use of car as the main means of transport have tremendously boosted tyre production. This has generated massive stockpiles of used tyres. In the early 1990s, extensive research projects were carried out on how to use used tyres in different applications. Scrap tyre is composed of ingredients that are non-degradable in nature at ambient conditions. They usually produce environmental mal-effects. Each year, India produces almost 1 billion waste tyres, or about one tyre per individual. This is a major concern for the planet and its population. Concrete has been the major instrument for providing stable and reliable infrastructure since the days of Greek and roman civilization. Concrete is the most worldwide used construction material. The increase in demand of concrete more the new method and materials are being developed for production of concrete. Ground Granulated Blast Furnace (GGBS) is a byproduct from the Blast furnace slag is a solid waste discharged in large quantities by the iron and steel industry in India. These operate at a temperature of about 1500 degree centigrade and are fed with a carefully controlled mixture of iron-ore, coke and limestone.

Advantages of GGBS and rubber pallets:

1. GGBS is an industrial byproduct, and its use reduces the environmental impact of cement production (which is energy-intensive and emits a large amount of CO_2).
2. Rubber pallets, typically made from recycled tires, help reduce non-biodegradable waste in landfills.
3. GGBS and recycled rubber materials are cheaper than traditional materials, including overall construction cost.
4. GGBS improves the long-term strength, sulfate resistance, and durability of concrete, particularly in aggressive environments.
5. Rubber pallets are lighter than natural aggregates, which can reduce the dead weight of structures and benefit seismic design.

Disadvantages of GGBS and rubber pallets:

1. Replacing of cement with GGBS may reduce early strength (although it improves later strength).

2. Rubber aggregates can significantly reduce the compressive strength of concrete due to poor bonding with the cement matrix.
3. Rubber particles may reduce workability and require the use of plasticizers or superplasticizers.
4. Consistency in the properties of GGBS and rubber materials can vary, affecting the uniformity of concrete.
5. Rubber does not bond well with cement paste, leading to potential durability issues, particularly in high-load structural applications.

II. LITRATURE REVIEW

1. T. Vijayagowri, P. Sravana, P. Srinivasa Rao (2014). "Studies on strength behaviour of high volumes of slag in concrete Investigated the Effects on compressive strength"[1]

Author used 50% GGBFS As replacement material of cement an also used various water/binder ratio are 0.55, 0.50, 0.45,0.40, 0.36, 0.32, 0.30 and 0.27. author observed that the strength gain by replacement of slag is Inversely proportional to the water/ binder ratio and slag concrete gains appreciable amount of strength at later ages (90 days onwards). author found out that the strength of high volume of Slag concrete is more at later ages because rate of hydration of slag with Ca-(OH)2 and water is Slow.

2. Reshma Rughooputh and Jaylina Rana (2014) "Partial replacement of cement by ground granulated blast furnace slag in concrete". [2]

Studied the effects on various properties of concrete including compressive strength, Tensile strength, splitting strength, flexure strength, modulus of elasticity, drying shrinkage and initial surface absorption by partial replacement of OPC by GGBFS on.

3. Santosh Kumar karri, G.V. Rama Rao, P. Markandeya Raju (2015) "Partial replacement of cement with GGBS in concrete". [3]

Researched by using 30%, 40% And 50% as cement replacement levels and cured the specimens of M20 and M40 grade of Concrete for 28 and 90 days. author tested various properties of concrete and found that the compressive strength and tensile strength of mortar mixes with slag when determined at the ages of 7, 14, 28 and days decreases at early ages of curing (3 and 7 days).

4. Santosh Kumar karri, G.V. Rama Rao, P. Markandeya Raju (2015) "Partial replacement of cement with GGBS in concrete". [4]

Researched by using 30%, 40% And 50% as cement replacement levels and cured the specimens of M20 and M40 grade of Concrete for 28 and 90 days. author tested various properties of concrete and found that the compressive strength and tensile strength of mortar mixes with slag when determined at the ages of 7, 14, 28 and days decreases at early ages of curing (3 and 7 days).

5. Yogendra O. Patil, Prof P.N. Patil, Dr, Arun Kumar Dwivedi (2013). "GGBS as partial replacement of OPC in cement concrete". [5]

Researched on the effects on Compressive strength and flexural strength of concrete when cement is partially replaced with Various percentages of GGBS. The tests were conducted with replacement ranging from 10 % To 40 % at 7, 28 and 90 days. It was observed that the strength of concrete is inversely proportional to the percentage of replacement of cement with GGBS.

6. Reza Hassanli, et.al. (2019) "Influence of mixing procedures, rubber treatment, and fibre additives on rub Crete performance". [6]

As the percentage of rubber used rises, the compressive strength, split tensile strength, and flexural strength are seen to decrease. The compressive strength was reduced by 30 %, 34 %, and 43 %, respectively, when 15 %, 20% and 30% rubber was used. The indirect tensile strength was reduced by 14.5% and 28.5% respectively, when 15% and 30% rubber content were used, while the flexural strength was reduced by 17% when 20% rubber content was used.

7. C.Sabeer Alavi, I. Bhaskar, R. Venkata Subramani (2013). "Strength and durability characteristics of GGBFS based SSC". [7]

'Studied the effects of partial replacement of cement with 10 - 50% of GGBFS and found that 30% GGBFS replacement is good as beyond that the compressive strength starts decreasing 'Studied the effects of partial replacement of cement

with 10 - 50% of GGBFS and found that 30% GGBFS replacement is good as beyond that the compressive strength starts decreasing.

8. "STRENGTH AND DURABILITY STUDIES ON CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY GGBS" BY MOHANKUMAR R, R. SRINIVAS RAJU, DR. V RAMESH (2017). [8]

The study they had used M40 grade of concrete. Cement is replaced in 20%, 35%, and 50% to the original dry weight with GGBS. They carried out various tests on M40 concrete viz. compressive strength, split tensile strength, flexural strength on the 7th,14th and 28th day from the day of cube casted. The cured each cube of every combination under normal curing, base curing and acid curing.

9. T R MORE, et.al. (2015) "strength appraisal of concrete containing waste tyre crumb rubber". [9]

The findings demonstrate show that adding recycled crumb rubber aggregates to a standard concrete mix reduces the workability of the various mix samples. When 3 percent sand is replaced by crumb rubber aggregates, the flexural strength of concrete drops by around 40%, and the strength drops even more as the amount of crumb rubber aggregates increases.

10. Sulagno Banerjee, et. al. (2019). "Studies on Mechanical Properties of Tyre Rubber Concrete". [10]

It is advised that 5-10% of waste tyre rubber aggregate be replaced with coarse aggregate, which is the best replacement in concrete composites.

11. L A Khan, et.al (2019) "Experimental Study on Mechanical Properties of Concrete Using Chipped Rubber Aggregates and Silica Fume". [11]

When 10% of the silica fume is replaced with cement and 2.5 percent of the rubber aggregate is replaced with coarse aggregates, the compressive strength of the concrete increases. To achieve the best split tensile strength of concrete, 10% silica can be replaced with cement and 2.5 percent rubber aggregates can be replaced with coarse aggregates.

12. S.A. A. Mustafa, et. al. (2020) "Rubberized concrete properties and its structural engineering applications". [12]

When compared to standard concrete mixtures, rubberized concrete has a lower compressive strength. If the total aggregate material is replaced with rubber at a rate of less than 20%, the loss in compressive strength can be tolerated.

13. Prof. (Dr) J. Bhattacharjee, et. al. (2020) "Experimental study of use of crumbed rubber in concrete". [13]

When compared to regular concrete, the compressive strength of crumb rubber concrete at 10% rubber mix with fine aggregate is practically good. We may utilize the rubber to replace 10% of the fine aggregate and achieve strength of more than 65 percent of compressive strength after 7 days and 99 percent after 28 days.

14. J. Jeya Arthi et.al "Partial Replacement of Cement by Ground Granulated Blast-Furnace Slag in Concrete". [14]

Concrete making is continuously seemed for additional cementitious material with the purpose of dropping the throws away solid difficulty. This project studies the inspection attempts about the probability by means of nearby accessible GGBS as partial replacements for cement in concrete. The tests such as compressive, split tensile and flexural strength were done in Cubes, cylinder and beam. Ground Granulated Blast Furnace Slag can recover the stability characteristic to control mix. Amongst the various mixes the substitute level as 0%, 10%, 20% and 30% of Ground Granulated Blast Furnace Slag is improved with respect to strength and durability.

15. Atul Dubey et.al. (2012) "Effect of blast furnace slag powder on compressive strength of concrete". [15]

The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming, hence it is inevitable either to search for another material or partially replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Concrete property can be maintained with advanced mineral admixtures such as blast furnace slag powder as partial replacement of cement 5 to 30%. Compressive strength of blast furnace slag concrete with different dosage of slag was studied as a partial replacement of cement.

16. V. Vinod et.al. (2017) "Study on Strength Properties of Concrete By Partially Replacing Cement With GGBS". [16]

Concrete is the most widely used material in the construction industry. Possessing high strength and stability, concrete is also an economical building material. The cement required in the concrete leaves enormous carbon foot print which shows an alarming impact on the global environmental conditions. Hence, there is a requirement of some material which can be

effective in supporting cement when added along with it shows similar characteristics. Ground granulated blast furnace slag (GGBS) is found to be one such material which has similar characteristics when mixed with cement. GGBS is a waste material which is required to be disposed. Instead, it can be used as a supporting material to cement in certain proportions to reduce the amount of cement in constructions in order to cut down the adverse effects on the environment. The principal objective is to study the strength properties of concrete by partially replacing cement with GGBS.

17. Syed Asif Ali et.al (2014) "Experimental Study on Partial Replacement of Cement by Fly ash and GGBS". [17]

This paper presents a laboratory investigation on optimum level of Fly ash and Ground Granulated Blast Furnace Slag (GGBS) as a partial replacement of cement to study the strength characteristics of concrete. Portland cement was partially replaced by 5%, 6%, 7%, 8%, 9%, 10% of GGBS and Fly ash by 20%, 40%, 60% respectively. The water to cementations materials ratio was maintained at 0.45 for all mixes. The strength characteristics of the concrete were evaluated by conducting Compressive strength test, Splitting Tensile strength test and Flexural strength test. The compression strength test was conducted for 7days and 28days of curing and split tensile strength test and flexural strength test were conducted for 28days of curing on a M25 grade concrete. The mix proportion M25 was found to be 1:1.36:2.71.

18. "STUDIES ON OPTIMUM USAGE OF GGBS IN CONCRETE" BY M. RAJARAM, A. RAVICHANDRAN, A. MUTHADHI. (2017). [18]

This research paper investigates the effect of ground granulated blast furnace slag (GGBS) on the properties of concrete of m25 grade. The study was conducted by preparing concrete mixes with 0%, 5%, 20%,35% and 50% GGBS replacement of cement. The compressive strength, split tensile strength, and flexural strength were evaluated at 7, 14, and 28 days. The study found that the test results for each test decreases with an increase in the percentage of GGBS replacement. However, the study also revealed that there is an optimum percentage of GGBS replacement for each grade of concrete, beyond which the strength properties decline significantly. Based on the results, the optimum replacement percentage of GGBS for M25 grade concrete was found to be 20% for 28-day compressive strength.

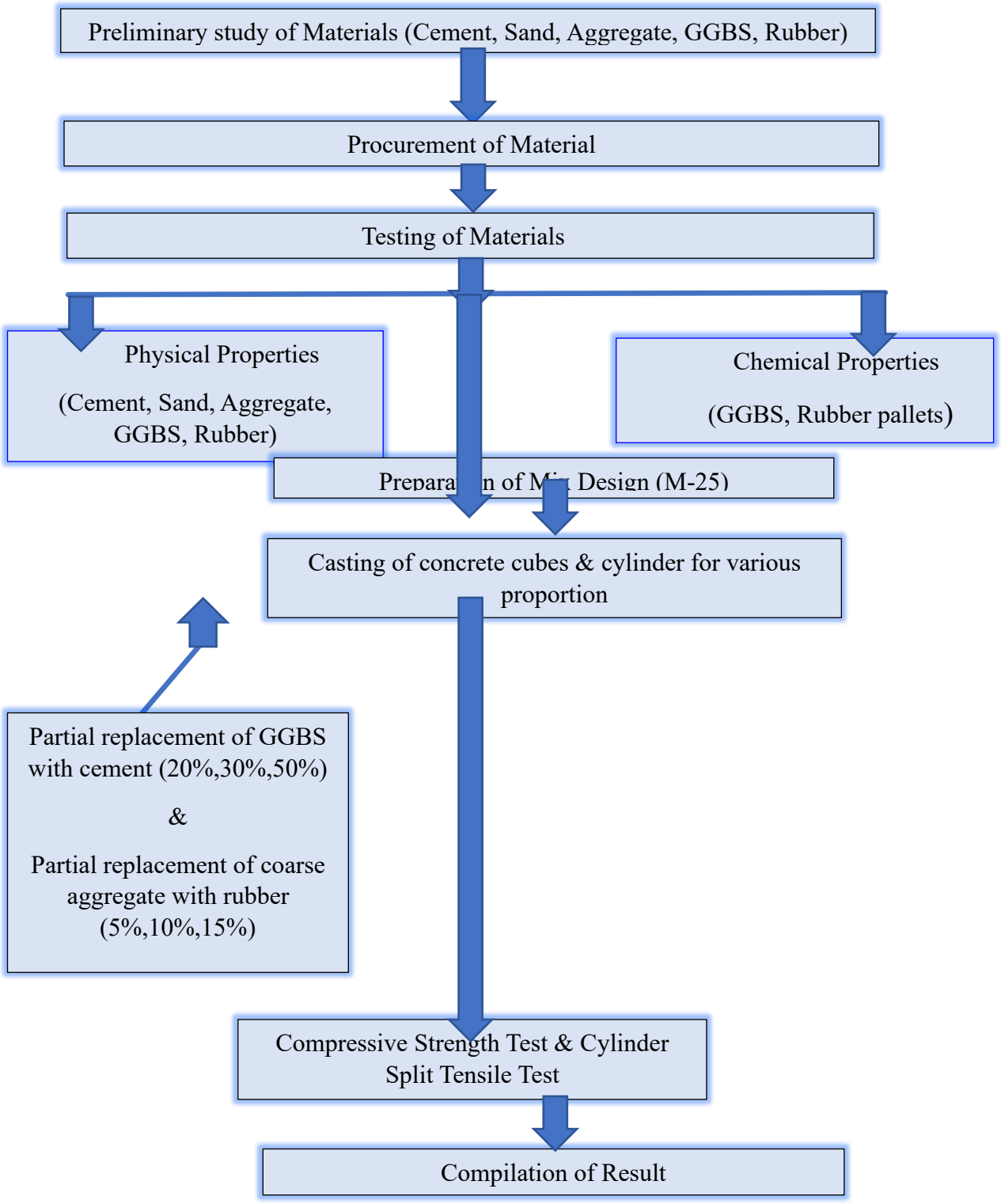
19. "STUDY ON COMPRESSIVE STRENGTH OF CONCRETE ON PARTIAL REPLACEMENT OF CEMENT WITH GROUND GRANULATED BLAST FURNACE SLAG (GGBS)" BY RATHOD RAVINDER, K. SAGARIKA, K. DEEPTHI, P. ALEKYA REDDY, R. SPANDANA, S. SRUTHI. (2018). [19]

The research paper titled "Study on Compressive Strength of Concrete on Partial Replacement of Cement with Ground Granulated Blast Furnace Slag (GGBS)" examines the effect of GGBS on the compressive strength of concrete. The study was conducted by preparing concrete mix by GGBS replacement of cement to 50%. The compressive strength of the concrete was evaluated at 7, 14, and 28 days. The study found that the compressive strength of concrete is less on the 7th day as compared to conventional concrete but it is found that the compressive strength is more on the 14th and 28th as compared to conventional concrete mix of M30 grade.

20. "EFFECT OF ADDITION OF FLYASH AND GGBS ON CEMENT CONCRETE IN FRESH AND HARDENED STATE" BY B K VARUN, HARISH B. A. (2018). [20]

This research paper investigates the effect of fly ash and GGBS on the properties of cement concrete in both fresh and hardened states. The study was conducted by preparing concrete mixes with varying percentages of fly ash and GGBS, ranging from 0% to 60% replacement of cement. The study was carried out on the M30 grade of concrete. the tests were conducted on 28th day, 56th day and 90th day from the day of specimens casted. The properties of the concrete were evaluated in terms of compressive strength, workability, and durability. The study found that the addition of fly ash and GGBS improved the workability of the concrete mix and also resulted in an increase in compressive strength. However, the addition of fly ash and GGBS beyond a certain percentage resulted in a decrease in compressive strength.

III. METHODOLOGY



IV. MATERIAL USED

1. Cement
2. Sand
3. Aggregate
4. GGBS
5. Rubber pallets

Cement: - A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (Aggregate) together. Cement mixed with fine aggregate produce mortar for masonry or with sand and gravel, produce concrete.

Sand: - Sand serves as a key fine aggregate in concrete, playing a vital role in its strength, workability, and durability. It fills the voids between larger coarse aggregate (like gravel) and helps create a more homogeneous and cohesive mix.

Aggregate: - Aggregate in concrete serve several crucial purposes, primarily providing bulk and contributing to the materials strength, durability, and stability. They also influence the overall weight and density of the concrete mix.

Ground granulated blast furnace slag (GGBS): - It's a cementitious material used in concrete, primarily as a partial replacement for Portland cement. It's a by-product of steel making process where molten iron slag is quenched in water to form granules, which are then ground into a fine powder.

Rubber pallets: - Rubber is used in concrete primarily as a replacement for traditional aggregate (sand and gravel) in what's called rubberized concrete (RUC) or crumb rubber concrete (CRC). This is achieved by incorporating recycled rubber, often from tires, into the concrete mix.

V. MIX DESIGN

Sample name	Cement (kg/m^3)	GGBS (kg/m^3)	Sand (kg/m^3)	Aggregate (kg/m^3)	Rubber (kg/m^3)	Admixture (kg/m^3)	Water (kg/m^3)
M-25	350.507	-	778.640	1131.523	-	3.92	157.728
G20-R5%	280.405	70.101	778.640	1074.945	23.833	3.92	157.728
G20-R10%	280.405	70.101	778.640	1018.369	47.664	3.92	157.728
G20-R15%	280.405	70.101	778.640	961.793	71.497	3.92	157.728
G30-R5%	245.354	105.152	778.640	1074.945	23.833	3.92	157.728
G30-R10%	245.354	105.152	778.640	1018.369	47.664	3.92	157.728
G30-R15%	245.354	105.152	778.640	961.793	71.497	3.92	157.728
G50-R5%	175.253	175.253	778.640	1074.945	23.833	3.92	157.728
G50-R10%	175.253	175.253	778.640	1018.369	47.664	3.92	157.728
G50-R15%	175.253	175.253	778.640	961.793	71.497	3.92	157.728

VI. MIX PROPORTIONS OF CONCRETE

M-25 Concrete mix is a combination of cement, sand, aggregate, water & sometimes other additives. The proportions of these ingredients determine the concrete strength, durability, workability, & finish.

Fig. No. 1. Concrete Mix

VII. CAST SAMPLE

Casting: - Concrete casting is the process of pouring liquid concrete into a Mold to create a specific shape. It's used in many construction projects from small garden paths to large infrastructure like bridges and skyscrapers. Concrete cubes size is usually 150 mm X 150 mm X 150 mm & Concrete cylindrical size are 150 mm X 300 mm.

Fig. No. 2. Cubes casting

Curing: - Concrete curing is the process of maintaining the right moisture and temperature for concrete to hydrate, which is a chemical reaction between water and cement. Curing concrete cubes & cylinders is important because it helps the concrete to develop its designed properties, such as strength, durability, and water resistance.

Curing process: - After pouring concrete into Molds, the cubes & cylinders are left to set for 24 hours. Then, they are submerged in water for curing until the test day for 7 & 28 days. Curing compounds can help prevent shrinkage cracking by reducing the evaporation of water from the concrete.

Fig. No. 3. Cubes curing

Fig. No. 4. Cylinders curing

VIII. TEST AND RESULTS

Workability Test: - A concrete workability test measures how easily concrete can be mixed, compacted, placed, & finished. Concrete workability is important because it helps ensure that the concrete is consolidated properly, which reduces the risk of voids, honeycombing, & cold joints.

Slump Test: - A popular test that measure the consistency of fresh concrete by removing a standard cone and measuring how much the concrete slumps. This test is inexpensive, quick, and can be used in the field.

Fig. No. 5. Measuring slump

Test on fresh concrete to check workability: -

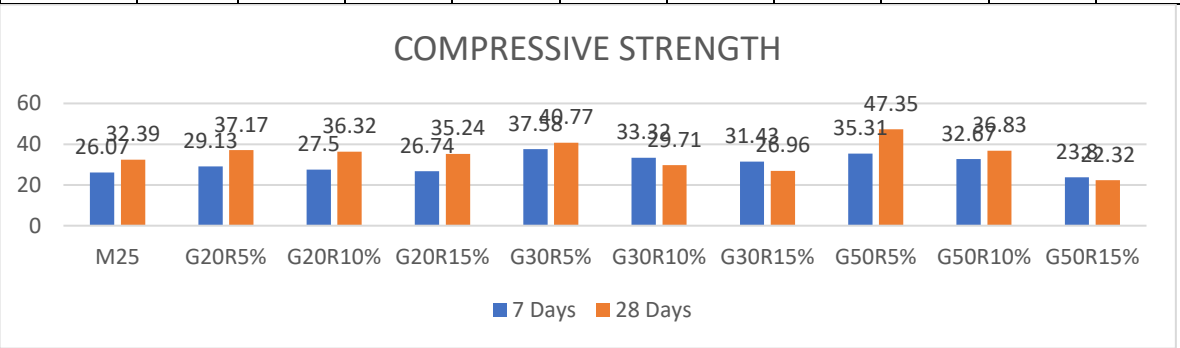
Sr.No.	Date	GGBS & Rubber Pallets	Slump	Time	Slump	Time
	16/11/24	-	110 mm	5 min	50 mm	40 min
2	15/12/24	G20R5%	100 mm	5 min	50 mm	35 min

3	03/01/25	G20R10%	115 mm	5 min	50 mm	40 min
4	03/01/25	G20R15%	115 mm	5 min	50 mm	40 min
5	23/12/25	G30R5%	125 mm	5 min	50 mm	45 min
6	26/02/25	G30R10%	105 mm	5 min	50 mm	35 min
7	02/03/25	G30R15%	120 mm	5 min	50 mm	50 min
8	29/12/25	G50R5%	115 mm	5 min	50 mm	40 min
9	23/02/25	G50R10%	125 mm	5 min	50 mm	50 min
10	02/03/25	G50R15%	110 mm	5 min	50 mm	40 min

Fig. No. 7. Slump cone test

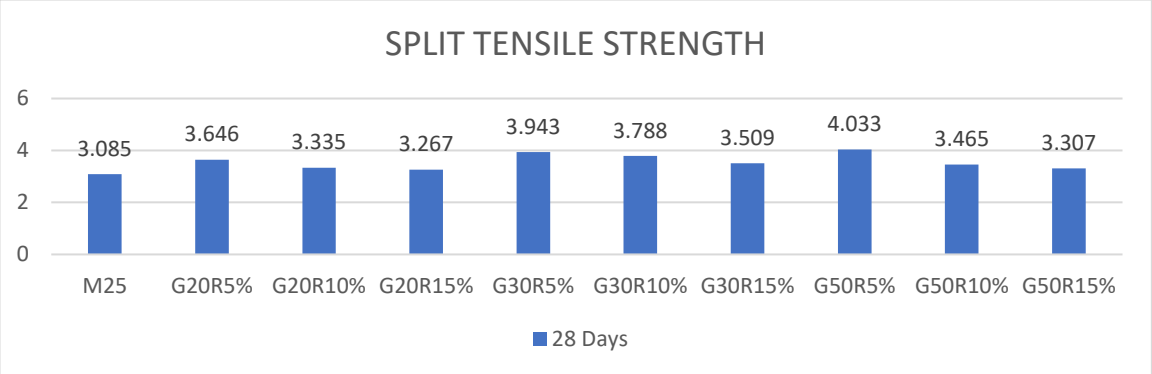
Compressive strength test: - A compressive strength test assesses a materials ability to withstand pressure without failing. It's a critical quality control method in concrete construction, ensuring structures can handle loads and maintain durability.

Days	**Compressive strength test (N/mm^2).**									
7 Days	26.07	29.13	27.50	26.74	37.58	33.32	31.43	35.31	32.67	23.80
28 Days	32.39	37.17	36.32	35.24	40.77	29.71	26.96	47.35	36.83	22.32



Split tensile strength test: - A method for determining the tensile strength of concrete by applying compressive force to a cylindrical specimen, causing it to split along a vertical plane.

Days	**Split tensile strength test (N/mm^2).**									
28 Days	3.085	3.646	3.335	3.267	3.943	3.788	3.509	4.033	3.465	3.307



IX. CONCLUSIONS

1. Replacement of cement by 50% GGBFS helps to reduce the cement Content of concrete, thereby reducing the cost of concrete and also protecting the environment from pollution.
2. Replacement ranging from 30 % to 50% at 7 and 28 days. It was found that Compressive strength is increase at the early age but lower after the later age time.
3. The result shows the marginal reduction of 4 – 6 % in compressive strength for 28 days curing with replacement of OPC by GGBS up to 20%
4. It's concluded that, the cost of concrete reduces at the current market rate by 14% by 20% replacement of OPC with GGBS.

5. The results we can see that for compressive strength, 20% of cement replacement with GGBS gives best results.
6. The concentration of rubber at the top surface is greater due to the lower specific gravity of rubber particles compared to fine aggregates.
7. Concrete cubes were prepared by replacing the cement with GGBS in three different proportions (20%, 30%, and 50%) & rubber with aggregate in three different proportions (5%, 10%, and 15%).
8. The cubes casted with the above proportions have been tested for the compressive strength & split tensile strength the values obtained were compared with those of control specimens at the end of 7- and 28-days curing periods.
9. Its concludes that the use of GGBS in concrete can improve its durability and reduce the amount of cement used, but its replacement percentage should be optimized to achieve the desired strength properties.
10. The study concludes that the use of GGBS as a partial replacement for cement can reduce the carbon footprint of concrete and also improve its long-term durability.
11. Tyres with a weight of more than 15% tend to weaken the bonding between cement and aggregate, resulting in a reduction in strength.
12. The usage of waste tyre rubber aggregates addresses a number of difficulties, including reducing the environmental risks posed by waste tyres.

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