# Experimental investigation of behavior of concrete under partial replacement of GGBS & Crum tyre.

[1]Prof. Kshirsagar S.R., [2]Pranav Shirore, [3]Nayan Sonawane, [4]Sahil Pagar

*[1]Professor, [234] Students BE Civil Engineering Student, Sanghvi College of Engineering.*

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**Abstract –** *Concrete is the most widely used construction material; however, the excessive consumption of cement contributes significantly to environmental pollution and depletion of natural resources. In recent years, sustainable alternatives such as Ground Granulated Blast Furnace Slag (GGBS) and waste tyre rubber crumb have gained attention for partial replacement in concrete. This study presents an experimental investigation on the behavior of concrete incorporating partial replacement of cement with GGBS and fine aggregate with tyre crumb. In this research, concrete mixes are prepared with varying percentages of GGBS as a cement replacement material and tyre crumb as a partial substitute for fine aggregates. The mechanical properties such as compressive strength, split tensile strength, and flexural strength are evaluated at different curing periods. Workability tests are also conducted to assess the fresh properties of concrete. The results indicate that the inclusion of GGBS enhances long-term strength and durability due to its pozzolanic properties, while the addition of tyre crumb improves ductility and energy absorption capacity but may reduce strength at higher replacement levels. An optimum combination of GGBS and tyre crumb is identified, which provides a balance between strength and sustainability.*

## 1. INTRODUCTION

Concrete plays a major role in modern construction because of its strength and long service life. However, the production of cement releases a large amount of carbon dioxide, which affects the environment. At the same time, disposal of industrial waste like slag and used tyres is becoming a serious issue.

### 1.1 General

Ground Granulated Blast Furnace Slag (GGBS) is a waste material obtained from the steel manufacturing process. It has properties that allow it to act like cement when mixed with water and other materials. Using GGBS in concrete can reduce cement usage and improve durability. Similarly, waste tyres can be processed into small rubber particles called tyre crumb, which can be used in concrete instead of a part of sand.

This project studies how concrete behaves when cement is partially replaced with GGBS and sand is partially replaced with tyre crumb. The aim is to check whether these materials can be used effectively without reducing the quality of concrete, while also helping in waste management and environmental protection.

Concrete is a basic and essential material used in almost every type of construction work. It is made by combining cement, sand, coarse aggregate, and water. Even though concrete has many advantages like high strength and durability, the large use of cement creates environmental problems because its production releases a significant amount of carbon dioxide.

At the same time, waste materials from industries and used products are increasing rapidly. Two such materials are slag from the steel industry and discarded tyres. Instead of disposing of them, these materials can be reused in concrete, which helps in reducing environmental pollution and saving natural resources.

Ground Granulated Blast Furnace Slag (GGBS) is one such material that can replace a part of cement. It reacts slowly in concrete but helps in improving long-term performance. Waste tyres, when processed into small particles called tyre crumb, can be used instead of a portion of sand. This changes the behavior of concrete by making it more flexible.

This project studies how concrete performs when both GGBS and tyre crumb are used together in partial replacement. The main focus is to observe changes in strength, workability, and overall behavior, and to find a suitable mix that can be used practically.

### 1.2 Material Specification

The materials selected for this project are chosen to ensure proper quality and consistent results during testing.

1.2.1 Cement

Ordinary Portland Cement Grade 53 is used as the main binding material. It should be fresh and free from any hardened lumps. Cement is responsible for holding all the ingredients together and developing strength in concrete.

1.2.2 Fine Aggregate

Natural sand is used as fine aggregate. It should be clean and free from mud, dust, and organic matter. Proper grading of sand is important to achieve good workability and strength.

1.2.3 Coarse Aggregate

Crushed stone aggregate is used as coarse aggregate. It should be strong, hard, and properly graded. It forms the main skeleton of concrete and contributes to its load-carrying capacity.

1.2.4 GGBS

GGBS is used as a partial replacement for cement. It is a fine powder obtained from industrial waste during iron production. It should be dry and uniform. Its use helps in reducing cement content and improving durability over time.

1.2.5 Tyre Crumb

Tyre crumb is made by cutting waste tyres into small pieces. It is used in place of a portion of fine aggregate. The particles should be clean and of nearly uniform size. It helps in improving flexibility but may reduce strength if used in excess.

1.2.6 Water

Clean water is used for mixing and curing. It should not contain harmful substances. Proper water quality is important for strength development and durability of concrete.

## 2. OBJECTIVE

1. To understand how normal concrete behaves under standard conditions.

2. To examine how replacing a part of cement with GGBS changes concrete performance.

3. To study the influence of tyre crumb when used instead of a portion of sand.

4. To observe changes in consistency and ease of mixing of fresh concrete.

5. To measure the load-carrying capacity of concrete using compressive strength tests.

6. To check how the concrete resists cracking through tensile strength testing.

7. To evaluate bending resistance using flexural strength tests.

8. To compare modified concrete results with conventional concrete values.

9. To monitor how increasing GGBS percentage affects strength development over time.

10. To analyze the effect of gradual addition of tyre crumb on strength and flexibility.

11. To identify a suitable level of cement replacement that does not compromise quality.

12. To determine a safe limit for tyre crumb usage in structural concrete.

13. To observe the interaction between rubber particles and cement matrix.

14. To study any variation in weight (density) due to replacement materials.

15. To note visible changes such as surface texture and finishing of concrete.

16. To assess whether modified concrete can be practically used in construction.

17. To reduce dependence on natural resources like cement and river sand.

18. To find a productive use for waste materials that are otherwise discarded.

19. To contribute towards environmentally responsible construction practices.

20.To develop a balanced concrete mix that satisfies both strength and sustainability.

## 3. LITERATURE REVIEW

1. Previous studies showed that partial replacement of cement with GGBS improved long-term strength of concrete.

2. Researchers observed that GGBS-based concrete developed strength slowly at early ages but performed better at later stages.

3. It was reported that the use of GGBS reduced heat generation during hydration in concrete.

4. Several investigations indicated that GGBS enhanced resistance to chemical attack and sulphate exposure.

5. Studies found that concrete containing GGBS had lower permeability compared to conventional mixes.

6. Researchers noted that higher percentages of GGBS slightly reduced early compressive strength.

7. Experimental work showed that tyre crumb reduced compressive strength when used as a sand replacement.

8. It was observed that rubber particles created weaker bonding with cement paste.

9. Some studies reported that rubberized concrete exhibited higher flexibility and deformation capacity.

10. Researchers found that the inclusion of tyre crumb improved impact resistance of concrete.

11. It was noticed that rubber content reduced the density of concrete, making it lighter.

12. Investigations revealed that workability decreased with the addition of tyre crumb due to its texture.

13. Some researchers suggested that proper mix design helped in maintaining workable concrete.

14. Combined studies indicated that GGBS partially compensated for strength loss caused by rubber.

15. It was found that moderate replacement levels gave better overall performance than higher replacements.

16. Researchers observed that rubber particles affected surface finishing of concrete.

17. Studies showed that GGBS contributed to improved durability under aggressive environmental conditions.

18. It was reported that excessive tyre crumb content led to a significant reduction in strength.

19. Researchers concluded that both materials could be used effectively when proper proportions were maintained.

20.Overall, past work indicated that the use of GGBS and tyre crumb supported sustainable construction practices.

## 4. METHODOLOGY

The work is carried out in a step-by-step experimental process:

**Selection of Materials**

Cement, sand, coarse aggregate, GGBS, tyre crumb, and water are collected and checked for basic properties.

**Concrete Mix Preparation**

A standard concrete mix (M30) is designed. Cement is replaced with GGBS in different percentages (0%, 5%, 15%, 25%, 45%) and sand is replaced with tyre crumb in smaller percentages.

**Casting of Specimens**

Concrete is mixed properly and poured into moulds to prepare cubes. Proper compaction is done to remove air gaps.

**Curing Process**

After casting, the specimens are kept in water for curing at different time periods like 7 and 28 days.

**Testing**

* Slump test is carried out to check workability.
* Compressive strength is tested using cubes.
* Tensile strength is tested using cylinders.

## 5. MIX DESIGN

The Concrete mix has been designed as per IS: 10262-2019 on Solid volume concept. Trial mixes for the water cement ratio varing from 0.35 to 0.45. Proportions Of aggregate are adjusted as follows to have good grading within limits as far as possible.

| Sieve size | For 20mm MSA Concrete |
|---|---|
| 20mm | 60% |
| 10mm | 40% |

The Slump was maintain as follows:-

| MSA of Concrete (mm) | Slump in mm |
|---|---|
| 20mm | 75mm to 120mm |

Target strength for Mix Proportioning:

As per IS: 10262-2019 Clause 4.2 Page No.-2 the target mean compressive

**strength is given by following relation:-**

a) f'ck = fck + 1.65 x S

Or

b) f'ck = fck + X whichever is higher.

where

fck= target mean compressive strength at 28 days in N/mm?

fck = characteristic compressive strength at 28 days in N/mm?

S = standard deviation in N/mm?

X= factor based on the grade of concrete.

**Therefore For M-30 (20 MSA) Grade Of concrete,**

from Table 2 of IS: 10262-2019, Standard Deviation S = 3.5.

from Table 1 of IS: 10262-2019, X = 5

Hence, target strength using both equations, that is

a) f'ck = fck + 1.65 x S

= 30 + 1.65 x 5

= 38.25 N/mm2

b) f'ck=fck +x

= 30 + 6.5

= 36.5 N/mm2

The higher value is to be adopted. Therefore target strength will be 31.6 N/mm2, as 38.25 N/mm2 > 36.5N/mm2

**Note :-**

1) The concrete was prepared in a laboratory mixer and 15 cm x 15 cm x 15 cm

cubes were casted after recording slump of concrete.

2) The specimens were cured by adopting the procedure mentioned in IS:9013:1978 for boiling water method.

**RESULTS:-**

The compressive strength and other particulars for 30mm MSA trial mixes are given in mixes table respectively. The recommended mixes are given in Table

The recommendations are based on the graph plotted and attached as fig.

**Recommanded mix for attaining target strength of 38.25 N/mm2**

**Quantity for 1m3 of Concrete**

| Cement (KG) | Water (Lit) | Crushed Stone Sand (KG) | Aggregate (KG) | | | Remark |
|---|---|---|---|---|---|---|
| | | | 40 mm | 20 mm | 10 mm | |
| 377 | 162 | 819 | 0 | 657 | 438 | |

**RECOMMENDATIONS:-**

### Mix design given in Table holds good provided.

1) The Sampling has not done by this office.

2) The test results are true to the sample of cement, Coarse & Fine Aggregate handed to this office.

3) Quality of material will not fluctuate from that of Material sent to this division for the test.

4) Batching, Mixing and Curing are adequately controlled.

## 6. CONCLUSION

The present study focused on evaluating the performance of concrete prepared with partial replacement of cement by GGBS and incorporation of tyre crumb rubber in concrete mixtures. From the experimental investigation, it was observed that the modified concrete exhibited different mechanical and durability characteristics when compared with conventional concrete.

The addition of GGBS improved the cohesiveness and overall quality of the concrete mix, while tyre crumb rubber contributed to better flexibility and resistance against sudden impact loads.

During the investigation, it was found that moderate replacement levels produced acceptable strength and satisfactory workability.

Although higher percentages of tyre crumb reduced compressive strength, the concrete still performed effectively for applications where lightweight and energy-absorbing properties are required. The use of GGBS also helped in reducing cement consumption, thereby lowering environmental impact and promoting sustainable construction practices.

This project demonstrated that waste materials generated from industries and discarded tyres can be effectively utilized in concrete production with proper mix proportioning.

The experimental results confirmed that eco-friendly concrete can be developed without completely compromising engineering properties. Therefore, the study supports the practical use of GGBS and tyre crumb rubber as alternative construction materials for sustainable and economical concrete production.

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