International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Impact Factor (2020): 6.733

Analysis of Concrete with CCR, GGBS and Waste Glass Pieces from Waste Bottle as Replacement Material at Harden and Fresh Stages

Anju Dhakad[1], Mahendra Saini[2]

[1]M. Tech. Scholar, Department of civil engineering (Structural Engineering), Regional College for Education Research & Technology, Jaipur, Rajasthan, India
anjudhakad96[at]gmail.com

[2]Assistant Professor, Department of civil engineering, Regional College for Education Research & Technology, Jaipur, Rajasthan, India
ms.cen.735[at]gmail.com

Abstract: ***Concrete is one of the most versatile and commonly used building materials on the planet. The reason for this is that elements like cement, river sand, coarse aggregate, and water are naturally, inexpensively, and readily available. Because there is no alternative binding substance that can completely replace cement, partial cement replacement is widely used in concrete composites. M30 grade of concrete has been taken. The cement is substituted by calcium carbide residue and with the ground granulated blast furnace slag in the second mix in varying percentages. The resultant mixture was tested to understand various mechanical and physical properties. For the present study, the calcium carbide residue and GGBS have been together substituted with the cement of the concrete by the percentage of 3%, 6%, 9% and 12%. In concrete mixture crushed glass bottles are replaced with coarse aggregates.***

Keywords: GGBS, Compressive, Strength, Durable

1. Introduction

The construction industry is currently faced with the challenge of incorporating sustainability into their production processes, either through the search for and incorporation of new environmentally friendly raw materials and products or by contributing to the reduction of CO2 emissions into the atmosphere. GGBS (Ground Granulated Blast Furnace Slag) is a by-product of iron production that is utilized in concrete as a cementitious material. GGBS is made by heating iron ore, limestone, and coke to roughly 15000 degrees Celsius. In a blast furnace, the process is carried out. It's made by quenching molten blast furnace slag in water or steam, then drying and grinding it into a fine powder.

The blast furnace is powdered separately and mixed with cement in the second process. GGBS can also be used as a straight weight-for-weight replacement for conventional Portland cement. Many RMC companies in India employ GGBS by mixing it with regular Portland cement, aggregates, and water in batching facilities.

1.1 Objectives of the research

The objectives of the dissertation are as follows-

- To replace cement with calcium carbide residue waste in varying percentages.
- To replace coarse aggregate in the concrete with Ground Granulated Blast Furnace Slag (GGBS).
- To study the mechanical and chemical properties of the mixtures obtained.
- To determine the changes observed with the replacements of the constituents.

2. Literature Survey

Kelechi, Sylvia E., et al. (2022)
CR is used as a good substitute for fine aggregate at 0%, 10% and 20% by volume of mix and CCW is used as a substitute for cement at 0%, 5% and 10% by volume in paddy fields. Research shows that blends with fly ash are up to 23% more resistant to acids and salts than blends without fly ash.

Uche, OkorieAustine, et al. (2022)
Therefore, this work (SCC) examines the effect of CR and CCR on the heat/temperature resistance and durability of

self-compacting materials. Analyse the effect of CR and CCR on SCC property, develop SCC properties and optimize the mix for best results, the experimental was planned utilizing response surface approach.

Kelechi, Sylvia E., et al. (2022)
However, while there are many benefits to using CR, one of the biggest drawbacks is the reduced horsepower. Therefore, waste calcium carbide (CCW) is used to prevent the adverse effects of CR and self-consolidating material (SCC). In this work, we investigate the durability of SCC with CR and CCW with fly ash.

Adamu, M., et al. (2021)
The cement fraction was replaced by CCR at weight replacement rates of 0%, 7.5%, 15%, 22.5% and 30% and Nano silica (NS) was added at 0%, 1% and 2%. And stuff. %, 3% and 4% substitute weight. Sag, compressive strength, flexural strength, tensile strength, modulus of elasticity and water absorption capacity were evaluated. FESEM and XRD analyzes were used to analyze the microstructural characteristics of the concrete. The results showed that CCR and NS increased the subject's water requirement, which reduced his performance.

3. Methodology

Cement
Cement is a dry powdery material formed by calcining lime and clay and then mixing it with water to make mortar or sand, gravel, and water to make concrete. It's a substance used to hold things together.

Sand
Sand is a granular combination of tiny rock grains and granular elements that is primarily defined by size, being finer than gravel but coarser than silt. And they come in sizes ranging from 0.06 mm to 2 mm. Silt is defined as particles bigger than 0.0078125 mm but less than 0.0625 mm. Sand is formed by erosion, shattered pebbles, and rock weathering, and is transported by waves and rivers.

Aggregate
Aggregate is the component of a composite material that resists compressive load and gives the composite material bulk. It is mostly utilised in the building industry. Sand, gravel, crushed stone, slag, and recycled aggregates are examples of inert materials. For the effective filling, the aggregate in a composite should be significantly smaller than the completed object and available in a variety of sizes.

Concrete
Concrete is a mixture formed by correctly mixing aggregates (such as sand, gravel, stone, or brick flakes), water, additives, or a binder (such as cement or lime). The blend's composition determines the product's strength and quality. Concrete is a crucial and practical material. Cement and water start to react and unite to form durable structure when all the ingredients—cement, clay, and water—are thoroughly combined.

Test of Concrete
Slump Cone Test
Compressive Strength of Concrete
Flexural Test
Split Tensile Test
Rebound Hammer
Durability Test by Rapid Chloride Permeability Test (RCPT)

Mix formation

Table 3.1: Mix Proportions of Samples Used for Concrete at 14% CCR

Mix No.	CCR	Crushed Glass Bottle	Cement	Aggregate	Sand
Mix 1	14%	3%	86%	97%	100%
Mix 2	14%	6%	86%	94%	100%
Mix 3	14%	9%	86%	91%	100%
Mix 4	14%	12%	86%	88%	100%

4. Result & Discussion

Results on Harden stage

Table 4.1: Data Analysis of Concrete Test At 0% CCR and Varying Percentage of Crushed Glass Bottles (7 Days)

Mix No.	CCR	Crushed Glass Bottles	7 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	15.69	12.39	2.432	1.406
Mix 1	0%	3%	17.28	14.00	2.552	1.548
Mix 2	0%	6%	18.81	14.76	2.663	1.685
Mix 3	0%	9%	19.23	15.96	2.693	1.723
Mix 4	0%	12%	17.27	14.16	2.552	1.547

Table 4.2: Data Analysis of Concrete Test At 14% CCR and Varying Percentage of Crushed Glass Bottles (7 Days)

Mix No.	CCR	Crushed Glass Bottles	7 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	15.69	12.39	2.432	1.406
Mix 1	14%	3%	20.3	16.44	2.766	1.819
Mix 2	14%	6%	21.83	17.13	2.869	1.956
Mix 3	14%	9%	22.25	18.47	2.896	1.994
Mix 4	14%	12%	20.29	16.63	2.766	1.818

Table 4.3: Data Analysis of Concrete Test At 14% CCR and Varying Percentage of Crushed Glass Bottles (14 Days)

Mix No.	CCR	Crushed Glass Bottles	14 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	23.78	18.78	2.994	2.131
Mix 1	14%	3%	29.31	23.74	3.324	2.626
Mix 2	14%	6%	31.22	24.50	3.431	2.797
Mix 3	14%	9%	32.49	26.97	3.500	2.911
Mix 4	14%	12%	27.15	22.26	3.199	2.433

Table 4.4: Data Analysis of Concrete Test At 0% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

Mix No.	CCR	Crushed Glass Bottles	28 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	26.15	20.65	3.140	2.343
Mix 1	0%	3%	27.81	22.53	3.238	2.492
Mix 2	0%	6%	29.48	23.14	3.334	2.641
Mix 3	0%	9%	30.11	24.99	3.369	2.698
Mix 4	0%	12%	26.62	21.82	3.168	2.385

Table 4.5: Data Analysis of Concrete Test At 7% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

Mix No.	CCR	Crushed Glass Bottles	28 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	26.15	20.65	3.140	2.343
Mix 1	7%	3%	28.94	23.44	3.303	2.593
Mix 2	7%	6%	30.61	24.03	3.397	2.743
Mix 3	7%	9%	31.24	25.93	3.432	2.799
Mix 4	7%	12%	27.75	22.75	3.234	2.486

Table 4.6: Data Analysis of Concrete Test At 14% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

Mix No.	CCR	Crushed Glass Bottles	28 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	26.15	20.65	3.140	2.343
Mix 1	14%	3%	30.83	24.97	3.409	2.762
Mix 2	14%	6%	32.5	25.51	3.500	2.912
Mix 3	14%	9%	33.13	27.50	3.534	2.968
Mix 4	14%	12%	29.64	24.30	3.343	2.656

Table 4.7: Data Analysis of Concrete Test At 7% GGBS and Varying Percentage of Crushed Glass Bottles (7 Days)

Mix No.	CCR	Crushed Glass Bottles	7 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	17.48	13.81	2.567	1.566
Mix 1	7%	3%	20.14	16.31	2.755	1.805
Mix 2	7%	6%	21.87	17.17	2.871	1.960
Mix 3	7%	9%	22.69	18.83	2.925	2.033
Mix 4	7%	12%	20.92	17.15	2.808	1.874

Table 4.8: Data Analysis of Concrete Test At 14% GGBS and Varying Percentage of Crushed Glass Bottles (7 Days)

Mix No.	CCR	Crushed Glass Bottles	7 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	17.48	13.81	2.567	1.566
Mix 1	14%	3%	21.52	17.43	2.848	1.928
Mix 2	14%	6%	23.05	18.09	2.948	2.065
Mix 3	14%	9%	23.47	19.48	2.975	2.103
Mix 4	14%	12%	21.51	17.64	2.848	1.927

Table 4.9: Data Analysis of Concrete Test At 7% GGBS and Varying Percentage of Crushed Glass Bottles (14 Days)

Mix No.	CCR	Crushed Glass Bottles	14 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	23.01	18.17	2.945	2.062
Mix 1	7%	3%	25.83	20.92	3.121	2.314
Mix 2	7%	6%	27.44	21.54	3.216	2.459
Mix 3	7%	9%	28.97	24.04	3.305	2.596
Mix 4	7%	12%	24.14	19.79	3.017	2.163

Table: 4.10: Data Analysis of Concrete Test At 14% GGBS and Varying Percentage of Crushed Glass Bottles (14 Days)

Mix No.	CCR	Crushed Glass Bottles	14 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	23.01	18.17	2.945	2.062
Mix 1	14%	3%	27.48	22.26	3.219	2.462
Mix 2	14%	6%	29.20	22.92	3.318	2.616
Mix 3	14%	9%	30.34	25.18	3.382	2.718
Mix 4	14%	12%	25.53	20.93	3.102	2.287

Table 4.11: Data Analysis of Concrete Test At 7% GGBS and Varying Percentage of Crushed Glass Bottles (28 Days)

Mix No.	CCR	Crushed Glass Bottles	28 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	25.57	20.20	3.105	2.291
Mix 1	7%	3%	28.70	23.25	3.289	2.572
Mix 2	7%	6%	30.49	23.93	3.390	2.732
Mix 3	7%	9%	32.19	26.72	3.484	2.884
Mix 4	7%	12%	26.82	21.99	3.180	2.403

Table: 4.12: Data Analysis of Concrete Test At 14% GGBS and Varying Percentage of Crushed Glass Bottles (28 Days)

Mix No.	CCR	Crushed Glass Bottles	28 Days (N/mm2)			
			Compressive Strength	RH Strength	Flexural Strength	Split Tensile
Standard	0%	0%	25.57	20.20	3.105	2.291
Mix 1	14%	3%	30.53	24.73	3.393	2.735
Mix 2	14%	6%	32.44	25.46	3.497	2.907
Mix 3	14%	9%	33.71	27.98	3.565	3.020
Mix 4	14%	12%	28.37	23.26	3.270	2.542

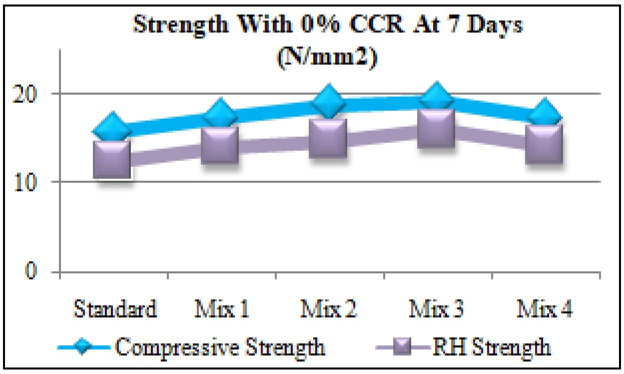

Figure 4.1: Data Analysis of Concrete Test At 0% CCR and Varying Percentage of Crushed Glass Bottles (7 Days)

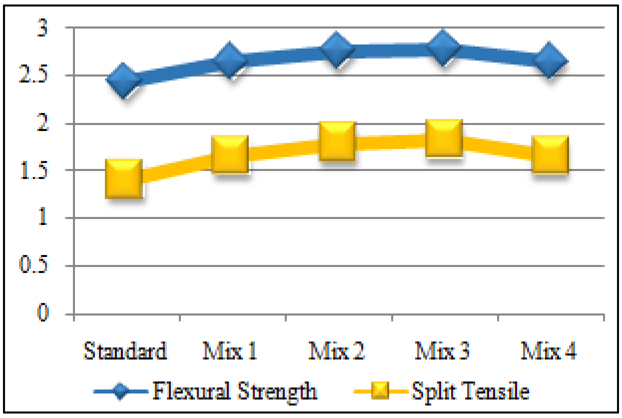

Figure 4.2: Data Analysis of Concrete Test At 7% CCR and Varying Percentage of Crushed Glass Bottles (7 Days)

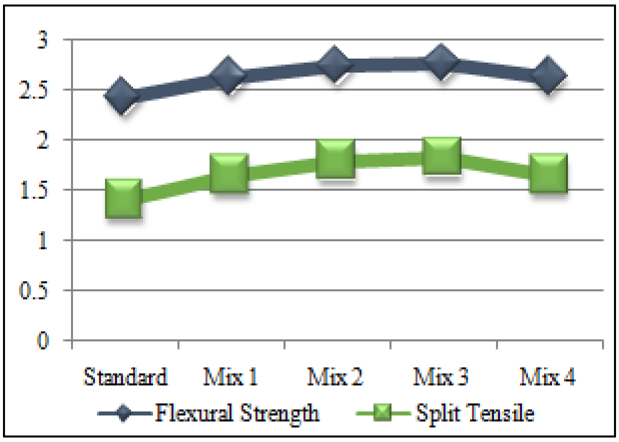

Figure 4.3: Data Analysis of Concrete Test At 14% CCR and Varying Percentage of Crushed Glass Bottles (7 Days)

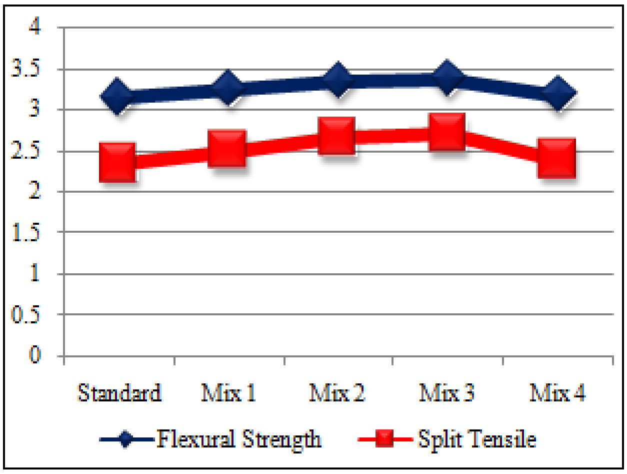

Figure 4.4: Data Analysis of Concrete Test At 0% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

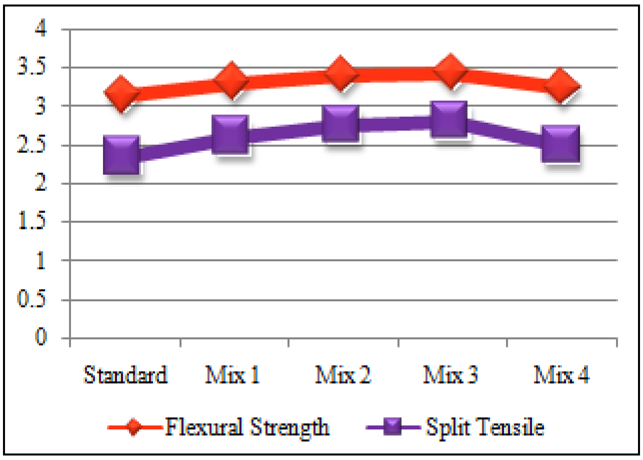

Figure 4.5: Data Analysis of Concrete Test At 7% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

.

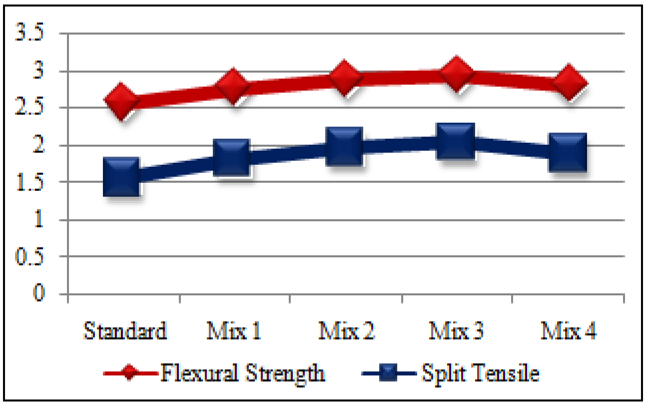

Figure 4.6: Data Analysis of Concrete Test At 7% GGBS and Varying Percentage of Crushed Glass Bottles (7 Days)

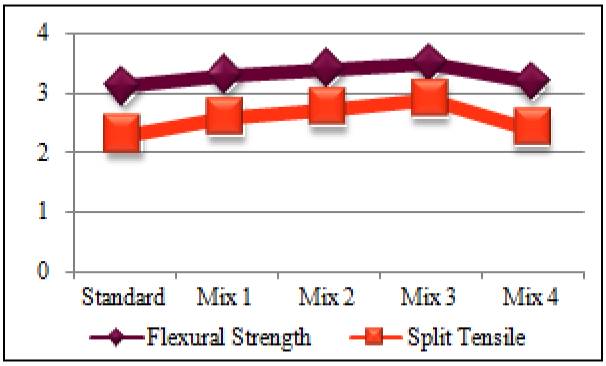

Figure 4.10: Data Analysis of Concrete Test At 7% GGBS and Varying Percentage of Crushed Glass Bottles (28 Days)

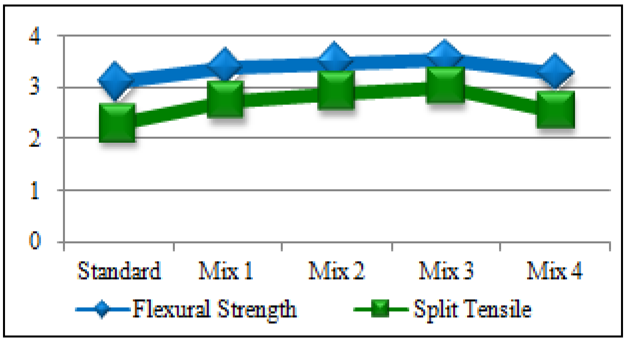

Figure 4.7: Data Analysis of Concrete Test At 14% GGBS and Varying Percentage of Crushed Glass Bottles (28 Days)

Results of Durability Test by Rapid Chloride Permeability Test (RCPT)

Table 4.15: RCPT of Concrete At 0% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

Mix No.	CCR	Crushed Glass Bottles	Charge Passed (Coulombs)
Standard	0%	0%	2118
Mix 1	0%	3%	2451
Mix 2	0%	6%	2724
Mix 3	0%	9%	2916
Mix 4	0%	12%	2143

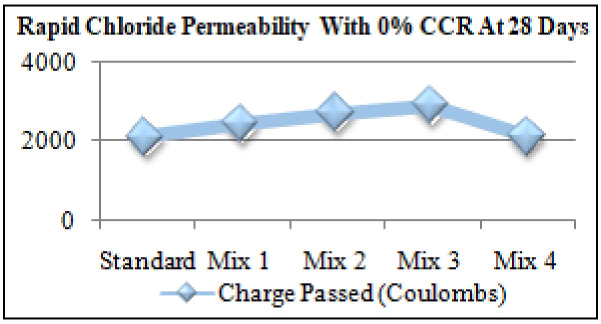

Figure 4.12: RCPT of Concrete At 0% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

Table 4.16: RCPT of Concrete At 14% CCR and Varying Percentage of Crushed Glass Bottles (28 Days)

Mix No.	CCR	Crushed Glass Bottles	Charge Passed (Coulombs)
Standard	14%	0%	2118
Mix 1	14%	3%	2703
Mix 2	14%	6%	2932
Mix 3	14%	9%	3051
Mix 4	14%	12%	2508

5. Conclusions

- In the standard mix, the GGBS was 7% and the crushed glass bottles were 0%, the compressive strength of concrete at 7 days was 17.48N/mm^2. In mix 3, the GGBS was 7% and the crushed glass bottles were 9%, the compressive strength of concrete at 7 days was 22.69N/mm^2. In mix 4, the GGBS was 7% and the crushed glass bottles were 12%, and the compressive strength of concrete at 7 days was 20.92N/mm^2.
- In the standard mix, the GGBS was 7% and the crushed glass bottles were 0%, the compressive strength of concrete at 14 days was 23.01N/mm^2. In mix 3, the GGBS was 7% and the crushed glass bottles were 9%, the compressive strength of concrete at 14 days was 28.97N/mm^2. In mix 4, the GGBS was 7% and the crushed glass bottles were 12%, the compressive strength of concrete at 14 days was 24.14N/mm^2.
- In the standard mix, the GGBS was 14% and the crushed glass bottles were 0%, the RH strength of concrete at 7 days was 13.81N/mm^2. In mix 3, the GGBS was 14% and the crushed glass bottles were 9%, the RH strength of concrete at 7 days was 19.48N/mm^2. In mix 4, the GGBS was 14% and the crushed glass bottles were 12%, the RH strength of concrete at 7 days was 17.64N/mm^2.
- In the standard mix, the GGBS was 14% and the crushed glass bottles were 0%, the RCPT of concrete at 28 days was 2329C. In mix 3, the GGBS was 14% and the crushed glass bottles were 9%, the RCPT of concrete at 28 days was 3341C. In mix 4, the GGBS was 14% and the crushed glass bottles were 12%, the RCPT of concrete at 28 days was 2793C.

References

[1] Kelechi, Sylvia E., et al. "Durability Performance of Self-Compacting Concrete Containing Crumb Rubber, Fly Ash and Calcium Carbide Waste. " Materials 15.2 (2022): 488.

[2] Uche, OkorieAustine, et al. "Modelling and Optimizing the Durability Performance of Self Consolidating Concrete Incorporating Crumb Rubber and Calcium Carbide Residue Using Response Surface Methodology. " Buildings 12.4 (2022): 398.

[3] Kelechi, Sylvia E., et al. "Durability Performance of Self-Compacting Concrete Containing Crumb Rubber, Fly Ash and Calcium Carbide Waste. " Materials 15.2 (2022): 488.

[4] Adamu, M., et al. "Mechanical properties and durability performance of concrete containing calcium carbide residue and nano silica. Materials, 2021; 14: 6960. " (2021).

[5] Malami, Salim Idris, et al. "Implementation of soft-computing models for prediction of flexural strength of pervious concrete hybridized with rice husk ash and calcium carbide waste. "Modeling Earth Systems and Environment (2021): 1-15.