Experimental Study on Use of Waste Material in Concrete for Rigid Pavement Construction

Mayank Singh[1] Pushpendra Kumar Kushwaha[2] Mithun Kumar Rana[3]
[1]M. Tech. Research Scholar [2,3]Assistant Professor
[1,2,3]Department of Civil Engineering
[1,2,3]RKDF College of Engineering, Bhopal, M. P., India

Abstract — Utilising waste materials not only enhances the microstructure of concrete and, as a result, improves its qualities, but it also offers a partial answer to ecological and environmental issues. In India, the production of these waste products is more than twice that of cement and other building materials used in all civil engineering operations. Numerous studies have been carried out globally to determine the detrimental impacts of various waste items on both the environment and human health. Based on various investigations, it was shown that large-scale cement production is also to blame for water contamination and a number of human ailments. Consequently, it is necessary in this case to use other waste materials in place of cement. By highlighting various ways to use the discarded components (i.e. trash), the current study aims to educate researchers and engineers on the need to create inexperienced concrete in order to achieve the balance between environmental, economical, and technical issues.

Keywords: Cement, Waste Material, Construction, Environment, Concrete

I. Introduction

Any nation's economy depends on having a strong infrastructure, which includes buildings, roads, bridges, airports, harbours, utility terminals, and warehouses. In the modern world, having a strong infrastructure is crucial for a nation's development and seems unachievable without the use of cement. Made of clay and lime that have been calcined, cement is a powder. In construction, cement is mostly used as a binding agent that is combined with water, sand and aggregates (i.e. roadways or building). However, the release of multiple toxic gases during the cement manufacturing process is a threat to the environment. According to a prior study (Mehraj et al., 2014), India's cement consumption is rising at a pace of 10% annually. It is noteworthy that, globally, cement ranks second in terms of consumable materials, only behind water.

Commonly recognised waste materials include fly ash, blast furnace slag, recycled aggregates from demolition sites, silica fume from power plants, solid garbage, plastic waste from homes, and rubber waste from businesses. Recycled aggregates from demolition sites, blast furnace slag, fly ash, silica fume from power plants, solid waste, plastic waste from homes, and rubber waste from businesses can all be used to partially replace Portland cement. This will help to reduce pollution in the environment and the amount of cement and other materials needed for construction projects. Protection the environment is one of the main issues facing our civilization today. Materials like concrete, steel, brick, stone, glass, clay, mud, wood, and so on are needed for any building project. Nonetheless, the most common building material utilized in the construction industry is still cement concrete. Concrete needs to be able to preserve resources, safeguard the environment, save money, and promote efficient energy use in order to be suitable and adaptable to the changing environment. The use of wastes and byproducts in cement and concrete used for new projects must be prioritised in order to accomplish this. Given that aggregates make about 75% of concrete, the use of recycled material shows great promise. Large amounts of concrete that has been demolished are available at different construction sites, and this is causing a significant issue with disposal in urban areas. This is easily recyclable and works well as aggregate in concrete. Reusing these waste materials properly in construction projects will greatly benefit society since the issue of how to dispose of them has grown to be a major environmental concern. The decrease of energy and natural raw material use, as well as the methodical usage and consumption of waste materials, are some of the crucial components in this regard. Even in India, research and development efforts have been made to demonstrate the practicality, economic viability, and cost-effectiveness of using waste materials in all building-related tasks.

Every year, the cement industry worldwide produces more than four billion tonnes of cement. According to the Indian Bureau of Mines' most recent report (2015), the country's various enterprises produce between 0.83 and 43.8 million tonnes of cement annually, as seen in table 1. Because the trash that these cement plants produce—cement dust—is extremely detrimental to both the environment and human health, the massive manufacturing of cement has drawn the attention of researchers worldwide. A few examples of waste materials that can be recycled and used as a polymer concrete mix include fly ash, steel slag, E-plastic, and recycled concrete aggregate. This will help with energy utilisation while reducing the need for ordinary Portland cement (OPC) and prevent environmental pollution.

II. Literature survey & background

Shariq and Prasad examined the impact of different curing methods on the compressive strength development of cement mortar and concrete incorporating ground granulated blast furnace slag (GGBFS). Their findings revealed that OPC (Ordinary Portland Cement) concrete exhibited higher compressive strength compared to GGBFS-based concrete across all replacement levels and ages. Among GGBFS replacements, 40% proved optimal, significantly improving compressive strength after 56 days, outperforming both 20% and 60% replacements.

Stanley researched the use of iron blast-furnace slag in concrete, either as an aggregate or a cementing material. Hanifi Binici and colleagues investigated blended cements containing corncob ash (CA) and GGBFS, concluding that these blends showed 15% lower compressive strength than control specimens when immersed in a sulfate solution over 24 months. However, blended cements demonstrated better resistance to sodium sulfate with higher percentages of additives.

Puertas and collaborators analyzed the carbonation behavior of water glass- or NaOH-activated slag mortars, finding that alkali-activated slag mortars carbonated more deeply than Portland cement mortars. Barnett et al. focused on strength development in mortars containing GGBFS and Portland cement, concluding that early-age strength in GGBFS mixtures is highly temperature-dependent.

Wang Ling studied the application of GGBFS in China, while An Cheng, Ran Huang, and colleagues investigated the durability of GGBFS concretes and the corrosion behavior of reinforced concrete beams under varying load ratios. Olorunsogo et al. explored the effect of particle size distribution (PSD) on the bleeding characteristics of slag cement mortars, revealing that for slag samples with a similar size range, the bleeding capacity increased with particle size, except for 30% slag mixes with a 0.35 water-to-cement ratio.

III. Objective

1) Investigate the physical and chemical properties of waste materials to promote their sustainable utilization.
2) Propose an alternative to cement that maintains the essential properties of conventional cement.
3) Optimize the cost-effectiveness of concrete by incorporating various waste materials.
4) Develop guidelines for the use of waste materials in pavement construction** and create new concrete mix designs.

IV. Result

To determine whether the material that is now available is suitable, various tests are carried out on it. Cement, sand, and aggregate were tested. Every material should have the same qualities and values according to mix design. Such as the water absorption test, the initial and final setting times, the specific gravities of the aggregate and sand cement, and the normal consistency test. Moreover, compressive strength testing was done

S N	Cement %	GGBS %	Compressive strength N/mm2		
			7 days	21 Day	28 day
1	100	0	27.5	33.32	41.56
2	95	5	29.38	35.21	44.21
3	90	10	30.68	36.23	45.2
4	85	15	27.21	33.35	41.23
5	80	20	26.26	31	39.21
6	75	25	24.2	29.45	38.21
7	70	30	20.23	28.95	36.34
8	65	35	19	26.12	32.45

Table 4.1: Compressive strength by using GGBS for 7, 21, 28 days

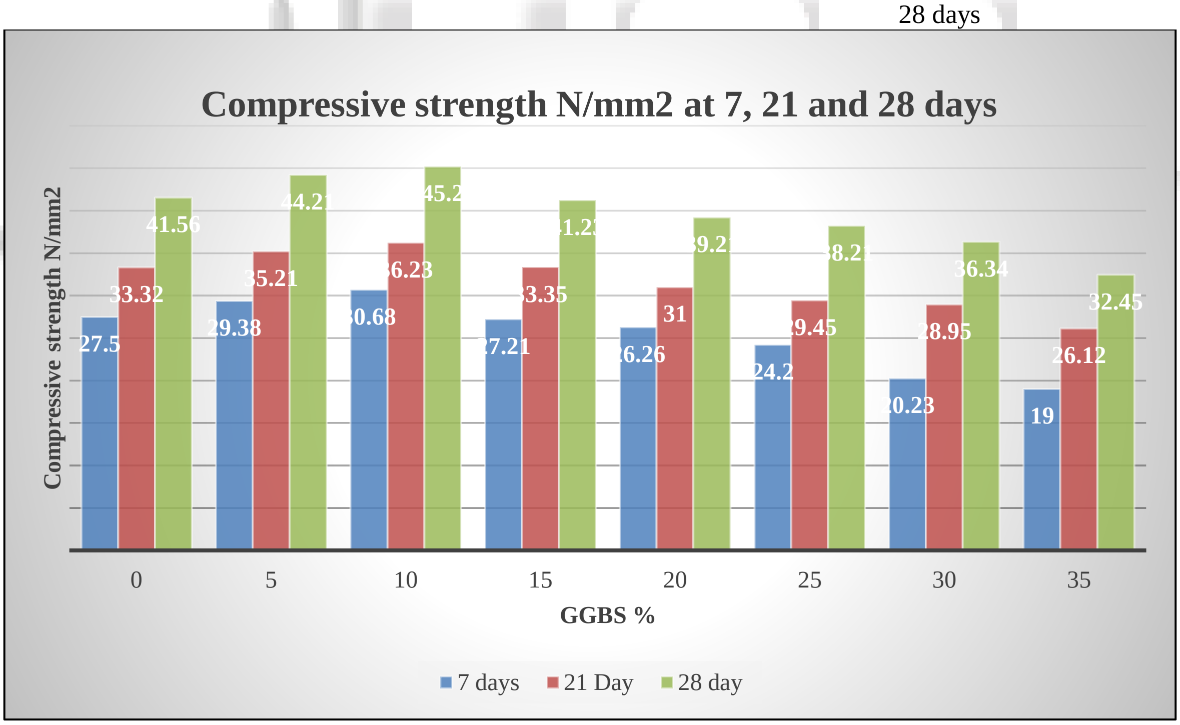

Fig. 4.1: Variation in compressive strength with the % of GGBS for 7, 21, 28 days

From experiment result it was found that Compressive strength for 28 days by using GGBS gives optimum results, whencement was replaced up to 15%. At 10 % replacement there was an increment of 12% compressive strength.

S N	Cement %	Ladle furnace slag %	Compressive strength N/mm2		
			7 days	21 Day	28 day
1	100	0	27.1	33.34	41.56
2	95	5	27.2	34	42
3	90	10	30.21	36.12	44
4	85	15	29.21	36.23	44.85

5	80	20	27.23	32.21	41.23
6	75	25	23.56	31	38.23
7	70	30	21	30	37.34
8	65	35	18.23	29.34	36.23

Table 4.2: Compressive strength by using Ladle furnace slag for 7, 21 and 28 days

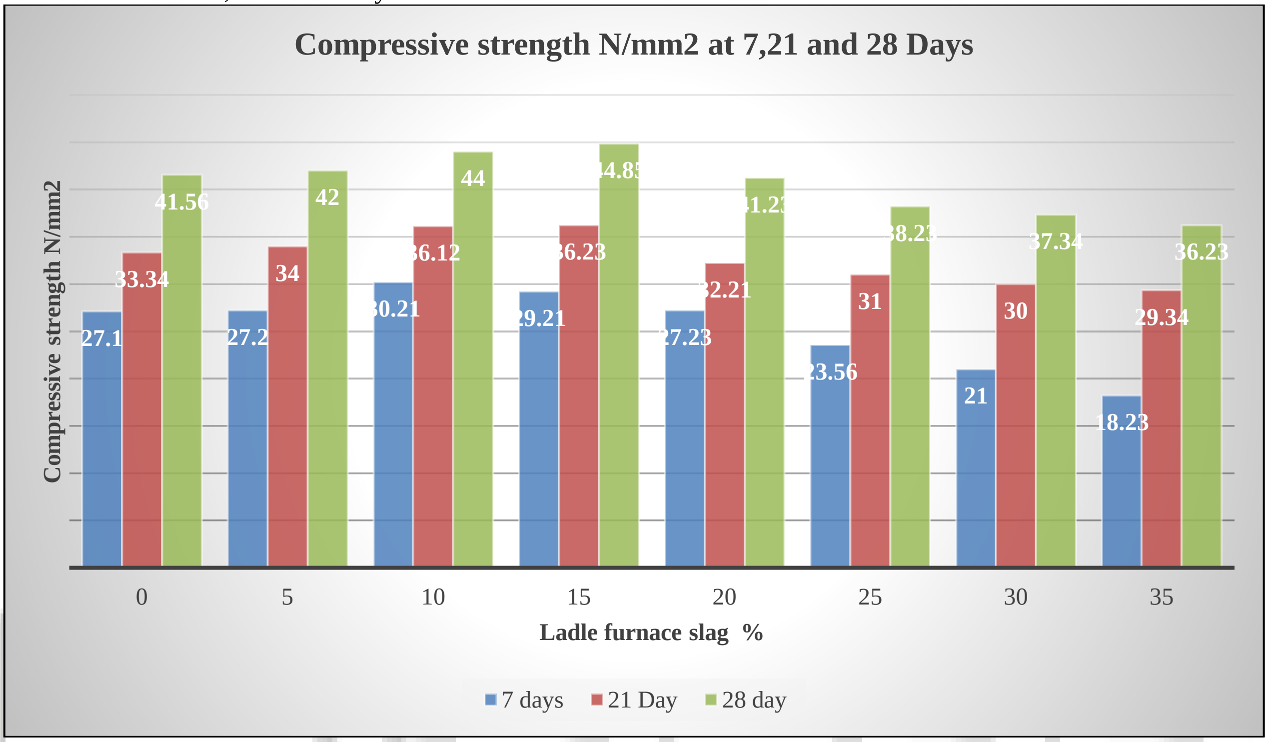

Fig. 4.2: Variation in compressive strength with the % of Ladle furnace slag for 7, 21, 28 days

S N	Cement %	Bagasse ash %	Compressive strength N/mm2		
			7 days	21 Day	28 day
1	100	0	27.1	33.21	41.45
2	95	5	27.67	35.1	44.34
3	90	10	29	37.1	46.5
4	85	15	29.6	38.6	48.5
5	80	20	27.34	34.3	43
6	75	25	25.34	31.23	39.2
7	70	30	24.45	30	38
8	65	35	23.45	29.33	37.2

Table 4.3 Compressive strength by using Bagasse ash for 7, 21 and 28 days

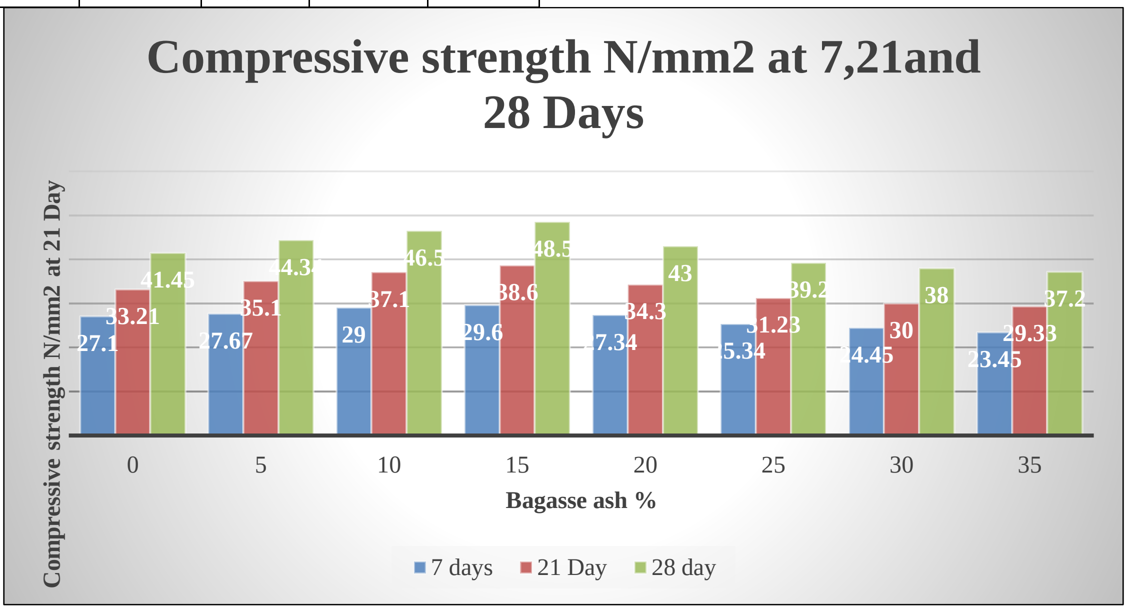

Fig. 4.3: Variation in compressive strength with the percentage of SCBA for 7, 21, 28 days

After that in Fig4.5 and 4.6 SCBA was partially replaced upto 50% and it was concluded that 15 % gives the maximum strength after 7 days and 28 days of curing.

A. Variation in Compressive Strength of Combinations of Waste Materials

The amalgamation of various waste materials was employed to substitute cement up to a maximum percentage, as seen in Table , where the compressive strength of the mixture is denoted as 5G5L5S, indicating the incorporation of 5% GGBS, 5% LFS, and 5% SCBA in the cube fabrication. Figure clearly demonstrates that a replacement of up to 30% does not significantly alter the outcome.

SN	Combination %	Compressive strength N/mm2
1	5G5L5S	44.51
2	5G5L10S	45.1
3	5G5L15S	41.5
4	5G5L20S	39.4
5	5G10L5S	43.23
6	5G10L10S	44.7
7	5G10L15S	46.1
8	5G15L5S	44.45
9	5G15L10S	40.2
10	5G20L5S	43.5
11	10G5L5S	43.65
12	10G5L10S	40.3
13	10G5L15S	40.45
14	10G10L5S	41.67
15	10G10L10S	43.4
16	10G15L5S	42.23
17	15G5L5S	41.45
18	15G5L10S	42.3
19	15G10L5S	39.45
20	20G5L5S	39

Table 4.4: Variation in compressive strength of combinations of waste materials

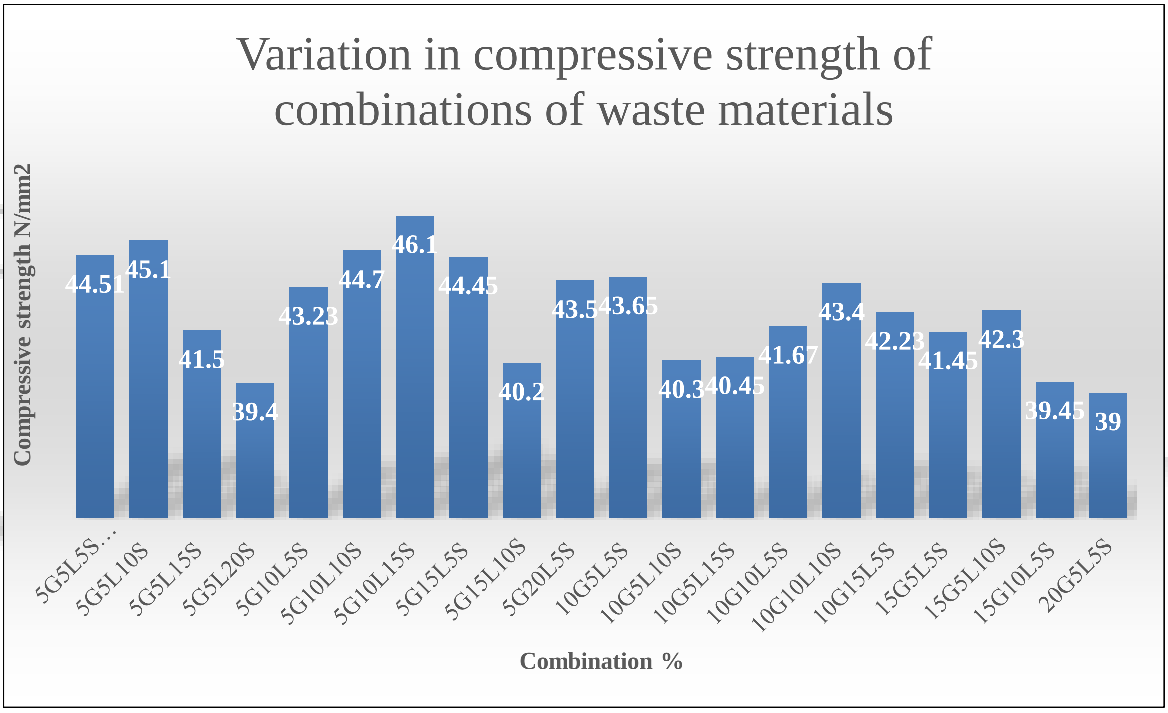

Fig. 4.12: Graph between compressive strength and combination % of waste material

V. FUTURE SCOPE

Concrete's chemical, mechanical, and physical qualities are enhanced by these waste products. When building stiff pavement with reinforcement, the suggested guidelines of the current study can be put into practice in the field. The investigation can be broadened by looking at how green concrete—that is, concrete built from waste materials—behaves under various loads and climate conditions. (i.e. to evaluate different pressures which will take on green concrete). Aside from this, by suggesting other mix designs (i.e., in variable proportions), the percentage utilisation of the waste material suggested in the current study can be raised (i.e., up to 80 or 100%). To create green concrete and a sustainable environment, additional waste materials can be added by examining their chemical and physical characteristics.

VI. CONCLUSION

Based on the findings of the experiments, it was discovered that there was a fluctuation in compressive strength with the percentage of GGBS for 7 and 28 days, resulting in an appropriate replacement of 15% of cement with GGBS. Compressive strength increased by 12% after 10% replacement.

The results of the experiments showed how the percentage of LFS changed the compressive strength over the course of seven and twenty-eight days, with a 20% replacement observed without sacrificing strength.

The results of the experiments revealed that the proportion of SCBA over 7 and 28 days varied with compressive strength. After 28 days of curing, 15% gave the highest strength when cement was replaced up to 50%.

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