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USE OF WASTE MATERIAL FOR THE CONSTRUCTION OF RIGID PAVMENTS

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ABSTRACT*- The goal of this research is to determine the best approach to use waste materials generated by various businesses as a substitute for cement in highway building. Several studies have been carried out all over the world to determine the negative impacts of various waste items on the environment as well as human health. On the basis of several investigations, it has been shown that large-scale cement manufacturing is also responsible for a variety of human ailments as well as water contamination. As a result, it is necessary in this case to use various waste materials instead of cement. Several studies were undertaken across the world with the same goal. As a result, several waste materials were discovered to be suitable for highway building applications, ranging from 5% to 50%. However, considering the chemical makeup of cement, there is still a requirement to entirely replace the cement by introducing another material (i.e. to achieve the same binding property as cement has). The goal of this study is to educate academics and engineers on how to make inexperienced concrete in order to strike a balance between environmental, economic, and technological concerns by showcasing various techniques of re-purposing rejected materials (i.e. waste).

***KEYWORDS*- waste material, cement, rigid pavement, environmental pollution**

I. INTRODUCTION

Every year, the worldwide cement industry generates more than four billion tonnes of cement. According to the Indian Bureau of Mines' most recent report (2015), cement output in India varies from 0.83 to 43.8 million tonnes per year. As a result, the vast production of cement has attracted the interest of academics all over the world, as the waste created (cement dust) from these facilities is exceedingly detrimental to the environment and human health. Fly ash, steel slag, E-plastic, and recycled concrete aggregate are just a few examples of waste materials that may be recovered and used in a polymer concrete mix to minimize the consumption of Ordinary Portland Cement (OPC) while also aiding in energy utilization without damaging the environment. Some garbage should be recycled to safeguard natural resources and for environmental sustainability. However, certain rules on the usage of fly ash in road building have been established. As a result, when individuals are exposed to various harmful diseases while working in these factories or living near them, it is necessary to suggest an alternative to cement for building work. The emission guidelines for cement plants were announced by the Ministry of Environment and Forests in 2016. One thing to keep in mind is that India's permissible stack dust emissions limit is set at 50 mg/Nm .In fig 1 the production rate of waste is shown below.

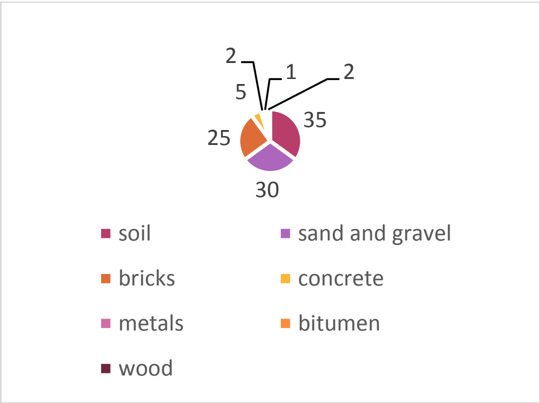

Fig. 1 waste production rate

II. LITERATURE REVIEW

Various literature works on research papers on this issue were collected and reviewed in order to obtain some information about the work done and the project work of the waste material, as well as the elements that are associated to the achievement of the work aim. This entails gathering data and resources on the subject, as well as research papers, journal articles, outlines, and technical information from research groups and government departments. Following the analysis of many study publications, certain conclusions were drawn based on personal experience. It gives an outline of how solid waste and nano-particles can be used to make green concrete mixes. The study's major purpose was to list all of the waste products that could be used in place of cement and aggregate to reduce CO2 emissions, which cause pollution in the environment. The study focused on a variety of waste materials, including those generated by agriculture, industry, and a variety of other sources. According to the study, adding SiO2 nanoparticles to the concrete mix will improve the structure's strength and longevity.

A. Aggregate from recycled concrete (RCA).

Wagih et al. (2013)[6] studied the use of recycled concrete and demolition debris as a replacement for natural aggregate (NA). A total of 50 samples were created by replacing NA with RCA at 0%, 25%, 50%, 75%, and 100% and adding superplasticizer at 0% to 1.30%.A modest amount of silica fume was added to 10% of the cement. Different qualities of concrete, such as compressive strength, were determined by various tests. The usage of RCA, according to the study's conclusions, would impair the workability and compressive strength of concrete mixtures

B. Red clay brick waste (RCBA).

A few years ago, Robayo et al. (2016)[8] investigated the behavior of RCBW as an alkaline and the mixing of Na2SiO3 and OPC. Five samples were obtained during the study. One sample included 100 percent RCBW, whereas the other samples contained OPC in various amounts, such as 5 percent, 10%, 15%, and 20%. The OPC sample combination's maximum compressive strength of 10% was found to be 41.39 MPa. The inclusion of corroborates improved the compressive strength of the mixture as well. At 25°C, the combination of NaOH + Na2SiO3 and 20% OPC has a strength of 102.6 MPa.

C. Fly ash.

Wang et al. (2017)[7] investigated the impact of adding fly ash to concrete mix. In place of cementitious materials like cement, fly ash was added to the mix. The w/c ratio must be kept in mind while preparing a sample for testing. It is possible to replace cement between the ages of 35 and 25, as well as from 8% to 15%. Compressive strength, chloride permeability, and shrinkage of a novel concrete mix are all tested. After evaluating the results, it was discovered that a 15% replacement yielded the best results.

D. Sugarcane Bagasse Ash (SCBA).

The construction properties of bagasse ash are investigated by Deepika et al. (2017)[3]. When bagasse ash is mixed with concrete, an alkaline byproduct is produced, which improves the mix's durability. Different tests were carried out to measure the compressive strength, abrasion resistance, water absorption, water permeability, and sorptivity of the material, with up to 20% of the bagasse ash being substituted. A 20% replacement rate had no harmful influence on concrete, according to the findings. Cordeiro et al. (2007) conducted study to assess the fineness of bagasse ash suitable for concrete use. The bagasse ash used to replace 20% of the cement had a particle size of less than 60 m, ensuring that its compressive strength was not impaired.

Amin NU.(2010)[2]. The influence of bagasse ash in concrete on strength 5rand chloride resistance. Nov 8;23(5):717-20 in Journal of Materials in Civil Engineering.

E. Furnace Granulated Slag (GGBS).

Manjunatha et al. (2014)[10] investigated the use of GGBS as a partial substitute for OPC cement. The durability and permeability of GGBS-based concrete and fly ash-based concrete were compared. It has been observed that GGBS has a comparable composition to regular cement. Each concrete grade was subjected to compressive and durability tests. After 28 days, a 50% substitution of GGBS with OPC yields the same strength. According to the results of the Rapid chloride penetration test, replacing cement with GGBS over time lowers voids in the mix and boosts the building's strength (RCPT). GGBS is a more sustainable material for future generations because to factors such as high quality, availability, energy efficiency, and cheap cost. GGBS has been treated as a waste material in the steel industry for many years, but it is nowbeing used to safeguard our environment from pollution.

F. Ladle Furnace Slag (LFS).

Chemical study by Razenovic et al. (2011)[9] revealed that the primary constituents are calcium, silica, magnesium, and aluminum oxides, which account for more than 92 percent of the total mass. Research on the use of LFS in building was undertaken by Manso et al. (2005). It was put to the test to see whether it could be used to pave roads instead of cement. LFS appears to be suitable for paving roads as a soil–cement combination, according to the findings. Its prospective usage is additionally aided by its low cost and time-dependent qualities, such as bearing to load and robustness.

III. METHODOLOGY

When the composition of various waste materials was compared to that of OPC cement, it was established that waste materials such as GGBS, LFS, and Bagasse ash may be utilized to partially replace cement, as shown in table 1. In place of sand, stone dust will be used, and recycled aggregate will make up a percentage of the aggregate. Different tests were performed, and recycled aggregate would be employed to a certain extent. Table 2 shows the many tests that will be carried out in order to determine the optimal proportion of cement substitution. Finally, the cost of conventional concrete will be compared to the cost of new eco-friendly concrete.

Table 1. Sample to be made of different proportion.

IV. PROCEDURE

- We'll start by identifying the issue.
- Based on literature evaluations, we find the gap.
- Selecting appropriate waste materials for the investigation.
- After that, we'll gather information (GGBS, LFS and SCBA).
- After that, we'll create a mix design, and the concrete cubes will be tested.
- The findings will be analysed, and if they are appropriate, we will go to step 3, if not, wewill return to step 3.

V. RESULTS

Various tests are carried out to determine the appropriateness of available materials. Sand, cement, and aggregate tests were carried out. Every material in a mix should have the same properties and values, according to mix design. Normal consistency, initial and final setting time, sand, cement, and aggregate specific gravity, water absorption, and compressive strength were all tested. The amount of material needed to make samples was also calculated.

For testing OPC, a variety of tests were carried out, and the findings were analyzed.

Table 2. results of various tests.

S no.	Experiments	values
1	Normal consistency of cement	28%
2	Initial setting time	28 minutes
3	Final setting time	7.2 hours
4	Compressive strength of cement 3,14, 28 days	25,28,45 N/mm^2
5	Tensile strength of cement 3, 14 days	25, 30 N/mm^2
6	Specific gravity of cement	3.16
7	Specific gravity of coarse aggregate	2.50
8	Specific gravity of fine aggregate	2.80

The compressive strength of concrete was determined by employing waste material in a cube with a typical dimension of 150 mm x 150 mm x 150 mm. Place cubes into the CTM plates

GGBS	LFS	Baggase Ash	CEMENT
0	0	0	100
5	5	5	95
10	10	10	90
15	15	15	85
20	20	20	80
25	25	25	75
30	30	30	70
35	35	35	65

and apply a steady rate of loading until the cubes fail. The ultimate load was calculated as indicated in table 3 below.

Table 3. compressive strength by using GGBS for 7 days.

%replacement of GGBS	Casting-I (MPa)	Casting-ii (MPa)	Casting-iii (MPa)	Average (MPa)
0%	27.42	28.41	28.21	28.01
5%	31.08	29.22	28.64	29.64
10%	31.22	31.66	32.02	31.66
15%	26.77	27.00	29.17	27.64
20%	26.53	27.35	26.91	26.93
25%	24.77	25.71	25.22	25.23
30%	22.33	21.57	21.84	21.91
35%	19.66	20.22	20.73	20.20

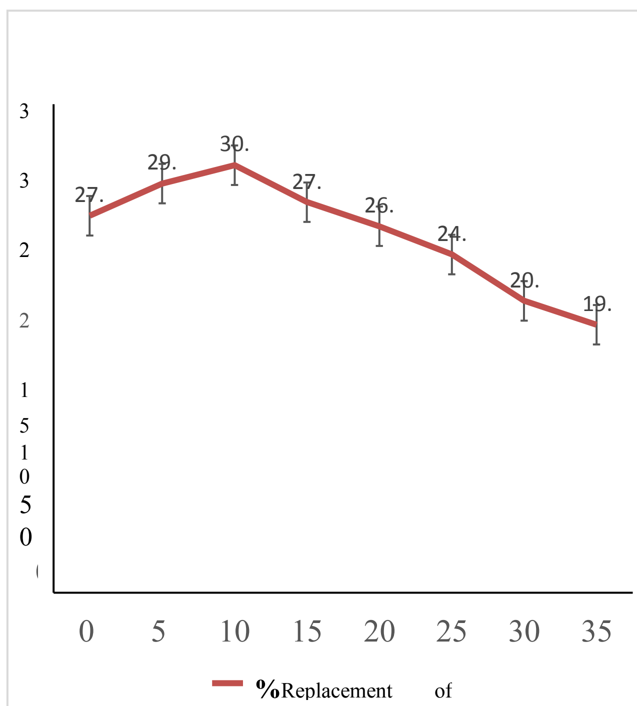

Fig 2. Variation in compressive strength with the % GGBS for 7 days.

Table 4. compressive strength by using LFS for 7 days.

%replacement of LFS	Casting-I (MPa)	Casting-ii (MPa)	Casting-iii (MPa)	Average (MPa)
0%	41.65	41.17	40.87	41.23
5%	43.77	45.09	45.52	44.79
10%	44.12	42.90	45.86	44.29
15%	41.57	41.66	43.73	42.32
20%	40.17	39.34	41.18	40.23
25%	39.97	39.15	39.74	39.62
30%	38.41	36.80	37.85	37.68
35%	35.00	34.80	31.50	33.76
40%	32.67	32.39	33.00	32.68
45%	31.80	30.50	31.00	31.10
50%	28.85	29.20	27.12	28.39

In fig 2 compressive strength for 28 days by using GGBS gives optimum results, when cement was replaced up to 15%. at 10% replacement there was an increment of 12% compressive strength.

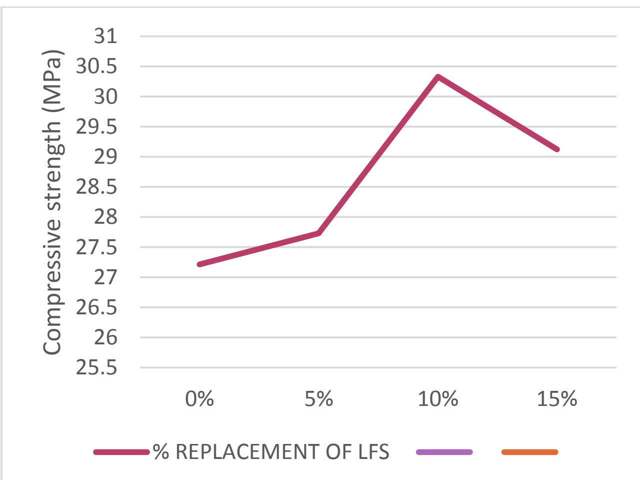

Table 5. Compressive strength by using SCBA for 7 days.

%replacement of SCBA	Casting-I (MPa)	Casting-ii (MPa)	Casting-iii (MPa)	Average (MPa)
0%	27.42	28.41	26.90	27.57
5%	25.43	28.77	28.25	27.48
10%	28.23	28.85	30.36	29.14
15%	31.18	28.95	27.57	29.23
20%	27.00	28.10	27.12	27.40
25%	26.25	26.00	26.12	26.12
30%	24.50	25.23	23.15	24.29
35%	23.23	21.85	22.45	22.51

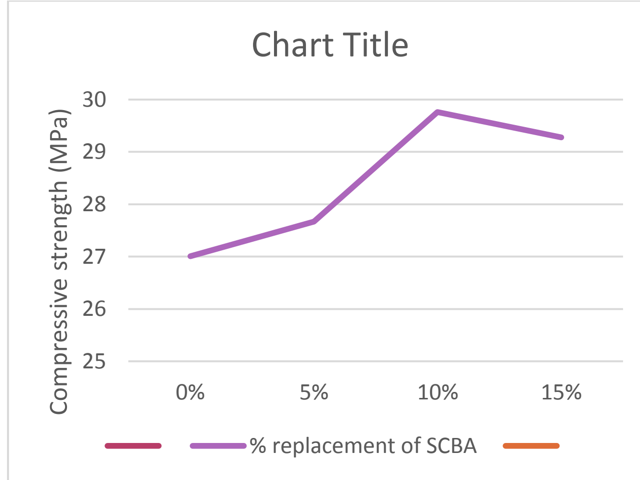

Fig 4. For 7 days, the compressive strength varied with the proportion of SCBA.

VII. DISCUSSION ON RESULT.

The fluctuation in compressive strength with the proportion of GGBS for 7 days is shown in fig.2, with a 15 percent replacement of cement by GGBS being ideal. There was a 125 percent compressive strength increase at 10% replacement.

Figures 3 depicted the fluctuation in compressive strength with percentage of LFS over 7 days showing a 20 percent replacement without compromising strength.

The fluctuation in compressive strength with the proportion of SCBA for 7 days is shown in fig.4. After changing cement up to 50%, it was shown that 15% provides the best strength after 28 days of curing.

The computed variation in split tensile strength with the proportion of GGBS, LFS, and SCBA for 28 days was greater than the usual concrete. Split tensile strength will not improve significantly, but neither will it deteriorate. After that, we may conclude that partially replacing waste material has no negative impact on tensile strength.

CONCLUSIONS

1. When cement is changed up to 15%, the compressive strength for 28 days using GGBS delivers the best results. There was a 12 percent increase in compressive strength after 10% replacement.
2. In the instance of LFS, a 20% replacement was seen without degrading the strength of the material.
3. After that, SCBA was partially substituted up to 50%, and after 28 days of curing, it was determined that 15% provided the highest strength.
4. During the research, many combinations of these three waste elements were created. According to the findings, the blend with 5% GGBS, 10% LFS, and 15% SCBA in it has the highest compressivestrength.
5. GGBS, LFS, and SCBA have somewhat higher split tensile strength than standard concrete.
6. Construction costs will be lowered by up to 18% of the overall project cost.

FUTURE SCOPE

Concrete's chemical, mechanical, and physical qualities are improved by these waste products. The recommended parameters of the current study may be used in the field in the building of rigid pavements with the use of reinforcement, and the study can be expanded by looking at the behaviour of green concrete. I.e., to investigate the material under various loads and environmental conditions. I.e., to investigate the various stresses that will occur on green concrete. Furthermore, by presenting other mix designs (i.e. in changing proportions), the percent use of the waste material provided in this study can be raised (i.e. up to 80 percent or 100 percent).In addition, by examining their chemical and physical qualities, other waste materials can be incorporated to create green concrete and a sustainable environment.

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