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Transformation of Waste Bakelite into Concrete and Solid Blocks

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Abstract:
Background*: Bakelite material has been used to produce the various components in India. Disposal of Bakelite through landfilling is prohibited and open burning because of the improper disposal and emission reasons. In an effort to use the Bakelite in large volume, research has being carried out for its possible utilization in making concrete and civil engineering materials as partial replacement of coarse aggregate. This experimental investigation was performed to evaluate the strength of concrete and solid block, in which coarse aggregate was partial replaced with Bakelite. Natural coarse aggregate was replaced with seven percentage (0%, 5%, 10%, 15%, 20%, 25% and 30%) of Bakelite by weight. A total of seven concrete mix proportions (M-1, M-2, M-3, M-4, M-5, M-6 and M-7) and solid blocks (S-1, S-2, S-3, S-4, S-5, S-6 and S-7) with and without Bakelite were developed. Compression test was carried out to evaluate the strength properties of concrete at the age of 7, 14 and 28 days. In case of solid block compression test, bulk density and water absorption was performed on all seven mix proportions. Test result indicate a marginal increase in strength properties of plain concrete and solid block by inclusion of Bakelite as a partial replacement of coarse aggregate.*
Key Word: *Bakelite, Concrete, Solid Block, Compressive Strength, Bulk Density*

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I. Introduction

The global need for plastic increasing day by day significantly over 300 Metric Tons of plastic produced every year in that 20-30 metric tons of E-waste is generated in the world[1,2]. It is estimated that 175,000 tons of Bakelite was produced in world every year and it was used in 15000 various form of products[3]. Bakelite is a type of thermosetting plastic which are the cross-linked & strong chemical bonds and Bakelite is made by Polymerization of phenol and formaldehyde through Condensation Process these are hard to recycle and cannot be softened by heating[4]. The Bakelite was invented by American chemist Leo Hendrik Baekeland, New York in the year of 1903[5]. Bakelite is thermosetting plastic which cannot be re-molten to new Material and disposal of Bakelite in the form of landfill and open burning leads to Environmental issues like Water, Land and Air pollution, Due to the presence of methyl and ethyl alcohol, it roots some toxic effects to the health problems[6,7,8,9]. Bakelite is a manufactured, synthetic plastic containing high amounts of toxic polymers like formaldehyde and asbestos among others[10]. Nearly, 15,342 tons of plastics are generated in India per day[11]. The disposal of Bakelite and its sustainability is obviously critical due to its hazardous qualities[13]. Disposal of Bakelite in an eco-friendly way is a challenging task and many research work are on progress. Construction industries plays a vital role in utilization of natural resources at a large quantity. The Large quantity of production of concrete in construction using conventional coarse aggregate such as granite extravagantly decreases the natural stone deposits and affecting the environment later causing ecology inequality[14]. Growing demand of conventional aggregates show that crushed stone demand will be 2050 million metric tonnes in 2020[15]. India is one of the largest global consumers of aggregates and global demand for construction aggregates is estimate to rise 2.3% per year to 47.5 billion metric tons in 2023, due to continued strong growth in global construction activity[16]. A rebound in global cement demand, which will support sales of concrete aggregates, increased sales to non-building markets in all regions, where aggregates are needed for ongoing infrastructure development. Since the future demand for construction and decreasing rate of natural materials used in construction, it is an important to develop alternate construction materials. The enormous demand of natural aggregate introduces a serious question about natural aggregate sources for sustainable development[15]. Therefore consumption of waste Bakelite material in place of natural aggregate in concrete production not only safeguards environment but also makes concrete a sustainable and environment friendly construction material. This research mainly focus on utilization of waste Bakelite as partial replacement for coarse aggregate in manufacturing of solid blocks.

II. Material And Methods

All materials used in this study are locally available. Type I Portland cement with grade 53 was used in this investigation. The properties of the cement are presented in Tables 1. The fine aggregate was manufacture sand (M-sand) of 4.75 mm maximum size. Its grading conformed to IS: 383-1970. The properties of M -sand are shown in Tables 2. Natural crushed stone aggregate supplied with maximum size of 20 mm and bulk density of 1580 kg/m3, was used in this study. Bakelite was used in this work as coarse aggregate and was analyzed in terms of physical properties. The waste bakelite from Railway Workshop Signal and Telecommunication, Southern Railway, Podanur, Coimbatore. The collected waste glass includes containers (bottles, jars) and flat glass (windows). The collected bakelite has some irregularities in its shapes and textures, bakelite is shredded into small pieces with the help of shredding machines. The properties of bakelite and coarse aggregates are shown in Tables 3.

Table 1: Properties of Cement

Properties	Limits
Specific Gravity	3.15
Standard Consistency (%)	28.5
Initial Setting Time (min.)	30
Final Setting Time (h)	5
Fineness (%)	1.5

Table 2: Properties of M-Sand

Properties	Limits
Specific Gravity	2.65
Water Absorption (%)	2.84
Fineness Modulus (%)	86.4

Table 3: Properties of Coarse Aggregate

Properties	Natural aggregate	Bakelite
	Limits	Limits
Specific Gravity	2.70	1.25
Water Absorption (%)	2.6	1.3
Crushing Value (%)	28.6	9.65
Impact Value (%)	26.44	7.42
Abrasion Value (%)	49.15	15.8
Density (Kg/m^3)	1398	1004.5

Mix Proportion: Two types of concrete mixes were prepared for casting concrete block and solid block in this study. The concrete block and solid blocks were casted using concrete mixes, which consisted of M- sand (523.87 kg/m3), gravel (1398 kg/m3), cement (498.92 kg/m3), and water (189.79 kg/m3), resulted in a water-concrete ratio of 0.5. The mix proportion for normal concrete and solid block was designated as M1 and S1 respectively. The other concrete mixes (concrete block & solid block) were made of waste bakelite aggregates of 5%, 10%, 15%, 20%, 25% and 30% as a partial replacement for coarse aggregate. The mix proportions are designated for partial replacement were M2, M3, M4, M5, M6 & M7 and S2, S3, S4, S5, S6 & S7 respectively. Both types of concrete and solid blocks were cured for 7, 14 and 28 days.

Preparation of Specimen: The mold was made for a dimension of 380mm x 150mm x 150mm to prepare solid blocks and conventional concrete block of size 150 mm x 150 mm x 150mm. The molds were coated with mineral oil to ensure that no water escaped during filling and to prevent adhesion of concrete. Concrete was placed in three layers and compacted by using a compacting rod. The molds were dried for 24 hours the concrete and solid block were removed from the molds and immediately submerged in fresh clean water and kept ready for testing.

III. Results and Discussions

Compressive Strength of Concrete : Compressive strength results of concrete mixtures with and without bakelite at the age of 28 days are shown in Table 4. It could be observed that concrete mixtures made with bakelite exhibited lower compressive strength than control concrete. Compressive strength of control mix was 32.5 N/mm2 on 28 days. From these results, it was observed that the target strength of 25 N/mm2 was achieved at a partial replacement of 10% bakelite for coarse aggregate. The compressive strength attained at 10% partial replacement was 25.2 N/mm2.

Table 4: Compressive Strength of Concrete

Mix Grade	M1	M2	M3	M4	M5	M6	M7
Replacement Percentage	0	5	10	15	20	25	30
Compressive Strength (N/mm^2)	32.5	28.6	25.2	23.8	21.4	20	18.8

In present investigation, compressive strength of concrete decreased with the increase in bakelite. However, the target strength was attained up to 10% as partial replacement of coarse aggregate. Reduction in compressive strength with the inclusion of 15% bakelite could probably due to poor binding process of coarse and fine aggregate in concrete.

Experimental Results of Solid Block: The bulk density, compressive strength and water absorption for solid block was conducted as per the IS code 2185 (Part 1):2005 and the results are presented in Table 5.

Table 5: Strength Properties of Solid Block

Mix Grade	S1	S2	S3	S4	S5	S6	S7
Replacement Percentage	0	5	10	15	20	25	30
Compressive Strength (N/mm^2)	5.1	4.7	4.5	4.1	3.8	3.62	3.24
Density (kN/m^3)	2455.85	2386.02	1983.56	1786.32	1721.82	1689.86	1508.62
Water Absorption (%)	5.36	4.56	4.71	4.91	5.02	5.17	5.86

From these results, it was observed that the compressive strength of 4.71 N/mm2 was achieved at a partial replacement of 10% bakelite for coarse aggregate the minimum compressive strength required for solid block is 4.5 N/mm2. The bulk density of solid block used for load bearing unit should not be less than 1800 N/mm2. From the present study, it was noted that bulk density of solid block at a partial replacement of 10% was 1983.56 kN/m3 it is clear that required density was attained and the corresponding water absorption was 4.71%.

IV. Conclusion

Following conclusion are drawn from the present investigation.

1. Partial replacement of coarse aggregate with bakelite (up to 10%) increases the compressive strength of concrete.
2. Partial replacement of coarse aggregate with bakelite (up to 10%) increases the compressive strength of solid block and required bulk density was achieved.
3. Bakelite can be suitably used in making structural grade concrete and solid block.

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