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Experimental Study on the Effect of Waste Bakelite Plastic as Coarse Aggregate in the Building Blocks

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ABSTRACT

Bakelite is difficult to dispose of and harmful to the environment and the general public's health due to its plastic makeup. In an effort to address this kind of issue, numerous scholars have been working to transform salvage Bakelite into a useful building material. In addition to creating challenging jobs, the utilisation of waste plastic in the construction sector improves the functionality of building materials. In this study, discarded Bakelite is used as a partial substitute for coarse aggregate in the construction sector. Its properties, durability, and assimilation into different types of building materials are discussed. Paver Blocks and Solid Blocks were made out of waste bakelite, and several tests were conducted to determine how strong and durable they were in contrast to other building materials. The test results showed that Paver block replacement can achieve an ideal compressive strength of 8% and solid block replacement with waste bakelite may attain a compressive strength of 35%. As a result, recycling unused bakelite will aid in waste management and give the construction industry access to a beneficial resource.

Keywords: *Paver Block; Bakelite; Compressive Strength.*

1.0 Introduction

A range of malleable, synthetic or semi-synthetic organic compounds can be moulded into solid objects to create plastic, one of the most contemporary engineering materials. Plastics may be heated up and moulded into a variety of shapes. They gradually devolved into rubbish and were found in a variety of shapes and sizes, including cups, furnishings, basins, plastic bags, and food and drink containers. Building up plastic waste can have negative effects on both people and plant life. As a result, appropriate disposal techniques must be used, and new applications for these wastes in their regenerated form must be developed. The most popular applications for bakelite, a thermoset plastic, include heat-resistant household appliances, phone casings, and vehicle parts. Bakelite is created through an elimination reaction between phenol and formaldehyde. It can be utilised as a heat-resistant material because it cannot be remelted to create a new product. Since, it contains methyl and ethyl alcohol, it has negative effects on the environment and health problems. In order to avoid these problems and water pollution, it is best to avoid disposing of Bakelite.

Waste Bakelite, a waste product obtained from Southern Railway's Workshop Signal and Telecommunication in Podanur, Coimbatore, is one of the cross-linked polymers. Urbanization, population growth, and contemporary lifestyles are all contributing to a noticeable increase in the use

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of plastic and related materials. Waste plastics cannot biodegrade, so their disposal has not been done in a way that is scientifically sound. This is a significant global problem that puts the ecosystem in peril. This recycled plastic debris has recently been used as an ingredient in road construction.

2.0 Material and Its Properties

2.1 Cement

According to the codal provision IS 12269:2013, the cement utilised for this project is 53 grades OPC. Used cement was lump-free and brand-new. The cement's empirically tested laboratory qualities are listed below.

Table 1: Properties of Cement

Physical Property	Cement
Specific gravity	3.15
Standard Consistency	29.4 %
Initial setting time	30 min
Final setting time	600 min
Fineness	1.5%
Soundness	7 mm

2.2 Aggregate

Sand, gravel, crushed stone, and other inert granular materials that provide volume, stability, and resistance to wear and tear are examples of aggregate. A significant role is played by aggregate, both fine and coarse, in the production of numerous construction components.

Crushed stone was used as the coarse aggregate and produced sand as the fine aggregate. Aggregates should conform to the requirements of IS: 383-1970 in terms of size, shape, and other characteristics. The characteristics of both fine and coarse aggregates are as follows:

2.3 Properties of aggregate

Table 2: Properties of Fine Aggregate

Property	Fine Aggregate	
Type	M – sand	Eco – sand
Specific gravity	2.63	2.30
Water Absorption	2.4%	2.04%
Sieve Analysis	83.5 %	98.6 %

Table 3: Properties of Coarse Aggregate

Property	Coarse Aggregate
Type	Crushed stone (10 mm)
Specific gravity	2.70
Water Absorption	2.4 %
Crushing Value	29.22 %
Impact Value	27.8 %
Bulk Density	1580.24kg/m^3
Abrasion Value	49.15

2.4 Bakelite

The condensation reaction of phenol and formaldehyde produced polyoxybenzylmethylenglycolanhydride, a thermosetting phenol formaldehyde resin.

Waste bakelite was obtained from the Southern Railway Workshop for Signal and Telecommunication in Podanur, Coimbatore.

Due to some abnormalities in its shapes and textures, the collected waste bakelite needs to be broken up into little pieces using shredding machines.

Figure 1: Waste Bakelite

Collected from workshop

Figure 2: Shredded Bakelite

The size of the shredded bakelite materials determines how they are categorised. Shredded material should be held on a 10 mm IS sieve after passing through a 12.5 mm IS sieve for coarse aggregates, and 4.75 mm IS sieve for fine aggregates.

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Figure 3: Coarser Size

Figure 4: Finer Size Particle Particle

Based on the codal provisions, the properties of bakelite in the form of fine and coarse aggregate were examined, and the findings are shown in the table below.

Table 4: Properties of Bakelite as a Coarse Aggregate

Property	Waste Bakelite
Type	Shredded bakelite (10 mm)
Specific gravity	1.26
Water Absorption	1.38 %
Crushing Value	9.78 %
Impact Value	7.14 %
Bulk Density	1003.42kg/m^3
Abrasion Value	14.8 %

2.5 Water

In accordance with IS - 456-2006, only potable water free of salt and contaminants was utilised for casting and curing the concrete blocks. It was 0.45 water to cement ratio.

3.0 Casting of Material

Waste bakelite is used as a partial replacement for coarse aggregate in the manufacture of solid block and paver block in this project, which is developed for M25 concrete.

3.1 Mix proportion of solid block

The solid block is 380 mm by 150 mm by 150 mm. The following table displays the ratio of various materials added in the manufacture of each Solid block for various ratios.

Table 5: Mix Proportion of Solid Block

%	Cement (kg)	Fine aggregate (kg)	Coarse Aggregate (kg)	Waste bakelite (kg)
0%	1	5	10	0
5%	1	5	9.5	0.5
15%	1	5	8.5	1.5
25%	1	5	8	2.0
35%	1	5	7.5	2.5
45%	1	5	7	3.0

Fig 5: Cast Solid Block for Various Proportions of Waste Bakelite

3.2 Mix proportion of paver block

A cast paver block measures 190 mm, 170 mm, and 60 mm in size. The following table displays different proportions of the amount of various materials added to each Paver block during manufacturing.

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Table 6: Mix Proportion of Paver Block

%	Cement (kg)	Fine aggregate (kg)	Coarse Aggregate (kg)	Waste bakelite (gm)
0 %	0.97	1.55	1.79	0
2 %	0.97	1.55	1.75	36
4 %	0.97	1.55	1.72	71
6 %	0.97	1.55	1.68	107
8 %	0.97	1.55	1.65	143
10 %	0.97	1.55	1.61	179

Figure 6: Cast Paver Block for Various Proportions of Waste Bakelite

The casted blocks were allowed for curing of 28 days and after proper curing the concrete solid blocks and paver blocks was tested for compressive strength, water absorption; block density, etc., in comparison with nominal blocks.

4.0 Result and Discussion

The tests listed below were used to examine the characteristics, durability, and effectiveness of aggregate and structural components constructed from different amounts of leftover bakelite.

4.1 Test results for solid block

According to IS code 2185 (Part 1):2005, a number of tests for solid blocks were carried out, and the results were analysed below.

4.2 Block density

According to the codal requirements, the block density for cast specimens was determined. The density of a solid block was calculated by dividing the mass (weight) of each block by its volume. Three samples were used for the test, and the outcomes were tabulated.

Table 7: Test Results for Block Density of Solid Block

% of Waste Bakelite	Density (Kg/ m^3)
0 %	2405.85
5 %	2206.24
15 %	1987.48
25 %	1796.10
35 %	1707.21
45 %	1538.91

According to the information provided in the code book, solid concrete blocks with a block density of at least 1800 kg/m3 are employed as a load-bearing unit. Therefore, it was determined from the test results that the block density of solid block was within the allowable limit when up to 35 percent of waste bakelite was replaced. Therefore, in accordance with codal requirements, the block can only be employed as a hollow block when the percentage rises above the optimal level (35 percent).

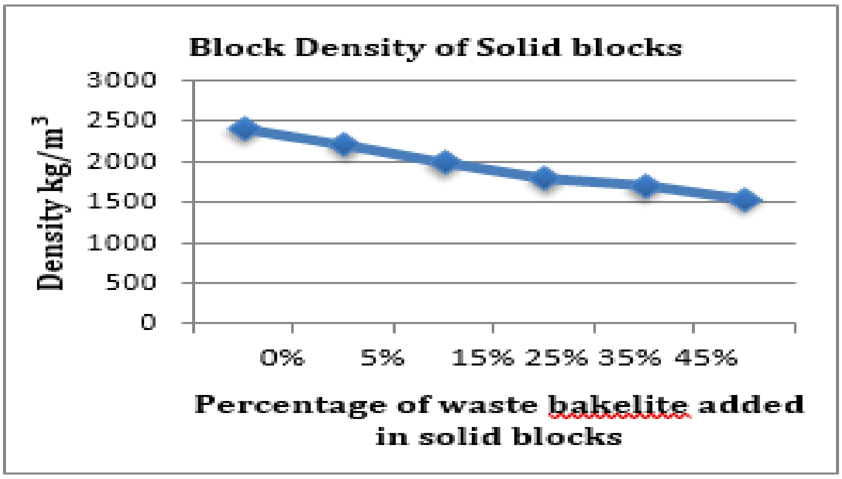

Chart – 1: Block density test of solid block

4.3 Water absorption

Solid blocks can be used to create structures since they have passed tests to determine how well they can absorb water. This test aids in determining a solid block's water absorption rate in accordance with IS 2185 (Part 1):2005. The test results are listed below in a table.

Table 8: Test Results for Water Absorption of Solid Block

% of Waste bakelite	Water Absorption (%)
0 %	5.68
5 %	4.52
15 %	4.67
25 %	4.75
35 %	5.17
45 %	5.93

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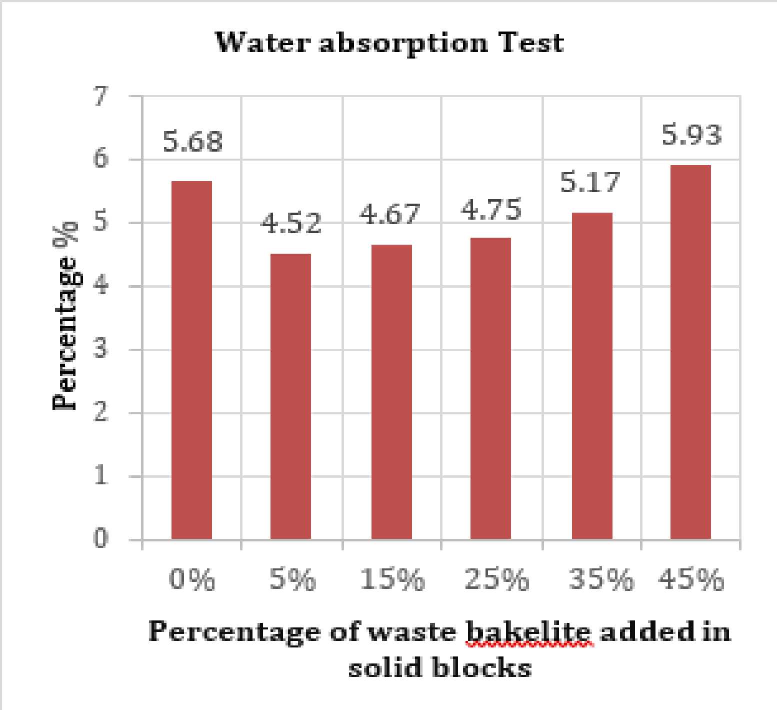

Chart – 2: Water Absorption test of solid block

According to the above test results, adding more waste bakelite to solid blocks causes the rate of water absorption to increase. However, its absorption rate is slightly lower when compared to nominal solid block.

4.4 Compression strength

One of the crucial tests for solid blocks to establish their applicability in the field of construction is the Compressive test, which is necessary to ascertain the strength of the specimen. The cast specimens were tested using a hydraulic compressive testing equipment for 7, 14, and 28 days, and the test results are tabulated.

Table 9: Test Results for Compression Strength of Solid Block

% of Waste bakelite	Compressive Strength 28 day test (N/mm^2)
0 %	3.33
5 %	3.51
15 %	3.68
25 %	3.86
35 %	4.03
45 %	2.46

According to the test results, the compressive strength of the Paver block steadily increases with the addition of bakelite up to 6 percent and gradually decreases after 8 percent of replacement at 7, 14 and 28 days. This demonstrates that the Paver block will only be strong enough to replace 6% of waste bakelite.

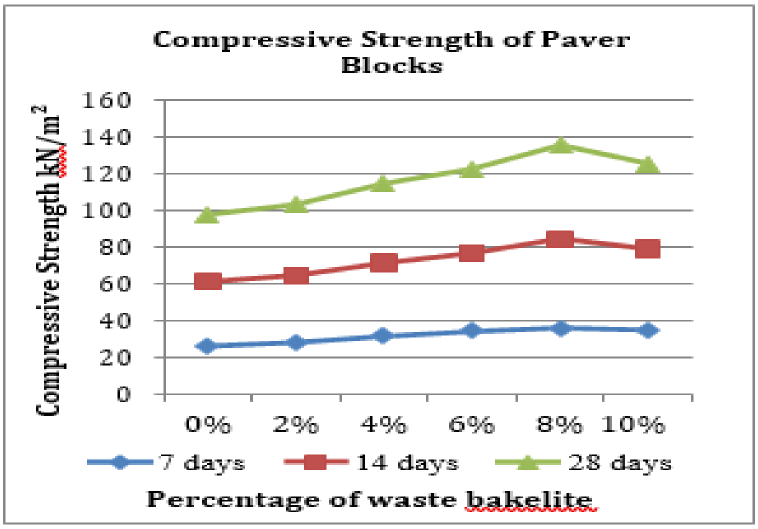

Chart – 5: Compressive Strength test of Paver block

According to the results of the current experimental study, the ideal replacement of waste bakelite in solid blocks is up to 35 percent, which results in a steady rise in compressive strength. The compressive strength value dropped with the inclusion of waste plastics more than 8% of waste bakelite, according to the results of tests on Paver blocks. In order to reuse waste plastic in construction materials, waste bakelite can be added to concrete blocks and Paver bricks.

5.0 Conclusion

The current investigation exposes the characteristics, durability, and application of waste Bakelite as a building material in solid blocks and paver blocks with the necessary standards. Based on the aforementioned factors, waste bakelite can be added to cement concrete in the building industry. For paver blocks and solid blocks, it has been discovered that the ideal modifier content of leftover bakelite is 8 percent and 35 percent, respectively. This research aids in the creation of a material that will somewhat lower construction costs while also reducing the waste management issue brought on by the disposal of waste plastics.

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