Waste Bakelite as Partial Replacement of Coarse Aggregate in Building Blocks

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Abstract – *Bakelite being a plastic material creates a disposal problem and causes health issues to the public as well as environment. In order to overcome this kind of problem, many researchers have involved in transforming waste Bakelite as a useful construction material in Civil engineering field. This usage of waste plastic material in construction industry creates a challenging job and also helps to improve the performance of building material in the construction sector. This study describes about the properties, strength and application of waste Bakelite into different forms of construction material by a partial replacement of coarse aggregate in construction sector. Paver Blocks & Solid Blocks were manufactured using waste Bakelite and various tests were conducted to examine its strength and durability by comparing with conventional material. Based on the test results, it is revealed that the optimum compressive strength achieved by the replacement of waste bakelite is 35% for solid block and 8% is for Paver block. Hence the application of waste bakelite will reduce the disposal problem and gives an effective building material in the construction sector.*

Key words: *Bakelite, paver block, solid block, aggregates.*

1. INTRODUCTION

Plastic is one of the recent engineering materials which consist of a wide range of synthetic or semi-synthetic organic compounds that are malleable and can be moulded into solid objects. Plastics can be made to different shapes when they are heated. It was found in the different forms such as cups, furniture, basins, plastic bags, food and drinking containers and they become waste material. Accumulation of plastic wastes can result into hazardous effects to both human and plant life. Therefore, there is a need for proper disposal method and also use of these wastes in the recycled form in various field are to be developed.

Bakelite is a thermoset plastic which is formed from an elimination reaction of phenol with formaldehyde and it is most commonly used for automobile parts, telephone casings, and kitchenware appliances for heat resistant. It cannot be remelted to form a new product and so it can be used as a heat resistant material. Due to the presence of methyl and ethyl alcohol, it causes some toxic effects to the environment as well as health problems. Therefore to avoid such problems and to prevent water pollution disposal of Bakelite is to be avoided.

Waste Bakelite is one of the cross linked polymer, is a waste product procured from Workshop Signal and Telecommunication, Southern Railway, Podanur, Coimbatore. The use of plastic and related materials is increasing tremendously due to growth in population, urbanization and modern life style. Waste plastics are not disposed scientifically due to their non-biodegradability hence its disposal is now become a very big global problem which creates an unsafe disposal to the environment. Recently this waste plastic material is used as additives in road construction.

2. MATERIAL AND ITS PROPERTIES

2.1 Cement: The cement used for this project is 53 grades OPC as per the codal provision IS 12269:2013. The cement used was fresh and free from lumps. Following are the properties of cement which have been experimentally done in the laboratory,

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: Aggregate is an inert granular material such as sand, gravel, crushed stone, etc. which gives volume, stability, resistance to wear and tear. Both fine and coarse aggregate plays a major part in the manufacturing of various construction members.

The fine aggregates used were manufactured sand and coarse aggregates used were crushed stone. The size, shape and other properties of aggregates should satisfy the code of IS: 383–1970. Following are the properties of both fine and coarse aggregates:

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 %

2.3 Bakelite: Polyoxybenzylmethylenglycolanhydride was thermosetting phenol formaldehyde resin made from the condensation reaction of phenol with formaldehyde.

Collection of material: Waste bakelite is procured from Workshop Signal and Telecommunication, Southern Railway, Podanur, Coimbatore.

Shredding Process: The Collected waste bakelite has some irregularities in its shapes and textures, so that the material should be shredded into small pieces with the help of shredding machines.

Fig – 1: Waste bakelite Collected from workshop

Fig – 2: Shredded bakelite

Classification of material: The shredded bakelite materials are classified based on their size. By means of coarse aggregates the shredded material should passed through 12.5 mm IS sieve and retained on 10 mm IS sieve, for fine aggregate the material should pass through 4.75 mm IS sieve.

Fig – 3: Coarser size Particle

Fig **– 4:** Finer size particle

The properties of bakelite in the form of fine and coarse aggregate were tested based on the codal provisions and results are tabulated 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 %

2.4 Water: Portable water that are free from impurities and salt have been used for casting and curing the concrete blocks as per IS – 456-2006. The Water cement ratio used was 0.45.

3. CASTING OF BUILDING MATERIALS

In this project M25 concrete is designed and waste bakelite is used as a partial replacement of Coarse aggregate in manufacturing of Solid block and Paver block.

3.1 Mix Proportion of Solid Block

Solid block is casted with the dimension of 380 mm x 150 mm x 150 mm. The following table indicates the proportion of various materials added in the manufacturing of each Solid block for different proportions.

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

Paver block is casted with the dimension of 190 mm x 170 mm x 60 mm. The following table indicates the proportion of various materials added in the manufacturing of each Paver block for different proportions.

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

Fig – 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. EXPERIMENTAL RESULTS

The various tests required to determine the properties, strength and performance of aggregate and structural elements made from various proportions of waste bakelite are as mentioned below.

4.1 Test results for Solid block

Various tests for Solid block was conducted as per the IS code 2185 (Part 1):2005 and the obtained results were analysed below.

Block Density

Determination of block density for casted specimens was done as per the codal provisions. By dividing the mass (weight) of each block by its volume, the density of solid block was known. The test was carried out with 3 samples and the results were tabulated.

Table – 7: Test results for block density of solid block

% of Waste Bakelite	Density (Kg/ m³)
0 %	2405.85
5 %	2206.24
15 %	1987.48
25 %	1796.10
35 %	1707.21
45 %	1538.91

Based on the data mentioned in the code book, the solid concrete blocks are used as a load bearing unit and have a block density not less than 1 800 kg/m³.

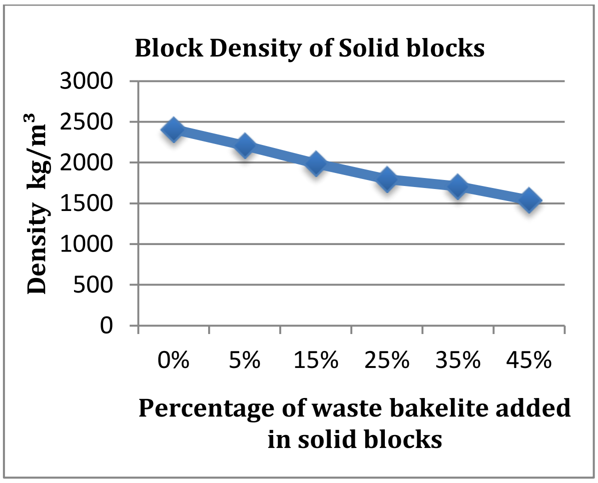

Chart – 1: Block density test of solid block

Therefore from the test results it was observed that upto 35% replacement of waste bakelite, the block density of solid block was in the permissible limit. Hence when the percentage increases above the optimum level (35%), the block can only be used as a hollow block as per codal provisions.

Water absorption

Solid block is tested for its absorption capacity of water hence it can be used in the construction of buildings. This test helps to determine the water absorption of solid block as per IS 2185 (Part 1):2005. The test results are tabulated below.

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

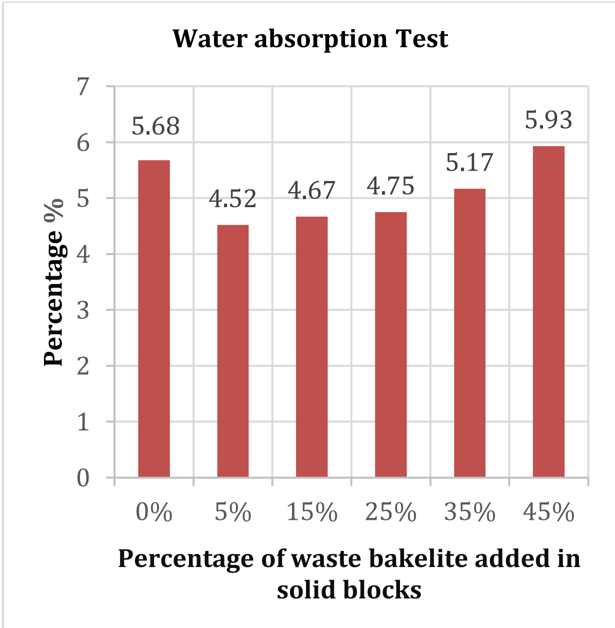

Chart – 2: Water Absorption test of solid block

From the above test results, it was found that the water absorption rate increases with increase in the addition of waste bakelite in solid block. But when it is compared with nominal solid block, there is a slight decrease in its absorption rate.

Compression strength

The Compressive tests are required to determine the strength of specimen which is one of the important tests for solid block to determine its suitability in construction field. The casted specimens were tested for 7, 14 and 28 days compressive strength by using hydraulic compressive testing machine strength 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

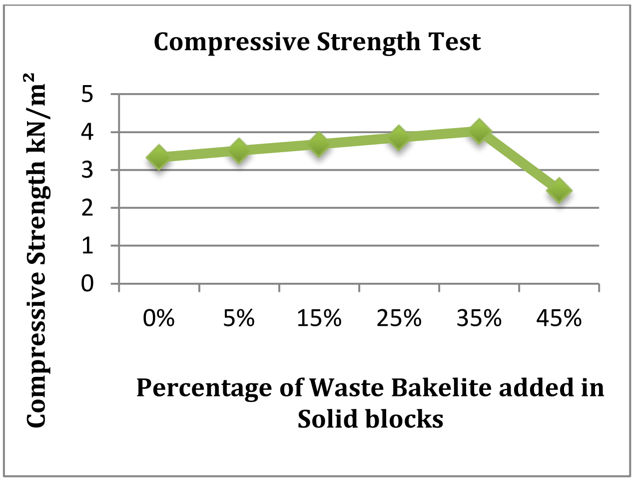

Chart – 3: Compressive Strength test of Solid block

The test results mentioned above indicates that the compressive strength of solid block at 28 days gradually increases with increase in addition of bakelite upto 35% and starts decreasing from 45% of replacement. This shows that the solid block will be strong enough only upto the optimum replacement of 35% of waste bakelite.

4.2 Test results for Paver block

Various tests for Paver block was conducted as per the IS code 15658:2006 and the obtained results were analysed below.

Water absorption

Paver block is tested for its absorption capacity of water hence it can be used in the construction of buildings. This test helps to determine the water absorption of Paver block as per IS 15658:2006 and the test results are tabulated below.

Table – 10: Test results for Water Absorption of paver block

% of Waste bakelite	Water Absorption (%)
0 %	3.58
2 %	2.13
4 %	1.96
6 %	1.55
8 %	1.46
10 %	1.42

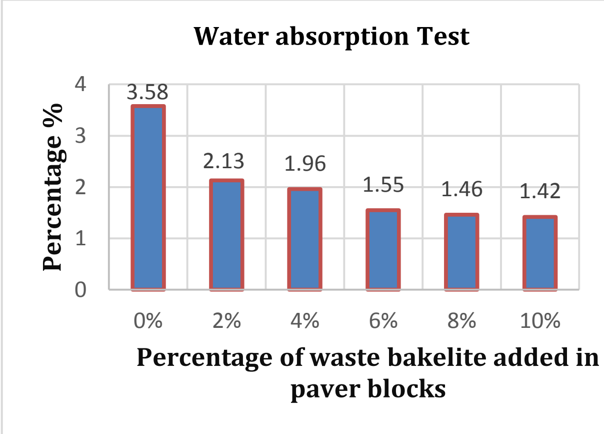

Chart – 4: Water Absorption test of Paver block

From the test results, it was observed that the water absorption rate decreases with increase in the addition of waste bakelite in Paver block. But when it is compared with conventional Paver block, there is a slight decrease in the rate of absorption.

Compression strength

The Compressive tests are required to determine the strength of specimen which is one of the important tests for Paver block to determine its suitability in construction field. The casted specimens were tested for 7, 14 and 28 days compressive strength by using hydraulic compressive testing machine strength and the test results are tabulated.

Table – 11: Test results for Compression Strength of Paver block

% of Waste Bakelite	Compressive Strength (N/mm^2)		
	7 days	14 days	28 days
0 %	26.26	34.82	36.71
2 %	28.13	36.37	38.80
4 %	31.58	39.72	43.44
6 %	34.15	42.41	46.07
8 %	36.06	48.39	51.08
10 %	34.93	43.95	46.53

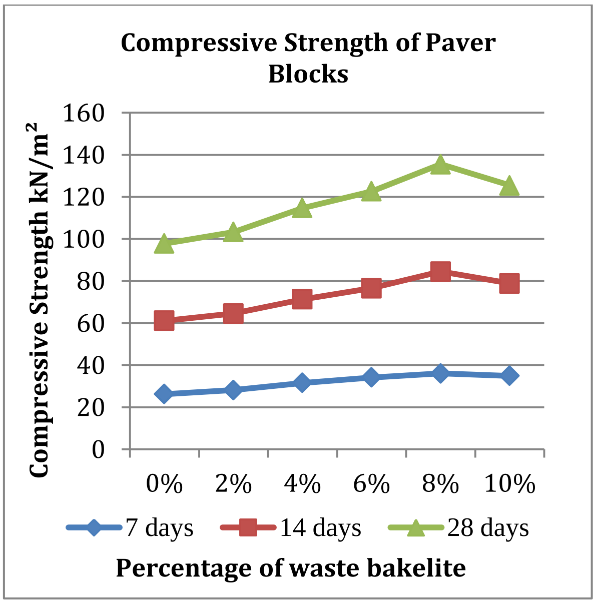

Chart – 5: Compressive Strength test of Paver block

From the test results it was observed that the compressive strength of Paver block at 7, 14 and 28 days gradually increases with increase in addition of bakelite upto 6% and starts decreasing from 8% of replacement. This shows that the Paver block will strength only upto the optimum replacement of 6% of waste bakelite.

5. RESULTS AND DISCUSSION

In the present experimental study it was found that the optimum replacement of waste bakelite up to 35% in solid block shows a gradual increase in its compressive strength. Similarly, from the test results of Paver block it was observed that the compressive strength value decreased with the addition of waste plastics more than 8% of waste bakelite. Hence the addition of waste bakelite in concrete blocks and Paver blocks will helps in reusing of waste plastics in construction materials.

6. CONCLUSION

The present study reveals the properties, strength and use of waste Bakelite as a construction material in paver blocks and solid blocks with appropriate specifications. From the above aspects, the waste bakelite can be used in the cement concrete mix in the construction field. The optimum modifier content of waste bakelite is found to be 8% for paver blocks and 35% for solid blocks. This study helps to develop a material which will reduce the cost of construction to some extent and also to minimize the waste management problem created by waste plastics disposal.

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