A Critical Review on the Application of Bakelite as a Partial Replacement of Fine and Coarse Aggregate

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Abstract- *Bakelite being a plastic material creates an environmental problem and causes health issues to public during its disposal process. In order to overcome this problem, many researchers involved in making waste Bakelite as a useful material for Civil engineering field. This study describes about the basic concept and application of Bakelite which is made into different forms of construction material. In order to reduce the waste management problem created by disposal of waste Bakelite into direct land filling and open burning, this study reveals the use of Bakelite as fine aggregate as well as coarse aggregate in construction field. Bricks, Paver Blocks & Solid Blocks are manufactured using waste Bakelite as a partial replacement of fine and coarse aggregate. Tests are conducted to examine its strength and compared with conventional material.*

Keywords- Bakelite, brick, paver block, aggregates.

I. INTRODUCTION

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.

II. MATERIAL AND ITS PROPERTIES

Bakelite: Polyoxybenzylmethylenglycolanhydride was thermosetting phenol formaldehyde resin made from the condensation reaction of phenol with formaldehyde. Waste bakelite is obtained from machine parts of electrical systems, automobile parts, telecommunication workshop, etc.,

Properties:

- It is a cross linked polymer
- Strong, rigid and light in weight
- Can be Molded easily
- It cannot be remelted
- Resistance to heat, electricity and chemical action

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 grading of aggregate should be properly done and an appropriate size is to be preferred for construction.

Properties:

- Particle size and gradation
- Resistance to wear
- Durability
- Chemical stability
- Specific gravity and absorption

III. MATERIAL TESTS

The various tests required to determine the properties and performance of aggregate and structural elements made from that are as mentioned below.

Tests for aggregate and brick

Tests for aggregate	Tests for brick
1) Specific gravity test 2) Aggregate impact tests 3) Aggregate crushing test 4) Los's Angeles abrasion test 5) Water absorption test 6) Stripping value test 7) Soundness test	1) Compressive strength test 2) Water absorption test 3) Efflorescence test 4) Impact test 5) Dimension tolerance test 6) Soundness test 7) Hardness test

Tests for paver and solid concrete block

Tests for paver block	Tests for solid concrete block
1) Compressive strength test 2) Water absorption test 3) Abrasion resistance test 4) Splitting tensile strength test 5) Flexural strength test 6) Free & thaw durability test	1) Dimension stability test 2) Block density test 3) Compressive strength test 4) Water absorption test 5) Flexural strength test 6) Splitting tensile strength test

IV. LITERATURE REVIEW

The extensive studies and research for incorporating waste Bakelite in the manufacturing of bricks, paver blocks and solid blocks are done.

Materials and Tests for Brick manufacturing

Lalith Prasanth et al, utilized flyash bricks with a combination of powdered plastics which is added as 5%, 10%, 15%, 20%. Raw materials used are Class F Flyash, Quarry dust, lime, waste plastic powder and water. Test results indicated that the compressive strength increases with increase in percentage of powdered plastic added. Moreover, there is a decrease in percentage of water absorption as the addition of plastic and there is a nil formation of white patches as per the result of efflorescence test. From this study, it was revealed that the partial replacement of plastic for quarry dust decreased the weight of brick and it can be effectively used in construction field.

S. Alan et al investigated the properties of flyash brick with waste Plastic Strips. The amount of plastic waste added is varies from 0% to 2% with an interval of 0.5%. Polyethylene tetra phthalate (PET) is added as a plastic in the manufacturing of flyash brick by varying the amount of percentage added and with a dimension of 220 mm x 115 mm x 70 mm. From the test results, the compressive strength is optimum at 1% replacement of PET where as in impact test; no bricks of any sample are forced to break while other clay bricks have been broken into two or more pieces. But there is a drastic change in water absorption test, only 2% absorption is yielded. From this it was known that Polyethylene tetra phthalate bricks are comparatively better than conventional brick and an economical product in construction field.

Lairenlakpam Billygraham Singh et al conducted an experimental program on waste compact disc and waste water bottles. Brick is manufactured by mixing the waste plastic pieces and sand in the proportion of 1:1.5 by weight. As the results of various tests indicates that the compressive strength is higher where as the water absorption rate, bulk density and apparent porosity becomes lower than normal clay bricks. It also revealed that these plastic bricks reduce environmental pollution.

Puttaraj Mallikarjun Hiremath et al utilized the waste plastic to manufacture Plastic – Soil brick. The materials to be added are Gravel, Sand, and Silt & Clay along with these materials waste plastic is added in the range of 60% to 80%. Based on the test results it was revealed that the compressive strength was increased with 70% replacement of waste plastic with sand and an addition of 2% of bitumen as a binder where as the water absorption rate was decreased with increase in waste plastic. From this it was absorbed that if there is an efficient usage of waste plastic in brick can also solve the waste disposal problem.

Ronak Shah et al reported to reduce the disposal problem caused by waste plastic thereby manufacturing a product of plastic dust. In this plastic dust is the main component which is formed by adding flyash, bitumen, plastic dust, etc., in a proposed mix. Results based on the tests conducted were proven to have more compressive strength and water absorption rate with a lower weight than conventional brick. This was made to be more economical which reduces the cost of incinerators for burning and land filling process.

Materials and Tests for Paver Block manufacturing

Nopagon Usahanunth et al studied the mechanical properties and application of Waste Bakelite Aggregate Concrete in construction industry. The sample was made in the form of Waste Bakelite Aggregate Concrete (WBAC) and Waste Bakelite Mortar (WBM) and tests were conducted as per the codal provisions. From the results it was absorbed that the 20% replacement was considered to be an appropriate mix

proportion to have higher compressive strength than conventional one. But waste bakelite mortar is less preferred for plastering work in construction field rather it can be used as bricks, pavers, blocks, etc. From this study it was understood that use of waste plastic in construction made to be more efficient and low cost material.

S. Dinesh et al utilized the waste plastic in manufacturing of paver block by using High–density polyethylene (HDPE) and Polyethylene (PE) bags at various percentages with sand and aggregate. Materials used are waste plastics, sand, flyash and red oxide, etc., with a mix proportion of 1:2, 1:3, 1:4, 1:5, 1:6 representing plastic and river sand respectively. Based on the results of tests conducted, the compressive strength of mix ratio 1:4 proven to be more strength and increases its fire resistance property compared to conventional block. More over the water absorption rate decreases with increase in waste plastic content.

K. Kalingarani et al developed an interlocking concrete paver block (ICPB) using industrial wastes. Materials used are Cement and its admixtures, Coarse aggregate, Fine aggregate and industrial wastes like copper slag, flyash, phosphogypsum, sludge, etc. The optimum ratio selected was 1:1.36:2.42 which includes cement (70%) and flyash (30%) as first part, copper slag as second part and coarse aggregate as third part. The tests are conducted as per the code book for Precast Concrete Block for Paving (IS15658:2006). As per the results of tests conducted, the compressive, flexural and tensile strength are higher than the conventional paver block. From this study, by the incorporation of industrial wastes in paver block reduces the waste management problem and also the usage of naturally available resources.

C. Nivetha et al studied the probability using plastic waste as a binding material in replacement of cement for the manufacturing of paver block. The waste plastic is mixed with flyash and quarry dust by varying the proportion of waste plastic about 25 – 35 %, flyash 25% and quarry dust 40-50%. Based on the test results, for 25% plastic waste, 25% flyash and 45% quarry dust was found to have more strength than other proportions. From this it was revealed that for the preparation of paver block if solid waste is added as a main constitution it can give more strength than conventional paver block.

Sarang Shashikant Pawar et al investigated about the usage of waste plastic material in paver block to reduce the aggregate content with better durability and economy. The paver block made with the size 100 mm x 100 mm x 100 mm.Various tests were conducted and based on the results it was proven to be stronger upto 30-35% replacement of plastic material. From this study it was known that the addition of plasticizers is not required for manufacturing of concrete plastic paver block which thereby decreases the cost of material.

Mohan D.M.S et al utilized the waste plastic bags in the manufacturing of paver blocks. Paver block is made by either varying the plastic and fine aggregate ratio or by varying quarry dust. Based on the test results, a plastic bag reduces the construction cost which in turn helps to avoid land filling and incineration method of disposal into the environment. From this study it was absorbed that for the manufacturing of paver block, the fine aggregate and quarry dust content was about 60-70% whereas the recycled plastic was about to 20% so that it does not cause any affect to the properties of paver block.

Materials and Tests for Solid Concrete Block manufacturing

Sina Safinia et al examined the probability of using waste plastic bottles in the manufacturing of concrete block. The size of concrete block with plastic bottles is about 200 mm x 200 mm x 400 mm. Each block consist of eight bottles which is of equal distance and wires are also used in the arrangement to ensure that during the process of concreting, bottles will not change their position. As per the results of tests conducted it was known that the compressive strength varies based on the addition of waste plastic bottles. This shows that there is a 57% difference in the strength of concrete plastic block compared with conventional concrete block.

S.Vanitha et al utilized the waste plastics as a partial replacement of coarse aggregate in concrete blocks in construction industry. The proportion of waste plastic added in percentage of 0%, 2%, 4%, 6%, 8% and 10% as a replacement of coarse aggregate. The dimension of concrete block used is 200 mm x 100 mm x 65 mm. After the test results, there is a slight deviations in compressive strength upto 4% replacement of waste plastics. This indicates that the recycled concrete block was applicable for the rigid pavement construction as well as it also reduces the cost of construction.

Praveen Mathew et al studied the incorporation of waste plastic in the concrete block. Plastic wastes used are polythene covers and Low Density Polyethylene (LDPE) which is replaced as an aggregate in concrete block. As per the code IS 2185:2005, the dimension of concrete block is of about 300 mm x 200 mm x 150 mm. Based on the test results, it was revealed that the optimum percentage of partial replacement of plastic as an aggregate ranges from 15% to

20%. It can be used as a light weight plastic concrete block which has lower water absorption rate and density of block.

R.S.Chougule studied about the use of waste plastic in the construction field in the form of solid concrete block. Here the replacement of plastic is made with the fine aggregate in the percentage of 0%, 2%, 4%, 6%, 8% and 10%. The plastic concrete block was casted in the size of 200 x 150 mm x 60 mm and tested for 7, 14, and 28 days for compressive strength. It was absorbed that the compressive strength, tensile strength, flexural strength and density decreases where as the water absorption increases with increase in waste plastic content.

Tanut Waroonkun et al examined the use of PET plastic bottle flakes in concrete block. Concrete blocks made are to be considered as a non load bearing member. The test carried for compressive strength based on four factors such as water-cement ratio, cement-aggregate ratio, size of plastic flakes used, proportion of plastic flake replaced instead of sand. Based on the result, the optimum value for cement-aggregate ratio and water cement ratio are 1:3 or higher and 0.4% or lower respectively. From this study it was absorbed that if the size of Polyethylene tetra phthalate (PET) aggregate is reduced then its impact on environment was reduced.

Werasak Raongjant et al investigated to manufacture a light weight concrete block using waste plastic EVA (Ethylene Vinyl Acetate). The dimension of concrete block recommended was 120 cm x 160 cm x 7 cm (height x length x thickness). From the results of various tests it was concluded that the compressive strength and shear strength decreases and the ductility of concrete block increases with increase in waste plastic content. Finally, the light weight concrete blocks have better mechanical properties which are appropriate for construction industry.

V. CONCLUSION

The present study reveals the properties and use of Bakelite as a construction material in bricks, paver blocks, and solid blocks with appropriate specifications. The use of waste material into construction industry creates a challenging job and better performance along with the development of construction sector. Incorporation of plastic waste in building material gives a cost effective and light weight sustainable component in construction which alters the strength and durability property. This study helps to develop a replaceable material (waste Bakelite) for fine and coarse aggregate in order to minimize disposal of plastics which creates a waste management problem.

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