INNOVATIVE TECHNOLOGIES OF NON-RECYCLABLE WASTE AS REPLACEMENT IN TRANSPORTATION ENGINEERING

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***Abstract*—The world is facing major problem of disposing frequent and tremendous non -recyclable waste generated. Non-recyclable waste ends up at the dumping ground causing land pollution. An attempt has been made through this paper to reuse few of the non-recyclable waste materials in the optimum way, by using it in the construction of components like paver blocks and railway sleeper in Transportation engineering. Waste such as plastics, waste tires, crushed glass, e-wastes, marble powder, etc. has been used by several researchers in the process of making concrete in transportation engineering. The experiments carried by using these waste in preparing paver block and railway sleeper are studied and the results obtained are reviewed. Compressive strengths of these components by using different wastes are studied and analyzed in this research paper.**

***Keywords:* Non-recyclable, waste, concrete, Transportation engineering**

I. INTRODUCTION

The increase in urbanization and rapid development led to generation of solid waste-recyclable and non-recyclable on a large scale. It is very important to trace the waste, recover and minimize it as much as possible.Waste minimization is defined as the process of reducing waste streams through source reduction, reuse and recycling of materials, thereby achieving a healthy environment. The non-recyclable waste such as plastics, waste tires, broken glass, e-wastes, waste steel, etc. which remains for a long term even after the landfill treatment, can be utilized in constructing the components in transportation engineering.

In recent years there has been an increasing worldwide demand of concrete paving blocks for the footpaths, roads and airfields which has led to a local depletion of aggregates. In some urban areas, the enormous quantities of aggregate that have already been used, means that local materials are no longer available and the deficit has to be made up by importing materials from other locations. On the other hand, most cities have areas of land covered by spoil heaps consisting of non- recyclable wastes which are unsightly and prevent large areas of land being used for anything else.

After aggregate, Cement is the significant segment of concrete. The manufacturing of cement is almost 3 billion tons for each year. About 7 % of the total world carbon-di-oxide discharge is contributed by cement industries. Decreasing the utilization of cement in concrete will thus reduce the emission. Utilizing of substitution materials of cement, for example, fly ash and granulated slag, waste steel rounded bearing, marble dust powder, re-used plastic, waste glass decrease utilization of cement. It will turn into eco-friendly strategy for disposal of vast amounts of materials that would otherwise pollute land, water and air. (Vishal Kumar, et al 2016).

Looking on all these aspects, the researchers urged a need to replace the elements in concrete with materials which will serve the purpose of conserving natural resources, disposing of waste materialsand also freeing up valuable land for other uses.(KoliNishikant, et al 2016)

A Concrete paver blocks were initially introduced in Holland in the fifties as substitution of paver bricks. These blocks were rectangular like bricks. With time the block shape has relentlessly developed from non-interlocking to somewhat interlocking to multiple interlocking shapes. Subsequently, the pavements in which non-interlocking blocks are utilized are assigned as Concrete Block Pavement (CBP) or non-interlocking CBP, and those in which completely, or multiple interlocking blocks are utilized are assigned as 'Interlocking Concrete Block Pavement (ICPB). An appropriately designed and constructed CBP/ICPB gives brilliant performance when applied,can be structurally modified as per the operational requirements. (Vishal Kumar, et al 2016)

II. LITERATURE REVIEW

Many researchers studied and carried out experimentations on concrete by replacing the conventional elements with various non-recyclable waste or waste that can have a long term effect on the environment such as plastic, broken glass, waste tires, e-waste, steel bearings etc. These are mentioned in the Literature review.

A] FOR PAVER BLOCK

Ankit Arora, (2013) have studied the effective ways to reutilize the waste plastic particles as replacement of aggregate. Grinded E-waste and plastic waste were replaced by 0%, 2%, and 4% of the fine aggregates. Compressive strength was tested and compared with control concrete. Experiments done shows increase in compressive strength by 5% and reduce cost of concrete production by 7% at optimum percentage of grinded waste. The authors from the study concluded that, the strength slightly reduced when the grinded e-waste was used and so the grinded e-waste can be used to replace fine aggregate. Also the strength reduced approximately 12% at 28 days when plastic flakes of 10 mm obtained from crushed bottles were used, as the surface area of the plastic was less thus the compressive strength reduces considerably.Feasibly 4% of e-waste aggregate can be incorporated as fine aggregate replacement without any long term detrimental effects and with acceptable strength development properties.

Table 1. Compressive strength test results in N/mm^2

Comp strength at 28 days	Mix Specification		
	0%	2%	4%
Proportion of E-waste	55.23	55.36	54.25
Crushed Plastic bottle waste	55.23	52.47	48.54

KoliNishikant and AiwaleNachiket (2016)studied the feasibility of waste glass inclusion as partial fine aggregate replacement systems. Properties of concrete incorporating waste glass as partial substitution for FA amounts of 15%, 30% and 45% were investigated. The waste glass material used was obtained from waste collectors. The results obtained show clearly that glass enhances the compressive strength properties of the final concrete product. The study indicated that waste glass can effectively be used as fine aggregate replacement (up to 45%) without substantial change in strength.

From experimental investigation, the author concluded that a) Density of concrete decreased with increase in waste glass making concrete light weight in nature. b) Compressive strength increases with increasing the glass parentage from 15% to 30% replacement of glass and after 45% waste glass replacement onwards the strength is decreases. c) Cost of paving blocks is decreases with increase in glass content.

Table 2. Compressive Testing Result for Ordinary Paving Blocks and 15%, 30% & 45% by replacement of glass

	Average Compressive Strength N/mm^2 for			
Period	0%	15%	30%	45%
At 28 Days	58.40	71.99	71.99	71.99

Sonu Pal and Amit Singh (2016) utilized the waste marble dust powder in concrete which is generated on the large scale due to quarrying and studied the enhancement of strength of concrete. They designed the concrete for grade of M20 and added Marble dust powder at (0%, 5%, 10%, 15%, 20%, 25% & 30%) with partial replacement by weight of cement. Water/Cement ratio (0.50) was kept constant, in all the concrete mixes. The concrete samples were tested for compressive strength after 28 days of proper curing. The results of the testing showed that replacement of cement with Marble dust powder increases the compressive strength of concrete up to 10% and with further increase in the percentage of marble dust powder the compressive strength of concrete decreases.

Table 3. Compressive strength of M20 grade concrete at 28 days

Period	0%	5%	10%	15%	20%
Comp. Strength At 28 days (N/mm^2) approx.	25	26	28	25.5	23

Eldhose C. and Dr. Soosan T. G (2014)studied the utility of scrap tire aggregate as a substitute for fine aggregate for the improvement of the concrete properties in road construction. The author conducted tests by adding different percentages of rubber tire aggregates to M35 mix. It was observed that there was gradual reduction in compressive strength and tensile strength with the addition of used rubber tire aggregate. From this study it can be concluded that up to 8% of rubber aggregate can be added into concrete mixes without considerable reduction in strength. The waste rubber tire aggregates can be utilize, in rigid pavements rather than other structural construction since it is economical and environmentally effective.

Table 4. Compressive strength test results in N/mm^2 addition of rubber aggregate

Period	% of rubber aggregate						
	0%	2%	4%	6%	8%	10%	12%
Comp. Strength At 28 days (N/mm^2) approx.	42.5	39	36	32	26	22.5	19

B] FOR RAILWAY SLEEPER

Afia S. Hameed (2016) investigated experimentally by replacing 15% by volume fraction of fine aggregate by crumb rubber to find the fatigue failure load and impact resistance. The design strength of 50 and 55 MPa was achieved. According to the lab test results it was found that there was reduction in compressive strength. The fatigue failure and impact resistance were high for rubber concrete when compared with ordinary high strength concrete. The impact strength for railway sleeper when replaced with crumb rubber showed increase of about 60% when compared to prestressed concrete sleeper.

Wahid Ferdous (2015) has worked on **s**leepers with short or no fiber reinforcements (Type-1) Sleepers that consist of recycled plastic (plastic bags, scrapped vehicle tires, plastic coffee cups, milk jugs, laundry detergent bottles etc.) or bitumen with fillers (sand, gravel, recycled glass or short glass fibers< 20 mm) falls under the category of Type-1 sleepers. The structural behavior of these sleepers is mainly polymer driven. While some of these technologies introduced short glass fiber to increase the stiffness and/or resist crack, they do not have major reinforcing effect to improve the structural performance required for heavy duty railway sleeper application. The high demand for alternative sleeper materials has resulted in

Chattree R., andManoharan S(2014) has highlighted on the aspect that Indian Railways have already adopted recycled High-density polyethylene (HDPE), crumbled rubber, glass reinforcement, mineral fillers, and some other patented items materials for use in bridge sleepers, and they also made a comparison of fiber reinforced plastic sleepers with wooden and steel ones (Table 5). Their composites consisted of E-glass woven fabric as the reinforcement and polyester as the resin. Polyester resin was also mixed with accelerator, hardener, fire retardant, and UV Stabilizer.

Table 5. Comparison of some bridge sleepers

Item	Type of Bridge Sleepers		
	Wooden	Steel	Composite
Durability (Years)	8-10	15-20	40-50
Weight (kg)	100-171	110	54
Replacement of sleepers	Easy	Difficult	Easy
Handling	Not so easy	Difficult	Easy
Suitability for Track circuited area	Suitable	Problematic	Suitable
Cost per Sleeper with fittings	Rs. 3500/-	Rs. 9500/-	Rs. 19240/-
Life Cycle cost (Rs./Year)	402/-	575/-	385/-

(Source: Chattree R., Manoharan S. Composite Sleepers for Bridges)

III CONCLUSION

Solid wastes like waste plastic, e-waste, broken glass, marble powder and rubber tires has been used in the manufacturing of concrete paver block and Railway Sleepers. Various researchers have concluded that waste plastic, e-waste, waste glass in the grinded form and marble powder increases the compressive strength of the concrete. It has been observed that even though, scrap rubber tires decreases the compressive strength of the concrete, used in railway sleepers give high values for fatigue failure value and impact resistance.

In this era of sustainable development it is beneficial and economical to use these waste materials essentially in the construction of transportation components like paver blocks and railway sleepers as it gives high compressive strength. The impact value given by waste like rubber is appreciable for manufacturing the sleepersand also assisting and reducing the waste disposal problems. Its utilization can be beneficial for a better cause in coming years as it is necessary to reclaim the natural resources and can stop quarrying operations.

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