EXPERIMENTAL STUDY ON USE OF RUBBER WASTE IN PAVER BLOCKS

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ABSTRACT

Nowadays in India useage of paver blocks has become important as it is durable, and if they are interlocked perfectly they can sustain the huge vehicular load for about 20-25 years. India is the largest generator of waste which includes both industrial waste and e-waste, where generation of plastic waste and rubber waste has become serious concern. The generation of rubber waste which is second largest waste generated in India and directly dumped into the landfill. The attempt has been done to utilize this rubber waste in the Paver Blocks. As the demand has increased for the use of natural aggregate, the natural resources have decreased. To overcome this problem main aim of the study is to make use of the industrial rubber waste as the partial replacement material with cement which is sustainable, durable, and environment friendly. The study includes experimental tests on rubber and aggregates used in the Paver Blocks. The papers attempts to carry out the study on the use of industrial rubber waste at 5%, 10%, 15% and 20% in the production of concrete paver blocks. After preparing the specimen according to mix proportions of M40 mix, curing was done at 7 days. Then samples were taken out and their hardened properties such as compressive strength check are carried out and strength was calculated. Results and conclusion are drawn from the test.

Keywords: - *Paver Blocks, Industrial Rubber Waste, Compressive Strength, and Mix Design.*

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1. INTRODUCTION

India produces large amount of the waste in the world. Highest amount of the waste generated is Plastic. Second largest waste produced is Rubber according to the recent study. Annually the world generates 2.01 billion ton of municipal solid waste, where 33% of the waste is not managed in an environmentally safe manner. Annually Urban India produces 62 million ton of waste (MSW), and it has been predicted that this will reach 165 million ton in 2030. 43 million ton of municipal solid waste is collected annually, out of which 31 million is dumped in landfill sites and just 11.9 million is treated. As there is an increase in automobile industry amount of the waste generated from industries is too high and treatment of this waste is not managed properly and let out into the environment which has become way hazardous and toxic. Many measures are taken to treat this waste by Government of India by raising funds, by setting local municipal bodies to collect the waste. Inspite of this measure, waste is directly dumped into the landfill without treating. Treatment of this waste has become major concern today. As the demand for aggregates has increased, natural resources are depleting and no measures are taken. To overcome this problem these wastes can be used in many construction activities. Year by year due to rapid increase in the population of country, problems related to waste has increased and amount of waste treated is low. Due to this health related issues has become major concern. So proper measures should be undertaken to treat this waste and make best use of it. The important criteria which to be considered for the progress of the country is infrastructure and economy. Waste management should be taken seriously and properly treated for our infrastructure growth and development. More focus should be given on reusable and recyclable waste. In the present study effort has been done to use the industrial rubber waste in the experimental study on the Rubber Paver Blocks. The work carried out aims to produce sustainable, ecofriendly, low cost and low maintenance paver blocks which can sustain heavy vehicular loads.

2. LITERATURE REVIEW

2.1 Related Research Work

1. Mr. Neeraj Kumar Gupta, Dr. Ajay Swarup et al. The research has focused on using scrap tires where rubber powder is obtained from cryogenic milling of tires. The main objective of this paper was to use the rubber powder as partial replacement material with fine aggregates in concrete. Study involves the distortion work carried out which includes Mix design, casting, curing, and testing of specimen. Utilization of rubber powder into concrete mix was up to 10%, 20% and 30%. Various Laboratory test was performed and results obtained were, Fineness of the cement 7.6%, standard consistency of the cement 35%, Initial and Final setting time of the cement that is 35 minutes and 310 minutes and Crushing strength of the aggregate 13.93%. Casting and Curing of the specimen was done for 7 and 28 days. After curing compressive test was carried out by using Universal testing Machine (UTM) and results obtained were 35.13N/mm^2. Thus paper concludes that results obtained, satisfied as per IS Specifications.

2. Naveen Kumar N V, Naveen B M, Manjunatha R, Puru V, Darshan H A et al. As there is increase in the vehicles every year huge number of rubber tyre have hit the roads which is major environmental concern. Waste rubber tyres have caused serious problems all around the globe. So the alternative used in the study is to use crumb rubber in concrete as partial replacement material with fine aggregates. The paper aims at preserving natural resources such as cement and aggregates and to overcome this problem waste is utilized and made best use of it. Materials used in the experimental study are Ordinary Portland cement of 43 grade, fine aggregates, coarse aggregates, crumb rubber and water. Basic tests of these materials are carried out to check its properties and characteristics. The process involved in the experimental study is basic test, mix design, casting, curing and testing of specimen. In an order to prepare the specimen crumb rubber is replaced with fine aggregates in different percentages that are 0%, 5%, 10% and 20%. The workability test and compressive strength test was carried out for M25 grade of concrete by replacing fine aggregates with crumb rubber. The results obtained were high workable concrete and compressive strength which initially increased and then later decreased. Therefore the investigation concludes that use of partial replacement of crumb rubber with fine aggregates. But Inspite of open disposal of rubber waste it can be used in the study for environment concern as it has good workability, thermal resistance and sustainability.

3. Partha Saika, Owais Mushtaq, and A.Arunya et al. The investigation is carried out by using rubber chips as replacement with coarse aggregate. Paper also explains about the statistics of rubber waste produced every year. Since there is an increase in the rubber tyre every year it has become serious environment concern. So measures were taken to use rubber chips in the experimental trials. Rubber chips were replaced with coarse aggregates at different percentages and Compressive Strength test and Split Tensile test was carried out. Four specimens with various percentages at 0%, 4%, 8% and 12% replacement of rubber chips with coarse aggregates was done. Experimental works involved in the study are mix design proportion, casting, curing, and testing of specimen. Workability of concrete was also carried out but results feared well when compared to compressive strength and tensile strength. Therefore study concluded by suggesting using the rubber chips as replacement material up to certain percentages to control the pollution and decrease the waste for our environment purpose.

4. Rohit Sharma, shalika Mehta et al. The unique method is used to replace rubber with fine aggregates. The paper includes the experimental study done by using rubber at various percentage replaced with fine aggregates along with silica fumes to alter the bonding properties of rubber in the positive manner. The paper also aims that by using this rubber tyre waste it decreases the environmental related issues. The main objective of the paper was to find the Compressive strength, Split Tensile strength, and Flexural strength. To find the properties of rubberized concrete experimental test procedures are done. Procedure involves, mix proportion design, compressive test, flexural strength, and split tensile test. Mix design was done according to IS-Code 1026-2009 and mix was obtained. Crumb rubber at various percentages of 5%, 10%, and 15% was replaced with fine aggregates. Preparation and details of specimen includes casting, curing and testing. Thus paper concluded that workability of the concrete increased with increase in crumb rubber but Compressive strength, split tensile strength and flexural strength decreased with increase in crumb rubber. To overcome this problem and maintain positive way of using rubber in concrete silica fumes were added as admixture to strengthen the concrete and use it efficiently to maintain durability, suitability and control environment issues.

3. METHODOLOGY

3.1 Materials Used

Cement

In manufacturing of paver blocks OPC 53 grade will be used. Ordinary Portland cement grade 53 confirming IS code has been selected. The test made on cement are Normal Consistency of cement - 26%, Initial setting time of cement - 30mins, Final setting time of cement – 280mins, and Specific gravity of cement 3.3.

Fine Aggregates

Fine sand having 4.75mm is used as fine aggregates. The test made on fine aggregates are Specific gravity – 2.64% and Water absorption test – 0.32%.

Coarse Aggregates

As per Indian Standards the nominal size of the coarse aggregates used for pavers is 10-12mm. The test made on coarse aggregates are Specific gravity 2.7 and water absorption test – 0.35%.

Industrial rubber waste

This waste is used as partial replacement material with cement in the experimental trials. Prior to the use in the experiment, basic tests were carried out to determine the properties and behavior of the rubber in the concrete.
Tests carried out are Specific gravity test – 0.52 and Bulk Density of rubber – 360.6 kg/m^3.

Fig -3.1: Industrial Rubber Waste

3.2 Mix Design

The mix design is calculated according to the IS code of (IS 10262 – 2009). The proportion of the concrete mix is calculated according to this IS code. Efforts were made all rounds to implement the design and take steps to increase the production of the paver blocks. Therefore IRC: SP: 63-2018 is used for reference while designing the paver blocks. According to the IRC: SP: 63-2018 Design Standards for Interlocking Paver Blocks are water cement ratio = 0.34-0.38, water content = 5 to 7% of total weight of mix, quantity of cement = 450 to 380 kg/m^3, aggregate to cement ratio = 3:1 - 6:1 and strength of the block = 20MPa - 40MPa. The table 3.2 consists of quantity of materials calculated which is used in the casting of the moulds. Mix trails were done at 5%, 10%, 15% and 20% replacement of rubber with cement whose properties and mix proportions are mentioned in the table 3.2.

Table -3.2: Mix Proportion Trials

Properties	Number of trials			
	5%	10%	15%	20%
Cement (grams)	582	643.35	723	752
Rubber (grams)	31	64.35	151	190
Fine Aggregates (grams)	1206.6	827.66	995	889
Coarse Aggregates (grams)	872	590.02	733	656
Water-Cement ratio	0.46	0.46	0.46	0.46
Water (Kg/m^3)	220	290	320	342

3.3 Design of Paver Blocks

In this project two types of the paver blocks shapes were designed, one is I shaped and another is puzzled shaped. 3D designs were prepared and then these shapes were tried on the thermocol sheets to see the better results of interlocking. Designs are shown in the figure 3.3. To get the clear picture of the interlocking of paver blocks, 3D designs which were prepared were tried on thermocol sheet. It is clear that I shape paver blocks interlock better than puzzle shape. Therefore it was decided to use the I-shape mould in the preparation of the blocks and mould were got done of particular dimension. The dimensions of the mould are shown in the figure.

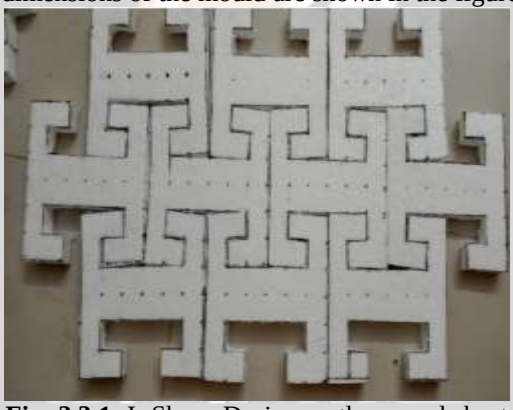

Fig -3.3.1: I- Shape Design on thermocol sheet

Fig -3.3.2: I- Shape Mould

3.4 Paver Property Testing

Workability Test

Workability of the concrete is defined as ease of placing the concrete without any difficulty and segregation. Tests carried to check the workability of concrete is Slump Test, Vee-Bee consistometer, and Compacting Factor Test. But most commonly used test is Slump Test. Apparatus used in the experiment are slump cone of dimension 30cm height, 20cm base in diameter and small opening at top of 10cm, scale for measurement, and tamping rod. Slump test carried out is same for all various percentages of rubber replaced with cement. During the casting of moulds, proper proportion mixes is done in the pan. Before placing the mix into the paver block mould, slump test is carried out for each mixes for different percentages of rubber mixed with concrete. For all mixes water cement ratio is same. Therefore workability results for all % of rubber mixed with concrete is tabulated in 3.4.

Fig -3.4: Slump Test

Table -3.4: Workability of Concrete

Proportions of mixes in %	Slump value in mm
5%	70
10%	82
15%	90
20%	95

3.5Casting and Curing

Testing is done for paver blocks. Casting and curing of specimen is carried out. First Step carried out was, casting is done for mould of size 180x180x60mm. Materials used in the casting is M-sand as fine aggregates, 10mm-12mm size coarse aggregates, cement and industrial rubber waste as partial replacement material with cement according to mix design. Materials used are of greater influence which affects the durability, strength and mechanical properties. Therefore maintaining the same water cement ratio of 0.35, mixes are done in the mixing pan at different percentages of rubber replacement. Rubber is partial replaced at 5%, 10%, 15%, and 20%. After proportionate mixing, place the mix in a mould and after 24 hours of casting, demould it. Curing is done by keeping the moulds in the water tank for 7 days and 28 days.

Fig -3.5.1: Casting of Specimen

Fig -3.5.2: De-moulding of specimen after 24 - hours

3.6 Compressive Strength Test

The term compression test refers to tests in which a prepared specimen is subjected to gradually increasing a load until failure occurs. The main aim of the test is to determine the compressive strength of the given specimen. The goal of this test is compressive load experienced by paver block. The test procedure confirms the properties such as durability, mechanical properties and sustainability of the paver block for load applied. It is one of the most popular test performed everywhere in India prior to the construction of building and other structures. The compressive strength of paver blocks is determined at 7 and 28 days after curing. Compressive strength test is carried out by placing these blocks in the compression testing machine of capacity 3000KN. Load is gradually applied on the blocks and ultimate strength is recorded after the specimen fails to resist the load. The procedure is carried out for each percentage of rubber replacement with cement and strength is recorded for every percentage. The compressive strength is calculated by using compressive strength formula.

$$\text{Compressive Strength} = \frac{\textbf{Failure load}}{\textbf{Corss Sectional Area}}$$

Fig -3.6: Compressive Testing Machine

The test results for compressive strength of M30 grade of concrete at different percentages of rubber replaced with the cement is tabulated in 3.6. Test results are calculated at 5%, 10%, 15% and 20%.

Table -3.6: Compressive strength at 7 days and 28 days

Proportions	Compressive strength of specimen KN/mm^2	
	7 days	28 days
5%	21.26	31.89
10%	18.14	27.22
15%	15.92	23.89
20%	14.09	21.14

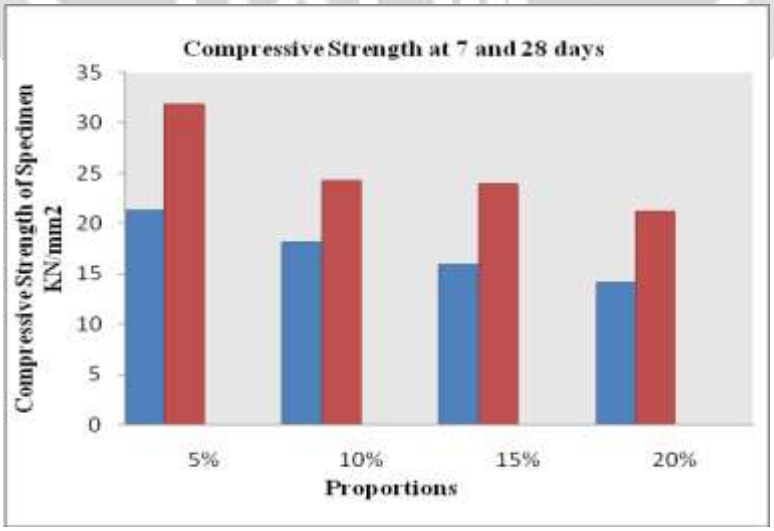

Chart -3.6: Graphical representation of Compressive Strength at 7 and 28 days

4. RESULTS

From the results obtained, it is observed that as the percentage of rubber increases the slump value also increases this means that workability increases. At 5%, slump obtained is 70mm and gradually it increased at 10%, 15%, and 20%. From the test results Compressive strength has decreased as the percentage of rubber has increased. Strength at 7 days and 28 days for 5% of rubber replacement has fared well when compared to other percentage of replacement. Strength obtained at 5% is 21.26MPa and 31.89 MPa, at 10% 18.14 MPa and 27.22 MPa, at 15% 15.92 MPa and 23.89 MPa, at 20% 14.09 MPa and 21.14 MPa.

5. CONCLUSION

Results from the basic test obtained were accurate and satisfied the design standards. From the results obtained, it is observed that as the percentage of rubber increases the slump value also increases this means that workability increases. From the test results Compressive strength has decreased as the percentage of rubber has increased. Compressive strength feared well initially at 5% and 10%. Later it started slightly decreasing. So the conclusion drawn from the present study is, fully replacement of the rubber is not possible. But partially replacement of the rubber is possible up to certain percentages. From the literature review and experimental studies it is concluded that despite of decrease in strength of concrete there is a very high demand of concrete so it can be used as a partial replacement. Inspite of decrease in the strength, partial replacement of rubber is possible and is very much beneficial according to environmental concern and can solve many disposal related problems easily.

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