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An Experimental Study on Properties of Concrete Paver Blocks Using Recycled Aggregates and Stone Polishing Waste

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ABSTRACT

In India, total quantity of waste from construction industry is estimated to be 14 million tons per year, out of which 7 to 8 million tones waste is from demolition and renovation of buildings which includes large amount of concrete waste. This waste is diverted towards landfill. This concrete waste can reused in various constructions. In the present study the concept of sustainable use of recycled aggregate in manufacturing of paver blocks with stone polishing waste is used.

In this study, the recycled aggregate obtained from concrete waste is used as replacement of coarse aggregate in percentages like 30, 60 and 90, the stone polishing waste is also used as replacement of cement in percentages like 12, 8 and 4. The materials used are as per the IS specifications and casting is done by considering specific casting methodology. The paver blocks are tested for compressive strength and water absorption.

Keywords: Paver blocks, Recycled aggregates, Compressive strength test, Water absorption test.

INTRODUCTION

A lot of face-lift is being given to roads, footpaths along with roadside. Concrete paving blocks are ideal materials on the footpaths for easy laying and finish. Cement concrete paving blocks are precast solid products made up of cement concrete. The product is made of various sizes and shapes. Rectangular, square and round blocks of different dimensions with designs for interlocking of adjacent paving blocks. The raw materials require for manufactures of the product are cement, fine aggregates and coarse aggregates which are locally available in every part of the country. Market potential cement concrete paving blocks find applications in pavements, footpaths, gardens, passengers waiting sheds, bus-stops, industry and other public places. The product is commonly used in urban areas for the above applications. Hence, the unit may be set up in urban and semi-urban areas, near the market.

In India there is large amount of use of concrete which is made from natural material like river sand, coarse aggregate from stone crusher and artificial material like cement. Indian buildings in 2013 have generated more than 626 million tons of solid waste which is 52 times more than official estimate. A great part of this waste is being used illegally for dumping and filling up urban water bodies. From the large amount of solid waste generated from various industries, construction and demolition waste contributes in large amount.

Construction and demolition waste is the waste which is generated from various activities like residential construction work, road work, renovation work demolition, etc. Recycled coarse aggregates are obtained by crushing of concrete waste from demolition of structural components in many structures such as old buildings, bridges, concrete pavements etc. concrete paving block is versatile, aesthetically attractive, functional and cost effective and requires little or no maintenance if correctly manufactured and laid. Paver block is solid, unreinforced precast cement concrete paving units used in the surface course of pavements. Interlocking concrete paving block technology has been introduced in India in construction, a decade ago for specific requirement like footpaths, parking areas, garden etc.

We all know that the basic requirement of paver blocks is high compressive strength and low water absorption, so in order to achieve the same conventional results we are trying to replace the coarse aggregate by recycled aggregates and partial replacement of cement by stone polishing waste.

Fig.1 Showing Building demolished waste material

2.LITERATURE REVIEW

Mr. Tushar R Sonawane at.al.: The author has studied the waste construction materials obtained in various countries. Further author conducted the basic tests on recycled coarse aggregate s and compared with natural aggregate such as water absorption, specific gravity, compressive strength etc. The author replaced the NCA with RCA in different percentage such as 0, 10, 20 and 30 with curing periods of 7, 14 and 28 days using M30 grade concrete. Finally concluded that use of recycled aggregates up to 30% does not affect the functional requirements of concrete as per tests results. Various tests conducted on recycled aggregates and results compared with NCA are satisfactory as per IS 2386.

Jayeshkumar Pitroda (2013)**:** The OPC cement has been replaced by stone waste accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight for M-25 grade concrete. Concrete mixtures were produced, tested and compared in terms of workability and strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. As a result, the compressive increased up to 30% replacing of stone waste. Keeping all this view, the aim of the investigation is the behavior of concrete while replacing of waste with different proportions of stone waste in concrete by using test like compression strength.

JIANZHUANG Xiao et al. (December-2013): Concludes that compressive strengths of recycled coarse aggregate are generally lower than those of conventional concrete. Furthermore, compressive strength values decrease with the increase of RCA amounts. Several reasons could be responsible for the reduction of the compressive strength for RAC, including an increased concrete porosity and a weak aggregate matrix interface bond.

Y.Yaswanth Kumar et al. (April 2015): With the ever increasing cost of construction materials there is a need to curtail the same by using cheaper substitutes. In this investigation Granite Slurry (GS) was used as partial substitute in proportions varying from 5% to 20% by weight to cement in concrete and tested for compressive strength, tensile strength and flexure strength. It was observed that substitution of 10% of cement by weight with GS in concrete resulted in an increase in compressive strength to 48 N/mm² compared to 35 N/mm² of conventional concrete. Tensile strength too followed a similar pattern with a 10% substitution with GS increasing the tensile strength to 3.6N/mm² compared with a 2.4 N/mm² of conventional concrete. However flexure strength of 10% GS replacement exhibited a good improvement of flexural strength to 4.6 N/mm² compared to a 3.2 N/mm² of conventional concrete. Further investigations revealed that to attain the same strength of conventional concrete a 20% substitution with GS is effective. So it can be concluded that when locally available GS is a good partial substitute to concrete and improves compressive, tensile and flexure characteristics of concrete, while simultaneously offsetting the overall cost of concrete substantially.

Mr. M. Vimalanathan et al. (March 2018): For paving block the author replaced natural resources with new materials which are abundant in environment such as Waste Kadapa Stone Chips, Quartz Sand, Fly ash (organic in nature), gypsum, and waste kadapa stone powder by partial replacement of cement with Waste Kadapa Stone Powder, Fly ash, and Gypsum, adding these components by 50% replacement to the cement. And completely replacing the Fine & Coarse Aggregate. This has been cast and tested for 3, 7, 14 and 28 days. Fresh and hardness of the concrete is tested by Compressive Testing Machine and Workability Test. The result is compared with normal concrete properties. All standard procedures (casting, curing and compression strength test) properly, author got compressive strength more than targeted strength. All set objectives were successfully achieved (except weight reduction). Strength considerably increased.

Anil Vasant Shirgire et al.(Aug 2018): This paper is based on experimental result of paver block casted with the use of waste construction material and coir fiber to study the compressive strength and water absorption of paver blocks. The author replaced the recycled aggregate with natural aggregate as fully and partially, with percentages of 100 and 40 respectively, with addition to coir fiber with less percentage of 0.1, 0.3 and 0.5. The size of cubes were of size 15cmx15cmx15cm and allowed the cubes to cure for 14 and 28days and tested the cubes for compressive strength and water absorption for corresponding curing days. The test results shows that the partial replacement of demolished aggregate paving blocks has higher compressive strength as compared to fully replacing. Demolished paving block at 14 and 28 days, water absorption and tensile strength of paving block increases with percentage of core fiber. In compressive strength test of paving blocks for 0.3% core fiber given optimum results.

3. OBJECTIVES OF THE PRESENT STUDY

1. To study the variation in compressive strength and water absorption of paver blocks made of conventional concrete and concrete made of waste materials as said above.

2. To compare the cost of conventional concrete and the concrete made up of waste materials.
3. To compare the strength between paver block and standard cube(15cm cube)

4. MATERIALS

The various materials used in the present study are given below:

4.1 Cement:

In the present experimental study “53 Grade PPC Cement” is used. The physical properties of the cement is found out from various tests conforming to Indian Standard IS: 12269:1987

Table 1. Showing Physical Properties of Cement

Sl. No	Physical Properties of cement	Requirements As Per Is: 12269:1987	Test Values
01	Normal Consistency (%)	-	34
02	Specific Gravity	3.15	2.89
03	Initial setting time (min)	Greater than 30	90
04	Final setting time (min)	Less than 600	300
06	Fineness (%)	Less than 10	3
07	Compressive strength (N/mm²) i. 3 days (N/mm²) ii. 7 days (N/mm²) iii. 28 days (N/mm²)	 ≥ 1/3 of 53 ≥ 2/3 of 53 ≥ of 53	 17.9 36 53.2

4.2 Coarse aggregate: -

The material whose particles are of such size as are retained on I.S. Sieve No. 480 (4.75mm) is used as coarse aggregates. In this project we used 60% of Aggregates of12.5mm down size and remaining 40% of 20mm and down size. The physical properties of coarse aggregate used in this project are tabulated in the Table

Table 2. Showing Physical Properties of Coarse aggregate

Sl. No	Physical Properties of coarse aggregate	Test Values
01	Specific Gravity	2.80
02	Water Absorption (%)	0.54
05	Crushing Value (%)	15.26

Table 3. Showing sieve analysis of Coarse aggregate

Total weight of sample taken = 3000gm

Sieve size in mm	Wt. of aggregate retained (gm)	% of total wt retained	Cumulative % wt. retained	% passing
20	0	0	0	100
16	141.9	4.73	4.73	95.27
12.5	1482	49.4	54.13	45.87
10	1124.1	37.47	91.6	8.4
4.75	252	8.4	100	0
Pan	0	0	100	0

Results: - single graded aggregates

4.3 Fine Aggregate: -

The aggregates which pass through 4.75 mm IS sieve is termed as fine aggregates. The physical characteristics of fine aggregates

Table 4. Showing Physical Properties of Fine Aggregate

Sl. No	Physical Properties	Test values
01	Specific gravity	2.64
02	Water absorption (%)	1.01
03	Zone	II

Table 5. Showing Results of sieve analysis of Fine Aggregate

Sieve Size	Cumulative % Finer	Grading Limits For Zone-II As Per IS 383:1970
4.75 mm	92.2	90-100
2.36 mm	83.0	75-100
1.18 mm	68.9	55-90
600 µ	46.2	35-59
300 µ	5.4	5-30
150µ	0.3	0-10

4.4 Recycled aggregate: -

The recycled aggregate which is generally obtained by crushing of concrete waste from demolition of structural components in many structures such as old buildings, bridges, concrete pavements etc.

Fig.2 showing sample of recycled coarse aggregate

Table 6. Showing Physical Properties of recycled coarse aggregate

Sl No	Physical Properties	Test Values
01	Water absorption (%)	0.84
02	Specific gravity	2.76
03	Maximum size	20mm down size

4.5 Stone polishing waste: -

The stone polishing waste which is generally obtained from polishing of stones and stone flooring slabs.

Fig.3 showing sample of Stone polishing waste

Table 7. Showing Physical Properties of stone polishing waste

Sl No	Physical Properties	Test Values
01	Specific gravity	2.18
02	Maximum size	90 micron

4.6 Water: -

The potable water is a general recommendation for mixing and curing of concrete. Hence potable water is used for manufacturing concrete.

Quantity and Mix proportion Of Conventional Concrete (0% Replacement)

Water (kg/m³)	Cement (kg/m³)	Fine aggregate (kg/m³)	Natural coarse aggregate (kg/m³)
204.62	399.13	666.06	1172.03
0.515	1	1.668	2.989

Quantity and Mix proportion for 30%Replacement

Water kg/m³	Cement kg/m³	Fine aggregate kg/m³	Natural coarse aggregate kg/m³	Recycled coarse aggregate kg/m³
205.63	399.13	666.06	821.03	346.31
0.515	1	1.668	2.05	0.86

Quantity and Mix proportion for 60%Replacement

Water kg/m³	Cement kg/m³	Fine aggregate kg/m³	Natural coarse aggregate kg/m³	Recycled coarse aggregate kg/m³
206.63	399.13	666.06	467.82	692.63
0.517	1	1.668	1.17	1.73

Quantity and Mix proportion for 90%Replacement

Water kg/m³	Cement kg/m³	Fine aggregate kg/m³	Natural coarse aggregate kg/m³	Recycled coarse aggregate kg/m³
207.65	399.13	666.06	116.48	1038.94
0.52	1	1.668	0.291	2.603

Quantity and Mix proportion for 30%Replacement Of C.A. And 12%Replacement Of Cement

Water kg/m³	Cement kg/m³	Stone polishing waste kg/m³	Fine aggregate kg/m³	Natural coarse aggregate kg/m³	Recycled coarse aggregate kg/m³
205.51	351.23	47.89	660.10	813.69	343.22
0.515	1	0.119	1.653	2.038	0.86

Quantity and Mix proportion for 60%Replacement Of C.A. And 8%Replacement Of Cement

Water kg/m³	Cement kg/m³	Stone polishing waste kg/m³	Fine aggregate kg/m³	Natural coarse aggregate kg/m³	Recycled coarse aggregate kg/m³
206.93	376.199	31.93	676.98	477.335	705.774
0.518	1	0.086	1.698	1.191	1.768

Quantity and Mix proportion for 90%Replacement Of C.A. And 4%Replacement Of Cement

water kg/m³	cement kg/m³	Stone polishing waste kg/m³	Fine aggregate kg/m³	Natural coarse aggregate kg/m³	Recycled coarse aggregate kg/m³
207.63	383.164	15.96	664.77	117.01	1038.04
0.52	1	0.039	1.665	0.293	2.60

5. RESULTS

GENERAL:

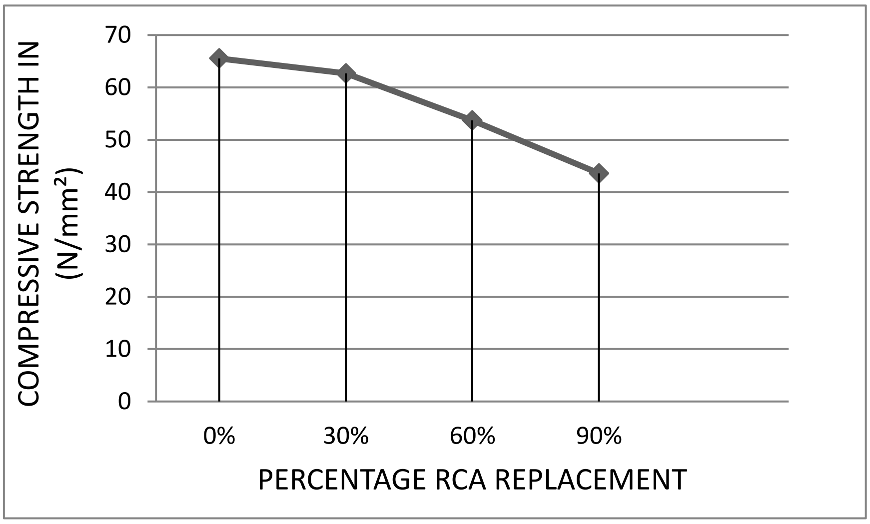
In this chapter the result obtained based on the experiments conducted and their inferences.

Results for compressive strength tests water absorption test on

Paver block

Table 8.showing the details of % of recycled aggregate used and compressive strength and water absorption results.

% of recycled aggregate	compressive strength In N/mm² Curing period		water absorption(%)
	14 days	28 days	
0	58.3	65.53	1.27
30	56.4	62.67	1.43
60	47.25	53.70	1.57
90	39.23	43.59	1.71



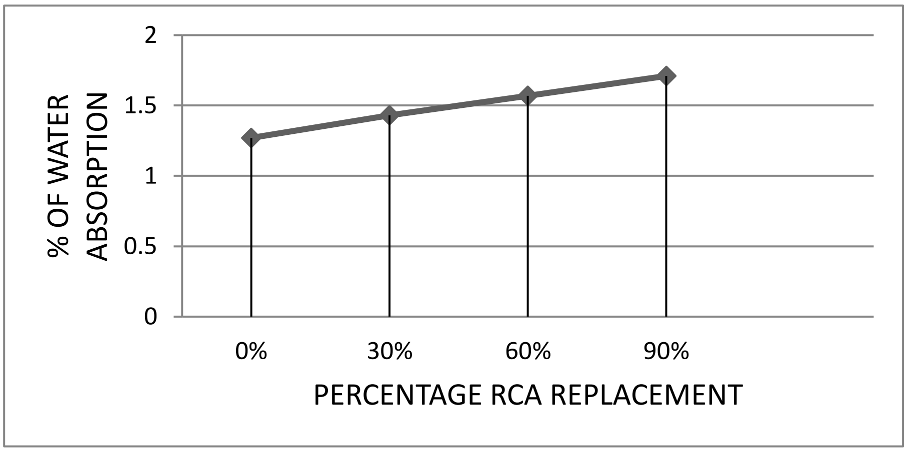


Table 9. Showing the details of % of recycled aggregate and stone polishingwaste used and compressive strength and water absorption results

% of recycled aggregate	% of stone Polishing waste	Compressive strength In N/mm² Curing period		Water absorption (%)
		14 days	28 days	
30	12	53.33	61.31	1.45
60	8	47.66	53.55	1.60
90	4	38.5	42.8	1.74

Results for Compressive strength tests on standard cube(15cm cube) Cube (15cm)

Table 10.showing the details of % of recycled aggregate used and compressive strength on cube result

% of recycled aggregate	compressive strength In N/mm²
0	29.13
30	27.87
60	24.17
90	18.51

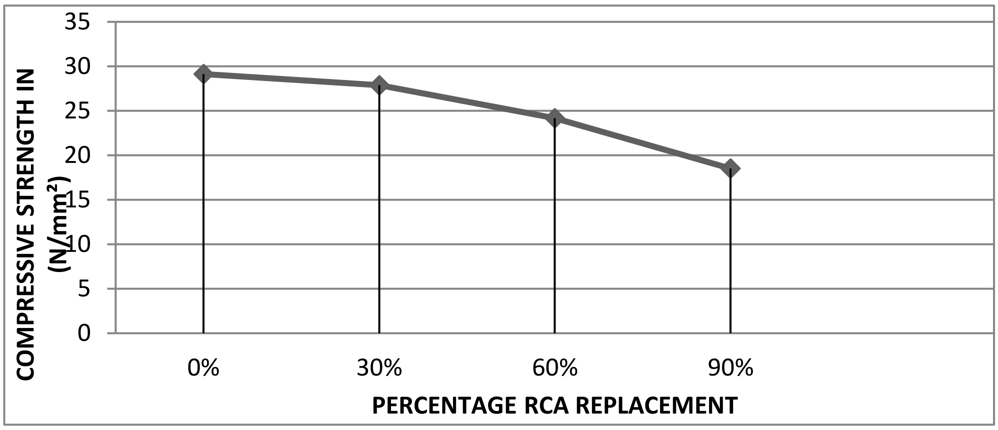


Table 11. Showing the details of % of recycled aggregate and stone polishing waste used and compressive strength results.

% of recycled aggregate	% of stone Polishing waste	Compressive strength In N/mm²
30	12	26.51
60	8	23.74
90	4	18.05

6. OBSERVATION AND DISCUSSION

Following are the Observations made during the experimental study

- From above results it is observed that there is increase in compressive strength of concrete (both cube and paver block) as the replacement of natural coarse aggregate up to 30% with recycled aggregate.
- When the natural coarse aggregate used above 30%, then there is decrease in compressive strength continuously 28 days of curing.
- Similarly when recycled aggregate is used in addition to stone polishing waste,it shows almost similar results as that of recycled aggregate concrete.
- Also it is observed that there is slightly increase in water absorption, as the percentage of replacement of recycled coarse aggregate increases.
- From the excrement it is observed that maximum value of water absorption is 1.74%

7. CONCLUSION

- From the present study and observation made during exprement it is concluded that we can replace the recycled coarse aggregate up to 30% to obtain the minimum required compressive strength. Replacement above 30% will leads to decrease in the compressive strength and the same will not give the minimum required compressive strength.
- As the percentage of replacement of recycled coarse aggregate increases water absorption will increases 0.44%.
- Since the maximum value of water absorption of pavers is found to be 1.74%, which is less than specified by the IS-15658-2006 i.e., 6%.
- As these pavers are having the capacity of water absorption less than 6% hence these pavers may be used even in high rainfall areas.
- Using stone polishing waste at 12% replacement with cement in addition to recycled aggregate at 30% replacement with natural aggregate shows almost similar result as that of conventional concrete.

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