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A Study on Properties of Paver Blocks Manufactured Using Different Percentage of Recycled Aggregates With Partial Replacement of Cement By Fly Ash"

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ABSTRACT: The increasing difficulty in securing natural coarse for the production of concrete coupled with the environmental issues and social costs of unlimited extraction of natural aggregates makes the usage of recycled aggregate concrete (RCA) in the construction industry of prime importance. Now a days, awareness of use of recycled aggregate as a construction material is gaining importance around the world. An attempt is made to use this recycled aggregate as a material replacing coarse aggregates in paver blocks. The properties of RCA namely specific gravity, particle size distribution, water absorption, moisture content ,impact value, crushing value, flakiness and elongation index are studied. As per the norms of IS 15658-2006 code, required samples of paver blocks of each type are casted and tested for compression, tensile, flexure and abrasion values. Changes in the properties of paver blocks with increasing RCA percentage with partial replacement of cement by fly ash (10% by weight of cement) are analyzed extensively. Conclusions regarding optimum use of RCA, ecological and economic benefits of RCA replacing conventional coarse aggregates are drawn.

Keywords: C & D waste, Recycled Aggregates, Recycled aggregate concrete, Fly ash.

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I. INTRODUCTION

Rapid infrastructural development such as highways, airports *etc*. and growing demand for housing has led to scarcity & rise in cost of construction materials. Most of waste materials produced by demolished structures are disposed off by dumping them as land fill. Dumping of wastes on land is causing shortage of dumping place in urban areas. Therefore, it is necessary to start recycling and re-use of demolition concrete waste to save environment, cost and energy. Recycling represents one way to convert a waste product into a resource. It has the potential to Extend the life of natural resources, reduce environmental disturbance around construction sites, enhance sustainable development of our natural resources. Investigating the potential of RCA to be used in subsidiary construction works like highway construction, paver block casting, plinth filling, *etc.* So an attempt has been made to use this RCA in paving blocks. study of concrete properties in terms of compressive strength, flexural strength and tensile strength considering various proportions of recycled aggregate as a partial replacement of natural aggregates and replacement of cement with constant weight of fly ash (10% by weight of cement) in the manufacturing of paver blocks.

II. EXPERIMENTAL PROGRAMME

2.1 Materials

The details of various materials used during the study are given below. The cement used is Ultratech Ordinary Portland Cement (OPC) of 53 Grade conforming to Bureau of Indian Standard Specifications (IS: 12269-1987) with a specific gravity of 3.15. The locally available natural sand conforming to grading Zone II (IS: 383-1970) is used in recycled aggregate concrete. The natural coarse aggregates obtained from the locally available quarries with maximum size of 20 mm and satisfying the grading requirements of BIS (IS: 383-1970) is used during this work. Recycled concrete aggregates are basically obtained from concrete scrap material. In case of RCC works, steel reinforcement is removed and remaining concrete scrap material is used as RCA. In this project, the main sources of RCA are tested concrete beams, columns, cylinders. The scrap concrete obtained from demolished building is transported to the nearby crusher and recycled aggregates of size less than 20 mm are obtained. The pieces greater than 20 mm are crushed again to the maximum size of 20mm. various physical properties of recycled aggregates are determined prior to concrete mix design. The same properties are listed in Table 1.

Test	Result
Aggregate crushing value	5.33%
Aggregate impact value	22.93%
Specific gravity	2.475
Water absorption	2.56%
Fineness modulus	6.96

Table 1: Properties of Recycled Aggregate

B. Testing of paver blocks and results:-

Hydraulic pressing method is used for the casting of paver blocks in which hydraulic jack is used for compression of lock after compaction the block has enough solidity to be transferred for curing. 28 days watering for the compete hydration reaction is given so that the block gains the required strength before being shipped at site.

Water absorption test: IS 15658-2006 clause 6.2.4, 7.3 and Annexure C. Three no of sample taken to determine the water absorption value of paver blocks with constant replacement of cement by fly ash (10% by weight of cement) for each variation of RCA.

W (%) = (w_w - w_d)/ w_d x 100

Designation	F	F20	F40	F60	F80	F100
W_{avg}(%)	4.81	4.96	5.28	5.63	5.89	5.95

Table 2:**Test results for water absorption with variation of RCA.**

Compressive strength: Four no of sample taken to determine the compressive strength of paver blocks with constant replacement of cement by fly ash (10% by weight of cement) for each variation of RCA.

IS 15658-2006 clause 6.2.5, 7.3 and Annexure D
Compressive strength = F/A
Area of paver block=275 cm^2

Designation	F	F20	F40	F60	F80	F100
Comp. strength(N/mm^2)	31.4	34.16	37.0	30.85	29.4	28.11

Table 3:Test results for compressive strength with variation of RCA.

Split tensile strength test: Four no of sample taken to determine the split tensile strength of paver blocks with constant replacement of cement by fly ash (10% by weight of cement) for each variation of RCA.
IS 15658-2006 clause 6.3.1, 7.3 and Annexure F

Split tensile strength(T) = 0.637kp/s
S=(L X T) area of the failure, in mm2

L= mean of two measurements of the failure length, one at the top and one at the bottom of the specimen, in mm.
T= mean of three measurements of thickness at the failure plane, one in the middle and one at either end, in mm.
P= failure load in N.

Designation	F	F20	F40	F60	F80	F100
Split tensile strength (N/mm^2)	2	2.1	2.4	1.8	1.8	1.7

Table 4: Test results for split tensile strength with variation of RCA

Flexural strength test: Four no of sample taken to determine the flexural strength of paver blocks with constant replacement of cement by fly ash (10% by weight of cement) for each variation of RCA.

IS 15658-2006 clause 6.3.2, 7.3 and Annexure G
F_b =3pl/2bd^2

Fb= flexural strength, in N/mm2.
P = maximum load, in N.
l = distance between central lines of supporting rollers, in mm=200 mm
b=average width of block, measured from both faces of the specimen,in mm=165mm
d = average thickness, measured from both ends of the fracture line, in mm=60 mm

Designation	F	F20	F40	F60	F80	F100
Flexural strength (N/mm^2)	3.51	3.88	4.2	3.6	3.1	2.88

Table 5: Test results for flexural strength with variation of RCA

Abrasion test: Four no of sample taken to determine the abrasive value of paver blocks with constant replacement of cement by fly ash (10% by weight of cement) for each variation of RCA.

IS 15658-2006 clause 6.3.6, 7.3 and Annexure E
$\Delta V = \Delta m/PR$
ΔV = loss in volume after 16 cycles, in mm3;
Δm = loss in mass after 16 cycles, in g
PR = density of the specimen, in g/mm3
Volume of block=70x70x60=294000mm3

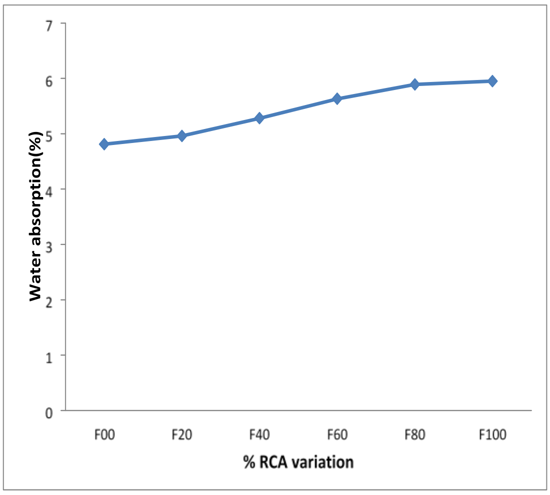
Designation	F	F20	F40	F60	F80	F100
Abrasive Wear(mm3)	1121.5	820.67	693.09	242.58	234	110.86

Table 6: Test results for Abrasive value with variation of RCA

III. RESULTS & DISCUSSION.

3.1 Water absorption test

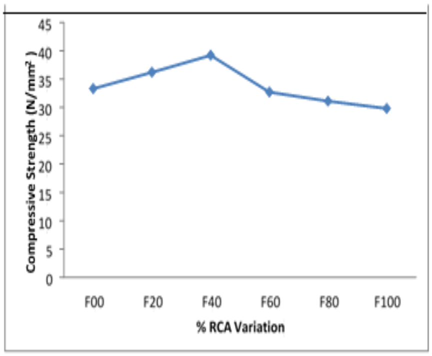
Designation	F	F20	F40	F60	F80	F100
W_{avg}(%)	4.81	4.96	5.28	5.63	5.89	5.95



The water absorption gradually increases from F00 to F100. This shows that water absorption increases as the RCA content (as coarse aggregate) increases. Increase in water absorption may be due to the cement mortar adhered to the surface of aggregate which absorbs more water. As per the norms of IS 15658:2006, the water absorption, being the average of three units, shall not be more than 6 percent by mass. All the samples satisfy the above norm and RCA inclusion does not cause excessive water absorption.

Compressive Strength:

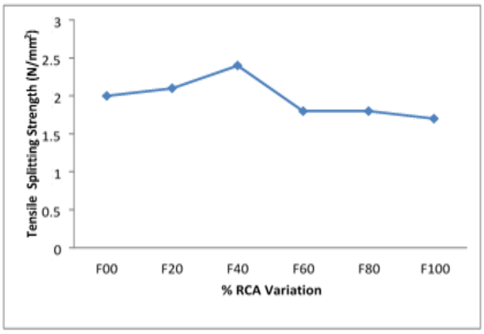
Designation	F	F20	F40	F60	F80	F100
Comp. strength(N/mm^2)	31.4	34.16	37	30.85	29.4	28.11



Aggregates take the major part of the compressive stress when subjected to loading. Thus, as the percentage of good quality RCA increases, the compressive strength also increases. F40 shows the highest value of compressive strength implying that 40% of the total coarse aggregate can be replaced by RCA. As the percentage of RCA in F60 is more than 50, particle packing is not proper and as expected, which results in the decrease of its compressive strength, same fact is applicable for F80, F100.

Tensile Splitting Strength

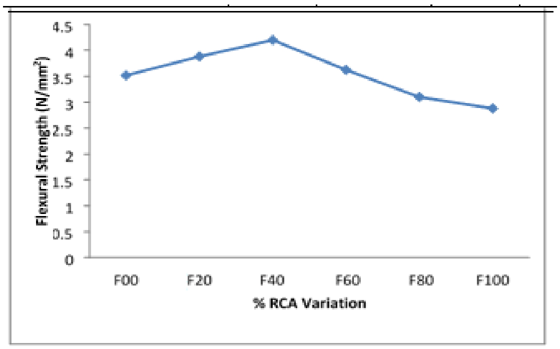
Designation	**F**	**F20**	**F40**	**F60**	**F80**	**F100**
Split tensile strength (N/mm^2)	2	2.1	2.4	1.8	1.8	1.7



From the above chart, it is seen that Tensile Splitting Strength increases slightly from F00 to F20 and there is a steep rise from F20 to F40.This may be due to the increase in proportion of RCA from 20% to 40% which in turn offers more resistance to the tensile loading. Test results for F60, F80, F100 shows that their tensile strengths are much lower compared to F40 which may be due to improper particle packing due to increased RCA percentage.

Flexural Strength

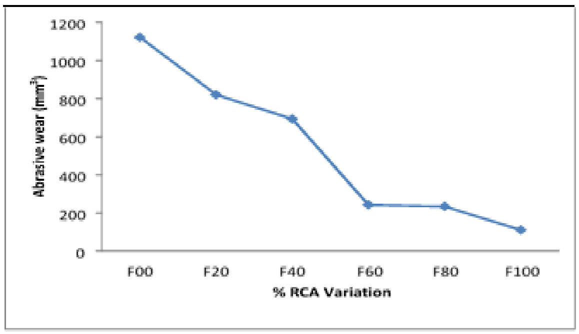
Designation	**F**	**F20**	**F40**	**F60**	**F80**	**F100**
Flexural strength (N/mm^2)	3.51	3.88	4.2	3.6	3.1	2.88



The above chart, it is seen that flexural strength increases gradually from F00 to F20 and there is a sudden rise from F20 to F40.This might be due to the increase in percentage of RCA from 20 to 40 which offers more resistance to the three point loading. Test results for F60, F80, F100 shows that their flexural strengths are much lower compared to F40 which may be due to improper particle packing due to increased RCA proportion.

Abrasion test

Designation	F	F20	F40	F60	F80	F100
Abrasive Wear(mm3)	1121.58	820. 67	693.09	242.58	234.06	110.86



The abrasive wear shows a decreasing trend from F00 to F100.This may be due to increasing RCA percentage from 20 to 100.This higher percentage of RCA offers greater resistance to the abrasive wear. As F100 contains highest percentage of RCA, it offers greatest resistance to abrasion and thus reports least abrasive wear.

IV. CONCLUSIONS

In the present research, the mechanical properties of paver blocks with fly ash, natural aggregates and recycled concrete aggregate are analyzed extensively. The RCA are added in increasing proportion of 20% from 0 to 100 with constant replacement of cement by fly ash. The properties such as water absorption, compressive strength, splitting tensile strength, flexural strength and abrasion resistance are studied.

1. Water absorption percentage increases as the
2. t increases. According to the Indian standard's recommended provisions, the specimens do not exceed the permissible water absorption limits.
3. F40 mix gives the highest compressive strength among all specimens.
4. The tensile spitting strength of the F40 mix is highest.
5. The flexural strength of the F40 specimen satisfies the recommended provisions of IS 456, ACI-318,EC-02.
6. It is observed that abrasive wear decreases as the percentage of RCA increases in the mix.

From all the above results, conclusions and discussions, it is clear that F40 might prove to be the optimum mix. It will be ideal to replace natural coarse aggregates by 40% of RCA which would prove to be cost-saving and earn environmental credits.

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