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An Experimental Study On Rapid Hardening Cement Concrete Paver Blocks By Using Corundum As A Mineral Admixture

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Abstract-*In this experimental investigation, the strength of rapid hardening cement concrete paver blocks were evaluated by adding corundum powder as a mineral admixture in M35 grade concrete. Rapid hardening Cement (RHC) is a kind of cement which achieves strength very fast where the 3 days strength of RHC is equal to the 7 days strength of OPC cement with the same water-cement ratio and Corundum is a crystalline form of Aluminium oxide (Al_2O_3) typically containing traces of iron, titanium, chromium and small amount of silica . It is a rock-forming mineral which has the highest hardness and commonly used as abrasion resistant. Corundum is added to the concrete mixer of paver blocks as an additive in the range of 0%, 5%, 10%, 15%, 20%, and 25% with adding superplasticizer admixture is maximum 2 % of superplasticizer weight of cement The Compressive strength, flexural and split tensile strength of paver blocks increases upto 15% addition of corundum . From the Water absorption test, the percentage absorption of water by paver blocks decreases by increase in amount of corundum.*

Index Terms-*Corundum, Rapid hardening cement, Compressive strength test ,Split tensile strength, Flexural strength test and Water absorption test of paver blocks.*

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I. Introduction

History of paver blocks starts from the Holland in fifties where they introduced firstly replacement of paver bricks which had became scarce due to the post-war building construction boom. About in 1990 research and development on the paver blocks started in INDIA by the Central Road Research Institute (CRRI). The standards are then finalized by the Flooring, Wall Finishing and Roof section Committee which approved by Civil Engineering Division Council (CEDC). Application of paver blocks popularity is increasing day by day in the country especially in the metropolitan cities as well as urban and rural areas. In this experiment the work has been done to use of Corundum in concrete paver blocks and improvement of the compressive strength.

II. Experimantal Study

In this experimental study, the experiment is done with the addition of corundum at 0 %, 5 %, 10 %, 15 %, 20 %, and 25 % in manufacturing of pave blocks and also the effect of admixture called superplasticizer in the manufacturing of paver blocks which is maximum 2 % by weight of the cement. Water absorption and compressive strength, split tensile strength and flexural strength of sample paver blocks are done at 1, 3 and 12 days.

III. Selection Of Materials

1.1 Corundum

Corundum is found as a primary mineral in igneous rocks such as syenite, nepheline syenite, and pegmatite. Some of the world's most important ruby and sapphire deposits are found where the gems have weathered from basalt flows and are now found in the downslope soils and sediments. It is widespread in nature, being found in igneous, metamorphic, and sedimentary rocks. Large deposits are rare, however. Some of the richest deposits occur in India, Myanmar (Burma), Russia, Zimbabwe, and South Africa.

Table1: Chemical properties of corundum

S.NO	Chemical constituents	Values in %
1	Al_2O_3	99.30
2	Sio_2	0.08
3	Na_2O	0.28
4	Fe_2O_3	0.02

3.2 Cement

As per concerning IS 15658: 2006 Precast concrete blocks for paving, there are given various types of cement which can be utilized for production of paver blocks. But in this experimental study the rapid hardening cement has been utilized which confirming IS: 8041-1990.

Table 2: Physical properties of rapid hardening cement

S.No	Test Properties	Natural coarse aggregate (10mm)	Relevant Indian Standards
1	Specific Gravity	2.87	IS 383-197
2	Fineness Modulus	5.6	IS 383-1970
3	Water Absorption (%)	0.83	IS 383-1970
4	Bulk density(kg/m^3)	1520	IS 383-1970

3.3 Fine aggregate

As per concerning IS 15658: 2006 Fine aggregates shall conform to the requirements of IS 383 both river/quarry sand and stone dust meeting the requirements can be used. In this experiment M-sand is used.

Table 3. Chemical Properties of M-sand

S.No	Constituents	Values in %
1	Loss of Ignition	1.81
2	Silica as Sio_2	61.77
3	Iron as Fe_2O_3	6.03
4	Titanium as TiO_2	NIL
5	Aluminium as Al_2O_3	16.74
6	Calcium as CaO	7.57
7	Magnesium as MgO	6.08

3.4 Coarse aggregate

3.4.1 As per concerning IS 15658: 2006 coarse aggregate shall conform to the requirement of IS 383. For ensuring durability, the aggregate used for the manufacturing of paver blocks shall be sound and free from honeycombed particles in this experiment.

3.4.2 The nominal size of coarse aggregates used in the production of paver block shall be between 6-12 mm. So in this experiment nominal aggregate size is taken 10 mm.

Table 4. Properties of Coarse aggregate

S.NO	TEST PROPERTIES	RESULT
1	Specific gravity	3.15
2	Initial setting time(mins)	35
3	Final Setting time (mins)	600
4	Consistency (%)	26

3.5 Superplasticizer

As per concerning IS 15658: 2006 admixture shall confirming to IS 9103-1990 and added for specific requirement without affecting the other quality parameter. The superplasticizer used was in the liquid state. We used Superplasticizer called MEL-PLAST which reduces the ratio of water and cement and it also helps in increasing the slump and work ability. The properties of super plasticizer as per manufacture's catalogue are given in table

Table 5. The properties of Superplasticizer

S.NO	PRODUCT	SULFONATED MELAMINE FORMALDEHYDE
1	Colour	Slight hazy liquid
2	Solid content	40%
3	Specific gravity	1. 2
4	pH	>9
5	Self-life	Six months in a closed container kept in room temperature
6	Packing	250 kg per drum
7	Water reduction	15% to 30% based on the dosage
8	Recommended dosage	1% to 2% w/w of cement

3.6 Water

The water to be used in production of paving blocks shall confirm to the requirements specified in **IS 456-2000** (water should be clean and free from deleterious materials).We used water available in paver block manufacturing factory satisfying the requirements of IS 456-2000.

3.7 Mix proportion

In this experiment trial mix proportion prepared as per IS 10262: 2009 to carry out by proportion of cement, water, admixture, fine aggregate, coarse aggregate with partial replacement of aggregates with corundum 0 %, 5 %, 10 %, 15 %, 20 %, and 25% in manufacturing of paver blocks. Compressive and split tensile strength result is concluded after 1, 3 and 12 days and flexural strength result after 12 days. A mix was designed with conventional materials for a characteristic strength of 35 Mpa with a water cement ratio of 0.45 and cement content of 300 kg/m^3. In this experiment 72 total sample blocks were manufactured to find out the compressive, split tensile, flexural strength of paver blocks and water absorption test with average of 3 samples for each proportion and each day of testing. Mix proportion with partial replacement is given below in the table 6.

Table 6. Mix proportion

% of CP	Cement (kg)	F.A (Kg)	C.A (kg)	Water %	Water (litres)	SP (ml)	CP (Kg)
0%	9.617	29.5	30.5	0.45	4.7	0.192	-
5%	9.617	29.3	30.2	0.45	4.7	0.192	0.481
10%	9.617	29.1	30.06	0.45	4.7	0.192	0.961
15%	9.617	29.0	30.0	0.45	4.7	0.192	1.4
20%	9.617	28.7	29.6	0.45	4.7	0.192	2
25%	9.617	28.5	29.4	0.45	4.7	0.192	2.4

IV. Casting And Testing

Mould of rubber based with size 250 x 150 x 60 mm^3 taken for the preparation of zig-zag shaped sample of paver block. Firstly find out the suitable water cement ratio with adding superplasticizer by workability test. After that deciding the suitable admixture proportion from trial mix for preparing of paver blocks is shown in the table 5. The material required like cement, water, superplasticizer, fine aggregate and coarse aggregate were mixed together as per trial mix proportion. After de-molding from mould samples of paver block were kept in under shade for one day and after that samples were kept in water to analysis of compressive strength through compressive machine, split tensile and flexural and water absorption of the paver blocks.

V. Experimental Investigation

In this experimental study experimental investigation were done on rapid hardening cement concrete paver blocks and varying percentage of aggregates with corundum at 0%, 5%, 10 %, 15 %, 20 %, and 25% for paver block were casted at M 35 grade of concrete.

5.1 Compressive Strength of Paver Blocks

Compressive strength of various concrete mixtures was determined on 250mm*150mm*60mm Zig-Zag shaped paver blocks at the age of 1, 3, 12 days. Automatic compression testing machine of capacity 3000 KN was used for testing the compression strength of specimens. The test specimens were placed at the center of the loading platform in which the longer side is placed along horizontal direction and tested under axial compression without any eccentricity. The load is increased gradually at a rate of 5 KN/Sec till the specimen crushes. The load at which the specimen failed was taken as ultimate compressive strength of concrete.

Table 7. Results from automatic compressive testing machine

S.NO	% of CP	Compressive strength , N/mm^2		
		1 day	3 days	12 days
1	0%	17.1	26.6	38.6
2	5%	18.45	28.7	41.32
3	10%	19.35	30.1	43.47
4	15%	20.7	32.2	46.23
5	20%	16.65	25.9	37.17
6	25%	13.95	21.7	31.92

Figure 1. Compression strength test setup

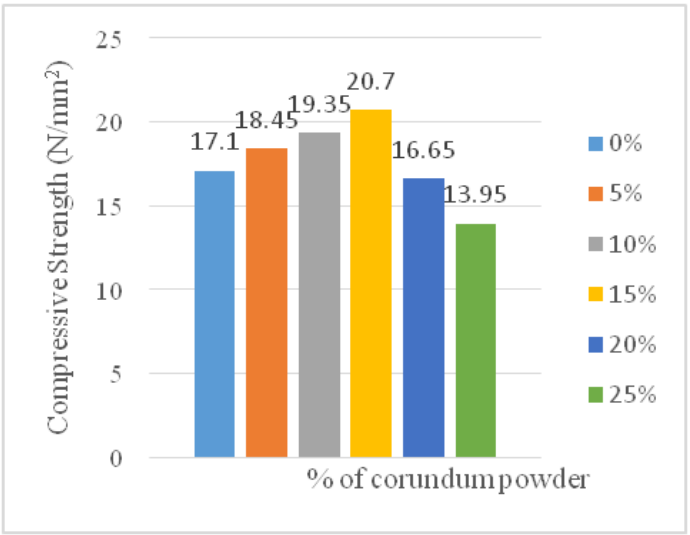

Figure 2. Compressive Strength Result For 1 Day

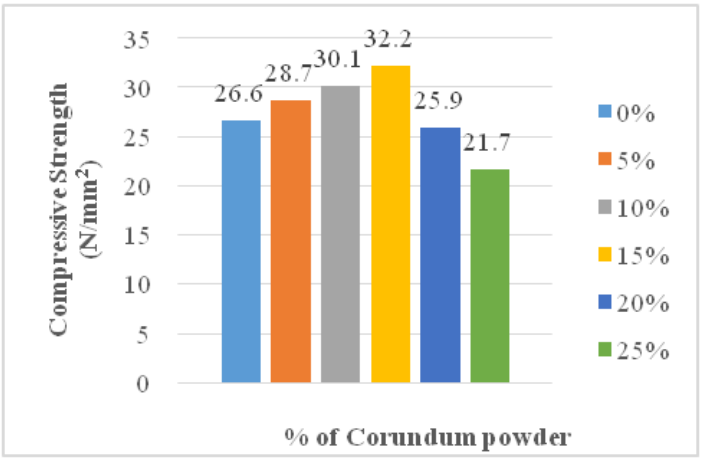

Figure 3. Compressive Strength Result For 3 Days

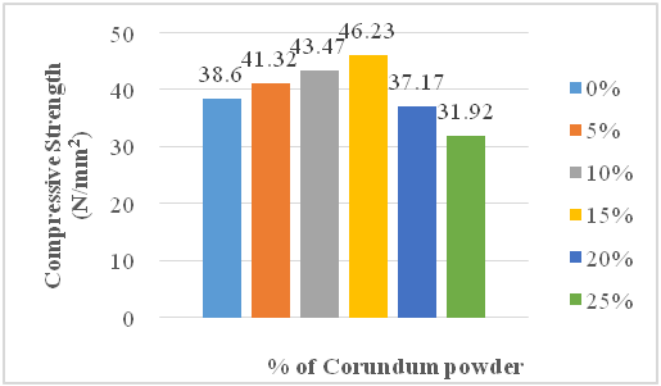

Figure4. Compressive Strength Result For 12 Days

5.2 Split tensile Strength of Paver Blocks

The test specimens were placed at the center of the loading platform in which the longer side is placed along vertical direction. The load is applied gradually till the specimen fails.

Table 8. Split Tensile Strength Results

S.NO	% of CP	Split tensile strength , N/mm²		
		1 day	3 days	12 days
1	0%	2.77	4.31	6.10
2	5%	2.88	4.48	6.33
3	10%	2.95	4.59	6.49
4	15%	3.05	4.74	6.71
5	20%	2.73	4.25	6.02
6	25%	2.505	3.89	5.51

Figure 5. Split Tensile Strength Setup

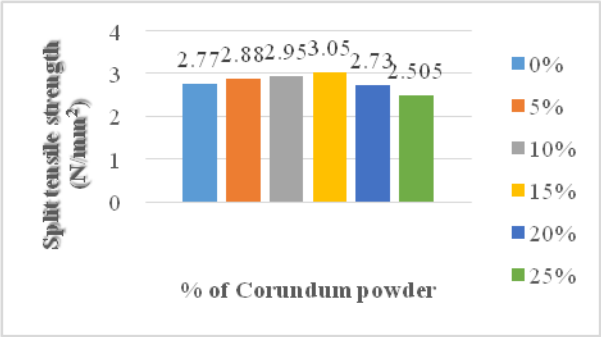

Figure 6. Split Tensile Strength For 1 Day

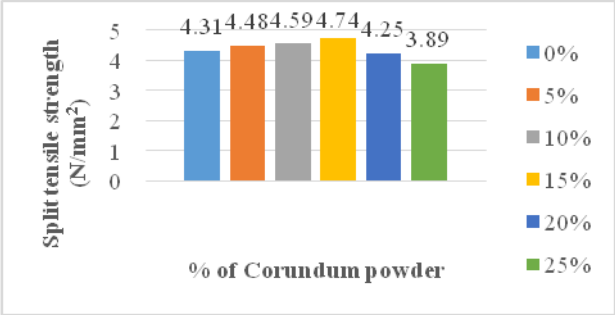

Figure 7. Split Tensile Strength For 3 Days

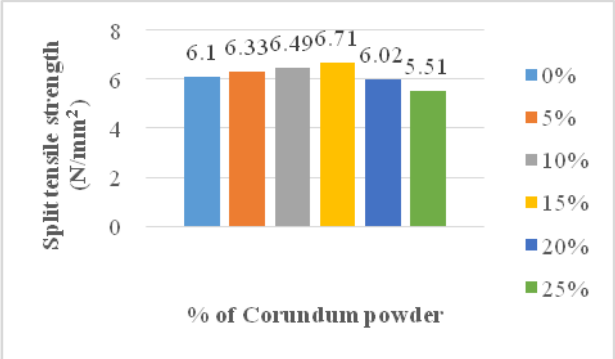

Figure 8. Split Tensile Strength For 12 Days

5.3 Flexural strength of paver blocks

Flexural strength of various concrete mixtures was determined on 250mm*150mm*60mm Zig-Zag shaped paver blocks at the age of 12 days. Automatic compression testing machine of capacity 3000 KN was used for testing the flexural strength of specimens.. The test specimens were placed at the center of the loading platform as shown in figure.

Table 9. Flexural Strength Test Results

S.No	% of CP	Flexural Strength, N/mm^2 (12th day)
1	0%	3.39
2	5%	3.56
3	10%	3.79
4	15%	4.67
5	20%	3.61
6	25%	3.70

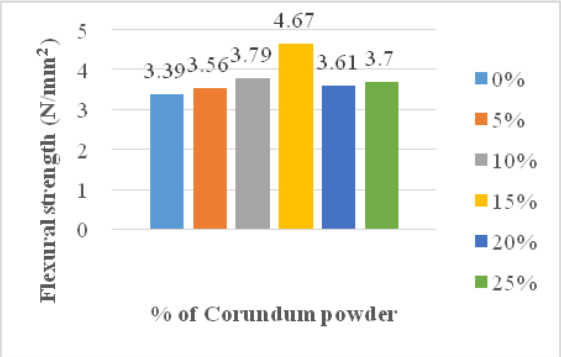

Figure 10. Flexural strength for 12 days

5.4 Water absorption test

This test method is used to determine the rate of absorption of water by Paver blocks by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when the specimen is soaked in water for 24 hours .Water absorption test was done at 12 days paver block samples.

5.4.1 Saturation weight (Ww) of paver block

To find out the saturation weight of the sample of the paver blocks, the sample of the paver blocks are kept in the completely immerged in the water at the room temperature for 24±2 hours. After that sample is taken out from the water and leave for 2 minute to drain. Visible water is removed from the sample by damping cloth and after that weight of sample is taken.

5.4.2 Dry weight (Wd) of paver block

To find out the dry weight of the sample of the paver blocks, the sample of the paver blocks are kept in the ventilated oven at 105±7°C for 24±2 hours. After that sample is taken out from the ventilated oven an interval of 2 hours as incremental of loss not should be greater than 0.2 percent.

5.4.3 Calculation of water absorption of paver block

The percentage of water absorption is calculated as

$$W_{percentage} = \frac{W_w - }{W_d} \times 100\ \%$$

Table 10. Water absorption percentages

S.NO	% of CP	W_d (kg)	W_w (kg)	% of water absorption
1	0%	4.687	4.766	1.68
2	5%	4.609	4.682	1.57
3	10%	4.560	4.627	1.46
4	15%	4.521	4.591	1.35
5	20%	4.505	4.555	1.22
6	25%	4.405	4.450	1.12

Figure 9. Flexural strength test setup

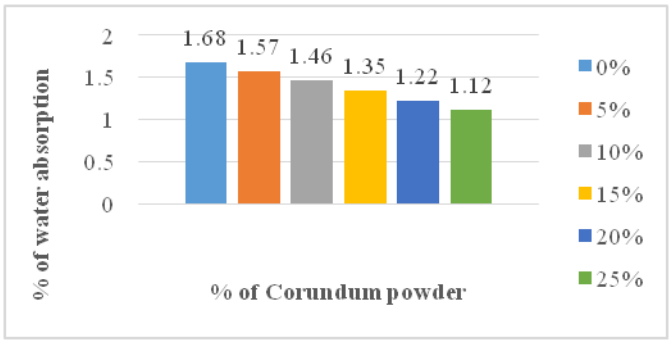

Figure 11. Water absorption percentages at 12 days

VI. Result And Discussions

6.1 Compressive strength

Figure 2, 3 and 4 shown the compressive strength of paver blocks at 7, 14 and 28 days of water curing. From the figure graph it can be concluded that the addition of corundum powder by weight of cement with 5 %, 10%, 15 % is reliable to use. From the figure 4 it has been also concluded that the compressive strength of paver blocks are increasing from the use of 5 % to 15% and the compressive strength is also decreasing from use of above 15 percent of corundum powder in the construction of the paver blocks.

6.2 Split tensile strength

Figure 6, 7 and 8 shown the split tensile strength of paver blocks at 1, 3 and 12 days of water curing. From the figure graph it can be concluded that the maximum split tensile strength is attained at 15% addition of corundum by weight of cement.

6.3 Flexural strength

Figure 10 shown the flexural strength of paver blocks at 12 days of water curing. From the figure graph it can be concluded that the maximum flexural strength is attained at 15% addition of corundum by weight of cement.

6.4 Water absorption test

Water absorption test done as per IS 15658: 2000 for 12 days. Water absorption percentage has been plotted in figure 11 for 12 days. As per figure 11 shown that the water absorption percentage is decreasing as the percentage addition of corundum powder increases by weight of cement.

VII. Conclusions

From this experimental study, it can be concluded that the corundum powder utilization up to 15 % maximum by weight of cement gives the good and effective result in the construction of the paver blocks. There is also the effect of using superplasticizer which is added 2 % by weight of the cement in the concrete mix while making the paver blocks. The utilization of corundum powder can give the solution of effective use of naturally occurring mineral which is cheap and abundant and the rapid hardening cement increases the production of paver blocks in short time with high strength.

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