EXPERIMENTAL INVESTIGATION ON REPLACEMENT OF AGGREGATES BY KOTA STONE CHIPS IN SOLID CONCRETE BLOCK

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Experimental Investigation on Replacement of Aggregates by Kota Stone Chips In Solid Concrete Block

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Abstract— India is a pioneer in the exploration, mining of commercial rock deposits and in establishing a firm base for stone industry of the 300 varieties of stone; being traded in the world market, nearly half of them are from India. The study concerns mainly on the possible use of stone waste in construction industry, which would reduce both environmental impacts and the production cost. Concrete works in the construction industry are particularly important as it is not only responsible for consuming natural resources and energy but also its capacity to absorb other industrial waste. The main objective of this investigation is to increase the compressive strength of concrete blocks and decrease the cost of concrete blocks by replacing aggregates with the Kota stone chips.

Keywords— Kota stone chips, Solid Concrete blocks, Compressive Strength, Water Absorption, Cost.

I. INTRODUCTION

In both developed and developing countries waste management problem has already become severe. The problem is compounded by the rapidly increasing amounts of industrial wastes of a complex nature and composition. Concrete works in the construction industry are particularly important as it is not only responsible for consuming natural resources and energy but also its capacity to absorb other industrial waste. Presently large amounts of stone wastes are generated in natural stone processing plants with an important impact on the environment due to its disposal. Stone chips aggregate are generated as a waste during the process of cutting and polishing of Marble/Granite/Kotastone. The producing useful shape of stone the various stone wastes are coming out from the various processes in stone industries. From the preliminary waste named as stone chips, due to minimum cost it is taken out to replace the natural basaltic coarse aggregate utilization in concrete. In current time natural basaltic aggregate are using and as it is costly, so it’s required to replace by stone waste such as stone chips conserves basaltic aggregate reduces the impact on landfills and for sustainable development. Decreases energy consumption and can provide cost savings also. Stone waste as aggregates are the materials for the future.

II. EXPERIMENTAL MATERIAL

2.1 Cement

Cement is the primary requirement of concrete and cement is a binding material in concrete so use of cement in now a day increased every year. For the experimental work OPC 53 grade cement is being used.

2.2 Fly ash

Fly Ash even though an environmental pollutant, is an important raw material for various applications. The utilization of Fly Ash in different sectors can help a great emphasis on the development of new technology for efficient utilization of Fly Ash. For the experimental work class-F fly ash is being used.

2.3 Fine aggregates

Fine aggregates consist of small angular or rounded grains of silica. Natural sand or crushed stone dust is used as a fine aggregate in concrete mix. When fine aggregate used in a concrete mix, it should be properly washed and tested to ascertain that the total percentage of clay, silt, salts and other organic matter does not exceed specified.

2.4 Aggregate [6-10 mm]

Aggregates are generally thought of as inert filler within a concrete mix. But a closer look reveals the major role and influence aggregate plays in the properties of both fresh and hardened concrete. Changes in gradation, maximum size, unit weigth, and moisture content can all alter the character and the performance of your concrete mix.

2.5 Water

The water is used in concrete plays an important part in the mixing, laying compaction setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water is used in the mix.

2.6 Kota Stone Chips

Kota Stone is a fine-grained variety of limestone quarried at Kota district, Rajasthan, India. Kota stone industry generates both solid waste and stone slurry. During the process of cutting, in that original stone waste mass is lost by 25-30% in the form of dust. Table 1 shows the Kota stone production v/s land requirements.

2.6.1 Kota Stone Production V/S Land Requirements

Table 1: Kota stone production v/s land requirements

Year	Production in MT (in lakh)	Land requirement for mining Ha.	Land requirement for waste disposal Ha.	Total land requirement Ha.
2008-09	45	30	53	83
2009-10	45	27	47	74
2010-11	50	34	59	93
2011-12	55	37	65	102
2012-13	**62**	**42**	**74**	**116**
2013-14	**68**	**46**	**81**	**127**
2014-15	**75**	**50**	**89**	**139 (Expected)**

Source: A. Hussain: kota stone mining – some critical aspects

The properties of Kota stone was tested for their properties according to the relevant IS code provisions. Table 2 shows the physical properties of Kota stone chips. Table 3 shows the chemical properties of Kota stone.

Table 2: Physical Properties of Kota Stone chips

Property	Grit 6-10mm	Kota Stone Chips
Specific Gravity	2.68	2.73
Impact Value	19.24%	20.36%
Los Angeles Abrasion Value	20.67%	18.3%

Table 3: Chemical Property of Kota Stone

Sr No	Chemical Constituent	Percentage By Weight
1	Calcium Oxide	38.86%
2	Magnesium Oxide	1.09%
3	Aluminium Oxide	2.20%
4	Silica	26.67%

(***Source: Geo Test House, Vadodara, Gujarat, India)***

III. MIX PROPORTIONS OF SOLID CONCRETE BLOCKS

Various Solid concrete block mix proportions for 12 blocks per batch is shown in table 4.

Table 4: Mix Proportions For 12 blocks per batch (By Weight in kilograms)

Solid Concrete Block Mixes	Cement	Fine Aggregate	Aggregate (6-10mm)	Fly Ash (Class-F)	Kota stone chips
A (0%)	16.70	80.24	143.36	41.88	0
K1 (20%)	16.70	80.24	114.56	41.88	28.8
K2 (40%)	16.70	80.24	85.76	41.88	57.6
K3 (60%)	16.70	80.24	56.96	41.88	86.4
K4 (80%)	16.70	80.24	28.16	41.88	115.20

IV. MANUFACTURING PROCESS OF SOLID CONCRETE BLOCK

Figure 1 shows the manufacturing process of solid concrete blocks.

Figure 1: Manufacturing Process of Concrete Blocks

V. TESTS ON SOLID CONCRETE BLOCKS [IS: 2185 (Part ll) -1983]

Compressive strength test and water absorption test are performed at the B.V.M Engineering College, Vallabh Vidyanagar, equipped with standardized and sophisticated instruments and testing machines.

5.1 Compressive Strength Test [IS: 2185 (Part ll) -1983]

381 mm × 229 mm × 153 mm concrete blocks Specimens with Ordinary Portland cement (OPC) and grit (6-10mm) partially replaced by and Kota stone chips, accordingly at 20%, 40%, 60%, 80% level is cast, individually. During casting, the blocks are made in the hand press machine. After making the specimens are removed from the moulds and subjected to water curing for 2 days. After curing, the specimens are tested for compressive strength using a calibrated compression testing machine of 2,000 KN capacities. The compression test is carried out on the specimens at the end of 7 days, 14 days and 28 days of curing.

Figure 2: Setup of Compressive Strength Test

Table 5: Compressive Strength Test Results of Blocks at 7, 14, 21days

Solid Concrete Block Mix	Average Compressive Strength (N/mm^2)			% Change in Compressive Strength
	7 DAYS	14 DAYS	28 DAYS	
Standard Concrete Block Mix				
A	6.25	8.76	14.57	0
% Replacement of Grit by Kota Stone Chips				
K1 (20%)	6.62	8.58	14.54	(-) 0.20
K2 (40%)	7.34	9.35	15.70	(+) 7.75
K3 (60%)	6.74	9.14	15.13	(+) 3.84
K4 (80%)	5.95	8.16	13.97	(-) 4.11

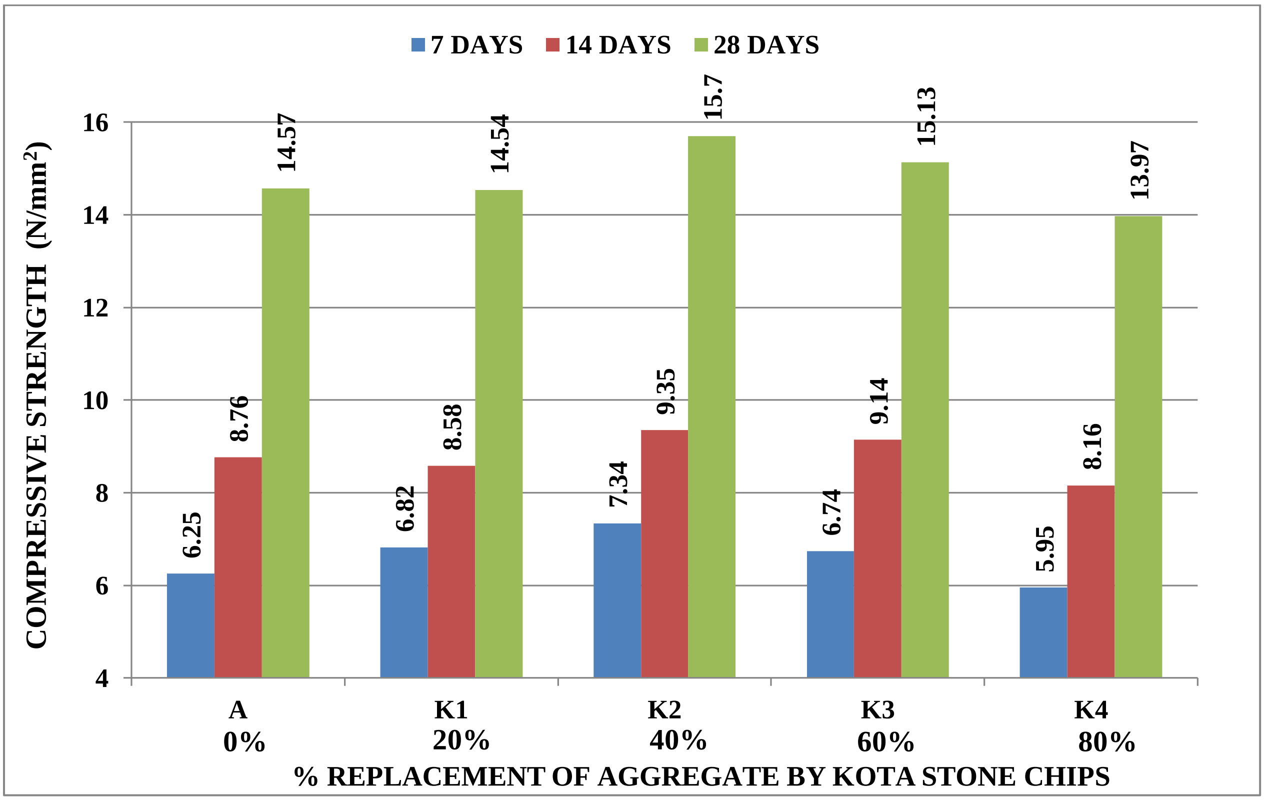

Figure 3: % Replacement of Kota Stone Chips V/S Compressive Strength (N/mm^2) at 7, 14, 28 Days (For A, K1, K2, K3, K4)

From above figure 3, it can be said that the compressive strength of solid concrete block increased with the increase in days. But for the 40-60% replacement of the Kota stones chips with aggregates (6-10mm) gives higher compressive strength compared to the standard solid concrete block at 28 days. So for the solid concrete block optimum percentage of replacement of cement by Kota stones chips is 40% as per weight of aggregate (6-10mm).

5.2 Water Absorption Test [IS 2185 PART 1 :2005]

Standard solid concrete blocks shall be completely immersed in clean water at room temperature for 24 hours. The blocks shall then be removed from the water and allowed to drain for one minute by placing them on a 10 mm or coarser wire mesh, visible surface water being removed with a damp cloth, the saturated and surface dry blocks immediately weighed. After weighing all blocks shall be dried in a ventilated oven at 100°c to 115°c for not less than 24 hours and until two successive weighing at intervals of 2 hours show an increment of loss not greater than 0.2 percent of the last previously determined the mass of the specimen.

The water absorption calculates as given below:

Absorption, percent = (A-B) /B * 100

Where,

A=wet mass of unit in kg.

B = dry mass of a unit in kg.

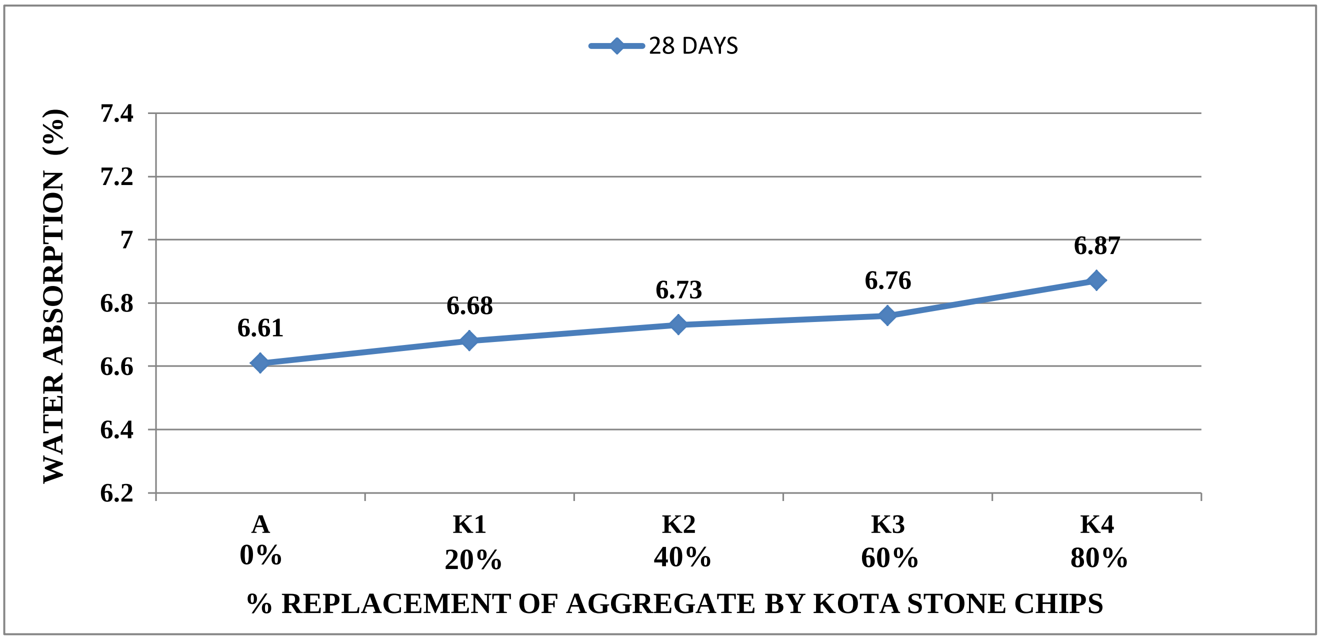

Figure 4: % Replacement of Kota Stone Chips V/S Water Absorption (%) at 28 Days (For A, K1, K2, K3, K4)

From above figure 4, The water absorption of solid concrete block increased with the increase in percentages of Kota stones chips in solid concrete blocks. But for the 20% replacement of the Kota stones chips with aggregate gives slightly higher water absorption to the standard concrete block at 28 days. Also increased percentage of kota stone chips in solid concrete block gives the negligible more water absorption compared to the standard concrete block.

VI. RATE ANALYSIS OF SOLID CONCRETE BLOCKS

Table 6 shows the rate of experimental materials per kilograms and Table 7 shows the total cost of solid concrete blocks.

Table 6: Rate of Experimental Materials

Material	Rate/Kg (Rs.)
Cement	5.60
Aggregate (6-10mm)	0.40
Fly ash	0.85
Sand	0.65
Kota Stone Chips	0.10

Table 7: Total Cost Per Solid Concrete Block

Solid Concrete Block Mix	Total Cost Per Block (Rs)
Standard Concrete Block Mix	
A (0%)	23.87
% Replacement of Aggregate By Kota Stone Chips	
K1 (20%)	23.15
K2 (40%)	22.43
K3 (60%)	21.70
K4 (80%)	20.99

VII. COST COMPARISON FOR SOLID CONCRETE BLOCKS AND CONVENTIONAL BRICK

Table 8: cost comparison of solid concrete blocks and conventional brick

Solid Concrete Blocks			Conventional Bricks	% Changes in Cost of Solid Concrete Block Compared to the Conventional Bricks
Solid Concrete block Mixes	75 Numbers of Solid Concrete Blocks Per m^3		500 Numbers of Bricks Per m^3 Cost of Brick = 4.50/Brick (Rs.)	
	Total cost Per block (Rs.)	Total cost Per m^3 (Rs.)		
A (0%)	23.87	1790.25	2250.00	(-) 25.68
K1 (20%)	23.15	1736.25		(-) 29.58
K2 (40%)	22.43	1682.25		(-) 33.74
K3 (60%)	21.70	1627.50		(-) 38.24
K4 (80%)	20.99	1574.25		(-) 42.92

From the Table 8, The cost of the solid concrete blocks is decreased compared to the conventional bricks per 1 m^3 volume. For the 40% replacement of the aggregates by kota stone chips in solid concrete blocks results in to the high compressive strength compared to the standard solid concrete blocks and also provides 33.74% cost savings compared to the conventional bricks per 1 m^3 volume.

VIII. CONCLUSION

Based on the experimental test results obtained from the study, the following conclusion are drawn

a. The replacement of Kota stone chips in solid concrete blocks the compressive strength increases gradually after replacing 40% and 60% of Aggregates by kota stone chips respectively 7.75% and 3.38% compared to the standard Solid Concrete Block mix.
b. Replacement of Kota stone chips in solid concrete blocks the percentage of Water absorption is negligible changes, compare to the standard concrete block mix.

c. It can also reduce the disposal problems of waste materials and also consume the aggregates used for making of Solid Concrete Block.
d. Production of solid concrete blocks using Kota stone chips is Eco friendly and economical.

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