Assessment of Strength of Paver Blocks by Partial Replacement of Coarse Aggregate with LECA

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***Abstract*— Presently the Concrete paving blocks has found its tremendous use in the construction industry because of its minimal maintenance after being it is laid, also of its good strength properties and durability characteristics. Paver blocks are mostly used in driveways, pavement, patios, town centres and non- traffic areas also. The main advantages of paver blocks include strength, maintenance, durability, environmental sustainability and abrasion resistance. This present study was dealt with the possibility of using Light Expanded Clay Aggregate (LECA) as the partial replacement of coarse aggregate in 10, 20 and 30 percentages for M40 Grade of concrete paver block to meet out the Medium traffic requirements as per IS 15658:2006 and to find the compressive, split tensile strengths, water absorption and abrasion resistance of control and LECA added specimens. Conclusions regarding the use of LECA in paver blocks based on the test results were drawn.**

***Keywords*— Paver blocks, Unipavers, coarse aggregate, LECA and Strength properties**

I. INTRODUCTION

Basically, the rigid pavements are done by paver blocks. They are presently used in many situations due to its abrasion resistance, resistance to acids, durability and strength. Paver blocks may get differed by their shapes, quality and grade of concrete which is used as per traffic requirements such as M30, M35, M40, M50, and M55. In the present study, an attempt was made to use LECA as partial replacement of coarse aggregate and the paver block was designed for M40 Grade to meet the Medium traffic requirements which includes ramps of shopping complexes, car parking, housing colonies, office complexes, rotaries on low volume traffic, farm houses, small market roads and boulevard. LECA being a Light Weight aggregate, because of its low density, it was selected to replace the normal coarse aggregate to assess the strength properties, abrasion resistance and water absorption.

II. MATERIALS USED

A. *Cement*

OPC 53 grade of cement conforming to IS 12269 – 2013 with specific gravity of 3.15 was used.

B. *Fine Aggregate*

Fine aggregate of River sand with specific gravity of 2.60 conforming to Grading Zone II as per IS 383 – 2016 was used.

C. *Coarse Aggregate*

Natural coarse aggregates from locally available quarries were used as per the specifications of IS 383 – 2016. Coarse aggregate with a maximum nominal size of 12 mm and specific gravity of 2.70 was used.

D. *Light Expanded Clay Aggregate*

LECA with a specific gravity of 1.00 and maximum size of 12 mm was used.

E. *Water*

Water used for the preparation of paver block was as per the requirements given in IS 456: 2000.

III. MOULD DESCRIPTION

The shape of the mould for the present study was Unipaver with plan area of 0.0322 sq.m and thickness of 80 mm with chamfered edges.

IV. EXPERIMENTAL PROGRAMME

The mix design for the selected M40 grade to meet out the medium traffic requirements were designed as per the design specifications of IS 10262 – 2009 and the mix proportion was arrived. Based on the mix proportions, the paver blocks of Unipaver shape were cast as per the sampling requirements of IS 15658:2006. LECA was added to the concrete mix such a way that it was kept soaked in water for about 24 hours prior to the day of casting. After the completion of casting, the paver blocks were demoulded after 24 hours and kept in water for curing for about 28 days and further it was used for testing.

Fig. 1 Unipaver mould and Casted Unipaver blocks

A. Compression Test

The paver block specimens of about 8 numbers were casted as control specimens (CS) and 8 numbers for every 10 % of LECA added specimens and a total of 32 paver block specimens were casted from which every 4 specimens were tested at 7 days and 28 days. The apparent compressive strength of the individual specimen was determined by dividing the maximum load (in N) by the plan area (in mm^2) and the corrected compressive strength was calculated by multiplying the apparent compressive strength by the appropriate correction factor as per IS 15658: 2006.

B. Split Tensile Strength Test

About 32 specimens including control and LECA added specimens were casted and were tested at 7 and 28 days. The split tensile strength for paver block is carried out the formula as per IS 15658: 2006. The specimen was placed on the testing machine such a way that the splitting section of the specimen at 0.5 times the thickness of the specimen to any side face of the specimen and the load was applied smoothly and progressively at a rate of 0.05 ± 0.01 MPa and the load at which the specimen failed was noted. The area of the failure planes of the specimen tested was calculated from the equation:

$$S = l \times t \quad (1)$$

Where,

S - Area of the failure, in mm^2;

l - Mean of two measurements of the failure length, one at the top and one at the bottom of the specimen, in mm; and

t - Average of three measurements of thickness at the failure plane, one in the middle and one at either end, in mm.

The tensile splitting strength of the test specimen is calculated from the equation:

$$T = 0.637 \times k \times (P/S) \quad (2)$$

Where,

T - Tensile splitting strength, in MPa; and

P - Failure load N.

C. Water Absorption

Generally the paver blocks do not allow the water to get penetrated into it and in order to develop the bond well with mortar, they should be capable of absorbing some water. Water absorption of pavers was carried out to find whether it must be soaked in water before laying. About 3 specimens were casted and the percentage of water absorption was measured in grams.

$$\% \text{ of water absorption} = (W-W_d) / W_d \quad (3)$$

where,

W - Wet weight of the paver block,

W_d - Dry weight of the paver block.

D. Abrasion Test

Due to the vehicular traffic, the surface of the paver blocks will be subjected to abrasive action. In order to find the abrasion resistance of the paver block, the square shaped specimens measuring 70 mm was cut out the paver block specimens and tested to determine the abrasive wear after allowing 16 cycles with 22 revolutions per cycle through a grinding disc with abrasive powder of 20 g which was placed before each cycle.

The mean loss in volume was calculated using the equation:

$$\Delta V = \Delta m / PR \quad (4)$$

Where,

ΔV = loss in volume after 16 cycles, in mm^3;

Δm = loss in mass after 16 cycles, in g; and

PR = density of the specimen, in g/mm^3.

V. TEST RESULTS AND DISCUSSION

The strength tests, abrasion resistance and water absorption tests were carried out on the cast specimens and the test results obtained were presented below. The control specimen, 10%, 20% and30 % LECA added specimens were denoted by CS, M1, M2 and M3 respectively.

A. Compression test Results

The compressive strengths of CS, M1, M2 and M3 were determined as per the procedure given in IS 15658 – 2006 and shown in Table I.

TABLE I
COMPRESSIVE STRENGTH TEST RESULTS

Specimen	Compressive strength in N/mm^2	
	7 days	28 days
CS	28.84	37.34
M1	10.92	18.68
M2	10.55	11.72
M3	8.19	9.16

B. Split Tension test Results

By using "(1)", the area of the failure plane was determined and then the split tensile strength of paver blocks were found out using "(2)".

Fig. 2 Compression and Split tension test on paver blocks

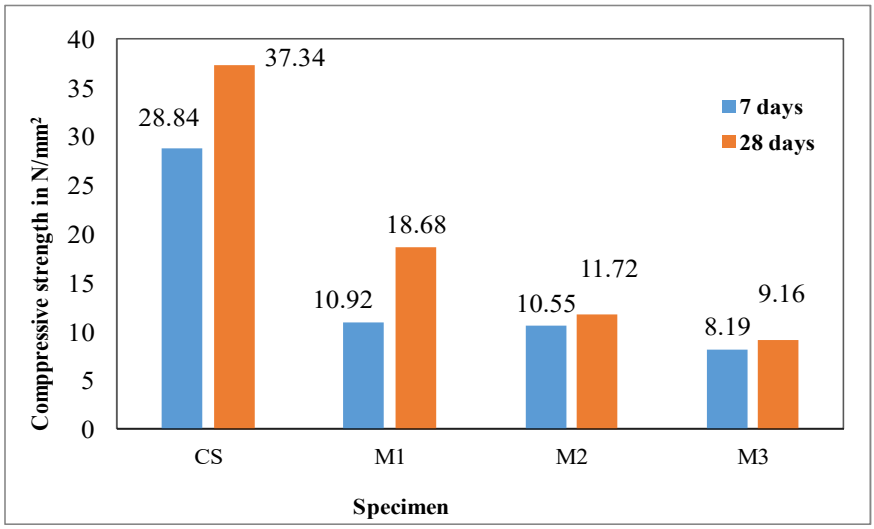

Fig. 3 Comparison of Compressive strength at 7 & 28 days

TABLE II

SPLIT TENSION TEST RESULTS

Specimen	Tensile strength at 28 days in N/mm^2
CS	4.08
M1	1.02
M2	1.18
M3	2.75

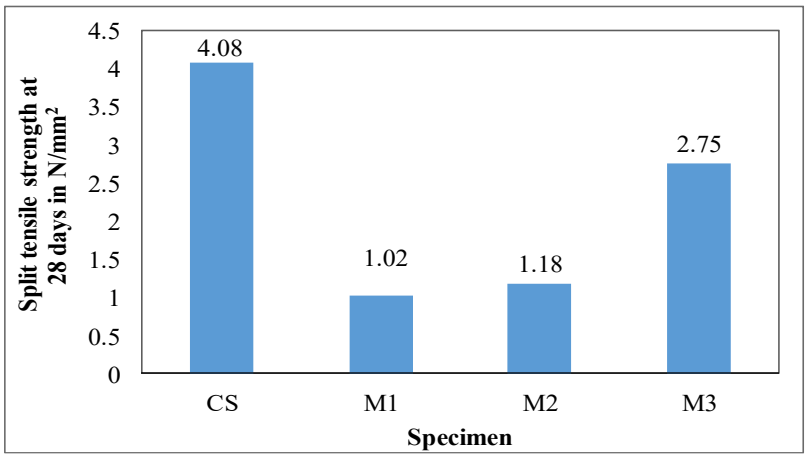

Fig. 4 Comparison of Split tensile strength at 28 days

C. Water Absorption Test Results

The water absorption test was determined by noting down the dry weight of specimen and kept it soaked in water for 24 hours and the wet weight was determined. The percentage of water absorption was calculated using "(3)".

TABLE III
WATER ABSORPTION TEST RESULTS

Specimen	Water absorption in %
CS	4.78
M1	3.59
M2	4.48
M3	6.04

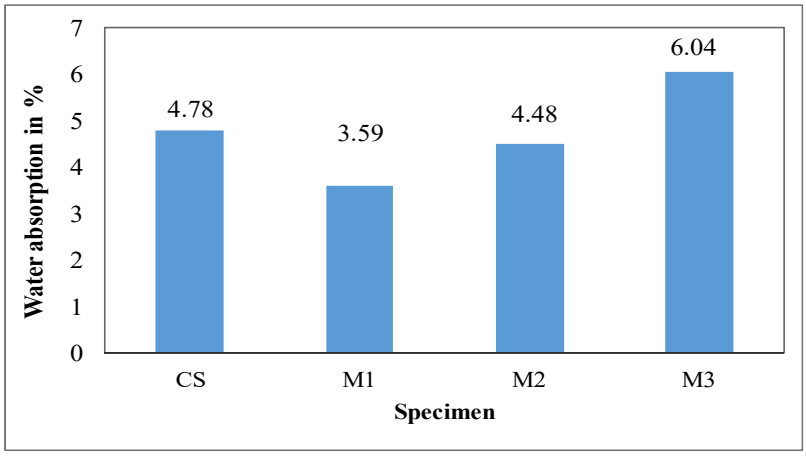

Fig. 5 Comparison of Water absorption of specimens

D. Abrasion Resistance Test Results

The abrasive wear of the specimens were calculated in terms of mean loss of volume in specimen in mm^3 using "(4)".

TABLE IV
ABRASIVE WEAR OF SPECIMENS

Specimen	Loss in Volume of specimen in mm^3
CS	1423.07
M1	2333.33
M2	2285.70
M3	2526.30

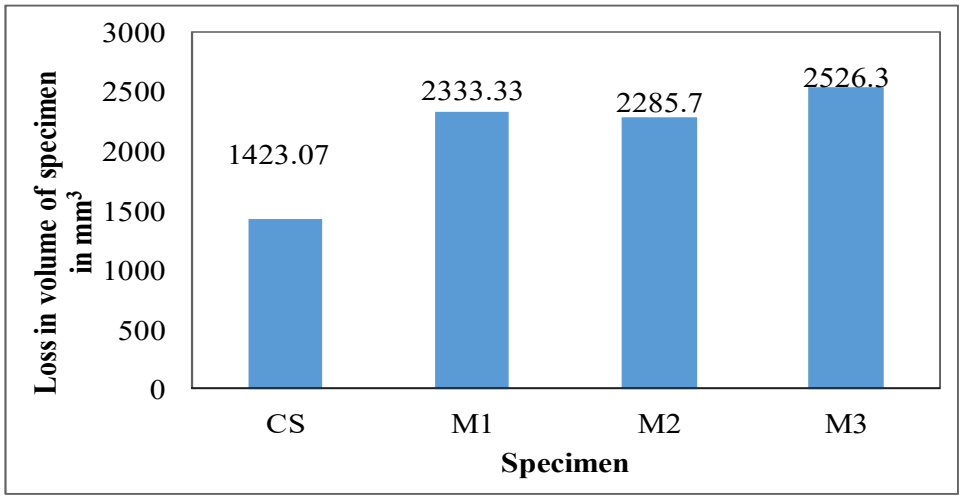

Fig. 6 Abrasion test results of paver blocks

V. CONCLUSION

From the present investigation on Light Weight Aggregate paver blocks with LECA, the following conclusions were drawn.

1. The Compressive strength of paver blocks have got decreased with the increase in addition of LECA in 10, 20 and 30% when with control specimen.

2. But the split tensile strength of the LECA added paver blocks have got increased with increase in percentage replacement.

3. The percentage of water absorption and abrasive wear measured by loss in volume was found to increase with increase in replacement percentages.

3. From this, it was concluded that since the present study was done for M40 grade, that is for Medium traffic requirements and if the design would be carried out for M30 or M35 grade to meet out the Non – traffic and Light traffic conditions, the strength properties can be get improved.

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