Experimental Investigations on Paver Blocks by Partial replacement of Cement by Lead slag and Natural sand by M-sand

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Abstract: Construction Industry plays a vital role in developing the economic growth of a country. Due to the rapid consumption of conventional raw materials such as sand and aggregates has resulted in non-availability of materials at the required time. This has made mankind to choose an alternative material such as M-sand, fly ash in construction projects. Lead battery manufacturing industries create a huge amount of by-products that are dumped into landfills. During the extraction of pure lead from exhausted batteries, it has resulted in the development of a by-product called lead slag during the smelting process. This material has found similarities in physical constituents with cement. Hence an attempt has been made to inculcate alternative materials during the manufacture of paver blocks. The concrete mix was designed for M30 grade. Materials such as Cement were replaced by Lead slag in varying percentages from 5%, 10%, 15%, and 20% respectively also Natural sand was replaced by 100% M-sand. From test results it was found that optimum content of lead slag that can be replaced is 15% without affecting the strength characteristics of paver blocks. This paper has also analyzed the cost involved for conventional and modified paver blocks per square feet.

Keywords: Paver block, Lead slag, Compressive strength, M-sand

1. Introduction

Paver blocks are individual units which are manufactured as per recommended thickness as mentioned in Indian Standard code book IS 15658:2006 for different traffic categories. Further during laying each unit is joined together by means of an interlocking mechanism which are placed above a rigid sub base. Later joints are filled by sand. Paver blocks are been vitally used in outdoors, gardens, footpaths, and also at inner edges in curved roads. For the manufacture of paver block requires an enormous amount of raw materials such as Cement, sand, and Coarse aggregates with proper water-cement ratio. Also, the cost of these raw materials keeps on fluctuating at regular intervals of time. In order to overcome this problem, alternative replaceable materials such as Lead slag and M-sand can be used. It has similar physical and chemical properties as that of conventional raw materials used during the manufacture of paver blocks. Lead slag is a by-product developed during th**e** smelting process of exhaust lead batteries at 1000 to 1200 ºC. M-sand is produced from hard granite during the crushing process. It can be used as an alternative material for natural sand. In this paper, lead slag is added in varying percentages from 5%, 10%, 15%, and 20% respectively also Natural sand is replaced by 100% M-sand.

2. objectives

1) To determine physical properties of conventional materials and alternative replacing ingredients such as lead slag, M-sand used in paver block.
2) To analyze the optimum replaceable percentage of materials to be incorporated in paver block.
3) Comparison of compressive strength characteristics between conventional and replaced materials in paver block.
4) To analyse the cost savings in cubic meter

3. Materials used

A. Cement

Portland Pozzolona cement of 53 grade confirming to Indian standard IS 1489 Part-1 was used. Cement was procured from Dakshina Kannada Nirmithi Kendra Suratkal Mangalore. The various properties of cement obtained from laboratory results are shown in Table 1.

Table I PROPERTIES OF CEMENT

Sl.No	Properties	Test results
1	Specific Gravity	3.15

2	Normal Consistency	28.5%
3	Initial Setting Time (minutes)	55
4	Final Setting Time (minutes)	600

B. River Sand

River sand had been procured from Dakshina Kannada Nirmithi Kendra Suratkal Mangalore. Properties of River sand obtained from Laboratory results are shown in Table II

Table II Properties of River Sand

Properties	Test Results
Specific gravity	2.65
Water absorption	1.52%
Fineness modulus	3.30

C. Lead Slag

Lead slag samples were procured from Eshwari Metals Baikampady Mangaluru. Properties of Lead slag obtained from Laboratory results are shown in Table III

Table III Properties of River Sand

Properties	Test Results
Specific gravity	3.11
Water absorption	11.01%
Fineness modulus	4.14

Fig.1 Lead slag obtained from industry in boulder form

Fig.2 Crushed lead slag

Fig.3 Powdered Lead slag

D. M-Sand

Manufactured sand was procured from Dakshina Kannada Nirmithi Kendra Suratkal Mangaluru. Properties of Manufactured sand obtained from Laboratory results are shown in Table IV

Table IV Properties of Manufactured Sand

Properties	Test Results
Specific gravity	2.52
Water absorption	3.80%
Fineness modulus	3.95

E. Coarse aggregates of 10mm sown size

Coarse aggregates was collected from Nirmithi Kendra Suratkal Mangaluru. Properties of Quarry dust are given in Table V

Table V Properties of Coarse Aggregates

Properties	Test results of 10mm down size
Specific gravity	2.71
Water absorption	1.31%
Fineness modulus	9.4

F. Water

Potable water used was verified as per the specifications of IS 456-2000 was used.

4. Methodology

1) Procurement of raw materials like lead slag from Eshwari metals Baikampadi Mangalore, Cement, M-sand from Dakshina Kannada Nirmithi Kendra Mangalore

2) Identification of similarity in physical constituents between lead slag and Pozzolana Portland cement, Natural sand and Manufactured sand.

3) Casting paver blocks in moulds of standard size (200mm×100mm×80mm) in varying percentage in cement and lead slag, M-sand in place of Natural sand for the preparation of M30 grade of concrete paver blocks.

4) Computing the compressive strength of paver block for 7, 14, and 28 days of concrete.

5) Comparing the conventional paver block and modified paver block to analyze cost saving per square feet.

5. Results And Discussions

A. Comparison between Chemical Composition of cement versus Lead Slag

The following Table VI shows the chemical composition of ingredients existing in Ordinary Portland cement and Lead slag. It has been found that lead Slag contains similarity in chemical compounds which includes Silica Iron and Magnesium.

Table VI Chemical composition of cement and lead slag

Parameters	Lead Slag	Oxide composition in PPC
Specific Gravity	3.11	3.15
Silica SiO_2 %	42.86	17-25
Iron Fe_2O_3 %	1.91	0.5-6
Aluminium Al %	40.28	-
Manganese Mn %	1.62	-
Magnesium Mg %	2.19	0.5-4
Calcium Cao %	7.24	-
Sulphur %	7.22	-

B. Quantiy of raw materials required for Paver blocks

The quantity of raw materials is calculated initially for one paver block and one cube mould on a volume basis. The size of paver block used was 200×100×80mm and cube moulds with size 150×150×150mm.Following Table VII shows the quantity of raw materials required for the manufacture of 10 Paver blocks and 6 cube moulds

Table VII Materials Required for Conventional and Modified Paver Blocks

	Raw Materials				
Type of Paver block	C (Kg)	C.A (Kg)	F.A (Kg)	L.S (Kg)	W (litrs)
Conventional Paver blocks	16.7	27.7	26.93	-	7.45
5 % of Lead Slag	15.8	27.7	26.93	0.83	7.45
10 % of Lead Slag Addition	15.02	27.7	26.93	1.66	7.45
15 % of Lead Slag Addition	4.19	27.7	26.93	2.50	7.45
20 % of Lead Slag Addition	13.33	27.7	26.93	3.38	7.45

C=Cement, C.A=Coarse aggregate F.A=Fine aggregate L.S=Lead Slag, W=Water

C. Mix design for M30 grade of paver block

Paver blocks were casted for M30 grade concrete. The following table VIII shows the proportion of raw materials used in the manufacture of Paver block.

Table VIII Mix Design Used for Paver Block

Water (Litres)	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)
208	462.22	746.505	799.6407
0.45	1	1.62	1.73

D. Compressive strength of Conventional Paver blocks

The compressive strength of Conventional Paver blocks were found out by casting moulds of size 200×100×80mm and was tested using compressive testing machine.

Fig.1 shown graph of Compressive strength of Conventional paver block. Paver blocks were tested after curing period of 7, 14 and 28 days respectively. It was found that Average Compressive strength values increased considerably from 27.71N/mm^2 at 7 days to 39.08 N/mm^2 at 28 days respectively.

Fig.4 Casted Rectangular paver blocks and cubes

Fig.4 Compressive strength of Paver blocks

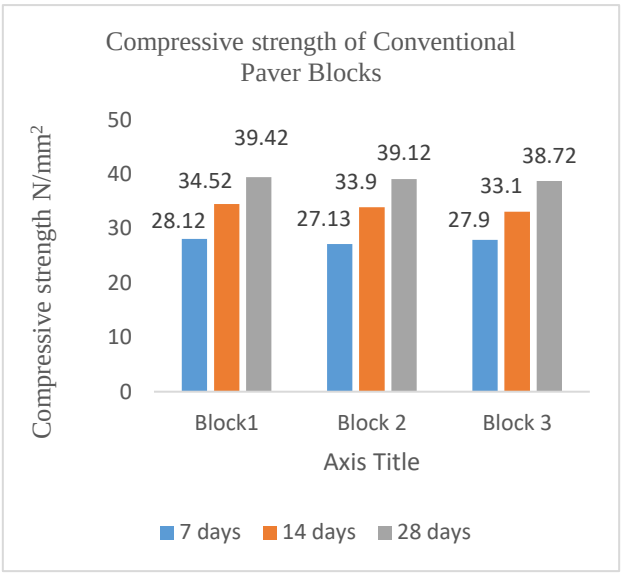

Fig.5 Compressive Strength Conventional of Paver Blocks

E. Compressive strength of Modified Paver blocks for varying percentage of Lead slag.

Modified paver blocks were casted of size 200×100×80mm with the addition of Lead slag and 100% M-sand. Initially, Cement was replaced by lead slag in varying percentages i.e 5%,10%,15%,and 20% respectively.Modified paver blocks were kept for curing for 7,14 and 28 respectively.The Compressive strength of paver blocks was tested on 7,14 and 28 respectively.Three paver blocks were tested on respective days and the average compressive strength value was determined. The obtained compressive strength values are anaylzed by plotting graphs in Ms.Excel sheets.

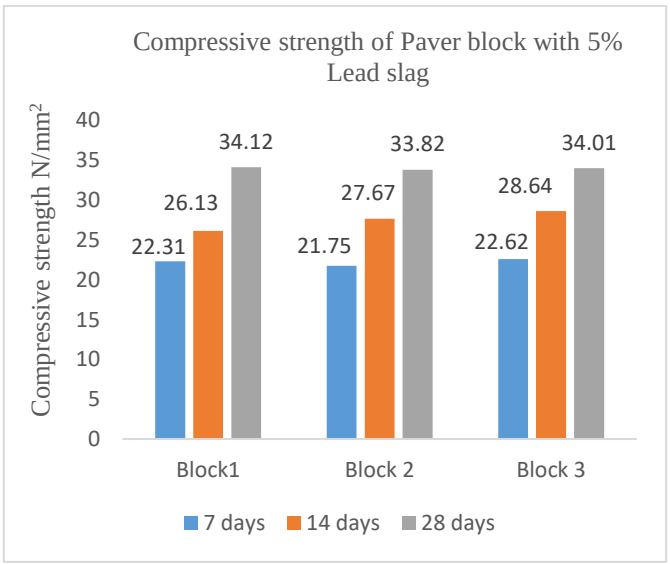

Fig. 6 Compressive Strength of Paver Blocks with 5% of lead slag

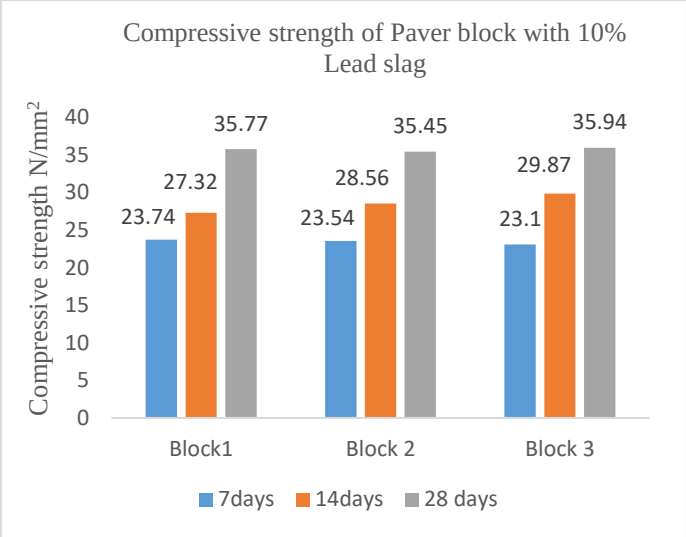

Fig.7 Compressive Strength of Paver Blocks with 10% of lead slag

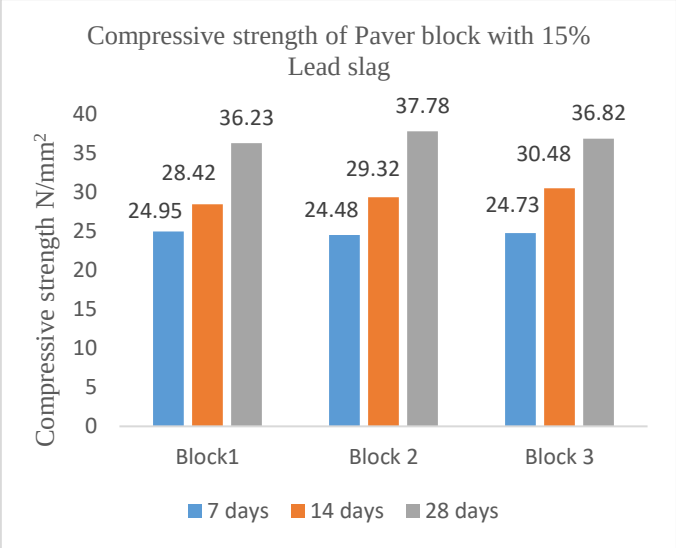

Fig.8 Compressive Strength of Paver Blocks with 15% of lead slag

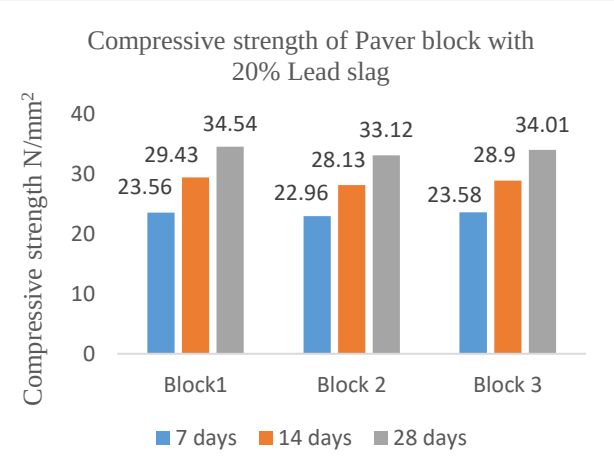

Fig.9 Compressive Strength of Paver Blocks with 20% of lead slag

From Fig.6 it was found that Compressive strength of paver block increased considerably in varying percentage up to 15% was found to be 37.27N/mm$^{2.}$With further increase in percentage of lead slag the strength reduced to 33.89 N/mm$^{2.}$.

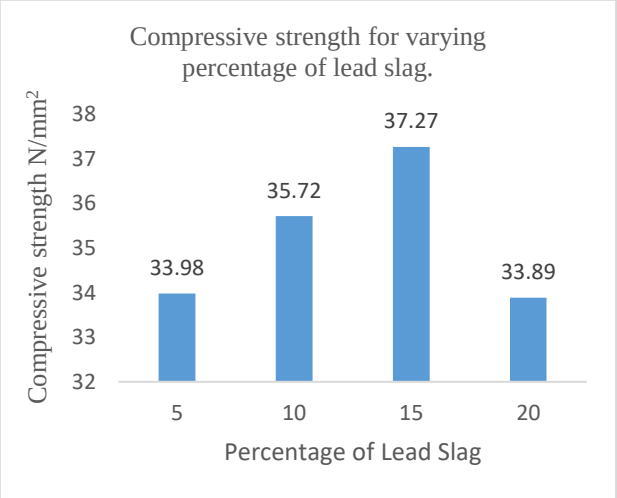

Fig.10 Optimum compressive strength of modified paver block at 28 days

F. Rate Analysis

Rate analysis was compared between conventional and modified paver blocks.

The following table VIII shows the quantity of materials required for preparation of 10 paver blocks.

Table VIII Quantity Of Materials And Rate of MATERIALS For Conventional Paver Block

Sl. No	Materials	Quantity of materials used in kg	Rate of materials used
1	Cement	7.45	50.66 Rs
2	Fine aggregate	12.00	21.60 Rs
3	Coarse aggregate	12.50	13.75 Rs

Cost for one sqft. Paver block of size (200X100X80 mm) is 38.705 Rs

The following table XI shows the quantity of materials required for preparation of 10 modified paver blocks

Table XI Quantity Of Materials And Rate of MATERIALS For Modified Paver Block

Sl. No	Materials	Quantity of materials used in kg	Rate of materials
1	Cement	6.33	43.04
2	Fine aggregate	12.00	14.40
3	Coarse aggregate	12.5	13.75
4	Lead slag	1.12	NIL

Cost for one sqft. of modified paver blocks of size (200X100X80 mm) is 31.95 Rs

6. Conclusions

1. Cement can be replaced by lead slag up to 15% in paver block without affecting strength characteristics
2. Target compressive strength for paver blocks theoretically was found to be 38.25 N/mm^2 and compressive strength gained by replacing cement by lead slag after 28 days were found to be 37.27N/mm^2.
3. Natural sand was replaced by 100% M-sand as an alternative material that overcomes the shortage of raw materials during the manufacture of paver blocks.

Cost Rate of Modified paver block per sqft feet was found to be 15% lesser than conventional paver block.

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