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Research Article

BEHAVIOUR OF PAVER BLOCKS BY REPLACEMENT OF FINE AGGREGATE WITH M-SAND AND CRUMB RUBBER WASTE

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A B S T R A C T

Paver blocks have been extensively used as a problem solving technique for providing pavement in areas where conventional type of construction are less durable due to many operational and environmental constraints. Rubber production is increased world wide and generally 1.3 billion tons of waste tyres generated every year. The volume is expected to increase upto 2.2 billion tons by 2025. It is not possible to discharge these huge tons of rubber in environment because they decompose very slowly and cause environmental pollution. So, it is necessary to have a relevant use of this waste. Also digging of river sand leads to the extinct of river. So, the availability of river sand is reduced and the cost of the river sand is high. Hence, Manufactured sand (M sand) which has same properties compared to natural sand is used as fine aggregate in concrete. In this study, an investigation was carried out to identify the behaviour of paver blocks by replacement of fine aggregate with rubber waste & M-sand and partial replacement of cement with dolomite. The grade of concrete used was M35. The replacement percentage of rubber waste was 3%, 6%, 9%, 12% and 15% of fine aggregate and the remaining percentages were replaced by M-sand. The replacement percentage of dolomite was 30 % of cement. Physical properties such as Compressive strength, split tensile strength & flexural strength were determined for 7 days, 14 days & 28 days and the results were discussed.

INTRODUCTION

Paver block is a small precast unit made of concrete. Paver blocks are manufactured concrete blocks that can be individually placed in a variety of patterns and shapes as per requirements. Paver blocks were first introduced in Holland in the fifties as a replacement of paver bricks. Paver blocks are commonly used decorative method of creating a pavements. Now a days paver blocks are used for both residential and commercial purposes including parking lots, sidewalls, pool decks, streets, golf cart paths, surface covering for drive ways and even root garden. It can be made in a variety of colours, patterns and style. Paver blocks are also known as interlocking blocks.

Globally around 15 million tonnes of waste tyres are generating annually, out of which one million tonnes of waste tyres are generated in India. Disposing of waste tyres by land filling can cause severe effects on environment and health conditions. Burning of scrap tyres pollutes the air by releasing toxins. Researches were carried out by using the scrap tyres in the construction field in the form of crumb rubber.

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Crumb rubber is produced by reducing the size of scrap tyres and can be used as an alternative for fine aggregate. River sand is the naturally available material. These are used in manufacture of concrete blocks. Nowadays the availability of river sand is reduced and the cost of the river sand is high. Hence, Manufactured sand (M sand) which has same properties compared to natural sand is used as fine aggregate in concrete Cement is one of the primary producers of carbon dioxide, a potent greenhouse gas. Dolomite is a rock forming mineral which consists of calcium magnesium carbonate with a chemical composition of $CaMg\ (co_3)_2$. Dolomite is a primary component of sedimentary rocks. Dolomite is preferred as a construction material due to its higher surface hardness and density. Dolomite may be locally available or may be sometimes transported and it is cheap. Hence, dolomite can be used as an alternative for cement.

In this paper, the fine aggregate is replaced by rubber waste &M-sand and cement is partially replaced by dolomite.The replacement percentage of rubber waste is 3%, 6%, 9%, 12% and 15% of fine aggregate and the remaining percentages were replaced by M-sand.The replacement percentage of dolomite is 30 % of cement. Physical properties such as Compressive strength, split tensile strength & flexural strength is determined for 7 days, 14 days & 28 days and the results are discussed.

The main objectives of the study are given below

- To determine the physical properties of paver blocks by replacement of fine aggregate with M-sand and crumb rubber waste.
- To find the optimum replacement percentage of rubber.
- To reduce the disposal of waste rubber.
- To introduce eco-friendly paver block.

Material Properties

Properties of Cement

Ordinary Portland cement of grade 53 and Dolomite of size 60 mesh was used for the study. Based on IS codal specifications, the physical properties of cement was determined and they are shown in table 1.

Table 1 Properties of Cement

Physical properties	Value
Standard consistency test	31%
Specific gravity of cement	3.15

Properties of Fine Aggregate

In this study, M-sand passing through 2.36mm sieve and crumb rubber of size 85microns was used as fine aggregate. Various properties of fine aggregate were determined based on specifications given in IS code and they are shown in table 2.

Table 2 Properties of Fine Aggregate (M-SAND)

Physical properties	Value
Specific gravity	2.63
Apparent specific gravity	2.7
Water absorption	1%
Fineness modulus	4.93

Properties of Coarse Aggregate

The aggregate of size 12mm was used and it is angular in shape. Important properties of coarse aggregate were determined based on specifications given in IS code and they are shown in table 3

Table 3 Properties of Coarse Aggregate

Physical properties	Value
specific gravity	2.66
Apparent specific gravity	2.7
Water absorption	0.51%

Experimental Investigation

An experimental investigation was carried on paver block specimens to identify its behaviour by replacement of fine aggregate with rubber waste & M-sand and partial replacement of cement with dolomite. The grade of concrete used was M35. The replacement percentage of rubber waste was 3%, 6%, 9%, 12% and 15% of fine aggregate and the remaining percentages were replaced by M-sand. The replacement percentage of dolomite is 30 % of cement. Physical properties such as Compressive strength, split tensile strength & flexural strength were determined for 7 days, 14 days & 28 days using Compressive strength test, Split tensile strength test and flexural strength test respectively.

Fig 1 Paver Blocks

RESULTS AND DISCUSSION

Compressive Strength Test

Compressive strength test of paver blocks was conducted for 7 days, 14 days, and 28 days of curing. The specimens with 0%, 3%, 6%, 9%, 12% and 15% replacement by crumb rubber waste & remaining percentages by M-sand as fine aggregate and 30 % replacement by dolomite as cement were denoted as B0, B3, B6, B9, B12 and B15 respectively. The compressive strength of the specimens are shown in Tables 4,5,6,7,8 and 9.

Table 4 Compressive Strength of B0 Specimens

specimen	Curing period (days)	Compressive strength (N/mm^2)	Mean value (N/mm^2)
B0	7	36.64	35.32
		37.96	
		31.36	
	14	48.55	50.70
		49.85	
		53.7	
	28	56.12	54.47
		52.82	
		54.47	

The compressive strength of B0 specimens for 7, 14& 28 days is 35.32N/mm^2, 50.70 N/mm^2& 54.47 N/mm^2 respectively.

Table 5 Compressive Strength of B3 Specimens

Specimen	Curing period (days)	Compressive strength (N/mm^2)	Mean value (N/mm^2)
B3	7	13.67	12.60
		11.54	
		12.59	
	14	17.46	15.67
		15.32	
		14.23	
	28	20.13	18.58
		17.5	
		18.11	

The compressive strength of B3 specimens for 7, 14& 28 days is 12.60 N/mm^2, 15.67N/mm^2& 18.58N/mm^2 respectively. The strength obtained at 28 days is 34.11% of compressive strength of nominal block.

Table 6 Compressive Strength of B6 Specimens

Specimen	Curing period (days)	Compressive strength (N/mm^2)	Mean value (N/mm^2)
B6	7	16.17	14.32
		12.87	
		13.92	
	14	15.32	17.20
		19.87	
		16.41	
	28	19.80	20.62
		21.45	
		20.61	

The compressive strength of B6specimens for 7, 14& 28 days is 14.32N/mm^2, 17.20 N/mm^2& 20.62N/mm^2 respectively. The strength obtained at 28 days is 37.82% of compressive strength of nominal block.

Table 7 Compressive Strength OF B9 Specimens

Specimen	Curing period (days)	Compressive strength (N/mm^2)	Mean value (N/mm^2)
B9	7	10.23 9.24 8.25	9.24
	14	14.76 18.56 16.84	16.72
	28	21.54 18.8 17.56	19.30

The compressive strength of B9specimens for 7, 14& 28 days is 9.24N/mm^2, 16.72N/mm^2& 19.30 N/mm^2 respectively. The strength obtained at 28 days is 35.43% of compressive strength of nominal block.

Table 8 compressive strength of B12 Specimens

Specimen	Curing period (days)	Compressive strength (N/mm^2)	Mean value (N/mm^2)
B12	7	7.92 7.59 7.29	7.60
	14	16.5 13.20 14.7	14.8
	28	17.49 19.80 18.63	18.64

The compressive strength ofB12 specimens for 7, 14& 28 days is 7.60 N/mm^2, 14.8N/mm^2& 18.64N/mm^2 respectively. The strength obtained at 28 days is 34.22%of compressive strength of nominal block.

Table 9 Compressive Strength of B15 Specimens

Specimen	Curing period (days)	Compressive strength (N/mm^2)	Mean value (N/mm^2)
B15	7	4.2 7.62 5.88	5.90
	14	10.23 10.89 10.56	10.56
	28	10.64 13.98 12.25	12.29

The compressive strength of B 15 specimens for 7, 14& 28 days is 5.90 N/mm^2, 10.56N/mm^2& 12.28N/mm^2 respectively. The strength obtained at 28 days is 22.56% of compressive strength of nominal block.

The compressive strength versus replacement percentage of crumb rubber is shown in Fig.2

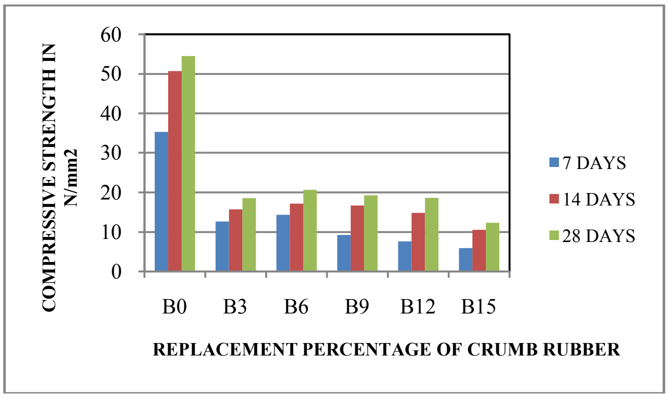

Fig 2 Compressive Strength VS. Replacement Percentage of Crumb Rubber

Split Tensile Strength Test

Split tensile strength test for the paver block specimens were conducted after 28 days of curing. The specimens with 0%, 3%, 6%, 9%, 12% and 15% replacement by crumb rubber waste & remaining percentages by M-sand as fine aggregate and 30 % replacement by dolomite as cement were denoted as B0, B3, B6, B9, B12 and B15 respectively. The split tensile strength of the specimens is shown in Table 10.

Table 10 Split Tensile Strength of Paver Block Specimens

Specimen	Curing period (days)	Split tensile strength (N/mm^2)	Mean value (N/mm^2)
B0	28	3.70 3.12 3.68	3.50
B3	28	2.13 1.97 1.87	1.99
B6	28	1.15 1.01 0.85	1.00
B9	28	0.33 0.5 0.64	0.49
B12	28	0.154 0.21 0.233	0.20
B15	28	0 0 0	0

The split tensile strength of specimens B0, B3, B6, B9, B12 & B15 for 28 days is 3.50 N/mm^2,1.99N/mm^2, 1.00 N/mm^2,0.49N/mm^2, 0.20 N/mm^2& 0 respectively. And the obtained strength is 56.85%, 28.51%, 14%, 5.6%, 0% of split tensile strength of nominal block.

The split tensile strength versus replacement percentage of crumb rubber is shown in Fig.3

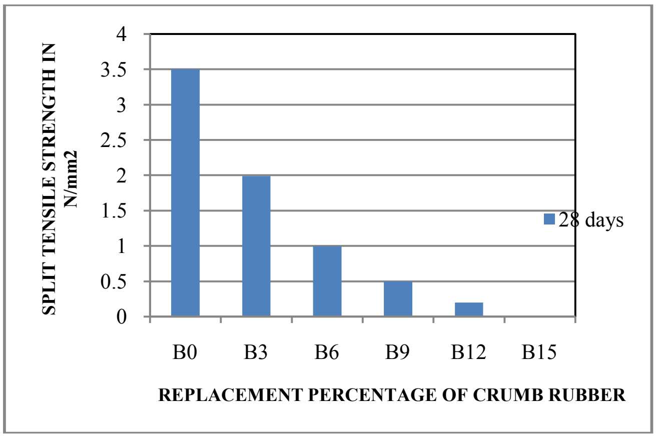

Fig 3 Split Tensile Strength VS. Replacement Percentage OF Crumb Rubber

Flexural Strength Test

Flexural strength for the paver block specimens were tested after 28 days of curing. The specimens with 0%, 3%, 6%, 9%, 12% and 15% replacement by crumb rubber waste & remaining percentages by M-sand as fine aggregate and 30 % replacement by dolomite as cement were denoted as B0, B3, B6, B9, B12 and B15 respectively. The flexural strength of the specimens is shown in Table 11.

Table 11 Flexural Strength of Paver Block Specimens

Specimen	Curing period (days)	Flexural strength (N/mm^2)	Mean value (N/mm^2)
B0	28	6.34 5.12 5.64	5.70
B3	28	4.36 2.98 2.92	3.42
B6	28	2.65 2.41 2.62	2.56
B9	28	2.14 1.56 1.43	1.71
B12	28	0.855 0.56 0.724	0.71
B15	28	0 0 0	0

The Flexural strength of specimens B0, B3, B6, B9, B12 & B15 for 28 days is $5.7N/mm^2$, $3.42N/mm^2$, $2.56N/mm^2$, $1.71N/mm^2$, 0.71 N/mm^2&0 respectively. And the obtained strength is 60%, 44.91%, 30%, 12.56% & 0% of flexural strength of nominal block.

The flexural strength versus replacement percentage of crumb rubber is shown in Fig.4

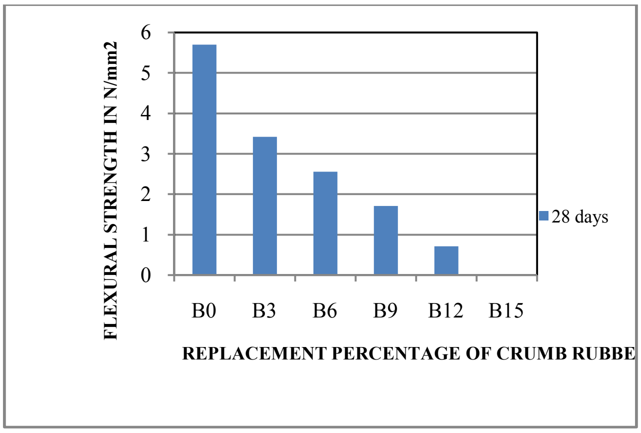

Fig 4 Flexural Strength VS. Replacement Percentage of Crumb Rubber

CONCLUSION

The fine aggregate was replaced with rubber waste & M-sand and cement was replaced with dolomite by 30% for all the specimens. The replacement percentage of crumb rubber is 0%,3%,6%,9%,12%&15% and remaining percentages were replaced by M-sand. From the results and discussion, the following points were observed.

- Compressive strength and split tensile strength of partially replaced paver block is reduced compare to nominal block.
- The average compressive strength of B6 specimens attains the maximum value of 20.62 N/mm^2which is 37.85% of compressive strength of nominal block.
- The average split tensile strength ofB3 specimens attains the maximum value of 1.99 N/mm^2 which is 60% of split tensile strength of nominal block.
- Flexural strength obtained for replaced paver block was low compared to nominal block but the obtained value met the suggested value of characteristic bearing load given in IS 15658:2006.
- The average flexural strength of B3 specimens attains the maximum value of 3.42 N/mm^2 which is 60% of flexural strength of nominal block.
- The replaced paver blocks can be used for aesthetic purposes and in lawn, parks, etc..,
- The advantage of rubberized paver blocks include reduction in density, improvement in drainage property, light weight & better thermal insulation
- The reduction in the strength of paver block may be due to the size of fine aggregate used. The strength may increase when there is increase in size of fine aggregate.
- To increase the adhesion between rubber & aggregate, pre-treatment is recommended.

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