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# **Comparative Study on Cement Concrete Paver Block as Replacement of Coarse Aggregate by using Construction Demolition Waste**

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**ABSTRACT:** Due to rapid urbanization there is a great increase in building construction, so is the demolition. There is no proper disposal of the demolition waste. About 530 million tons of C&D waste is generated annually. But only a few amounts of demolished concrete is recycled or reused. In this study, experimental investigations have been carried out to evaluate the effect of complete replacement of coarse aggregate by demolition waste on compressive strength, which is compared with a conventional block. The concrete blocks were made in M30 mix. We hereby tried to develop eco-friendly and economical blocks with good strength.

**KEYWORDS:** Demolition waste, Paver block, Replacement, Recycling.

## **I. INTRODUCTION**

Paver block interlocking also known as interlocking patio stones and interlocking paving bricks are compact paving materials. They are used for outdoor pavement design or flooring beautification. In simpler words, interlocking patio pavers are possibly the best cement or concrete material. That have been used in landscaping projects in recent times. Interlocking concrete block stone pavers are not only beautiful but also durable. Its gloss finish and texture make it unique in changing the game of your walkway or driveway.

The modern, interlocking concrete is manufactured in a variety of patterns to add vitality to any environment. When properly installed requires practically no maintenance. Interlocking pavers do not require expansion joint. They do not crack like asphalt or poured-in-place concrete or stamped concrete. Flex without cracking.

And today, world facing the severe crisis of natural aggregates for construction of infrastructure projects. Which depend on the particular region or nation now day. The demolition waste is dumped in and around water bodies and beside roads and vacant plots or land. This consumes the lot of space or land, which may be utilized for other development activities. The worldwide reached more than 3.0 billion tons annually and this trend increasing constantly and the conventional paver blocks which are manufacture from the demolition waste from the old residential building. By using this waste in paver block, which reduce the construction waste.

By using demolition waste and cement in the manufacture of the paver blocks. This is an effective way to reduce the waste materials in the surrounding.

The main objective is:

- To determine the basic properties of material such as cement, fine aggregate ,coarse aggregate and demolition coarse aggregate.
- To evaluate the mix design of M30 concrete.
- To compare the compressive strength of conventional paver block and paver block made by replacing coarse aggregate by demolition waste.
- To compare the water absorption of conventional paver block and paver block made by replacing coarse aggregate by demolition waste.
- To minimize the burden of demolished waste on environment and dumping issue.

- Identifying the uses and applications of these paver blocks with respect to their strength.

## II. LITERATURE SURVEY

[1] Dr. Rajendrakumar Harsoor, This review focuses on developing a sustainable construction material (paver blocks) using construction and demolition waste. Diverting construction and demolition waste from the main waste stream can help reclaim substantial land area. The fine aggregate used in this study is locally available sand, passed through a 4.75 mm sieve. Its specific gravity is 2.64, and the water absorption is 1.01%. Normally, crushed stone is used as coarse aggregate in concrete. The material whose particles are retained on a 4.75 mm IS sieve is used as coarse aggregate. In this project, we used 60% of aggregate with a 12.5 mm downsize and the remaining 40% with a 20 mm downsize. The physical properties of the coarse aggregate used in this project are as follows: specific gravity is 2.80, crushing value is 15.26%, and water absorption is 0.54%. In the study, 53-grade PPC cement is used. The physical properties of the cement were determined from various tests, conforming to Indian Standards IS12269:1987. The specific gravity of the cement is 2.89, and its fineness is 3%. The compressive strengths at 3, 7, and 28 days were found to be 17.19 MPa, 36 MPa, and 53.2 MPa, respectively. The initial and final setting times are 90 minutes and 300 minutes, respectively. The recycled aggregate used is generally obtained by crushing concrete waste from demolished structural components such as old buildings and bridges. The physical properties of the demolished waste show a specific gravity of 2.76. Portable water is generally recommended for mixing and curing the concrete. The compressive strength of the paver blocks after curing for 14 days and 28 days is 53.33 MPa respectively. The compressive strength tests were conducted on standard cubes of dimensions 150 mm. [2] Deepak Brijpuria, This paper studies the replacement of fine and coarse aggregates with demolition waste in the preparation of paver blocks. These paver blocks are made of cement, demolition waste, and coarse aggregate, which provide good compressive strength, referring to IS383-1970 and IS 2386-1963 code books. In this experiment, ordinary Portland cement (53-grade) is used. The preparation of paver blocks involves gradually replacing 20%, 40%, 60%, and 80% of coarse and fine aggregates with demolition waste, respectively. The paver blocks have dimensions of 200 mm × 120 mm × 80 mm and are of I-section shape. The physical properties of the demolished concrete aggregate are as follows: water absorption is 4.52%, specific gravity is 2.8, crushing value is 22.54%, impact value is 18.40%, and fineness modulus is 2.67. The compressive strength of cement paver blocks decreases as demolition concrete aggregate replaces natural aggregate. However, from this study, it was concluded that 100% of the natural aggregate can be replaced by demolition concrete aggregate.[3] Mr. Sonawane Kundankumar J, This paper presents a study on concrete paver blocks constructed using construction and demolition waste. The work focuses on using recycled aggregate as a partial replacement for natural aggregate. These paver blocks are made of cement, and the physical properties of the cement are as follows: fineness modulus is 2.86%, standard consistency is 26%, and the initial and final setting times are 32 minutes and 600 minutes, respectively. The physical properties of the coarse aggregate are: the specific gravity of the fine aggregate is 2.63, water absorption is 5.21%, impact value is 14.6%, and crushing value is 13.25%. In this experiment, 53-grade ordinary Portland cement is used. The preparation of paver blocks involves gradually replacing 20%, 40%, 60%, and 80% of coarse and fine aggregates with demolition waste. The compressive strengths of the paver blocks at 3, 7, 14, and 28 days are 14.89 MPa, 24.01 MPa, 31.39 MPa, 33.23 MPa, and 36.91 MPa, respectively. The research concludes that up to 10% of the cost can be reduced by using demolition waste. The dimensions of the paver blocks are 230 mm × 90 mm × 90 mm. [4] Bhagyashree S This paper studies the replacement of fine and coarse aggregate with demolition waste in the preparation of paver blocks. These paver blocks are made of cement, demolition waste and coarse aggregate, which provide good compressive strength, referring to IS383-1963 code book. In this experiment, ordinary Portland cement (53 grade) is used. The preparation of paver blocks involves gradually replacing 0%, 10%, 20% and 30% of coarse and fine aggregates with demolition waste, respectively. The paver block has dimensions of 150mmX150mmX150mm and are I-section shape. The specimen made in accordance with BS1881(1996). The compressive strength of cement paver blocks decreases as demolition concrete aggregate replaces natural aggregate. However, from this study, it was concluded that, the natural aggregate can be replaced by demolition concrete aggregate.[5] Shabiiman M.A, This study focuses on the manufacture of paver blocks. The material used for the paver blocks is aggregate, in accordance with IS 1526:2006, which specifies a maximum aggregate size of 12 mm. The permissible limits for aggregate tests are as follows: water absorption value of 30%, crushing value of 30%, and abrasion value of 30%. The commonly used cement is ordinary Portland cement (OPC), and its physical properties include a specific gravity of 3.15 g/cc, soundness in the range of 0.8–10 mm, and initial and final setting times of 30 minutes and 600 minutes, respectively. According to IS 456:1978, the maximum limit for chloride content in water is 100 mg per liter. For most construction work, M20 grade concrete is commonly used, and this project also utilizes M20 concrete. Waste plastic is used as a partial replacement for aggregate, with replacement percentages of 0%, 2%, 4%, 6%, and 10%. Both concrete blocks and solid blocks were cast and tested.

The paver blocks measured 200 mm × 150 mm × 60 mm, and the solid blocks measured 200 mm × 100 mm × 65 mm. These blocks were tested for strength at 7 and 28 days, which is a critical test to determine the cost- effectiveness of any building material. The compressive strength of the specimens was tested as per BS 6717. The cast specimens were tested for compressive strength at 7, 14, and 28 days. The compressive strength of the concrete with 0% plastic aggregate replacement at 14 days was 28.87 MPa, and at 28 days, it was 41.10 MPa. For 10% plastic aggregate replacement, the 14- day strength was 27.70 MPa, and the 28-day strength was 40.07 MPa. For 20% plastic aggregate replacement, the 14-day strength was 26.90 MPa, and the 28-day strength was 37.77 MPa. Another important test in this study was to calculate the water absorption capacity of the blocks. After weighing the dry blocks, they were submerged in water for 24 hours, and the wet weight minus the dry weight gave the water absorption capacity. The water absorption results for the plastic sand paver block and ordinary paver block were found to be 1.082% and 3.709%, respectively.[6] G. Balasubramanian In this study, an experimental investigation was carried out to evaluate the effect of complete replacement of fine aggregate with demolition waste on compressive strength. The test results for cubical specimens of 150 mm size, using an M20 concrete mix, were taken at 7, 14, 21, and 28 days and compared with conventional blocks. The fine aggregate used was locally available river sand, which passed through a 4.75 mm sieve. The specific gravity and fineness modulus of the sand were found to be 2.33 and 2.56, respectively. Crushed stone was used as the coarse aggregate, with sizes of 20 mm and 10 mm. The specific gravity of the coarse aggregate was found to be 2.7. In this experiment, ordinary Portland cement was used, meeting the requirements of IS (8112)-1989. Demolition waste was utilized as a pozzolanic material and served as the fine aggregate. The specific gravity, water absorption, and sieve analysis of the demolition waste were found to be 2.172, 8%, and 1.18 mm to 600 microns, respectively. The concrete mix design was conducted in accordance with IS-10262 (1982). Based on the test results, it can be inferred that the replacement of fine aggregate with demolition waste is recommended.[7] N. Moorthi, This paper reviews the development of sustainable construction materials (paver blocks) using construction and demolition waste. Diverting this waste stream can help reclaim substantial areas of land. The fine aggregate used was locally available sand, which passed through a 4.75 mm sieve. The physical properties of the fine aggregate were as follows: specific gravity of 3, bulk density of 13.27%, soundness of 3 mm, and fineness modulus of 2.49. Crushed stones are typically used as coarse aggregate in concrete. In this study, ordinary Portland cement was used. The physical properties of the cement were as follows: specific gravity of 3.12, fineness of 2.75%, consistency of 33%, soundness of 1.95%, bulk density of 0.871 kg/m<sup>3</sup>, and initial and final setting times of 30 and 600 minutes, respectively. Demolition waste was used as a pozzolanic material and served as fine aggregate. The physical properties of the demolition waste were: specific gravity of 2.15, fineness modulus of 2.28, and bulk density of 0.798 kg/m<sup>3</sup>. In the concrete mix design, the material percentages were follows: cement = 12%, demolition waste = 27.5%, coarse aggregate (3 mm), and water = 15%. An experimental investigation was carried out to evaluate the effect of complete replacement of fine aggregate with demolition waste on compressive strength. The test results for cubical specimens of 275 mm x 220 mm x 130 mm size using the M20 concrete mix were taken after 7, 14, 21, and 28 days of curing.

### III. MATERIALS

#### Used Procurement of Materials

**Cement:** The cement which will be used for the investigation is Ordinary Portland Cement (O.P.C) of 53 grade. Ordinary Portland cement (O.P.C): This is the basic type of cement which is used on large scale in all general types of construction works. The details regarding the composition and properties of this type of cement are given in IS: 269. These cements are available in different grades viz. 33, 43 and 53 grade. 43 grade O.P.C is used in the project. In this type of cement, the 28 days cement strength is expected to have a minimum value of 53Mpa.



Fig.: Cement

Sl.No.	Oxides	Percent Content
1	Cao	60.84
2	Sio <sub>2</sub>	16.34
3	Al <sub>2</sub> o <sub>3</sub>	6.95
4	Fe <sub>2</sub> o <sub>3</sub>	5.38
5	MgO	2.32
6	S0 <sub>3</sub>	1.99
7	K <sub>2</sub> o	2.73
8	Na <sub>2</sub> o	1.50

Table: 1-Grade Portland Cement Chemical Composition (IS: 12269-1987)

**Demolition waste:** Due to rapid urbanization, there is a great increase in building construction, so is the demolition. There is no proper disposal of the demolition waste. About 530 million tons of construction and demolition waste is generated annually. But only a few amounts of demolished waste are recycled or reused. In this study, experimental investigations have been carried out to evaluate the effect of complete replacement of fine aggregate by demolition waste.



**Fig.:** Demolition waste

**Fine Aggregate:** Fine aggregate is one of the crucial components of the concrete. For the present study, the fine aggregate proportion of the concrete constituted by the natural sand.



**Fig.:** Sand

**Coarse Aggregate** In the present study the natural coarse aggregates produced by crushing stones was procured from the local quarry. The coarse aggregates were 10mm down size also called chips. The specifications of IS:2386-1963 were followed while using the coarse aggregates for the study.



Fig.: Coarse Aggregate

### Preliminary Tests & Results

#### 1. Specific Gravity Test on Cement

Description of item	Trial 1	Trial2	Trial 3
Weight of empty bottle W1 g	51	51	51
Weight of bottle + Cement W2 g	77	68	71
Weight of bottle + Cement + Kerosene W3 g	149	143	146
Weight of bottle + Full Kerosene W4 g	130	130	130
Weight of bottle + Full Water W5 g	150	151	150
Specific gravity of cement	3.605		

#### 2. Normal Consistency Test on Cement

TRIAL	Mass of Cement (grams)	Percentage of Water Added	Vicat's Needle Penetration
1	400	30%	4.5 mm
2	400	28%	6.0 mm
3	400	26%	8.0 mm
4	400	24%	9.5 mm

### 3. Specific Gravity of Fine Aggregate

Observations	Trial 1	Trial 2	Trial 3
Weight of the pycnometer (W1), g	620	620	620
Weight of pycnometer + 1/3 <sup>rd</sup> filled with sand(W2), g	1189	1182	1179
Weight of pycnometer + 1/3 <sup>rd</sup> filled with sand + water(W3), g	1837	1839	1842
Weight of pycnometer + water (W4), g	1515	1515	1515
Specific gravity= (W2-W1)/((W4-W1) -(W3-W2))	2.52	2.51	2.50
Average Specific gravity	2.51		

### 4. Fine Aggregate Sieve Analysis Details.

Sieve size (mm)	Mass of sand retained(gm)	% Retained	Cumulative %retained	%Passing
4.75	31.5	3.15	3.15	96.85
2.36	108	10.8	13.95	86.05
1.18	103	10.3	24.25	75.75
0.6	262	26.2	50.45	49.55
0.3	442	44.2	94.65	5.35
0.15	44	4.4	99.05	0.95
Pan	9.5	0.95	100	0

### 5. Specific Gravity Test on Coarse Aggregate

W1- Weight of empty pycnometer with lid	0.627kg
W2- Weight of pycnometer + C.A	1.107kg
W3 -Weight of pycnometer + C.A +water	1.771kg
W4-Weight of pycnometer +water	1.482kg
Specific gravity	2.606



6. Coarse Aggregate Sieve Analysis Details

Sieve Size (mm)	Empty Weight (M1) (Kg)	Weight Of The Sieve + Weight of coarse aggregate (M2) (Kg)	Weight of coarse aggregate (M2- M1) (Kg)	%Retained In Each $\frac{M2-M1}{M} * 100$ (%)	Cumulative (%)	% FINES S
40	0.880	0.880	0	0	0	100
25	0.820	1.140	0.320	6.4	6.4	93.6
20	0.850	2.080	1.24	24.8	31.2	68.8
16	0.920	3.060	2.140	42.8	74	26
12.5	0.760	1.74	0.980	19.6	93.6	6.4
10	0.780	0.988	0.200	4	97.6	2.4
4.75	0.820	0.92	0.100	2	99.6	0.4
PAN	0.720	0.74	0.020	0.4	100	0

7. Coarse Aggregate Impact Test Details

OBSERVATION	Trial 1(gms)	Trial 2(gms)	Trial 3(gms)
Total weight of the aggregate filling the cylinder metal measure (W1)	320	325	318
Weight of aggregate passing through 2.36 mm sieve (W2)	55	57	50
Aggregate impact = $\frac{W2}{W1} * 100$	17.18	17.5	15.7

8. Coarse Aggregate Crushing Value Test Details

OBSERVATION	Trial 1(gms)	Trial 2(gms)	Trial 3(gms)
Total weight of the dry sample (W1)	3156	3115	3165
Weight of aggregate passing through 2.36 mm sieve (W2)	387	350	390
Aggregate crushing = $\frac{W2}{W1} * 100$	12.26	11.23	12.23

**9. Coarse Aggregate Crushing Value Test Details**

OBSERVATION	Trial 1(gms)	Trial 2(gms)	Trial 3(gms)
Total weight of the dry sample (W1)	31156	3115	3165
Weight of aggregate passing through 2.36 mm sieve (W2)	397	360	400
Aggregate crushing = $W2/W1 \times 100$	12.57	11.55	12.63

Result: - The average aggregate crushing value is = 12.25 %.

**10. Coarse Aggregate Impact Test Details:**

OBSERVATION	Trial 1(gms)	Trial 2(gms)	Trial 3(gms)
Total weight of the aggregate filling the cylinder metal measure (W1)	320	325	318
Weight of aggregate passing through 2.36 mm sieve (W2)	60	62	64
Aggregate impact = $W2/W1 \times 100$	18.75	19.07	20.125

Result: - The average aggregate impact value is = 19.315%

**IV. METHODOLOGY**

Basically, work is experimental oriented. Initially the guidance of IS10262-2019 a trial mix of concrete grade M30 has been designed. The mix proportions obtained for control concrete has been used for design of PAVER BLOCKS concrete pavers by replacing coarse aggregate by demolition waste. The unique mix design was made for Paver blocks and mixes was based on several trials using standardized code available.

- The methodology involved in manufacturing of Paver blocks is as follows
- The various literatures were reviewed as per the existing.
- The project utilizes demolition waste and that are collected from the demolition area.
- The steps involved are testing the raw materials on physical properties.
- In the next step the blended materials such as cement, coarse aggregate or demolition waste, fine aggregate in various proportions and to develop Paver blocks as per Indian Standard code of specifications.
- Then blocks are tested for “Standard quality control tests” such as compression test and water absorption.



Flow Chart

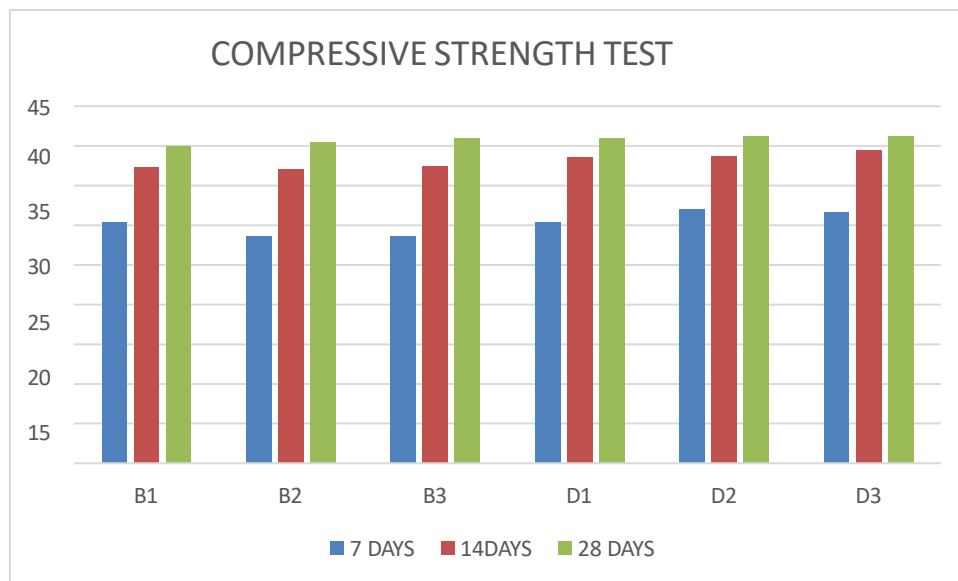
### V. EXPERIMENTAL TESTS AND RESULT

#### 1. Compressive Strength Test Details:

TYPE	COMPRESSIVE STRENGTH N/mm <sup>2</sup>		
	7-days	14-days	28-days
B-1	30.33	37.33	40.00
B-2	28.67	37.10	40.50

B-3	28.67	37.50	41.00
D-1	30.33	38.60	41.00
D-2	32.00	38.67	41.16
D-3	31.66	39.50	41.16

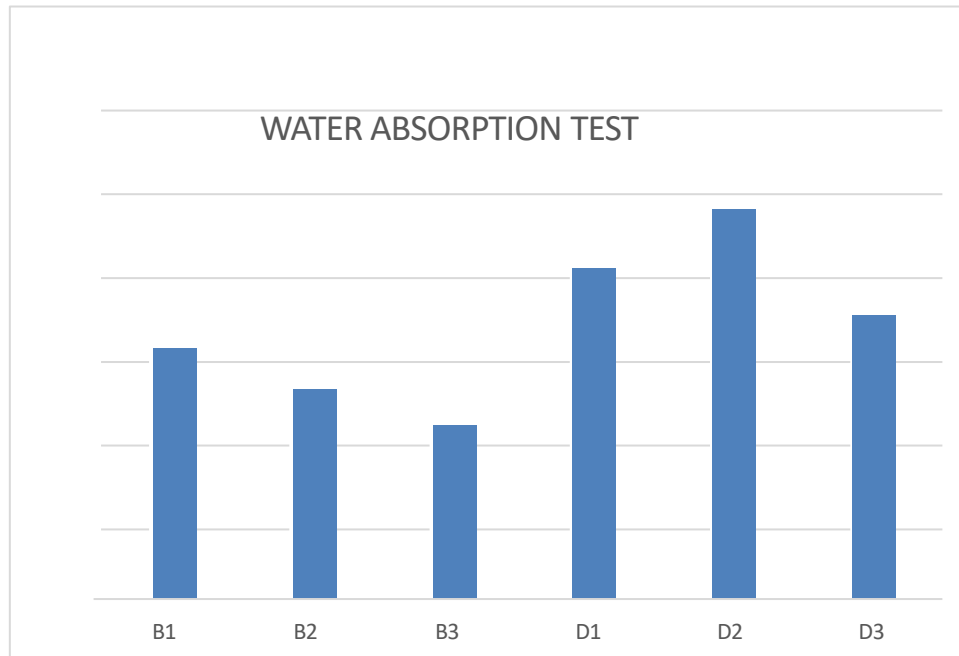
### 2. Compressive Strength Graph



### 3. Water Absorption Test Details

TYPE	WATER ABSORPTION (%)
	28-days
B-1	0.159
B-2	0.133
B-3	0.110
D-1	0.210
D-2	0.247
D-3	0.180

#### 4. Water Absorption Graph



#### VI. CONCLUSION

As this method encourages the utilization of demolition waste, it reduces the improper disposal of the same into landfills and it is more sustainable. From the test results, it can be inferred that the replacement of fine aggregate by demolition waste can be recommended. It can be used in non-traffic and light traffic load. Though the compressive strength is low when compare to the concrete paver it can be used in gardens, pedestrian path and cycle way etc.

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