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DEVELOPMENT OF PERVIOUS BIO-COMPOSITE PAVER BLOCKS USING PILGRIMAGE-DERIVED BIODEGRADABLE WASTE FOR SUSTAINABLE RIVERFRONT INFRASTRUCTURE

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ABSTRACT

This study examines whether coconut shell and coconut coir waste generated around pilgrimage areas can be put to practical use in concrete paver blocks. The idea developed from two local concerns: the accumulation of biodegradable coconut waste near pilgrimage locations and the continuing need for durable, more sustainable paving materials. Coconut shell and coir were collected from the Mahadev Temple area at Korti, then cleaned, dried and prepared for use in concrete. An M20 mix was used, with the processed waste added at 0%, 5%, 10%, 15% and 20% of the cement weight, while the conventional ingredients were kept unchanged. Milano-shaped paver blocks were cast, cured and tested for compressive strength, water absorption and density. The control specimen gave the highest compressive strength, 58.22, and strength gradually fell to 43.03, 32.91, 25.31 and 20.25 as the waste/fibre content increased. Water absorption increased from 0.78% to 1.49%, Indicating Greater Water absorption at higher fibre percentages. Density also varied, reaching its lowest value of 23.03 kN/m3 at 20% compared with 24.41 kN/m3 for the control. Overall, increasing the coconut-waste content reduced compressive strength, although the higher percentages produced lower water absorption and density in the reported tests. This means that a suitable mix cannot be selected from a single property alone; strength, moisture behaviour, unit weight and the intended paving application must all be considered together.

Keywords: Bio-composite paver block, Coconut shell, Coconut coir, Pilgrimage waste, Sustainable construction, Compressive strength, Water absorption, Density, Riverfront infrastructure

I. INTRODUCTION

Sustainable pavement systems have become increasingly relevant in civil engineering because conventional impervious surfaces can increase surface runoff, contribute to waterlogging and limit groundwater recharge. Pilgrimage centres face an additional problem: large religious gatherings generate considerable biodegradable waste. Pandharpur, one of Maharashtra's major pilgrimage destinations, receives many devotees during the Ashadhi and Kartiki Wari. This creates a combined need for better waste handling and safe pedestrian infrastructure.

The present work explores a simple way of connecting these two needs. Coconut shell and coconut coir collected from pilgrimage-related activities were introduced into concrete paver blocks as additional materials. Reusing this waste may reduce the amount requiring disposal while encouraging a more circular use of locally available resources. The developed pavers are considered mainly for pedestrian paths, temple surroundings and similar low-load public areas, provided that the required strength, durability and safety criteria are satisfied.

II. RESEARCH GAP AND OBJECTIVES

Research gap

Earlier studies have investigated coconut shell as a lightweight aggregate, coconut coir as a natural fibre reinforcement and pervious pavement systems as separate areas of research. However, the project identifies limited work that directly links biodegradable waste collected from pilgrimage activities with the development of paver blocks for riverfront infrastructure.

Objectives

- To make productive use of biodegradable coconut waste generated through pilgrimage activities in aneco-friendly construction material.
- To prepare bio-composite concrete paver blocks containing selected percentages of coconut shell and coconut coir.
- To study the compressive strength, water absorption and density of the developed paver blocks.
- To examine how this approach could support sustainable waste management and possible riverfront or pedestrian applications.

III. MATERIALS AND EXPERIMENTAL PROGRAMME

The materials used in the experimental work were cement, sand, coarse aggregate, water, coconut shell and coconut coir. Coconut waste was collected from the Mahadev Temple at Korti, near the institute. After collection, unwanted material and visible impurities were removed. The coconut shells were cleaned, dried and broken into smaller pieces, while the coir was cleaned, dried and cut into shorter fibres so that it could be distributed more evenly through the concrete mix.

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Fig. 1: Final pervious paver block (Milano shape)

3.1 Preliminary mix design

A preliminary M20 concrete mix was designed using the IS 10262 approach with a maximum aggregate size of 10 mm. A trial water-cement ratio of 0.45 was adopted.

Table 1: Preliminary M20 mix design quantities

Material	Calculated quantity
Cement	444.4 kg
Water	200 litres
Coarse aggregate (6.3-10 mm)	889 kg
Water-cement ratio	0.45

For casting, the reported batch quantities were 1.23 kg cement, 2.38 kg sand and 2.46 kg aggregate. Coconut waste/fibre was added at 0%, 5%, 10%, 15% and 20% of cement weight.

Table 2: Mix proportions of bio-composite paver blocks

Mix ID	Waste/Fibre (%)	Weight (g)	Cement (kg)	Sand (kg)	Aggregate (kg)
M0	0	0	1.23	2.38	2.46
M1	5	61	1.23	2.38	2.46
M2	10	123	1.23	2.38	2.46
M3	15	184	1.23	2.38	2.46
M4	20	246	1.23	2.38	2.46

IV. EXPERIMENTAL METHODOLOGY

The experimental work followed the sequence of study-area selection, waste collection and preparation, mix proportioning, casting, curing, testing and result analysis. Because the Milano paver has an irregular plan shape, its area was measured using a planimeter. Three readings of 355, 180 and 650 cm^2 gave an average area of 395 cm^2, equivalent to 39,500 mm^2.

The concrete ingredients were measured according to the selected proportions, after which coconut shell and coir were incorporated at the required percentages. The specimens were cast in Milano paver moulds, cured and then evaluated for compressive strength, water absorption and density.

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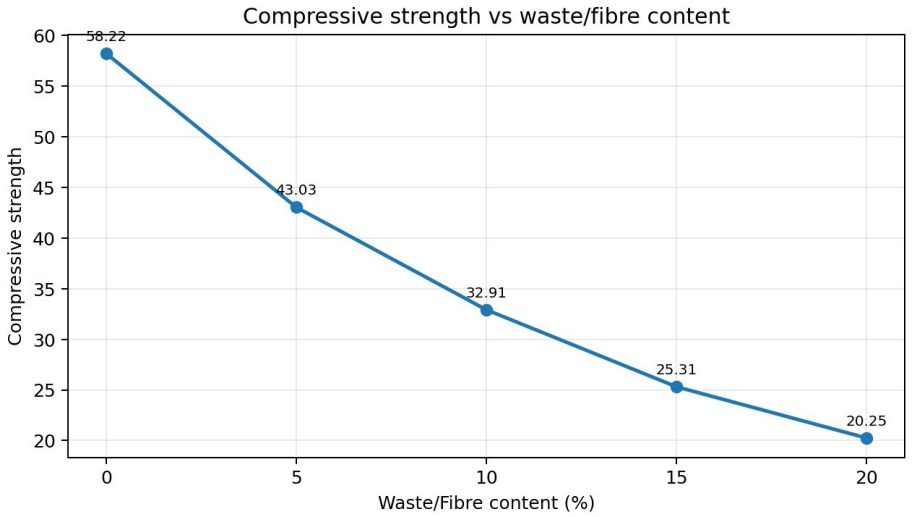
V. RESULTS AND DISCUSSION

Compressive strength

Table 3: Compressive strength results

Waste/Fibre (%)	Compressive strength
0	58.22
5	43.03
10	32.91
15	25.31
20	20.25

A clear reduction in compressive strength was observed as the waste/fibre content increased. The control mix produced 58.22, while the values decreased to 43.03, 32.91, 25.31 and 20.25 at 5%, 10%, 15% and 20%, respectively. The 20% mix therefore showed an approximate 65.22% reduction compared with the control.



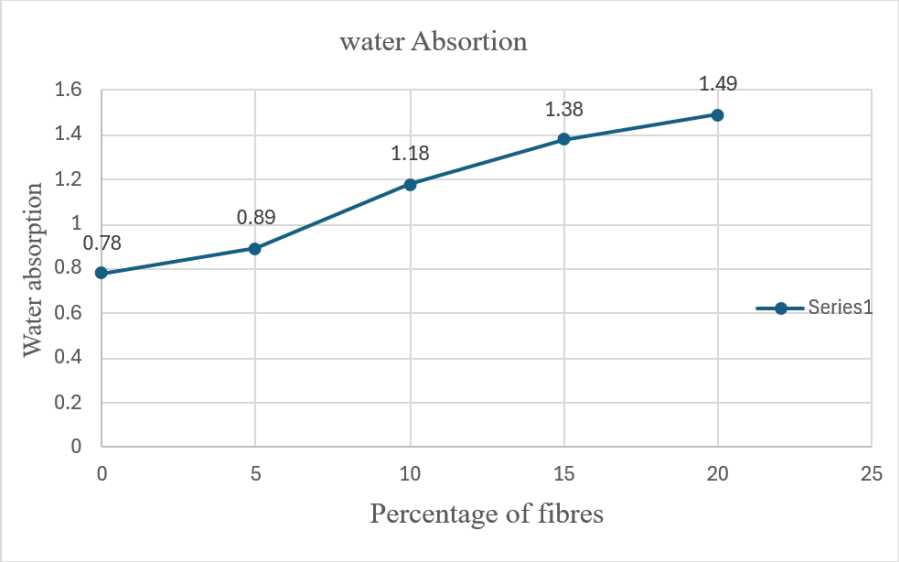
Graph 1: Variation of compressive strength with waste/fibre percentage

Water absorption

Table 4: Water absorption results

Waste/Fibre (%)	Water absorption (%)
0	0.78
5	0.89
10	1.18
15	1.38
20	1.49

Water absorption first increased from 1.18% in the control to 1.49% at 10%. It then fell to 0.89% at 15% and 0.78% at 20%, making the 20% mix the lowest measured absorption among the tested specimens.



Graph 2: Variation of water absorption with waste/fibre percentage

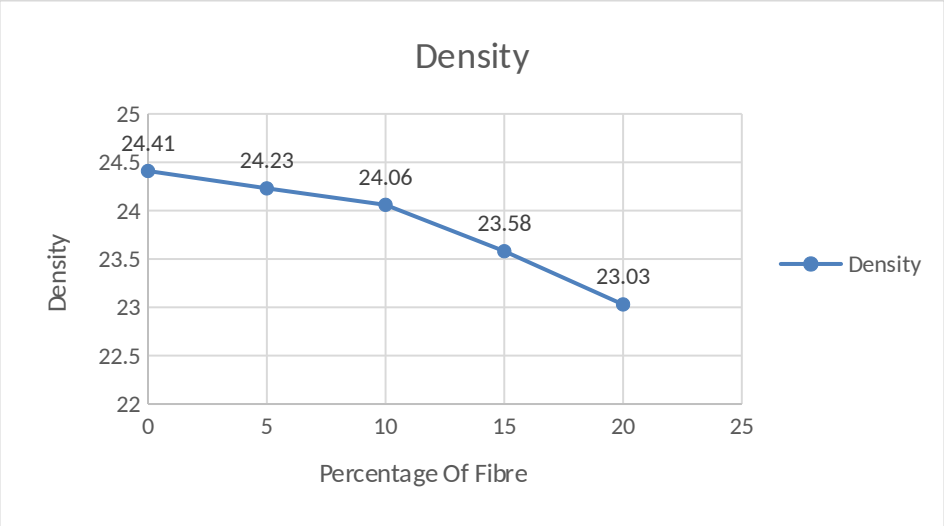
Density

Table 5: Density results

Waste/Fibre (%)	Density (kN/m3)
0	24.41
5	23.58
10	24.06
15	24.58
20	23.03

Density varied within a relatively narrow range. The control recorded 24.41 kN/m3, the 5% mix 23.58 kN/m^3, the 10% and 15% mixes 24.23 kN/ m^3, and the 20% mix the lowest value of 23.03 kN/ m^3

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Graph 3: Variation of density with waste/fibre percentage

Comparative performance analysis

The results show a clear trade-off. Increasing the waste/fibre percentage progressively reduced compressive strength, whereas the highest addition levels produced lower measured water absorption and density. The 20% mix gave the lowest water absorption and density but also the lowest compressive strength. The available dataset therefore does not establish one universally optimum percentage; the preferred proportion depends on the requirements of the intended paving application.

VI. ENGINEERING INTERPRETATION

A mix cannot be selected simply because it performs well in one test. Strength, moisture behaviour, unit weight and durability requirements must be considered together. From a sustainability perspective, the study offers a locally relevant route for diverting coconut shell and coir from disposal and using them in a construction product. Practical adoption would still require further durability, permeability, abrasion and field-performance testing.

Study limitations

The paper is limited to the experimental values reported in the project work. The available dataset does not provide repeated-specimen statistics, standard deviations or confidence intervals. The findings should therefore be treated as an experimental comparison of the tested Milano paver mixes rather than certification for direct field use.

VII. FUTURE SCOPE

- Optimise coconut shell and coir proportions to obtain a better balance of strength, water absorption and density.

- Future studies should explore different combinations of coconut shell and coconut coir to determine the most suitable proportions for improving the overall performance and durability of paver blocks.
- Further studies should evaluate the long-term durability of the developed paver blocks by conducting tests such as abrasion resistance and repeated wetting and drying cycles.
- Evaluate permeability and drainage performance for outdoor and riverfront applications.
- Install trial pavers and monitor pedestrian loading, weather exposure and long-term behaviour.
- Carry out environmental-impact and economic-feasibility assessments.
- Evaluate larger-scale production and verify compliance with IS 15658 and other applicable standards using repeated specimens and statistical analysis.

VIII. CONCLUSIONS

Bio-composite Milano Pervious paver blocks can be produced using locally collected coconut shell and coconut coir waste. Compressive strength declined from 58.22 for the control to 20.25 at 20% addition. Water absorption increased from 0.78% to 1.49%, Indicating Greater Water absorption at higher fibre percentages, while density reached its lowest measured value of 23.03 kN/m^3 at 20%. These results show that the pavers should not be judged from a single property. Future optimisation should identify a proportion that satisfies the strength and durability requirements of the intended application while providing a useful route for coconut-waste utilisation.

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