Sustainable Paver Block Development Using Silica Fume and Granite Waste

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Abstract: The rapid urbanization and increasing construction activities have led to a high demand for paver blocks, raising concerns about the depletion of natural resources and environmental sustainability. This study explores the development of sustainable paver blocks by incorporating silica fume and granite waste as partial replacements for cement and fine aggregates, respectively. Silica fume, a byproduct of the silicon and ferrosilicon industry, enhances the mechanical properties and durability of concrete, while granite waste, a byproduct of stone processing industries, serves as an eco-friendly alternative to sand. The research investigates the physical and mechanical properties of the developed paver blocks, including compressive strength, water absorption, and durability. Experimental results indicate that the optimized mix design with silica fume and granite waste not only improves strength and performance but also reduces the carbon footprint associated with conventional paver block production. The study concludes that utilizing industrial waste materials in paver block manufacturing presents a viable and sustainable solution for eco-friendly construction practices.
Key words: Granite wastes, Silica Fume, Partial replacement, Eco-friendly, Behavioral study.

I. INTRODUCTION

The construction industry is one of the largest consumers of natural resources, leading to environmental degradation and resource depletion. With the increasing demand for sustainable construction materials, there is a growing interest in utilizing industrial waste products to reduce environmental impact. Paver blocks, commonly used for pavements, driveways, and walkways, are primarily made of cement, sand, and aggregates. However, the excessive use of cement contributes to high carbon emissions, while the extraction of natural aggregates depletes natural resources.

To address these challenges, this study focuses on the development of sustainable paver blocks by incorporating silica fume and granite waste as alternative materials. Silica fume, a byproduct of the silicon and ferrosilicon industries, is a highly reactive pozzolanic material that enhances the strength and durability of concrete. On the other hand, granite waste, generated from stone processing industries, can be used as a replacement for fine aggregates, reducing environmental pollution and dependency on natural sand.

This research aims to evaluate the physical and mechanical properties of paver blocks made with silica fume and granite waste. By assessing parameters such as compressive strength, water absorption, and durability, the study seeks to determine the feasibility of these materials in producing high-performance and eco-friendly paver blocks. The successful implementation of such sustainable alternatives can contribute to waste management solutions while promoting greener construction practices.

which are then shaped into the appropriate shapes. Particularly in powdered form, ceramic powder is the main waste entering the ceramic industry. During the dressing and polishing process, ceramic waste is produced. It is estimated that between 15% and 30% of the total raw materials used result in waste. While some of this waste may be used on-site, for example, to refill excavation pits, the disposal of these waste materials takes up a lot of land and remains dispersed throughout the area, detracting from the area's overall aesthetic appeal. The trash generated by ceramics is extremely hard to find a use for. Concrete's strength and other durability aspects can be enhanced by adding ceramic waste. To change the characteristics of concrete, ceramic waste can be added as a supplemental ingredient or used in place of some of the cement or fine aggregate sand.

II. OBJECTIVE

- To develop a product from the effluent by reducing the pollution.
- To be prepared in a non-toxic behaviour and process is fully organic.
- To grow a new industry from the current innovative ideas of waste to wealth.

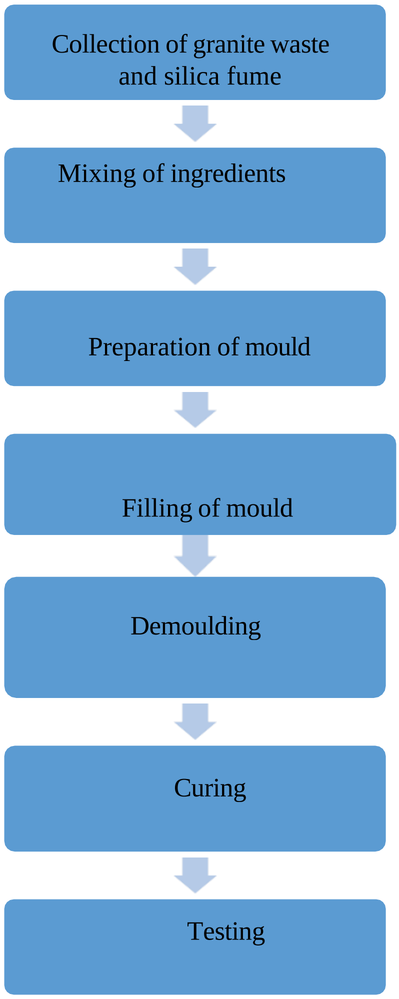
III LITERATURE REVIEW

Jain &. Pawade (2015) studied the Characteristics of Silica Fume Concrete.The physical properties of high strength silica fume concretes and their sensitivity to curing procedures were evaluated and compared with reference Portland cement concretes, having either the same concrete content as the silica fume concrete or the same water to cementitious materials ratio.The experimental program comprised six levels of silica-fume contents (as partial replacement of cement by weight) at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without superplasticizer. It also included two mixes with15% silica fume added to cement in normal concrete. Durability of silicafume mortar was tested in chemical environments of sulphate compounds, ammonium nitrate,calcium chloride, and various kinds of acids.

Hanumesh, Varun & Harish (2015) observes the Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement.The main aim of this work is to study the mechanical properties of M20 grade control concrete and silica fume concrete with different percentages (5, 10, 15 and 20%) of silica fume as a partial replacement of cement. The result showed that The compressive strength of concrete is increased by the use of silica fume up to 10% replacement of cement.From 10% there is a decrease in compressive strength and The split tensile strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in split tensile strength.The optimum percentage of replacement of cement by silica fume is 10% for M20 grade of concrete.

Amarkhail (2015) observed Effects of Silica Fume on Properties of High-Strength Concrete. He found that up to 10% cement may be replaced by silica fume without harming the concrete workability.Concrete containing 10% silica fume replacement achieved the highest compressive strength followed by 15% silica fume replacement with a small difference.Concrete with 15% silica fume content achieved the highest flexural strength.10% and 15% silica fume content as replacement of cement were found to be the optimum amount for significantly enhancement of compressive strength and flexural strength respectively.

IV. METHODOLOGY



V. Materials

i) Cement

The cement used needs to meet IS requirements. Although there are many different kinds of cements on the market, Portland cement is the most widely used, well-known, and accessible. For this investigation, PPC 43 grade was employed. The cement's physical characteristics, as determined by standard testing, meet IS 12269:1989 requirements. The physical properties of the cement are listed in the table 1

Table1 Physical Properties of Cement

S.No	Characteristiceramic wastes	experimental values
1	Standard Consistency	31%
2	Fineness of cement as retained on 90 micron sieve	5%
3	Initial setting time	35 minutes
4	Final setting time	520 minutes

ii) Fine Aggregate

Utilizing locally accessible river sand that passes through a 4.75 mm screen in accordance with IS 383:1970's recommendations. Specific Gravity of fine aggregate is found and the particle size distribution is listed below in the Table 2

iii) Coarse Aggregate

The coarse aggregate used to make concrete needs to be robust, impermeable, long-lasting, and able to create a workable mixture with the least amount of water cement needed to get the right strength. Coarse material that is readily available locally is retained on a 4.75 mm sieve. The coarse aggregate's specific gravity was determined, and Table 3 below shows the coarse aggregate's particle size distribution.

Sieve Size	**Weight Retained (grams)**	**Cumulative percentage retained**	**Cumulative percentage passed**
40mm	0	0	100
20mm	1598.00	46.74	53.26
16mm	793.50	73.55	26.45
12.5mm	343.70	88.55	11.45
10mm	231.11	92.29	7.71
4.75mm	33.69	98.88	1.12

iv) Water

The final hardened concrete is visually impacted by the quality of the water used to mix it. Water impurities can impact the strength and durability of concrete made with copper slag by interfering with the cement's setting time. The specimens are cast using fresh, clean water that is free of organic matter, silt, oil, and acid material according to regulations. The water utilized is piped from public supplies.

v) Granite Waste effluent

The final hardened concrete is visually impacted by the quality of the water used to mix it. Water impurities can impact the strength and durability of concrete made with copper slag by interfering with the cement's setting time. The specimens are cast using fresh, clean water that is free of organic matter, silt, oil, and acid material according to regulations. The water utilized is piped from public supplies. The sludge is obtained from the treatment of dye waste water. This sludge is rich in organic matter and can be used as a binding material for the eco- paver blocks.

Disposal of sludge in landfills can potentially contaminate soil and groundwater due to leaching of pollutants. Incineration may release harmful emissions into the atmosphere.

vi) Colour pigments

Colour pigments can be added to the mixture to give theblocks a desired colour.

vii)Curing of specimen

To find the effect of partial replacements of water by waste effluent, the specimen are air cured for 7, 28 and 56 days.

VI . PROBLEM STATEMENT

The biochemical and chemical oxygen demand (BOD and COD), impairment of photosynthesis, inhibition of plant growth, recalcitrance and bio- accumulation, and potential for toxicity, mutagenicity, and carcinogenicity are all significantly compromised by textile dyes, which also significantly reduce the aesthetic quality of water bodies.

The contamination of dye waste in water bodies, affects the penetration of natural sun light into the it, which hinders photosynthesis in plants. It leads an unbalanced eco-system of Aquatic life and plants perish, as results of this decrease in the amount of oxygen content in the water bodies.

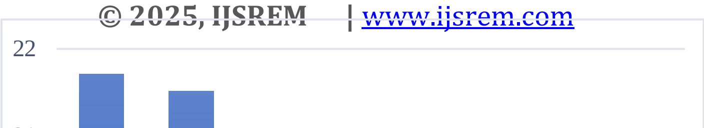
VII RESULTS AND DISCUSSION

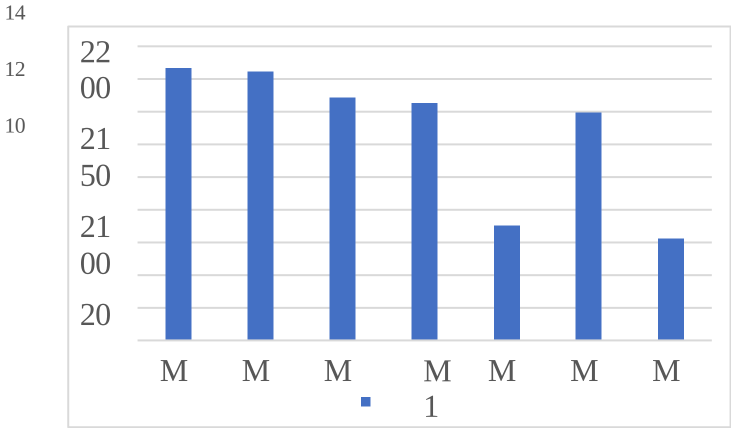
Density is an estimation that analyses the measure of issue an item has to its volume. An article with a lot matter in certain volume has high thickness an item with minimal issue in a similar measure of volume has a low density. Density of the specimen was carried according to the IS code. The test results for 7 & 28 days were tabulated in Table 6.1 and described in Figure 6.1.

COMPRESSIVE STRENGTH

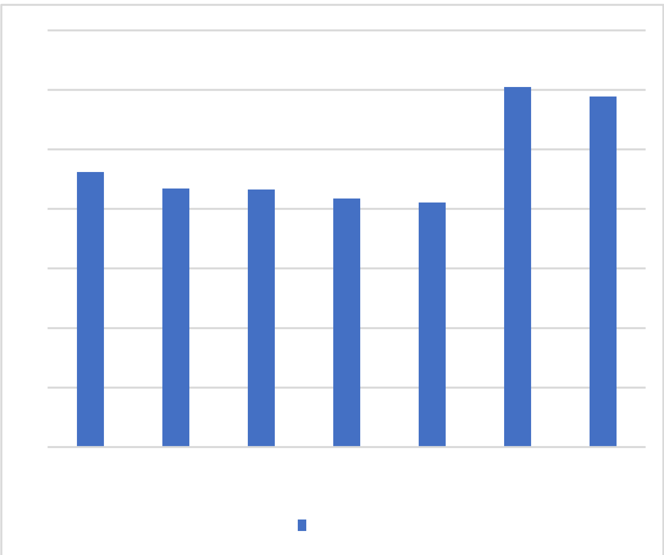
Compressive strength of paver blocks with textile effluent waste mixes are given in the Table 6.2 and the graphs were plotted for 7 days, 21days, and 28 days respectively. With the help of 2000 kN capacity CTM, the compressive strength was done as per the IS code.

Compressive strength is the ability of a material to resist forces that attempt to reduce its size. It is a crucial property in construction and material science, determining how well a material can withstand loads applied in compression before it fails or deforms. This strength is measured by applying a steadily increasing compressive force to a sample, such as a cube or cylinder, until it fractures or deforms significantly. The value is expressed in units like megapascals (MPa) or newtons per square millimeter (N/mm²). Materials like concrete, metals, bricks, and ceramics rely heavily on their compressive strength for structural applications, as they often bear weight and pressure in buildings, bridges, and other constructions. Various factors, including material composition, curing process, and environmental conditions, influence compressive strength. Engineers and architects use compressive strength data to ensure the safety and durability of structures, making it a fundamental aspect of material testing and quality control.





SI. No	Percent age of effluent for replacement of water	Percentage of sludge replaced for fine aggregate	Desig n mix	Days	Average density (kg/m^3)
1	25	50	M15	7	2171.41
2	25	50	M15	28	2166.67
3	50	50	M15	7	2151.25
4	50	50	M15	28	2161.67
5	75	50	M15	7	2091.50
6	75	50	M15	28	2121.50
7	100	50	M15	7	2075.23
8	100	50	M15	28	2113.15



IX. CONCLUSIONS

From the experimental investigation, the preliminary properties of materials obtained and verified with IS code. The percentage of sludge varies from 50% to 100 % for the replacement of fine aggregate in the manufacture of paver blocks. The following results are summarized for the manufacture of specimens in a very-effective manner by utilizing textile sludge in the construction industry,

- The pH test of the effluent paver block result is another promising factor. The pH test was carried out repeatedly, and the result was between the range of 6.5 to 6.9. This range is within the acceptable limits, which ensures that the effluent paver blocks do not have any harmful effects on the environment other users.
- With the addition of textile sludge and M-sand in the mix proportions, the density of the samples was decreased around 10
WATER ABSORPTION TEST
The water absorption, being the normal of three units, when decided in the way portrayed, will not be in excess of 6 percent by mass and in singular examples; the water ingestion ought to be limited to 7 percent. (According to IS 15658: 2006). The average of three specimen units shall not be more than 6 percent by mass of sample, and it should be restricted to 7 percent as per IS code. Finally, the dry density was used in the range of 1850 to 2172 kg/m³. The **Water Absorption Test** is conducted to determine the amount of water a material, such as concrete, brick, stone, or tile, can absorb. This test is crucial for assessing the durability and porosity of construction materials, as excessive water absorption can weaken structures and lead to issues like cracking, spalling, or reduced strength. The test involves drying the specimen in an oven at a specified temperature (usually around 105°C) until it reaches a constant weight. After cooling, the specimen is immersed in water for a set period, typically 24 hours, and then weighed again. The difference in weight before and after immersion is used to calculate the percentage of water absorbed. A lower water absorption rate indicates better resistance to moisture and environmental degradation, making the material more suitable for construction, especially in damp or harsh conditions.
percentage of conventional paver block.
- The water absorption of the paver block was within the limit and also it satisfies the IS 15658:2006.
- The compressive strength of the paver blocks are decreased with increasing the percentage of textile sludge and the density of the paver block also decreased. Overall, the effluent paver blocks have proved to be the best replacement for normal paver blocks due to eco-friendliness, cost-effectiveness, and durability. The use of effluent paver blocks will not only contribute to the sustainability of the ecosystem but will also help in reducing the cost of construction projects. However, further research needs to be done to explore the potential of effluent paver blocks in different construction applications. The use of effluent paver
blocks in construction will undoubtedly lead to a more
sustainable future.
- The development of sustainable paver blocks using silica fume and granite waste demonstrates a viable approach to enhancing environmental sustainability while improving construction materials. The experimental study indicates that incorporating silica fume and granite waste enhances the compressive strength, durability, and water resistance of the paver blocks compared to conventional ones. Additionally, the utilization of industrial by- products reduces dependency on natural resources, minimizes waste disposal issues, and contributes to cost-effective, eco-friendly construction. The results suggest that optimized proportions of these materials can significantly improve performance characteristics while adhering to standard quality requirements. Thus, this study supports the adoption of alternative materials in paver block manufacturing, promoting sustainability in the construction industry. Further research can focus on long-term performance assessment and field applications to validate large-scale implementation.

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