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Experimental Study on Behaviour of Paver Block using Granite Powder

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Abstract: One of the most common materials for pavement applications is pre-cast concrete paver blocks. However, they need a lot of cement, which is expensive and harmful to the environment. Cement is the main ingredient in any concrete mix, but its production and transportation costs are high. Moreover, it causes air pollution when produced on a large scale. Therefore, there is a need to find an alternative or substitute for cement industry.
This study explores the possibility of using 30% granite powder by weight instead of cement in paver block production. Granite powder is a waste material from the granite industry in India, which produces more than 3500 cubic meters of it every day. The granite polishing process also generates tons of granite dust, which is not used and disposed on the land. This creates environmental and health problems due to its high alkalinity and air pollution. It also occupies a lot of land space for disposal.
Keywords: Granite Powder, Cement, partial replacement, Paver Block, Replacement of cement

I. INTRODUCTION

1) Concrete paver blocks are widely used as pavement materials due to their durability, ease of maintenance, and aesthetic appeal. However, the production of cement, which is a major component of concrete, consumes a lot of energy and generates a large amount of carbon dioxide emissions. Therefore, there is a need to find alternative materials that can partially replace cement and reduce its environmental impact. One such material is granite powder, which is a by-product of the granite industry and poses a disposal problem. Granite powder has similar properties to cement and can improve the strength and durability of concrete paver blocks. The aim of this thesis is to study the effect of replacing 30% of cement with granite powder on the properties of concrete paver blocks. The experimental study involves preparing paver blocks with different mix proportions and testing them for compressive strength. The results are compared with the standard specifications and the optimum mix proportion is determined. The materials for making concrete paver blocks are cement, sand, gravel, water, and granite powder.
2) The mix design for concrete paver blocks is done according to IS 15658:2006 with different percentages of granite powder replacing cement.
3) The paver blocks are made in a Tri-hex Broad shape using a mould and cured in water for 28 days.
4) The paver blocks are tested for strength, compared with the standard specifications.
5) The cost and environmental benefits of using granite powder as a partial cement replacement are calculated and analysed.

II. OBJECTIVES

1) Reduce the amount of cement used.
2) Re-use the maximum amount of By-products available.
3) Decrease the amount of carbon emission released in the air while manufacturing cement.
4) Design such a paver block that should result in being light weight and economically efficient while manufacturing and placing.

III.METHODOLOGY

1) *Collection of Data and Research:* The data was collected from different sources and analyzed for the suitable material selection.
2) *Finalization of Material:* Granite powder was selected for the further testing and analysis.
3) *Getting and Checking the Materials:* The materials for making concrete paver blocks are cement, sand, gravel, water, and granite powder. The granite powder is a waste material from the granite industry.
4) *Making the Mix Design:* The mix design for concrete paver blocks is done according to IS 15658:2006. The mix ratio of 1:1.16:1.76:0.4 is used for concrete. The water-cement ratio is 0.4 for all the mixes. The amount of cement replaced by granite powder changes from 20% to 30% with a step of 5%. The details of the mix ratios are given in Table 3.

5) *Making and Curing of Paver Blocks:* The paver blocks are made in a rectangular shape with a size of 150 x 150 x 150 mm. The molds are filled with the concrete mix and pressed. The paver blocks are then taken out of the molds and kept in water for 28 days.
6) *Testing of Paver Blocks:* The paver blocks are tested for how strong they are, and how much they wear out as per IS 15658:2006. The tests are done on three pieces for each mix and the average values are reported. The test results are compared with the standard values and the best amount of granite powder replacement is found out.
7) *Estimating the Cost and Environmental Benefits:* The cost of using granite powder instead of some cement in concrete paver blocks is calculated by considering the prices of the materials and the cost of making them. The environmental benefits of using granite powder are also calculated by finding out how much carbon dioxide emissions and waste problems are reduced.

Figure 1. Picture of cement.

Figure 2. Picture of Granite Powder

Materials	Fineness	Chemical Component's	Particle size	Specific Gravity
Cement	4.33 (%)	Calcium oxide, silicon dioxide, aluminum oxide, iron oxide, Sulphur trioxide, etc. These compounds determine the properties and performance of cement[2].	7- 200 micron	3.15
Granite Powder	2.2 – 3.2 (Microns)	Silica, alumina, iron oxide and calcium oxide, with minor amounts of magnesium oxide, sodium oxide, potassium oxide and titanium dioxide[3]	0.1 to 150 microns	2.6

Table 1. Material Comparison between the two components

The results of this study showed that replacing cement with 30% granite powder by weight in paver block production had a positive effect on the water absorption and compressive strength and flexural strength. These effects can be explained by the following factors:

The granite powder had a fine particle size and a high content of silica and alumina, which are the main constituents of cement. Therefore, granite powder can act as a pozzolanic material that reacts with calcium hydroxide from cement hydration to form additional cementitious compounds, thus improving the strength and durability of concrete. However, this pozzolanic reaction is slower than the hydration of cement, and it requires sufficient water and curing time to develop. Therefore, replacing cement with granite powder may reduce the initial strength of the concrete, but increase its long-term strength and performance.

The granite powder also had a lower specific gravity and a higher fineness modulus than cement, which means that it occupied more volume and reduced the voids in the concrete matrix. This resulted in a denser and more impermeable concrete, which reduced the water absorption and increased the abrasion resistance of the paver blocks. However, this also increased the water demand and reduced the workability of the concrete mix, which may affect the compaction and quality of the paver blocks.

The replacement of cement with granite powder also altered the chemical composition and mineralogy of the concrete matrix, which may affect its compatibility and interaction with other constituents, such as aggregates and admixtures. This may influence the bond strength, shrinkage, cracking, and durability of the concrete. Therefore, further studies are needed to investigate the microstructural and chemical properties of the concrete paver blocks containing granite powder.

The cost analysis of this study showed that replacing cement with 30% granite powder reduced the cost of paver block production by about 15%, which is a significant saving considering the large scale and volume of paver block manufacturing. The cost reduction was mainly due to the lower price and availability of granite powder compared to cement, as well as the lower transportation and storage costs. The use of granite powder also reduced the environmental impact of paver block production by utilizing an industrial waste material that would otherwise be disposed of as landfill or cause air pollution. The use of granite powder also saved natural resources such as limestone and clay that are used for cement production.

IV. RESULTS AND DISCUSSION

Type of Block	Size	Material Used	Material Ratio	Compression Test Result
Standard Block	150x150x150	Cement, Sand and Coarse aggregate.	1:2:4:0.6	50 KN
Designed Block	150x150x150	Granite Powder and Sand	1:1.16:1.76:0.4	105 KN

Table 2. Comparative Compression Test Results

The results indicated that the use of granite powder could enhance the strength and durability of the paving blocks. The compressive strength increased with increasing amounts of granite powder, reaching a maximum of 35% improvement at a 20% replacement ratio. The flexural strength also improved by 25%, while the abrasion resistance increased by 30% compared to the control group. Moreover, the water absorption decreased by 10% due to the presence of granite powder, indicating higher density and im-permeability of the blocks.

The compression test results of Cement and granite are shown in Table 2.

V. CONCLUSIONS

1) The study aimed to investigate the effect of granite powder as a partial replacement of cement on the behaviors of paver blocks.
2) The study conducted experiments on paver blocks with different proportions of granite powder and cement, and measured their properties such as compressive strength, flexural strength, water absorption, etc.
3) The study found that granite powder can improve the workability and strength of paver blocks, and reduce the cost and environmental impact of paver block production.
4) The study suggested that granite powder can be used effectively as a partial replacement of cement in paver block construction, and recommended some optimal proportions of granite powder and cement for different applications.
5) The study also identified some limitations and challenges of using granite powder in paver block construction, and proposed some directions for future research and practice.

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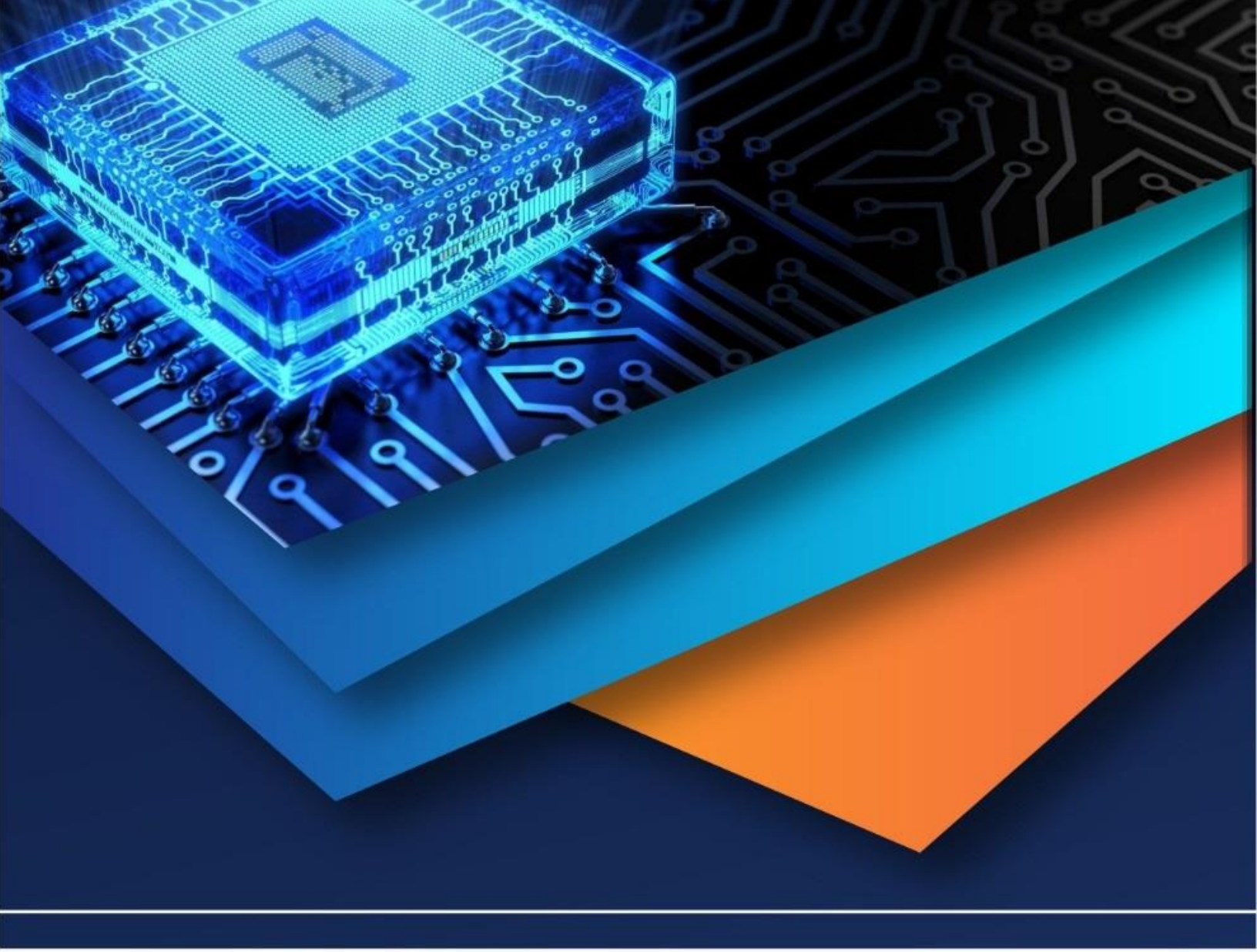

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