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Use of Granite Dust as a Replacement of Natural Sand in Brick Manufacturing

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Abstract— *India possesses one of the world's best granite deposits and accounts for more than 20% of global granite resources. During the process of extraction, many wastes are produced like rock waste, overburden, granite dust etc. Granite dust is a byproduct of granite processing produced during the cutting and polishing of granite slabs. The disposal of these granite fragments has become a major concern. Water contamination, habitat disruption, air pollution, landscape alteration, and soil erosion and contamination are all challenges produced by these wastes. One of the best ways to minimise these wastes is to reuse them based on their physical and chemical properties. In this study, fly ash bricks were produced by replacing natural sand with granite dust in different proportions (20%, 40%, 60%, 80% and 100%). These modified bricks were compared with standard fly ash bricks and optimum replacement value was determined. Bricks of size 230 X 110 X 70 mm and weighing at 3 kg were made. The specific gravity of granite used is 2.57. The water-cement ratio is maintained at 0.4. These bricks were tested for compressive strength and water absorption. The result shows an increase in compressive strength and a decrease in water absorption on increasing the percentage of replacement of sand. It is concluded that when 80% natural sand is replaced with granite dust the compressive strength and water absorption have no significant effect when compared to standard bricks. Overall, the modified bricks are of better quality as compared to standard bricks. It is also stated that the environmental effects of granite dust, such as pollution, soil contamination, respiratory difficulties, and so on, can be avoided by using it to make bricks of higher quality and reducing the problem of natural sand scarcity.*

Keywords— *Granite dust, fly ash, cement, brick.*

I. Introduction

Granite is a popular natural stone for both structural and decorative components. It is predominantly composed of felspars, plagioclase, and quartz (35%), with trace amounts of mafic minerals (45%), such as biotite, hornblende, pyroxene, iron oxides, and so on. It is popular due to its strength, longevity, and aesthetic appeal. India is a significant manufacturer of dimension stones and has extensive resources for all types of these stones. The Dimension Stone Industry employs over a million people across the country in its various divisions. This industry is vital to the economies of states such as Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, and Rajasthan. The $40 billion granite business, particularly in rural areas, has the potential to create semi-skilled jobs. [1]

However, granite quarrying processes have many environmental impacts, including air pollution, water pollution, noise pollution, biodiversity loss, land degradation, occupational human health issues, and poor mining waste disposal.[2] Millions of tons of granite refuse are stacked up and not repurposed.[3] The use of these wastes can benefit both the environment and the construction industry. Reusing granite particle waste in building materials such as concrete, for example, results in waste management techniques that are both cost-effective and ecologically friendly (green manufacturing).[4]

II. Literature Review

Shilar et al., 2023 manufactured high-quality and eco-friendly geopolymer bricks using granite waste powder (GWS) and iron chips (IC). GWS was added up to 40% of the overall content of the mix fraction, whereas GGBS (Ground Granulated Blast-Furnace Slag) and FA (Fine aggregate) in the FGG1 and FGG2 series changed with a 5% increment or decrement. It was determined that GWP and IC in geopolymer bricks are sustainable due to low embodied energy and carbon emissions. Because of the alkaline agent's faster silica dissolving rate, which resulted in greater geopolymer gel formation, each brick had a higher compressive strength, and the 1:3 ratio had the best value.

Ngayakamo et al., 2021 substituted granite micronized stone waste for natural clay in the manufacturing of eco-friendly bricks with distinct physical and mechanical qualities. The batches were then made with different quantities of granite powder and burned at different temperatures of 900, 1000, and 1100°C. The final testing approach has shown that eco-friendly bricks containing up to 30% granite powder with a bulk density of 2.2 g/cm^3 and the lowest water absorption value of 9.1% when burned at 1100°C are attainable.

Hamid 2021 used granite sludge waste (GSW) and silica fume (SF) as a replacement for clay in bricks. Five different weight ratios of clay to SF to GSW were tried: (70:5:25), (70:10:20), (70:15:15), (70:20:10), and (70:25:5). They were burnt at three different temperatures of 700°C, 750°C, and 800°C. The bricks with the highest compressive strength of 18.5 MPa at 700°C burning temperature were created utilizing 70% clay, 25% SF, and 5% granite sludge waste, with a water absorption of 18.2% and a saturation coefficient of 0.9.

Ngayakamo et al., 2020 reused granite powder (GP) and eggshell powder (ESP) wastes for the production of clay bricks as an alternative waste disposal approach while also improving the quality of the burnt clay bricks (FCBs). FCBs mixed with 20% GP and 10% ESP exhibited the maximum compressive strength of 3.12 MPa, bulk density of 1.76 g/cm^3, and water

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absorption of 12.2% at 900°C, which is regarded as an energy-saving technique for FCB manufacturing.

Kumar et al., 2020. During their experiment, they attempted to create bricks from industrial waste using fly ash (FA), granite waste (GW), and black cotton soil (BS). The FA and GW proportions in the block cotton soil (BS) brick mixture were varied by adding 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%. The highest compressive strength value was BS60:A20:W20. In all cases, water absorption was less than the standard value of 22%. Furthermore, the weight of these bricks was around 30% to 50% less than that of regular bricks. In all studies, the efflorescence test findings were negative.

Shilar et al., 2019. The study included an experimental investigation of the impacts of different amounts of granite waste powder and lime in the fly ash while creating a fly ash-based interlocking brick to examine the attributes of interlocking bricks such as compressive strength and water absorption. For 72% fly ash, 18% granite powder, and 10% lime mix the compressive strength was 3.96 N/mm^2 for 7 days and 8.59 N/mm^2 for 21 days, for 72% fly ash, 16% granite powder, and 6% lime mix the compressive strength was 3.98 N/mm^2 for 7 days and 8.96 N/mm^2 for 21 days and for 72% fly ash, 18% granite waste powder, and 10% lime mix the compressive strength was 3.78 N/mm^2 for 7 days and 8.32 N/mm^2 for 21 days. 15.20%,16.10%, and 16.50 % was the percentage of water absorption for all three mix proportions respectively.

Hamza et al., 2011. This study attempted to substitute conventional coarse and fine aggregates with scraps of marble waste and slurry powder containing up to 40% marble and granite waste in the manufacturing of concrete bricks. According to the test results, all cement brick samples evaluated in this study met the Egyptian code requirement for structural bricks, demonstrating that recycled goods have physical and mechanical attributes that make them suitable for use in the building sector. Granite slurry improved cement brick samples, reaching a peak at 10% slurry incorporation.

III. Material And Methodology

The following are the materials used in brickmaking:

1. *Fly Ash*

It is a fine, powdery byproduct of thermal power plant coal burning. It is made up of minerals including silica, alumina, iron oxide, and others. It is the principal source of pozzolanic material in bricks, adding strength and longevity. In most cases, 50 to 60% of fly ash is employed in the manufacture.

2. *Cement*

Ordinary Portland cement (OPC) is used as a binding material in fly ash bricks. Cement helps fly ash particles bond and provides the structural support required for bricks. The cement content is 10-15% by weight. Birla Shakti OPC grade 43 cement was utilized.

3. *Natural Sand*

Sand is a fine aggregate used in the production of fly ash bricks. It increases the workability of the mixture and contributes to the overall strength and density of the bricks. Sand is typically utilized in the construction of 20-30% of bricks.

4. *Granite*

Granite is crushed into fine aggregates that are used to substitute natural sand in the manufacture of bricks. When applied, it can increase the compressive strength and overall durability of bricks, making them more resistant to wear and environmental factors. The granite used has a specific gravity of 2.57.

5. *Granite Dust*

The granite dust obtained from the quarry is used. It is substituted in various proportions with natural sand. Granite dust is tougher and more durable than natural sand.

In this study, five sets of brick samples weighing 3 kg and measuring 230 mm X 110 mm X 70 mm were constructed. The first batch consists of regular bricks made of 60% fly ash, 28% natural sand, and 12% cement. The remaining sets are made up of modified bricks in which the natural sand is replaced by granite dust with replacement values of 20%, 40%, 60%, 80%, and 100%. First, a set of standard bricks is made by manually putting raw ingredients into a pan mixer, then adding water and lime based on the demand for homogenous mixing. After mixing, the mixture was transported on a conveyor belt from the mixer to the automatic brick-making equipment, which was pressed by a hydraulic press machine. Similarly, modified brick sets with 20%, 40%, 60%, 80%, and 100% natural sand substitution were created. After that, all of the samples were moved to wooden racks for setting, curing, and drying. Finally, the compressive strength and water absorption of these samples were evaluated.

TABLE 1. Percentage Composition of Each Set of Brick Samples

Mix	Fly Ash (%)	Natural Sand (%)	Granite Dust (%)	Cement (%)
1	60	28.0	0.0	12
2	60	22.4	5.6	12
3	60	16.8	11.2	12
4	60	11.2	16.8	12
5	60	5.6	22.4	12
6	60	0.0	28.0	12

IV. Results And Discussion

1. *Compressive Strength Test*

This test is carried out in accordance with IS code 3495 (Parts 1):1992 standards. To begin, the unevenness on the brick surface is removed and soaked in room temperature water for 24 hours. The specimen is then removed and the excess water is drained. The frog is filled in a 1:3 ratio with cement and sand (3mm). This example is horizontally positioned with the mortar-filled frog looking upwards between two 3mm thick 3-ply plywood sheets. It is positioned at the testing machine's centre. A uniform axial load of 14 N/mm^2 per minute is applied, and the highest load at failure is recorded.

2. *Water Absorption Test*

This test is carried out in accordance with IS code 3495 (Parts 2):1992 standards. In this test, the specimen is first dried in an oven at temperatures ranging from 105oC to 115oC. It is

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then cooled to room temperature and its weight (W1) is determined. For 24 hours, this dried specimen is totally immersed in clean water at room temperature. It is taken out and dried with a cloth. The weight (W2) is measured three minutes after removing the specimen from the water (W2). The proportion of water absorbed is calculated using the calculation below.

$$Water\ Absorption\ (\%) = \frac{W2 - W1}{W1} \times 100$$

TABLE 2. Compressive Strength and Water Absorption of each Mix

Mix	Compressive Strength (N/mm²)	Water Absorption (%)
1	11.12	8.77
2	7.38	16.61
3	7.67	13.83
4	9.26	11.40
5	11.00	9.30
6	12.22	7.14

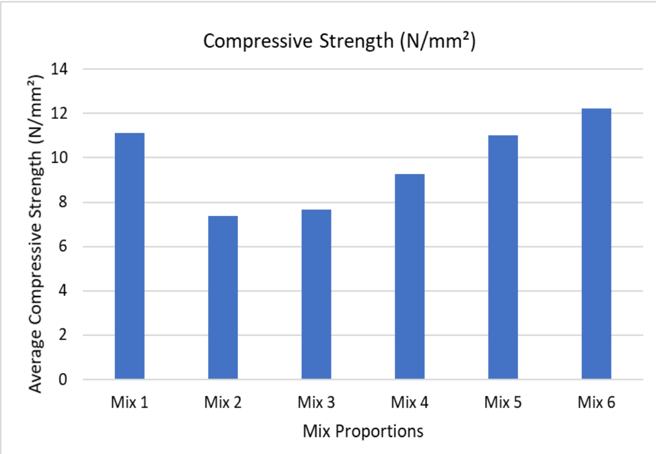

Fig. 1. Compressive Strength Comparison within the Mix

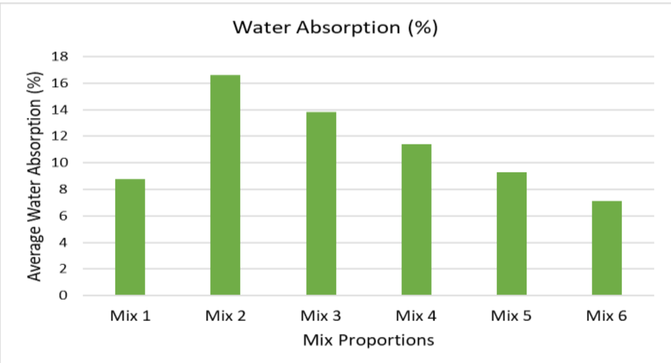

Fig. 2. Water Absorption Comparison with the Mix

According to the above results, there is a 33.6% drop in compressive strength of brick produced by Mix 2 when compared to Mix 1. Water absorption, on the other hand, increases by 89.4%. Similarly, there is a 31.02%, 16.72%, and 1.1% drop in compressive strength and a 57.7%, 30%, and 6.04% increase in water absorption for Mix 3, Mix 4, and Mix 5. Finally, Mix 6 has a 9.8% gain in comprehensive strength and an 18.58% decrease in water absorption. These results reveal that the maximum compressive strength is 12.22 N/mm2 and the minimum water absorption is 7.14% when natural sand is replaced 100%.

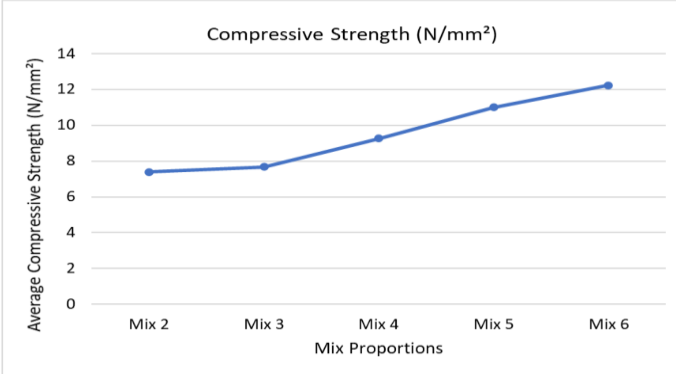

Fig. 3. Comparison of Compressive Strength based on % replacement of natural sand

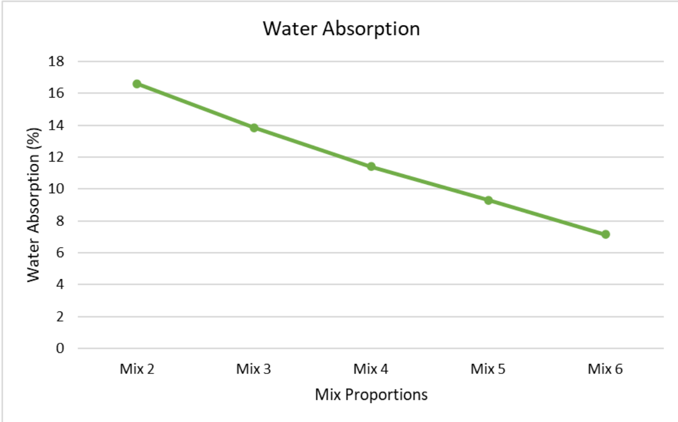

Fig. 4. Comparison of Water Absorption based on % replacement of natural sand

Based on these findings, it can be concluded that increasing the amount of natural sand replacement with granite dust increases compressive strength while decreasing water absorption. Additionally, higher-grade fly ash brick is created.

V. CONCLUSION

From the results obtained it is concluded that:

1. On increasing the percentage of replacement value of natural sand, there was an increase in compressive strength and a decrease in water absorption value when the modified bricks were compared with each other.
2. When 80% natural sand is substituted with granite dust, the compressive strength (11.00 N/mm2) and water absorption (9.30%) remain unchanged when compared to regular brick. This demonstrates that the brick samples produced using Mix 5 (60% fly ash, 5.6% natural sand, 22.4% granite dust, and 12% cement) will exhibit the same properties as regular fly ash brick.
3. Finally, it can be concluded that granite dust can be effectively used in the manufacture of bricks as a replacement for natural sand, which not only solves environmental problems such as air and water pollution, soil contamination, etc. but also reduces the exploitation of natural sand.

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