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Sustainable Polymer-Based Cementitious Composites with Granite Dust as Fine Aggregate: Strength and Durability Evaluation

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Abstract

This study investigates the potential for creating a new kind of cementitious composites that is obtained through the different compositions of rocks and chemicals in which granite dust that is helpful in resistance of chloride penetration and heat of hydration as a substitution with sand in composite. The primary goal of this study focuses on the effect of the stone waste like polymer matrix on evidence bases of researches for sand in the manufacturing of cementitious composites. The cementitious composites that are created with 0%, 5%, 10%, 15%, 20%, 25%, and 30% substitution of sand with powdered granite. Several mechanical parameters, including strength in compression and bending, were examined. To assure the dependability of its use in harsh conditions, durability qualities, such as capacity to absorb water and destruction by acids, were identified. A 15% level of replacement resulted in the maximum strength without compromising strength or durability standards. Different polymers like PET, polypropylene, fibres, rubber tyres are utilized in cementitious composite through earlier studies and a plan is ready for polypropylene plastic with composite in combinations of 15% concentration of granite dust that is optimum to produce the composite. According to the findings reported in this study, it may be concluded that using granite powder in blends of polymer and cement-based composite enhances the overall performance regarding the strength of composite production and it also provides an environmentally sustainable way of clearance of trash like polymeric and others obtained through the industrial process.

Keywords: Cementitious composite, polymer matrix, polypropylene, asbestos fibre, strength.

INTRODUCTION

Particulate-filled polymers for concrete composite components like cement, sand, and coarse aggregate for construction purposes, as well as some other types of engineering applications, are the subject of extensive studies and research regarding a large interest in nanocomposites, biomaterials, and natural fiber-reinforced composites. In previous years, the main reason fillers were added to polymers was to lower costs. It has become necessary to substitute conventional ceramics in composites with other inexpensive, readily available waste materials, either entirely or partially, without sacrificing quality, due to the expensive price of fillers like metal and ceramic powders to be used [6]. One such substance for cementitious composite that has the potential to be used as a filler in polymer matrix materials is waste Granite dust. Tamil Nadu accounts for 45% of India's entire granite reserve. Granite stones are turned into products from mines using various cutting methods, and the blocks are then delivered to local manufacturing companies.

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According to available literature, the waste that is generated in every aspect of the stone manufacturing process covers approximately 20–25% of its manufacturing process at a global level. As a result, granular waste that is in the millions of tons is generated an annual base, with disposal seen as a major global environmental concern. Some applications like polymer additives, fillers, aerospace engineering, septic tank etc. that have additional value are prepared from granite stone trash like polymer matrix, will reduce waste creation and act in an economical way for rock factories [21].

As we know the construction industry demands sustainability on a global scale in addition to improved functionality and a more prolonged lifespan for concrete composite structures, because it uses waste materials, supplemental cementitious materials, and geo polymeric material concrete (GPC) for concrete composites [1]. The significance of chemical interactions in the development of cracks in structures and the application of geopolymer composites as corrective methods are the main focus of this article [2]. The cost of deposition has increased along with the constraints on landfills in the surrounding area, forcing business companies are looking for various renewable resource-based matrix composites to reuse their waste. Although granite particles have been recycled, the amount of trash that is recycled in this way remains very little. Thus, its use in various sectors like sustainable polymer production for energy recover strategies has come out in an essential way. To address the environmental issue from various matrix formation, the construction sector, particularly the concrete composite manufacturing sector, has used nearly every form of rock debris over the past few decades. The optimal use of powdered granite in a sustainable rendering for a mix of cement-based mortar in the ratio of 1:3 (volumetric) by substituting 10% to 50% powder waste of granite for natural sand was the subject of the first known study on this matter. Out of all the alternatives, the 30% stone debris incorporation in construction mortar receives the highest score [3]. In the production of concrete composite, 40% GGBS and 10% metakaolin to control thermal cracking and anti-corrosion protection were employed as a part of the replacement for cement. Additionally, extremely strong plasticizer at a 0.3 percent concentration has been utilized to maintain the fresh properties of concrete composite, and stone waste was employed as a sand alternate in different ratios (0, 10%, 20%, 30%, and 40%) on the basis of weight in an effort to lower resource use from nature. For this experiment, the mechanical aspects of the combined composite of concrete were evaluated at 7 and 28 days using M_{45} standard concrete composite with a ratio of water and cement that is 0.36. The best strength in composite during compression of the mix was determined in order to replace rock debris by 20% based on the experimental data [4]. However, due to rising material and processing costs, as well as ever-increasing technical and aesthetic criteria, all potential benefits of fillers must be utilized [6]. This study's [7] objective is to examine how the hardened and environmentally harsh characteristics of mixture specimens in the solutions of NaCl and H_2SO_4, which are subjected to harsh environments are affected simultaneously by cutting waste of granite and magnetized water (MW), which were the substitutes for cement. The studies revealed that the use of water that is magnetized strengthens the hardened and environmentally harsh characteristics of concrete composite, independent of the GWD inclusion ratio.

Additionally, it was discovered that utilizing large doses of GWD results in decreased strength. The effects of using particles [8] of rock waste and slag of copper helpful in leaching or stabilize heavy metals iron, copper etc. for concrete composite matrix to partially substitute sand in concrete composite for 7, 28, 56, and 112 days are demonstrated in this research. When CS and GD were included in amounts up to 30%, all examined samples' strength increased by 19%; however, more CS and GD additions cause strength to decline. Slump continues to rise as particles of granite and slag of copper are replaced. In the current investigation [9], the fine stone aggregate is substituted by 50% of industrially produced sand for the concrete composite of M_{30} grade, and fractional substitution of cement is by particles of granite on weight proportions of 0%, 5%, 10%, 15%, and 20%. They noticed that adding fragments of granite greatly strengthens the construction material. The most appropriate number is 10% substitution for cement. A new study [10] investigates the possibility of substituting 5, 10, 15, and 20% parts by sand weight with unused fragments of granite in autoclave aerated concrete composite. The greatest gain in strength when compressed was noted when fragments of granite replaced 20% of the fine particles of sand. A research study [11] was conducted to determine the practicality of using granite debris as an alternative for coarse aggregate. The ratios of stone trash incorporated are 25%, 50%, 75%, and 100% exchange for the composite of concrete's aggregate that is coarse. The substitution of 25% stone pebbles reached its peak strength when contrasted with further substitution ratio. The concrete composite blends were partially supplemented with a proper interval of 5% to 25% with glass powder (GP), and 10% to 40% with granite powder (GrP), respectively. The concrete composite's resilience characteristics using 15% glass powder and 30% stone dust in ingredients of concrete composite, respectively, showed a notable increase. This ceramic waste reduces the effect of chloride penetration and lowering CO_2 emissions regarding pollution in sustainable way. Regarding mixed mixes of glass powder substitutions with cement at 20% and 25% and rock waste with sand at 40% and 50% so, the larger replacement levels result in higher values for compressive strength loss [12]. This study [13] evaluated the both characteristics like newly mixed and solidified concrete composite that self-compacts incorporating stone debris in powder form. Up to 100% rock waste was used in place of the fine stone at a higher step level. At the 20% level of substitution, the materials strength increased in case of flexural and compression. After 20% substitution both strength parameters decreased. After 20% replacement, the water absorption and permeability increased after initially declining with 20% GCW inclusion. This study [14] used two types of stones composite matrix that are coarse in concrete composite: untreated pebbles and fragmented stone of granite. According to test results, concrete composite made from raw gravel is more workable than granite that has been crushed. The enhancement at all periods of compressive strength was reported with concrete composite prepared from fragmented particles of granite. The powder form of natural stone has been employed in this investigation [15] as a form that is partially alternative to sand around concentrations of 10%, 20%, and 30%, while the fiber content of polypropylene had been set at 0.25% of the cement weight. A high level of heat 300°C was applied to the concrete compositions.

The GP20 blend, which substitutes 20% particles of granite for sand, performed the best overall in regard to properties of strength out of all the blends. At the concentrations of 5%, 10%, 15%, and 20%, the fractional replacement of sand in mixes was accomplished with a waste form of rock and iron powder. These metallic inorganic form of iron and stone acts as a filler with a good magnetic effect in polymer matrix also. In comparison to the other replacement levels, it is pointed out by research that substituting 10% of sand with the crusher form of granite produces the greatest enhancement for both the hardened state in compression and flexion [16]. It is suggested [17] that the localized availability of granite slurry (GS) is an appropriate alternative for concrete composite; it enhances the material's strength properties while also significantly reducing the total cost of concrete composite. Cement was partially substituted with granite powder at weight percentages of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, and 50%. To increase tensile properties, 1% steel fiber was also used. The specimen with 25% particles of granite had the largest excess strength under compression of all the mixes, showing the best overall economic performance, low sulfate degradation, and greater fire resistance [18]. A M_{30} grade concrete in which a powerful plasticizer with the mixtures of minerals like inorganic polymer which are helpful in chemical resistance and thermal stability was used in place of some of the cement and granite powder in place of 0, 25, and 50% of the sand. According to the experiment observations, adding granite fragments and additives to concrete composite has enhanced its resilience and long-lasting qualities [19]. Granite powder might be transformed into a useful resource with the extra advantage of protecting the environment by being used in high-performance concrete composite [20]. A proportion of stone particle replacement served as the study variable to evaluate. GP trash was used to replace 0%, 5%, 10%, 15%, 20%, and 25% of naturally occurring tiny particles of sand in concrete composites. On the basis of suggestions for results, it is beneficial for the concrete composite to use as much as 15% of GP waste in place of natural sand [21]. The stone dust was added in proportions by weight of 0, 5, 10, 15, 20, and 25 instead of sand. For effectiveness, 0.5% superplasticizer was used. 15% is shown to be the ideal replacement dosage. The experimentation results indicate that the use of granite powder in lieu of sand enhances composite's mechanical qualities like compressive and tensile strengths [22].

Since there aren't many studies on utilizing granite dust (GD) trash as a substance that serves like a filler elements form when concrete composite is being made, we looked for polypropylene plastic that could be used with granite powder in future investigations. In this inquiry, we discovered the ideal amount of granite. Additionally, a scientific analysis of the suggested concrete's composite qualities is necessary for improved performance of combination proportions. This study's primary goal is to determine through experimentation whether stone processing trash may be used in making of concrete composite to substitute fine aggregate.

The percentage-basis substitution of granite powder with sand was considered as the parameter of this experimentation work. GD waste was used to replace 0%, 5%, 10%, 15%, 20%, 25%, and 30% of the natural sand in the preparation of samples like concrete composite cubes and beams. Slump cone testing and flexural and compressive strengths were employed to assess the mechanical qualities of fresh composite of concrete. Powdered granite concrete composite was also subjected to durability testing, including chemical attack and water absorption tests, to make sure of its dependability in harsh conditions. Further some studies indicate that the use of varied polymers also enhance the characteristics of concrete composites. These polymers include utilization of polypropylene fibre, rubber fibre, asbestos fibres, etc. However, use of polymers in concrete composites needs to be analysed for their durability properties. The use of polymers in GP modified concrete has not been reported to a great extent.

In an economical way, we prefer granite dust instead of polymer matrix like metal and ceramic powders which are costly so to reduce the cost in present work we investigate the potential for creating concrete composites that are filled with unused granite dust in order to assess their mechanical qualities.

MATERIALS AND METHODS

One of the most common building materials used globally is concrete composite. The polymer-based components like cement, water, fine and coarse aggregates, and granite powder are combined in the right amounts to create concrete composite. The key binding component of concrete composite is cement. Portland cement is currently the most often used cement in building, which is why UltraTech brand Ordinary 43-grade Portland cement that complies with IS 8112:1989 has been chosen for the study. It is lump-free, powdered, and dry. Concrete composite requires aggregates, which are inactive materials that are granular like sand, pebbles, or broken stone.

There are two different types of aggregates, which are close to the percentage between 60 and 75 percent of the total concrete composite quantity: fine and coarse. All the stone particles employed in the current investigation have been used as coarse gravel in concrete composite. In most cases, 20 mm was the ideal size for the coarse aggregate. The coarse aggregates were subjected to sieve analysis, and Table 1 provides the percentages that passed through each screen. Additionally, the coarse sand that passes through the different sieves indicated in Table 2 and No. 5 sieve of 0.600 whose percentage passing criteria are related to the grading zone II in accordance with Table 4 of IS 383–2016. Granite dust is transported from a stone factory in Ajmer, Rajasthan.

It is evident from the sieve study that the GD has a higher concentration of tiny particles than sand. Good density and greater strength are the outcomes of smaller particle sizes. Additionally, it expands the surface area. Because GD has a larger surface area than sand, a greater bound area with hydrated cement results in concrete composite that is stronger [4]. Potable water was utilized in the present study. The fine gravel serves as a binding agent and fills up the gaps in the coarse crushed stone. Granite powder and coarse sand that were readily available in the area were used to make the concrete composite mixtures used in this investigation. The size of sand varies from a value of less than .15 mm to 4.75 mm. The sand's specific gravity and fineness modulus are 2.63 and 2.72, respectively. Granite powder has a specific gravity of 2.86 and an index of fineness of 3.15. The Table 2 and Figure 1 below present the findings of the sieve examination of sand dunes and powdery granite.

Table 1. Sieve test for coarse aggregate.

S.N.	Size of mesh	Coarse aggregate passing percentage
1.	80	100
2.	40	100
3.	20	77.34
4.	10	0.01
5.	4.75	0

Table 2. Sieve test for sand and granite powder.

S.N.	Sieve size	Percentage passing of sand	Percentage passing of granite powder
1.	10	100	100
2.	4.75	95	100
3.	2.36	91	97.9
4.	1.18	89	59.9
5.	0.600	85	10.9
6.	0.300	80	8.7
7.	0.150	76	6.8

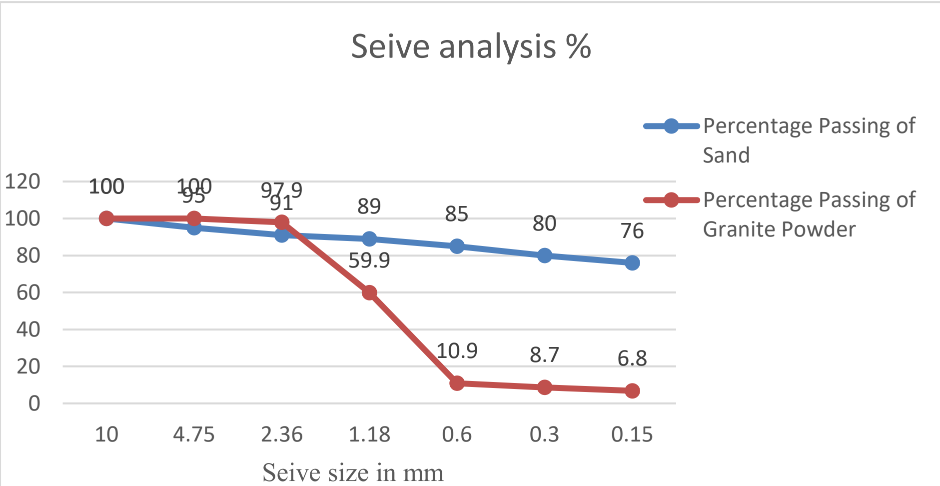

Figure 1. Sieve analysis for sand and granite powder.

It is demonstrated that granite powder has a significantly higher concentration of tiny particles than coarse sand. The Table 3 provides the specifics of the tested constituent materials employed in the present investigation of concrete composite preparation. Water is an essential part for making concrete composite, especially when it comes to its quantity. When a smaller amount of water is used to build concrete composite, the concrete's composite ability to retain strength increases. Consumption able water that is easily accessible locally has been employed in the current project. The Table 4 illustrates the chemical assessment of matrix which is similar to polymeric in composite for OPC and GP, which was assessed by [10].

EXPERIMENTATION

This experimental study's objective was to create superior achievement of concrete composite like a polymeric by using the granite powder. Research conducted all around the world clearly demonstrated that improving the strength of concrete composite would result from the appropriate addition or replacement of any concrete composite constituents [20]. The Granite powder's effect on mechanical characteristics was investigated experimentally in the current study. Concrete composite testing is crucial for regulating and verifying the quality of cementitious composite projects. The tests related to strength like compressive and flexural and durability like water absorption tests and chemical attack made up the entire experimental in this study. To determine the aforementioned qualities, a thorough investigation took place on concrete composite in compliance with the guidelines of the Indian standard specifications [23–25]. The test methodology used is explained further here.

Table 3. Physical characteristic of cementitious granite composite materials.

S.N.	Materials	Description
1.	Cement	Class - Grade OPC 43 Specific Gravity - 3.15 Normal Consistency – 28 % Time of Initial Setting - 90 Minutes Time of final Setting - 400 Minutes Fineness - 4 % Strength of Compression – At third day – 24.5 MPa – At seventh day – 24.5 MPa – At twenty-eight day – 24.5 MPa
2.	Coarse sand	Specific Gravity - 2.63 Fineness modulus – 2.74
3.	Coarse aggregate	Specific Gravity - 3.15 Fineness modulus – 6.22
4.	Granite powder	Specific Gravity - 2.86 Fineness modulus – 3.15

Table 4. Chemical constituents of OPC and granite powder.

Oxide%	OPC	Granite Dust
SiO_2	21.2	65.5
Al_2O_3	4.8	5.3
Fe_2O_3	3.8	15.0
CaO	65.	9.5
MgO	2.2	-
K_2O	0.4	2.6
LOI	2.2	1.8

Figure 2. Cube testing.

Compressive Strength Test

Due to its ease of use and the fact that many desired qualities of concrete composite are quantitatively correlated with its compression strength, a test for compressive strength is one of the commonly performed concrete composite tests. A testing device of 3000 KN capacity for compression had been used to determine the compressive strength as shown in Figure 2.

Cube specimens of 150 mm by 150 mm were used for evaluation of strength under compression. A specimen was positioned across the loading surfaces of a CTM for the test, and the load continued to be applied until the test sample failed. The compressive strength for every single test condition was measured using three samples used for testing, and the mean result was considered.

Flexural Strength Test

A measurement of a material's resistance to distortion under load is called flexural strength. The rectangular beam specimens of the material are loaded during a three-point test approach to measure the values required to compute flexural strength, as shown in Figure 3.

The stress that is placed on the topmost strands of a composite specimen being tested at the moment of fracture is a measurement of a specimen's material bending strength. Flexural strength, measured in MPa in a traditional test, is equivalent to (equation 1):

$$PL/\ bd^2 \tag{1}$$

Where P = the load placed on the composite specimen
b = beam's width
d = beam's depth

Water Absorption Test

Because water migration affects the degradation of permeable substances like concrete composite, it is crucial to examine water absorption, which is strongly related to concrete composite durability. The absorption test examined how granite powder affected concrete's composite ability to absorb water. In this project the cubes of size 150 mm by 150 mm were utilized for the absorption test. For 28 days, they were immersed in water for curing in a temperature range between 20 and 25 degrees Celsius. Once the composite specimen has cured, remove it and wipe any moisture from its surface. After oven-drying the sample at 105–110°C, let it cool to room temperature. Note the weight (W_1) after drying in the oven. For a whole day, submerge the specimen entirely in water. Take the specimen out, remove any surface water, and note the saturated weight (W_2). After this we calculate the percentage variations in between the two weights of various concrete composite mixes. When evaluating durability, permeability, and resilience to harsh conditions with granite powder, it shows the pore structure and quality of the concrete composite.

Figure 3. Beam testing.

Acid Attack Test

Specimens of blended concrete composite mixes that are resistant to acid attack at a concentration of pH ≈3 are developed in accordance with IS requirements. Concrete composite has a pH of more than 12, making it extremely alkaline. In this experiment, concrete composite samples were submerged in a 3% hydraulic acid solution for 28 days. The polymer-based composite specimen's surface was cleaned with a dry cloth after 28 days of exposure shown in Figure 4 and the subsequent formula was utilized in the computation of strength at compression.

Compressive strength loss (%) = $(Ccs\text{-}C_{ha})/Ccs \times 100$

Ccs = Concrete's composite compressive strength in water that is usable after 28 days
C_{ha} = Concrete composite hydraulic acid's compressive strength after 28 days

Details of Concrete Composite Mix

Based on results from earlier research, the recommended doses of granite powder utilized in the study plan were established. Consequently, samples of concrete composite mixed with 0% to 30% at an interval of 5% of granite powder in lieu of sand like polymer matrix were assessed without any other replacement of another ingredient of concrete composite. The investigation's experimental research concentrated on M_{20} grade concrete composite for seven fundamental mixes, each of which was identified by the category of sand. The following mixes were identified as GD_0, GD_5, GD_{10}, GD_{15}, GD_{20}, $GD_{25,}$ and GD_{30} in the formation of 0% granite dust (100% sand), 5% granite dust (95% sand), 10% granite dust (90% sand), 15% granite dust (85% sand), 20% granite dust (80% sand), 25% granite dust (75% sand), and 30% granite dust (70% sand). Table 5 displays the final combinations of mixtures. A 20 MPa strengths of cubes for the combination of materials was produced using the specifications of Indian Standards. For M_{20} grade, concrete composite samples were made with a w/c ratio of 0.5 and samples were immersed for curing at normal temperature in water for 7, 28, and 90 days.

Figure 4. Chemical attack at 28 days exposure.

Table 5. Details of mix design.

S.N.	Designation of mix	Cement (Kg/M^3)	Water (Litre/M^3)	Coarse sand (Kg/M^3)	Powdery granite (Kg/M^3)	All in aggregates (Kg/M^3)	W/C ratio
1.	GD_0	400	200	600	00	1200	0.50
2.	GD_5	400	200	570	27.587	1200	0.50
3.	GD_{10}	400	200	540	55.174	1200	0.50
4.	GD_{15}	400	200	510	82.762	1200	0.50
5.	GD_{20}	400	200	480	110.349	1200	0.50
6.	GD_{25}	400	200	450	137.937	1200	0.50
7.	GD_{30}	400	200	420	165.524	1200	0.50

Table 6. Composite specimens detail.

Characteristics of Material	Specimen Shape	Specimen Size in mm
Compressive strength at 7, 28 and 90 days	Cube	150 × 150 × 150
Flexural strength at 7, 28 and 90 days	Rectangular beam	100 × 100 × 500
Water retained	Cube	150 × 150 × 150
Resistance against acid attack	Cube	150 × 150 × 150

Table 7. Results of slump test.

S.N.	Designation of Mix	Measured Value in mm
1.	GD_0	89
2.	GD_5	87
3.	GD_{10}	85
4.	GD_{15}	83
5.	GD_{20}	82
6.	GD_{25}	80
7.	GD_{30}	76

Preparation of Test Specimens

The cementitious granite composite components cement, sand, and coarse aggregate like a matrix of polymer was mixed in proper mix proportions as per IS 10262-2019, 383-1970 and IS 456-2000. The mixing time is generally 3 to 5 minutes, and the ratio 1:1.5:3 is utilized for concrete composite mix. The water in proper amount was added and stirred into the composite mix according to the time interval. To examine the differences in strength characteristics caused by substituting granite powder for sand, a variety of composite specimens, including cubes and beams, were cast. For M_{20} grade, test samples were made with the ratio of 0.50 for water and cement. The cubes cured in water at normal temperature after a day with the demoulding process. Various composite samples shown in Table 6 have been used for curing ages of seven days, twenty-eight days, and ninety days. The total 147 number of composite specimens were casted for hardened and durability characteristics of concrete composite.

RESULTS ANALYSIS

In accordance with the above-described process, tests were carried out in a variety of experimental settings to determine the mechanical characteristics of an unconventional concrete composite blend that contains stone dust as another option to sand from rivers. The experimental findings regarding the concrete composite mixtures GD_0, GD_5, GD_{10}, GD_{15}, GD_{20}, GD_{25}, and GD_{30} under different operating conditions for 20 MPa strength in concrete composite are shown and discussed here.

Concrete Composite Workability

Concrete's composite workability has been measured for seven different mixes, and Table 7 provides their fluidity that is illustrate in Figure 5. When contrasted to the concrete composite blend that is conventional, the insufficient difference has been found in concrete composite mixes for the readings of slump. Additionally, it is demonstrated that as the proportion of granite powder rises in the concrete mix, it also lowers the fluidity of concrete composite. We see the slump was not larger in concrete composite mixes including granite powder than in those containing sand. Granite dust's extremely uneven and coarse form and greater retention of water compared to naturally occurring sand are the causes of the decline in durability. Additionally, granite rock dust contains more fine particles, increasing the mixture's area of coverage and producing the undesirable flow.

Compressive Strength

One of the most important Concrete's composite qualities is thought to be the strength of its compression. The Table 8 shows the impact of substituting stone dust for sand on M_{20} grade concrete's composite compressive strength. According to the results, granite powder concretes composite with variations up to 15% had a higher compressive strength that is same to trend of polymer granite composite [5] than the reference mix (CC) throughout every curing day. A blend of cementitious granite composite including 15% powdered granite (GD_{15}) achieved substantial improvement in same way of polymer matrix for the current investigation.

Figure 6 demonstrates that GD_{15} has a compression strength that is greater than traditional mix as well as all alternative mix types of concrete composite containing granite powder during the course of all curing days (7 days to 90 days). This could be because concrete composite mixes with more granite powder have more voids. Furthermore, as stone powder has a weaker strength for crushing instead of sand, adding more stone powder has caused decreases in strength [20]. On a percentage basis, the GD_{15}'s compressive property is 1.18–25.2% more than the conventional concrete composite.

Table 8. Ages of compressive strength at 7, 28, and 90 days.

S.N.	Designation of Mix	Strength at 7 Days N/mm^2	Strength at 28 Days N/mm^2	Strength at 90 Days N/mm^2
1.	GD_0	17.5	27.0	28.7
2.	GD_5	18.4	28.4	29.1
3.	GD_{10}	20.2	31.1	32.8
4.	GD_{15}	21.0	33.4	35.7
5.	GD_{20}	20.5	32.2	34.1
6.	GD_{25}	18.1	29.1	31.5
7.	GD_{30}	16.7	25.1	27.9

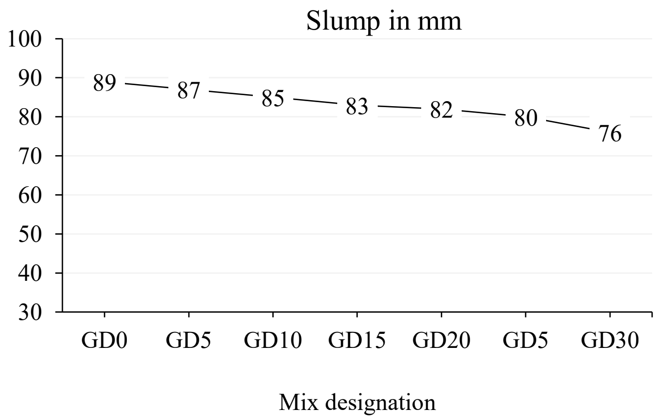

Figure 5. Graph for slump test results.

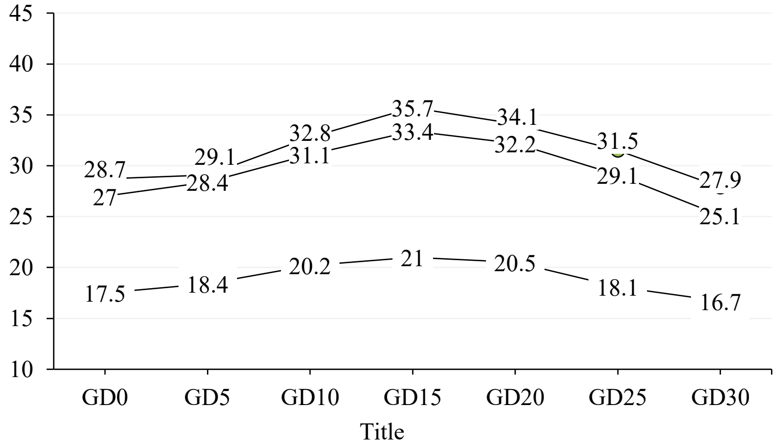

Figure 6. Graph for results of the 7-, 28-, and 90-day compressive strength tests.

Granite powders have potential advantages after their utilization that is demonstrate in present study without any additives. A pattern of decreasing compressive strength and the aggregate–cement paste transition zone's structural porosity increases which encourages the spread of cracks as the w/c ratio rises that is prove through the earlier studies.

Flexural Strength

The Table 9 shows how granite powder affects strength in flexion for all mix types of concrete composite. According to the experimental inquiry, flexural strength decreased when large amounts of granite powder were substituted for sand, whereas flexural strength increased when granite powder was substituted for 15% of the sand. It should be noticed that for every day of curing, the flexural strength of GD_{15} is 5.71% to 43.47% greater than the comparable amount that is utilized as a control mix, as shown in Figure 7.

The results also show that the absence of any chemical addition to concrete composite blends, which gives similarity to different strength attributes, was responsible for the notable gain in strength at flexion. For all ages and a water cement ratio of 0.5, the flexible capacity range expands from 39.13 to 52.17%, 25.9 to 36.9%, 12.9 to 25.8%, 12.1 to 18.18%, 38.4 to 42.3%, 45.8 to 50.0%, and 34.78 to 56.52% for GD_0, GD_5, GD_{10}, GD_{15}, GD_{20}, GD_{25}, and GD_{30}, respectively.

Water Absorption

The absorption of water in concrete composite generally results in major issues that could compromise the concrete's composite strength. The amount of water that rise in the cubes was measured after the age 28 days during the experimental research.

Table 9. Ages of flexural strength at 7, 28, and 90 days.

S.N.	Designation of mix	Strength at 7 Days N/mm^2	Strength at 28 Days N/mm^2	Strength at 90 Days N/mm^2
1.	GD_0	2.3	3.2	3.5
2.	GD_5	2.7	3.4	3.7
3.	GD_{10}	3.1	3.5	3.9
4.	GD_{15}	3.3	3.7	3.9
5.	GD_{20}	2.6	3.6	3.7
6.	GD_{25}	2.4	3.5	3.6
7.	GD_{30}	2.3	3.1	3.6

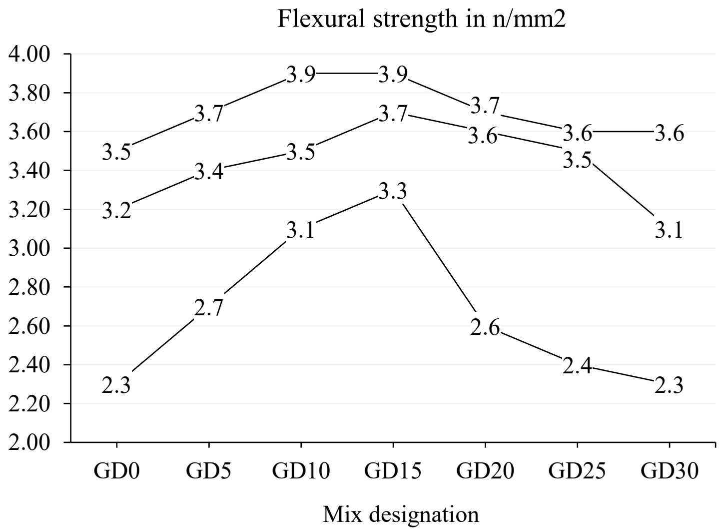

Figure 7. Graph for results of the 7-, 28-, and 90-day flexural strength tests.

Table 10. Results of a test on water absorption.

S.N.	Designation of mix	Water absorption percentage
1.	GD_0	0.820
2.	GD_5	0.785
3.	GD_{10}	0.618
4.	GD_{15}	0.516
5.	GD_{20}	0.810
6.	GD_{25}	1.42
7.	GD_{30}	2.46

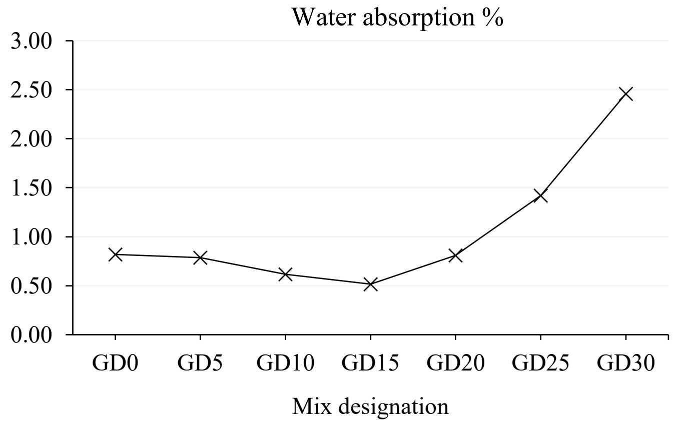

Figure 8. Water absorption test results.

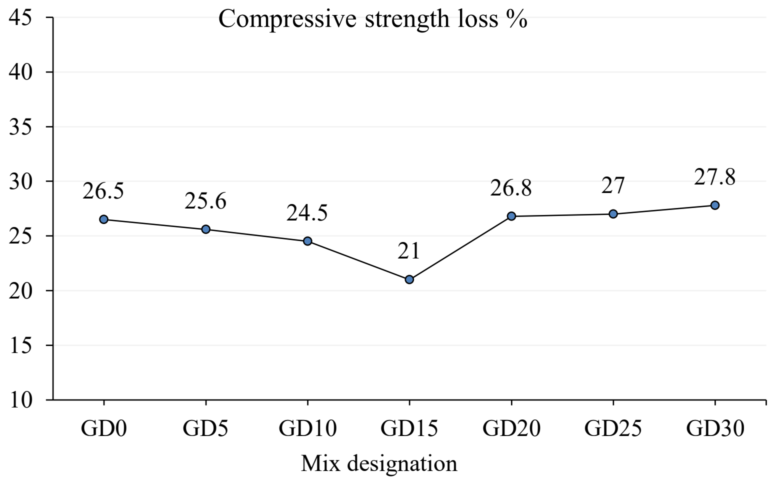

Figure 9. Compressive strength loss due to acid attack.

The Table 10 display the absorption test results. For the specified age of testing, the capacity of absorption reduces from 1.2 to 37.01% up to the 20% substitution of the 150 mm × 150 mm cubes with stone powder with the comparison of the traditional mixer. At the age of 28 days of testing, the absorption for concrete composite mix GD_{15} was 0.51%, which is low in comparison to other mixes due to its thick packing, dense microstructure and tiny filling of spaces reduce absorption capacity. The low porous characteristics reflects the chloride ion effects and oxygen contact that is helpful in protection of structure from corrosion effect that is in polymer granite composite series [5] and it is justified by present cementitious granite composite experimentation through the same characteristics of polymer matrix and granite dust in composite.

According to Table 10, there is a 4.2–37.07% decrease in water absorption for GD_{15} when compared to the traditional concrete composite mix. It should be mentioned that overall, the range of water absorption varies from 0.5 to 2.46% for different kinds of mixes of concrete composite illustrate in Figure 8 which should be in the favour of concrete composite. Higher absorption was noted in the concrete composite mix of GD_{30}. The observations indicate that the exchange of 15% stone powder in lieu of sand is performing at its best for newly formed concrete composite. Therefore, among the concrete composite combinations, GD_{15} is the best option.

Acid Attack Test

Figure 9 shows the difference in loss for strength in compression for granite powder blends during a 28-day period. In the instance of a chemical attack, the reaction between hydrated cement paste and hydrochloric acid produced some soluble salts that might leak out. Additionally, a few insoluble salts were created and are still present in the matrix in a layered pattern [10]. This calcium salt weakens concrete composite by attacking the cement paste. Compressive strength loss at 28 days for GD_{15} and control was 21% and 26.38%, respectively. It is 20.75% less than control concrete composite. The likely cause could be decreased gaps and tightly packed, tiny particles of granite in concrete composite [12]. For blended mixes like GD_{20}, $GD_{25,}$ and $GD_{30,}$ larger replacement levels are associated with higher compressive strength loss values. Lower compressive strength could be the result of an increase in the proportion of blends, which prohibits sufficient bond strength from being achieved. The following illustrations show the chemical reactions that take place during a hydrochloric acid attack [10].

$$HCl + Ca\,(OH)_2 \rightarrow CaCl_2 + 2H_2O$$

$$CaCl_2 + 3CaO.\ Al_2O_3 + 10H_2O \rightarrow 3CaO.\ Al_2O_3.\ CaCl_{2.}\ 10H_2O_3$$

The improved microstructure of the cement paste matrix was identified as the cause of the declining trend in strength loss of granite dust integrated blended mixes [10].

CONCLUDING AND SUMMARY

To determine the cementitious granite composite combinations' strength characteristics, like strength at compression, flexural strength, water-holding features, and chemical attack on matrix acts as a polymer, a laboratory investigation is carried out on concrete composite that uses powdered granite as a tiny sand particle in appropriate proportion after water curing. A ratio of 0.5 for water and cement was selected for making sample mixes of concrete composite up to the target strength of 26.6 MPa. The test findings completely indicate that the substitution in part for granite powder with sand improves the mechanical and durability qualities of normal concrete composite.

For all operational situations, concrete composite containing 15% granite powder (GD_{15}) outperformed other granite powder concrete composite percentages and conventional concrete composite out of the seven combinations that were examined. Therefore, based on the assessment of GD_{15} versus the control mix, the following findings are drawn here.

For all ages, mechanical aspects like flexural and compressive strength are stronger than those of the standard mix, as stated below. The strength improved with the time period of curing in ages.

- Compared to CC, the compressive strength is 1.18 to 25.2% higher.
- Compared to CC, the flexural strength is 0.43 to 42.8% higher.
- Compared to a traditional concrete composite mixture, the water absorption was between 4.2 and 37.07% lower.
- Compared to a traditional concrete composite mixture, the compressive strength loss is 20.75% less after an acid attack.

Therefore, the current experimental study suggests that using granite powder from the crushing machinery in concrete composite as an alternative to coarse sand could improve the concrete's composite strength characteristics, or it has better qualities than concrete composite created with sand. Thus, this composite acts as a polymer granite composite and can be utilized for various applications like pavements, anti-corrosive material for effluent drains, base construction for chemical plant and similar structures.

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