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Recycling of Basalt and Limestone Cutting Dust in Concrete Mix Design

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Abstract

Objectives: The goal is to integrate stone cutting waste into the concrete manufacturing industry to reduce environmental degradation. *Methods/Analysis*: Two types of stone cutting waste (Basalt and limestone) were separately collected from local facilities. An experimental program was conducted to prepare concrete mixes with 10%, 20%, 30%, and 40% replacement of sand by the two types of stone powder. Physical and chemical quality testing was carried out on the water, aggregates, and cement used in the concrete mix. The experiment compared a standard concrete mix (0% replacement) consisting of 6 cylinders and 6 cubes with a mix of 24 cylinders and 24 cubes after 7 days and 28 days. *Results:* Compression, tension, and stress tests were performed on the produced specimens. Regarding basalt replacement, a 10% replacement showed a higher impact on compressive strength and tension. For limestone, the 10% and 40% replacement fractions exhibited an insignificant reduction in compressive strength, indicating that a 40% replacement of sand with limestone dust is practical for most applications. Replacing sand with stone cutting waste in concrete can bring several benefits to the environment and enhance project feasibility. Even a small fraction of replacement can improve concrete properties. *Novelty:* Protect natural sand mining causes damage to ecosystems, leading to erosion and loss of biodiversity.

Keywords: Basalt Dust; Limestone Dust; Stone Cutting Waste; Reuse; Compression; Tension.

1. Introduction

Concrete, which is widely used in construction, is the most prevalent building material due to its simplicity, rigidity, and durability. However, the need for an alternative to natural sand in concrete mixes has become critical. Natural sand is a finite resource and is projected to be depleted within the next decade [1]. Typically, sand is employed as the fine aggregate in concrete, alongside coarse aggregate, a binding agent, and the necessary amount of water. Adding dust to the mixture's components may alter the strength, tension, and compression properties of concrete. Globally, approximately 2.01 billion tons of solid waste are generated annually, and at least 33% of it is not disposed of in an environmentally acceptable manner. This implies that the average daily waste production per person around the world is 0.74 kg, with a range of 0.11 to 4.54 kg. The amount of solid waste generated globally is projected to increase by almost 70% and reach 3.4 billion metric tons by 2050. Less than 20% of the waste is recycled annually, and a significant amount is still dumped in hazardous open landfills, posing a threat to the ecosystem [2].

Stone powder, which is a byproduct of stone crushing in quarries, can serve as a substitute for fine aggregate in concrete mixes. Recently, researchers have explored the possibility of using stone cutting dust as a replacement for sand in concrete mix designs. Stone cutting dust is a byproduct of the stone cutting industry and can be sourced from materials

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like marble, granite, and limestone. Several studies have investigated the incorporation of stone cutting dust into concrete mixes as either a full or partial replacement for sand. These studies have revealed that the addition of stone cutting dust to concrete mix designs can enhance the material's strength, durability, and workability, while also reducing its environmental impact. The optimal percentage of stone cutting dust to be used in concrete mix designs may vary depending on the source and composition of the dust. Overall, the utilization of stone cutting dust in concrete mix designs holds the potential to offer a sustainable alternative to sand in concrete production.

The utilization of stone powder in concrete offers several benefits, including a decrease in the demand for natural resources, a reduction in waste generated during stone crushing, and a lowering of the price of the concrete mix. Moreover, research has demonstrated that the incorporation of stone powder enhances the workability and finishing properties of concrete. By replacing fine aggregate like sand with stone powder, the use of natural resources is reduced, and waste produced during the stone crushing process is minimized. The addition of stone powder has been shown to improve the workability and finishing qualities of concrete. Furthermore, multiple studies have indicated that the inclusion of stone powder can increase the flexural and compressive strength of concrete. From an economic standpoint, incorporating stone powder into concrete can help reduce the cost of cement mixtures [3, 4]. However, it is important to note that the literature also highlights certain drawbacks of using stone powder, such as potential variations in quality, which can impact workability, and a potential decrease in abrasion resistance if high fractions are employed [5].

The increasing demand for natural aggregates is driven by the rapid growth of concrete production. Natural river sand, considered the most suitable and commonly used fine aggregate in mortar and concrete manufacturing, is being extensively extracted to meet this escalating demand. Consequently, significant environmental and economic consequences have arisen, as well as unregulated exploitation of natural aggregates [6]. River sand mining carries severe adverse environmental impacts, including alterations in river flow, increased erosion rates, and disruption of aquatic habitats. Dredging operations along riverbanks can destroy the habitats of bottom-dwelling organisms. The sediment accumulated during dredging can cloud the water, leading to suffocation of fish and obstructing sunlight required by aquatic vegetation [7, 8].

The global shortage of sand for building material manufacturing is a pressing issue due to the depletion of river sand resources and rigorous environmental regulations. Many regions around the world are currently experiencing a scarcity of high-quality natural sand, which is essential for concrete production. To protect invaluable natural areas, precautionary measures have been implemented in several countries to limit the extraction of river sand [8–12]. In Jordan, there is a lack of technical studies analyzing the concrete properties of typical rocks found in its geological composition. In Europe, approximately 4 billion metric tons of aggregate are produced and consumed, with nearly 91% of these aggregates sourced from natural resources [13]. Projections indicate that the United States will annually produce 2.5 billion metric tons of construction aggregate by 2020, with an anticipated growth rate of 3 to 5 percent per year [14]. Considering that natural sand constitutes around 35% of the concrete volume and the growing demand from the construction industry, a severe scarcity is anticipated. This scarcity poses challenges for the concrete sector to find suitable alternatives. As previously mentioned, rock dust presents a potential replacement for fine aggregate in concrete and mortar. These inert fillers, derived from various geological sources through the grinding process, can enhance packing density and particle size dispersion.

The powdery stone powder bears resemblance to clay in its appearance. Cement reacts with the surface of stone powder particles, potentially accelerating cement hydration and potentially substituting clay cement slurry. Significant quantities of solid stone powder waste are generated during automated aggregate processing, including crushing, grinding, transportation, and other operations. The utilization of stone quarry dust reduces the overall cost of construction. Stone powder is a fine waste material that resembles clay, with smaller cement particles. The presence of water serves as a medium for the attachment of cement hydration reaction, expediting cement hydration around the stone powder particles. Furthermore, the use of stone dust contributes to environmental benefits, serving as an efficient means of waste management in concrete construction. Incorporating stone powder in concrete provides advantages such as enhancing the mechanical properties of the material and reducing waste. It is possible for stone powder to replace traditional concrete in construction projects on a large scale [15]. Numerous studies have investigated the influence of stone powder on the mechanical characteristics of concrete. Al-Omari & Al-Mashhadani [3] discovered that increasing the amount of stone powder in concrete increased the compressive strength of the material up to a certain point. The inclusion of stone powder was also identified in the investigation by Islam & Hossain [4].

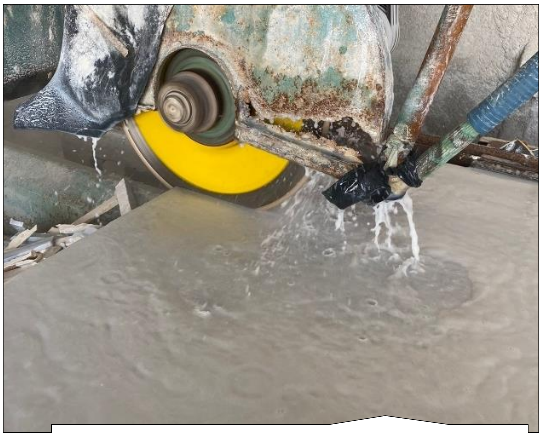
The utilization of stone powder as an additive in cement, mortar, concrete, and other mixtures has been investigated by Vardhan et al. [6], Aliabdo et al. [16], and Medina et al. [17]. The maximum compressive strength of the hardened material was achieved when 10% of the cement was replaced with stone powder. However, exceeding this content led to a rapid decline in the strength of the hardened material. The enhanced strength of concrete resulting from the substitution of rock dust for fine aggregate is attributed to the increased density of the hardened concrete structure, brought about by the formation of the C-S-H phase during the pozzolanic reaction, as described by Uchikawa et al. [18]. Additionally, the filling capacity of the mineral powder plays a role. Chen et al. [5] and Ergün [19] investigated the addition of stone powder to cement slurry as a composite additive. They found that substituting 5-10% stone powder improved the compressive and fluid properties of the cement. However, when the cement replacement with stone powder exceeded 10%, both fluidity and compressive characteristics gradually deteriorated. Atiyeh & Aydin [20] also examined the effects of adding bottom ash and marble powder to cement, with weight percentages of 20 and 25 respectively, on the properties of fresh and hardened concrete at curing ages of 7, 28, and 56 days. Subsequently, the physical and mechanical characteristics, sulphate resistance, workability, strengths, and durability features of the marble-bottom ash-cement mixture were evaluated.

The strength, impermeability, and durability of concrete are influenced by the content of stone powder. The mechanical characteristics and durability of concrete improve when the stone powder content is less than 7%, but decrease when the content exceeds 7%. Bayesteh et al. [21] and Gunjal & Kondraivendhan [22] also emphasize the significant impact of the cement ratio on strength. Their research reveals that as the cement ratio increases, the compressive strength of the hardened cement slurry body decreases rapidly. The addition of stone dust as a filler has a notable effect on the workability of concrete. Excessive fine filler additions can affect the workability of cementitious materials without necessarily increasing the water requirement [22–24]. When using excessive powder for a constant water-cement ratio, additional water is required to moisten the surface of the particles, leading to a reduction in the amount of mixing water and a negative impact on workability. However, compared to sand, crusher dust requires more water due to its abrasive structure, which further reduces workability [1]. The use of dust in concrete mixtures reduces waste and associated health problems. The role of stone powder as a filler primarily contributes to the strength enhancement in cement composites incorporating rock dust. Reusing stone powder can have positive impacts on both the economy and the environment, aligning with the principles of green development [23–25]. In Jordan, stone dust is collected and disposed of in landfills, resulting in significant business expenses. The monthly cost of stone dust disposal in a typical facility can reach $1 million, as shown in Table 1.

Table 1. Cost Estimation of Stone dust waste in Jordan

	Volume in m^3	**Cost per trip (USD)**	
Unit cost	30 –week	84.5	USD 2.81 / m^3
In Jordan 3000 facilities	360,000 per month		USD 1,011,600 total /month

The dust generation and collection process are shown in Figure 1.



a) Collect the stone dust: Collect the stone dust by applying runing water during cutting

b) Water carrying dust temporary storage pit

Figure 1. Wet Stone dust collection and temporary storage used in small and medium facilities

1.1. Stone Dust Reclamation Process

When a significant amount of stone dust slurry is generated, employing a separation procedure proves to be cost-effective. The choice of treatment system depends on factors such as the scale of the stone cutting facility, the quantity of stone powder produced, and cost-effectiveness considerations. Certain stone-cutting facilities employ mechanical methods to extract water from the dust. The aim is to reuse the water and compress the stone dust, thereby reducing its volume and subsequently decreasing the costs associated with disposal and transportation.

The separation process is demonstrated in Figure 2 with the following steps:

1) ***Collection***: The stone dust is collected from the quarry using methods such as blasting, drilling, or cutting.

2) ***Containment***: The stone dust is then contained in a designated area to prevent it from escaping into the environment.

3) ***Filtration***: A filtration system is used to capture the stone dust particles and prevent them from escaping into the air.

4) ***Washing***: The stone dust can be washed with water to remove any surface contaminants or impurities.

5) ***Stabilization***: Adding a stabilizing agent to the stone dust can improve its physical and chemical properties, making it suitable for use in construction.

6) ***Encapsulation***: Encapsulation involves coating the stone dust particles with a protective material to prevent them from releasing harmful chemicals into the environment.

7) ***Recycling as an additive to concrete***: After treatment, the stone dust can be safely disposed of in landfills or used in construction materials.

Figure 2. Stone dust generation and treatment stages in a typical stone cutting facilities

2. Materials and Methods

For this experiment, different forms of dust (limestone and basalt) were collected in dry blocks. The Los Angeles abrasion machine was used to separate and sieve the dust particles. The blocks were placed in the oven because it was necessary to eliminate moisture and transform them into little pebbles. In accordance with the EN 197-1:2005 procedure, Portland Pozzolanic Cement (CEM II/B-P 42.5 N) was utilized. This type of cement consists of a specific ratio of OPC clinker, gypsum, and pozzolanic ingredients. We made arrangements with a facility in Zarqa Governorate (Jordan) to collect the dust generated from the two types of rocks (basalt and limestone) separately.

2.1. Ingredients Quality Analysis

Ingredients of different dust types were analyzed using X-Ray Spectrometric test at the certified Ministry of Energy and Mineral Resources in Jordan. Basalt contains complex ferro-magnesian silicates that, on weathering, release the cations calcium, magnesium, iron, potassium, and phosphorus, as shown in Table 2.

Table 2. Composition of basalt stone powder using X-Ray spectrometric laboratory analysis

Sample Content / wt %	Fe_2O_3	MnO	TiO_2	CaO	K_2O	P_2O_5	SiO_2	Al_2O_3	MgO	Na_2O	L.O.I
Basalt	15.11	0.20	3.93	17.15	0.50	0.28	37.43	9.64	7.29	1.26	7.19

Also, Limestone dust composition was analyzed and it contains several metallic oxides as shown in Table 3.

Table 3. Composition of Limestone stone powder using X-Ray spectrometric laboratory analysis

Sample Content / wt %	Fe_2O_3	MnO	TiO_2	CaO	K_2O	P_2O_5	SiO_2	Al_2O_3	MgO	Na_2O	L.O.I
Limestone	0.40	0.005	<0.009	52.62	<0.015	0.26	4.69	0.27	<0.15	-	41.19

Mineralogical identification of dust types was conducted and the results are shown in Table 4.

Table 4. Dust types minerals content

Dust Sample	Minerals
Limestone	Major: Calcite, Minor: Quartz, Clay
Basalt	Major: Anorthite, Plagioclase, Augite, Quartz, Minor: Calcite

2.2. Water Quality Testing

The strength and longevity of concrete structures depend on the quality of the water. The ultimate strength and durability of the concrete are critically dependent upon the quality of the water used in mixing it [26]. Impurities like salts, acids, or organic matter in the water can have a negative impact on the properties of the concrete, causing decreased strength, cracking, or corrosion of the reinforcing steel. The presence of sulfate in the water used to mix concrete can result in the formation of ettringite, which is a mineral that can cause the concrete to expand and crack [27]. Therefore, using high-quality water is essential. The quality of the water used in the experiment (Table 5) was analyzed, and the results are acceptable.

Table 5. Properties of water quality used in concrete mix

Item	Property	Unit	Results	JS/286 Standard Limit
1	pH		7.6	6.5-8.5
2	Total Dissolved Solids	mg/l	364	Max 1500
3	Chloride	mg/l	78	Max 500
4	Sulphate	mg/l	96	Max 500

2.3. Cement Quality Testing Results

Standard laboratory testing for concrete, which shows acceptable levels, was conducted (Table 6).

Table 6. Cement quality testing results

Physical Properties			
Specific Surface	cm^2/g	4500-5000	Limits
Soundness (Expansion)	mm	0.5-2	<10
Setting time	min	130-165	>60
2-day Compression	MPa	24.2-29.9	>10
28-day Compression	MPa	45.5-51.7	42.5-62.5
Chemical Analysis (mg/l)			
SiO_2		22.3-24.7	No limit
Al_2O_3		5.8-6.8	No limit
Fe_2O_3		4.5-5.5	No limit
CaO		51.3-56.3	No limit
MgO		4.1-5.4	No limit
SO_3		2.7-3.4	<3.5
CL^-		0.02-0.04	<0.1
K_2O		0.6-1.1	No limit
Free Lime		1.5-2.2	No limit
Loss in ignition		1-2.1	No limit
Insoluble Residue		5-10	No limit

2.4. Physical and Chemical Properties for Aggregates

The size and grade distribution of aggregates play a crucial role in determining the strength, durability, and workability of concrete. The selection of aggregate size and grading is one of the most important factors in the production of high-quality concrete [28]. The size and distribution of aggregates affect the packing density of the concrete mix, which in turn impacts its strength and resistance to wear and tear [29]. A well-graded aggregate in the concrete mix improves its strength and durability, as well as its workability. The size and distribution of aggregates can also affect the water demand and cement content of the mix, which can impact its cost and environmental footprint. Therefore, it is important to carefully select the size and grade distribution of aggregates for each specific application to achieve the desired performance and quality of the concrete [29]. Table 7 shows an acceptable result of the sieving analysis. The quality of aggregates was analyzed by running laboratory tests of physical and chemical properties, as shown in Table 7. The physical and chemical properties fall within the range. Also, sieve analysis shows an acceptable grain size distribution.

Table 7. Coarse and Fine Aggregates Quality testing

Test	Coarse-large	Coarse-medium	Fine-Crushed sand	Fine-Natural sand
Oven dry (SG)	2.405	2.439	2.404	2.612
S. Surface Dry (SG)	2.499	2.529	2.498	2.622
Water Absorption	3.9	3.7	3.9	0.4
Sand Equivalent %	-	-	-	75
Abrasion at 500 rev.	29%	29%	-	-
Flakiness Index %	11.9	11.9	-	-
Elongation Index %	6.7	6.7	-	-
Chloride content %	0.009	0.009	-	0.012
Sulphate content %	0.075	0.075	-	0.106
Sieve Analysis				
1½”	100	100	100	100
1”	100	100	100	100
3/4”	62	100	100	100
3/8”	2.1	69	100	100
#4	1.9	3.8	55	100
#8	1.8	1.2	4.2	97
#16	1.8	1.2	4	90
#30	1.8	1.2	3.8	52.1
#50	1.8	1.2	3.7	22
#100	1.8	1.2	3.5	2.1
#200	1	1.2	3.1	1.2
Combined F. M	-	1.1	-	3.09

The distribution of aggregate size grading was evaluated using the grading curve as shown in Figure 3. The aggregate size distribution falls within the working range.

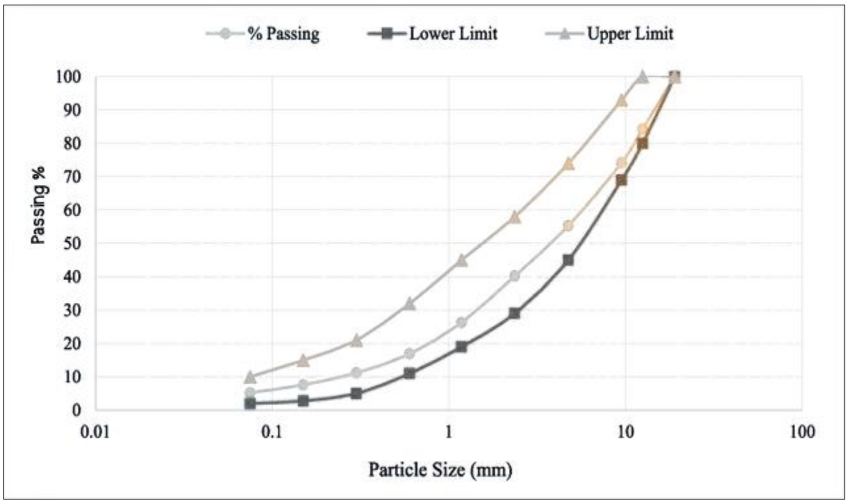


Figure 3. Combined Aggregate Grading Curve with minimum and maximum limits

2.5. Concrete Mix Design

In this study, two types of dust were investigated: limestone and basalt. We set several replacement fractions of sand for the two types of dust in the concrete mixture and worked to improve by substituting a percentage of dust—10, 20, 30, and 40%—for sand. The experiment includes 6 cubes with 0.15×0.15×0.15 m and 6 cylinders with 0.10×0.20 m. The experiment produced samples, which are shown in Figure 4.

Figure 4. Concrete Samples used in cubes and cylinders

For each test, 36 cubes and 36 cylinders of concrete frames were prepared, and the results were examined after 7 days and 28 days, respectively. In order to speed up the reaction, additives will also be added to the concrete mix. Cube molds of standard size 150mm for making the test specimens and weight batching for weighing the materials were taken throughout the investigation, with hand mixing to mix the constituents of concrete. A symmetrical distribution of the concrete mix was ensured as it was layered into the cube mold in layers about 5 cm deep, and each layer was compacted by a table vibrator. The concrete cubes were demolded for curing after 24 hours. Concrete cubes were crushed on specific days using a compression testing machine (CTM) with a 2000 KN capacity that complied with standard method IS:14858-2000 to assess the compressive strength. Standard concrete mix composition without replacement is shown in Table 8.

Table 8. Proposed components weights for one cubic meter of concrete Mix

Concrete Grade		25 N/mm^2
Type of Materials	**Unit**	**Weight fraction per m^3**
Coarse-Large	(kg/m^3) (Dry)	420
Coarse-Medium	(kg/m^3) (Dry)	455
Medium	(kg/m^3) (Dry)	235
Sand	(kg/m^3) (Dry)	700
Cement PPC	(kg/m^3)	280
Water (Net)	(L/m^3)	148
Water (Total)	(L/m^3)	194
SP6RR-AA additive	(L/m^3)	6
W/C	-	0.53
Air content	%	3.0

The replacement fractions are summarized in Table 9, where we have defined incremental fractions for increasing the replacement of fine aggregates.

Table 9. Dust replacement fractions as part of Sand

	Replacement percentage	Kg dust
Basalt dust Experiment and Sandstone dust Experiment	10%	2.4
	20%	4.8
	30%	7.2
	40%	9.6

3. Results

The compressive strength and tension of the concrete cube samples are calculated by dividing the maximum load applied to the sample during the test by the cross-sectional area. The average of three values of compressive strength was taken as the representative compressive strength. The cube samples are placed in the CTM machine in such a manner that the load is applied to the opposite sides of the concrete cube as cast, that is, not to the top and bottom as per IS:516-1959 specification.

3.1. Compression

Results show that a small basalt fraction of 10% increases compressive strength after 7 days of curing. Meanwhile, a 20%, 30%, and 40% replacement of sand caused a reduction, as shown in Figure 5.

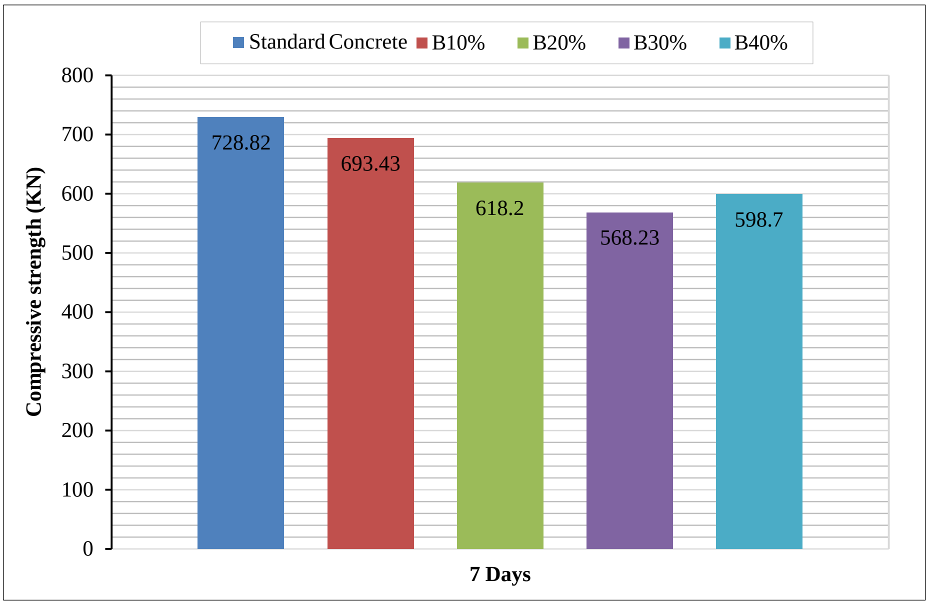


Figure 5. Compressive strength in KN Comparison with standard for Basalt powder replacement 7 days

Limestone dust replacement did not increase compressive strength; however, 20% replacement reached a similar level of compressive strength as shown in Figure 6.

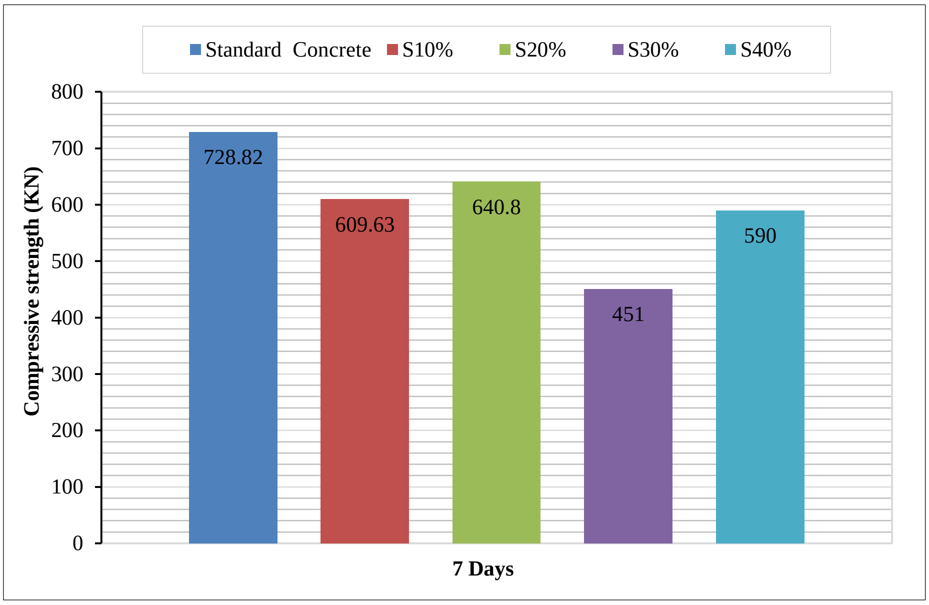


Figure 6. Compressive strength in KN Comparison with standard for Stone powder replacement 7 days

The 28-day strength is commonly used as a basis for quality control and acceptance of concrete in construction projects [30]. The standard practice is to measure concrete properties after a standard period of 28 days of curing. The 28-day mark is a reasonable period to obtain a good representation of the final properties of the concrete. This duration allows sufficient time for the hydration process to complete and for the concrete to achieve its maximum strength and durability [31]. Moreover, testing concrete properties at 28 days allows for comparison with standard specifications and guidelines, such as ASTM standards or building codes, which typically require 28-day test results for compliance [31]. The compression test results for basalt are shown in Figure 7. Basalt powder replacement of 20% shows the highest compression improvement.

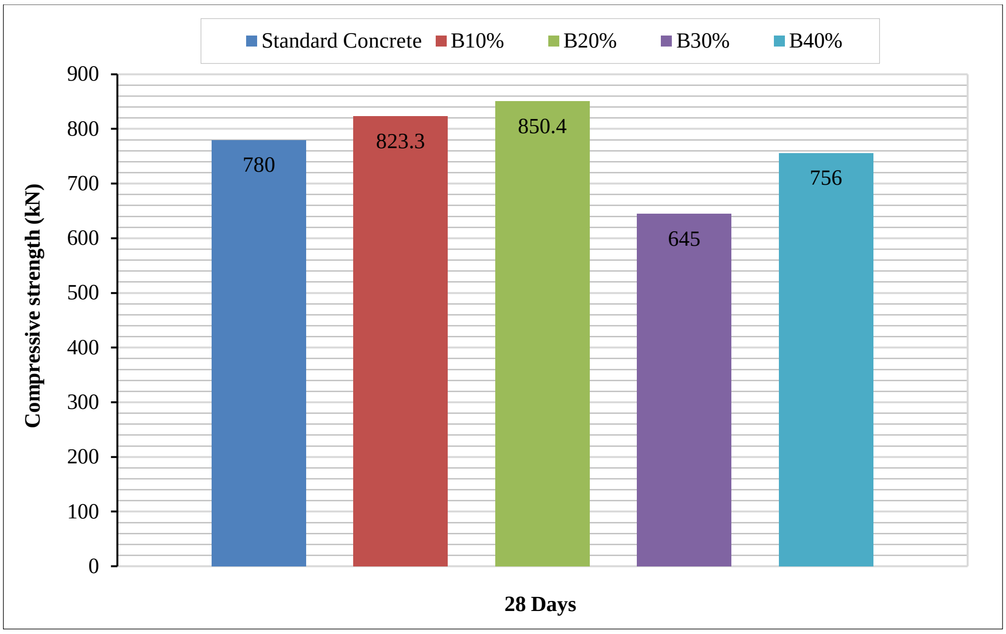


Figure 7. Compressive strength comparison with the standard for Basalt dust replacement 28 day

Compression results for limestone are shown in Figure 8. Limestone powder did not improve compression; however, reduction was marginal.

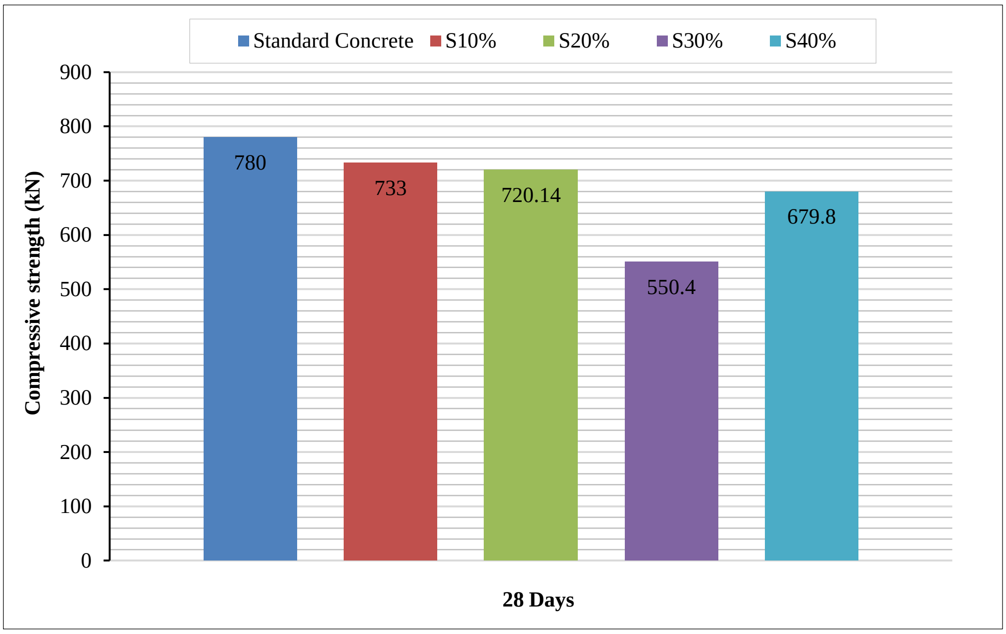


Figure 8. Compressive strength comparison with the standard for Limestone dust replacement 28 day

3.2. Tension

Tension is an important property of concrete that is measured to evaluate its strength and durability. To measure the tension in concrete cylinders, a testing machine is used to apply a uniaxial tensile force to the specimen until it fails. The force required to cause failure is measured, and the tensile strength of the concrete is calculated based on the cross-sectional area of the sample. Tension testing of concrete cylinders is a widely accepted and standardized method for evaluating the quality and performance of concrete in construction [28].

Basalt dust had a positive effect on the tension of the concrete mix compared to the reference no-replacement concrete on all levels. Specifically, when 40% of the silica sand was replaced with basalt dust, the tension increased by 22%. The 10, 20, and 30% provide less improvement in tension, which indicates a close to linear trend. Basalt powder replacement of 40% showed the highest improvement, as shown in Figure 9.

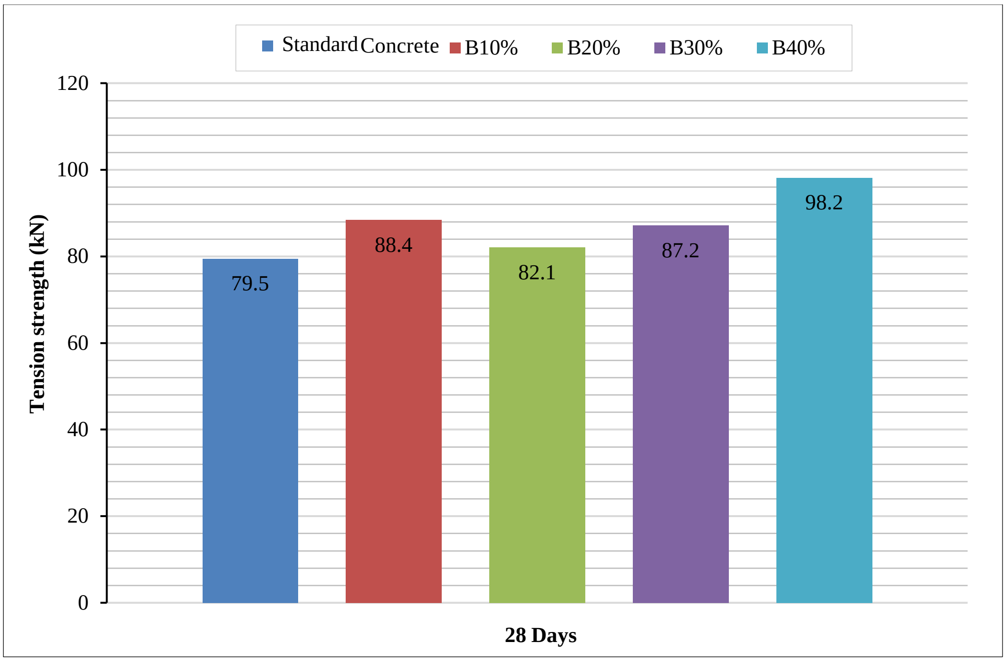


Figure 9. Tension strength comparison with the standard for Basalt dust replacement 28 day

Limestone dust addition impact is not proportional to replacement fraction. While 10, 30, and 40% show no significant change, 20% replacement induced a 37% increase in tension strength. Limestone replacement of 20% shows significant improvement, as shown in Figure 10.

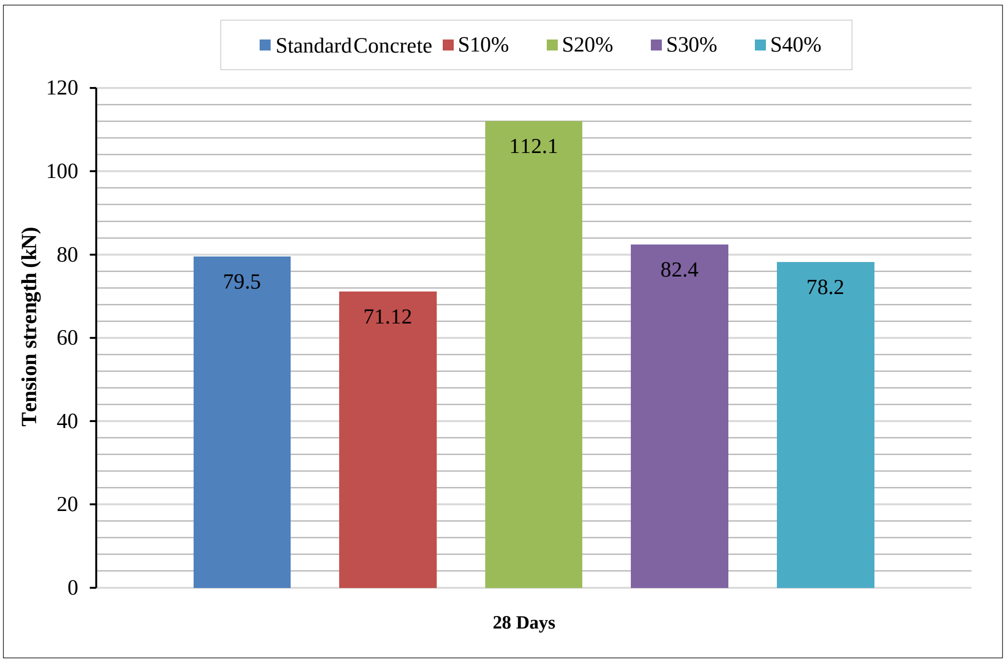


Figure 10. Tension strength comparison with the standard for Basalt dust replacement 28 day

3.3. Stress- Strain Behavior

A compressive stress-strain curve is an important material characteristic of concrete [30].

As observed, compressive stress-strain curves were accurately simulated. In fact, the PR algorithm was not only able to predict the elastic and hardening phases, but it also simulated the plastic phase. Due to the linear behavior in the elastic phase, the prediction of this part of the compressive stress-strain curves was easy. The basalt samples (Figure 11) show higher strain, especially at the 10% replacement fraction, which indicates higher tensile strength and ductility.

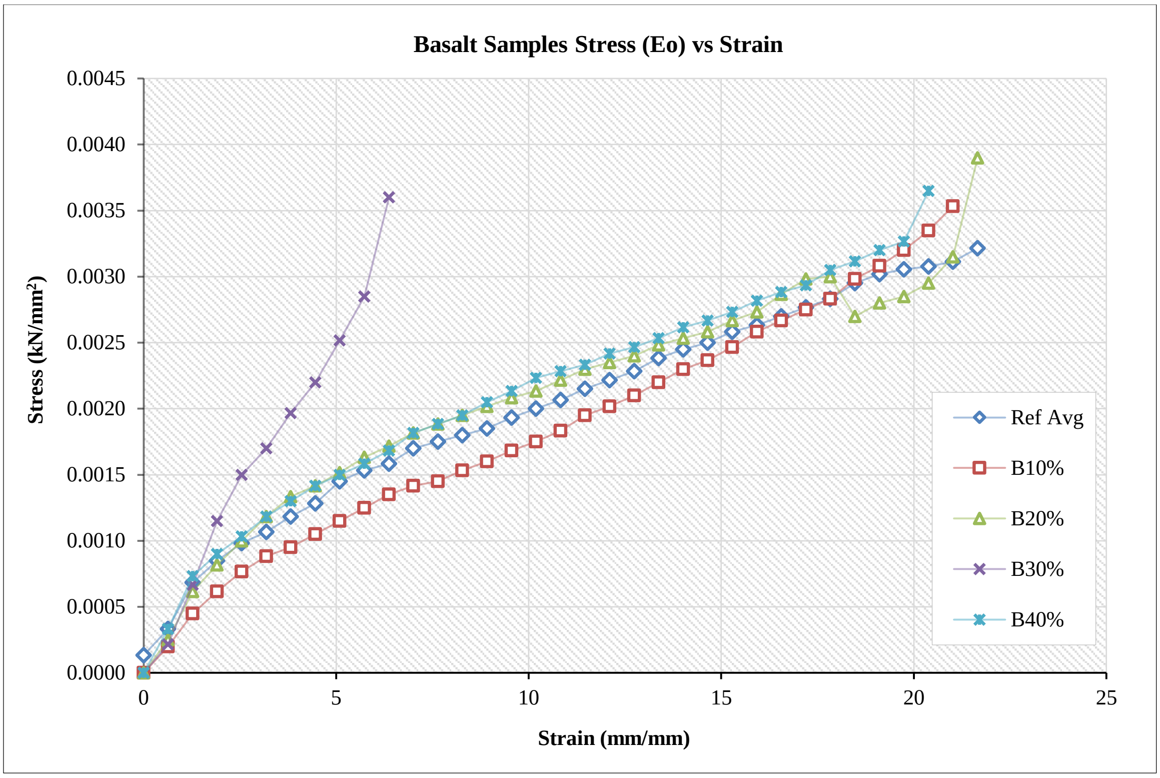


Figure 11. Stress-strain curves measured for Basalt replacement concrete samples

The limestone samples at 10% fraction show high strain (Figure 12). Also, at maximum value, the 40% curve shows slightly less strain than standard, which can be practical for applications where ductility is not needed.

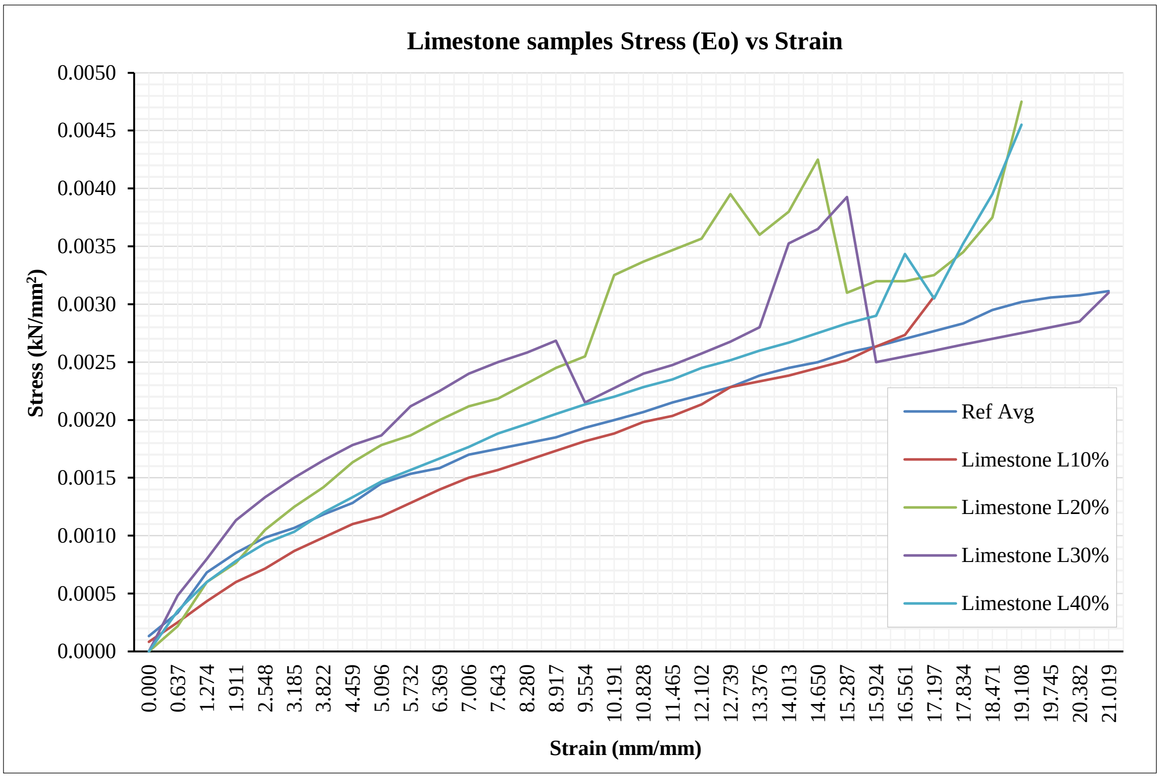


Figure 12. Stress-strain curves measured for Basalt replacement concrete samples

The average compressive strength of standard concrete for 7 days was tested as per MPa (32.4) guidelines, and results are tabulated in the tables and graphs above. Figure 13 shows that when 10% of the silica sand was replaced with basalt dust, the concrete mixture reached optimal compression, but the compression was greatly decreased when 30% of the silica sand was replaced with basalt dust.

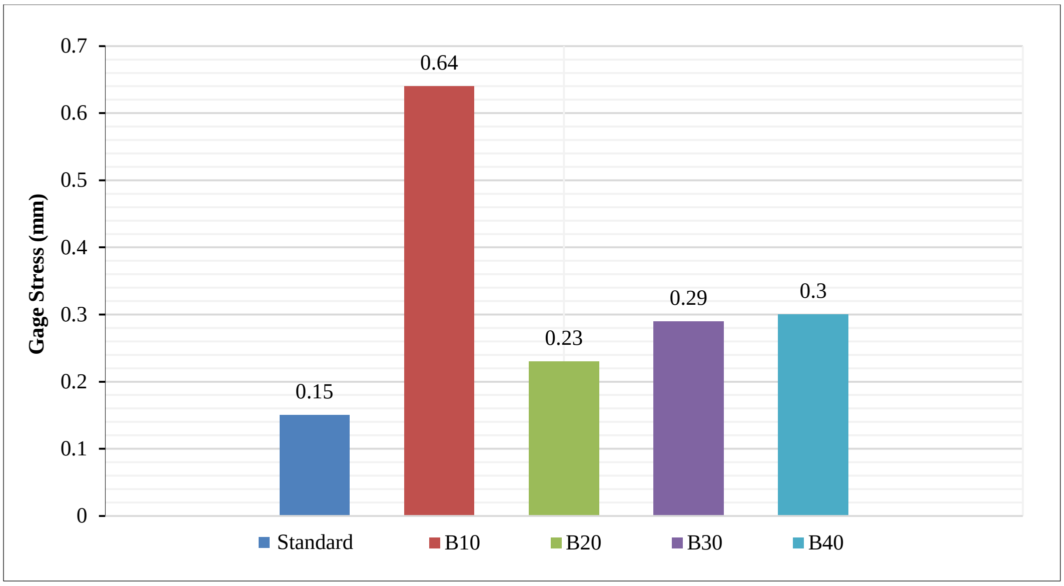


Figure 13. Maximum stress obtained for Basalt dust Replacement

For replacement with limestone dust, Figure 14 shows similar high stresses are observed with 40% and 10% fractions. However, when 20% of the silica sand was replaced with stone dust, the tension of the concrete mixture increased by 30% compared to the standard concrete mixture, but it did not improve the tension.

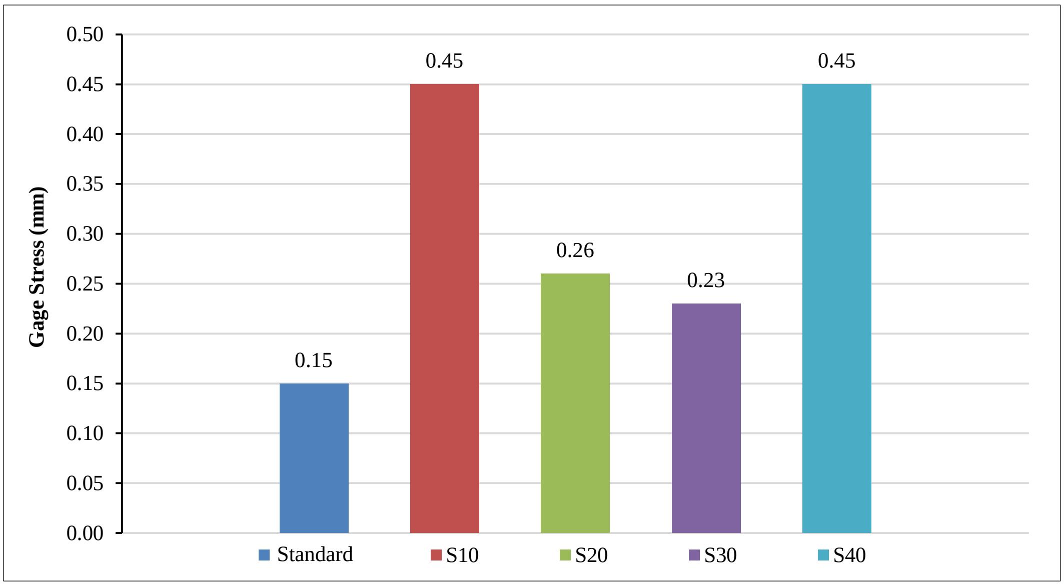


Figure 14. Maximum stress obtained for Limestone dust Replacement

4. Summary and Conclusion

The utilization of basalt dust and limestone dust as substitutes for sand in concrete mix designs demonstrates enhancements in physical properties such as compressive strength, strain, and tensile strength. These findings align with previous studies conducted on the subject. The outcomes support the recycling of waste from the stone cutting industry in concrete mixing, providing several benefits such as reduced disposal and treatment costs, construction material expenses, and the preservation of natural sand while improving the desirable properties of concrete. A study conducted by Dobiszewska & Barnes [32] examined the potential utilization of waste basalt powder in concrete production through various replacement proportions (10%, 20%, and 30%). The study revealed that the incorporation of basalt powder as a partial substitute for sand could result in an increase of up to 25% in the concrete's compressive strength. However, other studies [33-35] indicated a decrease in compressive strength when high fractions of basaltic waste were used as an additive in concrete mixtures. On the other hand, Aliabdo et al. [16] presented evidence of enhanced compressive strength in formulations incorporating 10% marble waste in mixtures, while Ergun [19] identified the highest compression strength in mixtures containing 7.5% marble residue. Similarly, Aruntas et al. [36] observed the maximum increase in compression strength in mixtures with 5% marble waste. These studies collectively suggest that the utilization of waste basalt or marble powder as a replacement for fine aggregate in cementitious mortar and concrete can lead to improvements in certain properties. However, it should be noted that the optimal percentage of substitution may vary depending on specific conditions and the materials used.

The present study reveals the following results: 1) Replacement of 10% of silica sand with basalt dust enhances compression strength; 2) Replacement of either 10% or 40% of silica sand improves tension strength; 3) Replacement of 30% of silica sand with basalt dust leads to a decrease in compression strength compared to standard concrete; 4) Substituting silica sand with stone dust does not enhance the compression strength of the concrete mixture; 5) Replacement of 20% of silica sand with stone dust improves the tension strength of the concrete mixture.

5. Declarations

5.1. Author Contributions

Conceptualization, A.S. and M.A.; methodology, A.S. and M.A.; validation, J.A.; formal analysis, A.S. and M.A.; investigation, M.A.; resources, F.M.; data curation, A.S.; writing—original draft preparation, A.S.; writing—review and editing, A.S.; visualization, A.S. and M.A.; supervision, A.S.; project administration, M.A.; funding acquisition, M.A. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

5.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

5.4. Conflicts of Interest

The authors declare no conflict of interest.

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