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Effect Of Quarry Dust On Mechanical Properties Of Rice Husk Ash-Based Concrete For Sustainable Environment

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ABSTRACT

As the global population has continued to grow, the costs and environmental issues associated with traditional construction materials like cement and river sand have become increasingly problematic. This research aimed to explore an alternative and eco-friendly approach to traditional building materials. The researchers conducted an experimental program to assess the mechanical properties of the rice husk ash-based concrete at different curing ages 7, 14, 21, and 28 days. Following the mix design, the concrete was produced using water to binder ratio of 0.5. A series of experiments were conducted on both fresh and hardened states to investigate the impact of quarry dust on rice husk ash-based concrete. It was observed from the experimental results that when 40% of the quarry dust was used as a replacement for fine aggregates, the concrete exhibited the highest strength. After 28 days of curing, the compressive strength showed a 0.65% improvement, while the splitting tensile strength displayed a 1.77% enhancement compared to the reference mix. To ensure the reliability of the experimental findings, a statistical analysis was conducted. The study concluded that certain factors, such as quarry dust, curing duration, and rice husk ash, interacted synergistically to influence the compressive and splitting tensile strengths of the concrete. The researchers also proposed equations to predict these strengths based on the aforementioned parameters.

Keywords: *Rice husk ash, quarry dust, compressive strength, splitting tensile strength, Statistical analysis*

1. INTRODUCTION

According to the concept of sustainable development, regular assets should be viewed as limited reserves, and trash should be logically governed. Researchers have created novel disposal techniques as a result of the increased amount of waste, which is now gathered more than 2500 million tonnes annually worldwide [1], [2]. Due to economic and environmental factors, sustainable construction is progressively getting more difficult. Because the construction industry consumes the majority of natural resources and generates a significant amount of trash [3], [4]. The creation of sustainable concrete using waste materials including fly ash, ground-granulated blast furnace slag, rice husk ash (RHA), silica fume, bagasse, and cement dust could result in long-lasting and reasonably priced building materials. [5]. Pozzolanic material is one of the most frequently used partial replacements for ordinary Portland cement (OPC) in concrete, and it can improve the quality and durability of concrete[6]. Throughout the history of humanity, concrete has been utilized widely and internationally. The demand for the resources used to make concrete's constituents will rise as its use increases [7].

Because all of the components of concrete are mostly obtained from natural sources, the primary cause of the depletion of natural resources might be linked to this [8]. One of the expensive components of concrete, cement produces a significant amount of CO_2 during manufacturing [7].

The major constituents required for cement production are calcium, silica, and alumina which are obtained from the natural resources. Concrete has been widely utilized throughout the world. The demand for the constituents of concrete has been increased which may lead to depletion of natural resources. Due to the increasing CO_2 emissions, rising temperatures, and loss of natural preserves, the building industry has shifted its focus to creating environmentally friendly and sustainable concrete [9]. Currently, it is quite difficult to dispose of agricultural and industrial trash. Rice husk is one of these agricultural wastes. About 120 million tonnes of rice husk are produced annually in paddy fields. RHA has a non-crystalline silica concentration of 85%, which makes it a

potential partial cement replacement material.[7], [10], [9]. RHA is a pozzolanic substance that has been proven to be effective since it has the most silica of any plant residue. When finely ground, the material can consume calcium hydroxide ($Ca(OH)_2$) at room temperature when it is present in water thanks to its pozzolanic capabilities. Strength is increased as a result of the silica and $Ca(OH)_2$ interaction. Utilizing RHA as a partial cement replacement will help produce more cost-effective and environmentally friendly concrete because it will reduce the cement content. Additionally, the usage of RHA benefits the environment because less of it would need to be dumped, resulting in a decrease in environmental pollution [9].
RHA can be used to make concrete and has an impact on several characteristics, including the internal pore structure, setting time, and development of compressive strength. Therefore, 10%wt is the ideal RHA percentage to produce concrete with good strength and performance [11]. For up to 28 days, 10% of RHA concrete's compressive strength was lower than the control mix's, but after that point it was equal to or greater. Early in the curing process, as the proportion of rice husk ash can be increased in comparison to regular concrete, the compressive strength of the concrete decreases. The rice husk ash increases the strength of concrete because it has a large quantity of silica and it is as effective as silica fume. It produced more C- S - H gel, less portlandite, smaller pores, and higher strength than conventional concrete because the silica in RHA reacted with the Ca^{2+} ions and OH^- make CSH gel. The optimal option in this situation is a 30% substitution of the RHA value [12]. Concrete's mechanical properties and durability are considerably improved when fine aggregate is replaced with quarry dust [13]. Numerous investigations on concrete with RHA have mostly focused on mechanical qualities, according to the prior literature. A summary of a few of these research studies may be found in **Table. 1.** The novelty of this research lies in its investigation of the mechanical properties of concrete through the replacement of 10% of the binder with rice husk ash (RHA) and the variation of fine aggregate proportions with quarry dust (10%, 20%, 30%, 40%, and 50%).In this research, 10% rice husk ash was used because it gives better strength at this optimal proportion which is recommended by previous research[11],[12],[16]. This investigation adds to the novelty of the research, as the specific combination of RHA and varying proportions of quarry dust has not been extensively studied before. The findings will provide valuable insights for the development of more sustainable and cost-effective concrete mixes, offering potential benefits for the construction industry and the environment.

2. CONCRETE MIX DESIGN AND COMPONENT CHARACTERISTICS

Ordinary Portland cement grade 53 conforming from ASTM C150 having a particle size of 18µm was used. The average particle size of rice husk was 80µm. **Table 2** depicts all the characteristics of cement and rice husk ash. In this research, rice husk ash, which is made by burning rice husk at 650°C for 4 hours such that the color of RHA turns into grey and after cooling thoroughly grinding it to create a fine powder, was employed as a partial replacement for binder. The binder plays a crucial part in the production of concrete, and it is vital to finish the experimental program within the allotted time from the date of cement purchase to preserve quality and reduce adverse effects from storage on the concrete's qualitie

Table 1 Findings from research on the influence of RHA on the characteristics of concrete

Author	Investigational Methodology	Conclusion
L. A. Taiwo et al [14]	The sand and cement were replaced by quarry dust and rice husk ash in specific proportions (5%, 10%, 15%, 20%, and 25% wt/wt) to produce concrete samples	By raising the RHA and QD percentages, the decline in compressive strength was seen as compared to conventional concrete samples.
S. Patil et al. [15]	The mechanical characteristics of the concrete were examined at 7, 14, and 28 days. The w/b ratio was kept at 0.4. The ratios of rice husk ash, silica fume, and quarry dust were 10%, 20%, and 30% respectively, with the quarry dust at 20%. Glass fibers were added 0.25%, 0.5%, and 0.75% by volume of concrete.	The maximum strength qualities were discovered to be achieved by substituting the binder with a blend of 20% rice husk ash, 20% silica fume, and 20% quarry dust while adding glass fiber at 0.75%.
S. Sahoo et al. [16]	Mechanical properties and Durability attributes of concrete were investigated by the addition of Silica fume (SF) rice husk ash (RHA) and Portland slag cement. SF and RHA are consumed as distinct amounts of 5%, 10%, 15%, and 20% of PSC, and the attributes of these mixes are compared to those of the control mix, which contains only PSC cement.	The compressive strength of the concrete after 28 days is increased by 23.6% and 20.3%, respectively, compared to the regular mix when 15% replacement SF and RHA are used. However, compared to the control mix, the concrete strength after 90 days increases by 31.7% and 30.95%. The RHA trend is likewise strikingly comparable to the SF concrete's durability characteristics.
G. Singh et al. [17]	Stone dust was consumed to partly substitute 20% of the fine aggregate and RHA was used to partially replace the binder in different proportions to determine the mechanical properties,	The compressive, tensile, and flexural strengths of the concrete were found to be enhanced by 12.17%, 6.60%, and 2.92%, respectively, during 28 days of curing when 15% of the cement had been replaced with RHA.

Table 2 Physical traits of the cement and rice husk ash

Property	Cement	RHA
Specific surface (m^2/kg)	-	54.6
Specific gravity (gm/cm^3)	3.15	2.14
Fineness (%)	94.3	98.5
Consistency	40	-
Initial setting time (min)	116	-
Final setting time (min)	392	-

During the process of quarrying, rocks undergo crushing to get various sizes, resulting in the generation of particulate matter known as quarry dust. The Sargodha crush, a type of coarse aggregate, was utilized in the study. Its size was evaluated by the process of sieve analysis, following the guidelines outlined in ASTM C 116-04. The determined size of the Sargodha crush was found to be 20 mm downwards. Locally abundant sand, such as Lawrencpur sand, was utilized as a fine aggregate or filler material. **Table 3** presents further aggregate characteristics. The water utilized in the experiment was sourced from a standard tap water supply, exhibiting a pH range between 6 and 8, rendering it suitable for human consumption.

Table 3 Physical properties of Aggregates

Property	Fine aggregates	Quarry Dust	Natural Coarse Aggregate
Specific gravity (SSD)(gm/cm^3)	2.67	2.62	2.75
Water absorption (%)	1.12	2.00	1.05
Fineness modulus (mm)	2.58	3.25	6.95
Bulk Density((kg/m^3)	1595	1630	1613

The size distribution of natural sand and quarry dust is shown in Figure 1. To get the desired slump range of 25-75mm, a concrete mix design was implemented by the ACI Code 211.91-09. This entailed doing thorough testing on the various components responsible for the formation of the concrete mixture. To evaluate the impact of varying concentrations of quarry dust on concrete including rice husk ash, a concrete mixture denoted as M1 (consisting of 10% rice husk ash, 90% cement, and 0% quarry dust) was formulated. The slump value of recycled aggregate concrete without any rice husk ash is measured at 55mm. However, the addition of 10 to 15% rice husk ash allows the recycled aggregate concrete to maintain workability, with slump values of about 50mm. This observation is consistent with the experimental findings and aligns with earlier research on the subject matter[12].

This study involves the substitution of different proportions of quarry dust for fine aggregate in concrete produced using rice husk. The percentages of quarry dust used range from 10% to 20%, 30%, 40%, and 50%. Cylinders were cast and subjected to curing at the ages of

7, 14, 21, and 28 days, with a total of 144 specimens being utilized for the assessment of mechanical characteristics. The slump test was employed as a means of assessing the workability of fresh concrete. The compression and splitting tensile strength test were conducted to assess the influence of quarry dust on concrete produced using rice husk. Table 4 presents the data to the mixing patron.

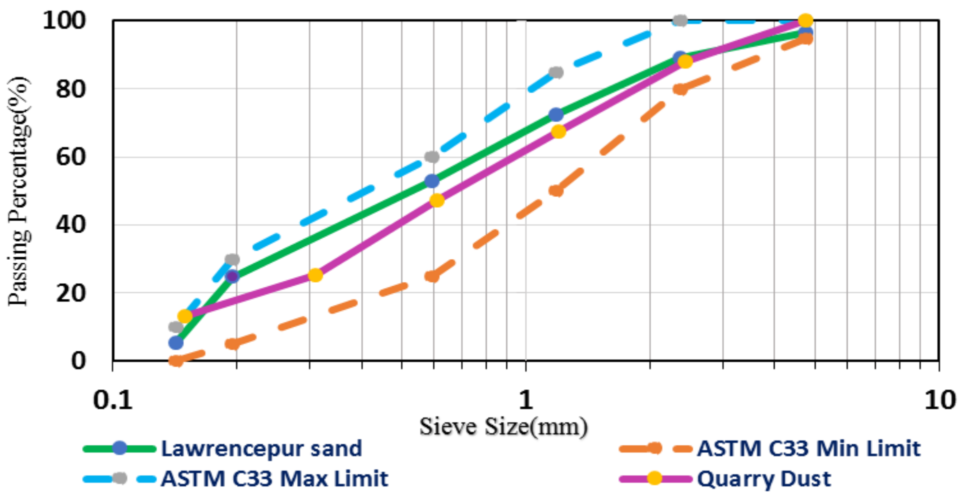


Figure 1 Size distribution of Lawrencpur sand and quarry dust

Table 4 Mix proportion of concrete

Specimen ID	Concrete Ingredients (Kg/m3)					
	Cement	Rice husk ash	Sand	Coarse Aggregate	Quarry Dust	Water
M0	306	0	592	1029	0	205
M1	275	30.6	592	1029	0	205
M2	275	30.6	533	1029	59.2	205
M3	275	30.6	474	1029	118	205
M4	275	30.6	414	1029	178	205
M5	275	30.6	355	1029	237	205
M6	275	30.6	296	1029	296	205

3. RESULTS AND DISCUSSION

The evaluative assessment of the workability of the novel concrete was conducted to ascertain the level of ease associated with its laying process. A slump test was performed following the specifications stated in the ASTM C 143 standard. Figure 2 depicts the relationship between slump values and quarry dust replacement ratios. It is clear from the results that slump values drop linearly as the replacement ratio of sand to quarry dust increases. The potential explanation for this drop might be attributed to the enhanced water absorption capability of quarry dust and rice husk ash. Nevertheless, to get comparable workability to that of fresh control concrete, a specific dose of superplasticizer is required for RHA concrete [18]. The rice husk ash has a significantly elevated specific surface area, hence facilitating prompt water absorption upon its incorporation. [3], [18]. As a result, it can be seen that for various mixes, the slump values are lower than reference mix M0 by roughly 9.33%, 13.7%, 17.8%, 21.9%, 26.0%, and 31.5%, respectively.

To assess the compressive strength, the compression test (ASTM C39) was carried out on concrete specimens made from rice husk by substituting varying percentages of fine aggregate with quarry dust. Following testing, the strength values are shown in Figures 3 and 4.

The aforementioned results indicate that the substitution of fine aggregate with quarry dust led to a decrease in the compressive strength of rice husk ash-based mixtures, in comparison to the control mix M0. However, when the percentage replacement of fine aggregate with quarry dust is increased, there is a noticeable gain in compressive strength, as seen in Figure 3. The compressive strength of Mix 5, which involved a 40% substitution of fine aggregate with quarry dust, was found to be 0.65% greater than the compressive strength of rice husk ash-based concrete mix M1. This increase in strength was observed after 28 days of curing, which is the maximum duration required for achieving optimal compressive strength. The observed increase in strength may be attributed to the pozzolanic interaction between rice husk ash (RHA) and quarry dust with calcium hydroxide ($Ca(OH)_2$), which is produced during the hydration process of cement. Consequently, a greater quantity of calcium silicate hydrate (CSH) was generated. The deposition of this product within the pore system resulted in an increased homogeneity and density of the cement paste, surpassing that of mix M1. Nevertheless, when the replacement level reaches 50%, the compressive strength experiences a sudden decline of 0.56% during 28 days. This decline might perhaps be attributed to the enhanced water absorption capacity of quarry dust.

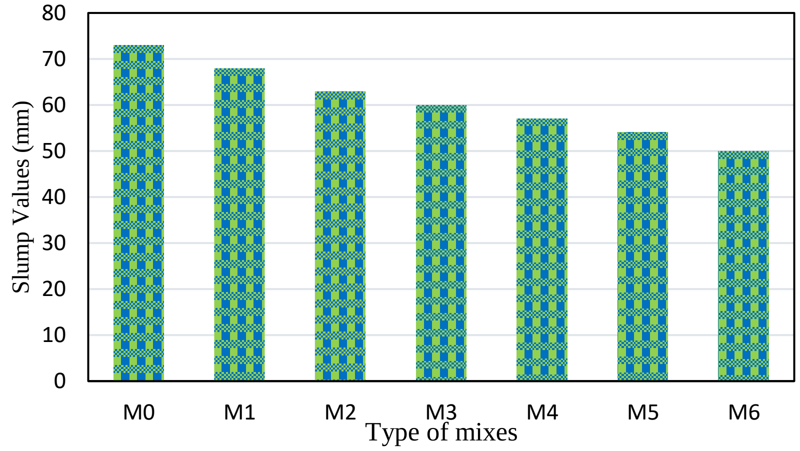


Figure. 2 Slump Values

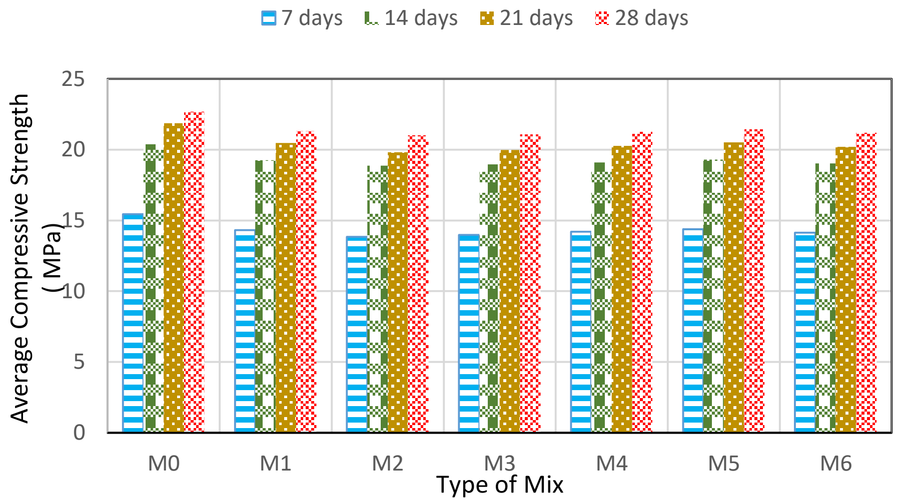


Figure. 3 Compressive strength result

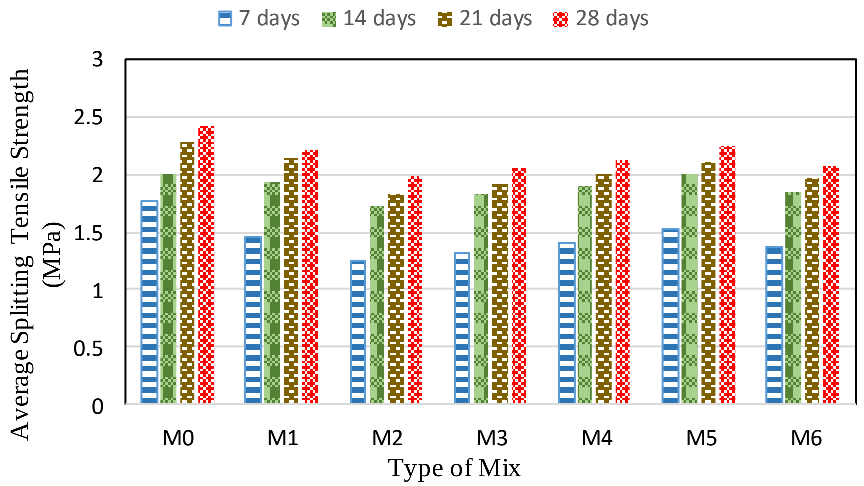


Figure. 4. Splitting Tensile strength result

To determine the effects of replacing a percentage of quarry dust with fine aggregate in concrete specimens made from rice husk ash, the splitting tensile strength test (ASTM C496 and BS 1881 117-83) was conducted. Figure 4 presents the splitting tensile strength data after experimentation. The splitting tensile strength at 28 days for rice husk ash-based concrete with a 40% substitution of fine aggregate with quarry dust reaches a maximum value of 2.25 MPa. Based on the findings of the experiment, the inclusion of additional quarry dust in all combinations leads to a notable enhancement in their splitting tensile strength. Following a curing period of 28 days, the compressive strength of mix M5 has exhibited a growth of 1.77% when compared to mix M1. The experimental results indicate a reduction of 6.33% in the splitting tensile strength when the fine aggregate is substituted with 50% quarry dust.

The observed decrease in compressive and splitting tensile strength can be attributed to the elevated silica (SiO_2) content present in the combination of RHA, quarry dust, cement, and river sand, which led to the chemical reaction. The reaction between calcium hydroxide ($Ca(OH)_2$) present in Portland cement and silicon dioxide (SiO_2) and aluminum oxide (Al_2O_3) derived from rice husk ash (RHA) and quarry dust (QD), respectively, leads to the production of calcium silicate hydrate (C-S-H) and calcium aluminate silicate hydrate (C-A-S-H)[14]. The rice husk ash (RHA) has an excessive amount of silica, which lacks an adequate amount of CaO or $Ca(OH)_2$ to undergo a reaction and generate cementitious compounds such as C-S-H and C-A-S-H. Consequently, this deficiency leads to reduced strength in the concrete made from rice husk ash and high levels of quarry dust. Previous studies have demonstrated a decrease in compressive strength when cement is partially substituted with RHA and sand is replaced with quarry dust [3], [11], [14]. In this research, the optimal percentage of RHA was fixed as 10% and quarry dust values would be varied because both waste material has high silica content. Table 5 presents the percentage strength variation to the control mix M0, as well as the corresponding standard deviation for all mixes.

4. REGRESSION ANALYSIS

This study used statistical analysis using Minitab software to evaluate the influence of quarry dust on the compressive and tensile strength of concrete produced from rice husk ash. Utilizing this methodology to establish the correlation between a limited number of input and output variables is a commendable proposition. In Table 6 and Table 7, the regression model's coded coefficients for the input variables are displayed. In contrast to the linear nature of single terms like Q.D and Time, Q.D*Time, Q.D*Q.D, and Time*Time, respectively, reflect two-way and quadratic interactions. Regression coefficients are referred to by the abbreviation "Coef," and these coefficients provide information on the strength and direction of the link between the input and output variables. Additionally, the constant terms that are multiplied in a regression equation are these coefficients. While the sign indicates the direction of the relationship, the size of the coefficients tells us how much of an impact a term has on the response variables. The standard error of the coefficients is denoted by the phrase "SE Coef." It demonstrates the accuracy with which can measure the coefficients; the less the error, the greater accuracy with which we can estimate the coefficients. Based on a 95% confidence interval, the "p" values demonstrate the relevance of the term in the regression equation. The terms that have a "p" value less than 0.05 are significant and have a substantial impact on the intended results.

Table 5 Percentage variations in compressive and splitting tensile strength test results with control mix (M0)

Type of Mix	28 days compressive strength			28 days split tensile strength		
	Mean value (MPa)	**Standard Deviation**	**Decrease in compressive strength (%)**	**Mean value (MPa)**	**Standard Deviation**	**Decrease in Splitting Tensile strength (%)**
M0	22.68	0.15	0	2.42	0.15	0
M1	21.31	0.14	6.04	2.21	0.06	8.68
M2	21.02	0.08	7.32	1.98	0.12	18.18
M3	21.09	0.26	7.01	2.06	0.09	14.87
M4	21.26	0.13	6.26	2.12	0.08	12.39
M5	21.45	0.35	5.42	2.25	0.08	7.02
M6	21.19	0.17	6.57	2.07	0.08	14.46

Table 6 Regression Analysis of Compressive Strength and Time

Term	Coef	SE Coef	T Value	P Value	VIF
Regression Constant	8.20	0.712	11.5	0.00	
Q.D	-0.009	0.0260	-0.37	0.717	17.72
Time	1.0194	0.0790	12.90	0.000	34.39
Q.D*Q.D	0.0002	0.0004	0.53	0.605	12.72
Time*time	-0.020	0.00215	-9.30	0.000	32.25
Q.D*Time	-0.00004	0.00078	0.05	0.961	8.41

Table 7 Regression Analysis of Splitting Tensile Strength and Time

Term	Coef	SE Coef	T Value	P Value	VIF
Regression Constant	0.792	0.157	5.06	0.000	
Q.D	-0.00280	0.00571	-0.49	0.630	17.72
Days	0.0999	0.0174	5.76	0.000	34.39
Q.D*Q.D	0.000097	0.000093	1.04	0.311	12.72
Days*Days	-0.001871	0.000473	-3.96	0.001	32.25
Q.D*Days	-0.000066	0.000173	-0.38	0.707	8.41

To examine the impacts of quarry dust and curing time on concrete made from rice husk ash, a regression equation for compressive and tensile strength is created. The software creates equation 1 to link compressive strength versus Q.D. and time on rice husk ash-based concrete. The compressive strength R^2 value after the regression analysis is 97.30%, and the R^2 adjusted value is 96.55%, which provides an outstanding example of a regression model. The coefficient of determination, or R^2, always has a value between 0 and 100%; a greater R^2 number indicates a better match[19]. After performing statistical analysis on experimental values of compressive strength the residual plots are shown in Figure 5. The link between splitting tensile strength and the variable parameters Q.D and time is also shown by equation (2). Following regression analysis, the splitting tensile strength R^2 value is 88.62%, and R^2 corrected is 85.64%. Here, R2 values are more similar to R^2 adjusted values, which demonstrate the models' suitability. After performing statistical analysis on experimental values of compressive strength the residual plots are shown in Figure 6.

The major effect graphs of compressive and breaking tensile strength are shown in Figure 7. These figures show that when substituting quarry dust for some of the fine aggregates, the strength is first reduced. However, increasing the amount of quarry dust substitution will significantly enhance the strength. In comparison to reference mix M0, which contains no quarry dust, it provides greater strength at 40% replacement. Additionally, the impact of curing days on strength reveals the tendency toward improvement.

$$C.S = 8.200- 0.0096\ Q.D+1.0194 Days+0.00023 Q.D*Q.D -0.02003 Days*Days+0.000039\ Q.D*Days \quad (1)$$

$$STS = 0.792-0.00280 Q.D+0.0999 Days+0.000097 Q.D*Q.D-0.001871 Days*Days-0.000066 Q.D*Days \quad (2)$$

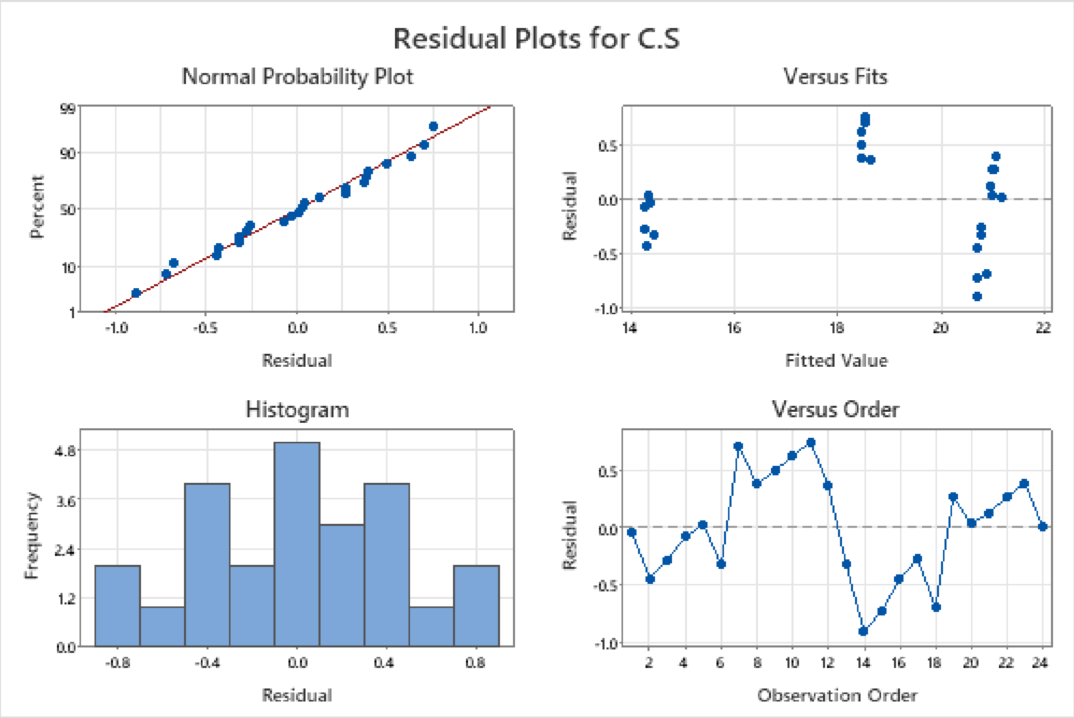


Figure 5 Residual plot for compressive strength values

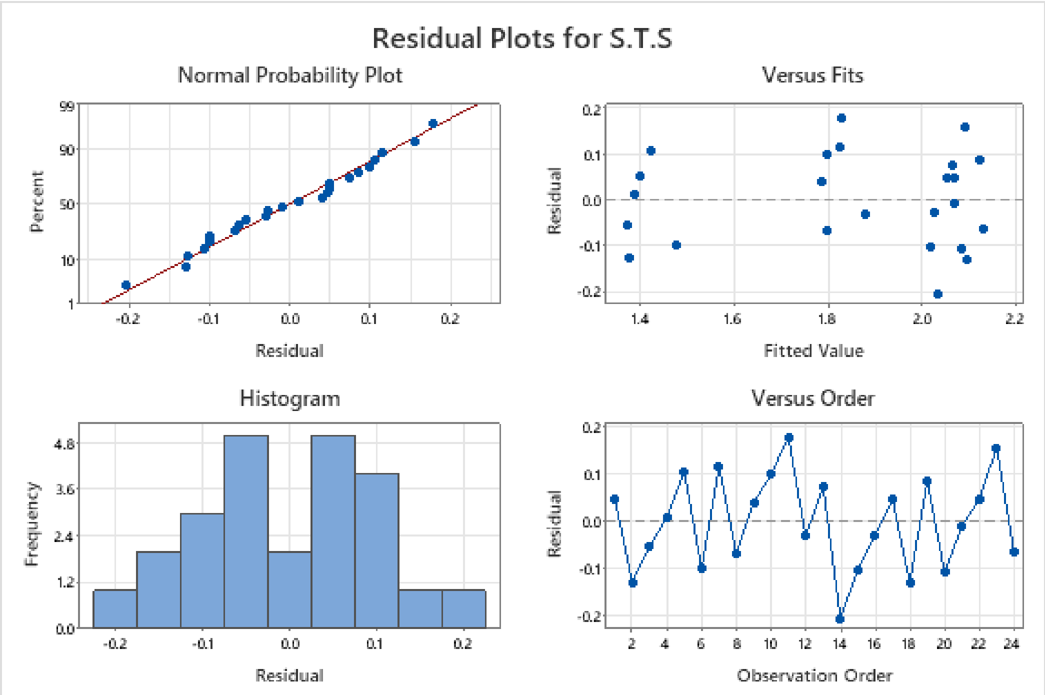
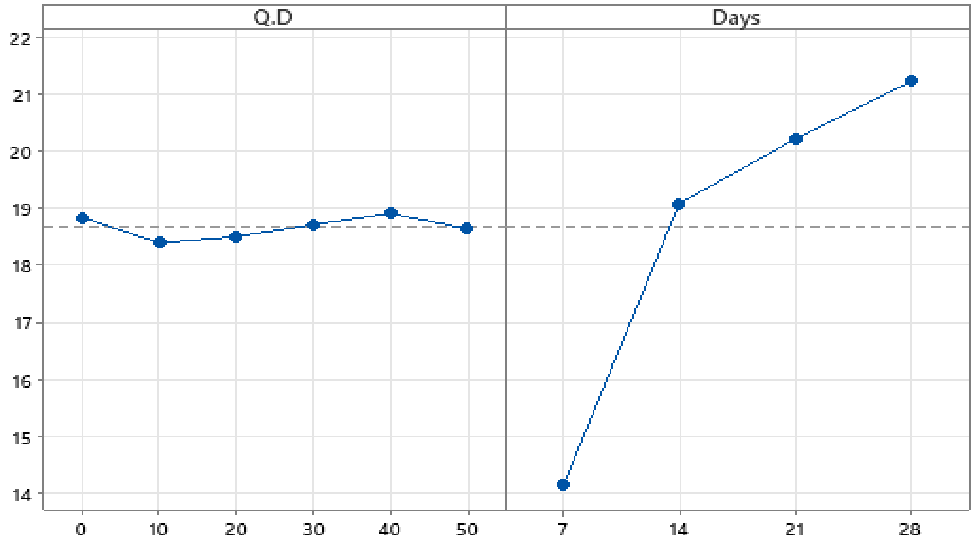
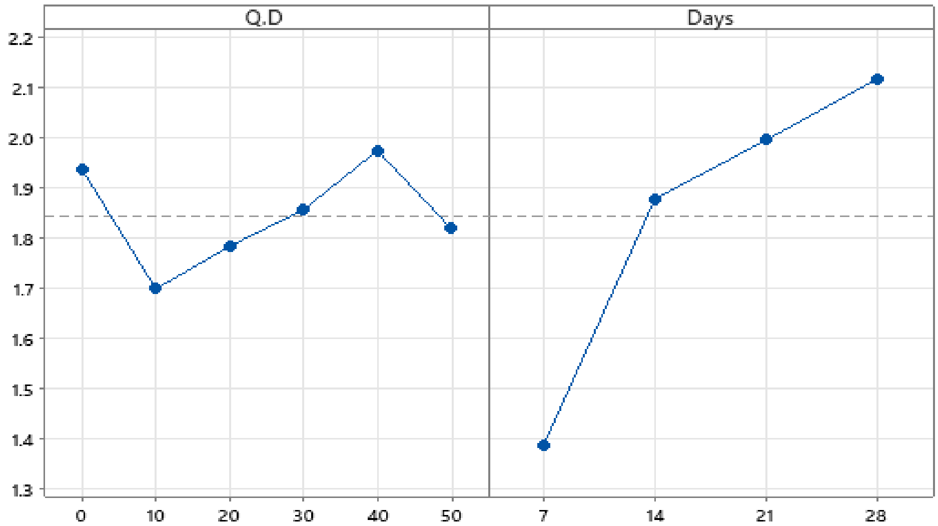


Figure 6 Residual plot for splitting tensile strength values



(a) Compressive strength vs Quarry dust and curing days



(b) Splitting Tensile strength vs Quarry dust and curing days

Figure 7 Main effects plots (a); compressive strength (b) Splitting tensile strength

5. CONCLUSIONS

To check the influence of various percentages of quarry dust on rice husk ash-based concrete, various experiments were conducted. The findings of the experiment led to the following conclusions.

- The workability of the rice husk ash-based concrete was reduced by increasing the percentages of quarry dust compared to the control mix M0.

- The compressive strength of rice husk ash-based concrete with various percentages of quarry dust initially decreased but at 10 to 40% replacement of quarry dust with fine aggregate an increase in strength was observed. In comparison to mix M1 having 10% rice husk ash, the 28-day compressive strength was increased by 0.65%, and the 28-day splitting tensile strength was increased by 1.77% at 40% substitution of fine aggregate with quarry dust.

- The compressive and splitting tensile strength effectiveness of rice husk ash-based concrete was found to be influenced by the combined effects of quarry dust and curing days. The inclusion of quarry dust as a parameter has a substantial influence on the characteristics of concrete. Consequently, the equations utilized for the computation of the CS and STS were introduced, employing a regression statistical analysis. As a result, a prognostic model was developed for the compressive strength of rice husk ash-based concrete

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REFERENCES

[1] J. Ahmad, F. Aslam, O. Zaid, R. Alyousef, and H. Alabduljabbar, "Mechanical and Durability Characteristics of Sustainable Concrete Modified with Partial Substitution of Waste Foundry Sand," *Struct. Concr.*, vol. 22, no. 5, pp. 2775–2790, 2021.

[2] S. Noshin, M. Shahzad Aslam, H. Kanwal, M. Adil Khan, and A. Ahmad, "Effects on Compressive and Tensile Strength of Concrete by Replacement of Natural Aggregates with Various Percentages of Recycled Aggregates," *Mehran Univ. Res. J. Eng. Technol.*, vol. 41, no. 1, pp. 195–201, 2022.

[3] A. Siddika et al., "Performance of Sustainable Green Concrete Incorporated with Fly Ash, Rice Husk Ash, and Stone Dust," *Acta Polytech.*, vol. 61, no. 1, pp. 279–291, 2021.

[4] F. Althoey and M.A. Hosen, "Physical and Mechanical Characteristics of Sustainable Concrete Comprising Industrial Waste Materials as a Replacement of Conventional Aggregate," *Sustain.*, vol. 13, no. 8, 2021.

[5] K.Y. Foong, U.J. Alengaram, M.Z. Jumaat, and K.H. Mo, "Enhancement of the Mechanical Properties of Lightweight Oil Palm Shell Concrete Using Rice Husk Ash and Manufactured Sand," *J. Zhejiang Univ. Sci. A*, vol. 16, no. 1, pp. 59–69, 2015.

[6] P. Rattanachu, P. Toolkasikorn, W. Tangchirapat, P. Chindaprasirt, and C. Jaturapitakkul, "Performance of Recycled Aggregate Concrete with Rice Husk Ash as Cement Binder," *Cem. Concr. Compos.*, vol. 108, p. 103533, 2020.

[7] N. Bheel, A.W. Abro, I.A. Shar, A.A. Dayo, S. Shaikh, and Z.H. Shaikh, "Use of Rice Husk Ash as Cementitious Material in Concrete," *Eng. Technol. Appl. Sci. Res.*, vol. 9, no. 3, pp. 4209–4212, 2019.

[8] S. Das, R.K. Patra, and B.B. Mukharjee, "Feasibility Study of Utilisation of Ferrochrome Slag as Fine Aggregate and Rice Husk Ash as Cement Replacement for Developing Sustainable Concrete," *Innov. Infrastruct. Solut.*, vol. 6, no. 2, pp. 1–18, 2021.

[9] A.A. Jhatial, W.I. Goh, K.H. Mo, S. Sohu, and I.A. Bhatti, "Green and Sustainable Concrete – The Potential Utilization of Rice Husk Ash and Egg Shells," *Civ. Eng. J.*, vol. 5, no. 1, p. 74, 2019.

[10] H. Ş. Arel and E. Aydin, "Use of Industrial and Agricultural Wastes in Construction Concrete," *ACI Mater. J.*, vol. 115, no. 1, pp. 55–64, 2018.

[11] G. Sua-iam, N. Makul, S. Cheng, and P. Sokrai, "Workability and Compressive Strength Development of Self-Consolidating Concrete Incorporating Rice Husk Ash and Foundry Sand Waste – A Preliminary Experimental Study," *Constr. Build. Mater.*, vol. 228, p. 103533, 2020.

[12] S. Noshin et al., "Evaluating the Compressive Strength of Concrete Containing Recycled Aggregate in Different Curing Conditions," *J. Appl. Eng. Sci.*, vol. 11, no. 2, pp. 127–136, 2021.

[13] B.K. Meisuh, C.K. Kankam, and T.K. Buabin, "Effect of Quarry Rock Dust on the Flexural Strength of Concrete," *Case Stud. Constr. Mater.*, vol. 8, no. July 2017, pp. 16–22, 2018.

[14] L.A. Taiwo, I.I. Obianyo, A.O. Omoniyi, A.P. Onwualu, A.B.O. Soboyejo, and O.O. Amu, "Mechanical Behavior of Composite Produced with Quarry Dust and Rice Husk Ash for Sustainable Building Applications," *Case Stud. Constr. Mater.*, vol. 17, no. April, p. e01157, 2022.

[15] S. Patil, T.H. Patel, and E. Yashodha, "The Effect of Rice Husk Ash, Silica Fume, and Quarry Dust on Glass Fibre Reinforced Concrete's Strength Properties," *Mater. Today Proc.*, vol. 59, pp. 918–925, 2022.

[16] S. Sahoo, P.K. Parhi, and B. Chandra Panda, "Durability Properties of Concrete with Silica Fume and Rice Husk Ash," *Clean. Eng. Technol.*, vol. 2, no. March, p. 100067, 2021.

[17] G. Singh, "Influence of RHA and Stone Dust on Properties of Concrete," *Mater. Today Proc.*, vol. 37, no. Part 2, pp. 2441–2445, 2020.

[18] S. Bahri, H.B. Mahmud, and P. Shafigh, "Effect of Utilizing Unground and Ground Normal and Black Rice Husk Ash on the Mechanical and Durability Properties of High-Strength Concrete," *Sadhana - Acad. Proc. Eng. Sci.*, vol. 43, no. 2, pp. 1–12, 2018.

[19] G.M. Uddin et al., "Comparative Performance Analysis of Cemented Carbide, TiN, TiAlN, and PCD Coated Inserts in Dry Machining of Al 2024 Alloy," *Int. J. Adv. Manuf. Technol.*, vol. 112, no. 5–6, pp. 1461–1481, 2021.