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# Silica Quartz Characteristics from Local Silica Sand on Compressive Strength of Mortar

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**Abstract**

Many minerals, including quartz sand, granite, and feldspar, contain silica ($SiO_2$), a substance that performs the same function as quartz. Silicate ($SiO_2$), the primary mineral found in silica sand, can be added to concrete mixtures to boost strength. This means that silica sand can be employed as a cementitious component in concrete because it is believed to have pozzolanic and amorphous qualities. This study is part of a series that tries to use silica sand from an area in Indonesia. The purpose of this research was to manufacture and describe quartz silica (QS) from Kolaka silica sand, which was acquired from Southeast Sulawesi province in eastern Indonesia. In order to improve the characteristics of mortar mixtures that use composite Portland cement as a binder, it is advised to combine the X-ray diffraction process with an evaluation of the impact of addition (QS) on their physical and mechanical properties (volume weight and compressive strength). Laboratory experimentation is being conducted here. Water, cement, and silica sand are used to make mortar specimens. Red and white silica sand is the type of silica utilized. The specimens were created with a 50 mm diameter and a 100 mm height. Tests on mortar's compressive strength were performed after 7, 14, and 28 days. The study's findings indicated that the amounts of quartz formed in red and white silica sand were 45.05% and 91.87%, respectively. The volume weight that results is approximately 2.78 gr/cm$^3$. Red silica sand was tested for compressive strength at ages 7, 14, and 28 days, and the findings were 20.73, 23.32, and 24.61 MPa, respectively. White silica sand has compressive strengths of 21.83, 24.67, and 26.52 MPa. We are aware of no prior studies examining the use of crystalline silica from Kolaka silica sand to enhance the mechanical qualities of cement mortar.

*Keywords:* Silica Quartz; Local Silica Sand; Compressive Strength; Mortar.

## 1. Introduction

The accessibility of concrete as a building material will be significantly impacted by the accelerating development. The need for construction supplies will rise as a result. Because cement is a component of concrete that is more expensive than other material components like sand and gravel, numerous studies on concrete materials have been conducted to find substitute materials that can replace cement (cementitious material) [1-3]. Fly ash is one example of a cementitious material. It is frequently used as a cement substitute and contains silicate ($SiO_2$) as its primary component. Because the primary constituent contains silicate ($SiO_2$), this research aims to find substitutes for cement, specifically silica sand.

When used in place of cement, silica sand is believed to strengthen concrete more than using regular sand since it contains more than 90% silicon dioxide ($SiO_2$) in the form of silica fume [4]. Salih et al. (2021) [5] have investigated silica sand, which is used to create the powder known as silica powder. According to the study's findings, silica powder

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can be added to concrete mixtures to boost their strength. The compressive strength can be increased by up to 40%, the tensile strength by 20%, and the flexural strength by 4% with the addition of 30% silica powder.

Silica is a substance that can be made from crystal synthesis, plant silica, or minerals having the molecular formula $SiO_2$ (silicon dioxide). Mineral silica is a substance that is frequently discovered in mined or excavated materials in the form of minerals that include silica crystals ($SiO_2$), such as quartz sand, granite, and feldspar [6, 7]. In addition to being formed naturally, quartz sand can be heated to a temperature of 870°C to produce silica with a tridymite crystal structure, and at a temperature of 1,470°C to produce silica with a cristobalite structure [8]. Impurities in silica are transported during the deposition process. White sand, sometimes referred to as quartz sand, is produced as a result of the weathering of rocks that contain the primary minerals quartz and feldspar. $SiO_2$, $Al_2O_3$, CaO, $Fe_2O_3$, $TiO_2$, CaO, MgO, and $K_2O$ make up quartz sand. The impurity compounds determine whether it is clear white or another hue. The mining method used to obtain common silica begins with the extraction of quartz sand as a raw material [9, 10]. Depending on the state of the quartz from the mining site, the quartz sand is next treated to a washing process to remove mud and biological contaminants, which are then separated and dried again to obtain sand with a greater silica content. After that, this sand is referred to as silica sand or silica with a specific amount [11-15].

Using a blend of silica sand, numerous scientific advancements have been made in recent years to boost the compressive strength of concrete. Mineral, vegetal, and crystalline silica can be used to create silicon dioxide, often known as silica sand ($SiO_2$), a naturally occurring mineral substance having the chemical formula $SiO_2$. The silica sand used in this study is ground into silica sand powder (SPS). After 28 days, the test results were acquired utilizing 30%, 40%, and 50% silica sand powder (SPS) variations. Concrete without SPs (0%) has a compressive strength of 63.26 MPa. The highest compressive strength at 30% SPS was attained with fineness I at 56.26 MPa, whereas at fineness II, the highest SPS at the 30% variation was 40.46 MPa. The $SiO_2$-containing fine aggregate content will speed up the concrete's hardening process and boost its compressive strength. The study's findings indicate that the compressive strength of concrete is greater than the compressive strength of concrete mixed with sand when the $SiO_2$ content of the sand is greater than 40%. Cement and river sand were combined using roof tile debris and silica powder in the K-250 concrete quality test investigation. With each addition of 10%, sample 2's roof tile powder to cement and silica sand to river sand produced the highest compressive strength, reaching K-258.

The silica sand used in this study will first be refined (gridded) with two levels of silica sand powder fineness, and then the chemical compound content will be sought out through chemical research. It is anticipated that this process will produce fineness and compounds whose levels meet the requirements of pozzolan, and it is also hoped that it will determine the strength of the resulting mortar. In order to assess the physical (volume) and mechanical (compressive strength) properties of the mortar made with silica sand and composite Portland cement at ages 7, 14, and 28 days, this study will first analyze the chemical properties of silica sand.

### 1.1. Environmental Benefits

Cement's use in the production of mortar and concrete has come under fire. This is especially concerning because the process of making Portland cement releases a lot of carbon dioxide ($CO_2$) into the atmosphere, which can harm the environment and contribute to global warming. It is vital to explore alternative environmentally acceptable materials to counteract these negative impacts, specifically by substituting Portland cement with different by-product materials (waste) from diverse sectors.

Silica sand and composite Portland cement have a lot of chemical features, according to research done by Cao et al. [16]. The mullite and quartz crystalline phases are also said to be destroyed by high-energy ball milling of boiler bottom slag, and the Al-O-Si and Si-O-Si bonds are broken while the amorphous $Al_2O_3$ and $SiO_2$ phases grow, increasing the activity slag quality [16]. Pozzolanic activity is frequently present in amorphous materials with $SiO_2$, which is advantageous for Portland cement-based products [17]. The amount of time coal-burning bottom ash is ground for enhances the activity of the micro filler created, allowing for a 20 to 40% replacement of cement [18]. The concrete industry will benefit and have another way to obtain efficient reactive micro fillers if high-energy grinding with a disintegrator can activate quartz sand, improving the hardening process in cement composites and increasing compressive strength.

Thus, employing silica sand can lessen the need for Portland cement, whose production is not ecologically friendly, which is advantageous from an environmental standpoint. This is shown by the fact that silica sand and Portland cement have a lot in common, especially silica and alumina. Additionally, it may have a higher compressive strength rating if employed in concrete buildings.

## 2. Material and Methods

### 2.1. Preparation of Silica Sand

Silica crystals ($SiO_2$) make up the mineral known as silica sand, which also includes impurities carried throughout the deposition process. White sand, commonly referred to as silica sand, is a byproduct of the weathering of rocks that include silica and feldspar as the primary minerals. Following the effects of weathering, they are washed and transported by wind or water and dumped on the banks of rivers, lakes, or oceans. Combining $SiO_2$, $Fe_2O_3$, $Al_2O_3$, $TiO_2$, CaO, MgO, and $K_2O$, silica sand has a hardness of 7 (on the Mohs scale), a specific gravity of 2.65, a melting point of 1715ºC, a hexagonal crystal shape, a specific heat of 0.185, and a thermal conductivity of 12-100ºC. It is translucent white in colour or other colours depending on the impurity compound.

The Tanggetada location in Kolaka, Southeast Sulawesi's province, was used to harvest natural silica sand. To get rid of dirt, silica sand must first be cleansed. The silica process is improved by using an acid leaching process to remove metal impurities (particularly the quantity of iron oxide and aluminium oxide in the final product), followed by a water wash and then drying in an oven at 120ºC for an hour. The sand is then placed into the sieve shaker to obtain a 300 µm size. Micro silica sand (MS) is then added to a ball mill and ground for two hours. After this, the sand is sent through a mesh for sizes smaller than 300 µm in order to remove impurities and large clusters that result from the grinding process. The sand is then dried once more for one hour in a 120ºC oven. There were four different filter sizes used: 600 µm, 300 µm, 140 µm, and 100 µm. A Malvern Instruments Master Size 2000 particle size analyzer was used to test the ball-milled silica sand after it had been ground for ten hours. The physical characteristics of the red and white silica sand used in this study are depicted in Figure 1.


**Figure 1. Physical appearance of red and white silica sand**

## 2.2. Portland Composite Cement (PCC)

Portland Composite Cement is a hydraulic binding substance made by combining Portland cement powder with other inorganic powders, grinding Portland cement slag and gypsum, and one or more other inorganic ingredients. These inorganic ingredients, which make up 6%–35% of the bulk of composite Portland cement, include limestone, pozzolan, silicate compounds, and blast furnace slag.

According to SNI 7064:2014 [19], Portland cement powder can be combined with additional inorganic powders to make composite Portland cement, or Portland cement clinker and gypsum can be ground together with one or more inorganic components (Table 1). A chemical reaction takes place when water and Portland cement are combined. A tiny quantity of the retarder initially dissolves fast and can interfere with already-occurring chemical reactions. Numerous chemical compounds that result from these reactions bind and solidify. The compressive strength of PCC is increased by the inclusion of lime stone. This happens because of the smooth physical form of the lime stone, which has this fineness value and can fill in cement cavities to increase compressive strength. The process by which cement particles and water react chemically and physically is known as cement hydration. Hydration is the main factor responsible for the bonding (setting) and hardening of freshly put concrete. Hard concrete's characteristics are also affected by the hydration process. Therefore, in order to understand cement properties and concrete behaviour, one must understand hydration chemistry.

**Table 1. Physical properties of Portland composite cement (SNI 7064:2014)**

| No. | Physical Properties | Unit | Specification |
|---|---|---|---|
| 1 | Smoothing with the Blaine tool | $M^2$/kg | Min. 280 |
| 2 | ***Preservation of shape by autoclave*** | | |
| | 1. Expansion | % | Max. 0.80 |
| | 2. Shrinkage | % | Max. 0.20 |
| 3 | ***Setting time with Vicat tool*** | | |
| | 1. Initial setting | Minutes | Min. 45 |
| | 2. Final setting | Minutes | Min. 375 |
| 4 | ***Compressive Strength*** | | |
| | 1. 3 days | kg/$cm^2$ | Min. 125 |
| | 2. 7 days | kg/$cm^2$ | Min. 200 |
| | 3. 28 days | kg/$cm^2$ | Min. 250 |
| 5 | ***Pseudo Binding*** | | |
| | 1. Final penetration | % | Min. 50 |
| 6 | Air content in mortar | % volume | Max. 12 |

## 2.3. Pozzolan Material

Pozzolan is a substance that contains silica and aluminium silica compounds, both of which lack adhesive qualities (cementation) on their own but have very tiny grains that can react with lime and water to create adhesives (hydraulic compounds) at room temperature. This substance is defined by ASTM C618-22 as a material [20].

According to ASTM C618-22 [20], the reaction between silica, lime, and water during the cement hydration process results in adhesive (CSH) and residual hydration (lime). The silica from the pozzolanic material will react with the residual hydration to create a new adhesive (CSH). The pozzolanic process is influenced by a number of factors, including the pozzolanic material's fineness, crystal form, and silica, alumina, ferrite, and base material content. Physical and chemical requirements Materials that constitute pozzolan type N (natural pozzolan), as defined by ASTM C618-03, can be observed in Table 2.

**Table 2. Chemical and physical specifications according to ASTM C618-03**

| Chemical Terms | N Type |
|---|---|
| Silica oxide ($SiO_2$) + Alumina oxide ($Al_2O_3$) + Iron oxide ($Fe_2O_3$), minimum % | 70.0 |
| Sulfur trioxide ($SO_3$), maximum % | 4.0 |
| Water content, maximum % | 3.0 |
| Availability of alkali ($Na_2O$), maximum % | 1.5 |
| Physical Terms | N Type |
| Fineness, maximum % (retained sieve No. 325) | 34 |

## 2.4. Specimen Preparation, Curing, and Testing

This study's goal was to ascertain how Portland composite cement and silica sand affected the compressive strength of cylindrically moulded mortar with a 5 × 10 cm size. Each mix's material volume needs to be correctly matched. To make the cement mortar mix, the dry materials (fine aggregate and Portland composite cement) are first mechanically combined in a mixer at a temperature of around 30°C. The mixture's ingredients are combined until dry after all the volumes have been measured for the various ingredients in accordance with the created proportions. The mixture should be turned over three times until dry for full mixing with a spoon. With the mixing spoon, turn the material by first moving it all to one side, then to the rear, and then back to the front. At this point, the mixture should be consistent in colour and free of any aggregate or binder lumps or pockets. Then, beginning from the inside of the ring, combine the dry ingredients with the water. Turning is repeated three times wet if there is sufficient water to give the mortar mixture a workable consistency. Following that, 5 × 10 cm cylinder specimens are cast for ASTM C780-20 [21] volume weight and compressive strength tests. For the first 24 hours, damp burlap was placed over the moulded specimens to stop moisture evaporation. After demoulding, the samples were dried at a temperature of around 30 °C in a mist chamber before testing. According to ASTM C780-20 [21], the compressive strength of the mortar is assessed after 7, 14, and 28 days.

Treatment (curing), specifically water curing, is applied to all test objects. Curing in the room refers to the process of post-printing storage of the test object at room temperature in the test object storage room. Until the test sample comes at the testing period, it is kept at the laboratory temperature, which is between 250°C and 320°C, with a humidity of 60°C to 74°C. In water curing, the test sample is taken out of the mould and submerged in fresh water until it reaches the testing period. Figure 2 depicts the laboratory water curing of mortar test specimens. The research flow diagram is displayed in Figure 3.

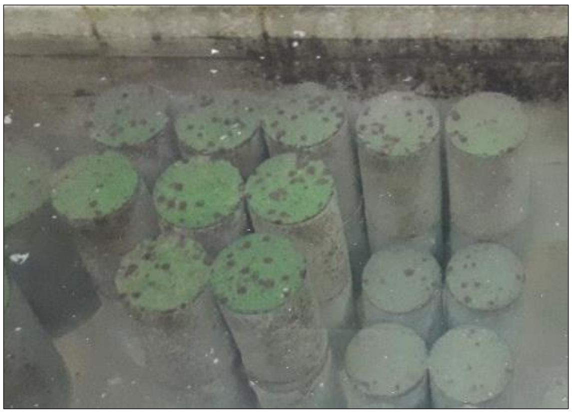


**Figure 2. Water curing in laboratory**

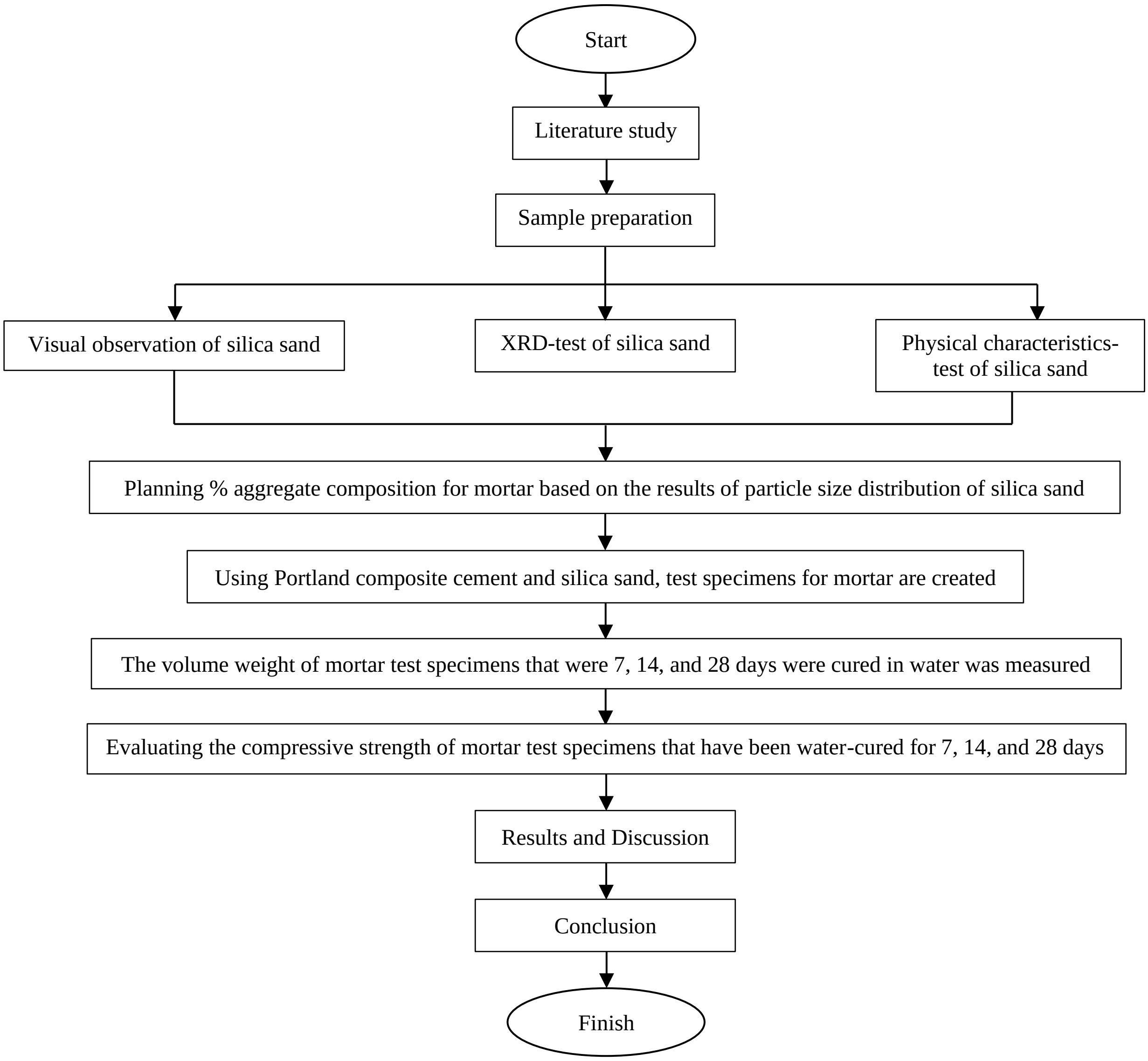



**Figure 3. Flowchart methodology of research**

## 2.5. X-Ray Diffraction

In addition to being used to identify the phase of crystalline materials, X-ray diffraction (XRD) is a quick, non-destructive analytical technique that can reveal information on unit cell dimensions. Solid substances in the form of powder or flour, particularly those having crystalline structures, can be the subject of analysis. An example of an analysis used to determine the existence of a compound is XRD analysis. This analysis makes use of patterns created by light rays that are refracted by substances that have an arrangement of atoms in their crystal lattice. Using an XRD instrument, one compound can be distinguished from another based on the distinctiveness of the diffraction pattern that is produced.

## 2.6. Volume Weight

SNI 1973:2016 defines volume weight as the weight per unit of volume. Equation 1 can be used to determine the volume weight (density) of fresh concrete based on SNI 1973:2016 [22].

$$D = \frac{M_c - M_m}{V_m} \tag{1}$$

where $D$ is Concrete density (kg/m$^3$), $M_c$ is Mass of measuring container filled with concrete (kg), $M_m$ is Mass of measuring vessel (kg), $V_c$ is Volume of measuring container (m$^3$).

Equation 2 can be used to determine the density of concrete in an atmosphere free of air.

$$D = \frac{M}{V} \tag{2}$$

where $D$ is Density of concrete in air-free conditions (kg/m$^3$), $M$ is Total mass of all materials in the mixture (kg), $V$ is Total absolute volume of material components in the mixture (m$^3$).

### 2.7. Compressive Strength

Depending on the type of combination, the characteristics of the aggregate, the length and quality of treatment, compressive strength can reach 14,000 psi or more. The strength of the most commonly used concrete is around 3000 psi (20,684 N/mm$^2$) to 6000 psi (41,368 N/mm$^2$), and commercial concrete with ordinary aggregate, the strength is around 300 psi (2,068 N/mm$^2$) to 10,000 psi (68,947 N/mm$^2$). A conventional cylinder (15.24 × 30.48 cm) treated for 28 days at a specific loading rate in a standard laboratory environment to measure the compressive strength $f'c$. The ASTM C-39 standard is frequently used as the basis for standard specifications in the United States. It is important to realize that the cylinder's strength is a result of variations in compaction and maintenance requirements. By dividing the greatest compressive loaded the test specimen experienced by the outer cross section represented in Equation 3, the compressive strength of concrete is determined. The results of the mortar test object's compressive strength test are depicted in Figure 4 in their final form.

$$f'c = \frac{P}{A} \tag{3}$$

where $f'c$ is compressive strength of concrete (N/mm$^2$), $P$ is Maximum load (N), $A$ is Cross-sectional area that receives the load (mm$^2$).

**Figure 4. The compressive strength test of mortar**

## 3. Results and Discussion

### 3.1. Physical Characteristics of Silica Sand

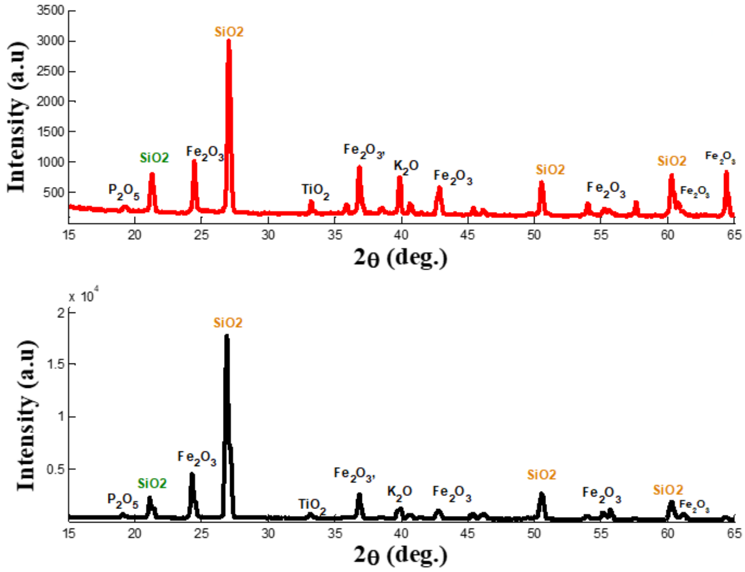
The outcomes of testing silica sand's physical properties in a lab are displayed in Table 3. Red and white silica sand were the two types of silica sand that were evaluated. The ASTM specifications are followed when conducting tests. It is clear that, with the exception of a few features, the red silica sand and white silica sand aggregate's physical properties mainly comply with the ASTM criteria. This shows that the subpar aggregate category also includes red silica sand and white silica sand aggregates.

**Table 3. Physical characteristics of red silica and white silica**

| No. | Test Description | Unit | Test result | | Specification (ASTM) | |
|---|---|---|---|---|---|---|
| | | | Red Silica | White Silica | Sand | Chipping |
| 1 | Fineness modulus | % | 2.63 | 0.92 | | |
| 2 | Apparent specific gravity | - | 2.61 | 2.62 | 2.2 – 3.1 | 5.5 – 8.5 |
| 3 | Bulk specific gravity | - | 2.35 | 2.51 | | |
| 4 | SSD specific gravity | - | 2.45 | 2.55 | 1.6 – 3.2 | 1.6 – 3.2 |
| 5 | Water absorption | % | 4.17 | 1.63 | 0.2 – 2.0 | 0.2 – 4.0 |
| 6 | Water content | % | 5.04 | 3.73 | 3.0 – 5.0 | 0.5 – 2.0 |
| 7 | Sludge content | % | 13.64 | 35.38 | 0.2 – 6.0 | 0.2 – 1.0 |
| 8 | Loose volume weight | kg/litre | 1.31 | 1.38 | 1.4 – 1.9 | 1.6 – 1.9 |
| 9 | Dense volume weight | kg/litre | 1.46 | 1.59 | | |

### 3.2. Characterization of Silica Sand by XRD Test

Figure 5 illustrates use of X-ray diffraction to characterize red and white silica sand by showing the link between 2θ and intensity of red and white silica sand and the dominating component. Additionally, a thorough study of the XRD test findings was done by displaying the crystalline and amorphous regions in red and white silica sand, which are displayed in Figures 6 and 7. A graph of the frequency levels that red and white silica sand reflect is shown in Figures 8 and 9.




| | | Red Silica | White Silica |
|---|---|---|---|
| Brookite | $TiO_2$ | 2.70 | 0.38 |
| Aluminium Oxide | $Al_2O_3$ | 0.18 | 0.02 |
| Tridymite | $SiO_2$ | 7.21 | 2.26 |
| Quartz | $SiO_2$ | 45.05 | 91.87 |
| Hematite | $Fe_2O_3$ | 30.63 | 4.03 |
| | $K_2O_5$ | 6.49 | 0.59 |
| | $P_2O_5$ | 4.14 | 0.35 |

**Figure 5. The relationship between the 2$\theta$ angle and the intensity of red silica sand and white silica sand**

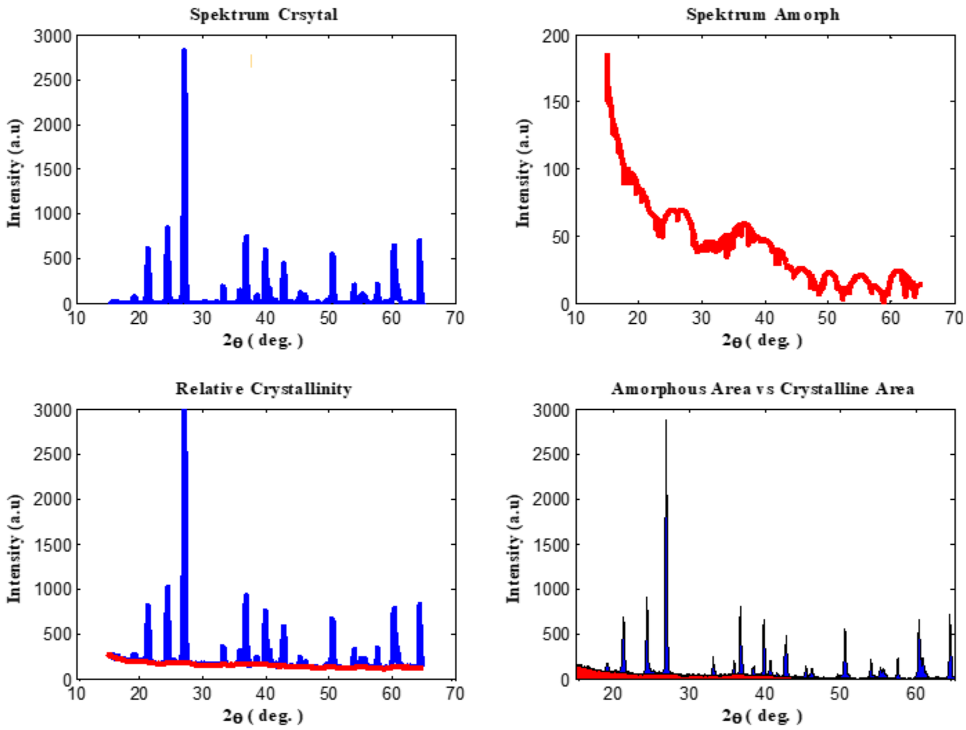



**Figure 6. Amorphous and crystalline areas of red silica sand material**

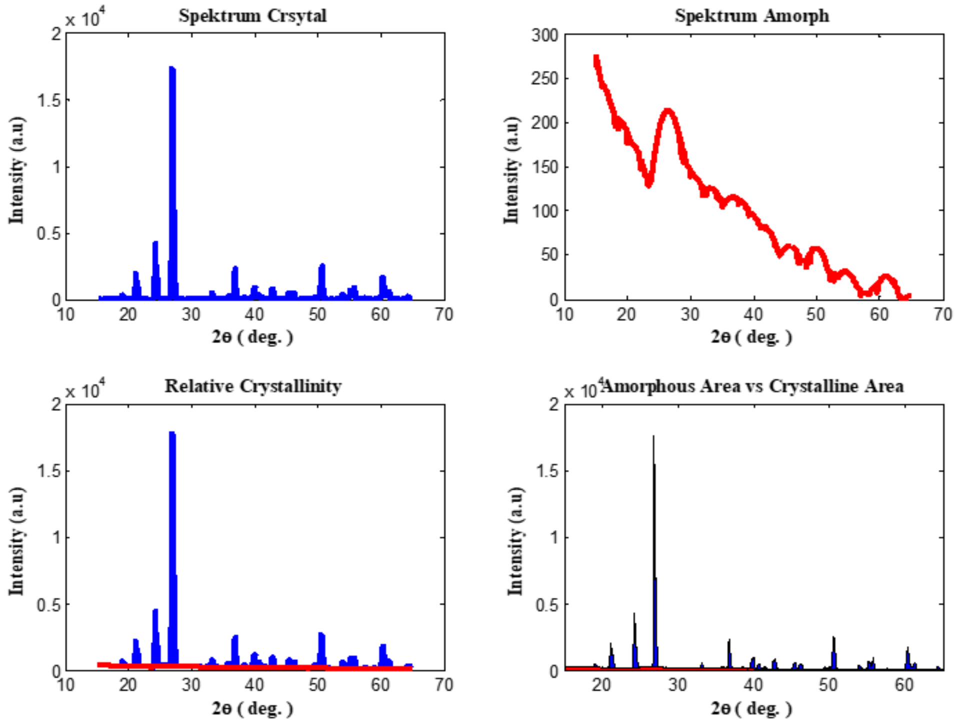



**Figure 7. Amorphous and crystalline areas of white silica sand material**

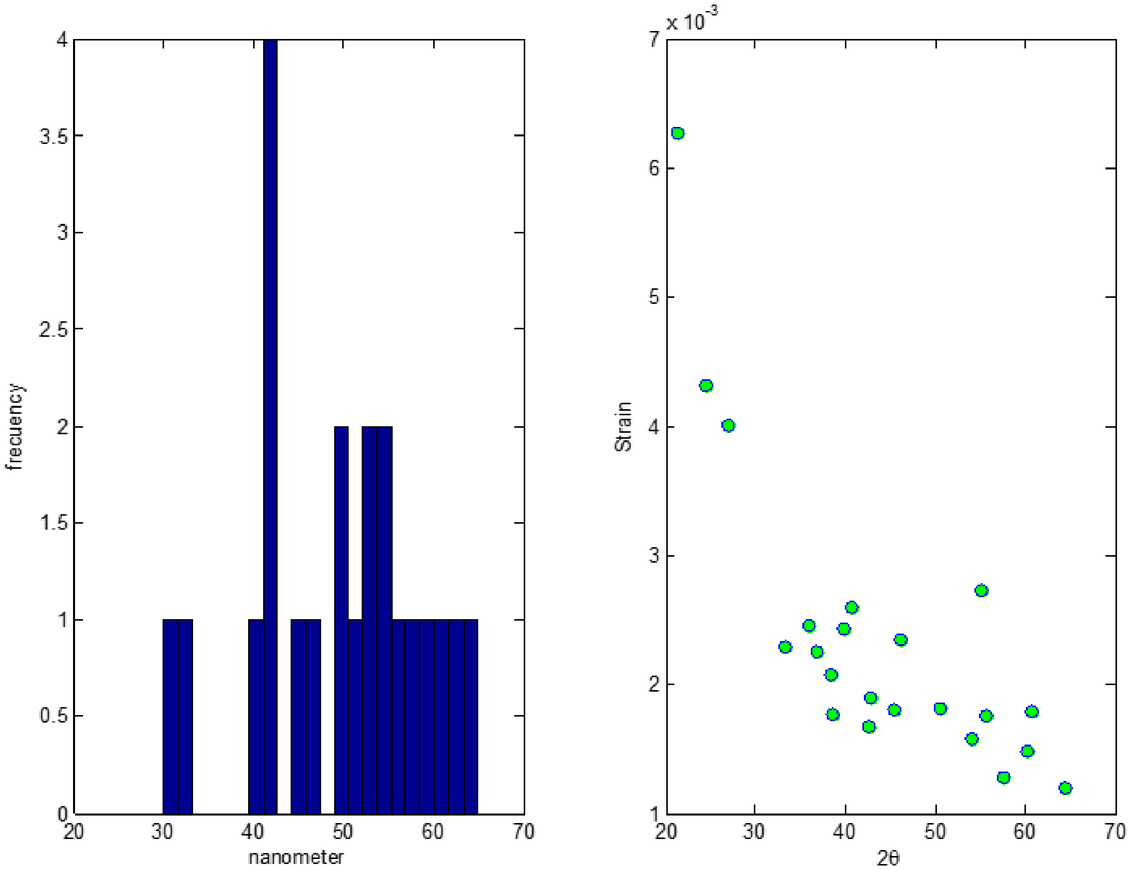



**Figure 8. Frequency level of red silica sand material**

Figure 5 depicts the correlation between 2θ and the relative amounts of red and white silica sand. As can be seen, the diffractogram patterns of the red and white silica sand aggregates are essentially identical, although the compounds in the white silica sand material are more intense than those in the red silica sand material. This is because white laterite produces more energy than other types. Additionally, red silica sand and white silica sand dominate the $SiO_2$ compound, which is quartz, with contents of 45.05% and 91.87%, respectively.

Figures 6 and 7 show that the proportions of amorphous and crystalline regions in the red silica sand and white silica sand material are, 37.32%; 62.67%, and 23.96%; 76.03%, respectively. Intensity level, which is shown in Figure 5 as a significant hardness measure, is connected with the proportion of amorphous and crystalline areas.

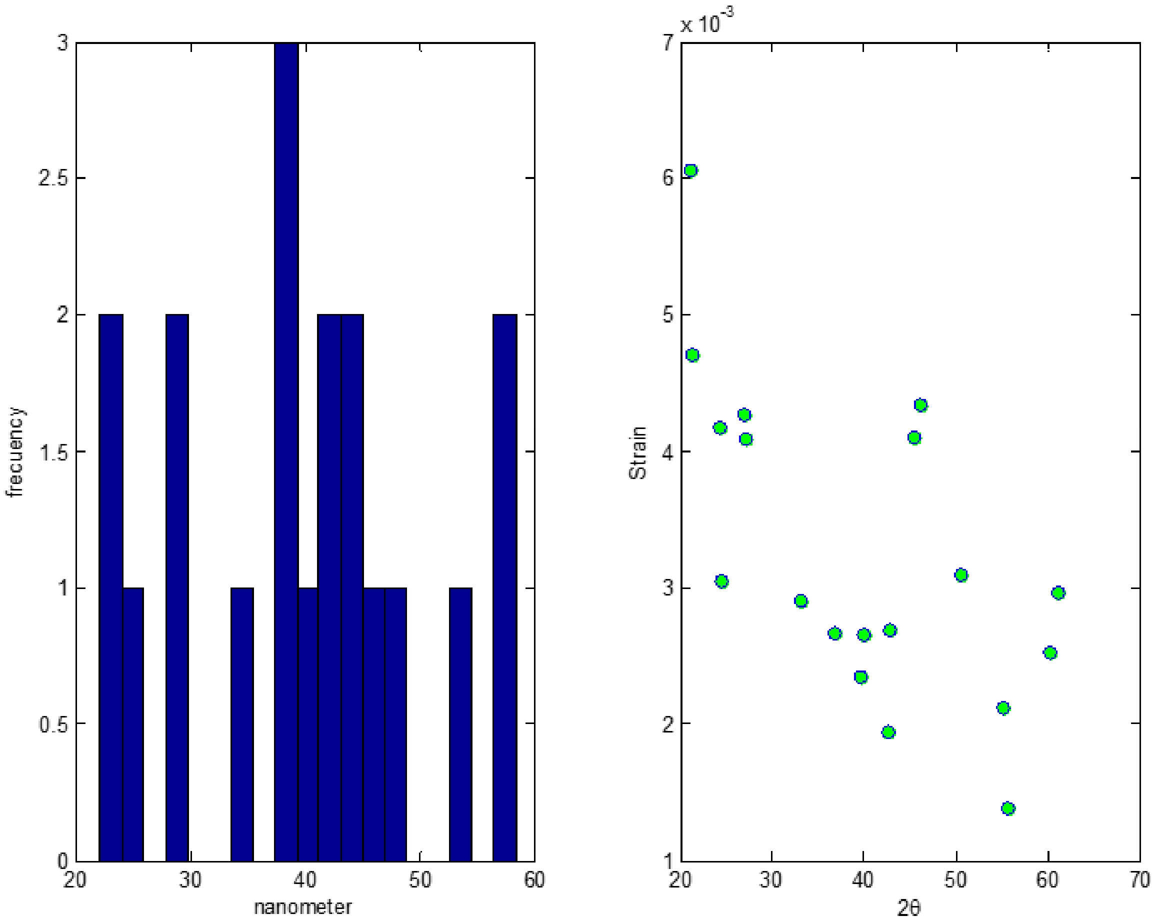



**Figure 9. Frequency level of white silica sand material**

The XRD test findings for red silica sand and white silica sand are shown in Figures 6 to 9; only $SiO_2$ is discernible on the graph in the form of peaks. The fact that $SiO_2$ has peaks, and the other chemicals do not demonstrate that $SiO_2$ is already a crystal. Red and white silica sand are therefore non-amorphous minerals and can only be used as fillers rather than pozzolans. As a result, in this investigation, Portland composite cement mortar was created using silica sand (red and white) as a fine aggregate.

Red silica sand has a crystal size of 64.9023 nm, a strain of 0.0018, and a relative texture coefficient of 0.9800, as shown in Figure 8. According to Figure 9, white silica sand has a crystal size of 58.3157 nm, a strain of 0.0014, and a relative texture coefficient of 2.5869. Observations made using atomic force microscopy revealed the manufactured silica sand's diameter. After 40 hours of grinding, the first group of samples, which ranged in size from 60 to 120 nm, had an average diameter of 88.87 nm and a greater particle size volume of 80 nm.

The Van-der-Waal forces operating between each particle are what cause the significant tendency for agglomeration within these particles. The results show that the silica sand particle size is not uniform, and some of the primary particles seem to have aggregated or clustered on the surface and range (159, 62, 50) nm.

### 3.3. Particle Size Distribution and Mixture Design

The particle size distribution of red silica sand and white silica sand are depicted in Figures 10 and 11, respectively. The findings of the sieve analysis test show that the fineness moduli of the red and white silica sand produced are 2.627 and 0.920, respectively. This demonstrates that white silica sand is less finely divided than red silica sand. Of course, this will have an impact on the mortar's mechanical properties. Additionally, white silica sand has a quartz $SiO_2$ content (degree of hardness) of 91.87%, whilst red silica sand has a content of 45.05%, with crystalline regions of 76.03% and 62.67%, respectively.

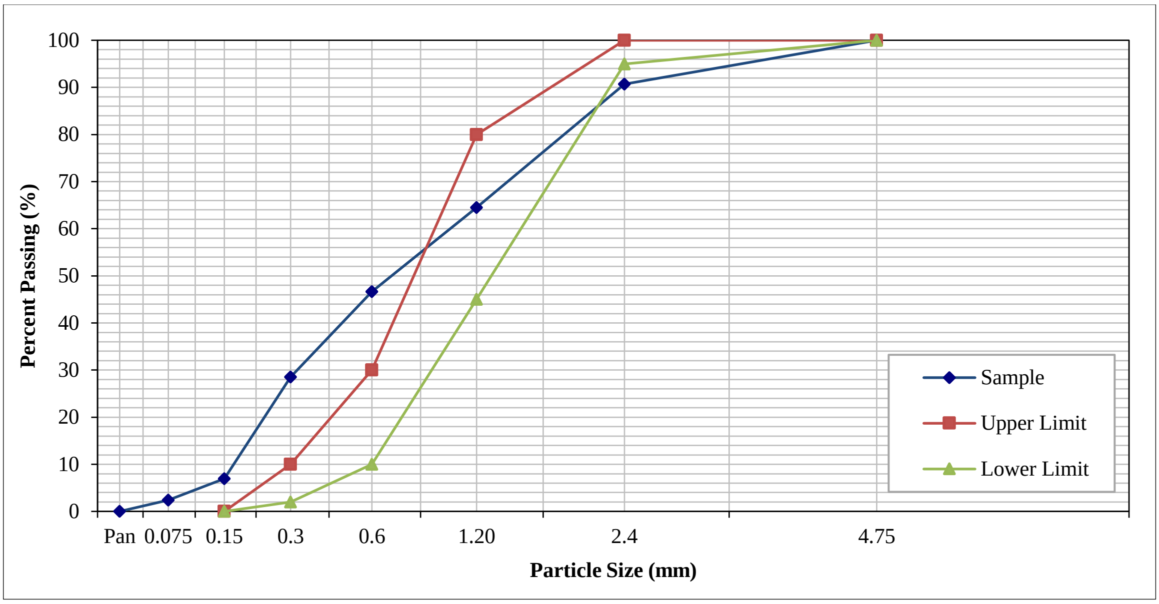



**Figure 10. Particle size distribution red silica sand**

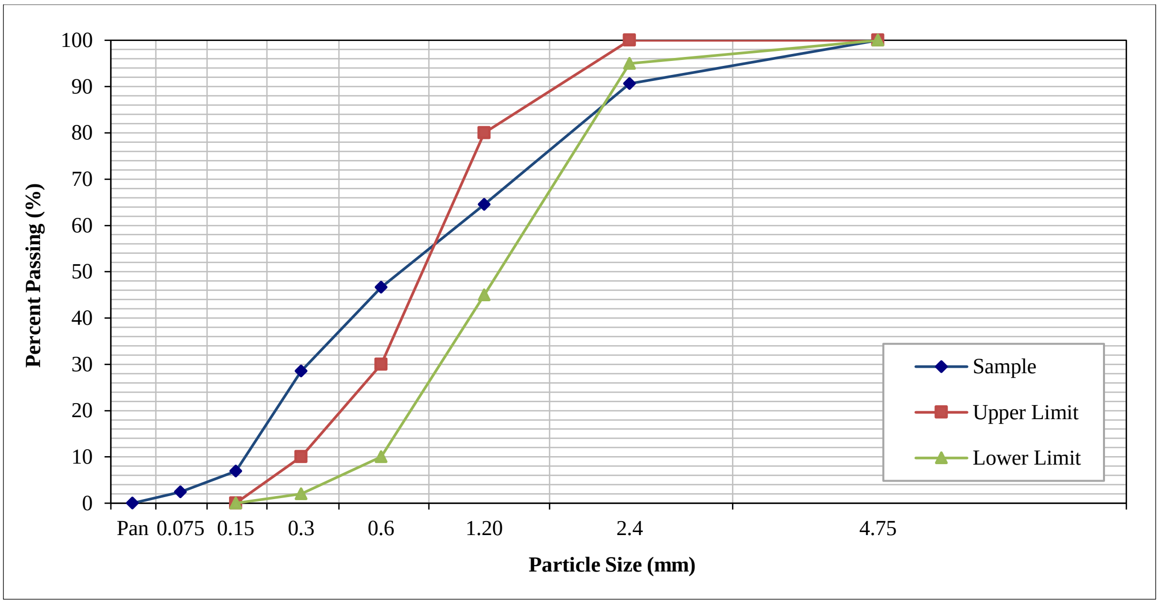



**Figure 11. Particle size distribution white silica sand**

Table 4 shows the design of mortar mixtures using silica sand as fine aggregate and composite Portland cement based on the outcomes of testing the physical and chemical properties of silica sand.

**Table 4. Mixtures design**

| No. | Materials | Weight (gram) |
|---|---|---|
| 1 | Water | 518.4 |
| 2 | Portland Composite Cement | 1087.2 |
| 3 | Silica sand | 2448.0 |

## 3.4. Volume Weight and Compressive Strength

The physical and mechanical properties of mortar formed from silica sand and composite Portland cement are volumetric weight and compressive strength. The performance of the materials utilized can be assessed using these qualities, and recommendations for the usage of environmentally friendly waste products can also be made. The volume weight and compressive strength of mortar made with red silica sand and white silica sand are shown in Table 5. The values for compressive strength, volume weight are averages across three test objects.

**Table 5. Volume weight and compressive strength of mortar made red and white silica sand**

| No. | Age (days) | Volume weight (gr/cm$^3$) | | Compressive strength (MPa) | |
|---|---|---|---|---|---|
| | | Red silica sand | White silica sand | Red silica sand | White silica sand |
| 1 | 7 | 2.756 | 2.801 | 20.725 | 20.938 |
| 2 | 14 | 2.784 | 2.846 | 23.316 | 23.189 |
| 3 | 28 | 2.797 | 2.913 | 24.611 | 25.122 |

Table 5 shows that, for both mortars constructed of red silica sand and white silica sand, the unit weight and compressive strength increase with increasing the age of the mortar. When compared to the white silica sand mortar, the volume weight of the red silica sand mortar grew by 3.84% and 2.30%, respectively, at the ages of 7 and 14 days to 28 days. Red silica sand mortar's compressive strength increased by 15.79% and 5.26%, respectively, in tests, whereas white silica sand mortar's compressive strength increased by 16.65% and 7.69%, respectively. Figures 12 and 13 for volume weight and compressive strength respectively show this

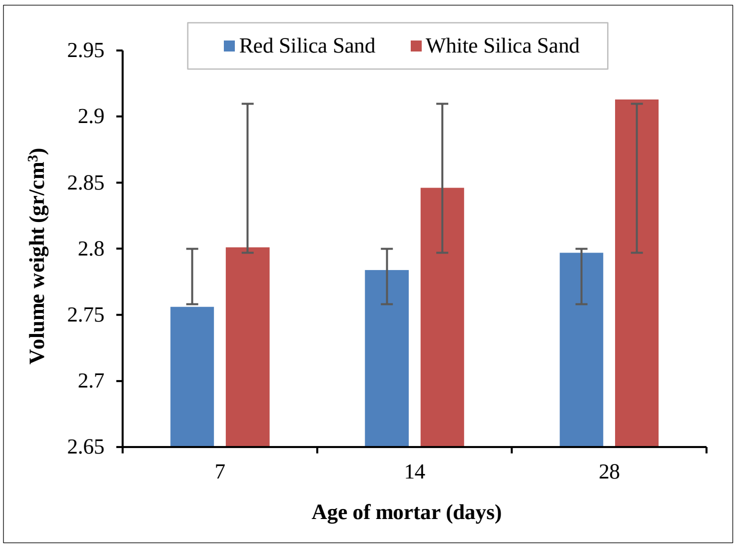



**Figure 12. Volume weight of mortar**

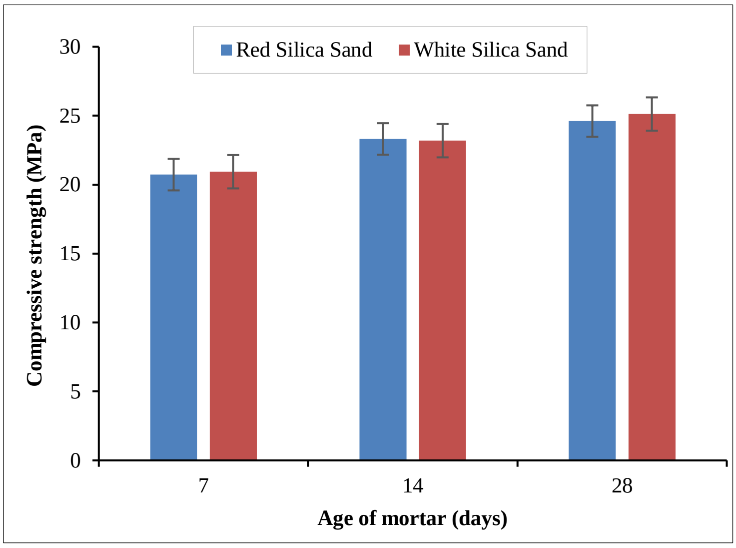



**Figure 13. Compressive strength of mortar**

It is evident in all mixes that the compressive strength improves as the specimen ages, which is the same behaviour as Portland cement-based concrete. As the age of the concrete increases, so does the load that mortar constructed of red or white silica sand can support. The stabilization of the bubbles that have formed as a result of the reaction of composite Portland cement with silica sand during the mixing of the mortar into the concrete and the subsequent course of the hydration process, which lasts until the age of 28 days, is what causes the increase in the load value, which has implications for the compressive strength value that occurs.

## 4. Conclusion

$SiO_2$, $Al_2O_3$, CaO, $Fe_2$O3, $TiO_2$, CaO, MgO, and $K_2O$ are the constituents of quartz sand. Clear white or various hues may be present, depending on the impurity component. The first step in a mining operation is often the extraction of quartz sand, which is used as the raw material to make silica. We wash the quartz sand to eliminate mud and biological impurities, then separate and dry it again to obtain sand with a higher silica content, depending on the state of the quartz from the mining site. Then, this sand is referred to as silica sand or silica having a particular amount of $SiO_2$. Effective compaction indicates that the silica, alumina, and other elements form a solid bind when PCC cement, silica sand, and water are mixed to generate mortar.

The good compatibility of all the constituents allows for smooth concrete hardening during the setting process, as demonstrated by the rise in mortar volume and compressive strength from 7 to 28 days. Studies showed that increasing the grinding energy was more successful than reducing the size of the silica sand particles. The PCC cement mortar's compressive strength is highly dependent on when fine particle size sand is applied; the highest strength is achieved when fine particle size sand is added to the mixed composition just after bonding. Sand with microscopic particles lost a great deal of its activity over time. When creating mortar and concrete, silica sand from Kolaka, Southeast Sulawesi, Indonesia, can be used as a fine aggregate. This is demonstrated by the results of evaluating the mechanical, chemical, and physical qualities of the mortar. The mortar has a compressive strength of 24 to 25 MPa at 28 days of age.

## 5. Declarations

### 5.1. Author Contributions

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

### 5.2. Data Availability Statement

Data sharing is not applicable to this article.

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### 5.5. Conflicts of Interest

The authors declare no conflict of interest.

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