JPPIPA 9(8) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Characteristics of Concrete With Red Sand Mixture 80 Mesh Grain Size After Combustion

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Received: February 6, 2023
Revised: April 18, 2023
Accepted: August 25, 2023
Published: August 31, 2023

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DOI: 10.29303/jppipa.v9i8.3107

Abstract: Research has been done on the Characteristics of Concrete with a Mix of Red Sand Grain Size 80 Mesh Post-burning. This study aims to determine the characteristics of concrete with a mixture of red sand grain size 80 Mesh Post-burning on the compressive strength, porosity and structure of the concrete. The test object is a cube of 15 cm x 15 cm x 15 cm with concrete quality K-225. In this study, variations in the composition of 80 mesh size red sand were made of 0%, 2%, 3% and 4%. After the concrete is 24 hours old, the mold is opened and given a sample code and treated in an immersion water bath. After going through an immersion period of 28 days, the concrete was burned in an oven with temperature variations of 400℃, 550℃, 700℃ and 850℃ and tested. The test methods used are compressive strength, porosity and Scanning Electron Microscope Energy Dispersive X-Ray (SEM-EDX). From the test results obtained the maximum average compressive strength obtained in concrete with a mixture of red sand of 4% with a temperature of 550℃ . From the results of the porosity test, there was a decrease in the concrete with the addition of red sand by 4%. From the results of the SEM test, the concrete structure with a mixture of red sand has fewer and smaller cavities. From the results of the EDX test on concrete with a mixture of red sand, Calcium (Ca) and Stibium (Sb) elements have increased intensity when compared to normal concrete. From the XRD test results obtained elements - elements SiO_2 (Silicon Oxide), $Ca(OH)_2$ (Calcium Hydroxide) and CaO_3 (Calcite) with the highest intensity is SiO_2.

Keywords: Compressive strength; Porosity; Post burn; Red sand; SEM-EDX

Introduction

Almost every civil engineering building, be it buildings, bridges, or water buildings, uses concrete as the main structure or complementary structure of a concrete structure consisting of structural elements consisting of foundations, columns, beams, floor plates, and others (Hidayat et al., 2021). One of the challenges faced by structural experts (civil engineering) is how to analyze the strength of concrete structures in buildings due to: (1) The highest temperature experienced by building elements during a fire, (2) The residual strength of the building after the fire, (3) The technique of strengthening the building as needed so that the function of the building can be restored as before the fire.If we look closely, the biggest loss that occurs in buildings as a result of a fire disaster is the destruction of the building (Hamdi et al., 2018). If we look closely, the biggest loss that occurs in buildings due to fire disasters is the damage to the building. The occurrence of high temperatures such as those that occur in a fire event will affect the structural elements (Lianasari et al., 2013). Building superstructure problems are very common in Indonesia (Kurniati, 2019) which are influenced by the unpredictable weather in tropical climates. Especially if the danger of fire occurs at any time caused caused by a short circuit. However, a problem in Indonesia that is very common in dak is due to the weather in tropical climates which will affect one of the properties of concrete (Kurniati, 2019), namely high impermeability high. With its large self weight, and its shape is difficult to change, it is certainly an unfavorable thing in terms of concrete construction planning, especially for areas that have poor soil bearing capacity (Sylvina, 2019). Concrete is a very strong

How to Cite:
Harahap, M. H., Ritonga, W., & Adelia, N. (2023). Characteristics of Concrete With Red Sand Mixture 80 Mesh Grain Size After Combustion. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6540–6547. https://doi.org/10.29303/jppipa.v9i8.3107

material, rustproof and resistant to fire. In addition, the advantages of concrete that are more prominent than other construction materials are high compressive strength (Haris et al., 2020). Concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without additives that form a solid mass (Budiman, 2018). Concrete is a mixture of Portland cement/other hydraulic cement, fine aggregate, coarse aggregate, and water with or without additives that form a solid mass (Agusri et al., 2019).

Hitipeuw et al (2020), the definition of concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate and water, with or without additional admixtures to form a solid mass. This plasticized mixture is cast into scaffolds and treated to obtain the strength of the hydration reaction of the cement, water mixture, which causes good hardening of the concrete. The formed material has high compressive strength and low compressive strength resistance. When compared to other materials, concrete is a building material that has relatively better fire resistance, because concrete is a material that has low heat conductivity, so it can block the propagation of heat to the inside of the concrete structure. When burning concrete cannot produce fire manum can absorb heat so that there will be excessive high temperatures, which will result in changes in the microstructure of the concrete. Changes due to fire are influenced by the height of the temperature, duration of combustion, type of concrete mix material, and loading behavior (Delia et al., 2021). Normal concrete is concrete that has a compressive strength ranging from 200 - 500 kg/cm2, this concrete has the largest portion of concrete production in Indonesia and is often found, for example, in the construction of high-rise buildings. The function of using aggregates in concrete is to produce great strength in concrete, reduce shrinkage of concrete hardening and with gradations that function as fillers, but because of the large percentage of aggregates in the volume of the mixture, aggregates contribute to the strength of concrete. Therefore, coarse aggregate in concrete mixtures has an important role (Haris, 2020).

Concrete is widely chosen because it has advantages over other materials. Concrete is a very sturdy building material, easy to make and shape, resistant to fire, little maintenance, resistant to weather, can protect steel reinforcement from corrosion, except for cement, concrete constituents are abundantly available and relatively cheap (Romadhon, 2021). High quality concrete can be produced by increasing the porosity of concrete. The porosity of concrete is affected by aggregate gradation and fineness of cement grains. The limited level of fineness of cement grains is a major problem in producing high quality concrete, in terms of porosity (Setiawati, 2018). Prayuda et al. (2018), the compressive strength value of concrete is obtained from standard tests with commonly used cylindrical specimens. The dimensions of the standard specimen are 30 cm high, 15 cm in diameter. Concrete will have a high compressive strength if it is composed of good quality local materials. The selection of concrete mix materials is very important because it will determine the quality of concrete. For example, the selection of sand as a concrete mix material needs to be a crucial concern (Muhammad et al., 2023). A concrete plant, also known as a batch plant or batching plant or a concrete batching plant, is equipment that combines various ingredients to form concrete. Concrete is a mixture of cement, water, coarse aggregate, fine aggregate, and other materials (Aziz et al., 2022). In addition, it is important to note that the concrete batching plant is not only designed to produce concrete, but it is also designed to produce concrete that is suitable for all types of construction projects. The quality characteristics of fine aggregates that function as structural components of concrete have an important role in determining the quality characteristics of the resulting concrete, because fine aggregates occupy most of the concrete volume (Arbain, 2019). The properties of sand that most affect the strength of concrete are the hardness of the sand grains and the maximum size of the concrete mix as required (Hadi, 2020). Coarse aggregate is gravel as a result of natural decomposition of stone or in the form of crushed stone obtained from the stone crushing industry and has a grain size between 5 mm - 40 mm. The aggregate is called coarse aggregate if the grain size exceeds 4.75 mm (Pagut et al., 2017). The purpose of concrete mix planning is to determine the proportion of cement, fine aggregate, coarse aggregate, water, and additives used must meet the following requirements: 1) A certain elasticity that allows the concrete mix to be placed in the mold/formwork (workability) and the smoothness of the face (finish ability) of wet concrete, which is determined from: a. Volume of mortar paste; b. Dilution of mortar paste; c. Comparison of fine and coarse aggregate mixtures. 2) Plan strength and durability in concrete conditions after hardening. 3) Economical and Optimum (Rivai et al., 2020). However, the use of water in concrete must be in accordance with the dosage. If too much water will cause the strength of the concrete to decrease due to porosity. If the water is too little, it causes the concrete to be difficult to work with (Nurjanah et al., 2020). Based on research Dewi et al. (2021), the magnitude of the effect of high temperature changes is relatively appropriate and the average compressive strength value of concrete produced after combustion always decreases. In each duration of burning concrete always experiences weight shrinkage, it is known that burning 3 hours experiences a shrinkage of 0.67%, and 6 hours experiences a shrinkage of about 2.49%, while the 9-hour burning duration experiences a shrinkage of about 3.1% of the average weight of unburned concrete.

Compared to other materials, concrete is a building material that is relatively fire resistant. Because concrete is a material with low thermal conductivity, it can inhibit heat transfer to the concrete structure. Combustible concrete does not cause fires but absorbs heat and generates excessive heat which changes the microstructure of the concrete. The occurrence of a rather high temperature change, such as a fire, affects the concrete structure. A common symptom of construction fires is the surface of the structure is blackened or charred due to the high flame temperature, which affects the quality/strength of the concrete structure use the structure.

The results of research Harahap et al. (2020) on concrete with a mixture of red sand, compressive strength with variations in composition and variations in the size of the red sand grains increase the compressive strength of concrete, but the results obtained have not found linearity. The optimum compressive strength is found in the red sand composition of 4% with a grain size of 80 mesh which is 32.3 MPa. The compressive strength data obtained has reached K-400 from K-225. This exceeds the strength of the pressure set by the Indonesian National Standards Agency.

Based on the background described above, the problem in this study is the effect of temperature on the compressive strength of concrete due to combustion with variations in the composition of the addition of red sand and changes in the characteristics of the concrete affected by changes in temperature. The goal achieved in this study was to determine the effect of temperature on the characteristics of post-combustible concrete (compressive strength, porosity and material elements).

Method

Experimental methods in the laboratory are used because they can be an effective method to determine the effect of bamboo on the tensile strength and compressive strength of concrete (Zhafirah et al., 2020). The method used in this study is an experimental study that refers to the quality of K-225 concrete. To determine the characteristics of post-combust red sand mixed concrete, compressive strength, porosity, Scanning Electron Microscope Energy Dispersive X-Ray (SEM-EDX) and X-Ray Diffraction (XRD) tests were carried out. The stages of the research are as follows:

Material Preparation

At this stage all the materials needed such as Type I Portland cement, sand, crushed stone, water and red sand are prepared in advance. In accordance with SNI standards the mass ratio of the materials is 1 cement: 1.9 sand: 2.8 gravel with a FAS of 0.5. To find out the mass of each material, a mix design calculation is carried out using the density of the material used. The red sand used in this study has a composition variation of 0%, 2%, 3% and 4%.

The properties and characteristics of the materials that make up the concrete will affect the performance of the concrete that is made. The performance of this concrete must be adjusted to the class and quality of the concrete being worked on done, so that in its use it can be adjusted to the building or construction to be built to obtain satisfactory and appropriate results construction to be built to obtain satisfactory results and according to the needs (Alkhamuddin et al., 2019).

Manufacture of Test Objects

At this stage, mixing all the ingredients is done manually with a shovel. First, the sand that has been added to the red sand is mixed with crushed stone until it is evenly distributed, then the cement is mixed into the mixture. Second, water is added little by little to the mixture with continuous stirring. Finally, the mixture is put into a cube mold of (15x15x15) cm. Then the surface is leveled and left for 24 hours.

Maintenance

At this stage the treatment is carried out by putting the sample into the soaking tub and then letting it sit for 28 days in the soaking tub. After soaking for 28 days the samples were taken out and dried for one day.

Sample Burning

Prior to testing, the samples were first burned in a furnace with temperature variations of 400°C, 550°C, 700°C and 850°C. Some basic assumptions as a limitation of the problem as follows: a) The planned concrete quality is f'c = 25 MPa. b) The test specimens made are cylinders with a diameter of 15 cm and a height of 30 cm for post-fire testing and cylinders with a diameter of 7.5 cm and a height of 15 cm for absorption testing made with paralon molds. Karkasa Journal Vol. 8 No. 1 2022, e-ISSN: 2721-9534 LPPM Politeknik Saint Paul Sorong 9 c. The combustion temperature for post-fire testing is 600o C for 3 hours (Masagala, 2022).

Testing

After the combustion stage is carried out, then the compressive strength, porosity, SEM-EDX, and XRD tests are carried out.

a) Strong Press

To determine the compressive strength of concrete, it is necessary to carry out tests that refer to SNI standards . The tool used to test the compressive strength is the Compression Testing Machine (CTM).

b) Porosity

to determine the percentage of air voids from the sample. The tools used in this test are scales. The formula used is as follows:

$$Porositas = \frac{M_{ssd} - M_b}{V \times \rho_{air}} \quad (1)$$

Information: M_{ssd} = Masssurface dry of test object (kg), M_b = Masspost-burn test object (kg), V =Volumestest piece (m^3), ρ_{air} = density of water (kg/m^3).

c) SEM-EDX (Scanning Electron Microscpe Energy Dispersive X-Ray)

To find out the microstructure of concrete, a Scanning Electron Microscope (SEM) test was carried out. This test is also carried out for surface examination and analysis which contains pore sizes in concrete samples.

d) XRD (X-Ray Diffraction)

To determine the phase angle, volume fraction, and crystals formed in the sample, X-Ray Diffraction (XRD) testing was carried out.

Result and Discussion

Compressive Strength Test

Based on Figure 1, at 400°C the optimum compressive strength is in concrete with 4% red sand mixture of 28.1 Mpa. At 550°C the optimum compressive strength is in a 4% red sand mixture of 30.94 MPa. At 700°C the optimum compressive strength is in a 3% red sand mixture of 24.74 MPa. At 850°C the optimum compressive strength is 18.3 Mpa in 3% red sand mixture. These results indicate that the 4% red sand mixture is the optimal mixture for concrete because at 550°C the sample has the most optimal compressive strength.This happens because the composition of 4% red sand is able to cover the voids in the concrete, only traps a little water in the concrete and increases the durability of the concrete.

Based on Harahap et al. (2020) research regarding red sand mixed concrete with a composition of 0%, 2%, 4%, 5%, and 6.5% and variations in grain size of 80 mesh, 100 mesh, and 120 mesh, the results of the highest compressive strength test values were in the composition 4% at 80 mesh size. In this study the concrete was not burned. To see the comparison of the compressive strength of concrete before and after burning it is presented in the following table 1.

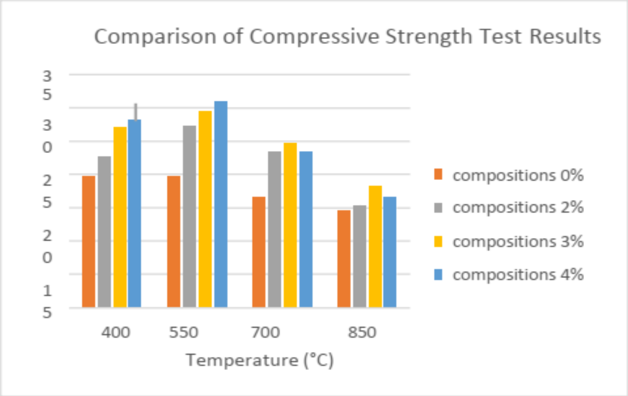


Figure 1. Graph of comparison of concrete compressive strength with temperature variations and composition variations

Table 1. Comparison of Concrete Compressive Strength Before and After Burning

	Pressure Strength (MPa)				
Composition (%)	Without Burning	400°C	550°C	700°C	850°C
0	25.37	19.69	19.63	16.69	14.56
2	27.98	10:55 p.m	27.20	23.36	15.33
4	32.30	28.10	30.94	23.35	16.60

Porosity

Concrete with a minimum porosity level will last longer than concrete with a maximum porosity value. From the graph in Figure 2 it is found that at 400°C the minimum porosity value is in a mixture of 4% and 3% of 13.6%. at 550°C the minimum porosity value is in a 3% mixture of 17.2%. At 700°C the minimum porosity value is in a 2% mixture of 19.10%. and at 850°C the minimum porosity value is in a mixture of 3% and 2% of 21.2%.

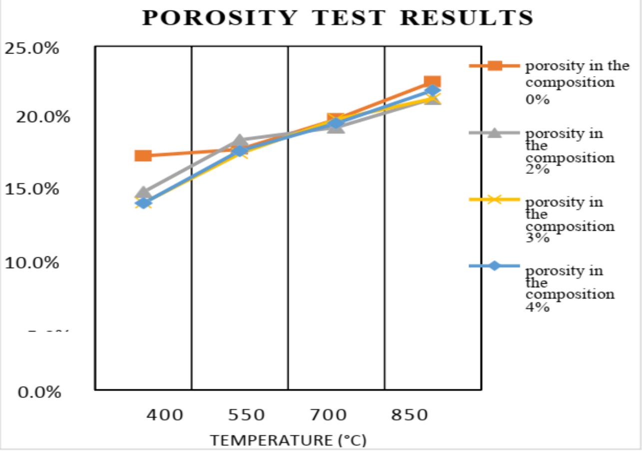
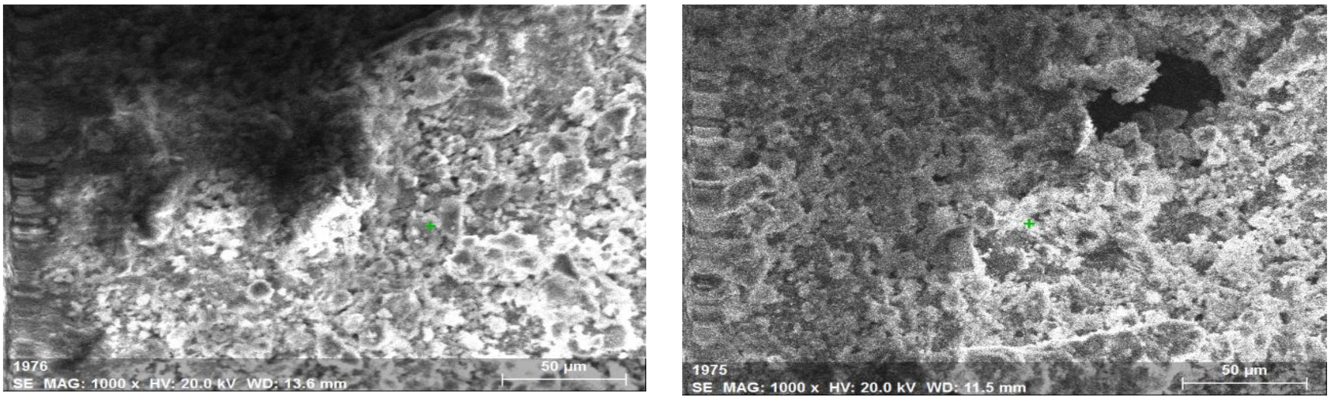


Figure 2. Graph comparison of concrete porosity with temperature variation and composition variation

From these results, it can be seen that red sand can reduce the porosity value of concrete. This is because the smaller grains will fill the pores between the larger grains, so the pores are getting smaller and the concrete has high compressive strength and small porosity (Hakim et al., 2020).

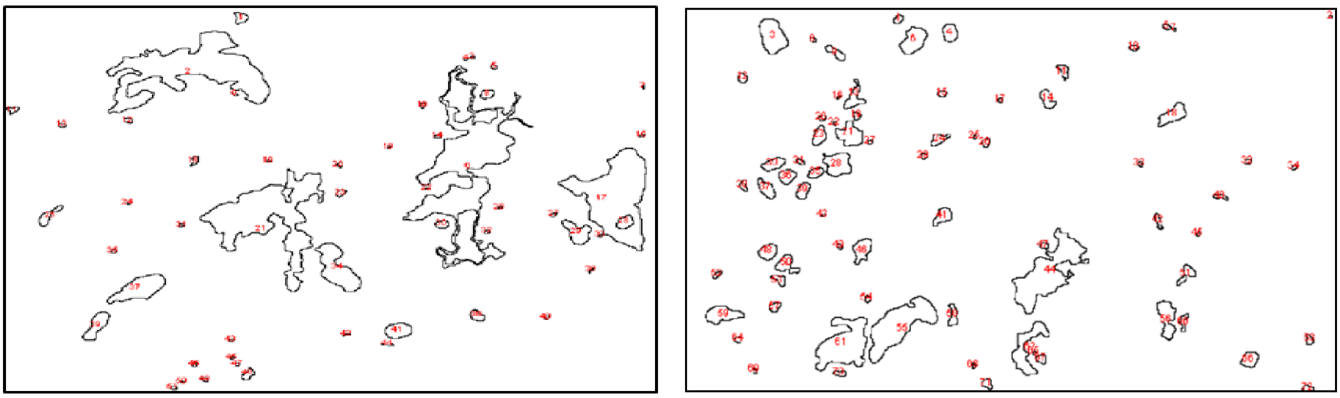
SEM-EDX (Scanning Electron Microscope Energy Dispersive X-Ray)

Pore analysis of the mixed particle positions in the concrete sample is shown in Figure 4. The above shows that the pores in images (a) and (b) appear to have different pore arrangements. In this morphology, the average pore sizes in figures (a) and (b) are 296,020 nm and 148,514 nm, respectively.



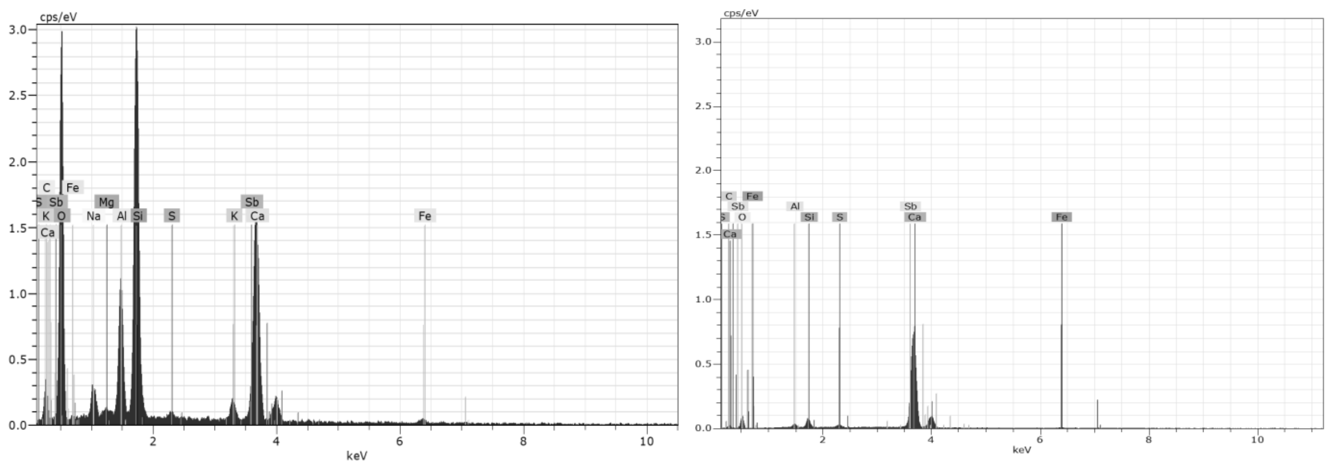
(a) (b)

Figure 3. Photo of SEM test results on concrete samples (a) Concrete mixed with red sand 0% at 550°C, (b) Concrete mixed with red sand 4% at 550°C



(a) (b)

Figure 4. Photo of pore analysis on a concrete sample (a) Concrete mixed with red sand 0% at 550°C, (b) Concrete mixed with red sand 4% at 550°C



(a) (b)

Figure 5. Characterization of EDX (a) 0% red sand mix concrete at 550°C, (b) 4% red sand mix concrete at 550°C

This shows that red sand can fill the spaces in the concrete which causes the pores to shrink and improves the quality of the concrete. The effect of temperature also affects the pores formed in concrete.

It can be seen in the figure 5, that the concrete without red sand mixture which is fired at 550℃ contains the elements Ca, O, Sb and Si respectively 15.16%, 53.73%, 5.34% and 14.14%. And in concrete mixed with 4% red sand and fired at the same temperature, the elemental content of Ca, O, Sb and Si were 49.61%, 23.69%, 21.69% and 2.20%, respectively. Ca and Sb content increased with the addition of red sand to the concrete mixture at 550°C. The Ca element is one of the main elements that supports the strength of concrete (Karolina et al., 2020).

XRD (X-Ray Diffraction)

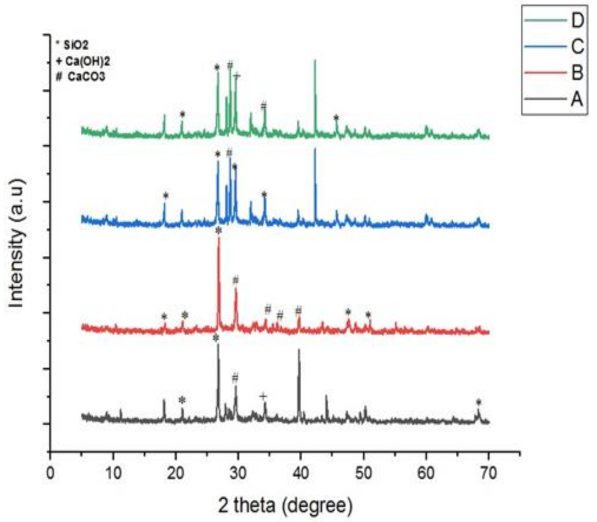


Figure 6. Diffraction pattern of concrete samples with 4% red sand composition at (A) 400℃ (B) 550℃ (C) 700℃ and (D) 850℃

Table 2 . Phase Angle Shift

Sample Code	Formed Phase		
	SiO_2	$Ca(OH)_2$	$CaCO_3$
A	26.55	34.05	29.39
B	26.94	-	29.70
C	26.55	34.07	29.27
D	26.58	28.50	29.38

The same crystal structure formed in samples A, B, C, and D, namely the SiO_2, $Ca(OH)_2$, and $CaCO_3$ phases which have a hexagonal crystal structure.

Table 3. Comparison of Volume Fractions

Sample Code	Volume Fraction (%)		
	SiO_2	$Ca(OH)_2$	$CaCO_3$
A	57.2	13.2	29.6
B	69.7	-	30.3
C	76.7	16.4	6.9
D	47.9	14.2	37.9

From Table 3 it can be seen that the volume fraction of SiO_2 is the largest compound. These compounds are compounds that make concrete stronger.

Conclusion

Of all the samples, the best composition for post-combustible concrete at various temperatures was obtained from a red sand mixture of 4% with a compressive strength of around 30.94 MPa. The compressive strength results obtained showed an increase from standard K-225 to standard K-350 at 550℃ and decrease occurred at 850℃ but still on the threshold of the K-225 standard. In the post-combustion concrete porosity test with a mixture of red sand, the composition that has the smallest porosity value is found in concrete with a mixture of 4% red sand of 13.0%. From the results of the XRD test, it was found that the elements SiO_2 (Silicon Oxide), $Ca(OH)_2$ (Calcium Hydroxide) and CaO_3 (Calcite) with the highest intensity are SiO_2 compared to other elements contained in concrete, the addition of silica (SiO_2) with high content and quantity can increase the compressive strength of concrete.

Author Contributions

Mukti Hamjah Harahap is in charge of the sample preparation section, Winsyahputra Ritonga is in charge of the analysis section, and Nova Adelia is in charge of report and article writing.

Funding

Funding source from LP2M Unimed. Under the Decree of the Chancellor of UNIMED No. 0141/UN33.8/PPKM/PT/2021 Dated 18 April 2022.

Conflicts of Interest

I declare no conflict of interest. The funder had no role in the research design; in the collection, analysis, or interpretation of data; in scriptwriting; or in the decision to announce the results.

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