IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 19, Issue 6 Ser. I (Nov. – Dec. 2022), PP 07-14
www.iosrjournals.org

The Influence of Lumajang Iron Sand in Flat Concrete Roof Tiles Manufacturing

Agus Budiono[1], Sutrisno[2]
[1]*Program Study of Mining Engineering, UIN Syarif Hidayatullah Jakarta, Indonesia*
[2]*Program Study of Physics, UIN Syarif Hidayatullah Jakarta, Indonesia*

Abstract:*Flat concrete tile is a good item for roof covering. Meanwhile, in the Lumajang area, there is many of iron sand, which comes from Semeru mountain. This iron sand has great traction as it is one of the ingredients used to make concrete tile. This research method uses an experimental research method. This research aims to know the effect of iron sand on the strength of the concrete tile. The composition of concrete tile is 30% iron sand, 30% rock sand, 20% cement, and 20% fly ash, and the materials for making the flat concrete roof tile. Besides that, in comparing the flat concrete roof tile, is made from mixed iron sand with regular river sand. The test of concrete roof tile comparison uses regular river sand and Lumajang iron sand through the bending load test and the test of water absorption resistance, and the test of water absorption towards the flat concrete tile. The finding shows that the average bending load is 595.84 Newton and the standard deviation is 233.53 Newton and the water resistance of iron sand concrete tile proved that there is no water drip on the bottom side of this tile. The opposite was shown by the regular sand-concrete tile. The average water absorption test is 8.4%.*

Key Word*: Lumajang iron sand, flat concrete roof tile,permeability, tensile strength, water absorption.*

Date of Submission: 22-10-2022 Date of Acceptance: 05-11-2022

I. Introduction

The need will increase significantly and the population of Indonesia, whose population growth continues to increase, needs adequate facilities for the region's current development. To make it happen with this desire, industries, both small, medium, and large industries, need building materials to realize housing growth and must be able to run properly. This means that all building materials, such as roof tiles, complimentary housing, and building materials, are available in good quality and the quantity and value of their use [1].

Many factors must be considered to determine whether the quality of the tile roof can be accounted for by the community or not. In addition, a method for making tile roofs is also needed so that tile roof users feel safe in having a good tile roof that has that quality. A house roof acts as a protective roof truss building to protect against weather influences such as heat, rain, and wind. Besides the roof, concrete tile requires a good roof covering that is durable and strong [2].

The number of houses and buildings that are built requires materials a good roof covering is a cover that meets the requirements of being strong, lightweight, and water-proof. This is a good roof covering for concrete tiles. The people who use concrete tiles, besides being expensive when compared to roof tiles, on the other hand, concrete roof tiles, which include roof coverings, are heavy enough to require a strong roof truss construction to withstand the weight of the tile [2].

Weaknesses of concrete until now are still being carried out, both improvements in compressive, tensile, and flexural strength, even to the point of trying to make the concrete lightweight but have high strength. A concrete tile is a form of application where the use of concrete as a non-structural building material automatically has the same weakness [3].

In addition, concrete tile is a building element made from a mixture of materials, such as Portland fine aggregate, which can be used for roofing. This concrete tile is very strong and weighs very heavily, reaching 4.4 kg per item. This matter becomes a problem in its use because the weight of the roof covering affects the batten size. For this reason, in this study, the tile was made thinner than the size of the tile, which is usually so that it can lighten the construction of the roof frame and save the use of quality materials to meet the requirements of SNI [3].

II. Literature Review

Fly ash can replace cement withup to 30% ofthe cement weight and increase durability and chemical resistance. Based on the above, it is necessary to research whether bottom ash can also act as a substitute for cement as well as fly ash. [3,4,5,6]

Not only plays an important role in physical development in the civil construction sector but also as a contributor to carbon dioxide gas, which is widespread worldwide. In the production of one ton of Portland cement, about one ton of carbon dioxide gas is released into the atmosphere. In 1995, cement production recorded 1.5 billion tons in the wild. [7]

The cement used is Portland Cement from the Semen Gresik brand It is known that this cement test material is produced by Cement in the Tuban area, East Java, with a pack of 40 kg.

Cement is one of the most important building materials in today's construction world. This material has a use for binding materials to other buildings at the same time. In ancient times, to make buildings, the materials used as adhesives were wet clay and lime. [7]

Rock ash is a material like coarse sand in size, solidity, and hardness that is produced by grinding rocks taken from rivers in mountainous areas; in East Java, the ingredients are mostly found in the areas of Lumajang (Semeru Mountain) and Blitar (Kelud Mountain) [8].In addition, rock ash is a fine aggregate that passes a 4.75 mm restrained size of 0.075 mm. Therefore, rock ash is a useful waste to become a mixture of construction building materials because rock ash can serve as a filler in the production of SCC, asphalt mixtures, and fine aggregates substitute for sand in concrete and asphalt mixtures. [9]

Iron sand is a type of sand with a significant concentration of iron, and is usually dark black or dark blue in color. This Lumajang iron sand consists of magnetite, and FeO4, and contains a small amount of titanium, manganese silica, calcium, and vanadium. Iron sand tends to heat up under direct sunlight, causing a fairly high temperature to cause minor burns [10].

The benefits of iron sand are one of the results of existing natural resources in Indonesia. It is one of the basic raw materials in the steel industry, and its availability can be found in coastal areas such as on the coast of Java, Sumatra, Sulawesi, and East Lombok Regency, West Nusa Tenggara [10,11].

Biodiesel or palm oil serves as a mattress lubricant or mold master so that the printed tile does not stick to the mat or the master mold that is in direct contact with the main raw material dough that has been mixed and is not sticky.A frozen malam or batik malam, the ingredients are mixed with bio-diesel or palm oil to make lubricants for molded mats.

III. Material And Methods

2.1.Place and Time

The place for making flat concrete tile is carried out at PT Abadi Utama Genteng, whose address is at Raya Karangpandan Street 265 T-junction of Bendo Pakisaji Kepanjen, Malang regency, East Java. This company is a home industry company.The flexural test,permeability test, and water absorption test are carried out at the Faculty of Civil Engineering, Brawijaya University, Malang, East Java.

2.2. Material and Equipment

In the manufacturing of flat concrete tiles in this study, researchers used the following material:

a) Portland cement
b) Rock ash
c) Fly Ash
d) Common sand
e) Lumajang iron sand
f) Biosolar and malam

Test equipment used in flat concrete tile manufacturing technology by using ordinary sand and Lumajang iron sand, including [12]:

a. Digital Balance/Digital Scales with a capacity of 15 kg with an accuracy of 9.5 grams
b. Loadcell is a test tool to measure flexural loads, while the mini logger is a bending test tool for measuring deflection.
c. The frame is used to print flat concrete tiles according to the shape that is desired. A plastic tub is used for water seepage resistance testing equipment and a tool for testing water absorption by dipping flat concrete tiles into a plastic tub.

2.3. Research Method

The research method used in this study is an experimental use of iron sand and ordinary sand, fly ash, cement, and ash stone as research materials. In addition, in the research method when conducting hardware experimental research, namely a technology for making flat concrete tiles using Lumajang iron sand which is used in this study as the component that is generated.

In addition to this research method, there are several samples of test objects with percentage composition addition of cement at 20%, fine sand with an iron content of 30%, rock ash at 30%, and fly ash at 20%, which are mixed evenly and dissolved into water adjusted to the material.

The equipment used in the process of making flat concrete roof tiles is as follows [3]:

a. Concrete mixermachine
   A concrete mixer machine is a tool that serves to mix concrete tile aggregates flats, the main raw material for flat concrete tiles, with a dose of 20% Portland cement, 30% fine iron sand, 30% rock ash, and 20% fly ash mixed evenly so that a concrete composition is formed which is ready to be processed into the Press Machine Hydraulic.
b. Hydraulic press machine
   A hydraulic press machine is a tool used to produce or mold concrete aggregates to become flat concrete tile products. Concrete aggregates which have been mixed into the concrete mixer machine will be printed and pressed with power from 200 bars to 250 bars.
c. Steel mat
   A steel mat is a foundation or mold for making and shaping motifs as well as the size of the flat concrete tile.
d. Plywood and iron placemat
   Flat concrete tiles are used as a base or holder for flat concrete tiles after they have just come out of the mold and are headed for the storage rack.

The material to be tested in this study is flat concrete tile, which will be made by the researcher with the composition of materials using ordinary sand and Lumajang iron sand.The process of making flat concrete roof tiles consists of several stages, including [13,14]:

a. Choosing the primaryraw material
   The main raw material commonly used by concrete roof tile manufacturers is fine iron sand, that is, solid material taken from mountain streams Mountain rivers for the East Java area are easy to find in the area Mount Lumajang (cement mountain) is also in the Blitar area on the border with Kediri, namely Kelud Mountain and the coastal areas of Mount Bromo Probolinggo, but the quality is good and it has high iron content in Semeru Mountain, Lumajang.
   Lumajang iron sand is divided into several types and qualities as follows [15,16]:
   a). Paliran Lumajang iron sand is Lumajang sand taken from rivers that are at the very bottom or downstream of the river, far from the center of the mountain lava flow. This lava flow causes the sand to become smoother, uniform in size, and have very low mud content because it is separated from the rocks
   (b). Keduk Lumajang iron sand is taken from the rivers below Semeru Mountain and has high-quality iron sand, but has an uneven size or small rocks that require processing sifting when it will be used for concrete roof tiles.

   All raw materials in the production area will be subjected to a quality control process (QC) to ensure that the raw materials used are still feasible to use and fit.
b. Measuring the primaryraw material
   After going through the process of selecting raw materials, the next step is to measure the amount of material to be used by the desired composition. The composition measurement is done by using the raw material volume ratio. The main ingredients that need to be measured are fine iron sand, stone ash, fly ash, and cement.
   In the manufacture of flat concrete tiles in this study, researchers used the composition of the ingredients as follows [17,18]

c. Mixing the primaryraw material
   In this process, all the main raw materials will be mixed with the addition of water until it becomes a homogeneous mixture of concrete tile material and is ready to print. This mixing process is carried out using a roller machine, or concrete mixer.
   The steps that must be taken in this process are that all the raw materials have been measured and then put one by one into the concrete mixer machine. After all the raw materials come in, the concrete mixer machine is turned on for some time so that all the main raw materials are mixed well. The next step is adding water enough to make a dough that has a certain level of viscosity.

The dough is continuously stirred in the concrete mixer machine until it is completely formed into a homogeneous mixture because this greatly affects the quality of the tiles produced. If the mixture is not completely homogeneous, it can cause the tile strength to be uneven and easy to crack.

d. Material Mixing Support

The supporting materials mixed in this process are bio-diesel or palm oil with frozen wax or batik wax. This mixture will be used later as a lubricant for mold mats or mold masters.A frozen malam or batik malam is first heated or baked inside a container made of aluminum or steel metal so that it changes shape from frozen or solid to liquid like water. The malam which has already melted biodiesel or palm oil is then stirred slowly until well mixed. The composition used is 75% biodiesel or palm oil and 25% liquefied wax.

e. Mold Mattress Lubricants

Before the main raw materials that have been mixed well are molded into tiles, the mold mat or mold master must be coated with a lubricant. Lubrication of the molding mat or the mold master is very important so that the main raw materials that have been well mixed, when pressed on a high-pressure hydraulic machine, do not stick to the master mold so that it is expected to produce a good product and maximum. The lubrication process is carried out by applying lubricant to the surface onto which the concrete tile material will be poured.

f. Roof Tile Printing Process

Several steps must be taken in the roof tile printing process, namely [19]:

a) Put the steel master on the hydraulic table.
b) Taking the concrete material from the concrete mixer machine which has been mixed equally into Cintung dosage
c) Pouring of concrete material that has undergone the Cintung dosage process.
d) Flatten concrete material. The process of pushing the steel master and the concrete material onto the hydraulic piston.
e) Pressure on Concrete Materials

The process of molding the concrete mixture with a hydraulic press machine takes between 3 and 4 seconds. This process aims to form the texture of the motif and reduce the water content in the concrete mixture so that it does not break easily when it is wet. It is just formed.

g. Placement of tile placemats

The flat concrete that just came out of the mold will be placed in storage in a stacking rack made of iron or wood that adjusts the length and width of the concrete tile. The tile will be stored for 12 hours along with the arrangement.Please note that the tile mat is made of a 0.5 mm iron plate or made of a triplex board with a thickness of 1.8 cm to 2 cm. The size and shape are adjusted with a concrete tile or a mold master, the medium that serves as a temporary storage area for newly molded concrete roof tiles that will be installed along with the tile mat.

h. Tile storage in stacking racks

The storage process of the new flat concrete tile after it is out of the machine print is used for stacking shelves and as a storage medium for concrete roof tiles. When the new concrete comes out of the molding machine, it will be stored for 12 hours in the stacking rack.

i. Immersion technique

After 12 hours in the stacking rack, the tiles go into the immersion process. The medium used for immersion is a pond measuring 4 x 4 meters and has a height of 1 meter from the floor surface, which has been plastered with cement. The pool is filled with clean water to the brim so that the entire surface of the tile can be completely submerged. The concrete tile was soaked for 18 hours, which aims to minimize the occurrence of liming.

j. Drying procedure

After going through the soaking process, the flat concrete tile will go through the drying process. The drying time for flat concrete tile is 28 days, counting from the process of rising from immersion. In this process, the tile that has been removed from the soaking area is neatly arranged in a shady place, not exposed to direct sunlight, and protected from rain. This is done so that the process of drying goes perfectly slowly to the deepest layer so that the concrete material can form a strong bond.

k. Painting technique

If the appropriate flat concrete tile has reached the appropriate age or has passed the period of 28 days from immersion to drying, it can be coated with a special tile paint that is widely available in the market or paint shop. In general, tile paint is mixed with clean water in a ratio of 80% paint to 20% water. The paint and water are stirred until evenly distributed. The painting process is carried out below direct sunlight for maximum results. The painting process is carried out three times using spray paint and a compressor. Each part of the surface is coated with paint to make it look better and more durable against fungal attacks caused by rainwater.

2.4. Testing Method

The testing of flat concrete roof tiles must refer to the Indonesian National Standard (SNI 0096-2007). There are 3 types of mechanical tests that need to be carried out on flat concrete roof tiles by these standards, which are as follows:flexural test, permeability test, and water absorption test.

IV. Result and Discussion

In general, to analyze the test data for Lumajang iron sand materials, stone ash, fly ash, cement, and ordinary sand, as well as flexural testing and water seepage resistance absorption testing, it is necessary to look at the test object as a first step with The average specifications of flat concrete roof tiles are as follows: The flat concrete roof tiles have a length of 42 cm from top to bottom of the tile body, a width of up to 33 cm on the left side, and a roof slope of 35° [19].

Figure 1: Flat concreteroof tileusing commonsand material (left) and Lumajang iron sand (right).

In Table 1, we can see the results of the flexural test from 5 samples of flat concrete roof tile with ordinary sand carried out on June 2, 2022, with the test number 5058/LBK.F.T/VI/2022.

Table 1: Bending Testing of flat concreteroof tileusing commonsand material.

No	Weight (Gram)	Max. Load Bending (N)	Avg. Load Bending (N)
1	3300.0	347.9	
2	3258.5	323.4	
3	3336.0	627.2	595.84
4	3385.0	749.7	
5	3310.0	931.0	

The flexural strength test from 5 samples of flat concrete tile with Lumajang iron sand material has carried out on June 2, 2022, with the test number 5043/LBK.F.T/VI/2022. In Table 2, we can see the complete result.

Table 2: Bending Testing of flat concreteroof tileusing Lumajang ironsand material.

No	Weight (Gram)	Max. Load Bending (N)	Avg. Load Bending (N)
1	4320.0	1710.1	
2	4372.5	1759.1	
3	4353.5	1612.1	1570.94
4	4409.0	1416.1	
5	4505.0	1357.3	

Based on the results of the flexural tests on both types of roof tiles. The results show that the roof tile with Lumajang sand as the base material has a higher flexural test strength value than ordinary sand. It shows that the grade of roof tile with iron sand is better because the maximum load bending from this roof tile can withstand almost three times larger than commons sand.

In Table 3, we can see the results of the permeability test of flat concrete roof tile with common sand carried out on June 2, 2022, with the test number 5056/LBK.F.T/VI/2022.

Table 3:Permeability tests of flat concreteroof tileusing common sand material.

Starting Time of Water Filling	End Time of Absorption Observation	Duration of Water Filling	Explanation
Tuesday, May 31st, 2022 at 10.30 a.m.	Wednesday, June 1st, 2022 at 10.30 a.m.	24 Hours	Water-translucent but no drops at the bottom of the tile.

According to Table 3,the permeability test ofcommonsand material that resists seepage is to determine the seepage power of flat concrete tile material when given water on top. For this reason, based on the test results, it is obtained that on a flat concrete tile with ordinary sand after being given water for 24 hours, the surface of the flat concrete tile penetrates to the bottom, but does not occur drops. For that, it can be said that water can seep into the flat concrete roof tile but only moisten the underside of the concrete tile [21].

The permeability test of flat concrete tile with Lumajang iron sand material has carried out on June 2, 2022, with the test number 5057/LBK.F.T/VI/2022. In Table 4, we can see the complete result.

Table 4: Permeability tests of flat concreteroof tileusing Lumajang ironsand material.

Starting Time of Water Filling	End Time of Absorption Observation	Duration of Water Filling	Explanation
Tuesday, May 31st, 2022 at 10.35 a.m.	Wednesday, June 1st, 2022 at 10.35 a.m.	24 Hours	The tile is not translucent and no drops at the bottom.

According to Table 4, the permeability test offlatconcrete rooftile with Lumajang ironsand shows that is no seepage and water drop on the bottom surface.The permeability test can indicate how many pores exist in the roof tiles. Numerous pores cause the possibility of water seeping into the tile to be larger, causing more significant water seepage. In roof tiles with commons sand, there is seepage on the undersurface of the roof tile. The bottom surface becomes moist, but not until water droplets form. While on the roof tile with Lumajang iron sand material, there is no seepage and water droplet. Based on this data, we can propose that lumajang iron sand fulfill the space in the concrete and can reduce the number of pores formed. The density of the concrete material on the roof tile using iron sand material greater than that using commons sand. The binding between the concrete constituents becomes more solid than before. This condition is consistent with the result of the flexural test.

In Table 5, we can see the results of the water absorption test from 10 samples of flat concrete roof tile with ordinary sand carried out on June 2, 2022, with the test number 5055/LBK.F.T/VI/2022.

Table 5: Water absorption tests of flat concreteroof tileusing Lumajang ironsand material.

No.	Weight of SSD (Gram)	Oven Dry Weight (Gram)	Air Weight (Gram)	Water Absorption (%)	Avg. Water Absorption (%)
1.	4654.00	4320.0	334.00	7.73	
2.	4749.00	4372.5	376.50	8.61	
3.	4710.50	4353.5	357.00	8.20	
4.	4759.00	4409.0	350.00	7.94	
5.	4865.50	4505.0	360.50	8.00	8.40
6.	4728.00	4359.0	369.00	8.47	
7.	4859.50	4449.5	410.00	9.21	
8.	4746.50	4381.5	365.00	8.33	
9.	4741.00	4363.0	378.00	8.66	
10.	4709.50	4326.5	383.00	8.85	

Table 5 shows the water absorption test of flat concrete tile with iron sand. In the above test, the flat concrete tile sample was immersed in water until it was saturated and then the mass was weighed (SDD). After that, the flat concrete tile is dried until the moisture content is gone by using an oven, and then the mass is weighed again. The difference between the mass of saturated water and the oven is used as a reference to determine the absorption of flat concrete tiles into water [23].This result is then calculated as a percentage of the dry mass. For this reason, complete data on the results of the water absorption test can be seen in Table 5.

The water absorption test of flat concrete tile with common sand material has carried out on June 2, 2022, with the test number 5044/LBK.F.T/VI/2022. In Table 6, we can see the complete result.

Table 6: Water absorption tests of flat concreteroof tileusing commonsand material.

No.	Weight of SSD (Gram)	Oven Dry Weight (Gram)	Air Weight (Gram)	Water Absorption (%)	Avg. Water Absorption (%)
1.	3777.00	3300.0	477.00	14.45	
2.	3770.50	3285.5	475.00	14.76	
3.	3807.50	3336.0	471.50	14.13	
4.	3818.50	3385.0	433.50	12.81	13.95
5.	3794.50	3310.0	484.50	14.64	
6.	4265.50	3785.0	480.50	12.69	
7.	3732.00	3268.0	464.00	14.20	

8.	3830.00	3378.0	452.00	13.38	
9.	3808.00	3340.5	467.50	13.99	
10.	3722.00	3253.0	469.00	14.42	

Table 6 shows the water absorption test for flat concrete tiles with common sand materials in the test above, the sample of ordinary flat concrete tile is first immersed in water until saturated and then the mass is weighed (SDD). Following that, flat sand concrete tiles are usually dried in an oven until there is no moisture content and then weighed to return [24].

The difference in mass between saturated water and the oven is used as a reference to determine the water absorption of flat concrete tile with ordinary sand material. This result is then calculated as a percentage of dry mass. For that, complete data on test results for water absorption can be seen in Table 6.From the results of the three tests above, it is evident that, in general, flat concrete tile is Lumajang iron sand. The tile has the resistance to hold water so that no seepage causes leakage or damage to the tile, which makes the quality of the tile decrease [25].

Common sand flat concrete roof tiles generally have a lower quality. Although the appearance is relatively the same, the flat concrete tile made of ordinary sand is not able to hold water from seeping into the pores of the tile, causing leakage and can reduce the life of the tile.Both affect the quality and affect consumer trust. Generally, consumers choose good quality and quality for housing so that there are no problems that arise as a result of flat concrete tile products [26].

V. Conclusion

1. Testing of water seepage of concrete tiles for the four percentages addition of sugarcane fiber and factory production there is no seepage below concrete roof tiles so that they meet the requirements of SNI 0096-2007 and PUBI-1982
2. The flexural test that has been carried out on both types of roof tiles has obtained that flat concrete tiles with Lumajang sand as the base material have an average load of 1570,994 Newtons and ordinary sand is 595.84 Newtons. So has a flexural test value using a larger Lumajang iron sand material compared to ordinary sand.
3. Seepage testing on flat concrete tiles using a mixture of sand and Lumajang shows better performance compared to ordinary sand. Flat concrete tile with ordinary sand: after being given water for 24 hours, water on top of the surface of the flat concrete tile penetrates to the bottom, but does not occur drops. So, it can be said that water can seep into the concrete tile flat but only moistens the bottom of the flat concrete tile. While on flat concrete tile using Lumajang sand material, water does not penetrate and there is no drip at the bottom of the flat concrete tile, so it meets the requirements of SNI 0096-2007 and PUBI-1982.
4. In the water absorption test for flat concrete roof tiles with Lumajang iron sand and commons sand, the percentage of water absorption using Lumajang iron sand is reduced by 8.4% versus using common sand by 13.95% on flat concrete tiles.

References

[1] The Center for Settlement Research and Development. 1985. PersyaratanUmumBahanBangunan di Indonesia (PUBI), 2nd Edition. Bandung: The Foundation of the Investigation Institute of Building Problems.

[2] National Standardization Agency. 2007. SNI 0096: 2007, Genteng Beton ICS 91.100.30. Jakarta: National Standardization Agency.

[3] Mira Setiawati. 2018. Fly Ash SebagaiBahanPengganti Semen Pada Beton. National Seminar on Science and Technology, 17th October 2018, Jakarta: Faculty of Engineering, University of Muhammadiyah Jakarta.

[4] Roni Adi Wijaya, SeptiWijayanti&YayukAstuti. 2021. Fly Ash LimbahPembakaran Batubara SebagaiZat Mineral Tambahan (Additive) untukPerbaikanKualitas Dan KuatTekan Semen. Communication Media of Civil Engineering, Volume 27, No.1, 2021, p. 127-134.

[5] Prabandiyani, S. 2008. PemanfaatanLimbah Batubara (Fly Ash) untukStabilisasi Tanah MaupunKeperluan Teknik SipillainnyadalamMengurangiPencemaranLingkungan. Inauguration Professors Speech of the Faculty of Engineering, Diponegoro University, Semarang. Date: 6th December 2008.

[6] Toon, J. 2009. New Coal Ash Use: Strong, Lightweight Alternative to Concrete without Cement. Electric Light and Power, May/June 2009,87,3: ProQuest Science, Journals, pp. 46.

[7] Malhotra, V.M. and Ramezanianpour, A.A. 1994. Fly Ash in Concrete (2rd ed.).Ottawa: CANMET.

[8] Raj Premani. 2017. Fly Ash-A Boon for Concrete. International Journal of Engineering Science and Computing (IJESC), Vol. 7, Issue 3.

[9] Shetty, M.S. & Jain A.K. 2019. Concrete Technology: Theory and Practices. New Dehli: S. Chand Publishing.

[10] RulliRanastraIrawan, SetyoHardono, YanuIkhtiar Budiman, OgiSoeherman, Desak Nyoman DeasyTriani&GugunGunawan. 2015. BetondenganSedikit Semen Portland dan Tanpa Semen Portland Memanfaatkan Abu Terbang dariPLTU Batubara. Bandung: The Center of Research and Development for Road and Bridges.

[11] Bureau of Indian Standards. 1991. IS 1489-1: Specification for Portland pozzolana cement, Part 1: Flyash based.

[12] PareaRusanRangan. 2020. DisertasiKarakteristikGeopolimer yang Menggunakan Abu Jerami, Abu Terbang, dan Tanah LateritSebagaiBahan Ramah Lingkungan. Makassar: Doctoral Program of Civil Engineering, Civil Engineering Department, Faculty Engineering, Hasanuddin University.

[13] Davis, R.E., Carlson, R.W., Kelly, J.W. & Davis, H.E. 1937. Properties of Cement and Concretes Containing Fly Ash. Paper presented to Journal Proceedings.

[14] ASTM International. 2008. ASTM C618-08a: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete, ICS Code (Concrete and concrete products) 91.100.30.
[15] Qiang Tang, Yu Zhang, Yufeng Gao, and Fan Gu, Use of cement-chelated, solidified, municipal solid waste incinerator (MSWI) fly ash for pavement material: mechanical and environmental evaluations, Can. Geotech. J. 54: 1553–1566 (2017) dx.doi.org/10.1139/cgj-2017-0007
[16] RatnaKartikasari, R. Soekrisno, M. NoerIlmanSuharno&HendriHestiawan. 2007. Karakterisasi Ball Mill Import pada Industri Semen di Indonesia, Jurnal Teknik Mesin, Vol. 9, No. 1, April 2007: 18 – 24.
[17] Novotest Indonesia. Pengertian Semen dan Klasifikasinya. https://novotest.id/pengertian-semen-dan-klasifikasinya/ (accessed 21st May 2022)
[18] Alexander Ivanischev, Kirill S Ribakov, Semen V Markov &Ambesh Dixit. 2019. Synthesis and Electrochemical Properties of Lithium-Accumulating Electrode Material Based on Li2MnSiO4, Smart Materials, Structures and Devices View project.
[19] FitriaHandayani. 2019. ManfaatLimbah Abu Batu sebagaiTambahan Material BahanBangunan. Seminar Nasional Tahunan VI, Magister Program of Civil Engineering, LambungMangkurat University, Banjarmasin, 26th October 2019. ISBN 978-623-7533-03-0, pg. 59-68.
[20] Griya Paving Mandiri. MengintipKeunggulan Abu Batu DalamProduksi Paving. https://griyapaving.com/keunggulan-abu-batu-untuk-paving-block/ (accessed on 21st May, 2022)
[21] Munasir, Triwikantoro, M. Zainuri&Darminto. 2012. Uji XRD Dan XRF pada Bahan Mineral (Batuan Dan Pasir) SebagaiSumber Material Cerdas (Caco3 Dan Sio2), Journal of PenelitianFisika dan Aplikasinya (JPFA) Vol. 2 No. 1, June 2012.
[22] HadiMasrufi&Bagus Aditya. 2019. KajiEksperimenPengaruh Waktu TahanTerhadapPembentukanFaseKalsiumFerit Dari Pencampuran Fe2O3 Dan Caco3 BerbasisBahanAlamPasirBesi Dan BahanKapur. Surabaya: Mechanical Engineering Study Program, Faculty of Engineering, University of August 17, 1945.
[23] EndangHaryati, Khaerian Dahlan, dan Shabri Putra Wirman. 2019. Karakterisasi Dan Sifat KemagnetanPasirBesiEkstraksiAsal Pantai BetafSarmi, Papua. Journal of Photon Vol. 9 No.2, June 2019.
[24] AanPamungkas. 2015. TinjauanKualitas Genteng BetonSebagaiPenutup Atap DenganBahanTambahSerat Tebu. Surakarta: Civil Engineering Study Program, Faculty of Engineering, University of Muhammadiyah.
[25] Arya Ananda. 2020. Analisa Pembuatan Genteng BetonSeratDenganBahanTambahSeratIjuk. Medan: Civil Engineering Study Program, Faculty of Engineering, University of Medan.
[26] Supatmi. 2011. AnalisisKualitas Genteng BetonDenganBahanTambahSeratIjuk Dan PenguranganPasir. Yogyakarta: Mechanical Engineering Study Program, Faculty of Engineering, Yogyakarta State University.

Agus Budiono, et. al. "The Influence of Lumajang Iron Sand in Flat Concrete Roof Tiles Manufacturing". *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 19(6), 2022, pp. 07-14.