

Study of Making Concrete Block Using Gawan River Sand and Coal Waste (Bottom Ash) with Portland Cement Padang Viewed from the Perspective of Strength and Production Costs

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Abstract - Data from the DPUPR of Sragen district, the price of Merapi sand in 2020 is IDR 1,590,000 then in 2021 the price of Merapi sand is IDR 1,680,000. The increase in the material price of Merapi sand in Sragen Regency has forced the brick maker UD. Cerah, whose address is in Dayu village, Jurang Jero sub-district, Karangmalang sub-district, Sragen district, is again racking her brains to set a selling price for the bricks to avoid losses. The making of the brick itself cannot be separated from the costs incurred for purchasing raw materials, purchasing equipment for making bricks, and labor costs. So with the high price of Merapi sand material, it requires that the brick maker, UD. Sunny innovates by replacing the cheaper sand material. In this study using experimental methods for making bricks, using the full costing method for calculating production costs and using the depreciation method to obtain the annual depreciation load for brick machines. Based on research on the characteristics of fine aggregate river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district, the results of testing for silt content, testing for organic matter content, testing for specific gravity and water absorption, gradation testing met the requirements while testing for saturated surface dry (SSD) did not meet the requirements. Then research on the characteristics of fine aggregate from coal waste (bottom ash) obtained the results of testing for mud content, testing for organic matter content, testing for gradation that met the requirements while testing for specific gravity and water absorption, testing for saturated surface dry (SSD) did not meet the requirements. Based on the research on the compressive strength test of the bricks, it was found that the compressive strength of the bricks from river sand, Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district was greater than the compressive strength of the bricks from coal waste (bottom ash), the maximum average compressive strength value of bricks from river sand in the village Ngiang, Gawan sub-district, Tanon sub-district, Sragen district obtained a value of 6.51 MPa on the 1PC : 5PS FAS mixture variation of 0.5, while the maximum compressive strength value of bricks made from coal waste (bottom ash) obtained a value of 5.10 MPa on the variation mix

1PC : 5BA FAS 0.6. Based on research on the production costs of making bricks, it was found that the production costs of making 1 m³ of river sand bricks in Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district were greater than the production costs of making 1 m³ of coal waste (bottom ash) bricks, the production costs of 1 m³ river sand bricks in Ngipang village, village Gawan, Tanon sub-district, Sragen district, the highest is in the mix variation of 1PC: 5PS FAS 0.6 with the production cost of IDR 962,237.49, while the largest 1 m³ coal waste (bottom ash) brick production cost is in the 1PC mix variation: 5BA FAS 0.6 with a production cost of IDR 659,285.51.

Keywords: bottom ash, compressive strength, concrete brick, gawan river sand, production costs.

I. PRELIMINARY

Walls are one of the building elements that limit one room to another (Sahid, 2016). In the current technological era, brick is one of the most widely used building materials in Indonesia, this is due to the large and uniform size of the bricks so that the process of pairing walls is faster and can save costs (Putra Y, 2020).

Data from DPUPR for Sragen district, the price for Merapi sand in 2020 is IDR 1,590,000, then in 2021 the price for Merapi sand is IDR 1,680,000 (DPUPR for Sragen district). The increase in the material price of Merapi sand in Sragen Regency has forced the brick maker UD. Cerah, whose address is in Dayu village, Jurang Jero sub-district, Karangmalang sub-district, Sragen district, is again racking her brains to set the sales price for the bricks to avoid losses. The making of the brick itself cannot be separated from the costs incurred for purchasing raw materials, purchasing equipment for making bricks, and labor costs. So with the high price of Merapi sand material, it requires that the brick maker, UD. Sunny innovates by replacing the cheaper sand material.

Data from the Ministry of Energy and Mineral Resources in 2021 there is 9.7 million tons of coal waste (bottom ash) (CNN Indonesia). The availability of coal waste (bottom ash)

can be used as a new innovation as a substitute for sand material for the mixture of brick making materials. In addition to coal waste (bottom ash), in Sragen Regency there is also a natural resource in the form of river sand in the Gawan River which can be used as an alternative as a substitute for sand in brick making.

According to Ukiman’s research (2017), brick making by replacing sand using Jaliyang river sand, Purworejo district, obtained the compressive strength test results of the bricks of 10.76 MPa.

According to Putri D's research (2019), brick making by replacing sand using coal waste (bottom ash) obtained the compressive strength test results of the bricks of 7.14 MPa.

Coal waste is a topic of discussion because of the environmental pollution it causes. Previous research on the use of coal waste in the construction industry has focused more on fly ash than bottom ash. However, recent research indicates that bottom ash has several desirable mechanical properties that make it a viable construction material. Minimum strength, workability, light material, and other specifications of products that are combined with bottom ash must be adjusted in composition (Qomarudin, 2018).

Recent research has even shown that the use of bottom ash as an aggregate substitute in making concrete is suitable because of its porous texture and low particle density (Susilowati A, 2021). Other literature shows the promising ability of bottom ash as a substitute for aggregate and cement in concrete blocks, especially for increasing the strength of concrete and its microstructural properties. Over the last few decades, there has been extensive research on the use of alternative materials in brick making. Bricks with substitution of bottom ash, require further research to identify the level of strength and suitability of the selling price. The measurable strength of adobe bricks will determine the innovation in terms of price in full costing. So the research entitled "Study of Making Bricks Using Gawan River Sand and Coal Waste (Bottom Ash) With Padang Portland Cement in View of Strength and Production Costs" was chosen to overcome this gap.

II. RESEARCH METHODS

In this study using experimental methods in making bricks, using the full costing method for calculating production costs, using the depreciation method to obtain the annual depreciation load for brick machines. The flowchart of the implementation of the research is illustrated as follows:

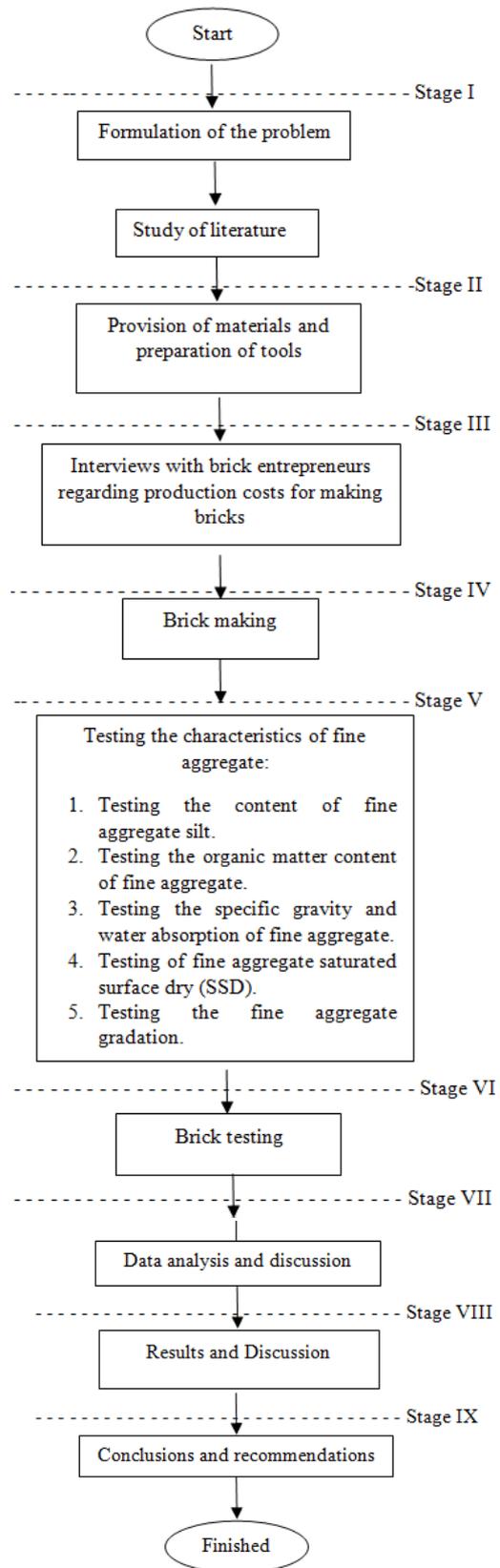


Figure 2.1: Flow chart of research implementation

Figure flow chart diagram of the flow of research implementation can be explained as follows:

Stage I: Formulation of the problem and study of literature. In this stage the researcher determines the problem in the form of what are the characteristics of Gawan river sand and bottom ash as a mixture of bricks, how much compressive strength is in each variation of the brick mixture from Gawan river sand and in each variation of the brick mixture from coal waste (bottom ash), how much is the composition cost in each variation of the mixture for making brick construction from Gawan river sand and in each variation for making brick construction from coal waste (bottom ash). In addition, the researcher also discussed the limitations of the problems to be raised and the benefits of the research. Literature study is used to obtain secondary data, so the authors collect data in the form of books, literary journals, and other sources related to the issues raised in this study.

Stage II: Provision of materials and preparation of tools. At this stage the provision of materials and preparation of tools is carried out before the research is carried out so that the research runs smoothly.

Stage III: Interviews with brick entrepreneurs regarding production costs for making bricks. At this stage the researcher conducted interviews by way of direct questioning with brick business owners in Dayu village, Jurang Jero sub-district, Karangmalang district, Sragen district regarding data on production costs for making bricks.

Stage IV: Brick making. Making bricks from Gawan river sand and bricks from coal waste (bottom ash) each made 6 variations of the mixture. Brick making was carried out in Dayu Village, Jurang Jero Village, Karangmalang District, Sragen Regency. In mixing the brick dough and printing bricks using a mixer machine and a hydraulic press machine.

Stage V: Testing the characteristics of fine aggregate. Testing of fine aggregate characteristics was carried out at the Civil Engineering Laboratory, Muhammadiyah University of Surakarta. As for testing the characteristics of fine aggregate as follows: Testing the silt content of fine aggregate. Testing the organic matter content of fine aggregate. Testing the specific gravity and water absorption of fine aggregate. Fine aggregate saturated surface dry (SSD) testing. Fine aggregate gradation test.

Stage VI: Brick testing. Brick testing was carried out when the bricks were 28 days old and carried out at the Civil Engineering Laboratory, Muhammadiyah University, Surakarta.

Stage VII: Data analysis and discussion. Conducting data analysis and discussion aims to determine the characteristics of Gawan river sand and coal waste (bottom ash) as a mixture of bricks, knowing the compressive strength in each variation

of the brick mixture from Gawan river sand and in each variation of the brick mixture from coal waste (bottom ash), and find out the cost of composition in each variation of the mixture for making brick construction from Gawan river sand and in each variation for making brick construction from coal waste (bottom ash).

Stage VIII: Results of the discussion. From the previous stage, the results obtained are the characteristics of Gawan river sand and coal waste (bottom ash) as a mixture of bricks, compressive strength in each variation of the brick mixture from Gawan river sand and in each variation of the brick mixture from coal waste (bottom ash), and the amount production costs in each variation of the mixture for making brick construction from Gawan river sand and in each variation for making brick construction from coal waste (bottom ash). So that the use of coal waste (bottom ash) as a substitute for fine aggregate affects the strength of bricks and reduces production costs incurred.

Stage IX: Conclusion and suggestions. After all the stages have been carried out and the desired results have been obtained, conclusions and suggestions are drawn as the final result of this study.

III. RESULTS AND DISCUSSION

A) Characteristics of Fine Aggregate

In the study of the characteristics of this fine aggregate using Gawan river sand and as a comparison the study used coal waste (bottom ash).

1. Gawan river sand

The results of the research on the characteristics of Gawan river sand can be seen in table 3.1.

Table 3.1: The results of the research on the characteristics of Gawan river sand

| No | Gawan river sand type testing | Test result |
|----|---|---------------------------|
| 1 | Sludge content testing | 1.23% |
| 2 | Testing the content of organic matter | Number : 1 (clear white) |
| 3 | Specific gravity and water absorption testing : | |
| | - Bulk specific gravity | 2.42 gram/cm ³ |
| | - Specific gravity (SSD) | 2.48 gram/cm ³ |
| | - Apparent specific gravity | 2.56 gram/cm ³ |
| | - Absorption | 2.25% |
| 4 | Saturated surface dry (SSD) testing | 1.53 cm |
| 5 | Gradation test (fine grain modulus) | 2.51 |

Source: Own Research

The results of the research on the characteristics of the Gawan river sand in table 3.1 can be explained as follows:

1) Sludge content testing

From the results of testing the mud content of river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district, a value of 1.23% was obtained. Based on SNI S-04-1989-F it is stated that the maximum limit of silt content in fine aggregate is 5%, so that river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district which will be used for brick making material meets the requirements.

2) Testing the content of organic matter

From the results of testing the organic matter content, it was found that the colored liquid at number 1 was clear white. Based on SNI 03-2816-1992 it is stated that the color of the organic matter content in the fine aggregate may not be above color 3 (hellige tester), so that river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district which will be used for brick making materials meets the requirements.

3) Specific gravity and water absorption testing

From the results of testing the specific gravity and water absorption of river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district, the bulk specific gravity value was 2.42 gram/cm³, the specific gravity value (SSD) was 2.48 gram/cm³, the apparent specific gravity value of 2.56 gram/cm³ and absorption value of 2.25%. Based on SNI 1970: 2008 it is stated that the absorption value of water in fine aggregates may not exceed 5%, so that river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district which will be used for brick making materials meets the requirements.

4) Saturated surface dry (SSD) testing

From the results of the saturated surface dry (SSD) test, there was a decrease of 1.53 cm. From this experiment it was found that river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district that was tested had not yet reached saturated surface dry (SSD). Because fine aggregate can be said to reach saturated surface dry (SSD) if the fine aggregate drops from the top of the cone to half of the height of the cone, which is 3.8 cm.

5) Gradation test (fine grain modulus)

From the results of the river sand gradation test from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen regency, it is classified as fine sand because it has a fine grain modulus (MHB) of 2.51. According to SNI ASTM C136 2012, fine sand has a fine grain modulus between 1.5 - 3.8, so that river sand from Ngipang village, Gawan sub-

district, Tanon sub-district, Sragen district, which will be used for brick making materials, meets the requirements.

2. Coal waste (bottom ash)

The results of the research on the characteristics of coal waste (bottom ash) can be seen in table 3.2.

Table 3.2: Results of research on the characteristics of coal waste (bottom ash)

| No | Type of coal waste testing (bottom ash) | Test result |
|----|---|---------------------------|
| 1 | Sludge content testing | 1.64% |
| 2 | Testing the content of organic matter | Number : 1 (clear white) |
| 3 | Specific gravity and water absorption testing : | |
| | - Bulk specific gravity | 1.74 gram/cm ³ |
| | - Specific gravity (SSD) | 1.86 gram/cm ³ |
| | - Apparent specific gravity | 1.97 gram/cm ³ |
| | - Absorption | 6.61% |
| 4 | Saturated surface dry (SSD) testing | 1.63 cm |
| 5 | Gradation test (fine grain modulus) | 3.53 |

Source: Own Research

The results of the research on the characteristics of coal waste (bottom ash) in table V.2 can be explained as follows:

1) Sludge content testing

From the results of testing the sludge content of coal waste (bottom ash) obtained a value of 1.64%. Based on SNI S-04-1989-F it is stated that the maximum limit of silt content in fine aggregate is 5%, so that coal waste (bottom ash) which will be used for brick making material meets the requirements.

2) Testing the content of organic matter

From the results of testing the organic matter content, it was found that the colored liquid at number 1 was clear white. Based on SNI 03-2816-1992 it is stated that the color of the organic matter content in the fine aggregate may not be above color 3 (hellige tester), so that the coal waste (bottom ash) to be used for brick making material meets the requirements.

3) Specific gravity and water absorption testing

From the results of testing the specific gravity and absorption of coal waste water (bottom ash) it was found that the bulk specific gravity value was 1.74 gram/cm³, the specific gravity value (SSD) was 1.86 gram/cm³, the apparent specific gravity value was 1.97 gram/cm³ and absorption value (absorption) of 6.61%. Based on SNI 1970: 2008 it is stated that the absorption value of water in fine aggregates may not exceed 5%, so that coal waste (bottom ash) to be used for brick making materials does not meet the requirements.

4) Saturated surface dry (SSD) testing

From the results of the saturated surface dry (SSD) test, there was a decrease of 1.63 cm. From this experiment it was found that the coal waste (bottom ash) tested had not yet reached saturated surface dry (SSD). Because fine aggregate can be said to reach saturated surface dry (SSD) if the fine aggregate drops from the top of the cone to half of the height of the cone, which is 3.8 cm.

5) Gradation test (fine grain modulus)

From the results of testing the gradation of coal waste (bottom ash) classified or included as fine sand because it has a fine grain modulus (MHB) of 3.53. According to SNI ASTM C136 2012, fine sand has a fine grain modulus between 1.5 - 3.8. So that the coal waste (bottom ash) that will be used for brick making materials meets the requirements.

B) Compressive Strength Testing of Brick

In this brick testing, the compressive strength test of bricks made from Gawan river sand was carried out and the compressive strength test of bricks made from coal waste (bottom ash). The following are the results of the compressive strength test of bricks made from Gawan river sand and the results of the compressive strength test of bricks made from coal waste (bottom ash).

1. Bricks from Gawan river sand

This test was carried out with the aim of knowing the compressive strength of bricks using Gawan river sand fine aggregate with a mixture variation of 1PC: 5PS FAS 0.5; 1PC: 6PS FAS 0.5; 1PC: 7PS FAS 0.5; 1PC: 5PS FAS 0.6; 1PC: 6PS FAS 0.6; 1PC: 7PS FAS 0.6. The results of the average compressive strength test of bricks from Gawan river sand can be seen in table 3.3.

Table 3.3: Results of the average compressive strength test of adobe bricks from Gawan river sand

| Mixed brick variations gawan river sand | Average compressive strength (MPa) |
|---|------------------------------------|
| 1PC : 5PS FAS 0.5 | 6,51 |
| 1PC : 6PS FAS 0.5 | 6,00 |
| 1PC : 7PS FAS 0.5 | 5,72 |
| 1PC : 5PS FAS 0.6 | 6,23 |
| 1PC : 6PS FAS 0.6 | 5,83 |
| 1PC : 7PS FAS 0.6 | 5,50 |

Source: Own Research

Based on the results of the average compressive strength test of bricks from river sand, Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district, in table 3.3 it can be explained that the 1PC: 5PS FAS 0.5 mixture variation is

capable of producing a compressive strength value of 6.51 MPa. The mixed variation 1PC: 6PS FAS 0.5 is capable of producing a compressive strength value of 6.00 MPa. The mixed variation 1PC: 7PS FAS 0.5 is capable of producing a compressive strength value of 5.72 MPa. The mixed variation of 1PC: 5PS FAS 0.6 is capable of producing a compressive strength value of 6.23 MPa. The mixed variation 1PC: 6PS FAS 0.6 is capable of producing a compressive strength value of 5.83 MPa. The mixed variation 1PC: 7PS FAS 0.6 is capable of producing a compressive strength value of 5.50 MPa.

2. Bricks from coal waste (bottom ash)

This test was carried out with the aim of knowing the compressive strength of bricks using fine aggregate waste coal (bottom ash) with a mixture of 1PC: 5BA FAS 0.5; 1PC: 6BA FAS 0.5; 1PC: 7BA FAS 0.5; 1PC: 5BA FAS 0.6; 1PC: 6BA FAS 0.6; 1PC: 7BA FAS 0.6. The results of testing the compressive strength of bricks from coal waste (bottom ash) can be seen in table 3.4.

Table 3.4: The results of the brick compressive strength test from coal waste (bottom ash)

| Mixed brick variations coal waste (bottom ash) | Average compressive strength (MPa) |
|--|------------------------------------|
| 1PC : 5BA FAS 0.5 | 4,93 |
| 1PC : 6BA FAS 0.5 | 4,70 |
| 1PC : 7BA FAS 0.5 | 4,36 |
| 1PC : 5BA FAS 0.6 | 5,10 |
| 1PC : 6BA FAS 0.6 | 4,76 |
| 1PC : 7BA FAS 0.6 | 4,53 |

Source: Own Research

Based on the results of the compressive strength test of bricks from coal waste (bottom ash) in table 3.4 it can be explained that the variation of the 1PC : 5BA FAS 0.5 mixture is capable of producing a compressive strength value of 4.93 MPa. The mixed variation 1PC: 6BA FAS 0.5 is capable of producing a compressive strength value of 4.70 MPa. The mixed variation 1PC: 7BA FAS 0.5 is capable of producing a compressive strength value of 4.36 MPa. The mixed variation 1PC: 5BA FAS 0.6 is capable of producing a compressive strength value of 5.10 MPa. The mixed variation 1PC: 6BA FAS 0.6 is capable of producing a compressive strength value of 4.76 MPa. The mixed variation 1PC: 7BA FAS 0.6 is capable of producing a compressive strength value of 4.53 MPa.

C) Production Cost of Brick Making

This study aims to determine the production costs in each variation of the mixture for making bricks from Gawan river sand and in each mixture for making bricks from coal waste

(bottom ash). The results of the production costs of making bricks from Gawan river sand and the results of the production costs of making bricks from coal waste (bottom ash) are as follows:

1. Production costs for making bricks from Gawan river sand

Table 3.5: The results of the production costs of making bricks from Gawan river sand

| Variation of gawan river sand brick mixture | Gawan river sand brick production cost |
|---|--|
| 1PC : 5PS FAS 0.5 | IDR 961,905.17 |
| 1PC : 6PS FAS 0.5 | IDR 853,288.14 |
| 1PC : 7PS FAS 0.5 | IDR 775,704.54 |
| 1PC : 5PS FAS 0.6 | IDR 962,237.49 |
| 1PC : 6PS FAS 0.6 | IDR 853,565.07 |
| 1PC : 7PS FAS 0.6 | IDR 775,941.92 |

Source: Own Research

Based on the results of the production costs of making bricks from river sand from Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district, in table 3.5 it can be explained that the manufacture of bricks with a mixture of 1PC: 5PS using 1 m³ of Gawan river sand with a FAS of 0.5 obtained a production cost of IDR 961,905.17. Making mixed variations of 1PC: 6PS brick using 1 m³ of Gawan river sand with FAS 0.5 obtained a production cost of IDR 853,288.14. Making bricks with mixed variations of 1PC: 7PS using 1 m³ of Gawan river sand with FAS 0.5 obtained a production cost of IDR 775,704.54. Making bricks with mixed variations of 1PC: 5PS using 1 m³ of Gawan river sand with FAS 0.6 obtained a production cost of IDR 962,237.49. Making mixed variations of 1PC: 6PS brick using 1 m³ of Gawan river sand with FAS 0.6 obtained a production cost of IDR 853,565.07. Making mixed variations of 1PC: 7PS brick using 1 m³ of Gawan river sand with FAS 0.6 obtained a production cost of IDR 775,941.92.

2. Production costs for making bricks from coal waste (bottom ash)

Table 3.6: The results of the production costs of making bricks from coal waste (bottom ash)

| Variation of coal waste (bottom ash) brick mixture | Coal waste (bottom ash) brick production cost |
|--|---|
| 1PC : 5BA FAS 0.5 | IDR 659,036.27 |
| 1PC : 6BA FAS 0.5 | IDR 576,899.22 |
| 1PC : 7BA FAS 0.5 | IDR 518,229.89 |
| 1PC : 5BA FAS 0.6 | IDR 659,285.51 |
| 1PC : 6BA FAS 0.6 | IDR 577,106.92 |
| 1PC : 7BA FAS 0.6 | IDR 518,407.92 |

Source: Own Research

Based on the results of the production costs of making bricks from coal waste (bottom ash) in table 3.6 it can be explained that the manufacture of mixed variations of 1PC: 5BA bricks uses 1 m³ of coal waste (bottom ash) with a FAS of 0.5 a production cost of IDR 659,036.27 is obtained. Making bricks with mixed variations of 1PC: 6BA using 1 m³ of coal waste (bottom ash) with a FAS of 0.5 obtained a production cost of IDR 576,899.22. Making bricks with mixed variations of 1PC: 7BA using 1 m³ of coal waste (bottom ash) with a FAS of 0.5 obtained a production cost of IDR 518,229.89. Making bricks with mixed variations of 1PC: 5BA using 1 m³ of coal waste (bottom ash) with a FAS of 0.6 obtained a production cost of IDR 659,285.51. Making bricks with mixed variations of 1PC: 6BA using 1 m³ of coal waste (bottom ash) with a FAS of 0.6 obtained a production cost of IDR 577,106.92. Making bricks with mixed variations of 1PC: 7BA using 1 m³ of coal waste (bottom ash) with a FAS of 0.6 obtained a production cost of IDR 518,407.92.

IV. CLOSING

A) Conclusion

Based on the results of the study, conclusions can be drawn, including the following:

The results of the research on the characteristics of river sand from Ngipang village, Gwan sub-district, Tanon sub-district, Sragen district found that the mud content value was 1.23% (meeting the requirements of SNI S-04-1989-F), the color of the solution in the organic matter test did not change, namely clear white (meets the requirements of SNI 03-2816-1992), the value of water absorption is 2.25% (meets the requirements of SNI 1970: 2008), the value of the decrease in saturated surface dry (SSD) is 1.53 cm (does not meet the requirements), the value of fine grain modulus (MHB) of 2.51 (meets the requirements of SNI ASTM C136 2012) and the sand gradation is in curve 2, namely rather coarse sand. The results of the research on the characteristics of coal waste (bottom ash) show that the value of the sludge content is 1.64% (fulfills the requirements of SNI S-04-1989-F), the color of the solution in the organic matter test does not change, namely clear white (meets the requirements of SNI 03-2816- 1992), a water absorption value of 6.61% (does not meet the requirements of SNI 1970: 2008), a decrease in saturated surface dry (SSD) value of 1.63 cm (does not meet the requirements), a fine grain modulus (MHB) value of 3, 43 (meets the requirements of SNI ASTM C136 2012) and the gradation of coal waste (bottom ash) is in curve 1, namely coarse sand.

The compressive strength of bricks made from river sand, Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district is greater than the compressive strength of

bricks made from coal waste (bottom ash). The maximum average compressive strength of bricks made from river sand, Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district obtained a value of 6.51 MPa in the IPC: 5PS FAS mixture variation of 0.5, while the maximum average compressive strength of bricks made from coal waste (bottom ash) obtained a value of 5.10 MPa in the mixed variation IPC : 5BA FAS 0.6. According to SNI 03-0349-1989 bricks made from river sand, Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district and bricks made from coal waste (bottom ash) all mixed variations are included in quality level III, quality level III bricks are used for construction that is not load-bearing, protected and not stucco.

The production cost of making 1 m³ of river sand bricks in Ngipang village, Gawan sub-district, Tanon sub-district, Sragen district is higher than the production cost of making 1 m³ of coal waste (bottom ash) bricks. The largest production cost for a 1 m³ river sand brick in Ngipang village, Gawan sub-district, Tanon sub-district, Sragen regency is in the mixed variation of IPC: 5PS FAS 0.6 with a production cost of IDR 962,237.49, while the production cost for 1 m³ brick waste coal (bottom ash) which is the largest in the mixed variation IPC: 5BA FAS 0.6 with a production cost of IDR 659,285.51.

B) Suggestion

As for some suggestions from this study, among others, as follows:

1. The need for accuracy when weighing mixed brick materials and mixing mixed brick materials so that the quality of the bricks is not reduced.
2. The next research is to make various variations of brick mixtures, especially on FAS (water-cement factor) in order to get the maximum quality of bricks.
3. For further research, make a sample for testing cylindrical bricks according to SNI.
4. The results of this study can be used or considered for contractor services as wall masonry materials.

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