

# Analysis of Brick Characteristics Using Iron Grit Addition

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## Abstract

The accumulation of waste from iron grit that has been left unattended can be reused as one of the additional materials for making bricks so that it can reduce the impact of waste accumulation which can become air pollution and interfere with the respiratory tract. One way is to mix the basic material of the bricks using waste iron grit which is waste from the steel smelting industry. This study aims to determine the quality of bricks with the addition (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%) iron grit waste and without the addition of iron grit waste. This research was carried out experimentally using treatment with a variety of iron grit addition and without addition to brick making. This research was carried out at the Civil Engineering Laboratory, University of Muhammadiyah Tangerang. The results of the appearance test showed that all samples showed that the shape, roughness and smoothness of the surface were in accordance with SNI and there were no cracks in all the samples made. The results of the research that have been carried out show that sample A that does not use iron grit and samples B, C, D, E and F that use additional iron grit mixture meet the standard of class 50 or equal to 5 MPa. All test samples have a maximum absorption of water that enters the SNI criteria of 20%. The smallest pseudo-density was obtained by sample B with a result of 1.49 while the largest density was obtained in sample J with a result of 1.93. The apparent density increases as the composition of iron grit increases. Bricks with optimal characteristics are obtained in the composition of mixing clay and iron grit of 90%:10%.

**Keywords:** Brick, iron grit, clay

## 1. INTRODUCTION

Indonesia is entering the era of massive infrastructure development until 2045, where the construction industry plays an important role in processing natural materials such as sand, stone, and manufactured materials such as steel, cement, and asphalt into buildings. Bricks are one of the basic materials that have been used for a long time, both in urban and rural areas, for various applications such as foundations, fences, channels, and building walls (Zebua & Sinulingga, 2018). Red brick as a traditional material is made from clay that is burnt to hard and does not easily destroy in water (Widodo & Artiningsih, 2021). Although modern alternatives such as light brick have been present (Windayati, 2023), red bricks remain the main choice of lower-middle-income people because of their more affordable price. On the other hand, the development of the steel industry produces waste such as iron sand ash, which has not been optimally utilized.

PT. Kawan Sejati Gunamulya is one of the companies that processes industrial waste into *blasting sand*, but this process also produces advanced waste in the form of *iron grit*. This waste has the potential to pollute the environment if not managed properly. This iron grit waste will later be used as a brick mixture. For this reason, it is necessary to know the characteristics of mechanical properties based on SNI 15-2094-2000 regarding solid red bricks for wall pairs. Therefore, this study wants to find out how to manage *iron grit* as an additional material in the manufacture of bricks, in order to improve mechanical properties such as compressive strength, pseudo-density, water absorption and appearance properties, while supporting the principle of sustainable development.

### 1.1. Literature Review

According to (SNI-15-2094-2000, 2000), brick is a building material that has a long rectangular prism shape, both solid and hollow, with a cavity volume not exceeding 15%, designed for the purpose of building wall construction. Bricks are made of molded clay and fired at high temperatures until they become solid (As et al., 2017).

#### 1.1.1. Brick Quality Requirements

The standard basis for the quality of red bricks as building materials that must be met must be in accordance with SNI 15-2094-2000, namely:

#### 1.1.2. Visible Properties

The visible nature of a brick is a physical property that is carried out without changing the shape or without putting a load on the brick itself. Based on SNI 15-2094-2000, the appearance properties of solid red brick for wall pairs must be in the form of a long rectangular prism, have elbow ribs, flat areas and do not show cracks. The color of the bricks depends on the color of the soil base, the type of additive mixture if present and the process of burning (Andayono et al., 2017).

1.1.3. Size and Tolerance

The size of bricks has many variations (Dasar et al., 2024). The size of bricks that have been allowed in the SNI regulation 15-2094-2000 can be seen in Table 1:

Table 1: Brick Dimensions

Types	Heights (mm)	Widths (mm)	Lengths (mm)
M-5a	65 ± 2	92 ± 2	190 ± 4
M-5b	65 ± 2	100 ± 2	190 ± 4
M-6a	52 ± 3	110 ± 2	230 ± 5
M-6b	55 ± 3	110 ± 2	230 ± 5
M-6c	70 ± 3	110 ± 2	230 ± 5
M-6d	80 ± 3	110 ± 2	230 ± 5

(Source: SNI 15-2094-2000)

However, there are also red bricks that have other sizes, for example, which are 20 cm x 10 cm x 7.5 cm. However, the dimensions of 20 cm x 10 cm x 5 cm are commonly used for domestic projects. The shape of bricks is in the form of blocks with a predetermined length, width, thickness. The surface of the brick is relatively flat and rough (Andayono et al., 2017).

1.1.4. Compressive Strength

The compressive strength of a brick is the amount of the load of the unit area that can cause the brick or test piece to be destroyed when subjected to a certain force (Nasution et al., 2023). In international units (SI), the unit of pressure is N/m<sup>2</sup>. The unit was also named Pascal (abbreviated as Pa). So, 1 N/m<sup>2</sup> = 1 Pa. Pascal units are the pressure exerted by Newton's force on a surface area of one square meter. The compressive strength equation can be calculated by the formula:

$$\sigma = \frac{P}{A} \dots\dots\dots (1)$$

Information:

$\sigma$  = Pressure (MPa)

$P$  = Maximum Load (N)

$A$  = Cross-sectional Area (mm<sup>2</sup>)

Table 2: Compressive Strong of Red Brick For Wall Pair

Classes	Minimum Average Compressive Strength Kg/Cm2 (MPa)	Coefficient of Variation of Average Compressive Strength Tested (%)
50	50 (5)	22
100	100 (10)	15
150	150 (15)	15

(Source: SNI 15-2094-2000)

1.1.5. Water Absorption

Water absorption is an important factor because one of the properties of bricks that greatly affects the strength of a brick job. The absorbency of the bricks is controlled to prevent water loss in the mortar being used (Gobhe et al., 2023). If the absorbency of the bricks is high enough, it can cause the adhesion of the mortar to weaken to the bricks. In addition, bricks with a high moisture content can also negatively impact the performance of the wall pair, especially during the stucco process (Ro et al., 2024). based on SNI 15-2094-2000 the maximum water absorption is 20%. The brick absorption test can be calculated by the formula:

$$P = \frac{A-B}{B} \times 100\% \dots\dots\dots (2)$$

Information:

$P$  = Water Absorption

$A$  = weight variation after soaking

$B$  = dry variation weight

1.1.6. Pseudo-density

Pseudo-density is the mass of a sample contained in a unit of volume. Density is often referred to as density or density or commonly also referred to as material density. (Wahyuni Ardi et al., 2016). Based on SNI 15-2094-2000, the minimum pseudo-density of bricks is 1.2 gr/cm<sup>3</sup>. Equations used in calculating pseudo-density with the formula:

$$Q_{Sch} = \frac{Md}{c-b} \times d_w \dots \dots \dots (3)$$

Information:

$Q_{Sch}$  = Pseudo-density (grams/cm<sup>3</sup>)

$Md$  = Oven dry weight (grams)

$b$  = Weight in water (grams)

$c$  = Weight after soaking (grams)

$d_w$  = Water density 1.0

## 2. METHOD

This research was carried out at the UMT Civil Engineering Laboratory with an experimental research method. The experimental method of this study was carried out by comparing the appearance properties, compressive strength values, water absorption and pseudo-density of bricks. The mixture used in this study is clay and *iron grit*. The clay was taken from Kakulu Village, Dangdeur Village, Jayanti District, Tangerang Regency. Meanwhile, *iron grit* is taken from PT. A True Friend of Gunamulya. The variations of clay and *iron grit* used in this study were with the composition of 100%:0% (A), 90%:10% (B), 80%:20% (C), 70%:30% (D), 60%:40% (E), 50%:50% (F), 40%:60% (G), 30%:70% (H), 20%:80% (I) and 10%:90% (J). The total number of brick samples tested was 20 samples as shown in table 3.

Table 3: Mixed Composition Iron Grit on Brick Making

Samples	Soil (T) (%)	Iron Grit (%)	Sum
A	100	0	2
B	90	10	2
C	80	20	2
D	70	30	2
E	60	40	2
F	50	50	2
G	40	60	2
H	30	70	2
I	20	80	2
J	10	90	2
Total			20

### 2.1. Mix Design

In the process of making brick test objects, mix design is a very important stage to determine the final quality of the product. Each constituent material, such as soil as the main material, iron grit as an additive, and water as a plasticity reagent, must be calculated and measured in the right proportions. The determination of this composition aims to obtain a homogeneous mixture, easy to print, and produce bricks with optimal mechanical and physical properties. Therefore, in this study, the material requirements in each test sample were calculated, which were then applied to one brick mold with the composition as shown in Table 4.

Table 4. Material requirements for brick making

Samples	Composition		
	Soil	Iron grit	Water
A	1960	0	250
B	1764	222,4	281
C	1568	444,8	311
D	1372	667,2	342
E	1176	889,6	372
F	980	1112	403
G	784	1334,4	434
H	588	1556,8	464
I	392	1779,2	495
J	196	2001,6	525

### 2.2. Making Test Object

In the process of making the test specimen, 20 brick samples were carried out. The materials used are soil, *iron grit* and water measured according to table 3.2. The materials that have been measured are then mixed together in a container and stirred manually by hand, then printed using a brick mold measuring 19 x 9.2 x 6.5 cm. as shown

in Picture 3.1 and Picture 3.2. After the printing is carried out, the drying carried out by the researchers are by drying in the UMT Civil Engineering laboratory.



Picture 1. Mixing of Materials



Picture 2. Brick Printing

### 2.3. Combustion

In the combustion process, the researchers prepared 20 dried samples to be burned. Combustion is carried out using firewood and rice husks with an arrangement of bricks in the form of mountains that are given gaps/holes to be filled with fuel. The outside of this pile is lined with clay so that a fire does not occur in the combustion stove. The covering layer should be exactly tight, so that the bricks will mature better. The duration of the combustion process in this study is 24 hours with a temperature of around 500-1000°C.



Picture 3. Ready-to-bake bricks



Picture 4. Combustion structuring process



Picture 5. Combustion Process

## 3. RESULTS AND DISCUSSION

The results of the brick test were carried out based on the SNI 15-2094-2000 standard. The test analysis is carried out based on classification and quality requirements. Where the classification is there are 3 classes, namely classes 50, 100 and 150. This classification must be in accordance with quality requirements which include appearance characteristics, pressure test results, water absorption test results and pseudo-density results. The samples made in the study were 2 pieces each of the variations. The number tested for the apparent properties was as many as 20 pieces. The number tested for compressive strength was 10 pieces. Meanwhile, the number tested for water absorption and pseudo-density was 10 pieces. The samples used for the compressive strength test are not used in water absorption and pseudo-density testing. The following are the results of the quality requirements test on bricks.

### 3.1. Visible Properties

The appearance properties were tested to determine the shape of the rectangular prism of the display, having elbow ribs, flat planes and not showing cracks. The results of the testing of the appearance properties of brick samples can be seen in picture 4.1 that all test samples have qualified appearance characteristics based on SNI 15-2094-2000. Judging from its shape, bricks have a rectangular shape. Judging from the ribs, all sides have elbowed sides and are not dull. Judging from the flat surface and no cracks.



Picture 6. Results after Combustion

### 3.2. Press Test

Testing the compressive strength of bricks was carried out at the Civil Engineering Laboratory of the University of Muhammadiyah Tangerang using the CTM (*Compression Testing Machine*) tool. Compressive strength is carried out to determine the quality of bearing lateral loads.



Picture 7. Press test process

The results of the compressive strength test of the bricks in samples A, B, C, D, E and F meet the category in class 50 (5 MPa), with the results of sample A that did not use additional *iron grit* had a compressive strength of 14.30 MPa. Meanwhile, those who used additional *iron grit* were in sample B of 8.58 MPa, Sample C of 8.01 MPa, Sample D of 6.29, sample E of 5.72 MPa and sample F of 5.15 MPa. Thus, the maximum compressive strength using *the iron grit* mixture is produced by sample B. while samples G to J do not meet the SNI 15-2094-2000 standard as shown in Table 5.

Table 5. Compressive test results

BRICK TEST PIECES					
Test Pieces	Composition Brick		Tool Readings (Maximum Load)		Compressive Strength (Mpa)
	Soil (%)	Iron Grit (%)	Kn	N	
A	100	0	250	250000	14,30
B	90	10	150	150000	8,58
C	80	20	140	140000	8,01
D	70	30	110	110000	6,29
E	60	40	100	100000	5,72
F	50	50	90	90000	5,15
G	40	60	80	80000	4,58
H	30	70	70	70000	4,00
I	20	80	50	50000	2,86
J	10	90	45	45000	2,57

### 3.3. Water Absorbency Testing

Water absorption testing aims to assess how well bricks are able to absorb water. This is important because in its application bricks are often installed using mortar. In this test, there were 10 samples of bricks produced by the researchers. The following is a picture of the water absorption testing process which begins with soaking for 24 hours which is then weighed.



Picture 8. Water absorption testing process

The results of the brick absorption test had the highest value in sample A 19.44% because it did not use *iron* grit. The highest value using additional *iron grit* was sample B with a result of 18.62%. Meanwhile, the lowest value in the J sample was 11.79%. The maximum value of water absorption based on SNI 15-2094-2000 is 20%. The test results can be seen from Table 6.

Table 6. Water absorption test results

Test Pieces	BRICK TEST PIECES				Water Absorption (%)
	Composition		Heavy		
	Soil (%)	Iron grit (%)	Dry (gram)	Wet (gram)	
A	100	0	1440	1720	19,44
B	90	10	1450	1720	18,62
C	80	20	1520	1790	17,76
D	70	30	1590	1850	16,35
E	60	40	1670	1930	15,57
F	50	50	1740	2000	14,94
G	40	60	1830	2090	14,21
H	30	70	1920	2180	13,54
I	20	80	2020	2280	12,87
J	10	90	2120	2370	11,79

### 3.4. Pseudo-Density Testing

The pseudo-density test of bricks aims to determine the mass per unit volume of the brick, including the pores in it. The test is carried out by weighing the sample in water. Furthermore, the data obtained are in the form of oven dry weight, surface dry weight and water weight. Then the data is processed based on SNI 15-2094-2000.



Picture 9. Pseudo-density testing process

The results of data processing in this test resulted in an average pseudo-density of 1.714 g/cm<sup>3</sup>. The largest pseudo-density with a mixture of *iron grit* was obtained in sample J with a result of 1.93 g/cm<sup>3</sup>, while the smallest was obtained in a sample of 1.49 g/cm<sup>3</sup>. This shows that there is an effect on the compressive strength and the increase in the amount of *iron grit*. The greater the apparent density value produced, the smaller the compressive strength produced, while the more *iron grit* is added, the greater the pseudo-density produced. The use of a lot of *iron grit* will produce cavities that make the compressive strength lower as shown in table 7.

Table 7. Pseudo-density test results

BRICK TEST PIECES						
Test Pieces	Composition		Heavy			Pseudo-density (gram/cm <sup>3</sup> )
	T	I	Dry	Wet	In Water	
	(%)	(%)	(gram)	(gram)	(gram)	
A	100	0	1440	1720	715	1,43
B	90	10	1450	1720	750	1,49
C	80	20	1520	1790	815	1,56
D	70	30	1590	1850	905	1,68
E	60	40	1670	1930	935	1,68
F	50	50	1740	2000	1030	1,79
G	40	60	1830	2090	1090	1,83
H	30	70	1920	2180	1145	1,86
I	20	80	2020	2280	1210	1,89
J	10	90	2120	2370	1270	1,93

#### 4. CONCLUSIONS

This study aims to determine the effect of the addition of *iron grit* to bricks on compressive strength, water absorption and apparent *density*. Based on the results of the research that has been conducted, the following conclusions can be drawn:

1. The results of the appearance test showed that the shape, roughness and smoothness of the surface were in accordance with SNI and there were no cracks in all samples made, so the appearance test met the SNI 15-2094-2000 standard.
2. The results of the research that have been carried out show that sample A that does not use iron grit and samples B, C, D, E and F that use additional iron grit mixture meet the standard of class 50 or equal to 5 MPa.
3. All test samples have a maximum water absorption capacity that enters the SNI criteria of 20%.
4. The smallest pseudo-density was obtained by sample B with a result of 1.49 while the largest density was obtained in sample J with a result of 1.93
5. The optimal mixture research obtained from this study was taken based on maximum compressive strength, maximum water absorption and minimum pseudo-density. So, sample B which has a ratio of 90:10 between soil and iron grit that meets the criteria with a compressive strength value of 8.85 MPa, water absorption capacity 18.62% and apparent *density* of 1.49 grams/cm<sup>2</sup>.

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