

ANALYSIS OF THE EFFECT OF THE ADDITION OF ZEOLITE ON COMPRESSIVE STRENGTH OF POST-FIRING BRICKS

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Abstract: As the demand for construction materials, especially bricks, increases, efforts are needed to improve product quality to meet strength and durability standards. This study aims to analyze the effect of the addition of zeolite as an additive in clay soil on the compressive strength of post-firing bricks. The variations of zeolite addition used are 0%, 5%, 10%, 15%, 20%, and 25%. Testing includes soil characteristics, shrinkage, and compressive strength of bricks at 3, 7, and 14 days of age. The results of the study show that the addition of zeolite is able to improve the mechanical properties of bricks, especially in reducing burn shrinkage and increasing compressive strength. The minimum burn shrinkage value was achieved at the addition of 25% zeolite of 21.4%, while the optimum compressive strength value of 55.97 kg/cm² was obtained at the 25% zeolite variation with a residence time of 5 days and a test life of 14 days. Thus, the addition of zeolite can be an effective alternative in improving the quality of bricks to support construction needs.

Keywords: Brick, zeolite, compressive strength, shrinkage, clay soil.

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1. Introduction

Along with the development of the construction sector, population growth, and improvement in economic conditions, the need for building materials has increased significantly to support the development of facilities and infrastructure. Bricks are one of the building materials that are increasingly needed to support these development activities. In Indonesia, the development of the construction sector, especially the construction of buildings and housing, has experienced very rapid growth. This condition has implications for increasing demand for bricks, so many manufacturers have started building brick factories to meet market needs. However, in the production process, producers generally only use certain types of soil to maintain the quality of the bricks produced. As a result, the availability of suitable land as the main raw material for making bricks is decreasing and the price tends to increase.

In this study, an additional material in the form of zeolite was used which aims to improve the quality of the soil as a basic material in making bricks. Zeolite is a type of non-metallic mineral that is included in the group of multi-purpose industrial excavated materials. One of the main benefits of zeolite is its ability to improve soil stability when mixed as an additive. Zeolite is able to bind to soil aggregate granules, resulting in a denser and firmer soil

mass. Thus, soil that has been mixed with zeolite will have better bearing capacity and compressive strength. In addition, zeolite also has the ability to interact with various types of soil, both non-cohesive coarse textured soils and very plastic soils.

Analysis of the effect of the addition of zeolite on the compressive strength of post-firing bricks is one of the approaches that aims to improve or eliminate negative properties of soil that is not suitable for use as raw materials for making bricks. The addition of zeolite material is expected to increase the compressive strength of the brick, resulting in a product with better quality. Bricks themselves are one of the main components in building construction, especially in the residential sector, which serves as a protector against temperature fluctuations and rainfall. Until now, bricks still play an important role in the world of construction, both as a structural and non-structural element. This is reflected in the widespread use of bricks in various development projects, such as in the construction of walls, fences, channels, and foundations.

According to research by M. Khoirul Anam (2019) based on a study entitled Analysis of the Effect of the Use of Soil Stabilization Materials on the Compressive Strength of Burning Bricks, it shows that the use of brick samples measures 23 cm long, 11 cm wide, and 5 cm high. The variations in addition of zeolite are 0%, 7%, 9%, 11% and 13%. The minimum burn shrinkage

value occurred at 13% zeolite of 21.22% and the optimum compressive strength value of 53.97 kg/cm² was achieved at 14 days of age during the 5-day residence of the mixture.

2. Literature Review

Soil is the earth's surface layer that has a physical role as a place for plant roots to grow, provide support for plant growth, and supply water and nutrients needed by roots. Chemically, soil functions as a storekeeper and provider of nutrients or nutrients, while from a biological perspective, soil acts as a habitat for soil organisms that play a role in providing nutrients and additives that are beneficial to plants.

Naturally, soil is made up of a mixture of mineral particles that may or may not contain organic matter. These particles can be separated from each other easily through the process of washing using water. Soil comes from the weathering of rocks, which can occur physically or chemically. In addition to being influenced by the nature of the parent rock as a material source, the technical nature of the soil is also influenced by external factors that cause the weathering of the rock.

In the field of Civil Engineering, terms such as gravel, sand, silt, and clay are used to classify soil types. Under natural conditions, soil is often made up of a mixture of two or more types of soil, and sometimes contains organic matter. The name of the land is then followed by the designation of the main types of materials that exist. For example, silty clay refers to soil that is predominantly clay but contains silt.

Red bricks are one of the important materials in building construction. These bricks are made from clay mixed with water, with or without the addition of other materials. The process of making bricks includes several stages, namely soil excavation, soil tillage, molding, drying, and burning at high temperatures until it reaches a mature and discolored condition. After cooling, the bricks will harden like stones and will not crumble even if they are soaked in water (Miftakhhul, 2012).

Clay is the main material in the manufacture of bricks that has plastic properties and shrinks when dry. The plasticity properties of clay are very important in facilitating the initial stage of brick making. The plasticity or flexibility of clay is affected by the size of the clay particles. This plasticity serves as a binder during the forming process, so that the formed bricks do not crack or deform. Meanwhile, the properties of dry strength refer to the ability of clay which, once formed and sufficiently dry, has stable strength and does not change when lifted for the finishing, drying, or structuring process before firing (Daryanto, 1994).

Red bricks are artificial materials created by humans to have similar properties to stone. This is achieved through the process of heating (combustion) or by carrying out chemical processing (Djoko Soejoto in Nuraisyah Siregar, 2010). Based on SNI 15-2094-1991 and SII-0021-78, there are several conditions that must be met by bricks, which include various aspects, such as:

1. An outside view.

Red bricks should have sharp, angular sides, with a flat side plane. The brick must not show any significant cracks or deformation, and must be resistant to damage or breakage. The color should be uniform, and when hit, the brick will produce a loud sound.

2. Size

The Standard for Red Bricks in Indonesia by Y.D.N.I (Yayasan Dana Normalization Indonesia) number 15-2094-1991 stipulates a standard size for red bricks as follows:

- a. It is 240 mm long, 115 mm wide and 52 mm thick.
- b. It is 230 mm long, 110 mm wide and 50 mm thick.
- c. Bricks have an atomic arrangement that is not yet fully crystalline arranged, so the structure has not yet formed a perfect crystal. This imperfection makes the brick material still brittle during the forming process (Van Flack, 1992).
- d. Clay as the main material that makes up bricks consists of five layers of atoms that form the thickness of particles. The surface of clay particles contains residual stress, the surface area is limited, and the atoms on the surface tend to fill the space to lower the surface energy. Because these particles are so thin, they are not attracted to the inside, but form positively and negatively charged poles on the surface. The charge is offset by the physical adsorption of water molecules which also forms a dipole moment, so that the water becomes bound and does not move easily. Clay particles can develop sideways or plane parallel, while the edges have imperfect bonds that are balanced by the attraction to water (Ramli, 2007).

The very small size of clay particles, less than 2 microns, makes the surface very large and allows for the absorption of large amounts of water (E. Sutarman, 2013). This water is not easily separated from clay except by heating above 1,000°C. Water plays an important role in the process of forming bricks. At low moisture content (less than 10%), water is not enough to neutralize the particle's surface charge, so the particles stick tightly to each other. At moderate moisture content (15–25%), water is enough to balance the particle load while also serving as a lubricant, so that the clay becomes more plastic. However, if the water content is too high, the clay particles will repel each other and form a suspension (Ramli, 2007). Over the past 30 years, the properties of zeolite have attracted a lot of attention from chemists because of their very special properties. Zeolite is widely used in chemical processes. At this time, the use of zeolite is increasing, mainly for use as an adsorbent, ion exchanger and catalyst. The basis for consideration is because zeolite has properties that are able to absorb steam/gas and liquids, are able to exchange cations, and have catalytic properties to various chemical reactions that are very good and environmentally friendly (Rian Alfian, Lusmeilia Afriani, Iswan, 2015).

In the last three decades, zeolite has attracted a lot of attention from chemists because it has unique properties. Zeolite is currently widely used in a variety of chemical processes, specifically as an adsorbent, ion exchanger, and catalyst. Its use is based on its ability to absorb steam, gas, and liquids, perform cation exchange, and exhibit high catalytic activity in various chemical reactions, with the added advantage of its environmentally friendly properties (Rian Alfian, Lusmeilia Afriani, Iswan, 2015).

Indonesia has considerable natural zeolite resources, and one of its potential areas is Lampung. Zeolite mining in this area is carried out by open cut, with the stripping of the overlay layer about 1–2 meters thick. Zeolite from Lampung is mined by PT. Minatama Mineral Perdana, which is located on the edge of the Bakauheni-Kalianda highway, about 32 kilometers from Kalianda

City, South Lampung. The results of X-ray diffraction analysis of Lampung zeolite samples showed that the content was relatively pure, dominated by the mineral clyoptilolite (Rian Alfian, Lusmeilia Afriani, Iswan, 2015).

3. Methods and Materials

The method used in this study is an experimental method. This method is a method based on the empirical method, which is by conducting experiments and measuring directly with test tools so that conclusions can be determined from the experiment. The materials used in this research process are zeolite and clay as the main materials for making bricks. This study conducted several tests whose results were used as a basis to determine conclusions. Material testing carried out as a reference for the manufacture of test specimens is soil moisture content testing, sieve analysis, specific gravity, hydrometer, and *atterberg testing* (plastic limit and liquid limit testing), as well as brick characteristic testing in the form of specific gravity testing, shrinkage and compressive strength tests of bricks.

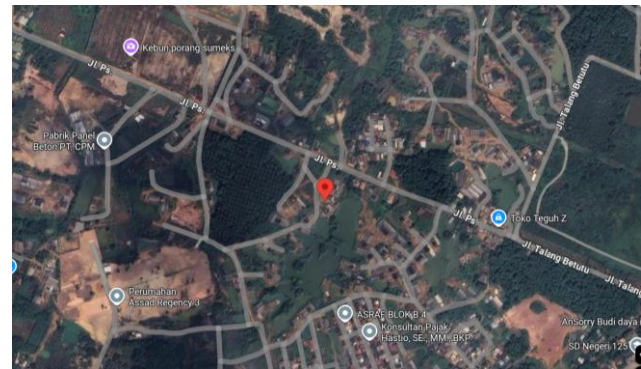


Figure 3.1. Test Specimen Manufacturing and Combustion Locations



Figure 3.2. Test Specimen Testing Locations

3.1 Materials That Make Up Bricks

In this study, several materials that make up bricks were used, namely clay, water and additional materials, namely zeolite.

3.3.1 Clay

The soil used as the main material for making bricks is soil provided from the brick making site located in Talang Betutu Village, Sukarne District, Palembang.



Figure 3.3. Clay

3.3.2 Water

Water is used as a mixing base material that provides plasticity and lubricant mixtures, and helps form mixtures from ponds around the brick manufacturing site located in Talang Betutu Village, Sukarne District, Palembang,



Figure 3.4. Water

3.3.3 Zeolite

The zeolite used is in the form of nano zeolite with a mesh size of 100.



Figure 3.5. Nano Zeolite

The incinerator used is a kiln belonging to one of the brick producing industries in Talang Betutu Village, Sukarame District, Palembang.



Figure 3.6. Incineration

3.4.1. Press Test Equipment



Figure 3.7. Compressive Strength Test Equipment

Mixing between soil and zeolite with variations of 0%, 5%, 10%, 15%, 20% and 25%. Then stir using a stirring tool in the form of a shovel or you can also use your hands or feet so that the mixture and soil are mixed until smooth. To mix evenly, add water little by little to keep the soil moist so that it is easy to mix with the added ingredients. Next, the raw material is left for 2-3 days, this stage is the performance process of the zeolite adding material to the clay so that it can bind the particles from the clay and the stage where the particles from the clay can absorb water evenly so that at the time of formation there is an even shrinkage. Next, the printing process uses a printing tool made of wood with a length of 190 mm, a width of 110 mm, and a height of 60 mm (SNI 15-2094-2000). Before printing, the soil that has been left alone is mixed with water until the texture of the soil is easy to form.

Printing is done by inserting raw materials into the mold, making sure there are no cavities left. Print as many as 9 samples per variation for the raw materials that have been left for 2-3 days. After printing, a drying period is carried out, which is for 7 days if the weather conditions are good, if the weather conditions are humid, then drying is carried out for at least 14 days. Drying the test specimen should not be exposed directly to sunlight as it may result in cracking. After drying the stacks of soil that have been molded into the incinerator, before burning is carried out first fumigation for 1 day, then after that the burning process with a high temperature $\pm$ around a temperature of 920°C - 1020°C for 2 days. After combustion, which is the process of cooling the bricks for 2-3 days, after cooling, a shrinkage test is carried out by remeasuring the dimensions of the bricks. After firing, refrigerate the bricks for 3.7, and 14 days before the compressive strength test. Cooling is carried out naturally, it should not be exposed to direct sunlight. Compressive strength testing, strong testing as many as 3 test pieces per variation. The way to use it is that the test piece is placed on the lower plate of the machine, then CTM (Compression Testing Machine) will apply a compressive force to the test piece. Once the test piece is pressed, the data parameters on the monitor will display the results of the test process. And the last stage Data processing.

4. Results and Discussion

Testing of the soil characteristics and compressive strength of bricks is carried out at the Soil and Concrete Mechanics Testing Laboratory. Soil characteristics checks include moisture content testing, sieve analysis tests, *attemberg limit tests*, and specific gravity testing.

Table 1. Hydrometer Test Results

Time, T	Hydrometer Reading	Temp.	Hydro. Reading Corrected for Meniscus	Zero Correction	K	L, cm	Corrected Reading	Diameter	% Finer	Corrected % Finer
0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
0.5	44.0	31.0	44.5	2.0	0.01236	9.10	44.5	0.0527	90.58	17.44
1	39.0	30.0	39.5	2.0	0.01236	9.90	39.5	0.0389	80.40	15.48
2	35.0	30.0	35.5	2.0	0.01236	10.50	35.5	0.0283	72.26	13.91
4	31.0	30.0	31.5	2.0	0.01236	11.20	31.5	0.0207	64.12	12.34
8	28.0	29.0	28.5	2.5	0.01236	11.70	28.0	0.0149	56.99	10.97
15	26.0	29.0	26.5	2.5	0.01236	12.00	26.0	0.0111	52.92	10.19
30	24.0	29.0	24.5	2.5	0.01236	12.40	24.0	0.0079	48.85	9.40
60	22.0	28.0	22.5	3.0	0.01236	12.70	21.5	0.0057	43.76	8.42
120	20.0	28.0	20.5	3.0	0.01236	13.00	19.5	0.0041	39.69	7.64
240	18.0	27.0	18.5	3.0	0.01236	13.30	17.5	0.0029	35.62	6.86
1440	14.0	27.5	14.5	3.0	0.01236	14.00	13.5	0.0012	27.48	5.29

Table 2. Results Plastic boundary testing

No cup	1	2
Weight of empty cups (gr)	9,54	8,86
Cup weight + wet soil (gr)	32,80	32,18
Cup weight + dry ground (gr)	27,65	27,02
Soil grain weight (gr)	0,69	0,87
Water weight (gr)	5,15	5,16
Moisture content (%)	28,44	28,41
Average moisture content (%)		28,43

Table 3. Liquid limit test results

No cup	1	2	3	4
Number of strokes	16	18	38	44
Weight of empty cups (gr)	8,91	9,03	9,07	9,41
Cup weight + wet soil (gr)	56,08	51,68	46,48	42,50
Cup weight + dry ground (gr)	38,85	36,81	36,85	34,14
Soil grain weight (gr)	2,45	1,68	1,86	2,66
Water weight (gr)	29,94	27,78	27,78	24,73
Moisture content (%)	57,55	53,53	34,67	33,81
Average moisture content (%)				

Table 4. Brick shrinkage test results

Yes	Mixed Variation (%)	Dimension	Average Dimensional Value		Percentage of depreciation (%)
			Before Burning	After Burning	
1	0	Long	19	17	26,93
		Wide	11	9,8	
		Tall	6	5,5	
		Volume	1254	916,3	
2	5	Long	19	17	25,44
		Wide	11	10	
		Tall	6	5,5	
		Volume	1254	935	
3	10	Long	19	17	23,95
		Wide	11	10,2	
		Tall	6	5,5	
		Volume	1254	953,7	
4	15	Long	19	17,5	20,94
		Wide	11	10,3	
		Tall	6	5,5	
		Volume	1254	991,375	
5	20	Long	19	17,8	18,03
		Wide	11	10,5	
			6	5,5	
		Volume	1254	1027,95	
6	25	Long	19	18	15,60
		Wide	11	10,5	
			6	5,6	
		Volume	1254	1058,4	

(Source : Research results, 2025.)

Table 5. 3-day life compressiveness test results

Variation (%)	Age (Days)	Burden		Area (cm²)	Compressive strength (Kg/cm²)
		KN	Kg		
0	3	5	510	94,5	5,395
		10	1020	94,5	10,790
		10	1020	94,5	10,790
Correspondence					8,992
5	3	10	1020	94,5	10,790
		10	1020	94,5	10,790
		30	3059	94,5	32,371
Correspondence					17,984
10	3	30	3059	94,5	32,371
		30	3059	94,5	32,371
		20	2039	94,5	21,581
Correspondence					28,775
15	3	30	3059	94,5	32,371
		30	3059	94,5	32,371
		30	3059	94,5	
Correspondence					32,371
20	3	30	3059	94,5	32,371
		40	4079	94,5	43,162
		30	3059	94,5	32,371
Correspondence					35,968
25	3	30	3059	94,5	32,371
		40	4079	94,5	43,162
		30	3059	94,5	32,371
Correspondence					35,968

(Source: Research results, 2025.)

Table 4.12 Results of the 7-day life compressive strength test

Variation (%)	Age (Days)	Burden		Area (cm²)	Compressive strength (Kg/cm²)
		KN	Kg		
0	7	5	510	94,5	5,397
		10	1020	94,5	10,794
		10	1020	94,5	10,794
Correspondence					8,995
5	7	10	1020	94,5	10,794
		10	1020	94,5	10,794
		30	3060	94,5	32,381
Correspondence					17,989
10	7	30	3060	94,5	32,381
		30	3060	94,5	32,381
		20	2040	94,5	21,587
Correspondence					28,783
15	7	30	3060	94,5	32,381
		30	3060	94,5	32,381
		-	-	-	-
Correspondence					32,381
20	7	30	3060	94,5	32,381
		40	4080	94,5	43,175
		30	3060	94,5	32,381
Correspondence					35,979
25	7	30	3060	94,5	32,381
		40	4080	94,5	43,175
		30	3060	94,5	32,381
Correspondence					35,979

(Source: Research results, 2025.)

Table 4.13 Compressive strength test results 14 days

Variation (%)	Age (Days)	Burden		Area (cm²)	Compressive strength (Kg/cm²)
		KN	Kg		
0	14	5	510	94,5	5,397
		10	1020	94,5	10,794
		10	1020	94,5	10,794
Correspondence					8,995
5	14	10	1020	94,5	10,794
		10	1020	94,5	10,794
		30	3060	94,5	32,381
Correspondence					17,989
10	14	30	3060	94,5	32,381
		30	3060	94,5	32,381
		20	2040	94,5	21,587
Correspondence					28,783
15	14	30	3060	94,5	32,381
		30	3060	94,5	32,381
		-	-	-	-
Correspondence					32,381
20	14	30	3060	94,5	32,381
		40	4080	94,5	43,175
		30	3060	94,5	32,381
Correspondence					35,979
25	14	30	3060	94,5	32,381
		40	4080	94,5	43,175
		30	3060	94,5	32,381
Correspondence					35,979

(Source: Research results, 2025.)

5. Conclusion

Based on the research that has been carried out, the following conclusions are obtained:

1. From testing soil characteristics, it was obtained that the type of soil was organic clay with high plasticity and poor gradation.
2. The addition of *zeolite* to clay soil used for making bricks with variations of 5%, 10%, 15%, 20% and 25% can affect the mechanical properties of bricks, namely reducing the presentation of burn shrinkage and can increase the compressive strength of bricks.
3. The minimum burn loss value was achieved at the percentage of *zeolite* with a variation of 25%, namely with a burn loss of 21.4%. The optimum compressive strength value was achieved at the percentage of *zeolite* with a variation of 25%

with mixed residence for 5 days and with a life of 14 days, the compressive strength value was obtained as 55.97 Kg/cm².

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