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Utilization of Clinker Brick Used for No-Fines Concrete

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***Abstract*—Clinker bricks go into excessive temperatures during the process, are waste in brick making, and tend to be unusable, but it can be used as an alternative material to coarse aggregate in concrete mixtures. This research is about clinker brick waste which is used as coarse aggregate in no-fines concrete with a water-cement ratio is 0.45 with a volume ratio of 1:3 for 4 sample variations at different concrete ages where a mixture of four variations 0%, 25%, 50%, and 100% will be tested at concrete age 7 days, 14 days, 28 days. The results have shown that the greatest concrete compressive strength at age 7 days, 25% mix is 19.22 MPa, and the lowest 50% mix is 13.99 MPa. For 14 days, the greatest compressive strength at variation 1 without clinker bricks (0%) compressive strength 16.78 MPa, and that the lowest at variation 3 with 50% at 11.71 MPa. For 28 days, concrete ages are the normal age commonly used, the most significant concrete compressive strength at 25% mix with compressive strength of 6.59 MPa and the lowest at 50% mix 10.27 MPa. The best compressive strength at 25% mix variation 2 with compressive strength of 16.59 MPa but still smaller than the reference design f'c ≤20 Mpa. Based on the weight of No-fine Concrete 70% lighter, that concrete without fines using clinker bricks, although lighter, cannot be for structural concrete because compressive strength tends to decrease, but it can still be for nonstructural concrete.**

***Keywords*— Compressive strength; clinker brick; coarse aggregate; substitute; no-fines concrete.**

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I. INTRODUCTION

Traditional brick factories are widely available in North Aceh, especially in Reuleut village North Aceh district, and the community carries out the production process as their livelihood. Each brick factory produces many clinker bricks that are when overheated, so they are black and are often not shaped or split and cannot be used as building materials because they tend to become waste. A traditional brick factory in North Aceh, as shown in Figure 1.

The bricks produced in Aceh province average 15,000 - 25,000 PCs in every manufactory, especially in the North Aceh district [1]. The bricks manufactured are still traditional, as shown in figure 1, so when burning, many of the bricks produced or burned into clinkers cannot be used in buildings and eventually become waste. This study intends to use brick waste for no-fines concrete as coarse aggregates classified as lightweight concrete made from coarse aggregate, cement, and water, by removing sand or fine aggregate from standard concrete. Based on the diagram of the cavity ratio in the concrete, it needs a fine aggregate to fill it related to the density of the concrete [2].

Fig. 1 Traditional brick factories in North Aceh

Clinker bricks are obtained from polymineral material, low-melting clay, and refractory. The optimal temperature burning time is determined at -1150 ± 5°C with 4 hours of burning at an optimal temperature [3]. No fines Concrete is lightweight concrete with a density of 25-30% lower than normal concrete and is concrete with no fine aggregate so that the structure weight is smaller. The dry shrinkage is smaller than normal concrete. Because it lacks fine aggregate, the surface area needed for the cement layer is significantly reduced. So, the amount of cement per cubic meter needed is reduced compared to normal concrete [4], which is low in cost.

Recycled materials are sometimes less desirable for use in concrete infrastructure. However, sometimes they need to be used when needing consistent characteristics higher in absorption than natural aggregates. There is potential for recycled aggregates to provide benefits such as internal treatment pads when adequately prepared before being put into concrete [5].

Recycled concrete aggregate quality is lower than normal concrete, so it uses limited up to 30% to replace natural aggregate [6]. Utilization of construction materials, wherever possible, is environmentally friendly material, and its use does not become a nuisance to the environment, which is not always significant at a low cost. Reusing existing waste potential is recommended in using construction materials and clinker brick waste so that this recycling will be beneficial as long as its use remains under control. Aggregate material produced by recycling is considered an environmentally friendly material [7].

In general, materials used in construction are iron or steel, which can be used as pillars or beams in construction after iron or steel is formed into profile steel. The wood material can also be used for poles and beams. However, wood material is still difficult to use for multi-story construction [8]. Its use will cut down trees in the forest, damaging the environment, and the price is prohibitive. So, it is less effective and efficient. Other materials are reinforced concrete made of cement, sand, gravel, mixed with water, and then reinforced iron to be easy to shape and use. The optimal amount of clinker usage of 30% increases brick strength thanks to the pozzolan effect of fine clinker [9]

Many construction materials exist, but the most widely used is concrete. Its enormous popularity is due to the many benefits gained, such as general availability, low cost, and easy application [10]. Materials to make concrete are cement fragments as aggregate binding media, granular, such as crushed stone or gravel as rough aggregates, sand as fine aggregates, and water. When sand is mixed with cement media, it is called hydraulic cement or mortar concrete [11]. After all materials (cement, sand, gravel, and water) are mixed and become concrete can be called composite material.

Coarse aggregate that passes through 4.75 mm or no. 4 sieves, and aggregates that pass through 4.75 mm smaller fineness are called fine aggregates but do not pass through sieve no. 200 or 0.075 mm [12]. Concrete that does not use fine aggregate only uses coarse aggregate bound with cement, given water is no-fines concrete [13]. Bricks clinker are residues from bricks that burn with excessive heat, which burns very hard and is distorted or bloated because the verification is almost complete [14]. Contemporary clinker bricks can be used to build exterior walls, which must have high durability and aesthetic quality. The desired effect depends not on the mortar used but on the clinker's nature [15].

Human civilization has combined clay with additives and burned it to produce better brick building materials to meet its building needs. However, an unstable combustion system that exceeds its temperature will become clinker bricks [16]. It was making bricks that are overheating, causing the bricks to be black and hard and cannot be decomposed naturally with the environment and is called clinker bricks. This stone cannot be used to make construction because it can damage the environment. The handling of this waste can be recycled and used in concrete and is expected to be of financial benefit and reduce pollution's environmental impact.

Utilization on a large scale can be done if known compressive strength and quality. In this case, clinker bricks are made into concrete and given a coarse aggregate material without using a fine aggregate or no-fines concrete as lightweight concrete. According to Park and Tucker [17], protecting the environment from waste materials can utilizing recycled waste used in the construction industry, which is effective and can minimize construction costs.

As an innovation in this study, the novelty is lightweight concrete that does not use fine aggregate with the waste clinker bricks utilized as coarse aggregate. Technological developments in building materials' use largely determine the construction quality. Among these technological developments, there are concrete building materials made from cement, water, and gravel (coarse aggregate), not using sand (fine aggregate) called no-fines concrete [19]. In this study, coarse aggregate used clinker bricks.

This study aims to determine whether the clinker brick, which is a waste from brick production, can be used as a coarse aggregate in the concrete mixture when viewed from the compressive strength of the concrete made with a mixture of 0%, 25%, 50%, and 100% variations. The 0% composition means that the concrete does not use clinker bricks but uses gravel as coarse aggregate. 25% variation means that the concrete is made with 25% clinker brick and 75% gravel of the amount of coarse aggregate.

The 50% variation means that the concrete is made with 50% clinker brick and 50% gravel of the amount of coarse aggregate, and the composition of the coarse aggregate mixture of 100% means that the coarse aggregate uses clinker stone. The percentage of concrete by weight, both of which are compared to other compositions, and wants to know whether clinker bricks can be used as a substitute for coarse aggregate for building materials. The percentage of use of clinker bricks is made in such a way and is a mixed variation in this study.

II. Material and Methods

A. Utilization of Waste Materials

Industrial waste is a consequence of urbanization, which is identified as a significant problem in the construction industry because it directly impacts the environment. An estimated 35% of industrial waste is stockpiled globally, and efforts are needed to manage the pile of waste to minimize the impact of losses [20]. Bricks, as products produced by the community, can be made environmentally friendly and produce sufficient strength. According to [21], lightweight clay bricks can be produced by adding 5%-25% reed crumbs and relatively good dry density and compressive strength. It can be made environmentally friendly.

The excess use of the no-fines concrete can be expressed by lower density than normal concrete and other advantages in terms of lower costs because the cement content is lower than normal concrete. Besides, the thermal conductivity is lower and relatively lower in the loss of drying, and the capillary movement of water tends to be absent and does not include separation. No-fines concrete has large holes, and because of the large voids, insulation characteristics will be better than conventional concrete, but no-fines concrete is unsuitable for reinforced concrete.

Besides structural applications, lightweight concrete can also be used, which has a strength equivalent to normal concrete. Among the benefits of using lightweight aggregate concrete is reducing the weight of dead loads to save the foundation cost and its reinforcement, which can improve thermal properties and increase fire resistance. In terms of transportation and handling precast units at the site, it reduces the use of formwork and supports it. The elastic modulus of lightweight concrete is lower than normal strength concrete of the same weight, but considering slab or beam deflection, this is offset by weight loss alone.

Fig. 2 The brick clinker

The material used in this study is no-fines concrete consisting of portland cement, gravel substituted with clinker bricks, and water. Concrete does not use fine aggregate because concrete without fines will be made as lightweight concrete. Clinker brick mixture Variations are 0%, 25%, 50%; and 100%. Specimens with a variation of 0% are specimens that no clinker bricks used as reference testing, as well as variations of 100%, which means coarse aggregates used are clinker bricks entirely as a comparison reference in testing. The grain size used is through a sieve 19.0 mm and does not pass through the sieve 4.75 mm.

The reference for compressive strength to be compared with the test results is the compressive strength fc'< 20 Mpa. The test object and size are a 15 cm diameter cylinder with a height of 30 cm. The clinker bricks used are bluish-black, as in Figure 2. To make no-fines concrete, in the sense of removing fine aggregate by combining a coarse aggregate bound using hydraulic cement and water, will reduce the structural weight so that it can be called lightweight concrete [22].

For paving applications, generally, no-fines concrete is used. In addition, nonstructural applications can also be considered for acoustic panels, thermal and permeability, or other nonstructural features [23]. This study tested coarse aggregate and clinker stones for their physical properties. Clinker and aggregate bricks are examined for their physical properties to determine specific gravity, sieve analysis, absorption, moisture content, and fineness modulus. This is done so that they can be analyzed carefully.

B. Research Method

Based on Fig. 3, the process begins with the determination of the material to be used. After the material is determined, the next step is to determine the Variation of Clinker Brick value. If the Value of Variation> = 0, it is categorized as a clinker; if Variation <0, it is categorized as Gravel. Both Clinker Brick and Gravel will be calculated for the values of Weight of Solid, Water Content, Specific Gravity, Concrete Mix Design, and Compressive Strength. The next step is comparing the results obtained for the Gravel and Clinker Brick. The Research Method can be seen in Figure 3.

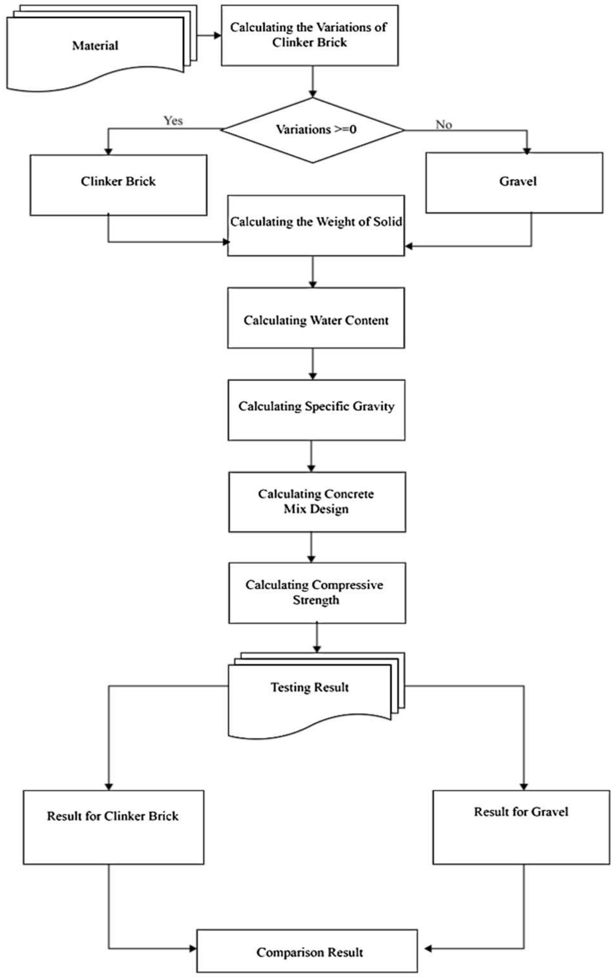

Fig. 3 Research Method

C. Physical Properties of The Material

Physical properties are behavior or material properties that lead to structural material, not caused by external influences such as loading [24]. The material's physical properties include the weight of solid volume, and the ratio of the weight of the aggregate in the solid-state to the volume of liters, which can be formulated as eq. (1) as follow:

$$\gamma = \frac{W_s}{V} \tag{1}$$

where the weight of solid volume is ɣ, the weight of aggregate is Ws and the volume of the container is V.

The next physical characteristic is water content, namely the ratio between the air's weight in the dry state expressed in percent. The water content is calculated using eq. (2) as follows:

$$Water\ Content = \frac{W_0 - W_1}{W_1} x100\% \quad (2)$$

where the weight of the initial specimen is W_0, and the weight of oven-dry aggregate is W_1

The material under water-saturated surface conditions of specific gravity can be interpreted as the ratio between the weights of the saturated material with the total volume of material [25]. In contrast, the material's specific gravity under oven-dry conditions is the ratio between the weights of dry material due to drying with the oven and the total material volume [26]. Water absorption is the ability of a material to absorb water. After the data is obtained, the results are acquired by calculation [27].

The specific gravity for saturated surface conditions is calculated by eq. (3), while in oven-dry conditions, calculation of the specific gravity can be used by eq. (4). For absorption, use eq. (5) as follow:

$$Sg_{(ssd)} = \frac{W_{ssd}}{(W_{ssd} - W_{ssdiw})\gamma d} \quad (3)$$

$$Sg_{(od)} = \frac{W_{od}}{(W_{ssd} - W_{ssdiw})\gamma d} \quad (4)$$

$$Abs = \frac{W_{ssd} - W_{od}}{W_{od}} x100\% \quad (5)$$

where the saturated surface conditions of the specific gravity are $Sg_{(ssd)}$. The dry oven conditions of the specific gravity are $Sg_{(od)}$. The weight of saturated surface condition is $W_{(ssd)}$; the weight in the oven-dry conditions is $W_{(od)}$. The weight in water of the dry saturated is $W_{(ssdiw)}$. The specific gravity water at 1 gram/cm^3 at 4° C the parameter of specific gravity is γ_d.

D. Concrete Mix Design

Furthermore, the mixture design was prepared for 36 samples by sample specimen variations of 0%, 25%, 50%, and 100%. All samples will be taken randomly for testing at 7 days, 14 days, 28 days. The samples that have been made will open the concrete mold after 24 hours, and then curing will be carried out by immersing the sample in a water bath according to its age design, where the compressive strength test is carried out. The compressive strength of concrete testing will show the trend of increasing strength of compressive every age of concrete. The representation of concrete compressive strength will differ in each mixture variation and different concrete ages [28]. Samples that have been soaked in water appropriate to the aged design are then dried and weighed. The design of strength of compressive concrete fc'<20 Mpa is a reference for sample testing the compressive strength of concrete.

E. Concrete Compressive Strength Test

The test placed the sample vertically on the test machine, and the test machine was run until the sample failed at constant pressure and the load button (dial) showed a crack. Based on this data, the compressive strength is calculated using eq. (6):

$$f' = \frac{Q}{A} \quad (6)$$

Where *f'*as strength of the compressive of the concrete cylinder (kg/cm^2); Q as Maximum crushing load of compressive (kg); A as the sample cross-section area (cm^2)

Furthermore, the compressive stress will be calculated using the following equation based on the load value conversion and the test object's age factor coefficient. (7):

$$f' = \frac{Q_{cl}}{AxF_a} \quad (7)$$

Where *f'* as the compressive strength (MPa); *Qcl* as a load of conversion (N); A as cross-sectional area (mm) and Fa as a factor of age at the testing time.

III. Result and Discussion

The material's physical properties are indicators of this material in stating whether it is strong, resilient, and others. Each material has specific physical properties; the better the material, the more commercial value it has [29]. To find out the material's physical properties can be done by testing where you want to know the material properties that are not caused by loading [30]. In this study, the surface's physical properties are saturation, specific gravity under oven-dry conditions, and water absorption.

The weight of the solid volume of gravel as coarse aggregate is checked from the weight of the container and its own weight so that the weight of the solid volume is obtained. The test results of the physical properties of the material on average for the weight of the solid volume gravel as coarse aggregate are 1.632 kg/liter; the complete results are as shown in Table I

TABLE I
THE WEIGHT OF SOLID VOLUME GRAVEL

S	Weight			Container Volume	weight of solid volume
	Container	Container + Gravel	Gravel		
I	4.13	9.0	4.87	3.03	1.606
II	4.13	9.12	4.99	3.03	1.648
III	4.13	9.1	4.97	3.03	1.642
The average weight of solid volume (kg/liter)					1.632

To test the physical properties of clinker brick as coarse aggregate material to the weight of the average solid volume is 1.189 kg/liter, the complete results are shown in Table II.

TABLE II
THE WEIGHT OF SOLID VOLUME CLINKER BRICK

S	Weight			Container Volume	weight of solid volume
	Container	Container + Clinker brick	Clinker Brick		
I	4.13	7.7	3.58	3.03	1.181
II	4.13	7.7	3.57	3.03	1.18
III	4.13	7.78	3.65	3.03	1.206
The average of weight of solid volume (kg/liter)					1.189

The average of weight of solid volume of gravel and clinker bricks as coarse aggregate in Table I and Table II shows that the average volume weight of gravel material is more decadent than clinker brick material, and it can mean that the use of clinker bricks for coarse aggregate will make the lightweight concrete [31].

The aggregate saturated surface is a condition where dry surface particles do not occur, so the cavity between the particles becomes water saturated. In this condition, the aggregate will not affect the free water content, the specific gravity of a saturated dry surface the ratio of the mass of the aggregate to the mass of the same volume of water while the absorption water content of the water content at the dry saturated surface conditions differs from the dry conditions in the oven [32].

On testing physical properties, the material obtained Gravel in surface saturation; the average specific gravity was 2.516 grams/cm^3. In conditions, dry oven Specific gravity was 2.449 gram/cm3 and water absorption 2.747%, as shown in Table III.

TABLE III
PROPERTIES OF PHYSICAL GRAVEL

S	Do	Dss	Dssiw	Sgw	Sgiss	Sgidoc	Wa
I	979.0	1,000	607	0.9962	2.535	2.482	2.145
II	979.5	1,000	609	0.9962	2.548	2.496	2.093
III	961.5	1,000	608	0.9662	2.465	2.370	4.004
		Average			2.516	2.449	2.747

Where is S as a sample; Do is the weight of the dry oven; Dss is the weight of the dry surface saturated; Dssiw is the dry saturated surface of weight in water; Sgw as water of specific gravity at 4°C = 1 gram/cm³; Sgiss is a specific gravity in surface saturation; Sgidoc as a dry oven of specific gravity and Wa is the percentage of water absorption.

The use of Spent Industrial Soil produced in the aromatic production process in the manufacture of clay bricks is mixed with clay and burned in an electric furnace at 950 °C for 8 hours to make brick samples. The use of Spent Industrial Soil in clay brick construction is an effective way to manufacture lightweight, porous bricks that meet the required standards of structural and environmental concerns [33].

The soil samples studied were known that their physical properties were examined against moisture content and grain size analysis of sand, silt, and clay proportions, respectively. Atterberg limit values are required to be known including the ratio of plastic limit, liquid limit, plasticity index and specific gravity range between [34].

In surface saturation conditions, a specific gravity of clinker was based on an average physical properties test of 2.078 gram/cm^3. The average dry oven of specific gravity was 1.971 gram/cm^3, with a rate of absorption of 5.476%, as shown in Table IV.

TABLE IV
PROPERTIES OF PHYSICAL CLINKER

S	Do	Dss	Dssiw	Sgw	Sgiss	Sgidoc	Wa
I	953.3	1,000	524	0.9962	2.093	1.995	4.899
II	945.5	1,000	525.5	0.9962	2.099	1.985	5.764
III	945.5	1,000	527	0.9662	2.043	1.931	5.764
		Average			2.078	1.971	5.476

The test results illustrate that the Specific Gravity in Surface Saturation of clinker bricks is smaller than that of gravel with a difference of 0.438 gram/cm^3. In comparison, the Specific Gravity in Dry Oven Conditions of clinker bricks are also smaller than gravel with a difference of 0.478 gram/cm^3. In water absorption, clinker stones absorb more water than gravel with a difference of 2.429%, which means that clinker bricks need more water. In accordance with previous studies that the compressive strength is affected the specific gravity at which the more significant the density of the aggregate, the greater the density will greater the compressive strength and specific gravity concrete will large [35], and the water absorption rate of clinker bricks is higher than broken stone, water absorption is higher than clinker bricks excluding crushed earth bricks [36].

From the test results of the material's physical properties, the composition of the concrete mixture was compiled, which will be used to manufacture test specimens where the material consists of Portland cement, Gravel or coarse aggregate clinker brick, and water. The proportion of materials in the concrete mixes' composition is as shown in Table V.

TABLE V
THE PROPORTION OF MATERIALS IN CONCRETE MIXES

Material	Variations				Total
	0%	25%	50%	100%	
Portland Cement	15.448	15.448	15.448	15.448	61.792
Gravel	65.28	48.96	32.64	0	146.88
Clinker brick	0	11.89	23.78	47.56	83.23
Water	6.997	6.997	6.997	6.997	27.988

Based on Table V, the proportion of material in a concrete mixture is analyzed based on the mixture's variation, namely 0% variation, 25% variation, 50% variation, and 100% variation. From this, it can be determined that the amount of material used is measured proportionally in material weight for each mixture variation. Determination of the proportion of this material is essential to make the test object so that as planned.

The composition variation 1 with 0% clinker bricks means that the concrete does not use clinker bricks but uses gravel as rough aggregate; the composition is 15.484 kg Portland cement, 65.28 kg gravel, and water of 6.997 kg. In the variation 2 were 25% clinker, 15.448 Portland cement compositions, 48.96 kg gravel, 11.89 kg clinker, and 6.997 kg water. For variations of 3 when 50% clinker bricks, the composition is 15.448 kg of Portland cement, 32.64 kg of Gravel, 23.78 kg of clinker bricks, and water 6.997 kg. For clinker bricks, 100% Variation 4, which means not using Gravel, the mixture consists of Portland cement 15.444 kg, clinker 47.56 kg, and 6.997 kg water. Variation 4 is used as a reference in comparing its utilization.

The effect of recycled bricks' moisture conditions and aggregate content on parameters of dynamic yield stress, plastic viscosity, and static yield stress, was investigated in detail after mixing. Recycled aggregate concrete has a greater effect on the time variable on the characteristics of rheological properties when compared to normal concrete [37].

A volume weight check is performed to determine the weight of the aggregate content in the mixture, which is defined between the weight of the dry matter and its volume.

Aggregate as a concrete filler in the mixture must be made possible and good aggregates that cannot be chemically treated with no cement [38]. In calculating concrete mixtures to regulate the solid volume of the selected parts, it is necessary to know the volume of space occupied by aggregate particles, regardless of the presence or absence of the particle inside [39].

The volume weight of aggregates is the aggregate weight ratio to the volume of aggregate. Containers are weighed, inserting the aggregate carefully so as not to separate the grains from the maximum height of 5 cm above the container until it meets the container. The average volume weight of normal aggregate concrete 1.539 kg/liter. Clinker bricks of concrete have an average volume weight of 1.049 kg/liter. This is consistent with previous studies on no fines concrete; the aggregate weight in a solid condition compared to the aggregate volume in the container is the aggregate volume weight [40].

The aggregate material is compacted by dropping the stick from 5 cm height 25 times; the aggregate consisting of three layers is placed into a container. Each layer is compressed with the same amount [41]. The results illustrate the volume weight of dense normal concrete with gravel volume weight obtained 1.632 kg/liter on average. For volume weight of clinker bricks concrete averages 1.189 kg/liter. This illustrates that the weight of normal concrete volume is greater than the volume weight using clinker bricks. This is in line with previous research on recycled brick masonry concrete aggregate, where the results obtained are that the weight of the concrete with normal aggregate will be greater than the weight of the concrete clinker brick aggregate [42].

Concrete compressive strength in recycled concrete inspection must pay attention to normal concrete volume so that the yield of the concrete's compressive strength will be in line with the prevailing conditions and the amount of concrete compressive strength matches the compressive strength of normal concrete [43]. To get tangible results, it is necessary to have a mixture variation, in this case, is a variation of 0%, which means that this mixture does not use clinker bricks, 25% variation, which has a mixed meaning given 25% clinker bricks, mixed with 50% variation means the mixture uses 50% clinker bricks and 100% variation which means the mixture is mixed with 100% clinker bricks.

The next step is to analyze the compressive strength based on variations of 0%, 25%, 50%, and 100%, according to variations in the age of concrete 7 days, 14 days, and 28 days as shown in Figure 4.

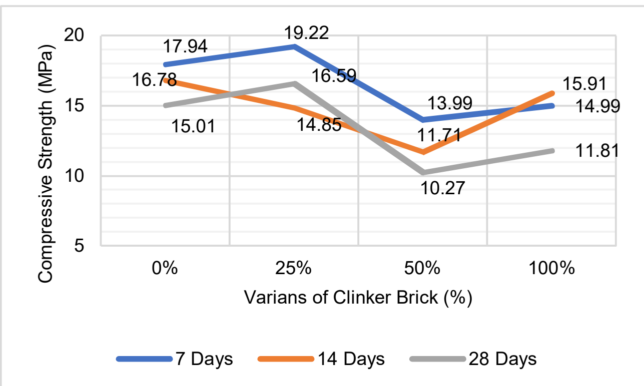

Fig. 4 Compressive strength concrete

The result compressive strength of testing as shown in Figure 4, is concrete gravel coarse aggregate variation 1 mix 0%, the largest concrete compressive strength in the 7-day test was 17.94 MPa, and the lowest in the 28-day test was 15.01 MPa, meaning that the plan of compressive strength 20 Mpa has not been reached. The mix variation 2 for 25% clinker, there concrete compressive strength was increased at 7 days by 19.22 MPa and 28 days by 16.59 MPa while at 14 days there was a decrease in strength. In variation 2, although the concrete compressive strength increased at 7 days and 28 days, it had not yet reached the concrete compressive strength design. Increased concrete compressive strength in the test in accordance with the day of testing has not been able to achieve the expected compressive strength, an increase in compressive strength of the concrete occurred in the second week and decreased in the third week, and the following week became stable [44].

For a mixture of variation 3 with 50% clinker, there was a very significant decrease for all concrete ages, at 7 days 13.99 MPa at 14 days 11.71 MPa and at 28 days it was 10.27 MPa. Variation 4 clinker bricks 100% means that no gravel is used, at all the ages of concrete compressive strength of results increases. At 7 days of the ages, the strength of concrete is 14.99 Mpa, age of 14 days, the concrete strength is 15.91 MPa, and at the age of 28 days, concrete's strength is 11.81 MPa. Although there are improvements, it has not yet reached the 20 Mpa design. According to the American Concrete Institute (ACI), concrete is defined as concrete having a compressive strength of at least 17 MPa at the age of 28 days [45], the strength of compressive concrete for 28 days is 11.81 MPa, indicating that clinker brick waste cannot be used for structural concrete, but its strength can be used for nonstructural concrete.

The use of nonstructural concrete with a modulus of elasticity of concrete for lightweight concrete and normal-weight concrete is suitable [46]. The compressive strength of concrete generally decreased, and the smallest decline magnitude occurred at 25% variation. In line with previous studies, the strength of compressive concrete without clinker bricks is smaller than the compressive strength of gravel concrete, but the use of clinker bricks is possible to produce lightweight concrete that is environmentally friendly by incorporating high volume lightweight aggregate waste as no-fines concrete.

The results of this study discuss clinker bricks that can be used in construction and structural concrete, which can be provided for related research and used in the use of recycled materials from waste. Recycled aggregate is one of the most popular methods used to improve road sustainability, whether from concrete or asphalt pavement materials. When evaluating the life cycle, it is possible to examine the possible social, environmental, and economic impacts and potential trade-offs that arise in the life cycle [47].

IV. Conclusions

No-fines concrete that substitutes gravel by clinker brick has concrete compressive strength, which tends to decrease compared to concrete that uses gravel. This happens from the effect of clinker bricks that absorb more water than gravel, and this illustrates that clinker bricks need more water.

Another good thing is the weight using clinker bricks can be lightweight concrete with no-fines concrete when compared with concrete using gravel it weighs 70% lighter. Furthermore, the water-cement ratio will affect the variability of the mixture where the greater the water-cement ratio, the greater the clinker bricks can be substituted as coarse aggregates. For Structural concrete, the strength of compressive concrete for 28 days is 11.81 MPa. According to the American Concrete Institute (ACI), concrete is defined as concrete having a compressive strength of at least 17 MPa at the age of 28 days. The concrete which uses clinker bricks as coarse aggregate has a compressive strength of concrete that does not yet fulfill the concrete compressive strength design, so it can be concluded that no-fines concrete using clinker bricks cannot be used for structural concrete, but it still can be for nonstructural concrete.

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