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Effect of Sand Gradient Variation on Properties of CLC Concrete Mansory Brick

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---ABSTRACT---
One of the methods used to reduce the weight of a construction is by reducing the weight of the walls of the building. In such a case, a wall made of red brick has a volume weight of 1,500–2,000 kg/m^3, and concrete masonry bricks made of CLC have a volume weight of 400–1,800 kg/m^3. So, in comparison, concrete masonry bricks have a volume weight that is ≤ 50% of that of red brick. In the manufacturing of concrete masonry bricks, one variant is CLC (Cellular Lightweight Concrete), produced using a mixture of cement, sand, chemical admixture and water, with the filler material in the form of air generated as microscale soap bubbles (microbubbles), also known as foam agent. In the manufacturing of concrete masonry bricks, the sand as a binder material clearly affects the physical and mechanical properties of the bricks produced. This research is conducted to investigate the effect of sand gradation which includes a gradation of coarse sand, quite coarse, quite smooth, and smooth, it can be concluded that there was an influence of graded sand against the physical and mechanical properties of CLC concrete masonry bricks that resulted in quite smooth gradations (zone III) of having good sand fineness modulus 3,030.

KEYWORDS;-*red brick, cement brick, CLC concrete masonry bricks, fineness modulus sand, physical and mechanical properties*

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I. INTRODUCTION

For the purpose of lightweight construction in soft soil or peatland areas, innovation is required to reduce the self-weight of the construction. One way to reduce this is by reducing the weight of the walls, which are generally made of red brick having a volume weight of 1,500–2,000 kg/m^3 [4], cement brick with a volume weight of 950 kg/m^3 - 1,000 kg/m^3 [11], and CLC masonry concrete brick lighter volume weight 400 – 900 kg/m^{3}This CLC masonry concrete brick can reduce reinforcement of the structure, reduce the size of the structure, reduce the amount of concrete, not using sand in the plaster and the building will be more economical [6]

CLC masonry concrete brick can be used as an alternative to red brick, to reduce environmental pollution and global warming. CLC masonry concrete brick is environmentally friendly. The energy consumed in the production of this type of masonry lightweight concrete brick is less than for the production of red brick, and it also neither produces pollution nor creates toxic products or have any impact on the environment [12] . This is because CLC masonry lightweight concrete brick is made of a mixture of cement, sand, water, and chemical admixture, to which is then added a foam that is stable in an ordinary concrete mixer. The addition of foam to the CLC mixture creates millions of voids or small cells in the material, which is why it is given the name of CLC masonry concrete brick.

Sand as one of the basic ingredients of CLC masonry concrete brick maker is a grain binder and cement into a solid foam. The sand gradation according to SNI - 03 - 2834 - 2002 determines limitations - restrictions for smooth fastener into four groups that are separated based on the level of fineness of sand material can be seen in table 2. In the making of bricks concrete lightweight CLC, sand gradation certainly will have an effect on the physical and mechanical properties. Therefore we need to conduct research to know the comparison physical and mechanical properties from the CLC masonry concrete brick produced.

II. METHOD

II.1. Material and Dimentions of the CLC masonry concrete brick [6][7][13]

II.1.1. Cement

Cement used in this research is cement sold in the market. Cement type III **(i.e. ASTM C 150-95a & SNI 15-2049-1994 & BS 12 :1989)** with the strength of the initial high PCC (*Portland Composite Cement*) with brand Holciem. The specific gravity of the type of cement is 2,950 kg/m^3 [12].

II.1.2. Fine Aggregate

Fine aggregate is one of the materials that must be done a series of tests of the properties and characteristics of the material. In this study, the type of fine aggregate used is just fine aggregate such as sand yellow (**SNI - 03 - 2834 – 2002**) determining the limits of fine aggregate into four groups based on the level of refinement separated sand material as shown in Table 1.

The opening of the sieve (mm)	Percent Passing the Sand			
	Zone I Coarse	The Zone II Quite Coarse	The Zone III Quite Smooth	The Zone IV Smooth
10	100	100	100	100
4.8	90 - 100	90 - 100	90 - 100	95 - 100
2.4	60 - 100	75 - 100	85 - 100	95 - 100
1.2	30 - 70	55 - 90	75 - 100	90 - 100
0.6	15 - 34	35 - 59	60 - 79	80 - 100
0.3	5 - 20	8 - 30	12 - 40	15 - 50
0.15	0 - 10	0 - 10	0 - 10	0 - 15

Table 1. Fine Aggregate Gradation Terms [8][14]

II.1.3. Water

The water used is taken from the local water company with a pH 6–7 (**SNI 03-2874-2002** and meeting the requirements of **PBBI 1971 NI-2**).

II.1.4. Foaming Agent

Foamed concrete is produced by either a pre-foaming method or a mixed foaming method. The pre-foaming method involves the separate production of a base mix cement slurry (cement paste or mortar) and a stable preformed aqueous addition (foam agent with water), and this foam is then thoroughly blended into the base mix. In mixed foaming, the surface active agent is mixed with the base mixture ingredients and, during the process of mixing, the foam is produced, resulting in a cellular structure in the concrete as shown in Fig. 1.

The preformed foam can be either wet or dry. Wet foam is produced by spraying a solution of foaming agent over a fine mesh, has a 2–5 mm bubble size, and is relatively less stable.

Dry foam is produced by forcing the foaming agent solution through a series of high-density restrictions and forcing compressed air simultaneously into the mixing chamber. Dry foam is extremely stable and has a size smaller than 1 mm.. Table 3 shows the properties of foamed concrete [1].

The container holding the foaming agent must be kept airtight and under temperatures not exceeding 25°C. Once diluted in 80 parts of potable water, the emulsion must be used as soon as possible. The weight of the foam solution used is a minimum of 80 g/l, the containment solution used is as close as possible to 10 litres in volume, to check the weight (density) of the foam. Under no circumstances must the foaming agent should not contact with any oil or fat, chemical or other material that might harm its function (oil has an influence on the surface tension of water) [6]. The foaming agent used is a brand under the trademark ADT.

II.1.5. Chemical Admixture

The chemical admixture is usually used in small amounts in the concrete mix. Its use is intended to improve certain properties of the mixture. The materials used are a high-range water-reducing admixture, wherein the material can reduce the water demand of the cement by up to a maximum of 15%. The product Sikament LN from Sika Company is a type of chemical additive used as a water reducer and to speed up the hardening of mortar that requires an immediate settling time or an accelerator. Sikament LN is an admixture classified as **ASTM C494-92 type F** [2]. With Sikament LN, the composition uses a dose rate of 0.40% of the total cement requirement of 300 kg, so the quantity needed for this experiment is as much as 1.2 kg

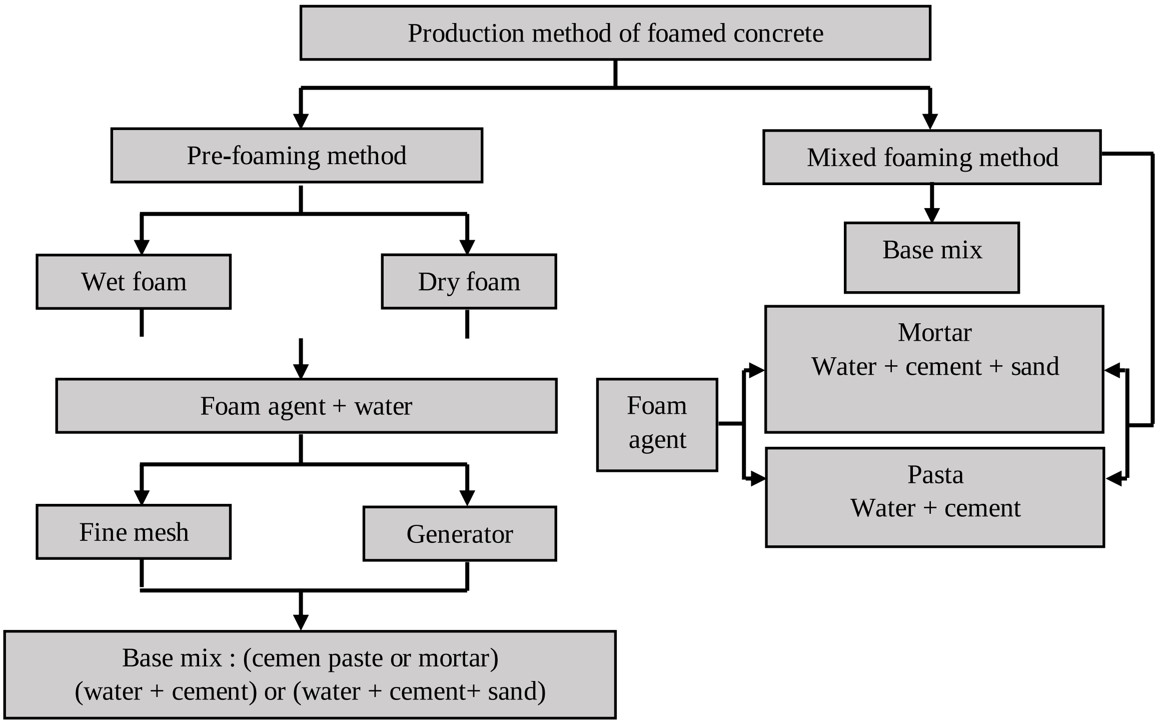


Fig. (1). Classification process of production method for foamed concrete

II.1.6. Dimensions of the test objects

The nominal dimensions of the CLC brick of the United States standard are as follows: length: 600 mm height: 200 mm, width: 75 mm. And the dimensions for modulus of elasticity testing diameter 150 mm and height 300 mm[6].

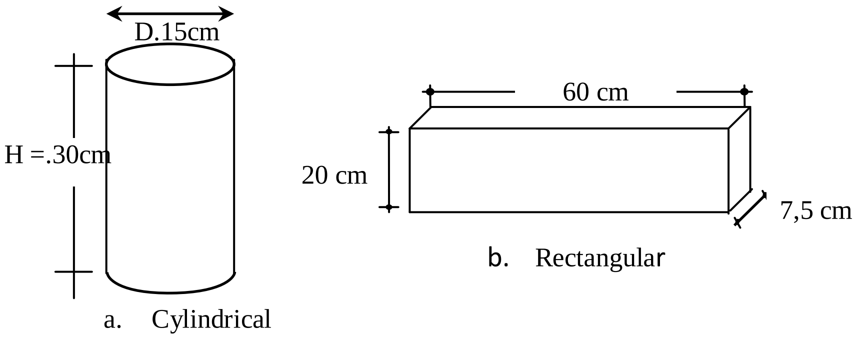


Fig. (2). Design Objects Shape Test

No	Sample	Rectangular					Cylindrical	
		Number of Test objects					Modulus elasticity	Porosity & Permeability
		Day to					Day to	Day to
		3	7	14	21	28	28	28
1	V1	15	15	15	15	15	6	6
2	V2	15	15	15	15	15	6	6
3	V3	15	15	15	15	15	6	6
4	V4	15	15	15	15	15	6	6
5	V5	15	15	15	15	15	6	6
Total		375					60	

TABLE 2. List of Objects Sample Test

II.2. Experimental

At this stage will be made to the plan of the mixture will be used in the creation of a sample of CLC masonry lightweight concrete brick. This swirl variations plan is a guide to the composition of the mixture that will be made in the future. Now the plan that will be created swirl variations is presented in Table 3. And the experimental procedure as follows Figure 3.

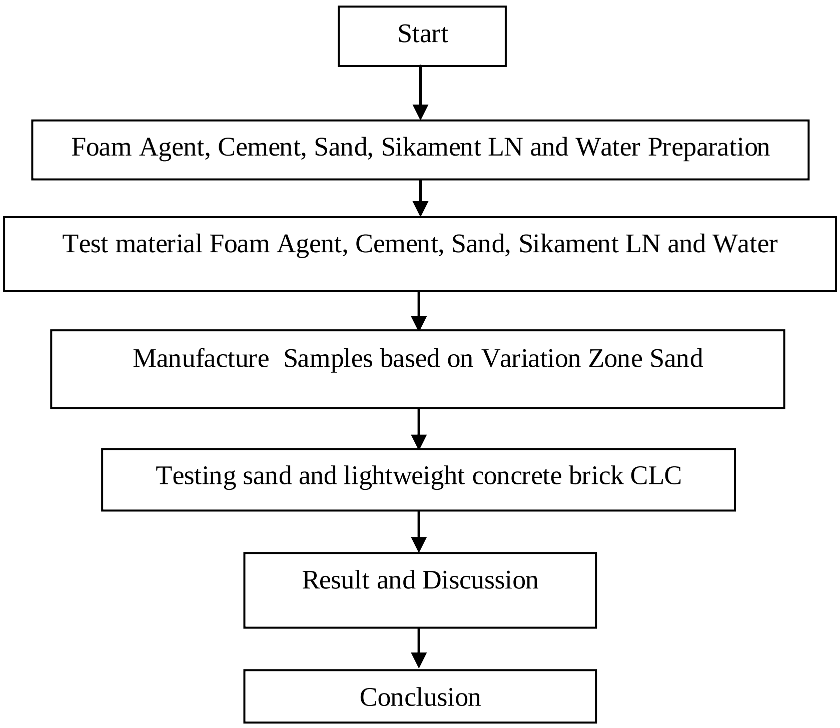


Fig. (3). Experimental Prosedure

No	Ingredients	The number of /m^3				Units
		Zone I Coarse	Zone II Quite Corse	Zone III Quite Smooth	Zone IV Smooth	
1	Sand	500	500	500	500	Kg
2	Cement	300				Kg
3	Foam Agent + water	64,8				Liters
5	Water	150				Kg
6	Sikamen LN	1,2				Kg

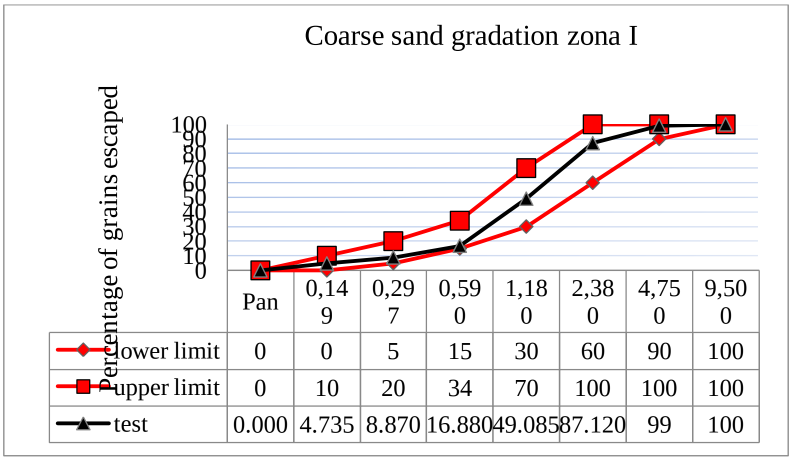
Table 3. Composition of the basic materials of Samples [3][9][15]

III. THE RESULTS AND DISCUSSION

III.1. Sand Test

The sand is a fine aggregate used as an ingredient in the lightweight foam concrete bricks, it is necessary to study whether the sand meets the standards as a mixture or not. These examinations of sand gradation, sand grain fineness modulus, obtained as follows:

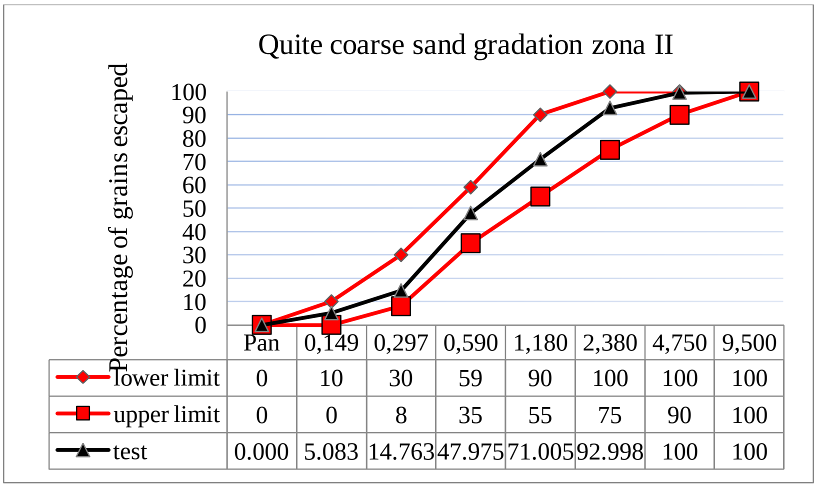
a. For fine aggregate coarse zone I of sand fineness modulus of 4,342 with a grain gradation graph as Figure 4



	Pan	0,149	0,297	0,590	1,180	2,380	4,750	9,500
lower limit	0	0	5	15	30	60	90	100
upper limit	0	10	20	34	70	100	100	100
test	0.000	4.735	8.870	16.880	49.085	87.120	99	100

Fig. (4). Coarse sand gradation

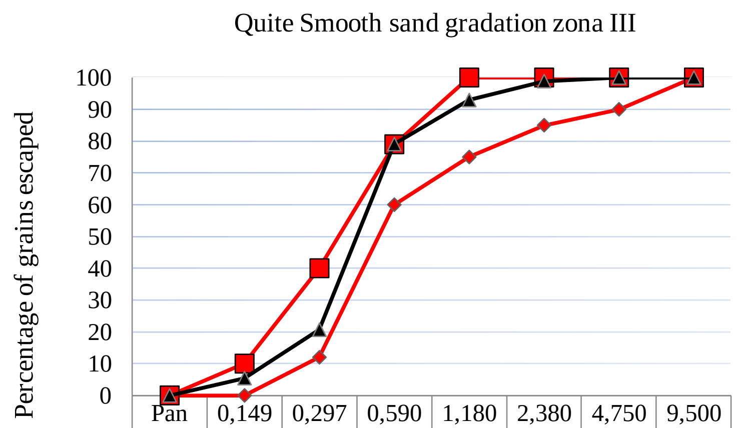
b. For fine aggregate quite coarse zone II of sand fineness modulus of 3.636 with a grain gradation graph as Figure 5.



	Pan	0,149	0,297	0,590	1,180	2,380	4,750	9,500
lower limit	0	10	30	59	90	100	100	100
upper limit	0	0	8	35	55	75	90	100
test	0.000	5.083	14.763	47.975	71.005	92.998	100	100

Fig. (5). Quite coarse sand gradation

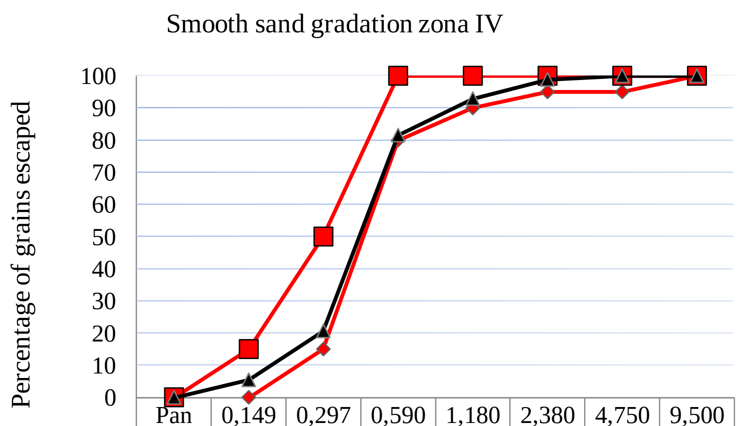
c. For fine aggregate quite smooth zone III of sand fineness modulus of 3,030 with a grain gradation graph as figure 6.



	Pan	0,149	0,297	0,590	1,180	2,380	4,750	9,500
lower limit	0	0	12	60	75	85	90	100
upper limit	0	10	40	79	100	100	100	100
test	0.000	5.430	20.655	79.070	92.925	98.875	100	100

Fig. (6). Quite smooth sand gradation

d. For fine aggregate smooth zone IV of sand fineness modulus of 3,005 with a grain gradation graph as figure 7.



	Pan	0,149	0,297	0,590	1,180	2,380	4,750	9,500
lower Limit		0	15	80	90	95	95	100
upper limit	0	15	50	100	100	100	100	100
test	0.000	5.430	20.655	81.575	92.925	98.875	100	100

Fig. (7). Smooth sand gradation

The sand density used is between 2,638.2 - 2,663.1 Kg /m^3. Where the largest is the coarse sand and the smallest is the smooth sand. This shows the rougher the sand the greater the weight of the species as well. This type of density is included in the subgroup type of fine aggregate to allow for fine aggregate in a CLC masonry lightweight concrete brick mixture. Absorption of the sand density used is between 0.89%-1.29%. Where the largest absorption is coarse sand, thus the greatest water absorption occurs to coarse sand compared with smooth sand. The weight of the loose volume of sand resulting from the material analysis is 1,159 – 1,513 kg/m^3 while the solid weight is 1,472 – 1,616 kg/m^3. With an average weight volume of 1,316 – 1,565 kg / m^3.

From the results of fluid color observation after 24 hours, obtained the color of the fluid in accordance with the standard color No 3. This means that the organic material contained in the sand does not exceed the tolerance (standard color No 3). The results of the research found that the mud content contained in the sand of 0.99 - 1.03%. From the results obtained can be concluded that the mud content contained in the sand is smaller than 5%, it is still feasible to be used in the mixture of lightweight concrete bricks foam. The moisture content of the sand used for CLC masonry lightweight concrete brick mixture is 5,675 - 6,075% where the largest water content is coarse sand.

III.2. Lightweight Concrete Bricks CLC

The results of this research have been tested by. ASTM and ACI, which can be seen in Figure 8 and Table 4.

Fig 8. CLC masonry lightweight concrete brick

No	Parameters	Zone I Coarse	Zone II Quite Corse	Zone III Quite Smooth	Zone IV Smooth
1	Qualified Brick CLC (%)	0	100	100	100
2	Slump flow (cm)	28	27,3	27,5	26,8
3	Drying shrinkage (%)	100	0	0	0
4	Porosity (%)	0	30,33	27,54	28,04
5	Sound resistance (db)	0	51,20	34,94	49,38
6	Thermal Conductivity (W/mK)	0	0.25	0.28	0.28
7	Permeability (cm/second)	0	$1{,}94x10^{-5}$	$1{,}61x10^{-5}$	$1{,}70x10^{-5}$
8	Modulus elasticity (MPa)		47,99	68,32	52,27
9.	The volume dry weight of the age of 28 (kg/m^3)	0	798	881	820
10.	Compressive Strenght (MPa)	0	0,38	1,28	0,56
11.	Absorption (%)	0	42,15	29, 12	36,69

Tabel 4. Comparison of the results of the Gradient Variation of Sand in the making of CLC masonry lightweight concrete brick

From table 4 it can be seen that the mansory concrete brick CLC from each of the variations that produce mansory concrete brick CLC only sand zona II, III, and IV. While using sand zona I produce as much as 100% drying shrinkage or the level of success only 0% after the age of 1 days. And from the slump test flow obtained the average above 27.5 cm, this means a mixture of sand variation of zona I, II, III and IV have a high workability level. So will be very easy to make mansory concrete brick CLC. With the easy transmission of a mixture of variation 1 s/d 4 into the mold and the mixture is very suitable to be concrete SCC (Self Compacting Concrete)[10]. Sand variations zona II, III, and IV suitable to become a mansory concrete brick CLC because don't shrinkage in age 1 until 28 day.

The mansory concrete brick CLC from each variation produces the average porosity total between 27,54 - 30,33%. Where the more porosity total from the mansory concrete brick CLC resulted in a brick is getting lighter. From porosity total the average so that is very good for a mixture of mansory concrete brick CLC is a variation of Sand zone II.

The average sound resistance between 34.94 - 51.20%. Where the greater the sound resistance from the mansory concrete brick CLC resulted in a brick is the better. From the sound resistance of the average so that is very good for a mixture of mansory concrete brick CLC is a variation of sand zone II because it has the biggest sound resistance.

The absorption between 29.12 - 42.15%. Where the greater the absorption of mansory concrete brick CLC resulted in a brick is the more severe. From absorption the average so that is very good for a mixture of mansory concrete brick CLC a variation of sand zone II.

The average volume weight mansory concrete brick CLC between 798-881 kg/cm^3. Thus varasi who qualify for a mansory concrete brick CLC is under 950 kg/cm^3 so the variation of sand Zona II, III and IV can be used for making mansory concrete brick CLC. Only from the four the variation the lightest is sand zone II. If seen from the development of the weight of the volume of mansory concrete brick CLC based on age and can be described in general under the weight of the volume of mansory concrete brick CLC will be more lightweight increases with age bricks..

The average permeability between 1.61 x 10^{-5} – 1.94 x 10^{-5} cm/second. The greater the permeability of mansory concrete brick CLC resulted in a brick is getting is not good. From the average permeability so that is very good for a mixture of mansory concrete brick CLC is a variation of sand zone III because it has small permeability.

The average thermal conductivity between 0.25 – 0.28 W/mK. Where the smallest the thermal conductivity from the mansory concrete brick CLC resulted in a brick is the better. From the average thermal conductivity so that is very good for a mixture of mansory concrete brick CLC is a variation of sand zone II because it has the smallest thermal conductivity.

Compressive strength of the age 28 between 0.38 – 1.28 MPa. Where the largest the Compressive strength from the mansory concrete brick CLC resulted in a brick is the better. From the average Compressive strength so that is very good for a mixture of mansory concrete brick CLC is a variation of sand zone III because it has the largest Compressive strength.

Modulus elasticity the age 28 between 47,99 – 68,32 MPa. Where the largest the modulus elasticity from the mansory concrete brick CLC resulted in a brick is the better. From the average modulus elasticity so that is very good for a mixture of mansory concrete brick CLC is a variation of sand zone III because it has the largest modulus elasticity

IV. CONCLUSION

The different sand gradation which includes gradation of coarse, quite coarse, quite smooth, and smooth sand, there was an influence of graded sand against the physical and mechanical properties of CLC masonry concrete brick. The volume weight/ average content of CLC masonry concrete brick is between 798-881 kg/cm3, which the most lightly variation is variation of quite smooth sand gradation. Volume weight of CLC masonry concrete brick in general will become lighter with increasing age of the brick. Average compressive strength for 28 days is between 0.38 to 1.28 MPa where greatest 28 days of compressive strength is zone III sand, with equation of the relation between the compressive strength versus brick age is y = 0.132 ln (x) + 0.88, with R2 = 0.9232. Based on the equation, it is obtained compressive strength CLC masonry concrete brick will be greater as the CLC masonry concrete brick age increases in linear. This can be seen in Figure 9

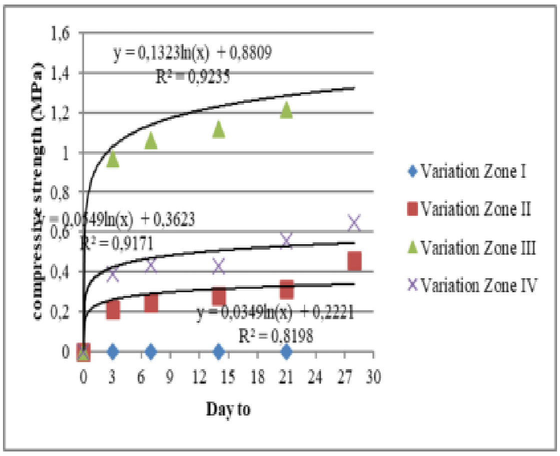


Figure 9.Correlation between day and compressive strength

Sand in various zones such as zone II, III and IV may be used as an ingredient in a mixture of CLC masonry concrete brick. The sand has a fineness modulus between 3.005-3.636, and the best gradation (optimum) which is 4 variations in gradation of sand in the mix of CLC masonry concrete brick in terms of brick physical and mechanical properties that resulted which is quite smooth gradations of having good and sand fineness modulus 3,030.

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