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Influence of Lime Addition Compressive Strength Against Increasing Paving Blocks

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Abstract: - Paving blocks composition is made by mixing cement, sand, water or other added ingredients. Widespread use of paving blocks, causing labored added alternative materials that can improve the compressive strength. Lime chosen as an additional alternative ingredients in the mixture of paving blocks. Lime is relatively easy and the price is cheap because it is a potential ingredient in Indonesia were spread in various islands namely in Java, Sumatra and Irian Jaya, so the availability of this material very much. The study aims to determine the effect of adding lime to the compressive strength of the paving blocks. Tests were done by making the specimen or printed manuals with a compressive strength test after test specimen aged 7 , 14 , 21 and 28 days to get the optimum composition in the addition of lime. Tests were carried out with the addition of lime to the levels 0, 2, 4, 6, 8 and 10% of the content of the cement used in the test object with a compressive strength test with a compressive strength testing machine pressed. The results of tests carried out will be known how much lime content that is optimal in order to improve the compressive strength of the paving blocks, so that the resulting quality will be better than normal paving blocks.

Keywords: - *compressive strength, compressive strength testing machine, lime, paving blocks, silt content*

I. INTRODUCTION

The use of paving blocks increasingly used them in place - a special place that require more strength to support the weight of the secondary as the region turns , stops , parking lots , ports , as well as to use the pavement in certain areas such as streets in residential areas / shops, port , footpath / alleys , sidewalks , roads tourist region , the yard office . Paving block is considered more practical and economical than the use of reinforced concrete pavement . Paving blocks easier in installation work , easily disassembled back without the need for heavy equipment , able to withstand the load within certain limits , and the construction is relatively durable and has a beautiful shape and color . Paving blocks can be produced either manually (manpower) and the machine tool . In general , paving blocks produced by the machine has a higher quality than in the printed manual. In the study by adding lime to the mixture of paving blocks.. Limestone is one of the potential rock that is widely available in Indonesia, spread from the mountains of Java, Sumatra and Irian Jaya. Therefore, the added material limestone is relatively easy and inexpensive to obtain paving block and is made by mixing cement composition of composite (binder), sand (filler), water (material for mix) and lime (material added) with a ratio of up correctly evenly. The printing process is done by means of paving blocks manually. Compressive strength testing is done at the age of 7, 14, 21 and 28 days. This study was conducted to determine the effect of adding lime where an increase or decrease in the compressive strength. The addition of lime percentage variation in the study of which 2%, 4%, 6%, 8% and 10% of the amount of cement. The test results of compressive strength of the paving blocks without the addition of lime (normal) will be compared to the compressive strength test paving block with the addition of lime. In order to obtain optimal percentage lime on a maximum compressive strength.

II. REVIEW OF LITERATURE

2.1. Paving Blocks

Paving blocks are the building blocks of cement that is used as an alternative ground cover or pavement, paving block also known as cone concrete brick or block. Paving block is a composition of building materials made with a mixture of cement and adhesive hydraulic Porland or the like, water and aggregates with or without other ingredients which do not reduce the quality of concrete brick that has been set, (SNI 03-0691-1996).

As the cover material and surface hardening soil and water infiltration, paving blocks is a new alternative system as pavement, paving blocks are very widely used for various purposes, ranging from the simple to use purposes that require special specifications. Paving blocks printed with different colors, sizes and shapes. Paving blocks form must be absolutely perfect, there are no cracks and defects in the corners and in the ribs so that it can be easily trimmed by hand..In general finger used is a square, hexagonal and round. Deviations

thick paving blocks for floors and road environment allowed is ± 3mm (research journals and settlements, 2003).

Bakhtiar A (2008) on study quality improvement paving block with the addition of rice husk ash (ASP), the conclusion that the addition of the percentage of rice husk ash to the mix paving block below 8 % resulted in the addition of compressive strength of the paving blocks while adding the percentage of rice husk. ash to in the mix paving block above 8 % resulted in a decrease in the compressive strength of the paving blocks Type of cement used is PC type I. The magnitude of the compressive strength of each paving block with a mix of ASP 5 % percent at 9.47 MPa ; ASP 10 % amounting to 9.64 MPa ; ASP 15 % at 8.29 MPa while the paving blocks that are not mixed with ASP at 8.45 MPa .

Nur Setiaji Pamungkas (2013) on the use of land blanket as a mixture of paving blocks with compressive strength of reviews we concluded that without the addition of the composition of the soil blanket with a mixture of 1 : 8 , compressive strength reached 12.19 MPa .

Sebayang Syukur , et al (2011) about the comparison of the quality of the production of paving blocks manually with machine production showed that the quality of paving blocks are made manually obtained an average compressive strength of 21.26 MPa , and the average compressive strength of the machine is obtained 23.07 Mpa . This is because of the pressure exerted by using a mixture machine to be printed higher than the manual devices . Compaction by using a more optimal engine .

2.2. Quality Requirements

Paving blocks according to the quality requirements of SNI - 03-0691-1996 as follows :

1. Nature looks
   Brick concrete for the floor should have a perfect shape , there are no cracks and defects , corners and ribs not easily direpihkan with fingers .
2. Shape and size
   Various shapes and sizes of concrete bricks for the floor , there is a market depends on the manufacturer . Usually every manufacturer provide a written explanation in the leaflet regarding the shape , size and carrying capacity and construction of the installation to the floor . Deviations thick concrete bricks for the floor which allowed is ± 3 mm .
3. Physical properties
   Brick concrete for the floor must have physical strength as shown in Table 1 .

Table 1: The physical strength of paving blocks

Quality	Average (Mpa)	Minimum (Mpa)
I	40	34
II	30	22,5
IIIa	20	17
IIIb	15	12,5

Source : SNI 03-0691-1996

Quality requirements for each type can be seen in Table 2.

Table 2: Quality requirements of each type of concrete brick

Type	Compressive Strength (mPa *)	
	Average	Minimum
A	40	35
B	20	17
C	15	12,5
D	10	8,5

Resistance to sodium sulfate should not be deformed and losing weight are allowed a maximum of 1.1
Remarks : * mPa = mega pascal , 1 mPa = 10 kg / cm2
Source: SNI 03-0691-1996

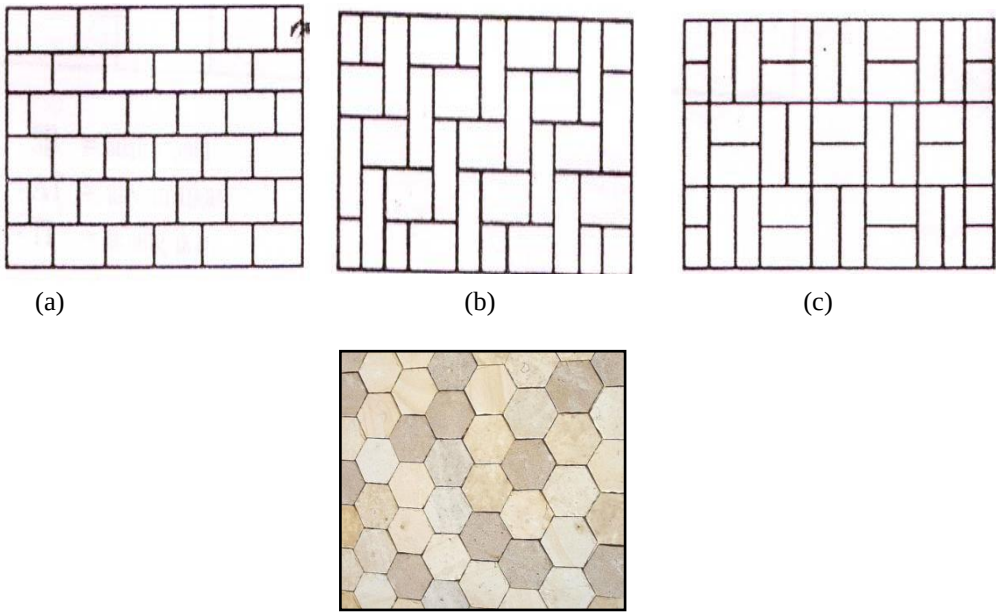
Description:

*) Quality I / Quality A: usually use for road use. Paving blocks of 10 cm thickness.
*) Quality II / Quality B: use is usually to the sidewalk, parking lot. Block paving thickness 6-8 cm.
*) Quality IIIa (quality C): usually use for pedestrians, a car garage. Block paving thickness 6-8 cm.
*) Quality IIIb (Quality D): usually for garden use. Block paving thickness 6-8 cm.

Based on SNI 03-0691-1996 clarification paving block (concrete brick) is distinguished by its use class as follows:
1. The quality concrete brick A: used for road
2. The quality concrete brick B: used for parking lot
3. The quality concrete brick C: is used for pedestrians
4. The quality concrete brick D: used for parks and other purposes.

Paving blocks manually produced are usually included in concrete quality class D or C is for the use of non-structural purposes, such as for parks and other uses that are not required to withstand heavy loads on it. Quality paving block the process by using a pressing machine can be categorized into concrete quality class C until a compressive strength above 125 kg / cm2 depends on the mixture ratio of the materials used. There must examine the strength of paving continuously / periodically for paving produced with special specifications. Sightings between paving blocks are manufactured by hand and pressed paving block machine are visible relatively similar, but the paving surface produced by a pressing machine looks more solid (meetings) than those made manually.

The installation of paving block pattern adapted to their intended use . cmmon patterns used see figure 1: stacking bricks (a) ; woven mat (b and c) ; fishbone 90º (d) ; hexagonal shape .



(a) (b) (c)

(d)

Fig: 1. Mounting pattern of paving blocks

2.3. Paving blocks of material

Paving block composed of a mixture of sand , cement and water , the mixture is referred to also as a mortar . Mortar is a mixture consisting of sand , adhesives as well as water and stirred homogeneously . Sand as the basic building material to be bonded with adhesive . The adhesive material can be clay , lime , red cement , and portland cement .

Mortar can be differentiated into three kinds **(Tjokrodimulyo , 1996**) , namely :
1. Mortar mud
2. Lime Mortar
3. Cement Mortar

In this study the mortar used is the type of lime mortar , which is made from a mixture of sand , lime , portland cement and water with an appropriate comparison .

2.4. Fine Aggregate

Aggregate gradation is the grain size distribution of aggregates. When a grain aggregate having the same size (uniform) then it will be a large pore volume . Conversely if the size of the grains varies happens that

small pore volume . This happens because the small grains filling the pores between the grains are large , so that the pores slightly . Gradation of sand divided into four zones namely Zone 1 , Zone 2 , Zone 3 and Zone 4. Each zone has an upper limit and a lower limit , can be seen in Table 3 .

Table 3: Terms fine aggregate gradation limits

Hole Sieve (mm)	Hole penetrating the cumulative weight (%)							
	Zone 1		Zone 2		Zone 3		Zone 4	
	Down	Up	Down	Up	Down	Up	Down	Up
10	100	100	100	100	100	100	100	100
4.8	90	100	90	100	90	100	95	100
2.4	60	95	75	100	85	100	95	100
1.2	30	70	55	100	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	

Source:ASTM C33-86

Aggregate used for mortar mix or mortar must meet the requirements set by SK SNI - S - 04-1989 - F ie with smooth modulus of 1.5 to 3.8.

III. RESEARCH OF METHODOLOGY

The activities conducted during the study are :

- Preparation of materials (sand , red and white cement , lime and water) .
- Examination of the sludge concentration of fine aggregate , an examination of the grain fineness modulus (MHB) fine aggregate .
- The first mortar insert (Pc : Ps = 1 : 2) into a mold with a thickness of 1 - 1.5 cm. Then put sand mortar main part (Pc : Ps = 1 : 8) to the brim . Inserting block paving material mixture into a mold , which was previously on the inside of the m
- Printing specimen block paving, Hexagonal shaped , with size length (p) = 16 cm ; Width (m) = 9.5 cm ; Thickness (t) = 6 cm .
- Immersion test piece , made to the treatment process
- Compressive strength testing with a compressive strength testing machine is done at the age of 7 , 14 , 21 and 28 days .

Percentage of the mixture of lime used in the manufacture of paving blocks is 2 % , 4 % , 6 % , 8 % and 10 % of the amount of cement . Quality paving blocks without the addition of lime (class D) , compressive strength must achieve a minimum of 12.5 Mpa .

IV. RESULTS AND DISCUSSION

4.1. Assays Results Mud of Sand

According to ASTM C33-86 , mud allowable concentration limit for sand is < 5 % . The test results are to be obtained slurry sand content of 3.9 % . Sand still meet ASTM standard C33-86 , meaning decent sand used for paving mixtures blocks.

4.2. Testing Sieve Analysis Sand

The test results are to be obtained by MHB 3.61 . This sand meet the standards SK - SNI - S - 04-1989 – F, meaning a decent sand used for paving mixtures blocks. This sand is classified, including the type of coarse sand. Grain size distribution , or better known as gradation, sand is included in Zone 1. Graph relationship with the cumulative percentage size sieve sieve can be seen in Figure 4.1.

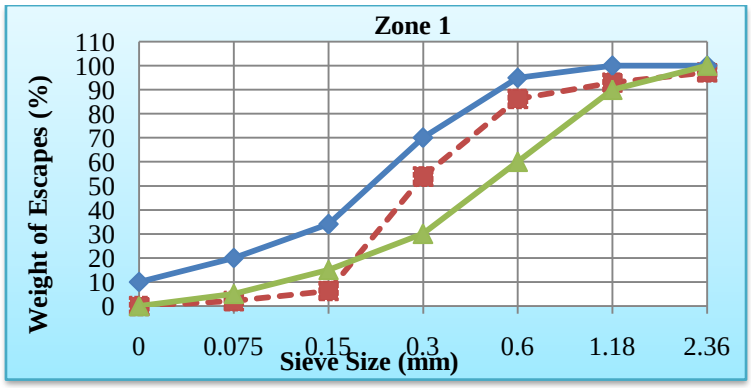


Fig: 2. Sieve size relationship with the cumulative percentage sieve sand

From the figure 2 shows that the red line shows the data of heavy sand passes into the upper limit and lower lim t . When compared with zones 2 , 3 , and 4 , the percentage weight of sand sieve is more fit in zone 1 (coarse sand) .

4.3. Relations Compressive Strngth Paving Blocks With the Addition of Lime At Age of 7 Days
The test results 7 days compressive strength , can be seen in Table 4.

Table 4: Results of testing the compressive strength of the paving blocks at the age of 7 days

No.	Test Object Name	Press Load (kg)	Compressive Strength (kg/cm2)
1	Paving Blocks Normal (PBN)	17750	92.84
2	PBN + Lime 2%	20250	105.91
3	PBN + Lime 4%	22500	117.68
4	PBN + Lime 6%	23750	124.22
5	PBN + Lime 8%	25250	132.06
6	PBN + Lime 10%	23000	120.29

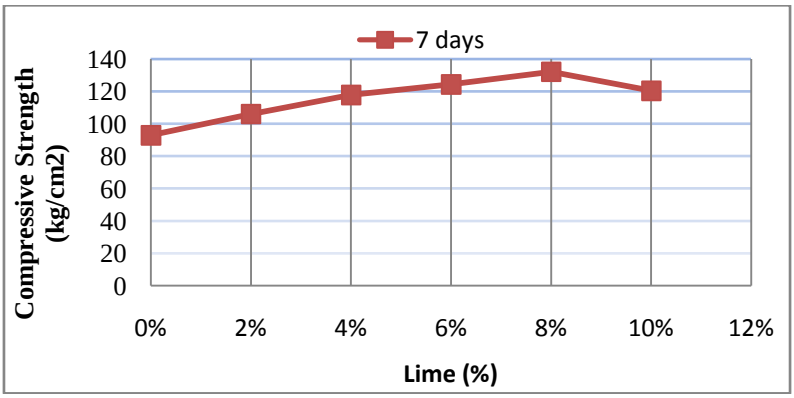


Fig. 3: Relationship compressive strength with the addition of lime at the age of 7 days

Table 4 and Figure 3 show that the compressive strength of the paving blocks age of 7 days on the addition of lime 2 % , 4 % , 6 % and 8 % increase in the compressive strength is continuous from the normal quality . The addition of lime from 2 % to 10 % lime at the age of 7 days showed the quality of paving blocks are still class D. The addition of 10 % limestone decreased compressive strength of limestone addition of 8 % as the reduction in the compressive strength of 6% .

4.4. Relations Compressive Strngth Paving Blocks With the Addition of Lime At Age of 14 Days
The test results 14 days compressive strength , can be seen in Table 5.

Table 5: Results of testing the compressive strength of the paving blocks at the age of 14 days

No.	Test Object Name	Press Load (kg)	Compressive Strength (kg/cm2)
1	Paving Blocks Normal (PBN)	23000	120.29
2	PBN + Lime 2%	24000	125.52
3	PBN + Lime 4%	24750	129.45
4	PBN + Lime 6%	26500	138.60
5	PBN + Lime 8%	27500	143.83
6	PBN + Lime 10%	26500	138.60

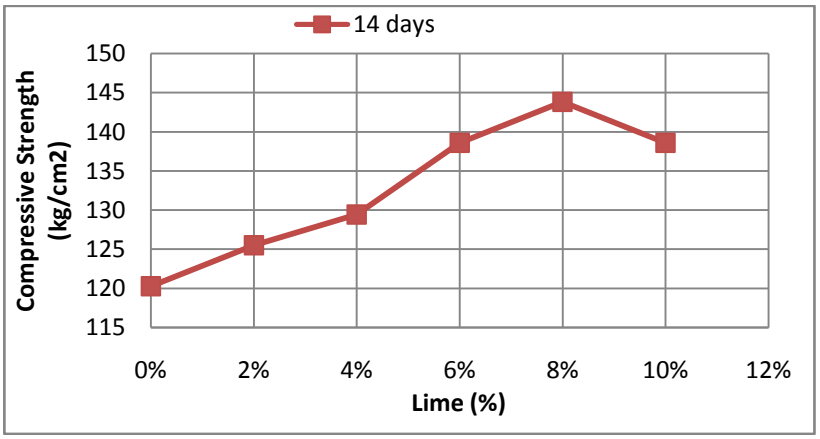


Fig. 4: Relationship compressive strength with the addition of lime at the age of 14 days

Table 5 and Figure 4 shows the compressive strength of the paving blocks at the age of 14 days had increased compressive strength at the age of 14 days . A large increase in the compressive strength ranges from 11-27 kg / cm2 . While the addition of 10 % limestone decreased by 3.63 % compressive strength compared to the compressive strength of lime addition of 8 % . Compressive strength with the addition of lime from 2 % to 10 % lime at 14 days showed the quality of paving blocks are still class D. The highest compressive strength on the addition of lime 8 % , which is 143.84 kg / cm2 (equivalent to 11.93 MPa) .

4.5. Relations Compressive Strngth Paving Blocks With the Addition of Lime At Age of 21 Days
The test results 21 days compressive strength , can be seen in Table 6.

Table 6: Results of testing the compressive strength of the paving blocks at the age of 21 days

No.	Test Object Name	Press Load (kg)	Compressive Strength (kg/cm2)
1	Paving Blocks Normal (PBN)	26500	138.68
2	PBN + Lime 2%	28250	147.75
3	PBN + Lime 4%	29500	154.29
4	PBN + Lime 6%	31250	163.44
5	PBN + Lime 8%	32750	171.29
6	PBN + Lime 10%	28750	150.37

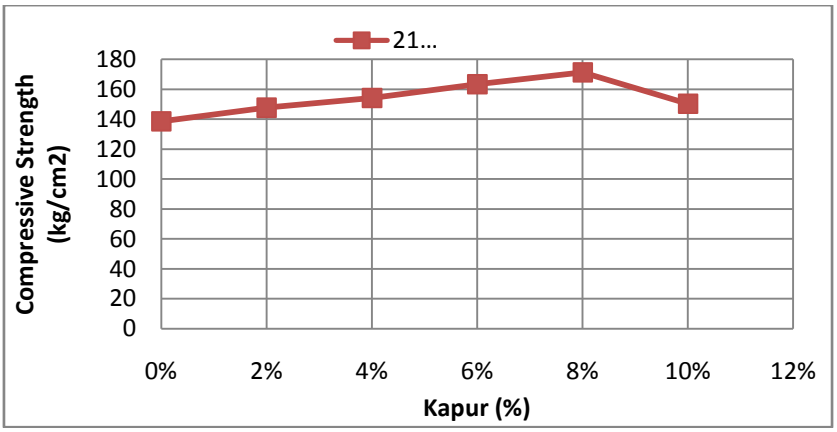


Fig. 5: Relationship compressive strength with the addition of lime at the age of 21 days

Tables.6 and Figure 5 show the picture compressive strength of paving blocks at the age of 21 days had increased compressive strength at the age of 21 days . A large increase in the compressive strength ranges from 22-28 kg / cm2 . While the addition of 10 % limestone decreased compressive strength at 12:21 % compared with the addition of lime 8 % . Compressive strength with the addition of lime from 2 % to 10 % at age 21, the quality of paving blocks are also still class D.

4.6. Relations Compressive Strngth Paving Blocks With the Addition of Lime At Age of 28 Days

The test results 21 days compressive strength , can be seen in Table 7.

Table 7: Results of testing the compressive strength of the paving blocks at the age of 28 days

No.	Test Object Name	Press Load (kg)	Compressive Strength (kg/cm2)
1	Paving Blocks Normal (PBN)	29250	152.98
2	PBN + Lime 2%	30750	160.83
3	PBN + Lime 4%	33250	173.90
4	PBN + Lime 6%	36250	189.59
5	PBN + Lime 8%	39250	205.28
6	PBN + Lime 10%	32500	169.98

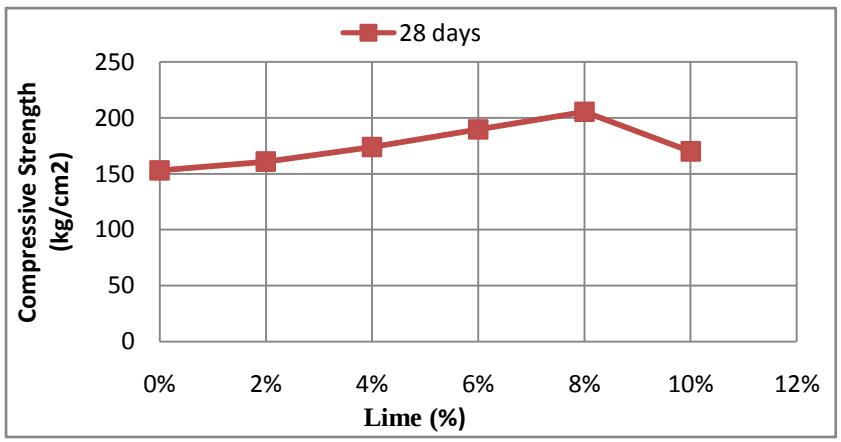


Fig. 6: Relationship compressive strength with the addition of lime at the age of 28 days

The compressive strength of the paving blocks 28 days increased compressive strength to the age of 21 a day. Compressive strength increased to the addition of lime 8 % , while the addition of 10 % limestone compressive strength decreased by 17.2 % compared to the compressive strength of limestone addition of 8 % . The addition of lime 2 % to 6 % at 28 days , the quality is still the quality paving block D , but the addition of 8 % increase to the quality of class C.

4.7. Merging Compressive Strength Test Results

Each specimen treatment process is carried out: by soaking and drying continued to do the testing . Comparison of compressive strength test between normal paving block and paving block with the addition of lime can be seen in Table 8.

Table 8:. Merging the results of compressive strength testing

No.	Age (days)	Paving Block Normal (PBN)	PBN + Kapur 2%	PBN + Kapur 4%	PBN + Kapur 6%	PBN + Kapur 8%	PBN + Kapur 10%
1	0	0	0	0	0	0	0
2	7	92.84	105.91	117.68	124.22	132.06	120.29
3	14	120.29	125.52	129.45	138.60	143.83	138.60
4	21	138.60	147.75	154.29	163.44	171.29	150.37
5	28	152.98	160.83	173.90	189.59	205.28	169.98

At the age of 28 the addition of lime to the 2 % increase in the compressive strength of 5% of normal . The addition of lime 4 % increase in the compressive strength at 13 % of normal . The addition of lime 6 % increase in the compressive strength at 23 % of normal . The addition of lime 8 % increase in the compressive strength at 34 % of normal . The addition of lime 10 % increase in compressive strength of 11 % of the normal compressive strength .

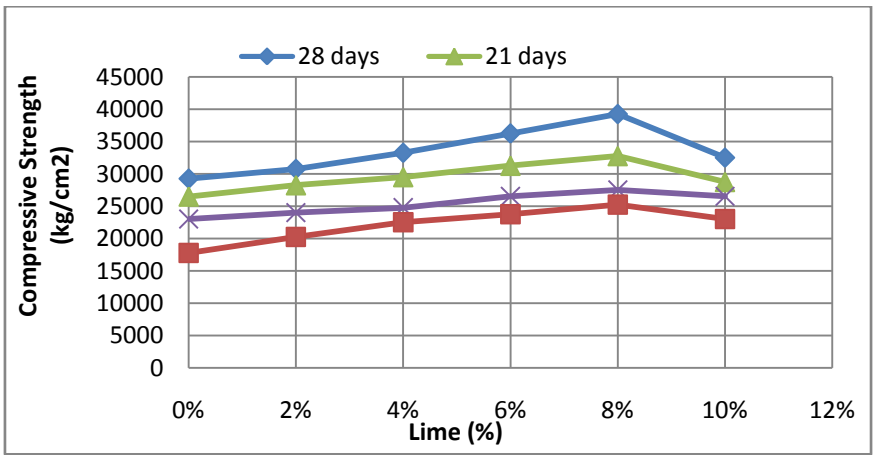


Fig. 7: The relationship between the ratio of the press load the addition of lime at the age of 7, 14, 21 and 28 days

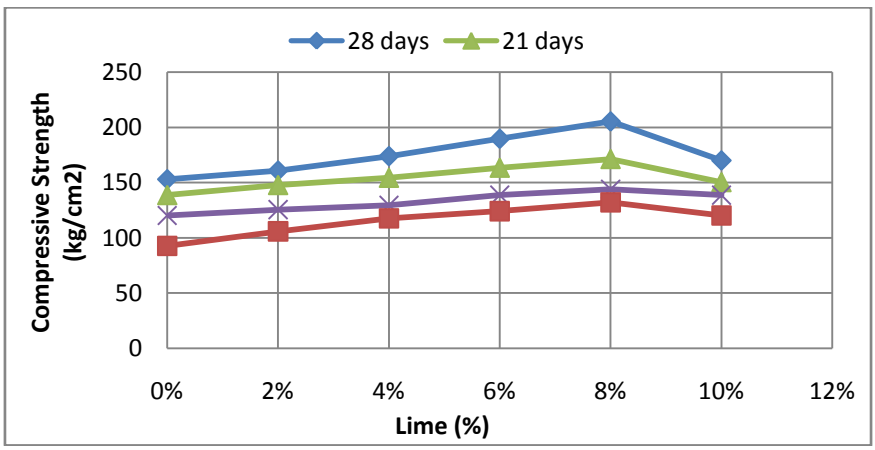


Fig. 7: The relationship between the ratio of the compressive strength the addition of lime at the age of 7, 14, 21 and 28 days

The results were obtained the highest compressive strength at 28 days. The compressive strength of the paving block addition of 2-6% lime at 28 days was classified as the type of quality D. After the addition of 8%,

the quality of paving blocks increased to quality class C. It can be concluded that the addition of lime to limit the increase in compressive strength is 8%. Maximum compressive strength occurred in 8% addition of lime that is 205 kg / cm2 (17 MPa). The addition of > 8% lime resulted in a decrease in compressive strength. The addition of lime to 10% at 28 days decreased by 17% compressive strength of the compressive strength of the addition of lime 8%, so it is still classified as class quality paving block D.

In a study of land use blanket (Nur Setiaji, 2013), the compressive strength of the paving blocks using a cement type I with the composition PC 1pc: 8PS without the addition of other materials obtained 12.19 MPa. Whereas in this study without the addition of lime (cement composite) gained 12.68 MPa. With the same mixture composition, compressive strength using composite cement (PCC), an increase of 4% of the compressive strength with cement PC type I. Results of comparative research quality manual paving block production with masinal (Sebayang Syukur, 2011), where the difference between a manual compressive strength with masinal 8%.

V. CONCLUSION

Based on the results of research conducted , it can be concluded as follows :

- According to ASTM C33-86 , mud allowable concentration limit for sand is < 5 % . The test results are to be obtained slurry sand content of 3.9 % . This sand meets the ASTM standard C33-86 , meaning decent sand used for paving mixtures blocks .
- Standard for grain fineness modulus (MHB) is 1.5 to 3.8 . The test results are to be obtained by MHB 3.61 This sand meet the standards SK - SNI - S - 04-1989 - F , meaning a decent sand used for paving mixtures blocks . This sand is classified , including the type of coarse sand .
- Grain size distribution , or better known as gradation , sand is included in zone 1 .
- The compressive strength of paving blocks with a ratio 1pc: 8PS , without the addition of lime obtained at 152.98 kg / cm2 .
- The addition of lime 2 % - 8 % resulting in an increase in the compressive strength of the paving blocks at the age of 7 , 14 , 21 and 28 days and the addition of lime more than 8 % will decrease the compressive strength of the paving blocks .
- Addition of lime 8 % on block paving mixture obtained maximum compressive strength of 205 kg / cm2 at 28 days . Increase the quality of paving blocks of quality D into quality C , based ISO - 0691-1996 , the paving blocks can be used for pedestrians .
- The addition of lime to 10% at 28 days resulted in 17 % reduction in the compressive strength of the compressive strength of limestone addition of 8 % .

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