THE USE OF NATURAL TRASS FROM SAYUTAN MAGETAN AND LIME FROM NGAMPEL BLORA AS THE MATERIAL OF CEMENT SUBSTITUTION FOR MORTAR MIXTURE

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ABSTRACT

Construction works in the Regency of Magetan, as well as in the mountain area far from capital cities and remote from transportation facilities, require large amount of material. In order to cope with the need of sand, people uses natural trass which are plenty to be found in the area. Test and research on its characteristic and strength with its potentials to be used as cement substitution have never been carried out. Lime was taken from Ngampel village, Blora as it is commonly sold in the area. The planned mixture of lime-trass paste was in the effort to obtain the best composition. The weight ratios used were 100%:0%, 80%:20%, 60%:40%, 40%:60%, 20%:80 and 0%:100%. The mortar mixture with cement substitution was 100%, 80%, 60%, 40%, 20% and 0%.The compressive strength of the lime-trash mixture was between 0.000 MPa and 2.545 MPa. The mortar compressive strength achieved was 0.373 MPa - 26.585 MPa. The test results of mortar compressive strength showed that the more cement substitution amount used, the less the compressive strength would be. The mortar compressive strength increased in line to the age of the mortar. The mortar tensile strength obtained was 0.000 MPa - 2.169 MPa. The block compressive strength obtained was 3.336 MPa - 3.403 MPa. Water absorbency of the block was 15.831% -16.056%.

Keywords: trass, lime, mortar, compressive strength, tensile strength

1 INTRODUCTION

Construction works in the Regency of Magetan, the Province of Jawa Timur, as well as in the remote areas around the regency, require significant amount of materials. One of such areas is Parang subdistrict, the regency of Magetan, which is one of the mountain areas afar from the capital city (more than 25-30 km). There is no sand mining and closest is about 50-55 km. To fulfill the need of sand, the people commonly use natural trass because it is widely available in the area as cement substance. Some of the people import the sand form other area such as from Wonogiri which also cause the expensive cost.

Traditionally, the natural trass in Parang subdistrict The regency of Magetan has been widely used by the people in the area as sand substance material for blocks, channels, tiles, and space mortar for clay brick masonry. However, researches and studies to identify their characteristics and strength as cement substitution have never been done.

The important characteristic of the trass is that when it is mixed with slake lime and water, it will form such substance similar to cement, due to the amorfed oxide silica (SiO_2) and oxide alumina (Al_2O_3) contained in the trass was acid. The two types of acid oxides are compounded to lime and water and will have cement characteristic (Sukandarrumidi, 2004). Lime is one of materials commonly used for plaster mixture, clay masonry mixture (mortar), and in the making of trass and red cement. Lime used in this study was slaked lime taken from Ngampel village, Blora subdistrict, the regency of Blora. This type of lime is widely available and sold in the regency of Magetan (Hijhof, 1970).

Mortar is a construction material functioning as the binder for clay brick, plasters and blocks. Portland cement and lime are the main binding material for mortar. It is required to have other alternatives of binding materials to substitute cement, especially for non-structural construction. Trass is one of the pozzolan types and most of them consisted of reactive silicate and aluminates, such as cement. Thus, trass is preferred as the alternative for additional substance in the mortar mixture (Tjokrodimuljo, 2010). It is expected from this study to raise the economic value

of trass and to reduce the dependency on portland cement.

2 LITERATURE REVIEW

Hariyanto (2008) studied the use of trass from Samigaluh Kulon Progo as pozzolan material for mortar mixture. The test results of compressive strength of 7 days lime-trass paste showed the highest compressive strength value of 0.4177 MPa for Pagerharjo paste and 0.8579 MPa for Purwoharjo paste within 2 lime : 3 trass lime : 3 trass ratio. The test results for mortar compressive strength indicated that the more amount of cement substitute was the less compressive strength. The compressive strength of 28 days mortar ranges between 16.2800 MPa - 0.6618 MPa. The test results for mortar tensile strength showed that the more lime and trass used was the less tensile strength. Tensile strength of 28 days mortar ranges between 2.2622 MPa – 0.2147 MPa. The water absorbency value of the mortar increases in line to the incensing amount of lime and trass. Water absorbency of 28 days mortar ranges between 9.78657% - 16.9024%.

Wibowo (2007) studied the influence of trass Muria addition to compressive strength, tensile strength and water absorbency to mortar. The addition of trass influences the mortar compressive strength, tensile strength and water absorbency. The test of compressive strength and tensile strength of 90 days mortar showed increasing values of compressive strength and tensile strength in compare to mortar with no trass addition within mixture variations. Compressive strength, tensile strength, and water absorbency of 90 days mortar ranges between 116.81 Kg/cm2 and 72.53 Kg/cm2, 11.40 Kg/cm2 and 13.57 Kg/cm2, respectively. For of 90 days mortar, it is indicated that more addition of trass will increase the water absorbency. It ranges between 9.00% and 11.06%.

Nugraheni (2007) studied the influence of the addition of trass Muria to compressive strength and water absorbency of solid concrete brick. The highest compressive strength of 47.576 kg/cm2 occurred in 0.27 trass : 1.00 cement : 5.92 sand ratio (the solid concrete brick is categorized in A1 and A2 quality according to PUBI-1982). The value of water absorbency indicated that the more trass added the higher the water absorbency will be. Water absorbency ranges between 14.79% and 17.62%.

3 RESEARCH METHOD

3.1 Materials

Materials used in this study included the natural trass taken from Sayutan village, the Regency of Magetan. There were three types of the trass: trass from Sumber, trass from Jeruk and trass from Dukuh (all of these types passed through sieve number 200), slake lime from Ngampel village, The regency of Blora (this lime passed through sieve number 200 or 0.075 mm), composite portland cement of Indocement/ Tiga Roda brand, sand from Sungai Gandong The regency of Magetan, and clean water from the laboratory of construction material of Gadjah Mada University.

3.2 Instruments

The instruments used in this study included: picnometer, digital scale, steel vessel, measuring cup, oven drying and weighting, cube molds, cylinder, bock and 8 number shaper, sieve, mortar mixer and concrete mixer, chronic cone, calipers, pile, shovel, spoon, compressive test machine of AVERY DENISON brand, UTM machine of RIEHLE – USA brand, flow table, tensile test machine of ELE Type T 223.72 in 6 KN maximum capacity. These instruments were available at the laboratory of construction material of Gadjah Mada University (Satyarno, 2010).

3.3 Variables and Parameters

3.3.1 Variables

a) For trass – lime paste, the variation in this study used the weight ratio of trass and lime of 100%:0%, 80%:20%, 60%:40%, 40%:60%, 20%:80 and 0%:100%.
b) For mortar mixture of cement – trass – lime – sand, the compositions of trass – lime were 0%, 20%, 40%, 60%, 80% and 100% to the cement weight.
c) For the block mixture of trass-lime, the compositions of trass and lime used were the results of the composition of the best compressive strength test results on trass and lime paste.

3.3.2 Parameters

Parameters are the data measurement obtained from the study, such as the compressive strength, tensile strength, water absorbency, and the weight changing.

3.4 Research Flowchart

This study was carried out within the flowchart in Figure 1.

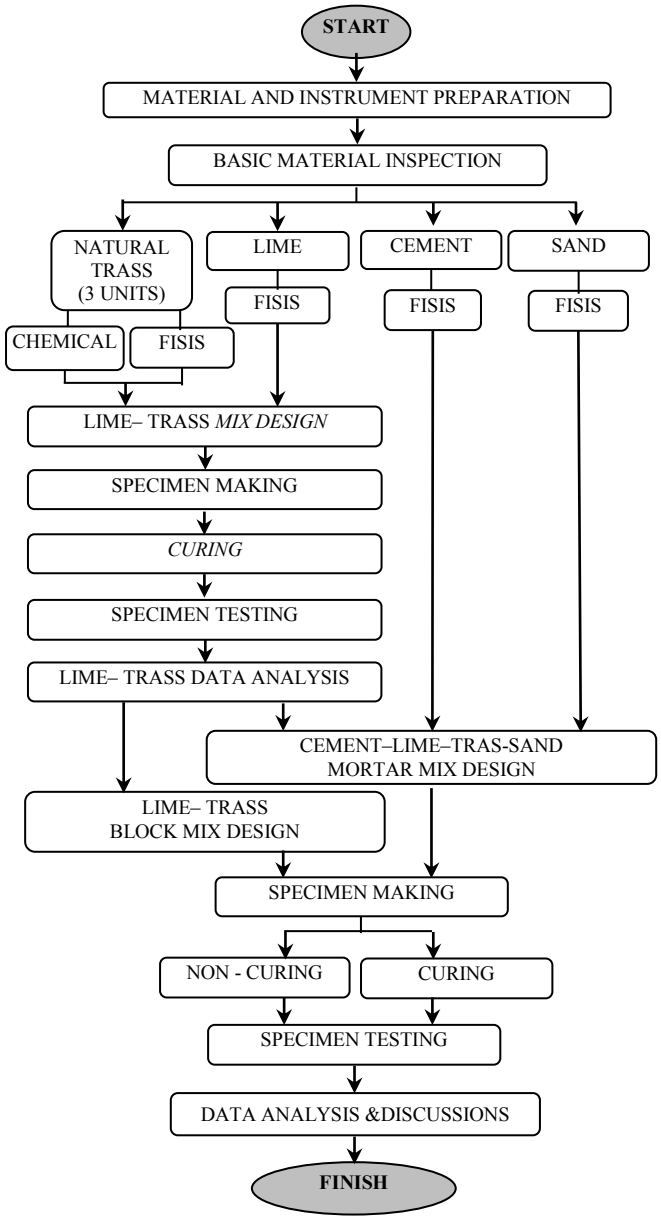

Figure 1. Flowchart of the study

4 RESULTS AND DISCUSSION

4.1 The Observation and Testsfor the Basic Materials

Results of the observation and tests for the basic materials are presented on Table 1 (ASTM, 2003; SNI 03-6882-2002).

Based on the observation in the Mineral Laboratory of The Geological Engineering Department of Gadjah Mada University, the three types of trass from Sayutan village were tufa which originally came from frozen intermediate rock composed from various minerals influencing the characteristics and color of the trass such as hornblende, plagioclase, volcano glass, coarse, biotitic, and andesitic.

Table 1. Results of the observation and test on the basic material

Basic Material	Test	Results
Trass Dukuh	Specific gravity	2.703
	Unit weight	1.171 gr/cm3
	Water absorbency	0.523%
	Chemical	Concentration (SiO_2 + Al_2O_3 + Fe_2O_3) = 87,747%
		Concentration CaO = 3.306%
		Concentration Na_2O = 1.343%
Trass Jeruk	Specific gravity	2.665
	Unit weight	1.051 gr/cm3
	Water absorbency	0.482%
	Chemical	Concentration (SiO_2 + Al_2O_3 + Fe_2O_3) = 9,940%
		Concentration CaO = 1.898%
		Concentration Na_2O = 1.317%
Trass Sumber	Specific gravity	2.672
	Unit weight	1.089 gr/cm3
	Water absorbency	0.725%
	Chemical	Concentration (SiO_2 + Al_2O_3 + Fe_2O_3) = 4,710%
		Concentration CaO = 2.086%
		Concentration Na_2O = 1.395%
Lime	Specific gravity	2.165
	Unit weight	0.474 gr/cm3
	Water absorbency	1.283%
Sand	Specific gravity	2.565
	Unit weight	1.511 gr/cm3
	Water absorbency	3.896%
	Mud content	1.010%
	Gradation	2.775

4.2 The Dispersion Value of Lime – Trass Paste

The consistency of the dispersion value of the lime and trass paste was set between 77.50% - 86.50% to have similar slash level that the water/ cement ratio would adjust to the dispersion value.

Figure 2 indicated that the tendency of water decreased in accordance to the decreasing of w/c ratio value in the paste mixture. Contrary, the addition of trass in the paste also indicated that the w/c ratio values decreased. It can be concluded that the addition of trass or the reduction of lime would reach similar slash level or dispersion value required lower w/c ratio.

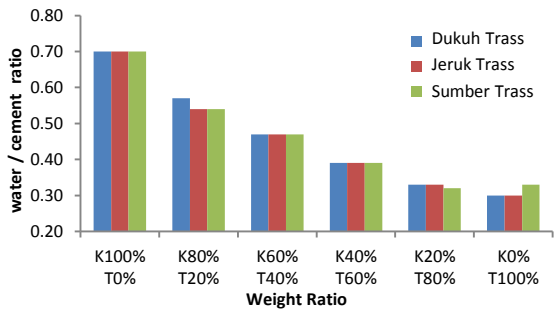

Figure 2. The relation of the composition of lime (K) - trass (T) paste and water / cement ratio

4.3 Compressive Strength of Lime-Trass Paste

The test of compressive strength for lime-trass was carried out for 14 days specimen. The test of compressive strength for lime-trass paste is presented on Figure 3 (SNI 03-2493-2002).

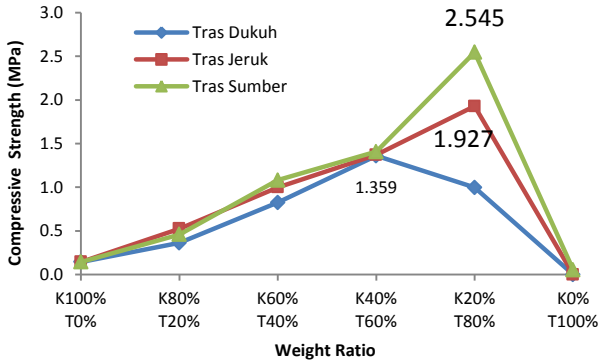

Figure 3. Results of the test of compressive strength for the three types of the lime (K) and trass (T) paste

Based on the results of the test of compressive strength for lime-trass paste cube specimens at room temperature, it was indicated that the highest compressive strength was 2.545 MPa which occurred on the specimen within 20% lime: 80% Trass Sumber composition.

4.4 The Mortar Weight of Content

The test results of the fresh mortar weight of content were 2101.428 kg/m3 - 2212.172 kg/m3. The planned weight was 2140.314 kg/m3 – 2209.871 kg/m3. The planned and resulted weight of content after correction is as presented in Figure 4.

Figure 4 shows the comparison graphics of the weight of content and w/c ratio of planned and resulted 0 day fresh mortar. It can be seen that the addition of lime–trass to substitute cement caused the weight of content to decrease. The consistency of the mortar dispersion value was set between 80.00% - 86.00% to obtain similar mortar slash level that the w/c ratio value would adjust to the dispersion value. Figure 4 also describes the comparison graphic of w/c ratio between the resulted and the planned for 0 day fresh mortar. The figure also describes that the addition of lime – trass to substitute cement would cause the w/c ratio of the mortar in the mixture to increase.

4.5 Compressive Strength of Mortar

The test of compressive strength for the mortar was carried out for 28, 56 and 90 days specimen (SNI 03-6825-2002). The results are as presented in Figure 5.

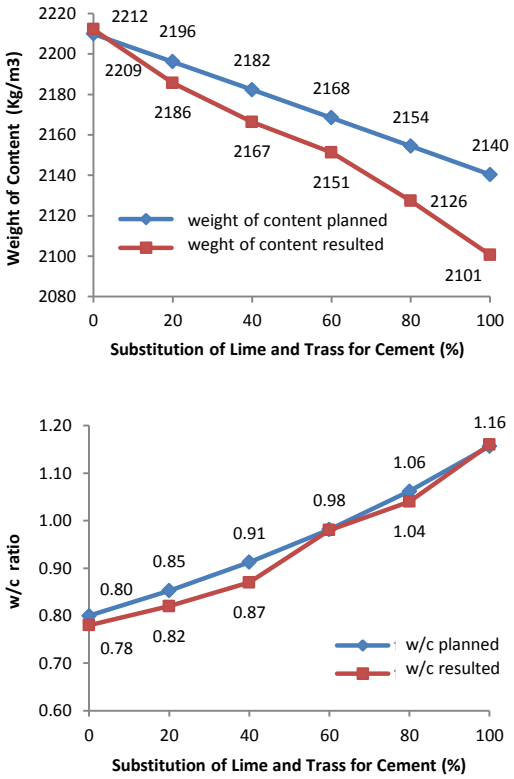

Figure 4. Graphic of the weight of content and w/c ratio of planned and resulted mortar

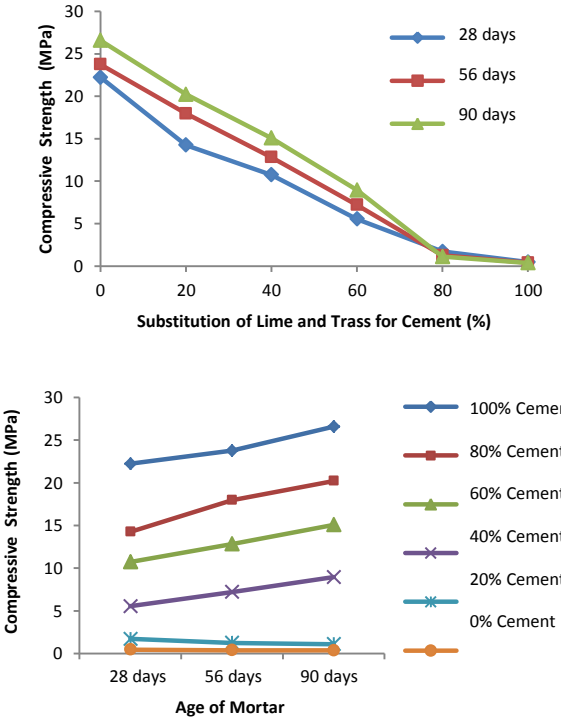

Figure 5. The relation of lime and trass substitution to the cement compressive strength based on the age of the mortar

In Figure 5, it is shown that the larger the lime and trass used to substitute cement, the lower the mortar strength will be. This figure also shows the increasing of mortar compressive strength for lime and trass variation to substitute cement up to 60% at 56 and 90 days specimen. In up to 80% and 100% variation the reverse condition occurred.

Results of the test of mortar compressive strength and the potential indicated that it is preferable to be used for mortar and solid concrete block masonry, as seen on Table 2.

Table 2. The results of the test of mortar compressive strength and the utility potential

Volume Ratio				Compressive strength of 90 days (MPa)	Utility Potential	
Cement	Lime	Trass	Sand		Mortar Type	Solid Concrete block Quality
1.00	0.00	0.00	4	26.585	M	I
0.80	0.04	0.16	4	20.231	M	I
0.60	0.08	0.32	4	15.088	S	I
0.40	0.12	0.48	4	8.952	N	II
0.20	0.16	0.64	4	1.098	-	-
0.00	0.20	0.80	4	0.373	-	-

Table 2 indicated that the average mortar compressive strength at 90 days and the utility potential. Mortar with lime and trass addition up to 60% was capable to be used for type N, a mortar with minimum compressive strength of 5.2 MPa. Mortar with additional lime and trass up to 60% was good for solid concrete block quality II, which was the solid concrete block with minimum compressive strength of 6.5 MPa (SNI 03-6861.1-2002 on the specification of Part A Construction material of non-metal material).

Figure 6 shows the comparison of the material for cement mortar required within several variations (comparison 1:4, 1:5, 1:6, and 1:7) as resulted from the study by Shidiqi (2005) and Yulianingsih (2005) and Hariyanto (2008).

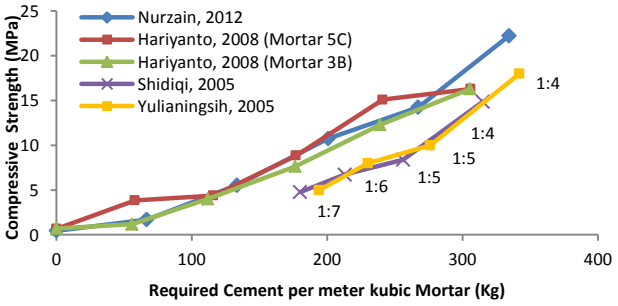

Figure 6. The comparison of the required cement per meter cubic mortar with mortar compressive strength

Figure 6 in Shidiqi (2005) and Yulianingsih (2005) shows the comparisons of 1:5, 1:6 and 1:7 of the cement required were 256 kg and 276 kg; 213 kg and 230 kg; and 180 kg and 194 kg with compressive strength achieved of 8.38-10 MPa, 6.2-8 MPa and 4,.8-5 MPa. When compared to this study, the addition of lime and trass to cement in 20%, 40% and 60%, it was indicated that the cement required was lower with achieved compressive strength of 14,250 MPa, 10.742 MPa and 5,541 MPa. It can be concluded that the use of lime and trass could decrease the amount of cement in the mortar with similar compressive strength.

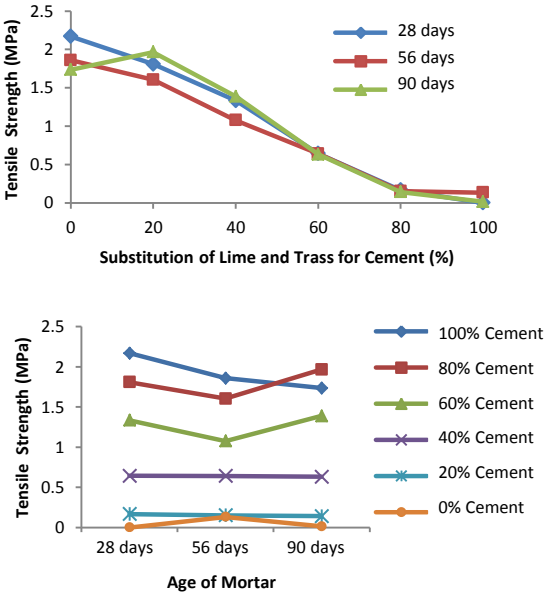

Figure 7. The comparison of lime and trass substitution of cement and tensile strength based on the mortar age

4.6 Tensile Strength of Mortar

The test of mortar tensile strength was carried out to the 28, 56 and 90 days specimens. The results are presented in Figure 7.

Based on the test of mortar tensile strength, it can be concluded that the more lime and trass added, the lower the mortar tensile strength would be. Figure 7 also shows the composition of lime and trass to cement. By the addition of lime and trass in 20 % and 40 %, the tensile strength of 90 days mortar increased.

4.7 Water Absorbency of Mortar

The test of water absorbency carried out for 10 minutes immersion for 24 hours for 28, 56 and 90 days mortar.

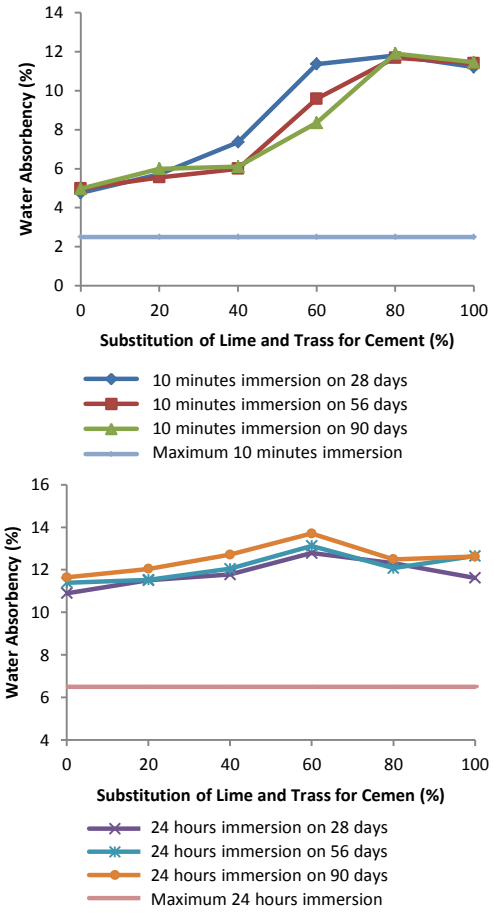

Figure 8. the relation of lime–trass and cement composition with water absorbency at 10 minutes and 24 hours immersion based on the mortar age

The water absorbency decreased by the addition of cement. Based on the data, it can be concluded that the more lime and trass used, the larger the water absorbency of the mortar. This was due to the high absorbency of the material in the lime and trass.

4.8 Decreasing Weight of Mortar

The test of mortar weight was carried out by scaling the 0 days mortar (fresh mortar), as well as the 28, 56, and 90 days mortar. Complete results are as seen in Figure 9 below.

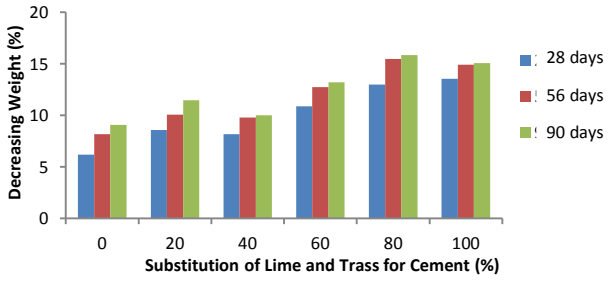

Figure 9. The relation of lime and trass substitution to the decreasing weight based on the mortar age

Figure 9 presents that the average decrease of the mortar weight with lime and trass substitution for 28, 56 and 90 days mortar ranged between 6.170 % and 15.823 %. The largest decrease was for mortar with lime and trass substitution up to 80 % at 90 days. The lowest decrease was mortar without lime and trass addition at 28 days.

4.9 Compressive Strength of Lime - Tras Block

The test of compressive strength for lime-trass block was carried out when the specimen was 28 days. The results are presented on Table 3.

Table 3. The results of compressive strength test of lime and trass concrete block at 28 days

Gradation of Trass and Lime	Weight Comparison		w/c ratio	Average compressive strength* (MPa)	Utility Potential for Solid concrete block
	Lime	Trass Sumber			
passed the 1.2 mm sieve	20%	80%	0.178	3.336	Quality IV
passed the 6,8 mm sieve	20%	80%	0.170	3.403	Quality IV

* block age 28 days

Table 3 shows the test of compressive strength of lime and trass block at 28 days with non-curing in the laboratory. Both types of the lime and trass block were able to be used as solid concrete block quality IV, the solid concrete block with minimum compressive strength of 2.5 MPa (SNI 03-6861.1-2002).

4.10 Water Absorbency of Lime – Trass Block

The test of water absorbency for 24 hours of lime-trass block immersion was carried out for 28 days specimen. The results are presented on Table 4.

Table 4. The results of water absorbency testing for 24 hours of immersion of lime and trass block at 28 days

Gradation of Trass and Lime	Weight Ratio		w/c ratio	Average water absorbency* (%)
	Lime	Trass Sumber		
Passed sieve 1.2 mm	20%	80%	0.178	15.831
Passed sieve 6,8 mm	20%	80%	0.170	16.056

* Concrete block at 28 days, 24 hours of immersion

Table 4 shows the water absorbency test for lime and trass block at 28 days for 24 hours of immersion. The water absorbency test for block resulted average absorbency to pass through the 1.2 mm sieve and 6.8 mm sieve were 15.831 % and 16.056 % respectively.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

a) The best mortar characteristic was identified for trass from Sumber, Sayutan village, Magetan with specific gravity of 2.672, unit weight of 1.089 gr/cm3. , water absorbency 0.725%, and chemical substance content of (SiO2 + Al2O3 + Fe2O3) 94,710% and concentration CaO 2.086% and concentration alkali as Na2O 1.395%. Lime from Ngampel, Blora showed specific gravity of 2.165, unit weight 0.474 gr/cm3 and water absorbency of 1.283%. Sand from Gandong River, Magetan indicated specific gravity of 2.469, unit weight 1.511 gr/cm^3 , water absorbency of 3.896%, and mud content of 1.010%. The sand gradation was categorized as rather-coarse aggregate.

b) In the test given to trass-lime paste, it was found that the best composition was weight ratio 20% of lime and 80% of trass Sumber. The compressive strength at 14 days was 2.545 MPa with w/c ratio as 3.2.

c) In the test indicated that the compressive strength for 56 and 90 days mortar increased when the cement substitution used were 100%, 80%, 60% and 40%. The more lime and trass used to substitute cement, the lower the compressive strength of the mortar would be. In tensile strength test for mortar, it was found that by adding lime and trass in 20 % and 40 %, the tensile strength for 90 days mortar increased. Water absorbency decreased in line to the addition of cement; and the more use of lime and trass, the larger the absorbency of the mortar would be. In the test of mortar weight changing, the largest weight changing of 15.823% occurred for 90 days mortar with 20% of cement substitution. The lowest weight changing of 6.170% was in 28 days mortar with 100% cement substitution. The weight decrease tended to rise due to the increasing addition of lime and trass and the decrease of cement and the more age of mortar.

d) In the test of compressive strength for lime-trass concrete block at 28 days. It was indicated that the compressive strength of specimen passed through the 1.2 mm sieve as 3.336 MPa and achieved at w/c ratio as 0.178. The compressive strength of lime-trass concrete block for specimen that passed through the 6.8 mm sieve was 3.403 MPa and achieved at w/c ratio as 0.17. The test of water absorbency of the lime – trass block at 28 days indicated that 24 hours of immersion resulted 15.831 %. Water absorbency for specimens that passed through the 1.2 mm sieve. The average water absorbency of the lime block that passed through 6.8 mm sieve was 16.056 %.

5.2 Recommendations

a) It is suggested that trass should be sieved to divide between fine and coarse aggregate in order to obtain the same gradation.

b) For lime-trass paste testing, it is suggested to be done for specimen in accordance to the set area to identify the optimum compressive strength of the mixture (based on SNI 06-6867-2002: on 7 days and at 54±2°C or 28 days and at 23±2°C).

c) It is required to study the making of mortar by using other brand of cement (other than composite portland cement of Tiga Roda brand) to identify the difference of strength obtained.

d) It is required to further study the making of block by using trass with coarser granule (that passes through sieve with general hole size fund in the market) with more variations of the composition in order to be easily applied on fields.

e) It is suggested to take further study on the development of trass for normal concrete.

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