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Mixture of clay and *telethong* as environmental friendly binder

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Abstract. This research was inspired by the phenomenon of local wisdom that has existed in the archipelago. In Bali using cow manure as stucco for finishing their walls. In the village of Teraseng, Menganti - Gresik Regency uses the waste as a cover for the walls of their houses from woven bamboo. In the village of Sade - Mataram, Lombok Island, a mixture of cow dung waste (*telethong*) has been used as stucco on the floor of the house. This paper examines to the extent that scientific evidence can be made of existing local wisdom. The combination of silicate-rich clay and *telethong* has been tested on mortar specimen. Sample mortar was physically and mechanically tested at 3, 7, 14 and 28 days. The results of the trials showed that the binding material produced by a combination of clay and *telethong* was still below the PC cement sample strength which was used as a control variable. In combination of clay and *telethong*, compressive test results show that the greater the *telethong* level, the lower the compressive strength produced. The test sample with a percentage of 25% gives the maximum results with ratio of 6% of the PC cement sample value as the control variable.

1. Background

The rapid pace of development has resulted in the destruction of the karst ecosystem as raw material for cement production. Therefore, it is necessary to look for alternative types of cement that do not damage the ecosystem. This type of cement by some researchers is called eco-cement or environmentally friendly cement.

In Indonesia the use of industrial and agricultural waste materials such as rice husks, wood scraps, sawmills, shells and coconut fibers, peanut shells, bagasse and others, to be processed into building materials, most of which have been tried. In order to develop local building materials that are non-conventional and non-traditional, Puslitbang Pemukiman has conducted research on the waste mentioned above. Some of the studies that have been carried out include the use of rice husks for making stone and cement boards, using adhesive materials consisting of a mixture of trash, lime, with or without Portland cement.

On the other hand, local wisdom turned out to be quite advanced. With the facts - the use of organic waste for building material needs. In Bali using cow manure as stucco for finishing their walls. In the village of Teraseng, Menganti Sub-district, Gresik Regency uses the waste as a cover for the walls of their houses from woven bamboo. In the village of Sade - Mataram, Lombok Island, a mixture of cow dung waste has been used as stucco on the floor of the house. This paper examines to the extent that scientific evidence can be made of existing local wisdom.

2. Previous research

Research on eco-cement began in 1992 in Japan. The results of the study stated that the ash from the combustion of waste can be used as the main ingredient in making cement. Comparison of composition of eco-cement making whose chemical compounds are almost similar to normal Portland cement, which is 58.2% rubbish ash, 40% limestone, 0.3% iron sand and 1.3% clay with the final burning of echoes at 1350°C. [1-5]

Eco-cement research has also been carried out [6-9] showed that the best composition of eco-cement was 55% organic ash and 45% limestone, with final combustion at 900°C. this study produced concrete with compressive strength 72.6 Kg/cm^2 at 7 day.

According to Neli Susanti (2009), the best composition for cement is 30% organic ash, 40% limestone and 20% clay. The rest is the addition of gypsum, iron sand and magnesium oxide (MgO). The results of the compressive test are 81.57 Kg/cm^2 at 28 days.

3. Material and methods

The main ingredient of this research is *telethong* which is the result of a waste from the PLTT (*telethong* Power Plant). Physically, the *telethong* used is no gas element. The dried *telethong* material is then finely ground until it passes the no. 200 or 212 μm diameter. For mixing soil clay is used with the chemical formula $Al_2O_3.nSiO_2.KH_2O$. This type of clay has a dominant element of alumina and silica. The variations in percentages or proportions are 25%, 50%, 75% and 100% *telethong*. This mixture is added with sugar cane waste as an additional ingredient as much as 10%. Variable control, which consists of water-cement-sand with a ratio of 0.5:1:3. Test specimens were printed on cylindrical PVC pipe molds (50/100 mm). The process of making this mortar takes around 15 to 30 minutes. Meanwhile, the treatment process (curing) is carried out since the mortar is one day to 28 days soaked in water at a temperature of 20 ± 2°C as water curing. Press is done on days 3, 7, 14 and 28 days after producing. All tests were carried out with 3 specimens.

4. Material examination result

Material examination results include examination of fine aggregates (sand), cement, *telethong* and clay. For fine aggregates, the water content value is 1.76%, for the specific gravity of the saturated surface dry condition, the value is 2.578. While the weight of the sand is 2,603 Kg/m^3 with 1.8% sludge content and fineness modulus value of 2.641. From the results of this examination it can be stated that the fine aggregate material (sand) that will be used meets the requirements to be used as a concrete constituent. Physical and chemical components of cement, *telethong* and clay are listed in table 1.

Table 1. Chemical and physical components

Chemical composition (%)	Cement	*telethong*	Clay
SiO_2	26.14	41.70	V
Al_2O_3	6.34	6.23	V
Fe_2O_3	4.08	4.33	V
CaCl	49.13	18.20	X
MgO	2.99	7.33	V
K_2O	0.55	2.58	V
SO_3	0.67	8.62	X

If the above table is observed, it will appear that the components of $SiO_2 + Al_2O_3 + Fe_2O_3$ for cement amounted to 36.56%, while the components of $SiO_2 + Al_2O_3 + Fe_2O_3$ for eco-cement were 52.26%. This does not conflict with previous research that has been done, either by Shimoda, Neli Susanti or Siswanti. In accordance with ASTM C-618 standards, if the amount of silicate, aluminate and ferro content exceeds 50%, then eco-cement is categorized as class C. The amount of eco-cement mixture has more silicate and aluminate elements because of each component (clay and *telethong*) has a fairly high silicate and aluminate element.

With a total calcium content of 18.2% in *telethong*, the clay and *telethong* mixture as eco-cement does not require the addition of more lime, as the previous researchers took precedence. For activator functions, if the previous researchers used sodium hydroxide and sodium silicate chemicals, then in this study used molasses waste which has a high sucrose content, which is 48-55%. In the industrial world, this waste is widely used as a raw material for cooking/MSG (Mono Sodium Glutamate).

Tabel 2. *Physical components*

	Cement	Eco-Cement
Specific Gravity	2.86	2.75
Initial setting (min)	90	325
Final setting (min)	165	510

Physically, cement and eco-cement do not have a significant difference in the specific gravity properties. The difference is only 0.11. However, in the aspect of initial setting time there are very striking differences. Portland cement only takes 90 minutes to start the hydration reaction and form a bond of cement paste. While eco-cement requires a much longer time, which is 325 minutes to start the hydration reaction and form eco-cement paste bonds. Likewise, for the final setting, Portland cement takes 165 minutes. While eco-cement takes 510 minutes.

Even though it is longer, but in the aspect of implementation, this is still acceptable because the producing process is given a final binding time of up to 1 day (24 hours) before the mold is released and water curing is carried out. The compressive test results on samples with different *telethong* levels can be seen in table 3. The data shows the effect of *telethong* percentage and the age of the sample on strength to pressure.

Table 3. Compressive strength at various ages

%	Age (days)			
	3	7	14	28
25	0	1,5	3,6	4,2
50	0	1,4	3,3	4
75	0	1,3	3,2	3,8
100	0	1	3	3,5
PC	24	52	65	75

From the table above, it appears that the maximum strength achieved by cement is 4.2 MPa at the age of 28 days. This strength was achieved by eco-cement mixture with a percentage of 25%. While the use of pure thelethong (without clay) produces a compressive strength of 3.5 MPa at 28 days. There is a difference of 17%. It appears that there is a similar pattern, where the addition of *thelethong* percentage is inversely proportional to eco-cement strength. The more *telethong* percentage the lower the compressive strength produced.

For an analysis of *telethong* percentage compared with strength, it appears that the addition of *telethong* by 2x fold (50%) results in a decrease in strength of (4.2-4) / 4.2 = 4.7%. For *telethong* addition as much as 3x (75%) resulted in a decrease in strength of (4.2-3.8) / 4.2 = 9.5%. Whereas if using theletong as a whole (100%) results in a decrease in strength of (4.2-3.5) / 4.2 = 17%. That is, the use of eco-cement mixture (thelethong + clay) will reduce the strength of the bond of pure clay (without mixture) by 17%. This means that at the centers of cattle farms with very abundant *telethong* waste there is no need to add more clay, because the difference in compressive strength produced is not too significant. For the percentage of strength at 28 days can be seen in the table below.

Table 4. *Percentage of strength against at 28*

%	age (days)			
	3	7	14	28
25	0	35	85	100
50	0	35	82,5	100
75	0	34	84	100
100	0	28	85	100
PC	30	70	90	100

In general, the rate of addition of eco-cement strength is indeed slower than the rate of addition of strength in Portland cement. At 3 days, eco-cement did not show any strength at all (0%) whereas in Portland cement the theory had given a rate of around 30%. The strength of eco-cement only appears at 7 days, with a strength percentage of about 35% and will be around 85% at 14 days. For Portland cement, the strength at 7 days has reached 70% and 90% at 14 days. The value of the rate of increase in strength per day is calculated by the formula = difference in percentage / difference in days. So, the power rate for a period of 0 - 3 days is (30% - 0%) / 3 days = 10 MPa/day. For complete information, see the table below.

Table 5. *The rate of increase in strength per day*

age	Power rate (MPa/day)	
	Eco-cement	PC
0 – 3	0	10
3 – 7	8,6	10
7 - 14	7,1	2,9
14 - 28	1,1	0,6

If the data in the table above is depicted on a graph it will look like in the picture below.

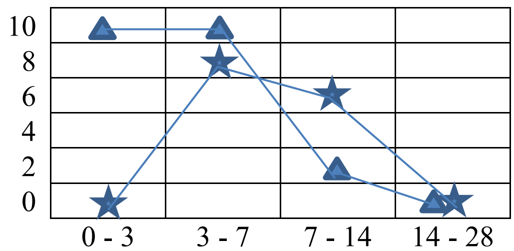

Figure 1. Graph power rate/day

Legend:
★ is Eco-cement
▲ is PC

From the graph above, it appears that PC cement has a high rate of addition of strength at the start of the hydration reaction and is constant (10 MPa/day) until the specimen is 7 days. After 7 days the value of this force starts to decrease to 2.9 MPa/day and even 0.6 MPa/day at 28 days. For the eco-cement, the old initial setting has caused the rate of increase to indicate a value of 0 MPa or no rate at all. Only after 3 days and exceeding the initial binding time did a hydration reaction occur with a rate of increase in strength reaching 8.6 MPa/day. This value is still below the reaction rate of PC cement hydration of 10 MPa/day. After 7 days, the rate of increase in strength is still quite high even though there is a slight decrease, which is 7.1 MPa/day. This rate decreases to 1.1 MPa/day at 14-28 days.

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5. Conclusion
Based on the results of the above analysis, the use of this eco-cement mixture is recommended to be used in mortar work which does not emphasize compressive strength and in an area that has a fairly large cattle breeding center with adequate clay type support. In addition, there is a possibility that eco-cement will still show an adequate increase in strength at more than 28 days.

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