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Bio-Cement as Environment Friendly Binders Based on Natural Waste

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Abstract

Many places in Indonesia use cow manure as construction material. In Panglipuran village Bali island, telethong is used for a bamboo wallcovering. In East Java Province, exactly at Menganti village, cow manure is used to cover their house's walls. In the Sade Mataram, Lombok Island, cow manure is used for floor of their house. This existing local wisdom is examined to scientific world by research process. The mixture of clay with high silicate and cow manure has been tested. The type of specimen is mortar, as the same material that used by local people. Bio-cement sample was tested at several age. The conclusion from data analysis is bio-cement characteristics still more below than standard sample. More greater the cow manure proportion, more lower the strength produced. The best proportion is 25% cow manure that gives results six percent of PC sample.

Keywords :
Bio-cement, Waste, Binders, Cow-manure, Wisdom.

1. Introduction

In Indonesia, waste material from various aspect of life such as coconut fibers, wood scraps, rice husks, molasses and others, to be used as green construction materials (Utari,2017). Those material have been studied and researched. Developing local waste for green construction component, the ministry of housing research centre has conducted research on that waste. Many research that have been done are boards and paving stone from rice husk, lime-based material as a binder with or without cement.

In 1992, Japan has been started research about bio-cement (Shimoda,2009). Specifically, cattle feedlot research start in 2010 (Bellizia,2012). That research report concluded that the ash from the combustion can be used as the main ingredient of bio-cement. This is because its chemical composition is similar with PC, which is 58.2% rubbish ash, 40% limestone, 0.3% iron sand and 1.3% clay with the final burning of echoes at 1350^{o}C. Study of bio-cement has also done in Indonesia since 2009 (Purwanto,2014). The conclusion of earlier research is 55%-45% between organic ash and limestone, with combustion until 900^{o}C (Johan,2016). The result of this research is 72.6 Kg/cm^2 on compressive strength at 7th day. The best composition suggested is 20%:40% and 30% for clay, limestone and organic ash. The others material that added are magnesium oxide, iron sand and gypsum. For the last composition, the result is 81.57 Kg/cm^2 at compressive strength in 28 day (Ruswandono,2019).

Now local wisdom increasingly known to the wider community because the use of telethong for green construction. In Panglipuran Village, telethong is used as a bamboo wallcovering. In East Java Province, exactly at Menganti Village, cow manure is used to cover their house's walls. In the Sade Mataram, Lombok Island, cow manure is used for floor of their house (Widisono,2019). This existing local wisdom is examined to scientific world by research process.

2. Materials and Methods

This study used telethong, local name of cow manure, which is the end result from PLTT (telethong power plant). So, this waste is no gas element anymore. This waste is burned until dry to became ash and grounded to passes filter no. 200. The chemical ingredient of soil clay formula is $Al_2O_3.nSiO_2.kH_2O$. Alumina and silica must be a dominant element of the clay. There are 4 (four) composition of proportions with 25% incremental. This sample is added with 10% molasses. As standard specimen is sand-cement-water with 3:1:0,5 ratio. This research used cylindrical sample standard with diameter = 50 mm and h=100 mm. The mortar making process takes around fifty minutes when produced. The curing is done after twenty four hours with soaked in water. Mechanical test have been done on several various age, that are 3, 7, 14 and 28 days after producing. Each test is done with 3 specimens.

3. Result and Discussion

The material test results include examination of clay, telethong and mortar components. The result of test for fine aggregates is 1.76% water content value. The result of test for the specific gravity in SSD is 2.578. While the result of test for specific gravity in bulk condition is 2.604 with one point eight sludge and the value of FM is 2.642. So, al of the material that will be used meets the requirements for mortar material. Table 1 shows components value of research material.

Table 1: Components of material

Composition	cement	telethong	clay
SiO_2	26.2	41.7	✓
Al_2O_3	6.4	6.3	✓
Fe_2O_3	4.1	4.4	✓
Ca Cl	49.2	18.2	none
M_gO	2.98	7.4	✓
K_2O	0.6	2.6	✓
SO_3	0.7	8.7	none

From table 1 above, amount of $SiO_2 + Al_2O_3 + Fe_2O_3$ components is 36.6%, while amount of $SiO_2 + Al_2O_3 + Fe_2O_3$ for bio-cement is fifty-two point three percent. It is a same with earlier study of previous researcher. American Standard C-618 mention, if percentage of silica, alumina and ferro more than fifty percent, will be categorized as C class. Because of the amount of calcium is eight-teen point two percent, so it does not require to add more lim. For stimulant functions, earlier researcher used sodium hydroxide and sodium silicate. In this research used sugar cane waste (molasses) which high sucrose content (until fifty percent).

Table 2. PC and Bio-Cement Characteristic

Variable	Cement	Bio-Cement
Initial set	95	330
Final set	170	515
Specific Gravity	2.9	2.8

Table 2 shows the characteristic of cement and bio-cement. For specific gravity characteristic, there is no significant difference between PC and bio-cement, only zero point one (see table 2 above). But for variable of setting time, there is a big differences. For initial set, the difference is 285 minute. For final set, the difference is 345 minute. This is still acceptable even though much longer. Because the placing concrete process will wait for one day (twenty-four hours) before releasing from the mold and give water for curing. Table 3 shows the different telethong levels and the result of compressive strength on sample.

Table 3. Result of strength test

%	Age (days)			
	3	7	14	28
25	0	1,6	3,7	4,3
50	0	1,5	3,4	4,1
75	0	1,4	3,3	3,9
100	0	1,1	3,1	3,6
PC	25	53	66	76

The test result shows the best value for bio-cement is four point three MPa (see table 3). This result was achieved when added 25% telethong. But, when all binder material is only telethong (100%), the result is three point six MPa. The difference is 17%. It describes a same model. The amount of telethong is inversely proportional to the strength. If the amount telethong added, the strength will be lower. It explains that doubling the amount of telethong (fifty percent) will decreasing strength until 4.8%. For three times addition, seventy five percent, will decreasing strength until 9.6%. For four times addition or pure telethong (one hundred percent) will decreasing strength until seventeen percent. Tentative conclusion, in a cow farms village with very much organic waste no need to add clay anymore. Because the result is not too significant. Table 4 show the strength ratio to 28th day.

Table 4. Strength Ratio to 28th day

%	age (days)			
	3	7	14	28
25	0	37	86	100
50	0	36	83	100
75	0	35	85	100
100	0	30	86	100
PC	31	75	93	100

Strength increasing behavior of bio-cement is slower than strength increasing behavior of PC (see table 4 above). At 3 days, there is no increasing of strength in bio-cement mixture. For PC, same as literature, had given value thirty percent. Bio-cement compressive strength starts to increase after 7 days has reached thirty five percent. It will be eighty five percent at fourteen days. For Portland cement, same as theory, at 7 days has reached 70% and 90% at 14 days. The power rate per day is calculated as difference in percentage divide by difference in days. For example, power rate for first period is thirty minus zero divided by three. The result is ten MPa/day. Table 5 show the all calculation. Figure 1 show depicted data from table 5.

Table 5. Strength Increasing

Day of test	Increasing strength (MPa/day)	
	Bio-cement	PC
3	0	10
7	8,7	10
14	7,2	2,8
28	1,2	0,7

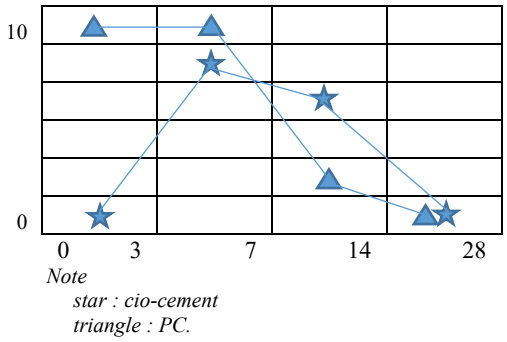

Figure 1. the number of increasing rate

figure 1 show that PC have a high power rate from the beginning of hydration and consistent about ten MPa per day for 7 days. And then, this value decrease 2.9 MPa per day, until 0.6 MPa per day at the end of the test. There is no reaction of hydration until 3 days for bio-cement. So, the value of power rate is zero. After that, reaction of hydration getting started, power rate reach 8.6 MPa per day. The power rate of bio-cement is still below than power rate of portland cement. After 7 days, the power rate is still 7.1 MPa per day. Even though there is a little decrease. The power rate value decreases 1.1 MPa per day from 14 to 28 days.

figure 2 shows that the value of compressive strength of control variable at 28 day is 32,.89 MPa. Then, from figure 3,4,5, dan 6 show that the optimum value of compressive strength from filtered bio-cement, bio-cement plus molasses, bio-cement "burn" and bio-cement "burn" plus molasses are 27.11 MPa, 26.33 MPa, 27.91 MPa, and 30.56 MPa. It is concluded, from that result, that the closest value to the control variable is the burning bio-cement plus molasses 10%, that is 30.56 MPa. There is a difference 2.33 MPa between value of compressive strength bio-cement from control variable. But the same sample have the highest value of compressive strength at 56 day, that is 32.77 MPa. Figure 7-10 below shows The value of *Strength Activity Index*.

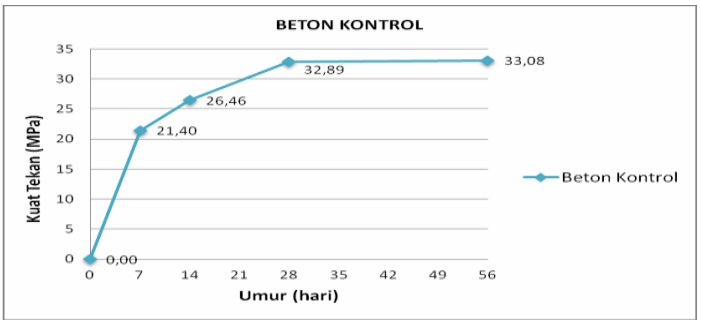

figure 2. control variable sample

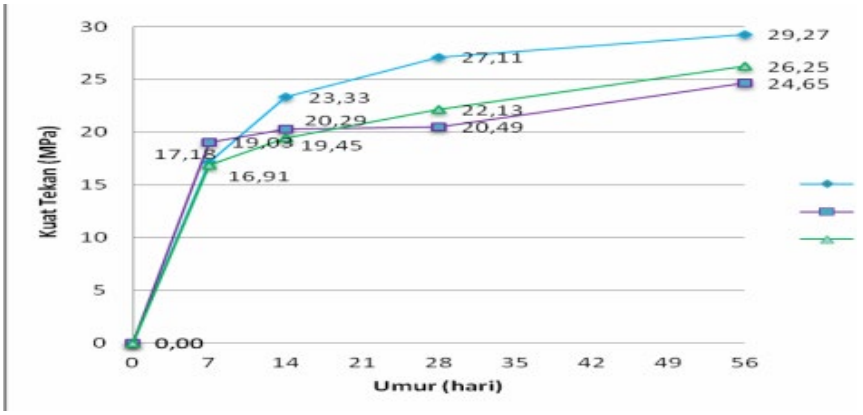

Figure 3. bio-cement sample

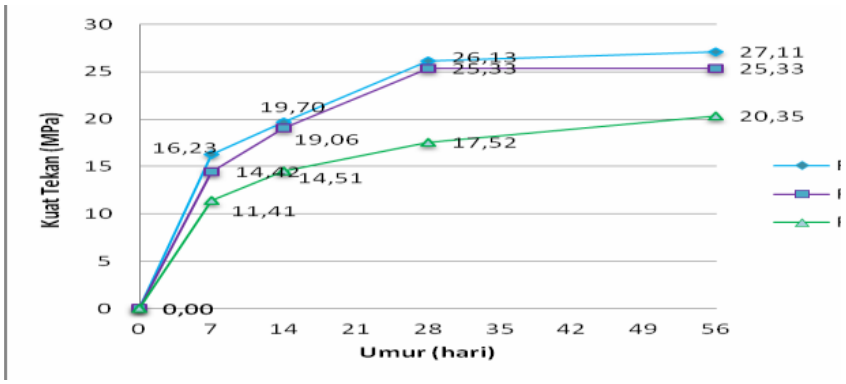

figure 4. bio-cement + molasses sample

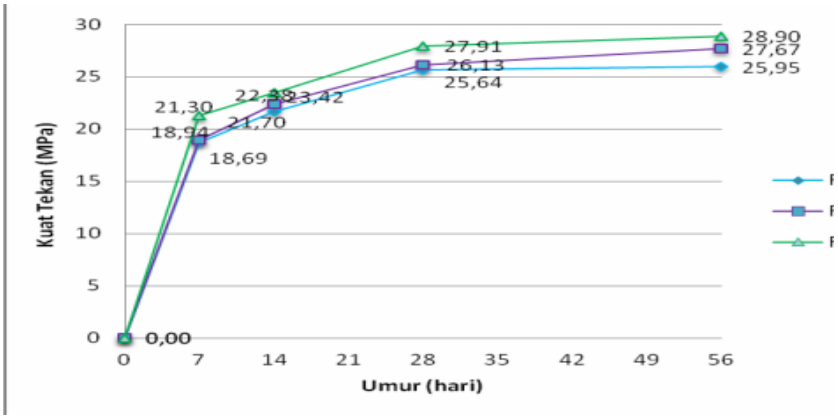

figure 5. bio-cement "burn" sample

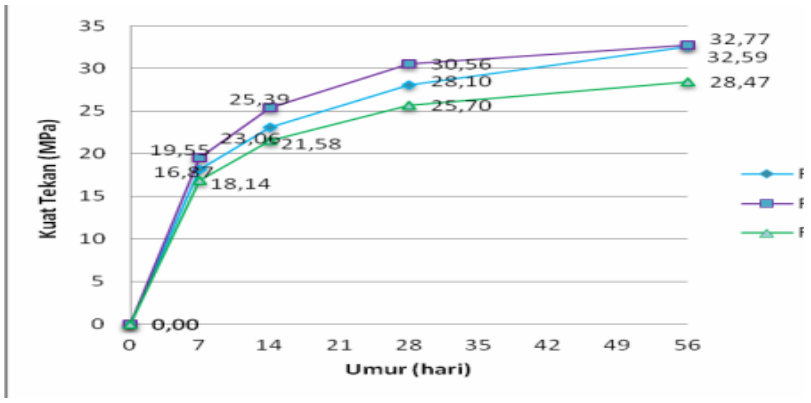

Figure 6. bio-cement "burn" plus molasses sample

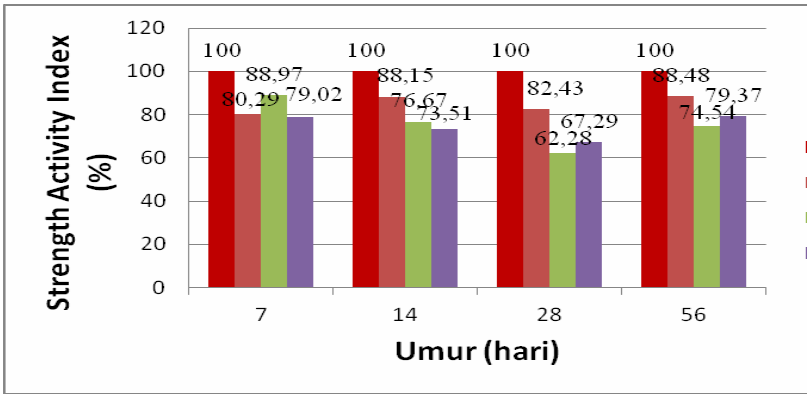

Figure 7. filtered bio-cement sample

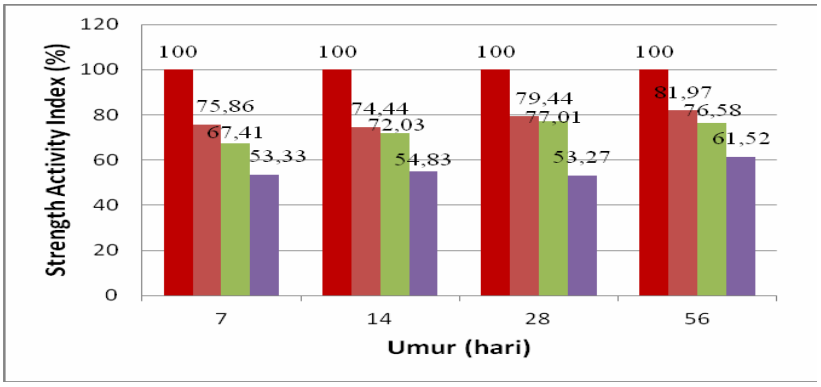

Figure 8. bio-cement plus molasses sample

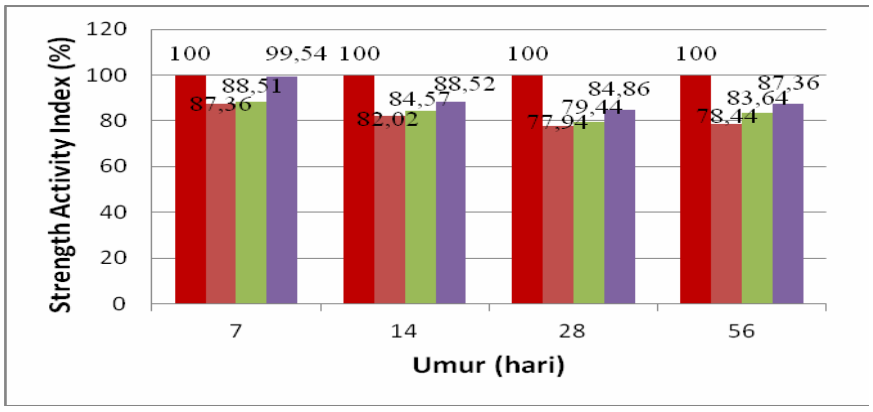

Figure 9. Bio-Cement "burn" sample

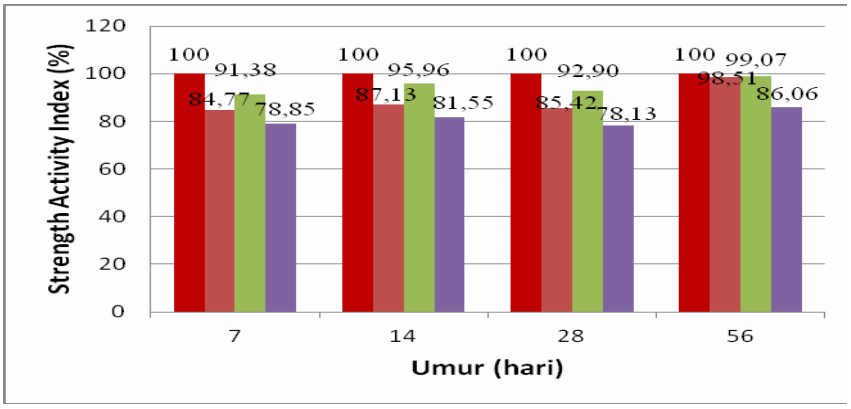

Figure 10. bio-cement "burn" plus molasses sample

4. Conclusion

From the data and analysis above, bio-cement is recommended for green construction material and used as mortar. Because of lower compressive strength, it is not recommended for structural element, but only for non-structural element. Bio-cement is recommended too for big cattle farm supported by cohesive soil. Last but not least, a chance for bio-cement will increase in strength through adding accelerator material is very much possible.

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