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Nano-Technology Based Polymer Brick Made Of Plastic and Sugar Industrial Waste

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Abstract

Research on Green-material products will meet the challenges of an economical and environmental aspects. Plastic and sugar industrial waste were used in this study to generate a light weight concrete and has a good resistance against seepage. While the use of bagasse ash in this study is intended as a cement substitute material, so the use of cement in the concrete mix can be reduced. The use of bagasse ash from sugar mills Trangkil-Pati, Central Java, Indonesia in previous research proven to increase the compressive strength of lightweight concrete produced because it is similar to fly ash. Then the concept of nano technology increasement will improve the quality of polymer-brick performance. In this study is used to grind the High Energy Milling bagasse ash to be nano silica bagasse ash. Working principle of this device is to use the energy of collisions between balls and walls of the container crusher to grind the material that initially micro-sized particles into nano-sized particles for 2 hours, with a rotation speed of 1200 rpm. Used to perform the characterization of Scanning Electron Microscopy (SEM) as an electron microscope that uses a beam of high-energy electrons to examine objects. This is because the size of the nano particles are very small (10-9 meters) so it can not be seen by light microscopy only visible light has a wavelength of about 400-700 nm.

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Keyword: Green building material, plastic and industrial waste, nano-technology concepts

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1. Background of Study

The application of green concepts influence to many fields and sciences (George, 2007). One of them is green material in building constructions. The implementation of environment-friendly materials and construction methods that have fuel and energy efficiency concepts, combining natural and artificial materials must start thinking in sustainable development, so that helped solve a global problem that is being developed at this time related to the environment and climate change, especially on clean up the earth from plastic waste. The plastic waste is difficult to disentangle. Plastic is often seen as electronic goods, packaging, and mineral water bottles. Increasing the value of plastic as a material for artificial replacement for coarse aggregate in this trial will help reduce the environmental problems associated with plastic waste problem.

(a) (b) (c)

Fig. 01. (a), (b). Plastic waste and f(c) Plastic-polymer as aggregate

Unlike the previous research written on Sustain conference 2013, which our research was about the green material by styrofoam waste (Giri, et.al, 2008; E. Setyowati, 2013), this research will discuss the other material made of plastic and sugar industrial waste. A building will be created from the elements and it is made through a system of structures, because it is the mastery of the material equipped with integrated technology based on green building design concepts. The problem is how we can reduce the load of construction by creating lightweight material. The usage of plastic in concrete will produce lightweight aerated concrete (light aerate concrete) because it has a very small density ranged between 13-16 kg/m3.

1.1. Research area

From the background mentioned previously, it is found out the problem statement about the effect of the nano-technology application in the refinement of bagasse ash polymer-brick products to improve the quality in terms of the magnitude of the compressive strength and the low specific gravity. The product of polymer-brick will also be examined on the ability of sound-proofing and heat proofing capabilities, so that it produced qualitied-concrete bricks that could provide comfort to the room from noise pollution and also reduce the use of air conditioners.

1.2. Research's Aim

This study aims to determine the level of compressive strength, density, lightweight concrete with a mixture of cement, sand, polymer and bagasse ash with nano technology material modification. By doing this research that has gained of polymer-brick product refinement, it will be able to know the intensity level of noise and heat insulation capability of this product that affects the quality of the product in terms of architectural and thermal comfort.

1.3. Rsearch's Benefits

This research is expected to contribute to the development of science and technology in concrete engineering design. Moreover, this study is expected to produce generated strong light-weight concrete, low cost (because it uses waste) and durable material which is easy to handle and environmentally friendly based on the design of earth-quake buildings resilient. This research is also expected to assist in the development of green construction and nano-technology in the field of construction services nationwide.

2. Literature Review

The main material in this study are polymer waste and sugar mills industrial bagasse ash which composition is expected to produce eco-materials such as building materials that are environmentally friendly and have a light weight performance. By its light weight, then this material is expected to save the structure in building construction world. In this literature review, we are going to discuss about the main material used in the research refered from the literature review.

2.1. Light-Concrete, polymer and Sugar Industry Fly-ash

Lightweight concrete is concrete containing lightweight aggregate that meets the requirements of ASTM-C.330 provisions and have unit mass of dry air as determined by ASTM-C.567 which has density no more than 1900 kg/cm3. In manufacturing, lightweight concrete can be made with two metode. First method is to form a lightweight concrete using lightweight aggregates which are porous and have light density. The material produced is called as a light-weight aggregate concrete. The second method is to create a high pore in concrete either by adding air to the concrete or vacuumming the concrete. Light-weight concrete has been an option for developed countries to construct buildings, bridges and offshore building because its density is very low. Light-weight concrete is a building material that has been used by the people of Asia and Europe decades ago. Buildings with lightweight concrete as a filler to reduce the risk of damage or collapsed by the earthquake due to the light mass of construction. Light-weight concrete is also able to reduce budget costs as the volume of structural elements such as columns, beams, floor plate and the foundation which can be reduced due to a light load. Plastic waste tersebar dimana-mana yang dihasilkan dari aktivitas manusia sehari-hari. Limbah plastik dapat berwujud kemasan air mineral, mie instan, snack dan lain sebagainya. Kalau tidak dimanfaatkan kembali, maka limbah plastik ini akan menumpuk di muka bumi dan tidak dapat dihancurkan dalam waktu yang sangat lama. Plastik yang sering diketemukan pada kemasan makanan dan minuman termasuk jenis plastik - polymer turunan poly prophilene. Pada concrete, polymer mensubstitusi agregat kasar.



The addition of polymer in concrete is directly proportional to the decrease in the unit weight of the concrete. Measurement results on average unit weight can be seen in table 2.

Table 1. Decrease in Average Weight of Concrete Unit with Polymer[4]

Addition of *Styrofoam* (%)	**Average Unit Weight (kg/m^3)**
0	2170.139
10	2044.594
20	1996.871
30	1864.319
40	1854.874

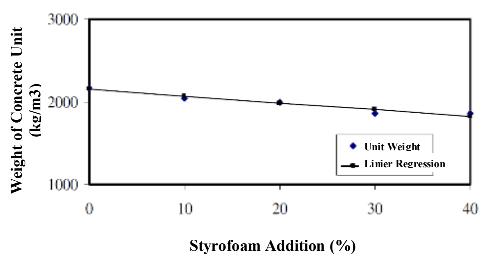


Fig. 1: Chart of Reduction in Unit weight of Concrete toward the

addition of polymer [4]

Bagasse is a side-product (residue) from the processing of sugar cane (*saccharum oficinarum*). Sugar cane processed to be taken its sap used for the manufacture of sugar. Fresh sugar cane obtained milled up by a huge milling to several times until it contains sap that can be completely issued. Sugar cane milling process is done until sugar is completely dry of sap.

Table 2: Chemical Composition of Sugarcane Waste Combustion Dregs [5,6]

Chemical Compounds	Pecentage (%)
SiO_2	71
Al_2O_3	1,9
Fe_2O_3	7,8
CaO	3,4
MgO	0,3
KzO	8,2
P_2O_5	3,0
MnO	0,2

Fig. 2: Sugar Industry Fly-ash (Baggase ash)[1]

When the sugar cane is still wet then it is milled again by adding milk of lime juice 3BE that is capable of absorbing even though the volume is not as much as previous milling. Bagasse processing results sap was used in sugar mills for fuel heating boiler for producing steam boiler . The heating boiler process reaches 500^{o}C-600^{o}C with long burning for 4-8 hours.

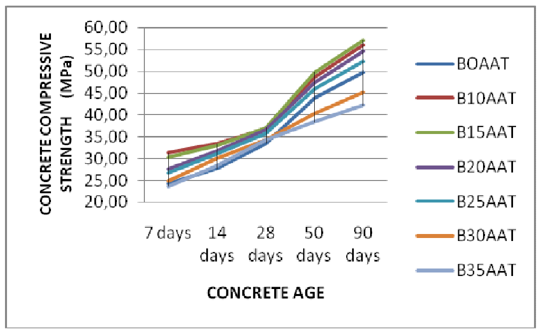
2.2. *The Increase of Concrete Compressive Strength with Waste Sugar cane pulp Combustion.*

Based on previous research,[7] the addition of bagasse ash as a substitution of cement with the variation of 10%, 15%, 20%, 25%, 30% and 35% in concrete composition influence the compressive strength of concrete as seen in table 3. It can be found out that the greater the compressive strength of concrete, the older the concrete age.[7]

Table 3. The increase of Concrete Compressive Strength with Waste Combustion Variations Cane Dregs[7]

No	Code	Concrete Compressive Strength (Mpa)				
		7 days	14 days	28 days	50 days	90 days
1	BOAAT	24,25	27,72	33,48	43,78	49,67
2	B10AAT	31,28	33,32	36,85	48,82	56,10
3	B15AAT	30,25	32,90	37,05	49,86	57,12
4	B20AAT	27,65	31,75	36,52	47,37	54,56
5	B25AAT	26,77	31,05	35,76	45,95	52,23
6	B30AAT	24,91	30,10	34,44	40,39	45,24
7	B35AAT	23,67	28,41	34,25	38,42	42,24

Fig 3: Correlation Graphs between Concrete Age and Compressive Strength [7]



2.3. *The principle mindset of Nano-materials with High Energy Milling and Characterization of Compounds with SEM*

Basically there are two approaches to get the nano-material. Firstly is the Bottom Up and the secondly is the Top Down. Bottom up is the method of getting the nano-material through chemical processes, such as liquid-phase techniques based on inverse micelles, sol-gel processing, Chemical Vapor Deposition (CVD), laser pyrolysis and molecular self-assembly. While Top down is the method of getting materials with nano-scale mechanical milling pro cess using high energy milling tool.[9] In this research we used the Planetary ball method to alter the micro material into nano material. For clearer discussion we describe it in the picture below:

(a) (b) (c)

Fig 4: (a) The *High Energy MillingMachine (b)the detail of jar (c)Iron ball to grind the material*

This research use High Energy Milling to grind bagasse ash to be nano silica bagasse ash. The working principle of this device is to use the energy of collisions between balls and walls of the container crusher to grind the material that initially micro-sized particles into nano-sized particles for 2 hours, with a rotation speed of 1200 rpm. It also use Scanning Electron Microscopy (SEM) to perform the characterization of compound. The SEM is a tool as an electron microscope that uses a beam of high-energy electrons to examine objects. This aim is conducted because the size of the nano particles are very small (10-9 meters) so it can not be seen by light microscopy only visible light has a wavelength of about 400-700 nm.[9,10]

Finally, the result data could be read in the X-ray difractometer (XRD). The equation used in the XRD is Scherer formulation model:

$$L = \frac{52{,}7 \times K \times \lambda}{\beta \times \cos\theta} \qquad L = \frac{57{,}3\ x\ K\ x\ \lambda}{\beta\ x\ cos0}$$

where:

L = ...

K = ...

λ = ...

θ = ...

β = ...

The output of the X-ray difractometer test is shown as follows:

Puncak ke	2 θ (°)	Cos θ	k	λ (nm)	β	L (nm)	Crystal Dimension (nm)
1	21,8888	0,9818	0,94	0,15406	0,2362	35,782	
2	26,6624	0,9731	0,94	0,15406	0,0787	108,358	57,2856
3	36,1206	0,9507	0,94	0,15406	0,3149	27,7167	

3. Research Method

Lightweight concrete mix design is conducted in this study by using DOE method with the addition of bagasse ash composition of 0%, 10%, 15%, 20% and 25% . Plastic waste is used as a substitute for coarse aggregate while the fine aggregate used is Muntilan sand as part of natural resource utilization outcomes Merapi mountain eruptions near Yogyakarta, Indonesia. From the results obtained 7 days at an optimum power contained in concrete with bagasse ash addition percentage of 15% with a value of 3.16 MPa and a compressive strength at 28 days to reach the compressive strength of 4.86 MPa. Concrete density obtained up to 1165 kg/m3. Polymer-brick also has relatively more stable temperature and lower than the temperature of solid brick market. This study aims to determine the level of compressive strength, density, lightweight concrete with a mixture of cement, sand, polymer and bagasse ash with nano-modification technology material. By this improved research of brick product, it will be found out the intensity noise and heat insulation capability in building science.
Mixdesign is a Concrete method in design of concrete masonry. This method is based on the material constituents of concrete aggregates, i.e., rough, smooth, cement and aggregates as binder. Mix design method used in this research is a method of DOE. This study compared the compressive strength of concrete and density on each type of ash composition of different cane dregs with the goal of finding an optimal composition. In addition, testing was carried out in some vulnerable aged concrete. For testing compressive strength test object, researcher created test objects in the shape of a cylinder of 2 types: ø = 15 cm and t = 30 cm. Each type consist of 9 test objects, and each test object consist of 3 to 7 days age object, 3 test objects for 14 days and 3 test objects for 28 days

(a) (b) (c)

Fig. 01. (a), Raw Aggregate □ 3-5 mm (b)Raw aggregate □ 10-12 mm and (c) Raw aggregate □ 18-25 mm

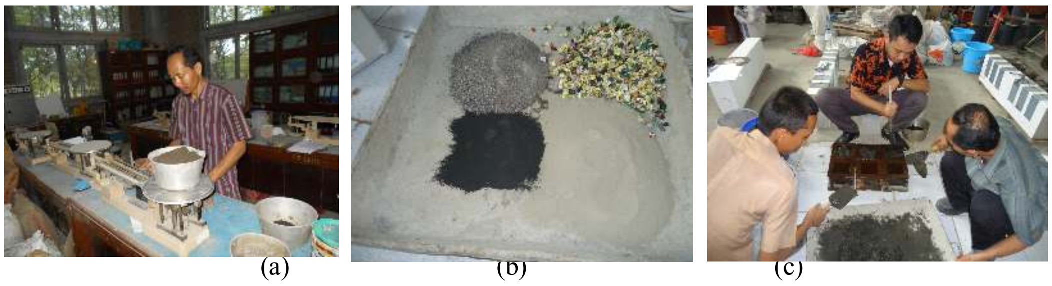
To determine the quality of the concrete with bagasse ash and polymer then performed the following tests:

1. The Compressive Strength
   With the addition of styrofoam and bagasse ash substitution is expected to produce lightweight concrete with a higher compressive strength.

$$\sigma = \frac{P}{A} \quad (1)$$

2. Material Density
   Obtaining the specific gravity level on styrofoam and concrete with bagasse ash

$$BJ = \frac{A}{V} \quad (2)$$



(a) (b) (c)

Fig. 01. (a), Penimbangan komponen bahan (bThe Mix Design and (c) The Process of compressive strength test model

4. Analysis

Bagasse ash retrieval is put from the factory located in the village of Trangkil, Pati, Central Java Province, Indonesia. The bagasse ash is taken from burning of bagasse itself, which is very much a waste by production process of the sugar factory. The Sand used in this research is the sand resulted from volcanic material of Mount Merapi in Magelang region, known as Muntilan sand. The choice of Muntilan sand is based on the excellent quality of the construction material. That the material is also very abundant in the area after the eruption of Mount Merapi in 2010 is the other benefit of this material. The polymer is made from plastic waste which is burned to be raw aggregate. The bagasse ash is grinded by using High Energy Milling in order to produce silica nano-particles.

4.1. Light Concrete Mix Design

Concrete Mix-design is a method in the design of light-weight concrete. This method is based on the constituent materials of concrete, the coarse aggregate, fine aggregate, and cement as a compound. The Concrete Mix design method used in this study is the DOE method. It aims to determine the composition ratio of the material, the ratio of coarse aggregate, fine aggregate and coarse aggregate in cement. In this research, the form of gravel in the manufacture of concrete was replaced with styrofoam to make light-weight concrete. In addition, it will also cement as a binder substituted with the bagasse ash.

This study compared the concrete compressive strength and density of the bagasse ash composition of each varying with the purpose of seeking the optimal. Moreover, the composition testing was done in a vulnerable age concrete. For the compressive strength test specimens shall be made cylindrical ø = 15 cm and t = 30 cm. Each type of test object as much as 9 are each 3 specimens for 7 days, 3 specimens for 14 days and 3 specimens for 28 days.

Table 4. Number of Objects Test Cylinders for Each Composition Variation Cane Dregs

TYPE	COMPOSITION OF WASTE BURNING CANE DREGS	AGE 7 DAYS	AGE 14 DAYS	AGE 28 DAYS	CAPTION
I	5%	3 units	3 units	3 units	*Styrofoam* limbah yang dihancurkan.
II	10%	3 units	3 units	3 units	Strength of concrete fc '40 MPa.
III	15%	3 units	3 units	3 units	Cement type I.
IV	20%	3 units	3 units	3 units	Volcanic sand.
V	25%	3 units	3 units	3 units	Ash dregs of the factory's Cane, Starch. Styrofoam waste is destroyed.

4.2. Material Analysis

The foam-brick of research that we have done previously obtained optimal percentage in the addition of 15% (see figure 2) with bagasse ash mix design as follows:

Tabel 5. : Optimal percentage of the addition of Sugarcane Waste Combustion Dregs 15%[1]

Cement	Sand	Split	Water
1	2.08	2.36	0.45

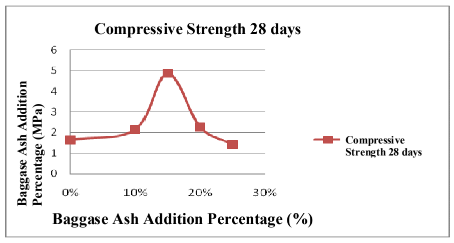


Fig. 6. The Charts of Baggase ash Addition to Compressive Strength of Concrete[1]

Polymer is used as an aggregate substitution in concrete of 100% split, but by using the ratio of the volume.

5. Research Findings and Conclusion

The advantages of using polymer as aerated lightweight concrete and fly ash usage forming materials is addressed to find an eco building material that has benefits:

1. The use of waste materials will reduce the cost of manufacture and improve the value of industrial waste.
2. Earthquake loads that work will be smaller because the weight of the structure is reduced, so that the structure will be safe and suitable for residential buildings in the earthquake area.
3. The green concept deployment because it helps to reduce the waste plastic in the earth

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