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Impact of filament and ash of Lontar Palm (*Borassusundaicus* L.) in the quality of stone block

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Abstract : *The aims of the research were to analyze the strength of fruit filament of lontar and its contribution to stone block compression strength. Based on the microscopy analyses, lontar palm filament has average diameters 0.40mm with single tensile strength 45.144N/cm^2. The comprehensive strength of stone block without filament was 80.985Kg/cm^{2}and water content 10.17%. The highest comprehensive strength of stone block (92.216 Kg/cm^2) was found in block with composites ash 0% and lontar fruits filaments 3%. The water content of such stone block was 12.73%. Compared to the stone block without composite materials, the stone block strength increase 13.86%. Compared to the quality of Indonesia national standard(SNI-03-0348-1989), the strength increase31.73Kg/cm^2.The use of lontar fiber 3%, 6% and 9% can be considered as composite material in stone block. The embedded filament in sand and cement mixing contributes to the strength of stone block, and therefore provides advantages as civil materials in tropical environments.*

Keywords: *Lontar fruit filaments, local materials, single strength test*

I. Introduction

One of the challenges in sustainable development is promoting reuse, recycle and reduce mechanism in natural resources management [1]. It is especially relevant with some problems faced by global community. It has been identified that exploitation of natural resources contributes significantly in environmental degradation. The exploitation of timber in tropical countries to meet physical development has been decreased tropical forest. Mining raw materials to supply infrastructure demand has been widely contributed to lands and soil degradation. There are also problem related increase of waste and pollutant [2]. The development of fibrous and composites materials for civil engineering application widely identified as a crucial technology in sustainable infrastructure development [3]. The use of local material has been promoted as an important strategy to reduce environmental impact of infrastructure development. Environmentally friendly composite has been proposed based on plant raw material and it has been considered as one of the green technology in infrastructure development [4].

Stone block is one of the crucial materials in civil construction. Basically, the block was produced from mixture of sand and cement. In order to increase the strength of stone block, some material such as plant filament was added. The additional of filament has been reported contribute to the compression strength aspect of block [5]. Scholars point out that the uses of grass filament as a composite of block [6]. There are also applications of filaments of *Imperata cylindrica* to make Autoclave Aerated Concrete/ ACC block [7]. There are benefit aspects of the use of plant filaments, including minimizing energy, reducing cost and minimizing environmental impact of stone block production [8]. The use of local material has been reported able to reduce cost about 60 %. The aggregate of *Arenga pinnata* filaments increase compression strength about 13.4%. The uses of Date palm filaments below 10% able to increase compression strength of block. Recently, the use of local filament from local plant material was preferred as a composite material in stone block production [9] [10] [11]. Lontar is one of the abundance palms in East Nusa Tenggara. So far, few technology was promoted to increase the value of lontar palm filaments as a composite material in stone block preparation. The development of lontar filament-based materials as a physical construction material is relevance with the agenda of global sustainable development. There are numerous benefits for the use of lontar filament-based building components for material in physical construction, including reduces cost of material processing and minimize environmental impact [12].Among the lontar palm organs, fruits have been indentified rich in term of filaments. It is especially potential to use in new civil construction material such as stone block. In East Nusa Tenggara, the fallen lontar fruit was not consumed and used by local people. The availability of lontar fruit in east Nusa Tenggara was abundance. In one fruit bunches, there are about 20 to 30 fruits. The length of fruits filaments was about 6-12cm, with yellow-brown color.Thediameters of filament was about 0.3-0.5mm and strong [13]. With its characteristic, it is clear that a filament of lontar fruit has its potentiality as an additional material of stone block. There are however, few studies related to the properties of lontar fruit filaments and its contribution in stone block quality. The aim of the research is to identify the strength of fruit filament of lontar and its contribution to stone block compression strength.

II. Methodology

Materials

Lontar fruit was collected from mature lontar palm tree from Kupang, East Nusa Tenggara. Ash for stone block material was processed from fruit palm trough burning. Ash as a composites material has size 0.075mm.

Filament preparation and observation

Filaments from fruit wereseparated from fruit using scissor. The filament materialswerewashed to eliminate the pollutant. Fiber was dried under the sun for ±4 hours. The dried fruit filaments were cut in size 1.5-2cm. The filament of fruit was separated and prepared as single filaments for further microscopy analysis (Fig. 1). Technically, the morphology of filaments was observed under digital microscopes, resolution 50-500x with digital zoom. About three to four filaments wereobserved using microscope.

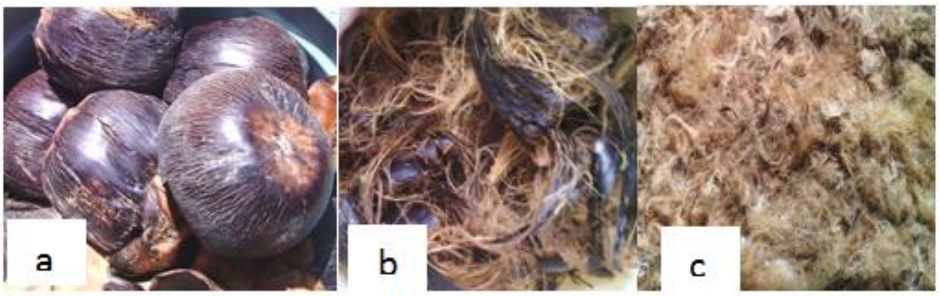

Fig.1 The material for research a. Lontar fruit, b. Outer fruit skin, c. Fruit filaments,

Filaments strength test

Single filaments tensile test of lontar palm was done using steam traction IMADA capacity 50kN. Four filaments were collected for filament strength test. The filament was prepared and put in the hollow paper sheet. A filament was put in the centre to assist the position in measurement instrument. After filament attached in the instrument, paper was taken and strength test was done. The weight of filaments was measured using digital scales with accuracy of 2 decimalsand exellent scales JCS-B capacity 30Kg/1g with accuracyof 3 decimal.

Stone block preparation

Stone block was made by mixing 1 portion of cement, 5 portions of sands and fiber and ash following combinations. The amount of ash and filament as a composites of stone block material for 0%, 3%, 6% and 9% were done through specific gravitycalculation of composites material. From the calculation, the stone block composites material was given in Table 1.

Tabel1.The composition of raw material for stone block (m^3)

Materials	Specific gravity	Agregate(m^3)	Amount of filaments as additional material (Gr).		
			3%	6%	9%
Cement	3.15	0.16	-	-	-
Sands	2.56	0.80	-	-	-
Water	1	0.04	-	-	-
Filaments	0.1	-	2.13	4.26	6.39
Ash	0.245	-	2.16	4.32	6.48

The combination of all materials for stone block was given in Table 2.

Table2. The percentage of material for stone block preparation

A	B	Number	A	B	Number		A	B	Number	A	B	Number
0%	0	3	6%	0	3		0	0	3	4.32	0	3
	3%	3		3%	3			2.13	3		2.13	3
	6%	3		6%	3			4.26	3		4.26	3
	9%	3		9%	3			6.39	3		6.39	3
3%	0	3	9%	0	3		2.16	0	3	6.48	0	3
	3%	3		3%	3			2.13	3		2.13	3
	6%	3		6%	3			4.26	3		4.26	3
	9%	3		9%	3			6.39	3		6.39	3

Stone block was prepared by mixing 1 portion of cement (266,67 mm³) and 5 portions of sands (1.333,33 mm³). These material was mixed homogenously and 40 ml water was added into mix material. Mix material was measured to meet stone molding volume. About 2.13 gr (3%) of fruit palm fiber and 2.16 gr (3%) of ash wereadded into mixed material, mixed homogenously and put into stone molding to make stone block (Fig. 2). The stone molding dimension was about 200 mm x 100 mm x 80 mm. Material was compacted using wood hammer. The stone block was proceed within 7 to 10 minutes. After compacted, the block was released from stone molding, labeled and air dried for 10 days. About 48 stone block was produced by size 20 cm in lenght, 10 cm in wide and 8 cm in thickness. The measurement of wide field of press was done using digital calipers.

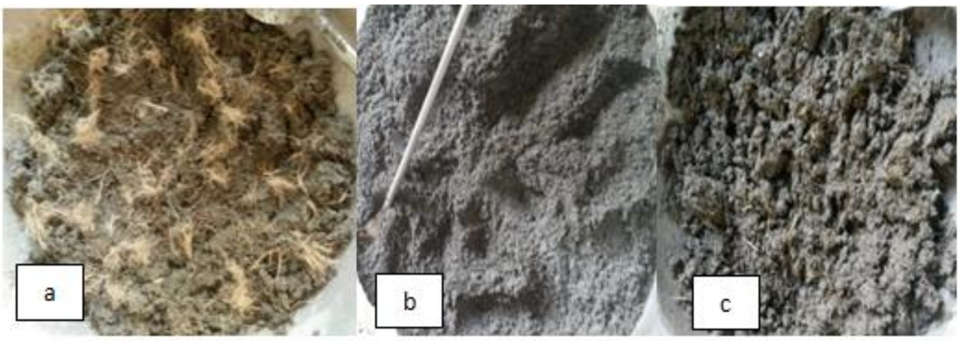

Fig.2.a. Cement, sands and filaments, b. Ash, c. Cement, sands, filament and ash was mixed,

Compression strength test

Stone block which was air dried at 14 days and in the day 15th the upper and bottom part was covered by material composed from 1 portion of cement and 5 portion of smooth sands with 3 mm thickness. The stone block was air dried for 3 days and then put into material testing equipment with capacity of 1500kN. In the maximumpressure, stone block shows critical crack and automatically highest value in instrument was recorded. In order to calculate the ability of stone block in hold maximum pressing, the value was divided by wide field of press.

Water content analysis of stone block

The initial measurement of stone weight was performed using stone block with 13 days of ages. The weigh measurement was done using digital balance. The stone block was soaked within 24 hours and then put into heater machine with temperature 110ºC within 24 hours. The weight of stone block was measured using digital balance. The finalweight of stone block was calculated by initial weigh minus final weigh multiplied by 100%.

Data analysis

Filament strength analysis was performed using tensile strength instruments IMADA type YP50N using formula:

$$\sigma = \frac{F}{A}$$

Water content was examined using heater with capacity 200^0C, thecompression testing was done using MBT (*material testing equipment*) force gauge machine with capacity 1500kN

The water content of fiber was examined using formula $= \frac{A-B}{B} X\ 100\%$.

III. Result and Discussion

Filaments strength

Based on the examination, the filament morphology and its strength were given in Table 3.

Tabel 3. Results of the filament strength isolated from lontar fruit

	Filaments diameters(mm)			Averages (mm)	Size (mm^2)	compressive strength (N)	Filament strength N/mm^2
	I	II	III				
Filament A	0.32	0.48	0.27	0.36	0.101	5.76	57.145
Filament B	0.36	0.51	0.46	0.44	0.155	3.77	24.325
Filament C	0.30	0.40	0.42	0.37	0.109	5.81	53.292
Filament D	0.40	0.46	0.40	0.42	0.138	7.38	53.295

The single test of filament strength with average diameters of0.40mm has tensile strength 45.144N/mm^{2}with profiles of test diagram was given in Fig. 3.

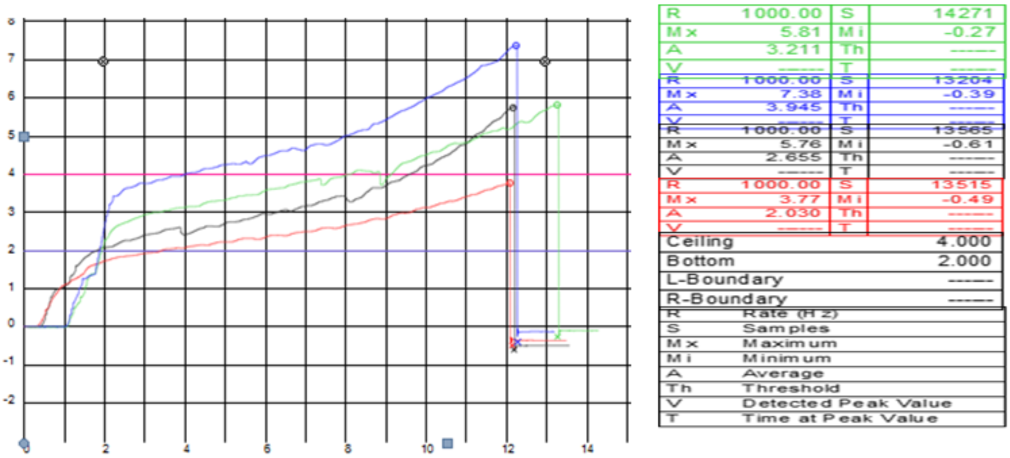

Fig. 3. Result of the single filaments test of lontar fruit filaments

Result of the single filament strength test showed different value with lowest strength was about 24.325N/mm^{2}in filaments with diameters of 0.44.mm and the highest was about 57.145N/mm^{2}in filaments with diameters 0.36.mm. Scholar point out that the strength of filament provides advantage for advance material construction. In such a case, an intensive exploration on the strength of plant filament material as a civil construction widely conducted [14] [15] [16].

Compression strength of stone block

Compared to the stone block which was recommended by Indonesian National Standard (SNI-03-0348-1989), stone block reduce to 1.24%. According to SNI standard, this reduction was allowed (maximum allowed reduction isabout 2.5%). The compression test of stone bock was given in Table 5. Following the national standard provides safety concern of the product and therefore it is projected to get success in market.Scholarpoint out that consumer dissatisfaction often caused by the low product performance, it is especially related to the product under standard production [17].

Table 5. Results of the compression strength test of stone block with lontar filament and ash as additional material

Ash (%)	Stone block compression strength Kg/cm²)				SNI
	0%	3%	6%	9%	(Kg/cm²)
0%	80.985±25.184	92.216±13.991	86.968±9.934	81.325±10.681	70
3%	6467.±17.082	80.109±10.041	76.127±8.314	77.748±15.895	70
6%	83.008±18.858	90.283±22.602	85.901±15.529	73.269±11.418	70
9%	70.430±9.711	72.586±16.603	67.564±10.752	73.860±9.000	70

The lowest Compression Strength Test (64.671 Kg/cm^2) was found at material composition with ash 3% and filament 0%. The strongest compression strength test (92.216 Kg/cm^2) with filament strength was found at material composition with ash 0% and filament 3% (Fig. 4).

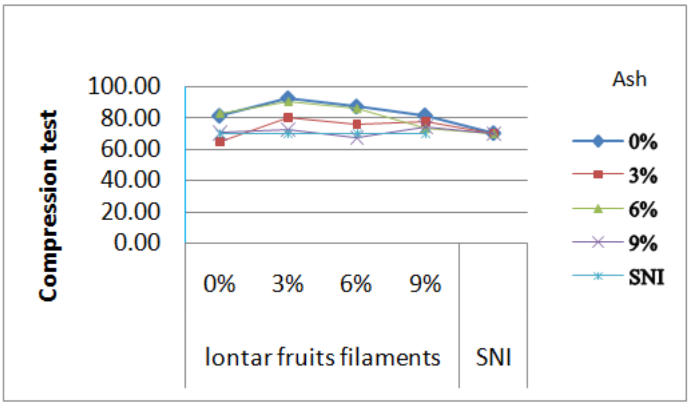

Fig. 4. The compression test of stone bock with ash an filaments additional materials

Result of the analysis shows that ash addition 3% and filament 0% decreases the compression strength -20.14% from the stone block without ash and filament additions and decrease the compression strength -7.61% from Indonesian National Standard (SNI-03-0348-1989). The addition of fruit filament 3%and ash 0% has higher compression strength compared to the stone block without additional materials (13.86%). Compared to the stone block standard of Indonesian National standard (SNI-03-0348-1989), it is able to increase compression strength about 31.73%.

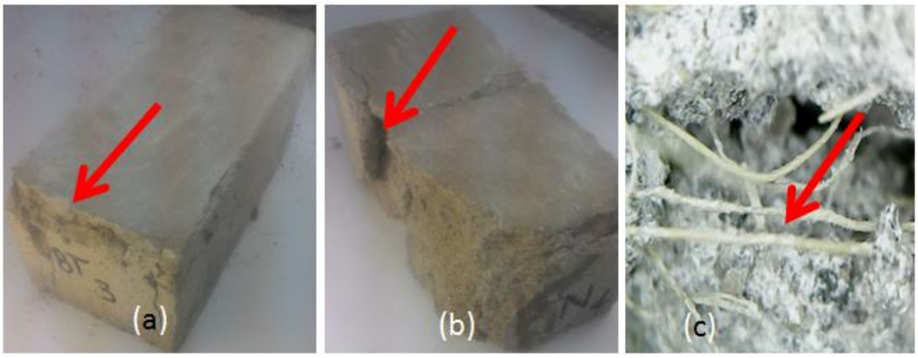

Fig.5 (a) The stone block condition before test, (b) Stone block without filament wrecked after compression test,(c) filament of lontar fruit in stone block after 5 month

Filament contributes in the stone block strength. This finding is similar with other research on the impact of filament addition in stone block which was reported by scholars.

The water content of stone block with 14.33% ash, 13.24% lontar fruit filament and 15.39% water was given in Table 5. Water is an important aspect in block quality. It is especially important in tropical area such as Indonesia.

Table 5. Water content of stone block with ash and fiber as additional material.

Ash	Lontar fruits filaments			
	0%	3%	6%	9%
0%	10.17	12.73	13.31	13.97
3%	13.52	14.91	12.29	14.58
6%	16.88	16.20	17.98	18.65
9%	16.76	17.67	18.34	18.41

The water content of stone block after 14 days of creation was about 14.32%. This value beyond Indonesian National Standard quality(SNI-03-0348-1989), it is about25% of quality B100 and 35% for quality B70. This data show that increase of additional material will increase water content and stone block.

IV. Conclusion

Filament isolated from lontar palm has an average diameter of 0.40mm with single tensile strength 45.144N/cm^2. The compression strength of stone block without additional materials was about 80.985Kg/cm^{2}with water content 10.17%. The compression strength of stone blockwith additional materials ash (0%) and filaments (3%) has compression strength 92.216 Kg/cm² with water content about 12.73%. In such materials combination, it is able to increase compression strength about 13.86% compared to the stone block without additional materials. The addition of filaments 3% able to increase compression strength 31.73Kg/cm² and it is higher thanIndonesian national standard (SNI-03-0348-1989). Addition of lontar filament 3%, 6% dan 9% can be implemented in the modification of stone block. The advantage of stone block enforced by filaments was influenced by the existence of lontar fruit filament in stone block structure. This can be concluded that filament contributes significantly to the stone block strength. The use of lontar filament can be promoted as a crucial technology in raw material supply for sustainable infrastructure development

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