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Impact and Flammability properties of Cotton Fiber (Batik) Reinforced Fiberglass Composite for Marine Application

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Abstract: The aim of this research is to study new alternatives material to replace Chopped Strain Mat (CSM) synthetic fiberglass for GRP product making in marine application. Fiberglass is renown to the world of Marine Industries for marine applications. It is not unfamiliar to the industries that fiberglass production causes pollutions to the environment. The recycling of fiberglass by incineration process consumes more energy than producing it. Thus, creating more pollution to the environment, but by replacing the fiberglass with cotton fiber it will reduce the pollution created by it. Cotton fiber was chosen because it is a natural fiber and it is eco-friendly to the environment. Cloth Batik fiber which is cotton fiber was chosen in this project to represent as a symbol of Malaysian-Asian. Three cotton fiber mat of different thickness were investigated under the name of specimen A (Batik Cloth + Woven Roving + Batik Cloth + Woven Roving+ Batik Cloth), specimen B (Batik Cloth + Woven Roving + Batik Cloth + Batik Cloth) and specimen C (Batik Cloth + Woven Roving + Batik Cloth + Woven Roving+ Batik Cloth). The most suitable specimen is specimen A in terms of flammability and impact test and most optimum in terms of light weight and high absorbent energy.

Keywords: *cotton; batik; fiber; mechanical; composite*

Introduction: Fiberglass is a renowned in the industry of shipbuilding, aerospace and even in other fields [1]. The environment plays an important role in our lives, and it is up to the human race to ensure that the earth by incineration process. Burning of fiberglass composites to be turn into energy consumes more energy than producing it therefore, it is wasting energy. Thru incineration process the resins and gelcoat burnt easily for it is petroleum based, while the fiberglass will turn to ash [2]. Studies showed that natural fiber such as cotton fiber (batik) produce minimal impact to the greenhouse effect. Batik is a technique of wax-resist dyeing applied to whole cloth, or cloth made using this technique. Batik is made either by drawing dots and lines of the resist with a spouted tool called a canting or by printing the resist with a copper stamp called a cap. The applied wax resists dyes and therefore allows the artisan to colour selectively by soaking the cloth in one colour, removing the wax with boiling water, and repeating if multiple colours are desired. A tradition of making batik is found in various countries, including Indonesia, Singapore, Malaysia, India, Bangladesh, Sri Lanka, and Nigeria; the batik of Indonesia, however, is the best-known. Indonesian batik made in the island of Java

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has a long history of acculturation, with diverse patterns influenced by a variety of cultures, and is the most developed in terms of pattern, technique, and the quality of workmanship [3]. In October 2009, UNESCO designated Indonesian batik as a Masterpiece of Oral and Intangible Heritage of Humanity [4]. Cotton fiber (batik) symbolizes the Malaysian-Asian of our country, does it not only save cost, and it will attract others (foreigners) on the beautiful designs of the batik cotton fiber [5]. The purpose of this paper is to show results in terms of mechanical properties (impact testing) and flammability test that cotton fiber is suitable to replace chop strand mat (CSM). By reducing the usage of the fiberglass (CSM) this will reduce the waste produced by the product. Testing was done to ensure it comply with Det Norske Veritas (DNV) for single skin construction of the hull side of a boat of 3m length.

Materials and Methods: Two testing was conducted to determine the toughness, resilience, energy absorbed, and flammability of material. Testing conducted on the materials are Charpy Izod Impact Test ASTM-D256 and Flammability Test UL-94-V0 Vertical Burning Test. All tests were conducted at UniKL MIMET facilities. The preparations of materials were conducted at GRP workshop at UniKL MIMET by using hand-lay-up method.

Hand-Lay-Up: The hand-lay-up method is by using a table glass as a mould (producing a flat panel). The composites of the materials are cotton batik fiber, woven roving, catalyst, resins (polyester, PE), gelcoat and wax [4]. The sequences of lamination are as shown in the Table 1. Cotton batik fiber and woven roving was cut into 350mm x 350mm.

Table 1. Cotton Batik Fiber Laminating Sequence

Specimen	Number of Fiber Mat	
Specimen A	Batik Cloth (Layer 1)	1 pcs
	Woven Roving (Layer 2)	1 pcs
	Batik Cloth (Layer 3)	1pcs
	Woven Roving (Layer 4)	1 pcs
	Batik Cloth (Layer 5)	1 pcs
Specimen B	Batik Cloth (Layer 1)	3 pcs
	Woven Roving (Layer 2)	1 pcs
	Batik Cloth (Layer 3)	4 pcs
	Batik Cloth (Layer 4)	4 pcs
Specimen C	Batik Cloth (Layer 1)	3 pcs
	Woven Roving (Layer 2)	1 pcs
	Batik Cloth (Layer 3)	4 pcs
	Woven Roving (Layer 4)	1 pcs
	Batik Cloth (Layer 5)	4 pcs

Preparation of the mould was cleaned and wax before applying gelcoat (include with 10% of catalyst) to the surface by using paint roller or a brush paint. Let the gelcoat rest for adequate time before applying 10% of catalyst mixed into the resin (polyethylene, PE). Then, the cotton batik fiber was applied on top of the resin. A roller was used to remove excess air bubbles. Resins are applied on each layer of fiber [6]. The flat panel was let to dry in a room temperature as shown in Figure 1. The flat panel was cut into 15 size of 55mm x 10mm and 15 specimens of size 127mm x 2.7mm.

Fig. 1: Hand-Lay-Up Lamination

Dnv Calculation For Minimum Thickness: The formula and calculation given as shown in Figure 2 and Table 2. Taking the minimum Bending Strength of 130 Mpa [7].

C 200 Laminate thickness:

$$t_{min} = (t_0 + kL)\sqrt{f_b} \quad (mm)$$

$$t_p = k_p f_p s \sqrt{P} \quad (mm)$$

t_0 and k are taken from the table below.

f_p is taken from the formulae in 202.

k_p = 3.82 for bottom panels
= 4.73 for side panels
= 4.11 for panels elsewhere and for all stiffening members.

Fig. 2: Formula for Minimum Thickness of Lamination

Table 2. Thickness Calculation

L	3	m
B	1	m
to	2	
k	0.58	
σbu	130	Mpa

<table>
<tr><td>t_{min} =</td><td colspan="3">(to + k.L) √fb</td></tr>
<tr><td rowspan="2">Where f_b=</td><td>130 / σbu</td><td rowspan="2">√fb =</td><td rowspan="2">1</td></tr>
<tr><td>1</td></tr>
<tr><td>Therefor t_{min}=</td><td>3.74</td><td colspan="2">mm</td></tr>
</table>

Charpy Izod Impact Testing: Charpy Izod Impact Test ASTM-D256 requires 5 sample of each specimen in size of 55±mm long and width of 10±mm [8]. A V-notched was notched on each specimens sample and an impact pendulum of 120° angle (303.44J) was tested. The notched sections were placed opposite directions of the impact. Results are taken and analyze [9].

Flammability Test: Flammability Test UL-94-V0 Vertical burning test requires 5 sample of specimen of length of 127mm and 2.7mm wide. Specimens are placed vertically with a fire of blue flames height of 20mm. The distance of the nozzle of the fire source (bunsen burner) with the specimen should be in 10mm height. A cotton ball is placed flat below the specimen as an indicator. The fire source was placed and removed after 10 seconds. The specimen was observed for any flames, glowing, falling, cotton ignite, and length of burned specimen. The testing was conducted for two times of 10 seconds [10].

Requirements by Dnv: Det Norske Veritas (DNV) is an international certification body and classification society. In order to have improvement from DNV all materials and procedure must follow the DNV rules and guidelines. The material requirements are that "The hull and canopy material should be flame tested to determine its fire-retarding characteristics by placing a test specimen in a flame. After removal from the flame the burning time and burning distance should be measured and should be to the satisfaction of the Administration" [11]. For the thickness of a single skin lamination a calculation was done based on the formula given in the DNV [12]. An impact property of material does not give an exact value of the acceptance of the material but it was given in the form of visual requirement. Impact test the material is accepted as long as the material is not in a brittle fracture [13].

Results and Discussion:

Charpy Izod Impact: Toughness is the ability of a material to absorb the energy applied to it. The higher the impact energy, the higher the toughness of the material [13]. The study of impact energy is to analyze the material ability to resist breaking under a shock loading or to resist fracture under stress applied at a high speed. The result shown in Figure 3 shows the total energy absorbed by Specimen A, B, and C. While, Figure 4 shows the impact strength of each specimen. While, Figure 5 shows the Resilience of the material.

From Figure 3 shows that specimen C absorbed more energy of 292.85J compare to A and B. But B has the lowest energy absorbed of 290.32J. The impact strength of the highest result is specimen A which is 11.34 J/mm^2. Resilience is the energy released in deformation recovery to the energy that caused the deformation. Specimen A has the highest resilience of 0.43 J/mm^2 and specimen C has the lowest of 0.24 J/mm^2.

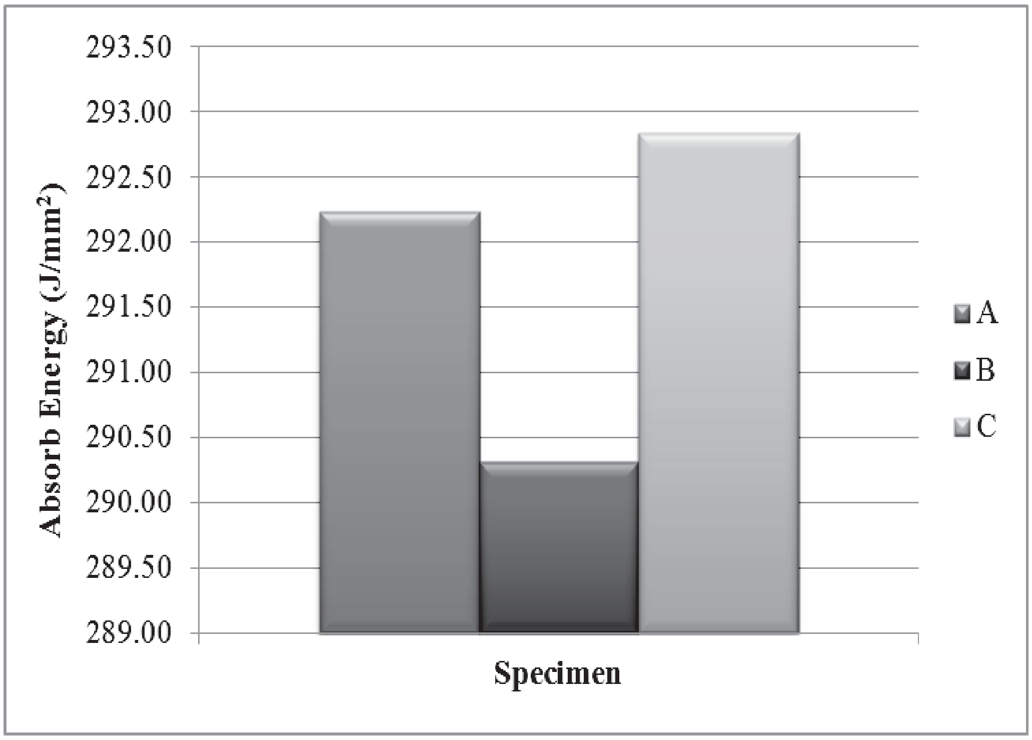

Fig. 3: Energy Absorbed by Specimen

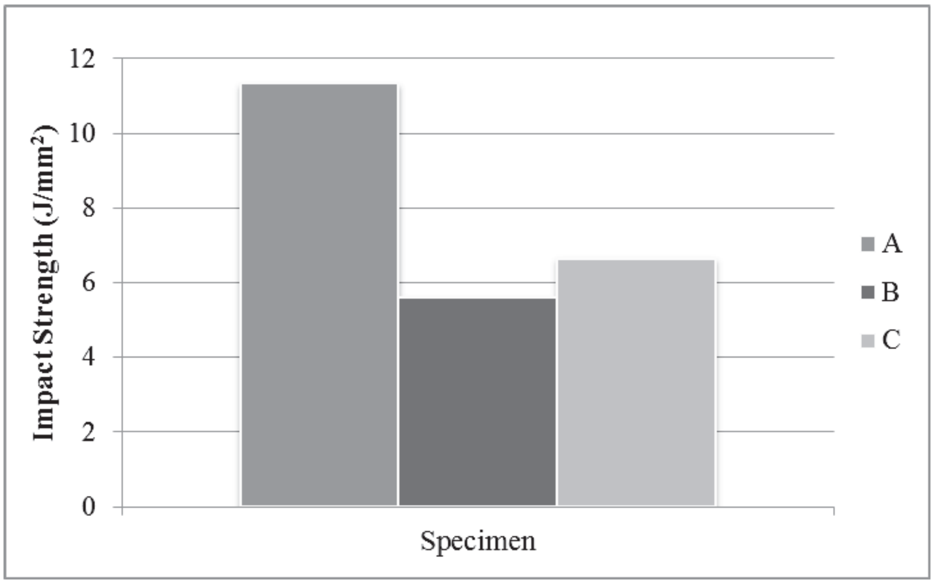

Fig. 4: Impact Strength of Specimen

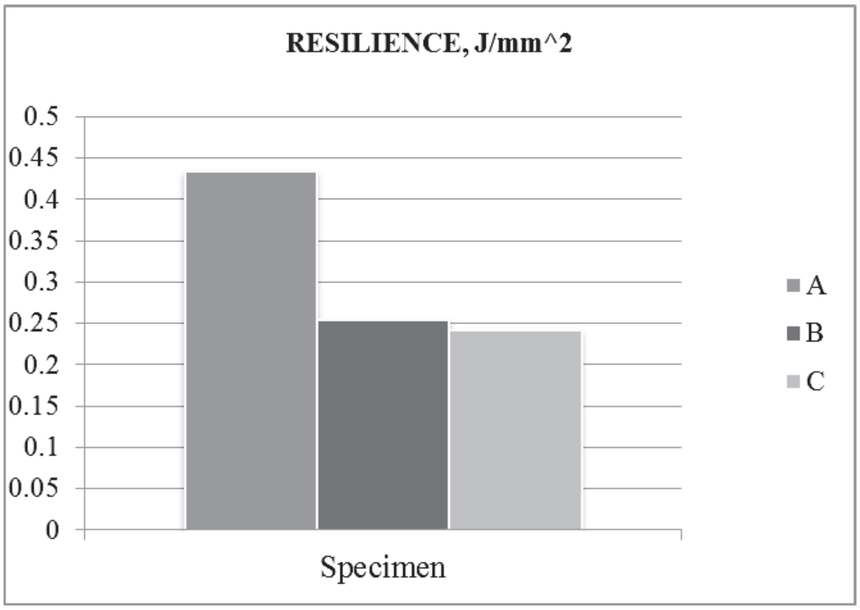

Fig. 5: Resilience of Specimen

Flammability Test Ul-94-V0 Vertical Burning Test: This test is to determine the material ability to propagate or extinguish a flame once ignited. The classification for V-0 is the ability of the specimen to stop burning within 10 seconds, no glow of material more than 30 seconds, no falling of material allowed and the cotton indicator cannot ignite. Source of flame is placed to the material twice (T1 is 10 second and T2 is 10 second). Measurement was taken for T1 and T2. The average burnt length of specimen A is 30.8mm, B is 26.78 mm and C is 80.00 mm. Figure 6 shows the bar chart of the average burnt. Figure 7 shows the length of 5 sample of each specimen burnt.

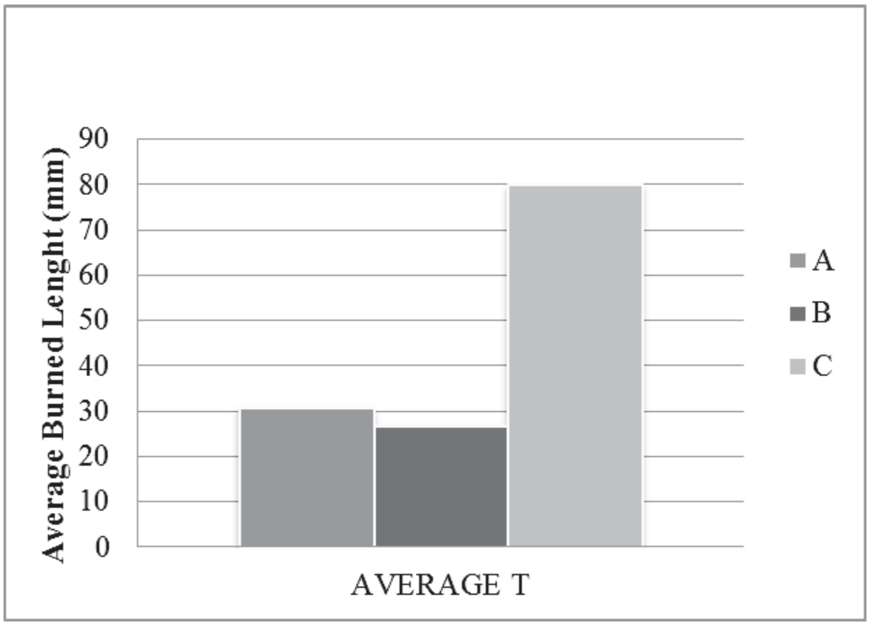

Fig. 6: Average Burned Length of Specimen

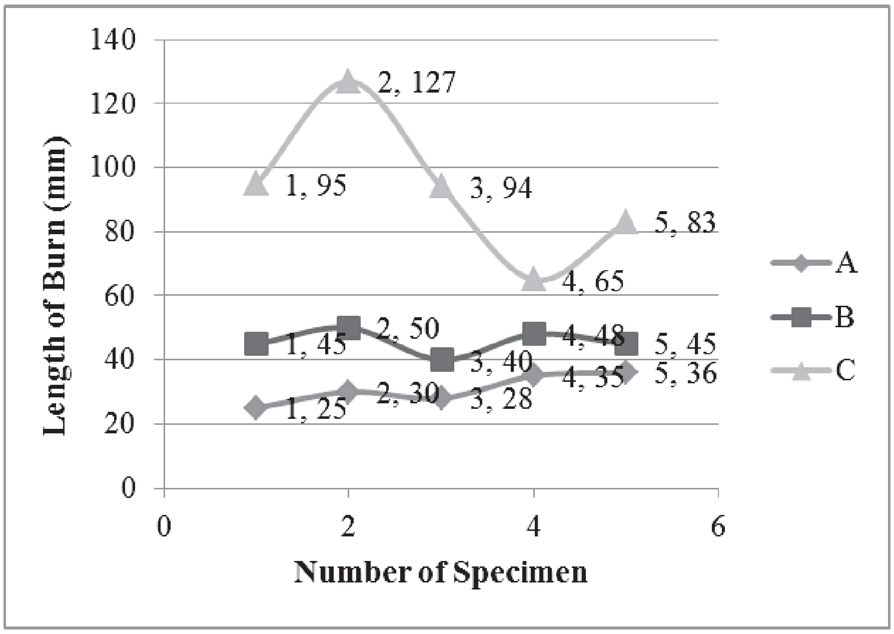

Fig. 7: Burnt Length of Specimen

The criteria to pass the flammability test of V-0 indicates that the specimen to stop burning within 10 seconds, no glow of material more than 30 seconds, no falling of material allowed and the cotton indicator cannot ignite. The specimens were tested with 5 samples and the results were produced in the form of table and graph as in Table 3 and Figure 8. Specimen B has the highest point in passing all the requirement of the flammability vertical burning test.

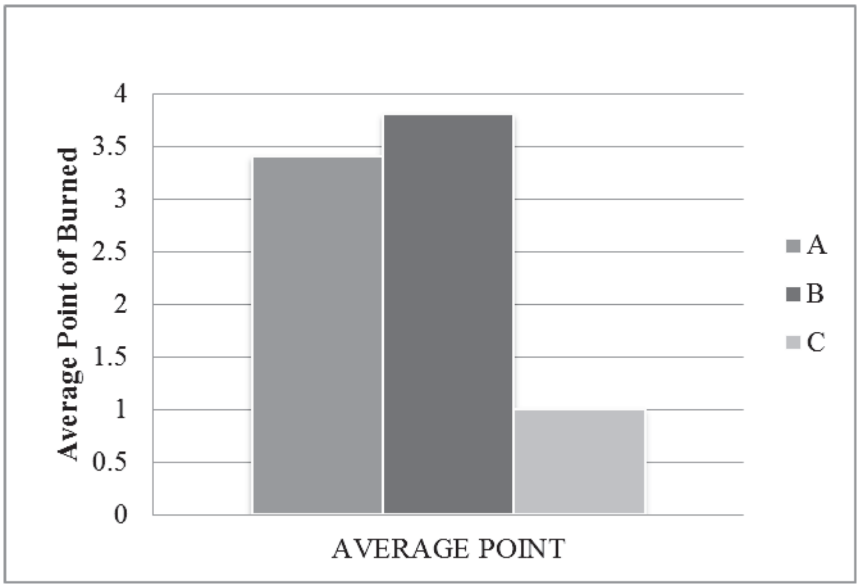

Fig. 8: Average Point of Specimen

Table 3. Average Point of Specimen

Specimen	No.	Pass 1, Fail 0						Average	Status
		T1 (Pass/Fail)	T2 (Pass/Fail)	Falling of Material	Burn To Top	Cotton Ignites	Total out of 5		
A	A1	1	1	1	1	1	5	3.4	PASS
	A2	1	0	0	1	0	2		
	A3	0	0	0	1	0	1		
	A4	1	0	1	1	1	4		
	A5	1	1	1	1	1	5		
B	B1	1	1	1	1	1	5	3.8	PASS
	B2	1	1	1	1	1	5		
	B3	1	0	0	1	1	3		
	B4	0	0	0	1	0	1		
	B5	1	1	1	1	1	5		
C	C1	0	0	0	1	0	1	1	FAIL
	C2	1	0	0	0	0	1		
	C3	0	0	0	1	0	1		
	C4	0	0	0	1	0	1		
	C5	0	0	0	1	0	1		

Thickness of Specimen: The thickness of specimen A, B, and C was measured in mm after the flat panel had been room dry and cut. Specimen A has the thickness of 3.0mm, B 5.0mm and C 6.00mm.

Conclusions: Specimen A has the thickness of 3mm which fail the minimum thickness requirements of DNV 3.74 mm. In terms of testing for impact it has shown that the Σenergy absorbed is 292.23J, impact strength of 11.34 J/mm^2 and resilience of 0.42 J/mm^2. The testing for flammability shows that ΣLength burned is 30.8 mm, having 3.4 points out of 5 and status of Pass. But overall it does not meet the requirements of DNV. Specimen B has the thickness of 5mm which pass the minimum thickness requirements of DNV 3.74 mm. In terms of testing for impact it has shown that the Σenergy absorbed is 290.32J, impact strength of 5.59 J/mm^2 and resilience of 0.25 J/mm^2. The testing for flammability shows that ΣLength burned is 26.78mm, having 3.8 points out of 5 and status of Pass. Overall it meets the requirements of DNV. Specimen C has the thickness of 6mm which pass the minimum thickness requirements of DNV 3.74mm. In terms of testing for impact it has shown that the Σenergy absorbed is 292.85J, impact strength of 6.65 J/mm^2 and resilience of 0.24 J/mm^2. The testing for flammability shows that Σ Length burned is 80 mm, having a 1.0 points out of 5 and status of FAIL. Overall it does not meets the requirements of DNV. The most suitable specimen is specimen A in terms of flammability and impact test, but the thickness does not meet the requirement of DNV. The thickness of specimen A can be added. The differences of thickness between specimen A and minimum thickness required by DNV is 0.74mm. Specimen A is the most optimum in terms of light weight and high absorbent energy. The thickness of the specimen needed to be added to meet its requirements. Specimen B passes all the requirements (UL-94, ASTM 256 & DNV thickness) but, comparing the absorbent energy by it with specimen A, it has a low value. Therefore, the most suitable is specimen A.

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References:

[1] Rusnáková S., Kučerka D., Husár Š., Hrmo R., Kučerková, Education in Composite Materials, In: International Conference on Interactive Collaborative Learning, ICL 2013, 213-218.

[2] Sue Halliwell, End of Life Option for Composite Waste Recyclee, Reuse or Dispose? Best Practice Guide, National Composite Network, UK, 2016.

[3] Sumarsono, Hartono; Ishwara, Helen; Yahya, L.R. Supriyapto; Moeis, Xenia (2013). Benang Raja: Menyimpul Keelokan Batik Pesisir. Jakarta: Kepustakaan Populer Gramedia. ISBN 978-979-9106-01 8.

[4] "Indonesian Batik", Inscribed in 2009 on the Representative List of the Intangible Cultural Heritage of Humanity". UNESCO. Archived from the original on 12 October 2014. Retrieved 10 October 2014.

[5] Arinchai Kitipong, W. Rueanangsirasak, R. Chaisricharoen, Classification System for Traditional Texile: Case Study of the Batik, In: 13th International Symposium on Communications and Information Technologies (ISCIT), 2013 767-771.

[6] Det Norske Veritas, Standard Certification of Craft, Chapter 3, Materials and Manufacturing, Section 3, Fiber Reinforced Plastics B 600 Manual Lamination, 2010. Pp. 30-31.

[7] Det Norske Veritas, Standard Certification of Craft, Chapter 4 Structures, Section 4 FRP Structural Design C Single Skin Construction, 2010. pp. 51-59.

[8] Vishu Shah, Handbook of Plastics Testing Technology, 2nd Ed, Wiley-Interscience, United states, 1998.

[9] Jatoh Prudhvi Raj Naik, B. Mahasenadhipathi Rao, B. Shiva Sambi Reddy, Experimental Test on Gfrp-Epoxy Composite Laminate for Mechanical, Chemical and Thermal Properties, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 8(6) (2013) 47-52.

[10] R. Daulath Banu, Studies on Flame Retardant Polyester Composites for Naval Application, Thesis Report, B.S. Abdur Rahman University, India, 2012.

[11] Det Norske Veritas, High Speed, Light Craft and Naval Surface Craft, Part 2 Chapter 4 Composite Materials, NO-1322, 2010. pp. 1-17.

[12] Patil Deoganda, Vijaykumar N C., Mechanical Property of Glass Fiber Reinforcement Epoxy Composites, International Journal of Scientific Engineering and Research (IJSER), 1(4) 2013 6-9(J201365).

[13] Det Norske Veritas, Standard Certification of Craft, Chapter 3 Materials and Manufacturing,, Section 6 Tables of Material Properties, 2010. pp. 35-37.