LAUTECH Journal of Engineering and Technology 19 (5) 2025: 123-130
10.36108/laujet/5202.91.0590

Development of Composite from Bamboo Shoots and Elephant Grass

[1]Adekunle, N. O., [1]Kuye, S. I., [2]Oladejo, K. A. and [1]Ajibode, G.

[1]*Department of Mechanical Engineering, College of Engineering, Federal University of Agriculture, Abeokuta, Nigeria.*
[2]*Department of Mechanical Engineering, Faculty of Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria.*

Article Info

Article history:

Received: October 10, 2025
Revised: November 28, 2025
Accepted: December 4, 2025

Keywords:

Bamboo Shoot, Elephant Grass, Mechanical Tests, Physical Properties, Epoxy Modified.

Corresponding Author:
adekunleno@funaab.edu.ng
oladejok@oauife.edu.ng

ABSTRACT

In this work experimental investigation was carried out to study the effect of bamboo shoot and elephant grass at varying weight percentages to modify epoxy resin with addition of steel slag. Physical and mechanical tests carried out are density, water absorption, tensile, hardness and flexural. Tests are conducted on 100 kN servohydraulic universal testing machine under displacement mode of control, digital Rockwell hardness testing machine and impact testing machine. Bamboo shoot and elephant grass fibres at different wt% (15), steel slag wt% (5) are filled in epoxy resin and hardener wt(80). The effects of mixing bamboo and elephant grass fibres on mechanical and physical properties are studied. On the basis of mechanical testing results it is found that sample D containing elephant grass (7% wt) and bamboo fibre (8% wt) mixed with epoxy is giving optimum mechanical properties. The addition of bamboo shoot fibre has improved tensile, flexural and impact properties of epoxy resin and increased water absorption of the material. On the basis of overall study, the epoxy modified with 15% of bamboo shoot fibre is found to be better than other combinations.

INTRODUCTION

Bumper is a structure that is attached to or integrated with the front and rear ends of the vehicle to absorb small and large impacts and thus minimise repair costs (Kruthiventi and Venkiah, 2018). The bumpers protect the system, grill, fuel cap, trunk, and exhaust and cooling compactment (Shukla and Sharma 2017; Zang *et al.*, 2019; Bhatia and Sharma 2022). A bumper is a shield made of aluminum, steel or plastic depending on the vehicle make (Waghode and Burande, 2019). The attributes of a good bumper system are geometry, stability and energy absorption (Patil and Ulhe (2017); Muhammad *et al.*, 2017; Seenuvas *et al.*, 2017; Dhamone and kumar 2019). To obtain high strength and high toughness properties of the impact beams of passenger cars conventional impact beams are made of high-strength alloy steel with several heat treatments (Lim and Lee, 2002). Bumpers of most modern automobiles have been made of a combination of polycarbonate (PC) and Acrylonitrile butadiene styrene (ABS) called PC/ABS (Sampathkumar, 2015; Seshagiri *et al.*, 2019). Natural fibre composite offers substantial opportunities for renewable, biodegradable and recyclable materials and from sustainable sources at the same time, Natural fibre composite have low cost, production energy requirements device wearing rate, health and protection risk and additionally excellent formability (Azman *et al.*, 2021). Prabhakaran *et al.* (2012) worked on the design and fabrication of composite bumper for light passenger vehicles made up of glass fiber reinforced polymer with reasonable reduction in weight without sacrificing the strength. Agunsoye *et al.* (2018) used epoxy-carbonized coconut shell nanoparticles composites for a car bumper application, they reported that the structure and mechanical properties of carbonized coconut shell nanoparticles (CSnp) reinforced epoxy had improved impact energy at break over Big Daddy Model and Carina model under the same testing conditions. Bamboo is the largest source of natural fibre and cellulose fibre bio-composite (Scurlock, 2000). Addition of short bamboo fibres into elastomer polymer matrix especially natural rubber (polyisoprene) gave a great mechanical performances (Ismail *et al.*, 2002). Low cost natural fiber bamboo materials are highly potential to be used in automotive parts (Proemper *et al.* 2004). Elephant grass (*Pennisetum purpureum*) is triploid tropical forage of African origin, which presents high production capacity and quality dry matter accumulation. In this regard, elephant grass has gained prominence as one of the main forage species used in energy production (Morais *et al.*, 2011).

Osokoya (2017) did an evaluation of polymer composite for car bumper beam, he reported in his research work that modern technology revealed plastics could be reinforced with certain materials to form new or novel materials called polymeric composites that can exhibit similar mechanical properties required for car structural components, such as metals. Bayene *et al.* (2014) developed some possible alternative solutions for the case of the front and rear bumper and the raw material put into consideration were agricultural wastes and local sourced wastes of timber. Kumar *et al.* (2014) did comparative study of automotive bumper with different materials for passenger and pedestrian safety. The bumper beam was analyzed for the steel and composite material with the basic bumper design in the first phase, and then front part was modeled with the honeycomb and foam type in the second phase to compare the deformation and energy absorbed during the impact. This research work investigated the possibility of producing composite bumper using bamboo shoots and elephant grass.

MATERIALS AND METHOD

Materials

Elephant grass (plate 1) and bamboo shoot (plate 2) were the major raw materials while, epoxy resin and steel slag were used as binder and reinforcement respectively (Vijay *et al.*, 2017; Swaroop 2022; Daniel et al., 2025). The raw materials were obtained at FUNAAB farm.

Equipment

Equipment used included: Electric Oven (Model memmert, Western Germany), Hardness Tester (Gunt Hamburg Hardness), Tensometric Machine (TUF–C-1000 KN (SERVO)), Ball Milling Machine (Model 87002 Limoges – France, A5043) and Hammer mill (Model 000T, Puissance: 1.5 KV, No 13634).

Raw material preparation

The base raw materials (bamboo shoot and elephant grass) were collected at FUNAAB farm, cleaned with water to remove impurities and properly sun-dried on screened surface. The dried raw materials were thereafter crushed to make milling faster and then ground into powder using the ball milling machine. A sieve of 200 µm was used to separate the crushed and fine bamboo shoot and elephant grass from shafts.

Formulation determination and method

Eight (8) samples labelled A, B, C, D, E, F, G and H were formulated with the combination of elephant grass, bamboo shoot, epoxy resin and hardener, and steel slag (Table 1). The control Sample, a popular bumper brand was bought from a market in Abeokuta. A 2^n fractional factorial design was employed to investigate the effects of key input

variables on the properties of composite materials produced.

Table 2: Composition of the samples A – H (% wt)

Samples	Elephant grass	Bamboo Shoot	Steel slag	Epoxy resin
A	10	5	5	80
B	9	6	5	80
C	8	7	5	80
D	7	8	5	80
E	6	9	5	80
F	5	10	5	80
G	20	0	5	80
H	0	20	5	80

Plate 1: Dried Elephant grass

Plate 2: Dried bamboo shoot

Plate 3: Laying up mould for the sample

Plate 4: Produced samples

Density Test

The true density of the samples was determined by calculating their mass on a digital weighing machine and determining their volume by liquid displacement method. The ASTM D792 standard which uses the Archimedes' principle (liquid displacement) was used to determine the density of composite samples developed.

Water absorption test

Water absorption was used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include type of plastic, additives used, temperature and length of exposure. The data sheds light on the performance of the materials in water or humid environments. The samples were dried in an oven and placed in a desiccator to cool. The specimen were weighed immediately after cooling and submerged in water. They were then removed, patted dry with a lint free cloth and weighed. Water absorption test is calculated using Equation (1):

$$\text{Water absorption test} = \frac{\text{Wet weight - dry weight}}{\text{dry weight}} \times 100 \qquad (1)$$

Impact test

A crash test is a form of destructive testing usually performed in order to ensure safe design standards in crashworthiness and crash compatibility for various modes of transportation or related systems and components. The produced composite samples were subjected to impact test which required slight hitting with a tough material to determine the effects of collision on it. The impact toughness of the composite samples were determined using Charpy pendulum impact test according to ASTM D256 standard.

Hardness Test

In Brinell hardness test, an optical method, the size of indentation left by the indenter was measured. It involves a pyramid-shaped indenter being pressed into a specimen, the Brinell method uses a spherical indenter. The Brinell hardness values of the samples were obtained using ASTM E10 standard.

Tensile test

The most popular method for determining the mechanical properties of isotropic materials is uniaxial tensile testing. Biaxial tensile testing is necessary for isotropic materials such as textiles and composite materials (Marichelva *et al.*, 2023; Panagiotis 2024.). The tensile strength of composite samples produced was determined according to ASTM D3039.

Flexural test

The flexibility test was carried out using a machine that could test the bending and stability of the specimen. The test result was conducted using three-point bending according to ASTM D7264 standard.

RESULTS AND DISCUSSION

Density test

Figure 1 shows the result of the density test samples. The values were 0.8786, 0.7825, 0.8967, 1.0321, 0.9843, 0.9356, 0.9124 and 0.7891 kg/m^3 for Samples A, B, C, D, E, F, G and H respectively. Sample D gave the highest value while Sample B had the lowest value. The results did not follow any regular trend from Samples A to D but from Samples E to H, it could be observed that density decreased with increase of bamboo shoot except in G that did not have bamboo shoot.

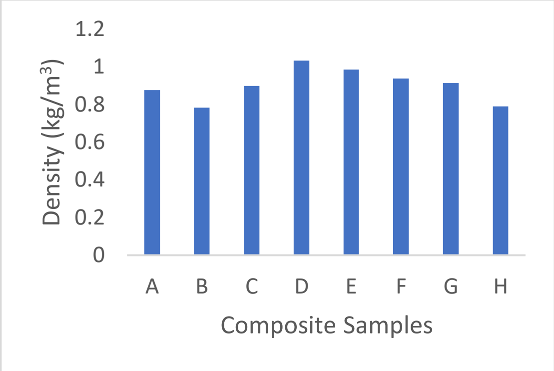

Figure 1: The variation of the density with the composite samples

Water absorption test

Figure 2 shows chart for water absorption test result obtained from the experimental test carried out on the produced sample with comparison alongside Toyota bumper. Water absorption values for the samples were 2.30%, 2.86%, 2.93%, 2.55%, 3.9%, 4.0%, 1.96% and 3.19% for A, B, C, D, E, F, G and H respectively. Highest water absorption value was recorded for Sample F while the lowest was recorded for Sample G. Water absorption values increased with increase in bamboo shoot and decrease in elephant grass until Sample D where it decreased and then increased again. It could be seen that Sample G with no bamboo shoot had the lowest water absorption value. All the values obtained were higher than that of the Control tested (0.27%).The results for Samples A and G agreed with the report of Yahaya *et al.*

(2016) that water absorption rate for any composite material should not exceed 2.5%.

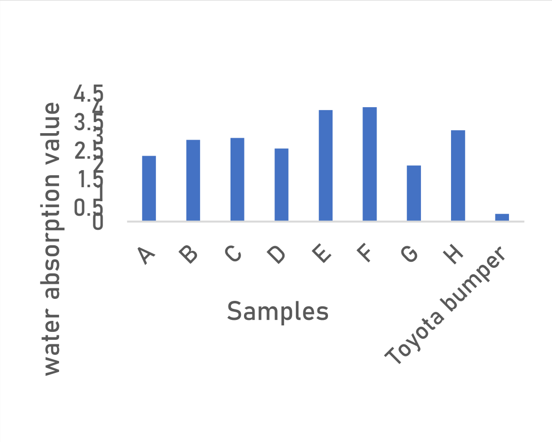

Figure 2: The water absorption values for the composites samples.

Hardness test

The hardness values for the samples were 12.47, 13.27, 16.50, 18.20, 13.40, 17.20, 9.97 and 13.3 BHN for A, B, C, D, E, F, G and H respectively. The hardness value of commercially obtained Toyota bumper was 36.4 BHN. It could be observed from Figure 1 that the hardness values increased consistently with increase in bamboo shoot and decrease in elephant grass and then decreased sharply after Sample D and rose again. Composite G had the lowest hardness value. The highest hardness value was in sample D.

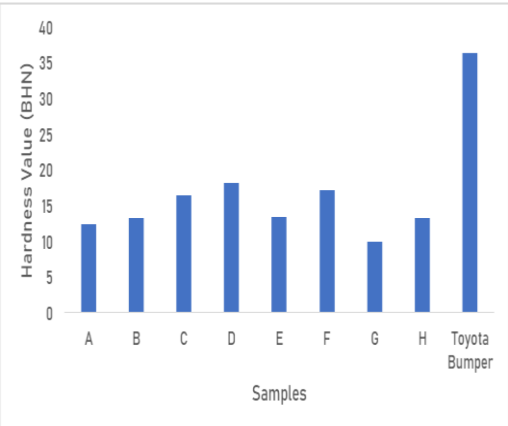

Figure 3: Shows the variation of the hardness test on the samples.

Impact test

Figure 4 shows the impact test result obtained from the experimental test carried out on the samples. Impact test values were 4.39, 3.44, 3.17, 3.22, 4.08, 4.51, 2.27 and 2.51 J for Samples A, B, C, D, E, F, G and H respectively. Impact test values decreased with decrease in elephant grass and then increased again. Samples of pure elephant grass or bamboo shoots had the lowest values. The highest values were recorded for Samples E and F. These values compared favourably with the value of the Control (4.17 J).

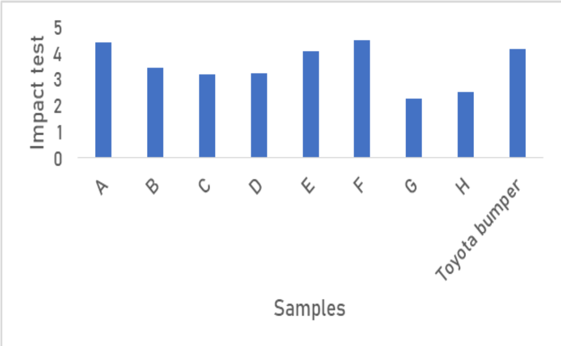

Figure 4: The impact fracture toughness of composite samples (4.51 F)

Tensile test

Figure 5 shows the results of the tensile test carried out. The values obtained were 7.548, 0.654, 10.169, 15.610, 13.661, 12.067, 7.849 and 6.863 N/mm^2 for Samples A, B, C, D, E, F, G and H respectively. The tensile strength increased initially with increase in bamboo shoot and decrease in elephant grass until Sample D (except in Sample B), the trend then reversed from Samples E to H. It could be seen that Sample D (15.610 N/mm^2) compared favourably with the Control (15.944 N/mm^2).

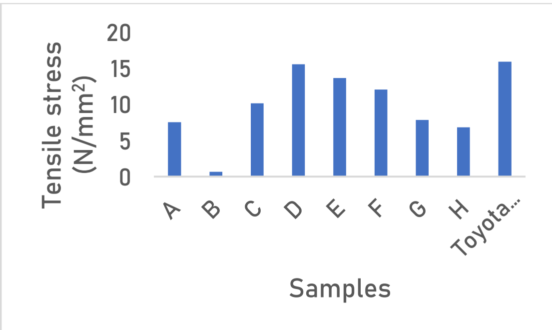

Figure 5: The tensile stress carried out on the samples.

Flexural test

The values obtained for the flexural test were 0.15, 0.27, 0.018, 0.14, 0.14, 0.013, 0.065 and 0.07 N/mm^2 for Samples A, B, C, D, E, F, G and H respectively. The values of Samples G (0.065 N/mm^2) and H (0.07 N/mm^2) compared favourably with the value of the Control (0.06044 N/mm^2). The mixing ratio and mode of sample production had great effects on the test sample as highlighted by Bayene *et al.* (2014).

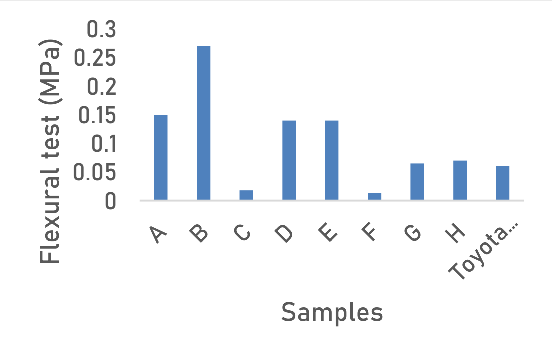

Figure 6: The variation property of the flexural stress on the samples.

Conclusion

Composite bumpers were produced in this work with bamboo shoot and elephant grass mixed in different proportions to form 15% of the total mixture, steel slag formed 5% and resin which formed the remaining 80% served as binder. The samples produced were tested for hardness, water absorption, density, impact, flexural and tensile strengths. The sample with 7% of elephant grass and 8% of bamboo shoot gave the best performance generally for all the tests carried out and its values favourably agreed with those of a popular vehicle brand.

REFERENCES

Agunsoye J.O., Odumosu A.K., and Dada O. (2018). Novel Epoxy-Carbonized Coconut Shell Nanoparticles Composites for Car Bumper Application, *International Journal of Advanced Manufacturing Technology*, 4 (3), 21 – 25. https://doi.org/10.1007/s00170-018-3206-0

Angad Singh Bhatia and Satyendra Sharma (2022). Safety and Reliability Enhancement of Car Front Bumper for Different Materials Using Ansys. International Journal of Research Publication and Reviews, Vol 3, no 9, pp 1679-1682.

Azman M.A., Ashraf M.R.M., Khalina A. and Ruzaidi C.M. (2021). Natural Fiber Reinforced *Composite Material for Product Design*, National Library for Medicine, 4(1), 2 – 7. DOI : 10.15224/978-1-63248-170-2-09.

ASTM, 2002. “Standard Specification for determining the density of composite materials”, American Society for Testing and Materials, D792.

ASTM, 2002. “Standard Specification for determining the impact toughness of composite materials”, American Society for Testing and Materials, D256.

ASTM, 2002. “Standard Specification for determining the Brinell hardness test of composite materials”, American Society for Testing and Materials, ASTME10.

ASTM, 2002. “Standard Specification for determining the tensile strength of composite materials”, American Society for Testing and Materials, D3039

ASTM, 2002. “Standard Specification for determining the flexural strength of composite materials”, American Society for Testing and Materials, D7264.

Bayene A.T., Koricho E.G., Belingardi G. and Martorana B. (2014). Design and Manufacturing Issues in the Development of Lightweight Solution for a Vehicle Frontal Bumper, *Elsevier Journal*, 88(3), 23 – 31. DOI:10.1016/j.proeng.2014.11.129

Bharat P. Patil. Prashant N. Ulhe (2017). Design Of Automobile Front Bumper For Collision Energy Attenuation. *International Research Journal Of Engineering And Technology* (IRJET). 04 (02) 819-824.

Charitidis J. Panagiotis (2024). Theoretical Review for Non-Destructive Techniques of Composite Materials,” *International Research Journal of Advanced Engineering and Science*, Volume 9, Issue 2, pp. 127-136.

Dasagrandhi Veda Swaroop (2022). Analysis of Mechanical Properties of Banana-Jute Hybrid Fiber-reinforced Epoxy composite by varying Stacking sequence. International Journal for Research in Applied Science & Engineering Technology (IJRASET). Vol 10, Issue II, ISSN: 2321-9653; IC

Dharmateja Kruthiventi and Venkaiah M. (2018). Modeling and Impact Analysis of Four Wheeler Car Bumper, International Journal of Research on Engineering Materials, 7(8),729–734.DOI: 11.1103/j.rem.2018.03.09879

Gandla Pradeep and Chandra Kumar P. (2018). Design and Experimental Analysis on Car Bumper with Composite Materials, *International Research Journal of Engineering andTechnology*, 5(10), 21 – 27. DOI: 10-11- 2320-2882.

Ismail H., Shuhelmy S., and Edyham M. R. (2002). The Effects of a Silane Coupling Agent on Curing Characteristic and Mechanical Properties of Bamboo Fibre Filled Natural Rubber Composites. *European Polymer Journal*, 38 (3), 47 – 52. DOI:10.3390/sym12122074

Lim T.S. and Lee D.G. (2002). Mechanically fastened composite side-door impact beams for passenger cars designed for shear-out failure modes, *Journal of Composition and Structure*, 56(4), 4 – 11. DOI:10.1016/S0263-8223(02)00005-3

Morais R.F., Quesada D.M., Reis V.M., (2011). Contribution of biological nitrogen fixation to Elephant grass (*Pennisetum purpureum Schum*.), *Journal of Plant Soil*, 34(9), 1 – 12. DOI: 10.1007/s11104-011-0944-2

M.K. Marichelvam, C. Labesh Kumar, K. Kandakodeeswaran, B. Thangagiri, Kuldeep K. Saxena, Kamal Kishore, Naresh Kumar Wagri, Sanjeev Kumar (2023). Investigation on mechanical properties of novel natural fiber-epoxy resin hybrid composites for engineering structural applications. Case Studies in Construction Materials 19 (2023) e02356

Muhammad Nasiruddin S, Hambali A., Rosidah J. and Widodo W.S.and Ahmad M.N (2017) A Review of Energy Absorption of Automotive Bumper Beam. *International Journal of Applied Engineering Research.* Volume12, Number 2, pp. 238-245

Olumide Osokoya (2017). An Evaluation of Polymer Composites for Car Bumper Beam, International Journal of Automotive Composites, 3(1), 45 – 59. DOI: 10.1504/IJAUTOC.2017.086521

Prabhakaram S., Chinnarasu K., Kumar Senthil M. (2012). Design and Fabrication of Composite Bumper for Light Passenger Vehicles, *International Journal of Modern Engineering Research*, 2(4), 2552 – 2556. DOI: 12.10.IJMER 8597577.

Praveen Kumar A., Sameer Belagali, and Bhaskar K. (2014). Comparative Study of Automotive Bumper with Different Materials for Passenger and Pedestrian Safety, *Journal of Mechanical and Civil Engineering*, 11(4), 60 – 64. DOI:10.15680/IJIRSET.2018.0705208

Proemper E. (2004). New Automotive International from Natural Fiber Materials, *International AVK-TV Conference for Reinforced Plastics and Thermoset Molding Compounds*, Germany,28–29. DOI:13.16.980 2004704067.

Sagar P Dhamone, Arun kumar P. (2019). Automobile bumper by Varying Materials to control energy Absorption for improve passenger car safety performance. *International Journal for Research in Engineering Application & Management* (IJREAM) 05(03) 145-163. ISSN : 2454-9150

Scurlock J. M. O., Dayton D. C, and Hames B. (2000). Bamboo: An Overlooked Biomass Resource, *Journal of Biomass and Bioenergy*, 19 (3), 29 – 44. DOI: 10.1016/S0961-9534(00)00038-6

Seshagiri Rao G.V.R., Vadnala Priyanka, Prasad, V. S. H. (2019). Design and Analysis of Automobile Bumper. International Journal of Innovative Technology and Exploring Engineering 9(1):512-516 DOI:10.35940/ijitee.G5615.119119

S. Seenuvas, N. Nagendran, N. Gayathri, T.V.B. Babu, R. Manjunathan (2017). Energy Absorption Analysis in Front Bumper of a Car. *Journal of Chemical and Pharmaceutical Sciences* JCHPS Special Issue 2: www.jchps.com Page 158. ISSN: 0974-2115

Sumeet Kumar Shukla and Suman Sharma (2017). Impact Analysis of Car Front Bumper to Enhance Crashworthiness. *International Journal of Engineering Trends and Technology (IJETT)* 46(5) 257- 261.ISSN: 2231-5381 http://www.ijettjournal.org

S. Sujay Daniel, M Karamchand, P Satyanarayana, G Ratna Kumar, G Moshe Babu (2025) Investigation of Mechanical Properties of Flax-Based Hybrid Epoxy Composites. International Journal Of Research In Aeronautical And Mechanical Engineering. 13(1) 18-31 ISSN (ONLINE): 2321-3051

Tie Wang and Yonggang Li (2010). Design and analysis of automotive composite bumper beam, *Journal of Advances Mechanical Engineering*, 7 (6), 1-1 DOI: 10.1177/1687814015589561.

Vijay Chaudhary, Pramendra Kumar Bajpai & Sachin Maheshwari (2017): Studies on Mechanical and Morphological Characterization of Developed Jute/Hemp/Flax Reinforced Hybrid Composites for Structural Applications, Journal of Natural Fibers. 1-19. DOI: 10.1080/15440478.2017.1320260

Waghmode S.D. and Burande D.H (2019). Design and Analysis of Bumper using Carbon Fibre395, *International Research Journal of Engineering and Technology*, 6 (8), 504 – 507. DOI: 10.5897/AJB2017.16014

Xiyuan Zhang (2019). Crashworthiness Characterization of the Car Front Bumper System Based on FEA Analysis, University of Derby, 3(2), 3 – 7. DOI:10.1504/IJAUTOC.2017.086521

R.Yahaya, S.M. Sapuan, M.Jawaid, Z. Leman and E.S. Zainudin (2016). Advanced Water Absorption Behaviour And Impact Strength Of Kenaf-Kelvar Reinforced Epoxy Hybrid Composites. Composites Letters, Vol. 25, Iss.4, 2016 98