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Jute-Glass Fiber Based Composite for Engineering Application

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ABSTRACT

Now a day the interest in using natural fibers as reinforcement in polymer composite material has increased significantly. Now this natural fiber based composite manufacturing has been a wide area of research and it is the most preferred choice for not only its superior properties like low density, stiffness, light weight and possesses better mechanical properties but also they are renewable, cheap, completely or partially recyclable, and biodegradable. In this study, an attempt has been made to fabricate jute-glass fiber based polymer composite skateboard and investigate its performances. For this skateboard, the materials were chosen epoxy resin (ADR 246 TX) as the matrix and jute mat and glass fiber as reinforcement. The construction of the skateboard is done by using hand layup techniques. The skateboard thus made was tested for its mechanical properties like tensile test, flexural test, drop test and impact test. Visual analysis of the skateboard shows that hand layup techniques provides a reliable process to make a perfect skateboard. The performance test results indicate that jute-glass fiber based polymer skateboard has a sustainable strength over Canadian hard rock maple wood for the application in constructing sportswear component i.e. skateboard. Cost analysis indicates that using this skateboard cost saving more than 20 % can be achieved.

Key words: Skateboard, Polymer composite, Jute fiber, Glass fiber, Mechanical performance

INTRODUCTION

Now-a-days a big portion of material science has been conquered by composite materials. Composites are one of the most widely used materials because of their adaptability to different situations and the relative ease of combination with other materials. They can serve specific purposes and exhibit desirable properties. This is a very important issue in many engineering works. Recently there has been a greater inclination towards natural fiber reinforced plastic composites because these are environmental friendly and cost effective to synthetic fiber reinforced composites. Additionally, Natural fibers have lot of advantages over traditional fibers in terms of low cost, low density, biodegradable and easily processed [1-5]. The conventional material such as glass, carbon and boron fibers are quite expensive and the use of fiber like carbon or boron is justified only in aerospace application [5]. Therefore it is meaningful to explore the possibility of using cheaper materials such as natural fiber as reinforcement. Various aspects of hybrid fiber based polymer composites has studied by various investigators. Rafiquzzaman et.al [6] investigated the mechanical performance of jute-glass fiber based polymer composite. Results indicated that jute fiber can be a very potential candidate in making of composites, especially for partial replacement of high-cost glass fibers for low load bearing applications. Jawaid *et al* [7] studied the mechanical behavior of hybrid composites based on jute and oil palm fiber. It has been found that the use of hybrid system was effective in increasing the tensile and dynamic mechanical properties of the oil palm-epoxy composite because of enhanced fiber/matrix interface bonding. Verma *et al* [8] examined the mechanical properties of glass/jute hybrid composites. The jute fabrics were modified by treatment with different chemicals. It has been observed that titanate treatment of jute fabric results in enhanced performance characteristics and mechanical properties of hybrid composites. Ashmed *et al* [9] investigated the elastic properties and notch sensitivity of untreated woven jute and jute-glass fabric reinforced polyester hybrid composites, analytically and experimentally. The jute composites exhibited higher notch sensitivity than jute–glass hybrid composites. Dixit *et al* [10] reported a remarkable improvement in the tensile and flexural properties of hybrid composites compared to the un-hybrid composites. It was also found that the hybrid composite offers better water absorption resistance. Ahmed *et al* [11] experimentally investigated the effect of stacking sequence on mechanical properties of woven jute and glass fabric reinforced polyester hybrid composites. The layering sequence has larger effect on the flexural and inter-laminar shear properties than tensile properties. On comparing the overall properties of the laminates it was concluded that the hybrid laminates with two extreme glass plies on both side has the optimum combination with a good balance between the properties and the cost. Thew and Liao [12] informed that mechanical properties of bamboo/glass fiber reinforced hybrid composites depends on fiber length, fiber weight ratio and adhesion characteristics between the matrix and the fiber. Experimental investigation carried out by Mishra *et al* [13] depicts that addition of quite small amount of glass fiber to the pineapple leaf fiber and sisal fiber-reinforced polyester matrix improves the mechanical properties of the resulting composites. The study also reported that the water absorption tendency of composites decreased because of hybridization and treatment of bio fibers. Pandya *et al* [14] found that on placing glass fabric layers in the exterior and carbon fabric layers in the interior of the hybrid composites gives higher tensile strength and ultimate tensile strain than hybrid composites with carbon fabric layers in the exterior and glass fabric layers in the interior. Sreekala *et al* [15] concluded that incorporation of small volume fraction of glass fiber in composites results in enhanced tensile and flexural properties. Velmurugan et.al [16] studied the tensile, shear, impact and flexural properties of the palmyra/glass fiber hybrid composites. The properties of the hybrid were found to be increasing continuously with the addition of glass fiber. Goud and Rao [17] found a considerable increase in the tensile, flexural, impact and hardness properties of Roystonearegia/glass fiber hybrid composites with the increase in glass fiber loading. However, the dielectric constant and electrical conductivity values decreased with increase in glass fiber loading in the hybrid composites at all frequencies. Pothan *et al* [18] studied on the banana-glass hybrid composites and found layering pattern or the geometry of the composites has a profound effect on the dynamic behavior of the composites. Thiruchitrambalam *et al* [19] studied the effect of Sodium LaulrylSulphate (SLS) and alkali treatment on the mechanical properties of banana/kenaf hybrid composites. Investigation result indicates that SLS treated hybrid composites exhibit better properties than alkali treated ones. Zhong *et al* [20] informed that the surface micro fibrillation of sisal fiber improves the compression strength, stability, tensile strength, internal bonding strength and wear resistance of the sisal/ aramid fiber hybrid composites. Sanjeevamurthy and Srinivas [21] studied the effect of moisture absorption on the mechanical properties of the coconut coir and sisal fiber hybrid composites and compared it with the composites with dry fires. It was found that the tensile and the flexural strength increased with increase in fiber loading of composites at dry condition. On the other hand at wet condition, the tensile and flexural strength have a high-level drop. Venkateshwaran*et al* [22] reported that the incorporation of sisal fiber in banana/epoxy composites of up to 50% by weight results in enhanced mechanical properties and decreased moisture absorption property. Girisha *et al* [23] found that the hybridized composite shows greater tensile strength compared to the composites with individual type of natural fires as reinforcement. Therefore, the aim of this research work is finding new alternative of sports equipment (skateboard) application in prospects of long-lasting and economic concern as well as better physical or mechanical properties. The present work focused on the fabrication of jute - glass fiber based skateboard by using hand layup method. Later the mechanical performances of these composite have been investigated experimentally.

MATERIALS AND METHODS

Materials Collection

In this study, jute and glass fiber were used as reinforcement and the epoxy resin (ADR 246 TX) was used as the matrix shown in Fig. 1. Hardener ADH 160 and Methyl Ethyl Ketone Peroxide (MEPOXE) were used to improve the interfacial adhesion and impart strength to the composites. The hardener and resin were purchased from a chemical company. The woven jute mat is collected from local market. A resin and hardener mixture of 3:1 was used to obtain optimum matrix composition. Mechanical properties of jute fiber, glass fiber and epoxy resin are shown in Table -1.

(a) **(b)** **(c)**

Fig. 1 (a) Glass fiber (b) Jute fiber (c) Epoxy Resin

Table -1 Mechanical Properties of Fiber and Matrix [6]

Properties	Jute fiber	Glass fiber	Epoxy resin
Density (g/cm^3)	1.3	2.54	1.2
Young modulus (GPa)	26.5	75	2.7
Specific Gravity (gm/cc)	1.3	2.5	—
Poisson's ratio	—	0.2	0.4

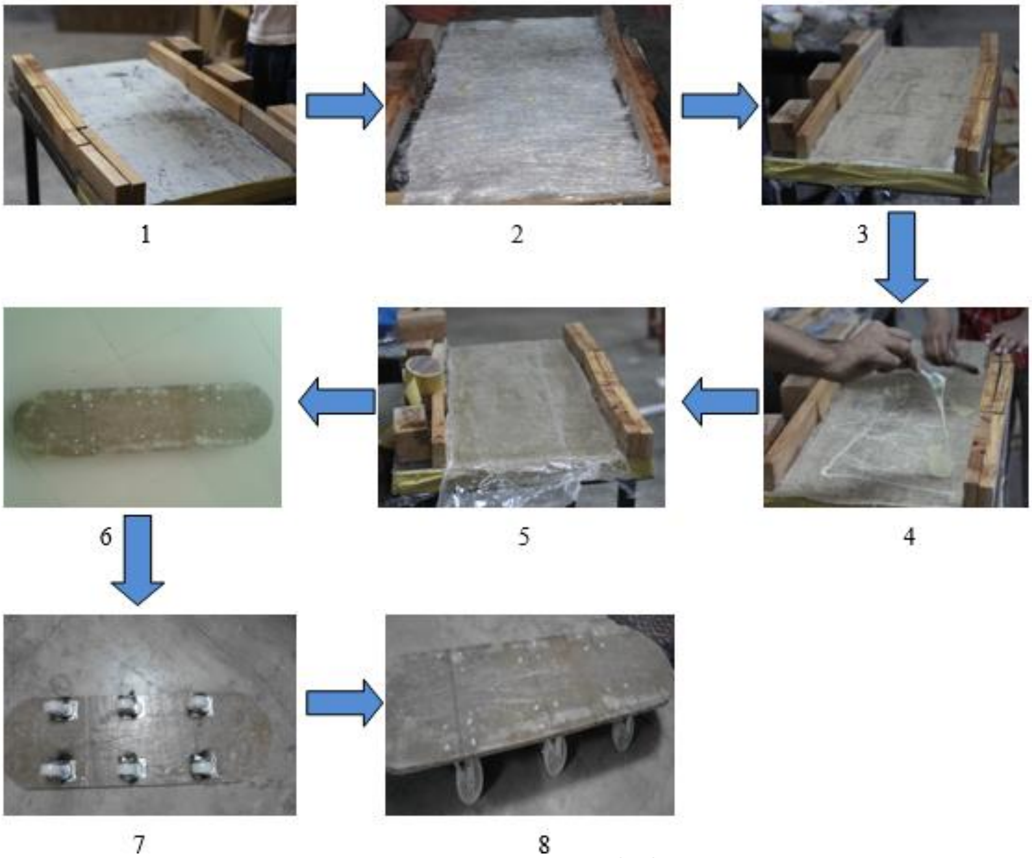

Fig. 2 Complete sequential processes for fabrication

(b)

Fig. 3 (a) Fabricated Skateboard (b) Photographic view of Test specimens

Fabrication Procedure

The fabrication of composite material was carried out by conventional hand layup technique. Jute fiber and scramble glass fibers were used as reinforcement and epoxy was taken as matrix material. The low temperature curing epoxy resin and hardener were mixed in a ratio of 3:1 by weight percentage. The epoxy resin (ADR 246 TX) was used as the matrix. Hardener ADH 160 was used to improve the interfacial adhesion and impart strength to the composites. First, a releasing agent and resin were applied to the mold surface. Then a layer of the jute fiber/glass fiber was laid down, followed by a quantity of liquid resin epoxy poured onto it. Brushes and hand rollers were used to remove any void in the fiber structure and to spread the resin evenly throughout the fibers. The process was repeated until the required number of layers was built up. Finally, these specimens are taken to the hydraulic press to force the air gap to remove any excess air present in between the fibers and resin, and then kept for several hours to get the perfect samples. The complete sequential fabrication process is shown in Fig. 2. After the composite material get hardened completely, the composite material is taken out from the hydraulic press and rough edges are neatly cut and removed as per the required dimensions. The composite laminate samples were cured by exposure to normal atmospheric conditions. The fabricated composites were cut using a grinding machine to obtain the skateboard and specimen for mechanical testing as per the ASTM D3039 standards is shown in Fig. 3.

Experimental Procedure

The tensile test of the specimen was performed using an electro-mechanical testing machine equipped with the maximum capacity of the load cell at 3 KN. The strength was calculated from the maximum load at failure of the tensile stress. Flexural testing commonly known as three-point bending testing was also carried out as per ASTMD790 the sample specimen was placed in the UTM (Universal testing machine). Composite specimens of dimensions 120 × 20 × 4 mm were horizontally placed on two supports. Then, load was applied gradually to the middle of the specimen by roller. At a specific load the sample is break, i.e. fracture is occurred. The deflection was measured by the gauge placed under the specimen, at the center. For the gradually increasing deformation of the specimen, the respective load is noted and further calculation is performed to find the bending strength of the specimens. Impact testing of the specimen was carried out on Tinius Olsen machine as per procedure mentioned in ASTM D256. The specimen is placed in the impact machine and impact force is applied to the specimen at the other side of the V-notch by releasing the hammer to make impact on specimens from a certain height. After impact the height of the hammer from the ground is noted. All experimental tests were repeated four times to generate the data. Further calculation is performed to find out the impact strength of the specimens. All experimental tests were repeated four times to generate the data.

EXPERIMENTAL RESULTS AND DISCUSSIONS

Tensile Test

The different composite specimen samples are tested in the universal testing machine (UTM) and the samples are left to break till the ultimate tensile strength occurs. Experimental results of tensile of various composites with different weight fractions of reinforcement are presented in Table 2. The comparison result of various composites with different weight fractions of reinforcement is shown in Fig. 4. The results show that the overall tensile strength of hybrid composites (Jute -Glass) is higher than other single jute fiber reinforced composite. However, single glass fiber exhibit higher tensile compare with other composites. Incorporate the jute fiber reinforcement, the composite becomes more brittle as jute shows brittle behavior and overall strength decreases.

Table -2 Experimental Results of Tensile, Flexural and Impact Test for Various Composites

No. of Experiment	Total Reinforcement Weight %	Fiber Weight %		Tensile Strength (M Pa)	Flexural strength (M Pa)	Impact Strength (KJ/m^2)
		Jute	Glass			
01	40	40	0	39.67	65.87	178.56
02		0	40	87.53	89.67	235.13
03		20	20	74.65	82.76	206.89

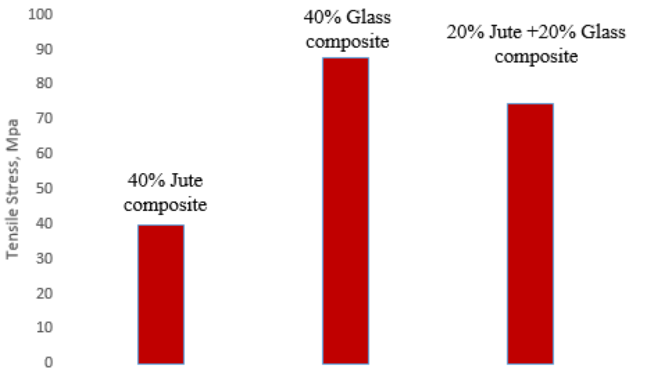

Fig. 4 Comparison of Tensile strength

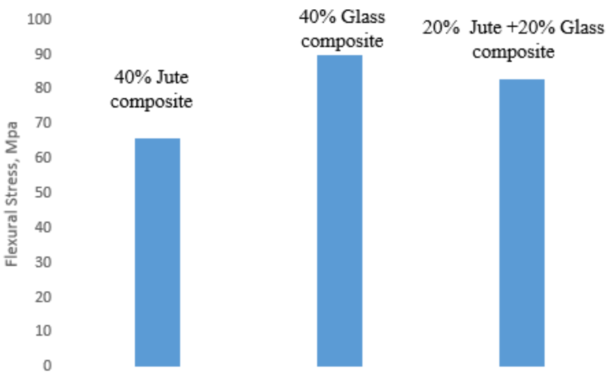

Fig. 5 Comparison of Flexural strength

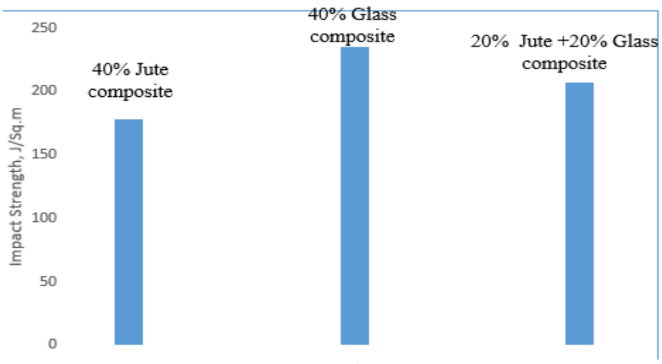

Fig. 6 Comparison of Impact strength

Fig. 7 Jute –Glass fiber based Skateboard

Flexural Test

Flexural results of various composites with different weight fractions of reinforcement are presented in Table 2. The comparison result of various composites with different weight fractions of reinforcement is shown in Fig. 5. Results show that flexural strength of jute composite is lower than that of glass fiber composites due to the less stiffness of jute fibers in comparison to glass. The addition of jute fiber with glass fiber, the composite gives better flexural strength compare with single reinforced composites.

Impact Test

For analyzing the impact capability of the different specimens an impact test is carried out by Charpy impact test. The energy loss is found out on the reading obtained from the Charpy impact machine. Experimental results of impact testing of various composites with different weight fractions of reinforcement are presented in Table 2 and the comparison results are presented in Fig. 6. The results indicated that the maximum impact strength is obtained for hybrid composites followed by glass fiber composites. However, jute composites exhibit low performance compared to other composites.

Skate Board Based on Jute and Glass Fiber

In this study a skateboard was fabricated with 20 wt% Glass, 20 wt% jute and rest epoxy resin. The construction of the skateboard is done by using hand layup techniques. The skateboard thus made was tested for its mechanical properties. The image of the skate board is shown in Fig. 7. Visual analysis of the skateboard shows that hand layup process provides a reliable process to make parts, especially ones without acute angles or small radii of curvature. The impact test on the skateboard was performed by a drop test where the skateboard a player on it was placed on a platform about 1ft height from ground. Then the player jumped from that height. This activity has been repeated from a height of 2ft and 3ft also. Then the skateboard was observed and quantified for any defect. The heights was chosen like that because while skating the player have to make stunt from this height.

The results of the drop test are shown in Table -3. The results indicate that there is no significance damage or crack observed after player jumped from the maximum 3 m height. The mechanical properties of glass-jute-epoxy composite are shown in Table -4. From the table we can see that the mechanical properties like tensile strength and flexural strength of the composite material are superior compare to maple wood for making skateboard. The performance test results indicate that jute-glass fiber based polymer skateboard has a sustainable strength over Canadian hard rock maple wood for the application in constructing sports component. The current market price of a maple wood skateboard is varies from $25 to $150. The making cost of the skate board made from jute and glass fiber is about $ 18. The cost analysis results show that the total cost reduced 20%, when the skateboard replaces by jute-glass polymer composite rather than maple wood.

Table -3 Skateboard Dropped Test Results

Dropped Height	1ft	2ft	3ft
Photograph after drop test			
Visual observation Remarks	No significant damage or crack observed	No significant damage or crack observed	No significant damage or crack observed

Table -4 Mechanical Properties of Glass-Jute-Epoxy Composite

Properties	Jute-glass fiber based composite	Comparable material (Maple Wood) [24]
Flexural Strength	76.78 MPa	34.5 MPa
Tensile Strength	64.89 MPa	5.31 MPa
Impact Strength	189.65 J/m^2	—

CONCLUSIONS

Now-a-days research is going on developing of bio-composites to replace traditional materials. Different natural fibers are being combined with synthetic fibers to give better mechanical and physical properties. In this study, a skateboard has been made by using natural fiber (Jute fiber) and glass fiber and then investigated its mechanical properties. Jute glass fiber based composite exhibits better tensile properties compare with single reinforced composite. Similarly, flexural and impact properties also exhibits better results. The performance test results of skateboard indicate that jute-glass fiber based polymer skateboard has a sustainable strength over Canadian hard rock maple wood for the application in constructing sports component i.e. skateboard. Cost analysis indicates that using this skateboard cost saving more than 20 % can be achieved. It can thus be inferred that jute fiber can be a very potential candidate in making of composites, especially for partial replacement of high-cost glass fibers for moderate load bearing applications.

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REFERENCES

[1] KK Chawla, *Composite Materials: Science and Engineering*, 2nd Edition, Springer, New York, **1998**, 13-87.
[2] F Gao, L Boniface and SL Ogin, Damage Accumulation in Woven Fabric CFRP Laminates Under Tensile Loads: Part 1, *Composite Science and Technology*, **1999**, 59, 123 –136.
[3] HMS Belmonte, CIC Manger and SL Ogin, Characterisation and modelling of the notch tensile fracture of woven quasi-isotropic GFRP laminates. Composite Science and Technology, **2001**, 61, 585- 597.
[4] Md. Rafiquzzaman, S Abdullah and A. M. T. Arifin, Behavioural Observation of Laminated Polymer Composite under Uniaxial Quasi-Static and Cyclic Loads, Fibers and Polymers, **2015**, 16, 640-649.
[5] G Kalaprasad and S Thomas, Hybrid Fiber Reinforced Polymer Composites, *International Plastics Engineering and Technology*, **1995**, 1, 87-98.
[6] Md. Rafiquzzaman, Md. Maksudul Islam, Md. Habibur Rahman, Md. Saniat Talukdar and Md. Nahid Hasan, Mechanical Property Evaluation of Glass–Jute Fiber Reinforced Polymer Composites, Polymer for Advance Technology, **2016**, 27, 1308- 1316.
[7] M Jawaid, HPSA Khalil, A Hassan and R Dungani and A Hadiyane, Effect of Jute Fiber Loading on Tensile and Dynamic Mechanical Properties of Oil Palm Epoxy Composites, *Composites*, **2013**, 45(1), 619–624.
[8] IK Verma, SR Anantha Krishnan and S Krishnamoorthy, Composites of Glass/Modified Jute Fabric and Unsaturated Polyester Resin, *Composites*, **1989**, 20 (4), 383- 388.
[9] KS Ahmed, S Vijayarangan and ACB Naidu, Elastic properties, Notched Strength and Fracture Criterion in Unsaturated Woven Jute-Glass Fabric Reinforced Polyester Hybrid Composite, Materials and Design, **2007**, 28(8), 2287-2294.
[10] S Dixit and P Verma, The effect of hybridization on Mechanical Behavior of Coir/Sisal / Jute Fibers Reinforced Polyester Composite Materials, *Research Journal of Chemical Sciences*, **2012**, 2(6), 91-93.
[11] KS Ahmed and S Vijayarangan, Tensile, Flexural and Inter-Laminar Shear Properties of Woven Jute and Jute-Glass Fabric Reinforced Polyester Composites, *Journal of Materials Processing Technology*, **2008**, 207 (1), 330-335.
[12] MM Thwe and K Liao, Characterization of Bamboo-Glass Fiber Reinforced Polymer Matrix Hybrid Composite, *Journal of Materials Science Letters*, **2000**, 19(20), 1873-1876.
[13] S Mishra, AK Mohanty, LT Drzal, M Misra, S Parija, SK Nayak and SS Tripathy, Studies on Mechanical Performance of Biofiber/Glass Reinforced Polyester Hybrid Composites, *Composites Science and Technology*, **2003**, 63(10), 1377-1385
[14] KS Pandya, C Veerraju and NK Naik, Hybrid Composites Made of Carbon and Glass Woven Fabrics Under Quasi-Static Loading, *Materials and Design*, **2011**, 32 (7), 4094-4099.
[15] MS Sreekala, J George, MG Kumaran and S Thomas, The Mechanical Performance of Hybrid Phenol-Formaldehyde-Based Composites Reinforced with Glass and Oil Palm Fibers, *Composites Science and Technology*, **2002**, 62 (3), 339-353.
[16] R Velmurugan and V Manikandan, Mechanical Properties of Palmyra/Glass Fiber Hybrid Composites, *Composites Part A: Applied Science and Manufacturing*, **2007**, 38 (10), 2216-2226.
[17] G Goud and R Rao, Mechanical and Electrical Performance of Roystonearegia/Glass Fiber Reinforced Epoxy Hybrid Composites, *Bulletin of Materials Science*, **2012**, 35(4), 595-599.
[18] LA Pothan, CN George, MJ John and S Thomas, Dynamic mechanical and dielectric behavior of banana-glass hybrid fiber reinforced polyester composites, *Journal of Reinforced Plastics and Composites*, **2010**, 29(8), 1131-1145.
[19] M Thiruchitrambalam, A Alavudeen, A Athijayamani, N Venkateshwaran and AE Perumal, Improving Mechanical Properties of Banana/Kenaf Polyester Hybrid Composites Using Sodium Laulryl Sulphate Treatment, *Materials Physics and Mechanics*, **2009**, 8(2), 165-173.
[20] LX Zhong, Fu Yu, XS Zhou and HS Zhan, Effect of Surface Micro-Fibrillation of Sisal Fiber on the Mechanical Properties of Sisal/Aramid Fiber Hybrid Composites, *Composites: Part A*, **2011**, 4(3), 244–252.
[21] CG Sanjeevamurthy and GR Srinivas, Sisal/Coconut Coir Natural Fibers – Epoxy Composites: Water Absorption and Mechanical Properties, *International Journal of Engineering and Innovative Technology*, **2012**, 2(3), 166-170.
[22] N Venkateshwaran, A ElayaPerumal, A Alavudeen and M Thiruchitrambalam, Mechanical and Water Absorption Behavior of Banana/Sisal Reinforced Hybrid Composites, *Materials and Design*, **2011**, 32(7), 4017-4021.
[23] C Girisha Sanjeevamurthy and Gunti Rangasrinivas, Tensile Properties of Natural Fiber-Reinforced Epoxy-Hybrid Composites, *International Journal of Modern Engineering Research*, **2012**, 2(2), 471-474.
[24] https://*skateboardpropertiesblog*.wordpress.com/*mechanical*-properties, **2013**.