RESEARCH UNIVERSITY GRANT SCHEME

Tier 1 Research Proposal

PY/2017/00300

Title of Proposal Research	:	**EXPERIMENTAL AND ANALYTICAL BENDING BEHAVIOUR OF SANDWICH COMPOSITES BEAM WITH POLYURETHANE FOAM FILLED KENAF/FRP RECYCLATES CORE**

A) PARTICULAR OF RESEARCHER

Name of Project Leader	:	**SHUKUR BIN HJ. ABU HASSAN**	Email Address	:	**shukur@utm.my**
Identity Card	:	**640319075385**	Type of Service	:	**PERMANENT**
Staff No.	:	**5244**	Staff Classification	:	**Major Research**
Position	:	**PENSYARAH KANAN (DS52)**	Handphone No	:	
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B) RESEARCHER INFORMATION

Start Date	:	**01/07/2017**	End Date	:	**31/12/2018**
Research Duration	:	**1 Year 6 Months**			
Research Area	:	**APPLIED SCIENCE**			

Field of Research

FOR Category	:	**F3010000 - ENGINEERING AND TECHNOLOGY**
FOR Group	:	**F3010100 - Mechanical Engineering**
FOR Code & Area	:	**F3010199 - Other Mechanical Engineering n.e.c.**

Socio-Economic Objective

SEO Category	:	**ADVANCEMENT OF KNOWLEDGE**
SEO Group	:	**S5010000 - NATURAL SCIENCES AND ENGINEERING**
SEO Code & Area	:	**S5019900 - Other Natural Sciences and Engineering n.e.c.**

Sponsor

Category of Sponsor	:	**NATIONAL**
Sponsor Agency	:	**Government - GOV**
Sub Sponsor	:	**UTM**
Sub Sponsor Detail	:	**RUG OF UTM**

Keyword	:	**SANDWICH COMPOSITES, KENAF FIBRE, RECYCLED FRP, PU FOAM CORE, NUMERICAL ANALYSIS**
Research Classification	:	**NOT CONFIDENTIAL**
Commercialisation	:	**POTENTIAL TO BE COMMERCIALIZED**

Team Members

No	IC No	Staff No	Name	Faculty	RA	Grade	CV
1	810807135163	11594	WONG KING JYE	FKM	FRONTIER MATERIALS	DS51A	CV-KJWONG CV.pdf
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No Record.

Researcher projects headed by the Applicant that have been completed or current ongoing in the last three (3) years.

No.	Title of research including RMC vote number	Duration	Type of Grant	Start Date	End Date	Project Status
1.	The Development and Fabrication of Automative Body Panel Structure from Glass Fiber Rubber Composite (GFRP).	1 years 0 months	Short Term	1990-12-31	1991-12-30	COMPLETED
2.	Engineering Design Data Of Advanced Polymer Composites	1 years 0 months	Short Term	1993-10-31	1994-10-30	COMPLETED
3.	Sustainable Hydrokinetic Renewable Energy (SHRE) - Hydrokinetic Turbine Energy Transmisson System (HTETS)	3 years 8 months	Others	2013-11-01	2017-06-30	ACTIVE
4.	MECHANICAL PROPERTIES OF HYBRID GLASS FIBRE RECYCLATE / MONTMORILLONITE NANOFILLER REINFORCED POLYMER COMPOSITES	1 years 3 months	Encouragement Grant	2014-04-01	2015-06-30	COMPLETED
5.	SUSTAINABLE BIOMIMETICS DESIGN OF POLYMER COMPOSITE ROTOR SHAFT FOR HYDROKINETIC APPLICATION	1 years 9 months	Tier 1	2015-05-01	2017-01-31	ENDED
6.	DEVELOPEMENT OF COMPOSITE WRAPPING FOR REPAIRING DAMAGED PIPELINES	2 years 0 months	Contract	2016-10-01	2018-09-30	ACTIVE

Information on academic publications that has been published by the researchers for the last three (3) years.

No	Title of Publication	Source	Impact Factor (IF)	Year published
1.	1ST ICRIL-INTERNATIONAL CONFERENCE ON INNOVATION IN SCIENCE AND TECHNOLOGY (IICIST 2015)	THE POTENTIAL OF BIOMIMETICS DESIGN IN THE DEVELOPMENT OF IMPACT RESISTANT MATERIAL	0	2015
2.	9TH ASIA PACIFIC STRUCTURAL ENGINEERING & CONSTRUCTION CONFERENCE (APSEC 2015) AND 8TH ASEAN CIVIL ENGINEERING CONFERENCE (ACEC 2015)	SHEAR STRENGTHENING OF SOLID TIMBER BEAMS USING HIGH STRENGTH FIBRE REINFORCED EPOXY SYSTEM	0	2015
3.	9TH ASIA PACIFIC STRUCTURAL ENGINEERING AND CONSTRUCTION CONFERENCE (APSEC2015) & 8TH ASEAN CIVIL ENGINEERING CONFERENCE (ACEC2015)	PERFORMANCE OF STEEL-CARBON FIBRE REINFORCED POLYMER PLATE BONDING SYSTEM UNDER VARIOUS ENVIRONMENTS CONDITIONS	0	2015
4.	9TH ASIA PACIFIC STRUCTURAL ENGINEERING AND CONSTRUCTION CONFERENCE AND 8TH ASEAN CIVIL ENGINEERING CONFERENCE	PERFORMANCE OF CARBON FIBRE REINFORCED POLYMER PLATE BONDING SYSTEM UNDER VARIOUS ENVIRONMENTAL CONDITIONS	0	2015
5.	CERAMICS INTERNATIONAL	MECHANICAL AND TRIBOLOGICAL PROPERTIES OF HYDROXYAPATITE NANOPARTICLES EXTRACTED FROM NATURAL BOVINE BONE AND THE BONE CEMENT DEVELOPED BY NANO-SIZED BOVINE HYDROXYAPATITE FILLER	2.086	2015
6.	CONSTRUCTION AND BUILDING MATERIALS	CHARACTERISTICS OF CONCRETE/CFRP BONDING SYSTEM UNDER NATURAL TROPICAL CLIMATE	2.265	2015
7.	INNOVATIVE PRACTICES IN HIGHER EDUCATION EXPO (I-PHEX 2015)	SHEAR STRENGTHENING OF SOLID TIMBER BEAMS USING HIGH STRENGTH FIBRE REINFORCED EPOXY SYSTEM	0	2015
8.	6TH INTERNATIONAL GRADUATE CONFERENCE ON ENGINEERING, SCIENCE AND HUMANITIES (IGCESH) 2016	MECHANICAL BEHAVIOUR OF UNBALANCED WOVEN KENAF REINFORCED POLYESTER COMPOSITES	0	2016
9.	6TH INTERNATIONAL GRADUATE CONFERENCE ON ENGINEERING, SCIENCE AND HUMANITIES (IGCESH) 2016	MECHANICAL RECYCLING OF GFRP WASTE AS REINFORCEMENT IN UNSATURATED POLYESTER COMPOSITES	0	2016
10.	ENGINEERING MATERIALS FOR SPECIFIC APPLICATION: MECHANICAL PROPERTIES	FINITE ELEMENT MODELLING FOR STRUCTURAL EPOXY	0	2016
11.	JOURNAL OF BUILT ENVIRONMENT, TECHNOLOGY AND ENGINEERING	FINITE ELEMENT MODELING OF ARCAN TESTING METHOD FOR DUCTILE AND BRITTLE MATERIAL UNDER DIFFERENT LOADING CONFIGURATION	0	2016
12.	JOURNAL OF BUILT ENVIRONMENT, TECHNOLOGY AND ENGINEERING	MECHANICAL PROPERTIES OF HYBRID WOVEN KENAF/RECYCLATE GLASS FIBRE REINFORCED POLYESTER COMPOSITES	0	2016
13.	THE JOURNAL OF BUILT ENVIRONMENT, ENGINEERING AND TECHNOLOGY (JBETE)	MECHANICAL PROPERTIES OF GLASS FIBRE WASTE/KENAF CORE REINFORCED UNSATURATED POLYESTER ECO-FRIENDLY COMPOSITES	0	2016

No	Title of Publication	Source	Impact Factor (IF)	Year published
14.	INTERNATIONAL JOURNAL OF ADVANCED AND APPLIED SCIENCES	FLEXURAL AND INTERLAMINAR SHEAR STUDY OF HYBRID WOVEN KENAF/RECYCLED GFRP (RGFRP) COMPOSITES SUBJECTED TO BENDING LOAD	0	2017
15.	INTERNATIONAL JOURNAL OF ADVANCED AND APPLIED SCIENCES	MECHANICAL PROPERTIES OF RECYCLED GLASS FIBRE REINFORCED NANOCLAY/UNSATURATED POLYESTER COMPOSITES	0	2017

Executive Summary of Research Proposal

Sandwich construction is an effective method of producing stiff and lightweight structures in order to tailor with design philosophy in automotive, marine and aerospace sectors. In mechanics structure, the sandwich skins act to resist the tensile and compressive stresses resulting from the bending moment induced by transverse loadings, while the core to resists shear stresses. Current polyurethane (PU) foam used as core in composites sandwich structures has low stiffness in both axial/bending and shear due to porosity properties which leads to low rigidity. The load transfer efficiency of sandwich structures is extremely denominated by interface bond strength between skins and core as well as core rigidity. By introducing fibrous wood and FRP recyclates (rFRP) fillers into the polyurethane foam, it is expected to improve both shear stress distribution efficiency and structural rigidity as a whole. Hybridization of kenaf fibre and rFRP has a great potential to be used as a filler to improve PU foam stiffness. The addition of rFRP is expected to increase interfacial bonding between the skin and the core by providing an efficient mechanical interlocking at the interface. Meanwhile, kenaf core in short fibrous form expected to increase PU foam stiffness. The core and sandwich test samples will be tested under mechanical load to obtain theirs respected properties for example flexural and shear stiffness and interfacial bond strength between skins and core. The validated numerical analysis (FEA) model will be used to analyze further bending behaviour of sandwich composites beam with PU Filled Kenaf/rFRP core samples with variables that experimental method is limited. The expected finding will be translated into engineering database such as in form of graphs of beam flexural rigidity versus deflection and core thickness and local bond stress distribution along shear span and all those relationships are function of in filler weight percentages.

Detailed proposal of research project:
(a) Research background including Hyphothesis/Research Questions and Literature Review:

Research Questions

1. What is the optimal mixture ratio of kenaf and FRP recyclates as filler to reduce porosity in PU foam?
2. Does the inclusion of kenaf/FRP recyclate filler increase flexural rigidity of the composites sandwich beam?
3. Does the inclusion of FRP recyclates improve the interfacial bond strength between the core and the skin of the sandwich structure?
4. Will numerical model be able to predict the behaviour of the composites sandwich beam due to the effect of kenaf/FRP recyclates filler inclusion in PU foam core?

Literature Review

Sandwich structures made of fibre reinforced polymer (FRP) skins and light-weight core materials are very effective approach for designing high load bearing and performance structures where lightweight is required. Generally, the sandwich structure uses thin, stiff, and strong FRP skins to resist the tensile and compressive stresses resulting from bending moments and axial forces, meanwhile the lightweight core made of either soft or rigid materials used to resists shear forces. As a result, the bending strength and lateral stiffness of sandwich structures are much larger than those of a single solid plate or beam (Zinno et al. 2008). Due to that, sandwich type structure is the right selection for aerospace, automotive, and marine industries (Fam et al. 2016).

Synthetic fibres and foam typically emits significant greenhouse gases contributing to the global warming and very difficult to recycle or convert to another form of product when their life span ended. Natural fibres extracted from plants (e.g. kenaf, flax, hemp, jute, and etc.) are good examples of renewable materials that offer technical and ecological advantages over synthetic materials to replace either fully or partially the core or the skins materials.In order to produce lightweight and rigid core materials, the core constituent requires low density materials such as polymer foams or balsa wood (Azmi et al., 2013).

Kenaf (*Hibiscus cannabinus*) has many potentials in bio-composite application. Based on their basic properties, both the bast fibres and core material of kenaf are distinctly different. While bast fibres are stiffer and low in wettability, the core material of kenaf is weaker and has excellent absorbing properties. Low density of kenaf core fibre (0.28g/cm3) makes it suitable for core material for sandwich composites (Nar et al., 2015). Previous studies have revealed the potential of kenaf core to make insulation composites (Batouli et al., 2014), medium-density particleboards (Birnin-Yauri et al., 2016), fire retardant-treated particleboards (Ayadi et al., 2016) and polymer composite. Hence, kenaf core is the preferable natural fibres to be utilized as core material in polymer sandwich composites.

Current standards suggest that PU foams utilized in sandwich core need to exhibit high stiffness in both tensile and compressive properties. Therefore, in this study, the rigidity of PU foams needs to be increased in order to be used in sandwich beam. Traditionally, to increase the rigidity of PU foams, the isocyanate content was increased. Composite theory suggests that fillers in the form of fibres embedded in a weaker matrix will improve the overall stiffness. Many recent studies (Nar et al., 2015; Yu et al., 2014; Hamilton et al., 2013; Gu et al., 2013; Shah et al., 2015; Yu et al., 2016; Wang et al., 2008; Kim et al., 2010) have discovered that introducing fibres into weaker foam matrices will improve the stiffness of the foam in compression, shear and tension. For example, Gu et al., (2013) found improvements in compressive strength when wood fibre was added to PU foams, and Siegmann et al. (1983) discovered increases in compressive modulus when virgin glass fibre and powder were added. However, previous studies have not covered the hybridization of kenaf and recycled FRP. Other than that, there is little understanding of how the fibre length and fibre aspect ratio affect fibre reinforcement in foams.

The investigation of adding milled glass fibres (280 micron) and nanoparticles (montmorillonite-carbon nanotubes) at different mass fractions into PU foams shows positive results in increasing the rigidity and stiffness of the PU foam (Hamilton et al., 2013). The analysis reveals nanoclay-PU foams exhibit up to an 11.1% degree of reinforcement, and glass fibres-PU foams up to 18.7%. This study can be improvise by replacing the milled glass fibres with recycled GFRP (rGFRP) because the fibre length and fibre aspect ratio of rGFRP is similar to the milled glass fibres. According to Hanan et al. (2017), fibre length of grounded rGFRP in the form of powder is approximately below 1000 micron. Further sieving process of rGFRP powder can be used to select appropriate fibre length and to be utilized as filler in PU foam.

Nar et al. (2015) explores the possibility of using kenaf core as reinforcement in PU foam. The compressive and flexural properties show improvement for PU foams with kenaf core at all loading percentages due to dense packing of more number of smaller foam cells as seen from ESEM images. This dense packing has contributed positively to the compressive and flexural properties. However, this study only limited to three type of weight percentage of kenaf core which 5, 10 and 15 wt.% only and did not consider the effect of kenaf fibre at various fibre length for reinforcing the PU foam.

Recently, study shows how the reinforcing fibre length can have an effect on the mechanical properties of PU foam. Hussain and Kortschot (2015) investigate the effect of fibre length and fibre aspect ratio on the reinforcement of soybean-based PU foams. Micro-crystalline cellulose fibres (50-μm) and 260-μm long glass fibres embedded inside PU foams were studied separately. The fibre reinforcement provided by the short MCC fibres was significant, but still much lower than the reinforcement observed in previous studies (Hussain et al., 2014) using 470-μm glass fibres in the same matrix foam system. The inclusion of 260 mm glass fibres, in contrast, produced almost no reinforcement. The 260 mm fibres were not long enough to form a mechanically percolating network, as confirmed by the tomography and the measured foam moduli. Furthermore, the 260μm fibres do not embed or reinforce the struts as observed for the MCC fibres.

South Koreans researchers (Yu et al., 2014), study the PU foam reinforced with chopped E-glass fibre at four different weight percentages of chopped E-glass which are 2.5, 5.0, 7.5 and 10.0 wt.%. The chopped glass fibre used in this study is 7mm in length. From the experimental results, it was found that the compressive strengths of the PU foam increased 35% and 54% at the room and cryogenic temperatures, respectively when the weight percentage of chopped glass fibre was 10%, while the tensile strengths increased 220% and 210% with the same weight percentages of 10% at the room and cryogenic temperatures, respectively. Based on this study, the use of rGFRP can be applied as reinforcement in PU foam. Study by Hanan et al. (2017) indicate that the grounded rGFRP of coarse grade has an average fibre length of 4-15mm which can provide a good reinforcement for PU foam.

Hybridization of kenaf core and rGFRP as lightweight particle board using urea formaldehyde binder has been studied (Amin, 2015). The study compared the internal bonding strength and bending properties of kenaf core particle board with hybrid kenaf core-rGFRP (70:30 wt/wt). The hybrid particle board shows an increase of 20% in term of flexural strength and modulus when the mixture of kenaf core and rGFRP is uniform as examined under optical microscopy. Furthermore, the internal bonding strength shows slight improvement in hybrid samples. The inclusion of rGFRP in the hybrid particle board increases slightly the board density by about 10% compared to kenaf only particle board.

The study on structural integrity effect of interleaf glass fibre mat and recycled GFRP waste (rGFRP) in woven kenaf reinforcement polyester composite was conducted by Jamal et al.(2017). Three types of composites samples were fabricated; 2 layers (2L) kenaf name as (KL00), 2L-kenaf/glass mat composites with chopped stand mat glass fibre (CSM) interleaf name as (KLCSM) and 2L-kenaf/rGFRP with the weight same as areal weight density as CSM name as (KLF100). Results revealed that the flexural strength and flexural shear measured for KLF100 were increased compared to KL00 and KLCSM. For instance, the flexural strength of KL00, KLCSM, KLF100 is 123.39 MPa, 124.07 MPa and 181.98 MPa respectively. The bending properties of woven kenaf composites using rGFRP as interleaf reinforcement shows good interlocking between kenaf and rGFRP. Based on this study, the use of rGFRP in PU foam core can possibly increase the interfacial bonding of core to the skin of the sandwich composites structure.

There are several studies on numerical analysis of Sandwich Composites with PU Foam Core and most of them focus on the failure mechanisms of sandwich panels. However, development of numerical model for sandwich composites beam have been made by some researchers to provide better understanding on its mechanical behaviour. Steeves and Fleck (2004a) developed a numerical model for sandwich beams in three-point bending using elastic skins and a foam damage model using ABAQUS. The results supported their analytical model of the collapse mechanisms (Steeves and Fleck, 2004b) and more accurately represented the measured responses during plastic deformation (Steeves and Fleck, 2004a).

Rizov (2008) investigated the importance of modeling damage for a sandwich beam under local indentation loading. A custom failure criterion was applied to the skins and was compared to Steeves and Fleck (2004a) purely elastic model. Rizov (2008) found that at smaller indentations, the two models agreed reasonably, but after a certain point, the linear elastic model began to overestimate the beam's strength (Rizov, 2010). Innumerical investigation of sandwich composites beam nonlinear failures, the plastic behaviours of both the foam (crushing) and the skins (progressive failure) must be considered. One of the required parameters in the ''Crushable Foam'' material model in ABAQUS is the ratio of yield stress in hydrostatic tension to initial yield stress in hydrostatic compression (Hibbitt et al, 2010). These values, however, are quite difficult to test, and an assumption value of 10% for this ratio is recommended by ABAQUS. However, this assumption is often inaccurate when any large tensile stresses are involved. Since the dominating stresses in a sandwich beam's core are compressive in nature, modifying this ratio should have minimal effect on the outcome of the simulation (Mines and Alias, 2002).

On the materials, Almeida et al. (2009) has demonstrated that composite sandwich panels using PU foam core between two GFRP skins have a great potential for structural applications, with a considerable strength and stiffness, particularly when reinforced with lateral GFRP ribs. The numerical models developed, which were calibrated with the experimental results, in general, are able to simulate the static and dynamic mechanical behaviour of the PU sandwich panels, for both service and failure conditions. Yu .et. al. (2016) studied on the mechanical properties of hollow glass microsphere/epoxy resin syntactic foams reinforced by short glass fibres using volume fractions and wall thickness as parameters. It is observed that addition of glass fibres increases the elastic modulus values of the composites structures, and large stress distribution areas on microspheres are reduced. The fibres aligned with the loading direction play an important load bearing role, indicating that adding fibres is beneficial to the improvement of the mechanical performance of syntactic foams such as Polyurethane.

References

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(b) Objective (s) of the Research

No	Objective
1	1. To determine the tensile and shear properties of polyurethane (PU) foam filled kenaf/FRP recyclates core
2	2. To investigate the interfacial bond behaviour between polymer composites sandwich skin and polyurethane foam filled natural fibre/FRP recyclates core
3	3. To study the flexural rigidity behaviour effect from filler materials mixture ratio and fibrous sizes on the polymer composites sandwich beam
4	4. To model and analyse the effect of behaviour of sandwich polymer composites beam under bending load under geometrical and filler volume fraction

(c) Methodology
1.Description of Methodology

1. PU foam filled Kenaf/FRP recyclates Core Materials System

1. KenafCore (KC) fibrous in form of chip at different sizes.
2. CFRP recyclates (rCFRP) at different fibre sizes.
3. GFRP recyclates (rGF) at different fibre sizes.
4. High density polyurethane (PU) Foam
5. Various core thicknesses (10, 15, 20, 25 and 30mm)

2. Core Fabrication

The polyurethane foam will be produced by mixing the polyol and isocynates. When the mixing of polyol and isocynate were prepared, the selected filler materials ranging from 0 wt% to 20 wt% will be added and stirred to ensure the filler materials is uniformly distributed in the mixture PU foam. Themixture then will be poured into the metal mould and left cured at a room temperature under constant compression load for 24 hours to ensure a perfect curing cycle.

3. Skins Material

1. Carbon fibre fabric/Epoxy (CFRP)–ranging from 1 to 6 layers
2. Glass fibre fabric/Epoxy (GFRP) –ranging from 1 to 6 layers
3. Fibre to matrix (epoxy) ratio is fixed to 45:55 by weight (wt%)

4. SkinsPreparation

Sandwich skin will be prepared by using compression moulding technique. The fabric reinforcing fibres will be impregnatedwith low viscosity epoxy system in order to ensure good impregnating process. The laminate (skin) will be left under constant compression load for 24 hours to ensure perfect curing cycle under laboratory room conditions.

5. Sandwich Beam Sample Preparation

The polymer composites sandwich samplesin form of small scale beam will be prepared by applying epoxy adhesive thin layer on both bond surfaces of skin and core. The bonded area will be kept under compression load at least for 12 hours in order to ensure good adhesion between both materials.

6. Testing

Series of mechanical testing will be conducted namely:

1. Tensile test for skin material (ASTM D3039)
2. Flexural and shear test for sandwich beam stiffness (ASTM D7250)
3. Bond test between skin and core (BS 4994-1987).
4. Compression test for corematerials (ISO 844 or ASTM Standard D1621)
5. Arcan(Shear) test for core materials

The types test above will be conducted to determine the following properties:

1. Skin Young Modulus, Es
2. Flexural and shear stiffness of sandwich beam
3. Core Young Modulus, Ec
4. Core Shear Modulus, Gc and Shear Strength, τc
5. Bond strength between skin and core, τs
6. Local bond stress distribution along beam shear span, τLocal

7. Numerical modeling and analysis

The numerical analysis (FEA) will be performed using ABAQUS software to validate bending behaviour of sandwich composites beams with PU Filled Kenaf/rFRP core samples with variables that experimental method is limited. Studied parameters consists as follows:

1. Filler wt.%
2. Core thickness
3. Skin layers
4. Foam density
5. Different core cross section

2.Flow Chart of Research Activities (Please enclose in the Appendix)
3.Grantt Chart of Research Activities

Project Schedule

No	Task	Start Date	End Date
1	Experimental Design	2017-07-01	2017-08-31
2	Literature Review	2017-07-01	2018-12-31
3	Material and Rig Preparation	2017-08-01	2017-10-31
4	Test Samples Fabrication	2017-09-01	2017-12-31
5	Experimental Work	2017-11-01	2018-03-31
6	Results Analysis and Discussion	2017-12-01	2018-12-31
7	Numerical Modeling and Analysis	2018-02-01	2018-07-31
8	Report Writing	2018-11-01	2018-12-31

Project Milestone

No	Milestone	Date (YYYY/MM/DD)
1	Test Samples Completed	2017-12-31
2	Experimental works completed	2018-03-31
3	Numerical modeling and analysis completed	2018-07-31
4	Report writing completed	2018-12-31

C) ACCESS TO EQUIPMENT AND MATERIAL

No	University	Place
1	100kN Compression Testing Machine	Structures and materials laboratory, D04, Faculty of Civil Engineering, UTM JB
2	100kN Universal Testing Machine	Material and Structure Laboratory, E04, Faculty of Mechanical Engineering
3	10kN Universal testing machine	Centre for Composites, P23
4	Hydraulic Press Machine 50 ton	Centre for Composites, P23

No Record.

D) BUDGET

V-Series	SODO Type	Description	Cost Year 1 (01/07/2017 - 30/6/2018)	Cost Year 2 (01/07/2018 - 30/6/2019)	Justification	Total Per Item	RA Recommend	
V11000 Salary & Wage / Overtime (Capping 0.0%) Salary Rate	B11000 Salary & wages		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
	B12000 Fixed allowances		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
	B13000 Statutory contributions to public staff		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
	B14000 Overtime		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
	B15000 Other financial benefits staff		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
Total Per VSeries			**0.00**	**0.00**		**(0.00%)** 0.00	0.0	**0.0**
V21000 Travelling expenses & Subsistence (Capping 20.0%)	B21000 Travel & subsistence	CONFERENCES, INDUSTRIAL VISIT AND MEETING	1500.0	1000.0				
	Total Per SODO		**1500.00**	**1000.00**		**2500.00**		
	B22000 Transport of goods	TRANSPORTATION OF RAW MATERIAL	1000.0	1000.0				
	Total Per SODO		**1000.00**	**1000.00**		**2000.00**		
Total Per VSeries			**2500.00**	**2000.00**		**(12.68%)** 4500.00	0.0	**0.0**
V24000 Rentals (Capping 0.0%)	B23000 Transportation & utilities		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
	B24000 Rentals		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
Total Per VSeries			**0.00**	**0.00**		**(0.00%)** 0.00	0.0	**0.0**
V26000 Research Materials & Supplies (Capping 0.0%)	B26000 Raw materials & spare parts	RECYCLATE GFRP AND CFRP, KENAF CORE, EPOXY RESIN POLYURETHANE FOAMS, GLASS	8000.0	8000.0				

		FIBRE FABRICS, CARBON FIBRE FABRICS						
	Total Per SODO		**8000.00**	**8000.00**		**16000.00**		
	B27000 Supplies & consumable goods	STRAIN GAUGES, SPRAY MOULD WAX, RUBBER GLOVE, ACETONE, MIXING CONTAINERS, PPE, ROLLER, BRUSH,	3000.0	2000.0				
	Total Per SODO		**3000.00**	**2000.00**		**5000.00**		
Total Per VSeries			**11000.00**	**10000.00**		**(59.15%)** 21000.00	**0.0**	**0.0**
V28000 Maintenance & Minor Repair Service (Capping 0.0%)	B28000 Maintenance & repairs		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
Total Per VSeries			**0.00**	**0.00**		**(0.00%)** 0.00	**0.0**	**0.0**
V29000 Professional Services (Capping 0.0%)	B29000 Professional services & hospitality	TEST RIG DESIGN AND FABRICATION, TESTING SERVICES, MOULD FABRICATION.	5000.0	5000.0				
	Total Per SODO		**5000.00**	**5000.00**		**10000.00**		
Total Per VSeries			**5000.00**	**5000.00**		**(28.17%)** 10000.00	**0.0**	**0.0**
V35000 Special Equipment & Accessories (Capping 40.0%)	B35000 Assets & equipments		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
	B36000 Inventory & furnitures		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
Total Per VSeries			**0.00**	**0.00**		**(0.00%)** 0.00	**0.0**	**0.0**
V40000 Biasiswa, Dermasiswa dan Bantuan Pelajaran (Capping 0.0%)	B41000 Biasiswa, Dermasiswa dan Bantuan Pelajaran		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
Total Per VSeries			**0.00**	**0.00**		**(0.00%)** 0.00	**0.0**	**0.0**
V50000 Other Charges & Distribution (Capping 0.0%)	B52000 Other Charges & Distribution		0.0	0.0				
	Total Per SODO		**0.00**	**0.00**		**0.00**		
Total Per VSeries			**0.00**	**0.00**		**(0.00%)** 0.00	**0.0**	**0.0**
GRAND TOTAL						35500.00		

E) EXPECTED OUTPUT

Indexed Paper = 2

Matching Grant (External) = RM 35500

F) DECLARATION BY APPLICANT

☑ 1. All information given are correct. UTM has the right to reject or to cancel the offer without prior notice if there is any incorrect information given.

Name: SHUKUR BIN HJ. ABU HASSAN
Date: 2017-05-08

Back