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Dr. Shukur Abu Hassan

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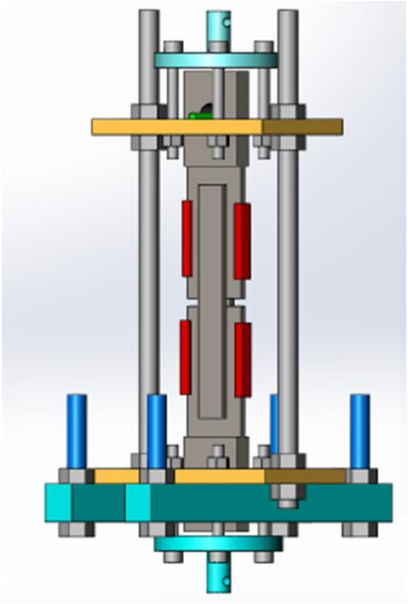
RESEARCH AREA

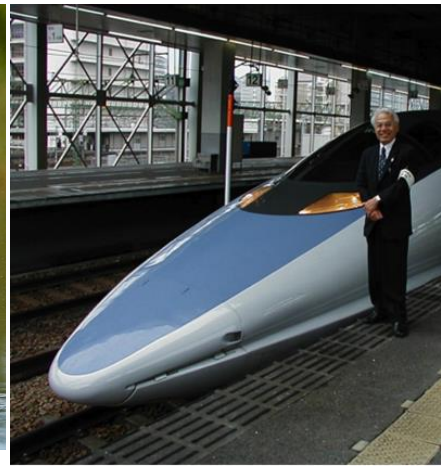
BOND DURABILITY

ECO-COMPOSITES MATERIALS (FRP WASTE + NATURAL FIBRE COMPOSITES)

and

BIOMIMETICS





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Glass Fibre Recyclate Reinforced Polyester

An Eco-Friendly Composites

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Centre for Composites
Research Group

Introduction

Background & Motivation

Every year, it is projected that more than 6 million tonnes of polymer matrix composite (PMC) products are manufactured worldwide, mostly dominated by glass fibre reinforced polymers (GFRPs) (Lester *et al.*, 2004). Furthermore, the amounts used are increasing annually. Increased PMC usage has led to mounting pressure to resolve issues relating to composite waste. For instance, sheet moulding compound (SMCs), which are based on glass fibre reinforced unsaturated polyester resin and one of the most commonly used composite materials, waste increase from 0.1 million tonnes in 1984 to about 0.4 million tonnes in 2000 (Perrin *et al.*, 2008). PMCs from thermosetting polymers are less obviously recyclabe because of the inability to remould them. However, several techniques can be used to breakdown these materials such as thermal recycling, chemical recycling and mechanical recycling (Asmatulu *et al.*, 2013). The use of mechanical means for recycling thermoset composite waste has received the most attention (Pickering and Beg, 2010).
Currently, extensive study has been done to explore the potential of glass fibre recyclate reinforced unsaturated polyester composites (rGFRP) for load bearing applications.

Materials and Methods

- **Glass fibre recyclate (rGF) was obtained through mechanical recycling process.**
- **rGF was used as reinforcement in polyester resin to create rGFRP composites.**

Flow Diagram of the Mechanical Recycling of PMC Waste (Makenji, 2010)


Examples of GFRP Waste

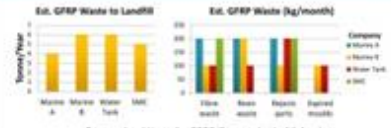

Granulation of GFRP Waste in Hammer Mill


Glass Fibre Recyclate (rGF)

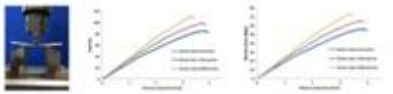

Diagram of Hammer Mill


Glass Fibre Recyclate Reinforced Polyester Composites (rGFRP)

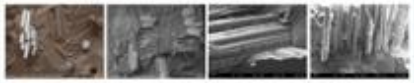
Current Results



Composites Waste by GFRP Companies in Malaysia


Bending Strength of rGFRP Composites

Tensile Properties of rGFRP Composites at Different rGF Percentage


Scanning Electron Microscope of Fractured Surface of rGFRP

Vacuum Assisted Resin Transfer Moulding (VARTM)

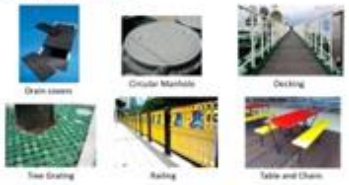
Trends & Directions

Future Directions

The mechanical performances of rGFRP composites can potentially be improved by:

- **Incorporating fillers or nano-fillers.**
- **Surface treatment of rGF to improve interfacial bonding with resin.**
- **Hybridizing with other recylates such as carbon fibre recyclate or Kevlar recyclate.**

Potential Applications



Medium Load Bearing GFRP Products

Conclusion

- Recycling of thermoset-based PMCs via mechanical means is the most commonly used method.
- Further study is required for rGF to be successfully used in PMC with load bearing capabilities.
- rGFRP is an eco-friendly material that reduces landfilling and incineration of GFRP waste.

Acknowledgements

The research team would like to acknowledge UTM for their support and funding of the research projects.

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ECO-COMPOSITES MATERIALS

environmental friendly materials

Mechanical Recycling of GFRP waste

GFRP WASTE

MECHANICAL RECYCLING

RECYCLATE

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GFRP RECYCLATE

Fibre Sizing Process

Recyclates
or
recycled glass fibre
or
Raw rGF

Sieve Shaker

Coarse rGF **(CrGF)**

Powder

Fine rGF **(FrGF)**

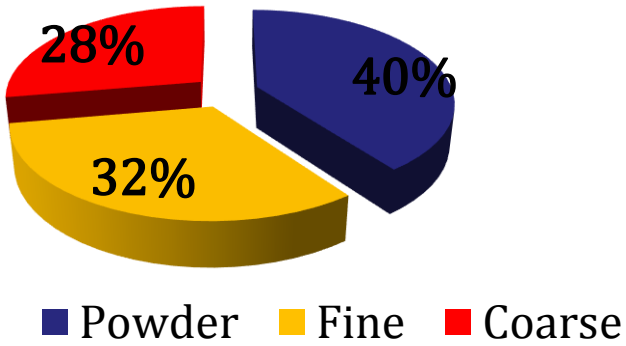
RESULTS

Fibre Size Groups

Recyclates Composition

Recyclate Grade	Weight Composition (%)	Fibre Length (mm)
Powder	40	<1
Fine (FrGF)	32	1-6
Coarse (CrGF)	28	4-15

Coarse rGF **(CrGF)**



Fine rGF **(FrGF)**

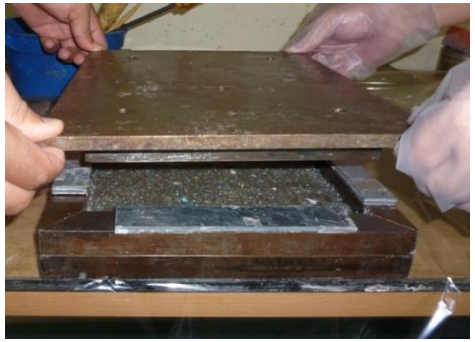
TEST SAMPLE

Compression Moulding Process

UP/MMT mixed with MEKP

rGF placed into the mould evenly

Resin poured into the mould and distributed by roller



Mould closed

Applied Pressure 100 bar

HYBRID WOVEN KENAF/RECYCLED GLASS FIBRE REINFORCED POLYESTER COMPOSITES

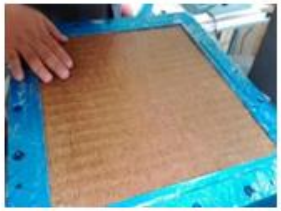
(a) Kenaf composites

(b) Kenaf/glass composites

(c) Kenaf/rGFRP composites

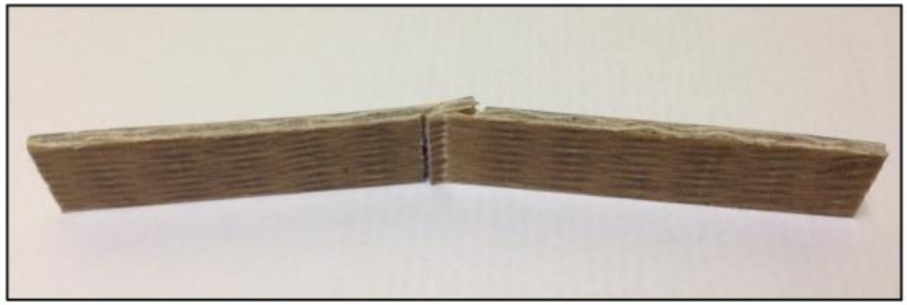
(a) Woven kenaf cut into mold size

(b) rGFRP interleaf between 2 layer kenaf

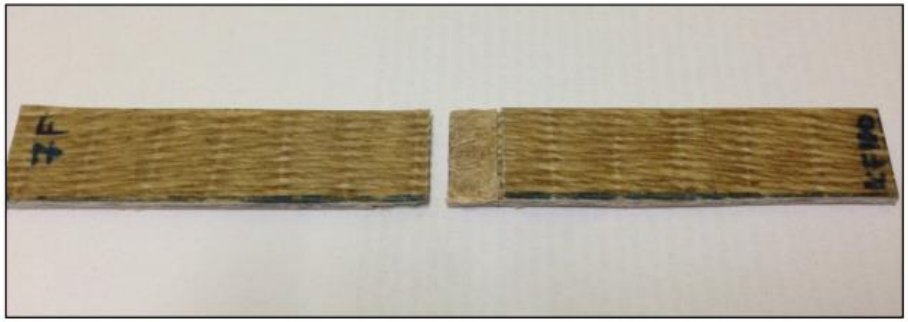


(c) Cured sampled after 24 hours in room temperature

INTERLAMINAR BEHAVIOUR OF KENAF/GFRP RECYCLATE REINFORCED POLYESTER



Bridging failure



Breakage failure

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Biomimetics in Engineering Composites Applications

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Research Group

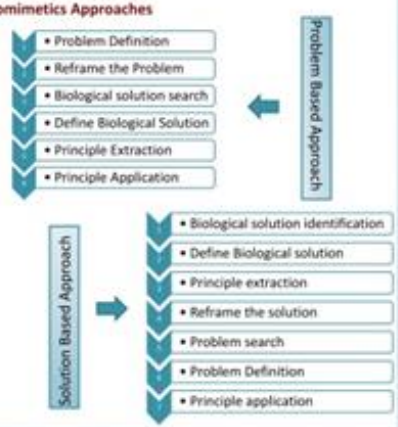
Introduction

Background & Motivation

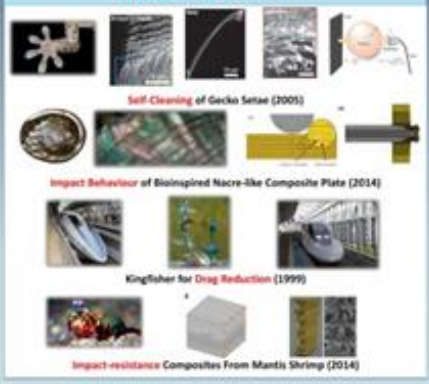
Nature has arrived to an optimal and efficient through natural selection after billion years of evolution. The word 'Biomimetics' was coined by Otto Schmitts for the transfer of ideas from biology to technology applications. Biomimetics rise the attention of researchers nowadays as Janine Benyus, a biologist who actively encourages and promotes the need to mimic biological model from nature by emerging discipline of Biomimetics .

Since the emerging of Biomimetics design, this discipline has keep enlarge its influence in the field of design, architecture, medical, and engineering. Now, biomimetics also refer as biomimicry, biognosis, bio-inspiration or biologically inspired design. In present time, Biomimetics is developing into a new creative design discipline that can be classified into two groups of physical biomimicry and behavioural biomimicry. Physical biomimicry focused on translating the interesting physical qualities of biological model while behavioural biomimicry stressed on imitate the functional advantages of creatures such as self-diagnosis, self-healing or water repellent effect.

Biomimetics Approaches



Literature Review



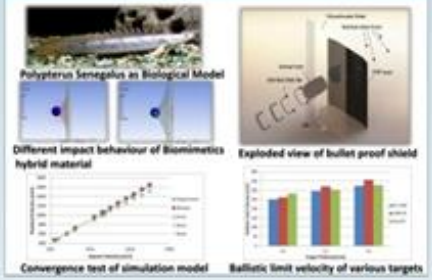
Self-Cleaning of Gecko Setae (2005)

Impact Behaviour of Bioinspired Nacre-like Composite Plate (2014)

Kingfisher for Drag Reduction (1999)

Impact-resistance Composites From Mantis Shrimp (2014)

Current Results



Polypterus Senegalus as Biological Model

Different impact behaviour of Biomimetics hybrid material

Exploded view of bullet proof shield

Convergence test of simulation model

Ballistic limit velocity of various targets

Trends & Directions

Current & Future Directions

- Bullet Proof Hybrid Materials Inspired From Fish Scale
- Hydrokinetic Shaft Inspired From Nature
- Biomimetics Design and Composites Manufacturing Process
- Durable Composites Inspired by Bamboo
- Composites Sandwich Structure Inspired by Bananas Tree

Conclusion

- Nature provides us unlimited inspirations for engineering applications. Better understanding in biological and ecological, developed different angle of engineering design from large and strong concepts to sustain concepts aided and support by analytical, experimental and computational tools the biomimetic concepts become part of engineering application.

Acknowledgements

We would like to thank MOE and UTM for their continual support in this research projects.

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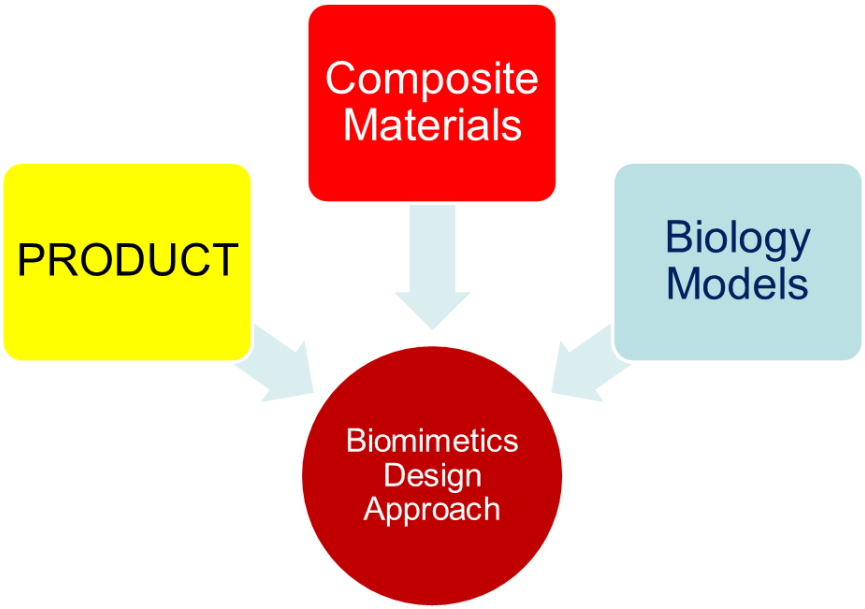
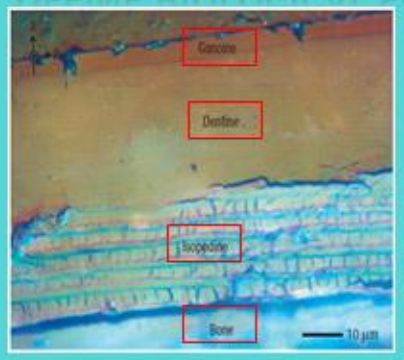
BIOMIMETICS

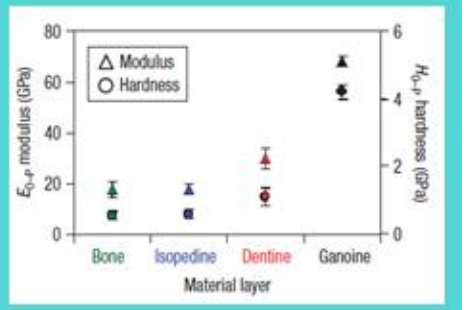
Bringing Nature for Sustainable Engineering Design



BIOMIMETICS: BULLET PROOF SHIELD

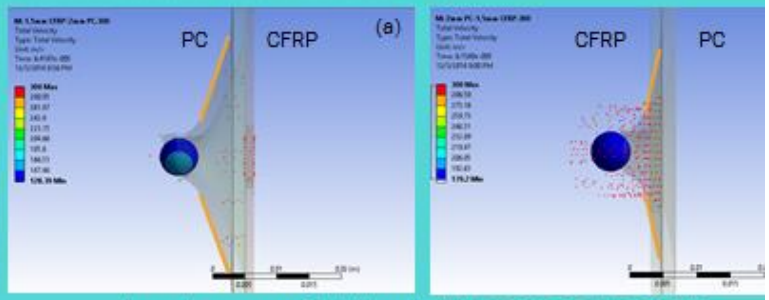
DEFINE BIOLOGICAL SOLUTION





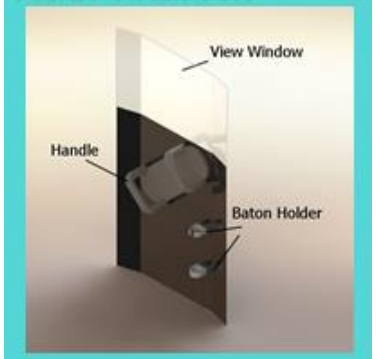
Reference: Benjamin J.F. Bruet, Juha Song et al. Materials design principles of ancient fish armour. Nature Materials, 2008. 7:748-756.

DEFORMATION BEHAVIOUR

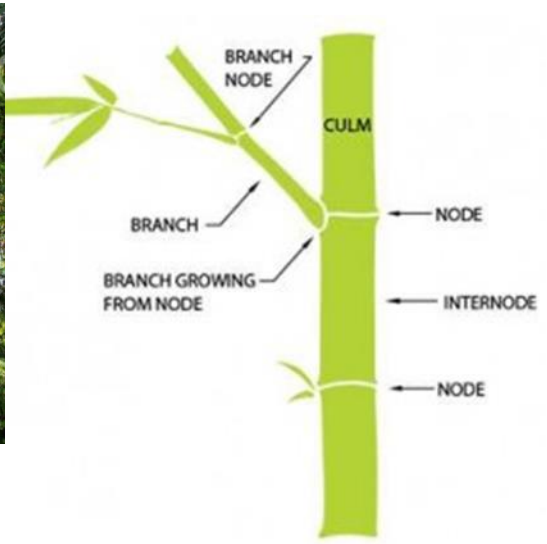


Impact response of hybrid material. (a) CFRP-PC; (b) PC-CFRP

FINAL CONCEPT



BIOMIMETICS: COMPOSITES HARVESTING POLE



BIOMIMETICS: ECO-CARE TRASH TRAP

‘Biomimetics’ design approach is the imitation of model/system that resembles the nature. The prototype will be designed to fit larger drainage (up to 10 meters wide) that only rely on the natural gravity flow and will be installed floating across the waterways. The prototype also requires no power pumps or electrical devices since it relies on the natural gravity flow and will be installed floating across the waterways.

THE END

Thank You