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Effects Of Kenaf And Basalt Facesheets Modified Nanosilica Of Closed Cell Aluminium Sandwich Panel

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Abstract*: *Sandwich structure made of metal sheet and foam core is widely used in various industries due to its excellent energy absorption and impact resistance properties. Recently, fiber reinforced polymers (FRP) such as carbon fiber reinforced polymer and glass fiber reinforced polymer have been used in sandwich panel as a face sheet. The addition of filler into FRP system is expected to enhance the mechanical properties and improve the specific strength of the resulted FRP. This paper presents the impact response of silica nanoparticles filled kenaf fiber reinforced polymer (KFRP) and basalt fiber reinforced polymer (BFRP) as a facesheet in sandwich structure. A series of nanocomposites, with 5wt%, 13wt% and 25wt% of silica nanoparticles were fabricated using mechanical stirrer. The KFRP and BFRP facesheets were fabricated using vacuum bagging method. The impact response of closed cell aluminium foam and natural FRP sandwich panel was investigated. It was found that, the addition of nanosilica into BFRP and KFRP facesheets results in higher energy absorbed required initiating the impact damage. The fractured surfaces of upper and lower face sheets and fracture mechanisms during impact test such as delamination between kenaf-nanomodified epoxy layers, basalt-nanomodified epoxy layers and aluminium core shear were evaluated.

Index Terms*: *Sandwich Panel, Closed Cell Aluminium Foam Core, Kenaf Fiber, Basalt Fiber, Silica Nanoparticle.

I. INTRODUCTION

Sandwich structures generally are contained of two facing skin layers and a lightweight core to carry shear loads. Usually, the material with high stiffness and strength such as metals or fiber reinforced polymers were used as face sheets. Common core materials used in sandwich structure are foam, honeycomb or truss structure to minimalize the weight of the composite itself [1]. Sandwich structure were used in numerous applications such as construction, automotive and aeronautical sector due to their excellent mechanical properties and light weight materials [2], [3].

Natural fibers are employed due to their outstandingly sustainable, biodegradable, eco-friendly and economic properties [4]. Natural fiber based composites have shown excellent mechanical properties comparable to those glass fiber [5]. Wu et al. [6] developed kenaf fiber reinforced polymer (KFRP) replacing glass fiber-SMC as automotive panels. It was found that natural fiber enhanced mechanical properties of the composite and reduced energy consumption [6]. Recently, numerous researchers have studied the effect of nanofillers on impact behaviour of composite laminates. A previous study conducted by Mingze Ma [3] has shown that fiber reinforced polymer – carbon nanotubes offer an enhancement towards the impact properties. Glass-flax with 1% wt-MWCNTs FRP presented better impact properties compared to the carbon – flax FRP with 1% wt-MWCNTs as reported by Ismail et al [4]. Another study on polymer nano-composites with nanomodified epoxy resin using nanoclay, revealed that addition of filler into the composite had prolonged the impact time [5].

Impact response of aluminium (Al) foam sandwich panel with variable face sheets is one of the current research area that need to be further explored. The effect of face sheet on the low velocity impact response of Al foam sandwich panels was studied by a few researcher. It was observed that a stiffer facesheet offers more impact resistant absorbed when subjected to low velocity impact. For example, the low velocity impact response of the Al foam sandwich structure with both aluminium and woven E-glass fiber as facesheets was observed by Cesim and Umut et al. [9]. The energy absorption improved by 60 % when the thickness of the facesheets are increased. Drop weight impact test on Al foam sandwich panels with aluminium and CFRP face sheets was conducted by Guanyong et al. [7]. It suggests that the combination of aluminium and CFRP as a facesheets offers better energy absorption capacity than using the pure system that consists only one type of material as facesheets [8]. Crupi et al. [9] also reported that the failure of these sandwich panels was strongly influenced by the inflexibility of the facesheets.

Therefore, this work is intended to examine the impact resistance responses of KFRP- and BFRP-Al foam sandwich panel with different impact energy level (20J and 40J) using drop weight impact test. FRP embedded silica nanoparticles was employed in this study as a facesheet to evaluate how much nanofillers influence the mechanical properties especially stiffness, strength and strain to failure of the sandwich panel. Unmodified and nano modified specimens of KFRP and BFRP were prepared to study the influence of silica nanoparticles filled facesheet composite laminates on the impact resistance of the sandwich panels.

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II. EXPERIMENTAL SETUP

A. Materials

The facesheets specimens were fabricated using Miracast 1517 A/B resin system purchased from Miracon Industry Sdn. Bhd., Selangor, Malaysia. The twill weave type of Basalt fibre and kenaf fibre were used as reinforcement material and purchased from Innovative Pultrusion Sdn.Bhd. Nanopox F400 nanosilica manufactured by nanoresin, Germany was used as the nanofiler material in the face sheet composite. Vistec Technology Sdn. Bhd supplied the commercial closed-cell aluminium foam. The dimension of closed-cell aluminium foam was 500 mm length x 500 mm width x 30 mm thickness which are prepared in the form of a wide plate.

B. Fabrication of Composites

Basalt fiber reinforced polymer (BFRP) and Kenaf fiber reinforced polymer (KFRP) facesheet composites were fabricated using vacuum bagging method. For unmodified face sheet composite laminates, epoxy resin and hardener were mixed in a ratio of 100:30 while for nanomodified face sheet composite laminates; mechanical stirrer was used to mix the silica nanoparticles into epoxy resin about an hour before the hardener was added. Three different weight percentages of silica nanoparticles were used in this study: 5wt%, 13wt% and 25wt%. The composite laminate specimens were made of 6 layers of woven fiber were laid onto silica nanoparticle epoxy resin to reached 2mm thickness of face sheet composite laminates. The laminates were vacuumed about an hour to remove entrapped bubbles. The specimens were cured about 24 hours at room temperature. FRP composite laminate (for face sheets) was cut into size of 50 mm x 50 mm for impact test. Face sheets (FRP composite laminate) and core closed-cell aluminium foam were bonded together using 5wt% of silica nanoparticle epoxy paste. The specimens were placed under a uniform load for 24 hours.

C. Drop Weight Impact Test

Impact test were conducted using the Instron Dynatup 9250 Drop weight Impact tester machine as shown in Fig. 1. ASTM D3763 was used as a reference in conducting the test . a suare type of specimen with 50 mm x 50 mm and the thickness 32 mm, where for KFRP and BFRP- Al foam sandwich panel.. The impactor used in this study was a hemispherical nose striker with a diameter 12mm and a mass of 6 kg. The corresponding impact energy was 20 and 40J. The peak load was determined from this impact test for every system with different types of facesheet.

D. Optical Microscope

The damage structures such as matrix cracking, delamination and fibre breakage occurs towards impacted specimens were captured and analyzed using a Stereo Zoom Microscope.

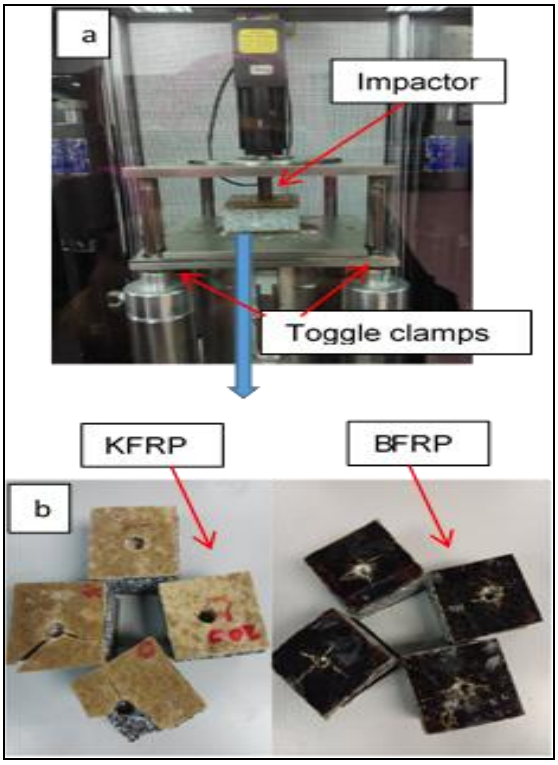

Fig 1. (a) Impact test of FRP-Al Foam sandwich panel (b) impacted samples of KFRP and BFRP- Al foam sandwich panel

III. RESULTS AND DISCUSSION

Impact Properties

Fig. 2 shows the impact responses of KFRPs and BFRPs –Al foam sandwich panel with the facing layers. The FRP composites modified with different silica nanoparticles content were tested under two different impact energies (20 and 40 J). As shown in Figure 2 (a), BFRP–Al foam sandwich panel with 25wt% of silica nanoparticles specimen recorded highest peak load and maximum initiation energy compared to those of BFRP and KFRP- Al Foam both tested under impact energy levels. The BFRP with 25% silica nanoparticles exhibit high load carrying capability to initiate damage. The lowest peak load was recorded for KFRP – Al foam sandwich panel which the composite did not contain of silica nanoparticles. The absence of silica nanoparticles into the FRP-al foam sandwich panel delayed the penetration and improves the stiffness of the specimens panel. Deflection at peak load and initiation energy (Fig. 2(b) and 2 (c)) shows similar trend for both BFRP and KFRP – Al foam sandwich panels where the addition of silica nanoparticles into the epoxy resin improved the impact properties of the panel. The propagation energy of KFRP- Al foam sandwich panel increased with increasing of silica nanoparticles content up to 5wt%. The addition of 13wt% silica nanoparticles content further decreased the propagation energy. Similar to BFRP-Al foam sandwich panel, the addition of silica nanoparticles also reduced the propagation energy.

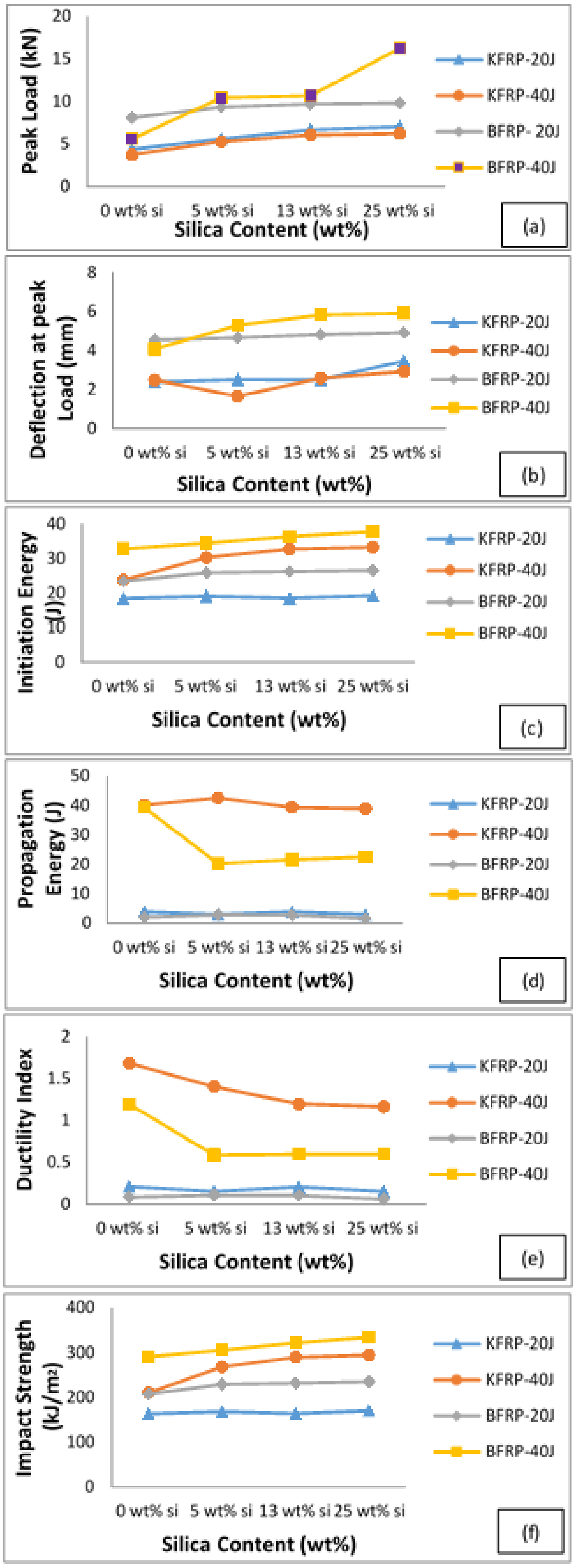

Fig. 2. Impact properties of KFRPs and BFRPs- Al Foam Sandwich Panel with Different Silica Nanoparticles Content;

a) peak load, b)deflection at peak, c)initiation energy, d) propagation energy, e)ductility index and f) impact strength.

The ductility index (Fig. 2 (e)) of BFRP-Al foam sandwich panel was observed to be lowest among the sandwich panel regardless of the impact energy applied. It reveals that basalt fiber is tougher than kenaf fiber or more energy required to initiate damage for the composite reinforced with those fibres. The impact strength of the specimens (Fig. 2(f) was taken from the value of the initiation energy divided with the diameter of the impactor. The highest value was recorded for BFRP-Al foam sandwich panel with 25wt% of silica nanoparticles at 40J impact energy. It is revealed that the panel made of BFRP marked higher resistance towards damage during the impact. The inclusion of nanofiller into the epoxy resin can create strong interfacial bonding between nanofiller and the matrix.

Damage Patterns

Fig. 3 and 4 show the fractured surface of KFRP- and BFRP-Al foam sandwich panel with silica nanoparticles embedded in the FRP system when subject to impact loading (20 and 40 J). There was penetration on KFRP – Al Foam sandwich panel observed as the impact energy increased. The KFRP –Al foam sandwich panel was fully penetrated when 40 J Impact Energy was struck out. The neat KFRP-Al foam and neat BFRP-Al foam sandwich panel was penetrated in a brittle manner in the middle, while for that of BFRP- Al foam sandwich panel, the brittle fracture occurred on the top of the specimens and the penetration hole is smaller compared to the one of KFRP-Al foam.

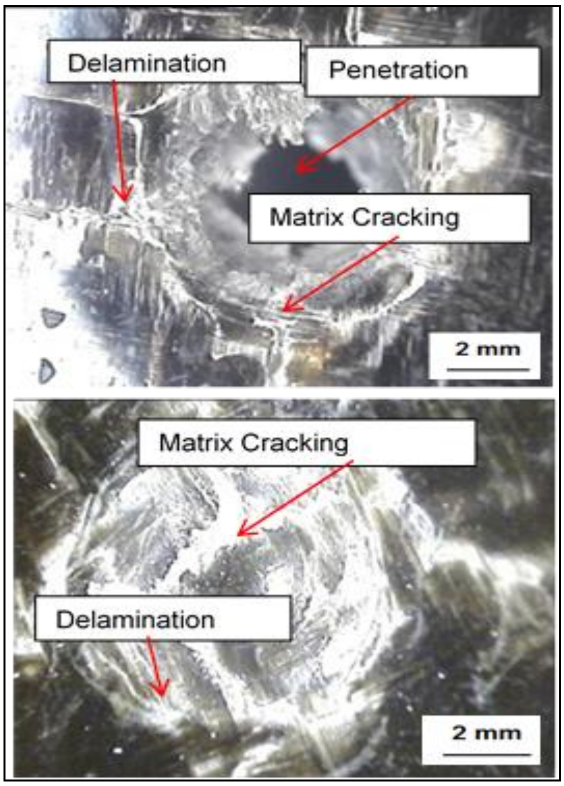

Fig. 3. Damage pattern of BFRP- Al foam sandwich Panel tested under; (a) 40 J Impact energy (b) 20 J Impact energy

It is clearly demonstrated that BFRP face sheets can withstand 20J energy while the KFRP one cannot withstand the same level of energy when applied to the panel. Matrix cracking has occurred near the impactor point for both specimens. Delamination occurs between face sheet and the Al foam core due to the impactor effect.

Based on Fig. 3 and 4, it can be deduced that BFRP facesheets possess higher impact resistant characteristics as the KFRP.

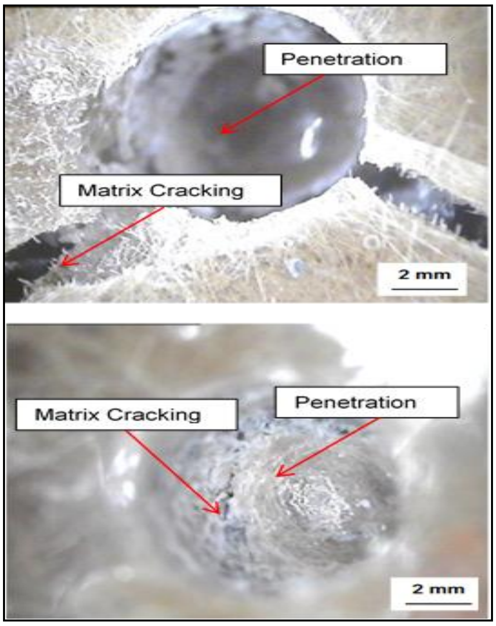

Fig. 4: Damage pattern of KFRP-Al foam sandwich Panel (a) 40J Impact energy (b) 20J Impact energy

IV. CONCLUSION

The KFRP-Al foam and BFRP-Al foam sandwich panels with the addition of silica nanoparticles in the FRP system were successfully fabricated using vacuum bagging method. The impact properties of kenaf and basalt were investigated and examined. Several conclusions were made as follows:

1. The results showed that the addition of nanosilica into BFRP and KFRP of the sandwiched Al-core panel system improved the impact properties. The energy absorbed required to initiate damage is higher for the panel that sandwiched with the BFRP and KFRP containing silica nanoparticles.
2. Penetration occurred as the impactor impacted at an energy level of 20J and 40J on the KFRP face sheets surfaces while penetration occurred at energy level 40J on the BFRP face sheets surfaces.

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REFERENCES

1. J. L. Chengjun Liu, Y.X. Zhang, "Impact Response of Sandwich Panels with Fibre Metal Laminate Skins and Aluminium Foam Core," Composite Structures, vol. 182, pp. 183–190, 2017.
2. A. S. Juan Pablo Vitale, Gaston Francucci, Jian Xiong, "Failure Mode Maps of Natural and Synthetic Fiber Reinforced Composite Sandwich Panels," Composites Part A: Applied Science and Manufacturing, vol. 94, pp. 217–225, 2017.
3. Y. C. Mingze Ma, Weixing Yao, Yan Chen, "Critical Energy Release Rate for Face Sheet/Core Delamination of Sandwich Panels," Engineering Fracture Mechanics., vol. 204, pp. 361–368, 2018.
4. S. N. A. S. K.I. Ismail, M.T.H. Sultan, A.U.M. Shah, M.Jawaid, "Low Velocity Impact and Compression after Impact Properties of Hybrid," Composites Part B: Engineering, vol. 163, pp. 455–463, 2019.
5. Shaari, N, Jumahat, A., Yahya, K.H. and Sulaiman, "Impact Resistance of Woven Fiber Reinforced Polymer Composites," Advances in Environmental Biology, vol. 8, pp. 2662–2668, 2014.
6. S. Q. S. Yingji Wu, Changlei Xia, Liping Cai, Andres C. Garcia, "Development of natural fiber-reinforced composite with comparable mechanical properties and reduced energy consumption and environmental impacts for replacing automotive glass-fiber sheet molding compound," Journal of Cleaner Production, vol. 1184, pp. 92–100, 2018.
7. S. S. Ashwin Sailesh, R. Arunkumar, "Mechanical Properties and wear properties of kenaf- Aloe Vera-Jute Fiber Reinforced Natural Fiber Composites," Mater. Today Proceeding, no. 5, pp. 7184–7190, 2018.
8. K. J. A.M.R. Azmi, M.T.H. Sultan, A. Hamdan, A.F.M. Nor, "Flexural and Impact Properties of a new bulletproof vest insert plate design using Kenaf Fibre Embedd with X-Ray Film," Mater. Today Proceeding, vol. 5, no. 2, pp. 11193–11197, 2018.
9. U. P. Cesim Atas, "The effects of face-sheet thickness on low velocity impact response of sandwich composites with foam cores," Journal of Sandwich Structures & Materials, vol. 18, no.2, DOI: 10.1177/1099636215613775, 2015.
10. Q. L. Guangyong Sun, Erdong Wang, Hongxu Wang, Zhi Xiao, "Low Velocity Impact Behaviour of Sandwich Panels with Homogeneous and Stepwise Graded Foam Cores," Materials & Design, vol. 160, pp. 1117–1136, 2018.
11. H. A. V. Crupi, E. Kara, G.Epasto, E. Guglielmino, "Prediction model for the impact response of glass fibre reinforced aluminium foam sandwiches," International Journal of Impact Engineering, vol. 77, pp. 97–107, 2015.
12. Jumahat, A. Soutis, C., Jones, F.R. and Hodzic, "Improved Compressive Properties of a Unidirectional CFRP Laminate using Nanosilica," Advanced Composites Letters, vol. 19, no. 6, pp. 204–207, 2010.

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