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Impact and Residual Strength of Fabric Reinforced Composite

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Abstract: Impact and residual strength of the fabric reinforced composite has investigated with aim for the structural application in civil and aerospace industry. As the quality of the composite is observed using c-scan with acoustic vibration mode before and after impact test. Four point bending test were carried out on the composite materials for the calculation of residual strength of the composite material after impact test. E-glass reinforced composite shows better behaviour on impact strength due to sliding behaviour of fiber within matrix. However carbon and basalt shows strong pull out of the fiber from the matrix.

Keywords: Impact Strength; Residual Strength; Geocomposite; Fabric.

1 Introduction

The geo-polymer matrix is being evaluated for fire proof aircraft cabin interior panels, marine structural composites, and an infrastructural application is a potassium or sodium aluminosilicate, or poly (sialate-siloxo). The process geopolymerization accelerates with the combinations of sodium hydroxide (NaOH) or otassium hydroxide (KOH) and sodium silicate or potassium silicate. The application of geo polymer is limited due to the brittle nature of the material and prone to high temperature areas. So the fabric reinforced geo polymer are the alternative material for the improvement of strength and enhancement of ductility. Application of fiber reinforced geo-polymer composite in damaged bridges and buildings in earthquake and hurricane prone areas [1]. Impact test is also one of the properties in concerned with the application related to those areas. The velocity of impact and height of the impact are the important parameter for determination of impact energy of the composite material.

In this article the aim is to investigate the impact strength of the fabric reinforced geo-composites (various fabric, such as carbon, E-glass and basalt reinforced) with matrix as geo-polymer. The impact strength of the composite material and the residual strength of the composite material after impact also measured and calculated. The quality of the manuscript before impact and after impact were scanned using C-scan instrument in acoustic vibration mode. The impact test were performed on the aim of energy of absorption by the composite material. After that C-scan test were carried out for the determination of damage area. Finally four point bending test were performed to calculate the residual strength of the composite material. Fabric orientation, delamination and alignment during the residual strength of the composite during 4 point bending test also examined using optical microscope.

2 Materials and Methods

Fabric reinforced geo-polymer composite were fabricated with carbon, E-glass and basalt fabrics in hand lay-up techniques with thickness 3 ± 0.08 mm. The matrix geo-polymer was prepared with aluminosilicate powder, met kaolin as the binder and alkali activator containing NaOH/KOH medium. The geo-composite samples were cured using vacuum assisted technique at 80 °C with 0.3 MPa pressure for 2 h. The sample was exposed at 60 °C curing temperature for 20 h in the oven. The impact test was carried out specimens for each material system with dimension $100 \times 130 \times 3$ mm were tested with built drop weight factor. The qualitative analysis of the composite samples was conducted using ultrasonic inspection (C-scan) before and after impact test. The residual test were calculated using four point bending test of the material. Composite

Tab. 1: Chemical composition of Geo-polymer (Matrix 1, Matrix 2).

Elements (matrix 1)	Percentage [%]	Elements (matrix 2)	Percentage [%]
Al	2.04	Al	22.04
Si	31.8	Si	65.1
P	0.08	Mg	0.18
K	15.2	Ca	0.14
Zr	1.76	Fe	0.18
Na	0.63	K	0.18
Ca	0.24	O	12.18
O	48.3		

laminates were prepared using unidirectional stacking sequence of (0/90) using various layers of fabric for uniform thickness. Tab. 1 provides the standard information about fabric and matrix geo-polymer and the fabric reinforced composites. The fiber volume fraction was calculated based on the thickness of the composite, the areal density of the fabric and the number of layers in the composite.

The aim of the impact test was to damage the specimen without any penetration. Five specimens for each material system with dimension 100 × 130 × 3 mm were tested with in house built drop weight factor. A hardened steel striker with a hemispherical tip of the diameter 16 mm was impacted on the sample from chosen drop height. The weight of the impactor was considered to be 3.072 kg. The energy 6.2 J was achieved from the chosen drop height of 0.50 mm. The qualitative analysis of the composite samples was conducted using ultrasonic inspection (C-scan) before and after impact test. The quality of the sample before impact test and the delamination area (damage area) were analyzed. The equipment was used a 5 GHz Transducer from Panametrics (V309), an Olympus pulser 5077PR, a Oscilloscope 9400A from le Croy and a Unidex 11 control unit.

3 Results and Discussion

Fig. 1 displays the C-scan image of the sample before and after impact test. Fig. 2 represents the derivative graph for the measured force with respect to duration of contact. The area under the force versus displacement curve as the function time represents the impact resistance of the composite. Composites with larger areas under force and displacement curve are more effective energy absorber. E-glass shows more energy abruption in compare to carbon and basalt fabrics that may be due to post-debond fiber sliding mechanism and fiber pull out is responsible for carbon reinforced composite [2]. Three basic damages of composite laminates (a) interplay cracking, (b) delamination mode (c) fiber breakage mode [3]. Matrix properties also play a significant role in determining the impact resistance and load bearing capacity of fabric reinforced composites. Tab. 2 represents the values of the impact test results of the geo composite. The data represents that E-glass fiber reinforced composite is more suitable in concern with impact strength.

4 Conclusion

E-glass fabric reinforced geo-polymer composite exhibit better response in impact testing. However carbon and basalt deviates from this principle.

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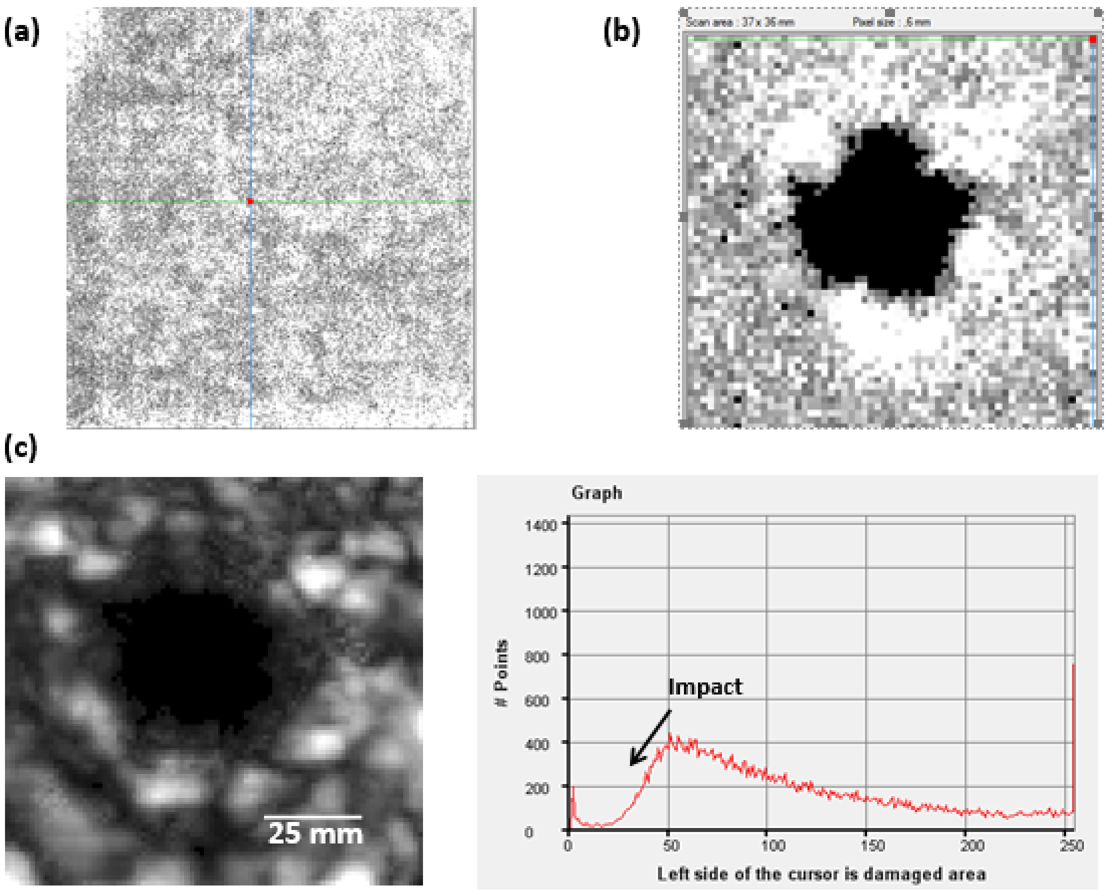

Fig. 1: The Quality of E-glass composite before and after C-scan test.

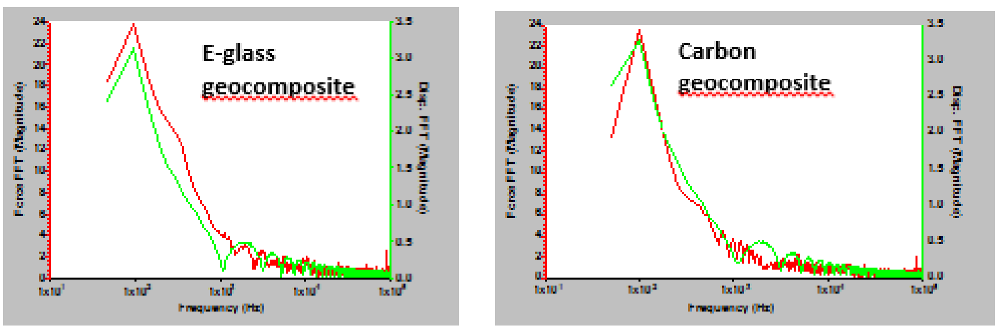

Fig. 2: Force-displacement curve for E-glass and carbon geocomposite.

Tab. 2: Impact test results of the experimental details on fabric reinforced composite.

Parameters	E-glass + Geo-polymer (FC4)	Basalt + Geo-polymer (FC4)	Carbon + geo-polymer (FC4)	Carbon + geo polymer (L 160)	Basalt + geo polymer (L 160)	E-glass + geo-polymer (L160)
Thickness [mm]	7±0.07	3±0.8	3±0.5	3.24±0.30	3.21±0.50	3.15±0.30
Fiber volume fraction [%]	40.5±0.8	40.2±0.3	40.7±0.4	40.3±0.5	40.1±0.2	40.4±0.6
Delamination area [mm^2]	1370±230	1920±451	1850±145	1865±230	1955±320	1275±215
Absorbed ±energy [J]	19.09±2.86	13.19±1.20	13.2±1.15	13.30±0.02	13.89±0.23	9.06±0.2
Contact duration [ms]	11.35±0.10	7.37±1.52	7.39±0.67	7.81±0.58	8.23±0.02	8.23±0.02
Maximum contact force [N]	9759±351	4478±220	1738±175	4810±109	5582±50	5582±50
Damage threshold load [N]	8570±415	3854±303	1474±427	3118±172	2996±20	2996±20

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