MECHANICAL PROPERTIES COMPARISON OF DIFFERENT SEQUENCED WEAVED HYBRID METALLIC FABRICS WITH INTERMADIATE ALUMINUM SHEETS

Ali Ihsan Kaya* , Kaan Emre Engin, Şerif Çitil
Adiyaman University, Engineering Faculty, Mechanical Engineering, Department,
Adiyaman, Turkey.

Abstract

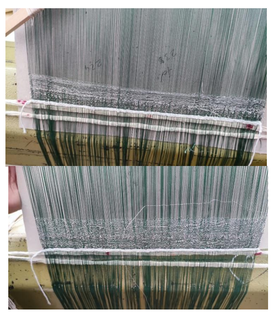
- In this study, hybrid metallic fabrics with thickness of 0.2 mm were manufactured by using traditional weaving method.
- The fishing line was used as warp whereas the aluminum wire was used as weft during the manufacturing of hybrid metallic fabrics.
- The manufactured fabrics were cut into layers having 30 mm x 300 mm dimensions.
- Each layer was bonded by using structural adhesive, FM® 73M.
- Acquired laminates were cured in a heat-controlled hydraulic press under designed die by applying additional.
- After curing was completed, specimens were cut out as per ASTM D3039 standard for tensile.
- Effect of intermediate Aluminum material on the weight were determined.
- Tensile test of three samples in each laminate group were performed.
- Al material as intermediate on the weight were determined.

Introduction

Due to their lightness and ease of application, studies on adhesive joints are extensively being carried out in the literature [1, 2]. Banea et al [3], investigated multi-material adhesive joints of high strength steel, aluminum and carbon fibre reinforced plastics both experimentally and numerically. Hybrid materials of Carbon Fiber Reinforced Polymers (CFRP), titanium alloy and AF 163-2K were studied for increasing peel strength of a CFRP substrate by dos Santos et al [4]. Gültekin et al [5], studied four different single lap joints hybrid AA2024-T3 aluminum alloy and carbon/epoxy composites. Çitil [6] studied curved lap joint of AA2024-T3 aluminum alloy sheets. Zamani et al [7], investigated crack initiation and fatigue life of Al-GFRP single lap joints under four-point bending loads. Sun et al [8], performed an experimental study on single lap bonding joints of CFRP, Steel and Al to determine the fracture behavior of joints considering the effects of material types and adherent thickness. Average shear strength of AA8011 Aluminum and GFRP the similar and dissimilar lap joints were studied by Reddy et al. [9]. Cakir and Kinay [10], researched shear strength of the Al-GFRP single lap joints of dissimilar adherents with regard to the adding different nanoparticles. Carbas et al [11], investigated the hybrid joint performance of CFRP/2024-T3 aluminum with adhesives of different stiffness.

Material and Method

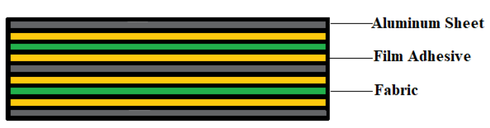
- Al 5005 wires having 0.2 mm thickness were used.
- Supplied aluminum wires were used as weft whereas polyethylene fishing line was used as warp.
- This fishing line called "*effe sumo x8*" was formed by braiding eight braided structures of the same material
- In the production process of hybrid metallic fabrics, fishing line and aluminum wires of the same thickness were used.

Production of fabrics with traditional weaving equipment

Produced hybrid metallic fabrics with traditional weaving equipment.

30 mm X 300 mm parts were cut from the whole fabric.



Sequence of Hybrid fabrics, Al sheets and adhesives

Number	Sequencing	Direction regard to weaving
Type I	ALS/SA/HF/SA/ALS/SA/HF/SA/ALS	X
Type I	ALS/SA/HF/SA/ALS/SA/HF/SA/ALS	Y
Type I	ALS/SA/PFL/SA/ALS/SA/PFL/SA/ALS	-
Type II*	ALS/SA/HF/SA/HF/SA/HF/SA/ALS	X
Type II*	ALS/SA/HF/SA/HF/SA/HF/SA/ALS	Y
Type II*	ALS/SA/PFL/SA/PFL/SA/PFL/SA/ALS	-

Sequencing of Laminates

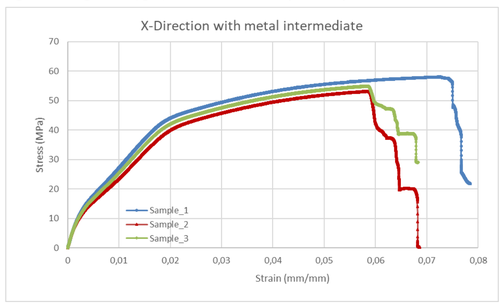
Preparation layers of laminates and ready-to-cure samples and hydraulic press

Tensile tests.

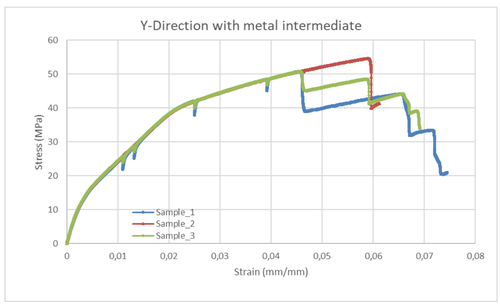
Results

	X-Direction	Y Direction	Fishing Line
Average weights of Type-I samples	38,71462	36,3998	38,80133
Density of Type-I (kg/m³)	1,179,87	1109,37	1182,52
Average weights of Type-II samples*	33,83413	31,06943	34,97352
Density of Type-II (kg/m³)	1031,13	946,88	1065,86

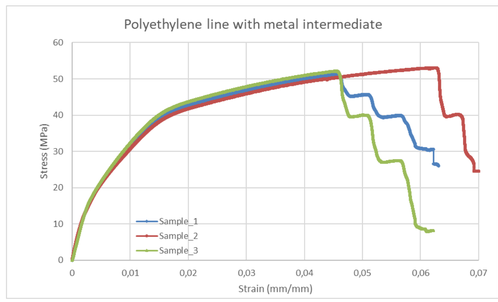
Average weights (gr) and density of specimens for each group



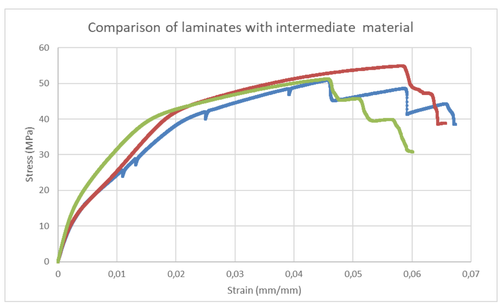
Tensile test results of Type-I laminates of X-direction with aluminum intermediate



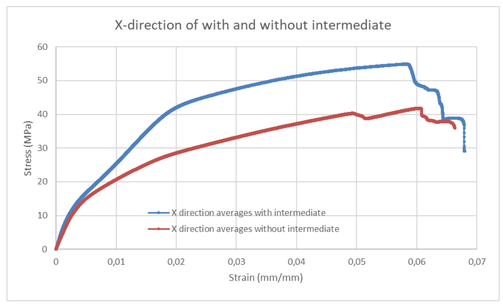
Tensile test results of Type-I laminates of Y-direction with aluminum intermediate



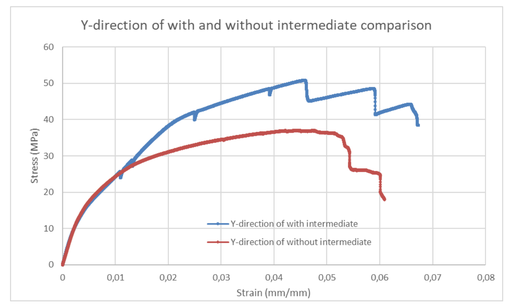
Tensile test results of Type-I laminates of PL fabrics with aluminum intermediate



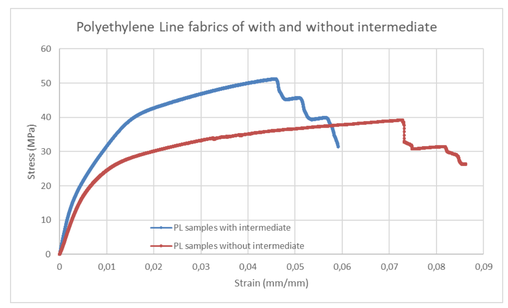
Tensile test result comparison of all Type-I laminates with intermediate material (Red: X-direction, Blue: Y-direction and Green: PL fabrics)



Tensile test result comparison of X-direction of Type-I and Type-II composites



Tensile test result comparison of Y-direction of Type-I and Type-II composites



Tensile test result comparison of PL fabrics of Type-I and Type-II composites

Discussion

- it was seen that the specimen containing the polyethylene fishing line had the highest weight among the intermediate metal-containing laminates, and its weight value was very close to weight of the X-direction specimen.
- it could be observed that Type-II have a lighter structure and density of them was found to be approximately 10-15% lower than Type-I laminates in each specific sequencing groups.
- the approximate yield strength of the X-direction samples was 13.25 MPa and the corresponding strain value was 0.0035%. the average modulus of elasticity of the X-direction obtained approximately as 3780 MPa.
- the average yield strength of Y-direction the samples was 14.71 MPa and the corresponding strain value was 0.0039%. the average modulus of elasticity was obtained approximately as 3770 MPa.
- the average yield strength of the PL laminates was 10.68 MPa, and the corresponding strain value was 0.0016%. The average modulus of elasticity was obtained as 6670 MPa.
- X-direction laminates of Type-I were bigger than Y-direction and all PL laminates both in terms of ultimate tensile strength and strain among all Al-containing intermediate metal.
- ultimate strength of with intermediate Al-containing composites were observed to have bigger value than without intermediate ones both for X- and Y-direction but they are heavier.
- Strength of intermediate Al-containing Type-II composite results were obtained higher than intermediate non-containing Type-I laminates however Type-I laminates were found to be heavier approximately 10% to 12 %
- it is seen that the density value of intermediate non-containing Type-II samples was quite low compared to intermediate Al-containing Type-I laminates.

Conclusion

- It was seen that Al and PL containing fabrics could be successively weaved in a traditional rug weaving equipment,
- Ultimate strength of X-direction of Type-I laminates were found bigger Y-direction samples.
- Type I samples were obtained approximately 5 gr heavier than Type-II specimens.
- The strength value of X-axis direction of Type-I was obtained higher than Y-axis direction of Type-I composites when results were compared depending on the direction,
- By comparing strength to weight ratio of Type-I and Type-II, it could be stated that weaving metal and non-metal materials would lead to increasing the strength values of material while decreasing the density value
- Modulus elasticity were found to have same value for X- and Y-axis direction.
- It was observed that yield strength region of X- and Y-direction of Type-I and Type-II were close regarding the utilization of Al-intermediate material

References

[1] Çitil, Ş. (2018). Eğrisel yüzeyli yapıştırma bağlantılarında malzemenin yapıştırıcı üzerine etkisinin incelenmesi. Dicle Üniversitesi Mühendislik Fakültesi Mühendislik Dergisi, 9(1), 225-234. In Turkish.
[2] da Silva, L. F. M., Marques, E. A. S. Joint Strength Optimization of Adhesively Bonded Patches, J. Adhesion 84, 915–934, 2008.
[3] Banea, M. D., Rosioara, M., Carbas, R. J. C., & Da Silva, L. F. M. (2018). Multi-material adhesive joints for automotive industry. Composites Part B: Engineering, 151, 71-77.
[4] dos Santos, D. G., Carbas, R. J. C., Marques, E. A. S., & da Silva, L. F. M. (2019). Reinforcement of CFRP joints with fibre metal laminates and additional adhesive layers. Composites Part B: Engineering, 165, 386-396.
[5] Gültekin, K., Akpinar, S., Özel, A., & Öner, G. A. (2017). Effects of unbalance on the adhesively bonded composites-aluminium joints. The Journal of Adhesion, 93(9), 674-687.
[6] Çitil, Ş. (2018). Experimental and numerical investigation of adhesively bonded curved lap joints under three-point bending. Mechanics, 24(6), 824-832.
[7] Zamani, P., Jaamialahmadi, A., & Da Silva, L. F. (2021). The influence of GNP and nano-silica additives on fatigue life and crack initiation phase of Al-GFRP bonded lap joints subjected to four-point bending. Composites Part B: Engineering, 207, 108589.
[8] Sun, G., Liu, X., Zheng, G., Gong, Z., & Li, Q. (2018). On fracture characteristics of adhesive joints with dissimilar materials–An experimental study using digital image correlation (DIC) technique. Composite Structures, 201, 1056-1075.
[9] Reddy, N. S., Jinaga, U. K., Charuku, B. R., Penumakala, P. K., & Prasad, A. S. (2019). Failure analysis of AA8011-pultruded GFRP adhesively bonded similar and dissimilar joints. International Journal of Adhesion and Adhesives, 90, 97-105.
[10] Cakir, M. V., & Kinay, D. (2021). MWCNT, nano-silica, and nano-clay additives effects on adhesion performance of dissimilar materials bonded joints. Polymer Composites, 42(11), 5880-5892.
[11] Carbas, R. J. C., Marques, E. A. S., & Da Silva, L. F. M. (2021). The influence of epoxy adhesive toughness on the strength of hybrid laminate adhesive joints. Applied Adhesion Science, 9(1), 1-14.

For any question: alikaya@adiyaman.edu.tr