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(54) Title: TEXTILE REINFORCEMENT COMPOSITE OF CARBON AND GLASS

(57) Abstract: The present invention relates to a textile composite of carbon and glass where the matrix used is epoxy resin and the fabric reinforcement is 2x2 twill weave carbon glass fabric with the method of wet layup of two types of composite layers.



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TEXTILE REINFORCEMENT COMPOSITE OF CARBON AND GLASS

Technical Field

An engineering project that is specifically related to the field of “General Mechanics and Sciences of Fibres” where a new composite material was implemented to be used in various fields starting from aviation where a whole aeroplane can be made from this material as well as various applications in the automotive sector such as manufacturing different parts of the car and even the whole frame and body. Other potential applications where this new composite can be implemented is the sports industry where a fine example of this use is the manufacturing of the tennis racquets frames instead of traditional steel and graphite. The use of composite materials instead of traditional materials is considered revolutionary in the industrial field.

Background Art

A composite material is a combination of a matrix and reinforcement. In a “fibre based composite material” the reinforcement used is fibres in various forms. The matrix can include epoxies, phenolics and cyanates while the main fibres used as reinforcements are glass fibres, carbon fibres, boron fibres, ceramic fibres, metal fibres, aramid fibres and natural fibres. Composite materials with fibre reinforcements are the most ones used because of their excellent mechanical properties. The fibre reinforcement has many forms, short fibres, unidirectional long continuous fibres or fabric. Hybrid composites are composites with more than one reinforcement. Among the first appearance of hybrid composites was hybrid mats; where short fibres hybrid mats were manufactured using a mixture of ‘sisal fibres’ and ‘glass fibres’ where the presence of ‘glass fibres’ along with the ‘sisal fibres’ yields to better mechanical properties of the mats.

On the other hand, the use of carbon fibres and glass fibres as reinforcement was and is still under scope. They are either used in the form of short fibres, long fibres or fabrics stacked in layers that are coated with a resin to get the final product. The composite has minimal weight, yet remarkable mechanical properties. Carbon has up to four times the tensile strength of high-grade steel, but is also extremely flexible which has led to its use in aerospace industry, automotive industry, sports cars along with other applications. The most famous example of a car for which carbon fibre was used is the ‘Lexus LFA’. Its body consists of 65% of this material. Glass fibres are widely used for their low cost, high tensile strength, high chemical resistance and excellent insulating properties.

Disclosure Of Invention

Implementation of Hybrid Intraply Textile Composite Laminates and Experimental Determination of Engineering Constants

This chapter includes:

- The implementation of Intraply Hybrid Composite laminates using wet layup method.
- Tensile testing of the hybrid specimens for the determination of the Engineering Constants.

4.1. The Implementation of Intraply Hybrid Composite Laminates:

Two intraply hybrid composite laminates were prepared using wet layup method. The dimensions of each laminate were 60cm x 60 cm along the length and the width respectively. The first laminate was prepared using two layers of the hybrid fabric reinforcement while the second laminate was prepared using four layers of the hybrid fabric reinforcement.

The resin used was epoxy resin produced from a reaction between bisphenol A and epichlorhydrin. The hardener that acts as the epoxy curing agent is made of a mixture of organic compounds. The mix ratio by weight is 5:2 for the resin and curing agent respectively. The mixture has a pot life of 28 minutes, where the pot life is the period of time a resin remains usable after mixed with a curing agent.

4.1.1. The Tools used during Implementation:

1. A glass plate of dimensions 75 cm x 75 cm along the length and the width respectively. The glass plate acts as the open mould for the wet layup method.
2. An analytical balance with a precision of 0.1 mg is used to measure the weight of the epoxy resin and the curing agent.
3. Wax that acts as the demoulding agent to easily separate the composite and the glass plate after curing and to prevent sticking of the composite to the glass.
4. A brush is used to distribute the mixture of epoxy resin and curing agent over the fabric.
5. A roller is used to evenly distribute the mixture and to remove air bubbles and to prevent any irregularities.

6. Mixing paper cups are used as containers for the epoxy resin and the curing agent.
7. Wood sticks are used to mix the epoxy resin and the hardener.
8. Scissors are used to cut the fabric.

4.1.2. The Realisation of Hybrid Composite Laminates using Wet Layup Method:

1. The molten wax is spread out and evenly distributed on the glass using a roller, it needs 2 hours to completely dry.
2. A quantity of the resin is mixed with the curing agent in the paper cups where the weight is measured using the analytical balance and a wood stick is used to mix them properly.
3. The first layer of the fabric with dimensions 60 cm x 60 cm is placed on the layer of dry wax.
4. The mixture of resin and hardener is then distributed over the fabric with a brush; and using a roller the mixture is evenly spread out and distributed to prevent any irregularities and ensure absence of air bubbles.
5. After coagulation further layers are then applied with the same technique.

For the two layers laminate a total of 135 grams of the epoxy resin was used with 54 grams of the hardener while for the four layers laminate a total of 270 grams of the epoxy resin was used with 108 grams of the hardener.

The composite laminates are left at 30 ± 2 °C for 48 hours to ensure the resin curing and hardening.

4.1.3. The Preparation of Specimens of Intraply Hybrid Composites for Tensile Testing:

After resin curing a square of 50cm x 50 cm is obtained where from this square two squares of dimensions 25 cm x 25 cm are obtained are a rectangle with dimensions 50 cm x 25 cm along the length and width directions respectively.

The first square was used to obtain 12 specimens 200 mm length x 20 mm width. The length direction is taken along the warp direction of the fabric reinforcement of the composite. These samples are used to obtain the engineering constant E_1 , the Young's Modulus along the warp direction.

The second square was used to obtain 12 specimens 200 mm length x 20 mm width. The length direction is taken along the weft direction of the fabric reinforcement of the composite, thus, in a direction perpendicular to that of the length direction of the samples obtained from the first square. These samples are used to obtain the engineering constant E_2 , the Young's Modulus along the weft direction.

The rectangle was used to obtain 15 samples with an angle 45° measured with a reference parallel to the yarns in the weft direction. These samples are used to obtain the engineering constant G_{12} , the longitudinal Shear Modulus.

The residuals were used at the tips of the specimens to avoid failure at the level of the grips during tensile testing.

Safety precautions should be taken:

1. Ensure good ventilation at the workplace.
2. Avoid contacts with eyes and skin.
3. Remove all soiled and contaminated clothing.
4. Use protective synthetic rubber gloves.
5. Eye protection is ensured using tightly sealed goggles.
6. Use protective work clothing.

4.2. Tensile Testing of Specimens and Determination of Engineering Constants:

The tensile tests were realised on the tensile machine INSTRON 3382 driven by the material testing program InstronBluehill Lite. All the tests were realised in a temperature $20\text{ }^\circ\text{C} \pm 3\text{ }^\circ\text{C}$ and a relative humidity $65\% \pm 2\%$. The velocity of the machine was set to 5 mm/min. The samples subjected to slipping or jaw break were immediately rejected. The vertical alignment of a specimen is an important factor to avoid sideloading or bending in the specimen.

As previously described in section 4.1.3, three groups of samples were obtained from the hybrid composite laminate prepared using wet layup method; the first group consists of specimens where the length direction of the specimens coincides with the warp direction of yarns in the fabric reinforcement, this group of specimens helps to determine the engineering constant E_1 which is the Young's Modulus in the warp direction. The second group consists of specimens where the length direction of the specimens coincides with the weft direction of yarns in the fabric reinforcement, this group of specimens helps to determine the engineering constant E_2 which is the Young's Modulus in the weft direction. The third group consists of

specimens with an angle 45° measured with a reference parallel to the yarns in the weft direction. These samples are used to obtain the engineering constant G_{12} , which is the longitudinal shear Modulus.

4.2.1. Tensile test results for a Hybrid Composite with two layers of hybrid fabric reinforcement:

For each specimen a stress-strain diagram and the results of the tensile test were obtained. The young's moduli in the linear portion were obtained and the chord moduli, the secant moduli and the tangent moduli at five different points for each specimen were obtained. The mean, standard deviation and coefficient of variation were evaluated for each group of specimens. The upper confidence limits and lower confidence limits with 90% confidence and 99% confidence were calculated according to t-distribution where the confidence limit coefficients were obtained based on the prescribed probabilities 90% and 99%.

4.2.1.1. Tensile Test for the determination of E_1 for two layer reinforcement composite

Specimen	Load at Break (N)	Tensile stress at break (MPa)	Tensile stress at maximum tensile extension (MPa)	Load at maximum tensile extension (N)	Tensile strain at maximum tensile extension (mm/mm)	Tensile strain at break (mm/mm)	Maximum tensile extension (mm)	Tensile extension at break (mm)
1	1563.38	156.33	46.85	468.47	0.01936	0.01933	2.90374	2.90003
2	1839.82	183.98	59.87	598.71	0.01979	0.01978	2.96879	2.96669
3	2020.77	202.08	59.5	595.05	0.01889	0.01883	2.83348	2.82511
4	1579.86	157.99	48.12	481.17	0.02285	0.02283	3.42719	3.42504
5	1612.27	161.23	47.57	475.66	0.02259	0.02256	3.38785	3.38343
6	2280.42	228.04	60.74	607.39	0.03353	0.0335	5.02961	5.02501
7	1610.42	161.04	46.85	468.46	0.02263	0.02261	3.39437	3.39156
8	1559.35	155.93	45.68	456.77	0.0193	0.01928	2.89447	2.89166
Mean	1758.29	175.83	51.90	518.96	0.02237	0.02234	3.35494	3.35107
standard	267.46	26.75	6.78	67.87	0.00481	0.00481	0.72200	0.72201
coeff	15.21	15.21	13.07	13.08	21.51710	21.54761	21.52063	21.54574
ucl 90%	1892.09	189.21	55.29	552.91	0.02478	0.02475	3.71612	3.71226
lcl 90%	1624.49	162.45	48.50	485.01	0.01996	0.01993	2.99375	2.98988
ucl 99%	2041.78	204.18	59.09	590.89	0.02747	0.02744	4.12022	4.11636
lcl 99%	1474.79	147.48	44.71	447.03	0.01727	0.01724	2.58965	2.58577

Specimen number	Young's Modulus (0 mm/mm-0.01 mm/mm)	Chord Modulus (0.001 mm/mm-0.002 mm/mm)	Chord Modulus (0.002m m/mm-0.004 mm/mm)	Chord Modulus (0.004 mm/mm-0.006 mm/mm)	Chord Modulus (0.006mm/m m-0.008 mm/mm)	Chord Modulus (0.008mm/m m-0.01 mm/mm)
1	17177.77	14166.88	14569.38	15023.83	13267.54	11695.23
2	16209.23	12122.66	13688.15	11741.32	15288.43	12288.43
3	15432.68	14984.29	14423.53	13544.19	11844.46	10044.93
4	15220.42	14737.67	11133.44	15251.11	11749.04	10995.96
5	15670.24	11517.06	13976.33	13121.86	13186.91	12616.64
6	15423.75	12146.38	11575.24	15553.82	11872.65	11375.54
7	15509.7	12416.03	14989.56	11985.39	15559.42	12756.23
8	15494.22	12563.17	13092.84	14362.48	11239.32	10462.45
Mean	15767.25	13081.77	13431.06	13823.00	13000.97125	11529.42625
standard	639.66	1336.01	1409.69	1466.18	1654.65291	995.78350
coeff	4.06	10.21	10.50	10.61	12.72715	8.63689
ucl 90%	16087.24	13750.11	14136.27	14556.47	13828.72125	12027.57289
lcl 90%	15447.26	12413.42	12725.85	13089.53	12173.22125	11031.27961
ucl 99%	16445.26	14497.86	14925.26	15377.07	14754.81324	12584.90254
lcl 99%	15089.25	11665.67	11936.86	12268.93	11247.12926	10473.94996

Specimen number	Secant Modulus (0.001 mm/mm)	Secant Modulus (0.002 mm/mm)	Secant Modulus (0.004 mm/mm)	Secant Modulus (0.006 mm/mm)	Secant Modulus (0.008 mm/mm)
1	16648.03	16907.46	14738.42	14166.89	13442.05
2	15880.56	14001.61	13844.88	13143.69	12628.46
3	15139.41	15061.85	14742.69	14343.19	13718.51
4	15518.53	13628.1	11380.77	14670.88	10190.42
5	16937.95	12727.51	11851.92	14608.56	12003.12
6	14300.58	13223.48	13034.54	13104.26	12070.36
7	14251.5	13333.76	11161.66	13436.24	13467.03
8	14805.57	13684.37	11388.6	13379.9	12844.75
Mean	15435.27	14071.02	12767.94	13856.70	12545.58
standard	1007.61	1333.34	1524.06	658.98	1145.91
coeff	6.53	9.48	11.94	4.76	9.13
ucl 90%	15939.33	14738.03	13530.36	14186.36	13118.83
lcl 90%	14931.20	13404.01	12005.51	13527.04	11972.34
ucl 99%	16503.28	15484.28	14383.36	14555.18	13760.19
lcl 99%	14367.26	12657.75	11152.51	13158.22	11330.99

Specimen number	Tangent Modulus (0.001 mm/mm)	Tangent Modulus (0.002 mm/mm)	Tangent Modulus (0.004 mm/mm)	Tangent Modulus (0.006 mm/mm)	Tangent Modulus (0.008 mm/mm)
1	17715.33	15438.53	14136.69	14846.61	12026.35
2	15447.94	12618.35	14731.82	13283.37	11461.55
3	14642.9	14881.22	12554.46	12965.94	11372.5
4	14677.32	14796.68	14821.73	12171.07	11228.19
5	12215.52	12643.53	14833.76	12876.32	12132.47
6	15142.05	14001.38	12899.95	13647.86	11794.07
7	13424.19	11788.17	12517.69	14811.07	12643.52
8	13496.95	14742.45	12455.01	13629.63	11879.77
Mean	14595.28	13863.79	13618.89	13528.98	11817.30
standard	1647.97	1337.62	1111.41	929.78	463.15
coeff	11.29	9.65	8.16	6.87	3.92
ucl 90%	15419.68	14532.94	14174.88	13994.11	12048.99
lcl 90%	13770.87	13194.64	13062.90	13063.86	11585.61
ucl 99%	16342.04	15281.59	14796.92	14514.50	12308.22
lcl 99%	12848.51	12445.98	12440.86	12543.47	11326.39

4.2.1.2. Tensile Test for the determination of E_2 for two layer reinforcement composite:

Specimen	Load at Break (N)	Tensile stress at break (MPa)	Tensile stress at maximum tensile extension (MPa)	Load at maximum tensile extension (N)	Tensile strain at maximum tensile extension (mm/mm)	Tensile strain at break (mm/mm)	Maximum tensile extension (mm)	Tensile extension at break (mm)
1	2179.313	217.93	56.607	566.607	0.02927	0.02922	4.391	4.383
2	2147.027	214.70	57.659	576.591	0.02676	0.02672	4.014	4.008
3	1895.411	189.54	51.771	517.711	0.02357	0.02356	3.536	3.534
4	1628.139	162.81	44.218	442.183	0.01704	0.017	2.555	2.55
5	1541.279	154.12	51.36	513.598	0.01979	0.01978	2.969	2.967
6	1606.97	160.7	46.38	463.79	0.02246	0.02244	3.36896	3.36896
7	1130.123	113.01	59.392	593.92	0.0304	0.03039	4.56	4.559
8	1323.238	132.32	52.17	521.699	0.02346	0.02345	3.518	3.517
Mean	1681.44	168.14	52.44	524.51	0.02409	0.02407	3.61400	3.61087
standard	372.39	37.24	5.33	53.37	0.00456	0.00455	0.68363	0.68307
coeff	22.15	22.15	10.17	10.18	18.90908	18.92017	18.91632	18.91708
ucl 90%	1867.73	186.77	55.11	551.21	0.02637	0.02635	3.95599	3.95258
lcl 90%	1495.15	149.52	49.78	497.81	0.02181	0.02179	3.27200	3.26916
ucl 99%	2076.15	207.62	58.10	581.08	0.02892	0.02890	4.33861	4.33489
lcl 99%	2179.313	217.93	56.607	566.607	0.02927	0.02922	4.391	4.383

Specimen number	Young's Modulus (0 mm/mm-0.01 mm/mm)	Chord Modulus (0.001 mm/mm-0.002 mm/mm)	Chord Modulus (0.002mm/mm-0.004 mm/mm)	Chord Modulus (0.004 mm/mm-0.006 mm/mm)	Chord Modulus (0.006mm/mm-0.008 mm/mm)	Chord Modulus (0.008mm/mm-0.01 mm/mm)
1	14258.77	13034.171	8473.527	6947.39	7445.356	8021.525
2	13728.903	11442.358	8564.621	8570.887	8230.841	8316.81
3	10944.413	12891.716	8573.934	7270.383	7743.103	8335.195
4	15296.501	13456.602	10106.832	8615.296	8724.196	8758.187
5	12898.605	12529.848	10898.237	7947.743	8202.719	8162.552
6	12932.032	11943.122	9354.939	6908.122	7062.96	7976.012
7	15113.156	10950.938	8452.713	7120.478	6385.301	6706.452
8	13652.282	10937.039	9318.555	7142.033	6953.772	7720.298
Mean	13603.08	12148.22	9217.92	7565.29	7593.53	7999.63
standard	1394.44	973.65	896.32	710.90	779.25	605.51
coeff	10.25	8.01	9.72	9.40	10.26	7.57
ucl 90%	14300.66	12635.30	9666.31	7920.92	7983.36	8302.54
lcl 90%	12905.50	11661.15	8769.53	7209.66	7203.71	7696.72
ucl 99%	15081.12	13180.24	10167.97	8318.81	8419.49	8641.44
lcl 99%	12125.05	11116.21	8267.87	6811.78	6767.57	7357.82
Specimen number	Secant Modulus (0.001 mm/mm)	Secant Modulus (0.002 mm/mm)	Secant Modulus (0.004 mm/mm)	Secant Modulus (0.006 mm/mm)	Secant Modulus (0.008 mm/mm)	
1	13024.928	10294.087	9039.076	8720.332	8487.396	
2	11426.913	11709.538	9282.544	9072.203	8820.406	
3	10873.891	10493.917	10285.05	8476.694	7762.861	
4	13417.307	11762.069	10713.14	9215.908	9924.364	
5	12505.577	11701.907	9824.828	9284.125	9003.732	
6	10541.083	12242.102	10109.80	8052.181	7101.573	
7	11936.612	10145.208	9375.924	8699.29	7927.96	
8	13199.234	12068.137	9693.346	8842.908	8370.042	
Mean	12115.69	11302.12	9790.46	8795.46	8424.79	
standard	1093.81	846.46	560.99	407.67	860.50	
coeff	9.03	7.49	5.73	4.64	10.21	
ucl 90%	12662.88	11725.57	10071.10	8999.40	8855.26	
lcl 90%	11568.51	10878.67	9509.83	8591.51	7994.32	
ucl 99%	13275.07	12199.32	10385.08	9227.57	9336.87	
lcl 99%	10956.31	10404.92	9195.85	8363.34	7512.71	

Specimen number	Tangent Modulus (0.001 mm/mm)	Tangent Modulus (0.002 mm/mm)	Tangent Modulus (0.004 mm/mm)	Tangent Modulus (0.006 mm/mm)	Tangent Modulus (0.008 mm/mm)
1	13068.294	7376.352	7020.221	9709.432	7973.549
2	13128.677	8434.423	7961.088	9031.585	9193.228
3	11030.768	8254.35	8262.821	8031.707	8521.128
4	12163.515	9448.038	8921.738	9569.433	7776.279
5	11022.115	8426.609	7005.686	9037.19	9175.326
6	12841.56	7859.915	8266.734	8687.007	8610.174
7	11486.88	9616.878	7779.86	8371.328	7800.422
8	13576.51	8902.015	7917.402	9751.551	9667.558
Mean	12289.79	8539.82	7891.94	9023.65	8589.71
standard	1008.72	759.46	643.85	634.83	710.97
coeff	8.21	8.89	8.16	7.04	8.28
ucl 90%	12794.41	8919.75	8214.04	9341.23	8945.38
lcl 90%	11785.17	8159.90	7569.85	8706.08	8234.04
ucl 99%	13358.98	9344.81	8574.39	9696.54	9343.30
lcl 99%	11220.60	7734.84	7209.49	8350.77	7836.12

4.2.1.3. Tensile Test for the determination of G_{12} for two layer reinforcement composite:

Specimen	Load at Break (N)	Tensile stress at break (MPa)	Tensile stress at maximum tensile extension (MPa)	Load at maximum tensile extension (N)	Tensile strain at maximum tensile extension (mm/mm)	Tensile strain at break (mm/mm)	Maximum tensile extension (mm)	Tensile extension at break (mm)
1	489.22	48.92	29.69	351.45	0.1167	0.1162	16.2887	16.2883
2	396.92	39.69	26.03	257.05	0.1132	0.1126	15.7936	15.7931
3	749.27	74.93	27.02	338.09	0.1012	0.1009	15.2642	15.2639
4	935.46	93.54	24.47	262.25	0.1132	0.1121	16.1121	16.1116
5	847.19	84.72	23.08	230	0.1223	0.1219	17.2765	17.2762
6	895.75	89.58	24.61	308.1	0.0932	0.0926	18.4254	18.4251
7	838.85	83.88	25.50	251.82	0.1011	0.1008	20.2774	20.2771
8	758.78	75.87	24.36	242.38	0.1076	0.1063	14.2531	14.2528
Mean	738.93	73.89	25.60	280.14	0.10856	0.10793	16.71138	16.71101
standard	194.48	19.45	2.04	46.01	0.00960	0.00957	1.90830	1.90833
coeff	26.32	26.32	7.96	16.42	8.84049	8.86437	11.41918	11.41958
ucl 90%	836.22	83.62	26.61	303.16	0.11336	0.11271	17.66601	17.66566
lcl 90%	641.64	64.16	24.58	257.12	0.10376	0.10314	15.75674	15.75636
ucl 99%	945.06	94.50	27.76	328.91	0.11874	0.11807	18.73407	18.73374
lcl 99%	532.80	53.28	23.43	231.37	0.09839	0.09778	14.68868	14.68829

Specimen number	Young's Modulus (0 mm/mm-0.01 mm/mm)	Chord Modulus (0.001 mm/mm-0.002 mm/mm)	Chord Modulus (0.002mm/mm-0.004 mm/mm)	Chord Modulus (0.004 mm/mm-0.006 mm/mm)	Chord Modulus (0.006mm/mm-0.008 mm/mm)	Chord Modulus (0.008mm/mm-0.01 mm/mm)
1	6729.04	1952.63	789.48	462.82	483.28	482.12
2	6669.67	1856.31	681.07	601	527.15	439.66
3	6063.57	1847.09	747.55	604.4	532.45	362.78
4	6240.34	1888.64	807.67	560.56	526.2	477.26
5	5337.29	1755.36	748.25	653.27	398.08	472.6
6	7134.7	1643.87	611.86	599.73	614.5	450.51
7	6853.18	1384.5	899.28	477.07	430.91	437.76
8	6334.31	1589.19	658.45	469.4	465.99	335.11
Mean	6420.26	1739.70	742.95	553.53	497.32	432.23
standard	560.00	189.32	91.80	73.80	67.75	54.54
coeff	8.72	10.88	12.36	13.33	13.62	12.62
ucl 90%	6700.41	1834.41	788.88	590.45	531.21	459.51
lcl 90%	6140.12	1644.99	697.03	516.61	463.43	404.94
ucl 99%	7013.83	1940.37	840.26	631.76	569.13	490.03
lcl 99%	5826.69	1539.03	645.64	475.31	425.51	374.42

Specimen number	Secant Modulus (0.001 mm/mm)	Secant Modulus (0.002 mm/mm)	Secant Modulus (0.004 mm/mm)	Secant Modulus (0.006 mm/mm)	Secant Modulus (0.008 mm/mm)
1	3309.64	2469.59	1967.90	1670.97	1472.83
2	3278.38	2412.61	1959.71	1673.20	1467.61
3	3190.02	2321.86	1892.50	1620.49	1410.87
4	3126.42	2353.50	1905.27	1629.45	1437.42
5	2931.15	2137.06	1691.11	1432.51	1255.86
6	3186.15	2328.05	1820.97	1579.68	1391.48
7	2907.27	2104.61	1697.72	1444.36	1276.59
8	2953.66	2155.26	1733.80	1480.13	1303.18
Mean	3110.34	2285.32	1833.62	1566.35	1376.98
standard	159.56	136.03	114.29	99.77	86.69
coeff	5.13	5.95	6.23	6.37	6.30
ucl 90%	3190.16	2353.37	1890.80	1616.26	1420.35
lcl 90%	3030.52	2217.27	1776.45	1516.44	1333.61
ucl 99%	3279.46	2429.50	1954.76	1672.10	1468.87
lcl 99%	2941.22	2141.14	1712.48	1460.60	1285.09

Specimen number	Tangent Modulus (0.001	Tangent Modulus (0.002	Tangent Modulus (0.004	Tangent Modulus (0.006	Tangent Modulus (0.008
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	mm/mm)	mm/mm)	mm/mm)	mm/mm)	mm/mm)
1	1615.73	1278.19	1406.83	1251.68	1476.59
2	1619.84	1238.85	1471.04	1512.42	1550.33
3	1825.97	1175.23	1362.69	1500.93	1583.79
4	1552.57	1292.97	1010.27	1169.05	1385.58
5	1668.21	1535.28	1353.35	1656.65	1624.53
6	2059.65	1390.49	1254.96	1153.74	1656.9
7	2315.14	1350.41	1527.42	1247.97	1129.22
8	1718.08	1303.95	1260.6	1403.8	1200.37
Mean	1796.90	1320.67	1330.90	1362.03	1450.91
standard	263.25	108.57	159.93	183.72	196.87
coeff	14.65	8.22	12.02	13.49	13.57
ucl 90%	1928.59	1374.99	1410.90	1453.94	1549.40
lcl 90%	1665.21	1266.36	1250.89	1270.12	1352.43
ucl 99%	2075.93	1435.75	1500.42	1556.76	1659.58
lcl 99%	1517.87	1205.59	1161.37	1167.30	1242.24

4.2.2. Tensile test results for a Hybrid Composite with four layers of hybrid fabric reinforcement:

4.2.2.1. Tensile Test for the determination of σ_f for four layer reinforcement composite:

Specimen	Load at Break (N)	Tensile stress at break (MPa)	Tensile stress at maximum tensile extension (MPa)	Load at maximum tensile extension (N)	Tensile strain at maximum tensile extension (mm/mm)	Tensile strain at break (mm/mm)	Maximum tensile extension (mm)	Tensile extension at break (mm)
1	2883.06	143.15	47.15	949.54	0.03229	0.03226	2.25254	2.25012
2	3960.70	186.34	54.56	1159.58	0.03722	0.03714	2.60509	2.60000
3	4328.50	196.59	51.53	1134.49	0.03806	0.03796	3.42558	3.41667
4	2692.50	130.17	42.06	870.00	0.02501	0.02500	4.00225	4.00004
5	4891.89	229.03	61.68	1317.47	0.03093	0.03089	4.63978	4.63327
6	4067.79	185.67	52.84	1157.74	0.03786	0.03778	3.40764	3.40005
7	4250.56	193.21	61.48	1352.6	0.04813	0.04810	3.36920	3.36675
8	2883.06	143.15	47.15	949.54	0.03229	0.03226	2.25254	2.25012
Mean	3744.76	175.91	52.31	1111.37	0.03522	0.03517	3.24433	3.23963
Standard	815.54	33.79	6.93	175.79	0.00682	0.00681	0.84285	0.84186
Coeff	21.78	19.21	13.25	15.82	19.35999	19.35246	25.97916	25.98627
UCL 90%	4152.74	192.82	55.77	1199.31	0.03864	0.03858	3.66597	3.66077

LCL 90%	3336.78	159.01	48.84	1023.43	0.03181	0.03177	2.82269	2.81848
UCL 99%	4609.19	211.73	59.65	1297.70	0.04245	0.04239	4.13770	4.13195
LCL 99%	2880.33	140.10	44.96	925.04	0.02800	0.02796	2.35095	2.34730

Specimen number	Young's Modulus (0 mm/mm-0.02 mm/mm)	Chord Modulus (0.001 mm/mm-0.005 mm/mm)	Chord Modulus (0.005 mm/mm-0.01 mm/mm)	Chord Modulus (0.01 mm/mm-0.015 mm/mm)	Chord Modulus (0.015 mm/mm-0.02 mm/mm)	Chord Modulus (0.02mm/m-0.025 mm/mm)
1	9221.38	3463.18	8747.55	5418.75	4140.93	4686.52
2	9616.63	4114.87	8585.96	4788.37	5406.62	5911.27
3	9435.9	4559.99	8557.86	4006.49	4834.66	5403.48
4	8662.55	4462.04	8937.97	4362.1	5366.26	5992.77
5	8156.47	3988.35	10903.88	5536.09	5847.24	4393.00
6	9023.92	4261.91	10122.69	5906.81	4682.38	5153.18
7	9602.26	3731.21	9884.98	4104.54	4846.12	5374.68
8	8488.09	3218.98	10306.19	4269.25	4969.62	4458.59
Mean	9025.90	3975.07	9505.89	4799.05	5011.73	5171.69
Standard	543.09	474.26	907.24	730.62	521.95	617.22
Coeff	6.02	11.93	9.54	15.22	10.41	11.93
UCL 90%	9297.58	4212.32	9959.74	5164.55	5272.84	5480.45
LCL 90%	8754.22	3737.82	9052.03	4433.55	4750.62	4862.92
UCL 99%	9601.55	4477.75	10467.52	5573.46	5564.97	5825.90
LCL 99%	8450.25	3472.38	8544.25	4024.64	4458.49	4517.47

Specimen number	Secant Modulus (0.005 mm/mm)	Secant Modulus (0.01 mm/mm)	Secant Modulus (0.015 mm/mm)	Secant Modulus (0.002 mm/mm)	Secant Modulus (0.025 mm/mm)
1	4537.79	3611.82	3547.46	4695.83	3893.97
2	5349.64	4967.8	4907.99	5032.65	5208.37
3	5487.38	4302.08	4203.55	4361.33	4569.76
4	4641.49	3362.39	3695.63	4113.29	3705.79
5	4993.54	4635	4935.36	5413.33	5209.46
6	5354.97	4640.53	4729.29	5967.55	5204.68
7	4856	4098.11	4100.26	4286.72	4504.31

8	4253.62	3393.32	3351.96	5506.38	3696.82
Mean	4934.30	4126.38	4183.94	4922.14	4499.15
Standard	442.60	615.11	624.43	666.70	670.79
Coeff	8.97	14.91	14.92	13.54	14.91
UCL 90%	5155.72	4434.09	4496.31	5255.66	4834.71
LCL 90%	4712.89	3818.67	3871.56	4588.61	4163.58
UCL 99%	5403.44	4778.37	4845.80	5628.80	5210.15
LCL 99%	4465.17	3474.40	3522.07	4215.47	3788.14
Specimen number	Tangent Modulus (0.005 mm/mm)	Tangent Modulus (0.01 mm/mm)	Tangent Modulus (0.015 mm/mm)	Tangent Modulus (0.02 mm/mm)	Tangent Modulus (0.025 mm/mm)
1	3640.00	3967.22	3895.15	4723.7	5012.28
2	3112.14	4551.42	3506.91	5758.4	6185.18
3	3226.61	3571.40	4732.84	4711.57	5834.10
4	3187.86	4137.55	4950.69	5867.77	6390.21
5	3432.9	4890.33	4755.92	5747.24	5011.07
6	3673.22	4019.38	4315.21	5418.16	6605.01
7	3345.32	3887.35	4705.21	4731.70	5274.93
8	3486.96	3302.11	3600.08	4241.10	5718.86
Mean	3388.13	4040.85	4307.75	5149.96	5753.96
standard	207.26	505.29	568.88	619.79	615.76
coeff	6.12	12.50	13.21	12.03	10.70
ucl 90%	3491.81	4293.62	4592.33	5460.01	6061.99
lcl 90%	3284.45	3788.07	4023.17	4839.90	5445.92
ucl 99%	3607.81	4576.42	4910.73	5806.90	6406.63
lcl 99%	3168.45	3505.27	3704.77	4493.01	5101.28

4.2.2.2. Tensile Test for the determination of σ_2 for four layer reinforcement composite:

Specimen	Load at Break (N)	Tensile stress at break (MPa)	Tensile stress at maximum tensile extension (MPa)	Load at maximum tensile extension (N)	Tensile strain at maximum tensile extension (mm/mm)	Tensile strain at break (mm/mm)	Maximum tensile extension (mm)	Tensile extension at break (mm)
1	3133.73	134.34	37.52	875.08	0.02984	0.02979	2.3871	2.3871
2	3227.28	145.77	48.97	1084.14	0.05003	0.05	3.50235	3.50026
3	2921.55	123.52	36.17	855.5	0.04447	0.0444	3.11312	3.10834
4	2395.29	111.37	46.53	1000.74	0.03627	0.04	2.9	2.9
5	3006.6	128.89	37.79	881.44	0.03216	0.03208	2.57298	2.56658

6	3900.51	179.23	46.67	1015.7	0.04007	0.04	3.20555	3.1999
7	3135.25	142.24	50.5	1113.21	0.0594	0.05937	4.75201	4.74998
8	4095.69	200.4	58.28	1191.01	0.041	0.04095	2.86996	2.86667
Mean	3226.99	145.72	45.30	1002.10	0.04166	0.04207	3.16288	3.15985
Standard	542.35	29.79	7.68	123.71	0.00967	0.00947	0.73189	0.73205
Coeff	16.81	20.44	16.95	12.35	23.21585	22.51276	23.13982	23.16708
UCL 90%	3498.30	160.62	49.14	1063.99	0.04649	0.04681	3.52901	3.52606
LCL 90%	2955.68	130.82	41.46	940.21	0.03682	0.03734	2.79675	2.79364
UCL 99%	3801.84	177.29	53.44	1133.23	0.05191	0.05211	3.93864	3.93578
LCL 99%	2652.13	114.15	37.17	870.97	0.03140	0.03203	2.38712	2.38392

Specimen number	Young's Modulus (0 mm/mm-0.02 mm/mm)	Chord Modulus (0.001 mm/mm-0.005 mm/mm)	Chord Modulus (0.005 mm/mm-0.01 mm/mm)	Chord Modulus (0.01 mm/mm-0.015 mm/mm)	Chord Modulus (0.015 mm/mm-0.02 mm/mm)	Chord Modulus (0.02 mm/mm-0.025 mm/mm)
1	6032.5	2529.44	9921.65	3948.33	5089.3	5606.41
2	4168.94	2400.2	7579.95	3445.21	3201.97	4044.28
3	4595.2	2731.85	7665.64	4657.38	3196.74	4838.44
4	6822.45	2188.78	9886.8	4108.61	5254.6	5966.93
5	4606.32	2556.99	8231.66	3375.58	4248.29	5078.56
6	4602.01	2423.82	9625.17	3135.57	4251.74	5186.24
7	6758.22	2204.69	8007.97	4101.08	3412.02	4246.77
8	6082.56	2162.11	9899.25	3526.41	4690.28	5502.61
Mean	5458.53	2399.74	8852.26	3787.27	4168.11	5058.78
Standard	1078.13	204.05	1071.20	502.00	824.94	662.82
Coeff	19.75	8.50	12.10	13.25	19.79	13.10
UCL 90%	5997.87	2501.81	9388.13	4038.40	4580.80	5390.36
LCL 90%	4919.18	2297.66	8316.39	3536.14	3755.43	4727.19
UCL 99%	6601.29	2616.01	9987.67	4319.36	5042.51	5761.34
LCL 99%	4315.76	2183.46	7716.85	3255.18	3293.71	4356.21

Specimen number	Secant Modulus (0.005 mm/mm)	Secant Modulus (0.01 mm/mm)	Secant Modulus (0.015 mm/mm)	Secant Modulus (0.002 mm/mm)	Secant Modulus (0.025 mm/mm)
1	3594.19	3857.75	3957.71	4240.61	4513.77
2	3173.7	3010.78	3155.59	4417.18	4742.6
3	2408.64	3292.07	3416.6	3611.63	3856.99
4	3452.59	3083.42	3425.15	3882.51	4299.4
5	2526.81	2477.79	2777.05	3144.86	3531.6
6	2432.75	2129.49	2464.85	4911.57	3366.51
7	3091.8	2138.9	2792.96	3697.73	4607.54
8	3342.09	2877.97	3094.12	3493.16	3895.05
Mean	3002.82	2858.52	3135.50	3924.91	4101.68
Standard	479.41	592.19	468.53	568.45	513.20
Coeff	15.97	20.72	14.94	14.48	12.51
UCL 90%	3242.65	3154.77	3369.89	4209.28	4358.41
LCL 90%	2762.99	2562.27	2901.12	3640.54	3844.95
UCL 99%	3510.97	3486.22	3632.12	4527.43	4645.65
LCL 99%	2494.67	2230.83	2638.89	3322.38	3557.72

Specimen number	Tangent Modulus (0.005 mm/mm)	Tangent Modulus (0.01 mm/mm)	Tangent Modulus (0.015 mm/mm)	Tangent Modulus (0.02 mm/mm)	Tangent Modulus (0.025 mm/mm)
1	2383.56	3622.58	4661.66	5468.82	5985.24
2	2549.77	2270.44	3678.84	5180.12	6608.8
3	1060.18	2462.82	4869.77	4032.79	6719.11
4	2451.17	3608.06	4557.26	5575.55	6342.29
5	1792.98	3126.56	3685.39	4583.77	5896.63
6	1164.07	3741.84	3631.9	4448.19	5738.16
7	1695.24	2377.17	3515.55	5252.84	5757.94
8	2030.44	3204.55	4198.17	5265.08	5552.35
Mean	1890.93	3051.75	4099.82	4975.90	6075.07
standard	570.27	603.90	539.41	551.14	430.66
coeff	30.16	19.79	13.16	11.08	7.09
ucl 90%	2176.21	3353.86	4369.66	5251.61	6290.51
lcl 90%	1605.65	2749.65	3829.98	4700.18	5859.62
ucl 99%	2495.38	3691.85	4671.56	5560.07	6531.54
lcl 99%	1286.47	2411.65	3528.08	4391.72	5618.59

4.2.2.3. Tensile Test for the determination of σ_{12} for four layer reinforcement composite:

Specimen	Load at Break (N)	Tensile stress at break (MPa)	Tensile stress at maximum tensile extension (MPa)	Load at maximum tensile extension (N)	Tensile strain at maximum tensile extension (mm/mm)	Tensile strain at break (mm/mm)	Maximum tensile extension (mm)	Tensile extension at break (mm)
1	1829.4	78.43	21.36	498.36	0.1928	0.19271	15.42437	15.41666
2	1930.8	82.77	21.7	506.14	0.17691	0.17687	14.15259	14.14996
3	1743.55	74.75	22.26	519.3	0.16673	0.16667	13.33862	13.33324
4	1753.26	75.16	20.03	467.15	0.17853	0.17844	14.28245	14.27498
5	1763.11	75.59	20.86	486.66	0.16673	0.16667	13.33832	13.33342
6	1574.74	67.51	19.65	458.46	0.16069	0.16062	12.8548	12.84996
7	1994.75	85.5	25.16	586.93	0.10483	0.10479	8.38643	8.38326.67
8	1432.41	61.4	14.45	336.98	0.15154	0.15146	12.12334	12.1167
Mean	1752.75	75.14	20.68	482.50	0.16235	0.16228	12.98762	13.63927
Standard	181.52	7.78	3.03	70.79	0.02637	0.02636	2.10961	1.07645
Coeff	10.36	10.35	14.66	14.67	16.24299	16.24286	16.24326	7.89229
UCL 90%	1843.56	79.03	22.20	517.91	0.17554	0.17546	14.04296	14.17778
LCL 90%	1661.95	71.25	19.17	447.09	0.14915	0.14909	11.93227	13.10077
UCL 99%	1945.15	83.39	23.90	557.53	0.19030	0.19022	15.22369	14.78025
LCL 99%	1560.35	66.89	17.47	407.47	0.13439	0.13434	10.75154	12.49830

Specimen number	Young's Modulus (0 mm/mm-0.02 mm/mm)	Chord Modulus (0.001 mm/mm-0.005 mm/mm)	Chord Modulus (0.005 mm/mm-0.01 mm/mm)	Chord Modulus (0.01 mm/mm-0.015 mm/mm)	Chord Modulus (0.015 mm/mm-0.02 mm/mm)	Chord Modulus (0.02 mm/mm-0.025 mm/mm)
1	2064.64	1204.37	921.41	890.65	788.02	870.9
2	2473.62	1080.14	1164.36	1038.75	929.75	872.17
3	2011.6	908.5	958.69	914.91	817.62	706.07
4	2876.65	958.53	1147.45	1118.13	978.87	767.06
5	3032.92	1238.37	1072.33	979.35	855.99	899.58
6	2797.37	1281.63	944.24	894.18	829.57	770.12
7	3517.75	1213.9	1101.3	1140.2	971.78	715.21
8	2555.25	943.03	982.49	843.36	764.99	826.48
Mean	2666.23	1103.56	1036.53	977.44	867.07375	803.44875
Standard	501.55	150.06	96.27	111.10	82.83870	74.40006
Coeff	18.81	13.60	9.29	11.37	9.55382	9.26009
UCL 90%	2917.13	1178.63	1084.69	1033.02	908.51431	840.66782
LCL 90%	2415.32	1028.49	988.38	921.86	825.63319	766.22968
UCL 99%	3197.84	1262.61	1138.57	1095.20	954.87826	882.30876
LCL 99%	2134.61	944.51	934.50	859.68	779.26924	724.58874

Specimen number	Secant Modulus (0.005 mm/mm)	Secant Modulus (0.01 mm/mm)	Secant Modulus (0.015 mm/mm)	Secant Modulus (0.02 mm/mm)	Secant Modulus (0.025 mm/mm)
1	1267.85	1319.03	1311.94	1387.15	1072.74
2	1197.65	1186.55	1149.6	1125.63	1083.39
3	1109.12	1058.98	1022.96	1181.89	1135.92
4	1227.98	1201.14	1180.38	1140.08	1077.91
5	1442.35	1319.01	1234.1	1158.48	1065.33
6	1173.14	1063.51	1021.18	1182.85	1030.73
7	1440.34	1327.33	1230.54	1338.79	1234.86
8	1319.74	1173.99	1066.34	1066.07	1159.47
Mean	1272.27	1206.19	1152.13	1197.62	1107.54
Standard	121.55	109.29	107.17	109.31	65.54

Coeff	9.55	9.06	9.30	9.13	5.92
UCL 90%	1333.08	1260.87	1205.74	1252.30	1140.33
LCL 90%	1211.46	1151.52	1098.52	1142.93	1074.76
UCL 99%	1401.11	1322.04	1265.73	1313.48	1177.01
LCL 99%	1143.43	1090.35	1038.53	1081.75	1038.08
Specimen number	Tangent Modulus (0.005 mm/mm)	Tangent Modulus (0.01 mm/mm)	Tangent Modulus (0.015 mm/mm)	Tangent Modulus (0.002 mm/mm)	Tangent Modulus (0.025 mm/mm)
1	1011.27	1177.15	1010.71	910.71	794.79
2	1112.35	1076.94	1093.8	857.73	874.39
3	1027.82	1287.31	1182.45	818.83	949.23
4	1198.05	1108.24	1136.53	747	686.81
5	1180.7	1290.09	1192.75	866.9	960.33
6	1132.02	1022.2	1265.97	928.78	901.86
7	1209.8	1122.96	1257.53	782.32	750.38
8	1092.72	1001.39	1064.43	910.93	794.3
Mean	1120.59	1135.79	1150.52	852.90	839.01
standard	74.74	109.43	90.99	65.51	97.87
coeff	6.67	9.64	7.91	7.68	11.66
ucl 90%	1157.98	1190.53	1196.04	885.67	887.97
lcl 90%	1083.20	1081.04	1105.00	820.13	790.05
ucl 99%	1199.81	1251.78	1246.97	922.34	942.74
lcl 99%	1041.37	1019.79	1054.08	783.46	735.28

Claims

- 1- The reinforcement used in the composite is a hybrid 2X2 twill weave textile. It consists of two types of fibres, the primary being glass and the secondary being carbon. In the warp direction the tows are placed with a ratio 4:1 where each four glass tows are followed by a carbon tow in a repetitive pattern while in the weft direction the ratio is 2:1 where each two glass tows are followed by a carbon tow in a repetitive pattern.
- 2- The resin used is an Epoxy resin produced from a reaction between bisphenol A and epichlorhydrin with an epoxy curing agent made of a mixture of organic compounds which are aminomethyl, trimethylcyclohexylamine, benzyl alcohol and trimethylhexane. The resin and the curing agent are mixed with a ratio 5:2.
- 3- The method used to prepare the hybrid composite is wet layup method. A glass plate is used as the open mould for the wet layup method. Wax is used as the de-moulding agent to easily separate the final composite from the glass mould. The first layer of the fabric is placed on the dry wax then the mixture of the resin and the hardener is distributed over the fabric with a brush and using a roller the mixture is evenly spread out and distributed to prevent any irregularities and to ensure the absence of air bubbles. After coagulation further layers of the fabric are then applied with the same technique. The number of layers is chosen according to the specifications needed. The composite laminates are left at 30 ± 2 °C for 48 hours to ensure the resin curing and hardening.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/EG2023/000009

A. CLASSIFICATION OF SUBJECT MATTER		
B32B 5/24 (2006.01)i; B32B 7/04 (2019.01)i; B29C 70/04 (2006.01)i; B29C 70/10 (2006.01)i; B29C 70/30 (2006.01)i; B29C 70/44 (2006.01)i; C08G 59/18 (2006.01)i; C08G 59/40 (2006.01)i; C08J 5/04 (2006.01)i; F17C 1/02 (2006.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) B32B 5/24; B32B 7/04; B29C 70/04; B29C 70/10; B29C 70/30; B29C 70/44; C08G 59/18; C08G 59/40; C08J 5/04; F17C 1/02		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Composite -weave- glass- carbon- fiber- resin bisphenol- Epichlorohydrin- wet layout method- warp-weft -plain weave-layers.		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PATENTSCOPE, Espacenet, Google Patents, Egyptian patent database.		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 20160052638 A (DAICEL EVONIK LTD [JP]) 12 May 2016 (2016-05-12) Description.	1-3
Y	EP 1526152 B1 (UNITED TECHNOLOGIES CORPORATION) 12 December 2007 (2007-12-12) Description: Paragraphs: [005]; [006]; [007]; [008]; [0015]; [0018]; [0019] - Claims: (1), (2), (6) and (7).	1-2
Y	JP 4658526 B2 (BOEING CO) 23 March 2011 (2011-03-23) Description-Claims (1), (2), (3) and (4).	1-2
Y	JP 2010059300 A (TORAY INDUSTRIES) 18 March 2010 (2010-03-18) Description.	1-2
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<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 26 November 2023		Date of mailing of the international search report 27 November 2023
Name and mailing address of the ISA/EG Egyptian Patent Office Academy of Scientific Research -- 101 Kasr Al Ainy st. P.O:11516 Cairo Egypt Telephone No. (202) 792 22 03, 792 12 72 Facsimile No. +2027921273		Authorized officer Dr. Noha Naguib Telephone No. +202- 27921272 - 27921274 - 27921291

INTERNATIONAL SEARCH REPORT

International application No.

PCT/EG2023/000009

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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Y	US 20060062973 A1 (SHORT BROTHERS PLC) 23 March 2006 (2006-03-23) Description Paragraphs: [0020] - [0021] – [0022]- [0071]- [0072]- [00106].	3
Y	US 2021308969 A1 (STEINBERG DOV [IL]) 07 October 2021 (2021-10-07) Description paragraphs [004], [006], [007], [0010], [0017] and [0033].	3

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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US	20060062973	A1	23 March 2006	NONE			
US	2021308969	A1	07 October 2021	NONE			