ASSESSMENT OF FIBER REINFORCED POLYMERS FOR A GILSON MAST STRUCTURE ON STEEL DECK SHIPS

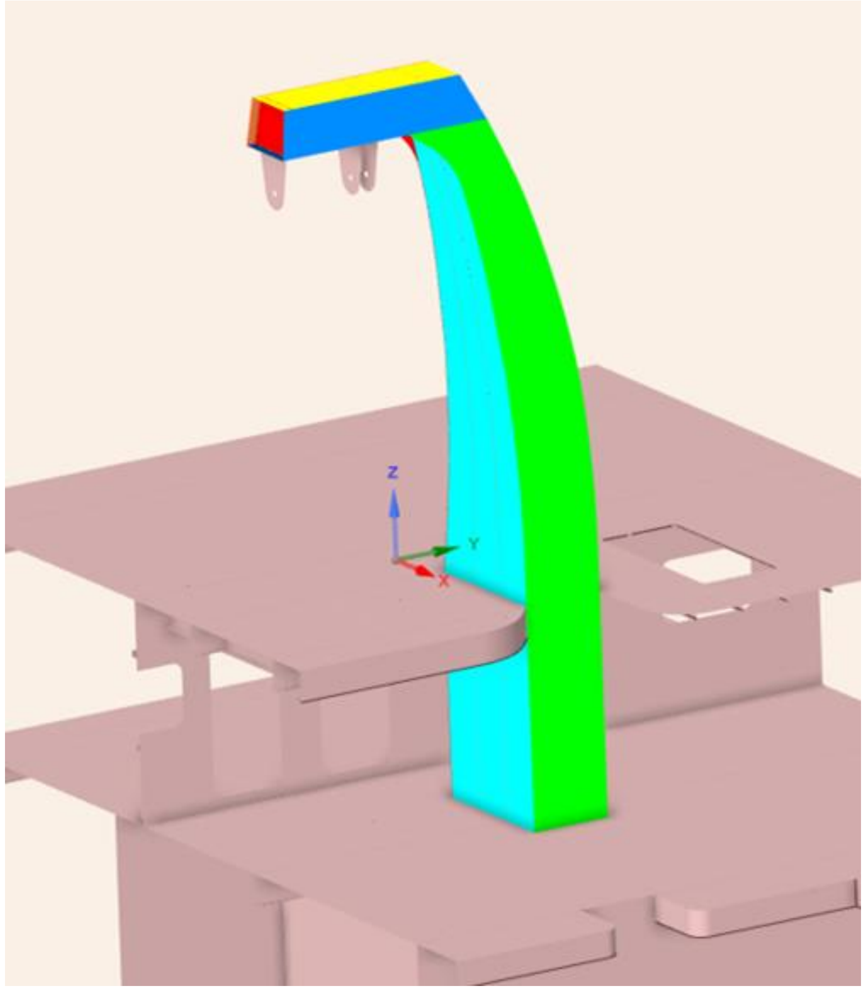
- E. Akarsu[1], B. Osma[1], Ş. Helvacıoğlu[2], İ.H. Helvacıoğlu[1], K. Bilge[1,3]*

[1]Department of Naval Architecture and Marine Engineering, Faculty of Engineering, Pîrî Reis University, İstanbul, Turkey

[2] Maritime Higher Vocational School (MHVS), Ship Construction Programme, Pîrî Reis University, İstanbul, Turkey,

[3]Insight Technology Development and Consultancy, Kozyatağı, Turkey

Corresponding author: (kbilge@pirireis.edu.tr)



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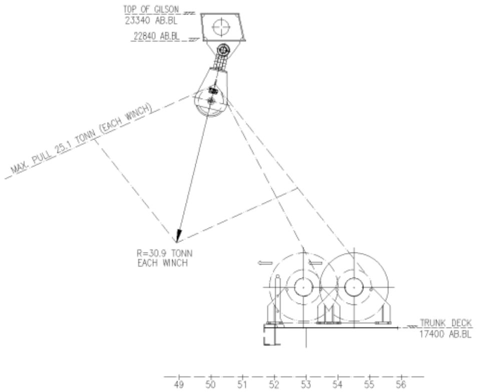
OUTLINES:

1) INTRODUCTION
2) MODELLING PROCEDURE
3) METHODOLOGY
4) RESULTS
5) CONCLUSIONS

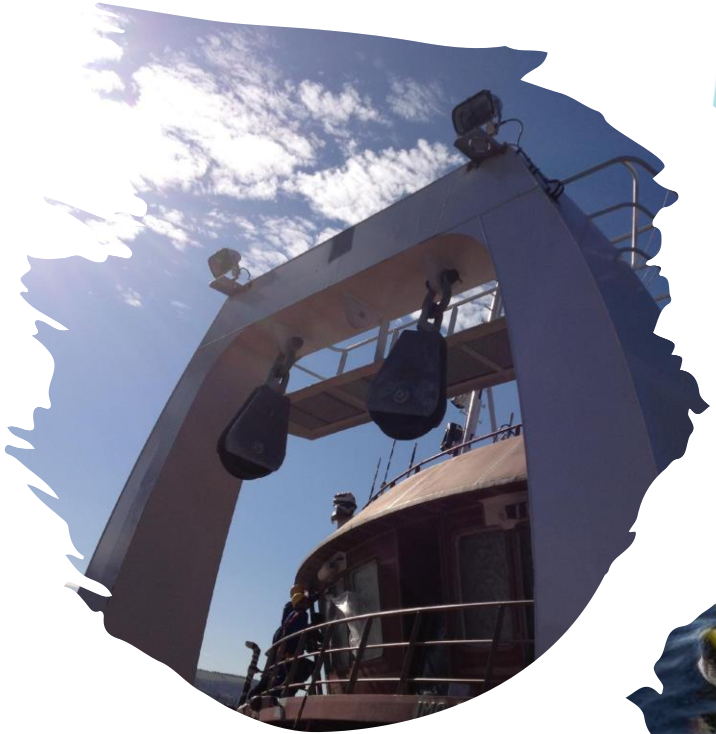
Figure 1: Gilson Mast Model

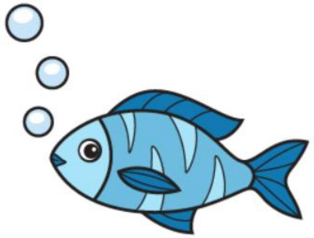
INTRODUCTION



Gilson Mast:

- The current study focuses on the adaptation of composite materials to the GM fishing vessel, which is typically constructed using normal strength steel materials. Despite the significance of addressing the joint problem in the overall issue, the study presented focusing implementation of the sub-laminate in this research.





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MODELLING PROCEDURE

- ANSYS SpaceClaim was utilized to model all the structural elements which includes the GM.
- Merely 50% of the model has been generated by utilizing the symmetry tool in ANSYS to reduce the amount of mesh elements.
- Boundary conditions were imposed at the decks and bulkhead ends, where the impact of the applied loads begins to diminish.
- The application of loads at the center of pad eyes has been identified.

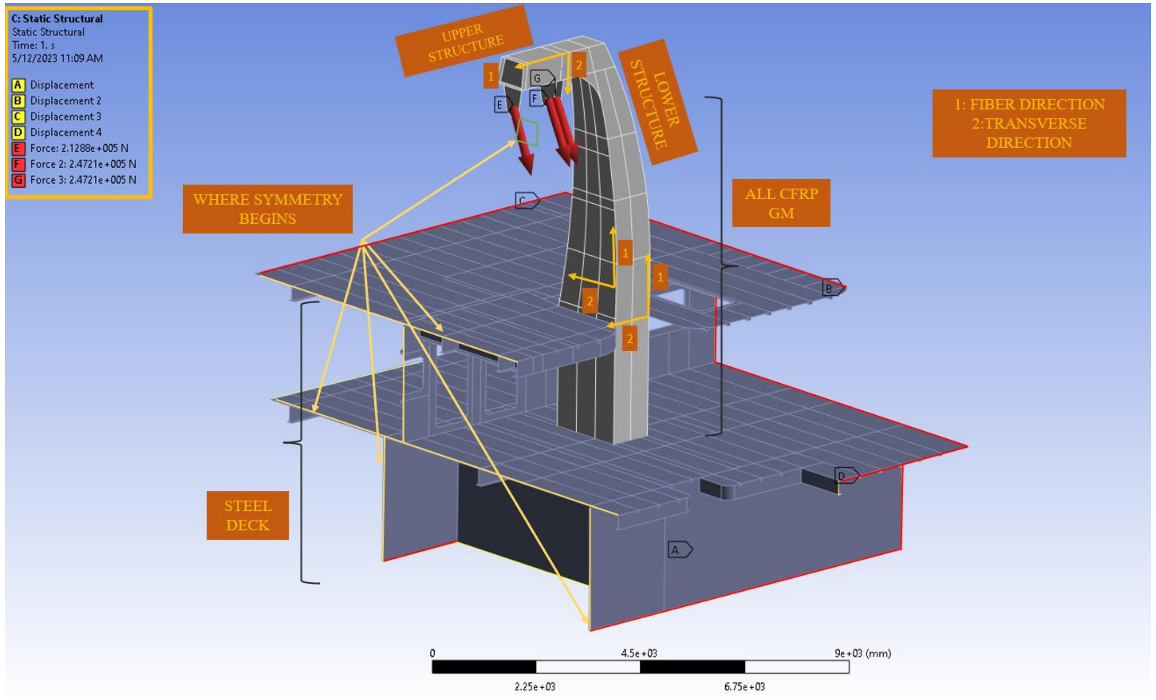

Figure 2: Boundary Conditions and Applied Loads

MODELLING PROCEDURE

Property	Value	Unit
Density	1490	kgm^3
E_1	121	GPa
E_2	8.6	GPa
E_3	8.6	GPa
V XY	0.27	-
V YZ	0.4	-
V XZ	0.27	-
G XY	4.7	GPa
G YZ	3.1	GPa
G XZ	4.7	GPa
$Tensile_1$	2231	MPa
$Tensile_2$	29	MPa
$Tensile_3$	29	MPa
$Compressive_1$	-1082	MPa
$Compressive_2$	-100	MPa
$Compressive_3$	-100	MPa
Shear XY	60	MPa
Shear YZ	32	MPa
Shear XZ	60	MPa

Table 1: Mechanical Properties of UD Carbon/Epoxy Prepreg 230 GPa Material. *1: longitudinal, 2: transverse, 3: through the thickness, E: Young's Modulus, v: Poisson's Ratio, G: Shear Modulus

MODELLING PROCEDURE

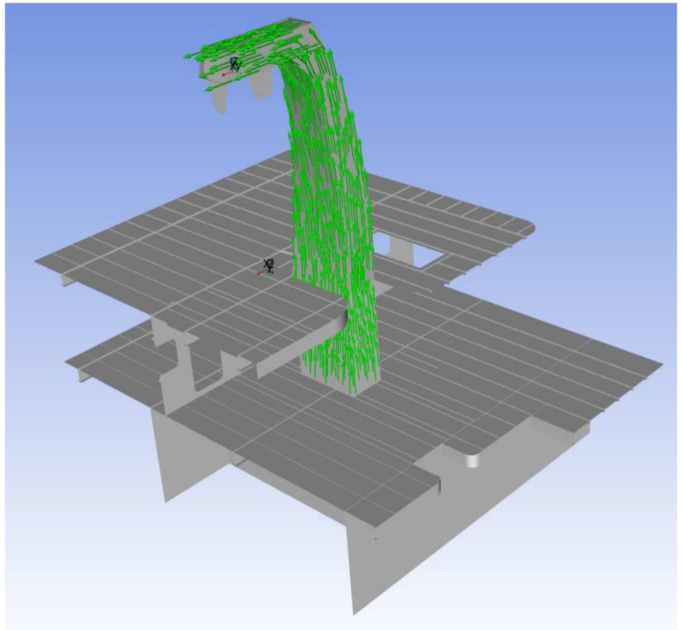

Figure 3: Fiber Directions on the Gilson Mast

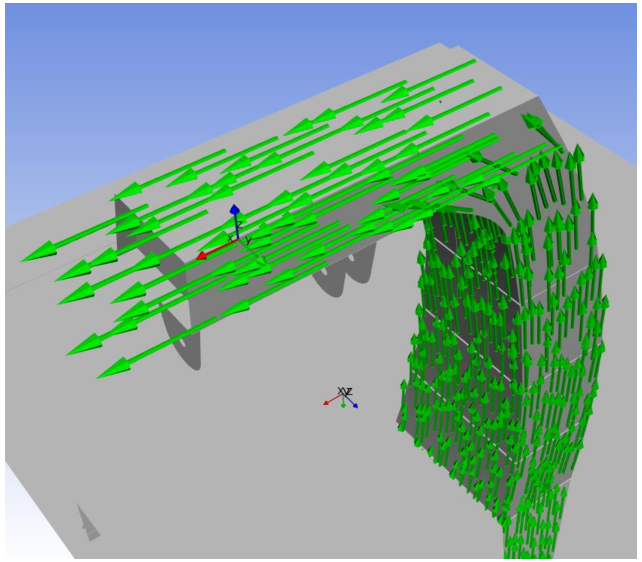

Figure 4: Close-up Fiber Directions on the Gilson Mast

Fiber Directions

- Prepared geometry is designated the ACP module, where each profile was meticulously assigned with fiber directions.

- Particularly, the longitudinal fiber direction was oriented towards the length of each profile, while the transverse direction was aligned with the width.

METHODOLOGY AND SUB-LAMINATE SELECTION

- Ply orientations, which are restricted to 0°, α°, - α°, 0°, used to build the actual layup for the laminate.
- Two different sub laminates have been employed, namely $(0/45/-45/0)_s$ and $(0/23/-23/0)_s$.
- The plates have been identified as A, B, C, D, E, F, G and H to be $(0/45/-45/0)_s$.

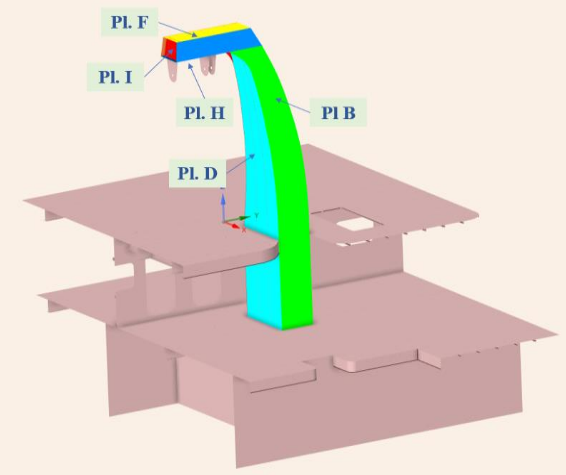

Figure 5a: Naming of plates from front view

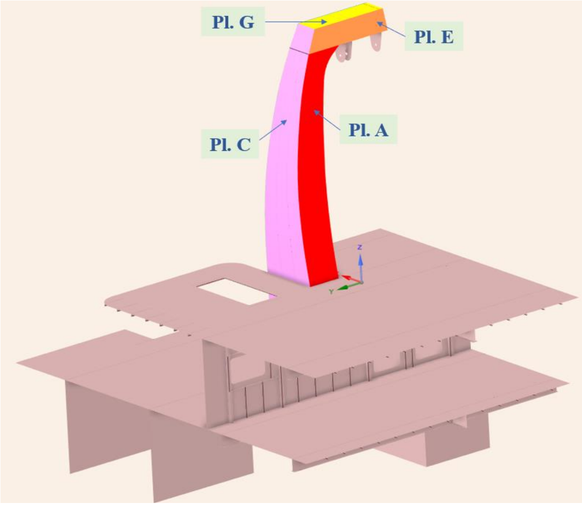

Figure 5b: Naming of Plates from aft view

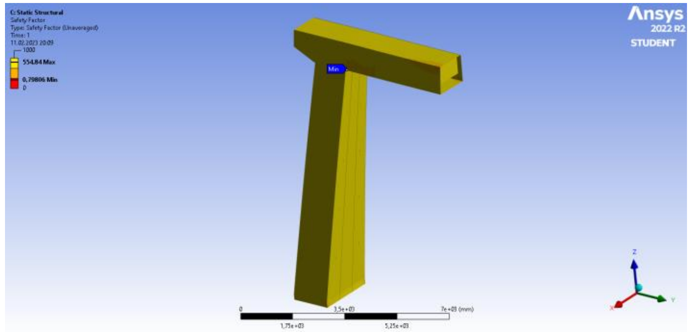

Figure 6a: (0/90/+45/-45)s[1]

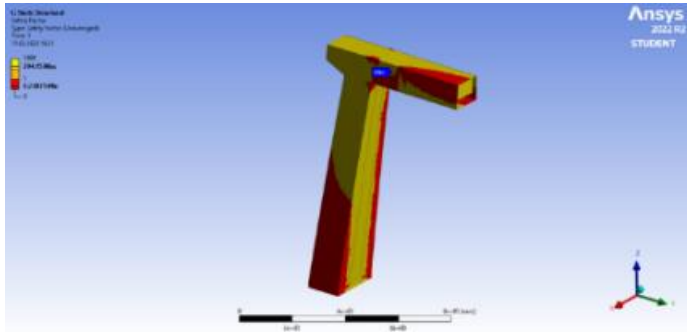

Figure 6b (0/90)s [1]

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[1] B. Osma, E. Akarsu, K. Bilge, Ş. Helvacioglu and İ. Helvacioglu, "Strength And Performance Of A Composite Gilson Mast For Steel Deck Fishing Vessels," in *International Maritime Science Conference*, Solin, 2023.

METHODOLOGY AND SUB-LAMINATE SELECTION

- To improve the results of particular components which is highlighted in Figure 7a-b, it is essential to rotate the ply angles of α° and - α° along the load angle.

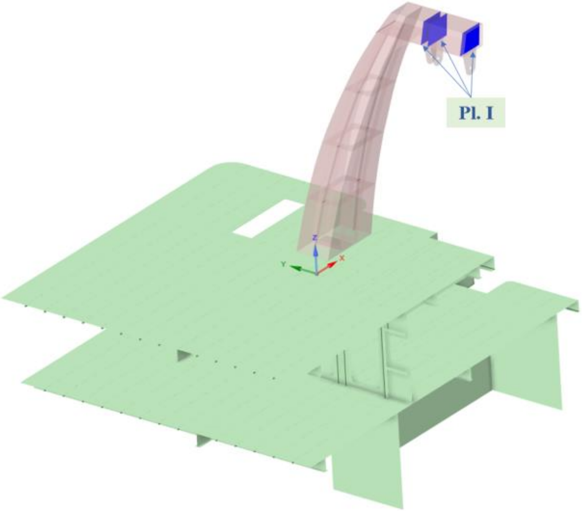

Figure 7a: Perspective of the Gilson Mast

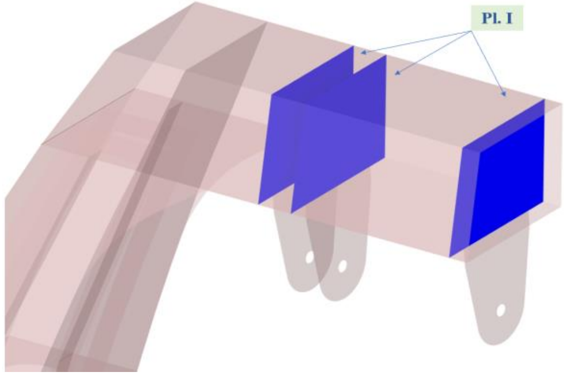

Figure 7b: Close-up View of the Pl. I

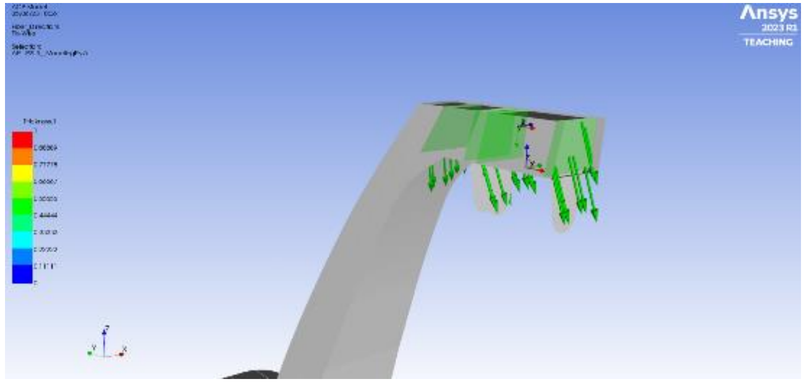

Figure 8: Fiber Directions of the Pl. I

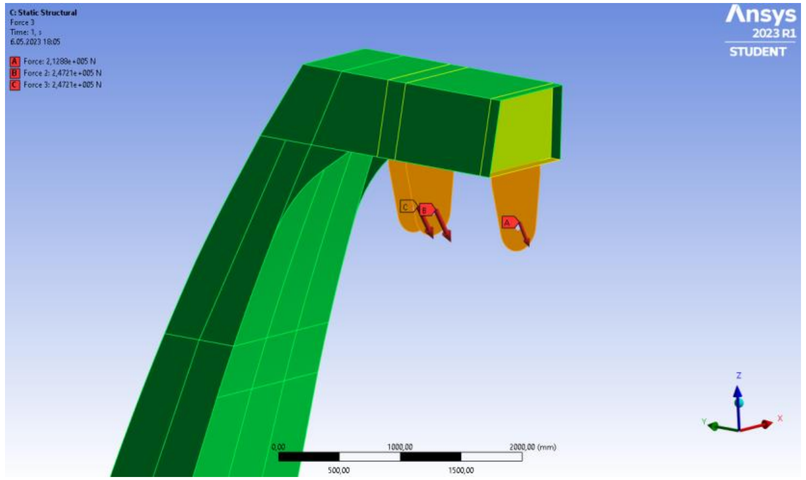

Figure 9: Applied Load Directions of Gilson Mast

METHODOLOGY AND SUB-LAMINATE SELECTION

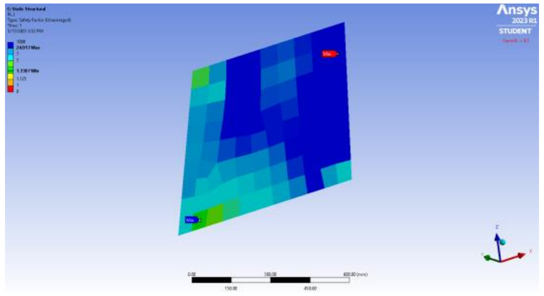

Figure 9a: (0/45-45/0)s

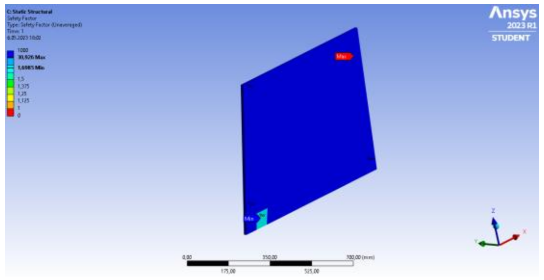

Figure 9b: (0/23-23/0)s

Comparison of the Analysis Results for Pl. I.

•The safety factor of Pl. I was found to be lower when utilizing (0/45/-45/0)s sub-laminate candidate as compared to other sub-laminate candidate that is (0/23/-23/0)s.

Name of Component	Name of Sub-Laminates	Min. Safety Factor
Pl. I	(0/45/-45/0)s	1,3307
Pl. I	(0/23/-23/0)s	1,6985

Table 2: Comparison of the Analysis Results for Pl. I

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RESULTS

Original Structural Steel Performance:

- It is typical to utilize structural steel as the primary material for constructing GM, which is a commonly employed material in maritime environments.
- The minimum safety factor based on von-Mises stress analysis was determined to be 1.1693 for the Pl. E component.

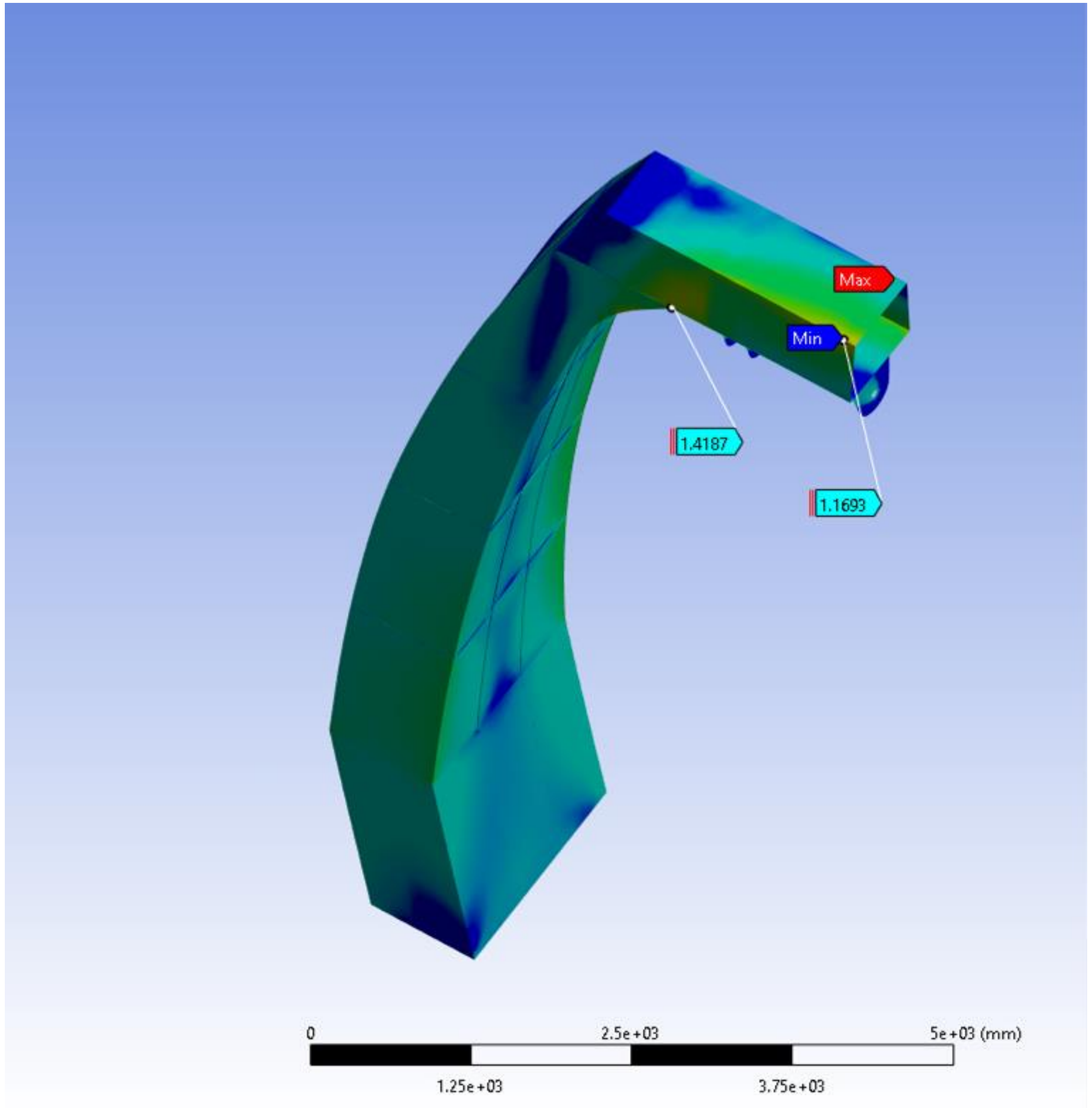

Figure 10: von-Mises based Safety Factor Distribution

RESULTS

CFRP Performance:

- The minimum Tsai-Wu based safety factor which, is 1.13665, closely coincides with the location of the minimum von-Mises safety factor obtained in the steel GM as the safety factor on pad eyes is not taken into consideration.

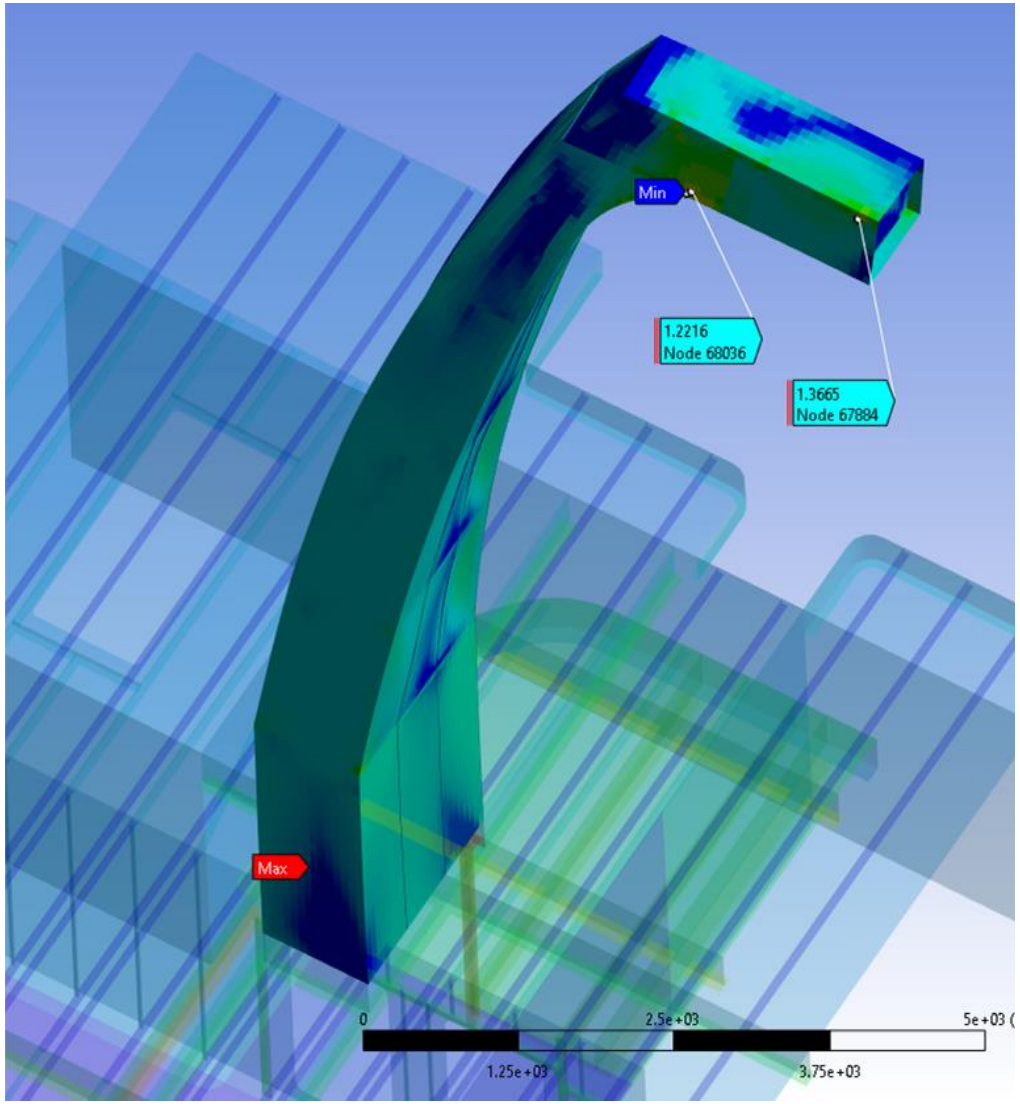

Figure 11: Tsu-Wu and based Safety Factor Distribution

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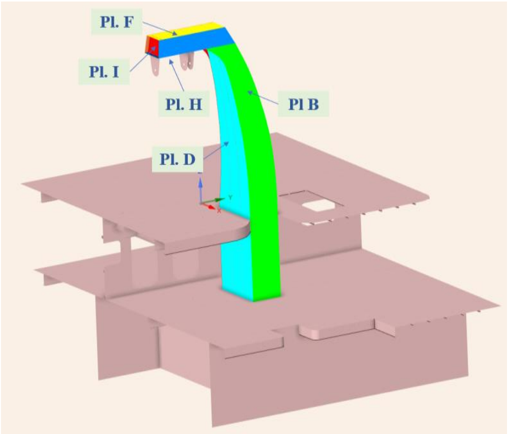
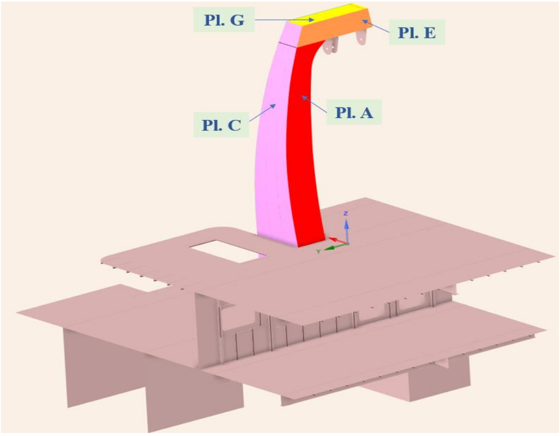
RESULTS





Comparison of the Analysis Results:

- The ratio of densities between the two materials is approximately 1 to 5.25. In other words, the utilization of structural steel in the construction of Gilson Mast results in a weight that is 5.25 times greater.

Plate Name	Thickness (mm)	Steel Weight (kg)	min. SF Steel	CFRP Weight (kg)	min. SF CFRP	Sub-Laminates
Pl. A.	7.00	461.53	1.36	87.60	1.40	$(0/45/-45/0)_s$
Pl. B.	10.00	646.63	1.65	122.74	1.82	$(0/45/-45/0)_s$
Pl. C.	12.00	1283.59	1.63	243.64	1.91	$(0/45/-45/0)_s$
Pl. D.	15.00	1526.06	1.60	289.66	1.31	$(0/45/-45/0)_s$
Pl. E.	11.00	139.84	1.24	26.54	1.22	$(0/45/-45/0)_s$
Pl. F.	8.00	98.79	1.19	18.75	1.45	$(0/45/-45/0)_s$
Pl. G.	12.00	155.84	1.23	29.58	1.50	$(0/45/-45/0)_s$
Pl. H.	10.00	134.10	1.17	25.45	1.34	$(0/45/-45/0)_s$
Pl. I.	15.00	54.16	1.17	10.28	1.70	$(0/23/-23/0)_s$

Table 3: Comparison of the Analysis Results for Pl. I

RESULTS

Comparison of the Performances:

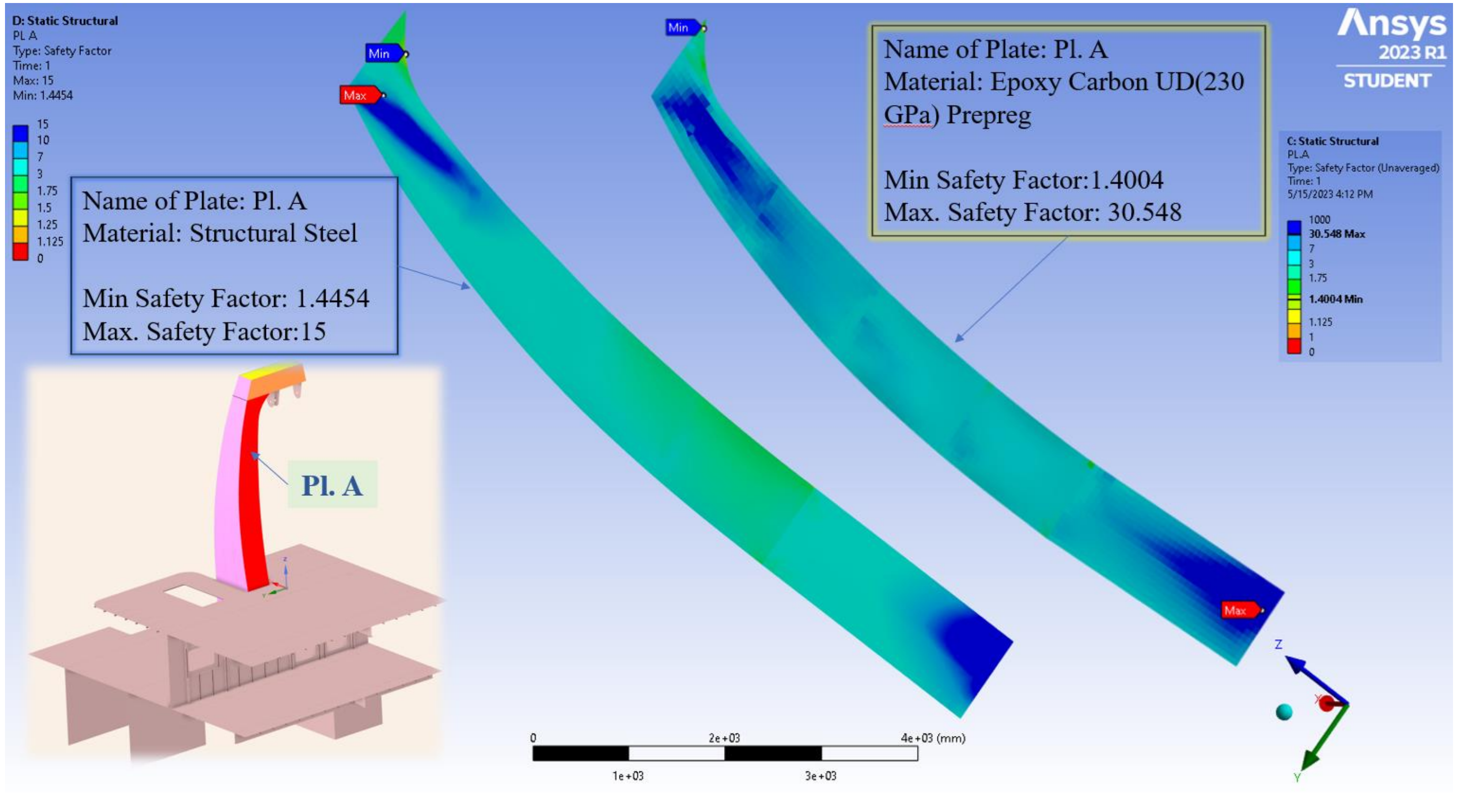
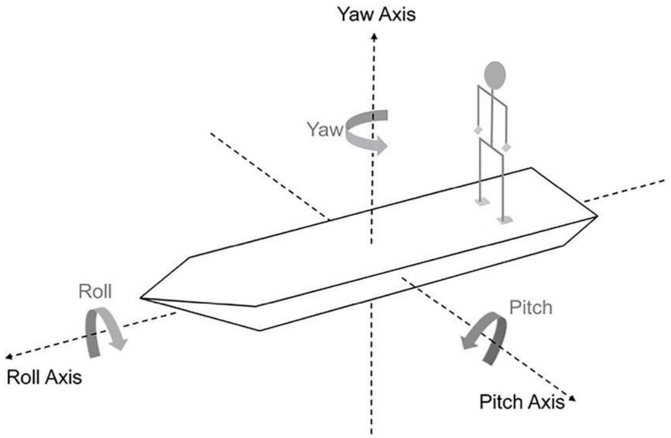


Figure 12: Tsu-Wu and von-Mises Safety Factor Distribution for Pl. A

RESULTS

Dependency of Ship Rolling and Rotation:

The roll motion might play vital role and change the direction of the load when ship is in cruising.



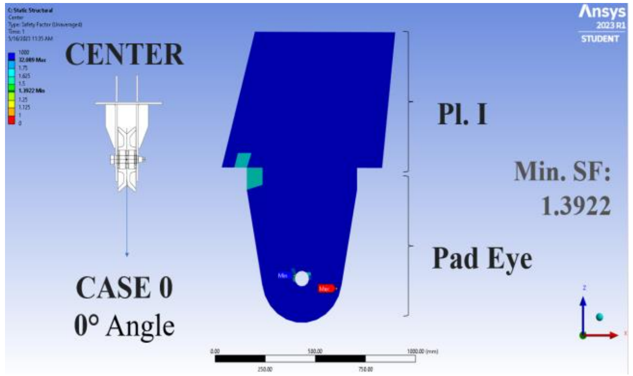


Figure 13a: Tsu-Wu Safety Factor Distribution for 0 Angle

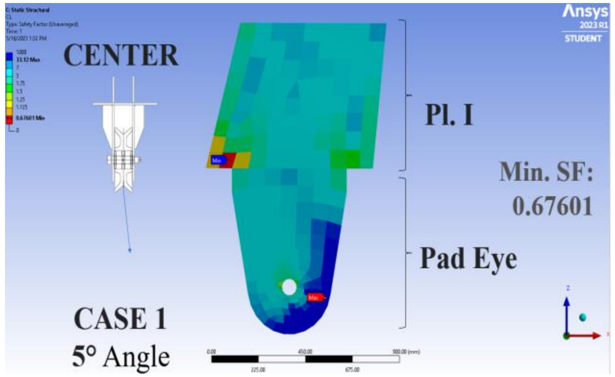


Figure 13b: Tsu-Wu Safety Factor Distribution for 5 Angle

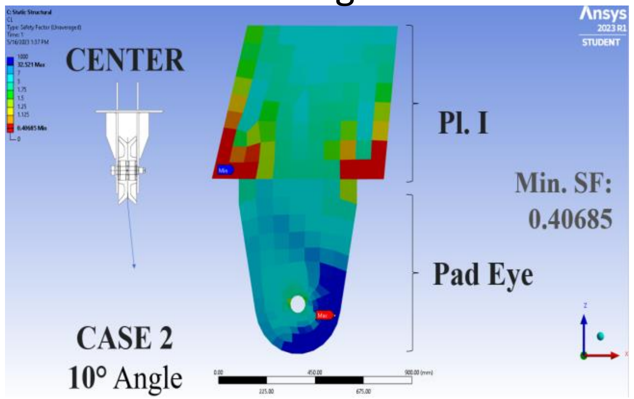


Figure 13c: Tsu-Wu Safety Factor Distribution for 10 Angle

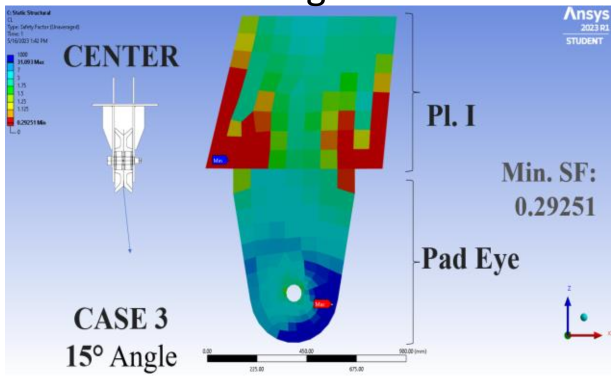


Figure 13d: Tsu-Wu Safety Factor Distribution for 15 Angle

CONCLUSION

- During the subsequent stage of the research, the utilization of the Epoxy Carbon UD (230 GPa) Prepreg has been used.
- Except for pad eyes and Pl. I., which are directly related to their fiber direction and load angle, a $(0/45/-45/0)_s$ sub-laminate was utilized for all structural members designated alphabetically as A through H.
- The implementation of a $(0/23/-23/0)_s$ sub-laminate was found to result in superior outcomes for pad eyes and Pl. I, as compared to the results obtained from a $(0/45/-45/0)_s$ sub-laminate.
- When the composite GM results were obtained, each component of the composite GM was compared to the structural steel GM.
- As indicated by observations, the use of composite materials did not result in lower safety factors.
- It has been reported that this material has the potential to reduce weight by up to 525%.
- In conclusion, the Epoxy Carbon UD (230 GPa) Prepreg material, which has a high strength, is an effective solution for implementation in GM applications.

Thank you