EMship+ Advanced Design

A Study of Basalt Fibers Composite on 23M Cruise Sailing Yacht

PREPARED BY : SRI LESTARI MAHARANI

SUPERVISED BY : JEAN-BAPTISTE R.G. SOUPPEZ

DEVELOPED AT SOUTHAMPTON SOLENT UNIVERSITY, UNITED KINGDOM

Objectives

Volcanic Rock

Basalt Fiber

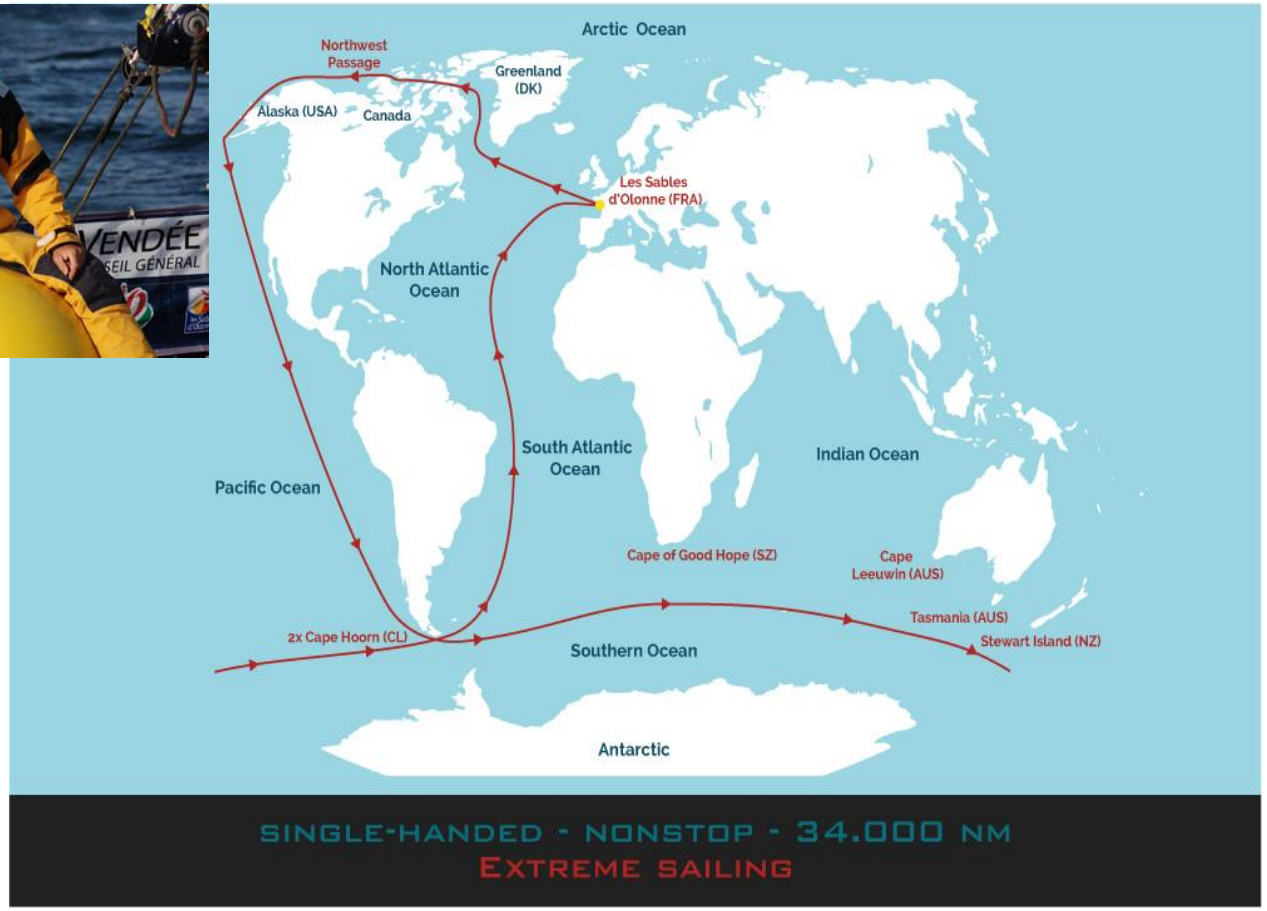
	E-glass	Basalt
Density (g/cm^3)	2.56	2.8
Elastic modulus (GPa)	76	89
Tensile strength (GPa)	1.4–2.5	2.8
Elongation to fracture (%)	1.8–3.2	3.15
Specific E modulus (GPa per g/cm^3)	30	31.78
Specific tensile strength (GPa per g/cm^3)	0.5–1	1

More Sustainable material and 100 % recyclable (natural matrix and core material)

Volcanic rock picture courtesy of wiseGeek, Basalt fibre picture courtesy of Isomatex

Table courtesy of Fiore V. (Glass-Basalt/epoxy hybrid composites)

Ant-Arctic-Lab (Norbert Sedlacek-Finisher of Vendee globe)



Picture courtesy of Ant-Arctic-Lab

Methodology of research

Material Testing

Specimen from glass and basalt fiber + bto epoxy, Vacuum Infusion Method

Burn off test

Tensile test (ISO 527-5)

Flexural Test (ISO 178)

Compressive test (ISO 14126)

Concept design of cruise sail yacht

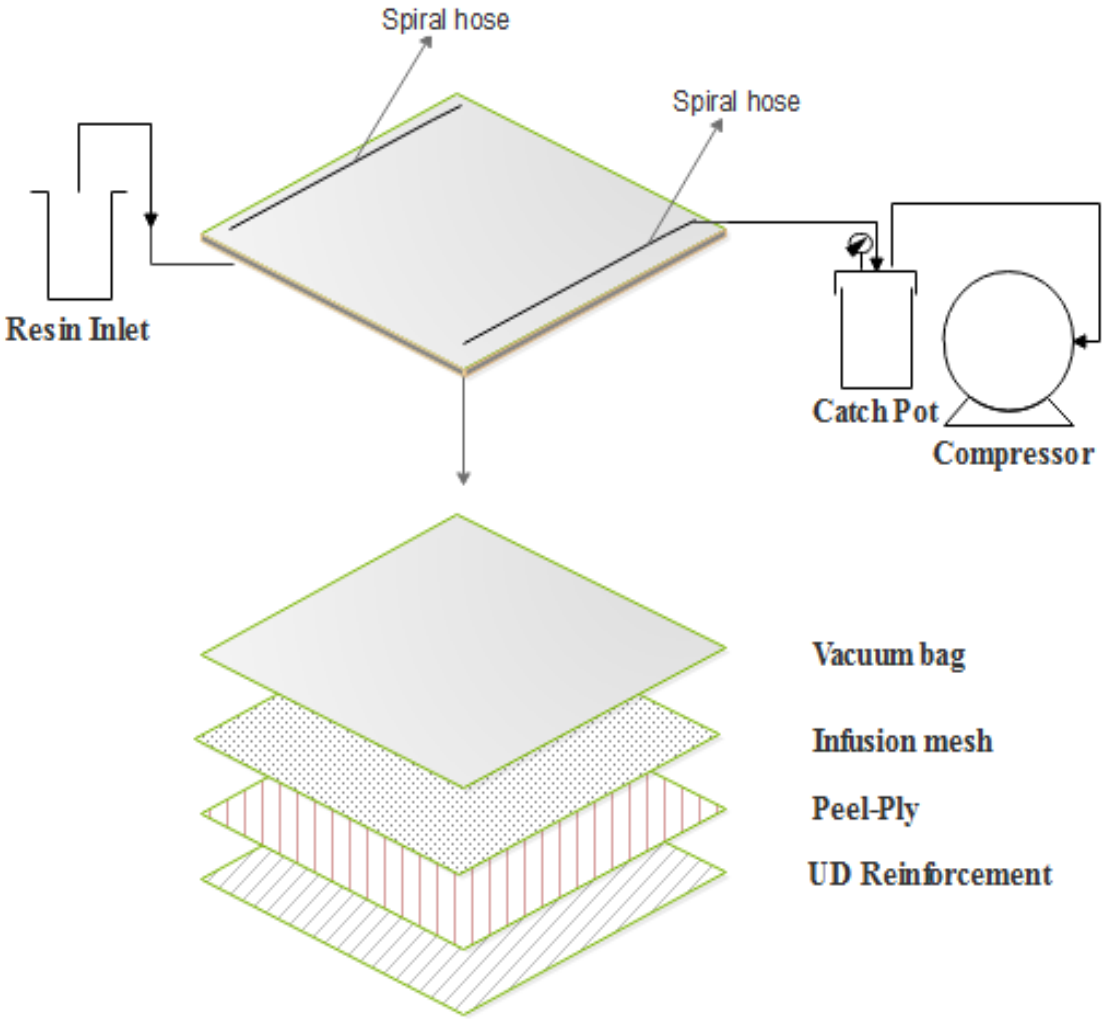
Parametric Study

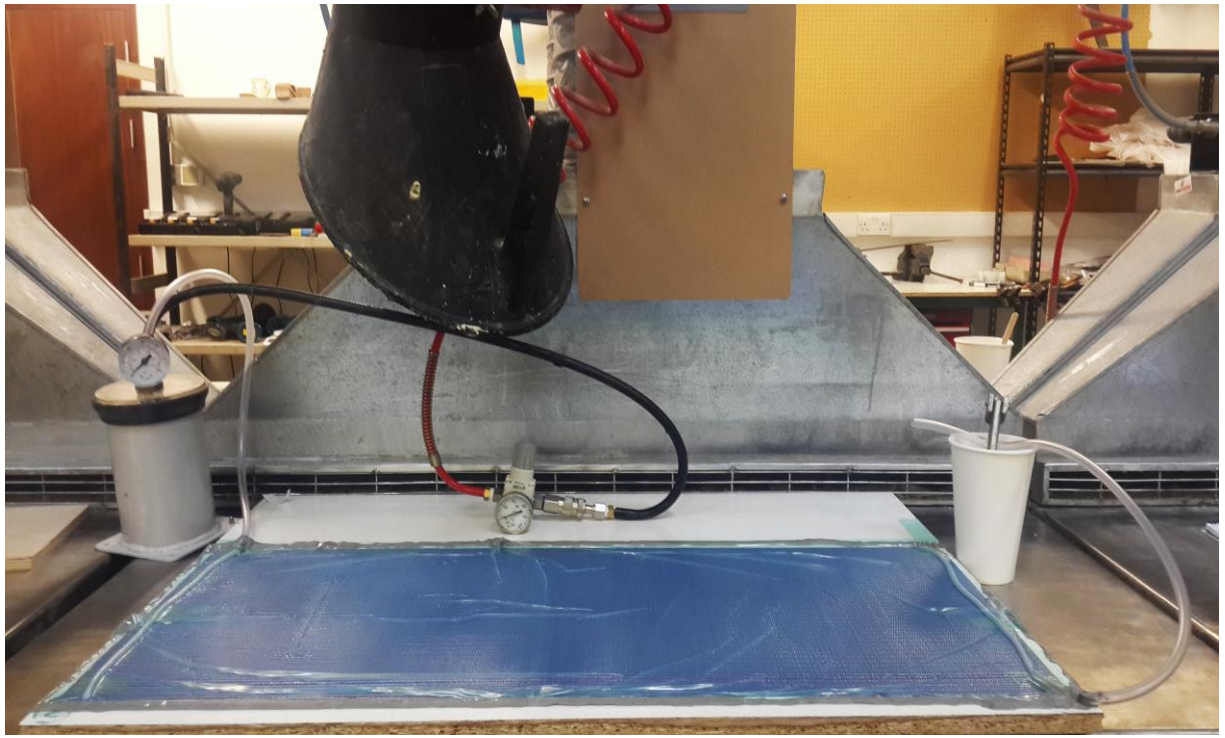
Hull, Appendages, Sail and Rig design

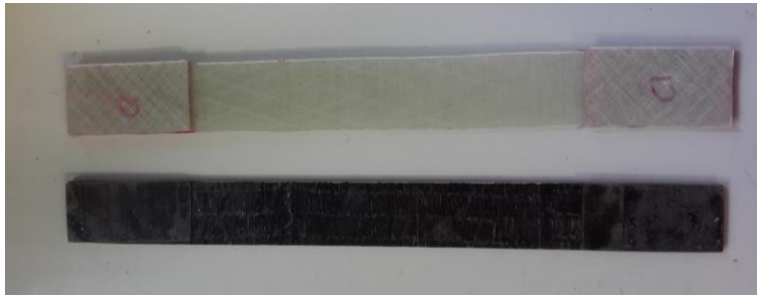
Structure Assessment

Weight estimation, Propulsion, Stability, and Cost comparison

Specimen creation







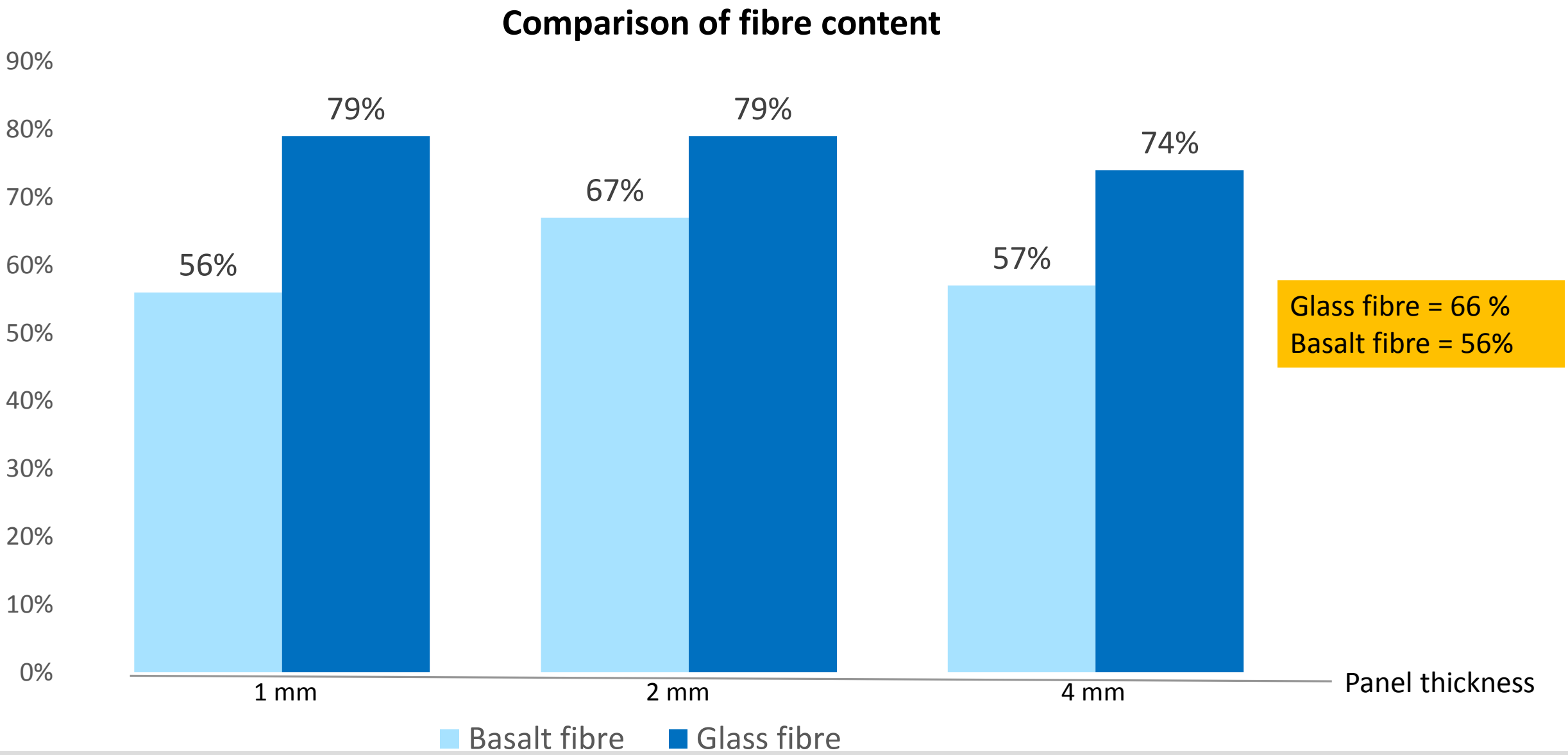
Glass fiber

Basalt fiber

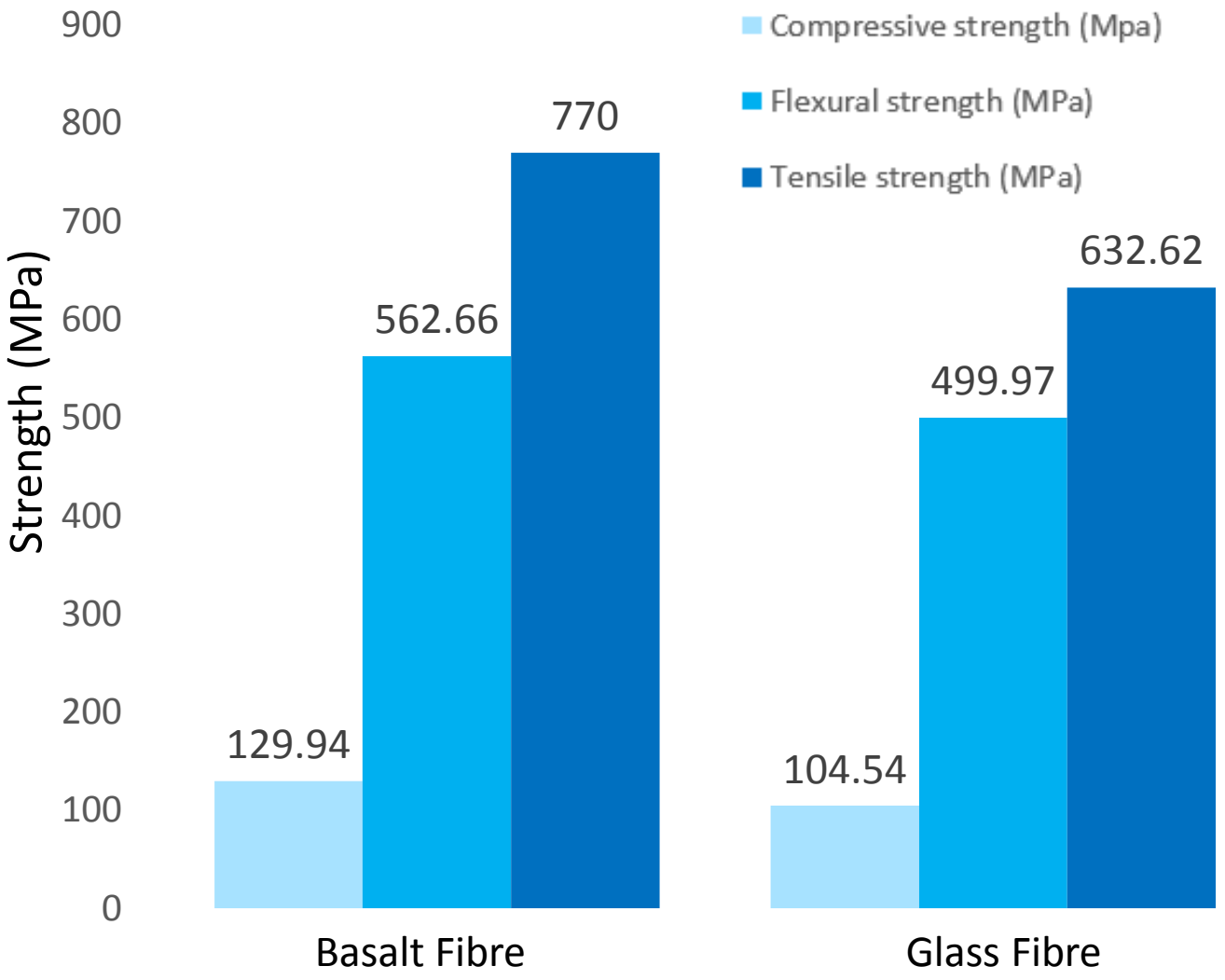
Basalt fibre (Filava) + BTO Epoxy IR 77.31

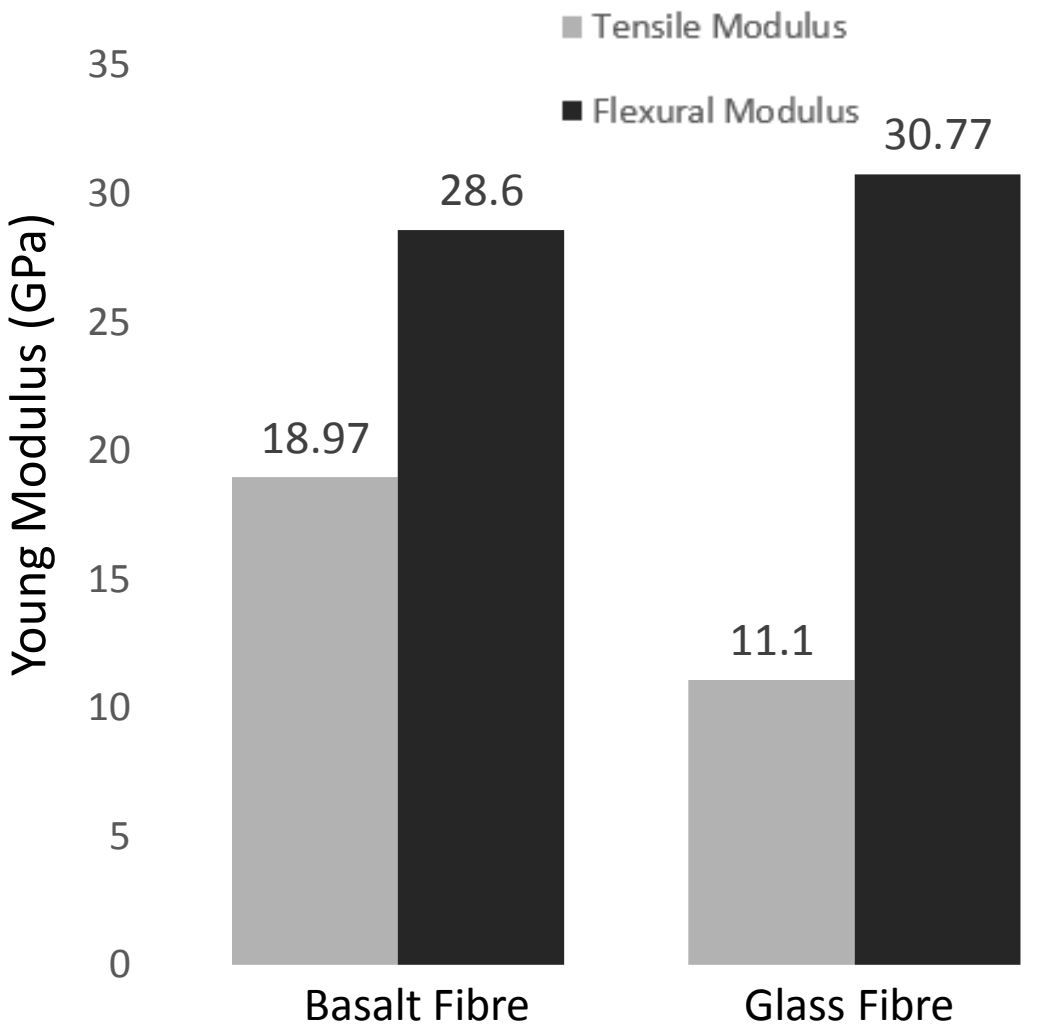
Glass Fibre + BTO Epoxy IR 77.31

Burn off Test Result



Tensile, Flexural, and Compressive Test Result





Tensile, Flexural, and Compressive Test Result

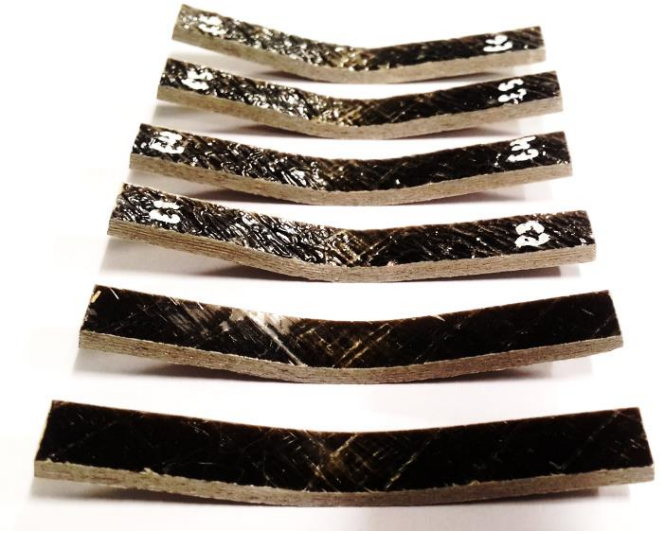
Tensile test

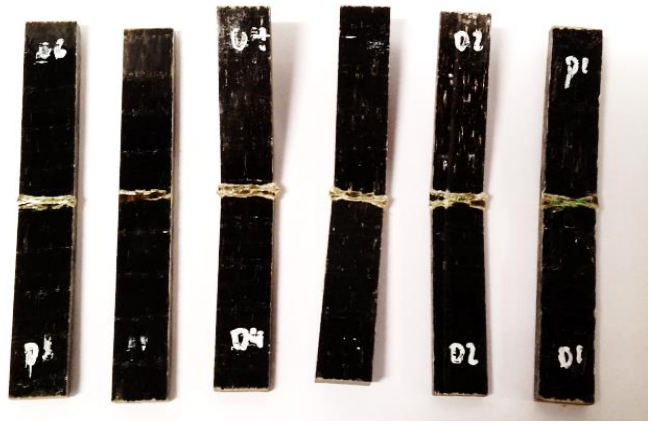
0^0

$+/-45^0$

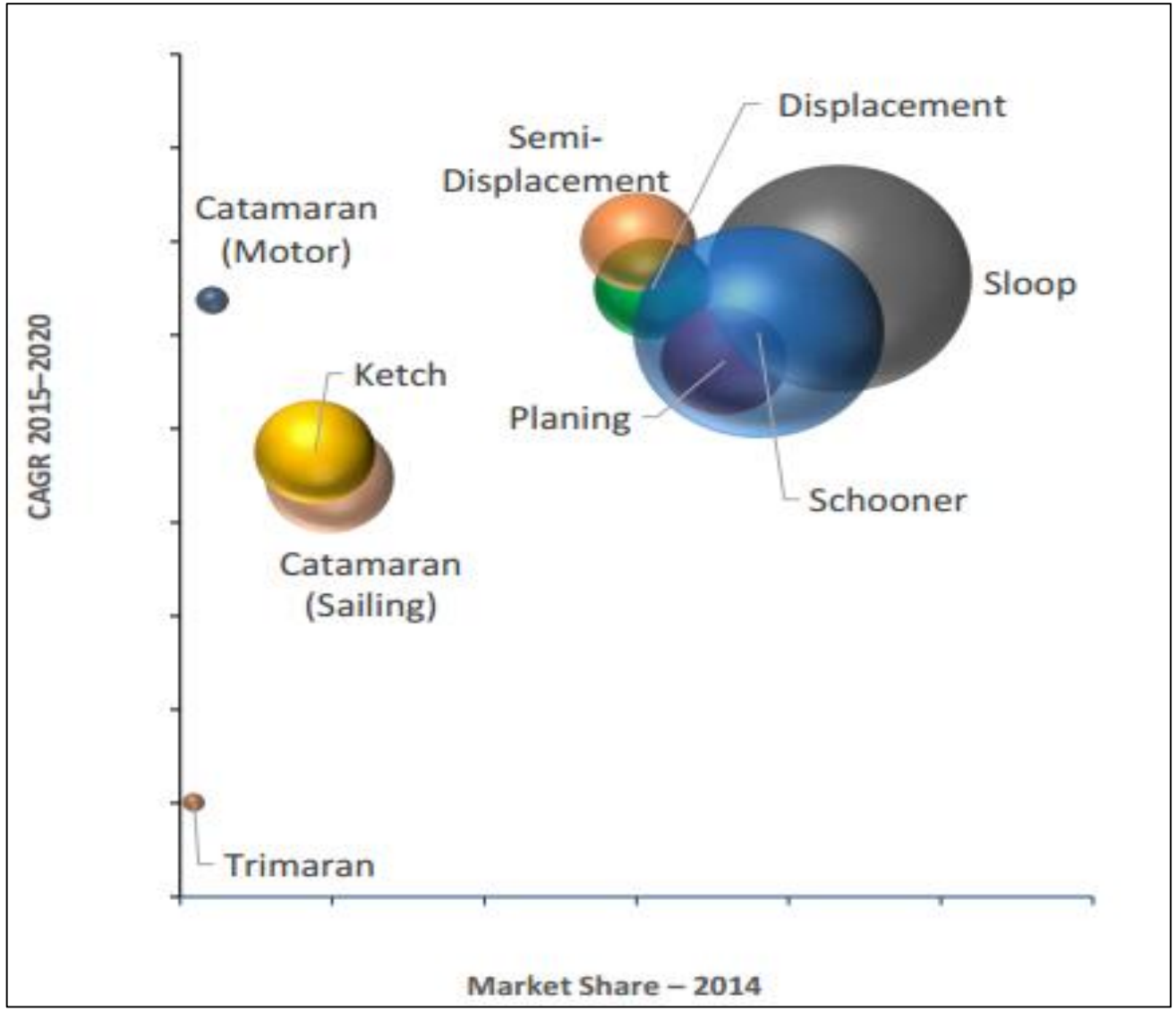
90^0

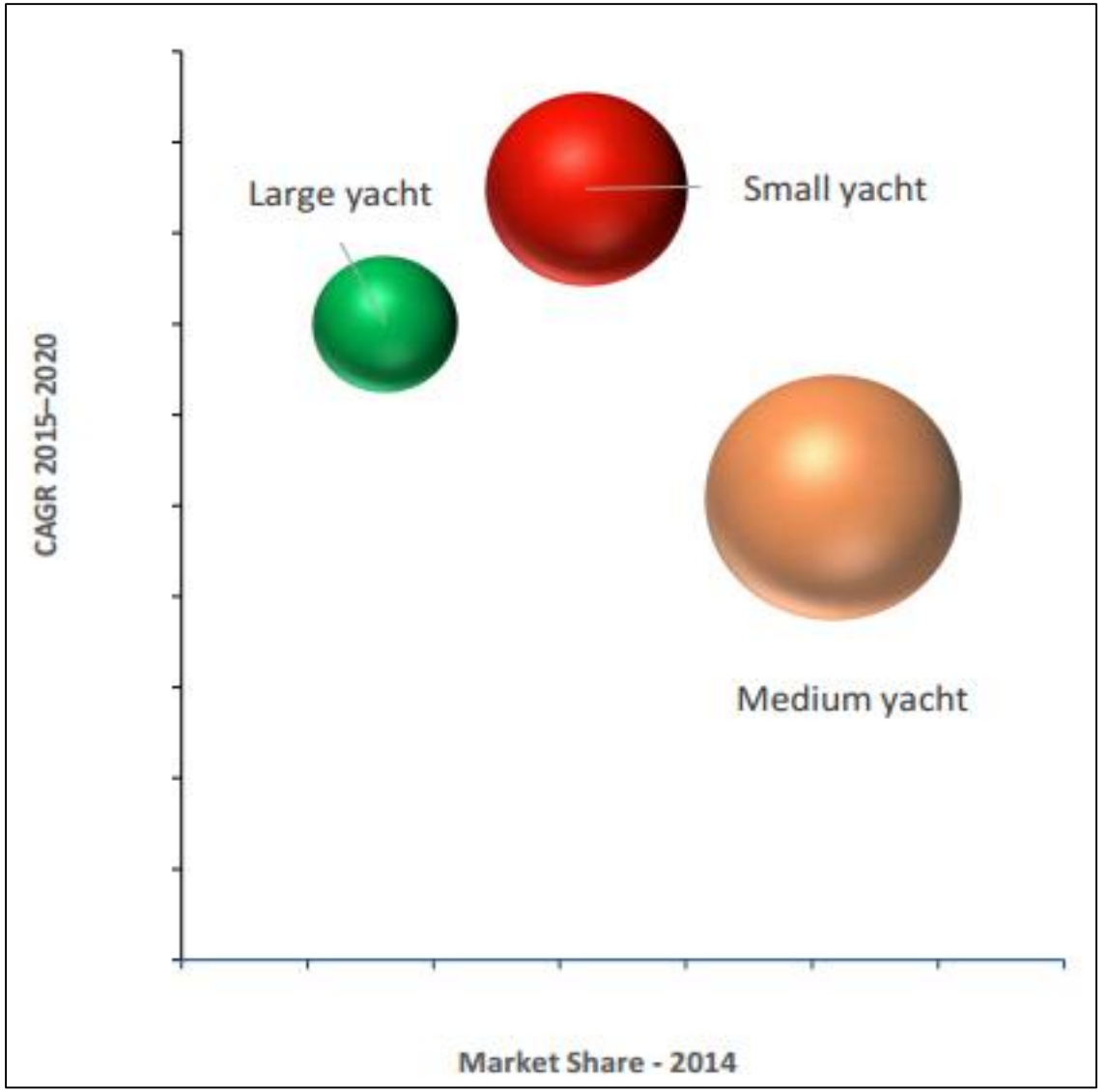
Flexural test





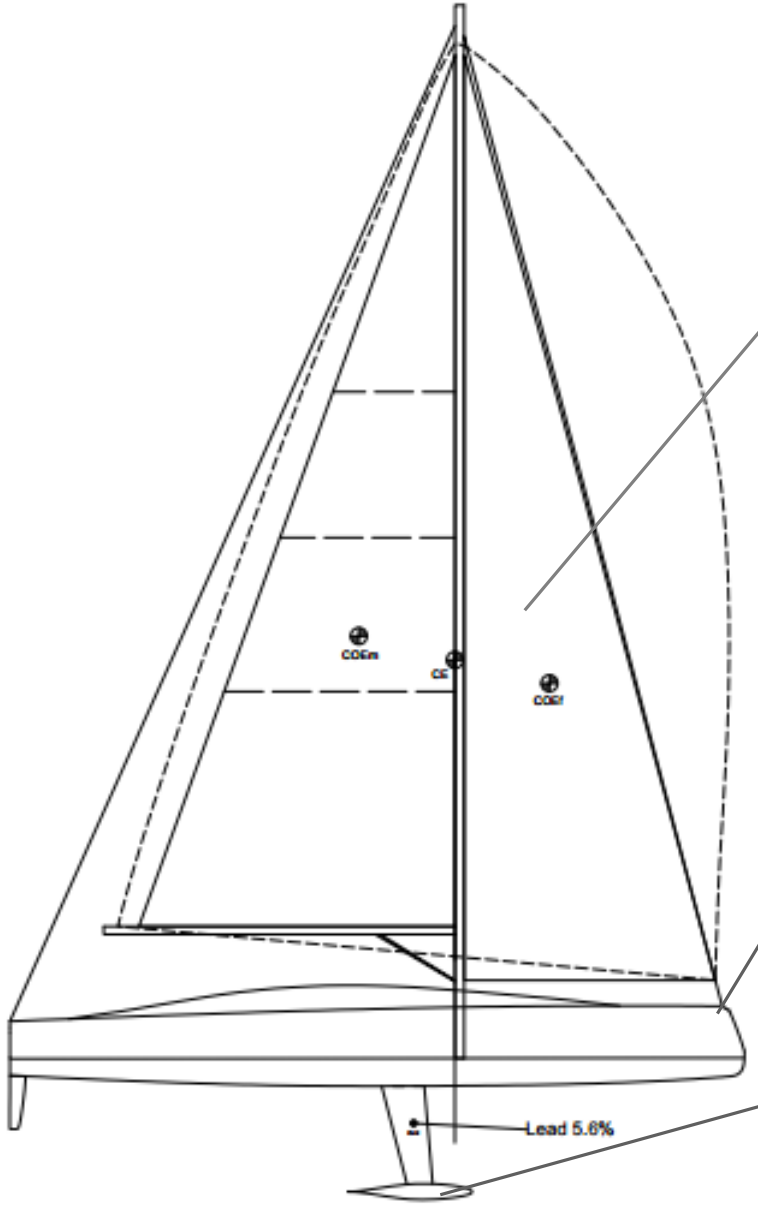
Market Share





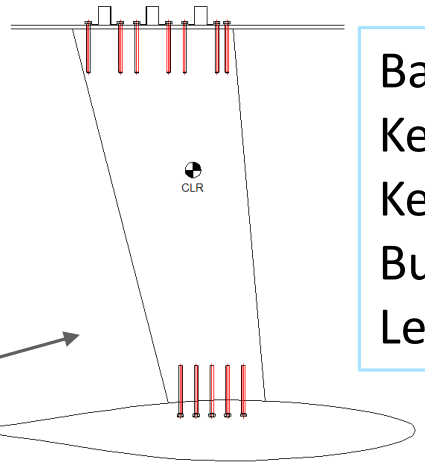
picture courtesy of Future Market Insight

Concept design of sailing yacht



Main sail area : 135 m^2
Fore triangle sail area : 131 m^2
Spinnaker sail area : 301.50 m^2

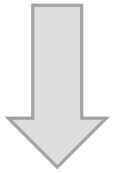
Length over All : 23 m
Length per pendicular : 22.9 m
Beam over all : 6.1 m
Draft : 4.1 m
Displacement : 32.63 ton



Ballast ratio: 35.9%
Keel draft : 3.676 m
Keel weight : 5164 kg
Bulb weight : 6555 kg
Lead : 5.6%

Structure design (ISO 12215-5)

	Basalt	Glass
Density (kg/m^3)	2600	2500
Fibre fraction	56%	66%



Partc	Glass fibre(A) & Basalt fibre(B)	Basalt fibre(C)
Bottom plating	$[0^0_4, \pm45^0, 90^0, 0^0_4]_{outer}$ $[balsa,27mm]_{core}$ $[\pm45^0, 0^0, \pm45^0, 0^0]_{inner}$	$[0^0_2, \pm45^0, 90^0, 0^0_2]_{outer}$ $[balsa,27mm]_{core}$ $[\pm45^0, 0^0, \pm45^0, 0^0]_{inner}$

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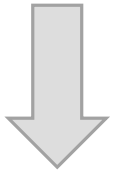
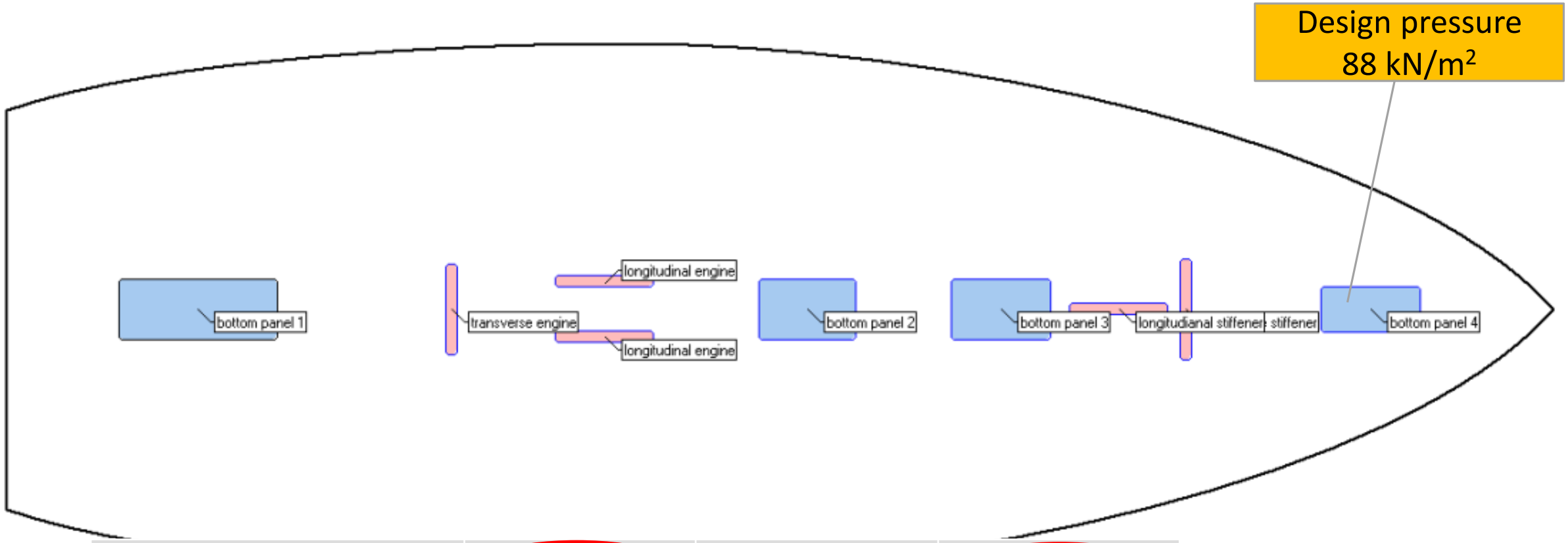


	Bottom		
	Glass fibre (A)	**Basalt fibre (B)**	**Basalt fibre (C)**
Total thickness (mm)	34.71	37.10	34.45
Total weight (kg/m^2)	15.77	17.84	14.11

Structure design (ISO 12215-5)



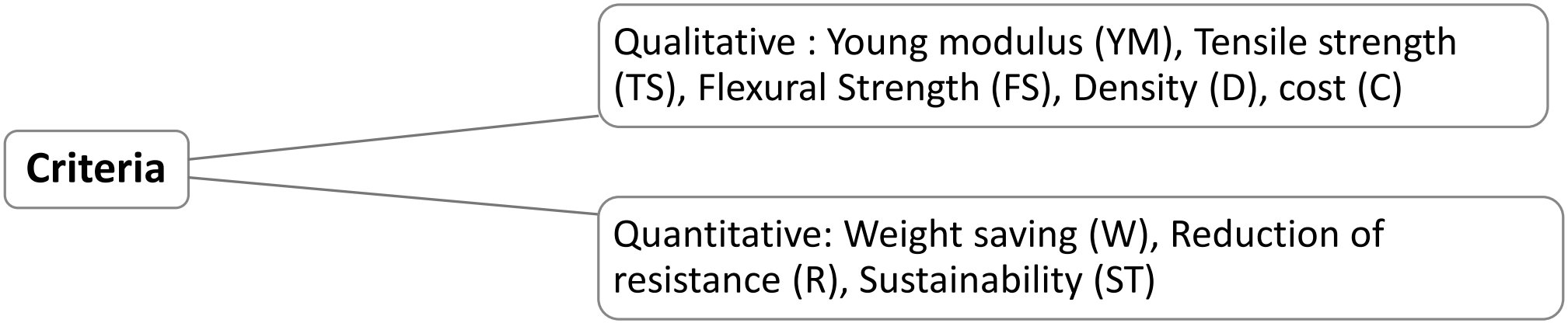
	Glass fibre (A)	Basalt fibre (B)	Basalt fibre (C)
Compliance stress factor	1.2	1.35	1.2

Weight Estimation

Item	Glass fibre	Basalt fibre
Lightship (Kg)	26,568	26,063
Deadweight (Kg)	7,574	7.574
Displacement (Kg)	32,628	32,123
LCG (m)	10.47	10.48
TCG (m)	-0.01	-0.01
VCG (m)	3.03	3.02
T (m)	4.115	4.110

Reduce 504 Kg

Multiple Attribute Decision Making (MADM)



Material	YM	TS	FS	D	W	C	R	ST	P_i^0	Rank
Glass fibre	11.10	632.62	499.97	2500	0	8.32	0	M3(0.2273)	0.0898	2
Basalt Fibre	18.97	770.73	562.66	2600	M2(0.1364)	15	M2(0.1364)	M8(0.6818)	0.1564	1

CONCLUSION

- ✓ Basalt fibre has a higher value in tensile, flexural, and compression strength. But has lower fibre content than glass fibre.
- ✓ In application of 23m cruise sailing yacht, the structure weight can be reduced up to 2%, but increase the structure material cost for 7%
- ✓ Basalt fibre is offer more sustainable process without bring huge changes into design and manufacturing process.