INPUTS:

$alt := 0\ ft$ $knts := 40$ $A_{main} := 21343\ in^2$ $A_{jib} := 7936\ in^2$

$TAS := knts \cdot 1.150779\ mph$

$TAS = 67.512\ \frac{ft}{sec}$

Did some digging for CL max and looks like 1.7 is a concervative estimate. So I used 2.0

$CL_{main} := 2$ $CL_{jib} := 2$

Calculation of Aero Pressures:

$\rho := .00238 \cdot \frac{slug}{ft^3}$ $q_f := \left(\frac{1}{2}\right) \cdot \rho \cdot TAS^2$ $q_f = 0.038\ psi$

$q := \frac{q_f}{psi}$ $q = 0.038$

Forces on Mast:

$W_{hull} := 9.5$ $L_{mast} := 20$

$P_{main} := CL_{main} \cdot A_{main} \cdot q$ $P_{jib} := CL_{jib} \cdot A_{jib} \cdot q$

$P_{main} = 1608$ $P_{jib} = 598$

$\alpha_{shroud} := atan\left(\frac{W_{hull}}{L_{mast}}\right)$ $V_{mast} := \frac{\left(P_{main} + P_{jib}\right)}{2}$ $V_{mast} = 1103$

$\alpha_{shroud} \cdot \frac{180}{\pi} = 25.408$ $R_{shroud} := \frac{V_{mast}}{\sin\left(\alpha_{shroud}\right)}$

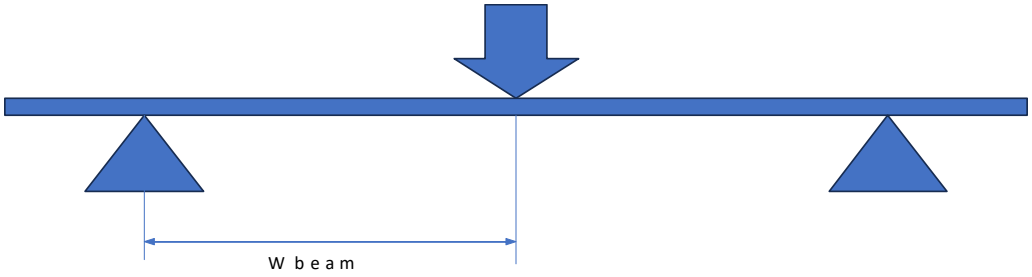
$R_{shroud} = 2570$

$R_{mast} := R_{shroud} \cdot \cos\left(\alpha_{shroud}\right)$

$R_{mast} = 2322$

Stress on Beam:

$W_{beam} := 36$ $I_{beam} := 4.8$ $c_{beam} := 2$



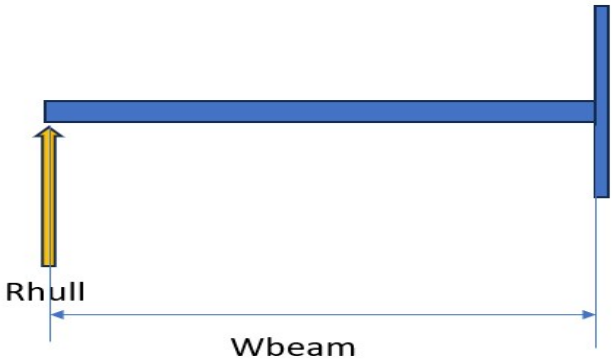
$$M_{beam} := \left(\frac{R_{mast}}{2}\right) \cdot W_{beam} \qquad M_{beam} = 41791$$

$$\sigma_{beam} := \frac{\left(M_{beam} \cdot c_{beam}\right)}{I_{beam}}$$

$$\sigma_{beam} = 17413$$

Deflection of the Beam:

$E := 10 \cdot 10^{6}$



$$R_{hull} := \frac{R_{mast}}{2}$$

$$\omega := \frac{\left(R_{hull} \cdot W_{beam}^{3}\right)}{3 \cdot E \cdot I_{beam}} \qquad \omega = 0.376$$

Summary :

For this condition

$CL_{main} = 2$

$CL_{jib} = 2$

knts = 40

$F_{tu} := 35000$

$F_{ty} := 31000$

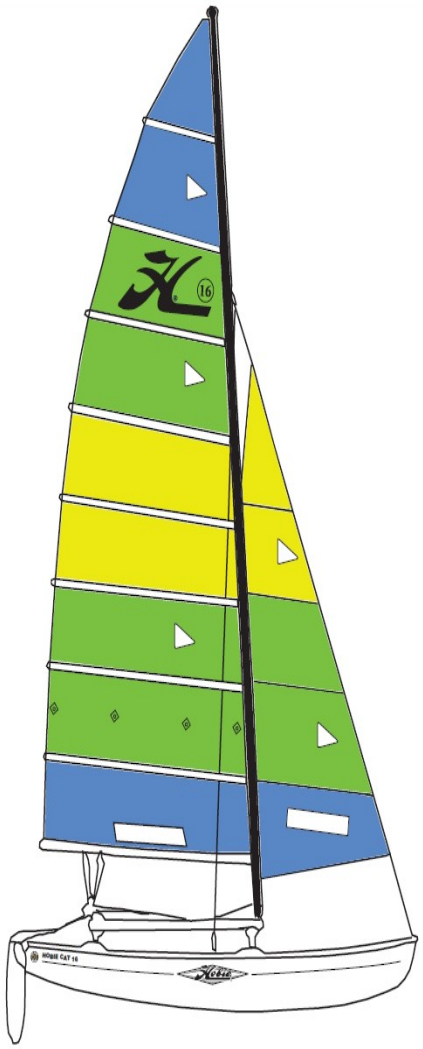
Safety Margin:

$$MS := \left(\frac{F_{tu}}{\sigma_{beam} \cdot 1.5} \right) - 1$$

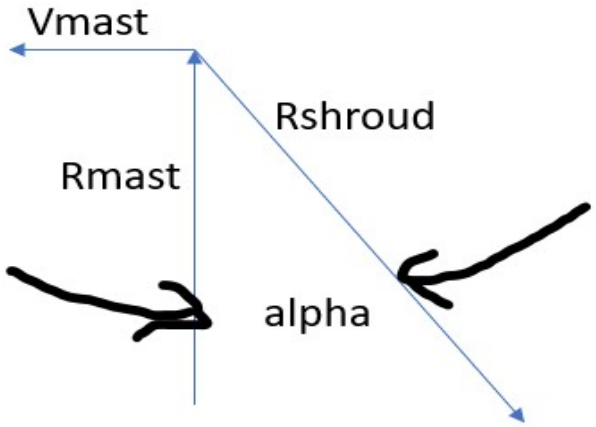
MS = 0.34

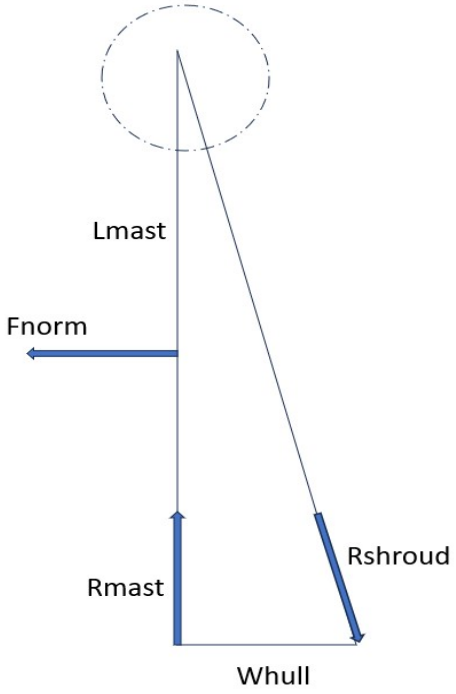
Deflection:

$\omega = 0.376$ inches



Length (m)	5,11
Beam (m)	2,41
Mast height (m)	7,92
Weight (kg)	de 145 à 155 selon modèle
Main sail area (m²)	13,77 / 10,50 (easy)
Jib area (m²)	5,12 / 3,70 (easy)
Spi area (m²)	17,5 (option)
Maximum load (kg)	240
Crew number	3
Homologation EC N°	HCE 97 0063 S
Module	Abis
Category	C
Hull construction	Sandwich polyester


Vmast
Rshroud
Rmast
alpha


Lmast
Fnorm
Rshroud
Rmast
Whull

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EXPERIMENTAL STUDY OF THE AERODYNAMICS OF SAIL IN NATURAL WIND

Tab. 5. Comparison of Lift coefficient and the drag coefficient under stable and fluctuating wind field

Attack angle α	Stable wind		Fluctuating wind		Comparison	
	Cl	Cd	Cl	Cd	Cl	Cd
–5°	0.25	0.3	0.14	0.23	44%	23%
0°	0.45	0.27	0.38	0.24	16%	11%
5°	0.75	0.3	0.6	0.26	20%	13%
10°	1.11	0.42	0.87	0.29	22%	31%
15°	1.64	0.58	1.11	0.36	32%	38%
20°	2.07	0.76	1.27	0.44	39%	42%
25°	2.26	0.91	1.41	0.53	38%	42%
30°	2.09	0.9	1.52	0.62	27%	31%
35°	2.03	0.97	1.57	0.72	23%	26%
40°	2.16	1.14	1.63	0.84	25%	26%

CONCLUSIONS

Previous researches of sail's aerodynamic characteristics were carried out in stable wind field, while the real sail is working under natural wind field. By modification of the wind tunnel with stable wind field, this paper simulated the wind field in line with characteristics of natural wind on the sea, and carried out comparison test of sail model's aerodynamic characteristics in two conditions. The results show that in fluctuating wind field, both lift coefficient and drag coefficient of the sail model presented significant falling, which also indicates that to more accurately analyze ship sail's aerodynamic characteristics, natural wind speed fluctuation and wind profile in the atmospheric boundary layer cannot be neglected.

Physical Properties	Metric	English
Density	2.7 g/cc	0.0975 lb/in³
Mechanical Properties		
Hardness, Brinell	73	73
Hardness, Knoop	96	96
Hardness, Vickers	83	83
Ultimate Tensile Strength	241 MPa	35000 psi
Tensile Yield Strength	214 MPa	31000 psi
Elongation at Break	12 %	12 %
Modulus of Elasticity	68.9 GPa	10000 ksi
Ultimate Bearing Strength	434 MPa	62900 psi
Bearing Yield Strength	276 MPa	40000 psi
Poisson's Ratio	0.33	0.33