

Sailboat spade rudder Calculation Sheet

U. Mancuso, Jan 13

INPUT DATA

HULL PARAMETERS

INPUT

L _{oa} (m)	8,00
L _{WL} (m)	7,85
m _{LDC} (kg)	2000
SA (m ²) - sail area, upwind	32,00

Design category (tick one)

Category A ("ocean")	<input type="radio"/>
Category B ("offshore")	<input type="radio"/>
Category C ("inshore")	<input checked="" type="radio"/>
Category D ("sheltered waters")	<input type="radio"/>

category of boats considered suitable to operate in seas with significant wave heights up to 2 m and a typical steady wind force of Beaufort Force 6 or less

f _{WR} (Design category factor)	0,75
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Instructions:

- 1) Fill all the input boxes (blue cells)
 - 2) Check the allowable ranges
 - 3) Visualize the results and charts
- Note: If one of the areas required is missing, input the empirically derived values.

Empirical Formulas used:

$$V = 2,7 \sqrt{K_v L_{WL}} \quad K_v = \frac{2,65 L_{WL}^2}{\sqrt[3]{m_{LDC}^2}}$$

DEDUCTED VALUES

K _v	1,029
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V (knts) - design speed	7,67
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V (m/s) - design speed	3,95
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V _{MAX} (knts) - max speed	11,6
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Fn _{MAX} (-) - max Froude nr	1,32
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Design information

Design n°	-	Revision nr°	2
Designer	-	Date	20-gen-12
Boat name	Spirit of Freedom	Boat owner	Mancuso

Design information

Club racer/weekend sailer.
Variation of Dudley Dix's Didi26

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INPUT DATA			Rudder dimensions					
Board parameters		INPUT	Suggested					
h_r (m) - Span		1,27						
b_1 (m) - Root chord		0,35						
b_2 (m) - tip chord		0,2						
A (m ²) - side area		0,39						
Δ (m ²) - Geometrical Aspect Ratio		4,10						
K_b (-) - rudder bending coefficient		0,45						
h_c (m) - bearing to root		0,04						
Z_b (m) - Bending arm		0,652						
u (m) - stock to leading edge		0,06						
c (m) - middle span chord		0,33						
r (m) - Torque arm		0,035	0,416					
Rudder load, ISO								
C_r (-) - Max lift coefficient		1,50				0,604		
F (N) - blade force		3.514						
T (Nm) - blade torque		124						
M (Nm) - blade bending moment		2.291						
Z_{eq} (-) - equivalent bending arm		0,653						
Rudder load, GERR			Material (choose one)					
W_p (kg) - Water pressure		161	AI EN 6082					
TM (kgm) - torque		5,7	σ_y 280 N/mmq					
BM (kgm) - bending moment		104,7	σ_u 330 N/mmq					
CM (Nm) - combinend moment		2055	σ_d 165 N/mmq					
			K_m 1,02 -					
Results - required stock diameter								
- use ISO diameter as design minimim. use GERR diameter for safety factor Check -								
Stock diameter, ISO			Stock diameter, GERR					
d_{316} (-) - S-steel diameter		51,04	Rudder type (tick one)	Sailboat, spade rudder	<input checked="" type="radio"/>	1		
Specific mass (kg/mc)		2,70		Sailboat, skeg rudder	<input type="radio"/>			
d_{MAX} (-) - Stock diameter		52,1		SF _{MIN} (-) - Minimum safety factor		3,34		
				SF(-) - Safety factor		4,4		
				d_{MAX} (-) - Stock diameter		51,9		
Stiffness check								
- calculate flexural rigidity and angular deflection at bottom bearing for stiffness Check -								
d_{MAX} (-)		52,0	mm					
E bending modulus		71.000	N/mmq					
I_x (mm ⁴) - Moment of Inertia		1.794.540,56						
I_{xx} (mm ⁴) - area modulus		3,6E+05						
EI flexural rigidity at bottom neck		2,5E+10	N/mmq					
ϕ_B (deg) - angular deflection		1,68°	deg.					
ϕ_B (deg) - angular deflection A316		0,64°	deg.					
δ_T (mm) - side deflection at tip		37	mm					
Material data								
Material		σ_y	σ_u	σ_d	ρ	E		
		N/mmq	N/mmq	N/mmq	g/cmc	N/mmq		
AISI 304		241	565	216,9	8,09	200.000		
AISI 316		200	600	180	8,09	200.000		
AISI 329		450	750	375	8,09	200.000		
AISI 630		720	930	465	8,09	200.000		
Aqualoy 22HS		986	986	493	8,14	600.000		
AI EN 6082		280	330	165	2,7	71.000		
AI Erqal 7075		460	520	260	2,69	71.000		