

Dinghy 13 hull investigation, for more RM and stability margin
The Bi-convex option, and comparison with a Convex-concav one
Rev. 1 with a soft transition between the two convexities

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A Bi-convex shape for the hull sections is proposed to combine a greater beam overall (to maximize the righting moment from the helmsman in hiking position) with a minimal beam at waterline (to reduce the drag) while maintaining a manageable stability (especially during a tack or a gybe by rough seas). **The Revision 1 introduces a soft transition between the two convexities**, to avoid the probable extra drag caused by a sharp transition, and also with two Bwl sub-options (*Bi-convex soft 1* with Bwl 0,92 m and *Bi-convex soft 2* with Bwl 0,97 m) to show the influence of this data on the stability. These new versions are compared with the previous ones, *Convex-concav* and *Bi-convex sharp*. All the versions share the same dimensions and identical (when Bwl 0,92m) or very similar (when Bwl 0,97 m) immersed hull waterlines :

Lhull : 3,97 m (13 ft) ; Bhull : 1,60 m ; Light weight assumed 59 kg (with a 8 m2 sail)

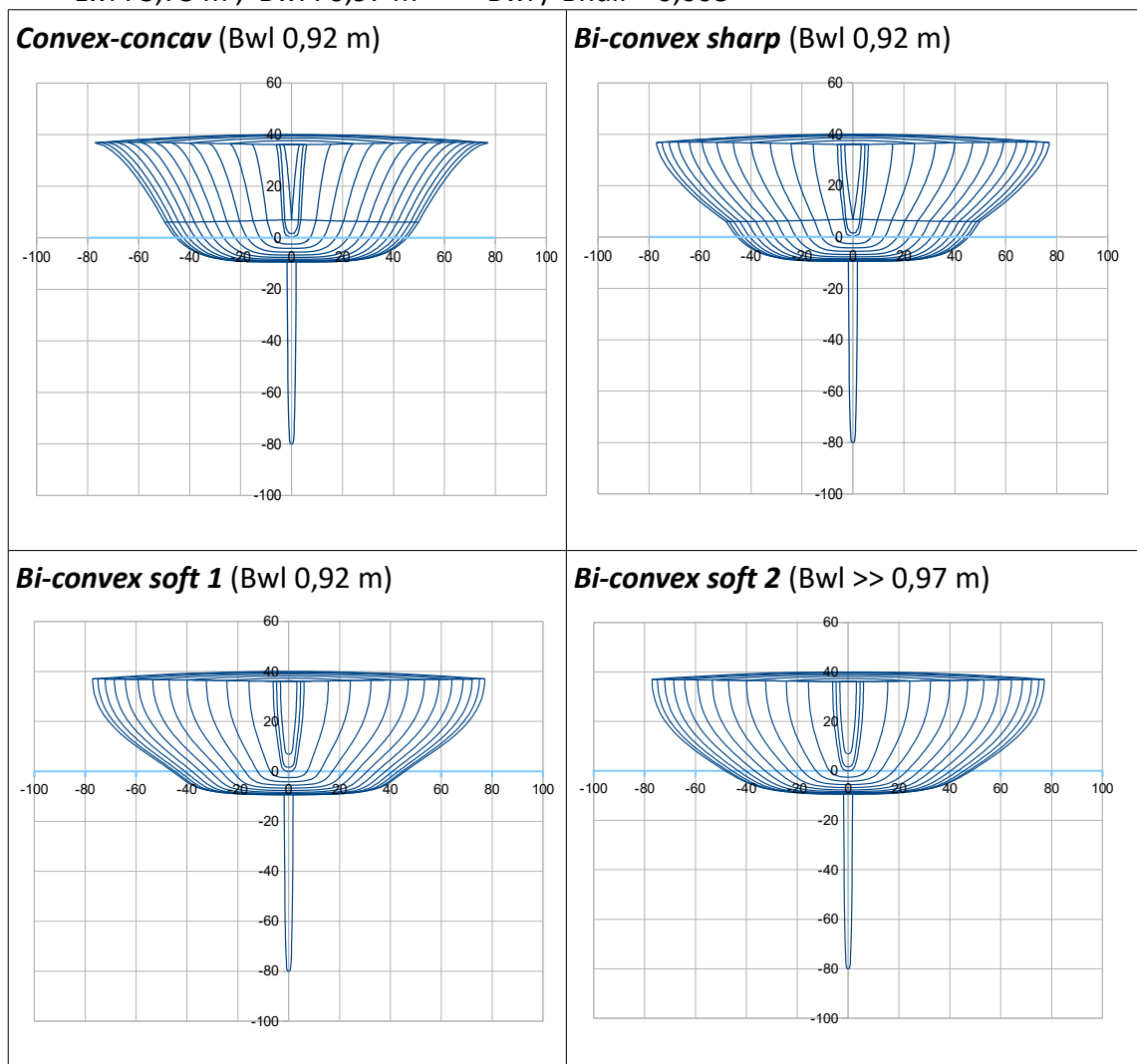
With the design « payload » 95 kg (a heavy helmsman case) :

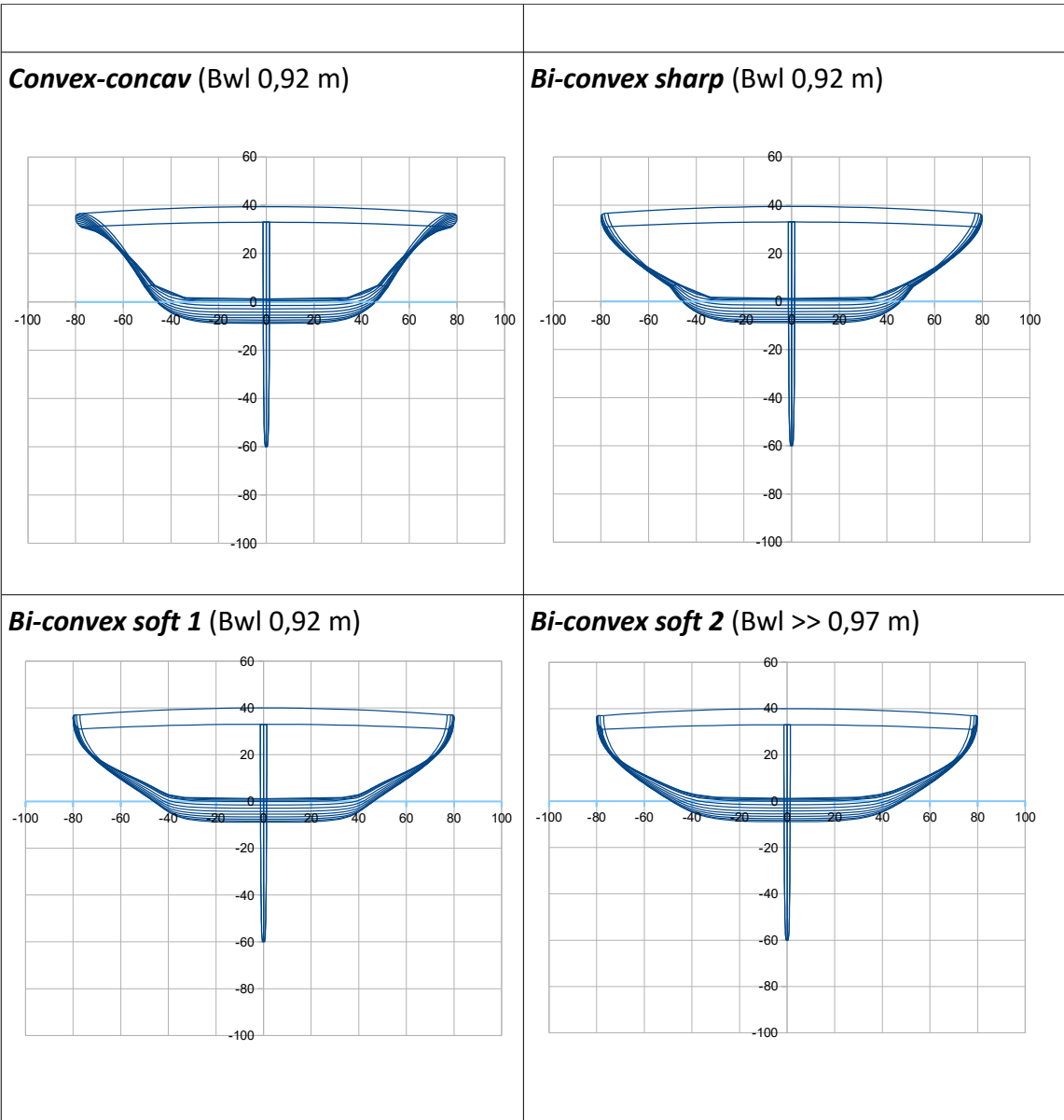
Convex-concav, Bi-convex sharp, Bi-convex soft 1 :

>>> Lwl : 3,75 m ; Bwl : 0,92 m >>> Bwl / Bhull = 0,575

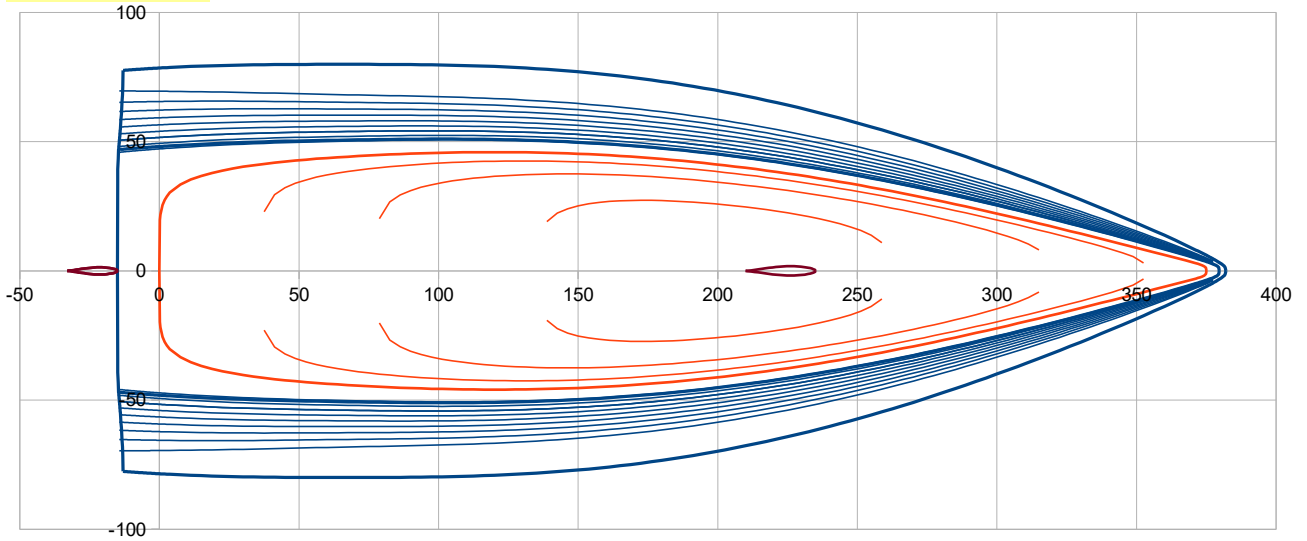
Bi-convex soft 2 :

>>> Lwl : 3,75 m ; Bwl : 0,97 m >>> Bwl / Bhull = 0,608

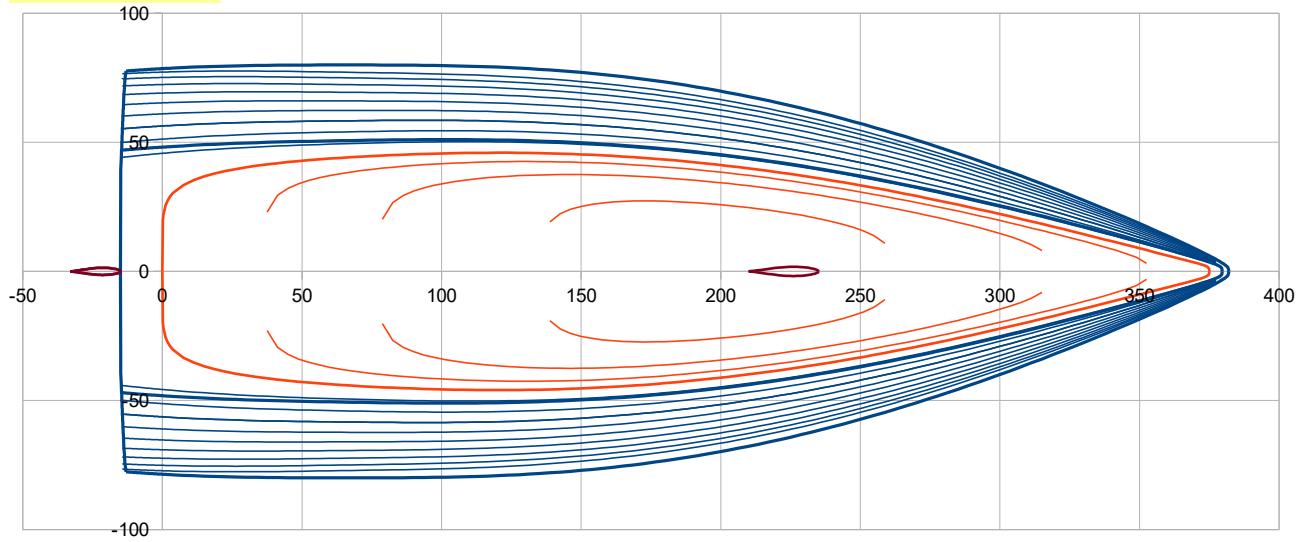




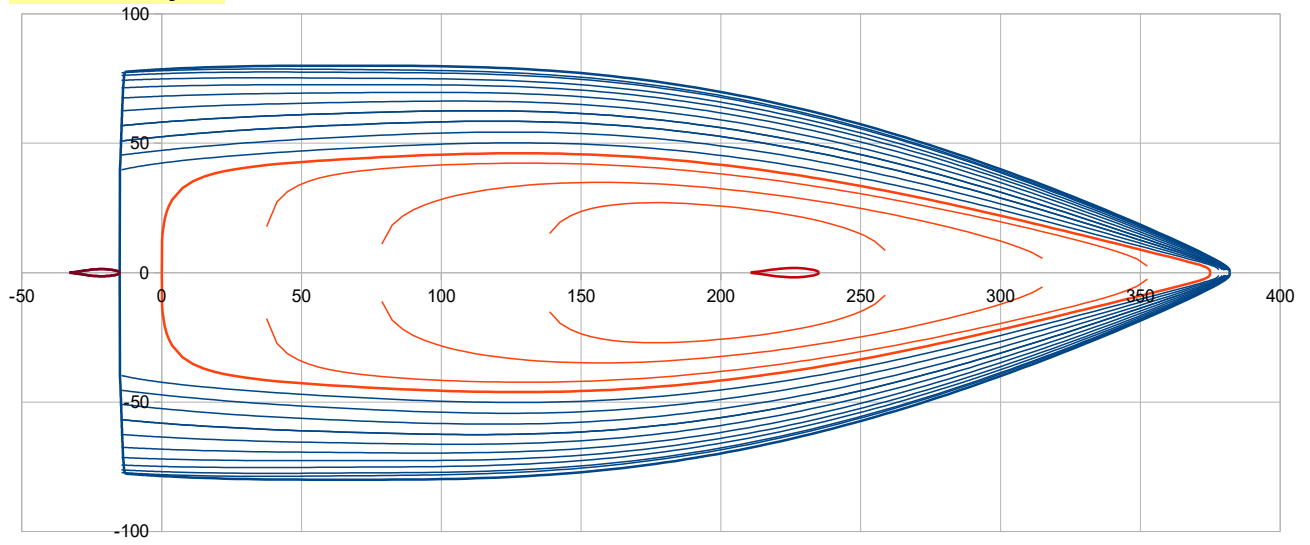
Convex-concav



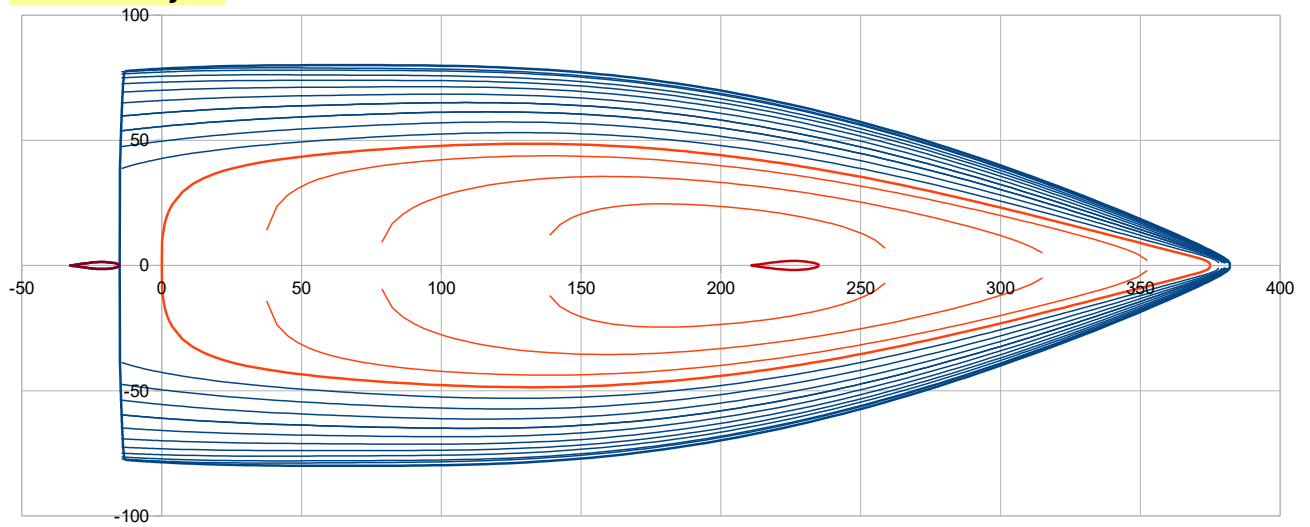
Bi-convex sharp



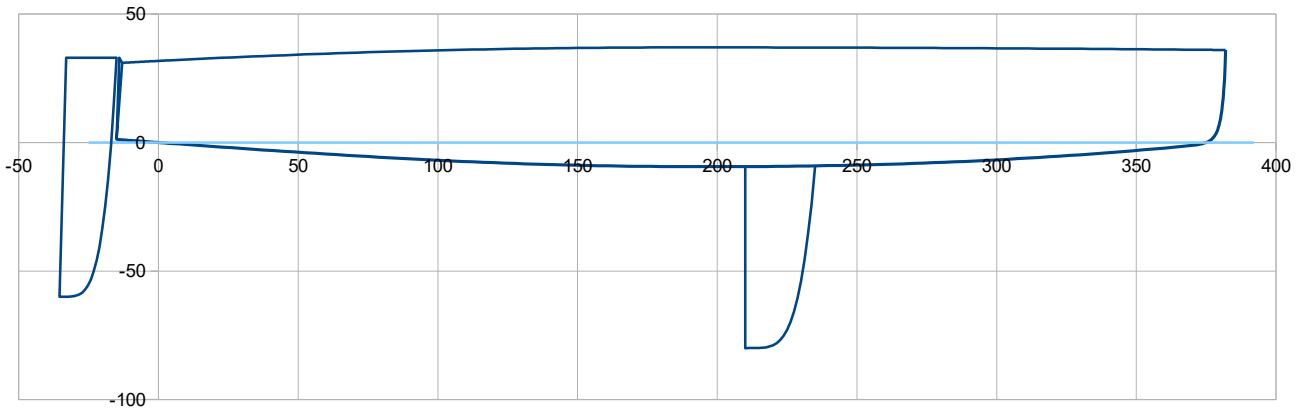
Bi-convex soft 1



Bi-convex soft 2



The longitudinal view, common to all versions :

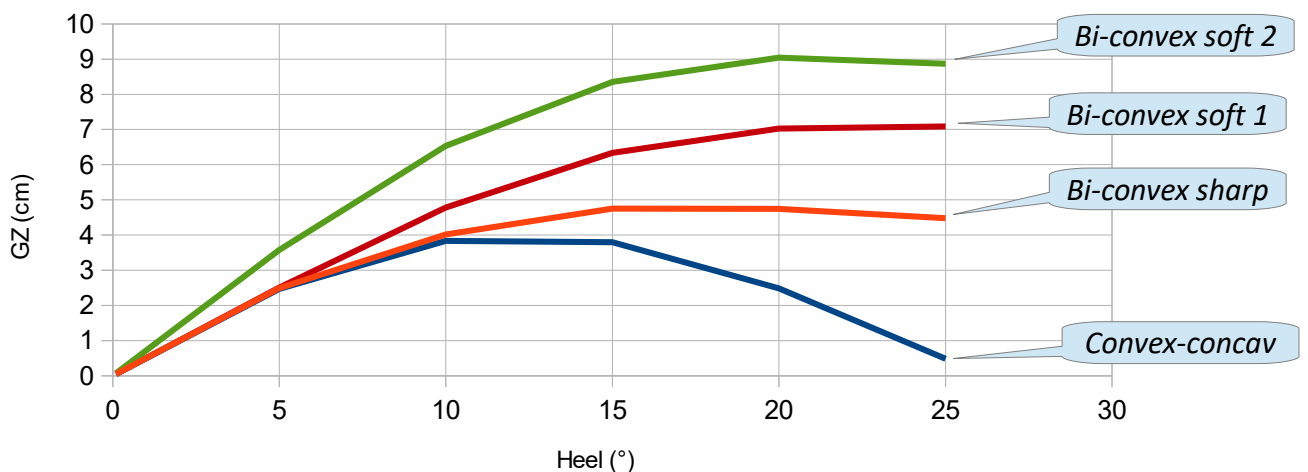


Stability issue when considering the « payload » in the center :

e.g. the helmsman squatted in the boat center under the boom, with his center of gravity at Z +65 cm. It is typically the tack or gybe configuration. Here for the stability comparison it is assumed that the helmsman is (temporarily) fixed like a statue in the center of the boat. and we look at the righting arm GZ evolution for heel up to 25°, due to external action (waves, dynamics of a manoeuver) and/or due to a transversal offset of the payload :

GZ versus Heel

Payload 95 kg at center (X150, Y0, Z65)



>>> It is the illustration of the stability margin searched for the bi-convex option, when the helmsman is temporarily in the center under the boom in rough seas. The 3 versions with Bwl 0,92 m have the same GZ for the low heel angles (up to 5°), then the upper convexity plays its role and differentiates the versions. A slight increase of the upper convexity, as in Soft 1 version / Sharp one, is immediately visible in the stability margin at 20°-25° heel angle. The Bi-convex soft 2 version with Bwl 0,97 m shows a better stability from the heel 0° configuration.

>>> If we translate the result into possible transversal offset dY of the 95 kg payload : at 25° heel angle, we still have an offset margin of ± 12,6 cm with the *Bi-convex soft 1* option (± 15,8 cm with the *Bi-convex soft 2*) to compare to less than 1 cm with the *Convex-concav* one.

Righting moment when the « payload » is hiking at windward :

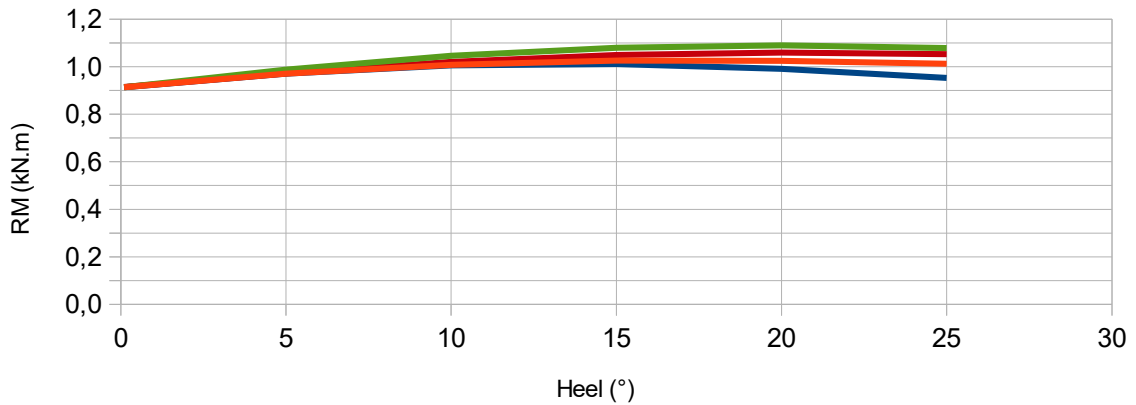
e.g. the helmsman is hiking with its center of gravity estimated at about $Y = B/2 + 15$ cm and $Z = 35$ cm (and X still at 150 cm).

Righting moment RM versus Heel

Payload 95 kg hiking windward ($X150, Y = B/2+15, Z35$)

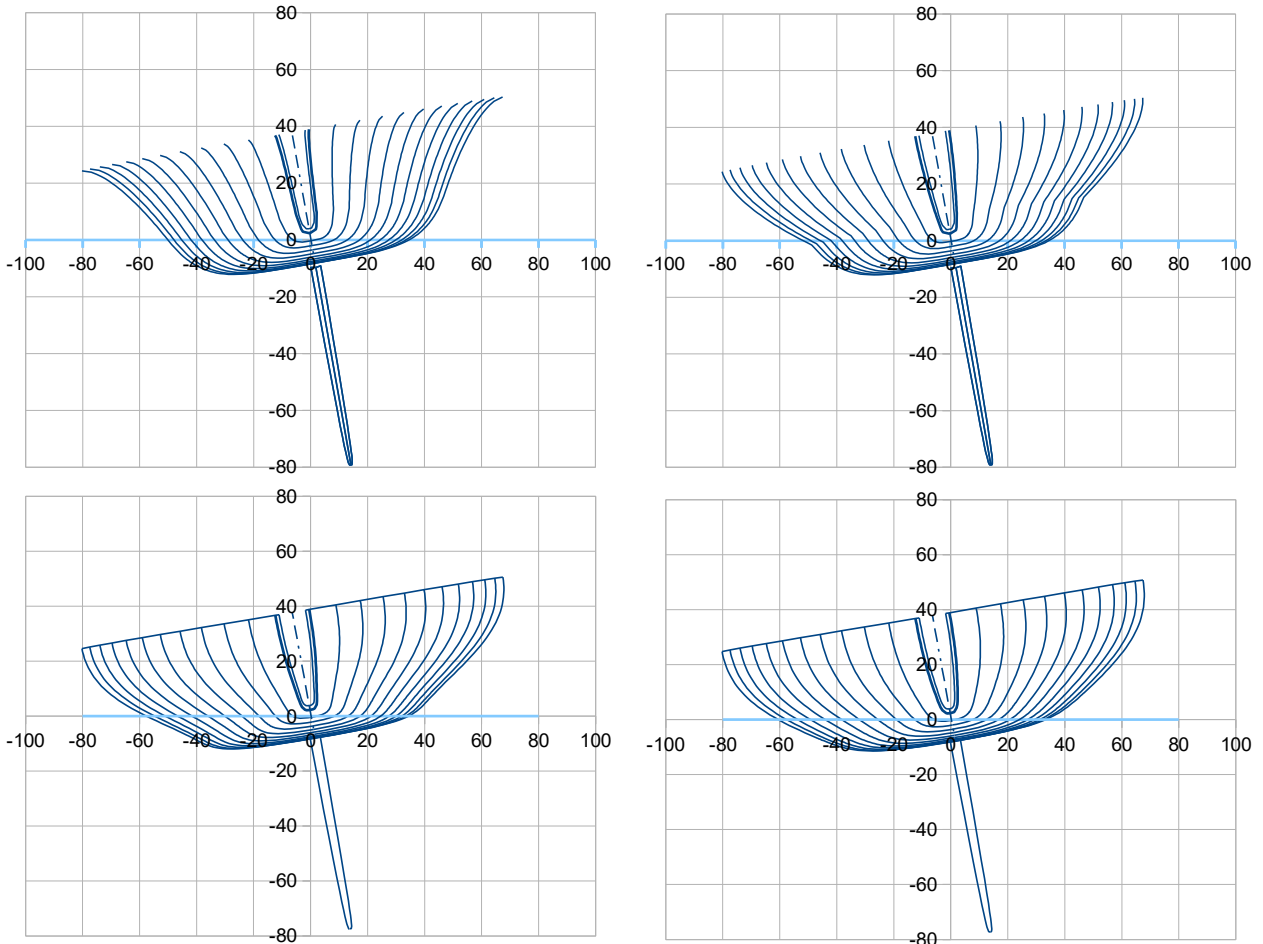
Blue : convex-concav, Bwl 0,92 m ; Red : bi-convex sharp, Bwl 0,92 m

Brown : bi-convex soft, Bwl 0,92 m ; Green : bi-convex soft, Bwl 0,97 m



>>> Very close values as expected for the usual heel angles for a dinghy sailing (0° to 10°), as the beam overall is the same and the righting moment is mostly due to the helmsman in hiking position. We can just note a slight advantage of the bi-convex versions at 25° heel angle (+ 6% to 13%), i.e. the heeled situation before a capsize.

Comparison at 10° heel angle :



Hydrostatics data upright (common to *Convex-concav, Bi-convex sharp, Bi-convex soft 1*) :

2.1 Hull

Loa (m)	3,97	Lwl (m)	3,75	> Lwl/D^(1/3)	7,12				
>> ft	13,02		12,30						
B (m)	1,60	at X (% Lwl)	18,0						
>> ft	5,25								
Bwl (m)	0,92	at X (% Lwl)	32,0	> Bwl / B	0,575				
>> ft	3,02								
Tc (m)	0,094	at X (%Lwl)	50			Freeboards (m) >	Aft	Midship	Fore
>> ft	0,31					>> ft	0,31	0,37	0,36
Displacement at H0 (m3)	0,14600	at Xc (m)	1,733	Xc (%Lwl)	46,23		1,02	1,21	1,18
>> lbs	330	w. seawater	1025	kg/m3				Zc (m)	-0,036
Cp (%)	56,94							>> ft	-0,12
Sf (m2)	2,56	at Xf (m)	1,555	Xf (%Lwl)	41,47	>>> Xc - Xf (%Lwl)			4,75
>> ft2	27,53	>> ft	5,10						
Angle immersed sheer li (°)	30,4	at section C4 (40% Lwl)		Angle at bi-convex point (°)	33,7				at C3
Sw (m2)	2,62	>Sw/D^(2/3)	9,46						
>> ft2	28,24								
Shull (m2)	6,47	at X (m)	1,622	Z (m)	0,071				
>> ft2	69,68	>> ft	5,32	>> ft	0,23				
Sdeck (m2)	4,72	at X (m)	1,433						
>> ft2	50,79	>> ft	4,70						

2.2 Daggerboard

Vol. keel(m3)	0,00282	at X (m)	2,226	X (%Lwl)	59,36	Z (m)	-0,37	
Mass keel(kg)	1,41	>> ft	7,30			>> ft	-1,22	
>> lbs	3							
Draft oa (m)	0,80	Sw (m2)	0,30	Sxz (m2)	0,14			
>> ft	2,62	>> ft2	3,24	>> ft2	1,56			
CLR (m)	2,288	CLR (%Lwl)	61,00	method : keel profile extended to the waterline, 25% c at 45% draft oa				
>> ft	7,50							

2.3 Rudder(s)

Number	1							
Volume (m3)	0,00143	at X (m)	-0,246	X (%Lwl)	-6,57	Z (m)	-0,05	
Sw (m2)	0,18	>> ft	-0,81			Sxz (m2)	0,09	per rudder
>> ft2	1,92					>> ft2	0,92	

2.4 Hull + Daggerboard + Rudder(s)

Displacement at H0 (m3)	0,15024	at Xc (m)	1,724	Xc (%Lwl)	45,97	Zc (m)	-0,04	
Disp. (kg)	154,0	>> ft	5,66			>> ft	-0,14	
>> lbs	340							
Sw (m2)	3,10	>Sw/D^(2/3)	10,98	Lwl/D^(1/3)	7,05			
>> ft2	33,39			DLR	81	M(lbs/2240)/(Lwl(ft)/100)^3		

Hydrostatics data upright for *Bi-convex soft 2 Bwl 0,97 m* :

2.1 Hull

Loa (m)	3,97	Lwl (m)	3,75	>Hull speed	4,7	(at Fn 0,4)		
>> ft	13,02		12,30					
B (m)	1,60	at X (% Lwl)	18,0					
>> ft	5,25							
Bwl (m)	0,97	at X (% Lwl)	35,0	> Bwl / B	0,608			
>> ft	3,19							
Tc (m)	0,094	at X (%Lwl)	50					
>> ft	0,31							
Displacement at H0 (m3)	0,14531	at Xc (m)	1,743	Xc (%Lwl)	46,47			
>> lbs	328	w. seawater	1025	kg/m3				
Disp at h (cm)	-0,376368726	at Xc (m)	1,753	Xc (%Lwl)	46,75			
Disp at h (cm)	0,376368726	at Xc (m)	1,731	Xc (%Lwl)	46,17			
Cp (%)	56,22							
Sf (m2)	2,66	at Xf (m)	1,575	Xf (%Lwl)	41,99	>>> Xc – Xf (%Lwl)		4,48
>> ft2	28,59	>> ft	5,17					
Angle immersed sheer li (°)	25,6	at section C4 (40% Lwl)						
Sw (m2)	2,71	>Sw/D^(2/3)	9,80					
>> ft2	29,15							
Shull (m2)	6,60	at X (m)	1,617	Z (m)	0,066			
>> ft2	71,02	>> ft	5,30	>> ft	0,22			
Sdeck (m2)	4,82	at X (m)	1,459					
>> ft2	51,86	>> ft	4,79					

2.2 Daggerboard

Volume (m3)	0,00282	at X (m)	2,226	X (%Lwl)	59,36	Z (m)	-0,37	
Draft oa (m)	0,80			Sw (m2)	0,30	Sxz (m2)	0,14	
>> ft	2,62			>> ft2	3,24	>> ft2	1,56	
CLR (m)	2,288	CLR (%Lwl)	61,00	method : keel profile extended to the waterline, 25% c at 45% draft oa				
>> ft	7,50							

2.3 Rudder(s)

Number	1							
Volume (m3)	0,00143	at X (m)	-0,246	X (%Lwl)	-6,57	Z (m)	-0,054	
Sw (m2)	0,18	>> ft	-0,81			Sxz (m2)	0,09	per rudder
>> ft2	1,92					>> ft2	0,92	

2.4 Hull + Daggerboard + Rudder(s)

Displacement at H0 (m3)	0,14956	at Xc (m)	1,733	Xc (%Lwl)	46,21	Zc (m)	-0,041	
Disp. (kg)	153,3	>> ft	0,53			>> ft	-0,13	
>> lbs	338							
Sw (m2)	3,19	>Sw/D^(2/3)	11,31	Lwl/D^(1/3)	7,06			
>> ft2	34,30			DLR	81	$M(lbs/2240)/(Lwl(ft)/100)^3$		

2.5 Data from the mass spreadsheet

Boat with payload	M(kg)	153,3	at Xg (m)	1,566	Xc (%Lwl)	41,77	at Zg (m)	0,587
Light boat		58,3		1,675				0,485

Sailplan (with sail 8 m2 and small sail option 6 m2)

