Keel proportions

(translation and completion of article Fra-19, available in French and Spanish)

The Argentine fleet are certainly the largest RG65 fleet, arguably one where competition would have let evolution laws rule, and I was very surprised to see how little draught they had.

I therefore attempted a set of calculations to review this against theory.

After a few attempts, I eventually concluded that a sensible criterion for the analysis was the submerged front surface of the model, i.e. taking into account its hull, keel and ballast. This assumes that the drag coefficient of all three elements is “comparable”, will come back to this in conclusion.

Calculations were run for several ballast/draught ratios giving the same stability to the model, the increased waterline width being taken into account in the stability calculation as the hull is loaded by heavier ballast, for several target stabilities and keel thicknesses. An example of result table is the following :

V(30°)		2.40 m/s							
Keel tk		3.5 mm							
Ballast	Weight (g)	700	650	600	550	**500**	450	400	350
	Dia (mm)	31.1	30.4	29.6	28.7	**27.8**	26.9	25.8	24.7
Hull	W (cm3)	1075	1030	985	940	**895**	850	805	760
	Bwl (cm)	12.1	12.0	11.9	11.7	**11.6**	11.5	11.3	11.1
	D (cm)	35.2	34.1	33.1	32.0	**30.9**	29.8	28.7	27.6
Keel	Keel H (cm)	16.6	18.9	21.7	25.2	**29.6**	35.5	43.7	55.9
Submerged front surfaces									
	Ahull (cm2)	30.3	29.0	27.8	26.5	**25.2**	24.0	22.7	21.4
	Alead (cm2)	7.6	7.2	6.9	6.5	**6.1**	5.7	5.2	4.8
	Akeel (cm2)	5.8	6.6	7.6	8.8	**10.4**	12.4	15.3	19.6
	Atotal (cm2)	43.7	42.9	42.2	41.8	**41.7**	42.1	43.2	45.8

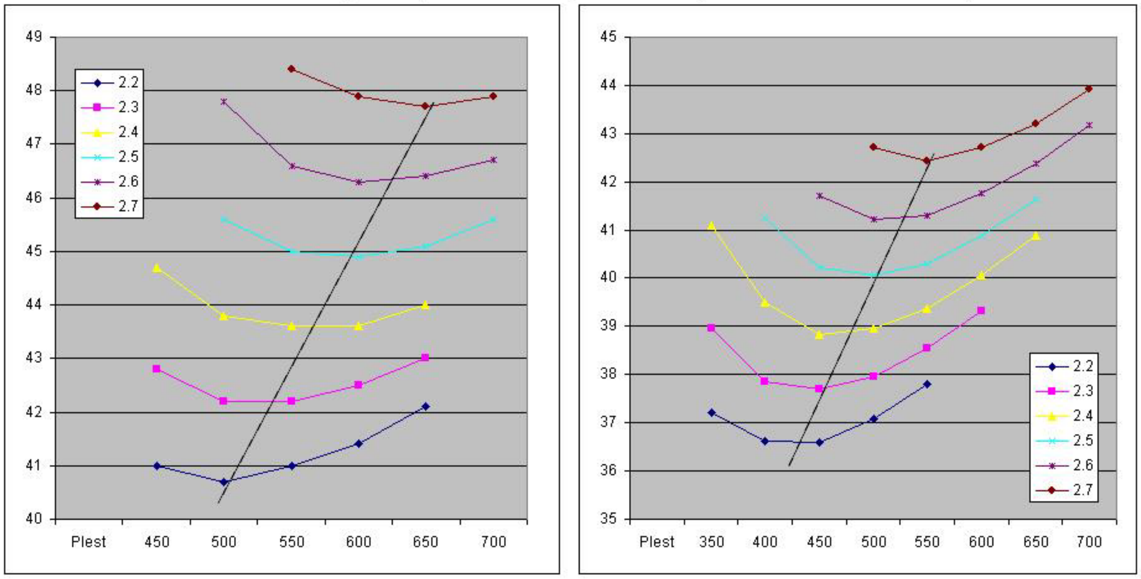
For that hull, stability target and keel thickness, the recommended keel is 500g ballast on a 29.6 cm deep keel.

From these tables, one can identify other key information :

- some 40% of the submerged front surface of a RG65 model is coming from the keel,
- the keel construction quality is paramount, a millimetre too many has more influence on the performance than anywhere else. If you have any carbon fibre, use it in the keel construction !

The curve below is an example of front surface calculation summary, it shows the minimal surface for successive keel thicknesses and stability requirements :

Surfaces frontales (en cm2) en fonction du poids de lest pour differentes stabilites requises

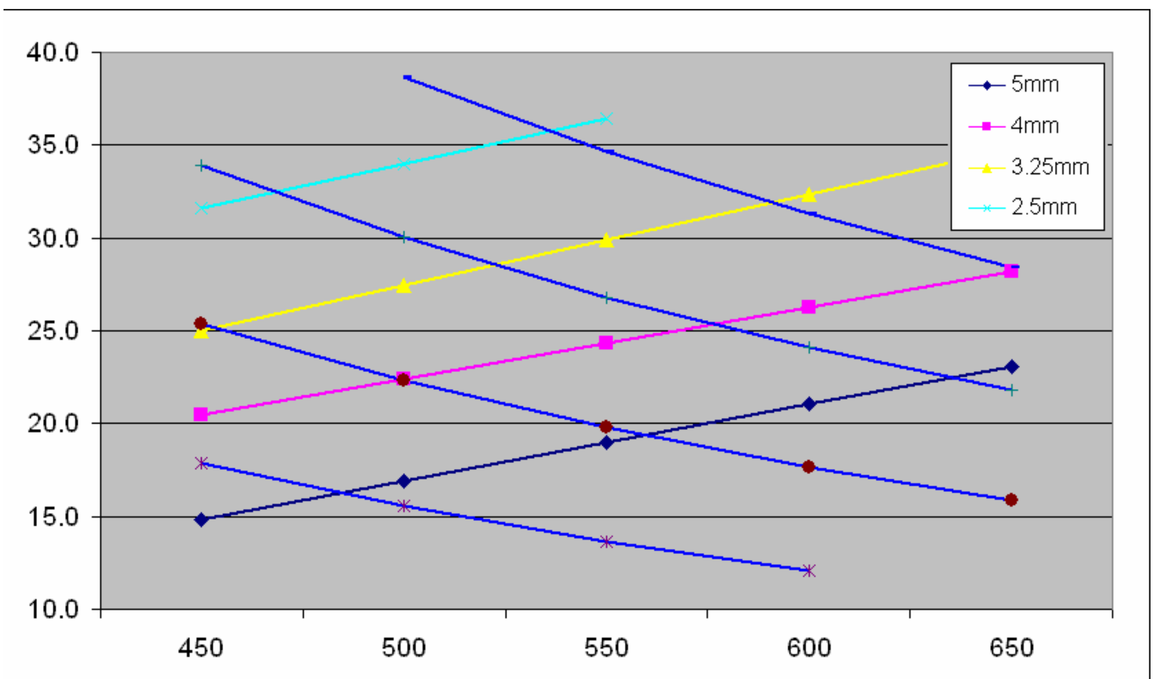


Epaisseur de quille : 4mm

Epaisseur de quille : 2.5mm

This family of curves is based on stability formulae published within article http://navi.modelisme.com/article135.html, completed to calculate the submerged front surfaces. Such diagram was produced for successive keel thicknesses.

The ballast weight / keel depth pairs providing minimal front surface for a given stability was finally presented in a single diagram, with keel thickness as additional parameter:



The blue lines are the iso-stability curves.

The calculations were made on three hull forms, 11, 12 and 14cm wide. The optimal pairs proved almost independent from the hull, the keel can therefore be selected before the hull…

These calculated optimal pairs propose deeper keels than certain Argentine ones, but the study clearly shows that draught cannot be increased forever. Finally, short keels still need to provide side surface, they become thicker when their chord increase …

How much stability do you need ?

The above calculations also show the cost for stability. The results using Colombine as example :

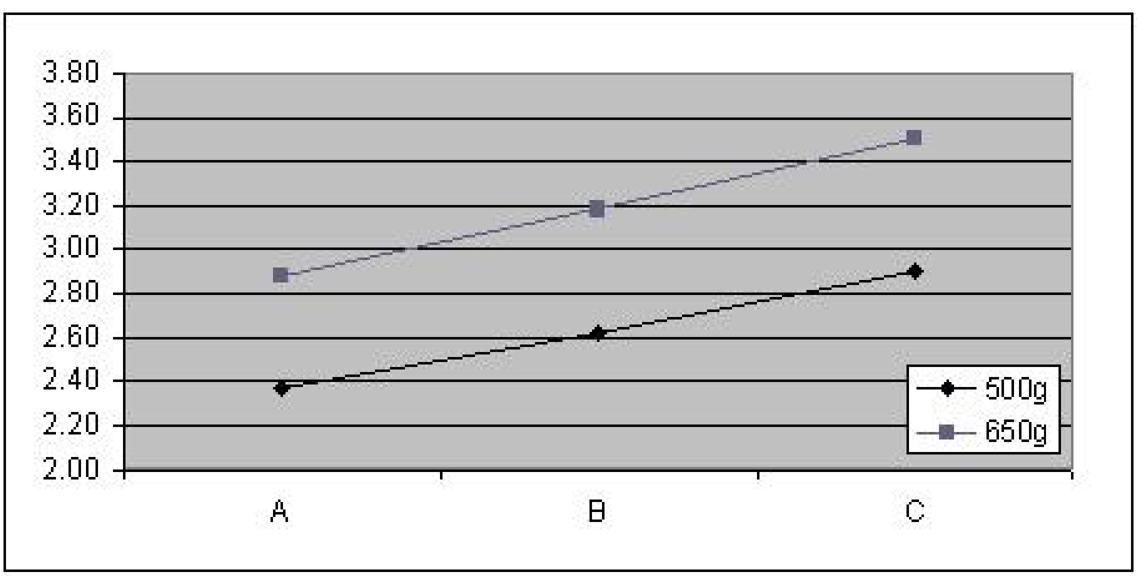
Stability (V30)	Frontal surface (3.25mm keel)	Corresponding lead weight and keel depth
2.3 m/s	39.0 cm2	475 g – 26.5 cm
2.5 m/s	41.7 cm2	550 g – 27.5 cm
2.7 m/s	44.4 cm2	600 g – 30.5 cm

Here again, several schools of thought co-exist ; In Brazil, ballast weights of 650g or more are common, in Argentine, the models seem less and less stable (ref. JIF2).

I currently plan to design against a 3.25mm keel thickness, and adopted :

- a 500g ballast with a keel height of 27cm, and
- a 650g ballast with a keel height of 33cm.

Three rigs and two keels, we have six gears to our model. An example of gearbox balance:



Construction

If you have carbon fibre, I recommend using it all for the keel; it is not essential for the hull.

I build my keel fins from a 1.5mm wood core, on which I resin two layers of carbon and fibreglass on each side. The wood core is cut 1cm narrower than the final keel chord to allow the two fibre skins to join at the edges.

The whole set is pressed together while curing.

The 500g selection is especially sexy, as it doe not require to turn into a alchemist to get one : it is available from stock in many fishing shops as “macquerel lead”. A few hammer fairing bangs, putty and you are there

I perform attachment o the keel via a steel wire « staple » :A

1. Hammer down a 5 to 8mm groove with a screwdriver head in the middle of the bulb.
2. Make a “U” shape in a steel wire and clue it with epoxy into the groove, the two ends should protrude 1cm minimum and be parallel.
3. Present the two ends to the keel wing and mark the positions to be drilled
4. Glue the two steel wire ends into the keel wing with epoxy.

The final product is meant to look like this…

Conclusion

The assumption that all three forms, hull, ballast and keel have the same drag coefficient is certainly false, but I failed to find sensible literature on the subject. Remember that we sail in the laminar phase for the keel, and transition zone for the hull, it’s all black art… Should you have reasons to believe that the keel is x% more drag for the same frontal surface than the rest, you just need to multiply the keel thickness by the same x% before using the curves.