Residuary drag estimation for a slender hull in mono and cata configuration

Comparison of a numerical computation using Wigley hull and Michell's thin ship theory with the synthesis of model tests series

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E. O. Tuck and L. Lazauskas carried out the computation the wave drag of a Wigley hull in both mono and cata configuration, offering the opportunity to compare their results with model test series after putting their data in the uniform adimensional format used to report on these series.

Sources :
Numerical computation :
(1) OPTIMUM HULL SPACING OF A FAMILY OF MULTIHULLS
E. O. Tuck and L. Lazauskas
http://www.maths.adelaide.edu.au/yvonne.stokes/Tuck/pdfiles/tuclaz.pdf
Model test series :
(2) « Southampton » series as reported in :
https://www.researchgate.net/publication/284260790_Resistance_experiments_on_a_systematic_series_of_high_speed_displacement_catamaran_forms_Variation_of_length-displacement_ratio_and_breadth-draught_ratio
(3) Series 64, SSPA series and NPL series as reported in :
https://www.oossanen.nl/beheer/wp-content/uploads/2013/02/petervanoossanen_-_resistance_prediction_of_small_high-speed_displacement_vessels.pdf

1. The residuary drag of the slender monohull

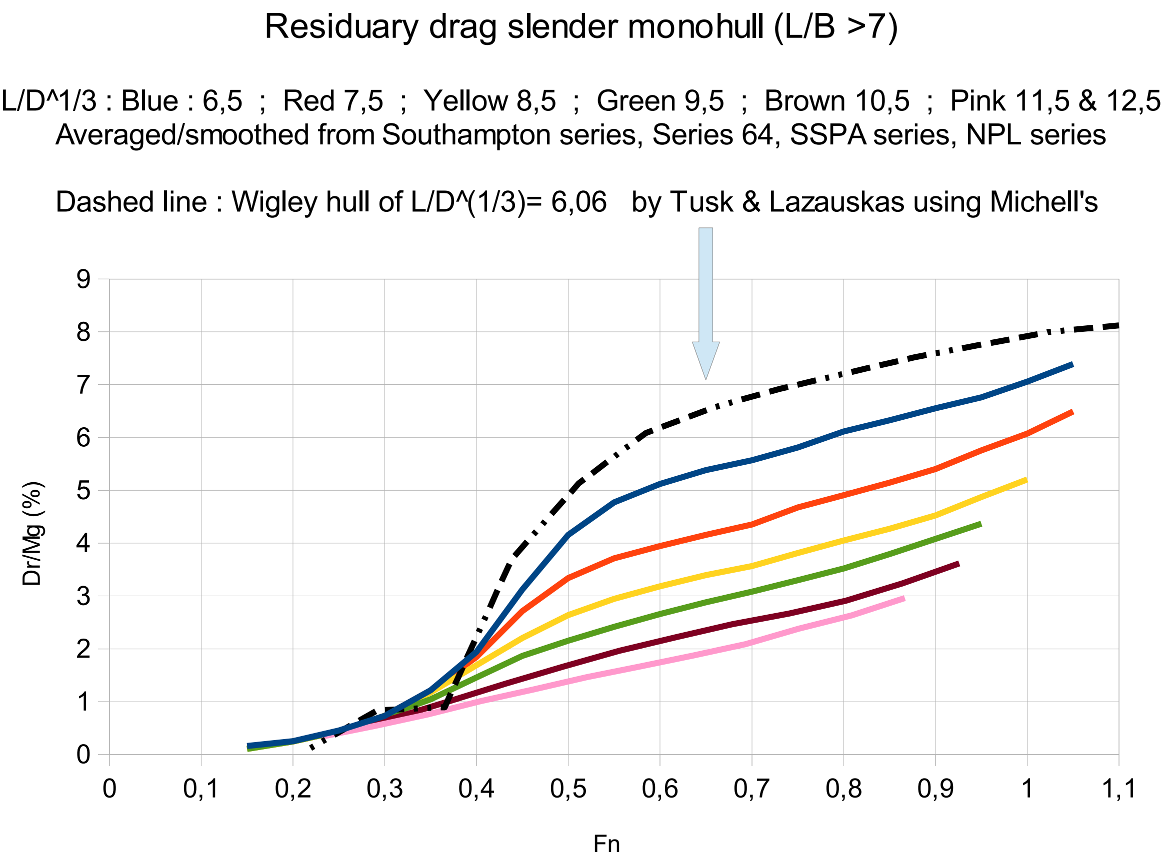
(1) Tuck & Lazauskas data :

Wigley hull in mono mode				
L (m)	Bwl (m)	Tc (m)	M (kg)	> Disp. (m3)
19,1	2,94	1,25	31250	31,25
>> Ratios	Lw/D^(1/3)	Lw/Bw	Bw/Tc	Cb
	6,06	6,50	2,35	0,45

Their results with Michell's theory (from their Figure 1) :

From their Fig. 1		**Wigley hull in mono mode**	
Speed (m/s)	>> Fn	Dr (kN)	> Dr/Mg (%)
3	0,22	0,37	0,12
4	0,29	2,56	0,84
5	0,37	2,74	0,90
6	0,44	11,34	3,70
7	0,51	15,73	5,13
8	0,58	18,66	6,09
9	0,66	20,12	6,56
10	0,73	21,22	6,92
12	0,88	23,05	7,52
14	1,02	24,51	8,00
16	1,17	25,24	8,23
18	1,31	25,61	8,35
20	1,46	25,79	8,41

Comparison with model test results :



>>> the shape of the curve is very similar in the Froude 0,35 – 1,0 zone and the order of magnitude is quite good according to the used graduation based on Lw/D^(1/3) and the fact that the Wigley Lw/Bw of 6,5 is slightly lower than the L/B > 7 which was used as « slender » criteria for the test results compilation.

For the hull in cata mode, (1) authors consider the half beam hull at same other dimensions, so also half displacement. The Michell's thin ship theory leads (by construction) to a « wave drag reduction as beam squared » : half beam leading itself to half displacement, in adimensional format that means « Dr/Mg reduction as beam ». On that basis, we can compute the half beam hull residuary drag from the previous one, which will be used further as comparison with the same hull within the cata mode :

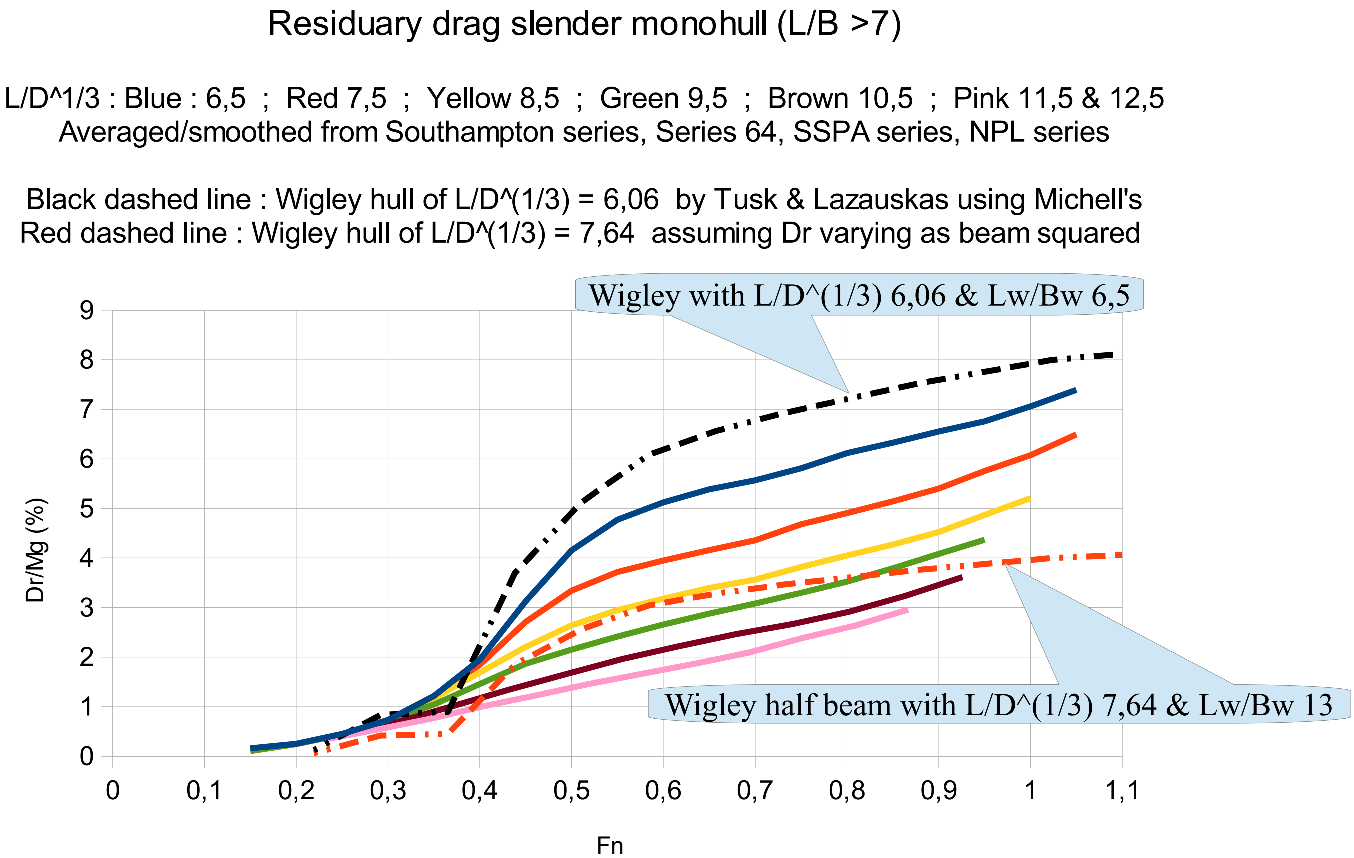
Wigley half beam hull for the cata mode				
L (m)	Bwl (m)	Tc (m)	M (kg)	> Disp. (m3)
19,1	1,47	1,25	15625	15,625
>> Ratios	Lw/D^(1/3)	Lw/Bw	Bw/Tc	Cb
	7,64	12,99	1,18	0,45

>>> Then, due to half beam and resulting half displacement, the ratios evolved, in particular Lw/D^(1/3) is now 7,64 (instead of 6,06) and the Lw/Bw is 13 (instead of 6,5).

The residuary drag of the half beam hull, as computed with the theoritical « wave drag reduction as beam squared » :

		Wigley hull for the cata mode	
Speed (m/s)	>> Fn	Dr (kN)	> Dr/Mg (%)
3	0,22	0,09	0,06
4	0,29	0,64	0,42
5	0,37	0,69	0,45
6	0,44	2,84	1,85
7	0,51	3,93	2,57
8	0,58	4,66	3,04
9	0,66	5,03	3,28
10	0,73	5,30	3,46
12	0,88	5,76	3,76
14	1,02	6,13	4,00
16	1,17	6,31	4,12
18	1,31	6,40	4,18
20	1,46	6,45	4,21

Comparison with model tests results :

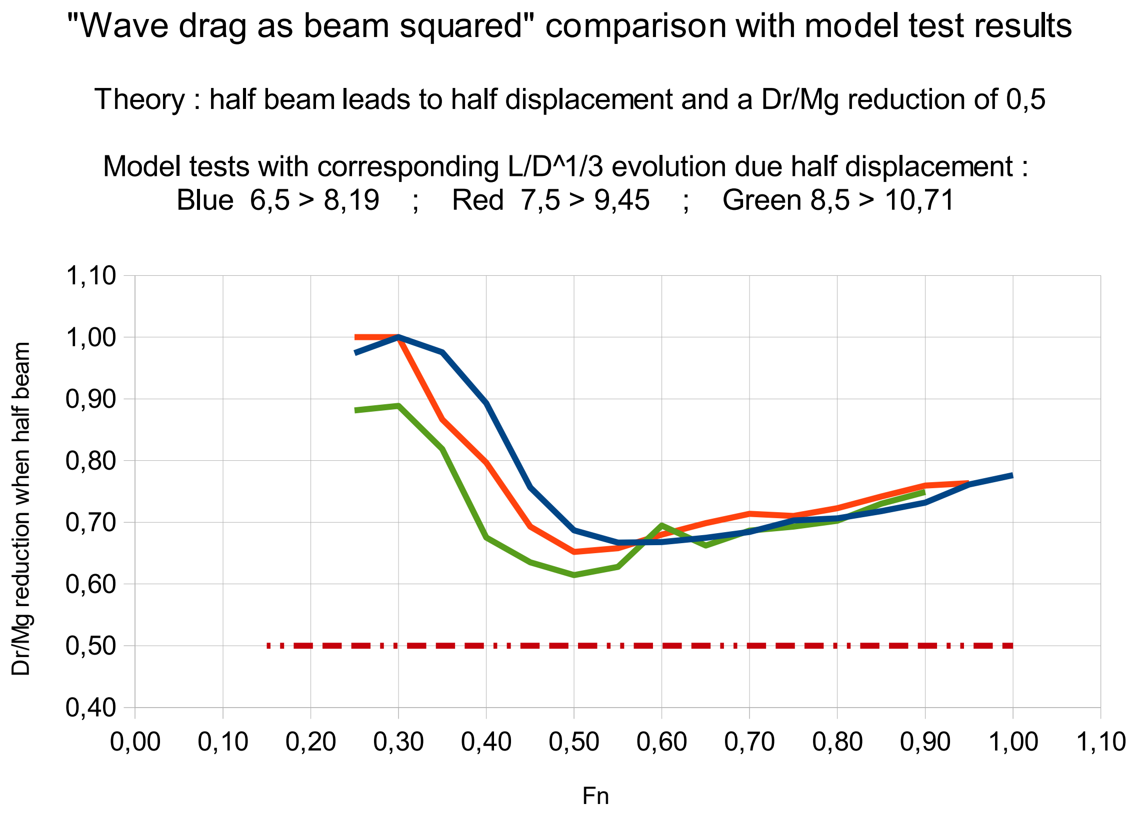


>>> The therotical half reduction of Dr/Mg with half beam is optimistic, the tests results with L/D^1/3 show a lesser reduction than 0,5.

It is the opportunity to investigate this aspect quantitavely : the half beam leading to half displacement at constant Lw, so we have a ratio increase of Lw/(D*0,5) ^(1/3) = 1,26 Lw/D^(1/3)

Lw/D^(1/3) = 6,5 => when D is half >> 8,19
Lw/D^(1/3) = 7,5 => when D is half >> 9,45
Lw/D^(1/3) = 8,5 => when D is half >> 10,71

From the model tests data and with such Lw/D^(1/3) evolution, that leads to Dr/Mg reduction such as :



>>> With a half beam hull, the residuary drag Dr/Mg reduction is around 0,7 instead of 0,5 in the Froude 0,45 – 1,0 range.

2. The residuary drag in the cata configuration

For the model test series in cata mode, we have considered an amplification factor (1+K) such as :

Dr/Mg (%) (hull in cata mode) = (1+K) * Dr/Mg (%) (hull in mono mode)

With this same approach, (1) Tuck & Lazauskas numerical results are reformatted such as :

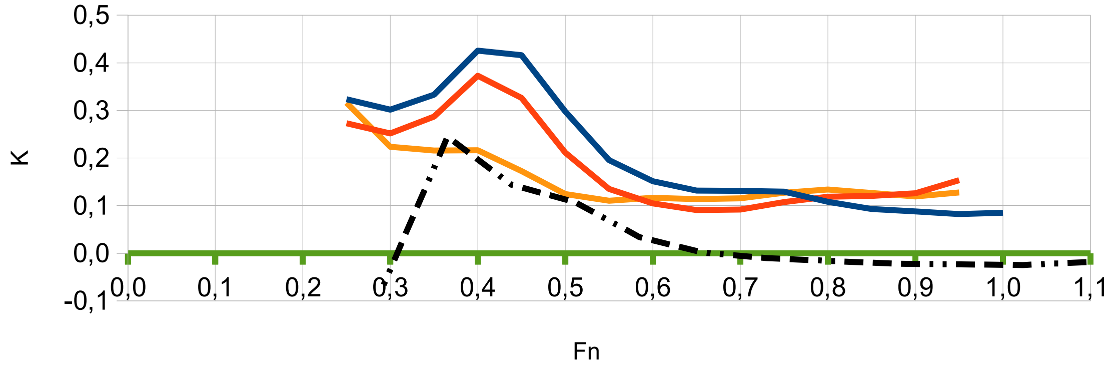
From their Fig. 5 :		**Cata**	**>> each hull**		
Speed (m/s)	>> Fn	Dr (kN)	Dr (kN)	> Dr/Mg (%)	> K factor
3					
4	0,29	1,20	0,60	0,39	-0,07
5	0,37	1,71	0,85	0,56	0,24
6	0,44	6,49	3,24	2,12	0,14
7	0,51	8,71	4,35	2,84	0,11
8	0,58	9,65	4,82	3,15	0,03
9	0,66	10,07	5,04	3,29	0,00
10	0,73	10,50	5,25	3,43	-0,01
12	0,88	11,27	5,63	3,68	-0,02
14	1,02	11,95	5,98	3,90	-0,02
16	1,17	12,46	6,23	4,07	-0,01
18	1,31	12,63	6,32	4,12	-0,01
20	1,46	12,72	6,36	4,15	-0,01

When putting these results in the model tests Figure which has a close Lw/D^(1/3) (7,64 / 7,4) and a high Lw/Bw (13 / 10,4) , and for S/Lw 0,47 close to 0,5 :

Amplification factor (1+K) when Lw/D^(1/3) = 7,4 ; Lwl/Bwl = 10,4 ; Bwl/Tc = 1,5

S/Lw : Blue 0,3 ; Red 0,4 ; Orange 0,5 Green : Monohull

Dashed line : Wigley catamaran Lw/D^(1/3) = 7,64 Lw/Bw = 13 Bw/Tc = 1,18 S/Lw = 0,47
(as computed with Michell's theory by Tusk & Lazauskas)



>>> The amplification factor is similar to model tests results for Froude 0,35 to 0,5, then for Fn > 0,6 the amplification factor vanished to zero (= no interference) instead of 0,1.