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CONSTRUCTIVE SOLUTION FOR THE WIDENING OF A PLANNING BOAT MADE OF COMPOSITE MATERIAL

Adrian Caramatescu
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture, Galati,
47 Domneasca Street, 800008, Romania,
E-mail:adrian.caramatescu@ugal.ro

Albert Graure
University "Dunarea de Jos" of Galati,
Faculty of Naval Architecture, Galati,
47 Domneasca Street,800008, Romania,
E-mail:albert_graure@yahoo.ro

ABSTRACT

Modelling a composite planning boat is a common feature of many 3D software programs focused on Naval Architecture domain. But sometimes, a particular hull form has to be modified to suit a particular need of a customer and the automated generation of the hull based on main particulars is not an option anymore, especially when the modification is regarding the beam of the hull.

Keywords: 3D modelling, GL Yacht scantling, Rhinoceros, Orca 3D.

1. INTRODUCTION

Considering a boat builder's point of view, the customer's demands can often be tailored to fit one of the existing models in its current production range of boats. But once in a while, a particular model of boat is demanded and the customer is determined to obtain a modification of an existing hull form in order to suit its particular needs.

The design proposal was assigned to a group of students attending an internship at PLASMA SRL, the boat builder company. The paper presents the outcome at the end of the internship. The hull has been modelled using the trial version of Rhinoceros, with the installed trial version of the Orca3D plug-in.

2. DESIGN PREREQUISITES

Customer's demands were translated into the main particulars as the project start line (Table 1).

Table 1. Main particulars of the derived hull as proposed by the customer. Bold text represents the must-reach characteristics.

Length of the hull	L=5.75m
Length of the waterline	L=4.95m
Beam	B=2.25m
Depth amidships	H=0.63m
Max Draught	**T=0.35m**
Max. Displacement	**D=2.2t**
Scantling length	L=5.35m
Capacity	10 pers.
Power requirement	**Max 70 HP (51.47 Kw)**

Widening a hull is not a common option for many naval architects. The returning customer is operating the boat in the Delta of the Danube and enjoys one of the boat models in particular due to the good stability offered. The demand was for a near identical boat with a wider cockpit to accommodate 10 passengers. Since the pre-existing hull had a semi-tunnel shape on the bottom section, the solution adopted was to extend the semi-flat surface of the bottom and to continue it to the bow of the hull.

Fig.1. Pictures of the pre-existing hull particularities in the aft (left) and bow (right)

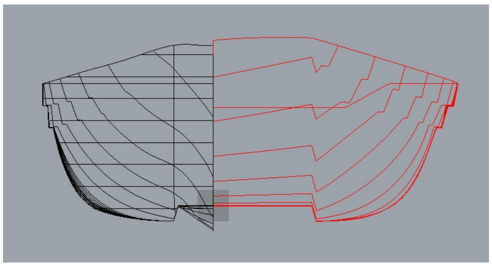

Fig.2. Sections comparaison of the pre-existing model (left) and the new proposal (right)

The proposal corresponds to the demand of the customer to keep the same design line of the hull as the pre-existing model, since it does not alter at all the side view. Widening the hull also creates more stability, one of the strong points that the customer mentioned appreciatively.

Due to the particular small wave conditions in the intended navigation range, the comfort aboard the modified hull is not significantly different from the pre-existing hull.

2. SCANTLING

Once a solution of the hull shape has been defined, the scantling is the next step. Germanischer Lloyd Rules for Yachts and Boats Up To 24 m (I-3-3) was used for the dimensioning of the composite shell and structural members, mainly due to its relatively simple calculation flow.

The same calculation flow allows the scantling to be evaluated for pleasure rating or workboat rating simply by the multiplying the results with two coefficients, one for shell glass weight (120%) and another for structural members glass weight (144%). This allows the workshop to easily assign proper reinforcement schedules for the boats intended to have an intensive operation rating.

Table 2. The scantling results for the bottom shell, based on design loads

SHELL BOTTOM		
DESIGN AREA	0.4 L - Fore	0.4 L - Aft
DESIGN LOADS [kN/m^2]	17.74	14.19
PLEASURE RATING SCANTLING		
GLASS WEIGHT [g/m^2]	2405	2151
KEEL [mm]	8.6	7.7
BOTTOM [mm]	5.5	5.0
WORKBOAT SCANTLING		
GLASS WEIGHT [g/m^2]	2886.6	2581.6
KEEL [mm]	10.3	9.2
BOTTOM [mm]	6.6	5.9

Table 3. The scantling results for the side shell

SHELL SIDE		
DESIGN AREA	0.4 L - Fore	0.4 L - Aft
DESIGN LOADS [kN/m^2]	11.82	9.44
PLEASURE RATING SCANTLING		
GLASS WEIGHT [g/m^2]	1648	1473
SHELL [mm]	3.8	3.4
WORKBOAT SCANTLING		
GLASS WEIGHT [g/m^2]	1978.1	1767.5
KEEL [mm]	4.6	4.1

In a similar manner, structural members section module is calculated using web opening and spacing. Any profiles for structural members can be used as the workshop's profile of choice, if they provide the minimal requirements stated in the scantling result. One of the most used reinforcement profile in the composite is the top hat profile, whose trapezoidal cross section is the most convenient for embedding it on the shell.

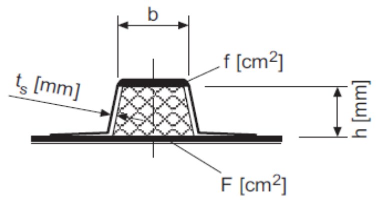

Fig.3. Top hat profile and its characteristics

Table 4. The scantling results for the deck shell

DECK	
DESIGN LOADS [kN/m^2]	9.63
PLEASURE RATING SCANTLING	
GLASS WEIGHT [g/m^2]	1341
SHELL [mm]	3.1
WORKBOAT SCANTLING	
GLASS WEIGHT [g/m^2]	1608.9
KEEL [mm]	3.7

For both simplicity of the construction and technological assembly procedures, the same top-hat profile section was chosen for both longitudinal and transversal frames; in any of the cases, the profile largely exceeds the calculation requirement for minimum section module as it can be seen, by a factor of approximate 10 times. The explanation of this comes from the double bottom height of 100 mm obtained between the bottom shell and the deck shell and the structural adhesive manufacturer recommendation to have at least 100 mm width on the joined profiles.

Table 5. The scantling results for bottom longitudinal frames and the profile selected

BOTTOM LONGITUDINAL FRAMES		
DESIGN AREA	0.4 L - Fore	0.4 L - Aft
PLEASURE RATING SCANTLING		
SECTION MODULI [cm^3]	3.66	4.57
WORKBOAT SCANTLING		
SECTION MODULI [cm^3]	5.27	6.58
PROFILE (hxbxt, mm)		100X100X3
CONNECTED PLATING (mm)		25X3
PROFILE MODULI (cm^3)		42.5

Table 6. The scantling results for bottom transversal frames and the profile selected

BOTTOM TRANSVERSAL FRAMES		
DESIGN AREA	0.4 L – Fore	0.4 L - Aft
PLEASURE RATING SCANTLING		
SECTION MODULI [cm^3]	2.86	3.59
WORKBOAT SCANTLING		
MIN. SECTION MODULI [cm^3]	4.12	5.17
PROFILE (hxbxt, mm)		100X100X3
CONNECTED PLATING (mm)		25X3
PROFILE MODULI (cm^3)		42.5

3. CONCLUSIONS

Using the scantling results, the weight of the hull can be properly evaluated, using the Orca 3D plug-in; the same tool offers the evaluation of the stability, as well as the performance prediction for planning, using the Savitsky method. The results proved that the solution adopted satisfies the customer's initial requests regarding the maximum power installed (51 kW) and the speed obtained with the maximum load of 10 passengers (18 kn).

Table 7. Power estimation by the Savitsky method

Speed (kt)	Fnv	Trim (deg)	Rbare (N)	Rtotal (N)	PEtotal (kW)	PPtotal (kW)
10	1.63	0.352	1554.7	1710.1	8.8	17.6
12	1.956	1.119	1347.4	1482.2	9.2	18.3
14	2.282	1.129	1684.2	1852.6	13.3	26.7
16	2.608	1.273	1935.6	2129.2	17.5	35.1
18	2.934	1.332	2238.9	2462.8	22.8	45.6
20	3.26	1.498	2473.1	2720.4	28	56
22	3.586	1.68	2695.9	2965.4	33.6	67.1

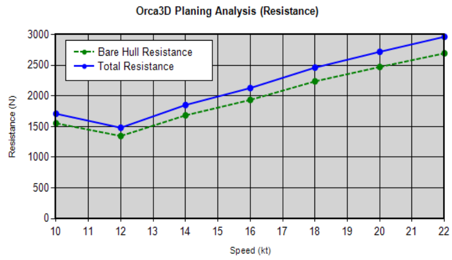

Fig. 4. Hull resistance graphic calculated by Orca 3D using the Savitsky method

Although it is a rather simple exercise, the outcome of this internship illustrates the practical approach using a real example of the workflow in designing and evaluating a composite workboat starting from the customer's demands.

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