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Concrete Hull: A New Experience in Northeast of the Brazil

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***Abstract* — In the present work a simple methodology in naval construction is developed using a concrete hull as objective of the study. This research was developed in the Pernambuco University in Brazil where the first one objective is find the best performance of the hull using construction material from the marketplace as: Portland cement, sand, steel and others. As practical work the research group E-Naval from the UFPe, had to build a hull made out of concrete. It had to be as light as possible and strong enough to support of the structural and hydrostatic tests. So, a new technique is in development to construct the concrete hull in the Pernambuco Federal University.**

***Index Terms*— Ship Design, Hull Concrete, Hull Form, Efficiency Calculation, Technology in Naval Building.**

I. INTRODUCTION

The Engineering Naval program in the Federal Pernambuco University is relatively new. This program was beginning in 2011, with undergraduate in Engineering Naval and the post-graduation in Naval Construction in specialization level. This course of expertise has received support from PETROBRAS. The objective of the research is presented here as a concrete hull model using all technology current as: software specialized, new product in the market, and the matter developed in the class room. Important is call the attention who in this development of the concrete hull, it is implemented across a pilot project localized in the campus of the Federal Pernambuco University. The research group E-Naval for develop this project was composed for Teachers and undergraduate and post-graduation students.

II. CONCRETE HULL PROJECT

The Concrete hull project with objective to the concrete hull followed a chronogram, this chronogram started with the producing a design paper in which they explain how they designed and built the hull, and also how they developed their concrete mix design. The figure 1 shown the Gantt time table of the all process developed.

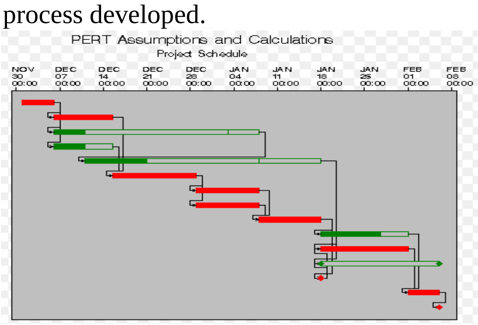

Fig. 1 – Concrete Hull Project Schedule using Gantt

In the figure 2 is showed the basic process to build the hull in concrete where this technic is very used to building water reserve Tory in the northeast of the Brazil.

Fig. 2 – Ferro cement technic to build water reservatory in northeast of the Brazil

III. BIBLIOGRAPHIC REVISION

In this work was studied many researchers and studies realized to show and give solution for more divers problem in concrete hull construction in first one we can show the work of [1] Nóbrega, J.C.C., "Post doctorate Report in Naval Architecture", Anast/ULG, Liège - Belgian, 2010. Where is find the project of the small boat to navigate in lakes and rivers. [2] MARTINS & TORMENA developed a design procedure "Projeto Canoas de Concreto : o desafio da prática no ensino da Engenharia Civil", this Project was developed only to give a stimulus for students from the engineering in respect to research. The work, of the DUMET and PINHEIRO [3], "A evolução do concreto: uma viagem no tempo", presented in the 42º IBRACON in Fortaleza city in Brazil show to us the history of the evolution in the apply the concrete in the civil construction. [4] BREWER wrote the paper "Understanding Boat Design 4TH Edition", explain over differences enter several tips of the hulls, Meyer and Mu, wrote the paper "Bending and Punching Shear of Fiber-Reinforced Glass Concrete Slabs" [5]. Nóbrega, J..C.C, Dan, Trinh Cong, Rubanenco, Ionicaro wrote the paper "Simple Calculation of Boat Propeller"[6], where was shown the all process the dimensioning of the boat hull. As basic bibliography we can show MARCHAL [7] with the book "Ship Theory" who is divided in three volumes, the first "The Static", this book give all the theory relative to stability of the ship, in the most divers situations, take in consideration stability of floating bodies, influence of geometry of the floating body over the centre of carene position, metacenter and others. In the second volume "The dynamic", that author describe about: Launch ship, stop the vessel, maneuverability study and others. Finally in the third volume "Propulsion" in

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this volume is described about: propeller, standardization, blades, engine and RIGO, Philippe and Rizzuto, Enrico, "Analysis and Design of Ship Structure" [8].

IV. METHODOLOGY DEVELOPMENT

In this item is shown the methodology used in the design of the concrete hull, who was developed in four parts, the first is the hydrostatic calculation, in this item is used the Free! Ship software [12], note that the Maxsurf [10,11] software used by NÓBREGA [1,6], could to be used, but to this project the Free! Ship is adequate. The second step is the development of the hull plant represented across his three geometric views [8,9]. Across that geometric vision is possible to know the hull dimension as the data in table 1. The third step was calculated the KAPER resistance where this method is intended for canoes and kayaks. It was originally developed by John Winters, a naval architect now specializing in designing canoes and kayaks. The fourth step was used to do budget, here is very important to show that in this implementation of the concrete hull who was not utilized a mold, but was developed a methodology of the construction very used in the northeast of the Brazil to building water reservatory. The study of the boat stability used here, is the same that is find in the Marchal [7], but in not necessary describe in this paper, but in Nóbrega [1] is easy find an example apply to a geographic boat.

A. *Hydrostatic calculation data*

In this item is developed the dimension of the boat hull [1], the calculation is describe as:

Table 1 – Hull basic data

Design length [m]	6.000
Length over all [m]	6.000
Design beam [m]	0.800
Beam over all [m]	0.795
Design draft [m]	0.102
Midship location [m]	3.000
Water density [t/m^3]	1.025
Appendage coefficient	1.000

Table 2 – Hydrostatic result for concrete hull

Drat [m]	0.100	Am [m^2]	0.048
Trim [m]	0.000	Cm [-]	0.7433
Lwl [m]	4.842	Aw [m^2]	2.143
Bwl [m]	0.642	Cw [-]	0.6891
Volume [m^3]	0.122	LCF [m]	2.782
Displ.[tonnes]	0.125	Cp [-]	0.5289
LCB [m]	2.901	S [m^2]	2.311
VCB [m]	0.065	KMt [m]	0.497
Cb [-]	0.3916	KMI [m]	21.366

Where

Lwl : Length on waterline
Bwl : Beam on waterline
Volume: Displaced volume
Displ. : Displacement
LCB : Longitudinal center of buoyancy, measured from the aft perpendicular at X = 0.0
VCB : Vertical center of buoyancy, measured from the keel line of the hull
Cb : Block coefficient
Am : Midship section area
Cm : Midship coefficient
Aw : Waterplane area
Cw : Waterplane coefficient

B. *Geometry of the boat concrete hull*

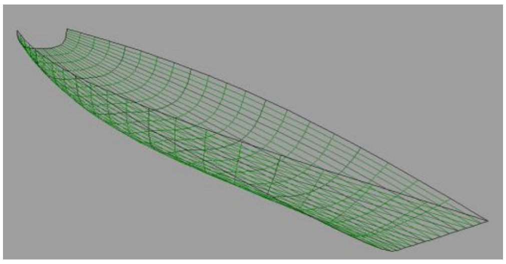

Fig. 3 – 3D design of the concrete hull

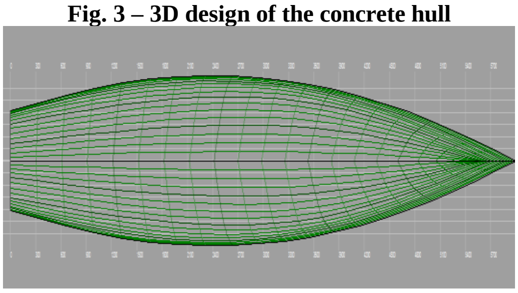

Fig. 4 – Superior vision of the concrete hull

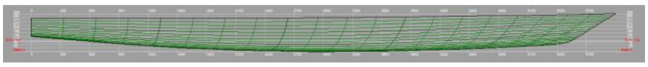

Fig. 5 – Lateral vision of the concrete hull

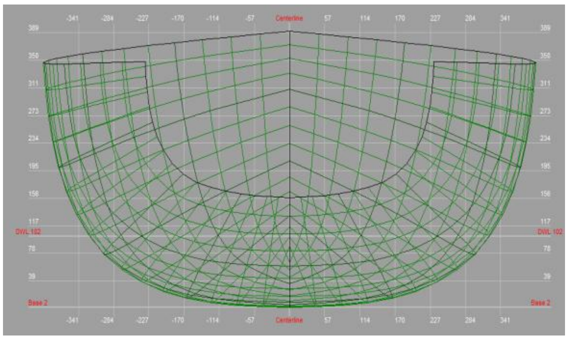

Fig. 6 - Frontal vision of the concrete hull

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C. KAPER resistance for canoes and kayaks, according to John Winters

With the design data shown in the table 3

Table 3 – Project design data

Design length	6.000 [m]
Design beam	0.800 [m]
Design draft	0.100 [m]
Midship location	3.000 [m]
Water density	1.025 [t/m^3]
Appendage coefficient	1.0000

The Hull Variables was calculated:

Table 4 – Hull variables

Effective waterline length	4.876 [m]
Beam on waterline	0.646 [m]
Draft hull	0.100 [m]
Wetted surface area	2.35 [m^2]
Prismatic coefficient	0.5279
Displacement	0.129 [tonnes]
Half entrance-angle of dwl	5.532 [degr]
Longitudinal center of buoyancy	0.539
Submerged transom area ratio	0.0000

Then, the Final calculations of resistance by KAPER are showed as in table 5:

Table 5 - Final calculations of resistance by KAPER

Speed [kn]	Speed [m/s]	S/L ratio	R frict [N]	R resid [N]	R total [N]	Spilman [N]
1.50	0.77	0.375	.661	0.107	2.767	3.220
1.60	0.82	0.400	.990	.128	.118	3.405
1.70	0.87	0.425	.337	0.152	3.488	3.662
1.80	0.93	0.450	.700	.178	.878	3.981
1.90	0.98	0.475	.081	.205	.286	4.355
2.00	1.03	0.500	.478	.233	4.711	4.774
2.10	1.08	0.525	.892	.262	.154	5.232
2.20	1.13	0.550	.323	.291	.614	5.724
2.30	1.18	0.575	.770	.320	.090	6.243
2.40	1.23	0.600	.234	.349	.582	6.785
2.50	1.29	0.625	.713	.377	.090	7.348
2.60	1.34	0.650	.209	.405	.614	7.929
2.70	1.39	0.675	.721	.434	.155	8.526
2.80	1.44	0.700	.248	.465	.713	9.138
2.90	1.49	0.725	.792	.481	.273	9.767
3.00	1.54	0.750	.351	.499	9.850	10.412

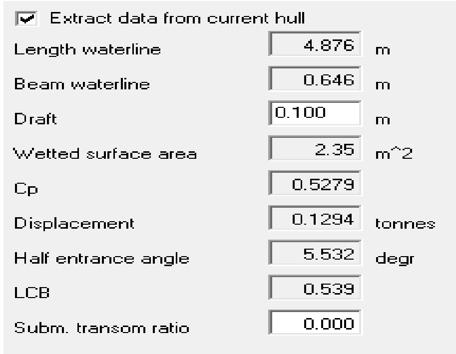
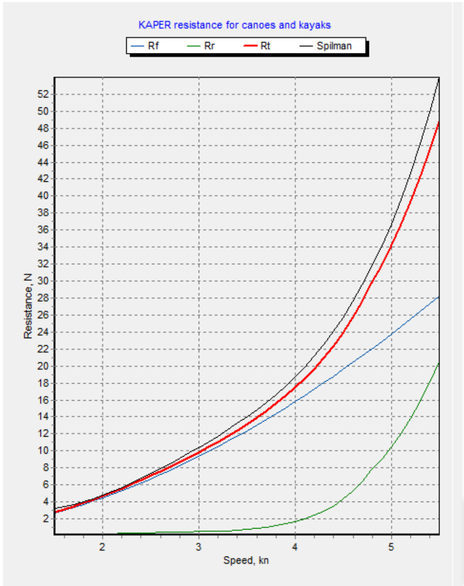


Fig. 7 – Input data to Hull in analysis



Graphic 1 – Kaper resistance for hull of the concrete

D. Material concrete hull budget

Table 6 – Material for construction of the hull

Item	Quantity	Discrimination
1	5 (Five)	Bags Portland Cement with 60 Kg
2	1/2 m^3	Standard Sand
3	9 (Nine)	Steel beam ϕ 5/16”- 12 m
4	1 (One)	Steel beam ϕ 1”-12 m
5	4 (Four)	Gallon of waterproofing
6	4 (Four)	Gallon of oil paint
7	2 (Two)	Gallon of coating
8	12 (Twelve)	Wood panel 0.4x0.03x3.0 m
9	2 (Two)	Wood Beam 0.14x0.1x3.0 m
10	1 (One)	Nail package
11	1 (One)	Steel wire double crimp screen
12	1 (One)	piece of galvanized wire

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Table 7 – Concrete hull Budget

Item	Quantity	Discrimination	Price USD
1	5 (Five)	Bags Portland Cement with 60 Kg	62.00
2	1/2 m^3	Standard Sand	25.00
3	9 (Nine)	Steel beam ϕ 5/16”-12 m	21.00
4	1 (One)	Steel beam ϕ 1”-12 m	19.00
5	4 (Four)	Gallon of waterproofing	44.00
6	4 (Four)	Gallon of oil paint	62.00
7	2 (Two)	Gallon of coating	23.00
8	12 (Twelve)	Wood panel 0.4x0.03x3.0 m	60.00
9	2 (Two)	Wood Beam 0.14x0.1x3.0 m	30.00
10	1 (One)	Nail package	07.50
11	1 (One)	Steel wire double crimp screen	75.00
12	1 (One)	piece of galvanized wire	15.00
		Total =	443.5

V. IMPLEMENTATION

In the present research project developed in the Federal Pernambuco University, The implementation practice of the concrete hull. In this project are participated teachers and students from under graduation and post-graduation in engineering Naval/Mechanic. The budget came from the PETROBRAS across the program PRH, and every execution work was developed for students from the engineering Naval/Mechanics from the UFPe. The figure 7, is shown the first step to build the concrete canoe where is shown the basic structure of the hull. In the figure 8 is shown the UFPe students building the concrete hull.

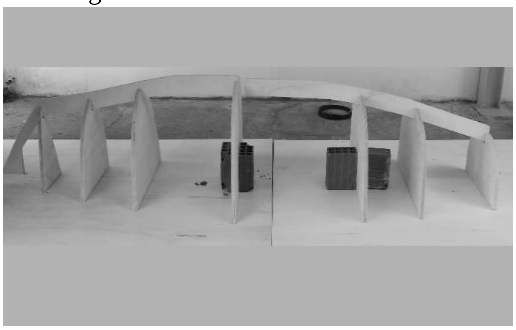

Fig. 8 – The first step to implementation of the concrete canoe

Fig. 9 - Implementation of the concrete hull

This pilot project was developed in the Pernambuco University in the Campus of the UFPe in the post-graduation building of the Naval Engineering.

VI. CONCLUSION

This paper was developed for students of naval and mechanics engineering from the PETROBRAS Program – PRH, they managed to develop and use a concrete technique for small construction application. The development of a new methodology was taken into account, also the new form of the construction naval for small hull. The development and using the new materials as well as the development the new mixes were developed and tested. he students build a hull in concrete as light as possible and strong enough to navigate in river and lakes. So, a new technique was developed to construct a concrete hull by Pernambuco Federal University. This article was developed in collaboration with the students from Naval engineering and post-graduate teachers from the UFPe, also with the E_Naval group from CNPq and with resources from Program of human resources of PETROBRAS - PRH.

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[10] hydromax, software voltado para cálculo da estabilidade estática de embarca.

[11] Maxsurf, software voltado para cálculo da estabilidade estática de embarca.

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AUTHOR'S PROFILE

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