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Ferrocement hull: A small Contribution of Civil Engineering for Brazil's Shipbuilding in Riverside Communities

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Abstract*— In the this present work is shown the research development to build a Ferrocement hull where the first one objective is find minor cost, taking in consideration easy construction form, minimum time to executing this hull. This final product have by objective take to the rivers communities a new method of the naval construction that come to be a cheap substitution for the woods hull and aluminum that exist. For this objective was developed a methodology specific about the production process where the first one step is the time table with all the steps that will be followed. Basically the methodology is the same find in Nóbrega, but in this case was used Maxsurf and Rhino software to calculate all the Naval Structure, hydrostatic date as stability and trim, also all design of the hull as geometry of the ship is obtained from the MaxSurf. The material and price was taken from the marketplace. The build was developed by Naval engineering students from the Federal University and ENSTA Bretagne University over orientation of the Teachers from UFPE. Important is that this project is part of the CAPES program called BRAFITEC, where the UFPe and ENSTA Bretagne University worked together.

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

I. INTRODUCTION

In the Brazil and especially in the Northeast [1] of the country, there is a gap between social classes; most of the people have to live with few resources. With the objective of help this social class, the E_Naval/UFPe/CNPq research group decided to develop a project aiming to design a small boat very cheap [4]. This kind of boat could be built afterward by the local population. To build this cheap ship, the mortar appeared to be the ideal material even if it is not very used in Naval Architecture. The manufacturing process is very cheap because we do not need to use a mold. At the end of this research, the building of the boat shows the viability of the project. Moreover studies about stability, structure, and advance resistance were realized in order to get the lightest possible hull. The performances test of the boat will be made later. Then the Naval Engineering program in the Federal Pernambuco University is relatively new [1]. This program was beginning in 2011, with undergraduate in Naval Engineering 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 finding a ferrocement hull with all technology current as: software specialized, new products from marketplace also with minimum fabrication price, minimum fabrication time but with maximum manufacturing quality e with a very easy manufacture form because of the objective of this research is anyone citizen poor from Brazil can doing it. Important is call the attention who in this development of the ferrocement 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. BIBLIOGRAPHIC REVISION

This is the second paper presented by E_Naval research group about this research developed in Pernambuco Federal University, then in this present work was continued the same research with new form of the construction and new hull design. In the work "Concrete Hull: A New Experience in Northeast of the Brazil", [1] is found the reference about ferrocement hull developed by E_Naval group. MARTINS & TORMENA [2] 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. BREWER wrote the paper "Understanding Boat Design 4TH Edition", explain over differences enter several tips of the hulls [4]. 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 using the software MaxSurf [8]. Gordon in 1972 published the work "An introduction to design for Ferrocement Vessels", for Vessel and Engineering Division Industrial Development Branch Fisheries Service Environment Canada[11]. Where this work show the potential designer of Ferrocement vessels to realistically predict the performance of a Ferrocement hull. In 2002 Maurilio M Fonseca Captain of the Brazilian Marine published the work "Arte Naval" [12], where many part of his work he write about of Ferrocement as material for hull construction of war ship (page 91, Chapter 3). Here is important to talk that the use of the NBR 5739 normalizes the test in the concrete by use de a

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body proof [13].

III. FERROCEMENT IN THE NAVAL ARCHITECTURE

The first boat concrete is built around the 1850s construction of the "Barque of Lambot" by Joseph Louis Lambot [2] all invention is reinforced concrete. This boat is made of a fine mesh wire mesh coated with concrete. During World War I, the concrete is used extensively in shipbuilding. This strong interest comes from the need of minimization of the use steel that were used in many other field. The United States then used to build the fifteen boats 133 feet long and weighs 7,500 tons. For the Second World War and for the same reasons, the concrete is used to build pontoons 65 meters by 18 meters for landing. Today the concrete is mostly used for small boats such as canoes. There are so various competitions including the United States (ASCE National Concrete Canoe Competition) where engineering students build canoes having previously done studies maneuverability, resistance to advancement, stability, structure to create the boat more efficient. Table 1 shows the main dimensions of some canoes ASCE which we can use to begin modeling the boat.

Table 1: Dimensions of some canoes of ASCE

University	Mass [kg]	Length [m]	Height [m]	Width [m]	Thickness [mm]
Nevada(Reno)	63.96	6.68	0.32	0.69	10.16
California (San Luis)	72.12	6.03	0.34	0.67	9.27
Florida	72.57	6.61	0.36	0.70	9.27

While it is rarely used today because of its high weight, however, presents some concrete benefits:

- Inexpensive Materials, simply raw materials (such as sand) and Due steel frame much cheaper than steel;
- Resistant to corrosion much better than a steel boat, so there is no need for protection;
- The molds used for the manufacture of a concrete boat are reusable. So there is a significant gain of money. In comparison, a boat molds for composites are much more expensive;
- High resistance to shock and friction against the docks: 100A1 Classification by Lloyd's Register of Shipping. - http://www.lr.org/Images/42%20class%20symbols_tcm155-248849.pdff
- Flexibility of concrete;
- Flammable Hull (temperature ranging closed to 1700 C° for 30 minutes);
- Facilitates repairs;
- Concrete is a very good insulator, preventing condensation problems.

IV. STUDIES CONDUCTED

A. *Characteristics of the Boats*

After reducing the thickness of the vessel to 15 mm and increase the width there of in order to satisfy the stability criterion, the dimensions of the main vessel obtained in Table 2. The shapes of the shell are represented in Figure.

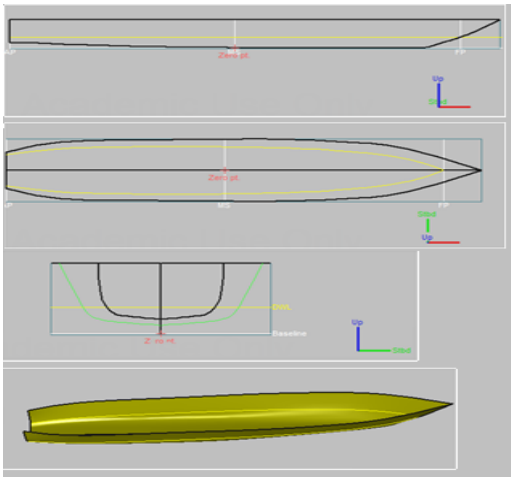

Fig 1: Side view, front, and perspective on Maxsurf Modeler

Table 2: Principal characteristics and coefficients boat

Dimensions et coefficients main	
Overall length [m]	5.93
Length between perpendiculars [m]	5.34
maximum width [m]	1.016
Draught [m]	0.131
Displacement [Kg]	291.5
wet surfasse [m²]	3.733
Surface flotation [m²]	3.354
prismatic coefficient	0.67
block coefficient	0.537

B. *Modeling of the hull*

The modeling of the hull was done through Maxsurf [8] Modeler software. This software is used to generate the shape of a shell from a library containing various types of vessels such as catamarans which monohull main dimensions of the boat to be modeled are added. And from the analysis of the existing on canoes built as part of the ASCE National Concrete Canoe Competition, we begin by modeling the boat as described in Figure 2.

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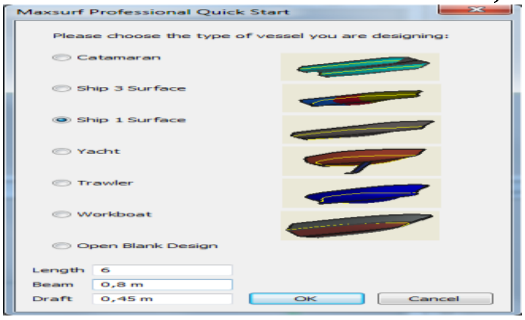

Fig 2: Interface starting on Maxsurf Modeler

Thereafter, to change the shape of the hull (which was necessary in this case to meet the stability criteria) must act directly on the various points of water lines modifying the coordinates of these or simply with your mouse. This step is done on the different views of the software (front, side, top and perspective).

C. *Work mass*

Following the study of structure, the Weight detailed boat could be done, it is found in Table 3. The lightship is the mass of the hull, the longitudinal and transverse stringers are metal frame as shown in Figure 3 the position of the center of gravity of each component was calculated using the software Rhino [10], weight it was calculated according to the geometry and thickness.

Table 3: Estimate the mass of the boat (Rhino Result)

	Item Name	Quantity	Unit Mass kg	Total Mass kg	Unit Volume m^3	Total Volume m^3	Long. Arm m	Trans. Arm m	Vert. Arm m
1	Lightship	1	238,0	238,0			2,650	0,000	0,174
2	Long Stringer1	1	10,6	10,6			2,960	0,000	0,450
3	Long Stringer2	1	10,1	10,1			2,840	0,000	0,300
4	Long Stringer3	1	9,3	9,3			2,660	0,000	0,120
5	Long Stringer4	1	9,0	9,0			2,950	0,000	0,050
6	Long Stringer5	1	5,3	5,3			3,010	0,000	0,050
7	Trans Stringer1	1	1,0	1,0			0,000	0,000	0,210
8	Trans Stringer2	1	1,2	1,2			0,900	0,000	0,170
9	Trans Stringer3	1	1,3	1,3			1,600	0,000	0,160
10	Trans Stringer4	1	1,3	1,3			2,500	0,000	0,140
11	Trans Stringer5	1	1,3	1,3			3,300	0,000	0,150
12	Trans Stringer6	1	1,2	1,2			4,200	0,000	0,160
13	Trans Stringer7	1	1,1	1,1			4,800	0,000	0,185
14	**Total Loadcase**			**290,8**	**0,000**	**0,000**	**2,680**	**0,000**	**0,180**
15	**FS correction**								**0,000**
16	**VCG fluid**								**0,180**

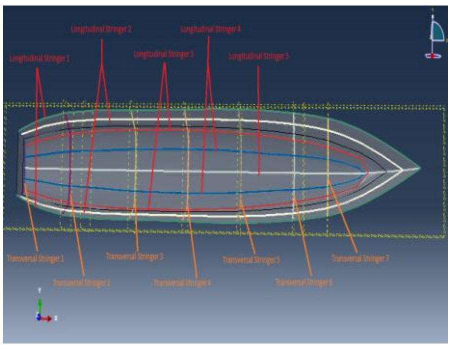

Fig 3: Appointment of different stringers on template

D. *Stability of the Vessel*

The software used to study the stability is Maxsurf Advanced Stability [8], it is very easy to import shell made with Maxsurf Modeler [8]. This software allows among others to study the stability for small and large angles and balance to trim the boat. Damage stability has not been studied since there is no compartment in the boat. In determining the trim of the vessel, all elements thereof have been listed in Table 4 Distribution of two passengers is then made so as to obtain a closest possible to zero trim. A height difference is obtained between the bow and stern of 6 m (see Figure 4).

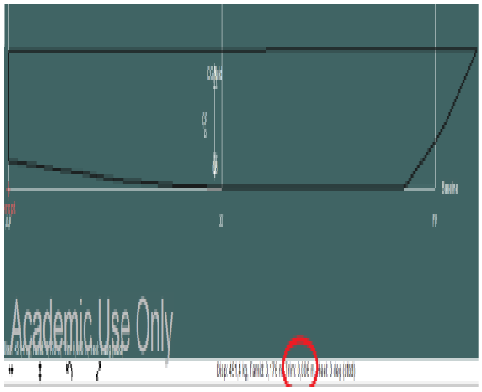

Fig 4: Stability in trim

Stability at large angles was then determined with and without passengers so as to respect the rules of Bureau Veritas for vessels less than 500GT (The regulations for boats concrete being sketchy). Figure 5 shows the GZ curve and the boat with passengers.

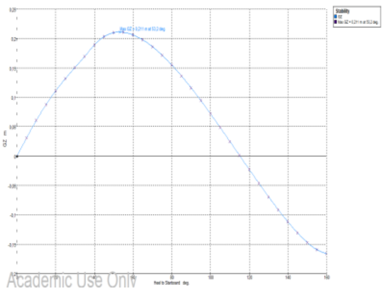

Fig 5: Curve GZ boat

The regulations for vessels less than 500 GT require respect for Chapter Steel Ships, Part B, Chapter3, and Section 2. As for the case without a passenger and passenger the Table 4 is obtained.

Table 4: Verification of stability

Criterion	value	without passengers	with passenger
Range 0 to 30 °	> 0.055 m.rad	0.15	0.065
Range 0 to 40 ° or invasion	> 0.090 m.rad	0.185	0.108
Range 30-40 ° or invasion	> 0.030 m.rad	0.35	0.043

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E. Calculation os structure

The purpose of this calculation is to determine the thickness of the vessel, the size and distribution of stiffeners for this Abaqus software will be used. The Maxsurf [8] file is imported, and it remains to partition the boat to create the stringers. The partition of the boat was made through datum plane so that you can easily change the position of stringers thereafter. This also simplifies the production since the longitudinal stringers are bent in a 2D plane and not 3D. Then applied loads correspond to: The water which is represented as a surface strain on the entire surface of the vessel under the waterline. The draft is weak, so we neglect the differences in pressure with depth. The mass of the boat is 451 kg with two passengers and 80 kg wet surface is 4.3 m² yields a surface effort in 1020 Pascal. We define two passengers in the worst case, that is to say, as one-time effort of about 800 Newton each. Several positions for these efforts have been tested to verify all the positions possible passengers. It give as 6 boundary conditions and loads applied to the boat.

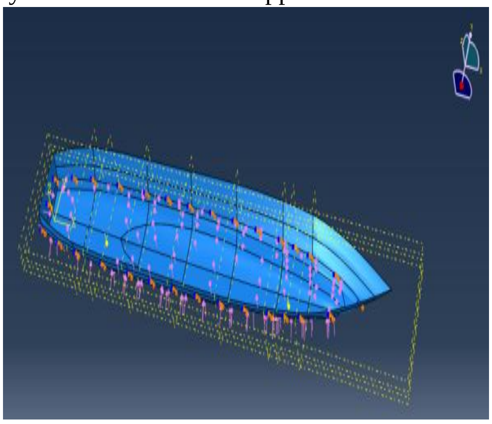

Fig 6: Loading and boundary condition on the boat

It then compares the Von Mises stress obtained with Template on the maximum allowable by the concrete stress. This maximum stress is obtained by experimental tests that will be discussed in next step. The number of transverse and longitudinal stiffeners required was determined to obtain the minimal stress of Von Mises. For different number of transverse stiffeners, this gives the detailed Table 5 constraints. Thus keep 7 transverse stiffeners.

Table 5: shows the constraints obtained for different positions of the longitudinal and transverse stringers

Number of transverse stiffeners	Stress [Mpa]
5	0.96
6	0.91
7	0.81
8	0.82
9	0.93

Table 6 shows the constraints obtained for different positions of the longitudinal and transverse stringers. We see that they are all less than the maximum stress of concrete time with a safety factor of 10 was thus able to diminish 65% the Von Mises stress by changing the positions of these stringers.

Table 6: constraints obtained for different positions of the longitudinal and transverse stringers

Position verticale des stringers longitudinaux (m)			Position longitudinal des stringers transversaux (m)	
Long Stringer 2	Long Stringer 3	Long Stringer 4	Trans Stringer2	Trans Stringer3
0,3	0,12	0,05	0,9	1,6
0,3	0,12	0,04	0,9	1,6
0,3	0,12	0,03	0,9	1,6
0,3	0,11	0,04	0,9	1,6
0,3	0,13	0,04	0,9	1,6
0,31	0,12	0,04	0,9	1,6
0,33	0,12	0,04	0,9	1,6
0,28	0,12	0,04	0,9	1,6
0,3	0,12	0,04	1	1,6
0,3	0,12	0,04	0,8	1,6
0,3	0,12	0,04	0,8	1,7
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,8	1,7
0,3	0,12	0,04	0,8	1,7
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,8	1,8
0,3	0,12	0,04	0,7	1,8

continued

Trans Stringer4	Trans Stringer5	Trans Stringer6	Trans Stringer7	Contrainte (Mpa)
2,5	3,3	4,2	4,8	1,88
2,5	3,3	4,2	4,8	1,71
2,5	3,3	4,2	4,8	1,76
2,5	3,3	4,2	4,8	1,71
2,5	3,3	4,2	4,8	1,71
2,5	3,3	4,2	4,8	1,71
2,5	3,3	4,2	4,8	1,71
2,5	3,3	4,2	4,8	1,71
2,5	3,3	4,2	4,8	1,88
2,5	3,3	4,2	4,8	1,71
2,5	3,3	4,2	4,8	1,29
2,5	3,3	4,2	4,8	1,29
2,6	3,3	4,2	4,8	1,29
2,4	3,3	4,2	4,8	1,71
2,4	3,3	4,2	4,8	1,29
2,5	3,4	4,2	4,8	1,29
2,5	3,2	4,2	4,8	1,29
2,5	3,2	4,1	4,8	1,23
2,5	3,2	4	4,8	1,24
2,5	3,2	4,1	4,7	1,23
2,5	3,2	4,1	4,6	1,23
2,5	3,2	4,1	4,6	1,23

Different load cases were also tested to verify that no matter the position of the passengers, the Von Mises stress does not exceed the maximum allowable stress. The worst is that the loading of a passenger is on the port side to a medium bounded by two longitudinal and two transverse stiffeners surface and the other is the location of another surface but to starboard. This would lead to additional bending [5]. We then obtain for this case charging a Von Mises stress of 1.76 MPa which is correct with respect to the maximum stress.

F. Frictional drag

For calculate the resistance to the advance, we will use the Maxsurf Resistance software [8]. This software calculates the resistance from several laws (Holtrop, Van Oortmerssen, Series60, Caompton and Fung), to choose the right, check the characteristics of the boat as the length or draft for example are not too low or too high. The Table 7 for the proposition that the law of Fung can be used for our case. Using Maxsurf Resistance [8], we obtain Figure 7 with the running resistance depending on the speed of the boat through the law of Fung.

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Table 7: Calculate the resistance to the advance

	Item	Value	Units	Holtrop	Van Oortmerssen	Series60	Compton	Fung
1	LWL	5,448	m	5,448	5,448 (high)	5,448 (high	5,448 (high	5,448
2	Beam	0,789	m	0,789 (hi	0,789 (high)	0,789 (high	0,789 (low)	0,789
3	Draft	0,171	m	0,171 (lo	0,171 (low)	0,171 (high	0,171	0,171
4	Displaced volume	0,423	m^3	0,423	0,423	0,423 (low)	0,423 (low)	0,423
5	Wetted area	4,249	m^2	4,249	4,249	4,249	4,249	4,249
6	Prismatic coeff. (Cp)	0,704		0,704	0,704	--	--	0,704
7	Waterpl. area coeff. (Cwp)	0,842		0,842	--	--	--	--
8	1/2 angle of entrance	18,6	deg.	18,6	18,6	--	--	18,6
9	LCG from midships(+ve for'	-0,088	m	-0,088	-0,088	--	-0,088 (hig	--
10	Transom area	0,001	m^2	0,001	--	--	--	0,001
11	Transom wl beam	0	m	--	--	--	--	0
12	Transom draft	0,064	m	--	--	--	--	0,064
13	Max sectional area	0,11	m^2	--	0,11	--	--	0,11
14	Bulb transverse area	0	m^2	0	--	--	--	0
15	Bulb height from keel	0	m	0	--	--	--	--
16	Draft at FP	0,171	m	0,171	--	--	--	--
17	Deadrise at 50% LWL	4,4	deg.	--	--	--	--	--
18	Hard chine or Round bilge	Round bilge		--	--	--	Round bilge	--
19								
20	Frontal Area	0	m^2					
21	Headwind	0	kts					
22	Drag Coefficient	0						
23	Air density	0,001	tonne/					
24	Appendage Area	0	m^2					
25	Nominal App. length	0	m					
26	Appendage Factor	1						
27								
28	Correlation allow.	0,0004		Calculate	0,0004	0,0004	0,0004	Fixed a
29	Kinematic viscosity	0,0000011	m^2/s					
30	Water Density	1,026	tonne/					

continued

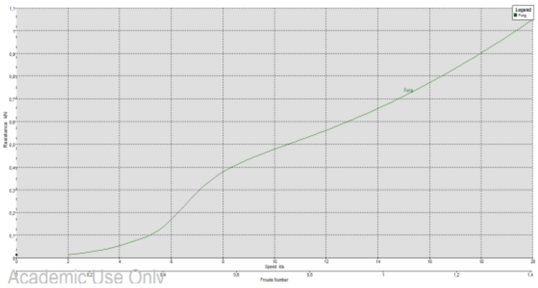

Fig 7 – Resistance to the advance – Maxsurf Resistance software

V. MAKING BOAT

A. Resource available

The estimated production budget of the boat is R$ 500 about 160 Euros, Table 8 shows the detail of the costs.

Table 8 – Material used in the hull

Product	quantity	Value [R$]
Bag of cement [50Kg]	4	99
Iron rod [7mm diameter]	7	209,3
Roasting [m²]	20	182
Wire [m]	25	13
Total [R$]	503.3	

B. A method of manufacturing

The method used can greatly reduce the price of the boat since not use mold. Teams from the ASCE National Concrete Canoe [6] Competition spend an average of $ 3,000 for such molds, representing a gain of money. The technique used here is then to make a metal frame that we will cover with two layers of mesh as in Figure 8 to deposit concrete directly.

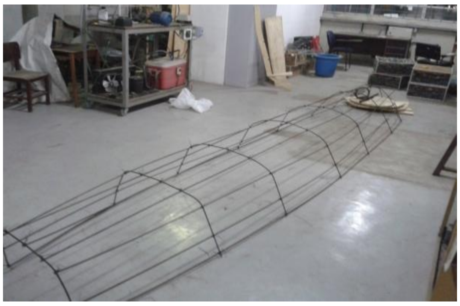

Fig 8 – Frame of the hull

To the metal frame, the iron bars are cut and fixed so make a transverse stiffener. Then are attached longitudinal stiffeners with transverse stiffeners as in Figure 10. To summarize, a wooden hole so as to pass the 9 iron longitudinal bars at the location determined on Template is then added transverse stiffeners already folded next to the wooden board and we just link the frame thanks to the line of iron that has just tighten with pliers.

Fig 9 – Template with the wooden board

Once this frame made it just have to remove the concrete on the fence. The proportions of the concrete used are: 1Kg of sand / cement of 0.5 Kg / Kg of CaO 0.25 / 350 ml of water in other terms 1 : 2: 0.5 .

Fig 10 – Hull construction

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VI. COMPOSITION OF THE MORTAR TO FERROCEMENT HULL

One of the most important part in the building of ferrocement hull, it is the mortar [3] composition used. So the composition that we used in this canoe, it is composted by Sand, Water, Cement and CaO hydrated. And the proportions it is 1 kg of Sand to 0.5 kg of Cement to 0.250 kg of CaO. Then was add water until get a good consistence, and normally it is 350 ml proportional for the mix describe above. To discover this mortar composition, it was done a lot of experimental tests, to find the best proportion with a good consistency and blind in stick in the wire. After That, Some tests we done to find the strength of the mortar for compression. First, we done oven specimens, that were cylinders with h = 10.0 cm and r = 2.5 cm, put him in the wet greenhouse for 7 days, for the mortar get the maximum performance and avoid cracks. Second, we calculate the density of the material, d = 1984.7 kg / m3, and use a machine to find the strength of composition, with the specimens, and get a general average 20 MPa for compression. So to cover all the Ferrocement [Hull 11, 12], that have a length 6m, beam 1.0 m and molded depth of the hull 0.45 m, we use 150 kg Cement, 300 kg of Sand, 75 kg of CaO and 100 l of water. When was done the mortar, in a big piece of wood on the floor, and mixed all the material with shovels. After, cover all the canoe in 4 hours without stop to avoid cracks. After the mortar finished was wait seven days then the ferrocement hull was transported to the landscape test. The first one was made the hydrostatic test with respect to the longitudinal and transversal stability; the second one was the test of the sealing. In all tests the ferrocement canoe was approved.

Fig 11 – Mortar in process

VII. FINAL RESULTS

Fig 12 – Two students make hydrostatics tests in the Lake of Federal Pernambuco University

In the seaworthiness test was tested if the hull will navigate in line straight and maneuverability test was verified if the hull will find any difficulty in make curves. But in all tests the hull was approved.

VIII. FINAL CONSIDERATION

In this research work was developed a methodology to build a Ferrocement hull where the first one objective was find minor cost, taking in consideration easy construction form, minimum execution time, less material waste with maximum security. This final product have by objective take to the riverside communities a new method of the naval construction that comes to be a cheap substitution for the hulls in woods and aluminum existing. For this objective was developed a methodology specific about the production process where the first one step was the time control over every one step developed in this research. Also was done the material waste control, but taking in consideration all structural calculations, and the material quality used in the mortar. Basically the methodology is the same that exist in Nóbrega [1], but in this research was used the softwares Maxsurf [8], Rheno [10] to calculate the hydrostatic parameters and Naval Structure. The material and price was taken from the marketplace. This research was developed by Naval Engineering students from the UFPE Pernambuco Federal University and ENSTA Bretagne University over orientation of the Teachers from UFPe. Important is that this project is part of the CAPES program called BRAFITEC, where the UFPe and ENSTA Bretagne University worked together. Important also is tell this hull is navigating in the lake of the Federal Pernambuco University in his University Campus where the workers of the lake are using this hull to give maintenance in the lake, other aspect important to emphasize is that project is sustainable Important also is tell this hull is navigating in the lake of the Federal Pernambuco University in his University Campus where the workers of the lake are using this hull to give maintenance in the lake, other aspect important to emphasize is that project is sustainable where anyone can executing this ferrocement hull. So this will facilitate the transport of the small cargo in the riversides communities in the waterways of the Pernambuco.

REFERENCES

[1] NÓBREGA, Juraci, "Concrete Hull: A New Experience in Northeast of the Brazil", Anast/ULG, Liège - Belgian, 2010.

[2] MARTINS & TORMENA developed a design procedure "Projeto Canoas de Concreto: o desafio da prática no ensino da Engenharia Civil".

[3] DUMET, T. B. E PINHEIRO, L. M. A evolução do concreto: uma viagem no tempo. 42º Congresso Brasileiro do Concreto. Fortaleza, IBRACON, 2000.

[4] BREWER wrote the paper "Understanding Boat Design 4TH Edition".

[5] MEYER, M. And MU, B. Wrote the paper "Bending and Punching Shear of Fiber-Reinforced Glass Concrete Slabs"

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[6] NÓBREGA, J.C.C, ""Simple Calculation of Boat Propeller", IJEIT.

[7] Hydromax, software.

[8] Maxsurf, software.

[9] Free! Ship, software.

[10] Rhino, software.

[11] GORDON, W. Bigg, "An introduction to design for Ferrocement Vessels", Ottawa/Hull, 1972.

[12] FONSECA, Maurílio M.. 'Arte Naval", 5o ed., Rio de Janeiro: Serviço de Documentação Geral da. Marinha, 1989.

[13] NBR 5739 normalizes the test in the concrete by use de a body proof.

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