FERROCEMENT IN CIVIL CONSTRUCTION: ITS USE IN LATIN AMERICA AND THE CARIBBEAN

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Abstract: Some of the most important applications of Ferrocement in Latin America and the Caribbean between the 70’s and 90’s and still in use are described. In Cuba the extensive construction of Ferrocement fishing boats starting in the 1970’s: the construction of a big prefabricated barge, 30 m long and 400 ton of capacity, water tanks, sculptures, houses and especially two swimming pools, one of Olympic dimensions and another of irregular form with a length of 100 m, the largest in Ferrocement at the time. In Mexico Prof. Alfonso Olvera constructed, using different building technologies, hundreds of prefabricated ferrocement houses, among them a group of prefabricated buildings used for cool storage. From Brazil, one of the American countries where Ferrocement has a broader use, schools, water tanks and large span roofs by the Sao Carlos Group, especially architect Joao Figueiras Lima and Professors Joao Bento de Hanai and Lafael Petroni are described. Also small and medium capacity water tanks by Prof. Rubén Jerves and prefabricated water tanks, drainage channels and sanitation water tanks by engineers Joao Bento de Hanai and Savio Nuñez are presented. From after the 90’s new applications built by Prof. Alonso Fernandez, Margarito Ortiz and others Mexican engineers of CIITDIR in Oaxaca Mexico are described, including the first time use of ferrocement in a dam wall. Also the work of ecologist architect Javier Senosiain in housing construction is described. Similarly modern houses, urban furniture and the biggest ferrocemento sculpture in America, built in Bolivia by ecologist architects Mario and Javier Moscoso are presented. From Chile, the work of Prof. Hernan Arnés and others building low cost ferrocement houses in seismic zones and useful floating barges are presented. The newest use of ferrocemento in Cuba in swimming pools, housing, sculptures and in equipment are described. Other noteworthy applications include: from Ecuador, irregular swimming pools by engineers Jaime and Javier Landivar; from Haiti, the Dominican Republic, and Nicaragua, prefabricated ferrocement houses by architects Pedro Galiano and Dr. Kurt Rhyner and finally from Honduras, treatment water tanks and rural water tanks of different uses and capacity are presented.

INTRODUCTION

A first stage of Ferrocement development in our region until the 90s resulted in many works that endure today and are paradigms which can be constructed using this material. In Cuba under the guidance of the author boats, swimming pools, warehouses, apartments and sculptures were built (Figs.1, 2, 3, 4 and 5). In Brazil, under the guidance of Architect Joao Figueiras Lima and Engineers Joao Bento de Hanai and Lafael Petroni, schools, water tanks and large roofs (Figs 6, 7) were built. In Mexico Prof. Alfonso Olvera built prefabricated houses and warehouses, the last used for refrigeration purposes with remarkable success (fig. 8). Thereafter and over 40 years the author, has been involved as a designer, consultant, partner or just being in contact with the authors of the most important examples built in Latin America and the Caribbean.
He has carried on national and internationally, many courses and conferences about the issue and written some books and many articles. He has had and maintains a personal relationship with the most important Professionals of Latin America and Caribbean on the issue.

Fig.1 and 2: Fishing and passenger ships. Cuba.

Fig. 3: Prefabricated barge 30 m long. Cuba.

Fig.4: Man and animals from the prehistory. Baconao, Cuba.
Fig. 5: First houses built with ferrocement, Santiago de Cuba.

Fig. 6: Olympic swimming pool, Cuba

Fig. 7: Prefabricated School and Florianopolis Terminal, Brazil. Ing. Joao B. de Hanai

Fig. 8: Cold Storage 60x50 m, México. Prof. Alfonso Olvera
DEVELOPMENT IN THE LAST 25 YEARS

In the 90’s a new and significant boost took place in Mexico, Bolivia, Chile, Cuba and other countries in the region where new professionals joined the civil construction field using Ferrocement. In Oaxaca, Mexico, Prof. Alonso Fernández and colleagues from the Interdisciplinary Technology Research Center for Integrated Regional Development (CIITDIR) of the National Polytechnic Institute developed houses, bridges, storages and a local auditorium applying the mortar directly by hand. (Fig. 9)

They have also successfully applied ferrocement in construction of medium tank capacity and for the first time in the construction of dams screens. (Figs. 10 and 11)

Meanwhile Arq Javier Sinesiai an ecological Architect designed and built homes of an undeniable aesthetic value (Fig. 12).
In Chile with the participation of Prof. Hernán Arnes, professionals related to the cement factory BioBio have built following Cuban experience, prefabricated housing adapted to the climate and seismicity of the country with very satisfactory results. They have built also barges used as stores in calm water. (Fig. 13 and 14).

![Fig.13: Barge with storage on deck](image1)
![Fig. 14: Houses, Prof. Hernán Arnés.](image2)

In Bolivia Architect Mario Moscoso with the collaboration of the Author, finished in 1993, a work that had begun years before in reinforced concrete and had to be paralyzed due to its high cost and technical difficulties: the Christ of Concordia (fig. 15). Today the big sculpture is representative of the city of Cochabamba. In Oruro was built the Jurassic Park, with very good technical quality and aesthetics, in the same place where found, decades ago, the original footprints of prehistoric animals that lived there (Fig. 16). It is to signify the high art and beauty, that Ecological Architects Mario Moscoso and his son Javier have shown building homes and other works of curved shapes. (Fig. 17 and 18)

![Fig.15: Cristo de la Concordia](image3)
![Fig. 16: Prehistóric animal (both Bolivia)](image4)

![Fig.17: House, Architect. M. Moscoso](image5)
![Fig. 18: Front of shopping center. Arch. Javier Moscoso.](image6)
In Brazil, although the retirements of several of its members has decreased the outputs of San Carlos Group, important applications of ferrocement continues to take place in that country, like the tanks for water treatment constructed by Eng. Savio Núñez and sanitation urban works in Rio de Janeiro designed by the Group, demonstrating the current strength of Ferrocement in that country. (Fig 19 and 20)

Fig. 19: Water tank and prefabricated drainage conduit, Brazil

Fig. 20: Water tanks. Brazil. Ing. Sabio Nuñes.

In Honduras Ferrocement has been developed by the Honduran Fund for Social Interest (FHIS) in water supply treatment and small tanks for social use, with excellent results (Fig. 21)

Fig. 21: Water treatments tanks, fhis. Honduras.
In La Habana, Cuba semi-prefabricated square small deposits were built, to replace those built before with asbestos and cement. In Guantánamo Eng. Miguel Moreno designed a prefabricated tank of 3000 m³ capacity (Fig. 22 and 23). Furthermore the Ministry of Sugar (MINAZ), under the guidance of the author is refurbishing old steel tanks of 500 m³, with an inside layer of ferrocemento using projecting mortar.

Similarly, a group of young sculptors continued to use Ferrocemento in this field. It is to signify the complexity and beauty of the works accomplished in this endeavor, as the crab or the city of Cardenas or specific sculptures for different hotels in the country. (fig. 24-26)

The production of prefabricated ferrocement panels in Cuba for housing became more technical, from the use of fixed molds to the use of portable steel ones, where the mortar set on place using a vibrating table. It markedly improved the quality of the results. Apart-
ment Buildings in Pinar del Rio and the hole small town of Minas 1 in the Escambray Mountains in the center of the country, are good examples (Fig. 27 and 28).

Fig. 27: Prefabricate building, Pinar del Rio  
Fig. 28: Pueblo Minas 1, Cienfuegos, Cuba

In the 90th was developed in the Higher Polytechnic Institute “Jose Antonio Echeverria” (ISPJAE) in Havana, by architect Emilio Loret de Mola and the author, the Ferrocement Residential Buildings System (SERF). This System uses modulated prefab panels for use in walls, floors and roofs. (Fig.29). Also a technology named PRELAB, was designed using an slide vibrating-compactor machine, allowing greater quality and productivity in panels construction. This technology, designed by Dr. Eng. Sergio Marrero with the participation of the author, presents many technical advantages and has been exported to other countries. All Ferrocement houses built in Cuba in the last years have been built using this system (Fig. 30, 31 and 32)

Fig. 29: SERF.  
Fig. 30: PRELAB (Tecnology. Dr. S. Marrero)

Fig. 31: Two stories high building  
Fig. 32: Building in La Havana.
In Dominican Republic, Haiti and Nicaragua, Architects Kurt Rhyner and Pedro Galiano, have built with the author advice earthquake-withstand ferrocement building, of great beauty and functionality. (Fig. 33 and 34)

Fig. 33 and 34: Building in Dominican Republic Arch. Pedro Galiano, Haiti house Arch. Kurt Rhyner

Starting in 90th, large pools of Ferrocement, both prefabricated and concreted in place have continued to be built in Cuba, reaching what Architect Joao Figueiras Lima and Eng. Lafael Petroni from University of San Pablo, named a Cuban school for making Ferrocement pools (Fig.35 and 36). In all cases, 2-3cm thick ferrocement sheets were used for the bottom and walls in swimming pools up to 2m deep and 2000m2 surface area, leading to costs between 4 or 5 times lower than those achieved with reinforced concrete pools.

Fig.35: Swimming pool, Varadero Fig.36: Pool, Punta Arenas Hotel

Ferrocemento swimming pools have also built in Brazil and Bolivia, usually for family use. In Ecuador under the author advise, Eng. Jaime and Javier Landivar and Marco Estupiñan have started to build free-form pools with very good results (Fig. 37 and 38).

Fig. 37: Esmeralda Pool, M. Estupiñan Fig. 38: Guayaquil Pool, Ing. J. Landivar
Also in Ecuador Prof. Rubén Jerves, from the University of Cuenca, has developed an interesting technique for the construction of medium capacity circular tanks (Fig. 39).

Fig. 39: Water tanks. Ecuador Prof. Rubén Jerves

CONCLUSIONS

Ferrocement has been widely used in civil construction in Latin America and the Caribbean, and have demonstrated to be an important, appropriate and sustainable alternative construction for developing countries and mainly for those buildings whose form can be very difficult and expensive to build in reinforced concrete. Ferrocement development in the region has allowed the International Ferrocement Society (IFS for its acronym in English) to organize in Cuba, two International Symposium on Ferrocement, the first FERRO 4, in October 1991 and the second FERRO 10 in October 2012. Additionally the author has been appointed as the current President of the IFS

BIBLIOGRAPHY: