Report on Ferrocement

Reported by ACI Committee 549

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This report provides an overview of the history, formulation, construction, and applications of ferrocement. The focus of this report is to create an awareness in engineers, architects, and potential end-users of the characteristics and capabilities of ferrocement.

Keywords: compressive strength; construction materials; crack width; ferrocement; fibers; flexural strength; mechanical properties; reinforced concrete; welded wire reinforcement.

CONTENTS

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Ferrocement is a form of reinforced concrete that differs from conventional reinforced or prestressed concrete primarily by the manner in which the reinforcing elements are dispersed and arranged. It consists of closely spaced, multiple layers of mesh or fine rods completely embedded in cementitious mortar. A composite material is formed that behaves differently from conventional reinforced concrete in strength, deformation, and potential applications, and thus is classified as a separate and distinct material. It can be formed into thin panels or sections, mostly less than 1 in. (25 mm) thick, with only a thin mortar cover over the outermost layers of reinforcement. Unlike conventional

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concrete, ferrocement reinforcement can be assembled into its final desired shape and the mortar plastered directly in place without the use of a form.

The term "ferrocement" implies the combination of a ferrous reinforcement embedded in a cementitious matrix, yet there are characteristics of ferrocement that can be achieved with reinforcement other than steel meshes or rods. The use of nonmetallic mesh is being explored by several researchers around the world (Brameshuber 2015). Such meshes include woven alkali-resistant glass; organic woven fabrics such as polypropylene; and organic natural fabrics made with jute, burlap, or bamboo fibers. Therefore, the term "ferrocement" currently includes material other than steel as reinforcement.

The definition for ferrocement has developed over the years to reflect advances in technology and practice. IFS 10-01 describes it as:

> … a type of reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of relatively small wire diameter mesh. The mesh may be made of metallic or other suitable materials. The fineness of the mortar mixture and its composition should be compatible with the opening and tightness of the reinforcing system it is meant to encapsulate. The matrix may contain discontinuous fibers.

1.2—Scope

This report includes the history, development, and applications of ferrocement together with composition and construction. Appendix A of this report provides several case studies of ferrocement applications.

CHAPTER 2—DEFINITIONS

ACI provides a comprehensive list of definitions through an online resource, "ACI Concrete Terminology."

CHAPTER 3—HISTORY

The origins of ferrocement can be traced to the work of Jean Louis Lambot who, in 1855, filed a patent for a material he called ferciment (Naaman 2000), which he claimed could replace wood in construction. He made numerous items, including two boats, one of which can be seen in Fig. 3a. Other contemporary researchers were looking at reinforcing of cement-based matrix with metallic reinforcement. Due to the difficulties in producing suitable wire reinforcement, the larger bars became popular and reinforced concrete was produced as we know it today.

Ferrocement, however, had a niche following and became a popular method for constructing boats, as shown in Fig. 3b.

Following the Second World War, Italian architect and engineer Pier Luigi Nervi developed the material for both marine and terrestrial applications with considerable success, as seen in Fig. 3c of his yacht, "Nanelle" (Huxtable 1960). Figure 3d shows an early warehouse and Fig. 3e shows the Turin Exhibition Hall roof. Further development moved to

Fig. 3a—Lambot's boat.

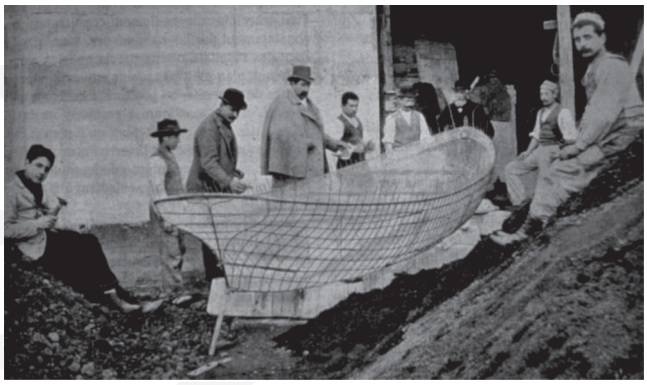

Fig. 3b—Early boat.

New Zealand where there was a thriving boat building and pontoon industry.

In 1972, the National Academy of Sciences, through its Board on Science and Technology for International Development, established the Ad Hoc Panel on the Utilization of Ferrocement in Developing Countries. The report of the panel (National Academy of Sciences 1973) stimulated interest in non-marine applications of this versatile material.

This led directly to the founding of the International Ferrocement Information Center (IFIC) at the Asian Institute of Technology, Bangkok, Thailand, in October 1976. In collaboration with the New Zealand Ferro Cement Marine Association (NZFCMA), the IFIC started publishing a quarterly journal, *The Journal of Ferrocement*. The IFIC developed outreach and training programs, and hosted the Second (Austriaco et al. 1985) and Eighth (Nimityongskul 2006) International Symposia. Unfortunately, through lack of funding, IFIC ceased production of the publication in 2006, and following intensive flooding in 2011, most of the remaining archive has been destroyed. A significant body of work, however, has been gathered from enthusiasts around the world and is held at the University of Manchester in the United Kingdom, where an electronic archive is being created.

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