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Structural integrity of ferrocement panels exposed to fire

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Abstract

The structural fire integrity performance of a ferrocement jacket was experimentally determined based on its flexural characteristics and damage after exposure to fire. The main parameters investigated were the volume fraction of wire mesh and mortar cover. A sandwich-sample configuration was adopted to simulate the actual conditions of exposure to fire in which the maximum temperature of 1060 °C was reached within 3 h. Tests showed that a ferrocement jacket was a satisfactory fire protection material due to its post-fire strength compared with that of plain mortar. Although an increase in wire mesh content significantly improved the mechanical properties of ferrocement under normal conditions, after fire exposure the content of wire mesh was no longer significant and higher volume fractions of wire mesh resulted in in-plane cracking. Mortar covers had negligible influence on the mechanical properties of ferrocement jackets under both normal and after fire exposures. However more visible fire damage occurred in ferrocement with thinner mortar cover.

Keywords: Ferrocement; Fire protection; Fire-damage; Post-fire strength; Toughness; Crack patterns

1. Introduction

Fire remains one of the serious potential risks to most buildings and structures [1]. A weakening of structural materials when exposed to high temperatures has potential for building collapse. Therefore, the use of fire protection materials to reduce thermal damage of structural members is important and necessary. Many types of fire protection material were developed to protect structural members. The main classes of material used are cementitious, intumescent, fibrous and composite materials. Ferrocement is one of the cementitious composite materials, which is constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small sized wire mesh [2]. Since mortar is a good insulator and the reinforcing wire mesh can reduce surface spalling better than plain concrete, the application of ferrocement jacketing for other structural components like reinforced concrete, prestressed concrete, or steel can protect these structural members from fire. Moreover, the influence of the encasing effect of ferrocement jackets, which behave as additional confinement [3–5], enhance the fire performance of the composite elements.

The use of ferrocement as a fire protection material requires a full understanding of the effects of fire on this material. However, most previous research has focused on the individual properties of ferrocement material, i.e. concrete, mortar and steel, at high temperatures [6–12]. Several studies have been conducted on the effects of high temperatures on the mechanical behavior of discontinuous-fiber reinforced materials, i.e. steel and polypropylene fiber [13–16]. Nevertheless, there is still a lack of knowledge and experimental data on the behavior of ferrocement exposed to fire.

The purpose of this study is to investigate the structural integrity of a ferrocement jacket exposed to fire. Structural integrity is obtained experimentally from the flexural characteristics and damage to ferrocement panels after exposure to fire. The investigated parameters are the volume fraction of wire mesh and mortar cover. The ferrocement

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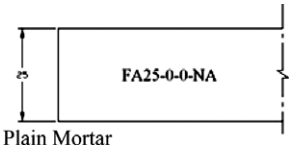
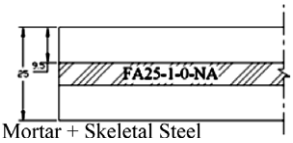
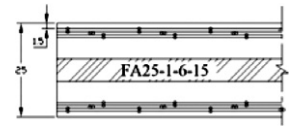
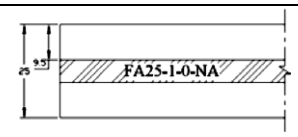
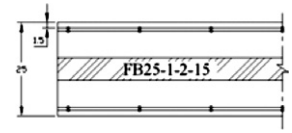
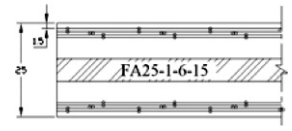
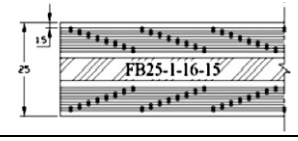
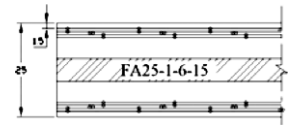
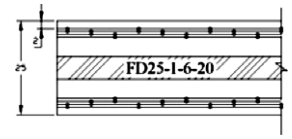
specimen had a dimension of 200 mm × 240 mm × 25 mm. Ordinary steel bar having a diameter of 6 mm was used as skeletal steel. Galvanized hexagonal steel wire meshes were used as mesh reinforcement. The mortar had a compressive strength of 57 MPa and was kept constant throughout. A sandwich-panel of ferrocement which consists of edge insulation was subjected to high temperature in order to simulate the heat transfer behavior of fire exposed ferrocement jackets. Type K thermocouples were used to record the temperatures. After being left to cool down in the furnace, the cracking, failure pattern, and damage to the ferrocement specimen's surface appearance

Table 1
Experimental program and details of test specimen

Series no.	Series code	Mortar overing (mm)	No. of wire mesh layers	Volume fraction (%)	Sectional geometry
A. Control specimen					
1	FA25-0-0-NA	NA	0	0	 Plain Mortar
2	FA25-1-0-NA	NA	0	0	 Mortar + Skeletal Steel
3	FA25-1-6-15	1.5	6	1.63	
B. To study the effect of volume fraction of wire mesh					
2	FA25-1-0-NA	NA	0	0	
4	FB25-1-2-15	1.5	2	0.54	
3	FA25-1-6-15	1.5	6	1.63	
5	FB25-1-16-15	1.5	16	4.36	
C. To study the effect of mortar cover					
3	FA25-1-6-15	1.5	6	1.63	
6	FC25-1-6-20	2.0	6	1.63	
7	FC25-1-6-25	2.5	6	1.63