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Tests on intumescent paints for fire protection of existing steel structures

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HIGHLIGHTS

- Intumescent coatings are often used to protect steel structures in fire.
- A 30-years old intumescent coating could be not particularly efficient.
- A new intumescent coating can be efficient also if the existing paint is not removed.

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ABSTRACT

Intumescent coatings (i.c.) are often used on steel structures to reduce the heating during a fire when the structural, aesthetic, and architectural value of the structural members should be preserved. Indeed, i.c. form a thin protective layer on the surface. When the i.c. are exposed to fire or excessive heat, volume expansion and density reduction take place. Therefore, the protective layer absorbs heat and protects the structural member from damage or excessive deformation.

To perform rigorous and realistic analyses on protected steel members, thermal properties of all materials, including i.c., should be known. Nevertheless, the thermal properties of these systems are not available, especially for existing buildings.

This paper shows experimental test on steel members protected with i.c., taken from an existing structure, which is thirty years old. I.c. thickness measurement and adhesion tests were performed in situ, whereas furnace tests were carried out at the Laboratory of the Italian National Fire Services.

The tested steel members have various section factors and behave two fire curves (Standard Fire and Smouldering Fire) during the tests in furnace. The furnace tests were performed on steel members with original i.c. (reference) and steel members protected by applying a new i.c. after removing the existing paint (restored) or simply by applying it on the existing paint (repainted). The results show that the existing i.c. is not very efficient, whereas the restored and repainted specimens showed similar performance. A law for the thermal conductivity of the i.c. was obtained from the experimental results, according to an European code, and used in a finite element numerical model.

1. Introduction

An increase of the fire resistance time for steel structures can be reached by applying fire protection materials, preventing the achievement of high temperatures in steel members during fire. They can be divided into two categories: passive materials (e.g. incombustible boards) and reactive materials (e.g. intumescent coatings). The intumescent coatings (i.c.) are solvent- or water-based systems applied with a dry thickness ranging between 400 μm and 3000 μm. The advantages of this protection include reduced invasiveness compared to other materials, an easy application and a good surfaces finishing.

Some studies show that during the reaction process, a first zone just below 300 °C can be identified as the melt zone, the second between 300 and 420 °C as the reaction zone and the third one above 420 °C as the charring zone. Above 420 °C, after consolidation of the foam, a rheologically stable period can be observed [1,2].

The fire resistance of a commercial i.c. is usually certified by means of experimental tests, which show its efficacy in fire situation [3]. Among the main problems for i.c. there are the adhesion to the steel profile during fire exposure and the dependence of thermal response (reaction of the paint) under different fires. In

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Fig. 1. Adhesion test (UNI EN ISO 4624).

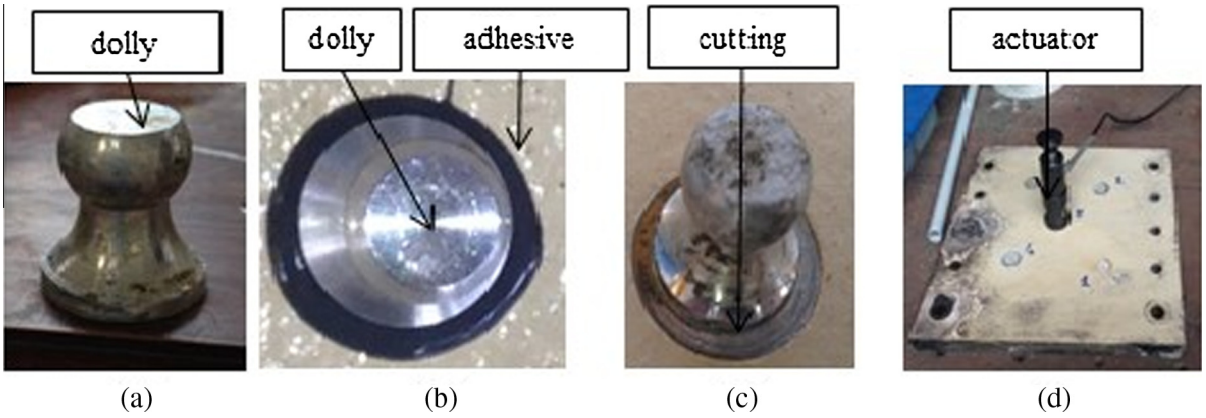

Fig. 2. Steps of adhesion test.

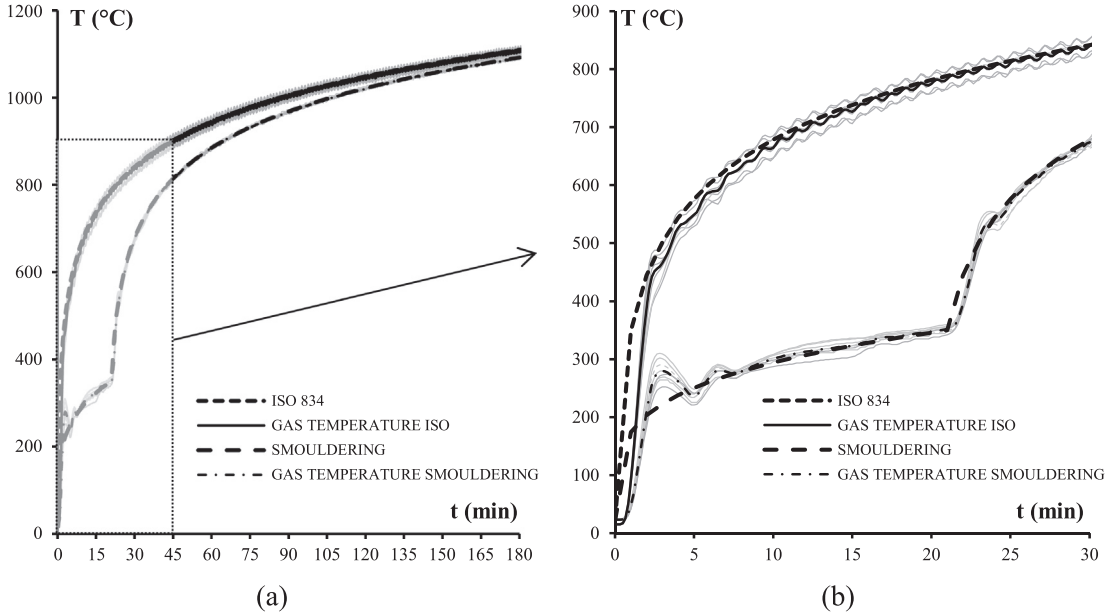

Fig. 3. Furnace temperature during the tests.

particular, the dissolution of the i.c., resulting in a reduction of performance, can occur for heating curves with thermal gradients lower than Standard fire curve ISO 834 (EN 1363-2 [4]) close to the i.c. initiation temperature. For this reason, in [4] a slow heating curve (smouldering curve) is also defined.

In the framework of a performance based approach [5], the knowledge of the thermal behaviour of the i.c. is essential. For existing buildings experimental tests are necessary to correctly represent i.c. in advanced calculation models.

The tests herein shown can contribute to define a test protocol for the intumescent paints applied on existing structures.

2. Experimental program

The fire behaviour of the i.c. mainly depends on thickness, adhesion during normal and fire situation and swelling reaction in fire situation. Therefore, the experimental tests concerned the measures of the thickness and the assessment of the adhesion of the i.c. as well as fire tests in furnace. Tests were performed on steel members protected with intumescent coating of an existing structure, which was thirty years old. Thickness measures and adhesion tests were also performed in situ during several surveys. High temperature tests were carried out at the Laboratory of the Italian National Fire Services on angle profiles. These members are used to increase the in-plane stiffness of the floor for seismic action, so they could be easily replaced under normal load conditions to obtain the samples used for the tests in furnace.