Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 151 (2016) 284 – 291

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Ecology and new Building materials and products, ICEBMP 2016

Material solutions for passive fire protection of buildings and structures and their performances testing

Katarzyna Mróz, Izabela Hager*, Kinga Korniejenko

Cracow University of Technology, Warszawska Str. 24, 31-155 Cracow, Poland

Abstract

In buildings and in civil engineering structures, both active and passive fire protection are used. Active fire protection includes automatic fire detection and fire suppression systems while the passive fire protection's main purpose is to attempt to contain fires or slower their spread. The aim of fire protection system's usage is to maintain the temperature of the building component (structural steel element, electrical installation) bellow the critical temperature during fire but also is intended to contain a fire in the origin fire compartment for a limited period of time. In this paper the passive fire protection material solutions were described and their action mode explained. Starting with thermal insulation barrier, endothermic building materials including concrete and gypsum and also novel solution based on alkali activated binders. Concrete is considered to be fire protective, however, in some specific cases, dense and low permeable concrete (i.e. high performance concrete) has a tendency to spall in explosive way under fire. Several fires in structures have caused the spalling of concrete elements that jeopardized the structure stability. In this specific case polypropylene fibres (PP) added to the concrete mix act as a passive protection system. Another group of passive fire protection materials, described in this document, are the intumescent and ablative materials for steel structure protection. The present manuscript describes also the techniques of passive fire protection testing in fire conditions.

Peer-review under responsibility of the organizing committee of ICEBMP 2016

Keywords: Passive fire protection; fire; building materials; concrete spalling

* Corresponding author. Tel.: +48-12-628-2371.
E-mail address: ihager@pk.edu.pl

Peer-review under responsibility of the organizing committee of ICEBMP 2016
doi:10.1016/j.proeng.2016.07.388

1. Introduction

In buildings and in civil engineering structures like tunnels, both active and passive fire protection are used. Active fire protection includes automatic fire detection and fire suppression systems while the passive fire protection main purpose is to attempt to contain fires or slower their spread. The aim of fire protection system's usage is to maintain the temperature of the building component (structural steel element, electrical installation) bellow the critical temperature during fire but also are intended to contain a fire in the origin fire compartment for a limited period of time.

Passive fire protection material solutions used for this purpose are as follows i) Thermal insulation barrier, ii) endothermic building materials including concrete and gypsum and also ii) novel solution based on alkali activated binders. In this listing of materials, a concrete is considered as the fire protective, however, in some specific cases, when dense and low permeable concrete (i.e. high performance concrete) is heated it has the tendency to spall in explosive way. Several fires in buildings and tunnels have caused the spalling of concrete elements that jeopardized the structure's stability. In this specific case polypropylene fibres (PP) added to the concrete mix act as a passive protection system. As the name suggests, passive fire protection remains inactive in the system until a fire occurs, as so does PP fibres in a concrete.

Another group of passive fire protection materials, described in this document, are the intumescent and ablative materials for steel structure protection. Steel is very sensitive to the temperature increase and 550 °C is considered as the critical temperature for structural steel because it induces an important strength loss. So the measures, like passive protection system, have to be taken to delay steel structure overheating by creating a layer of char between the steel and fire. The present manuscript describes also the techniques of passive fire protection systems effectiveness' testing in fire conditions.

2. Passive fire protection material solutions

2.1. Thermal insulation barrier

There is a wide variety of the thermal insulation materials that can be used for a basic purpose of insulation from heat transfer. However, while testing a fireproofing of thermal insulators, one can find only few materials that can resist a real fire conditions. Mineral wool, expanded aggregate and cellulose are representatives of fireproof material for thermal insulation.

Mineral wool, also known as rock wool or slag wool is one of the oldest types of insulation composed of non-combustible, naturally fire resistant stone wool. It can withstand temperature up to 1000 °C and does not burn. Over 1000 °C a mineral fibres start to melt. Mineral wool can be used as: the thermal and fire insulation between living area and non-heated roof spaces, a fire-resistant core for sandwich panels, a fireproof barrier for structural members in steel structures (Fig.1 a), and as the fireproof cover for industrial pipes and ducts as well. Well designed and tightly built-in insulation barrier can be therefore an efficient passive thermal and fire protection.

Other mineral materials are expanded perlite, shale, clay, slate and vermiculite. Those are recognized aggregate for fireproof cover manufacturing which offers the effective solution for life safety for both occupants and firefighting personnel. The non-combustible nature combined with high thermal insulation offers inherent structural integrity following exposure to fire what makes it the obvious choice for passive protection of building construction. Aggregate types affect fire ratings of cementitious composite material on the basis of heat transfer and on the basis of aggregate moisture absorption. Highly porous aggregates absorb moisture in varying degrees depending upon its type. The presence of moisture in the aggregate during a fire test extends the fire duration by the time when moisture is turned to steam and evaporated from the material.

Finally, the cellulose insulation is made in a loose form from a recycled paper, newspaper, cardboard or other similar materials, it is considered as one of the eco-friendliest thermal insulation materials. Although the composition of the material is associated with the high flammability, the chemical treatment with ammonium sulfate and borate provide its incombustibility. What is more, because of a high compactness of the cellulosic fibres, the material contains almost no oxygen and effectively chokes wall cavities of combustion air and thus can minimize