Analysis of Thermal Behavior of Protected and Unprotected Slim Floor Under Fire

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Abstract – *The slim floor system combines the advantages of flat slab construction with significant resistance to fire. This form of construction creates a flat floor in which steel beams are contained within the depth occupied by the floor. Shallow floors therefore achieve the minimum depth of construction and, by virtue of the partial encasement of the steel section. Generally do not require additional fire protection for up to 60 minutes fire resistance .The paper presents a numerical investigation to determine the fire resistance of slim floor system using different coatings. In partially encased slim floor three different thermal resistance coatings are provided to determine the model with maximum thermal resistance and the coatings provided are intumescent coating, mineral fiber spray coating and vermiculite coating*

Key Words: **Slim floor, Thermal resistant coating, intumescent coating, mineral fibre spray coating, vermiculite coating, Thermal analysis.**

1. INTRODUCTION

1.1 General Background

In recent years there has been considerable interest in many parts of Europe in developing and designing shallow floor systems for use in steel framed buildings. This form of construction creates a flat floor in which steel beams are contained within the depth occupied by the floor. Shallow floors therefore achieve the minimum depth of construction and, by virtue of the partial encasement of the steel section. Generally do not require additional fire protection for up to 60 minutes fire resistance. These floor systems can be designed to compete with reinforced concrete flat slabs, and offer distinct advantages relative to concrete in terms of speed of construction.

The principles and application rules for the design of steel and composite structures are now presented in Euro codes 3 [1] and 4 Part 1.1 [2] respectively, and in other national standards. However, these rules do not refer directly to shallow floor construction, although the principles still apply. The purpose of this paper is to review the information that is needed to enable this form of floor construction to be designed in accordance with these Euro codes.

This study focuses on the response of protected and unprotected slim floors in fire. Here the protection provided by giving an intumescent coating, mineral fibre spray, vermiculite cement spray. Intumescent systems in thermoplastics give fire-proofing properties by developing a carbonaceous shield which provides a protection to the material. The shield limits the heat transfer to the substrate. In this work, we use an intumescent formulation, which associates Ammonium Polyphosphate (APP) with Pentaerythritol (PER). In the conditions of the fire, the system develops an intumescence phenomenon and forms a carbonaceous coating. In both mineral fibre and vermiculite coatings the mix is made and sprayed to the prepared surface.

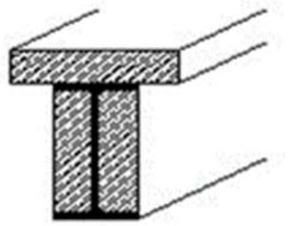

Fig -1: Slim floor

2. NUMERICAL INVESTIGATION USING ANSYS WORKBENCH 16.1

2.1 Base Model

Numerical modelling of Slim floor with different thermal resistant protective coatings were done using ANSYS 16.1 WORKBENCH, a finite element software for mathematical modelling and analysis. The dimensions of all the 4 specimens are same. The length of specimen is 4500 mm and the sectional properties of the slim floor is given in Table 1.

The Analysis requires input data for material properties are as shown in Table 2. Figure 2 showing the modelled view of Slim floor without coating. Figure 3 showing modelled view of Slim floor with intumescent coating. Figure 4 showing modelled view of Slim floor with mineral fibre spray coating.

Figure 5 showing modelled view of slim floor with vermiculite spray coating.

Table -1: Sectional Properties of Steel.

IS HB 300	
Section area	80.25 mm
Depth	300 mm
Width of flange	250 mm
Thickness of flange	10.6 mm
Thickness of web	9.4 mm

Table -2: Material Properties of Steel.

Thermal conductivity of concrete (W/m K)	1.9
Specific heat of concrete (J/Kg K)	780
Thermal conductivity of steel (W/m K)	60.5
Specific heat of steel (J/Kg K)	434

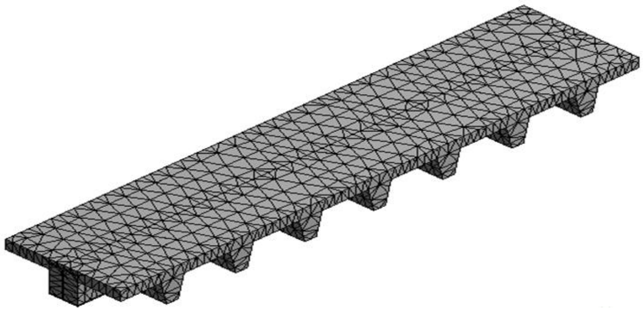

Fig -2: Modelled view of Slim floor without coating.

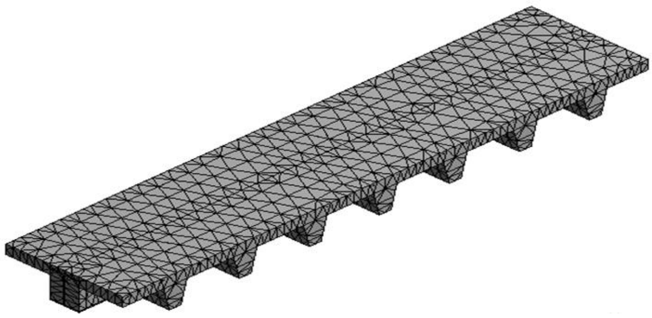

Fig -3: Modelled view of Slim floor with intumescent coating.

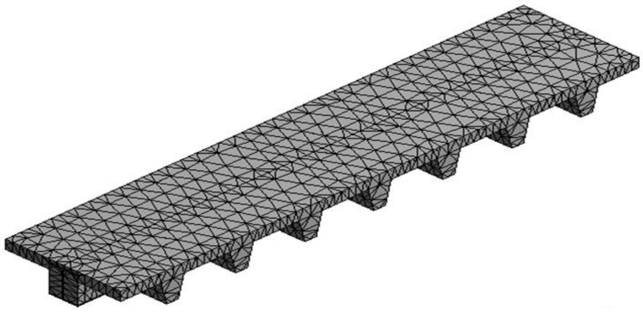

Fig -4: Modelled view of Slim floor with mineral fiber spray coating.

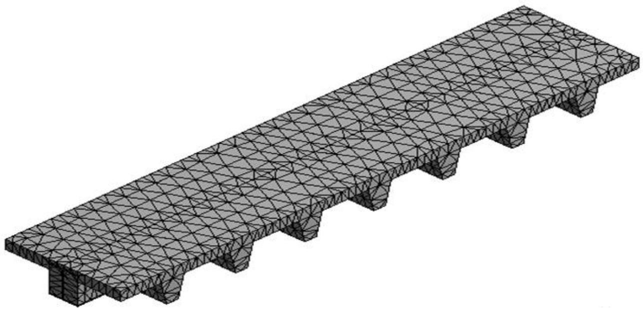

Fig -5: Modelled view of Slim floor with vermiculite spray coating.

2.2 Loading and Boundary Conditions

To simulate the real condition convective heat transfer coefficient is provided and the thermal analysis is being carried out.

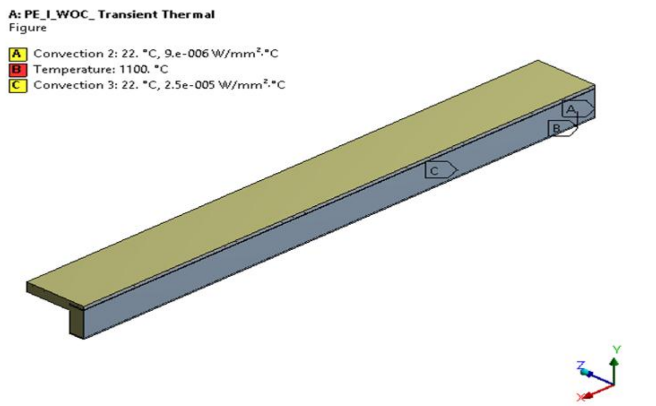

Fig -5: boundary condition of partially encased Slim floor.

3. RESULTS AND DISCUSSIONS

3.1 Temperature Distribution

The temperature developed and temperature distribution in the slim floor subjected to fire is obtained by the thermal analysis of the models. Thermal distribution in bottom ,middle and top are show in the charts below.

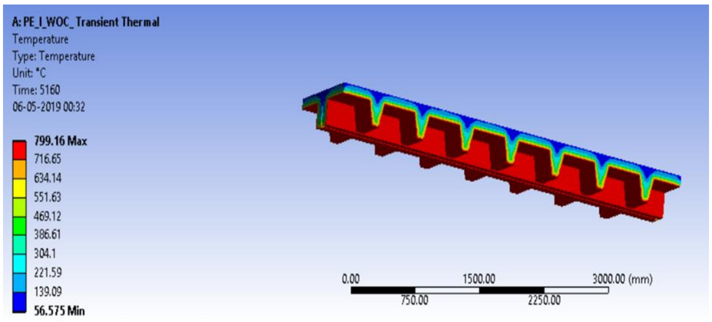

Fig -6: Thermal distribution of Slim floor without coating.

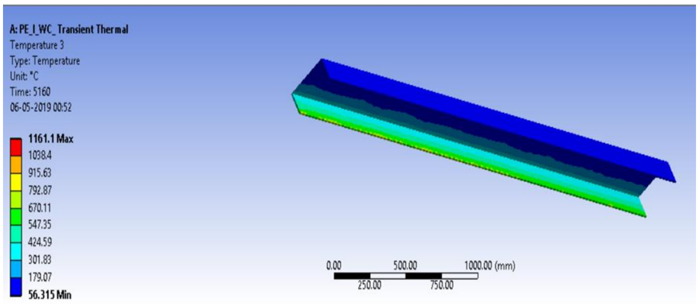

Fig -7: Thermal distribution of Slim floor with intumescent coating.

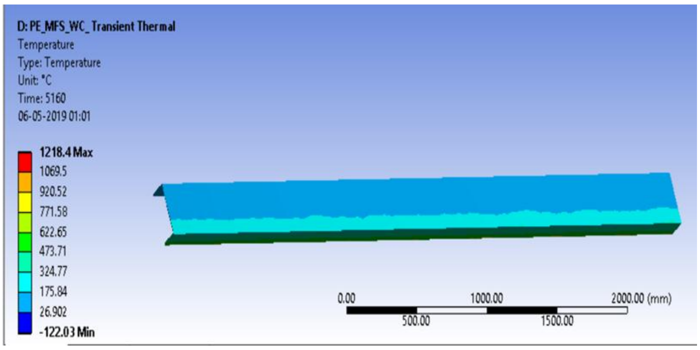

Fig -8: Thermal distribution of Slim floor with mineral fiber spray coating.

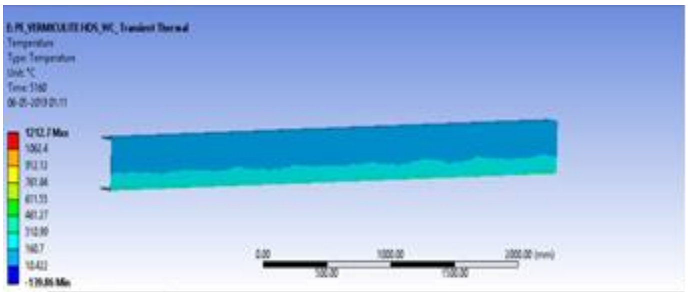

Fig -5: Thermal distribution of Slim floor with vermiculite spray coating.

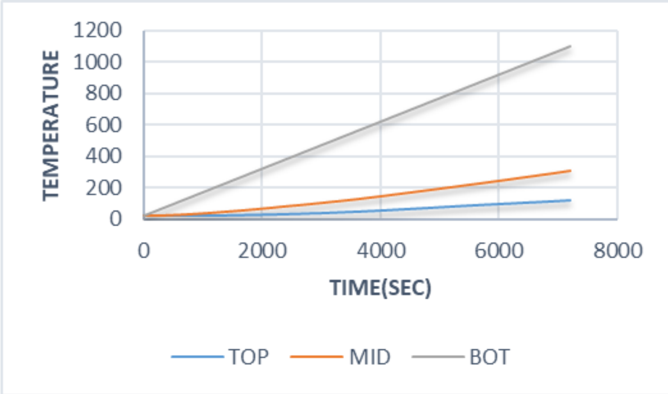

chart -1: Thermal distribution of Slim floor without coating.

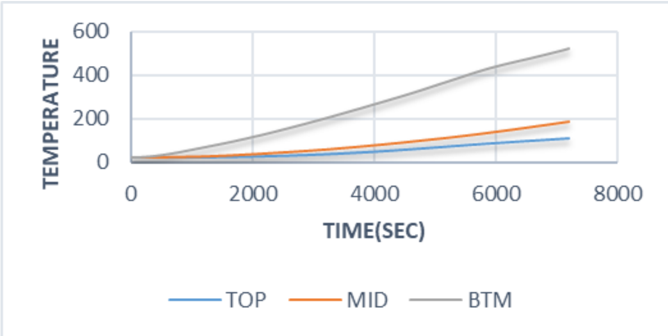

chart -2: Thermal distribution of Slim floor with intumescent coating.

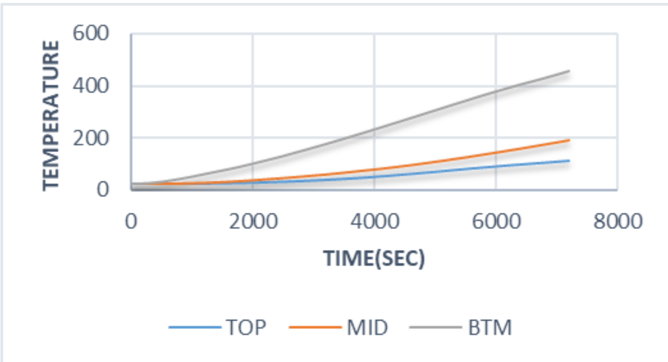

chart -3: Thermal distribution of Slim floor with mineral fiber spray coating.

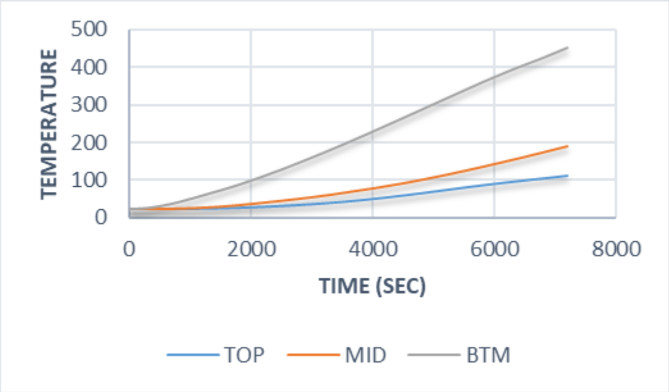

chart -4: Thermal distribution of Slim floor with vermiculite spray coating.

4. CONCLUSIONS

This study proposed a new model of partially encased slim floor with different thermal resistant coatings to improve the thermal performance of the structure, the conducted analytical study on the slim floor result in following conclusions:

- The pattern of temperature development and thermal distribution of slim floor with intumescent coating, mineral fiber spray coating and vermiculite coating are obtained.
- The model which gives maximum thermal resistance is the one coated with vermiculite spray coating.
- The use of thermal resistant coatings improve the thermal performance thereby a great improvement in the structural behavior can be obtained.

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