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EVALUATION OF THE BEARING CAPACITY OF FIBER REINFORCED CONCRETE SECTIONS UNDER FIRE EXPOSURE

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ABSTRACT

Aim of the paper is the evaluation of the bearing capacity of Fiber Reinforced Concrete (FRC) sections, without any traditional steel reinforcement, subjected to different values of the fire duration. At this purpose, bending moment (M) - axial force (N) interaction envelopes are defined, through an analytical model based on the direct integration of the hot or residual mechanical properties of the material throughout the member cross section. Finally, a parametric survey, with different geometries and FRC materials allows highlighting the worst (or better) scenarios.

Keywords: tunnel segments, fire damage, FRC segments; analytical models.

INTRODUCTION

The evaluation of behavior of Fiber Reinforced Concrete (FRC) sections under fire exposure is of paramount importance, particularly in road, railway and metro tunnels where the FRC solution (without any traditional reinforcement) is widely used. In order to evaluate the fire resistance of a FRC section, first of all the temperatures inside the element have to be evaluated, then the structural performance has to account for the degradation of the material properties (Compressive strength, Young's Modulus, post peak residual tensile strength,..) due to increase of the temperature. Finally, possible onset of spalling phenomena with a reduction of the lining thickness should be accounted for.

In the present paper analysis are made with reference to tunnel segments with different thicknesses and FRC material properties, subjected to fire on the intrados face only, (typical situation of fire in tunnels). The thermal analysis was performed by direct integration of the Fourier's equation for the transmission of the heat in non-steady conditions. The thermal properties of the material are represented by three parameters: the thermal conductivity, the specific heat and the density. Reference was made to the standard fire ISO 834 (Eurocode 1, 2004) that gives the temperature as function of the fire duration. ISO 834 fire scenario can be typically adopted in metro tunnels.

For the fiber reinforced concrete typically used in precast tunnel segments, the thermal properties of the fiber reinforced concrete can be taken as the same of the ordinary concrete (for example in agreement with Eurocode 2). On the contrary, the decay law of the FRC tensile strength is not yet codified at European level. In the paper, the suggestion provided in Italian Guidelines (CNR DT200, 2006) will be adopted.

Once known the temperature distribution in the tunnel thickness, the temperature-dependent constitutive laws of the materials are directly integrated, providing both M-N interaction

envelopes and the relationship between the bending moment and the mean curvature, for any given value of the axial load. As a matter of fact, the cross section is considered as a 'composite' cross section consisting of a number of layers (or 'subsections'). Each subsection has a constant temperature at each step of the thermal analysis and is characterized by the constitutive relationship of the concrete at that temperature.

RESULTS AND CONCLUSIONS

A typical example of the obtained results is shown in Figure 1, where the bending moment (M) - Axial Force (N) is plotted. In particular the response of a 300 mm thick tunnel segment made with a C 40 FRC 4.0 c material with siliceous aggregate concrete, and subjected to fire ISO 834 fire scenario (typical of metro tunnel) for a fire duration of 120 minutes, is shown and compared to the one related to the ambient temperature.

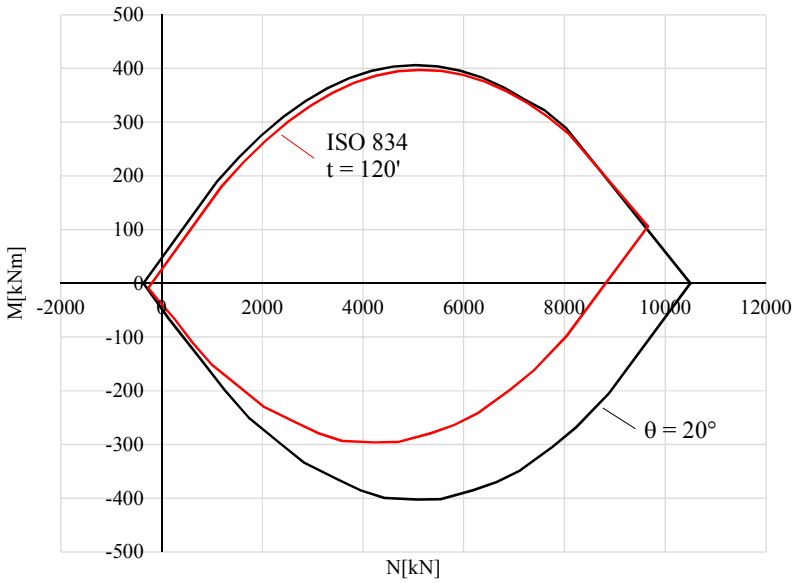

Fig. 1 - M-N Interaction Envelopes

Finally, the paper suggests a simplified procedure for the evaluation of the structural performances of FRC tunnel segments under fire. The parametric survey allows providing design suggestion for the optimization of the material properties.

REFERENCES

[1]-CNR DT 204/2006. Guidelines for the Design, Construction and Production Control of Fibre Reinforced Concrete Structures. 2006. Italian National Research Council - CNR, Rome.

[2]-EN1991-1-2 Eurocode 1: Actions on Structures. Part 1-2: General Actions - Actions on Structures Exposed to Fire. 2004. CEN, Bruxelles.

[3]-Leonardi A., Meda A., Rinaldi Z. Fire-damaged R/C Members repaired with high-performance fiber reinforced jacket. Strain. Volume 47, Issue s2. 2011. Pages: 28-35.

[4]-Di Carlo F., Meda A., Rinaldi Z. Design procedure of precast fiber reinforced concrete segments for tunnel lining construction. Structural Concrete. DOI: 10.1002/suco.201500194.