Proceedings of the 7th International Conference on Mechanics and Materials in Design,
Albufeira/Portugal 11-15 June 2017. Editors J.F. Silva Gomes and S.A. Meguid.
Publ. INEGI/FEUP (2017)

PAPER REF: 6625

CATENARY ACTION IN SINGLE STOREY INDUSTRIAL HALLS SUBJECTED TO LOCALIZED FIRES

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ABSTRACT

This paper reports on the results from extensive finite element study of single storey industrial halls subjected to the action of localized fires. The results show offer structural resistance in fire situations that are much higher than would be expected from a prescriptive approach. It has been shown that actual resistance of these structural members in fire situations can exceed their primary resistance mechanism through flexural action only. Alternative load transfer mechanism through catenary action offers the added resistance at much higher temperatures than the conventional critical temperatures from prescriptive design. The paper also presents simplified calculation procedures that can be used to reasonably predict the structural resistance at elevated temperatures considering the catenary action.

Keywords: localized fires, catenary action, fire design, fire resistence.

INTRODUCTION

The goals of structural design are fundamentally different when designing structures at normal temperature or when designing them in a fire situation. While structures are primarily designed for normal temperature situations considering the different design limit states, in the fire design situation, however, the already designed structure is assessed for its resistance in the fire design limit state. The assessment of the structure in the fire limit state may lead to either active or passive fire protection measures. The assessment of the structure in fire may be done in several different domains such as its structural resistance, integrity of structural components to prevent spread of fire and insulation properties of materials. The focus of the study presented here is on the structural resistance of single storey steel buildings in localized fire situations.

The Eurocodes permit designers to use either a simple prescriptive design procedure or a more complex performance based procedure for design of structures in fire. The prescriptive design is a simple choice regarding design of steel structures in fire due to their use of simple analytical equations; but through several studies it has been established that this approach might be conservative and in some situations it might not reflect the complexity of interaction between the heated structural members and its surrounding colder parts of the structure. The performance based approach has therefore been increasingly adopted in structural fire design, which, although more complex than the prescriptive approach, is closer to the real structural behaviour.

FINITE ELEMENTS MODEL

A three dimensional model of the single storey buildings as shown in figure 1 was created in the Finite element software ABAQUS. Steel structures in fire undergo excessive softening of the material at temperatures beyond 600°C; therefore dynamic solver ABAQUS/explicit is used, which solves for the dynamic equilibrium of the finite elements. To analyse essentially static problems such as the single storey building in fire using a dynamic solver like ABAQUS/explicit is to perform a quasi-static analysis.

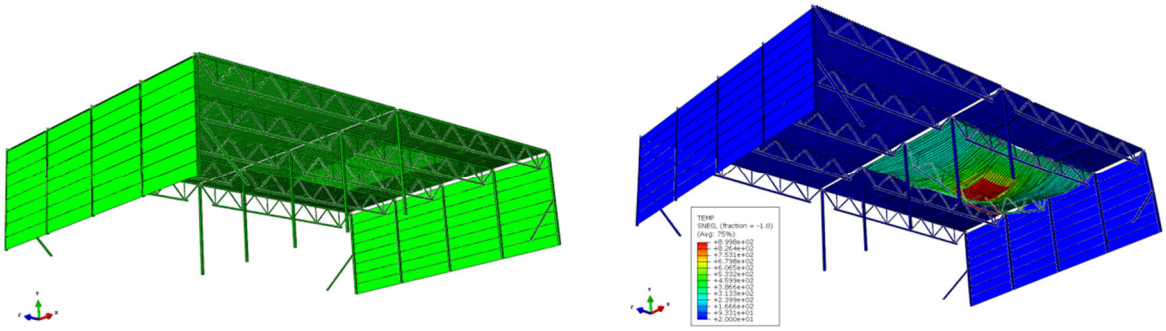

Fig. 1 - FE Model of the single storey industrial halls

HAND CALCULATION MODEL

A simplified hand calculation procedure is proposed based on the results obtained from the finite element analysis, summarized here in figure 2. The simplified calculation model presented here aims to calculate the actual resistance of the roof structure composed of steel beam and the roof sheeting together, when subjected to localized fire at midspan location. The additional resistance, as is proposed here, comes through the catenary action.

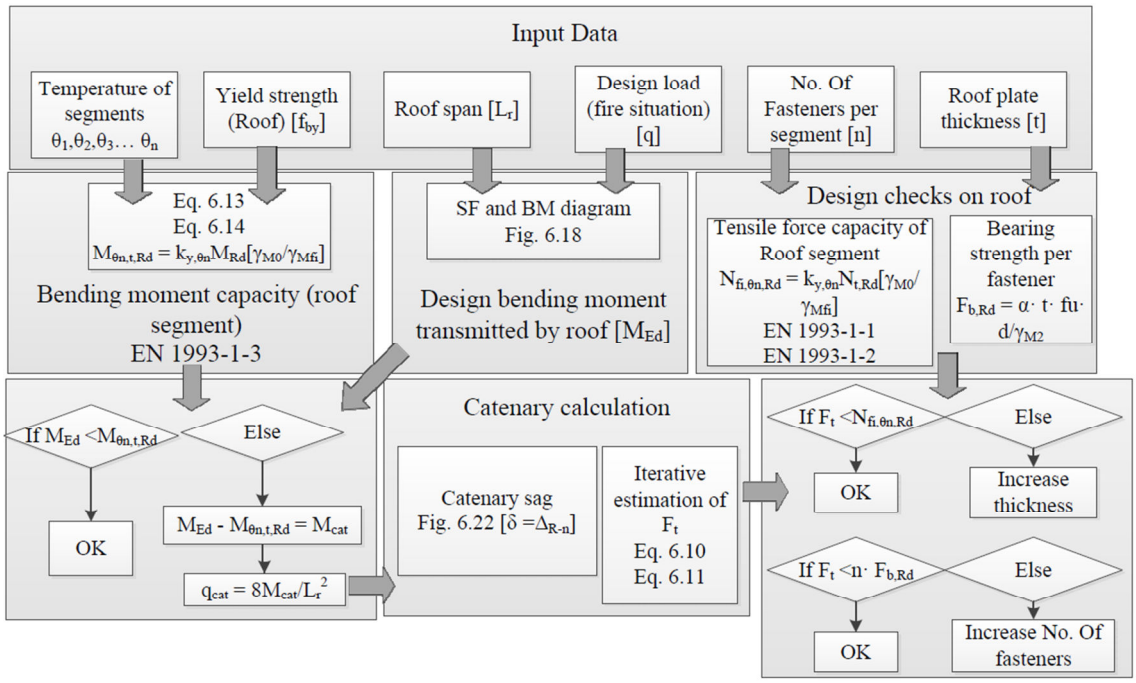

Fig. 2 - Scheme of calculation of the resistance of the roof structure due to catenary action