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Fire safety assessment of floors with the steel joists hidden within the slab thickness. the influence of initial assumptions and fire scenario adopted on the discrepancies in final outcomes

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Abstract

The purpose of this paper is to present procedures and methods for assessing fire resistance of steel-beam floors with the joists hidden within the thickness of the slab. These technologies, popular many years ago, are currently experiencing their renaissance, both in contemporarily designed buildings and the existing ones, subjected to comprehensive redevelopment, refurbishment or modernization. Due to their simplicity and ease of execution, these floors are just perfect as technology ideal for repairs or alterations of buildings under use or in the case of need of complete replacement of existing floors with new ones resulting e.g. from the change in use and function of the building, resizing of loads or degradation of existing structural members in historic buildings. These arguments justify the need to raise the subject of proper safety assessment of these floors in relation to the regulations and requirements of laws applicable in the European Union and pursuant to provisions of the latest codes for structural design. The author proposes to use procedures taken from Eurocode 3, Parts 1-2, to determine the fire resistance of this type of floors, while pointing out to the problem of significant discrepancies in final results, depending on the chosen path/variant of procedure and assumptions made. The results of computational example presented in the study shows that contrary to a popular belief, the use of standard fire model does not always lead to conservative estimates. This shows the need for a special insight when evaluating fire conditions and the necessity to treat each design case on an individual basis and with considerable attention. In the article summary, the author formulates a number of practical applications and conclusions.

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1. Introduction

New trends in the structural design and requirements arising from the content of legislation require participants in the construction process to face a difficult task of ensuring that the building and its systems are designed taking into account the danger of fire actions and that in the event of fire, the so-called basic requirements are satisfied, one of which concerns an appropriate structural resistance for a period of time specified in the technical and building regulations. This paper has been developed in response to the needs of the building industry including the procedure for the assessment of fire safety of steel-beam floors in relation to the said renaissance and the growing popularity of this type of solutions - used equally in the newly designed projects as well as for the purpose of reconstruction, renovation or modernization of existing buildings.

2. Construction methods and materials used in steel-beam floors

The most popular commercially available solutions that belong to this group of floors primarily include: ceramic steel-beam floors (known also under the name of Klein type), segmental brick vaults or floors filled with prefabricated reinforced concrete slabs especially popular in the countries of Central and Eastern Europe. This group may also include cast-in-situ reinforced concrete slab, although this type of technology was the most widely used as part of the so called "home-made" solutions, usually in the farm buildings erected independently. Although in practice floors with brick floor slab were constructed by about the end of the 50s of the last century, the technology using prefabricated concrete slabs was widely used in this part of Europe practically to the end of the period of political transformation and liquidation of state-owned concrete casting plants. In fact, ceramic steel-beam floors were used successfully, especially in rural areas and small towns, even to the end of the 80s of the twentieth century, and the floors filled with precast reinforced concrete, albeit at a smaller scale, have been successfully built to date. The group of buildings in which brick ceilings on steel beams are used is still very large.

In recent years, after a short period of a couple of years of oblivion, technology of floors on steel beams, apparently considered as archaic in the industry, began to live its renaissance. Many architectural firms currently use steel-beam floors in their designs. Due to their technological simplicity, these types of floors are very often designed and constructed today for the needs of reconstruction, repair, modernization or replacement of wooden floors that have lost their structural integrity - either due to natural degradation or, for instance, as a result of a fire. It is a technology that is just perfectly tailor-made for this purpose.

All these arguments justify the need for discussing issues of fire safety assessment of steel-beam floors and dedicating this paper to them.

3. Safety of building structures in case of fire in the context of the UE design codes and standards

As provided for in the preamble to the set of the latest European codes on structural design:

"The Member States of the EU and EFTA recognize that Eurocodes serve as reference documents for the following purposes: – as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 (Mechanical resistance and stability), and Essential Requirement N°2 (Safety in case of fire); – as a basis for specifying contracts for construction works and related engineering services; – as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs)".

The most important of them, used in assessing the fire safety of steel structures, are the following codes: *EN 1990* [4], *EN 1991-1-2* [1] and *EN 1993-1-2* [2].

The code *EN 1990* [4], defining basic principles of design and key requirements for ensuring the safety, operation and durability of the structure, performs a superior function in the whole set and its provisions must be respected in other parts of the set of codes. The principles stated therein are based on the concept of limit states, using in the