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Fire resistance of the ceiling in the old tenement house

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Abstract

This paper presents practical, engineering algorithm which may be used to analyse fire resistance of the Klein's ceiling after its renovation. This type of ceiling consists of bricks and steel beams for which the fire resistance may be obtained using the standard ISO curve and Eurocodes. The authors of this article show also the example in which the problem with fire resistance of Klein's floor is solved.

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Keywords: fire design, steel structures; Klein's ceiling, old ceiling

1. Introduction

Brick ceilings with steel beams were building by the end of the 19th century [1]. Designers often prepare building regeneration, renovations or reinforcement projects, in which they may encounter the problem with the fire resistance of vaulted brick ceilings (segment floors) or Klein's ceilings (Klein's floor) [2]. The vaulted brick ceilings consisted of steel I-beams and bricks whereas Klein's ceiling had steel flat bars yet [3]. The examples of cross sections of these ceilings are presented in Figure 1. The vaulted brick ceiling with steel beams in the fire situation was analysed in article [4]. The fire resistance time of steel beams from this ceiling was only 28.7 minutes, whereas the author of the paper [5] presented that fire resistance time of the brick ceiling with steel beams was 60.0 minutes. Moreover, when the flange of the I – section beam was protected by 2 cm layer of fire protection material, the fire

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resistance time was 120.0 minutes. The difference could be connected with methods of analysis. In the first paper, the steel beam was analysed without the cooperation with the brick ceiling whereas in the second paper the whole ceiling was analysed.

In this paper, fire resistance of Klein's ceiling in the old tenement house was analysed. This type of ceiling was also analysed in article [6], where the not protected steel beam had only 20 minutes fire resistance time. It allowed for the classification of the beam as R15. The authors of this article used the standard ISO curve and Eurocodes [7, 8] to obtain the fire resistance time not before the renovation of the floor but after it, what is a new concept. The authors of article [9] presented that standard [8] used in this paper gave only a simplified methodology for evaluation of real safety level of steel members during fire and they proposed in this field a new approach, based on the probabilistic concept, which seems to be more adequate. Moreover, test presented in paper [10] showed the conservatism of the Eurocode fire design. However, the authors of this paper did not use natural fire models, because in Poland the existing regulations provided for the use of the standard ISO curve to verify the fire resistance of structural elements [11]. However, there were a lot of papers about behaviour of structures under natural fire like the article [12] where mechanical response under natural fire of the barrel shape shell structure was analysed or [13] where the steel beam from the existing building was subjected to fire of a city bus. In this paper, authors focused on the steel beam from the brick ceiling which was laterally restrained. Thanks to it, the critical temperature of the beam could be obtained using the degree of utilization of the beam instead of the iterative method used in [14]. The fire resistance time could be obtained using very useful tables from [15].

2. Evaluation of the fire resistance of the Klein's ceiling after its renovation

The fire resistance of old steel-beam floor (see Fig. 2) should be obtained in few stages presented in Figure 1.

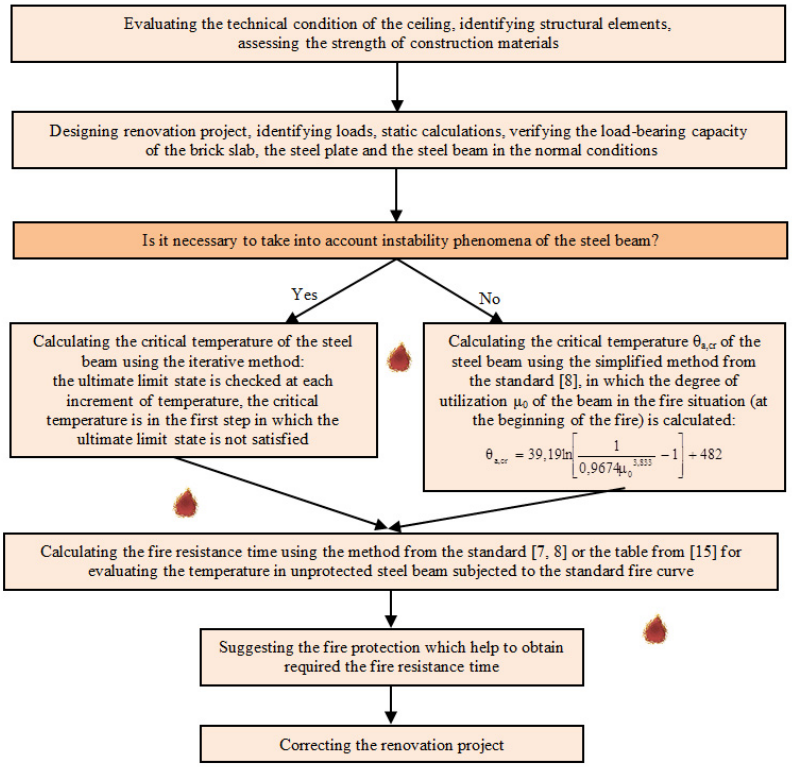

Fig. 1. Algorithm for determining the fire resistance of old steel-beam floor