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# Fire Resistance of Unprotected Steel Beams – Comparison between Fire Tests and Calculation Models

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**Abstract**

The paper presents results of fire resistance test of unprotected steel beams, compared with simple and advanced calculation models given in EN 1993-1-2. The comparison shows differences between temperatures recorded during tests, temperatures calculated in accordance with EN 1993-1-2 and temperatures calculated in FEM analysis. The resulting loadbearing capacity in fire situation and criteria used for its assessment in each method is also being discussed.


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*Keywords:* fire resistance, steel structures, steel beams, fire tests, simple calculation model, advanced calculation model.

## 1. Introduction

Methods for assessing the fire resistance of steel structures are among best reported in the literature and they are generally focused on analytical methods. Simplified calculation model given in EN 1993-1-1 [1] and EN 1993-1-2 [2] is easy to use and give a good estimate of the actual fire resistance. This is done either by comparing temperature of the element with its critical temperature or by direct calculations of element's loadbearing capacity in fire.

At the same time, fire resistance tests are still often used to assess the fire resistance, applying the criteria of maximum allowed deflection and rate of deflection. Comparison of both methods, with addition of advanced FEM analysis, shows that all these models are suitable for fire resistance assessment.

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## 2. Test procedure

Fire tests described further in this paper, where conducted in November 2014 in the Fire Testing Laboratory of Building Research Institute (ITB) as a part of the EGOLF (European Group of Organisations for Fire Testing, Inspection and Certification) round robin comparative studies. The same tests were performed in 16 participating fire testing laboratories.

Tests were performed on two identical HEB 300 hot rolled steel beams made of carbon steel of grade S355, reinforced by 8 welded stiffeners, in accordance with EN 1365-3 [3]. The real elastic limit has been determined by tensile tests at an average value of 448 MPa. The stiffeners were provided at the supports and at the load application points on both sides of the web. Aerated concrete blocks were placed on the upper flange of the beam, as required in EN 1365-3 [3] in order to simulate the floor and provide three-sided heating.

Total length of each beam was $L_{spec}$ = 4400 mm, with span between supports $L_{sup}$ = 4200 mm and length subjected to heating $L_{exp}$ = 4000 mm, see Fig. 1.

The load was applied with two hydraulic jacks, spaced 140 cm, each applying force $P$ = 100 kN.

No fire protection material was used to insulate the beams from the heating.

Tests were performed under standard fire heating conditions described in EN 1363-1 [4] and using the limiting value of deflection $D_{lim}$ = 147 mm, expressed as (1) and rate of deflection $dD/dt_{lim}$ = 6,53 mm/min, expressed as (2), where $L$ is the clear span of the test specimen, in millimeters and $d$ is the distance from the extreme fibre of the cold design compression zone to the extreme fibre of the cold design tension zone of the structural section, in millimeters, for assessing the fire loadbearing capacity of beams.

View of the tests specimens, prior to and after the test, are given in Fig. 2.

$$D_{\lim} = \frac{L^2}{400d} \text{ mm} \tag{1}$$

$$dD/dt_{\lim} = \frac{L^2}{9000d} \text{ mm/min} \tag{2}$$

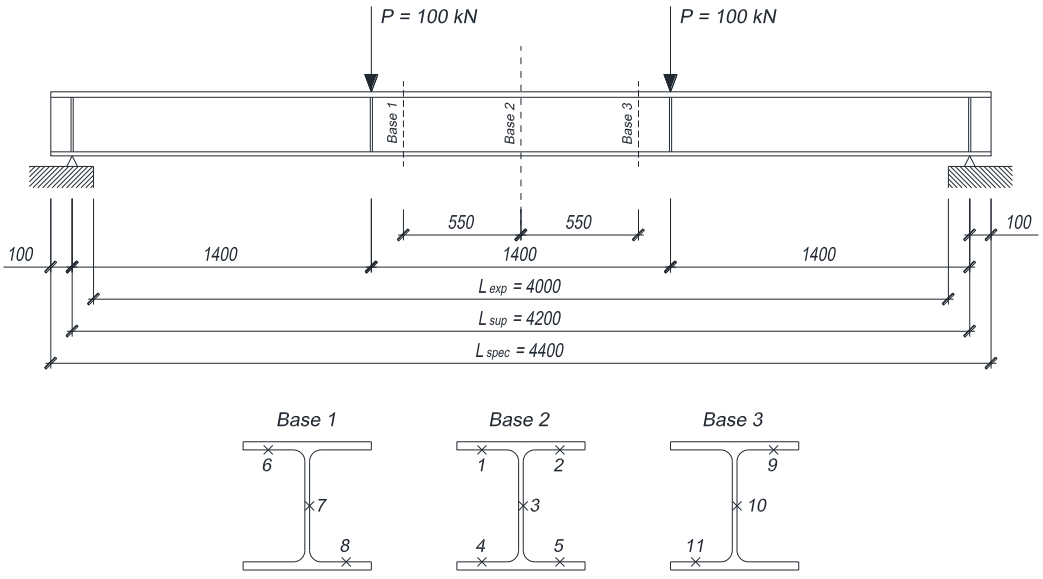


Fig. 1. Test specimen design and thermocouples locations.