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Fire resistance of timber stud walls

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Abstract: This paper deals with fire resistance tests of timber stud walls as a loadbearing elements according to EN 1365-1 [7] standard. The paper present a details of fire resistance tests procedure as well as examples of test results from conducted fire resistance tests of loadbearing timber walls.

Keywords: fire resistance, fire resistance tests, timber stud wall, timber

1. INTRODUCTION

Wood is a material commonly used in timber frame construction with a timber studs as loadbearing elements and wood-based panels, for example OSB, as cladding. The load-carrying capacity of the construction can be defined by calculation under normal condition pursuant to the standard EN 1995-1-1 [2] and under fire conditions according to the standard EN 1995-1-2 [3] and in [8] as well.

Standard EN 1995-1-2 [3] is a very useful tool in the design of timber stud walls but the methods for determining fire resistance are useful only in the design of typical construction. For non-standard solutions or walls for example with PIR core, or claddings other than timber or wood-based panels or gypsum plasterboards type A, H or F, fire resistance tests may be necessary. The case was widely described by authors in the article [9] (on the previous conference).

The fire resistance is related with the following criteria: R (loadbearing capacity), E (integrity) and I (insulation). This basic terms connected with fire resistance are defined in the standard EN 13501-2 [4] and articles [9, 10, 11].

Requirements defined in the regulation [1] for fire resistance of walls depending on the fire resistance class of the building are presented in Table 1.

In practice, timber framing construction are low (up to 12 m or 4 storeys) and the most stringent building fire class is B [9].

Table 1. Requirements for fire resistance of building's elements based on the Regulation [1]

Building's fire class	Fire resistance class of wall elements		
	Main loadbearing construction	External wall[1)]	Internal wall
"A"	R 240	EI 120 (o↔i)	EI 60
"B"	R 120	EI 60 (o↔i)	EI 30
"C"	R 60	EI 30 (o↔i)	EI 15
"D"	R 30	EI 30 (o↔i)	(–)
"E"	(–)	(–)	(–)

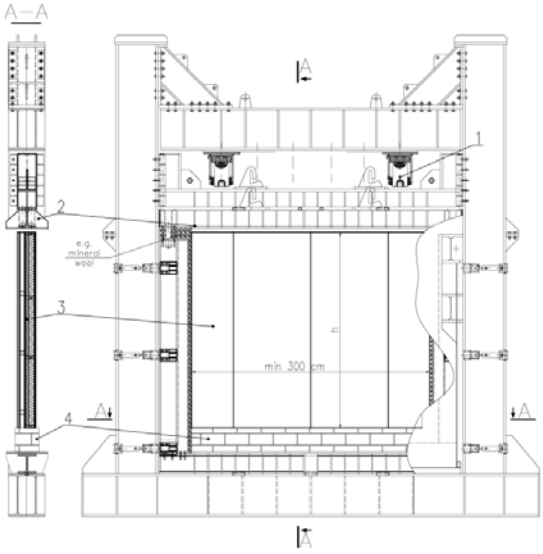
1) if the wall forms part of the main loadbearing construction, it should also meet the criteria for fire loadbearing capacity (R)

2. FIRE RESISTANCE TESTS

2.1. Test equipment and test conditions

Equipment and conditions for tests of loadbearing elements are given in the standard EN 1363-1 [5] and EN 1363-2 [6] whereas the standard EN 1365-1 [7] defines requirements.

A test frame should be designed in such a way as to accommodate the test specimen and apply the required test load. The load to the test specimen may be applied either axially or eccentrically by means of loading jacks located at the top or at the bottom of the frame (more common are jacks located at the top). An example of test frame with installed test specimen used in Fire Research Laboratory of ITB is shown in Figures 1.



Legend
1 – loading jacks
2 – rigid steel beam
3 – test specimen
4 – supporting construction

Fig. 1 Test frame with test specimen

If fire is expected from exterior side of the build/wall (case for external wall), to maintain a proper temperature inside a furnace an external fire exposure curve (according to equation 1) or a standard temperature/time curve (according to equation 2) should be used during fire resistance test. The standard temperature/time curve should be used to verify a fire resistance of an internal wall.

$$T = 660 \cdot [1 - 0{,}687 \cdot \exp(-0{,}32 \cdot t) - 0{,}313 \cdot \exp(-3{,}8 \cdot t)] + 20 \quad (1)$$

$$T = 345 \cdot \log(8 \cdot t + 1) + 20 \quad (2)$$

where:
"T" is the mean furnace temperature in degrees Celsius;
"t" is the time from the start of the test in minutes.

The fire scenarios (curves) are shown in figure 1.

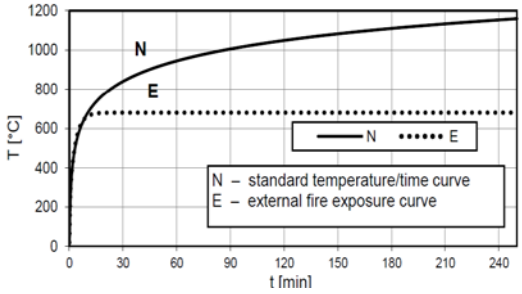


Fig. 2 Fire scenarios

2.2. Test specimen and test installation

Test specimens examined during fire resistance tests should have minimum dimensions of 3 x 3 m with two vertical edges unrestrained and with a gap of 25-50 mm (called as free edges). In addition, as far as a horizontal edge is concerned a specimen of stud wall used during the test should be exactly as the one intended to use, i.e. double fixed or with only one horizontal edge hinged.

In practice, if the height or width of the test specimen (loadbearing stud wall) is 3 m or smaller, then the test specimen should be tested at its full size. Moreover, the loadbearing stud wall should be fully representative of the construction intended for use in practice.

Furthermore, the moisture content of timber elements has an influence when the tested wall is exposed to fire conditions. High moisture contents can lead to the development of stream pockets which may cause delamination of timber. For this reason timber used for fire resistance tests should have moisture:

- 9% to 12 % for structural loadbearing and non-loadbearing timber where the timber will be exposed or partially exposed to a heated or unheated internal environment,
- 14% to 18% for all other applications, including structural loadbearing and non-loadbearing timber where the timber will be insulated from the ambient internal conditions of the building.

The results of the fire test are directly applicable to similar constructions. The standard [7] allows for the following changes:

- decrease in height of the wall,
- increase in the thickness of the wall,
- increase in the thickness of component materials,
- decrease in linear dimensions of boards or dimensions of panels of but not thickness,
- decrease in stud spacing,
- decrease in distance of fixing centres,
- increase in the number of horizontal joints when tested with one joint not more than 500 ± 150 mm from the top edge,
- decrease in the applied load,
- increase in the width provided that the specimen was tested at full width or 3 m wide, whichever is the larger.

2.3. Tests results

The results of fire resistance tests of loadbearing timber stud walls depends on various factors. The most important are:

- utilization level of load-carrying capacity – the most important element with this type of structures are timber studs,
- stiffness studs which is related to their cross-section, the size and spacing of used stiffeners,
- type of connections,
- height of the wall,
- the type of cladding, the number of layers, their thickness and method of attachment,
- type of core material.

Walls with loadbearing timber studs obtain fire resistance classes REI 30 or REI 60 with no difficulty and, when additionally protected, even REI 120. Obviously, the higher fire resistance class expected, the more massive a construction is which usually is connected with further costs.

The comparison of average temperature rise on unexposed surface of tested specimens – loadbearing timber stud walls with one-layer and two-layers of cladding (kind of panel not mention in the standard EN 1995-1-2 [3]) is shown in Figure 3. Timber studs with dimension of 150 x 80 mm and EPS core with width 150 mm were used on both tests.

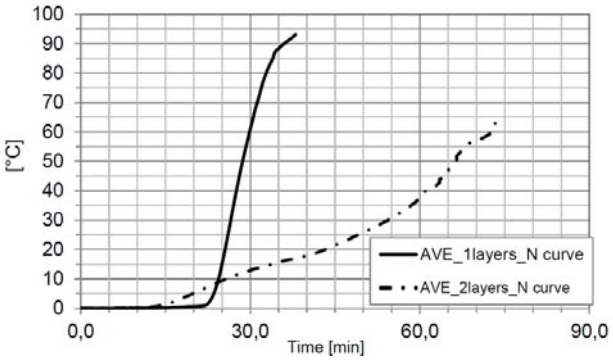


Fig. 3 Graph of temperature rises on unexposed surface of tested specimens - temperature measurements for average and maximum temperature

3. SUMMARY

In case we are not able to define fire resistance of walls with loadbearing timber studs by calculation based on the standard EN 1995-1-2 [3], implementation of fire resistance test based on EN 1265-1 [7] allow to qualify a fire resistance class precisely.

The standard EN 1995-1-2 [3] does not specify equations to define a fire resistance neither using external fire exposure curve (Fig. 2) nor in case a core with polyisocyanurate foam or EPS panels is applied.

The standard EN 1365-1 [7] is the only obligatory in Poland standard which allow to define a fire resistance of loadbearing walls. This standard [7] is mentioned in classification standard 13501-2 [4] by which fire resistance classes are given.

4. REFERENCE

1. Rozporządzenie Ministra Infrastruktury z dnia 12 kwietnia 2002 r. w sprawie warunków technicznych jakim powinny odpowiadać budynki i ich usytuowanie (Dz. Ust. Nr 75 poz. 690).
2. EN 1995-1-1:2004+AC:2006+A1:2008. Eurocode 5 – Design of timber structures Part 1-1: General – Common rules and rules for building
3. EN 1995-1-2:2004+AC:2006. Eurocode 5 – Design of timber structures Part 1-2: General – Structural fire design
4. EN 13501-2:2007+A1. Fire classification of construction products and building elements – Part 2: Classification using data from fire resistance tests, excluding ventilation services excluding ventilation services
5. EN 1363-1:2012 Fire resistance tests – Part 1: General Requirements
6. EN 1363-2:2001 Fire resistance tests – Part 2: Alternative and additional procedure
7. EN 1365-1: 2012. Fire resistance tests for loadbearing elements – Part 1: Walls.
8. Woźniak G., Roszkowski P., Projektowanie konstrukcji drewnianych z uwagi na warunki pożarowe według eurokodu 5, Warszawa 2014 r.
9. Roszkowski P., Sulik P. Wooden stud walls – problems with regard to structural fire design according to PN-EN 1995-1-2., Annals of Warsaw University of Life Sciences - SGGW Forestry and Wood Technology, 2014, nr 87, s. 181-185.
10. Sulik P., Odporność ogniowa konstrukcji drewnianych, „Ochrona Przeciwpożarowa" 2007, nr 4/07, s. 12-13.
11. Sulik P., Odporność ogniowa konstrukcji drewnianych, „Ochrona Przeciwpożarowa" 2008, nr 1/08, s. 2-5.

Streszczenie: *Odporność ogniowa drewnianych ścian szkieletowych*. W niniejszym artykule opisana została metoda badań odporności ogniowej drewnianych nośnych ścian szkieletowych, badanych według normy EN 1365-1 [7]. W artykule opisano procedurę badawczą jak również zaprezentowano przykład wyników z badań drewnianych nośnych ścian szkieletowych.