

## Wooden stud walls – problems with regard to structural fire design according to PN-EN 1995-1-2

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**Abstract:** This paper deals with problems or, more precisely, ambiguities and constraints faced when determining the fire resistance of wooden stud walls according to PN-EN 1995-1-2. The standard is a good tool for the design of typical wall arrangements. For more complex or unusual arrangements, fire resistance tests are necessary.

**Keywords:** fire resistance, fire load-bearing capacity, wooden stud walls, fire resistance tests

### 1. INTRODUCTION

Platform framing is the most common method of construction for small family buildings, which can be seen on a large scale in Canada, the United States of America and in Scandinavia. For some time now, this type of technology has been increasingly used in the Polish construction industry, not only in single-family housing, but also in multi-family and commercial buildings such as supermarkets, warehouses, etc.

While referring to wooden stud walls design according to PN-EN 1995-1-2 [3], we mean design by fire resistance requirements, which are closely related to fire resistance criteria. For standard fire, walls should meet the combination of the following criteria: R (loadbearing capacity), E (integrity) and I (insulation). Most available publications on the design of wooden structures in the event of fire ([12], [13] and [14]) do not consider in detail issues related to framing walls design.

### 2. FIRE RESISTANCE REQUIREMENTS

The Polish legal document that sets the requirements for fire resistance is the Regulation of the Minister of Infrastructure of 12 April 2002 on the technical conditions to be met by buildings and their location (Journal of Laws No 75, item 690) [1]. According to §216 of the Regulation [1], internal (non-load bearing) walls should meet the requirements of fire resistance classes between EI 15 and EI 60, and external (curtain) wall classes should range from EI 30 (o↔i) to EI 120 (o↔i). If external walls are also the main loadbearing structure, parameter R is required as well and the classification period is twice as high. Requirements for fire resistance of walls depending on the fire resistance class of the building are presented in Table 1.

In practice, wooden framing structures are low (up to 12 m or 4 storeys) and the most stringent building fire class is B.

**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 <sup>1)</sup>	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)			

### 3. PROBLEMS/AMBIGUITIES/CONSTRAINTS IN FIRE DESIGN

When analysing the separating function of walls (criteria of integrity and insulation), please note that the rules specified in PN-EN 1995-1-2 [3] relate to a fire resistance period not exceeding 60 minutes. The standard [3] does not provide any calculation rules for stud walls with fire resistance of REI 90, EI 90 (o↔i), EI 90 or higher classes. These rules are needed in the analysis of fire resistance of stud walls which act as external walls and/or are the main loadbearing contraction.

Another limitation in the design process may be the selection of the wall core material. The standard [3] defines the following solutions:

- core of rock fibre,
- core of glass fibre,
- void cavities.

This standard [3] does not provide answer to the situation when the spaces between loadbearing elements are filled with combustible thermal insulation in the form of increasingly popular expanded polystyrene boards or polyurethane foam (PUR or PIR).

In addition, some inaccuracies regarding the failure time of plasterboards are seen in the standard [3], while determining the fire resistance of stud walls with void cavities and clad with gypsum plasterboard. Although Annex D of the standard [3] relates to charring of elements in wall and floor sets assemblies, the failure time  $t_f$  of the cladding is described only for floor arrangements. There is no additional reference to wall arrangements. Is the formula for the failure time of claddings in wall elements the same? We are not sure of this.

The standard [3] also limits the designer in selecting the number of layers and types of claddings forming the wall plane, which make up the fire resistant cover of wooden elements. The number of these is limited to two. However, the standard [3] defines several types of cladding materials:

- claddings of wood or wood-based materials,
- claddings gypsum plasterboard type of A, H or F.

Our practise shows that this number and types of cladding materials is sometimes insufficient in some cases. There are more and more new facilities in Poland where, for example, magnesium oxide boards (MgO) are used.

It happens that due to different requirements for surface finish in rooms, the designer may need to use other cladding layers on both sides of the wall. For a wall with two layers of cladding it is impossible to perform the analysis of separating function for an asymmetrical system, for example with a different number of layers on both sides or made up of the same number of layers but different materials. This problem can be encountered when determining the coefficient needed to calculate the value of wall insulation – position coefficient  $k_{pos}$  from Table E5 [3].

When encountering one of the above-mentioned problems, the following solutions can be applied:

- using advanced calculation methods, which are described in very vague terms; to prove the correctness of the calculating assumptions made can be very burdensome or even impossible;
- estimating the results based on simplified methods available, bearing in mind that responsibility for such actions is to be taken by the designer; as with advanced calculation methods, the validity of the assumptions made is difficult to confirm.
- performing fire resistance tests.

#### 4. FIRE RESISTANCE TESTS

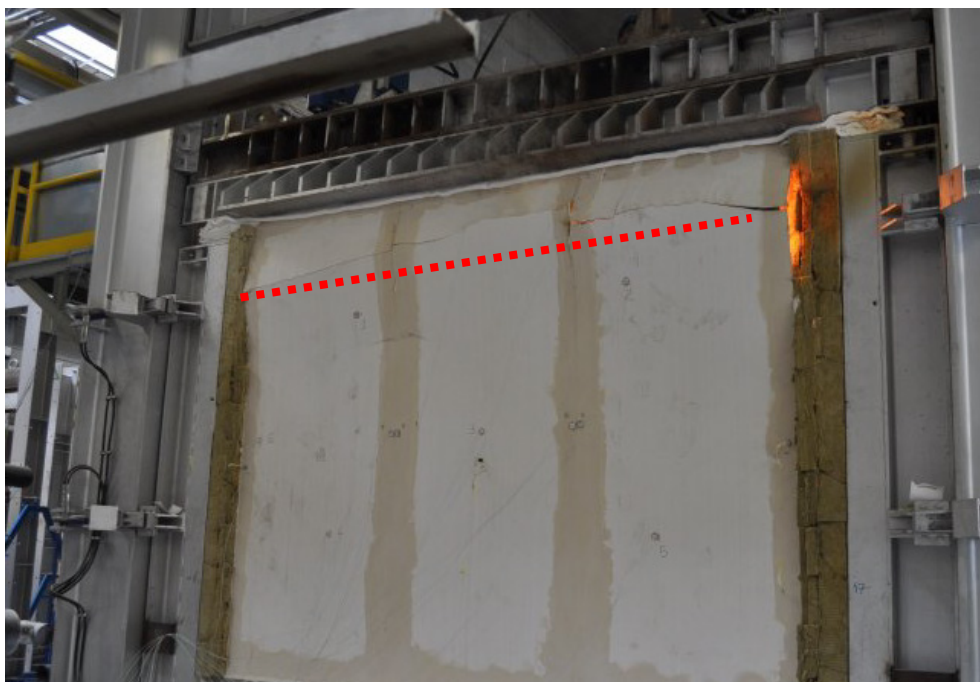
The safest and most reliable solution in the cases where the standard [3] does not provide rules of procedure is to perform fire resistance tests in accordance with methods described in detail. To verify the fire resistance of a wall or determine the effectiveness of fire resistant properties of cladding materials, testing may be carried out according to one of the following methods:

- PN-EN 1364-1 [6],
- PN-EN 2364-3 [7],
- PN-EN 1365-1 [8],
- PN-ENV 13381-7 [9].

The selection of a given method lies with the entity which orders the testing and depends on the expected scope of wall application. Fire resistance tests are carried out mainly by:

- manufacturers of wall claddings,
- manufacturers of insulation materials,
- manufacturers of load-bearing wood-based elements,
- system providers of the aforementioned components.

Persons/companies ordering the tests and intending to determine the fire resistance of loadbearing walls shall declare, among other things, the loads and utilization factor. The calculations of wooden loadbearing parts are best performed in accordance with standard PN-EN 1995-1-1 [2], [11]. Incorrect calculations of load capacities or an attempt to verify the fire resistance for too big loads for fire tests according to PN-EN 1365-1 [8] may result in the loss of load-capacity of the wall before the expected time. This type of situation can be seen in Photo 1 and 2, where the main loadbearing elements in the form of wooden studs were crushed/sheared before the expected period of fire resistance.



**Photo 1** Loadbearing wall after achieved the criterion of loadbearing capacity (R) – red dotted line marks the failure spot of the wall test specimen



**Photo 2** Loadbearing wall after achieved the criterion of loadbearing capacity (R)

## 5. SUMMARY

Standard PN-EN 1995-1-2 [3] is a very useful tool in the design of wooden stud walls. Simplified methods for determining fire resistance are extremely useful in the design of typical framing walls. For non-standard solutions or walls with cores other than rock or glass fibre, or claddings other than wood or wood-based panels or gypsum plasterboards type A, H or F, fire resistance tests may be necessary. Please note that great care needs to be taken with the design of an element for fire resistance tests; however, verification using fire tests can bring immense benefits in the form of higher classes of fire resistance.

## 6. REFERENCE

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**Streszczenie:** *drewniane ściany szkieletowe – problemy przy projektowaniu na warunki pożarowe wg PN-EN 1995-1-2.* Artykuł dotyczy problemów a właściwie niejasności, ograniczeń, przed jakimi stają osoby określające odporność ogniową ścian drewnianych o konstrukcji szkieletowej wg normy PN-EN 1995-1-2. Norma jest dobrym narzędziem przy projektowaniu typowych układów ściennych. W przypadku bardziej skomplikowanych lub nietypowych układów niezbędne są badania w zakresie odporności ogniowej.

*Słowa kluczowe:* odporność ogniowa, nośność ogniowa, ściany szkieletowe, badania w zakresie odporności ogniowej