21st International Conference Man and Working Environment
SEMSIE
Safety Engineering & Management – Science, Industry, Education

PROFESSIONAL PAPER

DOI: 10.46793/SEMSIE25.205S

NELI SIMEONOVA[1]

[1]Academy of the Ministry of Interior, Faculty of Fire Safety and Civil Protection, Bulgaria

[1]neli_sim@abv.bg

ESSENTIAL CHARACTERISTICS OF WALLS WITH FIRE PERFORMANCE

Abstract: *The report analyses the requirements for walls with fire performance, viewed through the prism of Regulation No. Iz-1971 on the Construction and Technical Rules and Norms for Fire Safety in the Republic of Bulgaria. It provides detailed information regarding the classification of fire resistance and reaction to fire. Lightweight partition structures and the determination of their maximum permissible construction height are thoroughly discussed. The relationship between fire resistance classification and factors such as load-bearing capacity, space layout, intended use, and wall material is discussed.*

Keywords: fire performance of walls, fire resistance of walls, reaction to fire of walls, maximum height of walls

ORCID iDs: Neli Simeonova N/A

INTRODUCTION

Walls with fire characteristics are the main passive measures, as specified in Ordinance No. Iz-1971 of 29.10.2009 on building-technical rules and norms to ensure safety in case of fire, and applied in the construction of buildings in the Republic of Bulgaria (Ordinance No. Iz-1971 of 29.10.2009 on building-technical rules and regulations for ensuring fire safety, OJ No. 96 of 4 December 2009, as subsequently amended and supplemented, OJ No. 91 of 29.10.2024). The correct definition of the performance of their necessary characteristics, the incorporation of assessed constructions, and building according to the requirements are crucial for fulfilling the objectives of all regulations aimed at ensuring safety in case of fire.

The essential characteristics of the walls for which there are requirements in the regulations are:

1) resistance to fire
2) reaction to fire
3) permissible wall height (lightweight partitions).

FIRE RESISTANCE CLASSES

For walls, the main criteria of fire resistance are R (load-bearing capacity), E (Integrity) and I (insulation). Walls can be analysed in terms of whether they are load-bearing or non-load-bearing, their spatial arrangement, their fire safety purpose (obstacles in the path of fire spread), and the material of which they are constructed.
The relationship of these factors to their fire resistance can be explained in the following way:

Classification of walls according to load-bearing capacity

Depending on the load-bearing capacity determined by the designer of the structural part, the wall may be:

- load-bearing - wall designed to carry the applied load (EN 1365-1 Fire resistance tests for loadbearing elements - Part 1: Walls, 2013). The fire resistance class is indicated by all three criteria R (load-bearing capacity), E (Integrity) and I (insulation) - REI;
- non-load-bearing - this is a wall which, except for supporting its own weight, is not designed to carry any additional load (EN 1364-1 Fire resistance tests for non-loadbearing elements - Part 1: Walls, 2015). The fire resistance class is indicated by criteria E (Integrity) and I (insulation) - EI.

Classification of walls depending on location

Depending on its space location, walls can be:

- internal - located inside the building. These walls can be either load-bearing (REI) or non-load-bearing (EI);
- external - a wall forming the external envelope of a building (EN 1364-1 Fire resistance tests for non-loadbearing elements - Part 1: Walls, 2015). In some cases, it may also be the curtain walling of a building which provides, by itself or together with the building structure, all the normal functions of an external wall but without having any load-bearing characteristics within the building (EN 13830:2015+A1:2020 Curtain walling - Product standard, 2020). In Regulation No. Iz-1971, note 5 to Tab. 3, there is an assumption that for external load-bearing walls, instead of the class REI, the REW criteria could be defined with the classes defined in columns 3 and 4 of Table 3 of the same Regulation. An element that meets the thermal insulation criterion I is also considered to meet the W requirement for the same period (EN 13501-2 Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance and/or smoke control tests, excluding ventilation services, 2023).

Classification of walls depending on the purpose for fire safety

Depending on the purpose of fire safety (barriers in the way of fire spread), the following types of walls are defined:

- walls to separate fire sectors - REI (EI) 120;
- brandmauern - REI (EI) 120;
- fire protection walls - REI (EI) 60;
- walls of fire protection vestibules - REI (EI) 60;
- walls to separate safe areas - REI (EI) 120;
- general purpose external walls (Table 3) - REI (EI);
- general purpose internal walls (Table 3) - REI (EI) and etc.

Types of walls according to the materials used

Based on the material used for wall construction, the following main types are used:

- reinforced concrete;
- brick (silicate, ordinary and hollow baked bricks, aerated concrete);
- sandwich panels;
- wooden;
- lightweight partitions;
- glass;
- mixed type.

However, the material from which they are made is only relevant to the characteristic Class of reaction to fire.

For a structural element to be defined as a wall (partition), it must necessarily enclose a space. If it is not adjacent to the structures enclosing it, it should not be considered as a wall, as it can fulfil neither a load-bearing, partitioning, nor an insulating function.

In the construction of the Republic of Bulgaria, only walls with fire resistance on both sides are allowed (Article 9, paragraph 6 of Ordinance No. Iz-1971) (see Figure 1).

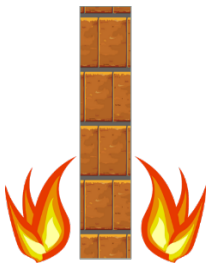

Figure 1. *Two-sided fire impact on the walls*

The fire resistance of the walls, according to Article 10, paragraph 2 of Ordinance No. Iz-1971, can be determined in the following three ways:

- tests (results of tests actually carried out);
- calculations (the norms and methods for design and calculation from the system of standards "Structural Eurocodes", introduced as EN 1990 (EN 1990 Eurocode - Basis of structural design, 2003)
- comparisons (Annex 5 of the same Regulation).

All three methods are applicable to walls with fire characteristics.

REACTION TO FIRE CLASS

Determining the reaction to fire class of walls, for example, concrete and brick, is easy, but for multi-component structures, it is a more complex process. These are sandwich panels and lightweight walls. The basic rule is that the reaction to fire class (RtF) is determined by taking into account the worst RtF of the main materials incorporated in the wall profiles, wood, wool, etc. The determination of the RtF of the materials of which the walls are constructed can be made in the following two ways:

- tests (results of tests actually carried out);
- comparisons (Annex No. 6 of Ordinance No. Iz-1971
- construction products for which testing is not required).

It is important to note that the material used to construct the walls has only RtF and no fire resistance rating. Fire resistance is only a characteristic of the partition element itself, and not of the materials used to build it.

An example of a wall constructed of timber and a wall constructed of gypsum board is given in Figure 2:

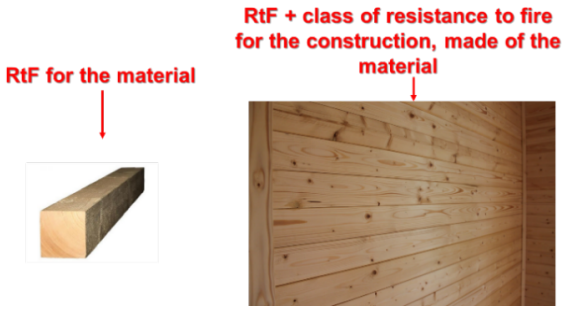

Figure 2. *RtF and fire resistance class of walls*

The only exception to this rule is for walls constructed of glazed (glass) elements.

Harmonised product standards exist for almost all types of glass and glazing units. Two of the essential characteristics included in these standards (especially for glazing units and multi-layer glazing) are reaction to fire and resistance to fire. However, it is important to understand that these characteristics are only indicative. The glass manufacturer decides which standard to use to determine them (most often as a wall). Glass and glazing shall have a permanent marking indicating these two characteristics.

However, when they are incorporated into a wall, door, roof or floor construction, or similar structure, the final building product, which is the wall, door, roof, slab etc., must be tested according to the appropriate standard and assigned its own fire resistance class. This class may be different from the class of the incorporated glass (glazing) (see Figure 3).

Figure 3. *Fire resistance class of glass and glass wall*

PERMISSIBLE WALL HEIGHT

This is the third characteristic related to the fire characteristics of the walls. Its determination is required only for internal non-load-bearing lightweight partitions, according to the Orders No-02-14-252 (Order of the Minister of Regional Development and Public Works No RD-02-14-252, 10.03.2021) and RD-02-14-229 (Order of the Minister of Regional Development and Public Works No RD-02-14-229, 25.02.2022).

A lightweight partition is a thin-walled steel structure (profile construction) to which one or more panels are fixed, either on one or both sides. There may also be a wool filling.

The maximum permissible height is the lesser of the height under static and dynamic loading without fire load and the height under fire load. The occurrence of a fire is a single event and the tested (calculated) maximum allowable height is important, but the wall is subjected to daily use and it should have the necessary strength and resistance under normal conditions.

The Order No. RD-02-14-229/25.02.2022, which provides the working procedure for the estimation of these heights, is based on a calculation algorithm developed by the MPA Braunschweig Institute, commissioned by the German Gypsum Industry Association (Association, 04.2016).

The algorithm is designed with several valid boundary conditions for Germany for the static, dynamic and console loads accompanying the daily operation of the wall, as follows:

Static loads

These are different deflections f, to which the walls are assigned depending on the maximum wall height h - $f \leq h/500$, $h/500 < f \leq h/350$, $h/350 < f \leq h/200$.

This classification should not be identified with a specific requirement for strain limitation as a determinant of serviceability. Practical construction experience in recent decades has shown that lightweight partition walls at the usual storey heights (2.40 m to 4.00 m) do not exhibit defects in limiting deflection to $f \leq h/200$ (2 cm deflection at a wall height of 4.00 m) (see Figure 4).

In order to ensure the absence of defects also at higher wall heights (from 4.00 m to 12.00 m), the bending is limited to the ratio h/350 (deviation of 3.4 cm at a wall height of 12 m). At a ratio of h/200, the deflection would be 6 cm, which is already too much at these heights.

In isolated cases (e.g., deformation-sensitive wall claddings), it is recommended to apply an aggravated bending criterion $f \leq h/500$ or, in some cases, an absolute bending limitation.

Dynamic loads

Examples of such loads are vibrations caused by the rhythmic pushing of the wall by many people, construction activity, etc.

This staggering effect is particularly noticeable in very high, free-standing claddings that are fixed on one side only. Although the stability of these claddings/shaft walls is guaranteed, subjectively, they can be perceived as operationally unsuitable. However, revision of existing structures for this reason is not necessary. Technically, this effect, which is a consequence of the dynamic loading, can be excluded if the truss structure is point-fixed backwards, e.g., to the rough wall or to the steel truss.

By applying a properly selected equivalent static load, the stability of the wall and thus its natural frequency of oscillation can be increased. In German practice, an equivalent surface load of 0,285 kN/m² (28,5 kg/m²) has proven to be justified.

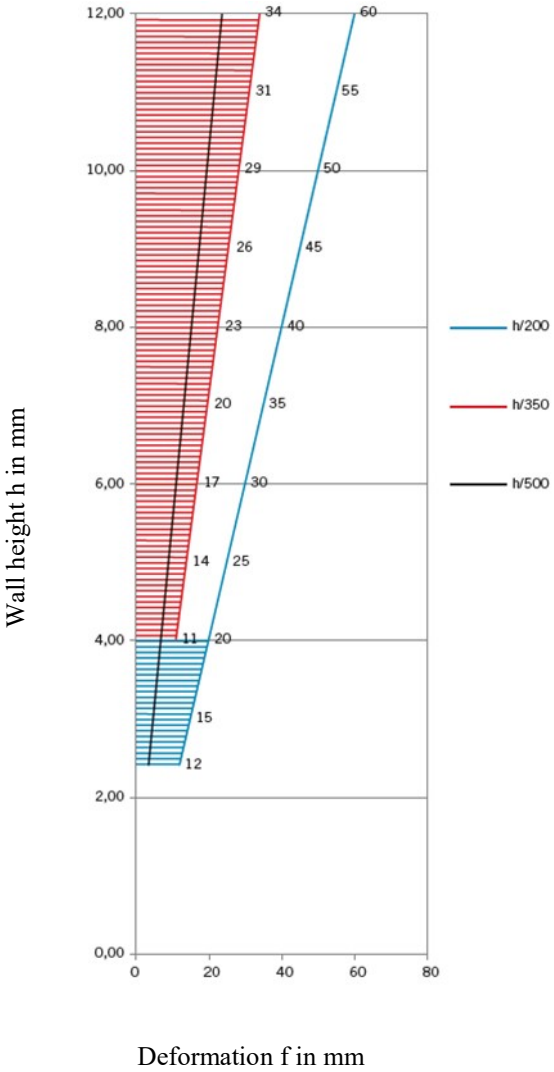

Figure 4. *Maximum wall deflection f as a function of height h.*

Equivalent surface load (wind load)

The equivalent surface load of 0.285 kN/m² (28.5 kg/m²) also includes the wind load criterion according to DIN 1055-4 (DIN 1055-4 Action on structures - Part 4: Wind loads) and EN 1991-1-4 (EN 1991-1-4 Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions, 2005) under the following boundary conditions:

- building height $h \leq 18$ m;

- wind zone 3, inner zone;
- back pressure q = 0,95 kN/m²;
- load coefficient c_{pi} = - 0,3 (for one-sided loading);
- surface wind load value, determined by the following formula:

$$w = c_{pi} \text{ x } q = 0{,}3 \text{ x } 0{,}95\ kN/m^2 = 0{,}285\ kN/m^2 \quad (1)$$

Console loads

For example, wall-mounted wardrobes or shelves transfer their weight to the base of the wall, while tightly installed cable runs beneath ceilings place stress on the upper wall fixings.

The maximum recommended height for console loads is 1.65 m, and this should be taken into account if cantilevered loads are applied at greater heights.

For partition walls, DIN 18183-1 (DIN 18183-1 Partitions and wall linings with gypsum boards on metal framing - Part 1: Cladding with gypsum plasterboards) defines console loads of 0.7 kN/m (70 kg/m). The condition is that the line of application of the loads is a maximum of 30 m from the wall surface. It may be applied at any random location on the wall provided that the thickness of the sheathing on each side of the wall is ≥ 18 mm.

For wall claddings (shaft walls), console loads are normatively limited to 0.4 kN/m (40 kg/m), regardless of the thickness of the cladding. However, numerous examples from practice show that often within a single room, heavier console loads are attached to all walls. For this reason, it is recommended that for both partition walls and shaft walls (wall claddings), calculations are made with increased console loads of 0.7 kN/m (70 kg/m) and that a thickness of ≥ 18 mm (exactly as for partition walls) is assumed when sizing shaft walls (wall linings).

CONCLUSION

This report provides a systematization of the wall types depending on their fire characteristics, purpose in the building and the materials used in their construction. The characteristics are in accordance with the regulatory requirements for new buildings and construction sites in the Republic of Bulgaria, namely Regulation No. Iz-1971. In addition, lightweight partition structures and the determination of their maximum permissible building height, depending on the different loads to which they are subjected in normal operation and under fire impact, are thoroughly considered.

REFERENCES

Association, G. G. (04.2016). Heights of lightweight partitions - slots, connections, doors and openings Revision 8.

DIN 1055-4 Action on structures - Part 4: Wind loads. (n.d.).

DIN 18183-1 Partitions and wall linings with gypsum boards on metal framing - Part 1: Cladding with gypsum plasterboards. (n.d.).

EN 13501-2 Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance and/or smoke control tests, excluding ventilation services. (2023).

EN 1364-1 Fire resistance tests for non-loadbearing elements - Part 1: Walls. (2015).

EN 1365-1 Fire resistance tests for loadbearing elements - Part 1: Walls. (2013).

EN 1990 Eurocode - Basis of structural design. (2003).

EN 1991-1-4 Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions. (2005).

EN EN 13830:2015+A1:2020 Curtain walling - Product standard. (2020).

https://bauhaus.bg. (n.d.). Retrieved 09 02, 2024, from https://bauhaus.bg/greda-rettenmeier/p/10704

https://bg.jenesis-glass.com/insulated-glass/. (n.d.). Retrieved 09 02, 2024, from https://bg.jenesis-glass.com/insulated-glass/

https://euroglass-bg.com. (n.d.). Retrieved 09 02, 2024, from https://euroglass-bg.com/bg/product/stykleni-pregradni-steni-za-ofis_9

https://ibuilders-bg.techinfus.com. (n.d.). Retrieved 09 02, 2024, from https://ibuilders-bg.techinfus.com/vagonka/sosna/

Order of the Minister of Regional Development and Public Works No RD-02-14-229. (25.02.2022).

Order of the Minister of Regional Development and Public Works No RD-02-14-252. (10.03.2021).

Ordinance No. Iz-1971 of 29.10.2009 on building-technical rules and regulations for ensuring fire safety. (OJ No. 96 of 4 December 2009, as subsequently amended and supplemented, OJ No. 91 of 29.10.2024).