
# Deliverable 2.1

# FireBIM Matrix and Fire Code Compendium

## ITEA4 22003 FireBIM

| | |
|---|---|
| Deliverable type | Document |
| Deliverable reference number | ITEA 22003 \| D2.1 |
| Work Package | WP2 |
| Submission date | 2025/02/28 |
| Dissemination level | Public |
| Abstract | This report introduces the development process of the FireBIM Matrix. It describes the mapping of fire safety codes from Denmark, Netherlands, Belgium and Portugal to data models for building information and compliance checking. The process follows the strategy of the designer starting out with the fire compartmentation in buildings. National Fire Safety Regulations are presented and linked. |
| Keywords | Fire Safety, Fire Codes, Building Regulations, Compliance |

**Contributors**

| Partner | Author | Role |
|---|---|---|
| Buildwise (BE) | Kurt de Proft | Fire Safety Expert |
| DBI (DK) | Lene Pingel | Fire Safety Expert |
| Peutz (NL) | Arjan Tijink | Fire Safety Expert |
| ISEP (PT) | Tomás Jorge | Fire Safety Expert |
| Exactusensu (PT) | José Aidos Rocha | Fire Safety Expert |
| Exactusensu (PT) | Daniel Afonso | Fire Safety Expert |
| VN2R (PT) | Jéssica Reis | BIM expert |
| D-Studio (BE) | Stefan Boeykens | BIM expert / Notion expert |
| Eindhoven University of Technology (TU/e) (NL) | Ekaterina Petrova | WP2 Lead / BIM expert |
| Technical University of Denmark (DTU) (DK) | Anne Dederichs | Project Coordinator / Fire Safety Expert |

**Document history**

| Date | Version | Editor | Status |
|---|---|---|---|
| 28.2.2025 | 1 | Kurt De Proft | Published |
| | | | |
| | | | |
| | | | |
| | | | |

**Summary**

The current report details the development process of the FireBIM Matrix, which maps fire safety codes from Denmark, the Netherlands, Belgium and Portugal to data models for building information and compliance checking. Initially the characteristics of the national fire safety codes are summarized. The first step for the implementation of the digitalization focuses on the fire compartmentation in buildings. The related odes and terminology form the foundation of the FireBIM Matrix, with future iterations addressing evacuation. The creation of the International Compendium of National Fire Safety Regulations provides a guide to using the FireBIM Matrix. The report concludes by linking these activities to broader FireBIM deliverables.

## List of Acronyms

| | |
|---|---|
| Architecture, Engineering and Construction | AEC |
| Automated Compliance Checking | ACC |
| Bouwbesluit | BBL |
| Common Data Environment | CDE |
| Autoridade Nacional de Emergência e Proteção Civil | ANEPC |
| European Union | EU |
| International Electrotechnical Commission | IEC |
| International Fire Safety Standards Coalition | IFSS |
| Industry Foundation Classes | IFC |
| International Organization for Standardization | ISO |
| Work-in-Progress | WIP |

# Table of Contents

# 1 Introduction

The International Fire Safety Standards (IFSS) Coalition called for a decade of action to achieve "the first agreement on fire safety actions on international scale" between 2022-2032. It calls for action to reduce fire hazards associated with built structures, including their planning, design, and operation. In building design, teams collaborate to fulfil the client requirements and comply with national and local regulations, including those related to occupant health, safety and well-being. However, compliance with fire safety regulations is often considered too late, despite it being a crucial ongoing requirement in all projects. Non-compliance with fire codes can lead to costly design changes, budget overruns, delays, and health hazards. In addition to cost-efficiency, quality in fire safety has become a serious concern since the Grenfell Tower fire in London. The European Fire Safety Alliance points to the potential for standardisation of fire protection measures. However, fire safety measures are typically descriptive codes that differ between countries, regions, and local administrations. The codes are scattered across each country's regulations without a centralized or well-established field of knowledge exchange. Furthermore, the codes result from historical work across many stakeholders and contain inaccuracies and inconsistencies. More importantly, their interpretations and the use of technical terms vary between stakeholders. Despite its importance, the fire safety field is dispersed, making multidisciplinary and cross-border collaboration extremely challenging. In addition, the lack of data standards and digital tools for fire safety engineering and compliance checking further complicates the challenges outlined above.

In response to the above, the FireBIM project aims to create embedded mechanisms for fire safety assessment in an open-source, web-based platform relying on Building Information Modelling (BIM), semantic data modelling and web technologies to increase the cross-disciplinary collaboration and assessment of fire safety to support building designers across European borders. More specifically, the goal of FireBIM is to develop a user-centred web-based platform to:

1. enable the collective interpretation of fire regulations in all partner countries.
2. reduce the barriers to international collaboration and fire safety design competition for Architecture, Engineering and Construction (AEC) companies.
3. enable automated compliance checking of buildings against fire safety regulations; and
4. reduce international barriers for building products and services.

Within the FireBIM consortium, four European countries (Denmark, Belgium, Netherlands, and Portugal) join forces to disentangle and structure different European fire safety regulations for buildings. Each partner country contributes with fire safety experts providing input on the national fire codes. In addition, each country is also represented by a wide range of AEC industry partners, each providing a variety of use cases. Each use case is specifically designed to test and value the applicability of the FireBIM solutions from the early design phase and throughout the later stages of a construction project.

The current report presents the first outputs of the FireBIM project, addressing the collective interpretation of fire regulations in all partner countries. That includes the FireBIM Matrix and the International Compendium of National Fire Safety Regulations that compile and provides access to the national codes from Denmark, Belgium, Netherlands and Portugal, paving the way to the in-depth fire code analysis, harmonisation, interpretation and digitalisation performed in the project.

To get there, the different approaches and interpretations as well as the differences in terminology in the four partner countries have been elaborated during the initial stages of the project. This report

documents the principles of this work, ultimately leading to the identification of the common and differing fire safety concepts and terminology across the participating countries. The output presents a consistent mapping of all partner countries' fire codes, as well as the common building fire safety concepts and definitions later utilised in the transformation of the regulations in machine-interpretable rules and the Automated Compliance Checking (ACC) approaches developed in the project.

This work first documents the first subsection (Theme 1) of the codes of all countries performed on a thematic basis, namely Fire Compartmentation in buildings. In this context, compartmentations are boundaries (surrounding walls, doors, etc. with specific fire safety properties) limiting the fire spread. In this regard, the codes and terminology related to compartmentation form the basis of the first version of the (web-based) FireBIM Matrix. Additional ongoing iterations aim to implement the other themes investigated in the project, namely Evacuation (Theme 2) and Structural Safety (Theme 3).

Based on the above, this report explains the process and method of developing the FireBIM Martix in detail. The FireBIM Matrix is the first step towards the regulation digitalization, presenting the agreement of the countries with respect to how to interpret the codes and map them to data models for building information, as well as code representation, execution and ACC.

The remainder of this document is organised as follows. Chapter 2 briefly outlines the principles of fire safety governance across Europe, including the different regulation strategies, approaches in the participating countries and the related fire safety standards. Chapter 3 presents the workflow for developing the FireBIM Matrix based on defined user stories (as per the themes described above, with compartmentation as an example), functional building requirements and defined workflows. The chapter further explains the principles behind the creation of the International Compendium of National Fire Safety Regulations and the national rule subset selection, translation and documentation. Finally, the developed FireBIM Matrix is shown and explained, including a guide on how to access and use it. Chapter 4 concludes the report and outlines the links with other activities and deliverables in FireBIM.

# 2 Fire safety governance within and beyond Europe

The following chapter explains the general principles of fire safety engineering and their implementation in each participating country. After explaining the main principles that fire safety regulations across Europe build on, the chapter briefly outlines the two main methods to incorporate fire safety in regulations, namely prescriptive and performance based. Each country explains which method, or a combination thereof, is used in the corresponding national regulations.

## 2.1 Principles of fire safety regulations (across Europe)

Fire safety is a national competence, resulting in different regulations and laws across the different countries. Each country defines specific requirements that the constructions and the construction products used in the buildings must comply with. The European Union (EU) is responsible for harmonizing the standards for testing and classifying the performance of construction products with regards to fire safety.

Even though the regulations differ per country, the main philosophy is comparable. In this regard, each fire safety regulation is based on (one of) the following general concepts that aim to minimize the risk of fire occurrence and its potential impact:

- Prevention
- Detection and warning
- Occupant protection
- Containment
- Extinguishment

### 1.1.1. Prevention

The first fundamental aspect of fire safety engineering is prevention. The first pillar of prevention addresses reducing and controlling risks as a key issue, i.e., fire risk assessment. The latter includes identifying potential hazards, assessing the likelihood of ignition for different sources and evaluating the vulnerability of occupants and assets. Prevention is typically done by creating awareness among the building occupants. The second pilar of prevention is the use of correct materials for specific room uses, including incombustible or fire-retardant materials for structural components. In rooms with a higher risk of fire (e.g. technical rooms), other fire loads must be limited and materials with a very good resistance to fire (incombustible) must be used. Furthermore, design strategies incorporating compartmentation and fire separation distances aim to contain fire within a limited are and prevent it from spreading.

### 1.1.2. Detection and warning

In case of fire, it is of the highest importance that users of the building are quickly informed about the so they can immediately start with evacuation. A good detection strategy is part of a robust fire safety. Detection is done using active fire detection systems such as smoke detectors reacting to soot particles or gaseous species, aiming to detect the fire early and alert the occupants. These systems are usually coupled with a warning system, notifying the surrounding through sound, light or vibration. Furthermore, some systems for remote monitoring and emergency response can notify the fire department by sending real-time alerts. Detection and warning systems enhance life safety and reduce property damage by facilitating timely evacuation and response.

### 1.1.3. Occupant protection

Occupant protection in fire safety engineering focuses on safeguarding individuals from fire hazards by implementing measures that ensure safe evacuation, minimize exposure to fire and smoke, and provide adequate fire resistance in buildings. As such, each building is designed to protect its users from a possible fire hazard. This mainly results in strategies for the users to escape the building in case of fire, known as evacuation strategies. This strategy may incorporate design of a relevant number of emergency exits, limiting the path to travel to those exits, protecting corridors to evacuate from fire, limiting the contribution to fire of materials used in evacuation corridors, etc. Appropriately designed evacuation routes allow occupants to escape quickly and safely during a fire emergency.

### 1.1.4. Containment

Once a fire is developed, the main strategy is to keep the fire limited to an area as small as possible. Fire containment in fire safety engineering focuses on limiting the spread of fire, smoke, and heat within a building or structure, essential for preserving life safety, reducing property damage, and ensuring that fires remain manageable until they are extinguished. Effective containment measures include compartmentation, where areas are separated by building elements, walls, or doors with an appropriate resistance to fire (fire-resistant sections). The building is also designed to structurally survive a fire (i.e., stability and structural integrity in fire conditions). Containment is a crucial element in fire safety engineering as it limits fire and smoke spread, ensures safe evacuation, and protects building integrity.

### 1.1.5. Extinguishment

In case of fire, fire services must arrive as soon as possible to help evacuate the occupants, fight the fire and prevent any further spread. Extinguishment in fire safety engineering refers to the process of suppressing and eliminating a fire to prevent loss of life, property damage, and environmental hazards. This process involves active fire protection systems, firefighting methods, and the scientific principles of fire suppression. Therefore, the building design must consider the ease of intervention and the safety of the fire service.

## 2.2 Regulation strategies

There are two main regulatory methods to demand fire safety measures in buildings: prescriptive and performance based. The risk of fire must be considered during the design process so the appropriate measures can be identified. The simplest approach to fire safety in buildings incorporates following the rules in the different regulations to make sure that the building design is compliant and safe. The key documentation for the rule-based approach across the countries is the Building Code (i.e., building regulations) that contains fire safety rules. The Building Code is usually prescriptive, i.e., it is a normative set of regulations that contains threshold values to be applied and complied with from the point of view of legal assurance.

### 1.1.6. Prescriptive fire safety regulations

The prescriptive fire regulations are based on given national requirements established by the relevant regulatory bodies. Sets of requirements must be fulfilled to obtain a fire safe building. This method applies several requirements given to the spaces defined in the design and the construction products used in the building. Harmonized testing and classification standards provide the way to prove the construction product fulfils the requirement. The regulations are applied with sets of guidelines

following national praxis and procedures, making the fire safety assessment complex even though the structured approach to fire safety governed by the prescriptive regulations that aim to ensure compliance without requiring complex fire engineering analyses and computations.

### 1.1.7. Performance-based fire safety regulations

The performance-based approach applies scientific methods to solve the safety assessment of a building, referring to scenarios. These regulations focus on achieving desired fire safety outcomes rather than prescribing specific materials, layouts, or systems. Here, numerical or experimental methods are used to investigate the evolution of a possible fire on one hand and the evacuation of people on the other hand. A building is considered safe, when people are assessed to be able to escape a fire without being exposed to critical conditions from the fire. Realistic fire scenarios are found and used to evaluate the fire safety of the design. Based on natural fires, calculations and/or simulations are used to evaluate the behaviour of the building. The design of the building is then changed to obtain the desired fire safety level. Performance-based approaches are particularly useful in complex or high-rise buildings and innovative architectural designs where traditional prescriptive methods are impractical or insufficient.

### 1.1.8. Intermediate regulations

In some countries, it is possible to deviate slightly from the prescriptive solutions without having to use a performance-based method. In that case, the deviation from the prescriptive solutions must be documented with a fire safety assessment or a comparative analysis based on the prescriptive solutions or performance-based solution. In both methods, the building design must be supplemented or improved in other ways to compensate for the deviation from the prescriptive solution. It must be justified that the safety level is maintained with compensatory measures in the specific case.

As fire safety is governed at national level, each country can decide what strategy to follow. The following sections give an overview of the approaches adopted in the different participating countries.

## 2.3 Approach in Belgium

In Belgium, all requirements with respect to fire safety are prescriptive. The main document in fire safety regulation in Belgium is the “KB Basisnormen” (“*Koninklijk Besluit van 7 juli 1994 tot vaststelling van de basisnormen voor de preventie van brand en ontploffing waaraan gebouwen moeten voldoen*”). This document is valid in the whole country, with no deviations in the regions. KB Basisnormen describes the minimal requirements that a building must follow, regardless of its function. The document represents the law, so its application is mandatory.

To better align safety regulations with the function or purpose of certain buildings, additional requirements might be issued on the local level. In Belgium, the local level can be defined in two ways:

1. Regions
2. Communities

Furthermore, Belgium is divided in three regions as follows:

- Flemish region
- Walloon region
- Brussels region

In addition, there are three representative communities:

- Flemish community
- French community
- German community

For example, homes for elderly people must follow the KB Basisnormen, but in addition, there are more prescriptive requirements on the regional level.

Even though finding the exact legislation can be a complex task in some cases, all requirements are prescriptive. The Belgian law does foresee a possibility to use a performance-based metrology; however, it is always seen as a deviation. Every deviation from the prescriptive ruleset must be handled by a special commission of derogation. This commission analyses if the proposed deviation reaches the minimal required level of fire safety.

In most cases, it is the designer that checks the fire safety of its design. It means that the designer is incorporating the prescriptive measures in the design. For bigger building projects, or in case when deviations are necessary, fire safety experts are consulted.

### 2.4 Approach in Denmark

In Denmark, buildings are categorised according to Fire Classes 1 to 4. Certified fire advisors are required for buildings in Fire Classes 2 to 4.

Fire Class 1 includes simple standard buildings, where there is no requirement for a certified fire consultant and the building must follow the prescriptive solutions in the building regulations, without deviations. The authority approves the fire requirements for buildings in Fire Class 1.

Fire Class 2 buildings are simple standard buildings or buildings where the risk class of the building is slightly higher than what is covered by Fire Class 1. Buildings in Fire Class 2 must have a certified fire consultant, certified for at least Fire Class 2. A few minor measurable deviations from the prescriptive solutions can be incorporated. It is the certified fire consultant that approves the fire requirements for buildings in Fire Class 2.

Buildings in Fire Classes 3-4 can be buildings in a higher risk class (e.g., high number of people, large area in square meters, high construction, high fire load, etc.) or simple buildings that cannot fully follow the prescriptive solutions. Buildings in Fire Class 3-4 can use performance-based fire design where fire safety must be documented with fire engineering assessment, comparative analysis, fire engineering calculation or fire testing. Buildings in Fire Classes 3-4 must have a certified fire consultant for Fire Classes 3-4, where Fire Class 4 specifically requires an independent certified fire consultant to be assigned as an inspector. For buildings in Fire Classes 2-4, it is the certified fire consultant assigned to the case who approves that the building complies with the building regulations. The authority does not verify the fire requirements for buildings in Fire Class 3-4, but the authority/fire brigade must approve if the building deviates from the traditional response tactical solutions, cf., the building regulations.

### 2.5 Approach in the Netherlands

In the Netherlands, building regulations in relation to fire safety are laid down in prescribed frameworks. Fire safety regulations for buildings are primarily governed by the Dutch Building Decree (Bouwbesluit (BBL)), which outlines minimum requirements to ensure safety, health, usability, energy efficiency, and environmental protection in building structures. These regulations apply to both new constructions and existing buildings and specify fire safety measures tailored to the function and use

of a building. The requirement frameworks depend on i) the nature of the building (e.g., new construction, renovation or existing construction), ii) type of building (e.g., office function or an apartment building), iii) height of the building and iv) its occupancy (e.g., number of people). The design of the building must comply with these regulations. This is assessed during a permit application by the authority having jurisdiction, usually a municipality. The municipality often follows the advice of the fire brigade (i.e., the municipality's advisor).

It is possible to deviate from the prescribed requirements if it is demonstrated that an equivalent level of safety is realized. There are several standard equivalent solutions (e.g., applying a sprinkler system for fire compartments that are too large). Equivalent solutions must always be explicitly checked by the authority having jurisdiction (the municipality/fire brigade).

New buildings require a higher safety level than existing buildings. The latter is related to the building lifetime, which is longer for new buildings compared to existing buildings. In certain high-risk situations, such as premises where large numbers of people gather (e.g., catering establishments or daycare centres), an Environment and Planning Permit covering fire safety is required. This ensures that additional safety measures are in place to address the increased risk.

For unique or complex building designs where prescriptive codes may be restrictive or insufficient, a performance-based approach to fire safety can be utilized. While the BBL provides the foundation of the building regulations, it allows for alternative solutions through performance-based designs, provided they can demonstrate compliance with the intended safety objectives. Such an approach allows for alternative solutions that meet the overarching fire safety objectives without strictly adhering to prescriptive requirements. A performance-based (or risk-based) approach implies a detailed engineering analysis to demonstrate that the proposed design achieves an equivalent or superior level of safety.

### 2.6 Approach in Portugal

In Portugal, the legislation is prescriptive. In general, designers must comply with the prescriptions. Fire safety plans are checked by an authority having jurisdiction, such as the National Civil Protection Service (Autoridade Nacional de Emergência e Proteção Civil (ANEPC)) or the municipality services.

Buildings can be classified in four risk categories, from 1st to 4th. Buildings classified from 2nd to 4th risk category must be designed by a certified designer.

The risk categories of buildings, depending on their use, are based on some of the following risk factors: i) height of the building, ii) number of occupants, iii) number of floors below the reference plane, iv) gross floor area and fire load density, v) number of occupants in accommodations for medical treatment or care of disabled people with a range of impairments including physical, sensory and cognitive, or mental health conditions, etc.

In the case of new buildings, when it is proven that the provisions of the technical regulations are inadequate given their large size in terms of altimetry or planimetry or their operating, operational or constructive characteristics, such buildings and enclosures or their fractions are classified as atypically dangerous. In this case, designers can follow a performance-based methodology to prove the fire safety level. These solutions must always be approved by the authority having jurisdiction.

In the case of a renovation or conversion of existing buildings, the application of certain provisions of the technical regulations may be waived when their application is manifestly disproportionate. In this

case the designer determines the fire safety measures to be implemented in the building, with adequate justification, using methods for analysing fire safety conditions or risk analysis methods. These solutions must always be approved by the authority having jurisdiction.

## 2.7 Fire safety standards

As most requirements are given via legislation in different countries, terminology may differ. However, there are different fire related standards in which a common terminology can be found.

### 2.7.1 Eurocodes

The [1]-[4] are a set of European standards that provide a common approach to the structural design of buildings and civil engineering works, including fire safety considerations. For instance, there are different parts related to the different construction materials, e.g.:

- EN 1992-1-1: Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
- EN 1993-1-1: Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
- EN 1995-1-1: Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings
- EN 1996-1-1: Eurocode 6: Design of masonry structures - Part 1-1: General rules for reinforced and unreinforced masonry structures, etc.

Each part of Eurocode has a first part describing design in ambient conditions and a second part describing design in case of fire, i.e.:

- EN 1992-1-2: Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design
- EN 1993-1-2: Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design
- EN 1995-1-2: Eurocode 5: Design of timber structures - Part 1-2: General - Structural fire design
- EN 1996-1-2: Eurocode 6: Design of masonry structures - Part 1-2: General rules - Structural fire design, etc.

Consequently, Eurocodes introduce many of fire related harmonised terms and definitions which are commonly applied by all countries.

### 2.7.2 Testing and classification standards

To meet prescriptive requirements, the behaviour of construction products must be evaluated [5]. For that purpose, the EU has also developed a set of harmonized standards for testing and classification of construction products. The EU Construction Products Regulation (CPR) forms the basis of the construction products regulations adopted by all EU member states. The CPR requires member states to amend their regulations to include the classification system described in EN 13501-1: Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests, which is to be used in all EU countries to classify construction products (e.g., wall linings, flooring and other fixed products such as linear pipe, insulation products, and cables).

As such, the Euroclass system (EN 13501) and fire testing standards (EN 1363, EN 1634, etc.) form the foundation of the fire safety regulations for construction products in the EU. According to EN 13501-

1 Classification & Performance Criteria, construction products are treated per the following three separate categories:

- Construction products, excluding floorings and linear pipe thermal insulation products
- Floorings
- Linear pipe thermal insulation products

Each of the above categories has five performance classes, namely A1, A2, B, C, D, E, and a non-performance determined 'F' class, including criteria and test methods for assessing the performance of products in reaction to fire.

These harmonized standards ensure that materials and building elements meet strict safety criteria before they are used in construction projects. The terminology used in these standards can also be considered as harmonized.

### 2.7.3 International Standards

In addition to the above, the FireBIM project relies on several existing international standards with respect to fire safety as well as the digital disciplines. To establish a common ground for the terminology and definitions used in the project, FireBIM adopts existing terms, definitions and processes from these standards.

In this regard, the International Organization for Standardization (ISO) has developed several standards related to fire safety, including areas like fire prevention, fire protection, firefighting equipment, fire-resistant materials, and emergency preparedness.

The core set of terms and definitions can be found in ISO 13943:2023 Fire Safety – Vocabulary[6] below, which defines the core terminology relating to fire safety as used in ISO and International Electrotechnical Commission (IEC) International Standards. This standard aims to establish a common language for professionals involved in fire safety, including those working in building and civil engineering sectors. The standard was significantly updated in 2023, with 86 terms added or revised to reflect evolutions in the fire safety practices.

This standard covers mainly performance-based codes. Consequently, definitions regarding prescriptive design are only partially or not present. Yet, its purpose is to ensure consistency and clarity in communication and documentation.

The focus of FireBIM sits predominantly with the prescriptive codes, so the number of definitions via this standard might be limited. However, when a useful definition is present, it will be used.

# 3 International Compendium of National Fire Safety Regulations

As described in Chapter 2, fire safety regulations differ from country to country. As these regulations are the backbone of the work performed in FireBIM, all relevant documents should be collected. This collection, the International Compendium of national Fire Safety Regulations, will be made accessible for the public. It is not only valuable for the work within this project, it will also help designers to point towards the governing regulations in each participating country.

The chapter summarizes the first version of the compendium. On the FireBIM website, the idea is to provide a general overview of codes used in the different countries

| **Belgium** |
| --- |
| KB Basisnormen<br>Interpretatie - Koninklijk besluit van 7 juli 1994 - Wijzigingen van KB van 20 mei 2022 \| Civiele Veiligheid<br><br>AR normes de base<br>Interprétation - Arrêté royal du 7 juillet 1994 - Modifications de l'AR du 20 mai 2022 \| Civiele Veiligheid<br><br>Interpretation of compartment area<br>Interpretatie - Koninklijk besluit van 7 juli 1994 - Definitie van de oppervlakte van een compartiment \| Civiele Veiligheid<br>Interprétation - Arrêté royal du 7 juillet 1994 - Définition de la superficie d'un compartiment \| Civiele Veiligheid |

| **Netherlands** |
| --- |
| Bouwbesluit<br>wetten.nl - Regeling - Besluit bouwwerken leefomgeving - BWBR0041297 |

| **Denmark** |
| --- |
| The Danish Building Regulations 2018 (BR18), chapter 5 Fire Safety (§82-158)<br>https://www.bygningsreglementet.dk/tekniske-bestemmelser/05/krav/<br><br>Building regulations guidelines to BR18 Chapter 5 – Fire safety (Guidelines chapter 1-8):<br>https://www.bygningsreglementet.dk/tekniske-bestemmelser/05/vejledninger/generel_brand/<br><br>Building regulations appendix for prescriptive solutions and definition list:<br>https://www.bygningsreglementet.dk/tekniske-bestemmelser/05/vejledninger/generel_brand/<br><br>Fire regulations for other than construction, e.g. buildings with flammable and combustible liquids, flammable solids, gases, ATEX etc.<br>https://www.brs.dk/da/virksomhed-institution/brandfarlige-virksomheder-og-oplag/ |

| **Portugal** |
| --- |
| Regime Jurídico da Segurança Contra Incêndio em Edifícios<br>https://files.diariodarepublica.pt/1s/2019/10/20100/0000300053.pdf |

Regulamento Técnico de Segurança Contra Incêndio em Edifícios
https://files.diariodarepublica.pt/1s/2020/06/10700/0000200214.pdf

Critérios técnicos para determinação da densidade de carga de incêndio modificada
https://files.diariodarepublica.pt/2s/2020/09/183000000/0010500129.pdf

Utilizações-tipo de edifícios e recintos
https://prociv.gov.pt/media/ix2fsrb3/nt_01_2021.pdf

Locais de risco
https://prociv.gov.pt/media/y4mldfu1/nt_05_2020.pdf

Categorias de risco
https://prociv.gov.pt/media/xylb1rea/nt_06_2022.pdf

# 4 FireBIM matrix: collection of national fire safety codes

The goal of the FireBIM Matrix is to unify and structure an agreed upon subset of the national fire codes and prepare them for digitalization. Therefore, the FireBIM matrix is a collection of definitions related to topics within the fire regulations. As described in the first section, fire regulations are based on the same starting points. These different points are used to structure the FireBIM Matrix.

In the current chapter, the user-based workflow leading to the matrix is described. This description will further clarify the goal of the FireBIM matrix.

Working in the structured way will identify differences in interpretations and processes within the regulations of the different countries. This knowledge can be used by the different countries to evaluate their regulation. It even may, in the future, help to evolve to a more harmonized European code system.

Besides that, the unveiling of the differences and gathering subsection by subsection of the codes into the FireBIM Matrix, as described in the current section, can be seen as a way towards a harmonization of the codes in the partner countries.

## 4.1 Workflow for developing the FireBIM Matrix

There are two processes that need to be considered: the process of the fire safety strategy in a building and the process of the design of the building.

### 4.1.1 The process of fire safety strategy in a building

### 4.1.2 This process is described in Figure 1. This process starts with:

- Prevention: take measures to prevent a fire. If that measure is unsuccessful,
- Systems for detection and warning shall enable and initiate an early extinguishing
- Early Suppression: stop within first minutes by manual extinguisher or automatic sprinkler

When fire cannot be stopped immediately:

- Evacuation is initiated and enabled by the design
- Compartmentation shall prevent the fire from spreading to other units of the buildings
- Structural safety shall prevent the building from collapsing

Firefighting comprises:

- Intervention of Fire services
- Evacuation of occupants
- Fight/control the fire and prevent further spread

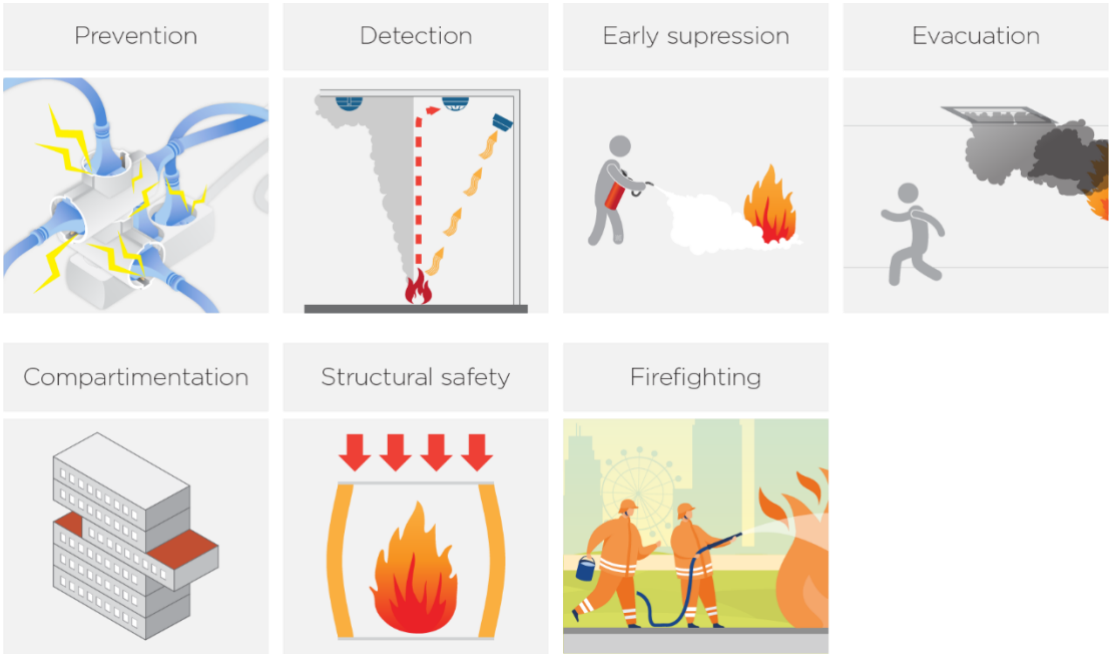



*Figure 1: Fire safety strategy*

### 4.1.3 The process of the designer

The process of the designer is not necessarily the same as the process of fire safety strategy.

When designing a building, the designer starts with defining the spaces and the layout of the building and the floor plans. This actually means that the designer starts placing walls, floors and doors. Then, the compartments are defined based on the floor plan, followed by integrating aspects of evacuation and structural safety.

This means that the designer is directly confronted with aspects of compartmentation, evacuation and structural safety. In that perspective, a first iteration of the FireBIM matrix was developed focussing on compartmentation, evacuation and structural integrity. In this matrix, building information (objects and properties) were collected necessary for the related checks. Table 1 shows the first version of the FireBIM matrix.

| **Evacuation** | Width | Length | Area | Material | Slope (max) | Type | Function | Fire rating Reaction to fire | Fire rating Resistance to fire | Use category |
|---|---|---|---|---|---|---|---|---|---|---|
| Staircase | X | | | X | X | X | X | | | X |
| Corridor | | | | | | | X | | | X |
| ramps | X | X | | | X | | | | | X |
| doors | X | | | | | | X | | X | |
| elevator | | | | | | | | | | X |
| universal design | | | | | | | | | | |
| width of evacuation routes | | | | | | | | | | |
| length of evacuation routes | | | | | | | | | | |
| type of path / path length | | | | | | | | | | |
| rescue openings | | | | | | | | | | |
| rooms | X | X | | X | | | | | | |
| number of people | | | | | | | | | | |
| function of the room | | | | | | | | | | |
| number of floors | | | | | | | | | | |
| height of the building | | | | | | | | | | |
| type of occupants | | | | | | | | | | |
| obstructions (BE) | | | | | | | | | | |
| active systems | | | | | | | | | | |

| **Compartmentation** | Width | Length | Area | Material | Slope (max) | Type | Function | Fire rating Reaction to fire | Fire rating Resistance to fire | Use category |
|---|---|---|---|---|---|---|---|---|---|---|
| room | X | X | X | | | | X | X | X | X |
| firecells | X | X | X | | | | | X | X | X |
| subcompartment | X | X | X | | | | | X | X | X |
| compartment | X | X | X | | | | | X | X | X |
| walls | | | | | | | | X | X | |
| ceiling | | | | | | | | X | X | |
| floor | | | | | | | | X | X | |
| height of the building | | | | | | | | | | |
| active systems | | | | | | | | | | |

| **Structural integrity** | Width | Length | Area | Material | Slope (max) | Type | Function | Fire rating Reaction to fire | Fire rating Resistance to fire | Use category |
|---|---|---|---|---|---|---|---|---|---|---|
| columns | X | | | X | | | | | X | X |
| beams | X | | | X | | | | | X | X |
| slabs | X | | | X | | | | | X | X |
| amount of floors | | | | | | | | | | |
| height of the building | | | | | | | | | | |
| basement | | | | | | | | | | |
| top floor | | | | | | | | | | |
| active systems | | | | | | | | | | |

*Table 1: First version of the FireBIM matrix - focus on evacuation, compartmentation and structural integrity*

In a second stage, the approach was more refined. The process for the further development of the FireBIM matrix was driven even more from the perspective of the designer. This was done by the concept of user stories, which is more explained in the next section.

#### 4.1.4 User stories

A user story is a set of wishes that a user has. Specifically for fire safety, a user story is a list of things that the user wishes to know about fire safety for his or her design.

As mentioned above, the first user story was defined and was related to compartmentation ("containing the fire to a limited area") and evacuation ("users can safely exit the building"). The concept of compartments was found in the different regulations, although with some small deviations in definitions.

The first definition of the first user story was:

*"Starting from a preliminary design of a floor plan, can we check if compartmentation and evacuation rules are compliant?"*

#### 4.1.5 Defining functional building requirements related to compartmentation

The user story is applied to a design. The first design used for the development of the FireBIM Matrix is. To determine a preliminary building design with fire safety legislation, the FireBIM project considers the following three levels of determination starting with a simple example case of an office building:

**Level 0 (fixed):**

- Type of the building: office building
- Height of the building: 3-storey building – highest finished floor level = 9,99 m
- No sprinklers
- No smoke or heat extraction
- Max number of people: 200 per level/compartment, 600 in total, 1 person per 5 m²

**Level 1:**

- Max floor area of fire compartments
- Min number of escape exits
- Maximum length to 1st exit, 2nd exit and dead ends
- Distance between staircases

**Level 2:**

- Level of the floor /width escape routes
- Separation between compartments (SAS)

#### 4.1.6 Detailed analysis of the user story

In order to reach the global goal defined in the user story, the user story was broken down into several items to be checked:

- Maximum floor area of the compartment
- Number of fire-exits in the compartment
- Maximal travel distances to respect in case of fire
- Distance between staircases
- Width of the evacuation routes
- Separation between compartments

### 4.1.7 Flowcharts for rule evaluation

Each country translated these checks into flowcharts (see an example of a flowchart in **Error! R eference source not found.**), describing how to analyse the evaluation. The goal of the flowcharts is to have a clear overview of all properties needed to evaluate the item.

Based on the flowcharts, a list of objects and properties can be derived:

- Object: related to items in the design e.g. a building, a compartment, a room, a wall, …
- Property: a property is related to an object e.g. area is a property of a compartment.

The list of objects and properties is the basis for the FireBIM matrix. In this matrix, the definitions of objects and properties are given based on definitions in legislation. The reference to the legislation is also written down in the matrix. When there is no definition found in the legislation, a fire expert interpretation of the definition is given. Consequently, there is no link to legislation for these definitions in the matrix. In this way, the interpretation was given by the fire expert.

As mentioned, the flowchart describes the way how a rule should be evaluated. From that flowchart, it also becomes clear how the objects and properties are used in the evaluation.

For the building example described above, the check of the compartment size was completely implemented in the FireBIM matrix. The first version was developed in *Microsoft Excel*. The first worksheet contains the rule to check and a link to all related properties. A short description on how the rule is to be checked and the reference to legislation is added. The following worksheets contain the definition of the objects and properties that are related. Each country has a separate worksheet.

## 4.2 Workflow identification

As regulations and requirements may differ from country to country, comparing might become difficult. To reduce this difficulty, the following strategy is adopted:

1. Define a user story
2. Assess the main concepts to be introduced in the evaluation
3. Each country produces flowcharts with necessary properties and objects
4. Fill in FireBIM matrix with objects and properties needed for the identified evaluations.

If possible, the terms of fire related standards will be used. In that way, the highest level of comparability can be obtained.

As more and more topics will be covered and the defined buildings become more and more complex, the FireBIM matrix will become a strong tool and a very good comparison between different fire regulations in different countries.

## 4.3 International Compendium of National Fire Safety Regulations

The international compendium of the national Fire Safety Regulations will make these accessible to the public. The codes, which might be a collection of different documents will from here be accessible through the FireBIM site. An introduction is provided in the current report.

On the FireBIM website, the idea is to provide a general overview of codes used in the different countries. Part of them is used in our work and used in the FireBIM matrix.

## 4.4 Regulation subset selection and translation

The national regulation subsets are described in the following sections.

### 4.4.1 Belgium

In Belgium, the main fire safety document is put into a law. This law is valid for the whole country ("*KB Basisnormen - Koninklijk Besluit van 7 juli 1994 tot vaststelling van de basisnormen voor de preventive van brand en ontploffing waaraan gebouwen moeten voldoen*").

The "KB Basisnormen" is applicable to all new buildings and extensions to existing buildings with exception of single-family houses and very small buildings (max 2 building layers and smaller than 100m²). For certain types of buildings there are separate regulations, which can be on the country level or regional. For hospitals, there is a separate Belgian law. Next to this law, there are regional laws to follow for certain types of buildings (e.g. buildings for elderly care). Finally, more demands are possible from municipalities and/or police.

The main fire safety document, "*KB Basisnormen"* consists of 7 chapters.

The first chapter is mainly terminology, where most properties used in the document are defined.

Chapters 2, 3 and 4 are related to requirements in respectively low, medium rise and high-rise buildings. In the chapter 5, reaction to fire requirements is given. Introducing the European classification of resistance to fire and reaction to fire in 2012, two versions of these chapters exist (2 and 2/1, 3 and 3/1, 4 and 4/1, 5 and 5/1). The "/1" version relates to the version with European classification and should be used for building permits starting from 01/12/2012.

Chapter 6 relates to the industrial buildings and Chapter 7 are some general aspects (e.g. penetration seals, parkings, …).

The main parameter used in Belgian legislation is height of the building. The height is defined from the ground level to the highest finished floor level. Low buildings have a height < 10m, middle rise have a height between 10m and 25m, high rise buildings are higher than 25m. Requirements are dependent on the height, and not necessarily of a used function of the building (except industrial use). But as mentioned before, for some types of uses, more legislation (Belgian, regional) is possible.

### 4.4.2 Denmark

In Denmark, *Building Regulation 18* (BR18) specifies the requirements of the Danish Building Act and contains the detailed requirements that all construction work must meet. BR18 applies to the construction of new buildings, the extension and conversion of buildings and the demolition of buildings. For existing buildings, however, the version of the building regulations according to which the building is approved is the applicable building code but only applies to remodeling and maintenance of the building.

The building regulations are divided into chapters, where chapter 5 (§82-§158) deals with fire requirements. The prescribed requirements in BR18 are mostly described as general requirements to maintain safety. In addition to the building regulations chapter 5 Fire, there are also guidelines 1-8 and appendices 1-16. The guidelines are primarily used for buildings in fire classes 3-4, with the exception of 3 Load-bearing structures, 5 Emergency response options and 7 Operation, control and maintenance of fire conditions, which apply to all buildings. The appendices describe the prescriptive solutions and are divided by use (single-family houses, secondary buildings, apartment buildings,

office buildings, assembly halls, classrooms, hotels, buildings where people cannot evacuate themselves, breeding and farm buildings, garages, industrial and storage buildings).

In addition to the building regulations, there are also technical regulations that must be followed if there is production or storage of flammable liquids, gases, solids, explosive substances, etc.

The BR18 classifies buildings based on their function and occupancy into six different “anvendelseskategorier” (usage categories). These categories determine the level of fire safety measures required:

1. Anvendelseskategori 1: Buildings without overnight stays where occupants are familiar with escape routes and can evacuate independently. Examples include offices, industrial buildings, and garages.
2. Anvendelseskategori 2: Buildings without overnight stays, designed for up to 50 people per room, where occupants are familiar with escape routes and can evacuate independently. This includes classrooms and day centers.
3. Anvendelseskategori 3: Buildings without overnight stays, accommodating more than 50 people, where occupants may not be familiar with escape routes but can evacuate independently. Examples include restaurants, shopping malls, and assembly halls.
4. Anvendelseskategori 4: Residential buildings where occupants are familiar with escape routes and can evacuate independently, such as single-family houses and apartment buildings.
5. Anvendelseskategori 5: Residential buildings where occupants may not be familiar with escape routes but can evacuate independently, such as hotels and dormitories.
6. Anvendelseskategori 6: Buildings where occupants cannot evacuate independently, such as hospitals, nursing homes, and childcare facilities.

The classification into these categories ensures that fire safety measures, such as fire alarms, sprinkler systems, and escape routes, are adapted to the specific risks associated with the building's function and its occupants' ability to evacuate. If a building has mixed-use, the highest required safety level applies to the entire building or relevant section.

### 4.4.3 Netherlands

In the Netherlands, building regulations are set out in a "Koninklijk Besluit". In this case *"Het Besluit bouwwerken leefomgeving (BBL)*”. The BBL describes the requirements for existing buildings, new buildings and renovation. Also included in this decree are the conditions of use. The BBL applies to all buildings. The prescribed set of requirements depends on the type of building. Buildings where people sleep or where there are less self-reliant people have stricter fire safety requirements than, for instance, industrial buildings. The requirements a building must meet also become stricter as the height of the building increases (in several steps). For buildings higher than 70 metres, direct requirements are no longer included, but the BBL refers to a specific publication *SBRCURnet Handreiking – Brandveiligheid in hoge gebouwen*).

The BBL consists of 9 chapters, with chapters 1, 3 to 6 being the most important for fire safety.

- Chapter 1: General provisions, these mainly concern the various definitions of terms used in the BBL.

- Chapter 3: Existing buildings This chapter contains the minimum requirements that an existing building must meet. The fire safety requirements are mainly included in paragraph 3.2 Safety (constructional conditions) and paragraph 3.7 (installations).
- Chapter 4: New buildings This chapter contains the minimum requirements that a new building must meet. The fire safety requirements are mainly included in paragraph 4.2 Safety (constructional conditions) and paragraph 4.7 (installations).
- Chapter 5: Renovation and change of use function This chapter applies to renovation, but also if the use of a building is changed (for example, a transformation from an office function to a residential function).
- Chapter 6: Use of buildings. The fire safety requirements are mainly included in paragraph 6.2 Fire safety and paragraph 6.5 (installations). The requirements included in this chapter are diverse and include, for example, the conditions that must be met if chairs are placed in rows in a room. Including the minimum width between rows (for example in a cinema). This chapter also includes, for example, that a parking function under a residential building must be equipped with a sprinkler system in some cases.

The BBL classifies 12 different use functions (or functional uses), namely:

- Residential function (e.g. apartment building);
- Assembly function (e.g. cinema);
- Detention Function (e.g. prison);
- Health care function (e.g. hospital);
- Industrial function;
- Office function;
- Temporary accommodation function (e.g. hotel);
- Educational functions (e.g. school/university);
- Sports function (fitness room);
- Shop function (shopping mall);
- Other functional use (e.g. parking garage);
- Structure other than a building (tunnel).

Different use functions can be combined in one building and can be in the same fire compartment (not always). The 12 use functions are often further specified into subcategories depending on the requirements to be assessed. For example, in a health care function, different requirements apply to areas with bed spaces and areas where these is not present.

The requirements mainly depend on:

- The use function, in functions where people sleep, or for use by less self-reliant persons, the requirements are stricter than for example an office function (for example by requiring additional requirements for a fire alarm system or additional fire compartmentation).
- The height of the building. The higher the building, the stricter the requirements. For example, from a height of 20 meters (location of the highest floor), additional requirements apply for fire brigade lifts, extra space for a staircase. Incidentally, there are many more height measurements in the BBL where there is a jump in the requirements to be set.
- The number of people present. If the occupancy is low, for example, the walking distance may be 60 meters, with high occupancy the maximum walking distance is limited to 30 meters. The number of people present is also important for the required capacity of the escape routes.

### 4.4.4 Portugal

In Portugal, fire safety legislation applies nationwide, with slight differences for the autonomous regions of Madeira and Azores. There are two main pieces of legislation:

1. Lei n.º 123/2019, de 18 de outubro (Law n.º 123/2019, published on October 18th) - Regime Jurídico da Segurança Contra Incêndio em Edifícios (Legal Framework for Fire Safety in Buildings);

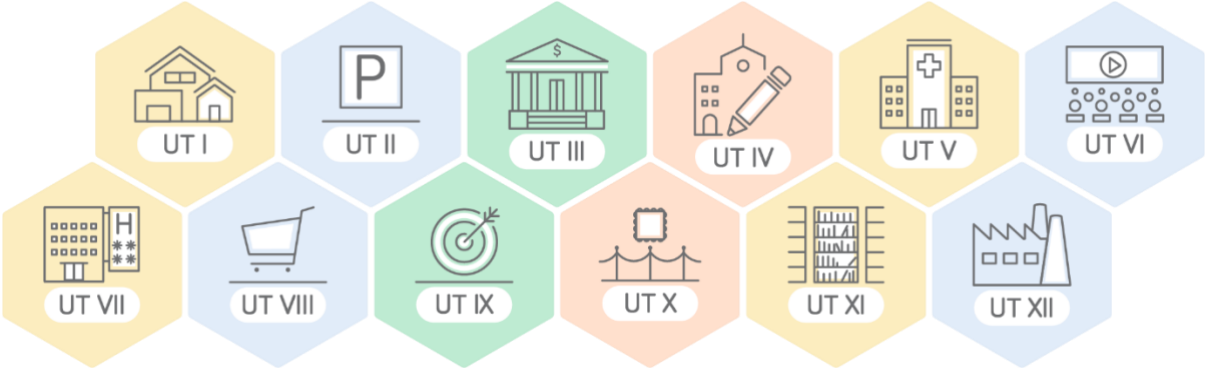
2. Portaria n.º 135/2020, de 02 de junho (Ordinance n.º 135/2020, published on June 2nd) - Regulamento Técnico de Segurança Contra Incêndios em Edifícios (Technical Regulations for Fire Safety in Buildings).

All new buildings or their autonomous compartment, whatever their use or surroundings, are subject to the fire safety regulations.

Also covered by the regulations are buildings that support very specific industries or activities, such as pyrotechnics and the extractive industry, establishments that process or store explosive or radioactive substances and products, oil and gas plants, etc.

The Legal Framework for Fire Safety in Buildings classifies buildings into 12 use types (UT), namely:

I. Residential buildings;
II. Car parks;
III. Offices;
IV. Schools;
V. Hospitals;
VI. Assembly and recreation;
VII. Hotels and restaurants;
VIII. Shop and commercial;
IX. Sports buildings;
X. Museums;
XI. Libraries;
XII. Industrial, workshops and storage.



The Technical Regulation on Fire Safety in Buildings includes the following headings:

I. Object and definitions;
II. External conditions (access and facilities for fire-fighting, facades, …);
III. Fire resistance and compartmentation;
IV. Evacuation;
V. Technical installations;
VI. Safety equipment and systems;
VII. Planning the response to an emergency;
VIII. Specific prescriptions for some types of buildings.

## 4.5 FireBIM Matrix

Based on the workflow identified above, the FireBIM matrix is created.

The FireBIM matrix is a collection of definitions of objects and properties needed to evaluate fire safety of a design. The matrix contains the rules and the link to the properties and objects necessary for that rule.

Strategically, the development of the matrix follows an approval and status workflow, which can be compared to the *ISO 19650 CDE-workflow*: at first, we start with a draft or work-in-progress version (WIP), which is created by the fire experts, collecting all concepts, definitions, properties and other related metadata. This is done as Excel worksheets. The second level can be seen as having a SHARED status: a version which can be used and consulted by others, both within the FireBIM consortium, but also beyond. This version will incorporate any updates from the WIP-version at agreed milestones and uses the Notion platform. This will be used by the BIM and Linked Data experts to develop the ontology, the transformation into digital and structured formats. And finally, a formal and public version will be provided in a software and platform-independent open format, most likely as an open database, spreadsheet or graph, which represents the PUBLISHED state.

### 4.5.1 First iteration of the FireBIM Matrix (Excel) - WIP state

The first draft version related to Compartmentation has been created in *Microsoft Excel*. In this workbook, the first worksheet contains the aggregated list of required properties related to compartmentation size, collecting the properties and objects from Denmark, Belgium, Portugal and the Netherlands. There are references to the original source articles from the national regulations, together with a list of linked properties. Figure 2 shows the the first worksheet of the Excel version.

*The definition of the properties and objects are found in the other worksheets, split up for each country.*

Figure 3 shows a fragment of the Danish worksheet. It shows a list of objects and properties, grouped by domains and including the original name (in native language), but also a basic English translation, for better comprehension. Many of these regulations are only available in the national languages, so no official translations are available. These are the properties which have been referred to from the main worksheet, shown above.

| Rule | Country | Document | Articles | How to | Properties |
|---|---|---|---|---|---|
| Compartment-Size | BE | KB/AR | Annex 2/1 - 2.1 + Annex 3/1 - 2.1 + Annex 4/1 - 2.1 | Floor surface, including colums, walls or elements resting on the floor, but excluding enclosed staircases and enclosed vertical technical shafts and technical rooms. A technical room should be a seperate compartment. | Room-type:staircase / Room-type:vertical_shaft / Room -type:technical / Compartment -automatic fire extinguishing system / Compartment-Smoke and heat extraction / Compartment-surface / Compartment-internal staircase / Compartment-number of building_layers |
| Compartment-Size | DK | BR18§455 + Appendix 3 (BR18-VK5-B03) | BR18-VK5-B03-Tabel 4.2.5 | The total area of the fire compartment is calculated as follows:<br><br>by adding the gross areas of all floors, including inserted floors, basements and usable attics as well as balcony openings, conservatories, connecting corridors and similar.<br>Rooms that pass through several floors are only included in the floor in which the floor is located. However, both external and internal stairs, stairwells, balconies, installation shafts and elevator shafts are counted for each floor.<br>The floor area is not included:<br>Open balconies (completely open above the railing on at least 2 sides)<br>Open roof terraces.<br>Bed lofts with an area of up to 4.5 m².<br>Projection of external stairs and balconies on the ground.<br>External fire escape stairs (escape stairs).<br>External insulation of a maximum of 25 cm.<br><br>The floor area is measured in a plane determined by the top of the finished floor to the outside of the limiting external walls with the following deviations:<br>1) In usable attics, the area in a horizontal plane 1.50 m above the finished floor is included within the intersection of the plane with the outside of the roof covering.<br>2) For open floors, gates, airlocks and the like, the area is counted to the line indicated by the outer walls of the building.<br>3) For common walls between rooms that are to be included in each floor area, measure to the middle of the wall; however, for common walls located above the boundary of the property line, measure to the boundary property line. | Use category / Building section - offices / Building-number of building layers / Compartment -automatic fire extinguishing system |
| Compartment-Size | PT | RT-SCIE and RJ-SCIE | §1 to 4 and §6 from Article 18º (RT)<br>§4 from Article 1º from Annex I (RT) | The total area of the fire compartment is calculated by adding the gross areas of all connected floors, including mezzanines. It is excluded any kind of exterior compartiment s like terraces or balconies.<br><br>Gross area is indicated by the outerwalls from each level.<br><br>It is only possible to connect different levels of an office fire compartiment that has:<br>1) less than 9,00m of height<br>2) maximum three floors connected<br>3) total floor area of 800m2<br>4) total area of 1600m2 (combined)<br>5) maximum one level below ground level | Gross area of a floor or fraction / Mezzanine / Height of a building / Fire compartment |

*Figure 2 : Required Properties from first worksheet (Excel)*

| Domain | Name | Type (object / property) | Unit | Property is linked to | Link to ISO | ISO-standard | Name (native language) | Definition - English (google translate - correction if necessary) |
|---|---|---|---|---|---|---|---|---|
| | Building-Firewall | | [-] | | | | Brandvæg | Wall in or against the neighboring boundary designed to prevent a fire from spreading to another property. |
| Evacuation | Clear opening area (geometric clear opening area) | | m2 | | | | Frit åbningsareal (geometrisk frit åbningsareal) | Geometric opening area (Ag) minus any obstructions in the opening (e.g. motors, opening mechanisms or grilles) and reduction due to the degree of opening of any window or hatch. |
| Fire Compartment | Comparment -Area - Floor area | property | m2 | Fire Compartment | | | Etageareal i brandmæssig henseende | The sum of the gross areas of all floors, including basements and usable roof spaces as well as balcony openings, closed porches, connecting corridors and similar. In connection with fire conditions, no deductions may be made, cf. BR18 § 455(3)(1), (4) and (5) and (4), which may only be used when calculating the building percentage. |
| Fire Compartment | Compartment - Subcompartment | object | [-] | Roomfunction | | | Brandcelle | One or more rooms from which the fire does not spread to other subcompartments during the time required for evacuation and rescue efforts in adjacent subcompartments. |
| Evacuation/Use category | Daytime occupancy buildings | property | Y/N | Compartment or building | | | Dagophold | Use that means that there are no sleeping persons in the building. Buildings used by people who are awake at night are also considered daytime occupancy buildings. |
| Evacuation | Distance - Actual travel distance | | m | | | | Ganglængde | The actual distance that a person must walk in a walking line to reach a given point. The walking line is laid out as the direct route, taking into account fixed obstacles or fixtures, and on a non-slip surface. Also used to refer to the physical length of a corridor. |
| Evacuation | Distance - Direct travel distance (theoretical) | | m | | | | Gangafstand | The theoretical longest distance a person must travel to reach the nearest exit or exit door by moving along a path of travel. The paths are laid out corresponding to the most unfavorable location of the person. In rooms, the distance along paths leading to the exit door in one direction only should be multiplied by 1.5. |
| Rescue service | Distance - Hose path | | m | | | | Slangevej | Distance for pulling the rescue service hoses to be determined corresponding to the length of the corridor. Any contribution from hose hauling via inside the staiweel or external hoisting to the stairwell must be included corresponding to the vertical distance. |

*Figure 3 : Danish worksheet screenshot (Excel)*

The matrix is also linked to the different flowcharts, created to document the logical decision flow found in the clauses of the regulation. The flowcharts translate a written rule into a graphical format, easy to read and follow.

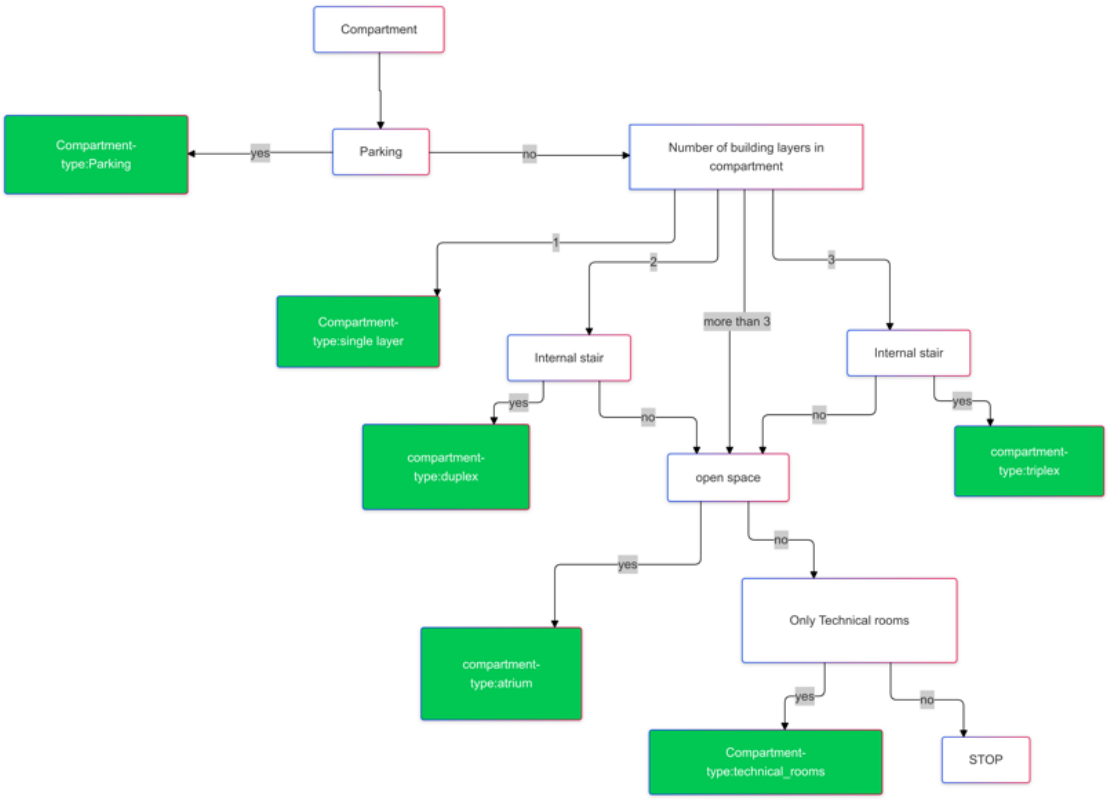



*Figure 4: Example of a flowchart explaining compartment types in the Belgian regulation*

While important for cross-national understanding, these diagrams are not the final source documents for the FireBIM platform, but act as a confirmed interpretation of the regulation logic by the fire experts. Deliverable D2.2 and D2.3 further expand on the actual digitization and structuring of these codes into machine-interpretable formats, ready to be using in Automatic Compliance Checking.

Throughout the FireBIM project, fire experts will continue to develop the FireBIM matrix, refining the rules and expanding it with more and more complex rules. However, it is also understood that within the scope of the FireBIM project, this is a continuous effort beyond the project timeframe. It is understood that it is more important to have a clear methodology, and a considerable subset of the regulations encoded, across the participating partner countries, rather than attempting full coverage of all relevant regulations for all EU countries. Future work can introduce new countries and add a wider variety of the national regulations into the matrix.

### 4.5.2 Converting and publishing the matrix into a database – SHARED state

As rules become more and more complex, and more and more complex relations will occur, using Excel presents limitations, as it will never properly work as a database, especially when linking information across tables and views.

After some experimentation using a few *no-code* platforms for information modelling and publication, such as *Airtable*[1], *Baserow*[2] and *Notion*[3], the first version of the matrix was transferred into Notion. This presents more options for linking between objects, properties, articles and documents and provides methods to define the dependency hierarchy between properties or rules and to capture mappings between e.g., terms and classifications or the IFC scheme.

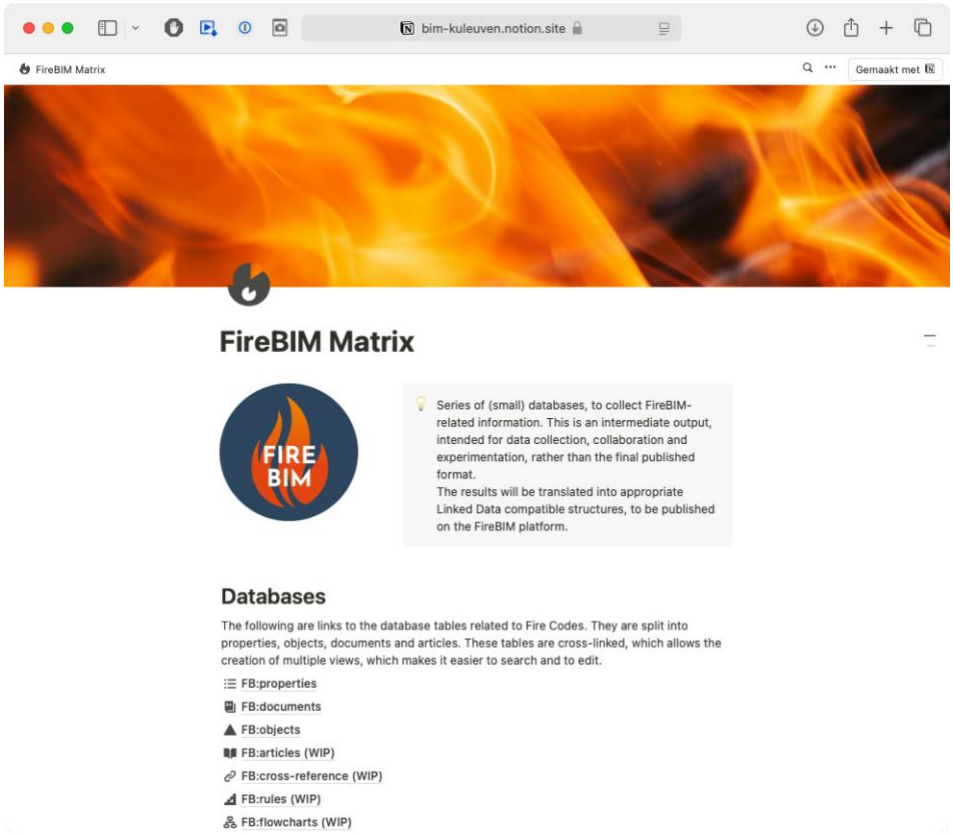



*Figure 5 : Landing page of the FireBIM Matrix (Notion)*

Within this system, the matrix behaves more like a proper database: different tables are constructed, split across objects, properties, but also documents, articles and rules. In this structure, the cross-linking between objects and properties, but also the relation between national terms and the unified European terms is easier to encode.

The following image displays the "*Mapping to ISO terms*" view of the "*FB:objects*" table, illustrating not only how object definitions at national level relate to the concepts at European level, but also the

[1] https://airtable.com
[2] https://baserow.io
[3] https://www.notion.com

possibility to map such terms to official, standardized terms from relevant ISO or CEN standards. Many of the objects have a related definition in ISO 6707-1.

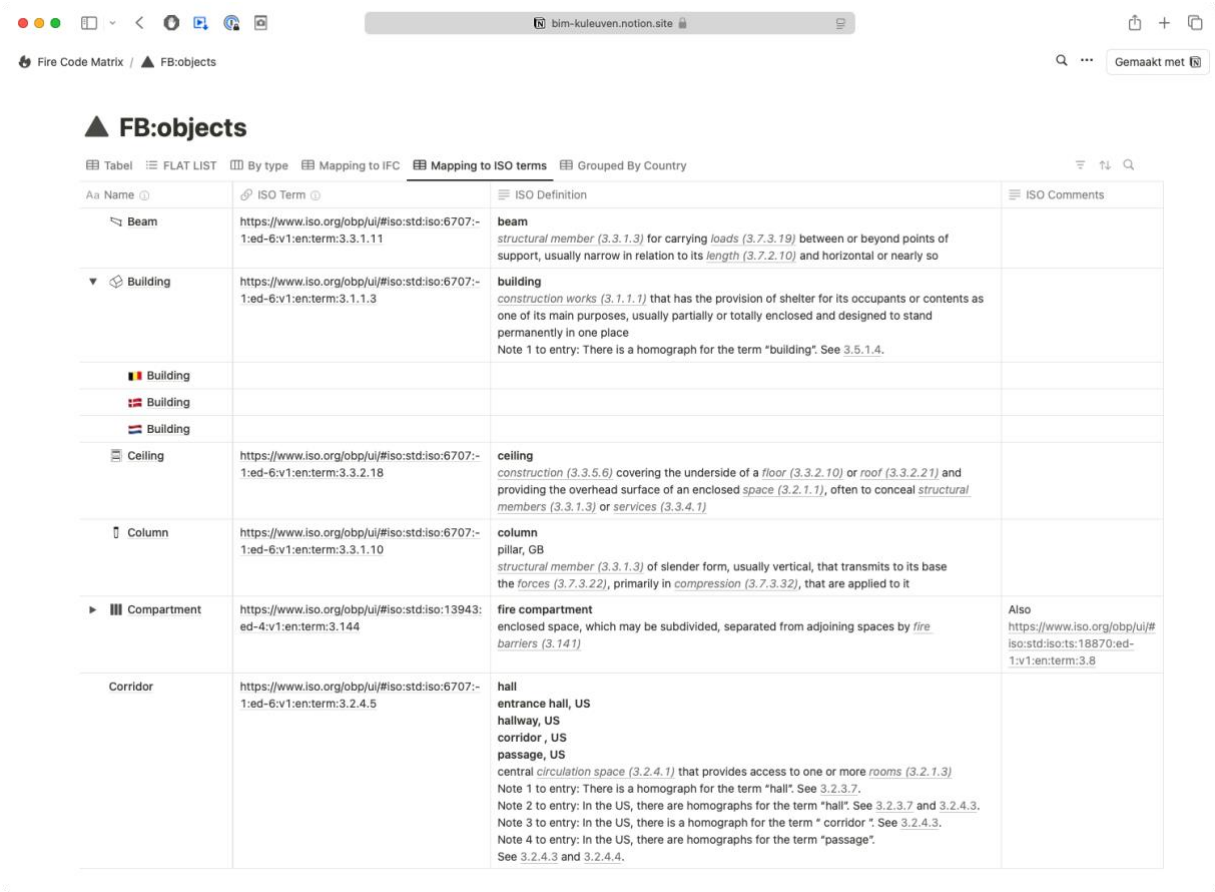



*Figure 6 : Fragment of the objects table (Notion)*

This matrix also contains a first iteration of the mapping between objects and properties against the IFC-scheme, required for further integration into BIM-based workflows. It also collects some considerations related to the mapping, as not every concept required for FireBIM is readily available in the IFC-scheme. Where possible, the mappings are set at the overarching European definitions, implying that country-specific mappings are inherited from the higher level, unless when overridden.

The final image shows a fragment of the "*By Object*" view of the "*FB:properties*" table. This shows how the building object has different country-specific variants, each containing country-specific properties, displayed in English and in the native language.

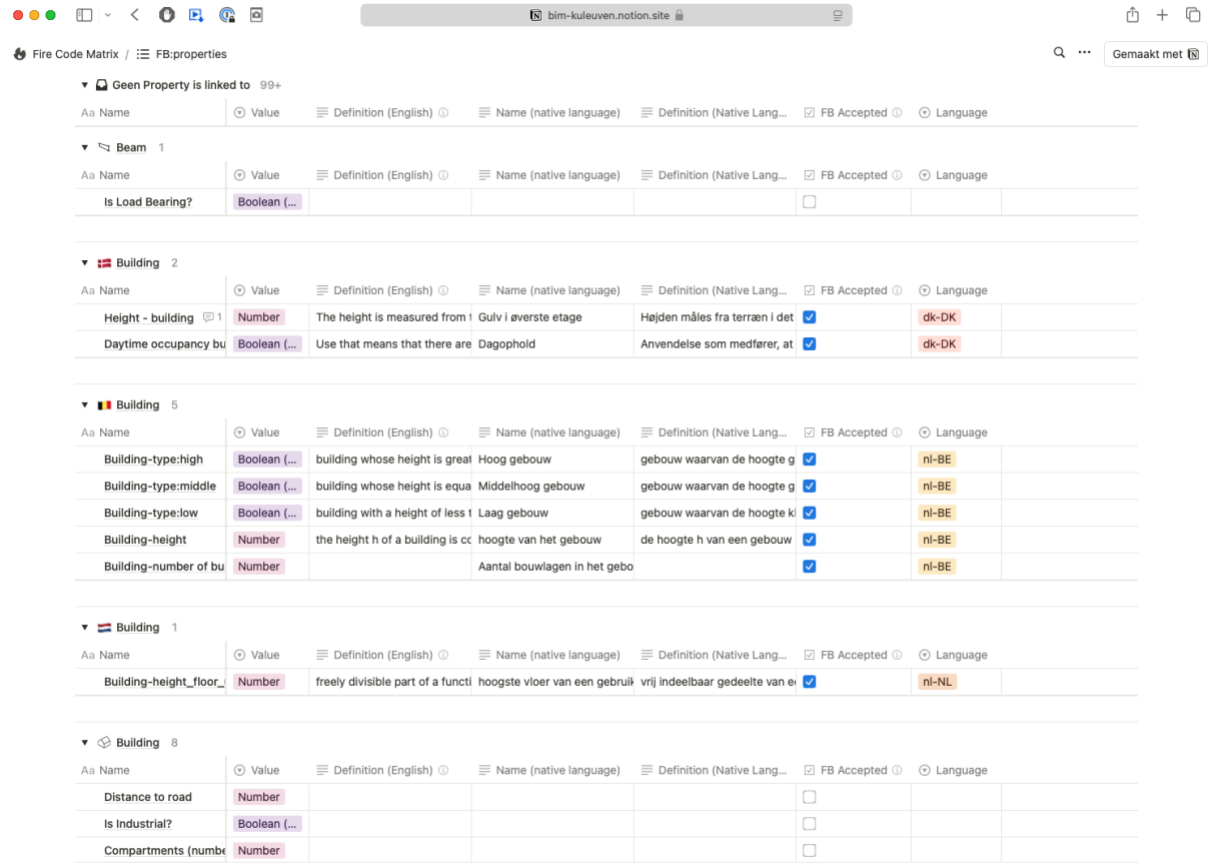



*Figure 7 : Properties table (Notion)*

The Notion database contains the full content of the first iteration of the FireBIM matrix from the Excel workbook.

At agreed milestones, the fire experts will present updates to the WIP matrix, to be incorporated into the SHARED Notion database, in so far changes are not already made directly in the database.

This Notion database can be consulted online in read-only mode (https://bim-kuleuven.notion.site/FireBIM-Matrix-8970296f91a94d969a1c4ecff8b83848), while invited project members have editing permissions, to refine and update the content in real-time.

### 4.5.3 FireBIM Matrix – PUBLISHED state

While the Notion database can be consulted online and represents a collaborative environment, it is the clear intention within the FireBIM consortium to provide the final outcomes into an open format – not embedded in proprietary software or databases. For this, through the export options of Notion (via CSV) or the API-connections, the content of the database will be transformed into different open formats, for public dissemination, such as spreadsheets, database (e.g., SQLite) and most notably as a graph (e.g., TTL). It may be possible to also generate a PDF report or other formats, but that has not been decided now. The structure of the graph aligns with the FireBIM ontology, as described in D2.2.

Since this will take more efforts and investigation, it is foreseen to deliver the published version at a later stage within the project timeline and focus on the content in the SHARED state for this deliverable.

# 5 References


[1] European Committee for Standardization, EN 1992-1-1: Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings, CEN, 2004.

[2] European Committee for Standardization. (2005). *EN 1993-1-1: Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings*. CEN.

[3] European Committee for Standardization, *EN 1995-1-1: Eurocode 5: Design of Timber Structures – Part 1-1: General Rules and Rules for Buildings*, CEN, 2004.

[4] European Committee for Standardization, *EN 1996-1-1: Eurocode 6: Design of Masonry Structures – Part 1-1: General Rules for Buildings*, CEN, 2005.

[5] European Parliament & Council. (2011). *Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC*. Official Journal of the European Union, L 88/5. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R0305

[6] International Organization for Standardization. *ISO 13943:2023 - Fire Safety – Vocabulary*. 2023. ISO.https://www.iso.org.