OPENBIM DIGITIZATION OF THE ITALIAN FIRE PREVENTION CODE: AN IMPLEMENTATION ON REACTION TO FIRE

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Abstract

The study explores the topic of digital transition applied to fire prevention. It investigates the potential of Industry Foundation Classes (IFC) implementation in Fire Safety Engineering. Literature review highlights that, at this moment, IFC classes and attributes related to fire prevention are limited and poorly defined. In particular, the study analyses the reaction to fire of building elements and develops an algorithm that automates the code checking process through an experimental application based on a simplified building model. The results prove that the IFC data model is promising for the Fire Prevention Code's digitization.

Introduction

In recent years, the AEC industry has undergone many changes due to the progressive implementation of Building Information Modeling (BIM). Globally, based on the ISO 19650 standard, the use of open formats has become mandatory to ensure interoperability among various actors and to protect data transmission throughout the building lifecycle. In this sense, ISO 16739 defines the Industry Foundation Classes (IFC) format as an international standard for information exchange within BIM processes. Despite the ambitions, the standard is not fully usable. To date, some engineering topics, such as energetics and its simulations, acoustics, fire protection or maintenance scheduling, are not yet fully manageable through the IFC standard. The main problem concerns the lack of a common international standard for engineering domains. Each country, having its own legislation, imposes different approaches that prevent a unified vision. This is notably typical in the field of fire prevention. An initial harmonization effort among European states concerns the reaction to fire of building materials. Many countries use Euro-classes to classify the reaction to fire of materials (Zaccarelli, 2020). Even Italy, while having its own system, has made mandatory for manufacturers to use products classified only according to the Euro-classes since October 2023.

To encourage digitization, in the 2020 the National Fire Service promoted the Fire Digital Check (FDC) project with the circular STAFFCNVVF prot. n. 18332, which aimed at the acceptance of the requirements of the Ministerial Decree 560/17. The final goal of this project is to automate the verification of the authorization process, thus reducing the time to verify projects compliancy, optimizing resources and at the same time ensuring greater control of projects, which results in high levels of safety and quality (Negri, 2022).

This initiative is aligned with the activity of the Regulatory Room of BuildingSMART, which points at the automation and digitization of building approvals (Moreno, 2020).

To achieve it, the FDC project identified three steps:

1. Digitization of the code: digitize and standardize the language for compiling a fire prevention project;
2. Project validation/verification: digitize and standardize the verification process of a fire prevention project to automate the check;
3. Performance management: digitize and standardize the performance management language for the entire life of the building also in terms of fire prevention.

Currently, only the first of the three steps outlined by the FDC has been analysed and lead to the creation of proprietary parameters (Lala et al., 2022). However, the work does not consider the actual development of the IFC standard; actually, proprietary parameters were created to describe information which was already available in IFC data model. This study, first, focuses on the reaction to fire to demonstrate the feasibility of digitizing the Italian Fire Prevention Code predominantly through the use of native IFC parameters; second, it wants to demonstrate how it is possible to pursue, the automation of project approval based on the ISO 16739 standard, in accordance with BuildingSMART's Regulatory Room and the principles behind the FDC project,. A small project was implemented with the identified parameters, and finally, using a Python script, it was possible to check the compliancy of the information model with the national standard.

Background

Italian Fire Prevention Code and reaction to fire

According to a study conducted by a European Commission of 34 countries, only 30 of them have a legislation based on a performance approach (Athanasopoulou et al., 2023). The change for most states came after 2015. In Italy, just in 2015, with the approval of the new Fire Prevention Code, there was a shift from a prescriptive approach to a performance based one.

This transition requires a technical understanding of fire safety principles, followed by the application of proven engineering methods and calculations (Puchovsky, 1996). Through a performance regulation, it is possible to identify, from the actual fire risk, a precise strategy targeted to the needs of the specific project.

The Italian Fire Prevention Code is divided into four parts, two of them were analyzed: sections G and S. In the first section, the risk profiles of activities and the methods for their determination are defined. In the second section, ten fire prevention measures applicable to all activities are described. The first measure is reaction to fire.

Reaction to fire expresses the “behaviour of a material that, with its decomposition, participates in a fire to which it has been subjected under specific conditions”(Ponziani, 2019). It is a passive measure of fire protection that effects the fire prevention strategy in the initial phase (pre-flashover phase). This measure delays the achievement of the flashover condition because it limits the ignition and participation of materials in combustion, preventing or delaying the spread of fire and smoke.

On a regulatory level, the degree of material participation is assigned through the determination of certain classes of reaction to fire. These must be assigned to all building materials and products, including coatings, insulation, mobile fittings, and curtains.

This performance specification is assigned by laboratory tests performed by technical reference standards, through which specific classes of reaction to fire are determined. In the Italian Fire Prevention Code minimum reaction to fire classifications are expressed, referring both to Italian and European classification systems. These are given for each performance level. From 2022 with Ministerial Decree No.251 of 14/10/2022, the use of Italian classes for the classification of reaction to fire of construction products is no longer allowed. These products become classifiable only with the European classes according to EN 13501-1.

The Italian reaction to fire classifications, indicated with [Ita], refer to the DM 26/06/1984 which identifies six classes: from class 0, relative to non-combustible materials, to class 5 with the increasing of the material's participation in combustion. These classes refer to furnishing materials and products, such as furniture, moquettes, curtains, blankets and parquet floors, but also to scenic elements and tent covers. The reaction to fire class for upholstered furniture (armchairs, sofas, mattresses, upholstered chairs) are 1IM, 2IM, 3IM, this increases as the fire participation rate increases. The reaction to fire class assigned must refer to the whole composition of the covering, the upholstery and any interposed element.

European reaction to fire classes is only assigned to products compliant to Regulation 305/2011/EU concerning construction products, with reference to DM 10/3/2005. In Code's tables, they are indicated with the abbreviation [EU]. According to the EN 13501-1: 2018, the European classification is carried out by an alphanumeric code made up of the combination of main classes (A1, A2, B, C, D, E, F) with complementary classes relating to smoke production (s1, s2, s3), flaming droplets (d0, d1, d2) and acid smoke production (a1, a2, a3).

Table 1: Additional classification for smoke production

Acronym	Description
s3	No limitation of smoke production required
s2	The total smoke production as well as the ratio of increase in smoke production are limited
s1	More stringent criteria than s2 are satisfied

Table 2: Additional classification for flaming droplets

Acronym	Description
d2	No limitation
d1	No flaming droplets/particles persisting longer than a given time occurred
d0	No flaming droplets/particles occurred

Products that, although not intrinsically hazardous, have not yet been classified (Sabatino et al., 2021) belong to class F. Moreover, subscript abbreviations are sometimes added to the main classes in the following cases:

- fl in the case of floor products;
- L in the case of linear thermal insulation;
- ca in the case of electrical cables.

The compliance check of materials' behaviour in terms of reaction to fire depends on the performance levels assigned. Thus, it is necessary to establish the performance levels for each area of the activity through the attribution criteria. These are indicative and in the case of reaction to fire, a distinction is made between an escape route and a room. This distinction is necessary because of the importance of escape routes in saving lives, which require a more demanding performance. Consequently, the accepted performance level for rooms is generally immediately lower than the one indicated for escape routes of the corresponding risk profile.

As shown in Table 3, four performance levels were identified, each with its own description in qualitative terms. It emerges that only those spaces falling within performance levels II, III and IV are those in which the participation of materials in combustion is to be limited (Dattilo & Cavriani, 2019).

Table 3: Reaction to fire's performance levels

Performance level	Description
I	The contribution of materials to the fire is not assessed
II	The contribution of materials to the fire is significant
III	The contribution of materials to the fire is moderate
IV	The contribution of materials to the fire is almost negligible

For each performance level there is a corresponding compliant solution which consists of the use of materials belonging to certain groups (GM) identified by a number varying from 0 to 4 as their contribution to the fire increases.

The GM0 materials group does not make any contribution to fire and consist of all those materials with Italian reaction to fire class 0 or European reaction to fire class A1. It includes all the, so-called, incombustible materials. Materials group GM4, on the other hand, consist of all the ones that are not included in groups GM0, GM1, GM2, GM3. Thus, it includes unclassified materials and class F construction products. Since there is no requirement at the first performance level, compliant solutions are only defined for performance levels II, III and IV as shown in Table 4.

Table 4: Compliant solutions for each performance level

Performance level	Compliant solutions
I	No requirement
II	GM3
III	GM2
IV	GM1

The reaction to fire classes of materials included in materials groups GM1, GM2, GM3 are specified from table S.1-5 to table S.1-8 of the Italian Fire Prevention Code.

Reliability of IFC data model to support BIM based Fire Safety code checking

IFC is an international standard, organized into hierarchical classes through which the building system can be described. IFC should describe all aspects of all engineering disciplines through entity, types and relationships.

All subjects, from different disciplines, can use the IFC standard to exchange information. To ensure fast and lightweight exchange, IFC can be filtered with reference to the Model View Definitions (MVD). BuildingSMART has created many official MVDs. Currently, a sponsor search is underway to build a new MVD dedicated to FireSafety Engineering. The main limitation always concerns the lack of single legislation, in fact this new MVD is a consequence of a proposal of the International Fire Safety Standards (IFSS) Coalition. To reach "the first agreement on fire safety actions on an international scale", the consortium agreed to a 10-year commitment until 2032 (buildingSMART International, 2022). Without the IFC standard the exchange of information between the various subjects would be much longer and complicated because the various software would have to find a way to talk to each other, instead by using the IFC standard all software would be able to speak the same language (Laakso & Student, 2012). To ensure a future in the AEC industry based on interoperability among various players, BuildingSMART continues to rework and improve the IFC standard. With the roadmap developed in 2020, the organization wanted to emphasize how the future of the construction industry must move away from adopting solutions that do not work "out of the box" and embrace generic solutions (buildingSMART, 2020).

However, the use of IFC encounters difficulties related to incorrect use by actors and inappropriate reading and writing by some software. In the field of fire prevention, the prime example of a lack of standardized communication between different software is with fire dynamic simulation (FDS). To be able to simulate the fire, inside the building, simulation software first needs geometric information. Although within the IFC data model the geometric and spatial structure is well defined many studies have shown that it is not so easy for dynamic simulation software to receive information from the standard (Dimyadi et al., 2008) (Shi et al., 2019). Most software can only read CAD and DXF format so all relational information cannot be exported and read, or software only processes a limited set of data from IFC, sufficient to obtain basic building geometry and properties (Spearpoint & Dimyadi, 2007). Another research (Siddiqui et al., 2021) highlights the difficulty of operators in exchanging performance information. Most fire and evacuation modelling tools do not export results via open formats, while those that are able to do so, limit the export to geometric data, and not to the information that must be provided. The most obvious problem relates to the gaps that IFC has in relation to fire prevention regulations.

Previous research (Zanchetta et al., 2023) highlights precisely the limitations of the IFC data model with reference to some aspects of fire prevention. This research shows how to include information related to fire resistance, compartmentalization, and evacuation; it also introduces the discussion related to the reaction to fire of the materials highlighting how a unified reference is lacking. This lack leads different parties to freely create proprietary parameters, although they are already available in the standard, clashing with the concept of interoperability. One draft project, developed by a team related to the Italian Fire Digital Check project followed this second approach. Although the IFC standard was analysed, the team merely transcribed the Fire Prevention Code through a set of proprietary parameters. Regarding the reaction to fire class, the research team created a proprietary PropertySet named "VVF_Reazione al fuoco" within which there is the property to express the fire reaction class "Classe di reazione al fuoco".

BIM and automated code checking

Regulatory check is one of the aspects most prone to human error, so in recent years there has been an increasing interest toward automation. Automated rule checking (Eastman et al., 2009) consists of verifying that the project meets certain requirements. Rules should have the outcome "passed", "failed", "warning", and it can be structured into four stages: (1) rule interpretation and logical structuring of rules for their application; (2) building model preparation, where the necessary information required for checking is prepared; (3) the rule execution phase, which carries out the checking, and (4) the reporting of the checking results.

There are several approaches available in literature related to automated rule checking. These are divided into systems known as "black box" and "white box" (Nidhra, 2012). The first ones involve the use of specific software generally difficult to implement and built through hard coding, while the second ones are transparent and involve the use of programming with codes or through visual programming tools (Ghannad et al., 2019). The latter approach is widely used mainly for the easy accessibility.

The software-based code is proving to be a popular choice for public administrations, which are thus able to combine a simplification of project approval work and with a potential saving of time and costs (Eastman et al., 2009). The most famous project is undoubtedly Singapore's CORENET (COnstruction and Real Estate NETwork), founded by the Minister of National Development (available at https://www.corenet.gov.sg/general/e-info.aspx). This project consists of three modules: CORENET e-Submission, CORENET e-PlanCheck and CORENET e-Info. With the e-PlanCheck module and FORENAX, it is possible to conduct a code check that includes different standards including those related to the fire Code (Greenwood et al., 2010). This project is a technology initiative that aimed to bring Singapore to the full integration of the phases of a building's lifecycle using IFC building model data.

This project was emulated in Norway with ByggSok project. The pilot project HITOS was checked with Solibri Model Checker (SMC) an IFC based commercial solution used for code checking. This software reads IFC model and is based on the Norwegian Stats'bugg handbook.

SMC and CORENET like many other applications, however, are "black box" because they present a set of rules that can be modified by the user and adapted to the specific project. On behalf they do not maintain the same freedom in creating new rules; the user must work on the product API to create them, which, however, are not public but only the developers themselves have access to them. (Simone et al., 2017).

Another approach to code checking is offered by visual programming solutions, which referring plug-ins such as Dynamo for Revit and Grasshopper for Rhino that support visual programming. A method, based on Dynamo, combines a semantic translation of the Malaysian fire safety regulations and the corresponding properties in Revit (Ismail et al., 2023). The regulations phrases are marked-up with four types of markers, using two of them ("requirements" and "exceptions") to identify the necessary parameters in Revit. Eight scripts in Dynamo are created to check the compliance of the BIM modelled elements with the regulation's provisions. Although this approach is very interesting, especially for the semantic translation implemented on regulatory aspects, it is a method focused on Revit's proprietary format and Dynamo, leaving no room for implementations in open formats.

Visual programming offers ease of programming and access to information, but it is based on solutions tied to proprietary formats as opposed to solutions implemented through scripts in python or java, which offer a wide range of completely open-source tools. IfcOpenShell is a python module which allows access to the elements contained in an IFC file and their properties, and its use is widespread because of its ease in extracting, manipulating, and creating information in an IFC data model. Several examples showing the potential of IfcOpenShell and its ability to extract information are available in literature (Narinder Singh et al., 2020; Singh et al., 2022). An interesting example of this Python module is used in an automated implementation of escape route information in IFC files (Haselberger, 2023).

The last relevant approach to code checking lies in the semantic web and graph databases. An interesting example (Peng & Liu, 2023) proposes an automatic code compliance checking based on BIM and Web technology. This study added the technique of knowledge graph to the structured processing of the rules. Its power lies in the application of natural language processing techniques to transform requirements into checking rules in the form of knowledge graphs.

Experimentation

In this section, it is illustrated the experimentation concerning the digitization of the reaction to fire measure. The purpose of this experimentation is to demonstrate that it is possible, through painstaking research, analysis, and definition, to achieve the objectives of the Fire Digital Check using exclusively ISO 16739. This turns out to be much more correct for the collaboration, interoperability and knowledge reuse because it does not consider parameters defined arbitrarily but relies on parameters already defined within an international and recognized standard, embracing the OpenBIM methodology. The following sub-sections explain the conceptual workflow and the translation in OpenBIM protocols.

Model construction

To test the experimental application, it was decided to consider a prototype nursing home. Therefore, the risk profile concerning human life safety (R_{life}), determined by the prevailing characteristics of the occupants, would be either D1 or D2. This assumption will then be used to determine the performance levels to be associated to the spaces. The digital model was developed using Autodesk's Revit. The modelled building, rectangular in shape, consists of two floors above ground, identically spaced. Each of the two floors, connected by a stairwell, consists of three rooms of equal size and a hallway (Figure 1, Figure 2, Figure 3).

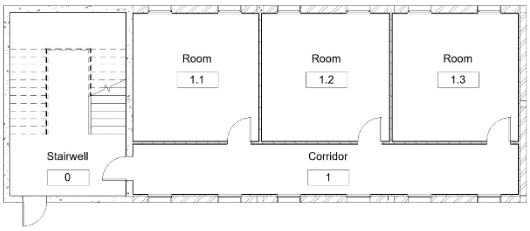

Figure 1: First-floor rooms

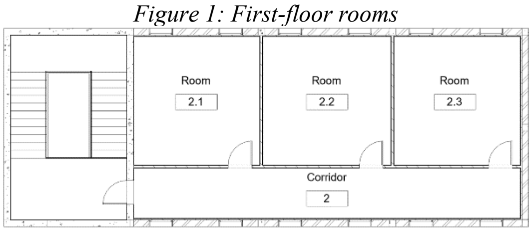

Figure 2: Second-floor rooms

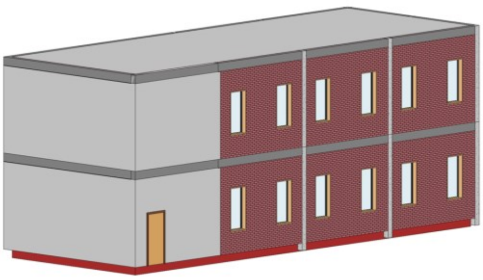

Figure 3: Building's Revit model

Check procedure

Before proceeding with the experiments, a verification procedure was devised. Starting with a room, which defines the required performance level, it is possible to identify all the boundary elements and, for each of them, check if their reaction to fire classes is compliant or not.

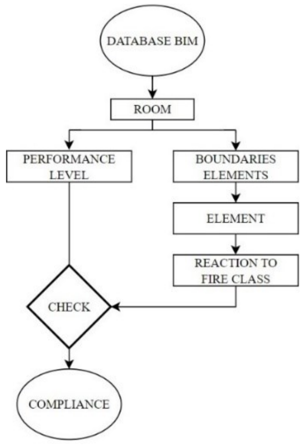

Figure 4: The assumed check procedure

Analysis of IFC attributes

For the study, the IFC version used is 4.3.2.0, made official in January 2024 (buildingSMART International, 2024).

Before compiling in the model the reaction to fire properties, it was necessary to understand where the information had to be placed according to IFC.

Reaction to fire is essentially a material property. In IFC materials are described through the class *IfcMaterial*. This entity is part of the resource domain, so it is just used to describe objects, it cannot have an instance of its own but must be related through *IfcRelAssociatesMaterial* to an entity of a higher layer. The entities in the resource layer do not have a unique identifier (Laakso & Student, 2012). For this reason, to clearly identify the uncompliant elements of the building, the reaction to fire property must be related to an object itself and not be attributed trough the material. This property can be attributed to objects such as walls, covering, roofs, siding, floors. Entities hierarchically lower than *IfcBuiltElement* and their properties were analysed. Specifically, the *IfcWall*, *IfcCovering*, *IfcSlab* and *IfcRoof* entities were analysed.

Regarding the reaction to fire performance of the elements, it was seen that *IfcWall*, *IfcSlab*, *IfcCovering* have two interesting properties: *Combustible* and *SurfaceSpreadOfFlame.* As highlighted in the previous research (Zanchetta et al., 2023) *IfcCovering* has a further possible property: *FlammabilityRating*. *IfcRoof*, instead, has none of these properties, as shown in Table 5.

Table 5: Entities of the IFC data model and the highlighted properties

	Property		
	FlammabilityRating	SurfaceSpreadOfFlame	Combustible
IfcCovering	✓	✓	✓
IfcRoof			
IfcSlab		✓	✓
IfcWall		✓	✓

Firstly, the properties *FlammabilityRating* and *SurfaceSpreadOfFlame* can be filled in with a string of text or numbers up to a maximum of 255 characters, while the property *Combustible* can assume a boolean value. The boolean value TRUE indicates that the object is made up of combustible material. If only this property is compiled, it could be assumed whether the material is combustible or not and thus whether it belongs to the GM0 material group (European class A1 and Italian class 0). However, this information is not relevant for the purpose of this research, because it does not provide any information about the specific reaction to fire class of the material and is therefore not useful for automatic verification of regulatory compliance. To best specify the fire behaviour of a material, it is necessary to assign to it a specific reaction to fire class, so the study proposes the inclusion of the specific class within the property.

FlammabilityRating and *SurfaceSpreadOfFlame* are very similar to each other (Table 6). The first one refers to the flammability of materials and the second to the way flames spread on the surface. The *SurfaceSpreadOfFlame* property seems to refer to the British standard, BS 476: Part 7: 1997, which defines a test method to measure lateral flame spread along wall and ceiling surfaces. The standard identifies four classes, from 1 to 4, of which Class 1 is the best in terms of flame propagation. However, this test doesn't specify the combustibility of a material. Instead, the European system based on Euroclasses (*EN 13501-1*, 2018), introduced in 2000 to eliminate trade barriers between member states and ensure consistent quality levels, refers to the reaction to fire of materials by considering not only the spread of flames but also many aspects, such as combustibility, the rate of participation in the fire and the ability to produce smoke. For this reason, the UK is still going through a transitional period in which it is still possible to find references to the national standard rather than the mandatory harmonized European classification, sometimes causing confusion about the performance of a given material as the two classifications refer to different aspects.

Table 6: IFC properties of interest

Property	Description
Flammability Rating	Flammability Rating for this object. It is given according to the national building code that governs the rating of flammability for materials
SurfaceSpread OfFlame	Indication on how the flames spread around the surface. It is given according to the national building code that governs the fire behaviour for materials
Combustible	Indication whether the object is made from combustible material (TRUE) or not (FALSE)

At the level of definition, it would be more correct to use the *FlammabilityRating* property because the concept of reaction to fire does not only refer to how the flame spreads on the wall, at the same time, this property it is attributable only to covering (*IfcCovering*). When the designer evaluates the reaction to fire of a wall, he must consider the whole stratigraphy not only the outermost layer although this one is more significant. So, it was decided to use the property *SurfaceSpreadOfFlame*. For the code checking, the reaction to fire within a space must be verified. The *IfcSpace* properties were analysed. As shown in Table 7, within the PropertySet *Pset_Risk*, there are four useful properties: *RiskType, RiskAssesmentMethodology, NatureOfRisk* and *RiskName*. The risk type Fire_Explosion was selected within the *RiskType* property, the regulatory reference (Fire Prevention Code) within the *RiskAssessmentMethodology* property, and the fire measure (reaction to fire) within the *NatureOfRisk* property. Finally, the performance level required for the fire reaction measure was associated with the *RiskName* property.

Table 7: IfcSpace Pset_Risk's properties

Property	Description
RiskType	Identifies the predefined types of risk from which the type required may be set
RiskAssessment Methodology	An indication or link to the chosen risk assessment methodology
NatureOfRisk	A description of the generic nature of the context or hazard that might be encountered
RiskName	A locally unique identifier for the risk entry that can be used to track the development and mitigation of the risk throughout the project life cycle

Selection of performance levels

Based on the use of the building, the model was implemented with the performance levels assumed within the *RiskName* property attributed to all rooms. According to the Fire Prevention Code, rooms and escape routes have different performance levels. Performance level 3 was assigned to rooms while performance level 4 (highest) was assigned to escape routes.

<Settings>

A	B	C	D	E	F
Type of room	Room number	Pset_Risk.RiskType	Pset_Risk.RiskAssessmentMethodology	Pset_Risk.NatureOfRisk	Pset_Risk.RiskName
Room	1.1	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	3
Room	1.2	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	3
Room	1.3	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	3
Corridor	1	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	4
Stairwell	0	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	4
Room	2.1	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	3
Room	2.2	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	3
Room	2.3	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	3
Corridor	2	FIRE_EXPLOSION	D.M. 3/8/2015 e s.m.i.	Reaction to fire	4

Figure 5: Properties of each room and evacuation route

Material selection

Various commercial materials were analysed and some with different reaction to fire classes were identified. A material with a reaction to fire class higher than the regulatory minimum was assigned to all walls except for one wall in rooms 1.1 on the first floor and 2.1 on the second one (Figure 6). For these two, wallpaper with a reaction to fire class lower than the regulatory minimum was installed. This distinction was necessary to validate the model-checking algorithm.

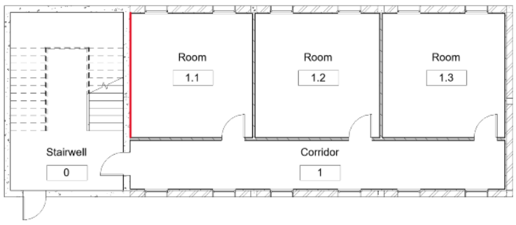

Figure 6: The wall where non-compliant wallpaper has been applied is highlighted in red. The same for the second floor

Algorithm development

The code checking algorithm was developed in open code using the Python programming language. Thanks to the IfcOpenShell library, it is possible to search all entities hierarchically below the IfcBuiltElement class previously identified properties for reaction to fire. This made it possible to implement computationally based compliance check. The script searches for every *IfcSpace* in the project the *IfcSpaceBoundaries* which enclose the room. The *IfcSpace* present the *Pset_Risk* which contains the *RiskName* property that express the reaction to fire's performance level. The algorithm reads the *RiskName* and compares the *SurfaceSpreadOfFlame* of each building element enclosing the *IfcSpace*.

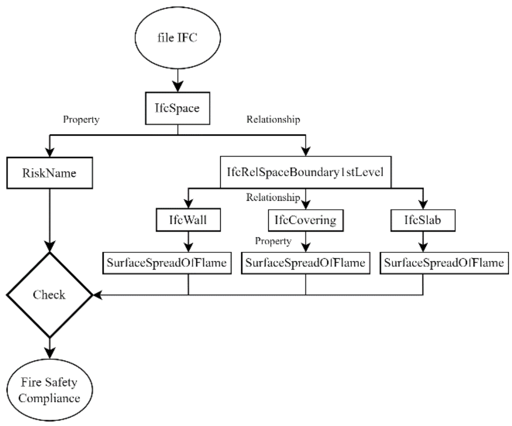

Figure 7: Script procedure

Results analysis

The algorithm was also set up to write an Excel file made up of several sheets, one for each room of the building, and one reporting every room and its compliance, which automatically is filled with True or False values. In the case of non-conforming elements, the global unique identifier (IfcGUID) and the name of the modelled element are reported. As can be seen from the Excel spreadsheets obtained, the only elements reported were the wallpapers installed in rooms1.1 and 2.1.

The algorithm was able to read all the boundary elements of each room, and to compare the values of the materials groups with the minimum values required by the performance level, thus automating the entire check. This approach, extended to all the other prescriptions contained in the Italian Fire Prevention Code could be the base of an automatic digital permitting, aligned with the BuildingSMART Regulatory Room's principles.

	A	B
1	IfcGUID	Element Name
2	0K1l1D0AXDQxbkzzu7PNr2	Base wall:WALLPAPER:144639
3		

report | 1.1 | 1.2 | 1.3 | 1 | 0 | 2.1 | 2.2 | 2.3 | 2

Figure 8: Excel results

	A	B	C
1	Room Number	Room Name	Compliance
2	1.1	Room	False
3	1.2	Room	True
4	1.3	Room	True
5	1	Corridor	True
6	0	Stairwell	True
7	2.1	Room	False
8	2.2	Room	True
9	2.3	Room	True
10	2	Corridor	True
11			

report | 1.1 | 1.2 | 1.3 | 1 | 0

Figure 9: Rooms' compliance report

Conclusions

In conclusion, the results give evidence of the high performance of the IFC format from the point of view of storing information, although they underline the difficulty of translating standards according to the logic of the IFC data format.

The study shows that, as a result of the normative translation, activities and analysis of the attributes and properties available in IFC, it is possible to use the properties already present within the IFC standard without creating new properties and to proceed to automatic code checking through the development of open algorithms. However, to achieve these results, it is necessary to have a detailed knowledge of the IFC architecture. Understanding which property to use was the biggest challenge because the definitions are not clear. Therefore, there is a need for BuildingSMART to comply with the standardization adopted by the different countries and to define a clear parameter within which the reaction-to-fire class can be entered, according to the Euroclasses. This research paves the way for many future developments, including refining what has been done about reaction to fire, digitization of other fire measures, and the mapping of regulatory requirements not currently covered by the IFC standard. The goal is the creation of an interoperable BIM database that serves both National Fire Service and fire prevention designers. The creation of an interoperable BIM database can be useful during design and verification for the issuance of the Fire Prevention Certificate.

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