The GIS-section of the building permit: the use of a BIM-based model to store geographic information

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Abstract. Building Information Modelling (BIM) is a key technology to achieve the digitization in architecture, engineering, construction (AEC), and facility management (FM) industry. A topic that has been less explored is the possibility of using the BIM model to digitize the building permit in order to help both designers and public administrations to automatize the procedure. This study aims to create a link between geodatabase information and building permit requirements using a digital model, analysing and classifying the Italian building permit standard requirements.

Key Words: Building Permit, Building Information Modelling (BIM), Geographic Information System (GIS)

1 Introduction

Digital transformation in architecture, engineering, construction (AEC), and facility management (FM) sectors has been a trending topic in the last years. A key technology to achieve the digitization is Building Information Modelling (BIM) [1], a representation of physical (geometric) and functional (non-geometric) information of a project [2]. BIM applications can be found in different stages of the building lifecycle, from early-stage design [3] to construction phase [4], up to operation and management (O&M) [5]. A topic that has been less explored is the possibility to use the BIM model to digitize the building permit (BP), a document granted by public authorities that legitimizes a building intervention. In Italy, this document is required for different interventions: new building, building renovation, shape changes, and exchange of intended use. Various interventions mean different information and documents required. BP redaction is a time-consuming and error-prone activity conducted manually with paperwork or, at best, PDF files [6]. Therefore, the building permit might represent an interesting case study to be processed with digital transformation [7] to help both designers and public administrations automate the procedure.

1.1 Background and bibliometric analysis

In recent years, other countries have investigated the possibility to digitalize the building permit process: for instance, Singapore developed CORENET [8], an internet-based system where industry professionals submit project-related files to regulatory authorities for approval; Norway elaborated ByggSøk [9], a public system that facilitates the electronic processing of zoning and building matters; the United Kingdom created Planning Portal [10], a system to provide online access to planning information and to submit online applications to any local planning authority in the country; and, South Korea proposed SEUMTER [11], a platform that currently bases the permission process on checking 2D drawings and is expanding towards checking based on BIM. Despite the differences, all the systems are trying to use both standard formats (IFC, COBie, etc.) and native file format.

A bibliometric analysis was carried out to define the ongoing direction of the scientific production about this topic. The Web of Science (WoS) and Scopus databases were queried (April 2021) with the keyword "*building permit**". The choice to use only one search term has the purpose to better understand the different research lines. A set of 363 results from WoS and 649 results from Scopus was found. The results have been then filtered, excluding the documents not related to the scope of the research (e.g., History, Agriculture, Water resources, etc.) and considering only the ones in English. At the end of the refining process, the final number of references was 136 (WoS) and 278 (Scopus). The defined sample was analysed using the R package Bibliometrix [12], version 3.0, in order to produce a bibliometric analysis. The annual scientific production from 1986 to 2020 (2021 was excluded because it is not yet completed at the time of the research) represents an increasing interest in the analysed topic, in fact, the annual growth rate is 11,76% (WoS) and 8,76% (Scopus). A significant increase of documents is registered from 2017 when a total of 30 references were published, and the peak was in 2019 with 50 references published. To better understand both the main topics included in these documents and how the research field is organized, network analyses were executed. Fig. 1 shows the author's keywords co-occurrence network (number of nodes of 30 and a minimum edge of 1). The results show that the structure is quite similar: the references are divided into three main clusters. The central cluster, led by Building Permit is more related to urban planning and land use; the cluster on the left considers the issue of rules interpretation and checking inside a BIM environment; and, the cluster on the right (red) presents a weak connection between GIS and BIM, underling that this is a recent topic and needs to be more investigate.

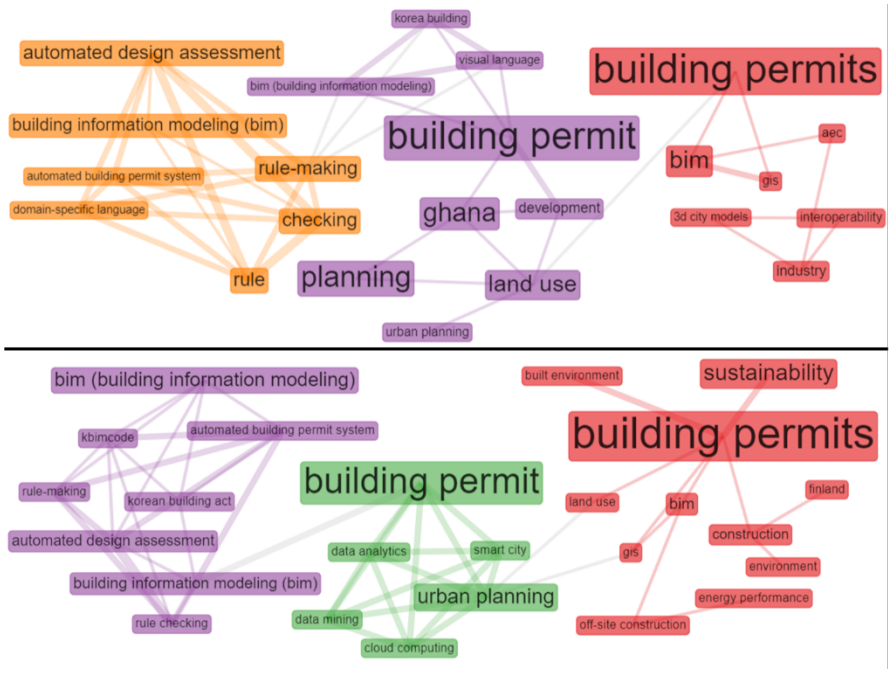

Fig. 1. Author's keywords co-occurence network (Web of Science at the top, Scopus at the bottom)

The following step of this research analyses and classifies the Italian BP requirements, especially considering the GIS-linked information; the second part evaluates what information is possible to include both in a BIM model and in the existing open, international standards such as Industry Foundation Classes (IFC) promoted by buildingSMART [13].

2 Methods and tools

The methodology used is described step-by-step: a) the analysis of the Italian building permit requirements to isolate the information derivable from a geodatabase (the GIS-part of the building permit), b) the use of a BIM model to store this information and, c) evaluate the possibility to share both the geometry and data in the IFC format.

In Italy, building management processes are regulated by different regulations and laws. The classification was made considering the hierarchical level of the law (national or local) and the type of regulation: process regulations to obtain the BP and asset regulations that specify the building standards. Table 1 reports the classification of Italian regulations. The National Law of Building Regulations [14] is the primary reference for the administrative processes, and it contains the building permit requirements. The other regulations are mainly linked to the final asset because they include specific national standards such as the Hygiene and Health [15] standards, the Fire Prevention Code [16], and the Elimination of Architectural Barriers Law [17]. At

a local level, the Territorial Government Plan [18] specifies regional territory planning strategies, and the Municipal Building Code [19] is the main regulatory body about asset characteristics and performances.

Table 1. Classification of Italian building regulations

	Process	Asset
National	"National Law of Building Regulations" (Testo Unico delle Norme per l'Edilizia) (*Decree of the President of the Republic no. 380/2001*) which includes: Building Permit standard form (*Official Gazette no. 119 dated 16/08/2017*)	"Hygiene and Health standards" (Regolamento di Igiene) (*Ministerial Decree no. 5/1975*) "Fire Prevention code" (Codice Prevenzione Incendi) (*DPR no. 151/2011*) "Elimination of Architectural Barriers Law" ("Disposizioni per favorire il superamento e l'abbattimento delle barriere architettoniche") (*Law no. 13/1989*) …
Local		"Territorial Government Plan" (Piano di Governo del Territorio) (*Lombardy Regional Law no. 12/2005*) "Building Code" (Regolamento Edilizio) (*Regolamento edilizio no. 27/2014*)

To define the GIS-linked information required, the building permit standard form [21] was analysed through XMLPad [22]: it is composed of 13 main sub-categories that include different types of specifications (the ones required by the building permit procedure itself and the technical ones) and 1 element that contains all the 44 attachments (5 are always mandatory while the other 39 depend on the intervention type). Fig. 2 shows the main BP sub-categories, underlining the GIS-related ones (localization, urban regularity, urban restrictions, constraints, geotechnical reports, and soil quality reports).

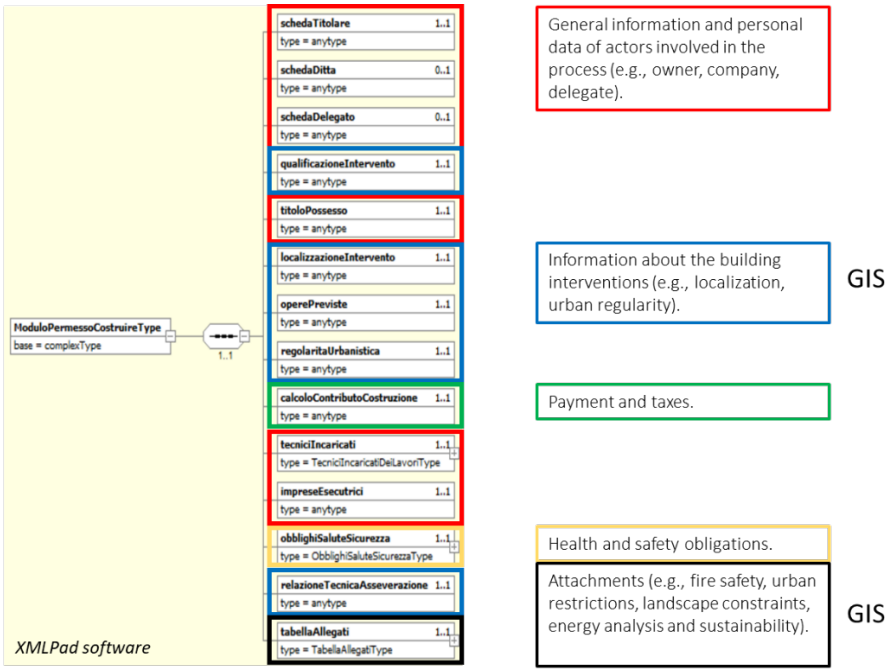

Fig. 2. Italian Building Permit analysis (sub-categories)

Once identified the list of these requirements, they were then classified according to the methodology showed in Fig. 3 [23].

COMPLEXITY	OPEN STANDARD	PROPRIETARY
CLASS 1	Explicit attributes and entitiy references.	Explicit attributes and entitiy references.
CLASS 2	Implicit relationships necessary to fulfil checking requirements.	Personalized non-standard data are needed for checking the requirements based on derived values.
CLASS 3	Extended data structures based on standard entities, relationships and properties.	Data non included in standards are required for generating extended data strucuture to check the requirements.

Fig. 3. Classification of the required information's complexity.

3 Results

The classification system used to analyse the BP requirements considers two aspects: the first is the complexity of the information required. The second is the possibility of finding the information inside an open standard or proprietary format. This study was

focused on the investigation of the IFC standard. Entities and related property sets define the IFC schema. Although the IFC schema allows the user to add personal property sets, this analysis evaluates only the existing ones. Considering in IFC4 [24] there is neither a Model View Definition (MVD) nor entities specific for the building permit, suitable entities were used.

First class considers explicit attributes and entity references. For instance, the first part of localization requirements, address and coordinates, can be stored in IFC standard entities (*IfcPostalAddress, RefLatitude,* and *RefLongitude*) while the cadastral data require custom entities; the second class considers requirements based on the calculation of parameters. For instance, some site specifications are calculated with open standard format parameters (*BuildableArea, SiteCoverageRatio, FloorAreaRatio, BuildingHeightLimit, TotalArea*) while the evaluation of the constraints needs new parameters; the third class includes requirements based on simulations. For example, a landscape report needs a combination of different parameters, both standard and proprietary.

4 Conclusions

The aim of this research was to analyse the Italian Building Permit standard form in order to investigate which are the GIS-related requirements. Then, they were classified considering the complexity of the information required and the possibility to find this information inside an open standard or proprietary format.

In conclusion, the BP analysis underlines two main critical issues linked to the high number and the variety of information required and the impossibility for the actual open standard (IFC4) to manage all this information.

Future developments will consider the use of the same methodology presented in this research to analyse other standards and deepening the complexity of the standard's requirements through the development of a case study. At the same time, two different approaches will be evaluated: i) the top-down approach that considers the lawmaker actions; ii) the bottom-up approach that includes all the best practices used during the design phase that could also be extended for the building permit.

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