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| Abstract | With the introduction of the BIM methodology, the digitalization is consolidating mostly the process of new building design defining new standardized working procedures in order to optimize the data flow. On the contrary, pertaining to existing buildings, the rules are still dictated by the traditional methodology leading to fragmented and disaggregated information flow. However, some tools have been recently developed and are quickly upgrading to meet the specific aim to pursue progress, dynamism and experimentation in order to stay in tune with market demands. One common issue, is due to the fact that the documents are paper, hard to find and numerous so that the digitalization represents the best real solution to improve their management.<br>In this regard, the heart of the informative flow is represented by the Common Data Environment (CDE), a cloud storage in which the documents are collected once uploaded and easily manageable with specific platforms. By way of example, a case study is developed in the paper in which the management process of the H-BIM of the XV century's structure placed in the old town of Naples is carried out in a digital way, through the usBIM.platform (released by ACCA software company) using specific tools, like links, markers and tags. The goal of the paper is to define both a new organization for the data archive, in which the documents are structured and easily traceable, both a new way of conceiving the BIM model that it is thought as an informative vehicle and a key access to the information rather than a mere geometric representation. |



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| Keywords (separated by '-') | H-BIM - Information management - Masonry buildings - Cultural heritage - Common Data Environment - #TagBIM |


# H-BIM – Innovative and Digital Tools to Improve the Management of the Existing Buildings

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**Keywords:** H-BIM · Information management · Masonry buildings · Cultural heritage · Common Data Environment · #TagBIM

## 1 Introduction

The Building Information Modelling BIM technologies (Penttilä 2006) are progressively getting used in the Architecture, Engineering and Construction AEC industry (Takim et al. 2013), increasingly conditioning the daily work method of professionals. These new operating methodologies are consolidating more in the field of design of new buildings, under the impulse of some European countries (Grzyl et al. 2017) that see in the


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new buildings the greatest field of application, through standardizing workflows that allow managing in a better way the exchange of information among the various actors involved in each contract. According to the open BIM practices, the information is placed in a known architecture, handled by software that refer to open standards such as IFC (Sustainability of Digital Formats: Planning for Library of Congress Collections 2016), an open format promoted by buildingSMART international (buildingSMARTInternational, n.d.), which guarantee the information exchange even through a Common Data Environment (CDE). In the design of new buildings, it is quite simple to pursue these objectives: in traditional workflows, a team of technicians with different skills meets to develop a design solution and summarizes all the information produced in a detailed and structured way in an informative model, which constitute the digital twin of the asset. This, in fact, allows the use of digital models in various cases, since the same information can be used several times for different BIM uses. Existing assets, instead, give a completely different panorama, in particular for the operations of Facility Management (FM) that involve them. In order to improve the management of the Historical Building Information Modelling H-BIM (Logothetis et al. 2015) a new digital methodology have been developed, involving new technologies that are nowadays strongly establishing on the market. It consists in an approach that overcome the traditional working methods encouraging communication in a multi-disciplinary team thanks to the revision of the customary steps. In fact, each of the different professional figures involved in the process works simultaneously to the others, taking care of different aspects of the same project so that all the activities are to be planned in advance in a detailed and schedule. Moreover, the activities accurately reprogrammed and carried out in a digital way allow the organization, time and costs result anticipated, consequently the financial compensation of the whole process can be easily determined.

## 2 The Complex Combination of BIM and Existing Buildings

In matter to existing buildings, due to the complexity of the intervention, a dedicated workflow has been developed. Differently from the design of new buildings, all the phases are often difficult to organize, monitor and achieve; in fact, the first difficulties already appear in the knowledge phase of the building in which the main building data is collected and design and construction choices are retraced. In this phase the historical documentation, if available, is digitalized, so that the information is not structured to be available in a timely, updated and reliable manner. Following, in order to establish the real condition of the heritage, those data collected need to be revised and raised through in-situ surveys, geometric reliefs (manual or digital), such as tests, inspections, thermographs and geo-radar. Moreover, the BIM model of the construction can be difficult to build due to disparate and irregular geometries of elements rather widespread in historical buildings. Given the complexity of the whole process, thus it is necessary to develop a workflow for a structured working phases and data, to obtain the benefits of the BIM also for the management of existing constructions (Khadda and Srour 2016). More in detail, the methodology performed allows to generate and manage information of buildings from H-BIM models that are not only three-dimensional representations, but dynamic models of data derived from a parametric model of the objects of the heritage. It is a

parameterization based on the Object Oriented logic (Liu 2001), which allows first the problem-free implementation and then the simple and automatic data extraction, thus creating new databases available to the entire supply chain operating in the sector. The workflow has been made up for the purpose and implemented in a dedicate platform called usBIM.platform (Piattaforma BIM (Collaboration Platform) - usBIM.platform, n.d.), developed by the Italian company ACCA software, that is a tool created and developed to support the control of the exchange of information among a project team, and applied in this specific case for the management of an existing building.

## 3 Palazzo Penne: Application on a Real Case Study

The application of the new methodology proposed, has been experienced in occasion of Palazzo Penne's renovation, a renaissance masonry palace located in the historical center of Naples and built in 1406. The renovation project was elaborated a few years ago in the traditional way so that the interventions will have to start soon.

Indeed, a digital way of information management has been simulated, having available all the documents elaborated in the several phases of the real case study so that all the information produced have been taken into account. The building is an example of civil habitation of XV century, one of the few constructions that did not collapsed after the devastating earthquake of 1456. Several changes of the building have undergone several time, as witnessed by the walled arches and the slabs built with different construction systems, such as wooden, steel, and reinforced concrete. The complex has been dived into three Minimal Unit of Intervention (MUI) that is a part of a construction consisting in uniform structural unit subject to the same retrofit intervention. Moreover, the number of levels results variable even for each MUI, because of the presence of lofts that raise the complexity of the building. Actually, the difficulties acknowledged in Palazzo Penne are rather common in the cultural heritage, so that it can be considered representative of a big amount of buildings (Fig. 1).

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**Fig. 1.** Palazzo Penne's main façade

Indeed, due to the complexity and the importance of this construction, a workflow developed taking into account all the difficulties in its management can result an accurate and transparent example for the information management. The aim of this process is to create adequate guidelines to improve the management of the existing buildings.

## 4 A Workflow for the H-BIM Management

Because of the complexity of the task, a dedicated workflow has been engineered for the improvement of the assets management. All the steps of the traditionally performed have been deployed but in a digital way. Thanks to the use of a collaborative platform, it has been given rise to new methodology that enables multiple applications. In fact, it results a simple tool that can be deployed quickly and on a large scale, so that all the operations that goes from the determination of the stat-of-art to inspections and subsequent actions to be taken, make up a continuous information stream that does never stops. Thanks to the automation of the processes, the possibilities of making mistakes are drastically reduced, thus raising the results and reducing the costs. The steps for the H-BIM management are summarized in Fig. 2.

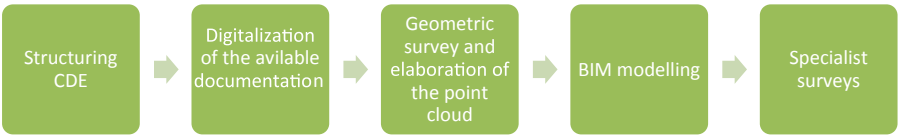


**Fig. 2.** H-BIM management

More in detail, all the specific activity to carry out in each step have been summarized in flow charts called “workflows”, which should be established well in advance, before starting any operation. As a way of example, the workflows for the geometric survey, the BIM modelling and the damage assessment (one of the activities to carry out during the specialist surveys) are reported in Fig. 3.

In particular, the interactions among the different actors involved are managed making clear the information exchange. Having a definite road map, in fact, make the progress status of the project clear to all the team members that always know when to perform their tasks. Moreover, they provide support in case of delays or unforeseen events, to take some actions aimed at bringing the project in the pre-arranged path.

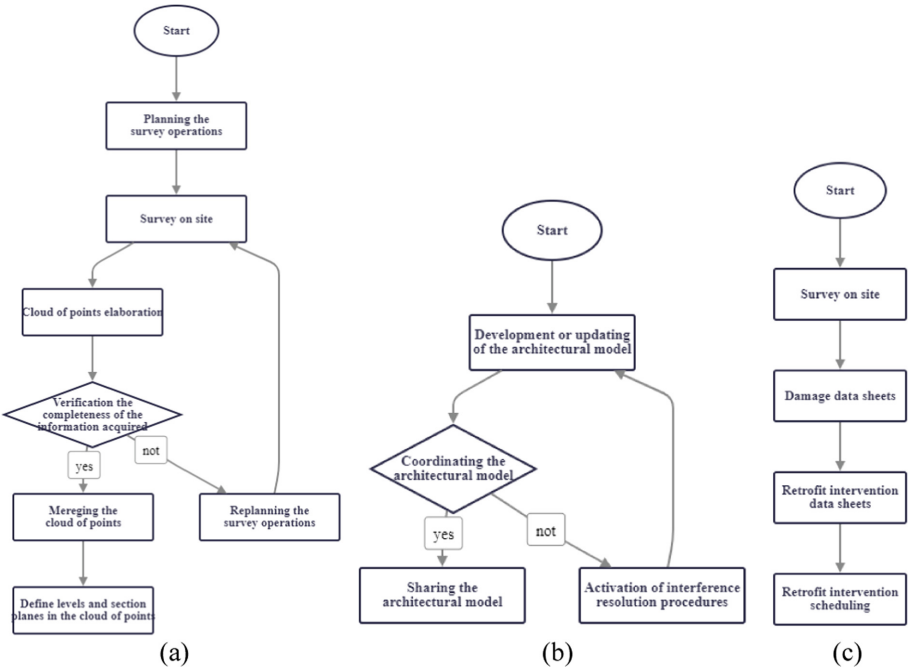


**Fig. 3.** Workflow for the geometric survey (a), the BIM modelling (b) and the damage assessment (c)

## 5 Digital and Smart Archive in the CDE

For the performance of all these operations, an IT structure has been established and identified in the CDE, which is the unique working environment in which all the information is shared among the team members. This instrument allows the complete stream of information and it is smartly accessible thanks to some platform tools.

More in detail, the CDE includes folders according to a Structured Query Language SQL (Fortier and Prichard 1994) database and it is organized according to the process phases, i.e. State-of-art, Survey, Investigation and tests and the Retrofit interventions. Each area has been sub-divided in Work in Progress, Shared, Published and Archive, i.e. the four processing states of the files within the CDE, according to ISO 19650-1 (Fig. 4).

In order to complete the settings of the CDE in usBIM.platform, the roles that each user have to endorse have been defined, taking into account both the technical roles (such as the structural engineer, the architect, etc.) and the informative ones (BIM modeler, BIM coordinator and BIM manager). It follows that a connection was established between each user and the tasks noted in the workflow that to be performed, so that each activity is defined and well-organized.

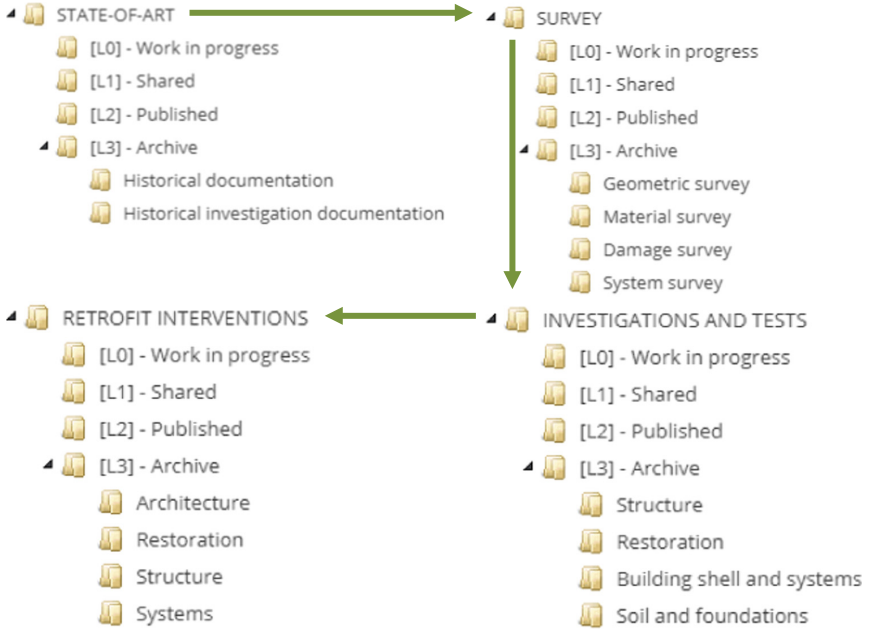


**Fig. 4.** Information flow in the Common Data Environment

Moreover, other important platform features are the definition of limitations to the access to each folder, ensuring the information security and confidentiality, and the historical storage of all the operation carried out. After establishing the CDE, a careful research of paper documentation, such as old reports, plants, elevations and sections was carried out.

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After establishing the CDE, a careful research of paper documentation, such as old reports, plants, elevations and sections was carried out. Together with the documentation produced for the renovation project, they have been digitalized to move the paper archives into digital ones. It resulted that in the platform have been uploaded:

– 97 documental report, including the damage data sheets, report for the state of art, report for the design project reports for the investigations;
– 30 multimedia documents, including material relief drawings, damage relief drawings;
– 39 graphic documents, including plants, elevations and sections;
– 5 digital models, including BIM models and 3D cloud of points.

A total of 171 documents have been placed in the platform so it has to be noticed that even after a structuring in a comfortable way the CDE, it could still be difficult the research of the documents both for the team members and for the customer. For this reason, some specific tools called #TagBIM have been introduced. They allow filter operations among documents thanks to markers pointed to the documents, to draw attention to information in a quick and smart way for the dynamic recovery of each file. Therefore, the #TagBIM, according to the Not only SQL (NoSQL), make possible transversal pathways within the different folders regardless of the folder structure. Indeed, in order to facilitate the research of the documents, they have been defined referring to the document year, type and nature, to the discipline involved and to the document content. They have been allocated to all documents of CDE as showed in Fig. 5.

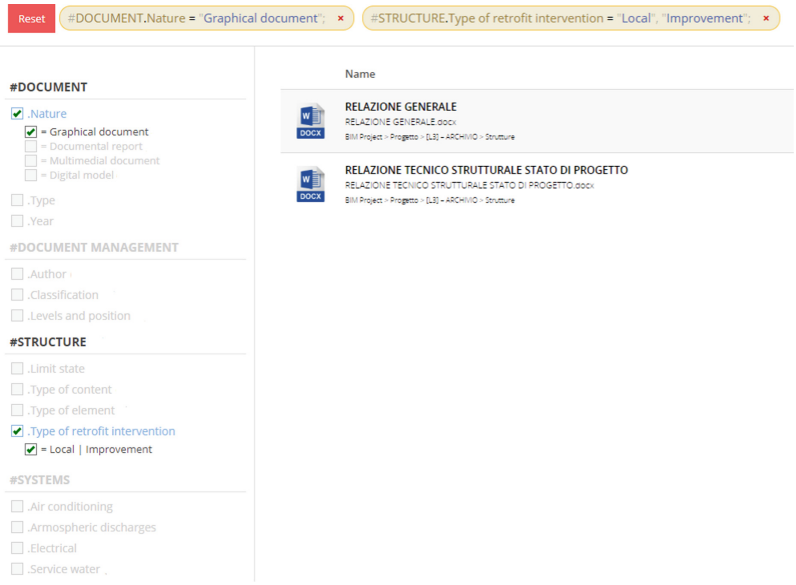


**Fig. 5.** #TagBIM for the documents

## 6 H-BIM Modelling and Management

Regarding to the geometry relief, with the traditional method, especially for historical construction as Palazzo Penne, the data derived are difficult to manage due to the complexity of the building itself. This operation, indeed, is simplified thanks to the support given by modern technologies for the elaboration of point clouds (Wong et al. 2014). In this regard, laser-scanning (Randall 2011) and photogrammetric techniques (Dore and Murphy 2013) are new ways of making surveys that meet the digital requirements and are little by little expanding their field of application. The point cloud derived from the digital relief represents a digital copy of the building in the form of a 3D model. The

laser-scanner technique has been used to acquire Palazzo Penne's point cloud and from it, bi-dimensional drawings have been obtained, as sections, plans and elevations. The graphics have been used as reference for the creation of the BIM Model in Edificius, the BIM authoring software. However, many difficulties have been encountered modelling the building as BIM authoring software have been developed for the design of new buildings, so that even the modelling operation is difficult to catty out for an existing one. The reason for that can be identified in the uniqueness and complexity of each element that hardly fit the concept of "parametric object" and even because of the absence of a dedicated BIM library for specific objects. Indeed, modelling Palazzo Penne, significant deficiencies have been identified about specific objects that characterize the historical buildings, such as wall openings that have been closed, arches and vaults. Nevertheless, an accurate reflection showed that it is not always necessary to model the objects in all the details. In fact, some elements, such as doors, windows and portals have been chosen among the objects already existing in the library that mostly matched the real ones in terms of shape and typological features. In this regard, the procedure implemented in usBIM.platform takes into account an important concept linked to BIM modelling: the model elaboration has to be commensurated with its use; the use and the Level of Detail of the objects modelling (LOD according to ISO 19650-2) are closely linked. Famous, in fact, is the motto "begin with the end in mind" which aim to state this concept. In this regard, the platform tools make possible to store information in different options so that, all the data and features of the objects resulting hard and heavy for the model, are made available in alternative way and no loss of information is ensured.

After the geometric survey, each specialist member can perform the investigations of its own competence and integrate the information collected pertaining the state-of-art of the construction on the BIM model. Hence, the structural engineer generates additional files regarding materials tests and cracks and collapses suffered by the building while the architect report and drawings pertaining the degradations. These files have been uploaded to the CDE and structured through the properly #TagsBIM.

Then, they have been introduced in the BIM model in its IFC format, making it not merely a geometric representation, but a real store of information in different form, including elements, parameters of BIM objects or alternative solutions. Because not all the data can be coded according to the IFC format specifications, some dedicated platform tools have resulted very useful allowing the data storage on the model and making them easily available. In particular, thanks to the online viewer usbim.browser directly connected to the platform, data, file and models even in different format, **are directly linked in the CDE.**

More in detail, the damage sheets, the degradation sheets and the mesh model of some specific elements impossible to model (like the front door or the façade ashlars with the coats of arms of d'Angiò and Penne) have been linked directly to the object to which they refer, placing the localization of the information directly on the model and so enabling advanced search capabilities. Thanks to the point cloud, it is even possible to deduce the measurements of objects not contained into the BIM model (Fig. 6).

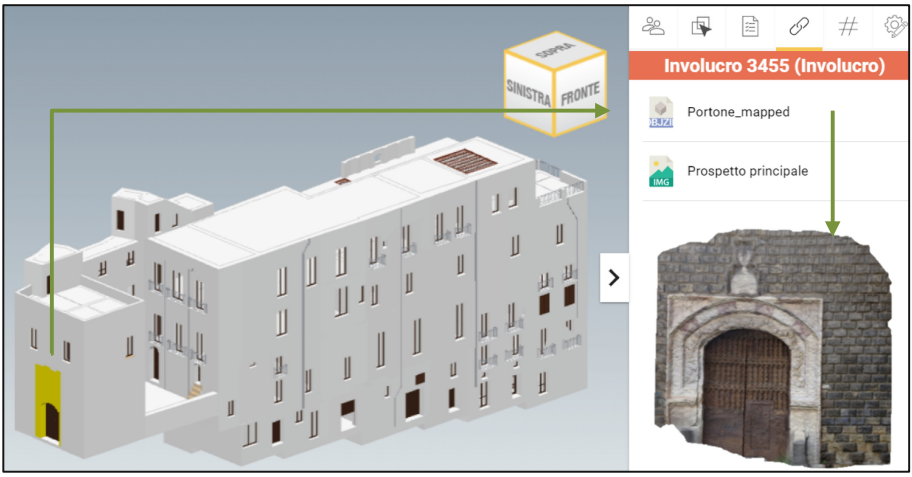


**Fig. 6.** Links among documents in the Common Data Environment

Moreover, even definite pointers allow data referencing on the model, favouring a quick and easy navigation and visualization of the files. With reference to the survey activity, the structural engineering has referenced photos of the endoscopy of the walls with its identification number while the architect photos of the degradations inspected, in order to have a visualization of the damage that has not been modelled directly (Fig. 7). This enables optimizing analysis phases and the scheduling of maintenance interventions downstream.

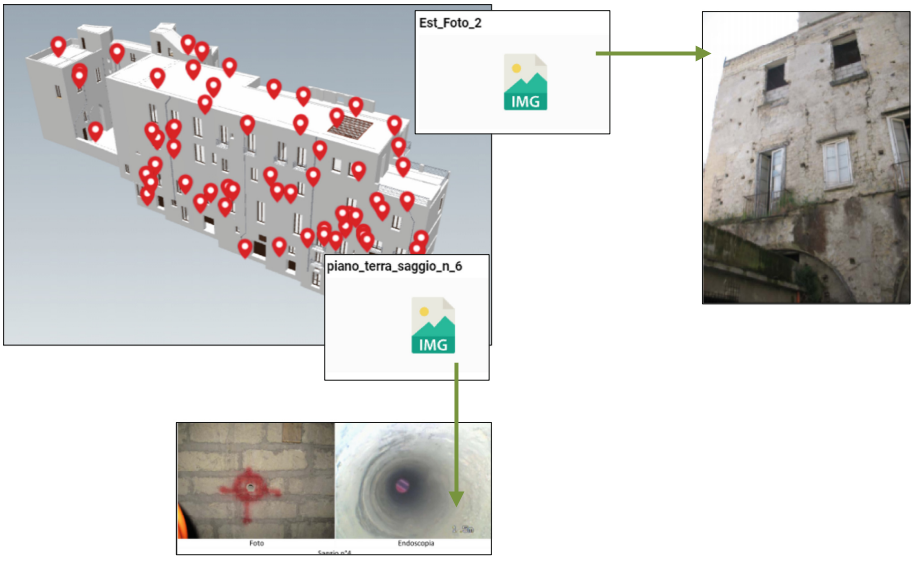


**Fig. 7.** Geolocation of the inspections on the model

In addition, the #TagBIM have been implemented even into the object of the model, a tool particularly useful to the user to quickly browse through it and view the objects and the content of CDE connected. In particular, the #TagBIM implemented pertain the damages inspected, the investigations and the retrofit interventions scheduled. Checking the options offered by the different #TagBIM, all this information can be crossed facilitating the research activities, as shown in Fig. 8.

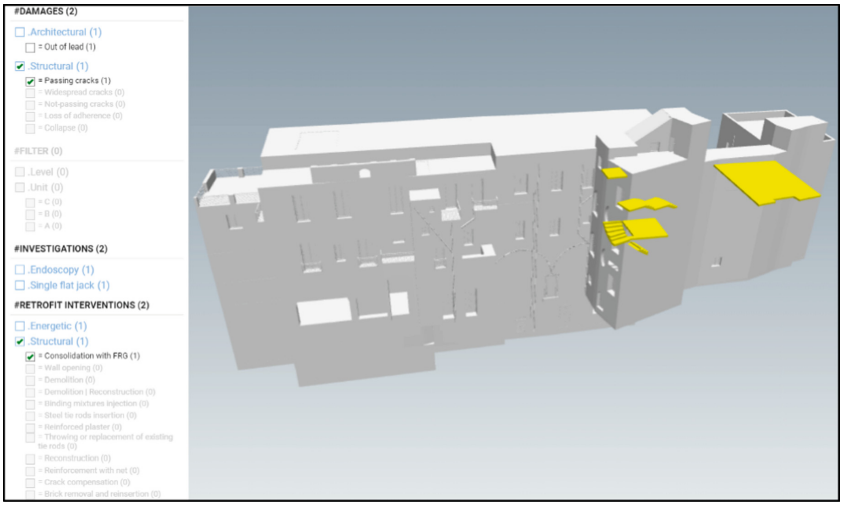


**Fig. 8.** #TagBIM of the model's objects

With these tools the information can be "googled" directly from an online browser and find the files and the documents linked to their respective objects.

## 7 Conclusions

In the steps below, it has been illustrated the potentialities of tools currently existing and their implementation for the H-BIM management. In particular, the strong point of the methodology explained consists in the fact that all the operations have been performed in a model in IFC format, the standard format introduced by buildingSMART that ensure that the openBIM principals have been taken into account, regardless of the software used for modelling. In the case study shown, it can be noticed how the model uses are completely different comparing to the common application for the design of new buildings. In this case, in fact, the model, after the uploading in the management platform, has been used as a storage for all the information produced in the renovation process of an ancient masonry building. The BIM model, in fact, rather than a mere 3D representation of the building, has become the key access to all the information of the CDE, dealing a huge amounts of data previously fragmented in the files. Thanks to pointers and #tagBIM, all the information has been centralized on the BIM model that in this way represents a point of reference for all the team members and constantly

support their activities. In fact, as the process goes on, the model is always enriched with new information input in a structured manner, in order to always be traceable. As in the traditional process the use a paper archive represents a significant source of loss of time, thanks to the digital instruments the process is improved, allowing to convey the right information at the right time and to the right people. This purpose is also achieved thanks to the implementation of standardized workflows, which introduce the quality principles in the management of the design of retrofit intervention phase. The BIM methodology, if correctly implemented, can indeed represent an important turning point even for the management of existing building, new frontier of digitization, overcoming the currently widely recognized limits of classical methodologies.

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## References

Logothetis, S., Delinasiou, A., Stylianidis, E.: Building information modelling for cultural heritage: a review. In: 25th International CIPA Symposium 2015, Taipei, Taiwan, pp. 177–183 (2015)

buildingSMART International: Retrieved from buildingSMART - The Home of BIM (n.d.). https://www.buildingsmart.org/about/

Dore, C., Murphy, M.: Grammars using historic building information modelling. In: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-5/W1, 2013 3D-ARCH 2013 - 3D Virtual Reconstruction and Visualization of Complex Architectures. Semi-Automatic Modelling of Building Façades with Shape, Trento, Italy, pp. 57–64 (2013)

Fortier, P., Prichard, J.: Concept for a real-time structured database query language (RT-SQL). Ann. Rev. Autom. Program. **27**, 167–174 (1994)

Grzyl, B., Miszewska-UrbaĔska, E., Apollo, M.: Building Information Modelling as an opportunity and risk for stakeholders involved in construction investment process. Procedia Eng. **196**, 1026–1033 (2017)

Khadda, M., Srour, I.: Using BIM to retrofit existing buildings. Procedia Eng. **145**, 1526–1533 (2016)

Liu, M.: Pluto: an object-oriented logic programming language. In: Proceedings 39th International Conference and Exhibition on Technology of Object-Oriented Languages and Systems, TOOLS 39, Santa Barbara, CA, USA, USA. IEEE (2001)

Penttilä, H.: Describing the changes in architectural information technology to understand design complexity and free-form architectural expression. ITcon **11**, 395–408 (2006)

Piattaforma BIM (Collaboration Platform) - usBIM.platform. Retrieved from BIM Collaboration Software | usBIM.platform | ACCA software (n.d.). https://www.acca.it/bim-collaboration-software

Randall, T.: Construction engineering requirements for integrating laser scanning technology and building information modeling. J. Constr. Eng. Manage. **137**(10), 797–805 (2011)

Sustainability of Digital Formats: Planning for Library of Congress Collections. Retrieved from Industry Foundation Classes (IFC), Clear Text Family (2016). https://www.loc.gov/preservation/digital/formats/fdd/fdd000447.shtml

Takim, R., Harris, M., Nawawi, A.: Building Information Modeling (BIM): a new paradigm for quality of life within Architectural, Engineering and Construction (AEC) industry. Procedia – Soc. Behav. Sci. **101**, 23–32 (2013)

Wong, J., Wang, X., Li, H., Chan, G., Li, H.: A review of cloud-based BIM technology in the construction sector. J. Inf. Technol. Constr. **19**, 281–287 (2014)

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