Article

The University of Lisbon's Short Professional Course in BIM: Practice, Construction, Structures and Historic Buildings

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Abstract: The implementation of building information modeling (BIM) methodology in the construction industry has wide applicability with recognized benefits when designing, constructing, and operating buildings. To stay competitive in business, companies are urged to recruit professionals that offer brand-new knowledge and skillsets. To meet this demand, BIM training regarding the concept, range of applications, and tools available is required within the construction profession. A recent short course organized by the University of Lisbon, Portugal, actualized with the most relevant achievements in Master's degree research, was offered to professionals in the industry, namely, architects and civil engineers coming from diverse engineering areas such as the environment, construction, maintenance, contracting and surveyors, and from patrimonial enterprises and public organizations, as well as city councils. The proposed action covers the areas of construction (conflict analysis, planning, and material quantity), structures (interoperability, analyses, and the transfer of information between software types), and the most recent heritage building information modeling (HBIM) perspectives. The methodology used was based on the presentation of case studies related to situations of conflict between disciplines, interoperability problems, and the structural rehabilitation of old buildings. The difficulties found in the course are mainly due to the heterogeneity of the participating population, who have different interests and specific perspectives. The participants followed the course with great interest and satisfaction, formulating several questions directed at the particular field of expertise of each professional. In general, the participants indicated a positive score, and changes in response to negative feedback will be adopted in future courses. The course aims to contribute to the dissemination of the potential of BIM in the design, construction, and refurbishment of historical buildings.

Keywords: BIM; training course; up-to-date information; improving professional skills

1. Introduction

The building information modeling (BIM) methodology is currently the main digital support for the elaboration of diverse construction activities. A BIM project is developed on a technological platform, within which all experts create, manipulate, and add the information that is required and generated in the context of the work of each professional involved [1]. In this process, the methodology supports the development of different components of the project, allows adequate interoperability between specific systems related to various types of analysis or simulation, facilitates the tasks of budgeting, construction, maintenance, and management, and controls the procedure for a possible demolition [2]. However, BIM is not a tool. BIM is a methodology or set of processes supported by advanced technology software, based on the parametric modeling concept. In the elaboration of a project, a BIM model, representing the building accurately and containing the information necessary to simulate various types of tasks, is usually executed for a project in the form of drawings, budgets, the simulation of energy consumption, or construction planning. In this way, the created BIM model supports a complete integration of the design stages, construction phase, or maintenance and management activities, improving the degree of collaboration among the professionals in the team.

The BIM concept began to be Implemented in the construction industry at the beginning of this century as an immersive innovation for the sector. Its benefits were quickly recognized, being reflected in the quality of the projects developed, based on effective process integration and clear collaboration between partners, related to the different specialties intrinsic to construction [3]. BIM computational tools offer strong support for the improvement of the different disciplines of a project, enabling their parametric modeling and offering easy access to all the information concentrated in the BIM model created in the course of the project.

In all areas of construction activity, the construction company, designers, builders, and managers have verified the benefits of adopting the BIM methodology. This fact has led to its growing acceptance at a global level and in an exponential way, leading government entities to establish rules of action and mandatory implementation dates for public construction [4]. In addition, an educational institution has the mission, essential in society, of training future engineers and providing the fundamental teaching related to different themes in the field of construction; it should also be attentive to the technological innovations applicable to the various sectors. Naturally, construction-related companies embrace this perspective, encouraging professionals to seek training that can add to the knowledge, in the BIM context, that is required in a globalized industrial world that is increasingly competitive.

Around the world, many countries have already applied BIM to public and private buildings by introducing changes to their laws (Singapore and the USA), by creating guidelines and directives regarding the use of BIM (Finland and Norway), by developing specific IfcObjects concerning infrastructures and bridges (China and Denmark), by applying maximum limits to the budget from which the project costs will have to be taken using a BIM platform (the Netherlands and Finland), and by implementing BIM with the aim of reducing carbon emissions (United Kingdom) [4]. Umar [5] presents several aspects of BIM implementation, based on a systematic literature review and a survey questionnaire, focused on aspects concerning the identification of the main challenges within construction organizations, governmental and legal environments, along with the social implications.

Despite the benefits that have been recognized in relation to BIM implementation in the construction industry, its adoption within companies and project enterprises has highlighted significant organizational challenges related to internal cultural adaptation, concerning work modes, data transfer processes between phases, and also communication with partners [6]. In addition, the relevant initial investment in technology and training is required. Although the available BIM support technology admits an integrated approach regarding the digital representation of all building disciplines, there are still gaps that researchers intend to overcome [4].

Given the multifaceted participation of the many professionals from distinctly different professional areas, a greater degree of integration, cooperation, and coordination is needed. In recent years, the construction industry has been adopting the BIM methodology in order to increase productivity, obtain more efficient constructions, and ensure satisfactory thermal and economic performance throughout the building's lifecycle [7]. The BIM model created during the development of a project contains the information necessary to automate the creation of distinct types of analyses (structural, economic or sustainability), project technical drawings, and tables for calculating the necessary quantities of materials, supporting cost estimations. However, it is necessary that the engineer or architect knows, in detail, the processes of modeling and the transposition of models between software types, as well as the limitations involved: essentially, interoperability problems [8]. It is also required that the designer understands the means of communication between computational systems of modeling and calculation. As such, the designer should carefully analyze the process of information transfer between systems and how the interpretation of the structural elements of the model is reached.

The amount of interest in teaching BIM within technical academies has been evidenced by the organization of specialization courses and workshops aimed at professionals in the

construction sector. The applicability range of BIM reaches across several disciplines, from technical drawing and modeling issues to structural analyses and construction planning. Industry professionals also feel the need to keep themselves up to date in the BIM context; the University of Lisbon's course contributes in a positive way to this demand for learning. The main objective of the course is essentially to empower participants with training and knowledge that are useful to them in their work. A short course, presented in March 2022, included the methodological concepts and a wide range of applicability sectors inherent to the development of projects in BIM. This text reflects the contents of the course, objectives, and satisfaction evaluation. The organizational structure of the course introduces the underlying fundaments of the methodology, such as parametric modeling and interoperability, and presents the scope of the applicability of BIM. The most recent research achievements in BIM applications were presented in the main lecture and highlighted in the present academic professional course.

2. BIM Education

Currently, the focus of civil engineering education is oriented to BIM, and it is up to the institution, as the main source of training for the future engineer, to introduce this topic as a concept that should be passed on, contributing to supporting all new subjects included in the curriculum with a BIM-based digital support network. The requirement of BIM skills in the sector has imposed an educational maturity of alertness in relation to the needs of society, which has led to a progressive adaptation of the curricula being taught [9]. Therefore, the principles of BIM must be understood by all teachers in order to be able to teach their specific sciences using BIM tools, following the emerging technologies that can be applied in the construction field.

The 3D representations created during the development of a project bring an important increment in understanding, integrating processes, and collaborating within a team. Umar [10] analyzes the implementation of 3D printing, identifying several key factors that influence its adaptation to the construction industry, mainly concerning the technology, the organization, the environment, and, naturally, the cost. Sampaio [11] described, in an academic research study, the introduction of BIM methodology in civil engineering education and the curricular program's adaptation. Essentially, the text reports syllabus-based web research concerning BIM teaching in some of the most relevant European technical schools, finding information in the Shanghai ranking of academic subjects, civil engineering, namely: the Polytechnic University of Madrid, the Swiss Federal Institute of Technology of Lausanne, and the University of Lisbon, Polytechnic University of Catalonia, and the Polytechnic University of Turin. The findings identify several modes of teaching the topic of BIM in architecture and civil engineering domains, as complete optional study units, in modules inserted into related units, in Master's degree-level professional courses, in international Master's degrees, and in subjects within specific Master's degrees, short courses, and M.Sc. theses:

- The *Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos* of the Polytechnic University of Madrid offers two curricular actions [12]: a discipline of specialization within the framework of a Master's degree in construction and the management of facilities, with the aim of training professionals in the application of the BIM methodology, covering the entire life cycle of a building (project, execution, and operation of the building), along with the use of the software required in modeling and information management; this is an advanced discipline of BIM methodology in the Master's course of project management, with a more specific and detailed programmatic content (concept and applicability, BIM model management, collision detection, collaborative workflow, and the conservation and exploitation of infrastructures). The architectural technology and construction course enables students to acquire the BIM skills related to construction, maintenance, rehabilitation, deconstruction, and urbanization [13];

- At the *École Polytechnique Fédérale de Lausanne*, the study plan identifies the introduction of BIM at a Master's level through a course for the introduction and application of BIM, covering the teaching of concepts (interoperability, IFC standards, and LOD levels), the generation of parametric models and conflict detection, the transfer of information between systems, the estimation of costs (5D), and construction monitoring (4D) [11];
- At the *Instituto Superior Técnico* of the University of Lisbon, at the level of the first cycle of teaching, the curriculum for the discipline of Technical Design includes an introduction to BIM wherein the procedure for parametric modeling is transmitted, using BIM-based tools [11];
- The curriculum of the *Collegio di Ingegneria Civile*, at the Polytechnic University of Turin, offers a master's course in BIM when applied to infrastructure in the second cycle of education, which includes aspects related to modeling and computer content, interoperability and formats, collision detection, structural dimensioning, and real-world case study analysis (bridges, tunnels, stations, schools, and hospitals). The graduate degree program in Architecture offers students adequate knowledge of architectural and construction history and innovative representation forms by using techniques and BIM-based tools [14].

In addition, practicing professionals should acquire competencies in BIM, allowing them to participate in the process of profound transformation that the construction sector is now experiencing. Improving competitiveness in the construction industry is needed. The responsibility for BIM education should be shared between industry and academia, in order that the introduction of BIM education in academia can achieve specific objectives related to specific Master's courses or professional needs. BIM is one of the most advanced methodologies applied in architecture and civil engineering in recent years; therefore, it becomes important to promote its integration into university education. For this reason, several modules, workshops, and short courses have been offered to professionals:

- In the United States of America, Huang [15] introduced a modular BIM session on construction education, focused on the speedy adoption of BIM in the architecture, engineering, and construction management programs in US technical academies. A BIM course, structured in the form of a lectures/lab-sessions combination, was implemented at the University of Texas in San Antonio, where the students were asked to complete individual projects and present them in different formats, allowing them to provide a sample structure to deliver BIM content [16];
- Virtual courses have also been organized, namely, a 3-day workshop course, *Virtual Project Training*, offered to professionals working at small- and medium-sized enterprises or large contractors, with the objective of experiencing BIM in a real-life collaborative environment [17], and the *BIM Implementation Training Course*, a 1-day live online training session, make BIM easily understood, concerning the strategic and technical processes required to apply BIM on all levels, allowing the participants to increment the knowledge and skills expected of professionals [18].

Some difficulty when introducing the BIM concept and tools management has also been reported, as the students present different technological abilities and skills [19]. Taylor et al. [20] defend the perspective that students must work on a project of challenging scope and complexity, in order to extend their development and increase the use of BIM models.

3. Professional Courses

Educational institutions have been contributing positively to the updating of knowledge of professionals in the sector through the organization of BIM training courses, in accordance with the interest and expectations expressed by businesses and public entities. Industry and the school act as partners in finding the best strategy for establishing effective ways of teaching that are useful to the community. The professional course, *BIM methodology: construction, structures, and HBIM*, presented in March 2022 and included as part of the activities of the Department of Civil Engineering of the University of Lisbon, in Portugal, was the most recent event offered to professionals in the construction industry. The range

of professionals, who attended the course in groups of 15, encompasses architects and civil engineers, coming from both construction enterprises and public organizations. The objective when attending the course was to improve their skills, in order to increase their individual competencies in each particular domain of activity in construction. Table 1 lists the detailed program of the course.

Table 1. The professional course on BIM methodology: construction, structures, and HBIM.

Topic	Contents
Building Information Modeling (**BIM**)	Concept, applicability, and implementation; Parametric modeling, interoperability, and centralization; BIM tool practice in generating model structures.
BIM in the **construction sector**	Conflict analysis; Adding parameters to objects; Construction planning; Quantification of materials.
BIM in **structural** design	Interoperability; Transfer and consistency check; Graphic documentation and information centralization.
Heritage Building Information Modeling (**HBIM**)	Concept and collection of information; Digital capture of images (photogrammetry, scanners, and drones); Generation of specific families of parametric objects; Documentation file (as-built); Practical case study: the repurposing and conversion of a heritage building.

3.1. Introduction to BIM

In order to contribute to achieving a better understanding of the applications presented during the course in the fields of construction, structures, and HBM, an introduction to the concept, level of implementation, and range of applicability should be made first, as well as a practical component regarding the use of BIM-based software package. These introductions do not go into great detail; they must be transmitted to an audience with just a little knowledge of BIM. With this basis of knowledge, the course may be appreciated more by every participant.

The introduction of the main fundaments of BIM began with the principal concept, the range of its applicability from a global perspective, and the state-of-the-art of its implementation (Figure 1). The central BIM notion is the generation of a centralized digital model of all construction-related information. The BIM model is frequently defined as a digital representation of the building or infrastructure, one that is strongly supported by parametric modeling and the standard formats of data. The model assists in the elaboration of collaborative projects that are developed with the help of the model, requiring the use of advanced technologies and a high level of interoperability.

A practical lesson concerning the use of BIM-based tools introduces the concept of parametric modeling, which is essential for an understanding of the development of multitasking. In the modeling process, the first step is to define the base settings (work units, elevation levels, and alignments), followed by the selection and adaptation of parametric objects, associated with particular physical properties [21]. As an example of how to handle BIM-based tools, a structural BIM model was created, as shown in Figure 2. Afterward, several tables were obtained, taking the materials and elements from the generated BIM model [22] (Figure 3).

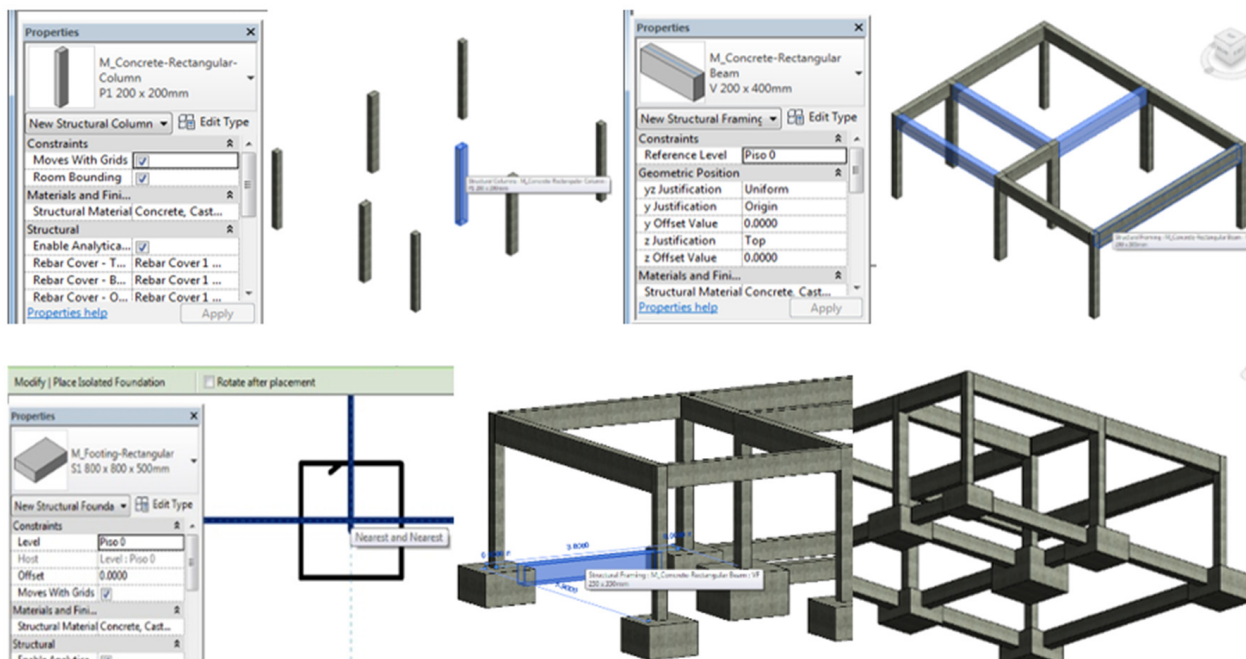**Figure 1.** Slides from the professional one-day course.

Figure 2. Using BIM to model columns, beams, and foundations.
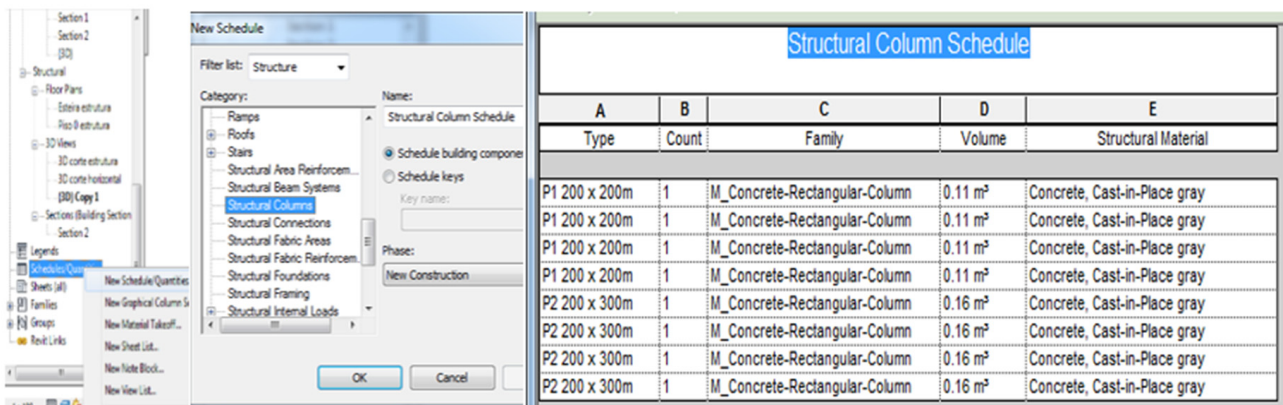

Figure 3. Interface with the selection of a new schedule and the table of columns extracted from the model.

Simulations of lighting, ventilation, acoustics, and energy consumption performance can be analyzed in a BIM context, extending its functionality. The complementary tools, like plugins or add-ins, that act in conjunction with the BIM models enable quantitative and qualitative analysis and results visualization. For that purpose, the parameters of the objects must include adequate information and correct values, supporting correct evaluations and simulations:

- To perform lighting analyses, the Elumtools and Dialux tools can be used [23]; to analyze air movement inside houses, the computational fluid dynamics simulation software (CFD) is frequently requested [24]; to study the acoustic performance at an early stage of the design process, the plugins Design Builder and IES VE can be used [25];
- To obtain results concerning carbon emissions or energy costs, each material that composes the parametric objects of the model must include information on specific properties related to thermal conductivity, specific heat, or reflection; then, the Green Building Studio plugin can be applied (Figure 4) [26]. This software uses a simulator (a DOE-2 simulation engine) to estimate the energy use of construction and operating costs; it is based on the effects and interactions of the building materials, equipment, level of use, and climate. This application dynamically analyzes the whole building's heat and energy levels; it is based on the Leadership in Energy and Environmental Design (LEED) recommendations (Figure 4).
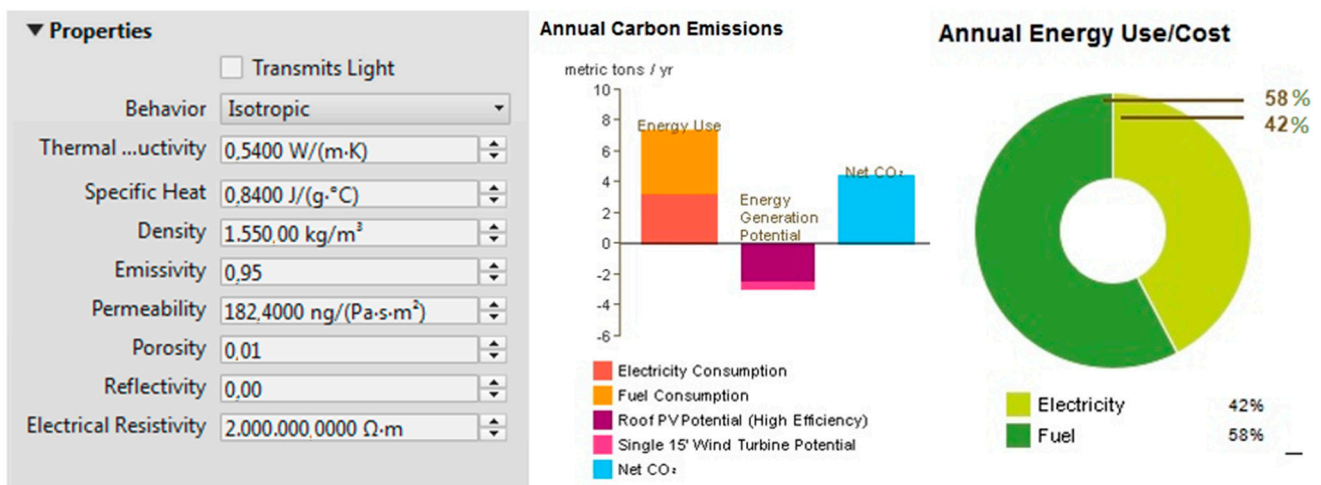

Figure 4. Physical proprieties of a material and an energetic analyses report of a simulation [26].

3.2. BIM in Construction

Two distinct aspects concerning construction activity were presented to the audience, namely, conflict detection analysis between disciplines in a project and construction planning, applied over different case studies.

The BIM modeling tools allow the overlap of the three disciplines (architecture, structures, and mechanics) and support the definition of each component by the direct analysis of conflicts, identified by the system with the issuance of inconsistency messages. There are several software packages with conflict analysis-oriented capabilities, namely, the Tekla BIMsight, Navisworks, and Solibri Model Checker tools. After running any of these systems, the modeler adjusts each conflict situation within the BIM model. In the case study shown in the course, the models of the MEP and structures were overlaid, and an analysis of inconsistency was applied [27]. Using Navisworks and Tekla BIMsight, a set of conflicts was listed and visualized (Figure 5). The conflicts that were detected were adjusted accordingly afterward, in order to obtain the correct scenario.
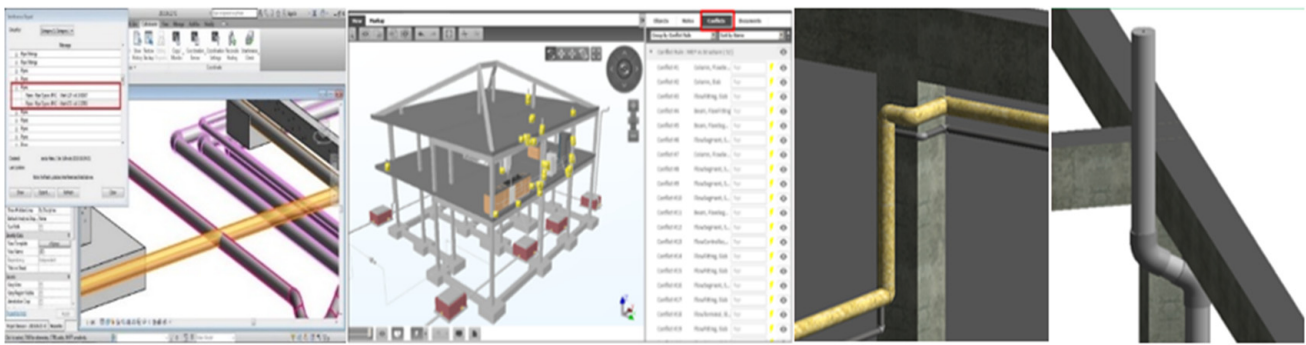
Figure 5. Analyses of the conflicts between models and changes performed in a modelling BIM software.

The course also illustrates how to generate a 4D BIM model, relating to the construction process of a building [28]. First, the complete 3D BIM model of the structural project must be defined; then, the construction sequence planning (phases and periods of implementation or placement) and allocation of human resources must be established in the form of a Gant map (Figure 6).
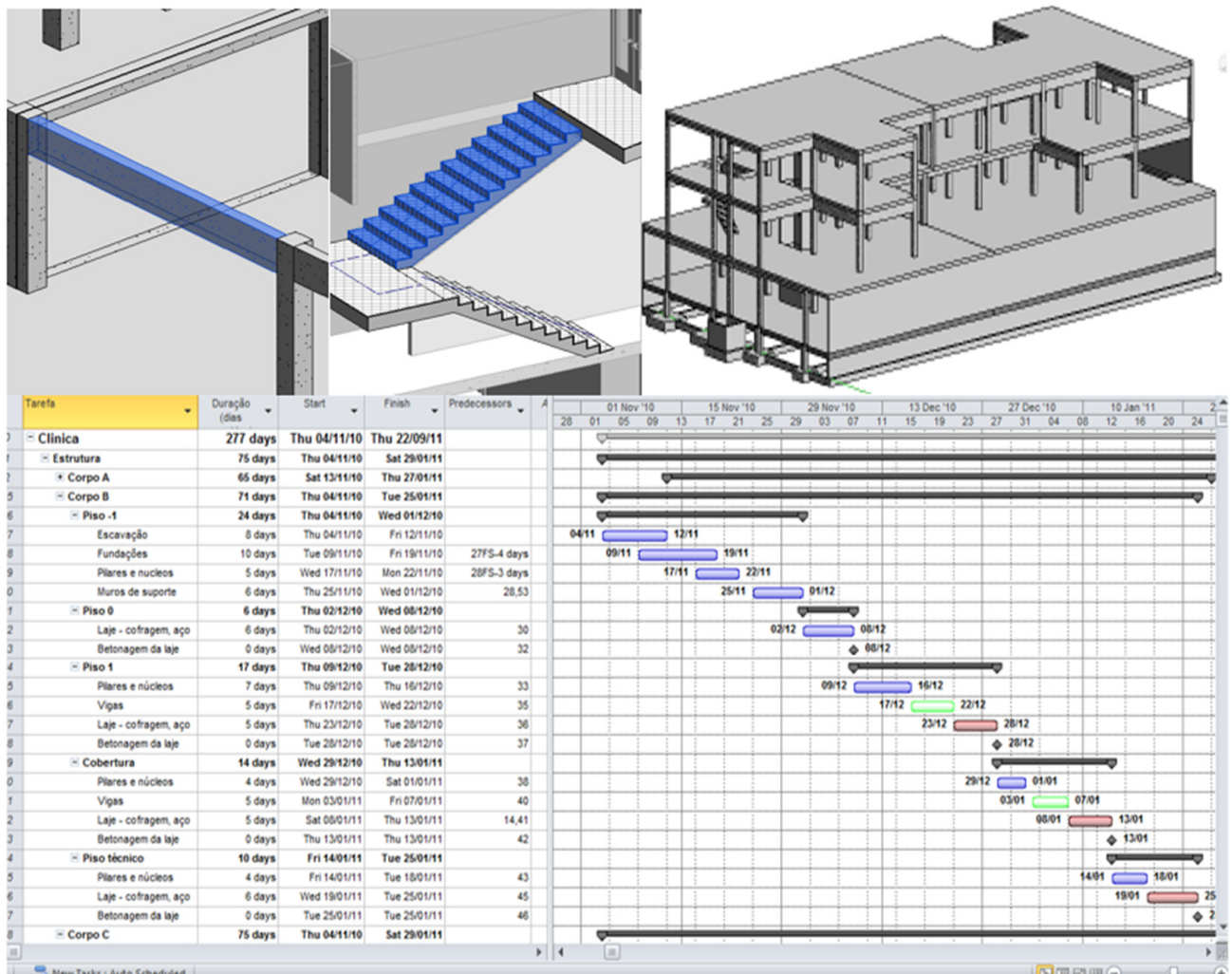

Figure 6. 3D BIM model of a structural project and the respective Gant map.

The 4D model is then created using the Navisworks software, which is a BIM viewer. The BIM model representing the structural project is then exported from the modeling system to the BIM viewer, performed in the native format of data, allowing a heightened level of interoperability. In addition, the construction planning file (Gant map) is transferred from the MS Project system to the Navisworks system. Next, it is necessary to associate the elements of the imported model, forming groups (sets) according to the activities of the schedule. Obtaining a correct and detailed 4D model requires that the created 3D model can represent the actual construction process (Figure 7):

- Elements must be modeled according to floors or zones that correspond to the actual construction process;
- It must consider the modeling of temporary elements to support the execution of the work (scaffolding, cranes, excavations, and aid);
- The elements shall contain information, in their name or parameters, that facilitates their subsequent selection and association (blocks A or B and floor 0 or floor 1).
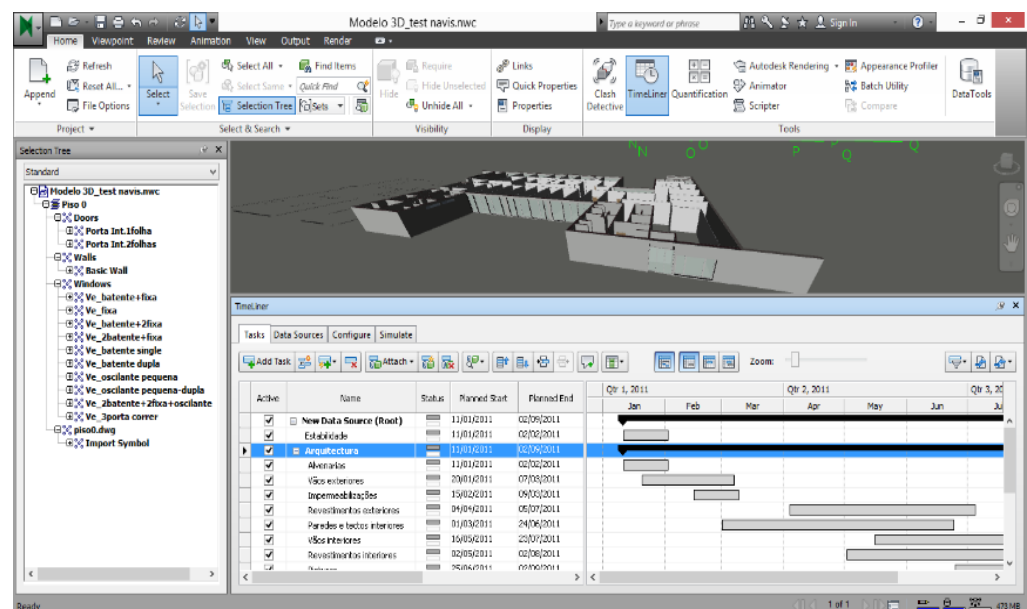

Figure 7. BIM 4D model generation.

The 4D model allows the user to visually simulate the planned construction. For the planned construction simulation view, on the Simulate tab of the TimeLine, the Play option should be selected. The simulation can be exported through the Animation command on the Output tab and is able to monetarize the real work on the site. It is also possible to perform virtual movements around the inside of the model by inserting an avatar (Figure 8). A comparison of the evolution stages of construction is represented in Figure 8: executed (grey), progressing (green), early (yellow), and with delay (red). The ability of the BIM 4D model to be transportable to the construction site supports control when creating the real construction.
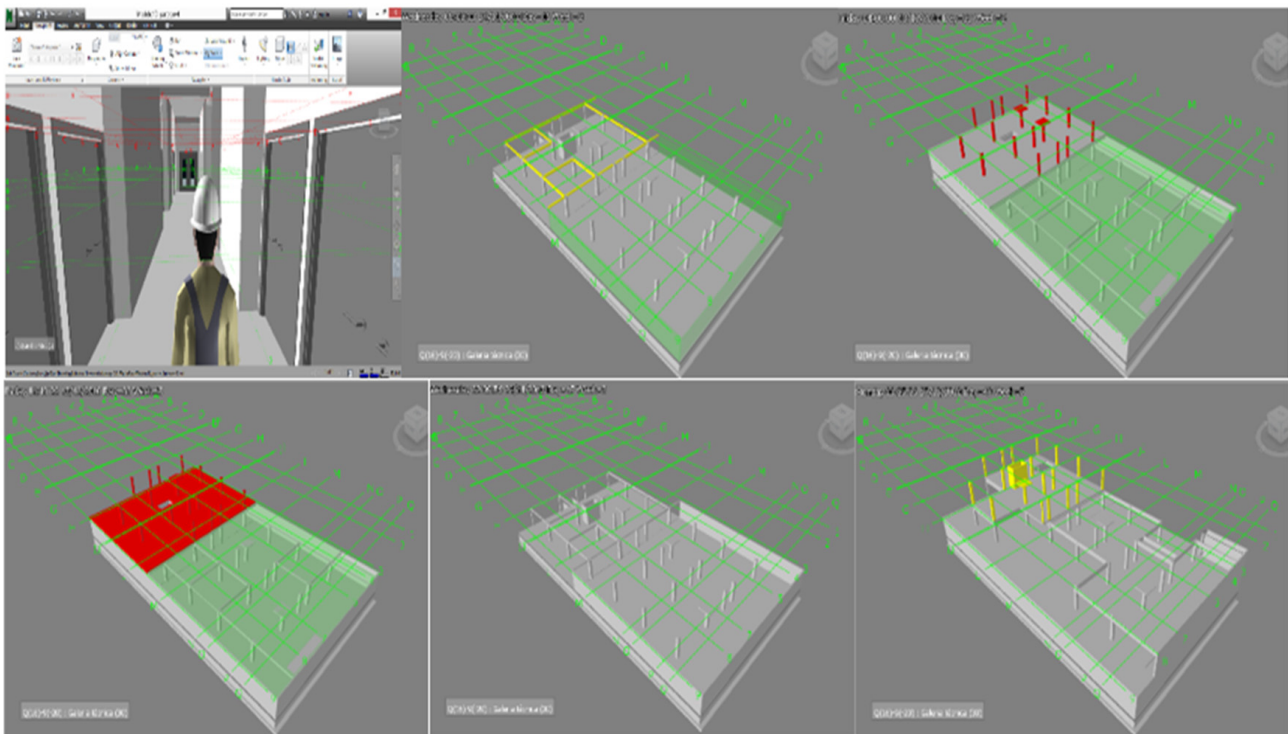
Figure 8. Virtually walking inside the construction site, and a comparative performance between the real progress of the construction and the planned work.

3.3. BIM in Structural Design

Throughout the development of a project and its later construction and use, several processes transferring data between software are normally performed; for that reason, a high level of interoperability is required. In a structural design, the transposition of models between BIM modeling and structural analysis tools is essential. To achieve the structural design, the interoperability capacity, the transfer and verification of consistencies, and the centralization of information and graphic documentation were performed [29].

In the course, the process of transposing the structural models between modeling and calculation systems (two-way flow) was analyzed for several situations involving the ArchiCAD, Revit, and AECOsim modeling tools and SAP, Robot, and ETABS structural dimensioning tools [30]. The transposition of models between systems is supported:

- In the native format, when both software packages are produced by the same manufacturer;
- Via recourse to the universal data transfer standard, the Industry Foundation Classes (IFC) format.

The interoperability capability analysis, verified in each model transposition process, is evaluated over several case studies with distinct volume and use. For several of the buildings, the architectural component was also modeled to offer the advantage of allowing the engineers and the architects to collaborate on a single and centralized model (Figure 9).

First, the BIM models were transferred from the modeling system to the analysis software and the geometric consistency was evaluated. Several inconsistencies were observed (Figure 10):

- The stair elements were not recognized (they were remodeled as sloped slabs in the analysis system);
- The foundations were not transposed (they were interpreted as supports);
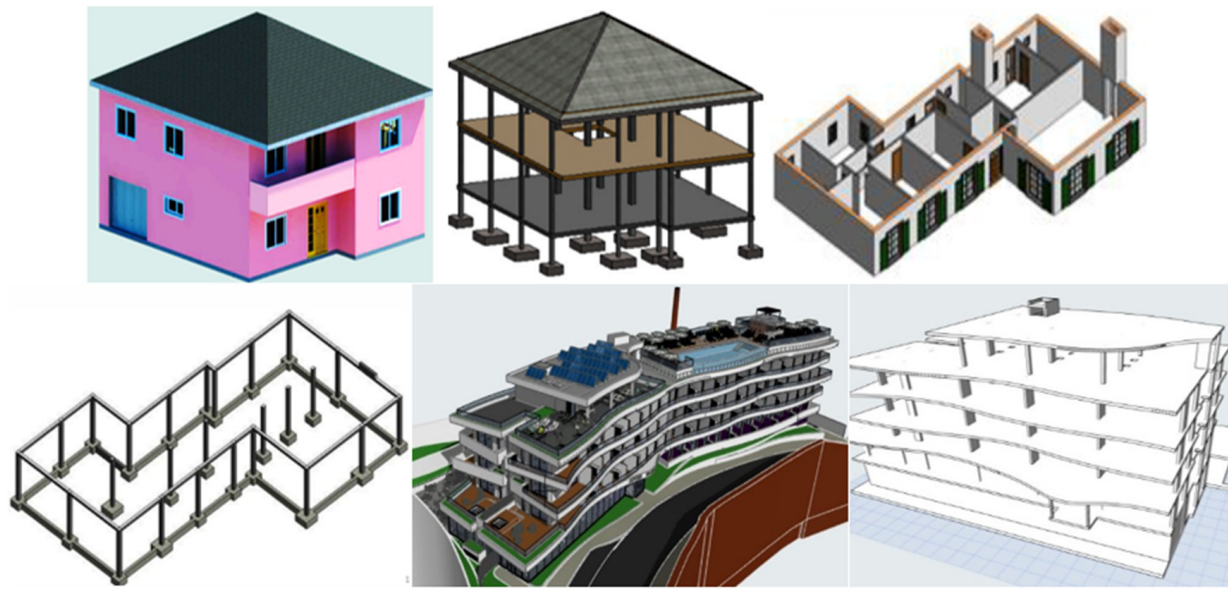- The analytical axis of some linear finite elements and rigid connections required additional adjustments.

Figure 9. Architectural and structural BIM models of distinctive buildings.
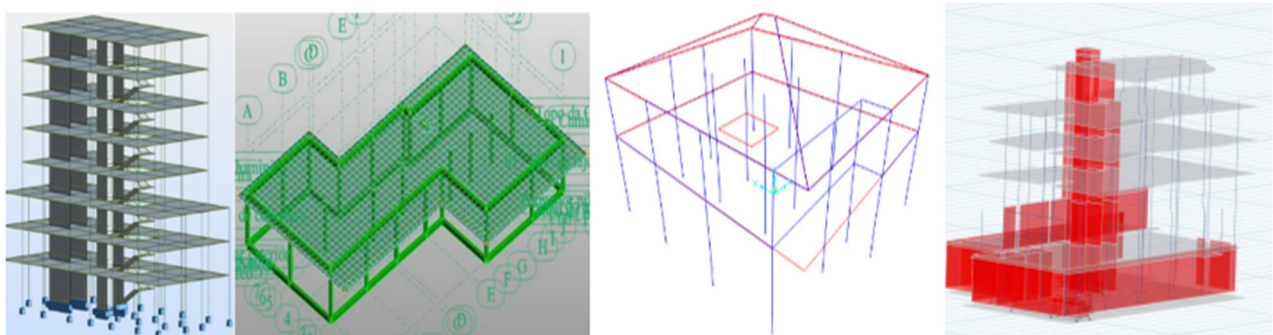

Figure 10. Structural BIM models, transferred to the analysis software.

However, the structural elements (columns, beams, and slabs), grids, and materials, concrete C30/37 and A500 NR SD steel were correctly transposed.

After the structural analyses were performed for each case:

- All loads and combinations were applied in each calculation system;
- The results were obtained in the form of diagrams and 3D models, deformations and efforts, as well as calculation notes;
- Calculation systems allow a high automation capacity of detailed drawings, based on the reinforcement area of the given values for each structural element.

Next, as the BIM centralization concept requires that the calculation result should be transferred to the initial BIM model, the reinforcements were defined in the dimensioning software and, afterward, were transferred to the initial structural model (Figure 11) [31].

- The model database should be updated and should be accessible to the different technicians involved.
- The reverse transfer process, however, has a much higher volume of inaccuracies.
- The above reason is often used to justify resistance to the implementation of BIM in the design of structures.
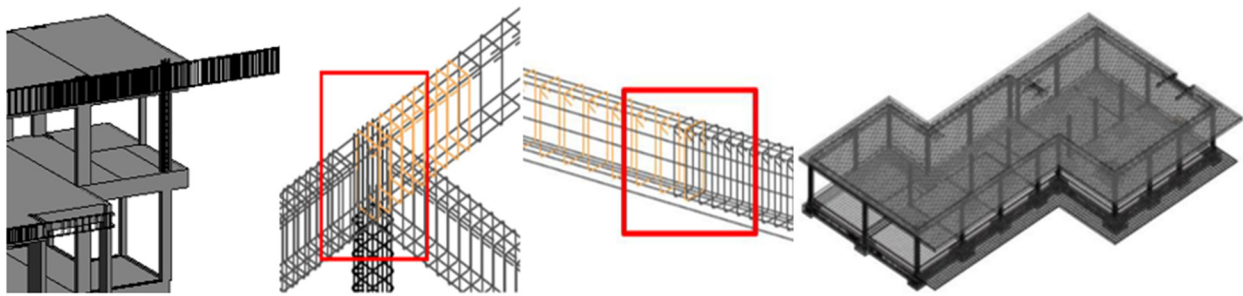
Figure 11. Inaccuracies detected in the reinforcement elements after the transposition of models.

The main feedback concerning the level of interoperability between BIM-based modeling and the calculation systems was assessed. It was found that:

- There are advantages to using the Revit/Robot integrated platforms; the data flow modeling/calculation can be performed with confidence, while the reverse flow is inefficient;
- The advantages are essentially related to the easy initial modeling, with some ability to transfer information post-calculation;
- It is appropriate to perform the detailing of reinforcements in the calculation system, as it allows a high capacity for the production of 3D designs and, subsequently, the inaccuracies are easily adjusted.

3.4. HBIM Concept

A recent implementation development, historic or heritage building information modeling (HBIM) is intended for properties of historical value or heritage relevance. Recent research related to HBIM addresses [32]:

- The standardization of architectural configurations and the creation of parametric objects that are representative of applicable and reusable forms in the old methods of construction;
- An analysis of the construction techniques used, in order to identify the materials used and the solutions applied;
- The archive of registration documents, studies carried out, or previous interventions, and their availability for consultation by experts involved in the project.

It is necessary to understand geometric rules, in parametric terms, from books of architectural patterns to enable the HBIM modeling process. Sets of specific parametric objects must be generated to permit the generation of old building models with accuracy (Figure 12).
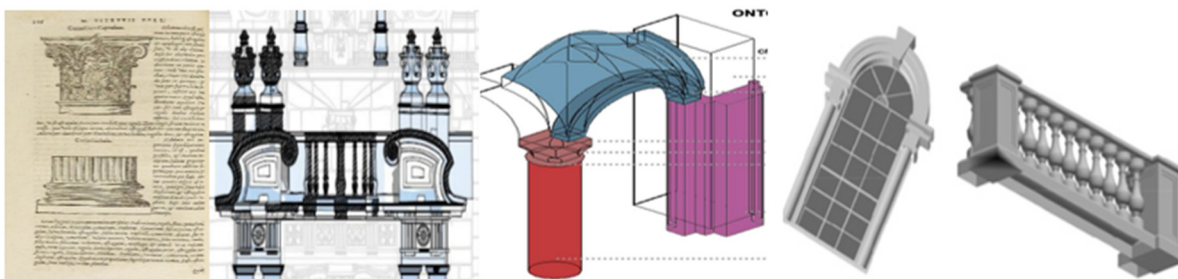

Figure 12. Architectural configurations and the creation of parametric objects.

The registered documentary information provides data concerning the characterization of the construction itself (historical epoch and traditional construction methods), the registration of refurbishing interventions, and local inspection reports. In addition, the documentary collection, along with materials in the municipal archives, comprised drawings of plans, elevations, and cutaways, referring to different dates and using yellows and reds

to create a complete description of the old building. The stratigraphic analysis covers the study of the constructive steps, which are represented by different colors, leading to a clear visual representation. In an HBIM process, it is also frequently necessary to establish a station of laser devices, properly positioned so that, later, the points obtained can be unified into a single cloud of space points (Figure 13).

Figure 13. Antique drawings of buildings, stratigraphic representations, and a drone.

A practical case study concerning the conversion of a building of heritage value was presented by [33,34]. A proposal for the adaptation of an old building, located in Lisbon, requiring the reorganization of internal compartmentalization, but preserving the building's architectural characteristics, illustrated the application of HBIM (Figure 14).
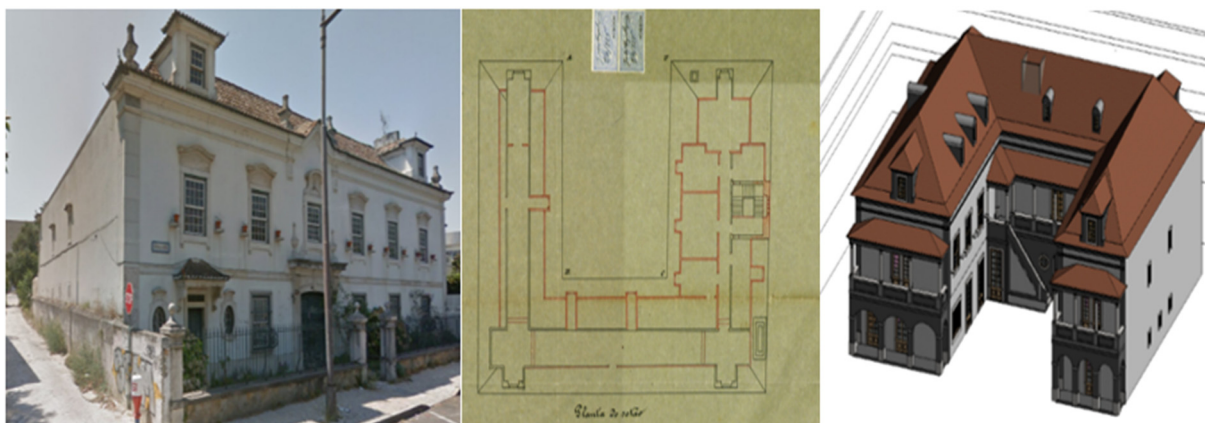

Figure 14. A building of heritage value, old drawings, and a BIM model of the proposed conversion.

Within HBIM, the creation of families of specific parametric objects was required for the rigorous representation of a building of patrimonial value. As a basis for modeling, it was necessary to collect the existing documentation stored in the Municipal Archive of Lisbon, obtain photographs from the outside and inside of the building, and enable the registration of detailed sketches. In addition, to allow correct geometry to be represented in the form of parametric objects, it was necessary to add the material type and adjust the physical and mechanical properties, in order to respect the historic techniques of its

construction. The work contributed to empowering the HBIM library of parametric objects of building components; namely, concerning a new library of window (Figure 15) and door (Figure 16) models.
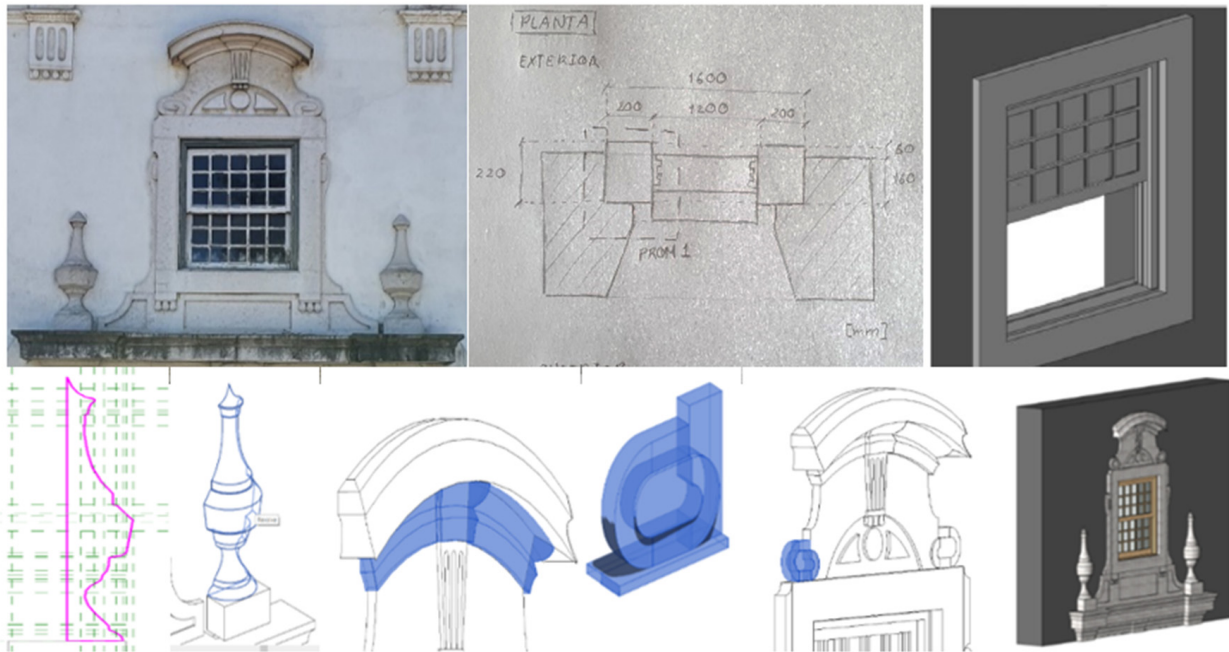

Figure 15. Image, sketches, and the sequence of the modeling process of a window.
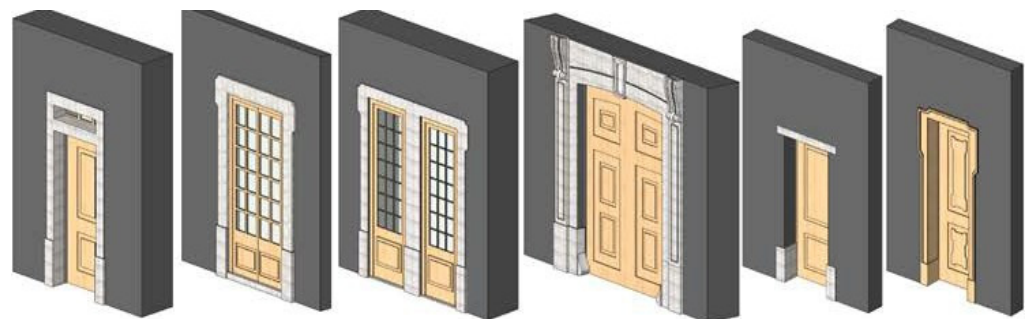

Figure 16. New parametric objects representing doors.

The proposed rehabilitation project maintains the identity of the building, with the preservation of the main part of the building and facades, but this requires the replacement of the wooden floor of the side wings, in order to accommodate the new reorganization of the internal walls. A mixed slab solution with reinforcing sheet metal was selected (Figure 17). For the security check, the robot structural analysis program was initially used, but this system does not allow for the analysis of a mixed solution. Alternatively, the ETABS software was adopted, which admits the import of BIM models in IFC (Industry Foundation Classes) format. The dimensioning was performed using the BIM model to present the current solution and the proposed solution.
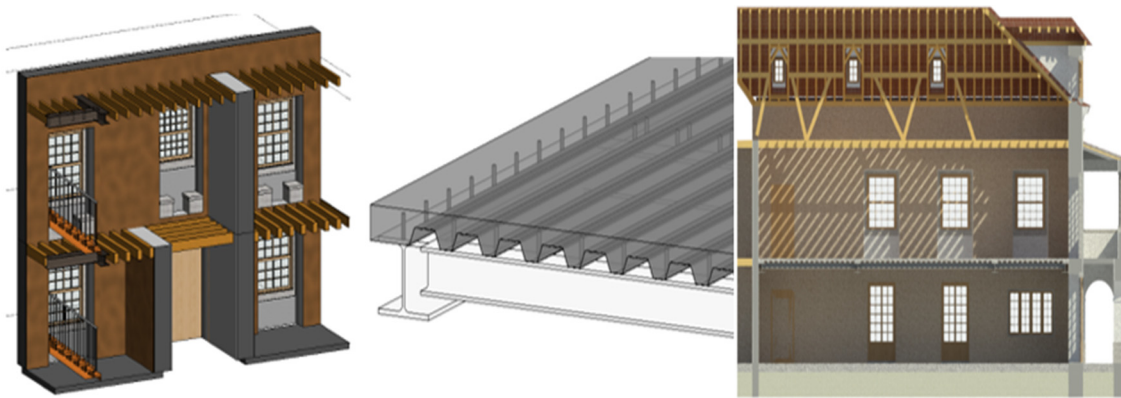
Figure 17. Visualization, using the HBIM model, of the replacement of the wooden floor with the mixed slab.

To represent an old building with accuracy, an adequate library of parametric objects is required, as well as a study of the traditional construction processes identified in the building. For that purpose, an inspection of the site must first be made in order to identify the history of the building, which has gone through several architectural trends, accompanied by the evolution of the construction solutions applied. The inspection reports and photos taken on-site must be collected, studied, and archived, comprising the basic documentation of the project development, whether for the purposes of maintenance, repair, or rehabilitation of the building. An analysis of the constructive techniques applied in the antique building, with the aim of preserving the methodological bases known in each epoch, identifying the materials and physical properties to be associated with the parametric objects [34].

One of the most innovative aspects of the HBIM concept is the as-built model, in which a BIM model is created in order to incorporate parameters with different types of information, organized by historical stages of construction, and archived as layers of duly dated data, forming a hierarchical and chronological sequence of information. The aim of the BIM model, comprised of various information "ages", is to promote the conservation and updating of heterogeneous information related to an old building [34].

3.5. Evaluation and Recommendations

This demonstration of the benefits inherent in the use of the methodology for BIM in the construction industry, in the development of various activities based on the project at a global level, is a matter of great interest, as recently verified by designers and managers eager to explore the BIM concept and the scope of its application. The course aims to contribute to the dissemination of the potential implementation of BIM methodology in sectors such as infrastructure, construction planning, conflict analysis, structural dimensioning, or HBIM. The course was oriented toward various levels and sectors of the construction industry.

It was found that in order to fulfill the industry requirements, academia should be oriented toward that perspective as a way to contribute to society, which is the most important role of a university. Schools should become leaders of the necessary partnerships with industry. To achieve better and more fruitful contributions to the construction industry, a collaborative approach between industry and academia should be instigated. The degree of satisfaction of the course attendees is evaluated in Figure 18.
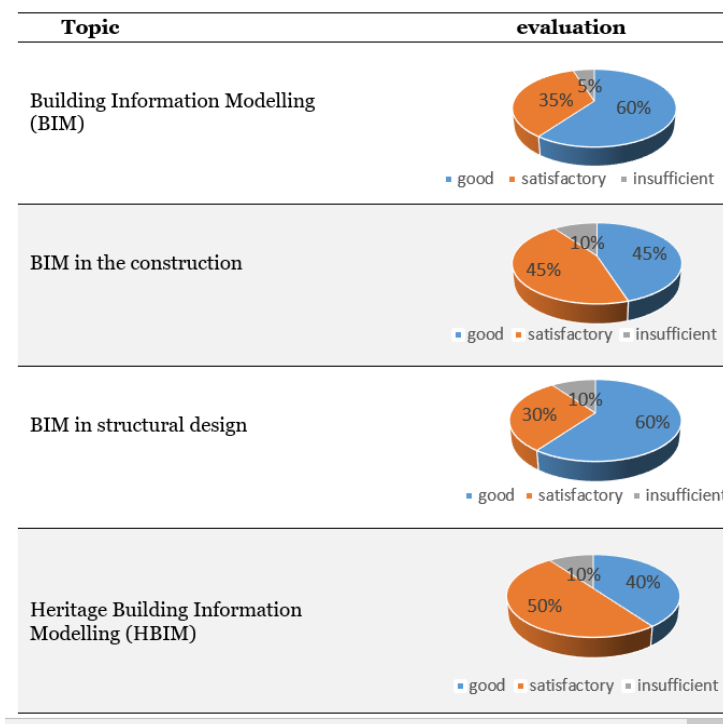
Topic	evaluation
Building Information Modelling (BIM)	
BIM in the construction	
BIM in structural design	
Heritage Building Information Modelling (HBIM)	

Figure 18. Evaluation of the BIM course methodology: construction, structures, and HBIM.

Some comments and recommendations were also expressed. The comments of the participants of the course were oriented toward general and specific appreciation:

- The course exceeded expectations, taking into account the time available, allowing an overview of BIM and its applicability;
- The insertion of a practical component in training was important, allowing participants to learn the fundaments of BIM base tool use;
- The structural design was presented in all stages of modeling and data transfer processes, showing the limitations and the best strategy by which to elaborate this type of project;
- The construction simulation capability was presented, showing the most effective way of creating construction planning and how to control the real-life work on the construction site.

Other topics were suggested that could be included in future BIM short courses:

- More practical components;
- BIM as applied to underground works;
- Exploring BIM in terms of the management and coordination of projects;
- Training using other BIM-based software;
- The generation and use of BIM 5D/6D/7D and 8D models.

4. Conclusions

A short course, *BIM methodology: construction, structures, and HBIM*, was offered at the University of Lisbon to professionals in the construction industry. The programmatic content of a BIM professional course was organized in order to address the requests and interest revealed by the construction industry. The course aims to contribute to the dissemination of the potential of BIM in the areas of designing, constructing, and refurbishing historical buildings. The course began with an introduction to this innovative topic and covered a wide range of applications of BIM in the construction sector. The course was presented as a 1-day session. The group of participants was composed of professionals from different engineering sectors: civil, mechanical, electrical, and informatics engineers, as well

as designers, architects, and managers. The participants in the course showed great interest in all the topics presented, often questioning the trainers, with the aim of clarifying some doubts concerning their particular field. The global satisfaction of the participants was good: a practical component was included, supporting an adequate basis of understanding of the BIM multi-application, in order to meet the various interests of the attendees; after an initial contextualization of the topic (concept, applicability, and implementation maturity), the proposed curricular program covered the areas of construction (conflict analysis, planning, and materials quantity), structures (interoperability, analyses and the transfer of information between software), and the most recent issue heritage building information modeling (HBIM) developments; from analyzing the surveys collected, it was clear that the course received a good overall classification and all topics were covered well.

The principal objective of the short course was to improve professional skills concerning BIM's main concepts, find working strategies for each BIM application, and clarify the benefits and limitations of BIM implementation. All parts of the course, including practice, construction, created structures, and HBIM, were illustrated with images retrieved from a set of selected case studies in accordance with the demographic of the participants. As construction professionals feel the need to improve their skills in the field of BIM, this academic course contributes, in a positive way, to achieving this end.

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