Academic One-Day Course Offered to Improve Engineers' BIM Skill

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Abstract: The construction industry has been adopting the new Building Information Modelling (BIM) methodology as the main approach of working, covering all sectors, including design, construction and maintenance. Construction enterprises have been demanding the University to carry out professional courses in order to be able to update their professionals with this new methodology. Recently, a design and construction office requested a one-day BIM training course, to increasing the BIM knowledge of the employees. The short course was properly designed to present the basic concepts, to experience the handling of the BIM modelling software most used, and to disseminate the large range of BIM applicability. The proposed professional 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 recent heritage building information modelling (HBIM) perspective. For it, the applied didactic procedure was based on the presentation of case studies related to situations of conflict between disciplines, of interoperability problems, and of rehabilitation of old buildings. This training involved all the company's employees, composed of designers, architects, civil engineers and economists. The difficulties found in the course are mainly due to the heterogeneity of the attendees, who have different interests and specific familiarity perspectives. The course was held with the objective of initiating professionals in the new topic and to acquiring knowledge in BIM adoption, in a way they can apply in their company. The participants followed the course with great interest and satisfaction, formulating several questions contextualized in the particular field of expertise of each professional. The course aims to contribute to the dissemination of the potential of BIM in the design, construction, and refurbishment of historical buildings. The course was evaluated in its generality and topic taught, resulting in a positive grade.

Keywords: BIM, On-day Course, Improving Skills, Construction, Management, Professionals

1. Introduction

The Building Information Modelling (BIM) methodology is currently the main digital support for the elaboration of distinct construction activities. A BIM project is developed using advanced BIM software allowing the professional team to create and to manipulate the information contained in the BIM model database (Sacks *et al.*, 2018). The methodology implementation supports the development of different stages of the project. For it, an adequate interoperability capacity between the BIM systems most used, is required to perform a large range of BIM applicability. Distinct BIM tasks are related to the various types of analysis or simulation performed over the building design information, namely the required tasks such as budgeting, construction planning, maintenance and management after occupation (Volk *et al.*, 2014).

BIM is a methodology involving a set of procedures supported by advanced technology software, based on the parametric modelling concept. In the elaboration of a project, a BIM digital model is generated, the BIM model. It is composed of parametric objects, representing with accuracy the building in analyses. The BIM model database contains the information necessary to develop distinct type of tasks, which are usually executed over the project documentation, namely, budgets, energetic simulations or construction schedules. The digital model supports a complete integration of the design stages, construction phase, or maintenance and management activities, improving the degree of collaboration among the team professionals.

The BIM concept has been implemented in the construction industry at the beginning of this century as an immersive innovation in the sector. Its benefits were quickly recognised, reflected in the quality of the projects that were developed, based on an effective process of integration and clear collaboration between partners, related to the distinct specialties involved in the construction activity (Lu *et al.*, 2014).

BIM computational tools are a strong support for the development of the different disciplines of the project, enabling their parametric modelling and easy access to all the information centralized in the BIM model created in along the project elaboration. In all areas of construction, namely, owner, designers, builders and managers, has verified the benefits in adopting BIM methodology in their activity and interest. 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 in public construction (Khattra and Jain, 2024). In addition, the school has the mission, essential in society, to train future engineers with the fundamental teachings related to different themes in the field of construction, and should also be attentive to the technological innovations

applicable to the sector. Naturally, construction-related companies follow this perspective, encouraging professionals to seek training actions that can add to professionals the knowledge, in the BIM context, required in a globalized industrial world, increasingly competitive.

The current attention of Civil Engineering education is oriented to BIM, and it is up to the school, as the main trainer of the future engineer, to introduce this theme, as a concept that should be transmitted, contributing to support all new subjects, included in the curriculum, on a BIM-based digital support (Sampaio, 2021):

- The requirement of BIM skills in the sector, has imposed an educational maturity of alert in relation to the need in society, which has led to a progressive adaptation of the curricula taught;
- The school 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 expectation expressed by the offices and public entities;
- Industry and the school are partners in finding the best strategy for establishing effective ways of teaching useful to the community.

The construction industry has demanded from schools an offer aimed at the specificity of the profession, focusing on different perspectives. Engineers and architects recognize that in a globalized world, in the pursuit of their activity, the use of BIM platforms, leads to the achievement of better products and the establishment of more competitive projects. The constant demonstration of the benefit inherent to the use of the BIM methodology, which has been registered in the various sectors, motivates designers and managers to acquire knowledge related to the concept and scope of its applicability. Professionals from all sectors are interested in knowing the BIM concept and the scope of its applicability and technical schools have been organising BIM training activities to help adding knowledge and competitiveness to industry professionals.

A short course, presented in November of 2024, at the University of Lisbon, included the methodological concepts and a wide range of the applicability sectors inherent to the development of projects in BIM. This text reflects the contents of the course. The organizational structure of the course introduces the underlying fundaments of the methodology, such as parametric modelling and interoperability, and presents the scope of the applicability of BIM.

2. Professional Course

The professional course, titled “BIM methodology: construction, structures and HBIM”, included within the activities of the Department of the Civil Engineering, of the University of Lisbon, was the most recent event offered to professionals of the construction industry. The range of professional englobes architects and civil engineers coming from consult enterprises and public organizations. The objective in attending the course was to improve their skills in order to increase competences in each particular domain of the construction activity. The contents of the program in presented in Table 1.

Table 1: Contents of the professional course “BIM methodology: construction, structures and HBIM”.

Topic	Contents
Building Information Modelling (BIM)	Concept, applicability and implementation; Parametric modelling, interoperability, and centralization; BIM tool practice in generating model structures.
BIM in construction	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 Modelling (HBIM)	Concept and collection of information; Digital capture of images (photogrammetry, scanner and drones); Generation of specific families of parametric objects; Documentation file (as-built); Practical case: reconversion of a heritage building.

This follow some activity online BIM courses concerning BIM modelling project, Revit architecture and structural, and also modelling plumbing and water supply systems. The contents of those type of course included: integrating architecture, structural, and mechanical disciplines; BIM architectural modelling; advanced

techniques for architectural walls; creating detailed ceilings; structural modelling of foundations and substructures; modelling beam elements and columns; HVAC coordination and modelling.

2.1 Introduction to BIM

The introduction of the main fundaments of BIM started with the exposition of the principal concept, the range of applicability and the state-of-the-art of its implementation around the wold. The fundamental BIM notion is the generation of a centralized digital model of all construction-related information (Lozano-Díez *et al.*, 2018). BIM is frequently defined as a digital representation of the building or infrastructure, strongly supported by parametric modelling and standard formats of data. Collaborative projects can be developed over the model, requiring the use of advanced technologies and a high level of interoperability.

A practical lesson concerning the use of BIM-based tool, introduces the concept of parametric modelling, essential, to the understanding of the development of multitasking. In the modelling 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 to physical properties (Araújo, 2016). As an example of how to handling with a BIM-based tools, a structural BIM model was created (Figure 1).

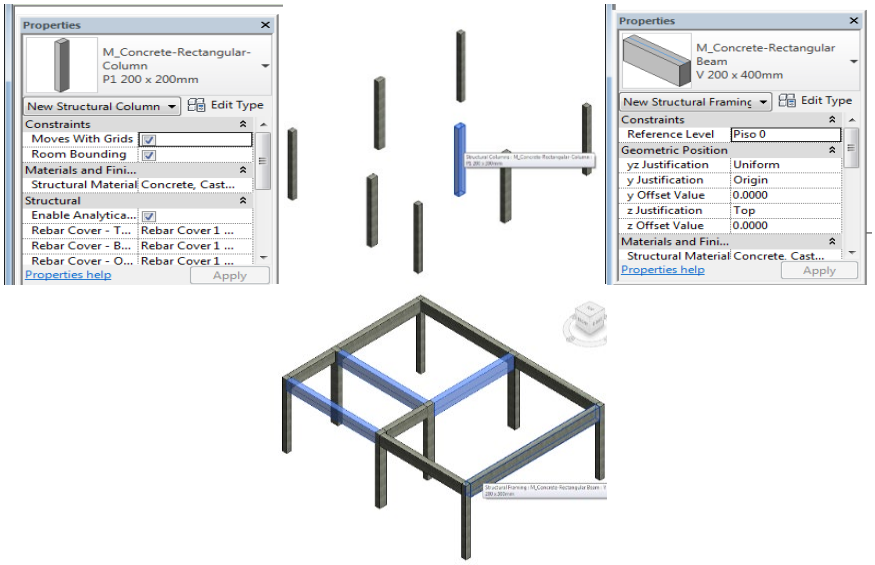

Figure 1: Modelling columns and beams.

After, there were obtained several tables of take-off of materials and elements from the generated BIM model (Sampaio, 2020) (Figure 2).

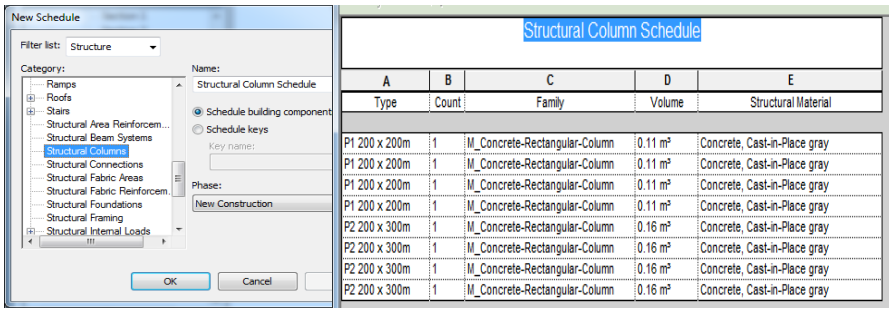

Figure 2: Interface with selection and table of columns extracted from the model.

2.2 BIM in Construction

The BIM modelling software allows to overlap the three modelled disciplines (architecture, structures and mechanic) and to support the definition of each component by a direct analysis of conflicts, identified by the system with the visualization of inconsistency messages. An analysis over the conflicts detected over the selected projects was also exposed to the audience. There are several software with conflict analysis-oriented

capabilities, namely, Tekla BIMsight, Navisworks, and Solibri Model Checker tools. In the study case shown in the course, the models of Mechanical, Electrical, and Plumbing (MEP) and structures were overlapped and an analysis of inconsistency was applied. In it, using the Navisworks and Tekla BIMsight systems a set of conflicts were listed and visualized (Figure 3)..

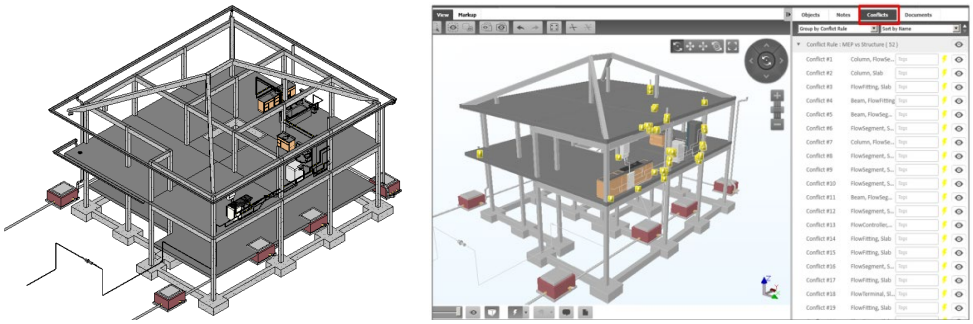

Figure 3: Identification of conflicts between models using the Navisworks BIM viewer software.

After running a conflict analyses system, the modeller adjusts each conflict situation over the BIM model, using the BIM modelling system. The conflicts detected were after adjusted accordingly in order to obtain correct situations (Figure 4).

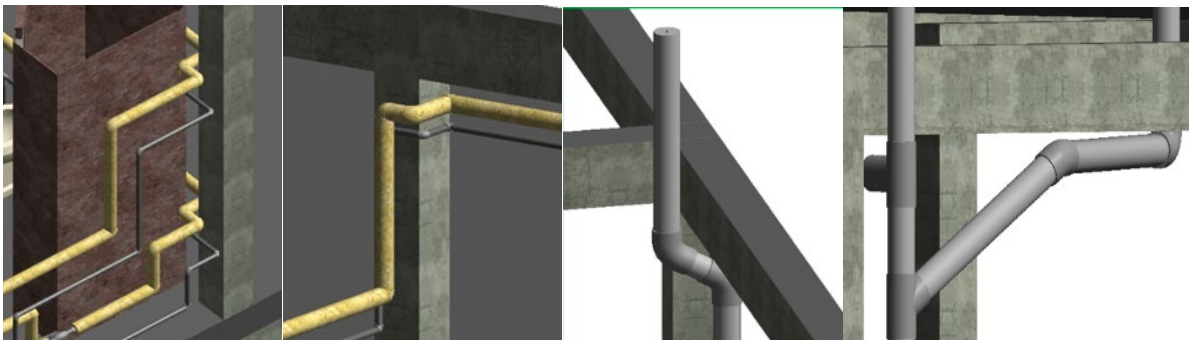

Figure 4: The required changes were after performed using a BIM modeller software.

The course also illustrates how to generate a 4D BIM model, relating to the construction process of a building (Jung and Joo, 2011). First, the complete 3D BIM model of the structural project must be defined and after the constructive sequence must be planned (phases and periods of execution). Also the allocation of human resources must be established. The construction schedule in presented in the form of a Gant map (Figure 5).

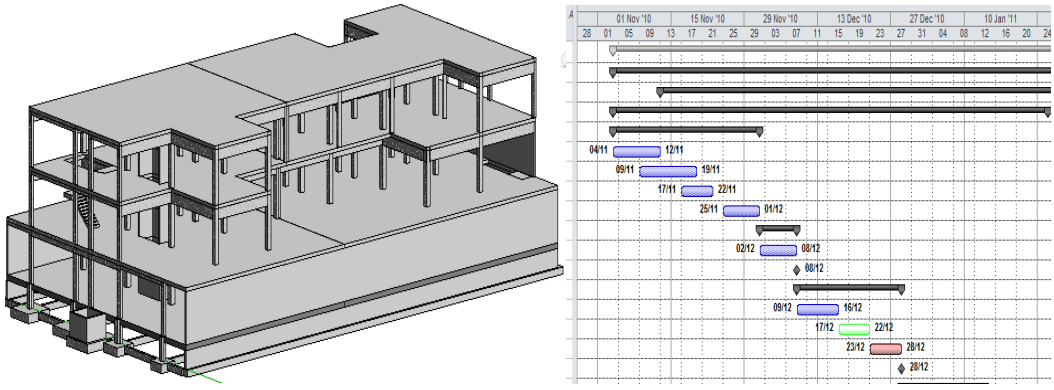

Figure 5: 3D BIM model of a structural project and the Gant map.

The 4D model is created using the Navisworks software, a BIM viewer system. The BIM model representing the structural project was exported from the modelling system to the selected BIM viewer. The model was transferred in the native format of data. In addition, the construction planning (Gantt map) file is also transferred from the Ms Project system to the Navisworks. In this software, the next step considers the association of the construction components of the imported model, forming groups or sets, with the respective construction activity identified in the Map schedule (Figure 6).

This procedure allows users to generate a 4D BIM model of the construction. The 4D model is activated and a animated simulation of the planned construction is visualized (Figure 7).

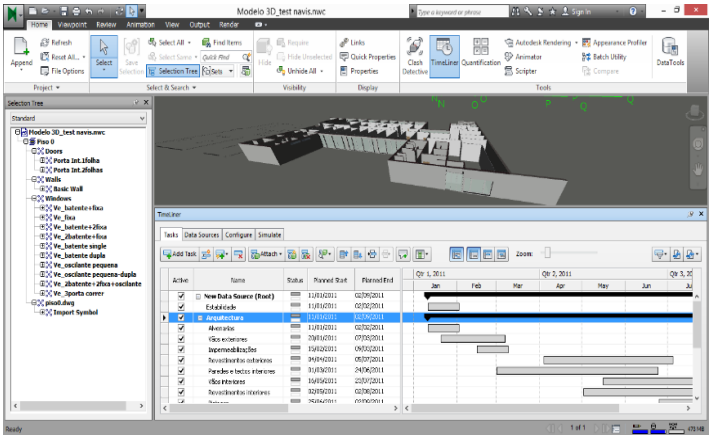

Figure 6: Generation of a 4D BIM model, by linking model elements to the respective construction task.

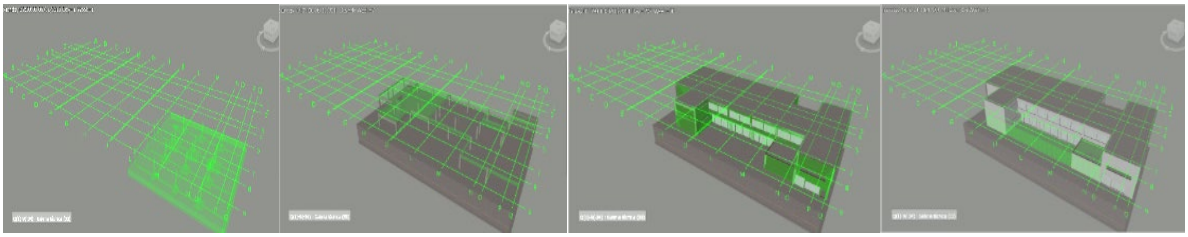

Figure 7: Simulation of the construction process.

2.3 BIM in Structural Design

Throughout the development of a project and later construction and use, several processes transferring data between software, are normally performed, and for that, a high level of interoperability, between the software used, is required. In a structural design, the transposition of models between the BIM modelling software and the structural analysis tool, is necessary. In the course, the process of transposition of structural models between modelling and calculation systems (two-way flow) was analysed in several situations involving (Sampaio *et al.*, 2021):

- ArchiCAD, Revit and AECOsim modelling system tools;
- SAP, Robot and ETABS structural dimensioning tools.

The transposition of models between systems is supported:

- in the native format, when the software belong to the same manufacturer;
- by recourse to the universal data transfer standard, the Industry Foundation Classes (IFC) format.

Concerning the structural design, the interoperability capacity, the transfer and verification of consistencies and the centralization of information and graphic documentation were performed over the selected case study presented in course (Oliveira and Sampaio, 2019). The interoperability capability analysis, verified in each model transposition process, is evaluated over several case studies of distinct volume and use (Figure 8).

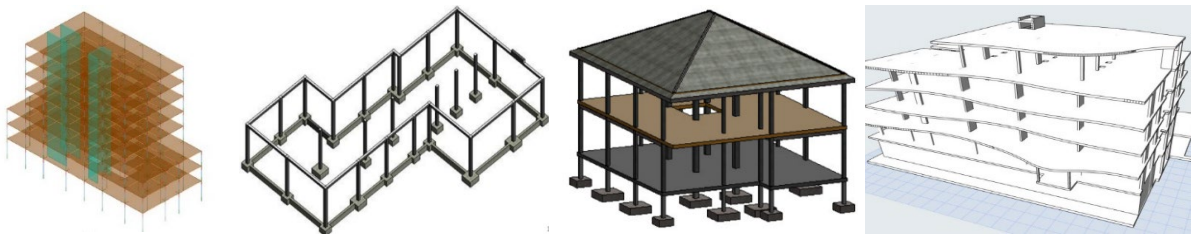

Figure 8: Structural BIM models of distinct buildings.

First, the BIM models were transferred from the modeller system to the analyses software and the geometric consistency was evaluated. Several inconsistencies were observed: stair elements were not recognized (remodelled as sloped slabs in the analyses system); the foundations were not transposed (considered as supports). However, the structural elements (columns, beams and slabs), grids and material, concrete C30/37 and A500 NR SD steel were correctly transposed, but the analytical axis of some linear finite elements and rigid connections were adapted (Figure 9).

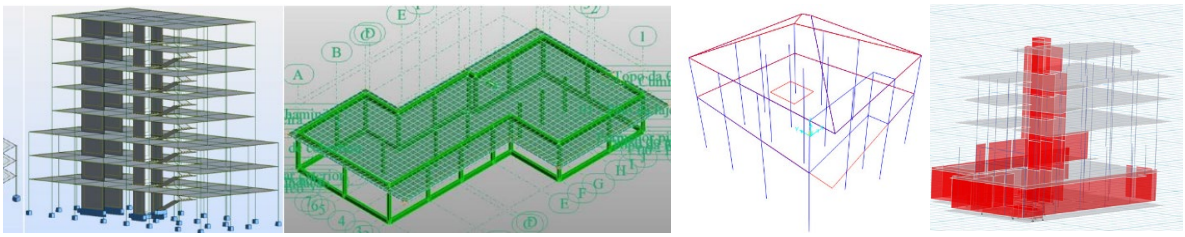

Figure 9: Structural BIM models transferr Tunkevichus Olga and Kovalerchik Arseniy, Konstantin Bagrationi ed to analyses software.

The level of interoperability between BIM-based modelling and calculation systems was assessed. It was found that:

- There are advantages of using Revit/Robot integrated platforms;
- The data flow modelling/calculation can be done with confidence, while the reverse flow is inefficient;
- The advantages are essentially related to the easy initial modelling, 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.

2.4 HBIM Concept

A recent BIM perspective the Historic or Heritage Building Information Modelling (HBIM) is applied on studies involved in the maintenance or reparation of buildings historical value or heritage relevance. Recent research related to HBIM addresses (Penjor *et al.*, 2024):

- The standardization of architectural configurations and creation parametric objects representative of applicable and reusable forms in the old construction;
- The analysis of constructive 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 required to understand geometric rules, in parametric terms, from the books of architectural patterns to the HBIM modelling process (Lagüela *et al.*, 2024). The documents of the municipal archives provides data concerning the characterization of the construction (historical epoch and traditional construction systems), the registration of refurbishing interventions and local inspection reports. In addition, the documentary collection, along with municipal archives, composed of drawings of plants, elevations and cut, referring to different dates and with yellows and reds, bring a complete description of the old building (Figure 10). Sets of specific parametric object must be generated to allow the generation of old buildings with accuracy.

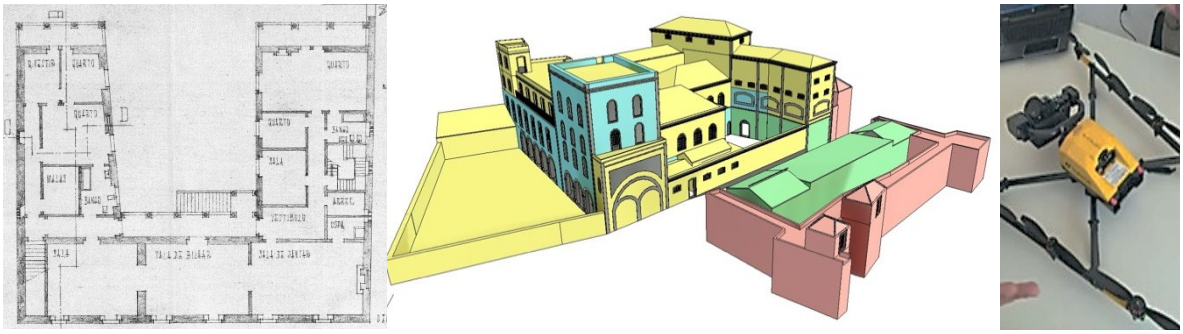

Figure 10: Technical drawing of an old building, stratigraphic representation and drone equipment.

The stratigraphic analysis covers the study of the constructive steps, which are represented through different colours, leading to a clear visual perception. 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, in a single cloud of space points (Figure 11). A practical case of reconversion of a building of heritage value was presented (Pinto, 2020). A proposal for the adaptation of an old building, located in Lisbon, requiring the reorganization of internal compartmentalization, but preserving their architectural characteristics, illustrated an application of HBIM (Figure 11).

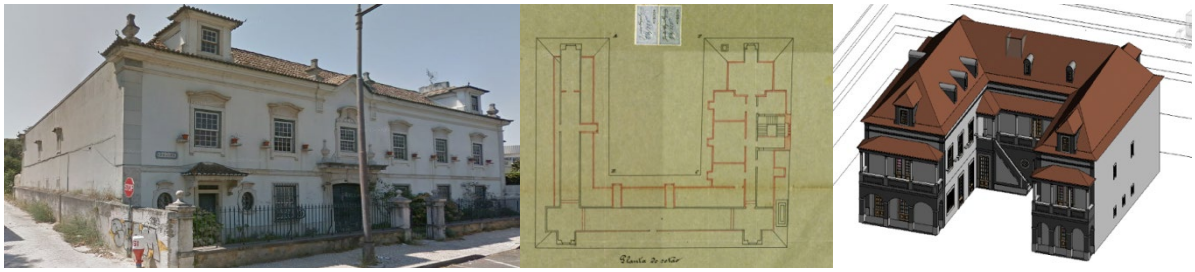

Figure 11: Building of heritage value, old drawing and BIM model of the proposal.

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 modelling, it was requested to collect the existing documentation in the Municipal Archive of Lisbon, to obtain photographs from outside and inside of the building and the registration of detailed sketches. In addition, to allow a correct geometry 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 ancestral techniques of construction. The work contributes to empowering the HBIM library of parametric objects of building components.

3. Course Evaluation

Once the training course is completed, participants are invited to respond to a small survey that allows them to convey to the coordinator and trainers their satisfaction regarding the initial expectations and what direction future courses may take in order to better meet the needs of the community. The statistical treatment was provided by the organization, illustrating in a quantitative way the quality of the course and the preferences of the topics covered, according to the perspective of the participants (Table 2).

Table 2: Evaluation of the professional course "BIM methodology: construction, structures and HBIM".

Topic	Comments
Building Information Modelling (BIM)	- Important inclusion of practical component in the training, allowing attendees learning to handle the using of a BIM tool. - Very practical, pragmatic, and available instructor who performed well as the course coordinator. - Easy empathy with the trainees and accessible responses to the questions raised. - There was a lack of IT support in the practical session and the practical case requires more time.

Topic	Comments
BIM in construction	- The available time clearly demonstrated the construction simulation capability, presenting the basic concepts in BIM, allowing for a more in-depth study in the future. - The trainer was very quick in the explanation and available to clarify questions appropriately, successfully presenting the advantages of usage.
BIM in structural design	- Practical trainer, explicit in the topics addressed, good ability to convey information and was able to respond to the questions raised. - Interesting and well-structured presentation of a practical example of software use and the application of BIM. - Demonstration of the software's potential and its limitations, well illustrated with appropriate examples.
Heritage Building Information Modelling (HBIM)	- In case of interest for very practical application in the activity of the coordinating designer. - The trainer expresses themselves clearly and demonstrates good theoretical and practical knowledge.

Compared to online BIM courses, this course adds the practical component, which adds value to the course, as it leads to a better understanding of the concept and application of BIM. The table also included the limitations identified by the participants, which supported the adjustment of the course program to be taught in the upcoming iterations of the course. Following this, the attendees listed some suggestions of topics to be included in future BIM courses: practical course on BIM; BIM applied to underground works; exploration of the BIM methodology in management and coordination; practical courses on other BIM-based software; standardization and parameterization of construction objects; characterization of BIM models 5D/6D/7D and 8D.

The course aimed to contribute to the dissemination of the potential of implementing the BIM methodology in sectors such as infrastructure, construction planning, conflict detection, or structural analyses, and was oriented to the various sectors of the construction industry. The level of satisfaction expressed by participants was analysed. The final comments were confronted with the expectation of the participants and interest in the courses.

4. Conclusions

A one-day course, BIM methodology: construction, structures and HBIM, was offered, at the University of Lisbon, to professionals of the construction industry. The contents of the training action was organized in order to cover a wide range of the applicability of BIM in the sector, and with the most recent achievements. The participants demonstrated a global interest in all topics presented, formulating questions oriented to their particular expertise. The global satisfaction of the attendance was good.

Naturally, the course, taught to a heterogeneous audience with different backgrounds, addresses the participants' initial expectations in a distinct manner. However, the overall assessment is very satisfactory, and it is noted that the topics that were most appreciated are related to the practical component, infrastructure, conflict detection, and parametric objects. According to the suggestions concerning topics to be addressed in the future, the coordination intends to include a more practical component regarding the use of BIM tools, not only for modelling but also for conflict detection, construction planning, or even structural calculation. However, its duration should be longer, with plans for courses to be two days long.

The main purpose of the course was to transmit the main concepts, the strategies of working in each type of BIM application and the reference to the main benefits and limitations. All parts of the course, including practice, construction, structures and HBIM, were essentially illustrated with study cases selected in accordance with the audience. Industry professionals feel the need to update themselves in the BIM context and the course contributes in a positive way to this learning. An in it the school and the industry collaborated in order to establish an interesting and useful program.

Ethics Declaration

No ethical clearance is needed

AI Declaration

No AI tool was applied.

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