BIM short course for construction industry professionals

Curso corto en BIM dirigido a los profesionales de la industria de la construcción

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HIGHLIGHTS

- Teaching BIM methodology in higher technical education.
- Training for construction industry professionals.
- Course program (concept, practice, structures and construction).
- Participant course-satisfaction survey

TITULARES

- Enseñanza de la metodología BIM en Escuelas Técnicas Superiores
- Formación para profesionales de la industria de la construcción
- Programa académico (conceptos, prácticas, estructuras y construcción)
- Encuestas de satisfacción de participantes en el curso

ABSTRACT

The *Building Information Modelling* (BIM) methodology is currently the main work platform in the construction industry, and all sectors have been enhancing its applicability. The demonstration of the benefits registered in the development of various activities motivates the great interest. affirmed by architects, engineers and managers, in knowing its concept and the scope of its applicability. Recently, higher education technical schools have been following this interest, introducing changes into their curricular programs and also offering short courses to construction industry professionals. In recent years, the Department of Civil Engineering of the University of Lisbon, Portugal, has organized courses concerning BIM with the aim of meeting the professionals' needs. To this end, the most recent short course offered to the technical community covered aspects, from the parametric modelling concept to the analysis of the interoperability capacity of the software. The text presents the course program - concept, practice, structures and construction - and the assessment of the degree of satisfaction of participants, based on their pre-course expectations and interest they had in attending the course. It can be concluded that the school and the industry should continue to collaborate in order to reinforce the efficiency of the construction sector.

Keywords: *BIM; training; professional course; construction industry*

RESUMEN

La metodología *Building Information Modelling* (BIM) es actualmente la principal plataforma de trabajo en la industria de la construcción, y todos los sectores han estado potenciando su aplicabilidad. La demostración de los beneficios registrados en el desarrollo de diversas actividades motiva el gran interés, verificado por arquitectos, ingenieros y gestores, por conocer su concepto y el alcance de su aplicabilidad. Las escuelas técnicas han estado siguiendo este interés, introduciendo cambios en sus programas curriculares y ofreciendo también cursos cortos a profesionales de la industria de la construcción. El Departamento de Ingeniería Civil de la Universidad de Lisboa, Portugal, ha estado organizando cursos sobre la cuestión BIM, en una perspectiva de lograr las necesidades de los profesionales. En este caso, el curso corto más reciente ofrecido a la comunidad técnica abarca varios aspectos, desde el concepto de modelado paramétrico hasta el análisis de la capacidad de interoperabilidad. El texto presenta el programa del curso (concepto, práctica, estructuras y construcción) y la evaluación del grado de satisfacción de los participantes, confrontado con sus expectativas e interés en asistir al curso. La escuela y la industria han estado colaborando para potenciar la eficiencia del sector de la construcción.

Palabras chave: *BIM; entrenamiento; corso profesional; industria de la construcción.*

1. INTRODUCTION

BIM is frequently defined as a digital representation of the building or infrastructure, strongly supported by parametric modelling and standard formats of data [1, 2, 3]. 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 is required [4]: In a structural design the transposition of models between BIM modelling and structural analysis tools is essential. A final BIM model is formed with the overlapping of all disciplines, mainly, architecture, structure, and service, which demanded a conflict analysis be made using a BIM visualizer. Additional applications were used to establish the construction planning, the preventive maintenance strategy, and the take-off of materials.

The generation of a BIM model and all the activities that can be developed with it, are concepts that the professionals are currently interested in understanding, as this knowledge and its practical application can improve efficiency and competitivity in their field. Therefore, professionals should introduce BIM into their work, to improve their skills with this tool and in the use of collaborative platforms.

In this context, technical schools and universities have been adapting their curricula to include the topic of BIM and in addition, they have recently organized training courses, with the aim of teaching BIM concepts and practice to professionals [5]. In the search for the best strategy for establishing effective teaching practices for this useful subject, Industry and education have become partners. The present text discusses the organization, the contents, and the evaluation by the participants of their satisfaction pertaining to a short course on BIM, offered at the University of Lisbon, in February 2020.

2. MANDATORY STRATEGY OF BIM

In a governmental context, the implementation of BIM use has, in recent years, been encouraged by industry and schools adopting progressively mandatory strategies. At the international level, the implementation of BIM as a norm in guide of construction practice has been affirmed in the different sectors of the construction industry, motivated not only by the advances in technology achieved but also by such government regulations already introduced in some countries.

The European Commission has emitted directives which serve as a base for the establishment of guidelines, adapted by each country for their particular construction environment. The evolving global BIM regulation lists countries where methodology implementation is mandatory or in process of so becoming [6]:

- Finland, Sweden, and Denmark defined mandatory requirement in 2017 and the United Kingdom in 2016.
- France, Italy, and Germany established mandatory guidelines in 2017, 2019 and 2020 respectively.
- Ireland established a roadmap to digital transition for the period between 2018 to 2021 and Austria followed in 2018.
- The Spanish government has requested that projects for the construction of public buildings be in place by the end of 2018.
- In Portugal, there is an increasing involvement of architects and engineers in design offices and construction enterprises, and some action on the definition of guidelines for BIM implementation, at a governmental level, with the aim of implementing a progressively mandatory strategy.

- In Belgium, the Czech Republic, the Netherlands, and Switzerland there is no regulation to-date.
- In Asia, it was found that Dubai mandated BIM in 2013, China required mandatory BIM implementation during their 12th national five-year plan and Hong Kong's mandate has been in place since 2014.
- In the Americas, a roadmap is under review and in Brazil and the USA multiple mandates are being considered for the different states.

This demand for implementing BIM around the world motivates the technical colleges and universities to introduce new disciplines or to adapt existing ones, with the objective of providing students with BIM skills and competences necessary in their future professions.

2.1 Curricular adaptation

At the Building School of the Polytechnic University of Madrid, in Spain, the education strategy was to propose a new optional unit, allowing students to familiarize themselves with a BIM-based tool during the elaboration of a collaborative project [7, 8]. The results obtained were highly satisfactory and presage a very high future demand for such a component in their training. The students themselves recognized the need to intensify and incorporate BIM teaching as an essential tool for their studies and subsequent professional development (Tab. 1).

Table 1: *Level of satisfaction of the students.*

Height satisfied	40,74%	
Satisfied	51,85%	
Neutral	7,41%	
Unsatisfied	0,00%	

At the University of Lisbon, Portugal, a BIM practical unit was introduced into the bachelor course in 2015, offered to civil engineering students as a unit on Computer Aided Drawing. A new curricular unit, focusing on concepts, practice and a wide range of applications, has been proposed for the academic year 2021/22, [9]. In addition, MSc students have been developing research papers on [10]: the analysis of interoperability in structural design; the generation of a water supply model; the analysis of conflicts between specialties; 4D/BIM models supporting construction planning (Fig. 1).

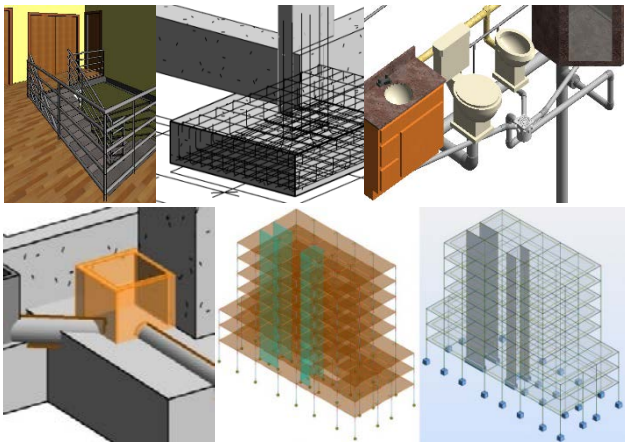


Fig. 1: *Results of MSc research.*

2.2 Industry demand

Faust [11] identifies the importance of BIM education following the lead of the industry advisory board that was eager to attract students and professionals. As a first step, a complete course aimed at detailing several disciplines was presented at the University of Arkansas, USA covering scheduling(4D), estimating (5D), sustainability (6D), facility management (7D) multitasking as required in the construction industry.

There is increasing collaboration between universities and industry to align learning objectives for BIM and methods for delivering different kinds of BIM training and education

strategies [12]. Currently, schools are conducting regular workshops and professional courses working together with the private sector in order to [13]: get feedback on the status of BIM implementation in the industry; invite as guest lecturers, professionals in the sector to present the use of BIM in real projects; draw up adequate strategies for keeping other professionals updated on the topic of BIM.

3. PROFESSIONAL BIM COURSE

At the Department of Civil Engineering BIM short courses are centred on different aspects of BIM. Since 2011 the courses, lasting one working day, three times a year, have been attended by professionals from all sectors of the industry. The attendance has been increasing recently, denoting a greater interest from the professionals in being updated on the BIM topic. The demand is diverse, attendees coming from architects, civil and mechanical engineers, designers and managers.

The course held in February 2020, *BIM methodology in the construction industry*, presented a program composed of three main components: the BIM concept; practice in handling a BIM modelling tool; BIM's applicability in a wide range of sectors:

- *Building Information Modelling* (BIM) - definition, state-of-the-art, application, benefits and limitations, parametric modelling and interoperability capacity and multi-utilization concept of BIM model information.
- *BIM-based tool practice* - initial definitions, levels of floors and grid of alignments, generation of a BIM 3D parametric model, automation of 2D and 3D projections and of tables of take-off quantities.
- *The BIM methodology in the design of structures* - modelling and interoperability analysis.
- *The 4D/BIM model as support for construction planning* - BIM modelling and visualization systems and the monitoring of the construction process.
- *Application of BIM methodology in infrastructures* - illustration in real cases of dams and motorways.
- *Generation, updating and application of parametric objects* - selection of specific parameters and study of alternative solutions.

3.1. BIM concept

The BIM methodology is introduced with reference to the main concepts (Fig. 2):

- All information is centralized in a BIM model created throughout the elaboration of a project using a parametric modelling process (Fig. 2). The parametric objects allow a geometric component to be associated to the physical properties of the materials. The data base of the model allows collaborative work on the project.

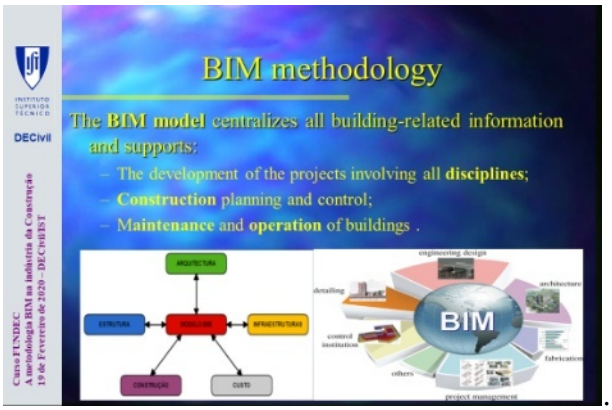


Fig. 2: *BIM methodology concept.*

- The interoperability capacity of the software used on the transposition of models throughout the design process is based on standard data formats. The benefits and the limitations found in the development of a range of applicability are mainly dependent

on the efficiency of their interoperability capacity (Fig. 3).

Fig. 3: *BIM methodology concept and applicability.*

- The degree of implementation in the industry has reached distinctly different levels in countries around the world depending of the mandatory requirements adopted by each of them.

3.2. Practical session

The course introduces participants to the concepts and practical uses of a new BIM-based tool. An architectural model is created, using the system available to all participants. A new architectural project is selected and the required basic configuration is established (work units, number of levels and the alignment grid).

The parametric modelling process allows the selection of all objects needed to represent the building. Each object of a specific family, wall, floor or roof, is retrieved from the library available in the tool in use (Fig. 4).

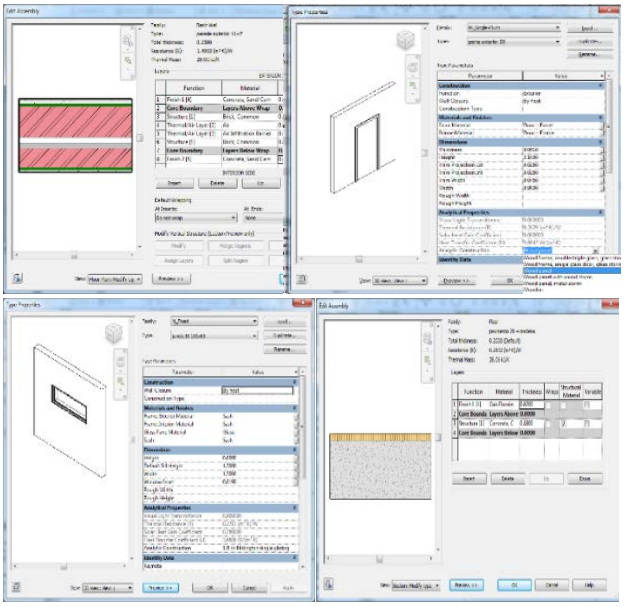


Fig. 4: *Parametric objects of building components.*

The selected element is adapted according to the geometric and physical characteristics of the component of the building. The walls are first modelled, guided by the alignments delineated in a plan view, then the windows and doors are placed in the walls, followed by the floors and roof and, finally, a safety guard-rail is positioned (Fig. 5).

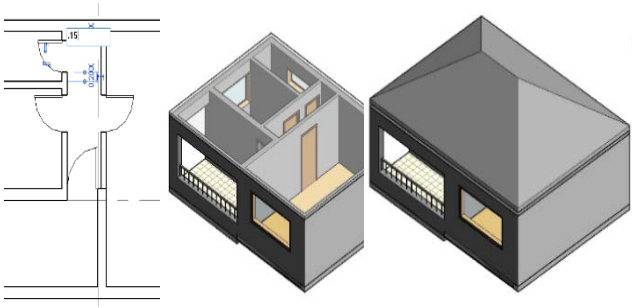


Fig. 5: *Generation and visualization of the BIM model.*

As the modelling process is easily defined over a plan view, a three-dimensional (3D) model is created. Thus, it is possible to obtain specific projections and cuts of the model, using the visualization capabilities available in the system (Fig. 5). In order to teach

students how to retrieve information from the created model, the definition of drawings and cross-sections are automatically performed by overlaying it (Fig. 6).

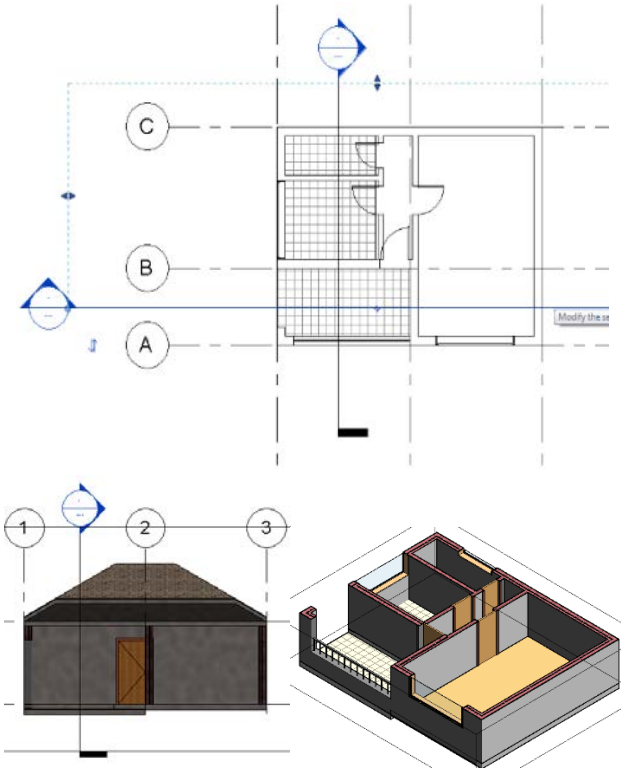


Fig. 6: *Representation of cuts applied over the model.*

The automatic generation of tables of quantities of elements can also be operated on the model (Tab. 2).

Tab. 2: *Table of quantities.*

<Door Schedule>

A	B	C	D	E
Type	Family and Type	Function	Count	Level
porta exterior 90	M_Single-Flush: porta exterior 90	Exterior	1	Piso 0
porta interior 80	M_Single-Flush: porta interior 80	Interior	1	Piso 0
porta interior 80	M_Single-Flush: porta interior 80	Interior	1	Piso 0
porta interior 70	M_Single-Flush: porta interior 70	Interior	1	Piso 0

3.3. Applicability of BIM

The basic concepts related to the implementation of BIM methodology and the main aspects concerning the use of parametric objects having been introduced, other more advanced aspects of the application of the BIM methodology are then presented:

- In the context of the development of a BIM **structural project**, a real case is presented [14]. A structural solution is defined over the architectural component, followed by structural analysis process, requiring the transposition of models between software. The reinforcement task is performed, and the result is then transposed to the initial structural model. This process requires a detailed analysis of the software interoperability capacity to identify the main benefits and limitations (Fig. 7).

- BIM methodology supports the **construction planning** task based on the generation of a 4D model [15]. A real case is presented illustrating the modelling process of the structural component and the establishment of a *Gantt* map. Both sets of information are then transposed to a BIM viewer where the construction activity is simulated. The generated 4D model supports the monitoring of real construction work (Fig. 8).

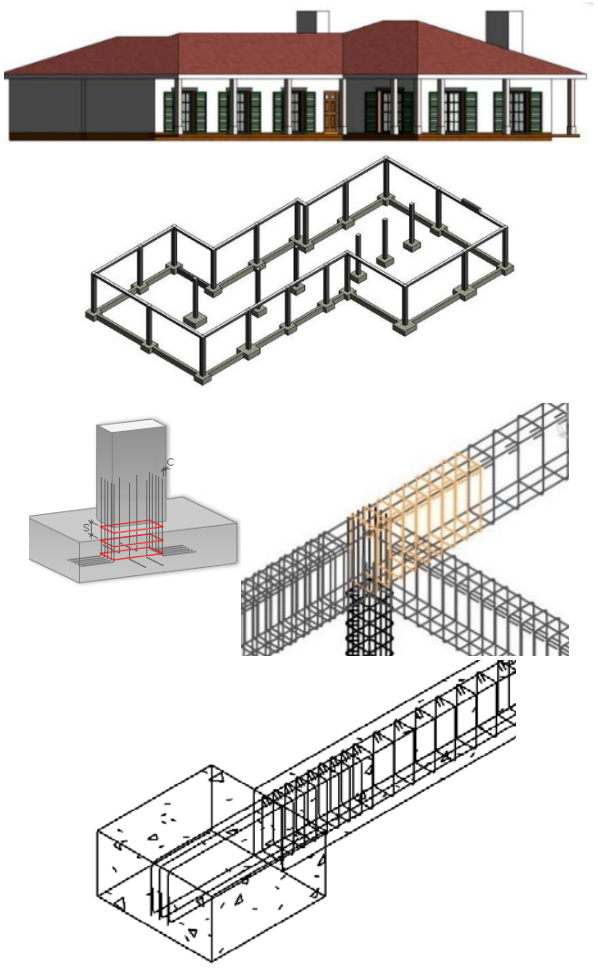


Fig. 7: *BIM architectural and structural models and reinforcement details.*

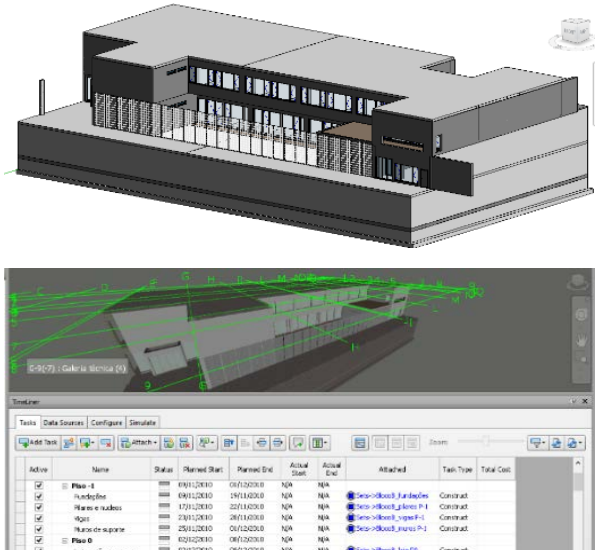


Fig. 8: *Generation and using the 4D/BIM model.*

- In order to analyse alternative solutions for an architectural project, it is necessary to generate a specific **library of parametric objects** with specific characteristics [16]. The visual aspect of the architectural design is the most evident, but the acoustic and thermal comfort analyses or the cost estimation of the construction, management, and maintenance, can be performed for each alternative solution in order to compare results (Fig. 9).

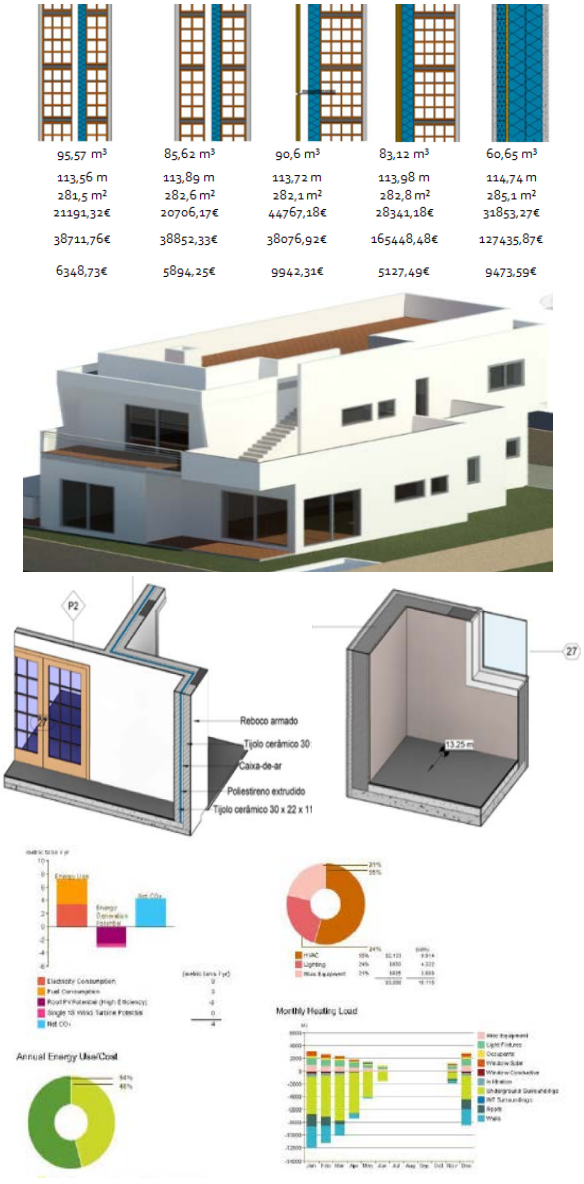


Fig. 9: *Generation and application of alternative solutions of external walls and an energy performance analysis.*

- Although the BIM methodology is used mainly for buildings, its applicability to **infrastructure** is now beginning to be recognized [17]. There are important benefits but also many limitations, based essentially on the lack of specific parametric objects related to motorways, railways, or dams, in the libraries of objects, available in the most used BIM-based modelling tools (Fig. 10).

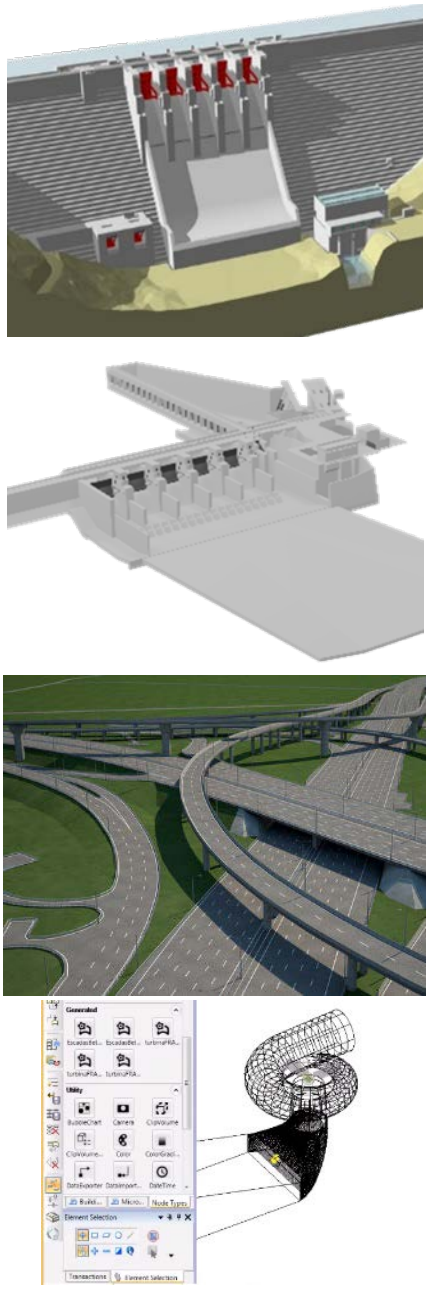


Fig. 10: *Models of real cases of highways and dams.*

- A model, to be completely satisfactory, needs to facilitate the overlapping of all the disciplines (architecture, structures, and systems) and the **conflict detection** capability provided by BIM-based tools. This last-mentioned capacity supports the designer of building networks, telecommunications, or air conditioning, in defining projects that they can be properly installed in the building (Fig. 11).

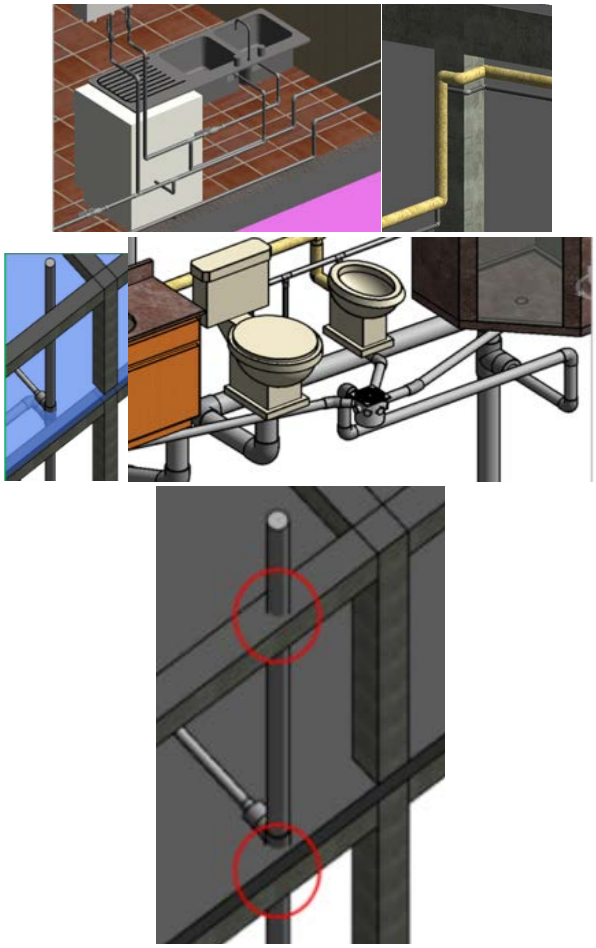


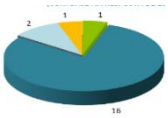
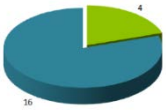
Fig. 11: *Conflict detection analyses.*

The course addresses the main requirements demanded by Construction industry professionals, providing them a opportunity to learn BIM concepts and applicability.

4. COURSE EVALUATION

After completing the course, the participants are invited to fill in a small survey of their satisfaction with the training. The analyses of the answers are important to the organizer and the invited speakers in order to reaffirm or restructure the course to better respond to the community requirements (Tab. 3).

Tab. 3: *Assessment of satisfaction with the course taught.*

Topics	Comments	Quality
Global appreciation	The training course exceeded expectations considering the time available, allowing the participant to obtain a global perspective of BIM and its applicability.	
Introduction to BIM and practice session	Important inclusion of a practical component in training, allowing learning of fundamentals of the use of BIM-based tool. Very practical, pragmatic and approachable trainer who performed the role of course coordinator well. Easy empathy with trainees and gave intelligent answer to the questions asked.	
Structural design	Development of structural design demonstrated in all stages of modelling and data transfer; trainer with good communication skills.	
Construction planning	Construction simulation capability was presented, with the basic concepts enabling further study in the future.	
Parametric objects	Demonstration of software strengths and limitations, well-illustrated with appropriate examples.	
Infrastructure	Demonstration of BIM applicability in motorways and dams, although without technical content but its purpose was generalised and useful.	
Conflict detection	Practical applications during the activity related to the designer /coordinator. The trainer expressed clearly the issue and demonstrated good theoretical and practical knowledge.	
Suggested topics to include in BIM courses	Practical complete BIM course IS this person saying the course should be completely pratical - or the course should include all aspects of BIM?. BIM applied to underground works. Exploration of BIM in management and coordination. Practical courses on other BIM-based software.	
	High quality Good quality Average quality Low quality	

The course was given to a heterogeneous group and as can be seen in Table 3, it satisfied, in different ways the requirements that the participants initially had on joining. The overall assessment is very satisfactory, and it can be concluded that the topics that most interested the audience were related to the practical session, infrastructure, conflict detection and parametric objects.

According to the suggestions on topics to be addressed in the future, it is the intention of the organizer to include a more practical component in the use of BIM-based tools, not only oriented to the modelling function, but also to support conflict detection tasks, construction planning or even structural analysis using BIM visualizer or specific BIM tools.

5. CONCLUSIONS

The contents of the BIM professional course, offered by the Dep. Civil Engineering of the University of Lisbon, was constructed both in order to accomplish the demands of the industry, and to cover a wide range of BIM applicability. The participants showed interest in all the topics presented, often questioning the trainers, in a view to clarification more directly relevant to their particular activity in the context of their public institution or private enterprise.

The practical component of the course proved to be one of the most satisfactory, as a support to a reasonable understanding of the specific issues concerning the methodology. From the analysis of the collected survey, the overall classification of the course was good, and the invited speakers demonstrated experience, good communication skills and knowledge of each specific topic.

The main purpose of the course was to provide the participants with knowledge useful in their activity. Industry professionals generally feel the need to update themselves in the BIM context and the attendees reported that the course contributed in a positive way to this learning. The school and industry should continue to collaborate, thus bringing advantage to both sectors.

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