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BIM AND PROJECT-BASED EDUCATION IN ARCHITECTURAL AND CIVIL ENGINEERING CURRICULA: EXPERIENCES FROM SZÉCHENYI ISTVÁN UNIVERSITY

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Abstract. The integration and continuous updating of digital tools and methods in higher education have become imperative due to national and international regulations and industrial trends. This study will share the experiences regarding the implementation of the Building Information Modeling (BIM) methodology and project-based education in architectural and civil engineering curricula. The organizational structure of the Faculty of Architecture, Civil Engineering, and Transport Sciences at Széchenyi István University in Győr facilitates effective interdisciplinary collaboration, enabling architecture and civil engineering students to work together on multiple subjects and professional projects. The study will also discuss the applied methods of project-based education and BIM integration in the Civil Engineering BSc and Structural Engineering MSc programs.

1 INTRODUCTION

The digital transformation of the construction industry imposes new challenges and requirements on archirecture and civil engineering education. The adoption of Building Information Modeling (BIM) technology has accelerated globally over the past decade: the majority of the institutions have integrated BIM into their curricula, either as standalone courses or embedded within other subjects [1]. For instance, Santos and Escórcio [2] found that approximately 62% of civil engineering program content involves some aspect of BIM. In response to this trend, new specializations and academic tracks have emerged worldwide, often supported by practice-oriented training and active collaboration with industry partners. While BIM education principles are broadly similar across institutions, their focus tends to vary according to institutional profiles, emphasizing architectural, structural, or construction management perspectives to different extents [4]. Despite these advances, current literature suggests that offering BIM as a single, isolated course is no longer sufficient. Wang et al. [3] argue that effective BIM education requires program-level integration through multi-course, collaborative educational frameworks. They further emphasize that BIM teaching must extend beyond disciplinary boundaries, advocating for stronger interdisciplinary collaboration across the AEC (Architecture, Engineering, and Construction) domains. This shift towards integrated and practice-based learning is also reflected in pedagogical strategies that emphasize real-life projects and teamwork. Santos and Escórcio [2] highlight the value of incorporating case studies and collaborative group work into BIM curricula, while Schmeckpeper [5] observes that many institutions opt to embed BIM modules within existing structural and design courses. This modular approach enables incremental knowledge development and situates BIM learning within the context of students' core disciplinary training.

In line with these international trends, this study presents the approach taken by Széchenyi István University's Faculty of Architecture, Civil Engineering, and Transport Sciences to implement BIM within civil engineering education. Chapter 2 introduces the structural engineering specialization of the BSc in Civil Engineering from the perspective of BIM education. Chapter 3 provides a detailed overview of the concept and development of a joint course introduced for both architecture and civil engineering students. Chapter 4 describes an integrated BIM-oriented teaching methodology designed to support thesis work in the Structural Engineering MSc program. Finally, Chapter 5 summarizes the experiences gained so far and outlines potential directions for future development.

2 IMPLEMENTATION OF BIM INTO CIVIL ENGINEERING CURRICULUM

At the Faculty of Architecture, Civil and Transport Engineering of Széchenyi István University, education in both civil and architectural engineering is fundamentally design-oriented. Within the civil engineering programme, students may choose between two specializations: structural engineering and infrastructure engineering. In the following, the BIM-oriented educational concept implemented in the structural engineering specialization will be presented in detail, however, it is important to emphasize that this approach has been concurrently integrated into the architectural engineering curriculum as well.

The concept for implementing BIM was derived from the set of competencies that students are expected to acquire upon completion of the training in the fields of CAD and BIM. These competencies include the following:

- understanding the differences between CAD and BIM,
- the ability to use BIM-based modeling software at an advanced level,
- familiarity with technical design processes and the capacity to situate BIM workflows within them,
- the ability to create a 3D model based on BIM principles, including domain-specific graphical and informational content,
- the ability to manage information related to specific workflows,
- an understanding of the basic workflows of related disciplines and their interdependencies.

In order to meet the above-mentioned expectations, the BIM-oriented mindset is introduced from the very beginning of the educational program. In the first semester, students acquire the fundamentals of CAD and gain practical experience in basic editing operations, representation methods, and drawing production — initially in two dimensions, followed by basic three-dimensional modeling. For this purpose, AutoCAD 2D and 3D, Civil 3D, and Archicad is used.

The concept and fundamental principles of BIM are introduced in the second semester, where students also gain practical insight into BIM-based modeling, primarily through the continued use of Archicad.

From the third semester onward, BIM appears more as an applied method and design approach embedded within the different subjects, rather than as a standalone topic. Model-based design is typically integrated into courses focused on the design of steel, reinforced concrete, and timber structures. In these courses, issues such as data exchange between software platforms and interdisciplinary collaboration are addressed as parallel threads. The primary software tools used in this context are AxisVM, ConSteel, and Tekla Structures. In the second year of the program, within the course Geoinformatics taught also in the third semester, students are introduced to advanced surveying technologies (such as laser scanning and photogrammetry), the fundamentals of the Scan-to-BIM methodology, and the techniques for aligning terrain and building models.

In the third year, the fourth and fifth dimensions of BIM are addressed in greater depth. Within the framework of construction management courses, students become familiar with contemporary methods of cost estimation and construction scheduling. At this stage, the standardized BIM environment is also explored in detail, including the technical content of documentation required from the perspective of project management and the procedures for their fulfillment. In parallel, building upon their previously acquired knowledge, students work in teams within the Structural Design Project course on the design tasks of real-world industrial projects in the fifth semester. In this context, they apply the previously introduced software tools in an integrated and complex manner, guided by a BIM-oriented approach. To support appropriate model-based processing and design documentation, the Structural CAD course further develops the modeling skills acquired during the first and second semesters. It expands this knowledge with advanced data management and quantity take-off techniques, as well as tools required for the preparation of structural (reinforced concrete and steel) design documentation.

At this point, it is important to highlight, that project-based learning has already been introduced in courses focused on structural design, allowing students to explore material properties and design considerations through real-world examples and individual design assignments. In the initial stages, this typically involves schematic, simplified projects — such as the design of a steel frame structure. However, as students' technical knowledge expands — by the fifth semester — there is a shift toward more complex design challenges, which also facilitates the integration of collaborative, team-based work.

The Structural BIM and BIM Management course, jointly taught to architecture and civil engineering students in the seventh semester, aims to integrate previously acquired knowledge into a comprehensive skill set. Within this course, students work in teams to develop real building projects, undertaking structural, architectural, and mechanical engineering tasks in a multidisciplinary context. A more detailed description of the course is provided in Chapter 3.

In parallel, the instruction of structural engineering subjects continues, where students also work on complex projects, typically in collaborative team settings. The final, eighth semester is dedicated to the completion of the thesis, which — due to the specific focus of the specialization — often involves a structural design task. In such cases, BIM is typically employed as a methodological framework throughout the design process. However, it is also common for students to address topics explicitly related to BIM itself, such as the optimization of specific workflows or the development of more efficient project delivery processes.

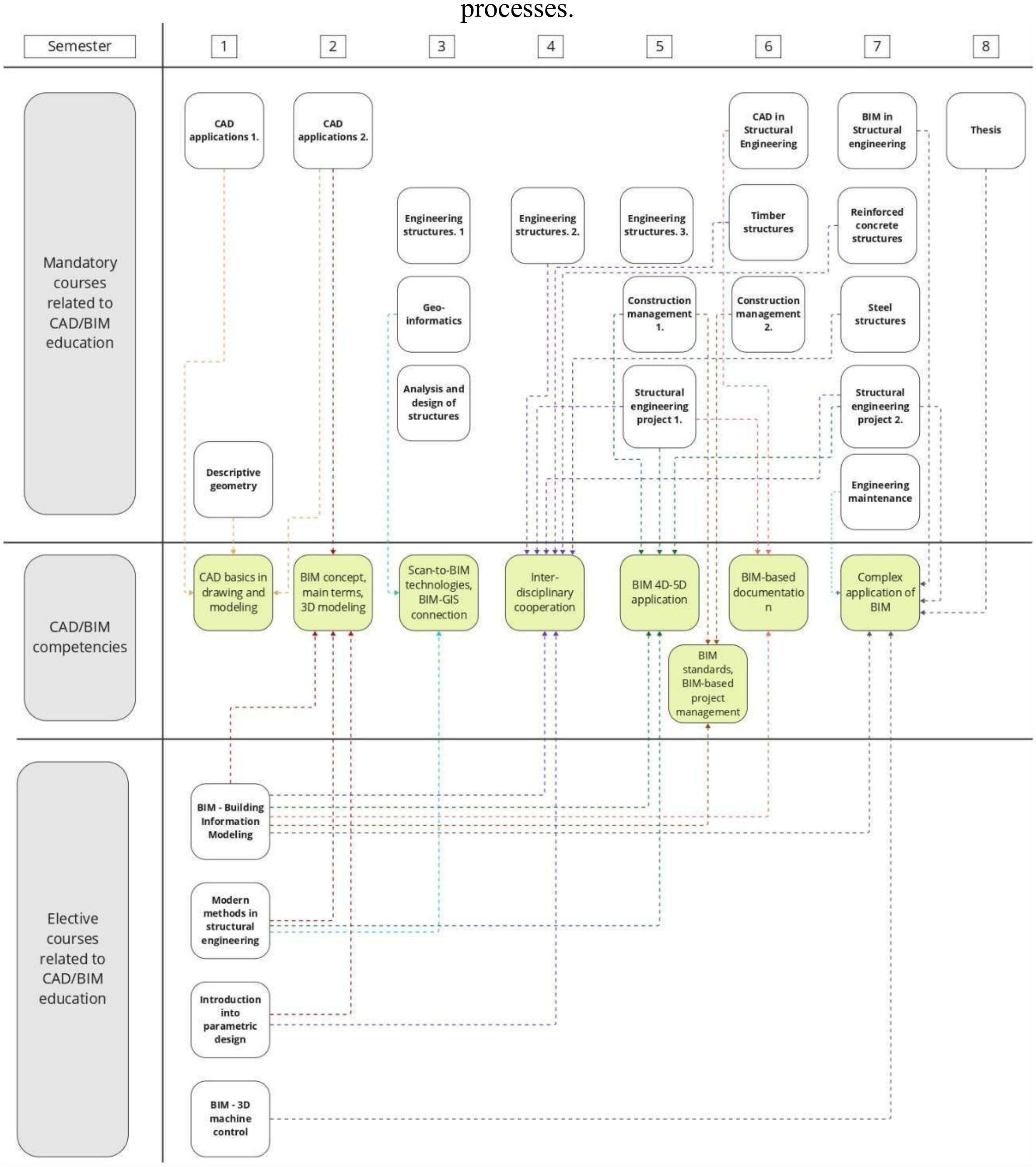

Figure 1: BIM implementation concept in civil engineering curriculum, structural design specialization

In addition to the core curriculum courses, students may choose from elective courses designed to foster the acquisition of a BIM-oriented mindset. For example, Building Information Modeling course demonstrates various practical applications of BIM, while BIM-3D machine control presenting the fundamentals of construction machinery control with up-to-date tools and methods. Furthermore, there is a course that theoretically summarizes modern methods and technologies, addressing topics such as artificial intelligence, VR/AR applications, smart cities, and aspects of geoinformatics. This course aims to bridge different disciplines under the overarching theme of digitalization. To further enhance modeling and data management efficiency, a course on parametric design is offered, where students learn the fundamentals of visual programming through Rhinoceros and Grasshopper. Figure 1 illustrates the CAD and BIM-related courses involved in the structural engineering specialization of the civil engineering program, along with the corresponding CAD/BIM competencies to be developed.

3 PROJECT-BASED EDUCATION AND INTERDISCIPLINARY COOPERATION

The courses Structural BIM and BIM Management takes place in the 7th semester of the architecture and civil engineering curricula. The courses are jointly taught by the Department of Structural and Geotechnical Engineering and the Department of Architecture and Building Construction. Their main objectives and characteristiscs are summarized in Figure 2 and outlined below.

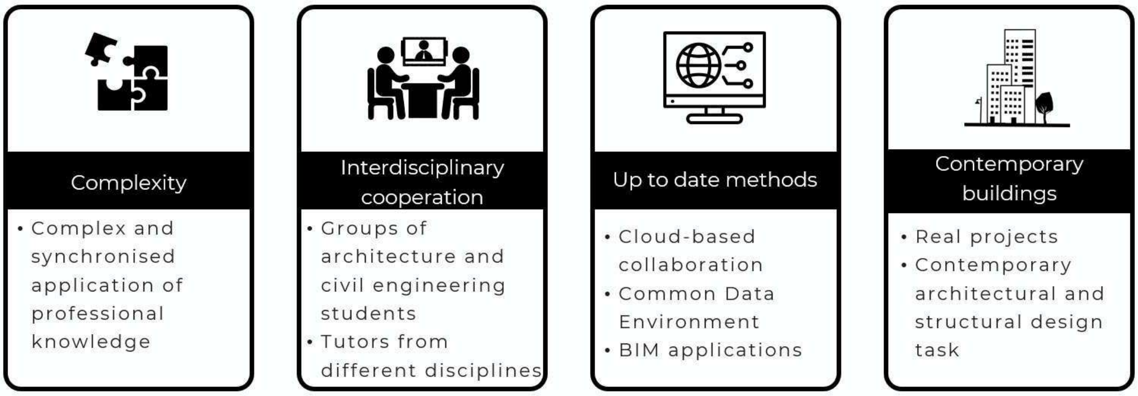

Figure 2: Goals and characteristics of the joint course in the 7th semester

Complexity: Completing the semester project requires the complex and coordinated application of previously acquired knowledge. This includes, on the architectural side, design, construction, building services, and building structure expertise; on the civil engineering side, knowledge of structural systems, materials science, and mechanics; and from both disciplines, digital competencies, modeling skills, and data management proficiency.

Interdisciplinary cooperation: Students work in interdisciplinary teams, typically composed of 2–3 architecture and 2–3 civil engineering students. Their work is supported by discipline-specific consultants — including an architect, structural engineer, building structure designer, building services engineer, and BIM manager —who provide expert guidance throughout the project. This setting allows students to gain deeper insight into the priorities and decision-making frameworks of other disciplines, which in turn have a direct impact on their own work. In addition to strengthening their professional skills, the collaboration also enhances their communication abilities: students must argue from the standpoint of their own field, while also engaging with the reasoning of other disciplines to arrive at mutually acceptable solutions. In doing so, the course effectively replicates the kind of integrated teamwork expected in professional construction practice.

Up to date methods: The design task is carried out in a modern software environment, using the latest version of Archicad. Projects are developed through cloud-based teamwork, enabling real-time collaboration. Discipline-specific outputs are shared within a Common Data Environment (CDE) using Trimble Connect, ensuring transparent access for both team.

Up to date methods: The design task is carried out in a modern software environment, using the latest version of Archicad. Projects are developed through cloud-based teamwork, enabling real-time collaboration. Discipline-specific outputs are shared within a Common Data Environment (CDE) using Trimble Connect, ensuring transparent access for both team members and instructors. The individual components of the project are developed on a BIM-based workflow, allowing students to apply their previously acquired knowledge of BIM dimensions in a practical context. To support this process, students use various specialized software tools, making data exchange between different applications an essential part of the project workflow.

Contemporary buildings: The semester project involves the redevelopment of a contemporary building, meaning that students redesign real-world buildings — often already constructed — based on the available documentation. Each team selects a building individually from the current issue of Detail magazine. Through this process, students not only become familiar with examples of contemporary architecture and structural design, but by reconstructing these buildings, they also encounter innovative solutions that may not have been covered — or only rarely touched upon — during their prior studies. This project-based approach further supports the development of professional skills aligned with real-world architectural and engineering practice.

The teaching approach is primarily mentoring-based, supplemented by topic-specific lectures and practical sessions. At the same time, students have the opportunity to consult with discipline-specific experts during every class. The semester is divided into five phases (Fig. 3), with each task building on the previous one. These five phases also correspond to the five submissions required throughout the semester. Each submission includes both an oral presentation by the team and the upload of the prepared files to the CDE.

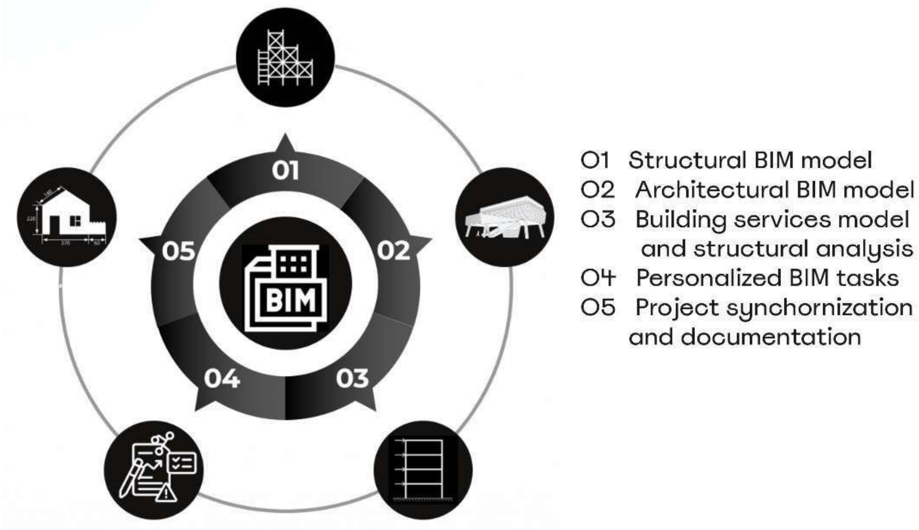

Figure 3: Parts of the project-based semester tasks

Once teams are formed and a building has been selected, the project development begins using Archicad in teamwork. The first task (01) involves creating the model of the structural system (Fig. 4) at LOD (Level of Development) 300, based on the BIMForum specification [6]. This model must include information on the appropriate building materials, strength class, structural function, and position (interior or exterior element). Teams are given four weeks to complete this phase.

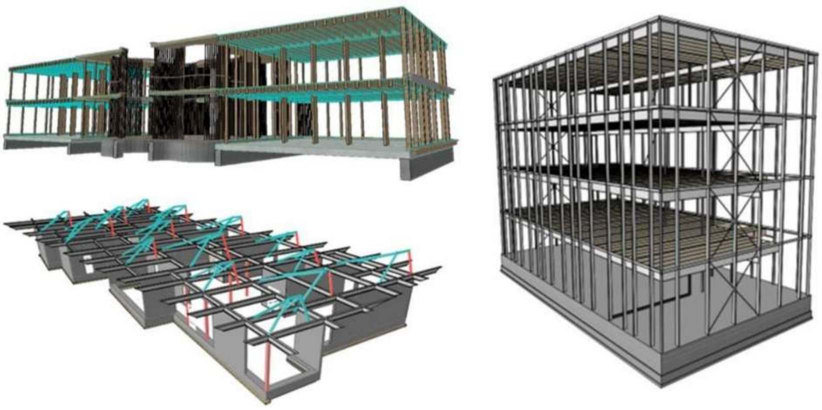

Figure 4: Examples of structural models made in phase 01

The second phase (02) involves extending the structural model with architectural elements to create a complete building model, also at LOD 300 level of detail. In addition, teams are required to prepare the structural model for data exchange, typically using the SAF (Structural Analysis Format). As such, this task includes checking the SAF translator settings and testing the export process. This is also the first phase during which, beyond the model itself, teams must submit drawings generated from the model — tipically at a scale of 1:100 (Fig. 5).

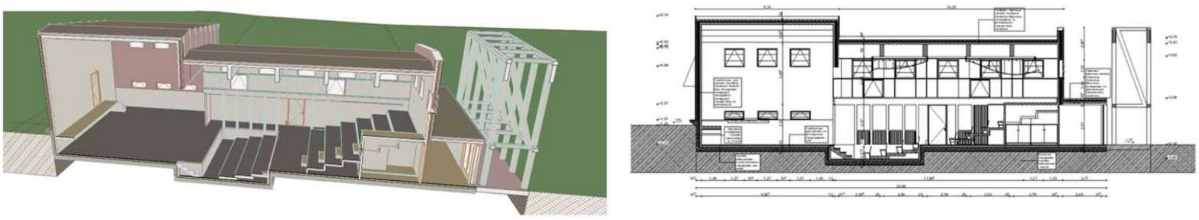

Figure 5: Examples of complete LOD300 models and documentation in phase 02

Teams are generally given three weeks to complete this phase. The first and second phases are developed collaboratively, regardless of discipline; in other words, any team member may model any building component. However, responsibility for the correctness of the structural model lies with the civil engineering students, while architecture students are accountable for the adequacy of the architectural elements. From the third phase onward (03), the disciplinary workflows begin to diverge. Architecture students focus on the design and modeling of building services systems, maintaining LOD 300 detail. This typically involves the development of heating, cooling, ventilation, and drainage systems for selected building parts or specific rooms

(Fig. 6a). In parallel, civil engineering students transfer the structural model into a finite element analysis software (usually AxisVM) via SAF-based data exchange. As a result of the structural analysis (Fig. 6b), they verify the adequacy of the initial cross-sections and material properties. Both disciplines are required to produce documentation for their respective tasks. For this phase, teams are given three weeks to complete their work.

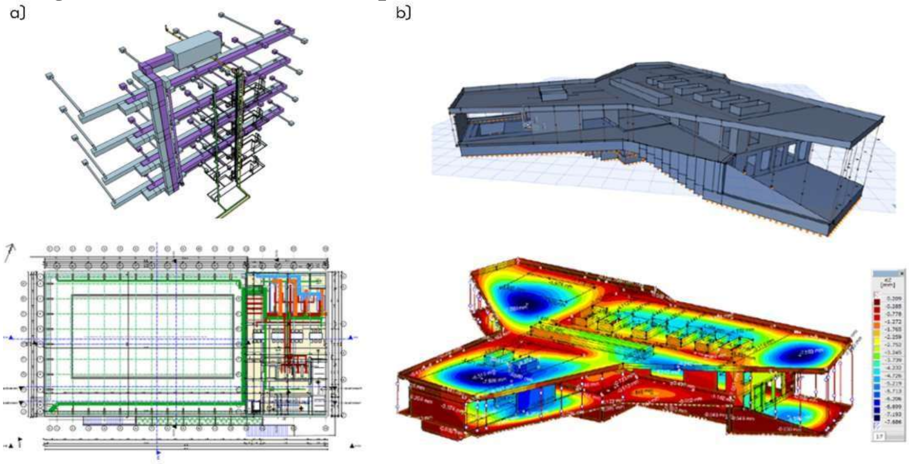

Figure 6: a) Examples of building services models, and b) structural analysis made in phase 03

In the fourth stage (04), students are assigned individual BIM-related tasks aligned with their respective disciplines, tailored specifically to the chosen building. For architecture students, this often involves preparing window and door schedules, conducting energy performance analyses, generating quantity take-offs, or performing clash detection. Civil engineering students, on the other hand, focus on the development of specific structural details, such as formwork, reinforcement, and fabrication drawings, and may also be tasked with construction simulations. The goal of this phase is to promote the most comprehensive use of the BIM model, translating various BIM use cases into practice. Students are typically given 3 to 4 weeks to complete this assignment. In the final, fifth phase (05), the teams are responsible for coordinating the model, incorporating any changes that have arisen — typically as a result of structural analysis or clash detection. In addition, teams prepare a detailed set of construction documents generated from the model, and they update and consolidate all previously submitted documentation. This phase is usually allocated two weeks. Successful completion of the course requires that all interim submissions have been satisfactorily delivered by each team member. The final grade for each student is calculated as the average of the four interim submission grades and the grade received for the fifth and final submission.

4 BIM IMPLEMENTATION IN STRUCTURAL DESIGN CURRICULUM

The Structural Engineering Master's program at the university has been structured around the diploma project, which serves as the backbone of the entire curriculum (Fig. 7). The project typically involves the structural design and preparation of construction documentation for a large-scale building. In the first semester, students begin with the architectural design, taking into account functional requirements and local building regulations, while also producing a preliminary structural concept. The diploma project is directly addressed in the Innovative Structures I. and II. courses during the first and second semesters, while the other courses support the completion of partial tasks by providing guidance from various disciplinary perspectives. Throughout the design process, BIM is employed as an integrated methodology across various courses.

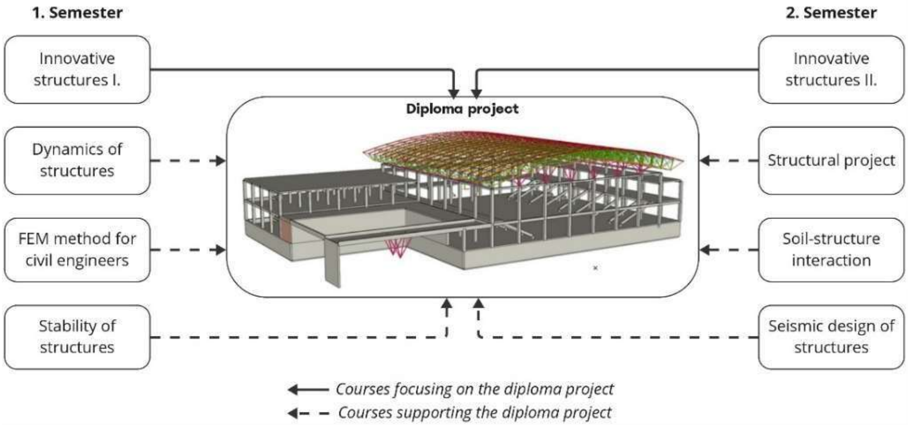

Figure 7: Courses supporting and focusing on the diploma project in Structural Engineering MSc

Each student is responsible for their own comprehensive project, effectively taking on the roles of architect, mechanical engineer, geotechnical engineer, and structural designer. From the second semester onward, the focus shifts primarily to structural design: students perform finite element analysis, design structural elements in detail, and develop full construction documentation. The final phase includes preparing a construction project plan and schedule. While the program maintains a strong emphasis on structural analysis and design, the diploma project highlights the importance of interdisciplinary collaboration, which is at the core of the BIM approach. By working within a BIM-based, project-oriented framework, students gain not only technical expertise but also insight into the workflows and perspectives of related disciplines. Although not all aspects of the project can be explored with equal depth, the primary objective is to foster a comprehensive and up-to-date BIM mindset alongside advanced structural engineering competence.

6 CONCLUSIONS

- The integration of BIM into the civil engineering curriculum requires continuous development and regular updates. At Széchenyi István University, BIM-related content was already introduced during the 2017 curriculum revision, primarily through several standalone courses. However, it soon became evident that a more integrated approach — embedding BIM into multiple subjects and thereby across various disciplines — was essential. Compared to the previous curriculum, the current integrated framework introduces both the theoretical foundations of BIM and the practical skills of BIM-based modeling and related software tools at a much earlier stage in the program. This shift has been positively evaluated by both students and instructors, as the early establishment of a BIM-oriented mindset enables more effective completion of tasks in other subjects — such as building structures or structural design courses. Similarly, the acquisition of software and technical skills at an early stage allows for a more advanced level of BIM-focused education. As a result, the curriculum can incorporate a greater number of real-world, project-based practical examples and assignments, thereby enhancing the overall quality and relevance of the training.

- Although the joint course for architecture and civil engineering students was officially launched in 2020, it has undergone several revisions in the years since. Initially, teams began their projects by developing the architectural model, which often led to structural design issues later on. To improve students' understanding of the building's composition and structural system, the semester now begins with the development of the structural model. This change has led to significantly higher-quality models. Another major improvement has been the shift from the IFC format to the SAF format for structural data exchange, which has enhanced the reliability and accuracy of the analytical modeling process. Beyond the technical complexity of the project itself, teamwork and communication also posed considerable challenges for students. Both a previous questionnaire-based survey [8] and recent student feedback from past semesters confirm that BIM-based collaboration proved highly effective in many aspects — such as error detection, documentation, and quantity take-offs. However, because students had not previously been required to collaborate across disciplines, this shift toward interdisciplinary teamwork also presented a steep learning curve — an experience that was not only a challenge but also a deliberate and important objective of the program to expose students to, and help them overcome.

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