Teaching the General Building Construction course at the Faculty of Architecture, Cracow University of Technology

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ABSTRACT: Legislation setting out the first energy saving requirements for buildings was introduced in Poland in the 1980s. The need to meet these requirements resulted in significant changes in the way buildings are constructed. New energy-efficient building technologies have been introduced in the building industry. This significantly contributed to a considerable broadening of the scope of knowledge in the field of general building construction. The transfer of this knowledge in the General Building Construction course has resulted in its very notable extension in relation to its previous scope. At the same time, huge technological progress and the emergence of new means of multimedia information transfer have created new learning opportunities. The following article is concerned with the issue of improving and updating methods for teaching General Building Construction to first-year first semester students of the first-cycle degree at the Faculty of Architecture at Cracow University of Technology, Kraków, Poland.

INTRODUCTION

Building engineering is a branch of technology (a field of engineering knowledge) that deals with the principles of design, construction and maintenance of buildings. It is a science that constitutes the fundamental basis for the professional skills of an architectural engineer. Knowledge in the field of building engineering is a science that includes theoretical and practical information necessary both in the design and construction of buildings. Along with the advancement in building construction technology, this knowledge is becoming increasingly extensive and complex. Acquiring it poses a growing challenge for students of the Faculty of Architecture at Cracow University of Technology (FA-CUT), Kraków, Poland. Transparent transfer of this knowledge to students also constitutes a considerable challenge for the academic teachers who conduct this course.

The basis for the education of future architects on the methods of building construction as part of the General Building Construction course is the scope of this knowledge. The energy efficiency requirement imposed for buildings resulted in a dramatic change in the way they were constructed in the second half of the 20th Century. New energy-efficient building technologies were introduced in the building industry. These technologies were developed on the basis of traditional construction methods and are to a large extent their only modern modification. However, these changes have contributed to a significant increase in the knowledge needed to be passed on to students. Limited time allocations force a condensed transfer of this knowledge. The possibility of using multimedia information transfer is most helpful in this respect. However, the question which still remains is whether the transfer of knowledge about construction methods should be limited to construction solutions currently in use or should also include knowledge of solutions from the past in native architecture.

SCOPE OF KNOWLEDGE IN THE GENERAL BUILDING CONSTRUCTION COURSE, SEMESTER 1

In accordance with a long tradition, the programme of General Building Construction in the Faculty of Architecture at Cracow University of Technology includes teaching the art of building to the full extent of its development and application in Poland. It seems that this is a right assumption. Progress in the field of building engineering has always been based on the principle of improving and modifying solutions that do not meet current requirements. The introduction of new building materials has been an important stimulus for these changes. Before, it was steel and reinforced concrete, and recently - plastic-based materials.

It seems that a well-educated student should know both the present technological achievements and the methods of building from the past. After all, during the course of studies, they learn about the history of architecture and its influence on contemporary architecture. The specificity of building solutions lies in the fact that their proper functioning is confirmed only by a period of several decades of their operation. The construction solutions applied in the past had

been positively verified only by long-term use in many cases, and, what is important, by proper satisfaction of human environmental needs. As far as energy-saving technologies introduced in recent years are concerned, there have been some very important reservations. The problem of the negative impact that the internal environment in buildings may have on human health increasingly is being raised [1]. Due to this, the returning to traditional methods of building construction is a current trend [2][3]. An example of this may be the return to the construction of single-family wooden houses, and the use of a corner-notched log structure commonly used in the past (see Figure 1a and Figure 1b).

a) b)

Figure 1: Examples of historical building techniques: a) contemporary single-family building constructed using a corner-notched log technology; b) assembly of a single-family corner-notched log building in 2015.

TEACHING GENERAL BUILDING CONSTRUCTION: SEMESTER 1, YEAR 1 OF THE FIRST-CYCLE DEGREE PROGRAMME

In accordance with the curriculum, the transfer of knowledge in the General Building Construction course takes place through lectures and design classes. The subject matter of the lectures includes theoretical knowledge, while the design classes are devoted to practical application of this knowledge in the process of designing and developing project documentation. The topic of the lectures in the first semester of the first year of the first-cycle degree programme in architecture at the Faculty of Architecture, CUT, includes methods applied in construction of the following three structural elements: foundations, walls and ceilings. In terms of construction and material possibilities available in the case of the last two building elements: walls and ceilings, the knowledge passed on to students has been limited to building technologies applied to small- and medium-sized building materials in low and medium-high residential and public buildings.

In addition to knowledge on the construction of the abovementioned structural elements, the topics of lectures in the first semester also cover issues related to legal regulations contained in the Ordinance determining the technical requirements to be met in buildings and the location of them in Poland [4][5]. Within the framework of legal regulations related to General Building Construction, the provisions referring to the principles of project documentation preparation, along with scope and formal requirements, are also important [6].

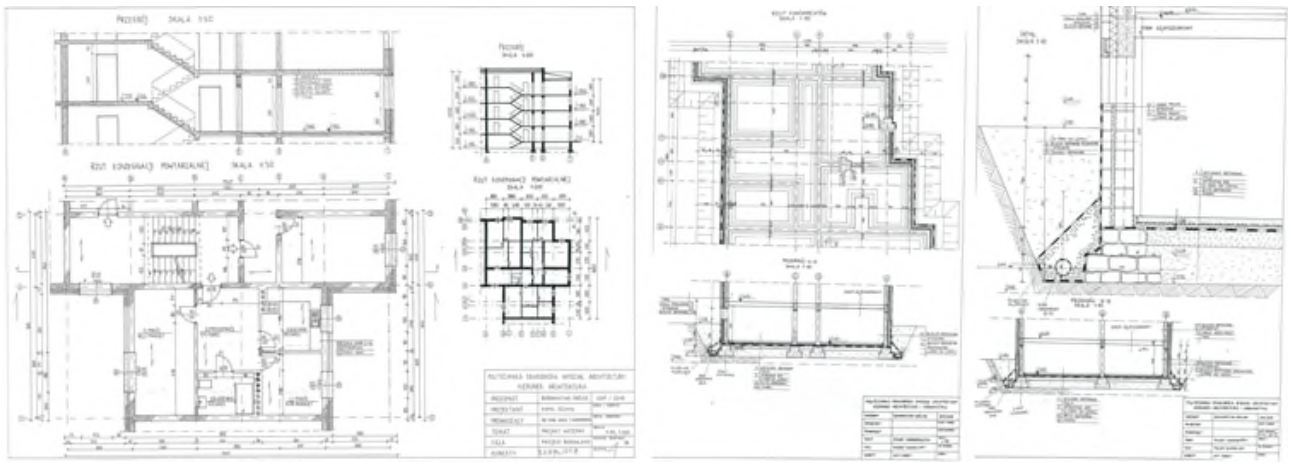
A student of architecture begins to acquire knowledge and skills in graphic development of design drafting in the first semester. Due to this, the topic of lectures in the first semester also takes into account the issue of Polish standards defining the use of graphic symbols in architectural and construction drawings with the first and second degree of accuracy, as well as the method of design dimensioning and graphic symbols for building materials [7-9]. The transfer of such extensive knowledge during only 15 one-and-a-half-hour lectures to students that regard drawing skills and principles of technical drawings as a complete novelty is an extremely daunting task.

Preparation of students to use all the substantive knowledge acquired during lectures in future professional practice takes place within design classes. During these classes, under the guidance of group instructors, students prepare four design studies. All these works are developed on the basis of a given plan of a repetitive storey of a conceptual design of a single section of a four-storey multi-family building.

DESIGN CLASSES IN GENERAL BUILDING CONSTRUCTION: ACADEMIC YEAR 2017-2018

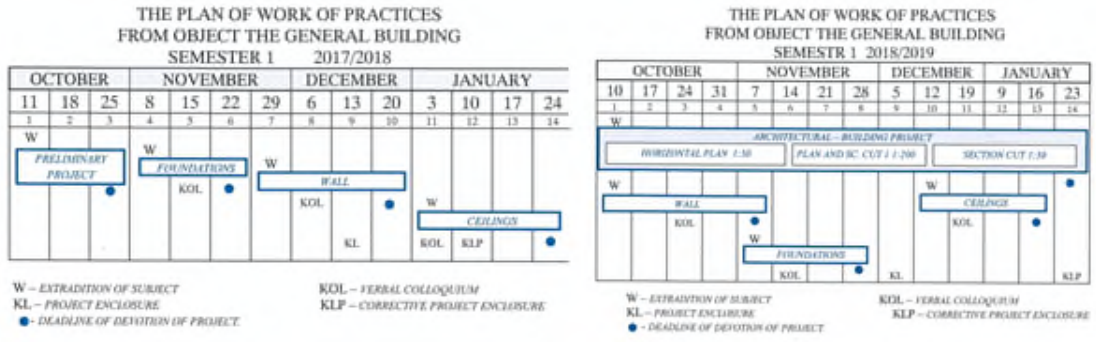
The first design project is related to the practical use of knowledge of legal and normative regulations. In this design project, the student drafts a 1:200 scale (first degree of accuracy) architectural and construction drawing of a plan of one section of a building and its cross-section. Then, to compare and visualise the differences between the first and second degree of accuracy, the student develops a fragment of the horizontal projection covering one flat with a staircase and a fragment of the cross-section covering one repetitive floor in a 1:50 scale (second degree of accuracy) (see Figure 2a).

In accordance with the programme of the design classes, a student was to develop this project before commencing further design tasks (see Figure 3a).



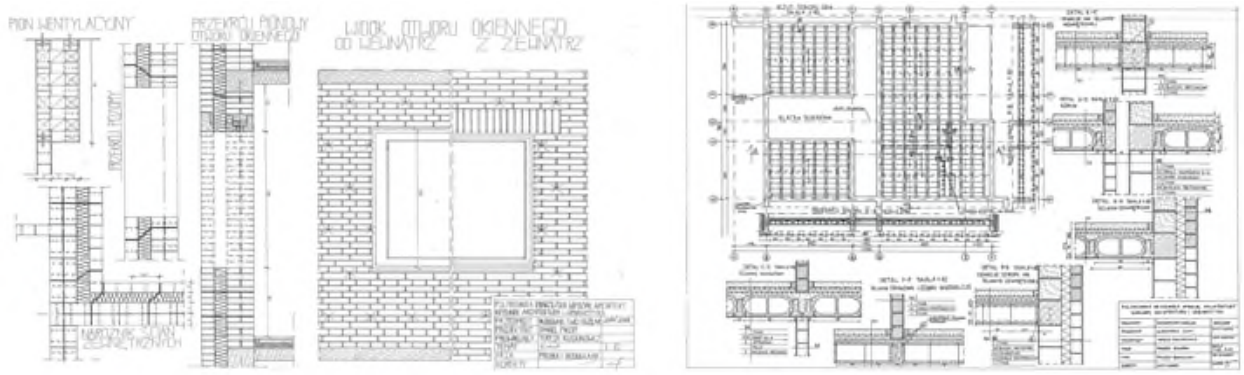
a) b)

Figure 2: Example of a design project developed by students: a) preliminary design of a fragment of a multi-family residential building, student: K. Ożana; instructor: T. Kusionowicz; b) design of foundations and the underground part of the external wall of a multi-family residential building, student: A. Cichy, instructor: T. Kusionowicz.



a) b)

Figure 3: Programme of design classes in General Building Construction in semester 1, year 1: a) in the academic year 2017-2018; b) in the academic year 2018-2019. Graphic design by T. Gaczoł.



a) b)

Figure 4: Example of a design project developed by students: a) design of a three-layered external wall of an above-ground storey in a multi-family residential building developed in a plan view, cross-sections and in a detailed view in a 1:10 scale, student: D. Pikor; instructor: T. Kusionowicz; b) design of a beam-and-block floor in a multi-family residential building in a plan view, cross-sections and details of the cross-sections, student: A. Cichy, instructor: T. Kusionowicz.

The next design task consisted of developing a given foundation structure for a fragment of a residential building that had been drafted in the first project in a 1:50 scale in a plan view and two cross-sections including the basement. Drafting a fragment of the vertical cross-section in a 1:10 scale containing the foundation and the external basement wall with a window opening may be helpful in constructing this part of the building with a clear presentation of the solution in a 1:50 scale. The scale of the detail allows for a more accurate presentation of the method of execution and

installation of thermal and damp insulation in the underground part of the building. In this drawing, students demonstrate their knowledge in the field of construction and environmental requirements for a fragment of the earth-sheltered building (Figure 2b).

The third task conducted by students is the development of a method for solving the external wall of the above-ground storey. The student determines the type of material and the size of the thermal insulation layer for a given material of the supporting and covering part. The whole design project is developed in a 1:10 scale, which shows the way of laying the given fine- and medium-dimensional material in detail. The design project includes basic details from the horizontal projection, vertical cross-section through one storey and views from the outside and inside of the structure. This design project shows how the external wall structure used in the first preliminary design is constructed and is related to it in terms of the details being developed (Figure 4a).

The final design project in the first semester is the design of a ceiling. Analogously to the foundations, the development of this structural element is performed for a fragment of a multi-family residential building. The drawings are made in a 1:50 basic scale with details in a 1:10 scale. The first case consists of a horizontal projection with an indication of the arrangement of structural elements of the ceiling and two cross-sections: longitudinal and transverse. Then, the details of important fragments of the cross-section of the ceiling are drafted in a larger scale covering, among other things, the way in which the ceiling is supported on the external and internal structural walls (Figure 4b).

LECTURES IN GENERAL BUILDING CONSTRUCTION: ACADEMIC YEAR 2017-2018

The design projects developed by students as part of design classes covered construction technologies primarily used in the construction of buildings at present, but also some previously used solutions. On the other hand, the knowledge conveyed in the lectures covered a much broader scope, both in terms of time and technology. The programme of lectures so far had been based on a chronological discussion of individual structural elements according to the process of erecting buildings and the development of the way in which they are constructed.

The introductory lecture was devoted to the presentation of basic definitions and terms, the discussion of the characteristics of buildings, their division according to purpose and height. It also included the knowledge of normative and legal regulations related to architectural engineering and the method of developing architectural and construction projects. The following lecture acquainted students with the investment process, general issues of building construction and structural systems.

In accordance with the course of building construction, the discussion of building elements began with a series of four lectures devoted to the construction of foundations and building fragments embedded in the ground. This series began with a lecture on construction land. The next one discussed the ways of delimiting, making and securing excavations. The third contained information on the basic methods of making direct and indirect foundations. The last lecture from the series was devoted to foundations covered the binding requirements of thermal insulation and the possibilities of making damp insulation, which are particularly important in this part of the building.

The following series of four lectures was devoted to wall constructions. In accordance with the historical development of the construction of these in Poland, this series began with a lecture on traditional structures made of wood and stone and their continuation in contemporary architecture. The second was devoted to the methods of constructing homogeneous, layered and skeletal wall systems. The next was devoted to the environmental function of walls, and the last to the methods of constructing openings and partition walls. Referring to the methods of wall construction, the next lecture was devoted to chimney ducts.

Traditionally, the first semester ended with a series of three lectures on ceilings. As in the case of walls, the knowledge of horizontal elements began with a lecture on wooden ceilings and vaults. The next was devoted to fire-resistant beam-and-block floors and the last to monolithic and prefabricated reinforced concrete ceilings.

RESULTS FOR GENERAL BUILDING CONSTRUCTION, SEMESTER 1, ACADEMIC YEAR 2017-2018

The analysis of student evaluation questionnaires and comments regarding students' expectations included therein provide impetus to verify the teaching methods for General Building Construction. It is in semester 1 that students begin to broaden their knowledge of the subject, which, as shown by many years of practice, poses a significant difficulty for them.

The preparation of students for the requirements of this course is getting worse every year. In the lower-level profiled teaching, the scope of material from science subjects has been limited. Also, such elements as technical drawing have been abandoned in the teaching. Apart from artistic talents, the profession of an architect requires an appropriate level of knowledge of humanities, science and biology. In this situation, profiled secondary education does not fully prepare future students of architecture for the tasks confronting them. Secondary schools do not prepare students to explore knowledge on their own, which is why first semester students have difficulties in finding the approach applicable for their studies. However, the curriculum does not allow filling in the gaps in their previous education.

Year by year, teachers of General Building Construction observe growing helplessness of students in completing the tasks of the course. This is clearly demonstrated by the reduced quality of design projects, mainly in the preliminary design. The amount of normative and legal provisions required to master this project is one of the reasons for this situation. Another is the lack of drafting skills. Students have raised the issue of difficulties in preparing the preliminary design. This was before considering the construction of walls and ceilings in lectures all of which should be properly presented in the design project.

To achieve satisfactory educational results, an in-depth analysis has been conducted, including not only student questionnaires, but also interviews with students and groups of students. As a result, it has been established that students are not interested in the knowledge of technologies used in the past in Poland. They do not understand the need for such knowledge. They approach the history of architecture with understanding, but only in stylistic terms. According to them, the knowledge of the history of architecture in terms of structure and construction is unnecessary *ballast*. Therefore, they are not interested in lectures on this subject. In terms of technical knowledge, they are only interested in technologies that are used in modern architecture. They believe that only the latest solutions should be the subject of design tasks.

In the programme of lectures held so far, knowledge about such technologies had been introduced at the end of each series of lectures on walls and ceilings. However, according to the schedule of design classes, by that time students should be at the stage of developing a design of a given solution for this structural element previously drafted in pencil. According to the students, the knowledge conveyed during the lecture did not adequately support the design tasks. They expected more help and more extensive inclusion of issues directly related to their design tasks in the lectures.

To achieve better co-operation and appropriate learning outcomes, an attempt was made in the academic year 2018-2019 to coordinate the programme of lectures and the programme of design classes. The order of design projects developed as part of the design classes has also been modified.

ORGANISATION OF GENERAL BUILDING CONSTRUCTION, SEMESTER 1: ACADEMIC YEAR 2018-2019

In the academic year 2018-2019, significant changes were introduced to the programme of design classes. The scope and number of design projects developed during this semester remained unchanged (Figure 3b). However, the order of design projects and the time allocated for the preparation of architectural and construction design changed. A student prepares the project, the scope of which is analogous to that of a preliminary project, throughout the whole semester.

The level of difficulty means the project is developed in stages. In the first stage, a student prepares a design of a horizontal projection of a fragment of a multi-family residential building, including one flat and a staircase with the second degree of accuracy in a 1:50 scale. In accordance with the PN-B-01025 standard, simplified symbols in architectural and construction drawings are applied, with the second degree of accuracy. Next, the student drafts a horizontal projection of a typical storey and a cross-section of the section of a multi-family residential building with the first degree of accuracy in a 1:200 scale. In accordance with the standard, the first degree of accuracy applies to contractual symbols in architectural and construction drawings. The last stage in the development of the basic design consists in drafting a fragment of a vertical section covering one storey of the designed residential building with the second degree of accuracy in a 1:50 scale.

Concurrently with the basic design project, designs are being developed of individual elements of a residential building structure. During the first stage, the student becomes acquainted with the structure of a three-layered energy-saving external wall. Students develop a design for this wall applying the given building materials. They determine the material and thickness of thermal insulation that meets the legal requirement for external walls in terms of energy efficiency. The design of the wall is made in a 1:10 scale, which requires not only determining the type of applied material, but also presenting the shape of the elements that make up the structure and the way they are arranged. Owing to this design project, the student gains knowledge about this structure and can consciously present it in a horizontal projection of the flat developed in the first stage of the basic architectural and construction project.

During the second stage of developing the basic design project, the student's task is to design the foundations for a residential building. The scope of this work includes both architectural and construction drawings with the second degree of accuracy and detail of a fragment of the underground part of the external wall, as it has been done so far. Designing the underground zone of a building should be a significant help in presenting this element in a cross-section of a residential building with the first degree of accuracy and with the use of contractual symbols developed within the second stage of the architectural and construction design.

Parallel with the third and final stage of the basic project, a design of a beam-and-block floor is being developed. The project is drafted in projection and cross-sections with the second degree of accuracy. The 1:50 scale cross-sections of the ceiling should help students to draw the cross-section of one storey drafted as part of the third stage of the basic project.

To synchronise the programme of lectures with the programme of design classes, the way and order of the transfer of knowledge were also significantly modified. Only the introductory lectures remained unchanged. The order was

changed of the subsequent series of thematic lectures. Instead of a series of lectures on foundations and the underground part of the building structure, which is in line with the progress of the construction of buildings, the first thematic series of lectures was devoted to walls. This series began with a lecture on the structural and environmental requirements of walls [1][10]. The following ones were devoted to solutions of these elements used in modern architectural engineering. In accordance with the programme of design classes, the knowledge about foundations was presented in the next series of lectures. The subsequent series of lectures was devoted to the construction of ceilings in housing today.

The final two lectures in the first semester were devoted to traditional wooden and masonry constructions made of stone and their continuing use in contemporary architecture. These lectures supplement knowledge of the methods of making foundations, walls and ceilings in the past, as well as their continuation and possibilities of applying them in modern construction [2].

At the end of each lecture, a presentation on the principles and methods of drafting the currently developed design projects, as well as the time for questions and possible discussion, were introduced. The part devoted to the presentation of exemplary design projects attracted much interest from students with a clear increase in their attention, which mirrors their increasingly pragmatic approach to studies. However, what is worrying is that students did not ask questions actively or discuss material in public. Occasionally, some students decided to ask questions, but only individually and only after the lecture had ended.

CONCLUSIONS

The main objective behind the modification in the programme of design classes in General Building Construction in the first semester of the first-cycle degree in the Faculty of Architecture at Cracow University of Technology was to improve learning outcomes. This modification was complemented with co-ordination of the lectures and the problems of the design projects being developed. The alterations were motivated by the need to adapt the method of teaching to the level of substantive preparation of students while maintaining the scope of knowledge transferred. The assumption was that co-ordination of the theoretical knowledge with its practical application in the design task would make it easier for students to complete the project on time. As a result of these modifications, students' interest in participating in the lectures has increased significantly.

Unfortunately, despite the extension of time allocated for development of the basic architectural and construction project and additional help during the lectures, better quality was not achieved. These solutions did not improve the timely completion of the remaining design tasks either. Compared to the academic year 2017-2018, there was no increase in the number of students who obtained credit in General Building Construction in the first term.

Both in the previous academic year and in the modified academic year, the number of students who obtained credit in the first term amounted to about 80 percent. Therefore, it seems advisable to continue activities aimed at improving the programme of the General Building Construction course for the first-year students of architecture. These activities should take into account the remarks contained in student questionnaires, as well as the ones from direct conversations with students and group instructors who conduct design classes. Consideration should be given to moving this subject to a later semester, where the students would have greater required knowledge and understanding.

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