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New Teaching Methods of Construction Teaching

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The Problem

The challenges of the new digital era in the field of construction at Architectural faculties may be listed as follows:

1. What will be the impact of the ongoing globalization on the methodology of teaching *construction*?
2. What will be the influence of implementing internet communication and specialized software on teaching *construction*?
3. What influence on teaching construction will the implementation of research results in *construction* solutions have (in projects and revitalization).
4. The role of the architect as the designer and leader of the development process is slowly loosing in importance. How to counter this phenomenon, how to revive the dominating role of the architect, how to train him/her in the field of *building structures* to take the role of a leader?
5. What will be the impact of the changes in building methods on teaching *construction*?

The future of building structures – trends of changes in the methods of teaching construction at the faculties of architecture.

The answer to this problem is complex and connected with other related issues:

- the industry producing for the needs of construction is likely to remain similar;
- the architect will still be the designer, and the contractor will be the contractor but the cooperation between them within one company seems probable;
- the typology will not change: residential houses, service facilities, public facilities, motorways, bridges, airports as well as all the structure types currently under construction;
- there will be a different process of designing, outsourcing, investment supervision, and different materials and technologies.

The greatest changes forced by commercialization of research will occur in the following areas of knowledge which are all part of the teaching process of *building structures*:

- designing building structures – changes in methods of design
- development of constructions for sustainable architecture and for new, extreme environments;
- introduction of new building materials and strengthening the existing ones;
- changes in the proportions of new investments, renovations and rehabilitation of existing facilities to the benefit of the latter;
- the lack of qualified engineers and architects combined with an increasingly complex knowledge in this area will necessitate permanent education, intensification of higher education enrollment and changes in the methods of education (implementation of e-learning);
- changes in the processes of outsourcing and cooperation between the designer and the contractor;
- changes in the scope of work of contracting companies, their globalization neces-

sitates the changes in the scope of knowledge of engineers regarding world cultures, environments and building technologies (low-tech, medium-tech, high-tech);
- changes in the organization and monitoring of construction works – it will be necessary to establish a regular payment plan for work performed.
- the costs of contracted work will be determined by the quality of work performed and its value to the user – purchaser, and not by its function and brand as it is today;

The changes in the educational program of *building structures* at architectural faculties should include the following issues:
- preparing graduates for the ongoing globalization;
- designing and implementing new educational programs which employ new methods of teaching: computer-aided design, long-distance education (e-learning);
- establishing new methods of teaching that enable education of a large number of students (e-learning);
- establishing courses designed to educate engineers of architecture for work in other cultural regions (for the needs of the international market);

Changes in the content of courses

The comparison of the content of current and future courses in the context of changes in the construction industry leads to the following conclusions:

The context of globalization
The current educational programs lack introductory courses. Uniform European construction standards, unified codes and standards for construction drawings. Globalization and the resulting exchange of students necessitates the uniformization of the content of courses in *building structures* so as to make them comparable (also in the field of ECTS).

The environmental context
In the current program there are none or few mentions of standard prefabricated solutions for *building structures* saturated with electronics and sensors – the so called intelligent structures. Modern constructions, especially those implemented in complex buildings – such as skyscrapers, vast halls, engineering facilities and those designed for extreme environmental conditions. Extreme environmental conditions in which we will be designing in the nearest future, require new, complex scientific knowledge that stems from research. Development of ocean surfaces, underwater habitats, orbital stations in space and on neighboring planets, planetoids and moons. We are experiencing the evolution towards balanced, ecological and energy-based architecture… intelligent architecture based on the rule of synergy of all its elements. The *construction and building* solutions are crucial, both passive and active.

The integration of *building and construction* elements with the installation equipment for electronically controlled facilities is the criterion which will determine the

quality and usefulness of architectural solutions in the nearest future. Therefore it is necessary to expand the educational program by teaching students how to use software which stimulates the behavior of facilities with respect to energy.

We should also introduced the issues of recycling of building materials into the educational program of *building materials*.

The context of designing

The content of courses in the field of *architectural design* is currently limited to solving elementary construction problems, usually out of context, i.e. staircases, rafters, terrace, etc. There is, however a connection between *architectural design* and *construction and building design* in the form of a course in *designing single-family houses* during the 4th semester. But the drawback of such a course curriculum is the implementation of solutions for single-family houses to other facilities characterized by a much greater level of complexity, in which case such solutions are wrong. It can be stated that the operational knowledge of students in the field of *construction* is limited to a traditional single-family house.

Integrated design, solving design problems at a much quicker pace in cooperation with the contractor and by implementing a specific technology.

The use of CAD software in designing is growing in popularity. The ability to use these programs is crucial in the field of integrated design.

On the other hand the amount of research is growing and so is its application in contracted work – this requires a much greater flexibility and receptiveness for new technologies. We can observe progress in the field of construction typology, which is currently divided into:

- traditional technologies
- prefabricated technologies
- unique technologies

Today, there is a tendency for classifying facilities according to the level of technological advancement:

- low advanced buildings technology
- medium advanced buildings technology
- high advanced buildings technology

These changes result in changes in the educational programs. Additionally the necessity to erect increasingly taller buildings alters the scope of *building and construction* solutions as well as the contents of the program.

The Internet opens the possibilities for creating long-distance designer teams. Internet-based team design should be a part of the educational program and at least one design task should be carried out in this manner.

The context of new building materials

There should be a radical change in the educational programs with respect to the content of the course in *building materials*. Apart from traditional materials, such as wood, steel, reinforced concrete, ceramics, whose strength characteristics will be optimized in future, new materials will be used. These new materials will be based on nanotechnologies and will possess characteristics of intelligent structures allow-

ing them to adapt to changes and external needs. Polymer materials will be widely used, reinforced with glass or carbon fiber, composites. New alloys of aluminum will emerge characterized by increased strength. All materials will be completely renewable. Such radical changes in the field of materials necessitates including them in the content of the courses: presenting the characteristics of new materials in laboratories and in computer simulations.

It should be underlined that the implementation of nanoparticles in new materials offers the possibilities to create intelligent architecture. Nanotechnology implies changeable states of matter at the level of nanoparticles. Most substances such as metals, ceramics, glass and semiconductors completely alter their characteristics. Those, which are normally solid become liquid. Metals may be semiconductors or color pigments, ceramics may be transparent or become an electric conductor, glass may be transformed into absorbable material. Nanoparticles possess characteristics which no other material possesses. These materials are manufactured in the process of Sol-Gel – a non-organic type of chemical synthesis which allows the creation of nanoparticles with controllable surface characteristics.

These surface characteristics serve as a significant criterion in the production of new composite nanostructures and coatings. Implementation of these technologies enables production of materials which may be used in construction, i.e. glass with special surface characteristics, etc. Some technologies of manufacturing nanomaterials are ready to use in industry.

Revitalisation context

In view of the tendency to decrease the number of new building investments it is necessary to expand the educational program of construction by introducing issues related to revitalization and renovation of existing buildings. This problem requires acquainting students with the investment process – which is very different from the process of building new objects (much more complex), as well as with appropriate building technologies that are implemented in designing transformations in existing facilities.

Due to the complexity of these problems Architectural Faculties need to start specialization areas with an extended program in the field of *construction, building* and *building physics* related to renovations and transformations of existing facilities. At the Architectural Faculty of Wroclaw University of Technology (the only one in Poland) there is a specialization area of this kind. The program includes courses whose content is significantly expanded in the field of revitalization and renovation of existing facilities. The following courses address the problem of revitalization, conservation and transformation of existing architectural objects:

- conservation material studies
- construction (mending and reinforcing structures)
- chemistry of materials
- modern inventory techniques
- conservation, architectural and technological projects
- the project on revitalization of postindustrial facilities

Methods of teaching

The context of globalization

The development of computer technology, software and internet communication causes changes in the tools of work and methods of teaching *building structures*. Due to globalization, the designing and building process is beginning to involve more and more participants that are scattered all over the world. On a global scale the building industry is moving towards the creation of an integrated system of communication and information exchange, which would allow close cooperation between the participants of the investment process at different levels: designing, building and investment management.

Today the Internet is conceived as the basic communication tool in the design process. Both the designers and contractors can e-mail drawings or technical documentation, which allows rapid exchange of information and time-saving cooperation.

The Internet offers the opportunity to e-mail information related to technical specifications of a building, as well as those related to designing standards. This type of cooperation on all levels of the investment process requires teaching methods that employ the use of the Internet which should be implemented already at the basic level of education. Designing tasks in the field of *building structures* may be carried out by means of software designed to create 3-D models, i.e. Archicad , Autocad, Microstation, Nemetschek, VRML and other.

Designing context

Introduction of computers into architectural design and installation of specialized software opens the door for effective team work, quick exchange of information, alternative designs, quick alterations and corrections. Using detail, brand manufacturers of building materials, and especially 3D simulation of architectural facilities, their construction detail, and the process of building and utilizing the facilities with their installations. Computer software which integrates all stages of the building and utilization processes will be the basic tool of the investment process in the nearest future.

Adapting the software to the needs of education is necessary. For those students who are becoming skilled in using computers, the Internet offers the opportunity of interactive education through chat rooms, team work on designing tasks, presentation of their designs, conducting research as well as using the resources and experience of higher education institutions.

The environmental context

Already today at some architectural faculties there are experimental educational programs whose main goal is to teach designing in extreme environmental conditions. In Texas at the Faculty of Architecture there is a MA study program: Experimental Architecture. This program focuses on research and designing problems of habitats in experimental environmental conditions and at the same time is characterized by limited availability of work force, materials and basic living conditions. The study program is mainly based on designing new habitats by means of computer simulation and specialized software (Meduza 2D and 3D, MegaCadd).

The problems of environmental conditions beyond our planet (space), i.e. the lack

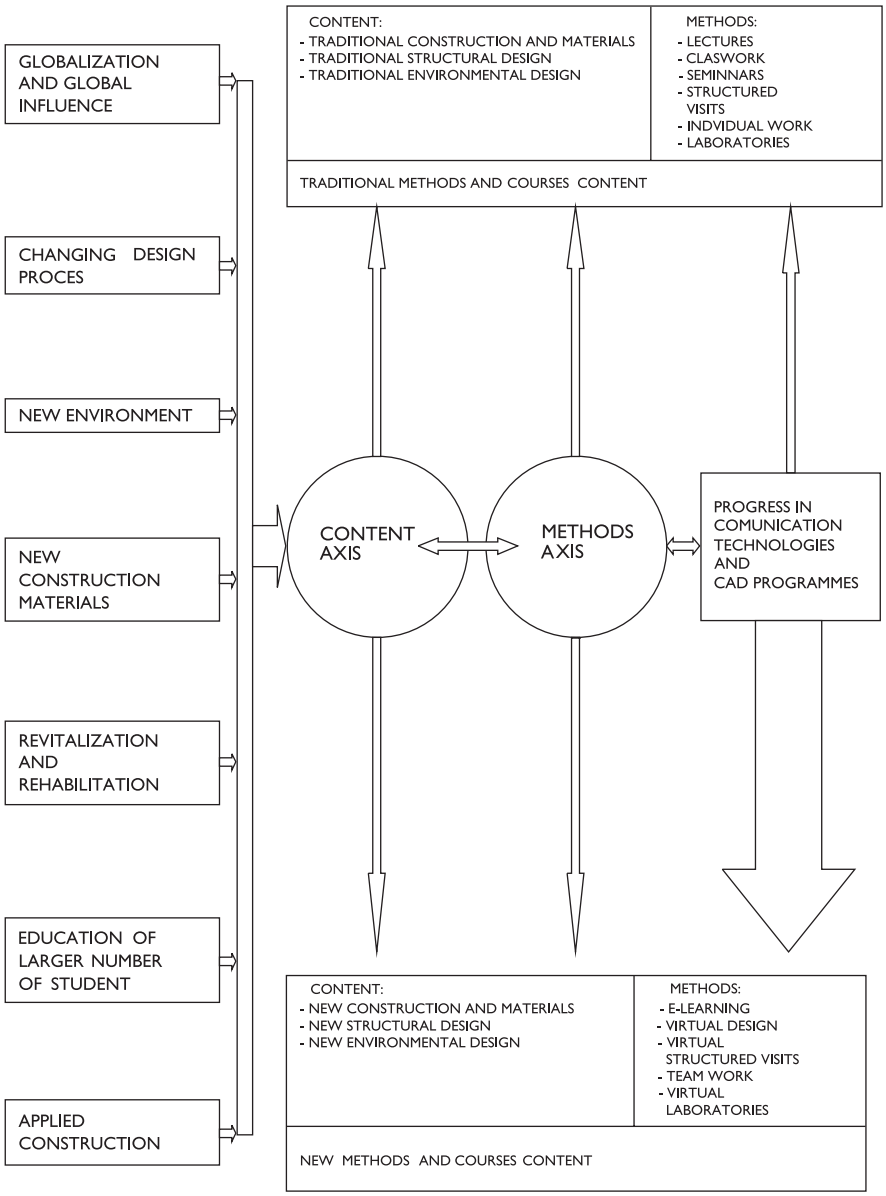

Fig. 1

of atmosphere and gravity, no protection from high temperature and solar radiation, completely change the requirements for *building structures*. It is necessary to carry out simulations of the specific space conditions in laboratories.

Due to the international range of operations of building corporations designers need to study new climatic and cultural environments. One of the possibilities to achieve this is to take part in scholarships for students at other Universities and in

designing internships and research trips to other countries. Students of the Faculty of Architecture at Wroclaw University of Technology participate in internships in most EU countries. They take part in research expeditions to European regions and cities in which major building investments are made.

Conclusions

Mass computerization, internet communication, and computer-aided programming have a significant influence on the educational programs and methods of teaching. Implementing these tools in the process of teaching *building structures* becomes a necessity in view of the challenges of modern civilization for the construction industry: globalization, internationalization, commercialization of research results, the need to educate a high number of engineers.

In the context of these phenomena it is necessary to revise the educational programs of *building structures* at architectural faculties and introduce courses which address the problems of internationalization of design and investments as well as their level of complexity and the necessity of team-work (fig.1)

At the Faculty of Architecture at Wroclaw University of Technology *construction* is being gradually adapted to the mentioned phenomena:

- e-learning methods are being introduced into the course in *designing building structures;*
- the faculty runs specialization areas in the fields of protection and rehabilitation of building facilities, and revitalization of postindustrial facilities;
- new optional courses have been introduced in the field of *designing "intelligent" structures;*
- CAD software is commonly used in *designing building structures*, already the 1st year students are taught to use this software;
- Students leave for building and design internships to different European countries, which greatly widens their knowledge about different cultural environments;
- the system of consulting specialists from different branches is being introduced.

Surely the program and teaching methods need further enhancements. Especially in relation to the content of courses and their availability on the Internet, as well as the insufficient number of studies in virtual design and virtual construction of facilities with the application of necessary software.