PROCEEDINGS OF THE 10TH AECEF SYMPOSIUM
AECEF 2019
20–23 NOVEMBER, WROCŁAW, POLAND

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Cooperation between Universities and Industry in the Education and Employment of Civil Engineers: Current Expectations, Future Challenges

Wrocław University of Science and Technology

Edited by

Piotr BERKOWSKI
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SCIENTIFIC TOPICS

Cooperation between technical universities and surrounding environment – local governments, industry, professional organizations:

- in the field of science and research:
  - conducting common research and development projects
  - joint implementation of research projects
  - performance of technical expertise by university professionals
- in the field of education:
  - CE curriculum design
  - creation and conducting of dual studies
  - seminars and trainings
  - internship cooperation
  - BSc and MSc thesis common supervision
  - employment offers for graduates
  - post-graduate studies
  - PhD theses
  - Life Long Learning

FOREWORD

The development of a knowledge-based economy requires stronger and continuous cooperation between the spheres of education, science and industry. The universities create their surroundings through transfer of technology and scientific staff, and through graduate´s preparation. Benefits of scientific institutions, including higher education ones, in this type of cooperation consist mainly of increasing their recognition among employers and candidates for study, improving the quality of education and research, receiving financial benefits and fulfilling legal obligations. As the other main partner, the industry can achieve, among others, the following benefits: improving the quality of human capital, using the university as a source of ideas, promoting the company's image as an attractive partner, creating a network of contacts with the academic environment. Because of the benefits mentioned the relationships between universities and the socio-economic environment are becoming more and more intensive. Research conducted at technical universities always had influence on what and how students were taught. Good and valuable education process cannot exist without the scientific research in the field of study represented. From the other side, there must exist synergy between research and industry, and what is nowadays extremely important, the learning outcomes such as knowledge and competences of graduates, have to fulfill the needs of industry.

Wrocław, November 2019

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"Cooperation between Universities and Industry in the Education and Employment of Civil Engineers: Current Expectations, Future Challenges"

Wroclaw University of Science and Technology, Faculty of Civil Engineering
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CAN THE CIVIL ENGINEERS RESCUE THE EXISTENCE OF HUMAN BEINGS ON THE EARTH?

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Key words: Global development and environmental impact; Civil engineering; Challenges

ABSTRACT

The paper deals with presentation of the changes at the Earth and challenges which the mankind is facing nowadays connected to global development and destruction of environment caused by human activity. The greatest threats to the existence of the world and humanity as: climate change, global warming, population increase, unrestrained urbanization, depletion of natural non-renewable land resources, excessive exploitation of the Earth's renewable resources, environmental degradation, deforestation, lack of drinking quality water, are briefly presented.

Taking into account the situation briefly presented above, the European Council of Civil Engineers (ECCE) tries to do its best to reinforce the fundamental role of civil engineers in society in improving the standard of human life, to make the case for the prestige of the civil engineering profession in the social community of European countries and to stress the pivotal role that civil engineers will play in addressing the challenges that will face society in the future. In order to support such ECCE activities there are enlisted United Nation's 17 Strategic Development Goals – SDGs, deeply and directly linked with the practice of Civil Engineering:

- Goal 6 - "Ensuring the availability and sustainable management of water and sanitation for all".
- Goal 7 - "Ensuring access to affordable, reliable, sustainable and modern energy for all".
- Goal 9 - "Building resilient infrastructure, promoting inclusive and sustainable industrialization and foster innovation".
- Goal 11 - "Making cities and human settlements inclusive, safe, resilient and sustainable".
- Goal 13 - "Take urgent measures to combat climate change and its impacts".
- Goal 14 - "Conserve and sustainably use oceans, seas and marine resources for sustainable development".
- Goal 15 - "Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt the loss of biodiversity".

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QUALIFICATION OF CIVIL ENGINEERS: LEARNING OUTCOMES AND COMPETENCE ASSESSMENT

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Key words: Learning Outcomes; Civil Engineering; Assessment; Competence; Qualification; Tuning

ABSTRACT

Existing approaches to assess quality of learning tend to look at processes and not at achieved learning by civil engineering students. CALOHEE applied a forward looking approach, focusing on what a graduate should know and be able to do in order to function successfully in life and contribute to society (learning outcomes perspective). The chosen approach brought evidence-based accountability into the teaching and learning role of HE institutions by focusing on competences acquired by students, which meet the needs of society and the graduates. The assessment framework included four strands: 1) Knowledge (theory and methodology); 2) Applying knowledge and skills; 3) Preparing for employability and 4) Civic, social and cultural engagement. CALOHEE also developed a set of reference points at 1st and 2nd cycles levels. The sets of learning outcomes' descriptors were prepared by teams from the respective academic communities, in close consultation with stakeholders and open to public scrutiny. CALOHEE developed the Assessment Framework for Civil Engineering Education that is based on a merger of the Qualification Framework for the European Higher Education Area and the European Qualification Framework for Lifelong Learning. The Assessment Framework is built on a set of learning outcomes' descriptors and related framework that is precise enough to offer a basis for assessment and broad enough to encompass a wide range of programme profiles. This Assessment Framework of Civil Engineering describes the discipline in terms of multiple dimensions: key elements which define a subject area. For example: 'knowledge and understanding', 'analysis and problem solving', 'design', 'investigation', 'practice', 'decision making', 'team working', 'communication' and 'lifelong learning'. In sum, CALOHEE offers academic engagement, subject focused context and evidence based tools for analysis and diagnosis, serving Higher Education institutions and providing meaningful information to stakeholders and society. The ultimate result is meaningful increase of the quality of civil engineers.

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DEVELOPMENT OF CIVIL ENGINEERING CURRICULA – FROM START OF BOLOGNA PROCESS TILL NOWADAYS

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Key words: Civil engineering (CE) curricula; Development; Cooperation; Industry

ABSTRACT

Poland joined the Bologna Process in 1999 and all higher education institutions started to introduce its ideas, having to overcome many difficulties and defeat different challenges. The Bologna agreement was prompted by geopolitical and economic developments that made graduate mobility desirable. It also had as a stated aim the development of a common European cultural identity. According to the Polish Law on Higher Education, from the academic year 2007/2008 two-level study programs (BSc and MSc), began to be obligatory at all Polish universities (in fact there was a three-level system because PhD studies were included in it). According to the amendment of the mentioned earlier Law, prepared in 2010, there was made a further step to integrate Polish higher education system with the European ones. From the academic year 2012/2013 all the universities in Poland had to develop existing three-level system by introducing new model of higher education based on the National Qualifications Framework. In turn amendments inducted in 2014 introduced, among others, demand of separation studies for practical and general academic profiles. The practical profile program is centered at gaining by the student practical skills, while for the general academic profile modules covering study program must be associated to the research activities carried out in the university, that lead to the acquisition by the student an in-depth knowledge in the specific field-of-study. Currently the new Law applicable from 2018, introduced some new requirements as, for example, compatibility of learning outcomes defined for study curricula with characteristics of the second degree learning outcomes for qualifications at levels 6-8 of the Polish Qualifications Framework. Another very interesting element is a possibility of creating for the practical profile the so-called dual studies, in agreement with external stakeholders, especially industrial environment.

The paper deals with presentation of the development in creating the Civil Engineering curricula in Poland due to the demands resulting from the legal requirements as well as taking into account the specifics of the profession of a civil engineer and requirements of the construction industry.

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TEACHING OF CONSTRUCTION PROJECT MANAGEMENT BY CASE METHOD

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Key words: Case method; Construction; Management

ABSTRACT

Teaching by the case method is discussion-oriented learning mode and has been identified mainly with business schools. Application of cases drawn from the complexity of real construction projects into the civil engineering teaching programs can considerably support process of linking the knowledge and application. The author, except of university teaching staff member experience, heaving several years of consulting experience in project management, does present in the paper effective methods of selecting and preparing cases to make them ready for classroom use. Moreover, practical recommendations for discussion teaching of future engineers as long as for dynamics of leading a case discussion, are shown on schemes presented in the paper. Case teaching methodology requires special preparation of both, the student and the teacher. Basic recommendations for teaching creative intercommunication in group of civil engineering students, are presented in the paper. Author proposed also the general methodology for preparation of the construction project management case, based on the true technical data, in order the case fits to the seminar objectives. Finally, the summary of the exemplary case, with schematic teaching "check list" is shown.

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ATTRACTING STUDENTS AND PROFESSIONALS TO THE HIGHER EDUCATION

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Key words: Higher Education Attractively; University vs Profession

ABSTRACT

With the goal of improving employability, attractiveness and visibility of Higher Education (HE), Faculty of Engineering University of Porto (FEUP), Portugal, Department of Civil Engineering (DEC), are aware about the importance of improving the quality, relevance and contact with HE, addressing the challenges of access to HE and school leaving during the current economic crisis.

Those are identified priorities within: a) general EU political objectives (Europe2020 and ET2020, Rethinking Education); b) national governmental policies (responsible for their education and training systems); and c) HEIs' goals regarding programmes' attractiveness, curricula development concerns and labour market needs.

Although engineering & science are popular HE fields of study, certain areas as civil engineering show fluctuating levels of popularity, emphasising the need of adopting pro-active strategies and tools and of discussing how professionals and HEIs may address the decline in undergraduate admissions. In addition advance in knowledge, new technologies, new materials and processes and many other permanent innovations create in professionals the need to upgrade their knowledge, the need to return to the University chairs.

Saying that, FEUP-DEC are trying to explore synergies and stimulate greater dialogue between HE and school education, in the scope of community and outreach activities; encourage (secondary) school students and its staff to interact with HEIs, its infrastructures/laboratories, as supporting effort to tackle early school leaving; promote the professional engineering career as an attractive path, among all students of the academic spectrum, including underrepresented groups who may constitute a potential group of new entrants; invest in seminars, short courses and project to involve professionals and to help upgrading certain company's needs.

By proposing new communication strategies and materials for visitors/schools, such as experiences, multimedia & videos, interactive constructions, virtual reality models, etc., partners expect to contribute to enhance access and participation, thus facilitating the transition between the two levels of education. The "HANDS ON" experimentation based on the concept of integrated design (project based learning) is seen as an attractive approach to learning, proved to be effective to engage secondary school students. This approach is expected to act as motivation for students to conclude their current level of education, focus on a specific field and pursue a HE degree.

It is also intending to promote best practice exchanges, supporting the development of more varied teaching methods and personalised learning, in accordance with the 2012 “Bucharest Communication” (Ministerial Conference-EHEA) recommendation of promoting ‘student-centred learning’ characterised by innovative methods of teaching that ‘involve students as active participants in their own learning’. And also of targeting the student body entering HEIs so as to widen access to HE, ‘raise completion rates and ensure timely progression in higher education in all EHEA countries’;

During this experience it was possible to indirectly contribute to help addressing underachievement in science through more effective, innovative teaching methods; develop innovative didactical materials and compelling tools, focusing on creativity and modernisation so as to increase motivation and target school education and children as pre-university students; also using methods building on foreign language skills (English) alongside the main language of instruction. Professionals stayed more close to the University which also means conducting common research and the growth of projects development.

This experience are susceptible of being replicated by other entities (HEIs/Schools) using ICT based methodologies (emphasised in the Agenda of Modernisation for HE in EU). It may also contribute for the adoption of innovative strategies to reinforce the attractiveness of HE programmes and its associated professional fields, according to the dynamics and changes of the labour market and consequent need of revaluation of communication strategies when reaching pre-university students.

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ATTITUDES TOWARD DOCTORATE DEGREE OF ADVANCED STUDY AND ORIGINAL RESEARCH OF HIGH QUALITY IN CIVIL ENGINEERING

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Key words: doctoral studies; technology; research projects; education; sustainability

ABSTRACT

Inspired by contemporary environmental and sustainability issues we think that interdisciplinary investigating to the science and engineering from many research domains and excellent research strategies should be supported by industry in the first line. To achieve excellence in civil engineering we need to educate our young generation to follow this trend. This issue requires a multidisciplinary approach and establishment of criteria in accredited study programmes to meet future challenges. If the supervisor of PhD. students will lead them to include in their study plan this mission they will support by their outputs the transition to the sustainable society.

The main aim of the article is to present the themes and study plans of doctoral student's research at Faculty of Civil Engineering in Slovakia. Our education of doctoral students is meeting future challenges of achieving sustainability in their proposals and designs by implementing green, smart and effective technologies and visions.

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CREATING A NEW PROGRAMME STRUCTURE TO IMPROVE ENGINEERING LEARNING

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Key words: Engineering programs, New learning and teaching approaches

ABSTRACT

It is found that traditional lectures followed by exercise sheets and tutorial classes are less effective and engaging than they have been for previous generations of university students. There are changes in pre-university education that university engineering programmes have perhaps been slow to adjust to, while at the same time, there is an increasing call from employers (of graduates, and not just engineering employers) for graduates to have wider and deeper developments of personal attributes and skills, and not merely good grasp of technical knowledge. Some institutions (e.g. Olin College) have emerged while others have been transformed to address these challenges, but they typically involve large changes/amount of resources, or small classes, or both. Cardiff Engineering is currently in the developmental stages of a new approach (for us) to learning and teaching, which tries to address the underlying issues, but without wholesale changes, and moving away from large cohorts of students. Civil Engineering is the early adopter of the new approach, and this presentation will be about these developments.

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E-PORTFOLIO TO FOR A BETTER COMPETENCE ASSESSMENT AND LEARNING

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Key words: E-portfolio; Civil Engineering; Assessment; Competence

ABSTRACT

The research proposal aims to transform the summative evaluation in education and training using e-portfolios. It is intended to be applied to a course devoted to the study and analysis of professional topics. The possibility of extending the approach to other higher education and VET areas is also considered after analysis of the pilot results.

In the tout two-thirds of the engineering students will have jobs in the area where professional competences are required. The pilot envisaged to test the innovative approaches is a course that uses the Moodle learning platforms since 2004/5. These have been used especially as the repository of supporting documents, as forum of communication between teacher and students and as a means of evaluation.

The motivation of this proposal intends to monitor the learning and the skills acquired throughout the attendance of the discipline along the entire semester. This monitoring is based on the preparation by each student of e-portfolios with range of two or three weeks. These e-portfolio documents will be registered in the library of competences acquired with percentage of the respective quantification and with presentation of relevant evidences.

The list of reference competences in the discipline are those attributed and approved by the academic bodies given to the course. Monitoring the progress of acquisition of competences by the teacher will allow to detect anomalies in accordance with the anticipated learning. This continuous evaluation will allow the teacher to define measures.

The following up of each student route will allow the teacher to personalize the learning needs of each student and to act during the semester along with the course implementation. It is intended to have a closer follow-up of each student studying and especially learning. This close and timely monitoring will allow improvement of teaching, of effective learning and of motivating students through reflection and self-awareness.

The use of e-portfolios shared between each student and teacher about what is beneficial for the learning, in terms of competences qualification, will probably ensure a better mode of assessing and of grading each student performance. This maybe a way of assessing each student progression and of providing insights about the teaching flaws.

One of the aims of this research proposal is to evaluate the effects and impact of applying this type of assessment in learning of students and verify the required needs of engineering graduates to comply with employers. The set of competences presented as the goal of the course are a combination of academic and professional requisites.

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A STUDY ON WHY DESIGN INTERVENTION IS NEEDED TO PREVENT ACCIDENTS AT INDIAN CONSTRUCTION WORKPLACE

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Key words: Safety; Design; Indian construction; Accidents

ABSTRACT

Globally, construction industry is considered as one of the most hazardous workplace. In India, construction is undoubtedly the most vulnerable industry being accountable for 58% of fall accidents during the year 2013-2016. This is due to limited resources to control the risks and affecting high to low level projects which needs comprehensive tools to prevent workers from accidents among all level of construction projects. To prevent accidents at workplace, different initiatives were launched by Indian government as like other countries. But, the results remain the same. From previous studies, it was found that design has the major impact on construction accidents. Many researchers argued that addressing workers safety in design stage will enhance the performance of safety in construction projects. However, studies related to relationship among design and construction accidents are not yet considered in India and also no such initiatives were taken to prevent accidents in Indian construction projects through design.

The purpose of this study was to examine why design intervention is needed to prevent accidents in Indian construction projects. The accident statistics were collected from the available resources such as National Crime Records Bureau (NCRB), Directorate General Factory Advice Service and Labour Institutes (DGFASLI), police records, newspapers and so on. Due to less availability of construction accidents data, fall from height in Thane region (Maharastra, India) during the year 2016 and 2017 was considered in this study to investigate the relationship between design and accidents. The findings of the paper have shown a strong relationship among design and accidents in Indian construction industry. From this study it was observed that if safety is considered in earlier stage, number of accidents could have been prevented or reduced to some acceptable level. Therefore, this study strongly recommended that there is a need of design intervention to prevent accidents in Indian construction workplace.

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COOPERATION EXPERIENCE OF TOMSK STATE UNIVERSITY OF ARCHITECTURE AND BUILDING (TSUAB) AND RUSSIAN CONSTRUCTION COMPANIES IN IMPROVING THE QUALITY OF CIVIL ENGINEERS TRAINING

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Key words: Practical training; Employment; Training enterprise; Research

ABSTRACT

The article provides analysis of cooperation between the university and employment organizations aimed at improving specialists training quality. On the national level, the university works in partnership with the Russian Academy of Architecture and Construction Sciences (RAACS), International Association of Educational Civil Engineering Institutions (ASV), National Union of Construction Organizations, National Association of Surveyors and Designers, "ATOMSTROY" Self-Regulatory Organization, etc. On the regional level, administrative and teaching staff of the university successfully work in the RAACS Regional Research and Education Center, the associated members of which are professional communities of the Union of Constructors and the Union of Architects; in the Expert Council under the Governor of Tomsk region; in Research and Technical Council and Urban Development Council of Tomsk region, as well as in self-regulatory organizations of Tomsk construction and engineering companies.

Strategic goals, key directions and development programs of TSUAB were discussed and confirmed in close cooperation with the employment organizations, the university Board of Trustees, headed by Aleksandr Shpeter, General Director of "Tomsk Building Company" (TDSK), the Honored Constructor of the Russian Federation, Candidate of Economics, and the Alumni Association of the University, headed by Pavel Semenyuk, Technical Director of "Tomsk Building Company (TDSK)", Associate Professor.

The article summarizes the results of cooperation between TSUAB and "Tomsk Building Company" (TDSK) holding, which is one of 10 biggest construction companies in Russia. Joint research and development works performed with TDSK enable to considerably increase the level of specialists training and to improve facilities and resources. Thus, joining efforts in developing a novel framed universal prefabricated construction system resulted in creating an energy efficient, seismic prefabricated system and involving more than 110 young researchers, PhD students, undergraduate students, as well as in publishing more than 200 research papers and getting more than 50 patents, including foreign ones. 4 research and education centers were created at the university ("Testing of Building Structures", "Building Physics", "Computer Modeling of Building Structures and

Systems", "Building Materials and Technologies") provided with modern world class equipment and software. At TDSK, a new branch "Stroytekhinnovatsii TDSK" headed by A. Petukhov, TSUAB Associate Professor, was open for developing and implementing innovative technical solutions, here students can perform their research and have their internships.

TDSK plays the role of training enterprise providing places for students' internships and preparation of graduation theses, the Large Panel Construction Plant of TDSK locates a branch of the department of building materials and technologies, and TDSK design bureau serves as a training enterprise for design engineers training. TDSK top managers and senior specialists act as independent experts in assessment of curricula and training programs. As the result of their activities 4 new disciplines were included in the curriculum and the requirements to graduation thesis were modified. State Examination Commissions are resided by heads of the holding subdivisions.

TDSK staff members participate in the educational process at the university, they give lectures, become supervisors of internships and preparation of graduation theses, also are included in the jury list of various academic competitions among students. Certain results of these activities are presented.

Based on the needs of construction companies and TDSK in particular, TSUAB prepares professional development programs for specialists in the field of construction. Training takes place both at the enterprise and at the university, within the last 3 years 224 employees have been trained and got their diploma on professional development.

Special attention is paid to assessment of the level of the university graduates training by professional organizations and international accreditation agencies. In 2018, the bachelor program "Industrial and Civil Engineering" and master's program "Modern Design Technologies for Buildings and Structures" were successfully accredited by the Association of Engineering Education in Russia and European Network for Accreditation of Engineering Education (EUR-ACE).

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HIGHER CONSTRUCTION EDUCATION IN RUSSIA

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Key words: Areas of study; Employment of graduates; Grants

ABSTRACT

The article is devoted to the issues of training builders in high schools of the Russian Federation.
On the example of National Research Moscow State University of Civil Engineering, all aspects of higher construction education in Russia are discussed.
The article discusses: The main areas of study, training programs (bachelor, master, specialist and graduate student); Issues of; Cooperation between universities and customers; International cooperation; Scientific research, participation in scientific and educational grants. The prospects for the development of construction education are discussed.

KEYNOTE LECTURES

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"Cooperation between Universities and Industry in the Education and Employment of Civil Engineers: Current Expectations, Future Challenges"

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CAN THE CIVIL ENGINEERS RESCUE THE EXISTENCE OF HUMAN BEINGS ON THE EARTH?

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Key words: Global development and environmental impact; Civil engineering; Challenges

ABSTRACT

The paper deals with presentation of the changes at the Earth and challenges which the mankind is facing nowadays connected to global development and destruction of environment caused by human activity. The greatest threats to the existence of the world and humanity are listed and described as well as the role of civil engineers in "repair" of our World is defined.

1. INTRODUCTION

Civil engineering belongs to the oldest domains of human activity – its history is as long as the history of civilization. The social role of civil engineering in the development of mankind has always been of fundamental importance because the standard of human life has been so highly dependent on its progress. This can be observed from the beginning of human history up to the present day. Civil engineering deals with all aspects of the built environment (either physical or natural) and can be dated to the first time someone placed a roof over his or her head or laid a tree trunk across a river to make it easier to get across. And we can be confident that the role of civil engineering will continue to grow into the future.

Civil engineering as a domain of technological activity is a key element of the national and international economy. Economic progress is impossible without adequately developed social and physical infrastructure, including, for example, buildings, water distribution networks and service, transport infrastructure networks or energy production and distribution systems.

As it has been already mentioned, the reality is that the role of civil engineers in advancing social, economic and cultural progress is especially high. Moreover, civil engineering is a profession that enjoys the highest level of public confidence. Civil engineers are ultimately responsible for the safe utilization of buildings and structures. This is an especially important and often forgotten aspect of the social role of civil engineers. Apart from their technological activities, civil engineers also increasingly consider the social effects of engineering decisions. To meet this condition, civil engineers continue to widen their knowledge of the economic, social sciences and so-called soft skills.

Taking into account the situation briefly presented above, the European Council of Civil Engineers (ECCE) tries to do its best to reinforce the fundamental role of civil engineers in society in improving the standard of human life, to make the case for the prestige of the civil engineering

profession in the social community of European countries and to stress the pivotal role that civil engineers will play in addressing the challenges that will face society in the future.
We have been living in the Holocene era for 11.5 thousand years: the last glaciations has subsided, the climate on Earth has stabilized at a level similar to the current one, which we can observe outside the window. This gave rise to an incredible development, even flourishing of human civilization, and led us to the place where we are today. But our present prosperity, our current level of life has its own price.
This price are the challenges, nowadays better to say threats, facing the Earth and its inhabitants, or rather the reverse, because we, the people have a problem! The Earth will cope alone regardless of us and our needs.

2. WHAT KIND OF CHALLENGES THE MANKIND FACES TODAY?

1. Climate change

The first one and the most important is climate change caused by human activity. First report on this matter - USA 60s of the twentieth century for President Lyndon Johnson. In 1988 - IPCC was created, which publishes every few years reports on the state of climate on Earth and its changes (Fig. 1).

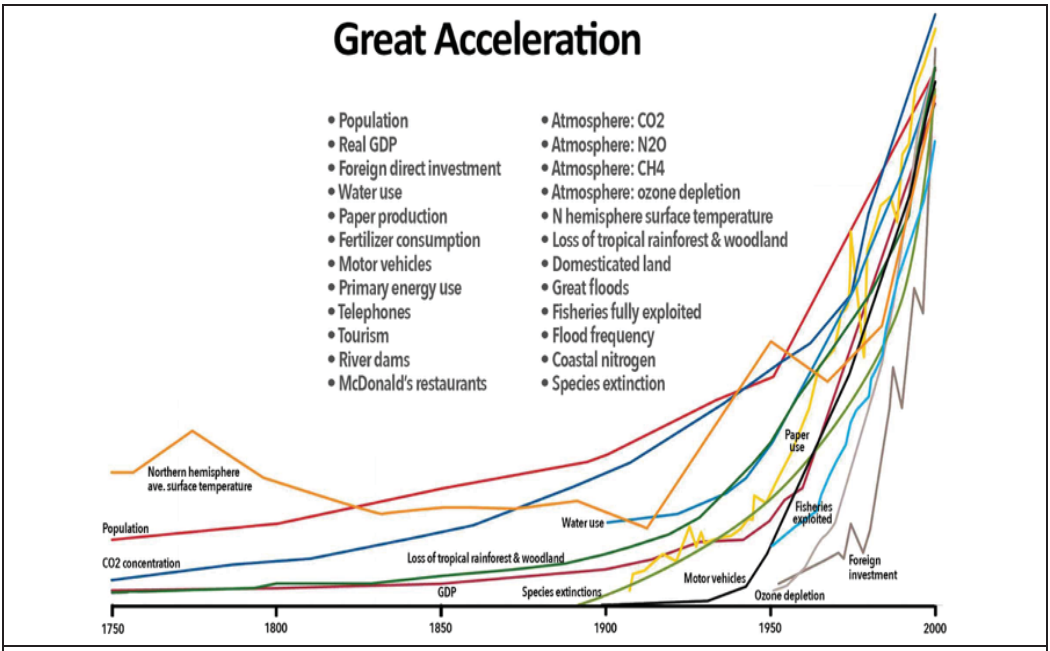

Fig. 1. Measures of the anthropocene

Source: http://humanorigins.si.edu/research/age-humans-evolutionary-perspectives-anthropocene

First report of the IPCC was published in 1990, the next ones in 1995, 2001, 2007, 2014 and the last one in 2019. On October 8, 2018, the IPCC Special Report on reducing global warming by 1.5°C

was published. The method of deciding on conclusions for publication makes IPCC reports conservative. The IPCC structure was formed under the influence of politicians who were afraid of overly "alarmist" reports, in the event that their wording was determined only by scientists. The conclusions are formulated during iterative rounds in which teams of scientists and government negotiators reach a consensus on the final wording of the documents.

2. Global warming

One degree, is it a lot or not much? At the height of the last ice age, 20,000 years ago, the average surface temperature of the Earth was 4 to 5 degrees lower than in the nineteenth century, and in dinosaur times - 6 degrees higher. Global warming - is the unusually rapid increase in Earth's average surface temperature (Fig. 2). In the past century alone, the temperature of Earth has climbed 0.9 degrees Celsius, roughly ten times faster than the average rate of ice-age-recovery warming. Models predict that Earth will warm between 2 and 6 degrees Celsius in this century. When global warming has happened at various times in the past a few million years, it has taken the planet about 5,000 years to warm 5 degrees. The predicted rate of warming for the XXI century is at least 20 times faster. This rate of change is extremely unusual.

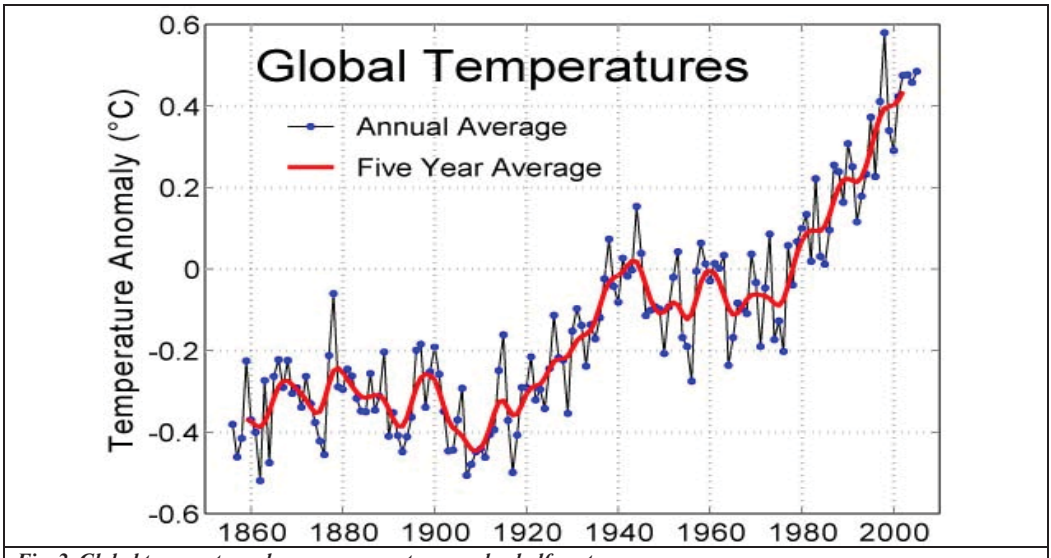

Fig. 2. Global temperature changes over past one-and-a-half century
Source: http://berkeleyearth.org/2018-temperatures/

The greenhouse effect - the trapping of the sun's warmth in a planet's lower atmosphere due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface. Anthropogenic emission of CO_2 and other greenhouse gases and its consequences are the most serious challenge and the threat we face today (Figs 3 & 4). Threat from the category of "To Be or Not To Be" for all inhabitants of the Earth. But natural greenhouse

effect enable the life on the Earth. If there were no natural greenhouse effect, the Earth's average surface temperature would be -18°C (0°F) instead of the comfortable 15°C (59°F) that it is today.

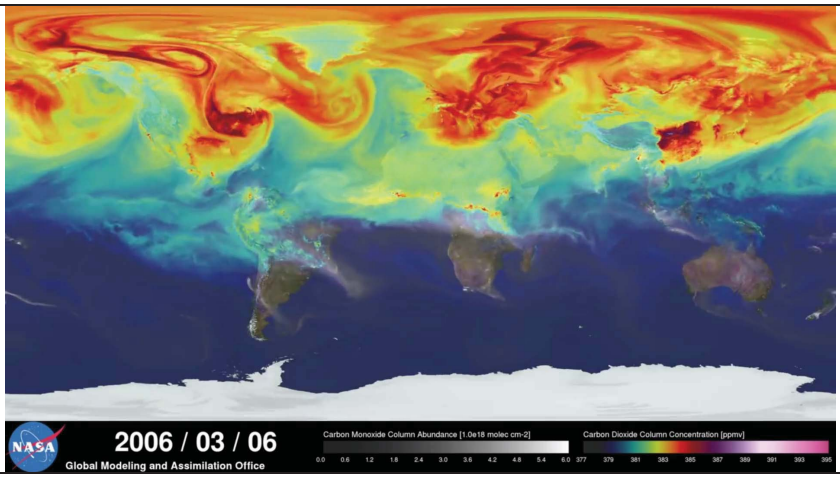

Fig. 3. CO_2 emissions and its journey in the Earth's atmosphere in winter

Source: NASA film about global CO_2 emissions and its journey in the Earth's atmosphere

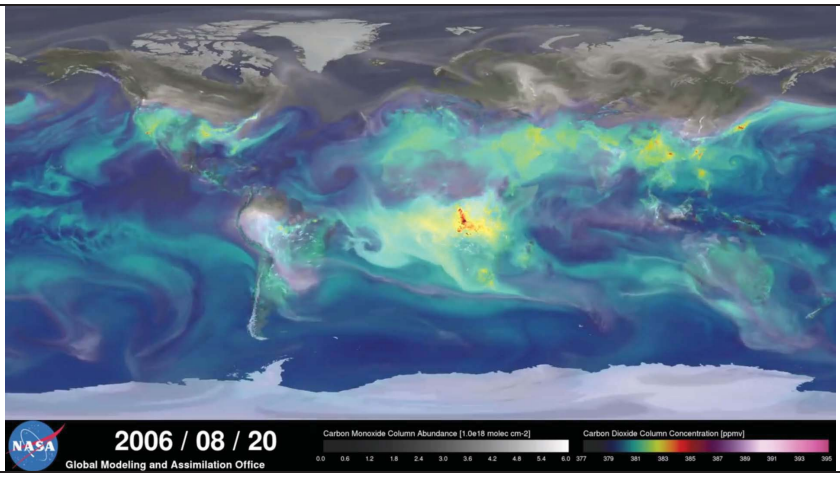

Fig. 4. CO_2 emissions and its journey in the Earth's atmosphere in summer

Source: NASA film about global CO_2 emissions and its journey in the Earth's atmosphere

What is the difference between greenhouse effect and global warming? It is not the same, global warming is a result of greenhouse effect enhanced artificially by human activity. Global warming is scientifically proven.

The main reason of it is anthropogenic CO_2 emissions from the burning of fossil fuels to obtain cheap and convenient in use energy, but also from cutting down carbon-absorbing forests, land use mostly for agriculture, or from cement industries.

The effects of global warming on Earth:

- Increase in average surface temperature of the Earth and oceans (Figs 5 & 6).
- Intensification of extreme weather phenomena.
- The increase in the level of waters in the seas and oceans, caused by melting of the Arctic and Antarctic ice, glaciers and continental ice sheets, and the decrease in the density of these waters due to the increase in their temperature.
- Desertification and complete sterilization of significant areas of the Earth, especially in the tropics.
- Great migrations of people from areas unfit for living in order to find survival conditions.
- The emergence of new diseases and epidemics in places around the world where they have not yet occurred.
- The deficit of fresh, potable water will increase.
- A drop in global GDP by several percent.
- A decrease in the level of security of the Earth's inhabitants in every dimension: physical, health, social, existential, economic, etc.

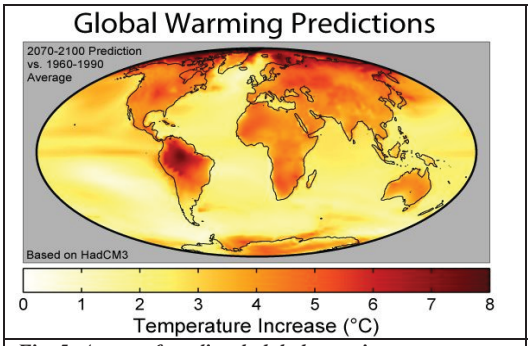

Fig. 5. A map of predicted global warming

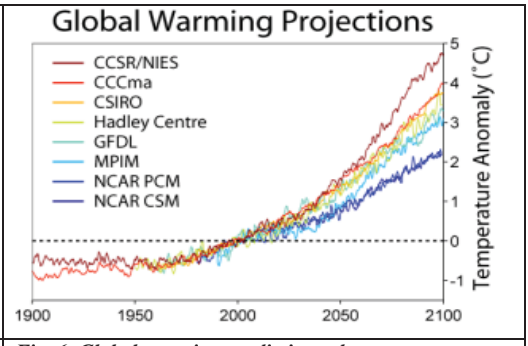

Fig. 6. Global warming predictions chart

Source: https://commons.wikimedia.org/wiki/File:Global_Warming_Predictions_Map.jpg;
Source:https://pl.m.wikipedia.org/wiki/Plik:Prognozy_globalnego_ocieplenia.PNG

3. The increase in the population of people on Earth

Are there too many of us? At the beginning of the 20th century there were 1.5 billion. Today there are 7.5 billion, in 2050 - 9.8 billion, in 2100 - 12.0 billion) (Fig. 7). The inhabitants of Africa reproduce twice as fast as the rest of the world on average. By the end of the century, the African population is likely to increase from 1 billion to around 4 billion. It's easy to imagine the tension it will cause. The more so that climate change will affect the Black Land more than the rest of the world. What will happen when the dry regions grow, agriculture collapses and then the entire economy and 100 or maybe 500 million Africans try to cross the Mediterranean?

Globalization and the IT revolution have made the inhabitants of the poorest corners of the world see that better living can be done elsewhere. So they want to improve their fate more and more. The problem is that if each of the 7.5 billion people would live at the level of an average US citizen, we would need five planets to feed us all.

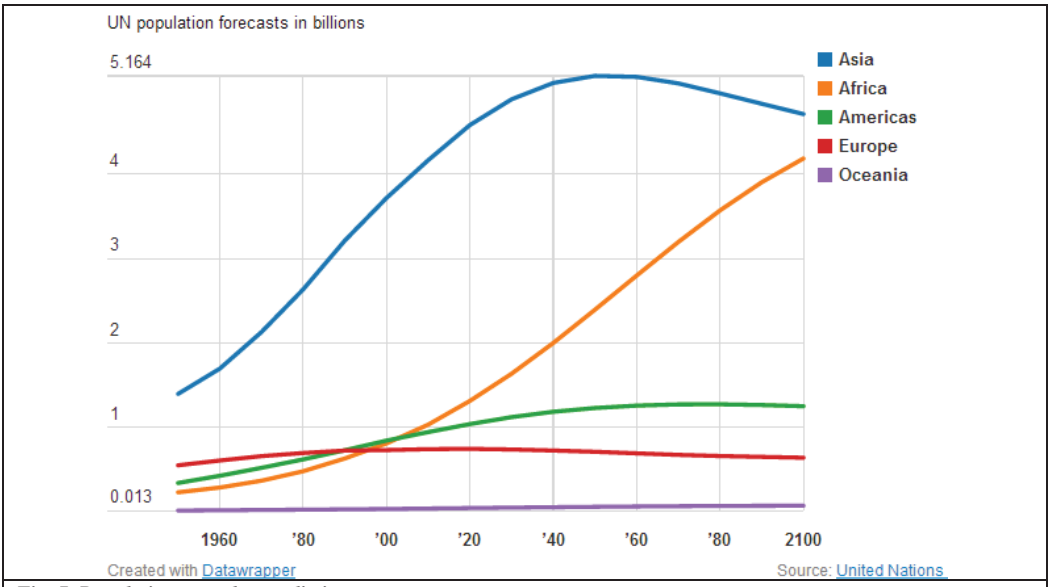

Fig. 7. Population growth - prediction
Source: https://abbiestempopgrowth.weebly.com/prediction.html

4. Unrestrained urbanization
By 2050, 75% of the world's population will live in cities (already 2/3 today).

5. The depletion of natural non-renewable land resources, including natural fossil fuels (oil, coal, gas) as well as ores of various minerals (gold, silver, copper, lead, etc.).

6. Excessive, robbery exploitation of the Earth's renewable resources (fish, forest, animals, vegetation, land, water, atmosphere).
It is already estimated that every year we eat half as much resources as the Earth can rebuild. We live on credit.

7. Environmental degradation
Currently, in oceans, 200 kg of plastic floats for every 1000 kg of fish. Between Hawaii and California, an island of plastic garbage is drifting with an area 5 times bigger than area of Poland, and 12 similar islands have been located so far at the oceans.

8. Deforestation (to obtain new cultivation areas)
It is estimated that 15 percent of all greenhouse gas emissions come from deforestation, according to the World Wildlife Fund (WWF). The Earth loses 7.5 million hectares of forests per year, which is equal to 27 soccer fields every minute, according to the World Wildlife Fund (WWF). Examples: Borneo – palm oil plantations; Haiti – charcoal production.

9. Lack of drinking quality water

2 billion people do not have access to such water, in Europe - 100 million people. In its reports, the EU indicates, among others, that in the most populated Member States - France, Spain, Germany, Poland, Great Britain and Italy - the level of fresh water resources per capita is alarmingly low. Is less than 3 thousand m³ per capita, while the deficit can be said when the ratio reaches 1,700 m³ per inhabitant. This critical state has been recorded by the Union in recent years not only in Malta but also in Cyprus, the Czech Republic and Poland. Poland has 1.6 thousand m3 / inhabitant / year.
That is all for now in the topic of challenges.

3. AND WHAT ARE THE CIVIL ENGINEERS GOT TO DO WITH IT?

Below there are the most important documents describing the present and requirements for the future, related to the successful existence of people on Earth.

- The UN 2030 Agenda for Sustainable Development with its 17 Sustainable Development Goals.
- Civil Engineers' Vision 2025 by American Society of Civil Engineers.
- Madrid declaration "Civil engineers committed to UN's objectives of sustainable development and climate action".
- IPCC reports and publications .

This documents also describing role, tasks, requirements, society expectations and responsibility of civil engineers and civil engineering organizations for addressing challenges facing society today and in the future. Such situation requires well targeted and sustained action in time, not subject to political cycles, with the joint commitment of governments, professionals and society as a whole.

Fig. 8. UN Sustainable Development Goals
Source: https://www.un.org/development/desa/disabilities/envision2030.html

A large share of United Nation's 17 Strategic Development Goals – SDGs are deeply and directly linked with the practice of Civil Engineering (Fig. 8):

- Goal 6 - "Ensuring the availability and sustainable management of water and sanitation for all".
- Goal 7 - "Ensuring access to affordable, reliable, sustainable and modern energy for all".
- Goal 9 - "Building resilient infrastructure, promoting inclusive and sustainable industrialization and foster innovation".
- Goal 11 - "Making cities and human settlements inclusive, safe, resilient and sustainable".
- Goal 13 - "Take urgent measures to combat climate change and its impacts".
- Goal 14 - "Conserve and sustainably use oceans, seas and marine resources for sustainable development".
- Goal 15 - "Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt the loss of biodiversity".

Energy Production and Consumption

The problem of carbon dioxide emissions is essentially a problem of energy – sources of its origin, demand for it and the effectiveness of its production and usage. And this is domain of civil engineering activity and responsibility (Fig. 9).

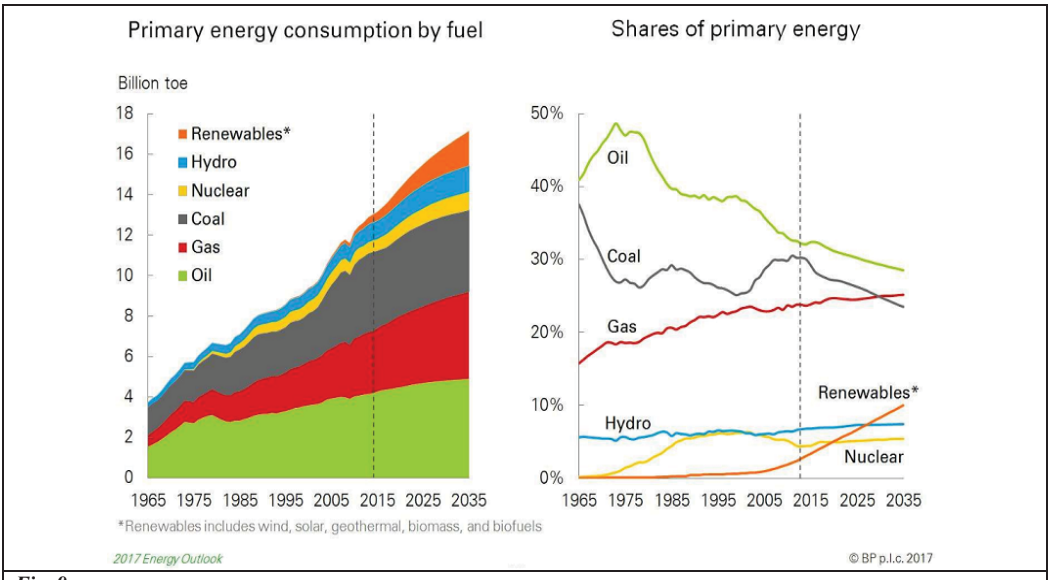

Fig. 9.

Source: 2017 Energy Outlook BP p.l.c. 2017

If we want to keep Earth's surface temperature rise below 2 degrees (as is in the Paris Agreement), a global energy / industrial revolution is necessary at all possible levels, from the consciousness of

each of us, through the actions of governments and international organizations, to economic and consumer actions and decisions taken practically every day.
- Limiting energy demand, rationalizing its consumption.
- Decarbonisation (release from dependence on fossil fuels).
- Development of energy, based on renewable energy sources.
- Diversification of energy production.
- Increasing the efficiency of existing energy sources.
- Minimization of energy losses in the source, in transmission, storage and at the final consumer.
- Computer control of energy flow and consumption.

The energy revolution can give us an opportunity for economic and social development, raising the quality of life, creating new jobs and new professions, creating new, innovative products and services.

Water Construction and Engineering

Professor Peter Ward, paleontologist: by the end of this century, the fight against the constantly rising level of seas and oceans (with water pressure) will be the main investor / principal / employer for the economy on our planet. Is predicted that by the end of this century level of water in oceans will increase 1.2 meter. It means catastrophe for many cities and human settlements located on the coasts and in the deltas of the great rivers. A special systems of protection have to be designed and built. In certain places in the world that kind of works have been started already (Venice, New Orleans, Holland) but the cost of it is tremendous.

Urban Population

According to UN report in 2018 4,2 billion people lived in cities. The most populated are:

1. Tokyo (population: 37,435,191)
2. Delhi (population: 29,399,141)
3. Shanghai (population: 26,317,104)
4. Sao Paulo (population: 21,846,507)
5. Mexico City (population: 21,671,908)
6. Cairo (population: 20,484,965)
7. Dhaka (population: 20,283,552)
8. Mumbai (population: 20,185,064)
9. Beijing (population: 20,035,455)
10. Osaka (population: 19,222,665)

How to deliver to these people housing, water and sanitation, energy, garbage collection, transportation, education, food and other service? How to create these cities as a pleasant, comfortable and safe place to live? How to manage tensions and conflicts which certainly occur?

As I mentioned above, the very first step in addressing challenges I am talking about is changing of our conscious which coming from knowledge. Therefore this knowledge ought to become important part of new curricula for civil engineers, especially when more and more companies understand that global warming and other listed by me challenges have already started to irreversibly change our economy and industry.

4. REFERENCES

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[3] https://naukaoklimacie.pl/.
[4] https://ec.europa.eu/clima/.
[5] https://www.eea.europa.eu/

10th AECEF Symposium

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QUALIFICATION OF CIVIL ENGINEERS: LEARNING OUTCOMES AND COMPETENCE ASSESSMENT

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Key words: Learning Outcomes; Civil Engineering; Assessment; Competence; Qualification; Tuning

ABSTRACT

Existing approaches to assess quality of learning tend to look at processes and not at achieved learning by civil engineering students. CALOHEE applied a forward looking approach, focusing on what a graduate should know and be able to do in order to function successfully in life and contribute to society (learning outcomes perspective). The chosen approach brought evidence-based accountability into the teaching and learning role of HE institutions by focusing on competences acquired by students, which meet the needs of society and the graduates. The assessment framework included four strands: 1) Knowledge (theory and methodology); 2) Applying knowledge and skills; 3) Preparing for employability and 4) Civic, social and cultural engagement. CALOHEE also developed a set of reference points at 1st and 2nd cycles levels. The sets of learning outcomes' descriptors were prepared by teams from the respective academic communities, in close consultation with stakeholders and open to public scrutiny. CALOHEE developed the Assessment Framework for Civil Engineering Education that is based on a merger of the Qualification Framework for the European Higher Education Area and the European Qualification Framework for Lifelong Learning. The Assessment Framework is built on a set of learning outcomes' descriptors and related framework that is precise enough to offer a basis for assessment and broad enough to encompass a wide range of programme profiles. This Assessment Framework of Civil Engineering describes the discipline in terms of multiple dimensions: key elements which define a subject area. For example: 'knowledge and understanding', 'analysis and problem solving', 'design', 'investigation', 'practice', 'decision making', 'team working', 'communication' and 'lifelong learning'. In sum, CALOHEE offers academic engagement, subject focused context and evidence based tools for analysis and diagnosis, serving Higher Education institutions and providing meaningful information to stakeholders and society. The ultimate result is meaningful increase of the quality of civil engineers.

1. INTRODUCTION

It is presented in this paper the summary of two documents [1], [2] that builds on documents published in the past, in particular the publication A Tuning-AHELO Conceptual Framework of Expected Desired/Learning Outcomes in Engineering, documents of the European Civil Engineering Education and Training (EUCEET) Association and the EUR-ACE Framework Standards and Guidelines (EAFSG).

This work done in the subject area of Civil Engineering concerns degree profiles and the tasks and societal roles graduates will take on, but also shows how different degrees fit into the wider context of overarching qualification frameworks. In other words, which are the essential elements that constitute a particular subject area in higher education? Among other aspects, the guidelines include general descriptors for the first and the second cycle, the bachelor and master, presented in easy-to-read tables, and are meant to be used as reference points for the design and delivery of individual degree programmes. According to the Tuning philosophy, each degree programme has its own unique profile, based on the mission of the institution and taking into account its social-cultural setting, its student body, and the strengths of its academic staff [3].

The Guidelines and Reference Points [1] are the outcome of a long and intense collaboration, starting in 2001, in conjunction with the early phases of the Bologna Process, which has now come to include 48 European countries. They are a result of the grassroots university-driven initiative called Tuning Educational Structures in Europe, or simply 'Tuning', that aims to offer a universally useful approach to the modernisation of higher education at the level of institutions and subject areas. The Tuning initiative has developed a methodology to (re-) design, develop, implement and evaluate study programmes for each of the Bologna cycles.

The Tuning methodology is based on student-centred and active learning approaches it has promoted since its very launching. Tuning's mission is to offer a platform for debate and reflection which leads to higher education models able to ensure that graduates are well prepared for their societal role, both in terms of employability and as citizens. Graduates need to have obtained as the outcome of their learning process the optimum set of competences required to execute their future tasks and take on their expected roles. As part of their education, graduates should have developed levels of critical thinking and awareness that foster civic, social and cultural engagement.

Using the Tuning reference points makes study programmes comparable, compatible and transparent. They are expressed in terms of learning outcomes and competences. Learning outcomes are statements of what a learner is expected to know, understand and be able to demonstrate after completion of a learning experience. According to Tuning, learning outcomes are expressed in terms of the level of competence to be obtained by the learner. Competences represent a dynamic combination of cognitive and meta-cognitive skills, knowledge and understanding, interpersonal, intellectual and practical skills, and ethical values. Fostering these competences is the object of all educational programmes. Competences are developed in all course units and assessed at many different stages of a programme. Some competences are subject-area related (specific to a subject area), others are generic (relevant for many or all in degree programmes). According to the Tuning philosophy, subject specific competences and generic competences or general academic skills should be developed together. Normally competence development proceeds in an integrated and cyclical manner throughout a programme.

The initial core competences of the subject area were identified in a consultation process involving four stakeholder groups - academics, graduates, students and employers - during the period 2001-2008. Since then similar consultation processes have been organised in many other parts of the world: these have been taken into consideration in developing this new edition. This edition has been elaborated as part of the CALOHEE project (Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Europe), co-financed and strongly supported by the European Commission as part of its Action Programmes for Higher Education. CALOHEE project aims to develop an infrastructure which allows for comparing and measuring learning in a (trans)national perspective. Besides updating and enhancing the reference points brochures it has also developed Assessment Frameworks which offer even more detailed descriptors than those presented in this document. The Assessment Frameworks are published separately.

To make levels of learning measurable, comparable and compatible across Europe, academics from the single subject areas have developed cycle (level) descriptors expressed in terms of learning outcomes statements. In this edition, for the first time these are related one-to-one to the two

overarching European qualifications frameworks, the 'Bologna' Qualifications Framework for the EHEA (QF for the EHEA) and the EU European Qualifications Framework for Lifelong Learning (EQF for LLL). In the CALOHEE project these two meta-frameworks have been merged into one model to combine 'the best of two worlds'. While the EQF for LLL is focused on the application of knowledge and skills in society, the focus of the QF for the EHEA is more related to the learning process itself: it applies descriptors which cover different areas or 'dimensions' of learning: knowledge and understanding, application of knowledge and understanding in relation to problem solving, making judgments, communicating information and conclusions, and finally, knowing how to learn.

In developing the CALOHEE Tuning model, it was concluded that 'dimensions' are an indispensable tool, because they make it possible to distinguish the principal aspects that constitute the subject area. Dimensions help give structure to a particular sector or subject area and also make its basic characteristics more transparent. Furthermore, the 'dimension approach' is complementary to the categories included in the EQF for LLL, which uses the categories of knowledge, skills and wider competences to structure its descriptors. Thus, in CALOHEE terms, the three columns correspond to a 'knowledge framework', a 'skills framework' and a 'wider competency framework', linked by level. The last column, the 'wider competency framework', refers to the wider world of work and society and identifies the competences required to operate successfully in the work place and as a citizen. It builds on the first two elements: knowledge and understanding and the skills necessary to develop and apply this knowledge.

The use of the learning outcomes and competences approach implies changes regarding the teaching, learning and assessment methods. Tuning has identified approaches and best practices to form the key generic and subject specific competences. Some examples of good practice are included in this brochure. More detailed examples can be found in the subject area based Assessment Frameworks.

Finally, Tuning has drawn attention to the role of quality in the process of (re-)designing, developing and implementing study programmes. It has developed an approach for quality enhancement which involves all elements of the learning chain. It has also developed a number of tools and identified examples of good practice which can help institutions to improve the quality of their degree programmes.

The outcomes of the work done by the Subject Area Group (SAG) in Civil Engineering, which was established in the context of the CALOHEE project, are presented in a template to facilitate readability and rapid comparison across the subject areas. The summary aims to provide, in a very succinct manner, the basic elements for a quick introduction into the subject area. It shows in synthesis the consensus reached by a subject area group after intense and lively discussions in the group [1].

2. TERMS OF REFERENCE AND TUNING

In order to develop the sectoral and the subject area frameworks, the SAG started from the EUR-ACE programme (learning) outcomes recently re-defined by the European Network for Accreditation of Engineering Education (ENAEE) in the document EUR-ACE Framework

Standards and Guidelines (EAFSG), approved by the Administrative Council of the European Network for the Accreditation of Engineering Education (ENAEE) on March 2016. The EUR-ACE programme outcomes (POs) are the basis for a European mutual recognition agreement, currently developed under the framework of ENAEE.

EUR-ACE programme outcomes (POs) and corresponding accreditation criteria have been integrated into national learning outcomes and accreditation requirements of thirteen European countries: Finland, France, Germany, Great Britain, Ireland, Italy, Poland, Portugal, Romania, Russia, Spain, Switzerland and Turkey. In addition, FEANI, the European Federation of Engineering Societies in 30 European Countries, recognises the EUR-ACE POs and accreditation results for their own index of accredited engineering programmes and the European engineering register of professional engineers.

EUR-ACE POs describe the knowledge, understanding and skills that an accredited engineering degree programme must enable a graduate to demonstrate. They are described separately for both Bachelor and Master degree programmes, with reference to the following eight 'learning areas':

a) Knowledge and understanding;
b) Engineering Analysis;
c) Engineering Design;
d) Investigations;
e) Engineering Practice;
f) Making Judgements;
g) Communication and Team-working;
h) Lifelong Learning.

First of all, the SAG has verified the capacity of the EUR-ACE learning areas to include the learning outcomes (LOs) established in the most influential LOs frameworks in the engineering field. In fact, that there is a common understanding throughout the world of what an engineer is supposed to know and be able to do is most striking and probably differentiates engineering from many other disciplines.

The frameworks that have been considered are:

a) the Tuning-AHELO framework [4];
b) the EUCEET framework [5];
c) the International Engineering Alliance (IEA) - Washington Accord framework [6];
d) the ABET framework [7];
e) the Conceiving, Designing, Implementing, Operating (CDIO) Initiative framework [8];
f) the National Society of Professional Engineers framework [9];
g) the American Society of Civil Engineering (ASCE) framework [10].

Consequently, the SAG has assumed the EUR-ACE learning areas as 'dimensions' for constructing the sectoral qualifications framework (SQF) for the engineering domain, renaming them as follows:

a) Knowledge and understanding;
b) Analysis and Problem Solving;
c) Design;
d) Investigations;
e) Practice;
f) Decision Making;

g) Team-working;
h) Communication;
i) Lifelong Learning.

Then, the SAG has checked the correspondence of the EUR-ACE POs with the LOs established in the considered frameworks. The members of the SAGS quickly came to the conclusion that, in spite of a different ordering, the EUR-ACE POs and the LOs established in the considered frameworks were highly compatible, but also that two major revisions of the EUR-ACE POs were necessary in order to improve the compatibility:

a) the introduction of a PO regarding the ability to implement and conduct engineering activities;
b) the necessity to provide better evidence to the social responsibility associated to the outcomes.

3. ASSESSMENT FRAMEWORK FOR CIVIL ENEGINEERS

The Tuning-CALOHEE Assessment Frameworks for Civil Engineering offers an important and novel tool for understanding, defining and visualising the requirements for any degree programme in the Subject Area or closely related to it. It shows, in a detailed but also general and flexible way, which competences should be developed by such a programme (the AF for Civil Engineering does not shows competences), giving useful indications about the relevant learning areas: not only core knowledge content, including theories and methodologies, but also skills for developing and applying that content, as well as the level at which the graduate will be able to operate meaningfully in his or her profession and, more broadly, in society. It distinguishes between the first and second cycle degree (Bachelor and Master) in the Subject Area, clarifying the progressive nature of the learning process, and showing the connections between levels of learning to be developed.

The CALOHEE Assessment Framework comprises easily read reference tables containing descriptors covering knowledge, skills and wider competences [2]. These tables are an integral part of the Tuning Guidelines and Reference Points 2018 for the Design and Delivery of Degree Programmes [1].

The advantages of being able to refer to an Assessment Framework are numerous. Such a framework provides:

a) a widely accepted comprehensive overview of the key learning topics a degree programme can include, developed by an international group of experts, and validated by peers and other stakeholders;
b) a range of up-to-date strategies, methodologies and approaches to learn, teach and assess the topics of learning, formulated in terms of learning outcomes.
c) different stakeholder groups' insight into what could be usually covered in terms of learning in a particular subject area and a particular degree programme. Stakeholders include disciplinary experts, teaching staff, university and faculty management, professional organisations, employers, and (potential) students;
d) a menu through which an individual degree programme at bachelor or master level can be composed and defined on the basis of motivated and articulated choices and a transparent decision-making process;

e) a fair indicator of the completeness and quality of a degree programme which allows for different institutional missions and profiles;
f) a reliable mechanism for quality assurance based on a robust reference framework based on well-defined sets of measurable learning outcomes;
g) a format for comparing different degree programmes in terms of profile, content and approach;
h) a robust and articulated framework for developing comparable diagnostic assessments which offer reliable evidence regarding the strengths and weaknesses of a particular degree programme benchmarked against programmes with comparable missions and profiles.

CALOHEE's Assessment Framework can be seen as a general table providing a complete overview of the Civil Engineering in terms of measurable learning outcomes statements [2]. These statements, taken together, are much more precise than the more general Reference Points descriptors of Civil Engineering [1]. The focus in the framework is not only on 'what' to learn, but also on 'how' this 'what' can be learned. It represents the lowest, but at the same time most detailed level in the hierarchy of qualifications frameworks. This hierarchy starts with the overarching European frameworks, followed by national, sectoral and the subject area frameworks. As in the case of the subject area frameworks, the Assessment Framework organises its descriptors according to the categories knowledge, skills and competences distributed among the 'dimensions', which are seen as the main building blocks of the subject area. The descriptors, formulated in this way, provide structure and transparency: a general way to look at Civil Engineering through which specific programmes can be formulated.

While the general descriptors have the primary purpose of indicating the type and level of learning, in an Assessment Framework these are broken down using 'sub-descriptors' or 'subsets' which describe the key elements and topics that constitute each descriptor in greater detail. Although the general descriptors are often called learning outcomes, in practice they are much more competence statements. The real, utilizable, learning outcomes of a subject area are the sub-descriptors, because they meet the condition of being measurable, indicating not only a subject, but also context and complexity. The dimensions, sub-dimensions, descriptors and sub-descriptors together make an assessment framework which is complemented by an overview of the most appropriate learning, teaching and assessment strategies and approaches to achieve the intended learning outcomes. These can be formulated per sub dimension but are more often formulated for several related sub descriptors in order to avoid repetition.

According to the Tuning and CALOHEE philosophy, learning, teaching and assessment – in that order - should be fully aligned. A specific body of learning (knowledge, skills and wider competences), identified by the intended learning outcomes, is split into modules or units spread over the available learning period (e.g. academic years) in such a way that progression routes are established. Appropriate modes of learning, teaching and assessment are linked to each unit or module. These, of course, should fit the level of learning identified.

An Assessment Framework should first and most of all be understood as a source of reference - inspiration and guidance - for modernising, revising and enhancing existing degree programmes and constructing new ones to meet the needs of the learners, preparing them appropriately for their role in society, in terms both of employability and as citizens. For this reason, CALOHEE has

developed a model in which the different aspects of the learning process are defined. The 'knowledge set of descriptors' is expected not only to cover core knowledge of the subject area but also related theories and methodologies. The 'skills set of descriptors' focusses on the skills/competences – generic and subject specific – which are relevant for applying knowledge. With regard to the generic skills /competences one normally thinks of such abilities as critical thinking, analysing and synthesising, creativity and originality and written and oral communication, but it is important to remember also value related competences such as ethical commitment.

4. EXAMPLES OF BACHELOR AND MASTER

The two levels of the European Qualification Framework, 6 and 7, represent the academic qualifications of the majority of civil engineers working as professionals. These two levels are generally known as qualifications denominated bachelor and master. For each one of these levels an example is presented with the indication of the dimension, the learning outcome (knowledge, skill or wider competence), the teaching approach, the learning approach and assessment methods proposed.

The teaching and learning approaches are proposals arising from the consultation among the project partners, targeted surveys and contribution of stakeholders. The proposal of assessment methods was obtained using a web-tool TALOE. This tool is the result of the application of the ALOA model that aligns the assessment methods with the different types of learning outcomes using revised Bloom's taxonomy and Biggs alignment model [11].

For level 6, first Bologna cycle or bachelor, an example is Analysis and problem solving. In this case for the knowledge dimension one of the learning outcomes is to Demonstrate knowledge and understanding of the process and established methods of analysis of civil engineering issues (products, processes, systems, situations) and of their limitations, of the process and established methods of solving civil engineering problems and of their limitations and demonstrate also awareness of the importance of non-technical, societal, health and safety, environmental, economic and industrial considerations in solving civil engineering problems. The teaching approaches proposed are lectures, seminars, tutorials, flipped classroom, blended teaching and problem-based classes. For the same learning outcome it is proposed in terms of learning attending lectures, attending seminars, attending tutorials, participating in flipped classroom, blended learning and problem-based learning. The assessment methods proposed are short answer questions, multiple choice questions and essays.

For level 7, second Bologna cycle or master, an example is Lifelong Learning. For this dimension the wider competences are defined as to Identify the most appropriate learning strategy and method in independent lifelong learning and to follow developments in science and technology and undertake further studies in new and emerging technologies in civil engineering subject area and within broader or multidisciplinary contexts. For this learning outcome the teaching approaches proposed are problem-based classes, design-based classes, work-based practice and individual supervision. The learning approaches are problem-based learning, design-based learning, practicing professional skills and individual supervision. The assessment methods proposed are problem solving, practical work and reflective practice assignments.

5. CONCLUSIONS

The ultimate ambition of the CALOHEE for Civil Engineering initiative is to develop a transnational multi-dimensional assessment model which allows for actual measuring and comparing of learning, taking into account the specific mission and profile of each degree programme, within its cultural and academic context. This model should offer sets of consistent test formats and items which make possible the assessment of deep knowledge and understanding as well as high level skills. One could think of, for example, critical awareness, analysing and composition skills.

An Assessment Framework is a key tool in this case because it offers a basis for identifying and developing the items to be tested. Although students' achievements will be individually assessed, the outcomes of the assessments will be generated at degree programme level (not at the individual student level), because the intention is – in line with traditional quality assurance systems – to diagnose whether the intended learning outcomes are actually achieved. In other words, does the programme offer what it has promised and does it meet the standards which have been agreed by the academic community? The Assessment Framework presented here should be understood as a planning tool, but also as a tool for answering this question. Since the project has the ended in 30 April 2018 the piloting and implementation phases proposal for financing by the European Commission was approved in 2019. In the meantime, some European engineering professional and academic organizations have already pledged their support for these future phases and will participate in the project CALOHE2 implementation.

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PAPERS

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DEVELOPMENT OF CIVIL ENGINEERING CURRICULA IN POLAND – FROM START OF BOLOGNA PROCESS TILL NOWADAYS – A REVIEW

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ABSTRACT

Poland entered the Bologna Process in 1999 and all higher education institutions started to introduce its ideas, having to overcome many difficulties and defeat different challenges. The Bologna agreement was prompted by geopolitical and economic developments that made graduate mobility desirable. It also had as a stated aim the development of a common European cultural identity. According to the Polish Law on Higher Education, from the academic year 2007/2008 two-level study programs (BSc and MSc), began to be obligatory at all Polish universities (in fact there was a three-level system as PhD studies were included). According to the amendment of the mentioned Law, introduced in 2010, there was made a further step to integrate Polish higher education system with the European one. From the academic year 2012/2013 all the universities in Poland had to develop existing three-level system by introducing new model of higher education based on the National Qualifications Framework. Amendments inducted in 2014 introduced, among others, demand of separation studies for practical and general academic profiles. The practical profile program is centered at gaining by the student mostly practical skills, while for the general academic profile modules covering study program must be associated to the research activities carried out in the university, that lead to the acquisition by the student an in-depth knowledge in the specific field-of-study. Currently, the new Law on Higher Education. applicable from 2018, introduced some new requirements as, for example, compatibility of learning outcomes defined for study curricula with characteristics of the second degree learning outcomes for qualifications at levels 6-8 of the Polish Qualifications Framework. Another very interesting element is a possibility of creating for the practical profile the so-called dual studies, in agreement with external stakeholders, especially industrial environment.

The paper deals with presentation of the development in creating the Civil Engineering curricula in Poland due to the demands resulting from the legal requirements as well as taking into account the specifics of the profession of a civil engineer and requirements of the construction industry.

1. INTRODUCTION

In Poland, creation of CE study programs depends on university faculties but its main assumptions and general principles were always defined by the state laws and regulations of the Ministry of Science and Higher Education [1÷12]. However, also other requirements had and have to be taken into account while creating study programs as, for example, included in building regulations [13÷15] or in standards for national [16, 17] and international accreditations [18, 19].

Until the beginning of the academic year 2007/2008 at most of the Polish technical universities the predominant system of full-time studies was a one-cycle, 5-year one. The program of studies was precisely described by national standards in which, for example, minimum number of hours, detailed content of every field of study subject and duration of internships were defined [1].

According to the amendment to this Law, made in 2005 [2, 3], from the academic year 2007/2008 two-level study programs began to be obligatory at all Polish universities, except of some specific fields of study, as medicine. The implementation of the two-level system of studies regarding all engineering fields was the biggest challenge for universities from all the actions within the framework of the Bologna Process.
Starting from the academic year 2012/2013 the model of study in Polish technical universities was marked by the obligatory implementation of the National Qualifications Framework [2, 4, 5, 6]. In the course of this reform universities and faculties developed their own programs of studies in which the emphasis was put on achieving by student the learning outcomes described in three groups: knowledge, skills and social competence. In years 2014 and 2016 there were introduced new amendments [7, 8, 9, 10] to the basic law [2]. The most important was a strict definition and division for general academic profile and practical profile of studies, both on BSc and MSc levels. The other main change was an introduction of a possibility to create studies on basis of cooperation and agreements between universities and industry or local governments. And the third important change gave to the potential candidates and to the universities a possibility of admission on basis of recognition of outcomes of self-education. All of those changes were introduced from the academic year 2015/16. One of them was clarification of definition and requirements that must be fulfilled by faculties for conducting education in practical and general academic profiles.
Currently, new changes in the organizing higher education institutions and conducting studies and in Poland are to be introduced by the new law [11] and will apply from the academic year 2019/2020.
Authors of the paper have made brief presentation and analysis of selected main aspects of evolution and development of higher studies (especially in the civil engineering field of study) in Poland from starting Bologna process to currently introduced amendments based on state regulations and own studies [20÷28].

2. CHANGES AND DEVELOPMENT OF CE STUDY PROGRAMS IN POLAND

2.1. Short description of one-cycle 5-year master study model

Until the beginning of the year 2007 at most Polish technical universities the main system of full-time studies was a 5-year, one-level one. Generally, in the case of the civil engineering field of study, the studies comprised of 6 or 7 semesters of common studies and then 4 or 3 semesters of specialization, mainly in accordance with the research activity of the faculties. It led the graduates to gain a professional title of “master of science (MSc) in civil engineering”. The program of studies was precisely described by national standards [1] in which there were defined: total minimum number of teaching hours and hours for each group of courses (general education, basic and field-of-study ones), and detailed content for every core subject. Of course, the specific content of each subject could be elaborated independently by faculties, based on the research and professional profile of the academic staff. In this Law [1] there were defined:

- General rules

Master studies had to last 5 years (10 semesters) with total number of hours equal to 3600 and at least 1935 hrs of courses defined in standards.

- Graduate's profile

Masters degree in civil engineering had to provide education of professionals who based on the acquired theoretical knowledge and practical skills would have a basis for creative work in the design of buildings and civil engineering structures, implementation of buildings and civil engineering structures, supervision of construction processes and management.

- Groups of courses and their minimal number of hours

General education courses (e.g. languages, humanistic and economic subjects) had to have 390 h of classes. For basic courses (e.g. mathematics, physics, general mechanics, descriptive geometry, information technology) at least 675 h had to be dedicated. As to the field of study courses (e.g. strength of materials, structural mechanics, building materials, concrete and metal structures, computer methods, building technology and organization) minimum number of hours was 870 h. Those courses created a so-called core-of-the-study program what meant that there were obligatory for every faculty that conducted education in the field of civil engineering and have to be included in the program. They also contained the minimal knowledge that was necessary to became a civil engineer.

- Professional internship

Program of studies had to contain a min. 12 weeks of internship, including a field of study and a diploma ones.

- Specific courses description

For each of the field of study core course there was precisely defined what must be taught during lectures, classes, projects, laboratories and seminars.

2.2. Short description of two-level (BSc & MSc) study model according to the Bologna system

From the academic year 2007/2008 two-level study programs (BSc and MSc) began to be obligatory at all Polish universities (in fact it was a three-level system because doctoral studies (PhD) were included in it). Implementation of the Bologna multi-level higher education system meant a transformation from an integrated, one-level study to the two-level system. The changed Law [2] defined the framework content of education – standards (including the minimal number of hours and ECTS points – which was completely new), and in them groups of subjects with the division into the basic and field of study subjects. The Law [2] and other regulations [3] also defined the required learning outcomes in the area of the skills and competence which was the most important action in order to adapt the curricula to the Bologna Process directives.

In the new directives included in Law [2] for each level of the study there were defined:

- General rules

First level studies in civil engineering should last at least 7 semesters and the minimum total number of organized classes should not be lower than 2500. The number of ECTS points assigned to all the types of classes was at least 210. Second level studies should last as a minimum 3 semesters and had at least 900 contact hours with 90 ECTS points designated.

- Graduate's qualifications defined by standards

For BSc graduates: having knowledge in the areas, for example, of: execution of building, industrial and communication constructions; designing of basic building elements and objects; technology and

the organization of the civil engineering; being skilled in (for example): management of the execution of all types of building objects; cooperation in the designing of public service objects; supervision of the building execution and to further update his education and skills related to his profession. A bachelor in CE will be allowed to take a job in: executive building companies; building supervision; concrete and building element plants, the building materials industry; and will be prepared to join 2nd level studies.

For MSc graduates: a graduate obtains an advanced knowledge of: design and construction of complex housing facilities, municipal, industrial, and communication objects; technology and construction organizations; computer techniques and modern technology in engineering practice; selection and application of building materials and managing teams and construction company. The graduate is prepared to solve complex design, organizational and technological problems; development and implementation of research programs; making projects of international scope; participate in the marketing and promotion of the construction products; continuing education and participate in research in areas directly related to construction and production of building elements; continuing raising qualifications and supplementing knowledge; control of large groups of people. The graduates will be prepared to work in construction and design offices; R&D centers and institutions involved in counseling and dissemination of knowledge in the field of widely understood building; prepared to join 3rd level studies.

- General content of courses

Groups of courses and their minimal number of organized hours as well as basic and field-of-study courses and their ECTS points were defined. Content of specific courses and their learning outcomes (abilities and competences) was also described.

In case of BSc level: for basic courses (i.e. mathematics, physics, chemistry, geology, mechanics, computational methods) 315 hrs/31 ECTS were a minimum, and for the field of study courses (i.e. descriptive geometry, geodesy, building materials, strength of materials, structural mechanics, general building, soil mechanics, foundation, concrete and steel structures, infrastructure engineering, building physics, hydraulics, project management and organization of building works) 660 hrs/64 ECTS were assigned.

For MSc level the following points were to be as minimum: for basic courses (i.e. advanced mathematics) – 30 hrs/3 ECTS, and for the field of study courses (i.e. theory of elasticity and plasticity, advanced computational methods, complex steel and RC structures, project management) – 150 hrs/15 ECTS. The rest of the teaching hours and ECTS points could defined by the faculties. Detailed content of the core subjects and way of teaching were a responsibility of faculties and depended on their research profiles.

In both leveles of study, instead of precisely defined courses with hours of duration, there were listed general descriptions of courses taking into account their content (knowledge) and educational effects in abilities and competences.

There was also an indication made that when creating a curriculum FEANI criteria might be used, what was a standard for Polish faculties teaching civil engineering.

- Requirements for internship

Program of studies had to contain a min. 8 weeks of internship, mainly for the first level of studies.

Students should carry out an appropriate range of work related to the field of study and selected study specialty.

2.3. Short description of two-level (BSc & MSc) study model based on NQF

According to the further amendment of the Law [2] there was made a further step to integrate Polish higher education system with the European ones that follow the Bologna Process. From the academic year 2012/13 all the universities in Poland had to develop three-level system by introducing new model of higher education based on the National Qualifications Framework. All the actions leading to this very profound reorganization of higher education process were based on years of own experience in bringing the Bologna system into Polish higher education and also gained while participating in the activities of the international organizations (e.g. EUCEET in case of civil engineering) as well based on professional organizations codes as ASCE BoK or cooperation with Polish Chamber of Civil Engineers and other professional organizations.

Currently, the process of creating the way of graduate education depends on faculties, and the Law [2, 7] and Regulations [4, 5, 6] gives only basis and general requirements. Among other they define requirements which the faculty must fulfill to create and conduct education in certain field of study (number of professors, scientific research, didactic infrastructure etc.) and National Qualifications Framework [5] describing expected education outcomes in the fields of knowledge, abilities and social competence for different areas of science (e.g. humanistic, technical, rural, medical etc.). As the field of study – civil engineering and also specializations defined by faculties (both for BSc and MSc levels), results ("outcomes") from previous education models and programs were well recognized and accepted by the labor market, employers and professional organizations, the name of the field of study was kept without change.

Then the steps were as follows:

- creating the **educational outcomes** for the field of study and specializations (if any were proposed);
- formulating the **program of studies** with detailed **plan of studies**;
- developing the description of all modules (**course catalogue**) which are taught during the study (they contain detailed description of entry requirements, module learning outcomes, ways of giving courses, methods of evaluating and matrix of correlation between module and field-of-study outcomes).

The practical profile program must cover modules and activities aimed at gaining by the student practical skills and social competence, carried out under the assumption that more than half of the study program, calculated in ECTS, include practical acquiring of these skills and competence. In this case the modules must as well include skills obtained at practical classes (workshops) and be given by persons who have professional experience formed outside the university. Moreover, the faculty must provide realization by students at least a three-month professional internship. This type of education may be organized alternately in the form of teaching carried out at university and in the form of internship completed in employer enterprises, but taking into account the implementation of all the learning outcomes set out in the curriculum for this course, level and profile of education.

For the general academic profile modules covering study program must be associated to the research activities carried out in the university, under the assumption that more than half of the study

program, referred to ECTS, includes activities that lead to the acquisition by the student an in-depth knowledge in the specific field-of-study. And what is more important and what would be a real challenge for the faculties university organizational unit may conduct studies on the general academic profile if it carries out research in the field of science related to the field of study and provides students: 1) at least preparing to conduct research - in the case of BSc studies; 2) participation in the research - in the case of MSc studies.

All these elements create a **program of education** for a specific field of study. In order to guarantee the proper realization of education program in accordance with all the ideas of qualification frameworks and learning outcomes, it is controlled by the **quality assurance system** which are to be created both at the university and faculty levels.

Assurance of the quality of newly developed study programs is one of the most important challenges to the faculties. General area of issues that the quality assurance covers can be defined, among others, as listed beneath:

- monitoring compliance with current legislation,
- revising updating educational programs,
- analysis of organization and infrastructure base of teaching,
- monitoring of academic staff qualifications,
- monitoring the progress of theses and diploma examinations,
- encourage students to participate in the scientific teams,
- monitoring the activity of doctoral students and international student exchange,
- supervising contacts with alumni, professionals and faculty council,

monitoring the efficiency of administrative services in the dean's office.

3. CURRENT STUDY PROGRAM MODEL AND ITS REFLECTION IN CE EDUCATION

Current changes in the organization of higher education in Poland have been introduced by the Law [12], using linked regulations [9, 10, 11] and will apply from the academic year 2019/2020. There are some new definitions and very important requirements introduced by this law as, for example:

a) The university provides education at a given field, level and profile. The university assigns direction to at least one discipline (in case of CE it is “civil enegineering and transportation”). Establishment of studies at a given field, level and profile requires the permission of the minister. However, permission is not required to create studies in a field assigned to the discipline in which the university has the scientific category A +, A or B +. In other cases he minister issues permission after consulting the PKA regarding the fulfillment of the conditions for conducting studies at a given field, level, profile and association studies with university strategy.
b) The university may conduct joint studies with another university, the PAS institute, research institute, institutean international, foreign university or scientific institution.
c) The university may conduct studies in cooperation with the body granting authorization to practice the profession, the body conducting the examination proceedings as part of obtaining authorization to perform profession, professional self-government body, business organization.

The university may conduct dual studies, which are practical studies conducted with participation employer.

d) Studies can be conducted at the profile of:
   1. practical, in which over half of the ECTS points are assigned to classes developing practical skills;
   2. academic, where more than half of the ECTS credits are assigned to classes related to the conducted courses cientific activity at the university.

   The practical study program provides for internships of at least:
   - 6 months - in the case of first-cycle and uniform Master's studies;
   - 3 months - in the case of second-cycle studies.

e) Studies are conducted at a specific field, level and profile based on the study program which defines:
   1. learning outcomes referred to in the Law [12] on the Integrated Qualifications System, taking into account the universal characteristics of the first degree specified in this Act and the characteristics of the second degree;
   2. a description of the process leading to achieving the learning outcomes;
   3. the number of ECTS points assigned to classes.

In relation to the civil engineering major the following exemplary educational outcomes (Tabs 1÷5) have been elaborated for the MSc level based on applicable regulations on higher education [9, 10, 11, 12] as well as on professional guidelines and requirements [13, 14, 15]. The very important issue is that these outcomes must include as obligatory not only universal characteristics defined for the level 7 of the Polish Qualifications Framework (PQF) and characteristics of the second level of learning outcomes for qualifications at levels 6-8 of PQF but also characteristics for qualifications on levels 6 and 7 of PQF that enable engineering competences.

Table 1. Characteristics of the PQF included in study programme for civil engineering at FCE of WUST for the academic profile

LEVEL	**KNOWLEDGE**		**SKILLS**		**SOCIAL COMPETENCES**	
	KNOWS AND UNDERSTANDS:		**IS ABLE TO:**		**IS READY TO:**	
7	P7U_W	in-depthselected facts, theories, methods and complex relationships between them, also, in connection with other fields, diverse, complex conditions and axiological context of the business	P7U_U	perform tasks and formulate and solve problems using new knowledge, also from other fields, plan own lifelong learning and guide others in this area, communicate with diverse audiences, properly justify positions	P7U_K	creating and developing patterns of proper conduct in the work and life environment, taking initiatives, critically assessing oneself as well as teams and organizations in which he participates in leading the group and taking responsibility for it

Table 2. Second level characteristics of learning outcomes for qualifications at levels 6-8 of the PQF

Categories of qualification characteristics	Descriptive categories / aspects of fundamental importance	Description component code	Level 6	Description component code	Level 7
Knowledge: the graduate knows and understands	the scope and depth / completeness of the cognitive perspective and dependence	P6S_WG	at an advanced level – selected facts, objects and phenomena and their methods and theories explaining complex relationships between them, constituting the primarygeneral knowledge in the field ofscientific or artistic	P7S_WG	in depth – selected facts, objects and phenomena andmethods and theories regarding them and explaining complex relationships between them, constituting advancedgeneral knowledge in the field ofscientific or artistic

			disciplines forming the basics theoretical and selected issues in the field of detailed knowledge - proper for program specific studies, and in the case of studies with a practical profile – also practical applications of this knowledge in professional activity associated with their direction		disciplines forming the basics theoretical, orderly and theoretically founded knowledge covering key issuesand selected issues in the field of advanced knowledge detailed – proper for study program, and in the case of practical studies – also practical applications of this knowledge in professional activity associated with direction of main development trends in scientific or artistic disciplines, to which it field of study is assigned – for studies with a general academic profile
Skills: the graduate can	Use of knowledge / problems solved and tasks performed	P6S_UW	use the knowledge to: - formulate and solve complex and unusual problems and perform tasks in conditions not fully predictable through: - proper selection of sources and information derived from them, making an assessment, critical analysis and synthesis of this information, - selection and use of appropriate methods and tools, including advanced information and communicative ones; use the knowledge to: - formulate and solve problems and perform tasks typical for professional activity related to the field of study – in the case of studies with a practical profile	P7S_UW	use the knowledge to: - formulate and solve complex and unusual problems and innovatively perform tasks in the unpredictable conditions by: - proper selection of sources and information derived from them, making a critical analysis, synthesis, creative interpretation and presentation of this information, - selection and use of appropriate methods and tools, advanced information and communicative ones - adaptation of existing ones or developing new methods and tools; use the knowledge to: - formulate and solve problems and perform tasks typical for professional activity related to the field of study – in the case of studies with a practical profile - formulate and test hypotheses related to simple problems research – for studies with an academic profile formulate and test hypotheses related to simple implementation problems – in the case of practical studies
Social competence: the graduate is ready to	Assessments / critical approach	P6S_KK	critical assessment of knowledge; recognizing the importance of knowledge in solving cognitive and practical problems, and consulting experts in case of difficulties with own solution of problem	P7S_KK	critical assessment of received knowledge content; recognizing the importance of knowledge in solving cognitive and practical problems, and consulting experts in case of difficulties with own solution to the problem

Table 3. Characteristics of the second level of learning outcomes for qualifications at levels 6 and 7 of the PQF enabling achievement of engineering competences

Characteristic category of learning outcomes	Descriptive category - basic aspects	Description component code	Level 6 & 7
Knowledge: the graduate knows and understands			
	Range and depth – completeness Cognitive perspectives and dependencies	P6S_WG_INZ P7S_WG_INZ	basic processes occurring in the life cycle of devices, objects and technical systems
	Context – conditions, effects	P6S_WK_INZ P7S_WK_INZ	basic rules for creating and developing various forms of individual entrepreneurship

Skills: the graduate can			
	Use of knowledge – problems solved and tasks performed	P6S_UW_INZ P7S_UW_INZ	plan and conduct experiments, including computer measurements and simulations, interpret obtained results and draw conclusions when identifying and formulating specifications of engineering tasks and solving them: - use analytical, simulation and experimental methods, - recognize their systemic and non-technical aspects, including ethical aspects, - make a preliminary economic assessment of the proposed solutions and undertaken engineering activities; make a critical analysis of how existing technical solutions work and evaluate them – in accordance with the given specification – make simple devices, objects, systems or implement processes typical for the field of study using appropriately selected methods, techniques, tools and materials used in practical engineering tasks that require the use of engineering standards and norms, and the use of technology appropriate for the field of study, using experience gained in the professionally involved environment engineering – for practical studies use the maintenance experience acquired in an environment engaged in engineering professionally devices, facilities and systems typical of the field of study – in the case of practical studies

Table 4. Description of selected learning outcomes for the civil engineering studies for CEB speciality at FEC of WUST

Symbol of the field of study learning outcomes	Description of learning outcomes for the civil engineering studies. After completing the field of study graduate:	Reference to NQF characteristics		
		Universal characteristics for the first degree (U)	Second degree characteristics typical of qualifications obtained in higher education (S)	
			Characteristics for qualifications on level 7 of NQF	Characteristics for qualifications on levels 6 & 7 of NQF, that enable engineering competences
KNOWLEDGE (W)				
K2_W01	possesses essential advanced knowledge in the area of chosen sections of mathematics and physics in the scope being the basis for the strength of materials, mechanics, including dynamics as well as the theory of structures.	P7U_W		P7S_WG_INZ
K2_W02	possesses broadened knowledge of advanced problems related to the strength of materials and materials modelling	P7U_W	P7S_WG,	P7S_WG_INZ
K2_W03	possesses the necessary knowledge about the theoretical basis of methods for modelling, analysis and dimensioning of advanced (complex) structures	P7U_W	P7S_WG	P7S_WG_INZ
K2_W04	knows advanced methods of mechanics and theory of structures	P7U_W	P7S_WG	P7S_WG_INZ
SKILLS (U)				
K2_U01	is able to use advanced specialist tools to search databases and other sources related to discipline of civil engineering and transport; is able to use information technologies for communication and knows how to choose software that supports the work of a designer and a person who organizes and manages building processes as well as operation and maintenance of building objects	P7U_U	P7S_UW, P7S_UU	P7S_UW_INZ
K2_U02	possesses language skills in fields of study related to the studied discipline according to CEFR requirements for at least B2+ level; possesses ability to communicate in foreign languages and knows elements of technical language in the area of civil engineering	P7U_U	P7S_UK	
K2_U03	is able to establish directions of further education and follow the process of self-learning	P7U_U	P7S_UK	

K2_U04	is able to make a classification of simple and complex building structures	P7U_U	P7S_UW	P7S_UW_INZ
K2_U05	is able to make assessment and any kind of loads combinations acting on building objects together with their adequate combinations	P7U_U	P7S_UW	P7S_UW_INZ
K2_U06	is able to use advanced methods of mechanics and the theory of structures	P7U_U	P7S_UW	P7S_UW_INZ
SOCIAL COMPETENCES (K)				
K2_K01	is aware of the need to continually improve professional and personal competences; in the form of formal or informal education, it complements and expands knowledge in the field of modern processes and technologies related to civil engineering and transport	P7U_K	P7S_KK	
K2_K02	realizes the significance and understands non-technical aspects and consequences of engineering activity and especially its influence on the natural environment and the related responsibility for decisions	P7U_K	P7S_KK	
K2_K03	is able to work independently and cooperate in a group on given tasks is responsible for safety of his own work as well as his team	P7U_K	P7S_KK, P7S_KO	

Table 5. Specialization: Civil Engineering (CEB)

Symbol of the field of study learning outcomes	Description of learning outcomes for the construction studies. After completing the field of study graduate:	Reference to NQF characteristics		
		Universal characteristics for the first degree (U)	Second degree characteristics typical of qualifications obtained in higher education (S)	
			Characteristics for qualifications on level 7 of NQF	Characteristics for qualifications on level 7 of NQF
KNOWLEDGE (W)				
K2S_CEB_W16	possesses deepened and broadened knowledge of analysis, dimensioning and construction of complex structures in general construction: metal and reinforced concrete (objects)	P7U_W	P7S_WG	
K2S_CEB_W17	possesses additional knowledge in the area of hydraulics	P7U_W	P7S_WG	P7S_WG_INZ
K2S_CEB_W18	possesses broadened knowledge of residential municipal structures	P7U_W	P7S_WG	P7S_WG_INZ
K2S_CEB_W19	possesses broadened knowledge of building roads, bridges and railways	P7U_W	P7S_WG	P7S_WG_INZ
SKLLS (U)				
K2S_CEB_U18	possesses ability to analyse, dimension and construct complex building structures in general construction: steel and reinforced concrete (objects)	P7U_U	P7S_UW	P7S_UW_INZ
K2S_CEB_U19	is able to apply advanced computational techniques, including optimization ones, to model and calculate complex building structures	P7U_U	P7S_UW	P7S_UW_INZ
K2S_CEB_U20	is able to design chosen elements of geotechnical structures taking into consideration hydraulics problems	P7U_U	P7S_UW	P7S_UW_INZ
K2S_CEB_U21	is able to design and carry out research of components and materials used in general construction	P7U_U	P7S_UW	P7S_UW_INZ

Description of symbols used in shortcuts:

P7U – universal characteristics of the Polish Qualifications Framework for the first degree – level 7 of NQF*

P7S – characteristics of the Polish Qualifications Framework for the second degree – level 7 of NQF *

W – category of knowledge

U – category of skills

K – category of personal and social competences

CEB – civil engineering specialization

…._INZ – learning outcomes that enable achieving of engineering competences

4. COOPERATION WITH INDUSTRY IN CE STUDY PROGRAM CREATION

The ability to perform professions of public trust (to which civil engineer profession belongs) depends in Poland on the fulfilment of various required conditions. Moreover, membership in the appropriate professional chamber of people that perform such a profession is compulsory.
All graduates of civil engineering studies can exercise their profession. However, in accordance to the Polish law [13, 14], only a person who:

- graduated in a relevant field of study (civil engineering) or in a given specialty and obtained a university diploma,
- completed professional training under the supervision of a person holding proper building qualifications,
- passed the exam for building qualifications,
- belongs to Polish Chamber of Civil Engineers,

can perform the civil engineering profession with independent technical functions. From the first of this requirements is obvious that cooperation of faculties in creation and development of CE study curricula is the must.
Generally, the enterprises are becoming increasingly active, and they offer universities various forms of cooperation in order to prepare graduates to enter the labour market.
In the field of education of future construction engineers this cooperation is conducted in the following forms:

- creation of curriculum of study consistent with the needs of business
- (e.g. by creating desired courses of study, especially of practical profile),
- participation in launching dual studies, included in the strategy of modernization the
- higher education (students will be educated both at the university and by the employer,
- gaining knowledge on the one hand and practical skills on the other one),
- individual support of the education process (e.g. in the form of providing materials
- and data for diploma thesis, involvement of practitioners into the teaching process,
- enabling students to complete traineeships and internships),
- choosing the best graduates for possible employment in companies.

4.1. Curriculum design

In the case of CE study curriculum design the idea of basing it on learning outcomes facilitates cooperation of universities with external stakeholders in the process of educational offer development. According the rules [7], every curriculum, regardless of profile, in some way should be assessed and accepted by the representatives of employers and professional organizations [7]. However, the cooperation with employers is the most significant matter in case of practical profile of study. The legislation [7] clearly differentiates the requirements for practical and academic profiles of education, among others, obliging universities to increase, within the framework of practical profile studies, the period of student internships or closer cooperation with experienced practitioners. Practical profile includes the modules for acquiring the practical skills and social competences. It is implemented with the assumption that more than a half of the study programme as defined in ECTS credits consists of practical classes forming these skills, including those

obtained during workshops conducted by practitioners with professional experience gained outside the university. Academic profile includes modules related to research conducted in the university, carried out with the assumption that more than a half of the study programme as defined in ECTS credits consists of classes for in-depth knowledge acquisition. The solutions should limit the popular fields of study with many graduates whose qualifications do not meet the needs of the labour market, in universities that do not guarantee a high level of education resulting from the lack of specialized academic staff. In addition, following the suggestions of employers in the current rules, the organizational units conducting the studies of practical profile are required to include at least six month at BSc level (one-cycle MSc) and three months at MSc level of professional internship in the curriculum.

4.2. Dual studies

One of the most effective forms of employers' participation in creation a curriculum and education of graduates for their needs is a dual study. The dual study is an innovative system of study, assuming the acquisition of academic knowledge and practical experience at the same time [7, 12]. The study programme includes the necessary theoretical knowledge acquired during lectures, classes and laboratories/workshops at the university, interconnected with periods of work in various positions in the company, within the frame of a contracted internship. Dual study is characterized by closely linking education with practical activity in the workplace. In this way the theoretical knowledge is immediately put into practice. In order to determine the course of study and professional practice the programme council is appointed in agreement with the professional organizations, which include representatives of the companies and institutions employing students. As a result of extensive discussions the best form of the course is determined. During studies the student learns about the structure and expectations of employers towards their employees. Student working at the plant also prepares interim papers thematically related to his work, and at the end of education he solves a specific problem associated with the plant, in the form of a thesis. The supervisors of the thesis are an employee of the university and a professional representative designated by the employer (with the title of at least MA/MSc). At the end of studies the graduate automatically becomes a potential full-fledged company employee, whose employment does not require any additional training or implementing to the corporate structure. However, the creation of such studies is associated with overcoming multiple organizational and financial barriers by all participants of the project.

4.3. Cooperation agreements

In the frame of bilateral agreement the university and enterprise declare their willingness to cooperate in the areas covered by their statutory activities, in all legally permissible forms. Usually the agreement concerns the cooperation for implementation of joint projects in a selected faculty of civil engineering, such as:

- optional (extra) courses for students and teaching staff of faculty,
- outdoor activities - technical trips to building sites ("meeting with reality"),
- scientific cooperation (joint projects, publications, conferences, etc.),
- implementation of practical PhD thesis,

- implementation of BSc and MSc theses suggested by enterprise with the participation of two supervisors (one from university, other from enterprise),
- 6-month internships according to the curriculum of study particularly important for study curricula with practical profile),
- optional internships for gaining practical skills,
- industrial internships for teaching staff of faculty (according to individual applications),
- competitions announced by enterprise for thesis in the specified topic,
- cooperation with the students' scientific teams,

as well as in other areas established during mutual cooperation. Particular activities under the agreement usually depend on the needs of the enterprise.

5. FINAL REMARKS

During nearly two last decades a great effort was made in Poland to create new programs of education resulting from the standards demanded by the Bologna Process, creation of the EHEA and overworking of common qualifications frameworks. Currently formulated curricula of two-level civil engineering studies is not only based on the knowledge and experience of the university staff but as well includes recommendations from building industry and professional organizations. In Poland the activity of the university should be not only aimed at the full use of the scientific potential in cooperation with the industry, but also at improving the quality of education and effective preparation of graduates - future employees and employers. The process of building the relationship and cooperation with entrepreneurs and business is one of the main elements of the development strategies Polish universities must implement. The benefits of higher education institutions from this type of cooperation include mainly: increasing their recognition among employers and candidates, improving the quality of education (by creating study curricula with participation of employers) and research.

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10th AECEF Symposium

"Cooperation between Universities and Industry in the Education and Employment of Civil Engineers: Current Expectations, Future Challenges"

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ATTRACTING STUDENTS AND FUTURE PROFESSIONALS TO CIVIL ENGINEERING

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ABSTRACT

With the goal of improving employability, attractiveness and visibility of Civil Engineering the departments of Civil Engineering of University of Porto, of University of Zagreb and of Aristotle University of Thessaloniki are aware about the importance of improving the quality, relevance and contact with the Higher Education (HE) environment. This awareness derives from addressing the challenges of access to HE and the common concerns about the difficulties that the subjects of Science, Technology and Mathematics create among pre-university students. Although engineering & science are HE fields of study that have been promoted among pre-university students, Civil Engineering shows fluctuating levels of popularity, emphasising the need of adopting pro-active strategies and tools and of discussing how to address the decline in undergraduate admissions. Saying that, the three universities of the project El Big Machine are trying to explore synergies and stimulate greater dialogue between their departments and secondary schools within the scope of community and outreach activities. The goals are to encourage secondary school students and its staff to interact with these departments, its infrastructures/laboratories, to support the efforts to tackle early school leavers, to promote a professional engineering career as an attractive path, and to invest in seminars, in short courses and in projects. By proposing new communication strategies and materials for visitors/schools, such as experiences, multimedia & videos, interactive constructions, virtual reality models, etc., partners expect to contribute to enhance access and participation, thus facilitating the transition between the two levels of education. It is based on a "hands-on" experimentation based on the concept of integrated design (project based learning) to be seen as an attractive approach to learning, proved to be effective to engage secondary school students. This approach is expected to act as motivation for students to conclude their current level of education, focus on a specific field and pursue a Civil Engineering degree. During this experience it was possible to indirectly contribute to help addressing underachievement in science through more effective, innovative teaching methods and to develop innovative didactical materials and compelling tools, focusing on creativity and modernisation. This experience is susceptible of being replicated by other entities (HEIs/Schools) using ICT based methodologies. It may also contribute for the adoption of innovative strategies to reinforce the attractiveness of Civil Engineering and its associated professional fields, according to the dynamics and changes of the labour market and consequent need of revaluation of communication strategies when reaching pre-university students.

1. PROJECT MOTIVATION

Civil Engineering is a field that is proving to be particularly sensitive to the dynamics of the labour market. It has become noticeably less popular in countries such as Portugal, Greece, Croatia (and other European Countries) where employment levels for Civil Engineers have dropped significantly. This is a problematic context for Civil Engineering since it is ubiquitous in everyday life and it is a fundamental profession to create and sustain the built environment, indeed a requisite for sustaining life as we have become used to understand it: buildings, roads, traffic, city planning, construction materials, hydraulics, etc.

It is believed that in this context, universities have an important role to play, reaching out to the community. It is very important to encourage secondary school students (the main target in this proposal), their parents and teachers to visit higher education institutions and their laboratories, supporting schools' efforts to tackle early school leavers and disadvantage as well as to address all students from the lowest to the highest end of the academic spectrum.

The fulfilment of this role requires the universities to develop strategies to invite the community to learn about its activities and goals and opening campus facilities to interested visitors. To make these facilities more attractive it is important to reflect on the most appropriate communication strategies and prepare the necessary materials – experiences with the participation of visitors, videos, interactive constructions, written materials, virtual reality models, etc. The project adopted aimed at developing an "educational laboratory" that can be deployed in different countries and in different environments, both inside and outside the participant universities' facilities.

This "educational laboratory", built in partnership by the three universities may be adapted or replicated in other countries and institutions and is available to be used by schools. This project included interactive equipment, and digital platforms (BIM and QR code format). The "educational laboratory" can also foster the development of pedagogical strategies and general teaching knowhow and the sharing of teamwork experiences. This project may be extended to other interested parties, in different countries with different construction techniques and needs regarding local climatic conditions (building solutions cannot be simply replicated across geographical borders regardless of climatic contexts), traditional techniques (each country has a specific culture and history in terms of techniques usually used in constructions) and available resources. Costs and legislation are also very specific and must be considered in the project.

Different configurations for learning materials and approaches were tested, leading to a virtual information repository that can be accessed by any student regardless of his/her location, allowing results to be compared, different scenarios to be tested and even different local prototypes to be visited and understood, underlining the requirement to adapt engineering solutions to local needs. Taking "hands-on" experiences and the digital platforms like BIM Virtual Reality (VR) and QR codes will be an innovative way of transmitting and exploring the different roles of Civil Engineering in a closer language to the youngsters, supporting schools in their efforts to guide secondary students' interests and decisions regarding higher education.

2. PROJECT MANAGEMENT AND IMPLEMENTATION

In accordance with the projects' planning, the outputs were six: Big Machine houses, BIM Models, Interactive Equipment, QR Codes, Big Machine Supportive Platform and Hands-on Civil Engineering Book. The descriptions of the outputs are:

a) Big Machine Houses

The Big Machine houses comprise the construction and design of a structure, a mobile laboratory, where students in the different countries will test their solutions for different components (material and wall systems). Three houses were built and in use by pre-university students from secondary schools and by students from the three universities. Participants were asked to developed construction solutions with waste materials following a guided procedure for the Big Machine house according to their traditional materials and techniques attending to local environmental conditions. To assemble the house, only basic tools such as screwdrivers, wrenches and hammers are needed. Minimum of two students can assemble the house on their own and four people are recommended. The main objective of building each house is to be the physical representation of the Big Machine experiments that are conducted within and outside of the house. The Big Machine house has a unique cubicle-like shape design with approximate 2,35 m dimension in every direction. The structural details varied depending on the partner involved. The main structural elements are made of laminated wood in standardized shapes and dimensions to represent different structural elements of a real-world house consisting of beams and columns. Besides the structural bearing elements, each house was built also of floor and wall infills that could be represented in variety of construction materials. The manuals for house construction can be viewed on ElBig Machine YouTube channel (Construction tutorial video: https://youtu.be/efVbBqVnG0Q).

b) BIM Models

BIM (Building Information Model) of the Big Machine house lab installations and the proposed building solutions that were tested have been developed along with other models that are considered relevant for the project. BIM models have been developed and disseminated during several activities including the Big Machine house model, and models of the University of Porto campus buildings (cafeteria, library, etc.) and relevant Civil Engineering structures: a dam and a high-rise building. For the construction of the house, a BIM-based Virtual Reality (VR) model was developed so that the students could assess their solutions for the building construction elements in an immersive VR environment.

c) Interactive Experiences/Equipment

The interactive experiences/equipment designed during the project are small models that represent the different Civil Engineering disciplines, so they can be moved and be presented at schools and other places. This set of small transportable interactive equipment was developed and two high tech

devices are in use: An Augmented Reality Sandbox and VR equipment to work with the models developed in BIM. This equipment has been presented and used in different events in the participating universities. In a one-day workshop at the beginning of the project, all partners had a meeting to discuss and identify the interactive equipment that covers most areas of Civil Engineering. These models comprised areas of Civil Engineering, like structure, bridges, water supply, dams, geotechnical, hydraulics, an augmented reality sandbox and an interactive online database with different construction systems available at Wikimedia accessible through QR codes.

d) QR Codes

QR Codes of an online database with different construction systems was proposed to grant easy access to a wiki (https://paginas.fe.up.pt/~elbigmac/mediawiki-1.23.15), that supports a wide range of media formats with free access. A Civil Engineering Lexicon was developed that included information about different building systems (written material, schematics, 3D models or BIM models). A group of students is feeding the library with information about various building systems. In addition, the final event/competition of the project included a QR code treasure hunt, with the main objective of the competition being to scan the QR codes that explained the elements or the material and lead them to the following destination. To create the list of different construction systems the parts of different construction systems were described and different construction elements were interconnected through links between mutual shared information. The whole database is made available through Wikimedia (https://paginas.fe.up.pt/~elbigmac/mediawiki-1.23.15).

e) Big Machine Supportive Platform

It is a platform to gather gamification elements with possibilities explored such as Virtual and Augmented Reality educational interfaces related to the Big Mac House and the Sandbox. Some VR interfaces (e.g., dam model, campus buildings) were derived from the BIM models developed and tested during activities in a Junior University and Engineer Profession Week, at school fairs and at local and international school events.

f) Hands-on Civil Engineering Book

Hands-on Civil Engineering Book was proposed to collect all the activities in an e-book. The e-book was distributed on USBs for students that were involved in the activities and is available on the website for easy access by secondary schools, universities and other related stakeholders like professional engineering organizations and education and training agencies. The e-book was structured with hands-on experiences and description of challenges made to be disseminated interested stakeholders. These exercises may complement the theoretical and practical classes in physics, mathematics or related disciplines with science and technology. There are simple examples that are capable to test the effects of the liquefaction, of a seismic event or to understand the structure of a stone bridge. The e-book also contains the manuals to replicate the equipment and the tools used,

the activities done by with guides to replicate the activities in other schools, the list of alternative tools and equipment's procedures. There are images of students working to illustrate what happened and to explain the process whenever the activity needs to be implemented in another context.

3. CONCLUSIONS

The project was carried out with some adaptations to local contexts and to available resources. In terms of context the construction techniques and secondary school characteristics. In fact, the adaptations to the techniques was the major theme of debate in the preparatory meetings and alternative solutions were adequate. Concerning the secondary school systems differences motivated more adjustments due to contents of the learning programs and structuring of the academic year. Sometimes was not easy to articulate the schedules with the secondary school calendars. Efforts were made to conduct events with students from different school years and classes, however organizing their schedules is a demanding task that requires the consent of all the professors involved. Moreover, in the same educational organisation, schedules had to be carefully managed, so students may balance these activities with programmes and exams. Concerning resources, the visits to universities involved a considerable number of students that made logistics difficult to bear by the local schools.

In terms of results and future developments the results were positive. In fact, the acceptance by secondary schools and other stakeholders was clearly positive. For instance, the professional engineering organizations joined the initiative and even included these events in their own programs. It is not clear the changes of students' choices but the participation during the experiments was enthusiastic and promising. The use of digital technologies for the experiments and for the recording of the tools and procedures was a major advantage since it allowed an easy reproduction and access of the approach. The use of digital tools also explained that Civil Engineering may involve technologies generally associated with other engineering areas. It was a proper combination of modelling, hands-on and virtual experimentation allowing a wide acquisition of skills and knowledge for potential future civil engineers.

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ATTITUDES TOWARD DOCTORATE DEGREE OF ADVANCED STUDY AND ORIGINAL RESEARCH OF HIGH QUALITY IN CIVIL ENGINEERING

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Key words: Doctoral degree; Faculty of Civil Engineering; Research; Industry

ABSTRACT

Inspired by development of a knowledge-based economy that requires stronger and continuous cooperation between the spheres of education, science and industry issues we think that interdisciplinary investigating to the science and engineering from many research domains and excellent research strategies should be supported by industry in the first line. To achieve excellence in civil engineering we need to educate our young generation to follow this trend. This issue requires a multidisciplinary approach and establishment of criteria in accredited study programmes to meet future challenges. If the supervisor of doctoral students will lead them to include in their study plan this mission, they will support by their outputs the transition to the sustainable society.

The main aim of the article is to present the themes of doctoral student's research at Faculty of Civil Engineering in Slovakia.

1. INTRODUCTION

Technical University of Kosice (TUKE) caters for a wide range of educational needs not only in the East-Slovak region, but throughout Slovakia and Central Europe, as in many specializations it is the only centre of education and research in this area. TUKE closely co-operates with other universities and with industrial organizations in the region and the Slovak Republic [1]. The renewed emphasis on knowledge has led to a shift in the nature of the relations between the academy and industry from sponsorship to partnership and the formation of new research institutions that allow researchers and practitioners to engage in continuous rather than problem based dialogue.

The Faculty of Civil Engineering, as a part of the Technical University of Kosice in Slovakia was established in 1976 (February 20, 1977). During 42 years of continuous operation about 7 000 successful graduates have passed through the gates of the faculty to take on positions such as foremen, successful designers, managers, CEOs, as well as scientific researchers. Within the further development of educational and research process it has the stable position as the internationally recognized university workplace. The main goal of the faculty is to contribute to development of R&D and educational process in Slovakia, as well as in Europe. The main interest of the faculty is to contribute to development of new effective design theory and methods concerning engineering

structures. Nowadays more than 700 full time students study at the Civil Engineering Faculty. The crucial research-educational units of the faculty are:

- Institute of Structural Engineering
- Institute of Architectural Engineering
- Institute of Construction Technology, Economy and Management
- Institute of Environmental Engineering [2].

Our faculty offers also Lifelong learning for candidates from companies, not only for students. Our study programmes are prepared in connection with partners from industry. Graduates are well skilled and prepared for their future. Also doctoral students, they prepare their research and goals in connection what "real world" needs. We would like to presents current experiments of our PhD candidates.

2. DOCTORAL STUDY PROGRAMMES

The main aim is to prepare students for their future work or scientific career. Successful applicants can fulfill their ideas in 4 study programmes:

- *Theory of Architectural and Indoor Engineering*

Duration of study: 4 years

- *Theory and Design of Engineering Structures*

Duration of study: 4 years.

- *Environmental Engineering*

Duration of study: 4 years

- *Theory of Technology and Management in Civil Engineering*

Duration of study: 4 years

Excellent laboratories [2] are prepared for them to create new experiments with the support of their supervisors and through research grants that complement dwindling government funding, and student exposure to current problems and issues with partners from industry. We strongly encourage them to spend the year abroad at the foreign university to get new ideas and inspiration. Presentation and articles at foreign conferences and symposium are also important part of their study plan. We would like to present 2 works for each study programme with the focus on their innovativeness and applicability.

2.1. Study programme Theory of Architectural and Indoor Engineering

Dissertations in Architectural Engineering are focused mainly on theoretical and experimental analysis of the building construction, perimeter, roofs and floors on the ground, light external walls, facades, transparent parts, but also the creation of indoor environment. This study programme is oriented towards students who need to develop more knowledge about buildings. Part "Building Services" focuses on environmental engineering, water supply buildings, heating, ventilation, air conditioning and so on. Research is also directed to energy efficiency in buildings, reducing the need for energy, the use of unconventional energy resources in supplying energy buildings,

sustainable buildings, development of new materials and technologies, fire safety of buildings. We would like to present 2 interesting works:

1. Short description: The theme *Effective use of water walls in buildings* (in terms of thermal comfort) A prerequisite for sustainable architecture and construction is the efficient use of all the elements present in the building. On the one hand we are dealing with sustainability today; on the other hand there is the aesthetic aspect of the building. For this reason, the aim of the dissertation thesis is to determine the effective use of the water wall (Fig. 1) and its effect on the physical parameters of indoor air, especially temperature and humidity. The water wall is a decorative element where water flows through the overflow edge, flows down the solid material and forms a continuous water film on it, which is in contact with air. A water wall prototype was designed and constructed to test the hypotheses and tested under laboratory conditions in a climate chamber where stable conditions can be maintained and can be used in practice.

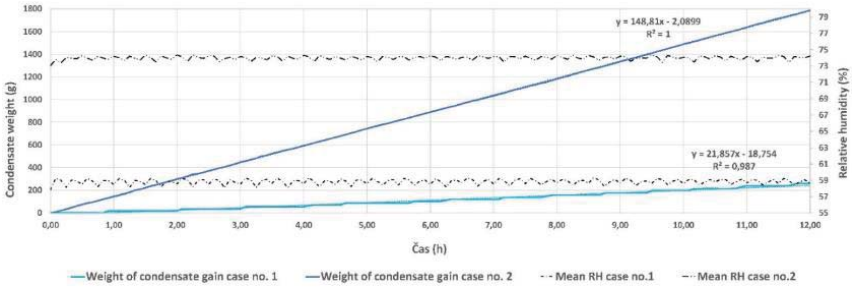

Fig. 1 Courses of weight gain of condensate at constant air temperature

2. Short description: The dissertation thesis deals with architectural designs that are not only based on the specific environmental conditions but also areable to react within their structure and overall shape to the changes in the wind conditions. The theme is interdisciplinary, involves architecture, computer engineering and civil and environmental engineering. The research of adaptive architecture is promising for the future, it seems to be inevitable to consider the environmental conditions, influenced by global warming. Re-thinking the conventional approaches in architectural design has opened up new ways of designing in architecture. Parametric designing compounded with simulation tools enable to create nature-adapted designs. Including the natural forces such as wind into the creative process from the very first ideas contribute to the blending of architecture into its surrounding environment. Moreover, architectural geometry can affect the wind situation in its proximity, as well as the conditions in the interior spaces. The proposed design strategy makes use of the rapidly developing digital design tools. It blends together the benefits of parametric designing and newly developed CFD approaches that provide fast and accurate feedback on the performance of the designed architecture. The design loop directs the design process towards finding the most suitable, or, in other words, optimal architectural solution incorporating the wind phenomenon as the main driving factor into the process. This design technique can be potentially adopted in the daily architectural routine. The wind is a complex phenomenon, and its behavior is closely related to the morphology – natural and artificial. Arid places would benefit from the

designs that enhance natural ventilation. At the same time, they need to be protected from the sand and dust storms. On the other hand, windy places would benefit from aerodynamic designs or designs that support wind energy harvesting (Fig. 2).

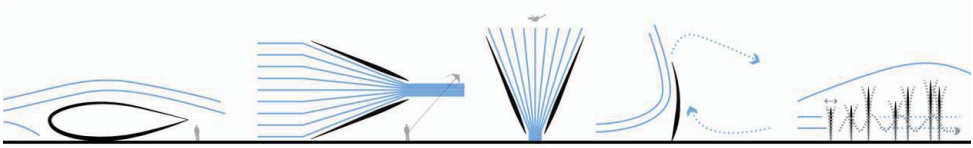

Fig. 2 From left to right: minimum resistance, concentration, diffusion, deflection of the wind flow, and wind energy harvesting

Architecture can be designed to control the wind flow according to the design intentions (see Fig. 3).

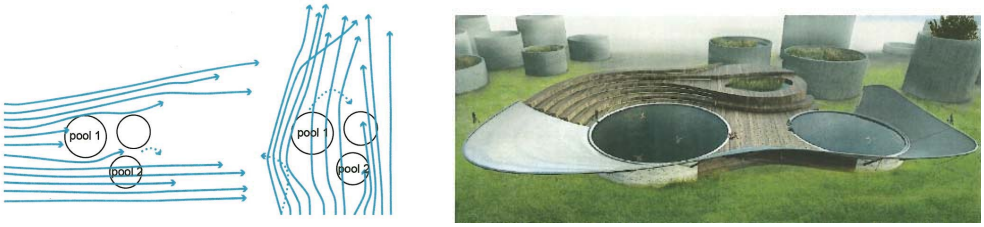

Fig. 3 Wind flow lines around the selected silos and flowbrane

2.2. Study programme Theory and Design of Engineering Structures

The theoretical basis of the study lies in the natural sciences, especially the physical and mathematical disciplines amplified in the field of mechanics, including Dynamics. A graduate of this programme has the ability to clearly formulate a scientific research problem, object and goal of research and progress in the applied theoretical subject as structural engineering, dimensioning concrete, steel, prestressed and timber structures.

The first thesis is aimed at damages of pavement surfaces.

1. Short description: Damages of pavement surfaces cause reduction or total closure of traffic in the road network. Observation of size and causes of pavement damages is important part of traffic engineering. Expectations for behaviour of asphalt materials could be reached by measuring of fatigue properties, stiffness, deformation resistance and other characteristics. Aim of this dissertation thesis is observation of fatigue properties of the asphalt mixture which is set because of previous reasons. Theoretical introduction of this thesis is focused on fatigue history and its knowledge background. Theoretical part also underlies used measurement and evaluation methods. The studied asphalt mixture was tested for empirical and functional properties and appropriate results are condition for dynamical fatigue testing. Results are classed into four sections based on testing temperatures (27 °C; 20 °C; 11 °C; 5°C). Other measurement conditions are set according to actual European standard.

Based on these results there can be done comparison of conventional and unconventional fatigue criteria and also these results can be used for bearing calculations of asphalt pavement layer (Fig. 4).

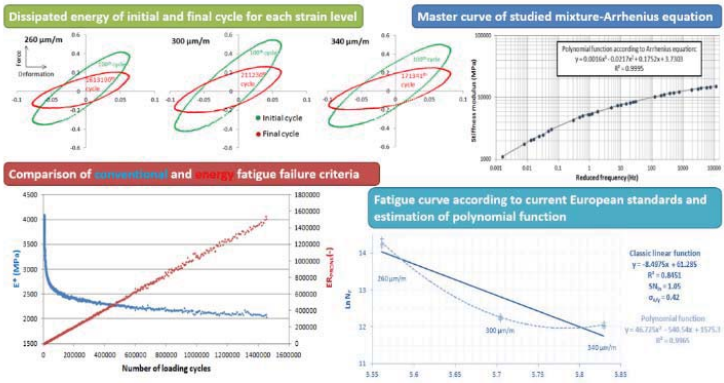

Fig. 4 Example from experiments

2. Short description: This work deals with dynamic nonlinear analysis of cables and cable structures under turbulent wind conditions. The introduction gives a review of development in analysis of cable structures, cable element applications and the wind loading estimation. Wind characteristics calculation process required for structural analysis is also described. Results obtained from wind velocity experimental measurements, wind field simulations based on measured data and the comparisons are presented. Using the computed local wind field characteristics, the program WindSimul for artificial wind field generation was developed. Simulated wind field time histories were applied in dynamic analysis of anchor cable of tower, analysis of flow past circular cylinder and for investigation of buffeting sensibility of cable-stayed footbridge. Another branch of this work is aimed on the risk of rain-wind induced vibrations of cables (Fig. 5).

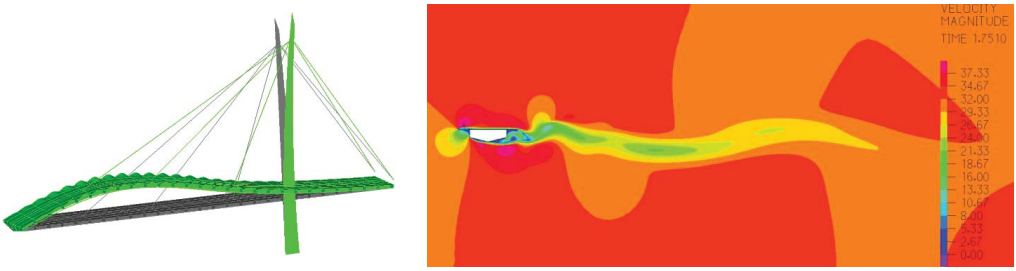

Fig. 5 WindSimul model and velocity magnitudes around the deck at time 1.751s depicted at the 5th FSI interface

2.3. Study programme Environmental Engineering

A graduate of this programme has the ability to clearly formulate a scientific research problem, object and goal of research and progress in the branch of environmental engineering, and to solve the formulated problem with appreciation of social, ethic, legal, and economic relations of research work.

1. Short description: The PhD thesis is focused on analysing the current state-of-art in field of degradation of cement composites due to microbiologically induced corrosion by analysing the formation of the biofilm, characterization of microorganisms causing biocorrosion, description of aggressive sulphate attack and different mechanisms of sulphate ion penetration into cement composites. The principal aim of the thesis is at the experimental study of cement composites under bio-corrosion in order to find the optimal composition by selection of suitable admixtures, with a special focus on the use of ground granulated blast furnace slag as a partial replacement of cement. The experimental study deals with the comparison of the resistance of cementitious composites with different share of blast furnace slag due to the action of sulphate microbiological corrosion caused by the action of the bacteria Acidithiobacillus thiooxidans, which is commonly present in waste water and can cause significant damage on cement-based materials. Various physical and mechanical (strength parameters, absorbability, mass changes, porosity), chemical (leachability of calcium and silicone, mineral phases, chemical composition etc.) and antibacterial parameters have been examined (Fig. 6).

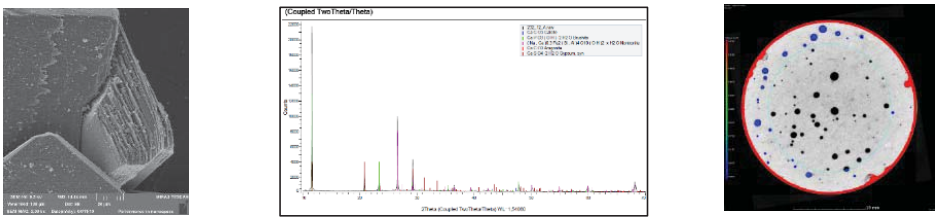

Fig. 6 X-ray diffraction analysis (XRD) of surface compounds of cement composites after biogenic sulphuric acid exposure and before bacterial corrosion

Results showed that selected physical, mechanical as well as chemical parameters of composites with blast furnace slag as a cement substitute has its justification by improving certain parameters over a Portland cement sample. High slag substitutions (from 65 wt.% to 85 wt.%) provided a partial increase in the resistance of the samples, but slag substitutes above 85 wt.% are not suitable for the corrosion induced by biogenic sulfuric acid.

2. Short description: The knowledge of high-risk localities in the Slovak Republic, in terms of floods, contributes to the overall safety of the local population. Appropriate incorporation of knowledge from areas affected by floods, supports the initiative of local people to deal with the flood situation in the locations in which they live. The rise of the water level not only in the flow, but especially in the surrounding terrain is usually related with great economic impacts that can result in various extraordinary situations that often end up tragically. The purpose of this work is to collect the theoretical knowledge necessary for mapping river Topľa located in the mountain range in northeastern Slovakia, from the source to the village of Lukov in the Čergov Mountains, which

has been increasingly plagued by lightning floods in recent years. The result of the lightning floods in this region is significant morphological changes in the banks of the main bed of the river Topľa. The overall situation described in this dissertation thesis points to the fact that in recent years the number of floods in mountain and submontane parts of Slovakia has been increasing compared to the rest of the country. This finding indicates that the flood does not only reach the valley parts of the country, but is increasingly manifested in mountain and foothill areas in Slovakia in the form of a flash flood. The thesis emphasizes the solution of this issue by using available information technologies and hydrodynamic models and describes the solution on the example of the design of the polders in the Čergov Mountains. The final chapteconclusion is dedicated to the evaluation of the achieved results, the representation of the flood wave transformations on the individual tributaries in the given area as outputs from TPV-F 1.0 (created by the author of the work) and the extent of inundation in the village of Lukov. In the conclusion, the knowledge from the solution of used information technologies and their transparent processing with recommendations for solving similar situations are evaluated.

2.4. Study programme Theory of Technology and Management in Civil Engineering

The integrated design and management of construction projects based on ICT (Building Information Modelling, Integrated design and Delivery Solution, Integrated Project Delivery, etc.) presents the relatively new approaches of solving of these projects. A research of doctoral students at Institute of construction technology and management moves towards the issue of increasing the efficiency of design and management of construction projects. The research in this field is focused on the investigation of opportunities and limitation through the base of knowledge about constructive, material, technological and cost parameters of construction.

1. Short description: Industry 4.0 has become an established term in recent years and the digitalisation of industrial production is gradually taking on real-world outlines. On the other hand, according to a 2016 McKinsey Global Institute analysis, construction is one of the least digitized unions. On the one hand, the builders themselves talk about the future use of modern technologies such as 3D modeling and simulation, virtual reality, 3D printing, BIM, automation, GPS localization, drones, and the use of large data from laser scanning. On the other hand, the civil engineering industry is still far behind industry. The dissertation thesis in the theoretical part based on the relevant literature analyzes the current state in the area of the progressive tools which are used for as-built surveying with the following use of measured data in the information modeling of existing building. The theoretical analysis deals with laser scanning technology and photogrammetry in more detail and with their application in construction industry. It analyzes these technologies from various perspectives and highlight their benefits and disadvantages. The last chapter of the theoretical part analyzes in more detail two main ways of using laser scanning and photogrammetry in the environment of information modeling of existing buildings. The main aim of the dissertation thesis is based on theoretical research, own research and processing of research data, the proposal of the methodology of the process of terrestrial laser scanning in integration with aerial photogrammetry for information modeling of existing buildings. The proposed methodology of the terrestrial laser scanning process was carried out on the basis of the terrain data collection

using a terrestrial laser 3D scanner on selected objects of investigation followed by the processing of measured data in selected software environments. The methodology of integration of the process of terrestrial laser scanning and aerial photogrammetry is a complex methodology in the individual phases of the digitization of the building where the building of the Faculty of Civil Engineering of the Technical University in Košice was chosen as the main object of the investigation (Fig. 7).

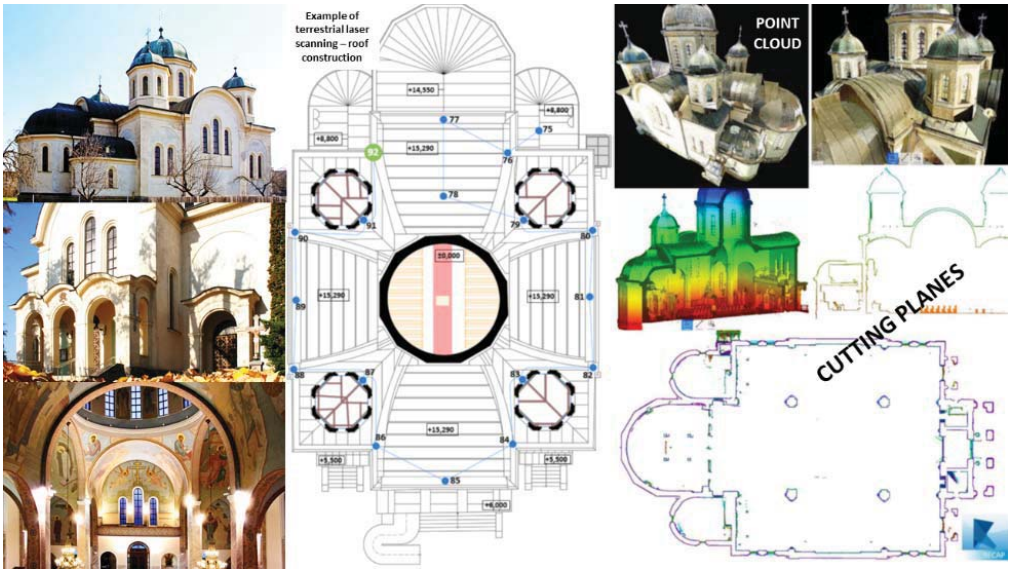

Fig. 7 Research examples

2. Short description: The topic of the dissertation thesis is based on the current issue of low efficiency of construction and sustainability as such. The development of construction industry is increasingly offering new and more efficient and sustainable technologies, technological processes and material bases. Response to this trend are the modern methods of construction based on wood offering effective procedures (design and implementation of construction), resulting in a larger volume of products (production), with higher quality and with shorter time of their purchase. Their goal is to increase the efficiency of construction by improving the quality, customer satisfaction, shortening construction times, sustainability and the impact of the construction and the construction itself on the environment. The main goal of the final thesis is to prove the efficiency of modern methods of construction based on wood based on theoretical backgrounds and realized researches and analyses. The practical part of the thesis focuses on the fulfillment of goals and also through the findings from the realized surveys and analyses, presented in three subchapters. The first subchapter presents the lessons learned from the realized survey focused on the perception of wood-based building parameters in the context of traditional construction methods by potential users. The second subchapter focuses on identifying user criteria for the efficiency of wood-based buildings in the context of sustainability. Selected user performance criteria are used in a socio-economic survey to measure the effectiveness of selected construction systems by assessing user parameters of wood

constructions, through users of already constructed buildings, in relation to the declared design parameter in the context of sustainability. The third subchapter highlights the benefits of the selected construction system of wood constructions compared to the classical construction of the case study in terms of economic and environmental characteristics within selected phases of the building's life cycle.

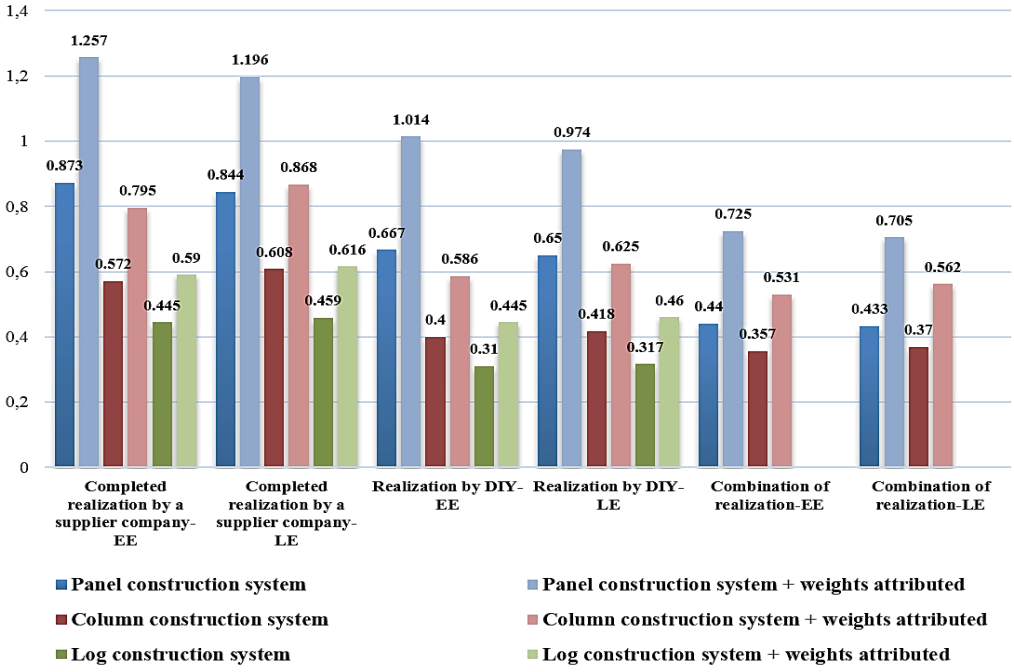

Fig. 8 Efficiency comparison of wood-based systems according to sustainability criteria.

ote: EE – energy-efficient, LE – low-energy house

4. CONCLUSIONS

Faculty of Civil Engineering as a part of TUKE is providing its environment with scientific and technological knowledge basis, innovation and workforce, in order to form beneficial and sustainable future and high quality of student's life. This is achieved at faculty by innovative research and excellent education in all scientific branches [1]. Within the continuously rising performance of the faculty focused on research and educational system our doctoral students have a lot of possibilities to obtained financial support for their projects, to attend the lesson, to use the laboratories of excellence to present their ideas at seminars and conferences. The quality high level education is confirmed by positive professional acceptation. A lot of our graduates are known

leading personalities of Civil Engineering. The young generation ideas help us to create synergy between research and industry that means they fulfill the needs of industry.

5. ACKNOWLEDGEMENTS

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E-PORTFOLIO FOR A BETTER COMPETENCE ASSESSMENT AND LEARNING

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Key words: E-portfolio; Assessment; Construction management; Competences

ABSTRACT

This research paper aims to transform the summative evaluation in education and training using e-portfolios. It is intended to be applied to a course devoted to the study and analysis of professional topics. The possibility of extending the approach to other higher education and VET areas is also considered after analysis of the pilot results. About two-thirds of the civil engineering students will have jobs in the area where professional competences are required. The pilot case study envisaged to test this innovative approach and it is a course that uses the Moodle learning platform since 2004/5. These past courses have been using the platform mostly as repository of supporting documents, as forum of communication between teacher and students and as a means of evaluation.

The motivation of this case study that is presented intends to monitor the learning and the competences acquired throughout the attendance of the discipline along the entire semester. This monitoring is based on the preparation by each student of e-portfolios during a period that oscillates between one and two weeks. These e-portfolio documents will be registered in the library of competences acquired by each student. It will indicate the percentage of the respective competence that was acquired by each student and with presentation of relevant evidences related with the competence. The reference list of competences of the discipline are attributed from the academic and professional bodies related with the course. Monitoring the progress of acquisition of competences by the teacher will allow the detection of anomalies in accordance with the anticipated planned learning. This continuous evaluation will allow the teacher to define corrective measures.

The following up of each student route will allow the teacher to personalize the additional learning needs of each student and to act during the semester along with the course implementation. It is intended to have a closer follow-up of each student studying and especially the learning. This close and timely monitoring will allow improvement of teaching, of effective learning and of motivating students through reflection and self-awareness. The use of e-portfolios shared between each student and teacher about the learning, in terms of competences acquisition, will probably also ensure a better mode of assessing and of grading each student performance. This method intends to be a way of assessing each student progression and of providing insights about teaching flaws. Another aim of this experience is to evaluate the effects and impact of applying this type of assessment of learning by students in terms of compliance with employers´ expectations.

1. INTRODUCTION

This paper describes a project of the University of Porto to implement the use of e-portfolios in the academic community to improve learning. The project was born out of the necessity to register and show each student the learning journey over time and to analyse the learning process. During the academic journey students experience several assessments and activities that are delivered to the teachers in paper or digital support. This is done without integration and in a less organized and contextualized registry of the initial and progression phases, work development, tutoring or mentoring comments or proper evaluation.

In this way students generally get to end of the school year only with a list of final grades in each course, but without a registry that demonstrates the progress and result of their own learning journey, assessments, research projects, knowledge, attitudes and skills acquired during their learning path of some years. Since learning is changing, the process of constructing an e-portfolio is a way to respond to new teaching and learning approaches that take into account a more participative, constructive, reflexive, interactive and creative attitude concerning learning experiences.
That also may enable learners to easily update the knowledge, skills and attitudes as competencies they have acquired. It is also this reflection about achievements and developments that is intended to clarify students learning outcomes in each course. Therefore, e-portfolio can be viewed as an important tool for validating competences that aim at the construction of a digital identity inside a school or organization or institution [1]. The current experiment mission is to encourage teachers and learners to use e-portfolios as an important tool to promote autonomy, interactivity and the integration of several learning elements. The e-portfolios can also perform as a stimulus for self-assessment, peer assessment and teacher assessment. This project is also targeting the continuous improvement of the quality of teaching and learning in the University of Porto and in Higher Education in general.

2. THE IDEAS

The teachers participating in this initiative – using e-portfolios in their classes - defined its use as a pedagogical tool which allows the use of a different methodology and an evaluation of the process of teaching and learning. The debate and conversations between teacher and learner indicate that, in most cases, the e-portfolio of the learner acted as a roadmap of personal growth, development and learning journey. That is due to the fact that, while demonstrating competences acquired, provides evidence of self-reflection and promotes self-knowledge. In an e-portfolio it is intended that the student register all the steps of the work: planning; collecting items; selecting and organizing documentation that demonstrates knowledge, reflection, skills, autonomy and responsibility besides those that are normally evaluated by the teacher like exams or reports.
One of the premises of this experiment is to encourage learners to learn autonomously outside the usual context of the educational curriculum, preparing them for professional life and for lifelong learning. This additional learning can originate due to the self-reflection about what is the purpose of attending the course. The main purpose of implementing this approach is to know and monitor the development of the students (cognitive, affective and metacognitive) through organized and planned collection of the learning results [2].
Thus, the institution in general and teachers in particular, allow learners to acquire greater maturity and professionalism, management, leadership and reflection skills for “real” life [3]. The learners will have to understand and assimilate the particularities of this methodology that require new ways of living, thinking and acting, in most cases, contrary to the passive learning attitude that is common throughout the higher education arena. One of the fundamental premises of this project is to encourage students to learn by themselves and cooperatively outside the context of the educational curriculum, preparing them for professional life and for lifelong learning.

3. CASE STUDY and RESULTS

3.1. Context

It was difficult to find teachers that were using already e-portfolios in their courses. Although a great number of teachers already had a component of e-learning associated to their face-to-face classes (blended-learning) some of them were already using portfolios in paper format and had tried portfolios but without much success [4]. The initial approach was to propose a flexible choice of e-portfolios templates. The idea was to have a solution that technologically could be useful for teachers from different academic backgrounds, with no imposed software or rigid structure.

Suggestions were given of possible structures, some examples, bibliography and personalized support so that these teachers could implement the approach in their classes. It was interesting to note that teachers rethought their usual techniques and methodology of teaching. This was due for being faced with different approaches from learners that stimulated their own reflection on teaching and making easier the recognition of strengths and weaknesses of learners.

This method fostered, along the construction process of e-portfolio, an active and important role of teachers in guiding and tutoring the learners in this new challenge and to acquire competences on how to understand and evaluate learners work [5]. Just a quick search on the Internet is enough to understand that there are many definitions of e-portfolios. The majority of these e-portfolios include keywords such as reflection, collection, competence, curriculum, digital repository, projects, work, planning. For the purposes of this method the definition considered was "An electronic portfolio (e-portfolio) provides an environment where students can: collect their work in a digital archive; select specific pieces of work to highlight specific achievements; reflect on the learning demonstrated in the e-portfolio, in either text or multimedia form; set goals for future learning to improve; and celebrate achievement through sharing this work with an audience, whether real or virtual" [6].

The idea of this approach is that when used in formative, classroom-based assessment, teachers (and peers) can review the e-portfolio document and provide formative feedback to learners so these can improve the competences. The teachers who are implementing the use of e-portfolios with their learners currently do not use specific software. There are questions related with the choice of e-portfolio in technical terms that recommend the development of e-portfolios in simple and accessible tools. There should be no conditions for constructing, structuring and content creation while illustrating with some concrete examples possible formats, common contents and possible tools for development may be useful. Other questions were: How e-portfolios will be used? Why? For what? When? How can e-portfolios support assessment and grades? What type of structure to adopt (rigid, recommended or flexible)? What are the evaluation criteria?

3.2. Case Study

The case study reports to a Construction Management course from Civil Engineering. It is a discipline from the last year of the integrated master which is the fifth year. The discipline is dedicated to the study and analysis of the following main themes: construction management; safety in construction; decision and economy of construction; industrialization of the construction, human resources; information in construction. There is a particular interest of students in this area because about two thirds of civil engineers will have jobs in this area either with the contractor or with the construction

owner. It is a course where the learning outcomes have a close connection with the exercise of the profession.

This course uses the e-learning supporting platform since 2004/2005 and the use of digital tools and documents has been increasing in terms of quantity of contents and type of activities carried out. These activities consist in using the platform as a repository of documents of support, as a communication forum between teachers and students and as a way of achieving and grading different works and tests during the semester. Initially it was planned in 2006/2007 to use the platform for the presentations of the final projects, with the consequent consideration and discussion, and to submit an e-portfolio. The strategy used was to request the preparation of an e-portfolio dedicated to the course. This request suggested a reflection on the course and the skills acquired, so it was the last work project asked from the students. The conclusion of work was completely in agreement with some clarifications related to the creation of e-portfolios which were provided offline.

One weakness of this strategy was that the formative learning and assessment was concentrated only at the end of the semester. A positive aspect was the fact that the experience acquired during these years allowed the preparation to start the current approach. In fact, although the creation of e-portfolios was done without the stress due to exams the learners had difficulty in recreating what happened during the semester. Most students participated, along these years, using the resources provided like the e-learning platform or the support given to students by the e-learning office or the support given by the teacher.

Results of using the e-portfolios exceeded the initial expectations because of the amount and quality of information collected from the learners. Generally, about half of the e-portfolios had a critical reflection on what they had learned: knowledge evaluation, competences, analysis of course curriculum and personal objectives. Ten per cent had a reflection about acquired competences and future professional capacities. Twenty per cent had a brief analysis of the discipline and about the teacher performance.

The use of e-portfolios as a summative tool to assess the students was complemented by other benefits for the learning process. The e-portfolios reflected a thorough work of the student learning experience that illustrated the progress, attempts, skills, knowledge and achievements. It was also possible to evaluate different capabilities because this kind of work required from students´ different skills: planning, constructive analysis, reflective thinking, redesign, (self) assessment, criticism and acceptance. It was important to analyze what was the perspective of the students in terms of their learning outcomes.

The application of this method of work allowed students to help the development of skills for reflected and contextualized learning. It also created the opportunity to demonstrate the results of their learning journey and not just the result of the exams and home-works. By using this type of resource it is obvious the importance of a more reflexive learning, in which students get used to review, consciously and systematically their work, analyze what has been done, its progress and what still needs to be done. The comments and suggestions about the learning outcomes were decisive in the current improvement of the course.

The case study presented won a prize of pedagogic innovation in 7Feb19. Therefore, during the semester starting in September of 2019 the students will have to have create an e-portfolio every week with the list of competences acquired in the different activities and the proof that they have obtained.

A comparison with the expected learning outcomes will be made by each student with a critical analysis why it is not 100%. The teacher will analyse the results of each e-portfolio and determine if there is a need for corrective measures. These measures will be discussed with student if it is considered necessary. The final grading will include the performance of the students with the e-portfolios. The e-portfolios will have a huge role in the objective of this experiment to change the evaluation to change the learning.

4. CONCLUSIONS

The conclusions about the experiment has some open questions that derive from the lack of experience in using this approach. Some issues are:
- Which are the effects and impact of applying this type of assessment in learning of students and to verify the required needs of engineering graduates to comply with employers?
- Should the set of competences presented as the goal of the course are a combination of academic and professional requisites?
- Does the use of materials online, dynamic and attractive to students that entice the awareness of the competences of the discipline?
- Can the acquired experience used to provide students possibilities of testing the prospective professional competences?
- Can the e-portfolios provide an overview and detailed at the same time about the development of the learning process of the student?
- Can e-portfolios foster students´ constant reflection about what they can do in a professional context?

The list of expected learning outcomes (competences) in the discipline are those attributed and approved by the academic and professional bodies. Monitoring the progress of acquisition of competences by the teacher will allow to detect anomalies in accordance with the anticipated learning. This continuous evaluation will allow the teacher to define corrective measures. The following up of each student route will allow the teacher to personalize the learning needs of each student and to act during the semester along with the course implementation. It is intended to have a closer follow-up of each student studying and especially the effective learning. This close and timely monitoring will allow improvement of teaching, of effective learning and of motivating students through reflection and self-awareness.
Also the use of e-portfolios shared between each student and teacher about what is beneficial for the learning, in terms of competences qualification, will probably ensure a better mode of assessing and of grading each student performance. Evaluating the achievements of this process of pedagogical use of e-portfolios may allow checking the effects, the impact and the success in this pilot attempt. It is intended to collect data about students and teachers' satisfaction with the approach, consider the impact and effects of the use of this method in the learning achievements of students, realize the lack of acquisition of required competences by employers. The experience will be monitored by the Laboratory of Teaching and Learning of the faculty of engineering to allow support and to provide insights to other engineering departments and other faculties.

5. ACKNOWLEDGEMENTS

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"Cooperation between Universities and Industry in the Education and Employment of Civil Engineers: Current Expectations, Future Challenges"

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COOPERATION EXPERIENCE OF TOMSK STATE UNIVERSITY OF ARCHITECTURE AND BUILDING (TSUAB) AND RUSSIAN CONSTRUCTION COMPANIES IN IMPROVING THE QUALITY OF CIVIL ENGINEERS TRAINING

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ABSTRACT

The article describes the issues of cooperation between Tomsk State University of Architecture and Building and construction organizations involved at various stages of civil engineers training.
Detailed considerations are provided on all aspects of partnership with Tomsk House Building Company, JSC which belongs to the construction elite of Russia. Emphasis is put on comprehensive approach that combines prospective planning; improvement of material, technical and research resources for educational processes; improvement of professional level of the university graduates; advanced training and retraining of construction industry specialists. The article provides the outcomes of joint innovative projects implementation and contribution to educational process, as well as examples of involvement of highly qualified specialists employed by the partner company in educational process at its various stages (including expert assessment of academic programs and curricula; teaching activities; supervision of internships, projects and graduation theses preparation; participation in the State Examination Commission, etc.). Besides, the results of public professional accreditation of academic programs by Russian and European agencies are described.

1. INTRODUCTION

Close cooperation between the educational institution and the employing organization on multiple aspects of specialists training is essential to provide high quality students training on basic Civil Engineering academic programs. Only those graduates will be in demand that will develop professional competencies meeting the requirements of professional standards and future professional activity. Tomsk State University of Architecture and Building (TSUAB) [1] has an extensive list of partners for cooperation on various levels of training.
On the national level, TSUAB cooperates with the Russian Academy of Architecture and Construction Sciences (RAACS), the International Association of Educational Civil Engineering Institutions of Construction, National Association of Civil Engineering Companies, National Association of Designer Engineers, Association for Engineering Education of Russia, as well as with a big number of civil engineering companies. Among the latter are “Soyuzatomstroy”, self-regulatory organization non-for-profit partnership (Moscow); “SCAD Soft, Ltd.” (Moscow);

"Gazkhimstroyinvest", finance and construction company (Tomsk); "SDS-Story", LLC (Kemerovo); "Gazprom Transgaz Tomsk", LLC (Tomsk), Research and Production Association "Mostovik", LLC (Omsk), "Vostokgazprom", JSC (Tomsk), etc.

On the regional level several self-regulatory organizations can be mentioned, such as Civil Engineers of Tomsk and Tomsk Association of Design Engineers, the Department of Architecture and Construction of Tomsk Region Administration, the Union of Civil Engineers of Tomsk and Tomsk Region, the Governor Expert Council, as well as Science and Engineering Board and Urban Development Board and Tomsk regional branch of Russian Society of Civil Engineering.

2. METHODOLOGY

This article considers various aspects of long-term and mutually beneficial effective partnership exemplified by cooperation between the Federal State Budget Educational Institution of Higher Education "Tomsk State University of Architecture and Building" (TSUAB) and the Joint Stock Company "Tomsk House-Building Company" (TDSK) [2].

Today, TDSK is a modern vertically integrated holding with diversified businesses. The holding includes one maternity company and twenty affiliated companies, each working in its business line and at the same time being a part of a unified technological complex that implements the full cycle of residential district construction (housing, social objects, utility networks, roads). TDSK is a major construction company in the Siberian Federal District. According to the results of a number of all-Russia competitions since 2006, the holding belongs to the Russian construction elite, and since 2014 is listed among top-five of major regional construction companies of Russia. The total contribution in the region development being 7,276,000 sq.m. Annually, the company produces 20 to 25 buildings, which become home to more than 4,000 families. In 2018, the gross turnover of TDSK amounted to 376 million euro (28.2 billion rubles). The total number of staff of the holding counts 3,683 people. Quality Management System and ISO 9001:2015 BUREAU VERITAS Certification are implemented at all levels of operation. Geographically, the activities of TDSK cover all the adjacent Siberian regions. The company is equipped with the state-of-the-art technical equipment for building materials production. TDSK Large Panel Construction Plant is one of the largest producers of pre-fabricated reinforced concrete in the region. The production facilities are equipped with WECKEN ANLAGENTECHNIK GMBH & Co KG line. In 2018, TDSK has built 288.7 thousand sq.m of housing in total. Among the reference projects of TDSK company are the following: construction of three modern public schools designed for 1,100 pupils per shift; primary school for 200 pupils; currently, the company is implementing a 2-year public-private partnership project on construction of 17 kindergartens for 2,840 children; and an ongoing project of construction of a residential micro-district "Sunny Valley" for 1,000,000 sq.m of housing.

Tomsk State University of Architecture and Building (TSUAB) is the leading civil engineering university in Siberia and Far East regions. The institution provides basic and applied training of bachelor, master and specialist students, as well as engineers in architecture and civil engineering related fields. Founded in 1952 by the resolution of the Ministry of Higher and Secondary Education of the USSR, the institution was awarded the status of the university in 1997.

TSUAB provides the full educational cycle, including pre-university training, professional secondary education, bachelor, specialist and master programs, PhD programs, advanced training and retraining, based on 45 programs of higher education, 2 PhD training programs, 5 programs of specialized professional education, and 101 programs of supplementary vocational education. All forms of training are provided: intramural, extramural and part-time. Distance and e-learning education formats are also available.

TSUAB includes 6 institutes, 7 faculties, 31 departments, and 6 research and education centers of international level. In 2014, preparatory department for foreign students was opened and has been successfully operating until now. To date, it is training more than 1,200 students from CIS countries and beyond (Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, Mongolia, Ukraine, Cameroon, Turkey, Azerbaijan), which makes around 20% of the total number of students, at all levels of training. TSUAB is leading among architecture and civil engineering universities in Russia, where 17 research directions are developing and thus implementing Scientific and Technological Development Strategy of the Russian Federation.

TSUAB has a Co-working Center designed for idea generation and projects implementation, it is a communication platform for interdisciplinary and international activities of TSUAB employees and foreign researchers. The university also has a business incubator for acceleration of spin-offs in the field of architecture and civil engineering. Here, postgraduate and PhD students and young researchers develop and create innovative technologies and field-specific projects.

The university is rich in traditions and achievements. TSUAB is one of initiators of the all-Russia movement of student construction brigades. TSUAB students participated in constructing Olympic objects in Sochi, “Vostochny” and “Plesetsk” cosmodromes, multiple nationwide constructions, as well as objects of Tomsk city and region.

Involvement of highly qualified specialists both in educational and industrial processes provides the basis for successful cooperation and engineers training quality improvement. Other important requirements are modern material and technical resources of partners and the ability to perform research, technical and R&D activities.

Common understanding of strategic objectives and tasks of the university is another important prerequisite for joining efforts and is impossible without engagement of employing organizations.

TSUAB is developing in accordance with the Complex Development Program, which is the document confirmed by the university Scientific Board and defining the strategy and key directions of activities related to education, research and innovation, finances, production, management and social activities for the next 5-year term. The draft of the Program is publicly discussed with the involvement of representatives of professional communities and organizations. The Board of Trustees presided by Aleksandr Shpeter, general director of TDSK company, and the Alumni Association and its head Pavel Semenyuk, technical director of TDSK company, PhD, together make a strong contribution to the agreement of the Program and substantiation of objectives and key indicators. This demonstrates that cooperation between the university and TDSK company starts with the crucial level of planning.

Beside, high level training of specialists is impossible without involvement of students in research activities, which requires modern material resources.

Over the last years, the partners have achieved some significant results in developing resource platform for research and development activities and in performing joint innovative research and projects.

In 2017, TSUAB became the first institution in Russia where the Regional Academic Research and Education Center of the Russian Academy of Architecture and Construction Sciences (RAACS) was opened. The head of the center is Viktor Vlasov, rector of TSUAB, and its co-head is Leonid Lyakhovich, RAACS academician.

The key objective of the Center is to enhance the role of the RAACS in the Siberian Federal District, including improvement of the efficiency of using research, educational and innovative potential of the RAASC, higher educational institutions and research institutions, and to boost innovative development of construction industry.

Research and educational activities of the Center are aimed at conducting basic, exploratory and applied research, developing cutting edge technologies and implementing them at the leading construction enterprises and various types of educational programs. A number of prominent scientists and RAACS academicians, such as Vladimir Travush, Pavel Akimov, Aleksandr Belostotskiy, Valeriy Telichenko, were involved in providing scientific consultations within the Center operation. Aleksandr Belostotskiy is a scientific supervisor of the Research and Education Center for Computer Modeling of Building Structures and Systems at TSUAB. Research is conducted in topical practical fields such as reduction of material consumption in buildings and structures, development of building materials with defined properties and resource efficient technologies of their production, development of new structural schemes for lightweight metal and wooden spatial framing systems.

Applied research is also ordered by and performed together with industrial companies, since among the associated members of Regional Academic Research and Education Center are Tomsk regional organization “Union of Architects of Russia”, self-regulatory organizations “Tomsk Project Association”, “Civil Engineers of Tomsk”, and Russian Union of Civil Engineers.

TDSK pays a lot of attention to corporate research and innovation. The company has a subsidiary enterprise “Stroytekhinnovatsii TDSK” headed by Pavel Semenyuk, technical director of TDSK, PhD and a graduate of TSUAB; it deals with developing new and modernizing existing construction systems and producing innovative solutions in the field of construction technologies and housing operation. TDSK is the first and the only construction company in Russia to win the competition organized by the Ministry of Economic Development of the Russian Federation for the residency in the special economic zone. The new subdivision of TDSK is located in the South Plot of Tomsk Special Economic Zone of Technical and Innovative Type. For that purpose a building with the area of 5,000 sq.m was built, where laboratories, a sample unit production facility and a polygon for testing structures are located. The company employs specialists in all related fields, such as structural designers, production engineers, scientists and employees of Moscow Research Institute of Structural Physics and Research Institute of Reinforced Concrete. The company has especially close cooperation with the university, since it serves as a platform for research internship and graduation thesis preparation for master and PhD students. Leading experts of the company took internships and did their PhD studies and advance training at TSUAB. Four of them successfully defended their PhD theses while combining their university studies and professional activities.

A special mention should be made of TSUAB and TDSK cooperation results in the field developing a novel universal prefabricated frame construction system. The joint research was performed in the framework of public-private partnership and cost around 7.4 million euro (550 million rubles). The project was headed by Pavel Semenyuk, technical director of TDSK, and Prof. Dr. Sergei Ovsyannikov, head of the Department of Architecture of Civil and Industrial Buildings at TSUAB. As a result of joint research unique technical parameters of the systems were obtained: highest energy efficiency class A++ due to highly efficient envelope structures and systems; percentage of prefabricated load bearing and envelope structures; improved seismic resistance up to 8 points with the use of seismic isolation (full-scale seismic tests were performed at TDSK facilities); resource efficiency improved by 20-30% compared to the counterparts; also, the project and engineering documentation for a building construction were developed; approval of state expertise was received; a project was developed for construction of a production facility for expanded clay gravel with improved strength parameter for load bearing and envelope structures of the novel universal prefabricated frame construction system.

The described project made a considerable contribution to the development of both TSUAB and "Stroytekhinnovatsii TDSK": more than 110 young researchers, PhD and undergraduate students and research engineers involved; top-tier equipment purchased for partners for the amount exceeding 1.5 million euro (110 million rubles); more than 200 research papers published; 52 patents received, including foreign ones. The material resources of both parties are renewed, new research and education centers are open, such as "Testing of Building Materials and Structures", "Structural Physics", "Structural Materials and Technologies", "Computer Modeling of Building Structures and Systems", which helped improve the level of specialists training at TSUAB.

Understanding the importance of developing material and technical resources of the university, TDSK makes a significant contribution to updating these resources. The company is one of the largest investors in TSUAB endowment foundation, including substantial personal contributions from the company leaders; it also is involved in reconstruction of study buildings of the university and in construction of new dormitories.

Special scholarships are provided for supporting bright undergraduate and PhD students. TDSK provides students with the opportunities of industrial internship and graduation thesis preparation. Almost all divisions of the holding are available for internships, which are supervised by the engineering staff members and senior specialists and are conducted in the residential buildings and unique objects, the latter include "Zvezdniy" Olympic class swimming pool, "Jupiter" ice rink, building of the Department of Radiation Oncology of Tomsk Oncology Center; residential buildings constructed with a new "CASCADE" technology, etc.

The Large Panel Construction Plant of TDSK directed by Nikolay Efremov, a member of TSUAB Board of Trustees, hosts a branch of TSUAB Department of Construction Material and Technologies.

Awarded with multiple diplomas of the All-Russia best design and engineering company competition, TDSK design and engineering bureau directed by Pavel Semeyuk is the training enterprise for Civil Engineering bachelor and master students.

TDSK top managers and senior specialists perform the role of independent experts for curricula and academic programs assessment. For instance, over the last two years current curriculum was

supplemented with four new disciplines according to their suggestion, including legal fundamentals in construction, BIM technologies in buildings and structures design, nanotechnologies in buildings materials design and international design regulations (Eurocodes). Also, changes to the requirements to graduation theses of students were introduced. State Examination Commission at TSUAB is chaired by the heads of the main TDSK holding divisions: Civil and Industrial Engineering specialization – by Aleksandr Pomortsev, director of Construction Department of TDSK; Production of Building Materials, Products and Structures specialization – by Nikolay Efremov, director of the Large Panel Construction Plant of TDSK; Construction of Unique Buildings and Structures specialization – by Pavel Semenyuk, director of design and construction bureau of TDSK. TDSK employees are part of educational process at TSUAB, they conduct lectures, supervise internships and graduation theses preparation, are members of organization committees and jury boards of student Olympiads and competitions.

Graduation theses of students in Civil and Industrial Engineering supervised by Viktor Rodevich, PhD, director of "Stroytekhinnovatsii TDSK", have won various all-Russian and international competitions multiple times.

Based on the requests of construction companies, TDSK and TSUAB jointly prepare special advanced training programs for construction industry specialists; training is implemented both at the university and at the enterprises. Over the last 3 years, 224 specialists have taken their advanced training programs.

Special attention is paid to professional assessment of TSUAB graduates' training level by professional organizations and international accreditation agencies. In 2017, the bachelor program "Civil and Industrial Engineering" and the master program "Modern Technologies in Design and Construction of Buildings and Structures" were successfully accredited by the Association for Engineering Education of Russia and European Accreditation of Engineering Programmes EUR-ACE Bachelor.

International expert committee gave a special notice to close cooperation between the university and the industry, particularly one of the key partners, TDSK company.

3. CONCLUSIONS

Partnership and cooperation with employing organizations enable the university to coordinate current and prospective development plans, perform educational activities with the account of modern advances in science, equipment and practice of educational and information technologies, to develop material resources of educational and research processes. All of the above becomes the solid foundation for training graduates that meet the requirements of state and professional standards together with engineering and technical staff and specialists of construction industry.

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