INQUIRIES INTO EUROPEAN HIGHER EDUCATION IN CIVIL ENGINEERING

SOCRATES - ERASMUS
THEMATIC NETWORK PROJECT

EUROPEAN CIVIL ENGINEERING EDUCATION AND TRAINING

EUCEET

FIFTH EUCEET VOLUME

Edited by
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FOREWORD

This is the fifth of a series of volumes to be published within the Thematic Network Project EUCEET (European Civil Engineering Education and Training) run on the basis of a grant of the European Commission under the auspices of the Erasmus component of the SOCRATES programme.

The volume comprises the Reports pertaining to two, out of the total of six, themes undertaken under EUCEET II:

- Theme A "*Curricula issues and developments in civil engineering education*" (coordinator: professor Iacint Manoliu, Technical University of Civil Engineering of Bucharest, Romania).
- Theme E "*Recognition of academic and professional civil engineering qualification*" (coordinator: professor Laurie Boswell, City University London).

There are six reports prepared by the Working Groups in charge with four Specific Projects under the theme A and two Specific Projects under the theme E.

In addition, the volume includes the Report of the EUCEET-Tuning Task Force on the cooperation as a Synergy Group of the Thematic Network EUCEET with the EC supported Project Tuning.

Due to space limitations, annexes to various reports could not be printed. However, the CD attached to the volume contains the reports in full extent, including annexes.

The editor expresses his gratitude to the authors of the Reports and to all active partners of EUCEET Consortium for their contribution and support.

Professor Iacint MANOLIU

Chairman of EUCEET II Management Committee

Report of the
Working Group for the
Specific Project 1

Studies and recommendation on core curricula for civil engineering

STUDIES AND RECOMMENDATIONS ON CORE CURRICULA FOR CIVIL ENGINEERING

Stanisław Majewski[1]

PREFACE

The specific project 1 (SP1) entitled ***"Studies and Recommendations on Core Curricula for Civil Engineering"*** was carried out within the Thematic Network EUCEET. The special team was organized to develop the project. At the launching meeting during the EUCEET General Assembly in Athens (February 2003) 40 delegates declared their participation in this team. Later on some of them didn't respond for any correspondence and didn't undertake any work within the project. Finally the official list of SP1 group (Appendix 1) comprises 31 persons who were more or less active in the project. On the other hand many persons, who are not included at the SP1 team list and officially didn't declare their engagement in this project responded for the questionnaires and contributed significantly to the work. This entitles me, as the chairman of the SP1 team, to express my conviction, that contents of this Report represents the average opinion of European academicians and professionals directly involved in Civil Engineering. Simultaneously I feel obliged to express my thanks and acknowledgments to all colleagues from many countries, whose proficiency and engagement created the basis for this elaboration.

Glossary

Core subject

A compact part of teaching material, which should be present in every course curriculum within a particular discipline irrespectively to the specialization.

Core Curriculum

List of subjects, which should be taught at every course within a particular discipline irrespectively to the specialization.

Frame Syllabus

A list of topics, which should be taught within a particular subject.

1. INTRODUCTION

1.1 Engineering Education.

Education is a crucial human activity, which conditions the growth and development of an individual, society and the whole world. Considering the

[1] Chairman of the WG for SP1
Professor, Silesian University of Technology, Gliwice

leading role of engineers in the society, the engineering education plays a very responsible role in the contemporary world. This refers not only to the professional competencies but also to the personal, interpersonal and most general human skills and attitudes. We must be aware of that if we plan and organize any educational activity, which is aimed not only at education and training of a well qualified professional, but of a responsible human person as well.

The project entitled *"Studies and Recommendations on Core Curricula for Civil Engineering"* carried out within the Thematic Network EUCEET deals just with one engineering discipline and touches only some aspects of the educational activity within this discipline. However considering, the role of the Civil Engineering profession in every society, as well as importance of the undertaken issues we dare consider, that the opinions presented herein can be of interest and benefit for those who deal with educational activity.

1.2 Scope of the SP1

While planning any educational activity we must consider three basic questions [1]:

- What should be taught?
- How should it be taught and learned?
- Who should teach and learn it?

The scope of the SP1 project is limited to the first question. However in the engineering education this question does not refer only to the domain of pure knowledge only. The graduate of an engineering faculty besides the scientific basis must be trained in skills, which make effective and creative application of his knowledge possible, as well as formed in attitudes which assure honest and responsible performance and approach to his work during all his professional life. Thus, the first question: 'what should be taught?' includes the range of knowledge which should be taught, skills which should be trained and attitudes which should be formed. All these attributes determine the competencies of a civil engineering professional. The first, general answer to the question: 'what should be taught' will be given in terms of competencies.

More detailed answer referring particularly to the scope of knowledge, which should be known by every graduate of a civil engineering faculty must be given in terms of subjects which should be taught. This leads to the definition of a Core Curriculum. Considering that the Civil Engineering is a very broad profession and consists of numerous specializations we must determine a set of Core Subjects, which must be known to every graduate of any Civil Engineering faculty irrespectively to her/his specialization.

Thus, within the first Specific Project (SP1) entitled *"Studies and Recommendations on Core Curricula for Civil Engineering"* the answer for the question: what should be taught? will be given both in terms of ***competencies*** of each civil engineering graduate, as well as ***core subjects***, which should be included in every civil engineering course curriculum.

2. OUTCOMES OF THE EDUCATION

2.1 Outcomes and Competencies versus Subjects and Curricula

Although the title of the first Specific Project: *"Studies and Recommendations on Core Curricula for Civil Engineering"* emphasizes the role of subjects, which create every curriculum, thus the Core Curriculum as well, we must univocally declare that the proficiency in any particular subject, even the most important one, cannot be considered as the final outcome of the education. Subjects are only the indispensable means to reach more general outcomes of the education. Therefore, the essential part of this report will begin with the presentation of outcomes of the Civil Engineering Education.

Every education is aimed at shaping a competent professional. Thus, the quality of education should be measured by the competencies of graduates.

Numerous Engineering Organizations have determined the set of outcomes of the education usually in form of competencies, which every graduate of a BSc or MSc course should achieve. Let us mention here some of them.

The Thematic Network TUNING has divided the competencies into generic and subject specific ones. The generic list (table 1) includes 17 competencies, which are important for every graduate of any higher education. Authors of this list assume, that the importance of competencies on this list will be arranged according to the results of wide inquiry among the academics, graduates and employers dealing with every single profession.

The lists of subject specific competencies were proposed by the E4[**] TN, Engineering Professors Council, QAA, Engineering Council and probably the most complete by the Body of Knowledge Committee of the American Society of Civil Engineers. In the EUCEET Specific Project 1 all these accomplishments were regarded, but majority of outcomes have been formulated in terms used by ASCE BOK Committee.

In October 2001 The American Society of Civil Engineers (ASCE) created the Task Committee on Academic Prerequisites for Professional Practice (TCAP3) which in turn founded the Body of Knowledge (BOK) Committee.

This Committee was in charge of defining the BOK needed to enter the practice of civil engineering at the professional level (licensure) in the 21st Century. The Final Report of the Committee [1] includes the comprehensive answer to all above mentioned questions referring to the education (what, how and who). Although we are aware, that all these questions are of great

[**] Enhancing European Engineering Education

importance to the education, just the first of them is within the area of interest of SP1.

Table 1. Generic competencies by TUNING

1.	Basic knowledge of the field of study
2.	Basic knowledge of the profession
3.	Ethical commitment
4.	Capacity for generating new ideas (creativity)
5.	Oral and written communication in your native language
6.	Elementary computing skills (word processing, database, other utilities)
7.	Knowledge of a second language
8.	Capacity to learn
9.	Capacity for applying knowledge in practice
10.	Capacity for analysis and synthesis
11.	Ability to work in an interdisciplinary team
12.	Research skills
13.	Capacity to adapt to new situations
14.	Interpersonal skills
15.	Decision-making
16.	Critical and self-critical abilities
17.	Appreciation of diversity and multiculturalism

2.2 Outcomes of the Civil Engineering Education expressed by the competencies of a graduate

The ASCE Body of Knowledge Committee has included 11 outcomes currently used by The Accreditation Board for Engineering and Technology (ABET) and added 4 others connected with the attitudes, that is the manner in which one approaches his or her work. The important feature of this elaboration is determining 3 levels of competency, which are required for particular outcomes.

The SP1 group has expressed the outcomes of the education in terms of competencies (table 2), which every Civil Engineering graduate should reach during her/his studies. Speaking solely about Civil Engineering we didn’t distinguish generic and subject specific competencies. We based mainly on the ASCE outcomes, taking into account the above mentioned elaborations (p. 2.1) as well. To each competency a brief commentary was added. The ASCE levels of competency were maintained.

Table 2. Outcomes of the education measured by Competencies of a Civil Engineering graduate

Scientific Basis: Knowledge Competencies
1. An ability to apply knowledge of mathematics and other basic subjects *Commentary*: Knowledge of Mathematics, Applied Physics, Applied Chemistry, forms the basis for the good understanding of the engineering sciences and provides graduates of civil engineering programs with intellectual tools.
2. An ability to use knowledge of mechanics, applied mechanics and of other core subjects relevant to civil engineering *Commentary*. Mechanics, applied mechanics (strength of materials, structural mechanics, soil mechanics, fluid mechanics & hydraulics) reinforced concrete, steel structures, engineering surveying, building materials, computer science and computational methods, construction technology & organization, buildings construction, transportation engineering, water structures and water management, environmental engineering are among the core subjects for civil engineering programs, as established within EUCEET Thematic Network on the base of a wide inquiry among European civil engineering faculties[***]. The core subjects are subjects common to all degree courses in the civil engineering field, regardless of the specialization.
3. An ability to apply knowledge in a specialized area related to civil engineering *Commentary*: Examples of specialized technical areas related to civil engineering are: structural engineering, water resources engineering, transportation engineering, geotechnical engineering, environmental engineering, construction engineering and management.
Professional Skills
4. An ability to identify, formulate and solve civil engineering problems *Commentary*: Assessing situations in order to identify problems, formulate alternatives and recommend feasible solutions is an important aspect of the professional responsibilities of the graduate of a civil engineering programme. Solving complex civil engineering problems, would require from the graduate, in addition to the ability to identify and formulate the problem, experience in performing numerical analysis and parametric analysis by using adequate computer codes, in assessing critically the results, in assessing risks, selecting constructions methods etc.
5. An ability to design a system or a component to meet desired needs *Commentary*: Design is at the heart of civil engineering and is where

[***] See point 3

graduates of civil engineering programs demonstrate their creative thinking and depth and breadth of knowledge and skills. The creative engineer must be able to recognise human, social and technical needs within his discipline and design the means to satisfy these needs. Design methodology includes problem definition, analysis, risk assessment, environmental impact, creativity, synthesizing alternatives, safety, security, constructability, sustainability, estimating engineering costs; interaction between planning, design and construction; and life-cycle assessment.
6. An ability to design and conduct experiments, as well as analyse and interpret data *Commentary*: Solving complex civil engineering problems sometimes requires using non-conventional methods among them design and conduct field and laboratory studies, gather data, analyze and interpret the results. The graduate of a civil engineering programme should be able to do this in at least one major civil engineering areas, such as structural engineering, geotechnics, transportation, water resources etc.
7. An ability to identify research needs and necessary resources *Commentary*: Complex civil engineering projects often require undertaking research activities to support the design. The graduate should be able to identify the appropriate area of research.
8. An ability to use the techniques, skills and modern engineering tools, including IT, necessary for engineering practice *Commentary*: This includes the role and use of appropriate information technology, contemporary analysis and design methods, and applicable design codes and standards as practical problem solving tools to complement knowledge of fundamental concepts.
9. An understanding of the elements of project and construction management *Commentary*: Important elements of the constructions activity involve constructions processes, methods, systems; equipment; planning; safety; cost analysis and cost control; labour issues. Projects management essentials include project manager responsibilities, defining and meeting client requirements. In the case of complex civil engineering works other elements are of relevance, such as owner-engineer-contractor relationship; project delivery systems; estimating construction costs; bidding by contractors; labour management issues etc. Project management essentials include project manager responsibilities, defining and meeting client requirements, risk assessment and management, contract negotiations, preparation and monitoring etc.
Personal, Interpersonal and Professional Attitudes and Skills
10. An understanding of ethical commitment and professional responsibility of civil engineers *Commentary*. Ethical commitment is one of basic factors of human

reliability. The graduates of civil engineering programmes should be also aware of the responsibility of the civil engineer for the public safety, health and welfare. They need to understand and be committed to apply the codes of conduct adopted by professional associations.

11. An understanding of the interaction between technical and environmental issues and ability to design and construct environmentally friendly civil engineering works

Commentary: Civil engineers must be aware that the built environment they create always interferes with the natural environment. The changes introduced by their activity cannot damage this environment, should be friendly not only to people but to the whole wildlife, as well. This refers to the aesthetic aspects, too.

12. An understanding of the impact of solutions for civil engineering works in a global and societal context

Commentary. Graduates of civil engineering programmes need to appreciate, from historical and contemporary perspectives, the technical, environmental, social, political, legal, aesthetic, economic and financial implications of civil engineering projects.

13. An ability to communicate effectively

Commentary. The graduates of civil engineering programmes should prove abilities in reading, speaking and writing, not only in their native language, but also in at least one foreign language. They should be able to present and communicate technical information to a range of audience and be versatile with graphics, the worldwide web and other communication tools.

14. An ability to function in multi-disciplinary teams

Commentary. Graduates of civil engineering programmes should be able to participate as a member of a team or to become eventually the leader of a team, which requires understanding team formation and evolution, collaboration with various personalities, co-operation among diverse disciplines etc.

15. An understanding of the role of the leader and leadership principles and attitudes

Commentary. Graduates of civil engineering programmes, who might well, during their professional career, reach positions of leadership, should be aware of the attitudes conducive to such positions and of the desirable behaviour of leaders.

16. A recognition of the need for, and the ability to engage in, life-long learning

Commentary. Graduates of civil engineering programmes should recognize that after getting an academic degree at University, they must strive for personal and professional development, through formal education, continuous education, professional experience, active involvement in professional societies etc.

The above set of competencies can be considered as outcomes of the education at the MSc level both for two-tiers system (4+1.5÷2 years) and the integrated course (5 years). The words: *recognition*, *understanding* and *ability* indicate the levels of competency, which should be achieved during the study period. Their importance differs depending not only on the level of education (BSc or BEng, MSc), but also within one level. We adopted here the following levels of competency and their definitions according to the proposal of the ASCE BOK Committee [1].

- Level 1 (**Recognition**) represents a reasonable level of familiarity with a concept. At this level, the engineer is familiar with a concept, but lacks the knowledge to specify and procure solutions without additional expertise. For example, an engineer might recognize that a particular architectural plan poses significant construction difficulties without having the expertise to devise improved construction or design alternatives.
- Level 2 (**Understanding**) implies a thorough mental grasp and comprehension of a concept or topic. Understanding requires more than abstract knowledge and is the basis for creative developing and practical applying this knowledge. Understanding refers not only to the scientific and technical aspects, but to the ethical consequences and responsibility as well.
- Level 3 (**Ability**) is a capability to perform with competence. An engineer with the ability to design a particular system can take responsibility for the system, identifying all the necessary aspects of the design, and match objectives with appropriate technological solutions. As an engineer develops, the engineer's abilities also develop so that more challenging and difficult problems can be solved.

Achieving the highest level of competency means, that the graduate is able to perform with competency, yet it does not mean that he reached the excellence or even proficiency of his performance. This should be reached due to life long learning (individual studies and postgraduate courses) as well as due to the professional work experience (fig. 1).

The vertical axis in figure 1 represents the level of particular competency in percentage. Let us emphasise that the Specific Project 1 is entitled *"Studies and Recommendations on Core Curricula for Civil Engineering"*. Just "*recommendations*" as the result of studies not obligatory rules. And so the values of "percentage of competency" should be understood.

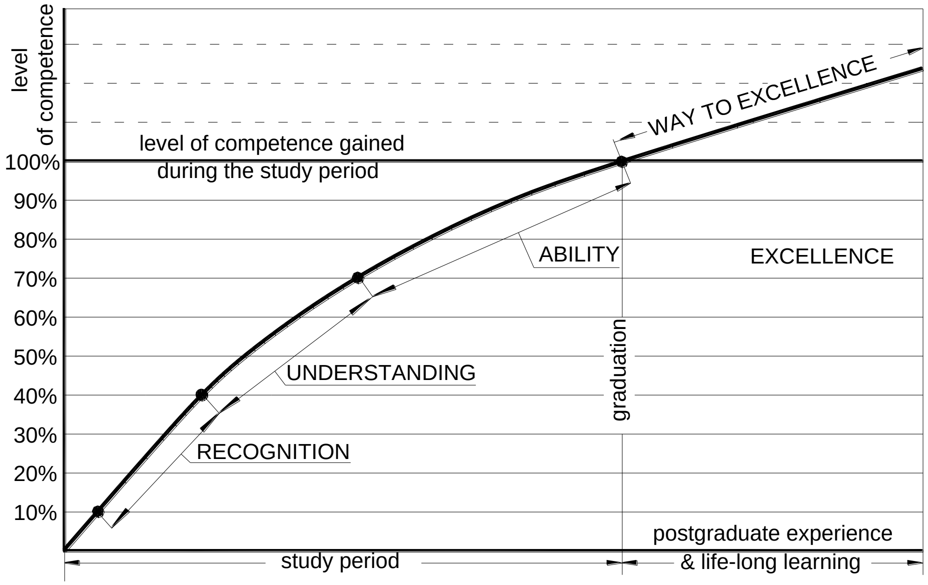

Figure 1. Life-long increase of the professional competency level

Assuming that the highest competency, assessed during the study period corresponds to 100% we propose the following intervals of competency percentage:

- Recognition 10-40%,
- Understanding 40-70%,
- Ability 70-100%.

This means that if our student reached for example 65% of the competency within a particular outcome, in which understanding level is required, we can evaluate his effort with highest possible mark. On the other hand this level of competency is insufficient if the ability level is required for this outcome.

The overall assessment of the graduate competency can be represented in the circular diagram (fig. 2). The filled area in this diagram represents the total competence of a graduate. According to the above assumptions the levels of competency for all outcomes satisfy the requirements presented in table 2, but not always at the highest possible level.

Discussing required competencies of a graduate, we must just mention two very important issues, though they exceed the area of interest of the reported project SP1. First of them is the question how to teach and train the above competencies and the second is: how to assess students' level within these competencies? More or less we know (or at least we believe that we know) how to teach particular subjects and how to evaluate the students' knowledge within these subjects.

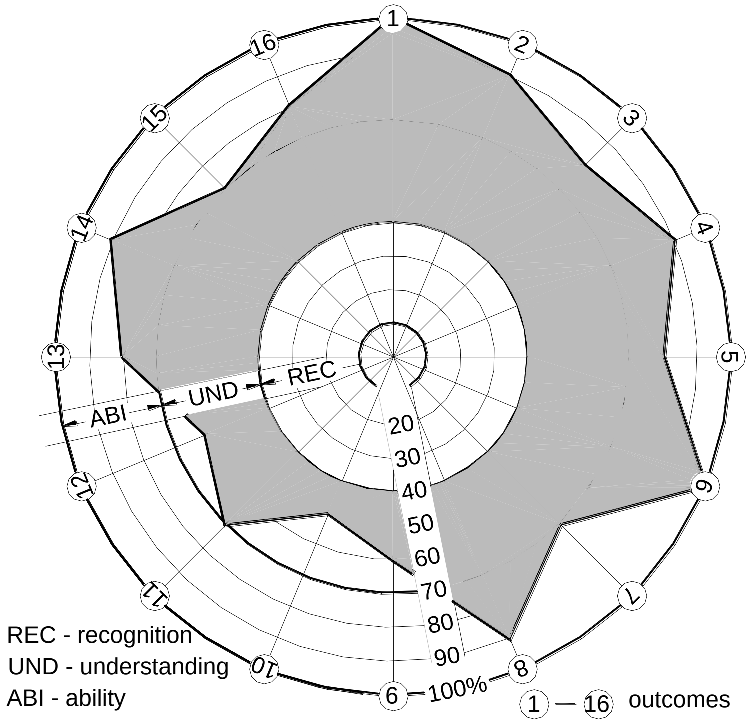

Figure 2. Circular diagram of the graduate's competency

Teaching and training competencies as well as evaluating the achieved level of competency is much more difficult and requires abandoning traditional educational scheme (chalk-talk-examining) and moving towards problem oriented education with solving design tasks, seminars with students' presentations, team work and other educational techniques. It is worthy of thinking about next EUCEET project to study and discuss these problems.

3. CORE CURRICULA

3.1 Core Subjects and their crediting

The SP1 was launched at the General Assembly in Athens in February 2003. There was one workshop of the group in Louvain la Neuve in June 2003. The meeting of the group took place during the General Assembly on Malta in May 2004. The Final Report was elaborated at the end of January and beginning of February 2005. In the meantime all the work was performed by electronic correspondence. The work was carried out in the following stages:

1. Determining the list of Core Subjects on the basis of first questionnaire since March 2003 to the workshop in Belgium on the 13th and 14th of June 2003. The list was discussed and agreed during the workshop. Later on just the slight changes of some subject names have been introduced. The list of core subjects was established on the basis of 22 answers to the first questionnaire, some of them expressed the opinion of a few people from particular universities. In the final discussion on the list of core subjects during the workshop in Louvain la Neuve participated 16 persons.
2. Assigning credits to the particular core subjects on the basis of the second questionnaire since June 2003 practically to the February 2004. Finally, the mean values of credits have been calculated on the base of 29 responses. Some of them expressed the opinion of more than one person. The list of credits for 25 core subjects was approved during the open SP1 group meeting on Malta in May 2004.
3. Elaboration of frame syllabuses for 25 core subjects.

All questionnaires were elaborated and data processing was carried out by Prof. S. Majewski, the SP1 chairman. The average credits have been calculated as the weighted average with use of a the specially designed iterative procedure, which automatically increased the weight of the data, close to the average value and decreased the weight of those strongly differing from this average. The procedure is explained in the Appendix 2.

The average credits rounded to 0.5 for core subjects are given in table 3. The possible intervals of credits are given in table 4. Using these intervals one should maintain the total sum of credits for core subjects on the constant level (140). This means that if we give more credits for one subject, we should decrease them for another one.

Core Curriculum

Credits represent the student's workload per subject. This work consists of:

- contact hours at school,
- student's individual studying (library, discussions),
- homework (project and design work),
- training before tests and exams.

Table 3. Core Subjects with Credits for basic types of courses Mean values rounded to 0.5

No	CORE SUBJECTS IN CURRICULA FOR CIVIL ENGINEERING	Credits for course:		
		Integrated	Two-tier system	
		10 sem	1st cycle 8 sem	2nd cycle 2 sem
1.	Mathematics and Applied Mathematics	23.0	16.0	6.0
2.	Applied Chemistry	3.5	3.0	
3.	Applied Physics	6.5	5.5	
4.	Computer Science and Computational Methods in C.E.	8.0	6.5	2.0
5.	Drawing and Descriptive Geometry	5.0	4.0	
6.	Mechanics	6.5	5.5	1.0
7.	Mechanics of Materials	9.5	7.5	2.0
8.	Structural Mechanics	11.0	8.5	2.0
9.	Fluid Mechanics & Hydraulics	6.0	5.5	1.0
10.	Engineering Surveying	5.5	5.0	1.0
11.	Building Materials	6.5	5.5	1.0
12.	Buildings	4.5	4.0	
13.	Basis of Structural Design	4.5	4.5	
14.	Engineering Geology	4.0	3.5	
15.	Soil Mechanics and Geotechnical Engineering	9.0	6.5	2.0
16.	Structural Concrete	9.5	7.5	2.0
17.	Steel structures	8.0	6.0	2.0
18.	Timber, Masonry and Composite Structures	4.5	3.5	
19.	Transportation Infrastructure	4.5	4.0	
20.	Urban and Regional Infrastructure	3.0	3.0	
21.	Water Structure and Water Management	4.5	3.5	1.0
22.	Construction Technology & Organisation	7.0	3.5	2.0
23.	Economics and Management	7.5	6.0	2.0
24.	Environmental Engineering	4.5	4.0	
25.	Non-technical subjects	9.0	6.0	3.0
Core subjects total		**175.0**	**140.0**	**30.0**
Specialization subjects total		**125.0**	**100.0**	**30.0**
Total		**300.0**	**240.0**	**60.0**

These parts differ for particular subjects, anyway we can assume that approximately 50-60% should be reserved for contact (teaching) hours. Assuming that the total student's workload should not surpass 40 hours per week we obtain 20-24 teaching hours per week. On the other hand we usually assume 30 credits and 15 weeks per semester, thus 2 credits correspond with 20-24 teaching hours. Constructing the Core Curriculum we assumed that 1 credit corresponds to 10-12 teaching hours. Regarding that we have 15 weeks in a semester we additionally assumed, that the total number of hours per subject should be a multiplicity of 15.

The recommended contact hours for core subjects in curricula for basic types of courses are presented in table 5.

Table 4. Recommended intervals of Credits for Core Subjects in basic types of courses

No	CORE SUBJECTS IN CURRICULA FOR CIVIL ENGINEERING	Credits for course:		
		Integrated	Two-tier system	
		10 sem	1st cycle 8 sem	2nd cycle 2 sem
1.	Mathematics and Applied Mathematics	19.0-27.0	13.0-19.0	5.0-7.0
2.	Applied Chemistry	3.0-4.0	2.5-3.5	
3.	Applied Physics	5.5-7.5	4.5-6.5	
4.	Computer Science and Computational Methods in C.E.	7.0-9.0	5.5-7.5	1.5-2.5
5.	Drawing and Descriptive Geometry	4.0-6.0	3.5-4.5	
6.	Mechanics	5.5-7.5	4.5-5.5	1.0
7.	Mechanics of Materials	8.0-11.0	6.5-8.5	1.5-2.5
8.	Structural Mechanics	9.0-13.0	7.0-10.0	1.5-2.5
9.	Fluid Mechanics & Hydraulics	5.0-7.0	4.5-6.5	1.0
10.	Engineering Surveying	4.5-6.5	4.0-6.0	1.0
11.	Building Materials	5.5-7.5	4.5-6.5	1.0
12.	Buildings	3.5-5.5	3.5-4.5	
13.	Basis of Structural Design	3.5-5.5	3.5-5.5	
14.	Engineering Geology	3.5-4.5	3.0-4.0	
15.	Soil Mechanics and Geotechnical Engineering	7.5-10.5	5.5-7.5	1.5-2.5
16.	Structural Concrete	8.0-11.0	6.0-9.0	1.5-2.5
17.	Steel structures	6.5-9.5	5.0-7.0	1.5-2.5
18.	Timber, Masonry and Composite Structures	3.5-5.5	3.0-4.0	
19.	Transportation Infrastructure	3.5-5.5	3.5-4.5	
20.	Urban and Regional Infrastructure	2.5-3.5	2.5-3.5	
21.	Water Structure and Water Management	3.5-5.5	3.0-4.0	
22.	Construction Technology & Organisation	6.0-8.0	4.5-6.5	1.5-2.5
23.	Economics and Management	6.0-9.0	5.0-7.0	1.5-2.5
24.	Environmental Engineering	3.5-5.5	3.5-4.5	
25.	Non-technical subjects	7.5-10.5	5.0-7.0	2.0-4.0
Core subjects total		**175.0**	**140.0**	**30.0**
Specialization subjects total		**125.0**	**100.0**	**30.0**
Total		**300.0**	**240.0**	**60.0**

The exemplary curriculum with core subjects for the 1st BSc stage of a two-tiers 8 semesters course is presented in table 6. That is just an example, which proves that on the basis of above accomplishments core subject can be easily and reasonably scheduled over 6 semesters. Let us observe that during initial 4 semesters all students of a civil engineering faculty are involved in core subjects only. Specialization subjects appear at the 3rd and 4th year of study, when students are prepared to choose what they are interested in and predestined to.

Frame Syllabi for Core Subjects

To determine unequivocally what is meant by a particular core subject frame syllabuses have been elaborated for each of them. The frame syllabus is a brief list of topics which should be known to every graduate of any civil engineering faculty irrespective to her/his specialization and the place of study. The topics are split into parts. The required level of competency* has been determined for each part of the teaching material.

The syllabi were determined on the basis of wide European survey. Altogether, 32 universities sent nearly 200 syllabuses. Some of them could not be used mainly because of the improper format or the use of a mother tongue. Finally, the frame syllabi for core subjects have been elaborated on the basis of 169 syllabuses from 23 universities. The list of these universities is given in table 7.

Table 5. Recommended contact hours in Core Curriculum for basic types of courses

No	**CORE SUBJECTS IN CURRICULA FOR CIVIL ENGINEERING**	**Credits for course:**		
		Integrated	**Two-tier system**	
		10 sem	**1st cycle 8 sem**	**2nd cycle 2 sem**
1.	Mathematics and Applied Mathematics	195-305	135-225	60-75
2.	Applied Chemistry	30-45	30-45	
3.	Applied Physics	60-75	45-75	
4.	Computer Science and Computational Methods in C.E.	75-105	60-90	30
5.	Drawing and Descriptive Geometry	45-75	45	
6.	Mechanics	60-90	45-60	15
7.	Mechanics of Materials	90-120	75-90	13-30
8.	Structural Mechanics	90-150	75-105	15-30
9.	Fluid Mechanics & Hydraulics	60-75	45-75	15
10.	Engineering Surveying	45-75	45-75	15
11.	Building Materials	60-75	45-75	15
12.	Buildings	45-60	45	
13.	Basis of Structural Design	45-60	45-60	
14.	Engineering Geology	45	30-45	
15.	Soil Mechanics and Geotechnical Engineering	75-120	60-75	15-30
16.	Structural Concrete	90-120	60-105	15-30
17.	Steel structures	75-105	60-75	15-30
18.	Timber, Masonry and Composite Structures	45-60	30-45	
19.	Transportation Infrastructure	45-60	45	
20.	Urban and Regional Infrastructure	30-45	30-45	
21.	Water Structure and Water Management	45-60	30-45	
22.	Construction Technology & Organisation	60-90	45-75	15-30
23.	Economics and Management	60-105	60-75	15-30
24.	Environmental Engineering	45-60	45	
25.	Non-technical subjects	75-120	60-75	15-45
Total hours for Core subjects not more than		**1750-2100**	**1400-1680**	**300-360**
Total hours for Specialization Subjects not more than		**1250-1500**	**1000-1200**	**300-360**
Total contact hours per course not more than		**3000-3600**	**2400-2880**	**600-720**

* 3 levels of competency used previously to determine the outcomes of education (point 2.2) have been applied to the teaching material as well

Table 6. Exemplary Curriculum with Core Subjects for 8 semester BSc course

First stage - Four years BSc Course	Schedule of teaching hours								Total hours
	1	2	3	4	5	6	7	8	
Mathematics and Applied Mathematics	75	60	30						165
Applied Chemistry	45								45
Applied Physics	45	30							75
Computer Science and Comp. Methods in C.E.	30	30		15					75
Drawing and Descriptive Geometry	45								45
Mechanics	60								60
Mechanics of Materials		60	30						90
Structural Mechanics			60	60					120
Fluid Mechanics & Hydraulics		45							45
Engineering Surveying		60							60
Building Materials	60								60
Buildings		45	15						60
Bases of Structural Design			60						60
Engineering Geology		30							30
Soil Mechanics and Geotechnical Engineering			45	30					75
Structural Concrete			45	45	30				120
Steel Structures				45	30				75
Timber, Masonry and Composite Structures				45					45
Transportation Infrastructure			30	30					60
Urban and Regional Infrastructure					30				30
Water Structures and Water Management						45			45
Construction Technology & Organisation			15	45					60
Economics and Management				15	30				45
Environmental Engineering					30	15			45
Non-technical subjects			30	30	30	30			120
Core subjects total	360	360	360	360	180	90	0	0	1710
Specialization subjects total	0	0	0	0	180	270	360	360	1170
Total	360	360	360	360	360	360	360	360	2880

Table 7. List of universities and number of sent syllabuses

No	***Country***	***University from City***	***Number of programs***
1	Poland	Gliwice	18
2		Bialystok	14
3		Lodz	4
4		Rzeszow	2
5		Wroclaw	1
6	Czech Republic	Brno	7
7		Ostrava	25[**]
8		Pardubice	2
9		Prague	5
10	Greece	Thessaloniki	18
11		Athens	4
12	Slovak Republic	Bratislava	5
13		Zilina	9
14	Spain	Cantabria	10
15		La Coruna	3
16	Lithuania	Vilnius	18
17	Romania	Bucharest	6
18	Estonia	Talinn	4
19	Germany	Oldenburg	4
20	Latvia	Riga	3
21	Portugal	Covilha	3
22	Ireland	Dublin	3
23	Sweden	Chalmers Univ.	1
Total			**169**

1. MATHEMATICS AND APPLIED MATHEMATICS [*]	13.0-19.0 credit points
Course contents	
MA1. *The course deals with basic knowledge and calculus of the matrix algebra, solving systems of equations and function analysis, graphing and approximation.* Matrices, elements of matrix algebra. Square matrices, regularity, singularity, determinants, inverse matrices. Methods for solving systems of linear equations. Cramer's rule and Frobenius theorem. Sequences of real numbers and their properties. Limits of sequences. Elementary functions, their properties and graphs. Compositions of functions, inverse functions.	

[**] Elaborated in the final stage as the "summary" of previously sent syllabuses

[*] Based on the syllabus from Bratislava and includes the topics from other 6 universities

Continuity and limits of functions. Basic methods for evaluation of limits. Derivative of a function. Geometric applications of derivatives. Tangent line and normal line to a graph of a function. Higher order derivatives. Mean value theorems and their application. Monotonicity for functions, concavity. Graphing a function, local and global extrema. Approximation of functions by polynomials, Taylor's theorem.

MA2. *The course deals with basic knowledge and calculus of integrals, analysis o functions of several variables, geometric and physical application.*

Antiderivative – primitive function, indefinite integral. Methods of integration of functions. Definite integral – definition, methods of computation. Improper integrals. Applications in geometry and physics. Basics of multivariable calculus, functions of two and three variables, determination of areas and volumes. Partial derivatives and gradient. Local and global extrema of functions of several variables. Infinite series of functions, power series, Fourier series. Double and triple integrals – basic concepts and computation. Line integral in a vector field. Analysis of function of several variables. Definite, multiple, and curvilinear integrals. Elements of field theory. Elements of differential geometry, moving trihedral, curvature, torsion, first quadratic form of surface.

MA3*. The course deals with basic knowledge and calculus of ordinary and partial differential equations, systems of differential equations.*

Fundamental elements of differential equations. Ordinary differential equations of first order. Applications of differential equations of first order. Ordinary differential equations of higher order. Linear differential equations of higher order. Methods of the solution of differential equations. Fundamental elements of system of differential equations. Methods of solution of differential equations systems. Linear systems of differential equations. Fundamental elements of partial differential equations. Linear partial differential equations. Special cases of partial differential equations. Linear partial differential equations.

MA4*. The course deals in first part with basic knowledge and calculus of statistics and probability in general and in engineering, in second part with numerical methods and techniques used in mathematics and engineering*

Introduction to Probability, One-Dimensional Random Variables and Distributions, Distributions for Discrete Random Variables, Distributions for Continuous Random Variables, Estimation of Parameters, Confidence Intervals for Mean Value, Correlation Analysis, Regression Models, Estimation of Regression Parameters, Prediction and Forecasting, Statistical Applications in Civil Engineering Problems.

Numerical solutions of equations with one variable and non-linear systems. Linear operators, interpolation, extrapolation. Numerical approximation, orthogonal polynomials. Numerical differentiation and integration. Numerical linear algebra, matrix computations. Numerical solution of: systems of linear equations, differential equations, partial differential equations. Examples of

applications for Civil Engineering.	
Level of competence	Ability in MA1 and MA2, Understanding in MA3, MA4.
Skills achieved	Proficiency in calculation of matrices, derivatives, integrals, solving of systems of equations, differential equations including systems as well as familiarity with statistics and probability, numerical methods and their use in engineering practice.

2. APPLIED CHEMISTRY *	2.5-3.5 credit points
Course contents	
CH1. *General Chemistry.* Atomic Theory. The Periodic Table and Periodic Trends in Atomic Properties. Chemical Bonds. Elements of the Gaseous, Liquid and Solid State Chemistry (Band theory and Electrical properties). Chemical Kinetics and Chemical Equilibrium. ***CH2.*** *Water and Air Chemistry.* **Water chemistry:** Hydrologic Cycle. Properties of water. Composition and Types of Natural Waters. Water Pollution. Drinking Water. Industrial Water. Desalination. **Atmospheric chemistry:** Composition and Regions of the atmosphere. Nitrogen and Carbon Cycles. The Ozon Layer. Air Pollution. ***CH3***. *Building Chemistry.* **Corrosion and Protection of Metals:** Electrochemical Corrosion. Galvanic Cells. Pourbaix Diagrams. Corrosion Rate. Uniform and Selective attack. The Corrosion Protection of Metals. ***CH4***. *Building Chemistry.* **Chemistry of Cement:** Raw materials. Types of Cement. Cement Properties. Hydration of Portland Cement.The role of Pozolans in cements. **Chemistry of Concrete:** Definition. Specifications. Durability of Concrete. Aggregates and Admixtures. Chemical attack of concrete and methods of confrontation.	
Level of competence	Understanding in CH2, CH3, CH4, Recognition in CH1.
Skills achieved	Students will get basic knowledge in general and physical chemistry required for better understanding of building materials. Deeper understanding of water chemistry and building chemistry is presupposed.

* Based on the syllabus from NTUA Athens and includes the topics from other 5 universities

3. APPLIED PHYSICS *	4.5-6.5 credit points
Course contents	
<u>Ph1. Heat</u> Fundamentals of heat conduction, thermal convection and heat radiation thermal properties of building materials, thermal characteristics. Thermal bridges: heat losses and characteristics, indoor surface temperatures, thermal and hygrical effects. Ventilation. Heat Balance: building components balance, room balance. Non-Steady State Thermal Behaviour of Buildings: heat transfer in building components, mechanism of heat storage, heating and overheating effects, passive solar energy utilization, sun spaces made of glass, thermal insulation in summer. Measures for Saving Heating and Cooling Energy: structural measures to reduce heat losses, energy-saving concepts, improvement of thermal insulation in old and new buildings, management of solar energy, balance of buildings. Thermal Load of Building Components. Thermal stresses and deformations. ***<u>Ph2 .Moisture</u>*** Fundamentals: relative air humidity, water vapour content in the air, characteristic water content of building materials, water vapour partial pressure, dew temperature, diffusion resistance, transport of liquid, water sorption. Moisture Storage: sorption and capillary condensation, moisture storage function, hygrical characterisation of pores, hygroscopic balance. Moisture Transport: diffusion, capillary suction and air flow, steady and non-steady state moisture transport, other mechanisms. Hygrical Load of Building Components: swelling and shrinking of building materials, hygrical dilatation and bending of multi-layer structures, selection of building materials under severe impact of moisture. Moisture Protection in Buildings: protection against driving rain on horizontal, inclined and vertical areas, protection against condensation or domestic hot water, protection against water in the soil, measures against moisture damage in new buildings. **<u>Ph3.Sound</u>** Fundamental Terms: sound field characteristics, wave propagation, perception and measurement of sound, calculations with sound levels. Room Acoustics: sound absorption and reflection, absorber types, reverberation time, principles of room acoustic planning, sound control, echoic criteria, room geometry. Airborne Sound Insulation: sound reduction coefficient and parameters derived from measurement, mono-layer building components, influence of area-related mass, stiffness, coincidence effect, two- or multi-layer building components, resonance, flanking transmission, resulting sound insulation, measures for airborne sound insulation. Impact Sound Insulation: impact sound level and transmission, impact sound insulation of characteristic building components, measures for impact sound reduction. Flanking Sound and Vibration: attenuation, water installations and technical systems, flanking sound attenuation and vibration insulation.	

* Based on the MEMORANDUM prepared by the members of the Permanent Conference of University Professors of Building Physics [4]

Environmental Noise Control: characteristic sound levels, sound radiation, punctual sources, linear sources, aerial sources, sound propagation in the open air and in urban areas, sound shields.
Ph4. Fire. Fire Protection Fundamentals: emergence of fire, fire load, ventilation, course and spread of fire. Fire Behaviour and Smoke Emission of Building Materials. Behaviour of Building Components and Dimensioning: concrete building components, heating processes and fire water effects, courses of temperature, stress peaks, calculation methods, design features to increase fire resistance, dimensioning of building components, specific problems of fireproof constructions masonry, steel building components, fire behaviour of timber, dimensioning of timber constructions, measures to increase the fire resistance of timber building parts. Pipes, Stacks, Tubes, Ducts. Equivalent Fire Loads, Rescue Provisions. ***Ph5. Climate.*** Climatological Fundamentals: Seasonal and day-time fluctuations of air temperature and air humidity, radiation intensity. Heat and Material Balance in the Open Air and in Urban Areas. Building Aero-Dynamics: wind profile over open air and urban areas, distribution of pressure in the boundary layers of buildings. Energy saving by urban area management, supply of fresh air in urban districts, generation of barriers, micro-climate design, especially in metropolises. Climate-Adjusted Construction ***Ph6. Light.*** Daylight: daylight in the open air and indoors, daylight ratio, distribution of lighting intensity. Artificial Lighting: daylight complementary lighting, operating hours, artificial light sources (lamps, tubes, radiators), electrical performance, efficiency, total energy balance.

Level of competence	Ability in Ph1-Ph4, Understanding in Ph5, Recognition in Ph6
Skills achieved	Proficiency to understand the methodology used in Physics and knowledge of the most important theorems and postulates as well as familiarity with the development of the analytic-synthetic capacity in the resolution of problems.

4. COMPUTER SCIENCE AND COMPUTATIONAL METHODS IN CE *	5.5-7.5 credit points
Course contents	
CS1. *The course regards to introduction to the computer science: theory of information, computer systems, hardware and software, operating systems, computer networks, computer security, software packages.* Basic notations of the information theory. Computer systems structure. General information of basic hardware and software. Operating systems	

* Based on the syllabus from Wroclaw

(review: DOS, Windows, Linux, etc.). Exchanging information by internet, ftp, e-mail (working groups), etc. Basis of computer and system security. Knowledge of software packages with application to solving engineering problems: word processor, spreadsheets presentation programme and data bases, .pdf files.
CS2. *The course regards to the basic knowledge of programming: algorithms, flow charts, programming languages (for example: Pascal, Fortran, C++, Basic etc.).* Definition of algorithms, elements of flow charts. Programming language elements: variables, statements, expressions, functions and sub-programmes. Writing, editing, running and debugging of programmes. Libraries. Ability of writing and running simple programmes for engineering purposes.
CS3. *The course regards to the computer aided graphics in civil engineering (for example AutoCAD, RoboCAD, Microstation, ArchiCAD etc.)* Presentation and instruction of CAD interface. Commands. Blocks and libraries. Import and export of drawings. Basis of CAD program macros. Plotting. Full 2-D drawing ability and 3-D drawing basis.
CS4. *The course regards to the basis of computational methods in engineering: FEM, BEM, optimisation methods, structural analysis and CAE (for example: Abaqus, Ansys, Cosmos, Diana, Lusas etc., for example: Robot, Sofistic, etc.).* Structural modelling. Numerical methods (numerical methods errors, systems of equations, interpolation and approximation methods, numerical derivation and integrals, etc.). Basis of computational mechanics. Computational formulation of FEM and BEM. Structural analysis: static & dynamic of different engineering structures. Basis of structural optimisation: mathematical model, programming, application to simple design programmes (for example using Solver application). ***CS5.*** *The course regards to the basis of GIS* System outline and its field of application. Data vs. information; geometric, temporal and ENGINEERING components of spatially related data; data models and structures; metadata. Spatial and spatial-temporal analyses. Spatial statistics, Spatial Decision Support System (SDSS). GIS vs map vs digital map. Review of possibilities of different GIS software. Data input and edition. Database navigation. Simple and complex requests to the database. Vector and raster data composition. Design of output documents. Design of application packages.

Level of competence	Ability in CS1, CS3 and CS4, Understanding in CS2 and CS5.
Skills achieved	Proficiency in using computers to solve different engineering problems by using standard software packages. Proficiency in using computer graphics software (drawing) and exploitation of structural analysis and design programmes. Familiarity with programming languages.

5. DRAWING AND DESCRIPTIVE GEOMETRY *	3.4-4.5 credit points
Course contents	
***DG1. In this course student gets general knowledge and ability in technical drawing both by hand and* using computer programs** • Introduction to technical drawing. Basic equipment for technical drawing. Kinds of drawing-lines and their usefulness in technical drawing. Kinds of lettering for technical drawing. Scales and dimensions in technical drawing. Architecture and building construction drawings: plans, elevations, sections. Civil engineering drawings. • Bases of Computer Aided Design programs (CAD). Logics of graphic editor on example of AutoCAD system. Creation of 2D and 3D drawings. Cover plate for standard program CAD in engineering designing. Spatial modeling, formation and modeling of curves and surfaces. Designing of residential building applying the graphical editor - dimensioning in CAD program. Lay-out applying the computer program. Principles of structural designing using CAD program on a project.	
DG2. *In this course student gets general knowledge and ability in constructive techniques used in technical praxis, especially in 2-D and 3-D projection.* Parallel (and orthogonal) projection and its properties. Affinity in 2-D and 3-D. Monge´s projection – definition, point, line and a plane, principal and steepest lines, intersection of simple geometric objects. Length of a line segment. Revolution of a plane into a projection plane. Image of a circle. Auxiliary views – side view and a third projection plane. Prisms and cylinders. Axonometry – definition, various sorts of axonometry. Transformation of an object from Monge´s projection into the axonometry. Orthogonal axonometry. Revolution of coordinate planes. Intersection of single geometric objects. Projective geometry – definition, elements, point, line and plane, interval, calibration and the slope, intersection of single geometric objects, revolution of a plane into a projection plane. Topographic (land) surfaces and roofs. Parallel shading – definition, main applications in	

* Based on the syllabus from Bratislava and includes the topics from other 6 universities

Monge´s projection and axonometry.	
Level of competence	Ability in DG1 and DG2.
Skills achieved	Proficiency in technical drawing both by hand and using computer programs, basic projection techniques as well as familiarity with some advanced projection and constructional methods.

6. MECHANICS *	4.5-5.5 credit points
Course contents	
ME1. *Basic concepts and methodology of Statics* **1.** The concept of a particle and a rigid body**.** The concept of a concentrated force, couple and distributed forces. The essence of the vectorial approach to Mechanics **2. Statics of a particle**: Forces acting on a particle. Resultant of concurrent forces. Equilibrium of a particle in plane and in space**.** Free-body diagram concept. **3. Statics of a rigid body and systems of rigid bodies**: Moment of a force about a point. Varignon's theorem. Moment of a force about an axis. A couple. Moment of a couple. Reduction of a system of forces to one force and one couple. Equivalent systems of forces. Equations of equilibrium of a rigid body in two dimensions (2D). Constraints imposed on a 2D rigid body by links and hinges. Statical determinacy and indeterminacy. Kinematic stability. Systems of 2D rigid bodies and related problems (equations of equilibrium, constraints, statical determinacy and kinematic stability). Equilibrium of a rigid body in three dimensions (3D). Systems of rigid bodies in 3D. **4. Principle of virtual work for rigid bodies:**The concept of a virtual work. Application of the Principle to determining support reactions and forces transmitted by links of systems of 2D rigid bodies. **5. Centroids and centres of gravity:** Centre of gravity of a 2D rigid body. Centroid of an area. Centre of gravity of a 3D rigid body. Centroid of a volume. **6. Moments of inertia of areas:** Second moment of an area. Polar moment of inertia. Product of inertia. Parallel-axis theorem. Principal axes and principal moments of inertia. Moments and products of inertia of composite areas. **7.Moments of inertia of masses:** Definition of a moment of inertia of mass**.** Mass product of inertia. Parallel-axis theorem**.** Moments of inertia of selected rigid bodies.	
Recommended texts to ME1 1. Beer F.P., Johnston E.R. Jr: Vector Mechanics for Engineers. Statics . Mc Graw Hill.	
ME2. *Kinematics of particles:* **1.** Rectilinear motion of particles**.** Curvilinear motion of particles**. 2 Kinetics**	

* Elaborated in UBI, Covilha on the base of own experience as well as the syllabi from other 7 universities

of particles: Linear and angular momentum of a particle. Newton's Second Law. Equations of motion of a particle: a/ in terms of rectangular components, b/ in terms of normal and tangential components, c/ in terms of radial and transverse components. Kinetic and potential energy of a particle. Principle of work and energy. Conservation of energy. Motion of a particle under a central force. Principle of impulse and momentum. Direct and oblique central impact. **3. Kinematics and kinetics of a system of particles:** Linear and angular momentum of a system of particles. Motion of a the centre of mass of a system of particles. Kinetic and potential energy of a system of particles. Principle of work and energy. Conservation of energy for a system of particles. Principle of impulse and momentum for a system of particles. **4. Kinematics of rigid bodies:** Translation and rotation of a rigid body about a fixed axis. General plane motion of a rigid body: absolute and relative velocity of a point belonging to a rigid body, instantaneous centre of rotation, absolute and relative acceleration of a point belonging to a rigid body. Equation of motion for a rigid body. D'Alembert's principle. Kinetic and potential energy of a rigid body. Principle of work and energy. Conservation of energy for a rigid body. Principle of impulse and momentum for a rigid body. Eccentric impact.
Recommended textbooks for ME2 1. Beer F.P., Johnston E.R. Jr: Vector Mechanics for Engineers. Dynamics . Mc Graw Hill. 2. Soutas-Little R., Inman D.J.: Engineering Mechanics. Dynamics. Prentice Hall

Level of competence	Ability, in M1 and M2.
Skills achieved	Proficiency in applying equations of equilibrium for solving simple statically determinate problems. Ability of applying principles of dynamics for the analysis of motion of particles and rigid bodies.

7. MECHANICS OF MATERIALS *	6.5-8.5 credit points
Course contents	
MM1. *Internal forces in simple structural elements.* **1.** The concept of an internal force and its diagram. Normal forces in struts subjected to axial loads. Diagrams of normal forces in struts. Twisting moments in shafts subjected to torques. Diagrams of twisting moments in shafts. Bending moments in beams subjected to couples. Diagrams of bending moments in beams. Bending moments and shear forces in beams subjected to transverse loads: diagrams of bending moments and shear forces,	

* Elaborated in UBI, Covilha on the base of own experience as well as the syllabi from other 8 universities

differential relationships between bending moment, shear force and distributed load **2. Stresses and strains in simple structural elements:** The elementary concept of a stress and strain**.** Stresses and strains produced by axial tension or compression in straight elements. Stresses and strains in shafts. Stresses and strains in beams subjected to pure bending. Stresses and strains in beams of solid and thin-walled sections subjected to bending and shear. Stresses in elements subjected to eccentric loads and other combined actions **3. Stresses in connector:** Stresses in connecting bolts and rivets. Stresses in welded connections. **4. Deflection lines for beams:** Differential equation of deflection line. Solution of the differential equation of deflection line. Direct integration method. Finite difference method **5. Plane state of stress and strain:** Review of cases where a plane state of stress and plane state of strain predominate. Transformation of plane stresses and strains. Principal values and principal directions for strains and stresses. Mohr's circle for stresses and strains. **6. 3-D state of stress and strain:** Differential equations of equilibrium for an infinitesimal internal part of a body. Equations of equilibrium for an infinitesimal boundary part of a body. Stresses on an oblique plane. Cauchy's stress tensor. Principal values and directions of the stress tensor. Mohr's circle for a 3D state of stress. Three dimensional state of strain. Infinitesimal stain tensor. Principal values and directions of the strain tensor. Compatibility equations**.** Strain energy. **7. Constitutive equations:** Various types of material behaviour**.** Material constants and their determination**.** Constitutive equations for isotropic materials. Constitutive equations for orthotropic materials. **8. Failure criteria for isotropic materials:** The onset of failure**.** Yield criteria: Huber-Mises-Hencky criterion. Tresca criterion. Fracture criterion of Coulomb- Mohr. **9. Stability of struts:** Stable and instable states of equilibrium**.** Stability of spring-rigid rod systems**.** Stability of elastic rods: Euler's formula. Geometrical and load imperfections. Generalization of the Euler formula. Stability of rods in elasto-plastic range **10. Introduction to design of simple structural elements:** Allowable stress versus limit states design philosophy. Dimensioning of simple structural elements (tension elements, shafts, beams and columns).	
Recommended textbooks for MM1: Beer F.P., Johnston E.R. Jr : Mechanics of Materials. Mc Graw Hill.	
Level of competence	Ability in MM.
Skills achieved	Proficiency in plotting diagrams of shear forces and bending moments in beams. Proficiency in calculating stresses and strains in struts and beams subjected to simple and combined actions. Proficiency in calculating displacements in beams. Ability to design a section of an element subjected to simple actions.

8. STRUCTURAL MECHANICS *	7.0-10.0 credit points
Course contents	

SM.1

1. Review of the basic concepts: Types of structures. Modelling of supports. Statical determinacy and indeterminacy. Kinematic stability and instability External actions—dead and live loads, change in temperature, settlements of supports. The concept of internal forces. Plotting the internal forces diagrams for statically determinate beams. **2. Displacements in statically determinate structures:** The Principle of Virtual Work for elastic bodies. Determination of the displacement of a point in a structure by the Principle of Virtual Work: Effect of external loads. Effect of change in temperature. Effect of support settlements. Determination of the deflected shapes of various structures. Deflected lines for beams (review of the material given by a Mechanics of Materials), Deflection of frames. Deflection of arches. Deflection of upper and lower chords of trusses. **3. Influence lines for statically determinate structures:** The concept of an influence line. Determination of the influence lines by the static method. Influence lines for beams. influence lines for frames. Influence lines for trusses. Influence lines for arches. **4. Static analysis of statically indeterminate structures:** Force method: basic concept of the method, application of the force method for the analysis of statically indeterminate trusses, beams, frames and arches. Displacement method: basic concept of the method, classical version of the method – application of the method for the analysis of statically indeterminate beams and frames. Matrix version of the method - application of the method for the analysis of statically indeterminate trusses, beams and frames. Moment distribution method: basic concepts of the method, iteration process for non-sway frames, iteration process for sway frames, effect of settlements of supports and changes in temperature. Frames with non-prismatic members.

SM.2

***5.* Displacements in statically indeterminate structures:** Determination of the linear displacements of points and angular displacements of sections: effect of external loads, effect of settlements of supports, effect of changes in temperature. Determination of the deflected shapes of structures: simple one-span beams, continuous beams, frames, trusses. **6. Influence lines for statically indeterminate structures:** Static approach: influence lines for one-span beams, influence lines for continuous beams, influence lines for frames, influence lines for trusses. Kinematic approach: influence lines for beams, influence lines for frames, influence lines for trusses. **7. Plastic analysis of structures.** Basic concepts: plastic moment of resistance,

* Elaborated in UBI, Covilha on the base of own experience as well as the syllabi from other 4 universities.

ultimate load and collapse mechanisms. Theorems of plastic collapse: static or lower bound theorem, kinematics or upper bound theorem, uniqueness theorem. Methods of plastic analysis: static method, method of mechanisms. **8. Stability of structures:** Stability criteria: energy criterion, stiffness criterion. Stability of simple systems with one degree of freedom: bifurcation of the equilibrium path, snap-troug phenomenon. Stability of complex struts: struts with complex support conditions, struts with stepped moments of inertia. Stability of plane frames: stability functions, numerical methods for determining the critical loads for frames. **9. Dynamics of structures:** Dynamics of SDOF systems: free vibrations, forced vibrations, response to harmonic loading, response to arbitrary loading, response to ground excitation. Dynamics of MDOF systems: free vibrations, forced vibrations. ***SM.3.*** **10 Plates and shells:** Thin plates subjected to in-plane loads. Bending of thin plates: internal forces and moments in thin plates, displacement-strain relations, equilibrium equations. Differential equation of deflected plate, some particular thin plate solutions. Basics of thin shell theory: internal forces and moments in thin shells, displacement - strain relations, equilibrium equations, some particular thin shell solutions. **11. Finite element method:** General idea of the method, Idealisation of structures. Analysis of two- dimensional elements: triangular element, rectangular element. Analysis of an entire structure: assembly of the structure stiffness matrix, determination of the nodal displacements and the element stresses.
Recommended books: 1. Chajes A.: STRUCTURAL ANALYSIS. Prentice Hall

Level of competence	Ability in SM.1, understanding in SM 2, recognition in SM 3
Skills achieved	Proficiency in calculation of inner forces as well as displacements in statically indeterminate structures, familiarity with numerical methods used in analysis of structures, knowledge of fundamentals of theory of plates and shells and of FEM.

9. FLUID MECHANICS AND HYDRAULICS *	4.5-6.5 credit points
Course contents	
*FMH1. **Fluids Mechanics***	
Basic principles. Properties of fluids. Hydrostatics. Pressure and its measurement. Forces on surfaces. Buoyancy and stability. Kinematics of	

* Based on syllabus from Aristotle University Thessaloniki and includes the topics from other 6 universities

fluids. Streamlines. Acceleration. Ideal fluids. Stream function and Potential. Bernoulli equation. Dynamics of real fluids. Mass conservation. Equations of momentum and energy. Navier-Stokes equations. Laminar and Turbulent flows. Characteristics of Turbulence and turbulence models. Friction losses. Laminar and turbulent flow in a pipe. Boundary layers.
FMH2. ***Hydraulics*** Steady flow in closed conduits. Friction losses. Moody diagram. Secondary losses. Energy and piezometric lines. Pipes in series. Parallel Pipes. Equivalent Pipe. Reservoirs and basic problems. Pumps and turbines. Siphons. Cavitatjon. Steady flow in open channels. Uniform flow. Manning's equation. Compound sections. Efficient hydraulic section. Specific energy and force. Critical depth. Control sections. Gradually varied flow. Profiles. Computations. Rapidly varied flow. Hydraulic jump. Jump in a horizontal bed. Location of jump. Weirs and orifices.
FMH3. ***Groundwater Hydraulics and Hydrology*** Darcy's law. Continuity equation. The mathematical model. Boundary conditions. Computations by means of the finite-difference method. Ditches and wells. Method of images. Infiltration force and the phenomenon of piping. Anisotropic and non-homogeneous aquifers. Analogue and physical models. Hydrologic cycle and balances. Measurement and analysis of precipitation and overland flow. Hydrologic parameters for engineering works. Floods and droughts. Simulation of watersheds.

Level of competence	Ability in FMH1, FMH2, FMH3.
Skills achieved	Proficiency in theory of Hydraulics and Fluid Mechanics

10. ENGINEERING SURVEYING *	4.0-6.0 credit points
Course contents	
S1. Principles Introduction. Units of measurement of geodetic parameters. Theory of errors. Concepts of the operation of classic and modern geodetic instruments. Geodetic instruments and methods for the measurement and computation of lengths, angles and height differences. Instruments and methods for the control of high structures. Systems of geodetic projections. Fundamental geodetic problems. Trigonometric determination of points. Polygonometric determination of points. Calibration, adjustment and maintenance of geodetic instruments	
S2. Geodesy Introduction. Surveying of small and big land areas. Digital terrain models. Surveying of buildings, monuments and archaeological sites. Area and volume	

* Based on the syllabus from Aristotle University Thessaloniki and includes the topics from other 6 universities

computations. Setting out of land properties and buildings. Setting out of roads and transportation works, tunnels and bridges. Setting out of port, hydraulic and drainage works. Setting out of dams. Cadastral and technical projects. Setting out of city plans. Expropriation and compulsory purchases. Recent developments in Geodesy.	
S3. Photogrametry and Geoinformation Systems Introduction. Fundamentals of mathematics and physics (for Photogrammetry). Stereoscopy, photography and other kinds of images. Photogrammetric takings, equipment, organisation. Photogrammetric instrumentation. Automated systems. Rectification, orthophotography, aerotriangulation. Close range, terrestrial, satellite and other kinds of Photogrammetry. Photogrammetry and digital terrain models, cartography. Geoinformatjon systems. Photogrammetry and Geoinformatjon systems (GIS). Photogrammetry and Remote Sensing. Applications.	
Level of competence	Understanding in S1, S2, S3
Skills achieved	Proficiency in capture and exploitation of the geographical information as well as in topographic and photogrammetric methods. Familiarity with the use of topographic instruments

11. BUILDING MATERIALS *	4.5-6.5 credit points
Course contents	
BM1. History of evolution of technology of building Materials. Criteria of the selection of building materials. Physicochemical, mechanical thermal and acoustic properties of materials. Quality control and standardization. Specifications. Stones. Classification mineralogical composition. Testing the properties of rocks. Marble. Causes of deterioration. Protection of stones and marble. Crushing of rocks. Aggregates. Origin, production, treatment. Properties of aggregate, sieve analysis. Specifications. Tests for suitability of aggregates for concrete and road construction. Modulus of elasticity of sand and fine aggregates. Ceramics. Raw materials, manufacture, ceramic bricks and roof tiles. Expanded clay - light aggregate for concrete. Properties. Binders. Classification, production, mechanisms of setting and hardening. Regulations. Lime. Sorel binder. Anhydrite Resins. Cement. Manufacture, mechanism of setting and hardening. Testing of properties of cement. Standards. Categories of cement. Mortars. Classification. Synthesis. Properties characteristics. Criteria for suitability of mortars. Specifications. Laboratory	

* Elaborated on the base of syllabi from Aristotle University Thessaloniki and includes the topics from other 6 universities

exercises: Sieve analysis of aggregates. Apparent specific density of coarse aggregate. Bulk density. Granulometric synthesis of aggregates. Measurement of fineness of cement by blaine: Manufacture and test of cement mortars.	
BM2. Concrete. Categories of concrete. Binders. Aggregates. Properties of fresh concrete. Workability. Tests of workability of concrete. Ready mixed concrete. Design of concrete mixtures. Properties of hardened concrete, compressive, flexure, tensile and biaxial actions. Lightweight concrete materials. Concrete bond by pull out test. Composition. Applications.	
BM3. Metallic building materials. Classification. Structure. Steel for reinforcement of concrete. Manufacture tests of steel quality. Corrosion of steel. Laboratory exercises: Design of concrete mixture. Manufacture of the designed concrete mixture. Testing of compressive and flexural strength measurement of steel. Stress strain curve and measurement of modulus of elasticity. Test of steel in tension. Yield point and ultimate elongation. Timber and manufactured boards – properties, durability, protection, products and their application. Thermal and acoustical insulating materials – properties, application. Bituminous materials: asphalt's, tars, mastics. Properties and application.	
Level of competence	Ability in BM1, BM2 and BM3
Skills achieved	Good knowledge of basic building materials' properties and application

12. BUILDINGS *	3.5-4.5 credit points
Course contents	
BC1. System concept and performance applied to domestic, industrial and commercial buildings. Modular coordination in building construction. Basic concepts in building design. Functional process and space planning. Buildings presentation in technical drawings: scale and conventions. Actions on buildings. Loads: permanent loads, live loads, climatic loads. Seismic action. Agents acting on buildings.	
BC2. Design fundamentals. Design codes. Structural planning and typical solutions. Dimensioning methods for structural elements. Seismic analysis. Typical solutions for ductility enhancement.	
BC3. Building infrastructure: basements and foundations. Geotechnical conditions and foundations depth. Typical foundation solutions. Waterproofing of	

* Based on the syllabus from TUCE Bucharest and includes the topics from other 5 universities

basements and foundations. Buildings with cast-in-place and precast concrete structure: shear-wall structures and dual structures. Buildings with masonry structural walls: layout, materials. Buildings with frame structures. Seismic behaviour. Typical solutions. Principles of design. Structural solutions for concrete and steel floor plates. Principles of design. Arches, vaults, domes. Vertical transport: stairs, ramps. ***BC4*** Types of roofs. Roofing works. General characteristic of wood and wooden structures. Cold and warm roofs. Thermal insulation of roofs. Attics and roof lights. Rainwater discharge. Openings and shutters in structural and partitioning walls. Floors: tasks, layout. Floor finishing. Suspended ceilings Partitions walls. Plastering and walls finishing	
BC5 Energy saving in the buildings. Thermal insulation of partitions. Water insulations. Hygrothermal comfort. Acoustical comfort and protection. Fire protection of buildings. Basic concepts for building services. Water supply, drainage and sanitary systems. Electromechanical installation. Heating systems.	
Level of competence	Ability in BC3 and BC4. Understanding in BC1, BC2 and BC5.
Skills achieved	Conception of a building structure. Design components and requirements. Design coordination. Building project layout.

13. BASIS OF STRUCTURAL DESIGN *	3.5-5.5 credit points
Course contents	
***BSD1**. The course presents the role and objectives of structural design within a process of civil and building design as well as the general rules of structural design.* Designing as a creative human activity. Project elements: architectural project - structural project - sanitary systems - construction - cost calculation. Aims and parts of a structural design. Modelling of a structural bearing system in 3D space of a building. Basic information about bearing systems. Partition of a building into independent segments; dilatation. Three dimensional, plane and linear structural systems. Subdivision of a structural system into structural elements. Structural stability and stiffness with reference to different types of structures (reinforced concrete cast in situ and precast, steel,	

* Elaborated on the base of syllabi from Rzeszow and Gliwice

timber, masonry).
BSD2. ***The course regards to the theoretical basis of the reliable structural design.*** General principles of structural design: basic requirements, limit state design. Uncertainties in the building process. Basic variables. Structural reliability analysis: geometrical and behavioural idealization of structures. Development of the structural reliability concepts: deterministic, semi-probabilistic (the Partial Factor Method), simplified probabilistic (Reliability Index Method), full probabilistic. Reliability measures. Models of structural loads: classification of loads, statistical parameters, methods of loads combination. Models of structural resistance: statistical parameters of materials and structural elements, references for models of resistance. Definitions of failure. Analytical, numerical integration and simulation methods in structural reliability and safety analysis. Reliability index: general, mean value, Hasofer-Lind. Uncorrelated and correlated basic random variables. Reliability analysis using simulation. Target values of reliability measures. Calibration of partial safety factors. Probabilistic design of structural elements and simple structures. National Standards and Euro-Codes. Examples of calculations.
BSD3*. The course regards to structural systems reliability, special problems and advanced methods of structural reliability assessment.* Elements and systems reliability. Series, parallel and mixed systems. Reliability bounds for structural systems. Time-variant reliability methods: transfer into independent systems, out-crossing approach, spectral analysis. Design and assessment of deteriorating structures. Life-cycle probabilistic design. Testing based design. Illustrative examples. Development of reliability-based design codes: European standards. Human errors: classification, error surveys, approach to errors. Advanced versions of simulation procedures. Stochastic Finite Element Method – brief introduction.

Level of competence	Ability in BSD1, Understanding in BSD2, Recognition in BSD3
Skills achieved	Proficiency in the knowledge of the behaviour of the most habitual structures as well as familiarity with the methods of conventional analysis.

14. ENGINEERING GEOLOGY *	3.0-4.0 credit points
Course contents	
G1. ***The course provides an introduction to fundamentals of Geology.*** The Earth zones. Geological processes of internal and external origin. Absolute and relative age of rocks. Geological time table. Tectonic	

* Elaborated on the base of syllabi from Riga, Aristotle University Thessaloniki, Cantabria and NTUA Athens

movements of Earth crust. Folding and faulting. Earthquakes. Seismic zoning and micro zoning. Weathering. Geological activities of wind. Eolian deposits. Water erosion. Sheet erosion. Gullies. Geological work of rivers. Alluvial deposits Glaciers. Glacial till, fluvioglacial and limnoglacial deposits. Coastal environment, marine erosion and deposition. Longshore drift. Swamps. Peat depositions. Origin of subsurface water. Aquifers, aquicludes. Ground water, capillary fringe, perched water, confined water. Water aggressiveness. Groundwater regime. Groundwater motion. Darcy's law. Determination of the coefficient of permeability. Inflow to foundation pits, trenches and wells. Geological activities of groundwater: karst, piping, landslides, frost heave. Rock-falls, talus, creep. Man-made geological process.

G2. *Geology and Geotechnics*

Engineering geological and geotechnical investigations. Engineering geology and geotechnics. Geotechnical problems in design. Engineering geological conditions of building site. Geotechnical design requirements of Eurocode. Geotechnical supervision. Field exploration: boring, sampling. In situ tests: cone penetration tests, standard penetration test, dynamic propping test, pressure meter test, field vane tests, plate loading test etc. Geophysical methods of investigation.

G3. *The course includes the study of advanced problems in engineering geology.*

Aspects of dam geology. Geology and tunnelling. Geology and surface excavations. Case studies of failures of civil constructions due to geological factors. Aspects of Environmental Engineering Geology. Practical exercises-Engineering applications.

Level of competence	Understanding in G1, G2, Recognition in G3.
Skills achieved	Proficiency in application of geology to civil engineering problems as well as familiarity with geological fundamentals.

15. SOIL MECHANICS AND GEOTECHNICAL ENGINEERING [*]	5.5-7.5 credit points

Course contents

SMG1. ***Geotechnics***

Soil and Rock identification. Soil classification (including geotechnical categories). Nature, physical and mechanical properties of soil. Ground water – appearance and phenomenon connected with it. Properties of dry and saturated soil. Laboratory and in-situ tests. Basic soil models. Bearing capacity of soils and foundations. Allowable pressure. Limit states. Stress distribution in the subsoil (total and effective stresses). Theory of consolidation and rheology of soil. Soil settlements. Slope stability.

[*] Based on the syllabus from Gliwice and includes the topics from other 7 universities

SMG1. ***Foundations*** Definitions, models and types of foundations. Limit states. Partial safety factors (Eurocode 7). Shallow foundations (including design). Deep foundations (especially pile foundations, including design). Excavations and protecting deep excavations. Dewatering of excavations.	
SMG3. *Special foundations and ground improvement techniques* ***Special Foundations*** **-** Wells and caissons. Diaphragm walls. Retaining structures. Structures of reinforced soil. ***Ground Improvement Techniques*** **-** Surface strengthening (mechanically stabilization, binder sealing), soil replacement, static and dynamic compaction, vibro systems (vibrocompaction, stone columns), grouting, micropiles, jet grouting method, vertical wick drains, lightweight fill materials, geotextiles, slope stability: anchoring, nailing.	
SMG4. *Advanced problems in geotechnics* Geotechnical problems in environmental protection. Seismic and para-seismic influences on soil behaviour. Numerical soil models.	
Bibliography: [1] Atkinson J.H., Bransby P.L. (1978): The mechanics of soil. An introduction to critical state soil mechanics. McGHRAW-HILL Book Company (UK) Limited, London, New York, St Louis, San Francisco, Auckland, Bogota, Düsseldorf, Johannesburg, Madrit, Mexico, Montreal, New Delhi, Panama, Paris, São Paulo, Singapore, Sydney, Tokyo, Toronto. [2] Foundation Engineering Handbook Edited by Hans F. Winterkorn and Hsai-Yang Fang (1975). Van Nostrand Reinhold Company, New York, Cincinnati, Toronto, London, Melbourne. [3] Head K.H. (1992): Manual of soil laboratory testing. Volume 1, Soil classification and compaction tests. Volume 2, Permeability, shear strength and compressibility tests. Volume 3, Effective stress tests. Second Edition. Halsted Press: an Imprint of JOHN WILEY & SONS, INC. New York – Toronto.	
Level of competence	Ability in SMG1 and SMG2, Understanding in SMG3, Recognition in SMG4.
Skills achieved	Proficiency in basic knowledge on identification and classification of soil and ability in designing shallow and deep foundations, familiarity with the knowledge of advanced problems in geotechnics such seismic and para-seismic activity, numerical soil models and application of Finite Elements Method in geotechnics.

16. STRUCTURAL CONCRETE *	6.0-9.0 credit points
Course contents	
RC1. ***The course regards to the design of RC beams, one way slabs and columns, comprising the dimensioning rules under bending, shear and torsion (beams) as well as simultaneous action of bending, and axial force (columns) with regard to ultimate load and serviceability limit states.***	
Concept and idea of concrete reinforcement. Historical background. Material properties - concrete and steel. General characteristic of RC design principles (limit state approach), EC2 and national version. Design of beams(rectangular and T section) with regard to ultimate load limit state under bending, shear and torsion. Single- and multi-span one-way slabs and beams. Design of columns subjected to axial force and bending. Compression: general rules, slenderness and stability. Design with regard to ultimate load limit state for rectangular section. M-N interaction diagrams. Confined columns. Tension: design with regard to ultimate load limit state for rectangular section. Limit states of serviceability - deflection of RC beams, cracking in reinforced concrete.	
RC2.*The course regards to principals of RC elements design. These principals will be presented at simple and popular in constructional practice elements such as floor structures (beam-and-slab, flat slab), stairs, frames, and retaining walls.*	
Beam-and-slab floors. Two-way slabs: calculation in elastic stadium and by critical load method; reinforcement distribution. Reinforced concrete stairs. Reinforced concrete frame structures. Approximate methods of frame analysis under vertical and horizontal load. Computational methods of frame analysis. Reinforcing rules for frame structures. Reinforced concrete spot footings and strip foundations. Spot footings for pre-cast columns. Retaining walls: calculation and rules of reinforcing.	
RC3*. The course regards to principals of pre-stressed concrete.*	
Concept of pre-stressing of structural concrete members. Materials and techniques for pre-stressed concrete. High strength concrete and steel for pre-stressing. Pre-tensioning and post-tensioning techniques. Losses of pre-stressing force – short time and long term effects. Basic assumptions and procedures for design of prestressed concrete members subjected to bending for serviceability limit state and ultimate limit state methods Verification of limit states in prestressed members.	

* Based on the syllabus from Gliwice and includes the topics from other 6 universities

***RC4*.** Brief presentation of advanced reinforced concrete and pre-stressed structures proving the possibilities and advantages of structural concrete.	
Level of competence	Ability in RC1 and RC2, Understanding in RC3, Recognition in RC4.
Skills achieved	Proficiency in calculation of reinforcement and loading capacity of beams, slabs and columns subjected to bending moment, shear and axial force as well as familiarity with reinforcing rules for elements discussed within RC2.

17. STEEL STRUCTURES *	5.0-7.0 credit points
Course contents	
SS1. ***The course regards to the design of SS beams, slabs and columns, comprising the dimensioning rules under bending, shear and torsion as well as simultaneous action of bending, and axial force with regard to ultimate load and serviceability limit states.*** Concept and idea of steel structures. Historical background. Materials (material properties, ductility, fracture toughness, production tolerances design, values of material coefficient). Basis of design (Principles of limit states design, design actions, design resistance, design codes, environmental influences).Structural analysis (structural modelling, global and local structural analysis, imperfections, material and geometrical non-linearity, elastic and plastic global analysis, cross section classification). Limit state evaluation. Resistance of cross sections (tension, compression, shear and bending resistance of members, torsion, combination of basic resistances). Buckling resistance of members (uniform compression members, built-up compression members, lateral- torsional buckling of beams). Buckling of plates (column type buckling behaviour, single plate elements with longitudinal stiffeners, resistance to shear, resistance to transfer loads, interactions of shear force, bending moment and axial force on web stability). Design of joints (welded connections, bolts, rivets, pins, analysis and modelling). Beams. Trusses. Design and detailing of beams and trusses' joints and nodes. Fragile breaking and fatigue. Laboratory-practices in welding, flexion, buckling, screws and extensometers.	

* Elaborated on the base of syllabi from Pardubice and Rzeszow

SS2. *The course regards to principles of popular SS design.* Types of steel structures, industrial structures and buildings. General arrangement and analysis of structural system. Modelling of structures. Space rigidity of steel structures Evaluation of internal forces. Design of multi-storey buildings. Roofs. Roof trusses, Flooring systems. Design of column base plates. Design particularities of crane girders. Tubular constructions. Structural details and their static models, application of computer technique. Design for fire. Design particularities of prestressed girders. Fabrication of steel structures. Erection. Corrosion protection.
SS3. *The course regards to principles of advanced SS design.* Steel bridges: Types of bridges (railroads bridges, highways, bridges). Structural detailing (Deck plates, main girders). Plate girders truss bridges, arch, suspended and cable-stayed bridges. Introduction to the design of bridges. Cold-formed steel structures: corrugated steel sheets, thin-walled structural elements - design rules and application. Aluminium and stainless steel as structural materials, basis of design, EC9 approach, implementation. Design of multi-storey buildings. Industrial steel structures: tanks for oil and water, containers for granular materials (bins and silos), steel lattice towers and guyed masts, steel chimneys, steel and composite bridges. Strengthening of steel structures.
SS4. Brief presentation of advanced steel structures proving the possibilities and advantages of steel structures.

Level of competence	Ability in SS1 Understanding in SS3 and SS3, Recognition in SS4.
Skills achieved	Proficiency in calculation of loading capacity of beams, slabs and columns subjected to bending moment, shear and axial force as well as familiarity with design rules for elements, ability to utilize theirs knowledge in building praxis.

18. TIMBER – MASONRY – COMPOSITE STRUCTURES *	3.0-4.0 credit points
Course contents	
TMC1**.** ***Timber structures.*** Wood as a building material. Timber in construction. Solid timber, glued laminated timber, wood-based materials. Material properties. Limit states and design situations – design requirements, ultimate limit states, and serviceability limit states. Stress-strain relations. Calculation models. Tension, compression, bending, shear, torsion, combined bending and axial	

* Elaborated on the base of syllabi from Brno, Pardubice, Zilina, Gliwice and Vilnius

tension, combined bending and axial compression. Columns and beams. Trusses – general analysis, trusses with punched metal plate fasteners. Roof and floor diaphragms. Bracing of beam or truss systems. Joints – timber-to-timber joints, steel-to-timber joints, joints made with punched metal plate fasteners. Structural detailing and control. Structural systems – plane frames and arches, timber frame houses, timber concrete composite structures, round-wood structures, spatial frames and domes.

TMC2. *Masonry structures*

The course regards to the design of widely comprehended un-reinforced masonry structures in addition to simplified cases of masonry walls and columns subjected to compressive loads acted with eccentricity, in-plane bending walls and walls subjected to lateral loads.

Materials for masonry structures. Specific of design and workmanship of masonry structures. Influence of some factors on mechanical properties of masonry. Theoretical model of failure of masonry elements under compression (Hilsdorf criterion). Mechanical properties of masonry: σ - ε relationship, compressive strength, bending strength, shear strength, modulus of elasticity, shear modulus, deformation of masonry (non-dilatational strain angle). Design masonry elements under compressive loads. Design of external walls subjected to lateral loads. Reinforced and prestressed masonry. Masonry arches.

TMC3. *Composite structures*

Steel-concrete composite structures: slabs, beams, columns, beam-columns - design and application. Timber-concrete composite structures. Concrete-masonry structures: floor structures, walls and columns.

Level of competence	Ability in TMC1, TMC2 and in TMC3
Skills achieved	Proficiency in calculation and familiarity with basic rules of design of timber, masonry and composite structural elements,.

19. TRANSPORTATION INFRASTRUCTURE *	3.5-4.5 credit points

Course contents

T1. *The course regards to the design* to principals *of transportation engineering*

Traffic engineering documentation, planning process in transportation engineering. Methodology, types and census organisation. Traffic forecast. Public transport. Network, Integrated Transport Systems. Traffic accidents. Reasons, statistical evaluation, arrangements to accident risk decreasing. Capacity calculation of the roads and intersections. Traffic management Provision/encouragement of non-motorised traffic modes (cycling, pedestrians). Introduction to the transport prognosis

* Based on the syllabus from Pardubice and includes the topics from other 7 universities

T2. *The course regards to principals of* railway lines. Railway construction history and development of railway lines. Main characteristic of rail types. Principles of track and construction design. The basis of organisation and protection of railway traffic. Alignment of lines inside and outside towns. Solution of interconnections, switch junctions and embranchments, renovation of railway substructure and superstructure, reconstruction and maintenance of rail tracks. Principles of drainage of a line and a station Mechanisation used in track works in railway superstructure and substructure, diagnostics of geometric track position	
T3. *The course regards of* road, road constructions and urban planning: Road user and vehicle characteristics. Road junctions - non-signalised, traffic signals, roundabouts, multilevel junctions. Introduction to the traffic flow theory.. Highway and roads planning and location. Basic design principles. Environmental protection measures in road construction process. Categorisation of the roads and highways. Traditional and modern sub-base construction components. Soil improvement and stabilisation. Mechanization of earth work. Technology of construction of typical subgrade. Earth work designing. Construction of road surfaces. Elements of pavement design: materials, types, analysis. Methods and equipment of pavement construction. Roads and streets dewatering. Basis of building organization, management and planning. Investment processes, Costs and design. Maintenance works. Modern materials and technologies used in roads maintenance.	
Level of competence	Ability in T1 Understanding in T2 and T3.
Skills achieved	The students should achieve the skills in designing and evaluation of road route and road construction, transport system in towns, urban traffic, urban road network, traffic flow theory, organisation of traffic.

20. URBAN AND REGIONAL INFRASTRUCTURE *	2.5-3.5 credit points
Course contents	
***UP1**. The course provides a comprehensive introduction to the urban and regional science.* City and Urbanism: conceptual aspects. History and models of urban development. Principles and theories of urban structure and regional organization. Social, economic and environmental context in which planning issues arise.	
***UP2.**The course focus on theories, methods and techniques of Urban and Regional Planning.*	

* Based on the syllabi from Cantabria and Aristotle University Thessaloniki

Theoretical underpinnings of past and contemporary approaches to planning. Institutional context and legal framework within which planning operates. Types of plans: Regional, master and site plans. Planning process: How to formulate & implement Plans. Planning Analysis: Database systems, information resources, elements and techniques. Discovering and exploring alternatives. Urban design problems and methods. Instruments for urban and regional management.	
***UP3**. The course regards to principals of infrastructures, community facilities and services.* Types of infrastructure systems (water, sewer, storm water, solid waste and transportation) and facilities (parks, schools, libraries, police, fire…). Standards to meet citizens´ needs. Location criteria.	
***UP4**. The course approaches aspects of professional planning practice.* The course includes a report and the completion of a dissertation by groups related to a planning project.	
Level of competence	Ability in UP1 and UP2, Understanding in UP3, Recognition in UP4.
Skills achieved	Proficiency in conceptual framework, analysis and planning methods as well as familiarity with graphic expression techniques and urban design.

21. WATER STRUCTURES AND WATER MANAGEMENT *	3.0-4.0 credit points
Course contents	
WS1. ***Introduction into Hydraulic engineering*.** Introduction, circulation of water, definitions. Precipitation, evaporation, discharge. Analysis of discharge measurements, design flood. Design flood, catchment area. Ecology of surface water bodies. River training. Hydraulic constructions on rivers. Flood protection and hydropower (overview). Ships and waterway channels. Navigational structures. Locks. Ports. Coastal engineering. Legal foundations of water related projects. Preparation of examination	
***WS2.** Introduction into hydrology, ecology of surface water bodies, river training, coastal engineering (overview), waterway channels, locks (overview).* Introduction, circulation of water, definitions. Precipitation, evaporation, discharge. Evaluation of discharge measurements, design flood. Appraisal of design flood, catchment area, SCS-equations. Appraisal of discharge, when precipitation is known. Ecology of surface water bodies, valuation systems for the ecological status. Open channel hydraulics, sediment transport. Design and realisation of River training. Design and construction of weirs and dams.	

* Elaborated on the base of syllabi from Oldenburg, Prague and other 5 universities

Design and construction of outlets, inlets, culverts. Flood protection (overview), drainage. Navigational structures (overview). Coastal engineering (overview). Legal foundations of water related projects.
WS3. *Water Structures.* Water Supply and Structures for Water Supply, Waste Water Treatment and Structures. Stream – channel Regulation and Revitalization. Irrigation and Drainage. Ponds, Water Reservoirs, Dams. Hydro Power – Low and High Head Water Power Plants. Weirs and Navigation.
***WS4*. *** *Water Management.* Water Balance, Water Resources and their Protection. Legal Foundation in Water management and Planning.

Level of competence	Understanding in WS1,WS2, WS3, Recognition in WS4
Skills achieved	Proficiency in the design of water structures as well as familiarity with water management techniques.

22. CONSTRUCTION TECHNOLOGY AND ORGANISATION *	4.5-6.5 credit points
Course contents	
***CTO1*. ** *Construction Technology* Characteristic of building production. Principles of building processes design. Comprehensive mechanization. Machinery and equipment used in building. Technology of building transport, materials handling, long-distance transport, horizontal transport, vertical transport. Technology of earth work, land leveling, excavations, backfilling, compaction of earth works. Technology of concrete and reinforcing works. Technology of assembling, selection of assembling equipment, types of lifting sling, technology of assembling of basic structural elements. Economic means and their sources. Basic principles of accountancy. Specific attributes of building accountancy. Fillings of enterprise activity. Finance accountancy and analysis of account of results. Analysis of enterprise activity and evaluation of finance situation. Application of finance activity in recording of economic operation.	
CTO2. *Organization and Management* Essentiality of network method. CPM method. Building graphic schedules. Basic principles of site organization. Methods of organization of the site (deterministic approach). Progress of the site-work management. Compensation of perturbations in building engineering processes. Principles of design of site planning. Elements of design of site road access. Designing of stockyards. Equipment on the site. Designing: Selected elements of designing of organization and site planning (for small and not complicated	

* Based on the syllabus from Bialystok and includes the topics from other 4 universities.

building project). Network design according to CPM method; analysis of network dependence time; basic building time schedules; conceptual lay-out of the building site. Basic organizational structures of building engineering tasks and processes. Methodology of technology and organization processes designing. Formulation of criteria and methods of selection of building processes models.
***CTO3**. Organization and Management* Time-costs analysis of building engineering tasks. Methods of selection of equipment and production plants. Problems and methods in designing of interior transport roads. Conditions for storing of basic building materials. Deterministic evaluation of building materials reserves. Methodology in determining of surfaces and front of storage area. Location of production plant and material back-up on the site. Bases of optimal realization of building processes Formulation of extreme tasks in building engineering processes. Criteria, decisive variables and limitations in formulation of tasks. Classifications of optimization problems and methods their solving. Transportation problems as the task of linear programming. Methods of solving in non-linear tasks from Kuhn-Tucker's conditions. Problems of building processes optimization in assumptions of theory of random variable function , application in tasks of theory of mass service. Problems of optimization of graphic schedules - realization of construction works on lots in operational sequence ensuring the shortest construction period.

Level of competence	Ability in CTO1 and CTO2, Understanding in CTO3
Skills achieved	Proficiency in calculation and scheduling of different resources needed for a building process and familiarity with building technology and technological order of main construction works.

23. ECONOMICS AND MANAGEMENT *	5.0-7.0 credit points
Course contents	
***EM1.** Building Economics* *Building cost calculations - resource cost:* Management and control. Estimate cost. Tendering planning. Calculation of unit rates. Calculation of preliminary and temporary works. Cost classification. Cost monitoring and cost control on site. Cost analysis. Estimate of profit, risk, and inflation. Economics, human and resources. Investment policy.	
Finance resources of investments: Working capital. Credits and save deposits. Performance efficiency. Planning methods of building works.	

* Elaborated on the base of syllabi from Gliwice, Prague other 4 universities.

Building - invest market. Building contractor - organisation form commercial activity: Structure, function of building construction company. Investment analysis. Introduction to marketing. Participants of investment process: investor, contractor, bank, designer, etc. *Licence and duties*: architect, surveyor, and site manager. Planning methods of building works. Hardware and software and their practical application within organisations. Schedules networks. Business presentations using various software packages for work processing, financial mobility databases spreadsheet, graphics and project management packages. Aims of: business, invest, investment. Establishment and its connections with market of: work, outlet, equipment, capital, human environment. Project and cost documentation of investment. Processing dimension and types of building process. Assignation conditions, methods and manners making building process. Estimate resources to realising process. Assignation orders and times to realise building process. Production and market planning. Building marketing. Market strategy. Cost counting. Supply and demand. Function of the invest -building market. Procurement studies - alternative tendering/ contractual arrangements. Application and consideration - case studies. Function and format of procedure systems, tendering and contractual arrangement. Financial control of pre and post contract. Valuation of progress and the variations in work. Application of computer software in the administration	
EM2. *Project Management* Management of life cycle of construction projects. Analysis of project phases. Types of construction contracts. General Conditions of Construction Contracts including Design/Build. Principles of estimating. Time scheduling. Cost control. Contruction Operations Manual - policies and procedures. Contract documents management. Project engineering. Controlling	
EM3. *Special Topics of Construction Management* Preparing bids for international projects and general approach to international constructing. Risk management systems for construction projects. Management of equipment and other capital investment. Procurement in construction firm and projects, Information technologies for project management.	
EM4. *Management of Construction Firms*: Strategic corporate management, organizational strategy, business management, company operations handbook, corporate financing, financial analysis and performance benchmarking, management accounting and internal market, capital investment, controlling, auditing, valuation of firms, crisis management, litigation and claiming.	
Level of competence	Ability in EM1 Understanding in EM2, Recognition in EM3 and EM4.
Skills achieved	Proficiency in project planning, project

	management, familiarity with management basis of construction firms

24. ENVIRONMENTAL ENGINEERING *		3.5-4.5 credit points
Course contents		
***EE1**. Ecology.* Environment, biosphere, natural resources. Elements of ecology: ecosystems, symbiotic and antagonistic relationship, ecological niche, biocenosis and biotop. The turnover of materials and energy in ecosystems. Point and non-point sources of pollutants. Fate of pollutants in environment. Effects caused by environmental pollutants in various ecosystems. Acidification and eutrophication of terrestrial and aquatic ecosystems. The essence of critical load approach. Toxicology, uptake of toxic pollutants, effects in individuals and ecosystems. Technical means for improving environmental quality. Air cleaning methods. Wastewater treatment practice. Solid waste, sources and categories. Handling of solid waste. Environmental monitoring, main aim and objectives. Implementation of environmental monitoring. Subprogrammes of integrated monitoring. Physical pollution: ionizing and non-ionizing electromagnetic radiation, noise, vibrations and thermal pollution. Effects on humans and means of protection from physical pollution. How much the environment should be improved? Value of our environment. Policy instruments used for reduction of environmental pollution. International environmental programmes.		
***EE2.** Soil, air and water pollution.* Pollution sources (point, non-point sources), air pollution, soil contamination.		
***EE3** Waste treatment, remediation.* Waste water treatment, methods of sludge treatment, dumping, incineration, composting, wetlands. Toxicology. Policy instruments for reduction of environmental pollution.		
***EE4.** Basic information about building services.* Water supply. Heating. Sewage systems. Air condition systems. Wiring.		
Level of competence	Recognition in EE1, Understanding in EE2, EE3, EE4.	
Skills achieved	Understanding of the basic environmental processes, soil, air and water pollution and treatment methods. Familiarity with basic ecological principles and functions. Familiarity of building services.	

* Based on the syllabi from Prague and Vilnius with additional part EE4.

25. NON-TECHNICAL SUBJECTS	5.0-7.0 credit points
Course contents	
NT1. **English language**	
NT2. *Building Law* Building law in National and European Law System. Terminology used in building law. Principle of design, construction and maintenance accordance with regulations. Rights in disposing of real estate for building purposes. Protection of individual interest in Building Law. Building technical regulations and principles of building technical knowledge. Proceeding principles of administrative building engineering supervision and technical architectural management. Conditions in obtaining permission for construction. Construction and operational commissioning of building. Exploitation of buildings. Building catastrophe. Individual technical function in building engineering - amenability to law and technical.	
NT3. *History of Civil Engineering and Architecture* Beginning of civil engineering and architecture in prehistoric and ancient age. Ancient Greek and Rome. Early Christian and Medieval C.E. and Architecture. Renaissance, Baroque and Rococo. C.E. and Architecture from 19th and beginning 20th century. Contemporary C.E and Architecture.	
NT4. *Aesthetics. The aim of the course is to define the object and content of aesthetics as a field of science. To learn how to find and perceive beauty by the way of cultural heritage.* Aesthetics as a field of science about beauty and art; object and tasks of aesthetics, aesthetic categories; categories of aesthetics, aesthetic experience. 2. Prehistoric art. 3. Ancient art. 4. Art of Middle Ages. 5. Renaissance art. 6. Art of Baroque and Rococo. 7. Art of Classicism. 8. - 9. Art forms of the 19th century. 10. – 11. Art forms of the 20th century. 12. National Art.	
NT4. *Ethics* The course is focused on acquisition of the fundamentals of ethics. It seeks to understand morality as a social phenomenon, its origin, development and role in society. Basic human values and social norms. It also examines many dimensions of the term “meaning of life”. An analysis of interpersonal relationships in contemporary society is also included.	
NT5. *Philosophy* The aim of this subject is to provide the students with a survey of cardinal problems of individual philosophical disciplines (ontology, epistemology, philosophical logic, methodology, philosophical anthropology, social philosophy, aesthetics, axiology and ethics). The intention is a transfer of problems solved in the range of history of philosophy to modern language and updating of the demand of clear explications of fundamental scientific categories as an inevitable condition for a reasonable dialogue between sciences (physics) and philosophy.	

NT6*.* *Psychology* This course aims to give the student knowledge on the object, system, content, goal and development of psychology with an accent on academic psychology. To explain some basic conceptions and categories. General psychology offers knowledge which can be used as a foundation for extended psychological themes.	
NT7*.* *Economics* Market, its' equilibrium, elasticity, costs and profits differentiation, perfect competition, calculation of gross national product, money demand and supply, regulation of exchange rates, prices stabilisation means. Object of economics science in market conditions. Behaviour and market consumer. Costs and profits. Competition, its model and economic effect. National product and its calculation. Cyclic fluctuations. Fiscal policy. Money, banks and monetary policy. Inflation and economic stabilisation. Currency courses and the international financial system.	
Level of competence	Ability in NT1, Understanding in NT2, Recognition in at least one from among NT3-NT7.
Skills achieved	General Education

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[1] American Society of Civil Engineers (ASCE), BOK Committee of the Committee on Academic Prerequisites for Professional Practice: ***Civil Engineering Body of Knowledge for 21st Century. Preparing the Civil Engineer for the Future***, January 2004.

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[3] MANOLIU Iacint et al. (editor): **Inquiries into European Higher Education in Civil Engineering. EUCEET volumes 1, 2, 3 & 4**, Bucharest, 2001, 2003.

[4] MANOLIU Iacint (editor): ***Challenges to the Civil Engineering Profession in Europe at the beginning of the third millennium.*** Proceedings of the EUCEET-ECCE International Conference, Sinaia, Romania, 13-17 July 2001, EUCEET volume 2, Bucharest, 2002.

[5] Permanent Conference of University Professors of Building Physics: **MEMORANDUM on teaching of Building Physics for Universities and Scientific Colleges,** Bauphysik, 21 (1999), issue 4, p 171-175.

Appendix 1

List of the SP1 group

No	Name/Surname	University	City	Country
1	BARANSKI Wojciech	Technical University of Lodz	Lodz	Poland
2	BERKOWSKI Piotr	Technical University of Wroclaw	Wroclaw	Poland
3	BREABAN Virgil	Ovidius University Constantza	Constantza	Romania
4	BUGNARIU Tudor	Technical University of Civil Eng.Bucharest	Bucharest	Romania
5	COKCA Erdal	Middle East Techn. University Ankara	Ankara	Turkey
6	DICKY Josef	Slovak Univ. of Technology	Bratislava	Slovak Rep.
7	ESPINO Manuel	Technical University of Catalonia	Barcelona	Spain
8	FANNING Paul	University of Dublin	Dublin	Ireland
9	JUTILA Aarne	Helsinki University of Technology	Espoo	Finland
10	KLEMCZAK Barbara	Silesian University of Technology	Gliwice	Poland
11	KOWALCZYK Ryszard	University of Beira Interior	Covilha	Portugal
12	KURAZ Vaclav	Czech Technical University Prague	Prague	Czech Rep.
13	LAPKO Andrzej	Technical University of Bialystok	Bialystok	Poland
14	LAUR Toomas	Tallin Technical University	Tallin	Estonia
15	LERAU Jacues	Inst. National des Sciences. Appliqueés INSA	Toulouse	France
16	LINHARTOWA Yveta	University of Pardubice	Pardubice	Czech Rep.
17	LOVAS Antal	Budapest Univ. of Techn. and Economics	Budapest	Hungary
18	MAJEWSKI Stanislaw **(chairman)**	Silesian University of Technology	Gliwice	Poland
19	MANOLIU Iacint	Technical Univ. of Civil Eng. Bucharest	Bucharest	Romania
20	MATERNA Alois	Technical University of Ostrava	Ostrava	Czech Rep.
21	NOGUES LINARES Soledad	Technical University of Cantabria	Cantabria	Spain
22	PAPANICOLAU Panos	University of Tessaly		Greece
23	PRETORIAN Alexandrina	Technical Univ. of Civil Eng. Bucharest	Bucharest	Romania
24	SERTLER Hynek	University of Pardubice	Pardubice	Czech Rep.
25	SMIRNOVS Juris	University of Riga	Riga	Latvia
26	STEPANEK Petr	University of Technology Brno	Brno	Czech Rep.
27	STRAGYS Vincentas	Vilnius Gediminas University	Vilnius	Lithuania
28	THIMUS Jean Francois	Catholic University of Louvain	Louvain	Belgium
29	VELLANDO Pablo	University of La Coruna	La Coruna	Spain
30	VILA Xavier Sanchez	Technical University of Catalunya	Barcelona	Spain
31	WOLINSKI Szczepan	Technical University of Rzeszow	Rzeszow	Poland

Weighted Average Algorithm

The average value of credits for the core subjects was calculated according to the following algorithm:

1. In the first iteration the wage coefficients are assumed as $w_i = 1$.
2. The average value is calculated with assumed wage coefficients

$$c_{sr} = \sum_{i=1}^{n} w_i c_i \left(\sum_{i=1}^{n} w_i \right)^{-1}$$

3. For every data the deviation c_i is calculated as $\Delta_i = \left| c_i - c_{śr} \right|$
4. New wage coefficients are calculated in dependence on the above deviation from the formula: $w_i = b^{-\Delta_i / c_{sr}}$.
5. Return to point 2.

The variation of average values for selected subjects is presented in figure 1. Quick convergence towards the weighted average can be observed. The coefficient *b* effects only on the rate of the convergence without any influence on the final average value.

The algorithm effectively eliminates these data, which strongly differ from the average value. Let us observe, that in the subsequent iterations we don't remove any results only correct the wage coefficients, adjusting them to their deviation from the average value.

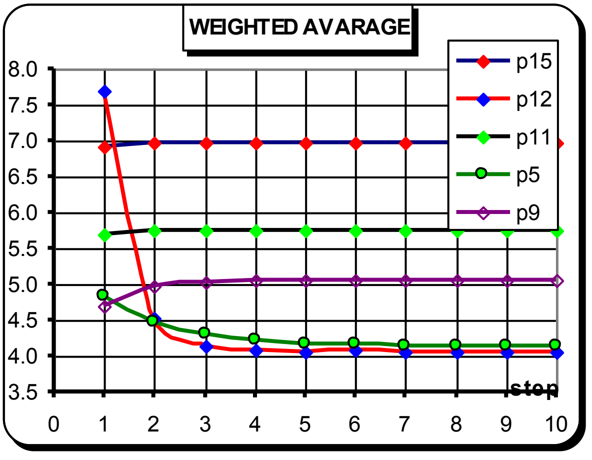

Figure 1. Variation of weighted average in the subsequent steps of iteration.

The calculations were carried out in the following Excel spread sheet.

iter	c_1	c_i	c_n	$c_{sr} = \sum_{i=1}^{n} w_i c_i \left(\sum_{i=1}^{n} w_i \right)^{-1}$
1		$\Delta_{i,1} = \lvert c_i - c_{śr} \rvert$		
		$w_{i,1} = b^{-\Delta_{i,1} / c_{sr}}$		$\sum_{i=1}^{n} w_{i,1}$
		$c_{i,1} = w_{i,1} c_i \left(\sum_{i=1}^{n} w_{i,1} \right)^{-1}$		$c_{sr,1} = \sum_{i=1}^{n} w_{i,1} c_{i,1} \left(\sum_{i=1}^{n} w_{i,1} \right)^{-1}$
2		$\Delta_{i,2} = \lvert c_i - c_{śr,1} \rvert$		
		$w_{i,2} = b^{-\Delta_{i,2} / c_{sr,1}}$		$\sum_{i=1}^{n} w_{i,2}$
		$c_{i,2} = w_{i,2} c_i \left(\sum_{i=1}^{n} w_{i,2} \right)^{-1}$		$c_{sr,2} = \sum_{i=1}^{n} w_{i,2} c_{i,2} \left(\sum_{i=1}^{n} w_{i,2} \right)^{-1}$
k		$\Delta_{i,k} = \lvert c_i - c_{śr,k-1} \rvert$		
		$w_{i,k} = b^{-\Delta_{i,2} / c_{sr,k-1}}$		$\sum_{i=1}^{n} w_{i,k}$
		$c_{i,k} = w_{i,k} c_{i,k} \left(\sum_{i=1}^{n} w_{i,k} \right)^{-1}$		$c_{sr,k} = \sum_{i=1}^{n} w_{i,k} c_{i,k} \left(\sum_{i=1}^{n} w_{i,k} \right)^{-1}$

Report of the
Working Group for the
Specific Project 2

Practical placements as part of the civil engineering curricula

Report of the **Working Group** for the Specific Project 3

Environmental and sustainable development matters in civil engineering education

Report of the
Working Group for the
Specific Project 4

The need for subjects complementing civil engineering technical studies in CE curricula

Report of the
Working Group for the
Specific Project 10

Specialised knowledge and abilities of graduates of civil engineering programmes

Report of the
Working Group for the
Specific Project 11

Academic and professional recognition and mobility of European civil engineers

Report of the **EUCEET-Tuning** Task Force on the Cooperation as a Synergy Group of the Thematic Network **EUCEET** (European Civil Engineering Education and Training) with **Tuning**

EUCEET - Tuning

Theme A

Curricula issues and developments in civil engineering

Theme E

Recognition of academic and professional civil engineering qualifications