

## THE ELEMENTS OF THE QUALIFICATIONS STANDARD FOR AN ENGINEERING STUDY PROGRAM AT THE BACHELOR LEVEL

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### ABSTRACT

*The report presents the elements of the Qualifications Standard for an engineering study program based on learning outcomes. The study is a summary of main outputs of the Joint EU/CoE Project "Strategic Development of Higher Education and Qualification Standards", Component 2-Qualification Standards, conducted by the authors as a working group for engineering. The basic approach and strategy in implementing the project activities are briefly explained and the minimal elements of qualifications standard for the study program of Civil Engineering at the first study cycle are suggested. Once implemented, the Qualifications Standard should assure a higher quality in engineering education and be in accordance to the European High Education Area.*

**Keywords:** qualifications standard, engineering, learning outcomes

### 1. INTRODUCTION

The Bosnia and Herzegovina Qualifications Framework (BHQF) [1] is at an early stage of development, having a set of generic descriptors designed to describe different levels of achievement in a generic education field. These generic level descriptors require further specification in specific areas of education. The joint EU/CoE project, termed "Strategic Development of Higher Education and Qualification Standards (QS)", took up the task of developing and specifying the level descriptors in five selected subject areas applying to higher education qualifications, namely agriculture and food processing, engineering, ICT,

economy/business studies and teacher education. The aim was to develop sufficient subject-related content in the selected areas which will become standards to make them a useful tool for stakeholders, i.e. academic staff, professionals and employers, thus contributing to the qualifications framework in Bosnia and Herzegovina [2,3]. The qualifications standards should provide benchmarks for quality assurance and international recognition of qualifications, as well as contribute to a harmonisation of the education and degree system across Bosnia and Herzegovina. In describing the individual qualifications standard the main specific attributes and capabilities of students who gain the qualification must be identified and expressed in terms of learning outcomes that must also be approved by academics and practitioners in the specific field. To this end, five working groups were constituted, one per subject field, consisted of academic staff from public universities in Bosnia and Herzegovina.

## **2. LEARNING OUTCOME BASED CURRICULA**

The reform of the higher education area putting learning outcomes and competencies in focus of the curricula and the qualifications is aimed at improving the learning process. The prescribed learning outcomes should enable estimations of the achievements of students with the accent on what the student knows, understands and can do, regardless of how the process of learning itself. The learning outcomes based approach is becoming the main principle for the cooperation in the education system across Europe and is the long-term perspective in higher education. While in the teacher-centred curriculum the teachers decided on the content, delivery and the assessment, the new trends in education are shifting to a student-centred approach, focusing on the exact specification what the students are expected to be able to do after applying the learning process [4]. There are a number of projects at national and international levels trying to define and implement the learning outcomes based curricula, such as PISA and DeseCo by OECD, the Danish KOM project or the European Society for Engineering Education SEFI. The European Network for Accreditation of Engineering Education ENAEE has developed the EUR-ACE Framework Standards EFS [5] defining the outcomes of the study programme of an accredited engineering degree: knowledge and understanding, engineering analysis, engineering design, investigations, engineering practice and transferable skills, applying to both bachelor and master levels. Examples for the basic competences for a specific field in an engineering study programme are given in the SEFI framework [6] for mathematics. Based on this, in a recent contribution [7] the practices in Western Balkan Countries and in Bosnia and Herzegovina are compared by collecting learning outcomes for mathematical courses in engineering curricula at universities in Bosnia and Herzegovina and in the surrounding Western Balkan Countries. The Baseline of the QFBH also describes the main purposes of the framework that is based on the European Qualifications Framework consisting of eight generic referent levels classifying knowledge, skills and competencies achieved as the learning outcomes. The qualifications framework as such is also used as the base in development of curricula, methods of assessment and monitoring the educational process. In the context of the previous considerations, the elements of the qualifications standard for the study program of civil engineering at the bachelor level are formulated and presented. In the scope of recommendations on the establishment of QS, the term *qualification* is understood as *a formal result of the assessment and evaluation, with which the competent authority certifies that an individual has achieved learning outcomes in accordance with established standards*. This quite pragmatic definition serves as the basis for a common understanding of the context of the application of QS. Nevertheless, the concept of qualification varies considerably in different EU countries, depending on the source, level of detail, shape and structure of the qualification.

### 3. MINIMAL ELEMENTS OF THE QS FOR CIVIL ENGINEERING

#### 3.1. Basics of the qualifications standard

Name-s:	generic + subject specific: Bachelor of Civil Engineering
Minimal volume:	180 ECTS
Level according to BHQS:	Level six (6)
Entry routes:	Secondary school, four year minimum

#### 3.2. Competencies / learning outcomes

##### Competences at the level of qualification

- Recognize, describe and solve technical problems in civil engineering.
- Understand the effects of civil engineering on the society and environment.
- Critically estimate arguments, presumptions and data in making decisions and solve technical problems in a creative manner.
- Make use of common computer tools for creating documents, presentations, performing calculations and simulations.
- Create and conduct experiments and analyse and interpret the results.
- Dimension smaller building and hydrotechnical structures.
- Project buildings at the basic level.
- Lead a smaller building operation.
- Put into a proper relation the projecting, building and end-user requests.
- Communicate and exchange information and ideas related to problems in civil engineering with professionals from within and beyond the branch.
- Cooperate in professional groups and adapt to the requests from the environment,
- Plan, project, perform, supervise and maintain bigger building operation in team work.
- Respect moral and ethical principles and attitudes in solving technical problems.
- Improve and develop further the achieved competencies with the help of skilled professionals having higher qualification levels.

##### Learning outcomes

###### Mathematics and Physics (min 30 ECTS)

- Make use of basic and advanced principles in analysis, algebra and numerical mathematics required for modelling and optimization in solving practical engineering problems.
- Estimate the quality, practical usability and feasibility of the obtained solutions and monitor their implementation.
- Describe and make use of basic principles in probability and statistics and advanced methods for solving and describing engineering problems.
- Describe and analyse basic laws of physics taught in lectures and make use of the knowledge achieved to solve simple problems and tasks, emphasising the content that simplifies learning in skilled topics.
- Assess and make use of basic skills in descriptive geometry, make projections connecting 2D i 3D view to be used in practical work.
- Describe non-methodological approaches in descriptive statistics and probability analysis, distinguish methods of error estimation, hypothesis testing in the framework of building.

###### Foreign language (min 3 ECTS)

- Communicate (read, write, talk) in foreign language in general and at the skilled level.

###### ICT (min 6 ECTS)

- Create individual program solutions of mathematical problems using some of the programming languages.

- Make use of computer tools and software packages for drawing, modelling, data analysis, text processing and spreadsheet calculations.
- Make use of computers in projecting and calculating structures.

#### Theory of structures (min 30 ECTS)

- Distinguish and analyse basic theoretical laws of statics as a part of mechanics and define perpendicular forces on statically determined structures.
- Describe and analyse theoretical laws of kinematics and dynamics of material point and rigid body and basic presumptions of oscillations of a system with one degree of freedom.
- Comment and analyse stresses, stiffness and stability of engineering structures.
- Calculate and dimension simple statically determined and undetermined structures.
- Solve different problems in mechanics of rigid and deformable body.
- Describe geometrical constancy and laws of kinematic stability of line structures.
- Define, analyse and calculate the statics of line and panel structures, walls and rocks.
- Describe dynamical properties of structures.
- Perform dynamic calculation of simple structures according to legitimate rules for building structures in seismic areas.
- Participate in conducting dynamic calculations of simple buildings.

#### Civil engineering structures (min 35 ECTS)

- Distinguish and describe basic steps in historical development of civil engineering.
- Analyse and create parts of the final and detailed architecture design of a simple building.
- Construct classical structures of armoured concrete in detail.
- Dimension cross sections subjected to bending, shear, torsion, tenuous elements subjected to pressure load, twodimensional panels and panels supported in points.
- Confirm the condition of cracks in usable cross sections.
- Describe basic theoretical presumptions of structures made of different materials (concrete, timber, steel and masonry).
- Dimension cross sections and connections and extensions of simple structures.
- Project systems, components or processes for the purpose of projecting taking care of economy, environment, social, political, ethical, health and security elements and sustainability.

#### Materials (min 10 ECTS)

- Distinguish basic materials and their properties.
- Test the properties of materials.
- Project and conduct experiment, analyse and interpret the data obtained.

#### Hydromechanics and hydrotechnics (min 12 ECTS)

- Comment stationary flow of liquids, open channel flow and underground water flow.
- Perform simple engineering calculations of flows in ducts and pipelines, channels and water intakes.
- Research and estimate the functions of water supply and sewerage systems with their elements.
- Choose the best option in planning, design and management of water supply and sewerage systems and their functional elements.
- Judge and research the basic functions of hydrotechnical structures, basic accompanying processes and use basic methods in design and building hydrotechnical structures.
- Research and analyse the components of the hydrologic cycle.
- Make use of mathematical and statistical methods for solving engineering hydrotechnical problems.

- Perform basic elementary calculations in hydrotechnics.

#### Geology and geotechnics (min 6 ECTS)

- Describe ground properties required for calculations.
- Perform calculation of foundation loads, consolidation, stability of slopes and ground pressure on supporting structures.
- Describe and analyse the ground substance, particularly lithosphere, distinguish processes and phenomena at the surface of the lithosphere, comment emergence of quakes, volcanoes and orogen.
- Describe basic presumptions of load calculations and dimensioning geotechnical structures (support walls, sheet-pile walls, foundation pits, excavations and dikes).
- Dimension shallow and deep foundations.

#### Geodesy (min 3 ECTS)

- Distinguish and make use of plans and charts.
- Create basic geodetic tasks, such as measuring angles and detailed levelling.

#### Transportation engineering (min 8 ECTS)

- Describe, analyse and argue the methods of projecting and building of railways.
- Analyse basic elements of railways and methods of planning, projecting and maintenance.
- Design routs beyond cities up to the level of basic design with detailed understanding of conditions for choosing optimum elements (geometry, route).

#### Organisation of building (min 6 ECTS)

- Distinguish basic principles and methods of organisation, planning, management and conducting civil engineering projects.
- Comment the law regulation in conducting and contracting civil engineering projects.
- Create and make use of the project of organisation and planning in practical work.
- Describe and define principles of the market, laws of offer and demand, economic organisation of companies, entrepreneurship.
- Distinguish costs, analyse business results in production and confirm the scales of business success.
- Analyse the effects of engineering solutions on economic and legal aspects in the surroundings.

#### Practical work (min 3 ECTS)

- Describe, analyse and judge critically the ability for solving a practical problem.
- Communicate and work in multidisciplinary team.
- Confirm professional and ethical responsibility.
- Recognize the need for the long-life learning.

#### Final thesis (min 8 ECTS)

- Show in written report and oral presentation the connection between specific groups of learning outcomes and competencies at the qualification level.

### **3.3. Relevance**

#### Labour market

- Building site engineer
- Chief of the building site, with previously accomplished the state/professional exam
- Project engineer assistant in engineering biro
- Professional fellow worker in administration (urbanism, inspectorate)

- Lab worker in secondary school for civil engineering and architecture, with previously accomplished pedagogic subjects
- Lab fellow worker at technical institutes/departments

#### Further education and progression

- State/professional exam
- Further education at the second cycle engineering study program.

### **3.4. Criteria for the institution giving the qualification**

The higher education institution should fulfil the criteria prescribed in the appropriate law for higher education and the prescribed norms and standards.

## **4. CONCLUSIONS**

The report presents the elements of the QS for the study program of civil engineering based on learning outcomes as a summary of the Joint EU/CoE Project “Strategic Development of Higher Education and Qualification Standards”. The Baseline of the QFBH is a beginning of a long-term process of establishing sustainable social and economic development in Bosnia and Herzegovina. Further activities include the establishment of a transparent system of recognition of the previously achieved competencies in informal education, then defining specific descriptors for all occupations based in the qualifications framework, as well as the reconstruction of curricula at all levels of education to serve as the means of achieving the specified learning outcomes. In addition, it will be necessary to create the occupational standard for the civil engineering by determining the tasks and expectations related to the profession. The qualifications framework should have implications to all forms of the development of human resources in Bosnia and Herzegovina, which is a long-term task for the academic community and other social partners. With all the above, it is necessary to improve international understanding of skill levels. It is of crucial importance to ensure the sustainability and further development of the qualifications framework.

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