

SCIENCE FUNDING AS A WAY TO IMPROVE THE QUALITY OF EDUCATION PROCESS

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Abstract: In order to maximize the contribution of science towards the implementation of the sustainable development goals, such as: energy and natural resources preservation, waste management and lowering carbon footprint, Republic of Serbia supports innovative research projects by securing sustainable investments in science. This paper presents the bilateral project: "BIO-based cementitious composites with recycled aggregates", conducted by team members of TU Wien (Austria) and Faculty of technical sciences (Serbia) including: research objectives, expected outcome and conducted activities. The influence of the project research on the educational process is highlighted, as the students of undergraduate studies of Civil Engineering will be directly involved in the project realization. This indicates science education is expected to play an important role in their development.

Key Words: scientific bilateral project, educational process, sustainable development goals

1. INTRODUCTION

The Ministry of Education, in its desire to develop and promote the education system of the Republic of Serbia, intensively develops cooperation with other countries and international organizations. Exchange of experiences in the field of professional and technical education, in that manner, is conducted through international scientific projects. In 2022, a bilateral scientific project was signed by Faculty of technical sciences in Novi Sad and Technical University in Vienna, titled: BIO-based cementitious composites with recycled aggregates (Bio-gates). The project is financed by the Ministries of both countries: Austria and Serbia and is scheduled to last two years.

Through this project, a number of researchers will have an opportunity to gain expertise and experience and create an important foundation for planned future cooperation in the European research programs. The project is set to establish a strong experts-network of the researchers of the two institutions in area of sustainable novel eco-friendly building composites, meeting the principles of sustainable development in civil engineering.

Furthermore, students in 4th year of undergraduate studies of Civil Engineering will be directly involved in the research activities of the project, as part of the experimental research will be conducted during the summer semester of 2023 in the Laboratory for testing building materials at the Department of Civil Engineering and Geodesy, Faculty of technical sciences in Novi Sad.

The relevant data on the project, including: research objectives, expected outcome, description of so far conducted activities and the involvement of the project research in the educational process, are briefly presented in this paper.

2. RESEARCH OBJECTIVES AND EXPECTED OUTCOME

The construction industry is one of the greatest CO₂ emitters and the production of concrete - as the most widely used construction material on Earth (over 4.7 tons per person per year) - is responsible for 8% of global anthropogenic greenhouse gas emissions [1]. The majority of traditional building materials in infrastructures are made out of the cement-based materials (such as concrete). Concrete is the second most consumed material in the world (after water) and the most used man-made material at all. Concrete is generally made from aggregate, cement and water and due to its low tensile strength and brittleness it is reinforced (with steel bars, steel or synthetic fibres, etc.). The major component of concrete (up to 70% of its volume) is natural aggregate, such as sand, gravel or crushed stone. Aggregate is the world's number-one nonfuel mineral commodity in terms of both volume and value. Its worldwide demand is estimated to be rising by 4.7% annually. The excessive extractions of rocks and aggregates result in the depletion of natural resources and lead to secondary effects such as erosion, deforestation, and damage to river ecosystems. The traditional reinforcement in concrete with steel bars or fiber reinforcement (from steel, synthetic, glass, etc.) requires deployment of vast non-renewable Earth's minerals, they are extremely energy intensive to manufacture and their production contributes to significant environmental pollution.

The growing environmental awareness and need for reducing both the raw material consumption and CO₂ emission of the construction industry are recently strongly anchored in various European directives. Hence, the research is focusing toward seeking on one side alternative low-CO₂ binders for replacement of Portland cement in concrete, replacement of natural aggregates in concrete with recycled aggregates obtained from construction and demolition waste (CDW) as well as alternative sustainable replacement for steel (and synthetic) reinforcement.

The objective of the BIO-gates project is to develop novel eco-friendly cement-based composites (mortars and/or concretes) where: 1) the natural aggregate will be partially replaced by recycled aggregates from CDW and by hemp shives (chopped woody core of industrial hemp plant), and 2) the traditional steel fibre reinforcement will be substituted by industrial hemp fibres.

BIO-gates aims to investigate the advanced properties of the composites based on experiments conducted in the laboratories of the TU Wien and of the FTN Novi Sad. It will include the characterization of the input materials, investigations of the various physical, mechanical, microstructural and durability properties of the developed composite in fresh and hardened state as well as the optimization of the composites design parameters for selected applications and load cases.

The outcomes of the research will deliver valuable information for both the academy and the industry, concerning a possible application of this novel building material in various civil- and infrastructural applications in the region. The gained basic knowledge of the various physical, mechanical and durability properties of the composite will be applicable in a more general sense on a variety of similar cementitious composites. Through the complementary and comprehensive experimental and analytical expertise of the involved research groups accompanied with strong embedment in the international scientific community, the most valuable profit of this cooperation is the establishment of a strong experts-network of the researchers of the two institutions in area of sustainable novel composites.

The results of the research will be continuously published in refereed scientific journals and presented at international conferences. This will enable the access of the broader international scientific community to the important findings and conclusions of the research work. A detailed research report will be published in a form of a scientific monograph which will be available on the project applicant's personal and the host institutions' websites.

3. CONDUCTED RESEARCH ACTIVITIES

In the first period of project implementation, following activities were conducted:

- Kick off project meeting in Vienna (Figure 1);
- Joint participation of team members at the international conference in Serbia (Figure 2).

Kick off meeting of team members, which officially got the project off the ground, was organized in Vienna, Austria, in September 2022. In the scope of the meeting, project activities in the first period of realization have been defined and timeline of activities for the first year of the project has been created. Furthermore, FTN team members have been introduced to the Laboratories for testing materials and structures in TU Vienna.

The following month, team members from both countries participated at the International conference on the research and application of modern achievements in construction in the field of materials and structures, which took place in Divčibare, Serbia. The conference was an effective occasion to communicate key project information to the relevant public audience.



Figure 1. Project meeting and the visit to the Laboratory of TU Vienna



Figure 2. Joint participation of project members at the International civil engineering conference DIMK in Divčibare

The research will be mainly experimentally based and will be conducted in the laboratories of the TU Wien and of the FTN Novi Sad. The first part of the experimental program: the mortar mix design optimization of the composite will be carried out at the TU Wien. At the FTN Novi Sad, the upscale of the material will be conducted. Based on the results on mortar specimens at the TU Wien, the most optimal mix design will be chosen for upscale to concrete specimens. This phase of the project realization is expected to be performed along with the educational process of undergraduate studies in Civil engineering.

4. INVOLMENT OF THE PROJECT RESEARCH AND FINDINGS IN THE EDUCATIONAL PROCESS

In April 2018, in accordance with the Law on Higher Education of the Republic of Serbia [2], within IPA Interreg project: Agricultural Waste – Challenges and Business Opportunities (Eco Build), an elective teaching course: "Contemporary composites based on agriculture, industry and construction waste" was accredited in the undergraduate academic studies at the Department of civil engineering and geodesy, 4th year of the Structures program. The main goal of the course is understanding the importance of application of waste materials in construction industry in the scope of sustainable development and environmental protection - Figure 3. Acquired knowledge from the course is used in engineering practice. Students are competent to select the adequate waste material depending on necessary concrete composite properties.

Up till now, students of five generations had an opportunity to choose and attend the classes within the new course, among 4 available elective courses. Based on their selection, it can be stated that there is a growing interest on the new course - Table 1.

Table 1. Numbers of students attending the course per year

School year	Total number of student in 4 th academic year	Number of students attending the new course	Percentage share of the new course
2018/19	55	16	29,1%
2019/20	48	14	29,2%
2020/21	35	15	42,9%
2021/22	40	10	25%
2022/23	30	50	60%

Students who attended the course have gone through detailed laboratory experimental programme and created their own modern eco-friendly composites produced from different locally available waste materials, such as: fly ash, biomass ash, granulated blast furnace slag etc - Figure 4. One group of students was chosen to participate at the international student conference CoNStRuction in November 2019 and share their gained knowledge and results to the wider audience of students from the country and abroad.



Figure 3. Laboratory exercises at the Department of civil engineering and geodesy



Figure 4. Modern eco-friendly composites produced by students within educational process

As the idea of Bio-gates project is innovative, regarding scarce research of simultaneous utilization of recycled concrete aggregate and hemp fibres in concrete production in Serbia so far, students of 2022/23 generation will be pioneers in Serbia to explore the possibility of application of these waste resources in sustainable cement-based composites. Their goal in summer semester course will be to design the optimal concrete mix and produce sustainable load-bearing composites in a way to: 1) reduce natural aggregate and partially (or completely) replace it with aggregates from CDW; 2) substitute the traditional reinforcement in concrete with fibres of different natural plants (such as hemp), as the employment of natural fibres ensures the development of economically and ecologically sustainable composite materials that are considerably less dependent on non-renewable energy resources. Achieving these goals may be a viable direction and way to increasing the greenness and sustainability of cement-based materials.

The education improved by science, in striving towards motivation of students, can be expected to pay much

attention to developing a personal identity and to develop self actualization, self efficacy and clearly self worth. Learning to study and work for the common good at the same time, rather than individual isolationism, can be a particularly strong component of student engagement and commitment. This is promoted through teamwork in laboratory work activities and through participation in discussions, reasoned decision-making and analysis.

5. CONCLUSIONS

This paper briefly described an innovative bilateral project: "BIO-based cementitious composites with recycled aggregates", that will be conducted by team members of two institutions: TU Wien (Austria) and Faculty of technical sciences (Serbia). The objective of the BIO-gates project is to develop novel eco-friendly cement-based composites by utilizing locally available waste materials: construction and demolition waste, as natural aggregate replacement, and hemp shives, instead of traditional steel fibre reinforcement.

The complementary and comprehensive experimental and analytical expertise of the research teams accompanied with the strong embedding of each team in various national and international scientific communities represents a valuable basis of this cooperation and a benefit for each of the team members. The established solid foundations for a future cooperation are the most valuable profit and benefits of the two research teams. The gained expertise, experience and mutual confidence during this cooperation-project will provide the researchers with an important foundation for planned future cooperation in the European research programs, such as Horizon 2020, Life+, Eurostars as well as in the bilateral/trilateral joint research projects of the prospective countries, such as the Joint project of the Austrian Science Fund (FWF). The cooperation partners belong to the European Danube region and a joint research proposal is planned within the EUREKA Danube Region Programs and/or within the Interreg Danube Transnational Program.

Furthermore, as the idea of the Bio-gates project is innovative, students in 4th year of undergraduate studies at the Department of civil engineering and geodesy, 2022/23 generation, will be pioneers in Serbia to explore the possibility of utilization of selected waste materials in sustainable cement-based composites and create their own eco-friendly products. This implies that improved education through the scientific project is expected to play an important role in their development as young engineers.

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6. REFERENCES

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