

MODERN BUILDING MATERIAL COMPOSITES - NEW ELECTIVE COURSE WITHIN IPA PROJECT

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Abstract: The use of ash, generated by the combustion of biomass, as a building material is a sustainable solution not only from the aspect of pollution (reduction of CO₂ emission), but also from the aspect of landfilling, conservation of natural resources for future generations and high prices of construction materials. The possibility of application of biomass ashes, waste material generated in AP Vojvodina, as a binder in cement composites will be tested experimentally within the IPA Interreg project, as well as the new elective course in the undergraduate studies of Civil engineering. The paper presents the results of the previous research on the availability of biomass ashes in Vojvodina and briefly describes new teaching course, within which students will, during laboratory exercises, learn about innovative research on modern building materials and participate in the process of creating engineering products based on biomass ashes.

Key Words: biomass ash, eco material, IPA, elective course, inovative research

1. INTRODUCTION

Renewable energy sources (RES) are inexhaustible energy sources, sourcing from nature, that are renewed at a certain time interval, in whole or in part. RES are exploited to produce electrical, heat and mechanical energy, and their significant viability is environmental harmony, with reduced CO₂ emissions in the process of energy production. Republic of Serbia disposes of renewable energy sources of sun, water, wind, geothermal energy and biomass.

Serbia's potential in renewable energy sources (RES) is around 6 Mt (million tonnes of oil equivalent) per year. By utilizing this potential, the use of fossil fuels can be significantly reduced. The greatest potential is biomass, which accounts for 64% of all other renewable energy sources, amounting 3.4 Mt per year. The total availability of biomass waste in Serbia amounts to about 13 million tons [1].

Due to recent increases in production, waste products from biomass combustion are becoming a relevant environmental and economic problem. Substitution of cement in mortar and concrete, with ash generated by combustion of biomass (ash containing Al, Ca, Fe, Mg, Na, P, Si), as CO₂ neutral fuel, would reduce the negative impact of concrete industry on global warming, give new use value and possibility of economic evaluation of biomass ash as a raw material. All these effects would be a powerful incentive for integrated management and sustainable utilization of large quantities of biomass ash originating from agriculture in Vojvodina and Serbia [2].

Within IPA Interreg project: Agricultural Waste – Challenges and Business Opportunities (Eco Build), a team of experts from Department of Civil Engineering and Geodesy in Novi Sad investigate the availability of different types of biomass ashes in AP Vojvodina, conduct their classification, cataloguing, determine possible utilization in civil engineering practice and, finally, will introduce these results to professional public and potential users.

Within this project, new elective teaching course is introduced in the undergraduate academic studies at the Department of civil engineering and geodesy, 4th year of the modul Structures: Contemporary composites based on agriculture, industry and construction waste. Basic information, educational goal, outcomes, content and teaching methods of the course are briefly presented in this paper.

2. RESEARCH ON THE AVAILABILITY OF AGRICULTURAL BIOMASS ASHES IN SERBIA WITHIN ECO BUILD PROJECT

In the region, which is involved in the research (Bačka, Srem and Mačva), in the previous period of realization of the project IPA ECO Build, research on the availability of biomass ashes was conducted. Team of professors from Department of civil engineering and geodesy established the cooperation with representatives of eleven companies that use harvest residues as energy sources for obtaining heat energy and produce biomass ashes as waste material. Figures 1-6 illustrate work of the companies in terms of biomass combustion and ashes production.



Figure 1. Landfill of biomass ashes in Mitrosrem



Figure 2. Biomass ashes stored in Soya Protein company rooms



Figure 3. Soya straw pellets, prepared for combustion in Hipol



Figure 4. Unregulated landfill of biomass ash in Victoria Starch



Figure 5. Bale chopper in Ipok



Figure 6. Biomass boiler room 18MW in TETO

Basic data on the process of production were collected, including:

- types of used biomass,
- combustion technology,
- achieved combustion temperatures in boiler furnace,
- generated quantities of biomass ash per year,
- way of disposal of biomass ash.

A brief overview of the received information and data is given in Table 1. Based on the obtained data, it can be concluded that, at this moment, available amount of biomass ashes in Vojvodina, is 4200t per year. Regarding the method of ash disposal, a small amount of ash is deposited on the unregulated landfill in the company's circle, and the largest quantity of ash is disposed in containers and transported to municipal landfills.

Table 1. Available quantities of biomass ashes in AP Vojvodina

Company	Biomass type	Temperature of combustion	Types of biomass ashes	Produced quantities of ash per year (tons)
Mitrosrem Sremska Mitrovica	wheat straw soya straw	600-650°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	15
Soya Protein Bečej	wheat straw soya straw silo waste melasa	700-900°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	1100
The Veterinary Institute Subotica	agro pellets of wheat straw and soya straw	450-550°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	240
Hipol Odžaci	agro pellets of soya straw	800-1000°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	700
Victoria Starch Zrenjanin	agro pellets of wheat straw and soya straw	unknown	1. ash from boiler furnace	9

Almex-IPOK Zrenjanin	agro pellets of wheat straw and soya straw sunflower husk	700-900°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	1100
KNOT- AUTOFLEX Bečej	wheat straw soya straw	unknown	1. ash from boiler furnace	60
Fishery Lovćenac	soya straw	unknown	1. ash from boiler furnace 2. ash from multiciklon	9
Victoria Oil Šid	sunflower husk	700-1000°C	1. ash from boiler furnace 2. ash from multiciklon	720
Sava Kovačević Vrbas	cob corn	500°C	1. ash from boiler furnace	30
PTK Panonija Mecker farm	wheat straw soya straw	500°C	1. ash from boiler furnace	60
Total				≈ 4.200 tons

These ashes can be potentially used as mineral additive and/or aggregate in cement based composites, which depends on the chemical composition and pozzolanic activity of these ashes. Experimental research of biomass ashes as potentially building materials, according to the Eco build project, should result in guidelines relevant for its further use of biomass ashes as a mineral additive in cement-based composites. To achieve this goal, further investigations will include determination of biomass ash influence on basic properties of mortars and concretes.

The results of the experimental research should verify the possibility to obtain biomass ash-based ECO mortar and concrete with comparable or better physical and mechanical properties than those of the reference composites. These composites will be characterized by a lower consumption of cement, thus reducing the CO₂ emissions and meeting the principles of sustainable development.

A part of these activities will be carried out with students within a teaching process at the Faculty of technical sciences. New elective course, in which students will participate in production process of eco building materials based on biomass ashes, has been created. Summary of the course and its goals are presented in the next chapter.

3. NEW ELECTIVE TEACHING COURSE AT THE DEPARTMENT OF CIVIL ENGINEERING AND GEODESY

In April 2018, in accordance with the Law on Higher Education of the Republic of Serbia [3], within the undergraduate academic studies at the Department of civil engineering and geodesy, 4th year of the Structures program, a new subject was accredited: Contemporary composites based on agriculture, industry and construction waste. Students can attend the course of the 8th semester.

The curriculum of the course was created within the project activities of the Eco Build IPA INTERREG project, in order to transfer the acquired knowledge and experience during the implementation of the project to the new generation of civil engineers, which will enable the sustainability of the project results. In addition, this course will contribute to the application of project results in engineering practice after the project implementation period.

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. Within the course, students will get to know about the availability of waste materials in the world and in Serbia. These materials could be used as a substitution for aggregate or binder in cement composites: pastes, mortars, concretes. Mastering knowledge on the properties and possibilities of application of cement composites based on selected waste materials is one of the main outcomes of the course.

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.

Principles of sustainable development and environmental protection are the modern topics the course incorporates. First classes of the course will be dedicated to exploring the availability of waste materials from agriculture, industry and construction in the world and in Serbia. Production, preparation and testing of basic properties of selected waste materials which are used as aggregate in concrete (crushed bricks, crushed old concrete, expanded glass and alkali activated fly ash) and for substitution of part of cement (fly ash, silica fume and biomass-ashes such as rice husk ash, wheat straw ash, soya straw ash and cob corn ash) will be conducted within practical exercises in the Laboratory for testing of materials at the Department of civil engineering and geodesy.

Classes will include: lectures, auditory and laboratory practice and consultations. During lectures, presentations with photographs, tables, diagrams, formulas and appropriate text – definitions will be used to explain the students the course content predicted by the curriculum. In laboratory practice, students will design and batch and mix mortar and concrete mixtures and test basic properties of fresh and hardened cement composites, blended with selected waste materials. A part of the practice is used for computing, where students through different tasks connect the presented course content with the construction practice. Students are evaluated during lectures and exercises as well as their graphic work. The exam is taken orally in examination terms.

Laboratory exercises on the application of biomass ashes will include:

- characterization of biomass ash: testing of basic physical properties of the material: specific surface area, density; testing of pozzolanic activity, activity index, setting time, soundness, fineness etc;
- preparation of mortars with cement, lime and biomass ashes; production of material, testing of consistency, compressive strength, flexural strength, capillary water absorption etc.

4. CONCLUSIONS

The utilization of industrial, construction and agricultural waste materials can be a breakthrough step to make the industry more environmentally friendly and sustainable. Various waste materials, such as fly ash, silica fume, ground granulated blast furnace slag, recycled concrete, recycled glass, recycled tyres, recycled plastics, metakaolin, have been successfully used in cement-based composites for years. Recent studies have shown the successful use of agricultural waste: straw ash, husks ash, cob ash etc., as mineral additives or aggregates in composites: pastes, mortars and concretes. This contributes to energy saving, conservation of natural resources, pollution reduction, and a reduction in the cost of construction materials. It also solves the disposal problem of the wastes, and, hence, helps environmental protection.

This paper briefly described new elective course, accredited within the undergraduate academic studies at the Department of civil engineering and geodesy, at the 4th year of the Structures program: Contemporary composites based on agriculture, industry and construction waste.

The course was introduced via IPA CBC Interreg project Croatia-Serbia: Agricultural Waste – Challenges and Business Opportunities (Eco Build). Creation of new teaching material for elective course on use of available waste materials has the main goal of empowering students, SMEs, agricultural subjects and construction businesses and providing them with new knowledge and skills. This new course will become available to all interested parties, as created teaching materials will be made available to regular students of both Faculties: Faculty of technical sciences in Novi Sad and Faculty of Civil Engineering and Architecture in Osijek.

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5. LITERATURA

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