10. Međunarodna konferencija o obnovljivim izvorima električne energije

10th International Conference on Renewable Electrical Power Sources

Beograd, 17. i 18. oktobar 2022 | Belgrade, October 17 & 18, 2022

ZBORNIK RADOVA
PROCEEDINGS

SMEITS

DOIEE

ПРИВРЕДНА КОМОРА СРБИЈЕ
1857

ZBORNIK RADOVA
Proceedings

pisanih za 10. Međunarodnu konferenciju o obnovljivim izvorima električne energije

10th International Conference on Renewable Electrical Power Sources

2022

ZBORNIK RADOVA
pisanih za 10. Međunarodnu konferenciju o obnovljivim izvorima električne energije
Privredna komora Srbije,
Beograd, 17. i 18. oktobar 2022.

PROCEEDINGS
10th International Conference on Renewable Electrical Power Sources
Chamber of Commerce and Industry of Serbia,
Belgrade, October 17. and 18., 2022

Izdavač
Savez mašinskih i elektrotehničk ihinženjera i tehničara Srbije (SMEITS)
Društvo za obnovljive izvore električne energije
Kneza Miloša 7a/II,
11000 Beograd

Publisher
Union of Mechanical and Electrotechnical Engineers and Technicians of Serbia (SMEITS)
Society for Renewable Electrical Power Sources
Kneza Miloša str. 7a/II,
11000 Beograd

Predsednik Društva za obnovljive izvore električne energije pri SMEITS-u
Prof. dr Zoran Lazarević

President to the Society for Renewable Electrical Power Sources within the SMEITS
Prof Zoran Lazarević, Ph. D.

Urednik
V.prof. dr Aleksandar Savić

Editor
Assoc. prof Aleksandar Savić, Ph. D.

Za izdavača
Vladan Galebović

For Publisher
Vladan Galebović

Tiraž
50 primeraka

CD umnožava
PR Priprema za štampu „BEOŽivković“, Beograd

ISBN
978-86-85535-13-0

CIP - Каталогизација у публикацији - Народна библиотека Србије, Београд

502.171:620.9(082)(0.034.2)

MEĐUNARODNA konferencija o obnovljivim izvorima električne energije (10 ; 2022 ; Beograd)

Zbornik radova pisanih za 10. Međunarodnu konferenciju o obnovljivim izvorima električne energije [Elektronski izvor] : [Beograd, 17. i 18. oktobar 2022.] / [urednik Aleksandar Savić] = Proceedings / 10th International Conference on Renewable Electrical Power Sources : [Belgrade, October 17. and 18., 2022] ; [editor Aleksandar Savić]. - Beograd : Savez mašinskih i elektrotehničkih inženjera i tehničara Srbije SMEITS, Društvo za obnovljive izvore električne energije = Union of Mechanical and Electrotechnical Engineers and Technicians of Serbia (SMEITS), Society for Renewable Electrical Power Sources, 2022 (Beograd : BEOŽivković). - 1 elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 50. - Bibliografija uz svaki rad.

ISBN 978-86-85535-13-0

a) Енергетски извори - Одрживи развој - Зборници

COBISS.SR-ID 77216265

Organizator
Organizer

Savez mašinskih i elektrotehničkih
inženjera i tehničara Srbije (SMEITS),
Društvo za obnovljive izvore
električne energije

Surganizator
Co-organizer

Institut za arhitekturu i urbanizam Srbije,
Beograd

Privredna komora Srbije,
Beograd

Sponzor / Sponsor

Andreja d.o.o, Temerin

Podrška / Endorsement

MT-KOMEX, Beograd

Održavanje 10. MKOIEE finansijski je pomoglo
Ministarstvo prosvete, nauke i tehnološkog
razvoja Republike Srbije

Međunarodni programski odbor
International Programme Committee

Prof. dr Slađana Alagić	Srbija
Prof. Viorel Badescu	Rumunija
Prof. dr Pellumb Berberi	Albanija
Prof. dr Miroslav Bjekić	Srbija
Prof. dr Oleksandr Bondarenko	Ukrajina
Prof. dr Alla Denysova	Bugarska
Dr Silvana Dimitrijević	Srbija
Dr Stevan Dimitrijević	Srbija
Dr Aleksandar Ivančić	Španija
Prof. dr Miroljub Jevtić	Srbija

Prof. dr Branko Kovačević	Srbija
Prof. Vladimir Krstić	Kanada
Dr Mirza Kušljugić	BiH
Prof. dr Zoran Lazarević	Srbija
Dr Zorica Lazarević	Srbija
Prof. Nikolay Lopatkin	Rusija
Dr Nataša Markovska	Severna Makedonija
Prof. Nikolay Mihailov	Bugarska
Dr Emilija Mihajlovska	Severna Makedonija
Prof. dr Stefka Nedeltcheva	Bugarska
Dr Marina Nenković-Riznić	Srbija
Dr Dušan Nikolić	Australija
Dr Sanja Petronić	Srbija
Prof. dr Elena Ponomaryova	Ukrajina
Dr Mila Pucar	Srbija
Prof. dr Nikola Rajaković	Srbija
Prof. dr Ivan Rajšl	Hrvatska
V.prof. dr Aleksandar Savić	Srbija (predsednik)
Prof. dr Pavlo Safronov	Ukrajina
Prof. dr Birgit Scheppat	Nemačka
Prof. dr Valerij Sytnikov	Ukrajina
Prof. dr Zoran Stević	Srbija
Prof. dr Nada Štrbac	Srbija
Prof. dr Dragan Tasić	Srbija
Prof. dr Dejan Tanikić	Srbija
Prof. dr Michael Todorov	Bugarska
Dr Nataša Tomić	Srbija
Dr Milica Vlahović	Srbija
Dr Suzana Veličković	Srbija
Prof. dr Igor Vušanović	Crna Gora
Dr Zhongying Wang	Kina
Dr Wanxing Wang	Kina
Dr Xuejun Wang	Kina

Organizacioni odbor
Organizing Committee

Borjan Brankov
Vladan Galebović
Dr Stevan Dimitrijević
Prof. dr Zoran Lazarević
Dr Sanja Petronić
Dr Mila Pucar
Ilija Radovanović
Vera Ražnatović
Jelena Salević
V. prof. dr Aleksandar Savić (predsednik)
Prof. dr Zoran Stević
Žarko Ševaljević

ISKORIŠĆENJE ENERGIJE TALASA ZA DOBIJANJE KINETIČKE ENERGIJE

USE OF WAVE ENERGY TO OBTAIN KINETIC ENERGY

Nenad STANISAVLJEVIĆ[1], Aleksandar SAVIĆ[2]
[1] Institut of Transportation CIP, Nemanjina 6/IV 11000 Belgrade, Serbia
[2] University of Belgrade, Faculty of Civil Engineering, Bulevar kralja Aleksandra 73, 11000 Belgrade, Serbia

Energija talasa u velikoj meri predstavlja neiskorišćen resurs za dobijanje električne energije, gde se putem kinetičke energije pretvara u električnu. Postoje niz prednosti usvajanjem ovog rešenja. Dve najbitnije su: ne narušava se izgled morske obale raznim objektima kao i to da se ne zagađuje morsko dno. Eksploatacija počinje odmah po postavljanju uređaja u moru. Mogućnost upotrebe betona kao građevinskog materijala u ove svrhe je diskutovana u radu. Dati su osnovni principi projektovanja sastava betona za ove uslove i diskutovani karakteristični detalji o kojima treba voditi računa kod ovih specifičnih konstrukcija.

Ključne reči: *energija talasa; beton; čelik; materijali; zahtevi; primena;*

Wave energy is largely an unused resource for generating electricity, where it is converted into electricity through kinetic energy. There are a number of advantages to adopting this solution. Two of the most important are: the appearance of the sea coast is not disturbed by various objects, and the seabed is not polluted. Exploitation begins immediately after placing the device in the sea. The possibility of using concrete as a construction material for these purposes is discussed in the paper. The basic principles of designing the composition of concrete for these conditions are given and the characteristic details that should be taken into account for these specific structures are discussed.

Key words: *energy; concrete; steel; materials; requirements; application;*

1 Introduction

At a time when the whole world depends dominantly on oil and gas, it is necessary to activate the theme of renewable energy sources, especially in coastal and island countries where the petroleum products are much more expensive. The advantages of wave energy from wind generators are that the waves are always present during the year, so the profitability is multiple. Waves are created by the wind which in turn is caused by the Sun. This makes wave energy a renewable resource. A solution of the structure that makes this kind of effect is given in the Figure 1. The main constituents of these structures include: light - a flashing beacon on top of the device alerts passing ships; float - as the surface of the water moves up and down, the float moves with the waves while pulling on a cable below; magnets - the column of magnets moves up and down with the waves inside the generator coils; generator coils - an electric current is induced in the coils of wire as the magnets move up and down; foundation- the wave energy machine is securely anchored to the seabed; cables- the electric current from the machine is carried through cables to the shore.

All structure elements are available today, and with their combination such a construction element that will be stable due to the influence of sea water can be produced. It is very easy to achieve pre-fabrication of elements from sulfate concrete and thus the entire construction can be produced as prefabricated. Utilization of potential and kinetic energy principle is given in the Figure 2.

2 Key advantages and disadvantages of the energy wave concept

From a construction standpoint, a larger percentage of parts tend to be prefabricated and mass-produced. In this case, structures for the accumulation of kinetic energy can be of different shapes, depending on the need for consumption. They can be made to be easily transportable using road as well as sea transport. The largest percentage of material that can be used for production of such a

structure is concrete, together with specific kinds of elements for sea water applications with additional measures for greater durability.

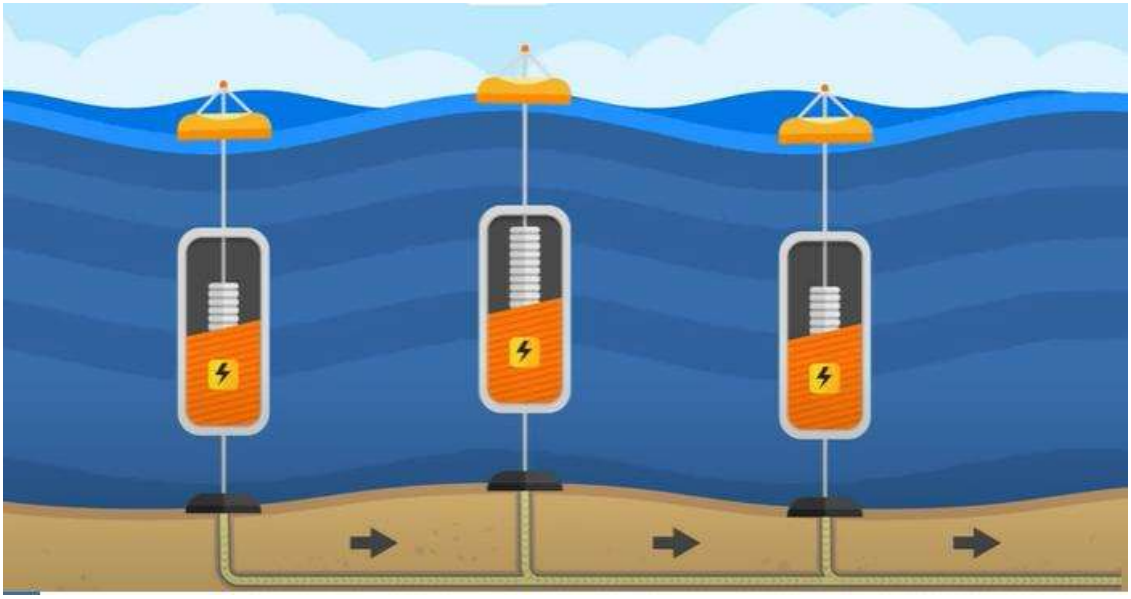

Figure 1: A device that takes wave energy and transfers it into kinetic energy [1]

Considering that the concept is ideal from the point of view of exploitation, this model also brings some disadvantages. Foundation elements cannot be standardized, due to the extremely diverse geological nature of the seabed. Therefore, that part must be unique for certain structure, designed and constructed depending on the terrain configuration and soil material below sea level. In some applications, the piles have to be longer and in others shorter, thereby increasing the cost of construction.

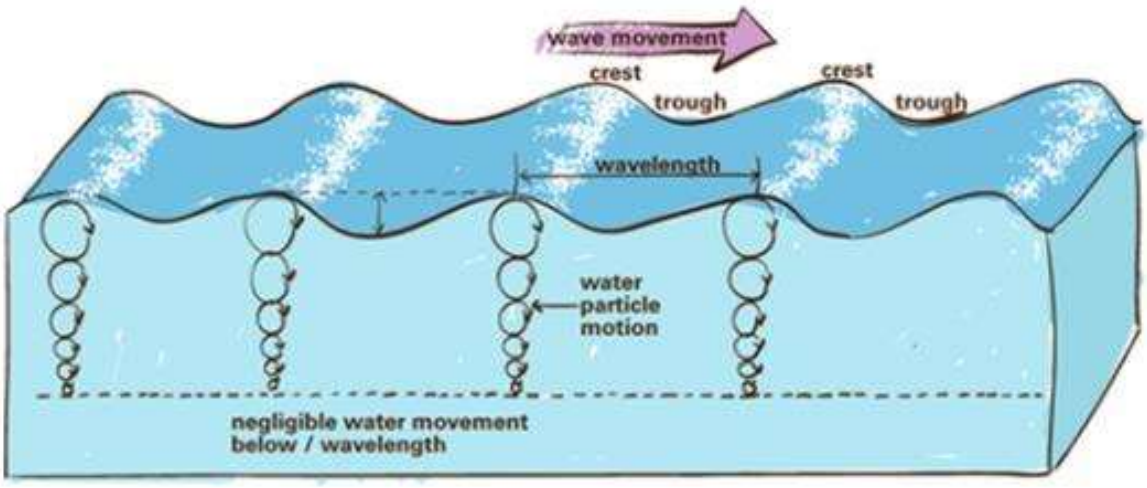

Figure 2: Utilization of potential and kinetic energy [2]

Corpus of basic advantages and disadvantages of marine conditions for concrete in the construction sector is summarized in Table 1. These aspects will be discussed further in the paper.

Table 1 – The principal advantages and disadvantages of marine conditions for concrete

Advantages	*Disadvantages*
If concrete is made from bio-blocks, it has a pH value close to that of seawater.	Classical concrete has a pH of 12-13, which is not favorable for the colonization of marine life. Therefore, environmentally acceptable materials for installation in seas and oceans must have a pH value of 9 to 10.
Synthetic fibers, if added to the concrete mix, can reduce abrasive wear from sand.	Concrete usually is, but must not be smooth due to the colonization of organisms.
When the concrete is made according to the appropriate recipe, it is not necessary to do any more rehabilitation.	If classic concrete is produced, subsequent protection of the concrete must be done using various protective layers and sealants.
Durability of the properly designed, produced and placed concrete is higher.	The non-standard concrete mixtures usually have higher price.
Promotion of sustainability through the use of recycled materials and industrial by-products can be done.	

3 Materials and technology of the concrete energy wave concept with respect to the energy efficiency

Contemporary construction accentuates the use of the alternative materials that have less impact on the environment. Those alternatives may already exist. Among them is a material called ECOncrete (bio-block concrete), developed as environmentally friendly concrete [3]. It is made using a mixture that is almost entirely made from by-products and recycled materials, meaning that no carbon is released to produce this material. This mixture is combined with slag (about 70%) which gives this material a high chloride resistance, which is suitable when used in saline environments.

Unlike traditional concrete, which is highly alkaline (pH of 12-13), bio-block concrete has a pH value close to that of seawater (close to 8), which helps promote the growth of marine species such as crabs, mollusks, clams, mussels and oysters. A relatively neutral pH value of bio-blocks of 9-10 can be achieved when Portland cement is replaced by slag [3].

However, it is also the nature of the contact between concrete and water that makes the difference in the natural environment. The smooth concrete surfaces of artificial seawalls are not habitable for marine organisms. However, their subsequent treatment with ecological slabs with a rough surface texture allows marine flora and fauna to colonize, ultimately leading to improved seawall biodiversity.

While environmentally friendly concrete requires further testing, there are other potential solutions, such as bio-cement which may be particularly suitable for marine infrastructures [4]. Bio-cement is created by mixing sand or other forms of aggregate, then adding bacteria and urea, a component of urine. Urea triggers the bacteria to produce calcite – a form of calcium carbonate – binding the mixture into a solid limestone-like material. There are advantages of such a cement, firstly it can improve coastal stability, second much lower CO2 emission (one-third of the conventional concrete), and the possibility of shaping it into a bio-friendly structure. Nevertheless, there is still not enough data on the pros and cons of its' use, due to the scarce application evidences.

Generally, seawater contains 3.5 per cent of soluble salts (salinity) by weight. The ionic concentration of Na^+ and Cl^- are maximum in seawater, normally 11,000 and 20,000 mg/lit respectively. Seawater also contains Mg^{2+} and SO_4^{2-} about 1400 and 2700 mg/lit, respectively. As already stated, the pH of seawater fluctuates between 7.5 and 8.4. The average pH of seawater amounts to about 8.2.

Seawater also contains a certain amount of CO_2. If higher concentration of CO_2 dissolved in seawater, then the pH may fall below 7.5. Table 2 gives the major ions concentration in some of the world seas.

Table 2: Major Ions Concentration in some of The Famous World Seas [4]

World seas/ Major Ions	*Concentration of ions (mg/lit)*					
	Sodium	*Magnesium*	*Chloride*	*Sulfate*	*TDS*	*TDS Ratio*
Black Sea	4900	640	9500	1362	17085	3.9
Marmara Sea	8100	1035	14390	2034	26409	2.52
Mediterranean Sea	12400	1500	21270	2596	38795	1.72
North sea	12200	1110	16550	2220	33060	2.02
Atlantic Sea	11100	1210	20000	2180	35370	1.88
Baltic Sea	2190	260	3960	580	7110	9.37
Arabian Gulf	20700	2300	36900	5120	66650	1
BRE** Exposure	9740	1200	18200	2600	32540	2.05
Red sea	11350	1867	22660	3050	40960	1.63

The analysis of the conditions that takes into account these differences in salinity has to be done from case to case. For instance, the sea around the Arabian Gulf is the saltiest, with a significantly higher proportion of chlorides and other elements. This is a very high figure that the waters of the sea could reach due to the hot, dry climate of the coast. When evaporation of water is very high, and the incoming less salty water is limited, there is no time to dilute the already made solution. Therefore, the conclusion would be that on the coast of this bay, special attention must be paid to the unique recipe for concrete and its durability.

4 Theoretical aspects of concrete use in salt water conditions

If concrete structure is built in seawater, then the most affected area of the structure is well above the high-water mark. The area between low water level and high-water level is less affected while the area which is continuously submerged under the seawater is least effected. The reason behind this is, when the seawater forcibly contacts the area above the high-water mark due to wave action, some salty water gets deposited in the concrete pores. When this area dries, the water will crystallize into salt particles, and due to that crystallization, a disruption of concrete takes place. Similarly, when the water in concrete pores is allowed to freeze in cold climates, the concrete will expand and lost its durability. Figure 3 is a depiction of seawater effect on concrete.

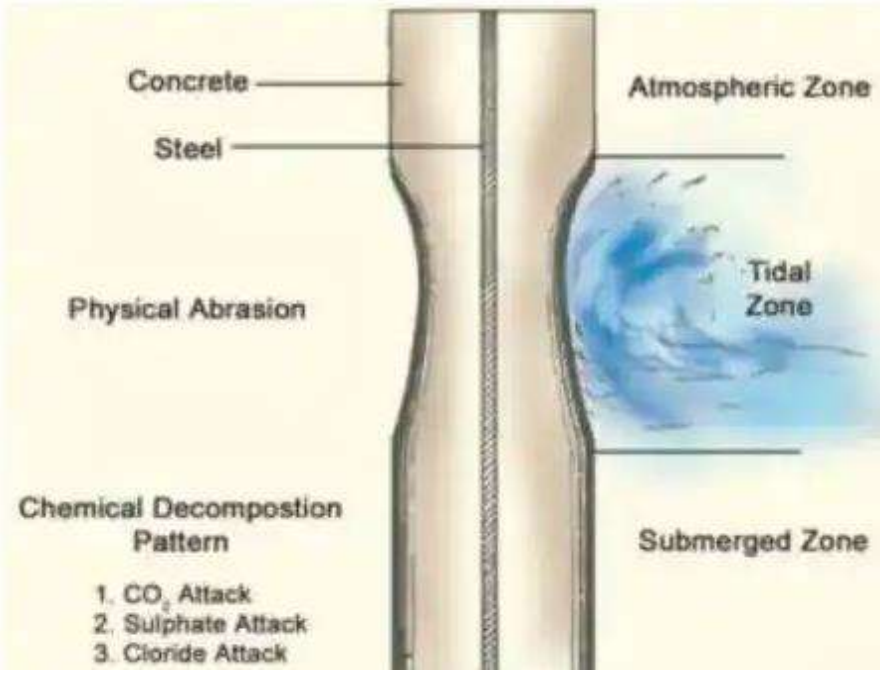

Fig 3: Diagrammatic Representation of Concrete Exposed to Seawater [5]

To improve durability of concrete structure which are exposed to marine conditions, several methods can be applied, regarding the composition and design of this concrete, as follows:

1. Cement with low C3A content should be preferable to make concrete;

2. Low water to cement ratio can be applied, which makes the concrete impervious; In this case the pores in concrete are very small and they cannot contain seawater.

3. To make it workable for placement of fresh concrete, water reducing admixtures should be added to the concrete.

4. The admixtures should not contain chloride in any form, otherwise corrosion of reinforcement takes place.

5. Adequate cover should be provided for reinforcement in concrete structure to enhance durability. Cover layer of concrete over the reinforcement bars recommended values are shown in Table 3.

Table 3: Cover recommended for reinforcement bars

Zone	Cover over reinforcing steel, mm	Cover over post tensioning ducts, mm
Atmospheric zone not subjected to slat spray	50	75
Atmospheric zone subjected to slat spray	65	90
Submerged zone	50	75
Cover of stirrups	12 mm less than above	12 mm less than above

6. Good compaction and well-made construction joints in the structure both help the concrete structure to withstand against expansion caused by seawater;

7. Use of pozzolanic material and slag in the preparation of concrete are good against salt water;

8. For better durability, high pressure steam cured concrete elements can be used for construction in marine conditions;

9. Aggregates used for production of concrete should be thoroughly washed with fresh water to reduce the chloride ion concentration in it;

10. The use of Self-Compacting Concrete with recycled or industrial pozzolanic by-products, on site or precast, and with the aid of fibers can improve the durability of such structures, while promoting the idea of sustainability [6,7].

5 Conclusion

Switching from the oil and coal-based energy industries to clean energy harvesting can incorporate solutions such as marine generators - structures for harvesting this type of energy through wave energy. Concrete, as a suitable low-cost material can be used in such conditions too, but with respect to the specific requirements that outcome from the harsh environment conditions that act on these elements. On the other hand, modern concrete, which is based on Portland cement, has to be altered in order to produce a viable solution that could be considered sustainable and environmentally friendly.

The research discussed in this paper opens up several new perspectives for concrete production, also taking into account the corrosion processes that actually create the extremely useful mineral cement that will lead to the permanent durability of the concrete, and maybe even increasing it over time.

6 References

[1] *https://ourfuture.energy/how-it-works/wave-energy/ (10.07.2022)*

[2] *https://www.mocean.energy/founders-blog-the-potential-of-wave-energy/ (08.08.2022)*

[3] *https://econcretetech.com/ (12.08.2022)*

[4] *https://www.sciencedirect.c.om/topics/engineering/biocement (14.08.2022)*

[5] *https://theconstructor.org/concrete/concrete-seawater-effects-preventions/843/ (16.09.2022)*

[6] **Savić A., Marinković S., Jevtić D., Zakić D., Aškrabić M.:** *Properties of Fresh Self-compacting Concrete with Recycled Concrete Filler*, Construction materials for sustainable future, 1st International Conference COMS 2017, Proceedings, pp. 229-236. ISBN: 978-953-8168-04-8, Editors: Ivana Banjad Pecur, Ana Baricevic, Nina Stirmer, Dubravka Bjegovic, Publisher: University of Zagreb, Faculty of Civil Engineering, Zadar, Croatia, 2017;

[7] **Savić A., Jevtić D., Marinković S., Volkov-Husović T.:** *Properties of fresh and hardened Self-compacting Concrete with mineral addition of industrial byproducts*, Contemporary civil engineering practice 2017, Proceedings, pp. 145-172., ISBN 978-86-7892-917-5, COBISS.SR-ID 314297095, Editors: Radonjanin V., Folić R., Publisher: Department of Civil Engineering and Geodesy, Faculty of Technical Sciencies, Novi Sad.