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Podgorica, 15.07.2020.

Broj: 903

UNIVERZITET CRNE GORE

SENATU

Pošovani,

U prilogu vam dostavljamo predlog Vijeća Građevinskog fakulteta o imenovanju komisije za ocjenu doktorske disertacije mr Željke Beljkaš, dipl.inž.grad, sa propratnom dokumentacijom.

Srdačno,

DEKAN,

Prof. dr Marina Rakočević

УНИВЕРЗИТЕТ ЦРНЕ ГОРЕ
ГРАЂЕВИНСКИ ФАКУЛТЕТ - ПОДГОРИЦА
Број 902
Подгорица 15.07.2020. год.

Na osnovu člana 64. Statuta Univerziteta Crne Gore i člana 41. Pravila doktorskih studija Univerziteta Crne Gore, Vijeće Građevinskog fakulteta u Podgorici na sjednici održanoj 11.07.2020.godine, utvrdilo je

PREDLOG

Predlaže se Senatu Univerziteta Crne Gore da imenuje Komisiju za ocjenu doktorske disertacije mr Željke Beljkaš, dipl.inž.građ., pod naslovom „Prognozni model za procjenu izgradnje integralnih drumskih mostova“, u sastavu:

1. Prof. dr Nenad Ivanišević,dipl.inž.građ., redovni profesor Građevinskog fakulteta Univerziteta u Beogradu.
2. Prof. dr Miloš Knežević,dipl.inž.građ., redovni profesor Građevinskog fakulteta Univerziteta Crne Gore.
3. Dr Snežana Rutešić,dipl.inž.građ., docent Građevinskog fakulteta Univerziteta Crne Gore.

Komisija je dužna da Vijeću Građevinskog fakulteta u Podgorici, podnese izvještaj koji sadrži ocjenu doktorske disertacije, u roku od 45 dana od dana imenovanja.

- VIJEĆE GRAĐEVINSKOG FAKULTETA U PODGORICI -

DEKAN,
Prof. dr Marina Rakočević

УНИВЕРЗИТЕТ ЦРНЕ ГОРЕ
ГРАЂЕВИНСКИ ФАКУЛТЕТ - ПОДГОРИЦА
Број 902/1
Подгорица 15.07.2020. год.

UCG

ISPUNJENOST USLOVA DOKTORANDA

OPŠTI PODACI O DOKTORANDU			
Titula, ime, ime roditelja, prezime	Mr Željka Branka Beljkaš		
Fakultet	Građevinski fakultet		
Studijski program	Građevinarstvo – Menadžment i tehnologija u građevinarstvu		
Broj indeksa	4/12		
NAZIV DOKTORSKE DISERTACIJE			
Na službenom jeziku	Prognozni model za procjenu troškova izgradnje integralnih drumskih mostova		
Na engleskom jeziku	Forecast model for estimation of construction cost of integral road bridges		
Naučna oblast	Menadžment i tehnologija u građevinarstvu		
MENTOR/MENTORI			
Prvi mentor	Prof.dr Miloš Knežević, dipl.inž.građ, redovni profesor	Univerzitet Crne Gore, Građevinski fakultet, Crna Gora	Građevinarstvo – Menadžment i tehnologija u građevinarstvu
KOMISIJA ZA PREGLED I OCJENU DOKTORSKE DISERTACIJE			
Prof.dr Nenad Ivanišević, dipl.inž.građ, redovni profesor		Univerzitet u Beogradu, Građevinski fakultet, Srbija	Građevinarstvo – Menadžment i tehnologija u građevinarstvu
Doc.dr Snežena Rutešić, dipl.inž.građ, docent		Univerzitet Crne Gore, Građevinski fakultet, Crna Gora	Građevinarstvo – Menadžment i tehnologija u građevinarstvu
Prof.dr Miloš Knežević, dipl.inž.građ, redovni profesor		Univerzitet Crne Gore, Građevinski fakultet, Crna Gora	Građevinarstvo – Menadžment i tehnologija u građevinarstvu
Datum značajni za ocjenu doktorske disertacije			
Sjednica Senata na kojoj je data saglasnost na ocjenu teme i kandidata	03.07.2018.		
Dostavljanje doktorske disertacije organizacionoj jedinici i saglasanost mentora	09.07.2020.		
Sjednica Vijeća organizacione jedinice na kojoj je dat prijedlog za imenovanje Komisije za pregled i ocjenu doktorske disertacije	11.07.2020.		

ISPUNJENOST USLOVA DOKTORANDA

U skladu sa članom 38 pravila doktorskih studija kandidat **je** dio sopstvenih istraživanja vezanih za doktorsku disertaciju publikovao u časopisu sa **SCI/SCIE** liste kao prvi autor.

Spisak radova doktoranda iz oblasti doktorskih studija koje je publikovao u časopisima sa SCI/SCIE liste

Beljkaš Željka, Knežević Miloš, Snežana Rutešić, Nenad Ivanišević: "*Application of Artificial Intelligence for the Estimation of Concrete and Reinforcement Consumption in the Construction of Integral Bridges*", Advances in Civil Engineering, Volume 2020, Article ID 8645031, 8 pages, ISSN: 1687-8086 (Print), ISSN: 1687-8094 (Online) *https://doi.org/10.1155/2020/8645031*

Obrazloženje mentora o korišćenju doktorske disertacije u publikovanim radovima

Rad pod nazivom "Application of Artificial Intelligence for the Estimation of Concrete and Reinforcement Consumption in the Construction of Integral Bridges" je u direktnoj vezi sa doktorskom disertacijom i dio je istraživanja koje je sprovedeno u doktoskoj disertaciji. Rad prikazuje proces formiranja modela za procjenu utrošaka betona i armature kod izgradnje integralnih drumskih mostova. Procjena utroška osnovnih materijala u građevinarstvu je veoma važna u početnim fazama realizacije projekata. Njena važnost se ogleda u uticaju količina materijala na formiranje cijena pojedinačnih pozicija a samim tim i na formiranje ukupne cijene izgradnje. Na osnovu procjene o količini materijala koja će se utrošiti, između ostalog, građevinske kompanije formiraju ponudu sa kojom izlaze na tržište. Preciznost ponude, uz sagledavanje ukupnih uslova realizacije posla, direktno utiče na profit koji kompanija može da ostvari na konkretnom projektu. U ranim fazama realizacije projekta nema dovoljno dostupnih podataka, naročito kada je riječ o podacima potrebnim za procjenu utroška materijala, pa je i preciznost procjene utroška materijala u ranim fazama realizacije projekta manja. U radu je prikazano istraživanje o korišćenju vještačke inteligencije za procjenu utroška betona i armature i izbor optimalnih modela za procjenu. Model za procjenu je urađen uz pomoć vještakih neuralnih mreža. Najbolji model vještačkih neuralnih mreža je pokazao visoku tačnost pri procjeni utrošaka betona i armature.

Datum i ovjera (pečat i potpis odgovorne osobe)

U Podgorici, 11.07.2020.god.

UNIVERZITET CRNE GORE
Građevinski fakultet

MP

DEKAN

Prilog dokumenta sadrži:

1. Potvrdu o predaji doktorske disertacije organizacionoj jedinici
2. Odluku o imenovanju komisije za pregled i ocjenu doktorske disertacije
3. Kopiju rada publikovanog u časopisu sa odgovarajuće liste
4. Biografiju i bibliografiju kandidata
5. Biografiju i bibliografiju članova komisije za pregled i ocjenu doktorske disertacije sa potvrdom o izboru u odgovarajuće akademsko zvanje i potvrdom da barem jedan član komisije nije u radnom odnosu na Univerzitetu Crne Gore

VIJEĆU GRAĐEVINSKOG FAKULTETA UNIVERZITETA CRNE GORE

Predmet: *ZAHTJEV ZA OCJENU DOKTORSKE DISERTACIJE*

kandidata mr Željke Beljkaš

Poštovani,

Molim Vas da imenujete komisiju za ocjenu doktorske disertacije pod nazivom: **„Prognozni model za procjenu troškova izgradnje integralnih drumskih mostova"**

Uz molbu prilažem sledeću dokumentaciju:

- Pisanu saglasnost mentora da rad zadovoljava kriterijume doktorske disertacije,
- Primjerak doktorske disertacije u štampanoj formi,
- CD sa cjelokupnim sadržajem doktorske disertacije u PDF/A formatu,
- Fotokopiju objavljenog rada tematski vezanog za doktorsku disertaciju,
- Rad objavljen u časopisu na SCI listi, u štampanoj formi,
- Potpisanu izjavu, datu kao prilog 1 Uputstva za oblikovanje doktorske disertacije i
- Biografiju.

Potpis doktoranda

U Podgorici

09.07.2020

UNIVERZITET CRNE GORE

GRAĐEVINSKI FAKULTET

PODGORICA

Na osnovu člana 37. Pravila doktorskih studija Univerziteta Crne Gore dajem sljedeću

SAGLASNOST

Rad pod nazivom:

„Prognozni model za procjenu troškova izgradnje integralnih drumskih mostova",

Autora mr Željke Beljkaš, dipl. inž. građ., stručnog saradnika Građevinskog fakulteta Univerziteta Crne Gore, zadovoljava kriterijume doktorske disertacije, propisane Statutom Univerziteta Crne Gore i Pravilima doktorskih studija.

Mentor

U Podgorici

09.07.2020.

Prof. dr Miloš Knežević

УНИВЕРЗИТЕТ ЦРНЕ ГОРЕ
ГРАЂЕВИНСКИ ФАКУЛТЕТ - ПОДГОРИЦА
Број 891
Подгорица 10. 07. 2020. год.

Na osnovu člana 41. Pravila doktorskih studija Univerziteta Crne Gore, Komisija za doktorske studije Građevinskog fakulteta u Podgorici, na sjednici održanoj 10.07.2020.godine, utvrdila je sljedeći

PREDLOG

Predlaže se Vijeću Građevinskog fakulteta da imenuje Komisiju za ocjenu doktorske disertacije mr Željke Beljkaš, dipl.inž.građ, pod naslovom „Prognozni model za procjenu izgradnje integralnih drumskih mostova", u sastavu:

1. Prof. dr Nenad Ivanišević, dipl.inž.građ, redovni profesor Građevinskog fakulteta Univerziteta u Beogradu;
2. Prof. dr Miloš Knežević, dipl.inž.građ, redovni profesor Građevinskog fakulteta Univerziteta Crne Gore;
3. Dr Snežana Rutešić, dipl.inž.građ, docent Građevinskog fakulteta Univerziteta Crne Gore.

OBRAZLOŽENJE

Student Željka Beljkaš je dostavila zahtjev za ocjenu doktorske disertacije dana 09.07.2020.godine sa svom neophodnom dokumentacijom. Komisija za doktorske studije je utvrdila, na osnovu softverske analize, da doktorska disertacija nema elemenata koji bi se mogli tumačiti kao plagijat.

\- KOMISIJA ZA DOKTORSKE STUDIJE -

PREDSJEDNIK KOMISIJE,

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УНИВЕРЗИТЕТ ЦРНЕ ГОРЕ
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god, Pula, Hrvatska Postdiplomske studije: Gđeski faetrzet Crn G Postdiplomske magistarske akademske studije, Studijski program Gđe vinatstvo, Smjer - i tehnologija nja, 2011. god. Mentor: Prof. dr . . niverziteta Crne Gore Komisija za ocjenu podobnosti doktorske teze i kandidata: prof. dr Mlaniće , dipl. in . gra . Redovni profesor Graving fat U niverziteta Crne Gore prof. dr Nenad Ivaiše i ć, dipl in . gra . Redovni profeso niverziteta u Beogradu prof.

dr Milo š Knev i ć, dipl in . gra . Redovni prsorđeskokultea niverziteta Crne Gore Komisija za ocjenu doktorske disertacije: Komisija za odbranu doktorske disertacije: Lektor: Danka Red žić Datum odbrane: REZIME PODACI O DOKTORSKOJ DISERTACIJI Naziv doktorskih studija: Doktorske studije Univerziteta Crne Gore Građevinskakult Studijski program – Građevinarstvo Naslov doktorske disertacije: Prognozni mo del za projenu troš kova izgradnje integralnih drumskih mostova Rezime: Ptroškova ramostje sastavni dio kompleksne oblasti izgradnje mostOno je evidentno je da p nj a posvećovom eoblastinij proporcionalna njegovoj važnost i u kompleksnom procesu realizacije projekta.

U prilog ovome ide i činjenica da oji j radova koji se bave ovom problematikom. Razlog za takvo stanje je nepostojanje sistematskog realizovanih projekata, a o zgradnje mostova, karakteristike m realizacije projekata. Proc ije p dobro obavljene procjene ili u

Prilog 1.

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Potpisana Željka Beljkaš

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Ime i prezime autora	Željka Beljkaš
Broj indeksa/upisa	4/12
Studijski program	Građevinarstvo
Naslov rada	Prognozni model za procjenu troškova izgradnje integralnih drumskih mostova
Mentor	Prof.dr Miloš Knežević, dipl. inž. građ.
Potpisana	mr Željka Beljkaš, dipl. inž. građ.

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U Podgorici, 08.07.2020.

Potpis doktoranda

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Research Article

Application of Artificial Intelligence for the Estimation of Concrete and Reinforcement Consumption in the Construction of Integral Bridges

Željka Beljkaš,[1] **Miloš Knežević**,[1] **Snežana Rutešić**,[1] **and Nenad Ivanišević**[2]

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Estimation of basic material consumption in civil engineering is very important in the initial phases of project implementation. Its importance is reflected in the impact of material quantities on forming the prices of individual positions, hence on forming the total cost of construction. The construction companies use the estimate of material quantity, among other things, as a base to make a bid on the market. The precision of the offer, taking into account the overall conditions of the business realization, directly influences the profit that the company can make on a specific project. In the early stages of project implementation, there are not enough available data, especially when it comes to the data needed to estimate material consumption, and therefore, the accuracy of material consumption estimation in the early stages of project realization is smaller. The paper presents the research on the use of artificial intelligence for the estimation of concrete and reinforcement consumption and the selection of optimal models for estimation. The estimation model was developed by using artificial neural networks. The best artificial neural network model showed high accuracy in material consumption estimation expressed as the mean absolute percentage error, 8.56% for concrete consumption estimate and 17.31% for reinforcement consumption estimate.

1. Introduction

Cost estimation in construction represents a quantitative estimate of the probable resource expenses required for completing the activity [1]. A lot of factors affect the cost price. Each of these factors must be analysed, quantified, and estimated.

Estimating the final price requires a large number of elements to be synchronized. The process of defining the elements determining total costs includes the calculation of work quantities and then transferring them into expected costs. The basic elements or resources used and involved in the project during construction can be divided into several groups as follows:

(i) Work
(ii) Material
(iii) Equipment
(iv) Profit
(v) Time [2]

In order to carry out a project, it is necessary to organize teams with a large number of people. The initiative for entering the process of project implementation is started by the investor. The other participants in the project are a consultant, designer, expert supervision, contractor, and stakeholders.

In addition to the investor, the contractor has an important role on the project, since he represents a direct executor of the construction. An investor chooses a contractor based on certain criteria. Most commonly, these criteria require the construction of the highest quality structure with the minimum amount of money expended and in the shortest time possible. Clearly, these are the criteria that strive to idealize the entire course of the project and are therefore difficult to achieve.

The investor and contractor estimate costs for themselves, separately. Depending on the cost estimation results, the decisions are made about the further steps in the project. It is often the case that certain project implementation is withdrawn after the estimation, or the design is significantly modified.

A large number of factors, such as availability, quality, and the level of details in technical documentation, estimation method as well as the expertise of people performing the estimate, determine its quality and reliability from the aspect of satisfactory accuracy. The initial phases of project implementation are characterized by the insufficient data quantity. Each subsequent phase brings new data. The availability of the necessary data helps to increase the accuracy of the estimate. In 1974, Barnes presented the dependence of cost estimate accuracy and the phase of the project (see Figure 1).

The price offered by a contractor for project implementation is usually the main and quite often the only criteria based on which the investor chooses a contractor. Thus, the procedure for choosing a contractor according to this criterion is extremely simple, since the bidder with the lowest price will be chosen as the contractor. The problem with this method of contractor selection is the inability to see whether the project will be successfully completed, i.e., whether the contractor who offered the lowest price will be able to complete the project in the expected or at least satisfactory way (taking into account expenses, quality, and time).

A preliminary project cost estimate is the first serious estimate to be made on a project. During the initial phases of project implementation, it is not necessary to have a sufficiently accurate cost estimate. Since the material is one of the elements that affects the overall cost of the project, in order to reach its estimate, it is necessary, among other things, to determine the quantities of construction material required in the project. After determining the quantities, they are multiplied by the corresponding unit prices of these materials, and thus, we arrive at an estimate of the material costs which is one of the items in the sum of total expenses. The advantage of the cost estimation algorithm, in which there is a cost breakdown of items, is that it updates the cost separately, position by position, when new data become available. Also, the positive side of this approach is that positions can be monitored separately, allowing decision makers to make better decisions about the project during its initial phase.

In this study, the estimate of material consumption is performed for the materials which are most present in bridge construction, reinforcement, and concrete. The estimate is based on the values taken from the bills of quantities and cost estimates from the design documentation based on which the works were contracted.

2. Application of Artificial Neural Networks in Construction

Application of neural networks, one of the artificial intelligence techniques, in construction engineering, is quite widespread. They can be used in all the project implementation phases. The journal Microcomputers in Civil Engineering published a paper in 1989 which refers to the use of neural networks in this area. The authors of this paper are Adeli and Yeh [4]. The application of neural networks in construction is becoming more and more common because, in addition to the wide range of abilities they have, the rapid development of software packages has contributed to this.

Neural networks can be used for different types of estimates. One of them is the cost estimation of different types of construction and it has been processed by a large number of authors in their works [5–11]. In addition to cost estimation, neural networks can be used to estimate the duration of construction projects, which was also a topic dealt with by certain authors [8, 12]. Estimation of material consumption for the facility construction is another one of the estimates that is possible to be performed by applying neural networks. Despite this, there are only few papers in the literature that present the results of neural network applications for the purpose of estimating material consumption.

Fragkakis et al. represented the conceptual model for cost estimation of bridge foundations, which also gives the estimation of material consumption. Independent variables, which are relevant to the model, were identified by experts in the interviews. For defining this model, the authors used the stepwise regression methodology in order to determine whether the results were consistent with the expert opinion. The main assumptions underlying the correct application of the regression method were examined, and the necessary adjustments were made. The proposed method of conceptual cost estimation and material consumption estimation provides quick and reliable results that can be very useful in the early phases of a project [13].

An estimation of required material quantities, concrete, and reinforcement in multistorey buildings was performed by Mučenski et al. The forecasting model was defined using neural networks. Model analysis and definition data were taken from 115 major multistorey projects. The input variables of the model for forecasting the required amount of concrete and reinforcement are as follows: total gross area, average gross floor area, number of stiffening walls, longitudinal raster, transverse raster, and type of landing structure. The best results were shown by a network trained with the BFGS (Broyden–Fletcher–Goldfarb–Shanno) algorithm with an average error of 12.49% [14].

Garcia de Sotto et al. made an estimate of the materials and presented the methodology which was used to achieve estimate of satisfactory accuracy in the early phases of project implementation. They used neural networks, among other things, for modelling. Obtained results showed a significant improvement compared to the situation in practice [15].

The same authors, Garcia de Sotto et al., aimed to devise a process for developing a model which would be used for the preparation of preliminary estimates of construction material quantities taking into consideration data which are available during the early phases of the project and to assess the model by using the Akaike information criterion. The

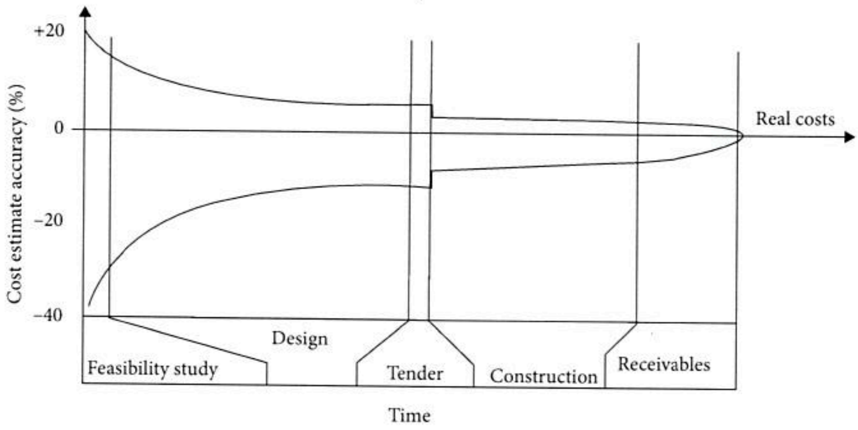

FIGURE 1: Cost estimate reliability [3].

proposed procedure is illustrated by an example in which data from 58 designs were used to define the model. These data were used for estimating used up concrete and reinforcement by using the neural network technique. For choosing the model with the highest accuracy, Akaike information criteria were used [16].

3. Materials and Methods

The first step undertaken for the purposes of this research is data collection and analysis. The data collected, after analysis, had to be prepared for model formation. In the end, two final models for the estimation of construction material consumption were defined, one for the concrete consumption and the other for reinforcement consumption.

The data were collected from the Main Designs of Integral Road Bridges, which were built on highways in the territories of Montenegro, Bosnia and Herzegovina, and Serbia. The term integral bridges is a modern term for concrete and composite frame structures of bridges without expansion joints and bearings [17]. There are several definitions of integral bridges. According to some, integral bridges are single-span frames with no expansion joints and bearings. In addition to this, we can find other definitions in the literature. They define this type of bridges as continuous frames without expansion joints and bearings just above the piers.

The research included 101 structures. Among them, there are 48 bridges from Montenegro, 29 bridges from Bosnia and Herzegovina, and 24 bridges from Serbia. The design documentation was prepared in three countries, so its form differs from one another. Therefore, the analysis and data preparation processes were complex. Only the same types of work were taken from all the bills of quantities and cost estimates in order to achieve data uniformity. In bills of quantities and cost estimates, the types of works are divided into preliminary, earthworks, concrete, reinforcement, tensioning works and prestressing, insulating, asphalt, and finishing works. Data on quantities of concrete and reinforcement were taken from concrete and reinforcement types of work.

An integral part of the technical documentation for the main design of bridges is the bill of quantities and cost estimate, and all the necessary data are obtained from them. The spans of these bridges range from 11.5 to 28 meters, the number of spans is from 1 to 18, the length of bridges without wing walls ranges from 11.5 to 784.4 meters, and the pier height is from 2.8 up to 65 meters. These projects were carried out in the period from 2010 until 2016.

After collecting the material quantity data, model input data were determined. Model inputs will represent certain design characteristics of bridges. The criteria for choosing such characteristics were their direct impact on material consumption. Based on this, the following characteristics were chosen: bridge length, bridge width, pier height, and bridge span. The data about bridge characteristics were taken from the main designs of these structures. Some of the data, such as pier height and bridge span, had to be corrected in such a way that a single value could be used as an input size. This is the reason why, when pier height is mentioned, as input data, it implies the mean height of middle piers. In case of a single-span structure, as a mean pier height, it is implied that the mean abutment height was used. Regarding the span of the bridge, this parameter had to be corrected for the fact that it is not the same if you have a larger number of smaller spans or a smaller number of larger spans in the identical length of the bridge. Due to this fact, the bridge span, as an input parameter, implies the mean of the span. The input data, prepared in the aforementioned manner, are presented with their limit and mean values in the table (see Table 1).

In order to improve the model for the material consumption estimate, as the input parameters, the data on construction technology and structure foundation are introduced.

For the span structure of analysed bridges, two types of formworks were used: formworks on a fixed scaffolding and formworks on mobile scaffolding. For that reason, the new input variable, named construction technology, has a value of 0 for formworks on a fixed scaffolding and the value is 1 when the formworks are on a mobile scaffolding.

The method of founding determines the amount of material used for founding. The bridges whose data were

Table 1: Input data.

Input data number	Input data description	Data type	Meas. unit	Min	Max	Mean value
Input 1	Bridge length	Numeric	m	11.5	784.4	153.25
Input 2	Bridge width	Numeric	m	6.5	30.55	11.52
Input 3	Pier height	Numeric	m	2.8	35.9	13.65
Input 4	Bridge span	Numeric	m	11.3	44.5	24.07
Input 5	Construction technology	Discrete	—	0	1	—
Input 6	Founding method	Discrete	—	0	2	—

used in this research were founded shallow, deep, or combined. The new input variable, named the founding method, depending on the method of founding, has the following values: 0 in case of shallow founding, 1 in case of deep founding, and 2 in case of combined founding.

The next step is defining the model output data. Based on the considered parts of the research, one output from each model was determined, which is the total amount of concrete and the total amount of reinforcement for the construction of integral road bridges (see Tables 2 and 3).

In the process of model formation using artificial neural networks, the available data should be divided into two sets. These two sets represent the training and test sets. The data of the training set are used for training and from the test set for checking the network.

Various recommendations can be found in the literature regarding the percentage ratio of these sets. A large number of authors select data in the ratio 90% to 10%, 80% to 20%, 85% to 15%, or 70% to 30% [18]. Of course, these are just recommendations, and the specificity of each of the problems being solved makes us decide on the appropriate ratio between the two sets. In this research, the training and test set will be divided in the ratio 80% to 20%. In 6 models, a direct division will be made into training and test sets, and in 2 models, a random selection of data will be done. The cross-validation procedure (k-fold cross-validation and leave-one-out cross-validation) shall be used to randomly select data.

Network training is preceded by a transformation, i.e., scaling data to fit everyone within a certain size range. The choice of ranges for scaling inputs and outputs depends on the activation function of the output quantities. Data can be scaled using standardization and normalization [19, 20]. The result of these methods is to reduce certain data to the same order of magnitude. Moreover, they enable the analysis of data of the same importance when forming the model, which means that it will also provide data analysis with a smaller size range. The data scaling methods used in the study are StandardScaler (Z-score normalization) and min-max normalization.

Network formation begins with determining the network architecture. This involves defining the number of layers and the number of neurons in each of the layers. Some authors recommend that it is not necessary to take more than two hidden layers when defining an artificial neural network [18, 21, 22]. The confirmation that the networks with two hidden layers gave reliable results is found in many theoretical results and numerous simulations in various engineering fields. In addition, there are theoretical results that indicate that a single hidden layer is sufficient for the network to approximate any complex nonlinear function with sufficient accuracy [23].

The number of neurons in the hidden layers is not uniquely determined. There are recommendations in the literature but not a precise and reliable way of determining them. A large number of neurons lead to the problem of overfitting, while the insufficient number of neurons leads to the problem of underfitting, i.e., poor approximation of the dependence between input and output quantities. The number of neurons should be such that it does not lead to any of these issues, but to enable data to exhibit its most useful characteristics. The recommendations made by some authors refer to the upper limit of the number of neurons in the hidden layer. Lippmann (1987), Nielsen (1987), and Hecht-Nielsen (1990) recommend determining the number of neurons following inequality (1), whereas Rogers and Dowla (1994) give recommendations for the maximum number of neurons, N_H, following inequality (2). It is advisable to accept a smaller number from the ones stated in the inequality, where N_i is the number of input parameters and N_S is the number of training samples:

$$N_H \leq 2 \times N_i + 1, \tag{1}$$

$$N_H \leq \frac{N_S}{N_i + 1}. \tag{2}$$

In the process of defining a model, one must strive to find a model with the best possible opportunity for generalization. Generalization is a process in which knowledge that is valid for a certain set of cases is transferred to some of its supersets [24], i.e., based on data which are not presented to the model during the training (the validation set), the model has the ability to result in satisfactory sizes even though based on data which are not presented during training. The validation set is introduced to avoid the problem of overfitting or determine stopping points of the training process [25]. Generalization in forecasting is further enhanced by the cross-validation process. This procedure is performed on the data from the test set.

Constant performance measurement is done during the model definition. Performance measurement, in fact, is an accuracy forecast. The difference between the actual (desired) and the forecast value is the forecasting error, and a measure of accuracy is defined. There are a number of accuracy measures for forecasting in the literature. The accuracy of the model in this study was determined using the mean absolute percentage error (MAPE). A satisfactory generalization probability in models is achieved if the

Table 2: Output data of the first model.

Output data number	Output data description	Data type	Meas. unit	Min	Max	Mean value
Output 1	Total quantity of concrete	Numeric	m^3/m^2	1.05	3.11	1.54

Table 3: Output data of the second model.

Output data number	Output data description	Data type	Meas. unit	Min	Max	Mean value
Output 1	Total quantity of reinforcement	Numeric	kg/m^2	117.26	415.58	250.8

Table 4: Activation functions of a multilayer perceptron model of the artificial neural network.

Function	Mark	Explanation	Range
Identity	x	Only in the output layer	$(-\infty, +\infty)$
Rectified linear unit function	$\mathrm{Max}(0, x)$	Neuron activation is forwarded directly as an output if positive, and if negative, it is forwarded to 0. It has been shown to have 6 times better convergence than a hyperbolic tangent function	$(0, +\infty)$
A hyperbolic tangent	$[2/(1 + e^{-2x})] - 1$	Neuron activation is forwarded directly as an output if positive, and if negative, it is forwarded to 0. It has been shown to have 6 times better convergence than a hyperbolic tangent function	$(-1, +1)$

deviation between the forecasted and expected results at the training and test set is small.

The forecasting model was formed in Python 3.7 software package. In order to solve the problem that is the subject of the research, models about estimating material consumption, a multilayer perceptron MLP is formed, which is one of the artificial neural network types.

The most commonly used neuron activation functions in the hidden layers are logistic sigmoid (logistic), a hyperbolic tangent (tanh), and the function of rectified linear unit (ReLu). The activation function of output neurons is mostly linear. Bearing in mind, the number and other data characteristics, following the aforementioned recommendations, during the model formation, for hidden neurons, the function of rectified linear unit (ReLu), and a hyperbolic tangent (tanh) were used, whereas for the output neurons, the identity function was used (see Table 4).

4. Results

Artificial neural network models, multilayer perceptron (MLP), are formed based on defined input and output sizes and other required parameters. The number of layers as well as the number of neurons in hidden layers is determined based on recommendations, and the number of neurons in the input and output layer is determined based on the number of input and output sizes. The largest number of hidden neurons which was taken in the models is 13 based on expressions (1) and (2). 8 artificial neural network models were formed. In one half of these models, the data were used which were scaled by using the StandardScaler procedure, whereas for the other the min-max procedure was used.

All neural networks in both models, NMB1, NMB2, NMB3, NMB4, NMB5, NMB6, NMB7, and NMB8 for the model forecasting concrete consumption and NMA1, NMA2, NMA3, NMA4, NMA5, NMA6, NMA7, and NMA8 for the model forecasting reinforcement consumption, have 6 input and 1 output size. Neural network models with StandardScaler standardization for forecasting concrete consumption and reinforcement consumption are presented in tables (see Tables 5 and 6). They also list the characteristics of each model with a measure of accuracy given by the mean absolute percentage error (MAPE).

The following three neural network models are formed using the data which were scaled by applying the principle of min-max normalization. Data about model characteristics as well as the estimation accuracy which is determined by the mean absolute percentage error (MAPE) are presented in tables (see Tables 7 and 8).

Random data selection was done with two models using k-fold cross-validation for $k = 10$ and leave-one-out cross-validation (LOOCV). Estimation accuracy in these models is determined through mean absolute percentage error (MAPE) (see Tables 9–12). In those models where data division was done in accordance with k-fold cross-validation, the data were scaled by using a Standard Scaler, and in those models where the division was done with LOOCV, the data were scaled with min-max function. Two of each model that gave the best results are presented here.

By comparing presented models, it can clearly be seen that models NMB1 and NMA8 have the highest estimation accuracy. For model NMB1, StandardScaler was used for scaling the data. It defines 3 layers of neurons, one of which is input and one output layer. In the hidden layer, there are 12 neurons. The activation function of a hidden layer is the function of rectified linear unit (ReLu). The measure of the accuracy assessment model is expressed through mean absolute percentage error and is 8.56%.

Model NMA8 processed data which were scaled by using min-max normalization. The network architecture of this model is represented by 3 layers of neurons. There are 6 neurons in the input layer, 1 in the output, and 9 neurons in a hidden layer. The activation function of a hidden layer is

Table 5: Artificial neural network models for estimating concrete consumption (StandardScaler).

Model name	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE training set (%)	MAPE test set (%)
NMB1	MLP 6-12-1	ReLu	Identity	7.68	8.56
NMB2	MLP 6-4-1	Tanh	Identity	10.7	11.51
NMB5	MLP 6-7-1	ReLu	Identity	8.01	9.95

Table 6: Artificial neural network models for estimating reinforcement consumption (StandardScaler).

Model name	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE training set (%)	MAPE test set (%)
NMA1	MLP 6-7-1	Tanh	Identity	18.85	20.74
NMA2	MLP 6-13-1	ReLu	Identity	10.83	18.51
NMA5	MLP 6-8-1	ReLu	Identity	16.74	19.33

Table 7: Artificial neural network models for estimating concrete consumption (min-max normalization).

Model name	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE training set (%)	MAPE test set (%)
NMB3	MLP 6-11-1	ReLu	Identity	9.97	10.5
NMB4	MLP 6-12-1	Tanh	Identity	10.78	10.81
NMB6	MLP 6-7-1	ReLu	Identity	8.78	10.73

Table 8: Artificial neural network models for estimating reinforcement consumption (min-max normalization).

Model name	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE training set (%)	MAPE test set (%)
NMA3	MLP 6-7-1	ReLu	Identity	18.28	19.03
NMA4	MLP 6-3-1	Tanh	Identity	19.15	19.41
NMA6	MLP 6-9-1	ReLu	Identity	18.26	18.78

Table 9: Artificial neural network models with random data choice for estimating concrete consumption (k-fold cross-validation, $k = 10$).

Model name	Data-scaling procedure	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE (%)	σ (%)
NMB7	StandardScaler	MLP 6-4-1	ReLu	Identity	12.69	3.64

Table 10: Artificial neural network models with random data choice for estimating concrete consumption (LOOCV).

Model name	Data-scaling procedure	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE training set (%)	MAPE test set (%)
NMB8	Min-max	MLP 6-11-1	ReLu	Identity	10.69	11.06

Table 11: Artificial neural network models with random data choice for estimating reinforcement consumption (k-fold cross-validation, $k = 10$).

Model name	Data-scaling procedure	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE (%)	σ (%)
NMA7	StandardScaler	MLP 6-4-1	ReLu	Identity	22.91	2.5

Table 12: Artificial neural network models with random data choice for estimating reinforcement consumption (LOOCV).

Model name	Data scaling procedure	Model characteristics	Activation function of hidden layers	Activation function of an output layer	MAPE training set (%)	MAPE test set (%)
NMA8	Min-max	MLP 6-9-1	ReLu	Identity	14.12	17.31

the function of a rectified linear unit (ReLu). Mean absolute percentage error is 17.31%.

The two models with the highest accuracy were selected as the final models for the estimation of concrete and reinforcement consumption, and based on them, the forecasting models were defined.

5. Conclusion

Based on the results presented in the study, it is concluded that the models with the highest accuracy of concrete consumption and reinforcement for the construction of integral road bridges are artificial neural network models whose architecture is represented by three layers of neurons, six of which are in the first layer, and one in the last output layer. In the hidden layer, there are 12 neurons in the concrete consumption estimation model, while 9 neurons are in the reinforcement consumption estimation model. The activation function of the hidden layers of neurons is the function of a rectified linear unit (ReLu), while the activation function of the output layers is linear (Identity). The accuracy measure is represented in both models by mean absolute percentage error (MAPE). In the model for concrete consumption, MAPE = 8.56%, whereas MAPE for the estimate of reinforcement consumption is 17.31%.

It is possible to improve the accuracy of a forecasting model by increasing the number of data in the data base. Additionally, the forecasting model would have the potential to be more widely applied if the database was expanded with certain features of the structures such as the type of cross section, height of the cross section, number of spans, number of piers, and structural system. The database could be improved by entering data on the category of the road (type and significance of the road) on which the bridges are located. The justification for the existence of this type of data in the database lies in the fact that the category of the road directly affects the load of bridges, which affects main characteristics of bridges and thus the amount of concrete and reinforcement. The potential parameters by which the database could be expanded would, in fact, be the input parameters of the forecasting model.

The use of a forecasting model would be particularly beneficial to the contractor when he is also the designer (for the contract-type design-build). With the help of a forecast model, without having to develop the preliminary design and only on the basis of sketches, the contractor could estimate the amount of material. The estimated amount of material is significant to him in the competitive bidding phase in order to submit as precise a bid as possible.

In the early phases, the amount of data available on future structures is insufficient for forming the accurate estimate. This means that the error in estimating material consumption is also greater than the estimates made in the subsequent phases of implementation. Quantity, type, and quality of data, which are available at the time of evaluation, condition the application of a model. This is the reason why it is necessary to adjust the input parameters to the data we have. The estimation importance in the early phases lies in the fact that the results of this early estimate directly affect assessing a total cost which in the further process determines/recommends us, or not for entering into the project implementation.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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имен.

УНИВЕРЗИТЕТ У БЕОГРАДУ

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СЕНАТ УНИВЕРЗИТЕТА
У БЕОГРАДУ

Београд, 20.02.2019. године
06-01 Број: 61202-521/3-19
МЦ

На основу чл. 75. ст. 2 Закона о високом образовању ("Службени гласник РС", број 88/17 и 73/18), чл. 43. ст. 1. тач. 22. и чл. 44. ст. 4. Статута Универзитета у Београду ("Гласник Универзитета у Београду", број 201/18), чл. 26. ст. 1. и ст. 2. тач. 1. Правилника о начину и поступку стицања звања и заснивања радног односа наставника Универзитета у Београду ("Гласник Универзитета у Београду", број 200/17) и Правилника о минималним условима за стицање звања наставника на Универзитету у Београду ("Гласник Универзитета у Београду", број 192/16, 195/16, 196/16, 197/17 и 199/17), а на предлог Изборног већа Грађевинског факултета, број: 464/9-18 од 24.01.2019. године и мишљења Већа научних области грађевинско-урбанистичких наука, број: 61202-521/2-19 од 05.02.2019. године, Сенат Универзитета, на седници одржаној 20.02.2019. године, донео је

ОДЛУКУ

БИРА СЕ др Ненад Иванишевић у звање редовног професора на Универзитету у Београду-Грађевински факултет, за ужу научну област Менаџмент и технологија грађења.

Образложење

Грађевински факултет је дана 28.11.2018. године у листу „Послови" објавио конкурс за избор у звање редовног професора, за ужу научну област Менаџмент и технологија грађења, због потреба Факултета.

Извештај Комисије за припрему извештаја о пријављеним кандидатима стављен је на увид јавности дана 17.12.2018. године преко Библиотеке и сајта Факултета.

На основу предлога Комисије за припрему извештаја о пријављеним кандидатима, Изборно веће Грађевинског факултета, на седници одржаној дана 24.01.2019. године, донело је одлуку о утврђивању предлога да се кандидат др Ненад Иванишевић изабере у звање редовног професора.

Грађевински факултет је дана 28.01.2018. године доставио Универзитету комплетан захтев за избор у звање на прописаним обрасцима.

Универзитет је комплетну документацију коју је доставио Факултет ставио на web страницу Универзитета дана 29.01.2018. године.

Веће научних области грађевинско-урбанистичких наука, на седници одржаној дана 05.02.2019. године дало је мишљење да се др Ненад Иванишевић може изабрати у звање редовног професора.

Сенат Универзитета, на седници одржаној дана 20.02.2019. године разматрао је захтев Грађевинског факултета и утврдио да кандидат испуњава услове прописане чл. 74. и 75. Закона о високом образовању и чланом 135. Статута Универзитета у Београду, као и услове прописане и Правилником о минималним условима за стицање звања наставника на Универзитету у Београду, па је донета одлука као у изреци.

Поука о правном леку:
Против ове одлуке кандидат пријављен на конкурс може изјавити жалбу Сенату Универзитета, преко факултета. Жалба се доставља факултету у року од 8 дана од дана достављања одлуке.

ПРЕДСЕДНИЦА СЕНАТА
Ректорка
Проф. др Иванка Поповић

UNIVERSITAS BELGRADENSIS

Доставити:
- Факултету (2)
- архиви Универзитета
- сектору 06

Curriculum Vitae (CV)
Prof dr Nenad Ivanišević, dipl.inž.građ i dipl. pravnik

Nenad Ivanišević rođen je 25.11.1960. godine u Mostaru. Završio je Matematičku gimnaziju u Beogradu, programerski smer 1979. godine. Diplomirao je na Građevinskom fakultetu Univerziteta u Begradu 1986. godine. Na Pravnom fakultetu Univerzitea u Beogradu diplomirao je 1995. godine. Magistrirsku tezu "Prilog sistematizovanju i anlalizi tipova međunarodnih ugovora u građevinarstvu, sa posebnim osvrtom na FIDIC-ove uslove po sistemu projektuj-izgradi i ključ u ruke" odbranio je na Građevinskom fakultetu u Beogradu 1999. godine, a doktorsku disertaciju pod naslovom: "Upravljanje procesom izbora ugovorne strategije u građevinarstvu uz primenu teorije fazi (rasplinutih) skupova" odbranio je na istom fakultetu 2007. godine.

Zaposlen je od 1989. godine na Građevinskom fakultetu u Beogradu, prvo kao stručni saradnik, a potom u nastavnim zvanjima. U februaru 2019. godine postao je redovni profesor. Šef je katedre za upravljanje projektima u građevinarstvu. Predmetni je nastavnik na predmetima: „Menadžment i tehnologija građenja“, „Ugovaranje u građevinarstvu“, „Pravna regulativa u građevinarstvu“, „Merenje i vrednovanje radova“, „Upravljanje projektima“ (na redovnim studijama), „Vrednovanje građevinskih objekata“ (na master studijama) i „Međunarodne tenderske procedure“ (na doktorskim studijama).

Gostujući je nastavnik na Univerzitetu Crne Gore, Građevinskom fakultetu u Podgorici (Crna Gora) na predmetu Projektovanje organizacije građenja, rekonstrukcije i održavanja objekata (od školske 2009/10).

Osim u nastavi radio je i na realizaciji većeg broja velikih investicionih projekata u Srbiji i inostranstvu (u periodu od 1989 do 1995. godine radio je na projektima u Iraku i Rusiji).

U Inženjerskoj komori Srbije bio je zamenik tužioca Suda časti (od 2005. do 2013. god), a u periodu 2013. do 2014. godine član Nadzornog odbora

Član Državne komisije za stručnu kontrolu (reviziju) projekata od značaja za Republiku Srbiju bio je u periodu od 2007. do 2014.godine, a od tada je izvestilac komisije

Bio je član prvog upravnog odbora „Koridor 10“ d.o.o. (sada „Koridori Srbije“ d.o.o.), a od tada je član Skupštine „Koridori Srbije“ d.o.o.

Obavljao je funkcije posebnog savetnika ministra za Nacionalni investicioni plan (od oktobra 2008. godine do februara 2011.), Savetnik podpredsednika Vlade za ekonomiju i regionalni razvoj (od aprila 2011 godine do jula 2012. godine) i Posebnog savetnika ministra za regionalni razvoj i lokalnu samoupravu (2012- 2014 god)

Problematika kojom se bavi je vezana za oblast upravljanja projektima u građevinarstvu, a naročito vezanom za ugovaranje radova i ugovornu problematiku, projektovanje organizacije građenja, dinamiku realizacije radova, planiranje i kontrolu troškova u građevinarstvu. Posebna oblast rada i istraživanja je vazana za procene vrednosti nepokretnosti (licencirani je procenitelj u Srbiji i počasni član Instituta ovlašćenih procjenjivača Crne Gore).

Mentor je na izradi 3 doktorske disertacije (jedna odbranjena), a bio je član više od 10 komisija za ocenu i odbranu doktorskih disertacija. Bio je mentor i član više desetina komisija za odbranu master, specijalističkih i magistarskih radova na više fakulteta.

Koautor je 5 knjiga i 3 monografije koje se bave navedenom problematikom. Ima preko 20 objavljenih radova u vodećim domaćim i međunarodnim časopisima od čega su 6 radovi u časopisima na SCI listi i više od više od 40 naučnih i stručnih radova, koji su izloženi i publikovani u zbornicima radova sa domaćih i međunarodnih naučno-stručnih skupova.

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2. "DINAMIČKI PLANOVI UTEMELJENI NA CIKLUSIMA RADA" - rad objavljen u međunarodnom časopisu na SCI listi "GRAĐEVINAR" no. 11/ 2013 – vol.65/2013, UDK: UDK 69.008.001.8:624.032.22 (ISSN (on line): 1333-9095; ISSN (tisak) 0350-2465), Zagreb, 2013. (str.993-1002), (2014 Impact Factor 0,202) autori: dr Dejan Marinković, dr Zoran Stojadinović, **dr Nenad Ivanišević** - **[M23]**

3. "A COMPUTATIONAL METHOD FOR LAMINATED COMPOSITE PLATES BASED ON LAYERWISE THEORY", rad objavljen u međunarodnom časopisu na SCI listi *"Composites Part B" Volume 122, 1 August 2017, Pages* 202-218 (Impact Factor 3,850), doi: 10.1016/ j.compositesb.2017.03.044, article reference: JCOMB4978, final version published online: 18-May-2017, autori: Rakočević M, Popović S, **Ivanišević N** - **[M21a]**

4. "THE SUCCESSFUL DELIVERY OF MEGAPROJECTS: A NOVEL RESEARCH - METHOD) " - (Paper ID: 106331_PMJ_05_001-017) rad objavljen u međunarodnom časopisu na SCI listi "Project Management Journal" Vol.48, No.5, Pages 78-94, October 2017, Publisher Project Management Institute, 14 Campus Blvd., Newtown Square, PA 19073-3299, USA, autori: Gorgio Locatelli, Miljan Mikić, Miloš Kovačević, Naomi Brookes i **Nenad Ivanišević** - **[M22]**

5. "APPLICATION OF ARTIFICIAL NEURAL NETWORKS IN HYDROLOGICAL MODELLING IN KARST" rad objavljen u međunarodnom časopisu na SCI listi "GRAĐEVINAR" (eng. "CIVIL ENGINEER") – Volume 70 (2018), Issue 1, UDK: 624+69(05)=862, ISSN(electronic version): 1333-9095, ISSN (printed version): 0350-2465, (2016 Impact Factor 0,323) (str. 1-10), doi: https://doi.org/10.14256/JCE.1594.2016, autori: Miljan Kovačević, **Nenad Ivanišević**, Tina Dašić i Ljubo Marković - **[M23]**

6. "Application of Artificial Intelligence for the Estimation of Concrete and Reinforcement Consumption in the Construction of Integral Bridges" rad objavljen u međunarodnom časopisu na SCI listi Hindawi, Advances in Civil Engineering Volume 2020, Article ID 8645031, 8 pages https://doi.org/10.1155/2020/8645031, autori: Željka Beljkaš, Miloš Knežević, Snežana Rutešić i **Nenad Ivanišević** - **[M23]**

Radovi koji su povezani sa tematikom doktorske disertacije

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2. "MARK OF THE INVESTMENT PROJECTS IN CIVIL ENGINEERING WITH THE SPECIAL RETROSPECTION TO THE ECONOMICAL-FINANCIAL MARK OF THE PROJECT" - rad objavljen u međunarodnom časopisu: Central European Journal of Spatial and Landscape Planning "TERRA SPECTRA STU", Volume 1/2010 (ISSN 1338-0370) Bratislava, 2010. (str.47-55), autori: Jasmina Ćetković, Miloš Knežević, Nenad Ivanišević i Snežana Rutešić
3. "METHODS OF CALCULATING DEPRECIATION EXPENCES OF CONSTRUCTION MACHINERY" - rad objavljen u međunarodnom časopisu rangiranom na SCImago Journal Rank listi od 2011: "Journal of APPLIED ENGINEERING SCIENCE" no. 1 – year 2012 – vol.10, (ISSN 1451-4117 UDC: 33), Beograd, 2012.(str.43-48), (doi:10.5937/jaes10-1664), autori: dr Predrag Petronijević, dr Nenad Ivanišević, dr Marina Rakočević i dr Dragan Arizanović
4. "MERENJE PRODUKTIVNOSTI U GRAĐEVINARSTVU" - rad prezentiran na IX međunarodnom naučno stručnom skupu "Savremena teorija i praksa u graditeljstvu" Banja Luka 11. i 12. april 2013. godine (zbornik radova ISBN 978-99955-630-8-0, COBISS.BH-ID 3623704, str.243-253) (Dejan Marinković, Nenad Ivanišević i Zoran Stojadinović)
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6. "AKTUELNA STRATEGIJA REALZIACIJE IZGRADNJE AUTOPUTEVA U REPUBLICI SRBIJI" – rad po pozivu prezentiran kao uvodno izlaganje na internacionalnom naučno-stručnom skupu "14 KONGRES DRUŠTVA GRAĐEVINSKIH KONSTRUKTERA SRBIJE 2014" Novi Sad, 24-26. septembar 2014. (zbornik radova ISBN 978-86-85073-19-9, COBISS.SR-ID 209958412, str. 109-120) (Nenad Ivanišević, Dragan Arizanović, Predrag Petronijević, Miljan Mikić)
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8. "APPLICATION OF FUZZY LOGIC ON SELECTION OF CONTRACTORS FOR CONSTRUCTION OF HIGH RISE BUILDINGS" rad objavljen u IOP Conference Series Earth and Environmental Science 222:012021 January 2019. DOI: 10.1088/1755-1315/222/1/012021, autori Z. Beljkas, Z. Prascevic, N. Ivanisevic, M. Knezevic i M. Cvetkovska
9. "APPLICATION OF ARTIFICIAL INTELLIGENCE FOR THE ESTIMATION OF CONCRETE AND REINFORCEMENT CONSUMPTION IN THE CONSTRUCTION OF INTEGRAL BRIDGES" rad objavljen u međunarodnom časopisu na SCI listi Hindawi, Advances in Civil Engineering Volume 2020, Article ID 8645031, 8 pages https://doi.org/10.1155/2020/8645031, autori: Željka Beljkaš, Miloš Knežević, Snežana Rutešić i Nenad Ivanišević - [M23]

Univerzitet Crne Gore

UCG

University of Montenegro

08-3361
23. 12. 15

Na osnovu člana 72 stav 2 Zakona o visokom obrazovanju (Službeni list Crne Gore br. 44/14, 52/14 i 47/15) i člana 32 stav 1 tačka 9 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 23. decembra 2015. godine, donio je

ODLUKU
O IZBORU U ZVANJE

Dr MILOŠ KNEŽEVIĆ bira se u akademsko zvanje **redovni profesor Univerziteta Crne Gore** za predmete: Upravljanje projektima, Građenje i održavanje puteva i Tehnologija građenja objekata niskogradnje na Građevinskom fakultetu Univerziteta Crne Gore.

REKTOR

Prof. Radmila Vojvodić

24. 12. 2015.

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Miloš KNEŽEVIĆ rodjen je 25.novembra 1965.godine u Nikšiću. Završio je Srednju školu – matematički odsjek u Nikšiću. Za postignuti uspjeh nagrađen je diplomom „Luča".

Poslije završetka Srednje škole (sa prekidom za odsluženje vojnog roka) upisao se na Gradjevinski fakultet u Titogradu. Studije na Gradjevinskom fakultetu u Podgorici završio je 1992.godine.Magistrirao je na Fakultetu tehničkih nauka u Novom Sadu 2001.godine. sa temom: „Podloge za izradu baze podataka za upravljanje projektovanjem i građenjem autoputeva". Doktorirao je 2005. godine na Građevinskom fakultetu Univerziteta u Beogradu na temu „Upravljanje rizikom pri realizaciji gradjevinskih projekata", a pod mentorstvom prof.dr Živojina Praščevića.

Obavljao je funkciju prodekana za finansije od 2005 do 2010 godine i dekana Fakulteta od 2010-2016. Bio je predsjednik Strukovne Komore gradjevinskih inženjera Crne Gore od 2009. -2012. godine. i član Upravnog odbora Inženjerske Komore Crne Gore i Upravnog odbora Project consulting d.o.o. u istom periodu. Predsjednik je upravnog odbora Instituta ovlašćenih procjenjivača Crne Gore i Predsjednik tehničkog komiteta Instituta za standardizaciju.

Od 1992. radio je u više gradjevinskih preduzeća u Crnoj Gori, Ruskoj federaciji i Uzbekistanu, a od 1998. godine radi na Građevinskom fakultetu Univerziteta Crne Gore u Podgorici. Održava nastavu iz oblasti Upravljanje projektima u građevinartvu, Građenja i održavanja objekata niskogradnje, Procjene vrijednosti nepokretnosti.

Učestovao je u gradjenju velikog broja objekata u funkciji neposrenog rukovodioca objekta, tehničkog rukovodioca gradilišta i direktora gradnje: rukovodilac izgradnje puta Nikšić-Cetinje, 1993., rukovodilac izgradnje gimnazije "Stojan Cerović" u Nikšiću, 1994., rukovodilac izgradnje objekta RTV u Nikšiću, 1995., rukovodilac izgradnje hale u Pivari Trebjesa u Nikšiću.1995., rukovodilac izgradnje ambasade Republike Baškirije u Moskvi, 1995/96., rukovodilac pripreme na izgradnji velikog broja reprezentativnih objekata u Taškentu, 1996/1997. orijentacione vrijednosti 106 miliona USA$ (preko 195.000 m2 reprezantivnih i rezidencijalnih objekata: hotel Inturist u Taškentu, rezidencija predsjednika Republike Durmenj, Administrativna zgrada predsjednika Republike, objekat ljetnje rezidencije Kajnersaj, Olimpijski muzej, muzej Amira Temura, Centralna banka i dr.).

Studijski je boravio u Beču (Universität Wien (TU Wien), Wien, Österreich) 2003. Držao je predavanja u trajanju do mjesec dana na УАСГ София, София, България (2005,2014), Slovak University of Technology in Bratislava, Slovakia (2006 , 2009 i 2016) i Vysoké učení technické (VUT v Brně), Brno, Česka Republika (2008,2010,2013,2015 i 2017). Boravio je na Universidad de Granada, Granada, España 2016 po CEEPUS+ programu.

Bio je vodeći projektant na izradi Glavnog projekta rekonstrukcije magistralnog puta Bar-Budva na lokalitetu Petrovac za koji je dodijeljena graditeljska nagrada CEMEX za 2008. godinu.

Bio je konsultant Ministarstva uredjenja prostora i zaštite životne sredine za izradu Strategije razvoja gradjevinarstva do 2020 godine (2009-2010).

Izabran je u zvanje redovnog profesora na Građevinskom fakultetu u Podgorici 2016. godine.

Rukovodilac je primijenjenog studijskog programa Menadžment u građevinarstvu na Građevinskom fakultetu u Podgorici od 2006. godine

Do sada je napisao i objavio 12 radova u časopisima na SCI listi, više od 90 naučnih i stručnih radova, koji su publikovani u domaćim časopisima i zbornicima radova sa domaćih i međunarodnih naučno-stručnih skupova. Učetvovao je u izradi u više od 30 ekspetriza, 45 ugovornih dokumenata, 30 projekata i 40 projektnih zadataka. Bio je u član komisija za više od 30 tehničkih kontrola dokumentacije i više od 15 tehničkih pregleda objekata.

dr Miloš Knežević, dipl.inž.građ i dipl. pravnik

RADOVI NA SCI LISTI:

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2. *Milun Krgović, Ivana Bošković, Radomir Zejak, **Miloš Knežević**, "Influence of temperature and binder content on the properties of a sintered product based on red mud," Materiali in Tehnologije/Materials and Technology (ISSN:1580-2949), Volume 48, Issue 4, Aug. 2014, Page(s) 125-128 ▪ B.Šćepanović , M. Knežević ,D. Lučić*
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ODLUKU
O IZBORU U ZVANJE

Dr SNEŽANA RUTEŠIĆ bira se u akademsko zvanje **docenta Univerziteta Crne Gore** za predmete: Organizacija i tehnologija građenja, Građevinska regulativa, Primjena računara za upravljanje projektima, Upravljanje kvalitetom u građevinarstvu, Organizacija građenja i građevinska mehanizacija na **Građevinskom fakultetu,** na period od pet godina.

REKTOR

Prof. Radmila Vojvodić

Snežana Rutešić

BIOGRAFIJA

Rođena je 28.12.1963. godine u Nikšiću. U Podgorici je završila osnovnu i srednju školu.

Na Građevinski fakultet u Podgorici upisala se školske 1982/83 godine, gdje je i diplomirala 07.jula 1988. godine na smjeru za konstrukcije iz predmeta Organizacija i tehnologija građenja.

Na poslijediplomske studije na Građevinskom fakultetu Univerziteta u Beogradu upisala se školske 1988/89 godine na Odsjeku za organizaciju i tehnologiju građenja. Magistrarski rad pod nazivom *"Model podsistema kontrole u sistemu upravljanja investicionim projektima"* uradila je pod mentorstvom prof. dr Živojina Praščevića i prof. dr Petra Đuranovića i dobranila ga na Građevinskom fakultetu Univerziteta u Beogradu 11. decembra 1997. godine.

Doktorat pod nazivom *"Model sistema upravljanja investicionim projektom- informacioni aspekt i aspekt upravljanja kvalitetom"* uradila je pod mentorstvom prof. dr Živojina Praščevića i odbranila ga 31.oktobra 2005. godine na Građevinskom fakultetu Univerziteta Crne Gore u Podgorici.

Od februara 1989. do januara 1996. godine radila je na Građevinskom fakultetu u Podgorici, kao asistent pripravnik, a od januara 1996. godine kao saradnik na istom fakultetu na predmetu Organizacija i tehnologija građenja. Izabrana je u zvanje asistenta juna 1998. godine na predmetima Organizacija i tehnologija građevinskih radova, Organizacija građenja i Upravljanje projektima. U periodu do izbora u zvanje docenta radila je na realizaciji vježbi iz navedenih predmeta i učestvovala u praćenju i kontroli izrade velikog broja diplomskih radova (oko 170). Takođe je oko 170 puta bila član komisije za odbranu diplomskog rada. Reizabrana je u zvanje docenta na Građevinskom fakultetu 2016. godine.

Od 2001. do 2012. godine je bila šef Centra za obradu projekata, koji radi kao organizaciona jedinica Instituta za građevinarstvo Građevinskog fakulteta u Podgorici.

Obavljala je funkciju prodekana za finansije od 2010. do 2013. godine. U periodu od 2011-2014. godine je bila rukovodilac specijalističkog primijenjenog studijskog programa Menadžment u građevinarstvu na Građevinskom fakultetu u Podgorici. Od 2019. godine je rukovodilac osnovnog i specijalističkog primijenjenog studijskog programa Menadžment u građevinarstvu na Građevinskom fakultetu u Podgorici.

Govori ruski i engleski jezik.

Član je Inženjerske komore Crne Gore.

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