REVIEW
OF RESEARCH
AND BUSINESS RESULTS
OF THE IMS INSTITUTE
IN 2022

PREGLED
NAUČNIH I STRUČNIH
REZULTATA
INSTITUTA IMS
U 2022. GODINI

Institut za ispitivanje materijala a.d.

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PREGLED NAUČNIH I STRUČNIH REZULTATA INSTITUTA IMS U 2022. GODINI

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U 2022. godini Institut IMS je, u saradnji sa svojim dugogodišnjim partnerima iz javnog sektora, građevinske industrije i energetike, nastavio da niže poslovne uspehe.

Institut IMS i ove godine učestvuje u najznačajnijim građevinskim poduhvatima, i to u svim fazama - od istražnih radova i projekata, preko ispitivanja, nadzora i kontrole kvaliteta, do izvođenja specijalističkih radova. Pored rada na geotehničkim konstrukcijama i objektima putne privrede, nastavljen je rad i na remontima hidro i termo-energetskih postrojenja, sanaciji konstrukcija i zaštićenog graditeljskog nasleđa, primeni sistema prednaprezanja. Akreditovane laboratorije Instituta IMS punim kapacitetom su ispitivale brojne građevinske proizvode, kao i građevinske i mašinske konstrukcije, buku i drugo, prema obimu svoje akreditacije.

Naučno-istraživački rad nastavljen je kroz realizaciju ugovora sa Ministarstvom prosvete, nauke i tehnološkog razvoja Republike Srbije, u koji je uključeno dvadesetak istraživača Instituta IMS. U ovoj godini, možemo se pohvaliti i učešćem naših stručnjaka u Programu za izvrsne projekte mladih istraživača Fonda za nauku Republike Srbije, kao i u programu bilateralne naučne i tehničke saradnje Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije i Saveta za naučno-tehnološka istraživanja Turske.

Ističemo veliki broj publikovanih radova, o čemu svedoče priloženi apstrakti. U saradnji sa dugogodišnjim partnerskim akademskim i naučno-istraživačkim organizacijama, učestvovali smo u organizaciji dva stručna skupa.

U ovoj godini se navršava 70 godina od osnivanja Instituta za ispitivanje materijala Srpske akademije nauka za industriju i građevinarstvo, kada je u današnjem obliku definisana delatnost i organizacija našeg Instituta. U mnoštvu jubileja, posebno se pripremamo za narednu godinu, u kojoj ćemo obeležiti 75 godina od daleke 1948. godine, kada je osnovan Savezni institut za građevinarstvo, u kome su se, pod rukovodstvom Branka Žeželja, okupili tada mladi inženjeri, a budući ključni stručnjaci Instituta IMS.

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RAD U ISTAKNUTNOM MEĐUNARODNOM ČASOPISU (M22)

A. Terzić, L. Pezo, M. Pezo

APPLICATION OF ARTIFICIAL NEURAL NETWORKS IN PERFORMANCE PREDICTION OF CEMENT MORTARS WITH VARIOUS MINERAL ADDITIVES

Science of Sintering, 2022, Vol. 55.

The machine learning technique for prediction and optimization of building material performances became an essential feature in the contemporary civil engineering. The Artificial Neural Network (ANN) prognosis of mortar behavior was conducted in this study. The model appraised the design and characteristics of seventeen either building or high-temperature mortars. Seven different cement types were employed. Seventeen mineral additives of primary and secondary origin were embedded in the mortar mixtures. Cluster Analysis and Principal Component Analysis designated groups of similar mortars assigning them a specific purpose based on monitored characteristics. ANN foresaw the quality of designed mortars. The impact of implemented raw materials on the mortar quality was assessed and evaluated. ANN outputs highlighted the high suitability level of anticipation, i.e., 0.999 during the training period, which is regarded appropriate enough to correctly predict the observed outputs in a wide range of processing parameters. Due to the high predictive accuracy, ANN can replace or be used in combination with standard destructive tests thereby saving the construction industry time, resources, and capital. Good performances of altered cement mortars are positive sign for widening of economical mineral additives application in building materials and making progress towards achieved carbon neutrality by reducing its emission.

Keywords: masonry cements, high-temperature cements, industrial byproducts, low-cost primary raw materials, circular economy, carbon footprint reduction.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

K. Janković, M. Stojanović, A. Terzić, D. Bojović, S. Stanković

PROPERTIES OF HEAVYWEIGHT SCC WITH FLY ASH

XXVIII Congress DIMK and IX Congress SIGP with International Symposium on Research and Application of Contemporary Achievements in Civil Engineering in the Field of Materials and Structures, Divčibare, Serbia, 2022, 389–396.

Fly ash is a highly effective mineral additive whose role is reflected in the improvement of microstructural packing, strength and durability of composite building materials such as self-compacting concrete (SCC). Reference SCC was designed with Portland cement, river aggregate and limestone filler. The experimental program included the production of five self-compacting concretes with different types of fine aggregates, fillers and additive to increase frost resistance. The effects that barite sand and additions have on the properties of fresh SCC (slump-flow test, V-funnel test, and L-box test) and compressive strengths were investigated and discussed.

Keywords: fly ash, limestone filler, barite, SCC, compressive strength

K. Janković, M. Stojanović, A. Terzić, D. Bojović, S. Stanković

IMPACT OF FINE AGGREGATE PARTICLE SIZE AND MORPHOLOGY ON THE EARLY STRENGTHS OF SCC

ASES International Symposium, Aranđelovac, Serbia, 2022, 422–429.

A comparative study of performances of self compacting concrete (SCC) with fly ash and limestone filler was conducted. The experimental program included the production of reference SCC designed with Portland cement, river sand and limestone filler and four experimental self compacting concretes with different types of fine aggregates, fillers and special additive to increase freeze-thaw resistance. The effects that different sand and additions have on the properties of fresh SCC (slump-flow test, V-funnel test, and L-box test) and compressive strengths in early ages (3 and 7 days) were investigated and discussed.

Keywords: fly ash, limestone filler, SCC, compressive strength.

M. Stojanović, L. Antić Aranđelović, K. Janković, D. Bojović, Lj. Lončar

INFLUENCE OF DIFFERENT TYPES OF FIBERS ON FLEXURAL TENSILE STRENGTH

ASES International Symposium, Aranđelovac, Serbia, 2022, 430–439.

The paper presents the influence of the application of different types of fibers in concrete beams on the flexural tensile strength. All concrete beams were made of the same component materials and composition, except for the amount of fiber, which is varied. After hardening, the height of the concrete beams in the central part was reduced to 125 mm by cutting. The measurement of flexural tensile strength by was performed according to SRPS EN 14651. Based on the test results, depending on the type, shape, quantity and distribution of fibers, the values of ultimate and residual strengths were analyzed.

Keywords: fiber concrete, residual flexural tensile strength.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U IZVODU (M34)

E. Nikolić, Lj. Miličić, I. Delić-Nikolić, M. Jovičić, N. Mijatović, S. Vučetić

MORTARS OF THE ROMAN FRONTIER ON THE DANUBE

6th Historic Mortars Conference *HMC2022*, Ljubljana, Slovenia, 2022, 33.

The mortars have been always one of the most interesting topics for the researchers of Roman building constructions. The knowledge of this complex building material used in Roman architecture is mostly based on the research of the monumental structures in the territory of today Italy. However, many mortar examinations were executed by the researchers of provincial Roman archaeology as well, who tried to find evidence of the quality of building activities in the provinces. The territory of today's Serbia, except for the existence of scarce studies, was never in the research focus. Even the monumental bridge over the Danube, built at the beginning of the 2nd century that made Trajan's conquest of Dacia possible, has not been researched thoroughly enough when we speak of its building materials. During the last few years, the interest in the Roman buildings in the Danube territory has grown. Mortar Design for Conservation – Danube Roman Frontier 2000 Years After (MoDeCo2000) project is funded by the Science Fund of the Republic of Serbia. Its aim is to investigate the mortars used in Roman buildings along the former Danube Limes in Serbia, as well as to offer mortar recipes for building conservation practice. The project includes 24 archaeological sites, dating to the period spanning from the 1st to the 6th century, with more than 120 different mortar samples that originate from 40 buildings of military and civilian function. The project results are intended to be an important contribution to the nomination dossier of a cultural property tending to be included in the UNESCO World Heritage List, named *Frontiers of the Roman Empire – Danube Limes in Serbia*. Conducted laboratory analyses showed a great diversity of mortar samples. Immensely important are the results offering the characterisation of some local raw materials known to date as used for masonry, as important components of the mortars, but also the possibility to conclude that the mortars for the most important buildings in this territory were made using the rare local or imported raw materials. After sampling and research, laboratory models of mortars were made, the most promising recipes were chosen, and the

application of new mortars was performed in real environmental conditions and on historic walls. The project results formed a database on archaeology, architectural and construction history, technology, geology, and chemistry of raw materials and mortars, that will greatly contribute to heritage protection in Serbia, as an exceptionally important input for conservation practice. The objectives of the MoDeCo2000 project are connected to the research of physical and social elements of former Roman fortresses and cities in Serbia, as well as to the conservation practice and contribution to contemporary engineering. Its biggest scientific significance is in the revealing of different aspects of building technologies in the Roman period in the mentioned territory, but also of the economy, trade, and everyday life of its inhabitants.

Keywords: Roman mortars, Danube limes, Roman construction, conservation mortar, UNESCO.

L. Radovanović, Ž. Radovanović, A. Kremenović, B. Simović, M. V. Vasić, J. Rogan

MANGANESE-PYROMELLITATE COMPLEX AS A PRECURSOR FOR PREPARATION OF SPINEL MN_3O_4

XIV Conference of Chemists, Technologists and Environmentalists of Republic of Srpska, Banja Luka, Bosnia and Herzegovina, 2022, 192.

In recent years, thermal decomposition studies of transition metal complexes with benzenepolycarboxylate ligands have become an area of a great importance due to the possibility of obtaining useful metal oxides with desirable electrical, magnetic and catalytic properties. As a contrast to conventional methods for the preparation of metal oxides, such as hydrothermal or sol–gel treatment, thermolysis is faster, more efficient and environmentally friendly. Mn(II) – dipya (dipya = 2,2' – dipyridylamine) complex with tetraanion of 1,2,4,5 – benzenetetracarboxylic (pyromellitic, H_4pyr) acid, $[Mn_2(dipya)_2(pyr)(H_2O)_2]$, has been prepared and characterized by elemental, spectral and microscopy analyses. Direct thermolysis of the complex up to 1200 °C in an air atmosphere yielded spinel Mn_3O_4 oxide material. The obtained Mn_3O_4 has been characterized for its structural, spectroscopic, morphological and optical properties. The possibilities of using this oxide as photocatalyst or co-photocatalyst for removing textile organic dyes, as well as inorganic pigmentary material, were also investigated and discussed.

Keywords: manganese (II)-complex, thermolysis, Mn_3O_4, photocatalysis, pigment.

Lj. Miličić, I. Delić-Nikolić, N. Mijatović, B. Ilić, E. Nikolić, S Vučetić, M. Jovičić, J. Ranogajec

LIME MORTARS CONTAINING CLAYS FOR THE CONSERVATION OF THE DANUBE LIMES

Chemistry for Cultural Heritage 6th *ChemCH* Congress, Ravenna, Italy, 2022, 128.

During the work on the MoDeCo2000 project financed by the Science Fund of the Republic of Serbia, samples of Roman lime mortar originating from buildings situated along the former Danube Limes in Serbia were investigated with an aim of detecting raw materials and technologies used for their preparation which should be taken into account during conservation practice. The remains of the buildings dated to the period from the 1st to the 6th CE AD form a unique serial monument currently on the Serbian tentative list for the UNESCO World heritage.

Laboratory research of sampled mortars showed that their composition depended on the availability of raw materials and that natural resources which are still available today for construction materials in Serbia were used. Lime mortars with the addition of materials with pozzolanic properties showed high compactness, homogeneity, and compression strength during the tests. Although mortars with the addition of natural materials containing minerals from the zeolite group, the origin of which is still being investigated, showed the expected high values of compressive strength, the values were higher in those in which the pozzolanic addition was a clay component. The addition of ground brick as an artificial pozzolanic material led to the formation of mortars with high values of compactness and compression strength, the mortar in which kaolinite was found, with large crushed brick fragments, had even higher values, while the highest values were possessed by mortar without brick, with both clay minerals and those from the zeolite group detected.

This paper will present the work on the preparation of lime mortar mixtures for the conservation of the Danube Limes in Serbia, as well as their compatibility with the historical mortars. Mixtures with the addition of domestic clay used for

traditional brick manufacture, domestic and imported kaolin clays, imported and laboratory-produced metakaolins, as well as zeolite of domestic origin, were prepared and tested in the laboratory and later applied at experimental masonry structures, being monitored since. The potential long-term success of the application of lime mortar mixtures containing mechanically or thermally activated different types of domestic clays will be of exceptional importance for conservation in Serbia.

Keywords: Roman mortars, conservation mortars, kaolin clay, metakaolin, zeolite.

I. Delić-Nikolić, E. Nikolić, Lj. Miličić, M. Jovičić

GEOLOGY OF RAW MATERIALS IN ROMAN MORTARS OF THE DANUBE LIMES IN SERBIA

Science for Conservation of the Danube Limes Mortar Design for Conservation – Danube Roman Frontier 2000 Years After, Viminacium, Serbia, 2022, 44–48.

Geological building materials have always played a very important role in the construction of all types of buildings. They were among the first mineral raw materials exploited, processed, and used by man. In most cases, these are raw materials of a local character, cheap, and easily available. Accordingly, geological building materials used to make Roman mortars, known for their enviable mechanical properties and durability, played a very important role in the area of the Danube Limes in Serbia. Geologically, this area is built of petrologically different rocks of different geological ages. The rocks formed from the Palaeozoic to the Quaternary contain all the basic geological building materials: sand and gravel, stone, clay, etc.

Probably the most important and most exploited and used mineral raw material in the Roman mortars of this area is sand and, less frequently, gravel, from the alluvial deposits of the Danube and other local watercourses, created by the mechanical accumulation of clastic material made in the process of decay of parent rocks. These alluvial sediments of the Quaternary age have a heterogeneous mineralogical-petrographic composition, conditioned by the hydrogeological regime and geological structure, i.e., the character of the rocks exposed to decay within the catchment zones and geomorphological conditions. They consist of unevenly rounded grains of quartz, chert, quartzite, metamorphic

rocks, sandstones, volcanic rocks, etc. As the grain size of these unbound rocks decreases, the percentage of minerals increases.

In addition to sand and gravel, in the area of the Danube Limes, local stone fragments were occasionally used as an aggregate for making mortar. Thus, in the area around the village of Ram, schist grains were used as an aggregate, the origin of which is most likely the surroundings of the village itself, i.e., the Ram-Zatonje area. These schists represent the oldest geological formations in the wider area. They have a low degree of metamorphism, caused by the intensive transformation of volcanogenic-sedimentary rocks, i.e., gabbroid rocks and fine-grained sandstones, siltstones and clays. According to the mineral composition, these schists are determined as: epidotechlorite- actinolytic, chlorite-epidote-mica-actinolytic, epidoteamphibolytic, sericite-muscovite, muscovite, chlorite and chloritesericite - quartz.

Limestones are of special importance among geological building materials, as raw materials for lime production. Limestones are not very common in the area of the Danube Limes, they can be found in the area of Belgrade, in the vicinity of Golubac, and Veliko Gradište, along the Danube gorge. They are mostly Mesozoic, Cretaceous and Jurassic, but in the area of Belgrade, the Danube Key and in the vicinity of Donji Milanovac there are lithotamnian limestones with numerous remains of marine fauna. They are Tortonian, i.e., middle Miocene age.

In the area of Viminacium, crushed or ground bricks were often used as an aggregate, but also as an additive to mortars. In this area, brick raw materials had a significant distribution, so in accordance with that, Viminacium was a provincial centre for brick production. These raw materials are genetically related to Quaternary sediments, more precisely the occurrence of loess and clay, in the area of Požarevac ridge and villages around Kostolac: Kličevac, Majilovac, Kurjače, etc. In addition to brick and stone, “naturally baked bricks” were used to build ancient Viminacium. These were known locally as *crvenka*, and were formed as a product of combustion of clay sediments after self-ignition of coal deposits, which was found to have certain pozzolanic properties and is, therefore, assumed to have been added to lime mortars after crushing or grinding to improve their properties.

Natural materials with pozzolanic properties certainly played an important role in the production of historical mortars of the Danube Limes, and research into their use is still in its early stages. Since they did not necessarily have to be local

raw materials, the process of their identification, role, importance, origin, etc. is a challenging task for researchers of various disciplines, and it can bring extremely important knowledge to the field of exploitation and use of raw materials and their transport, such as the economic flows between different territories in a given historical period.

Keywords: Roman mortars, raw materials, local resources, geological landscape, Danube Limes.

SAOPŠTENJE SA SKUPA NACIONALNOG ZNAČAJA ŠTAMPANO U CELINI (M63)

M. Vasić, Z. Radojević

USAGLAŠENI ZAHTEVI ZA PLASMAN GRAĐEVINSKIH PROIZVODA – PREDLOG NOVE UREDBE EU COM 2022 144 FINAL

XXVIII kongres DIMK i IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 299–308.

Postojeću Uredbu o građevinskim proizvodima treba revidirati jer više nije u skladu sa širim prioritetima politike, posebno u vezi sa evropskim zelenim dogovorom. Takođe je neophodno stvoriti normativni okrvir koji će prepoznati digitalne tehnologije, definisati performanse održivosti građevinskih proizvoda i razrešiti problem pravne nadležnosti u procesu izrade harmonizovanih standarda za građevinske proizvode. Pored opisa izmena uredbe u radu su jasno definisane koje su nadležnosti predlogom revizije prebačene na Evropsku komisiju kao i koje su nove obaveze za proizvođače.

Ključne reči: građevinski proizvodi, COM 2022 144,CPR 305/2011.

N. Mijatović, A. Terzić, Lj. Miličić

MEHANIZMI ADSORPCIJE JONA MN2+ U STRUKTURI KOMPOZITA NA BAZI CEMENTA I MINERALNIH ADITIVA

XXVIII kongres DIMK i IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 199–206.

Prirodni zeolit i bentonit korišćeni su kao mineralni aditivi za pripremu građevinskih kompozita na bazi cementa bezbednih za životnu sredinu. Ovo istraživanje se fokusira na adsorpcione kvalitete i mehanizme ove dve glinene sirovine, odnosno njihovu sklonost ka imobilizaciji jona teških metala poput Mn^{2+}. Dobijeni rezultati su ispitani korišćenjem kinetičkih modela pseudo-prvog i pseudo-drugog reda. Ispitane su Langmirove i Frojndlihove izoterme. Zeolit i bentonit imaju različite adsorpcione afinitete za Mn^{2+} katjone. Sedam cementnih

kompozita sa različitim mineralnim dodacima (leteći pepeo, zeolit, bentonit) podvrgnuto je ispitivanju luženja. Mehanizmi adsorpcije i hidratacije koji su imobilisali teške metale unutar cementnih kompozita doveli su do toga da eluati dobijeni na uzorcima cementa sa dodatkom letećeg pepela i gline (zeolit ili bentonit) sadrže niže koncentracije Mn^{2+} jona od procednih voda dobijenih na uzorcima cementa sa elektrofilterskim pepelom.

Ključne reči: građevinski materijal, reciklaža, imobilizacija jona, kontrola ispiranja, hemijska analiza, ED-XRF, ICP-OES.

Z. Radojević, M. V. Vasić

ANALIZA NEGATIVNIH UTICAJA KORIŠĆENJA PETROL KOKSA SA POVIŠENIM SADRŽAJEM SUMPORA

XXVIII kongres DIMK i IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 117.

U ovoj studiji utvrđeni su tehnički aspekti problema koji se javljaju usled korišćenja petrol koksa kao goriva u opekarskoj industriji. Uticaji su procenjeni sa stanovišta sadržaja štetnih materija u petrol koksu, povećanja emisije CO_2 iz peći, korozije vatrostalnih materijala u peći, korozije cevovoda i metalnih konstrukcija u sušari i peći, deponovanja sulfatnih skrama na suvim proizvodima i fiksiranje belih skrama na pečenim proizvodima. Uzorci vatrostalne opeke sa ozida peći su analizirani mikroskopskom metodom da bi se utvrdila mikrostruktura i sastav delova uzoraka izloženih dimnim gasovima i onih u unutrašnjosti. Zaključeno je da postoje uslovi za ubrzane korozijske procese i da sadržaj sumpora u petrol koksu, ukoliko se koristi kao energent u industriji, mora biti ispod 5% bez obzira na moguće uštede u energiji.

Ključne reči: Petrol koks, opekarska industrija, korozija.

B.Ilić, Lj. Miličić, D. Milinković, Z. Radojević

PUT DO PRVE SRPSKE TEHNIČKE OCENE ZA PORTLAND-KOMPOZITNI CEMENT SA SMANJENIM SADRŽAJEM KLINKERA

XXVIII kongres DIMK i IX kongres SIGP sa i međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 175–182.

Zakon o građevinskim proizvodima omogućio je stavljanje na tržište inovativnih građevinskih proizvoda, kroz izradu srpskog dokumenta za ocenjivanje i izdavanje srpske tehničke ocene. Srpska tehnička ocena obezbeđuje proizvođačima građevinskih proizvoda put do srpskog znaka usaglašenosti i deklaracije o performansama.

Ovim radom predstavljen je postupak izrade prve srpske tehničke ocene za portland-kompozitni cement sa smanjenim sadržajem klinkera, za koji je imenovano Telo za tehničko ocenjivanje Instituta IMS izradilo Srpski dokument za ocenjivanje SDO 15 001:2021. Takođe, obuhvaćen je postupak ocenjivanja i verifikacije stalnosti performansi portland-kompozitnog cementa sa smanjenim sadržajem klinkera.

Ključne reči: portland-kompozitni cement sa smanjenim sadržajem klinkera, srpska tehnička ocena, srpski dokument za ocenjivanje, telo za tehničko ocenjivanje.

BITNO POBOLJŠANO TEHNIČKO REŠENJE NA NACIONALNOM NIVOU (M84)

M. Stojanović, K. Janković, D. Bojović, Lj. Lončar, L. Antić Aranđelović

POBOLJŠANJE SVOJSTAVA PREFABRIKOVANIH BETONSKIH ELEMENATA PRIMENOM SIKA AER SOLID

Da bi se obezbedila trajnost betona, potrebno je zaštititi betonske infrastrukturne objekte u zemljama u kojima se smenjuju godišnja doba i različiti vremenski uslovi, jer je njihovo izlaganje ciklusima zamrzavanja i odmrzavanja (eng. FTC – freezing and thawing cycles) u prisustvu soli za odmrzavanje jedan od najagresivnijih mehanizama za propadanje betona. Šteta od mraza, progresivno pogoršanje koje započinje ljuštenjem površinskog maltera i završava potpunim urušavanjem betonskih elemenata, glavna je briga kada se beton koristi u hladnijim regionima. Ponavljanjem ciklusa zamrzavanja i odmrzavanja javljaju se prsline i pukotine, a beton postepeno gubi svoja prvobitno projektovana svojstva. Betoni koji će biti izloženi dejstvu mraza u svom sastavu imaju veće količine cementa, a problem primene veće količine cementa se poslednjih godina posebno naglašava zbog sve većeg zagađenja životne sredine i stvaranja efekta staklene bašte. Betoni koji se izlažu dejstvu mraza i/ili mraza i soli štite se aeriranjem. To često nije garancija da će se postići projektovan sadržaj vazduha u svežem betonu. Zbog toga se htelo doći do rešenja nekim drugim sredstvima zaštite betona izloženih dejstvu mraza. Jedno od rešenja je Sika Aer Solid. Kako bi ovaj materijal mogao da se primenjuje na našem podneblju i sa našim materijalima, obavljena su ispitivanja svojstava betona u svežem i očvrslom stanju, sa posebnom osvrtom na trajnost betona. Primenom Sika Aer Solid kao zamene za aerant, moguće je proizvesti betonske elemente čija svojstva zadovoljavaju zahtevane klase izloženosti koje su definisane prema SRPS EN 206 i SRPS U.M1.206. Dodavanjem Sika Aer Solid u beton postiže se trajnost betonskih prefabrikovanih elemenata kroz postizanje otpornosti na dejstvo mraza, otpornosti na dejstvo mraza u prisustvu soli za odmrzavanje, otpornosti na penetraciju vode pod prisitkom, kao i otpornosti na migraciju hloridnih jona.

Ključne reči: Sika Aer Solid, otpornost betona na destvo mraza, betonski prefabrikovani mostovski elementi.

Korisnik / naručilac: GP Nikolić d.o.o. Kraljevo.

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KERAMIČKI I PRAŠKASTI MATERIJALI

RAD U MEĐUNARODNOM ČASOPISU IZUZETNIH VREDNOSTI (M21A)

M. V. Vasić, A. Terzić, Ž. Radovanović, Z. Radojević, L. Warr

ALKALI-ACTIVATED GEOPOLYMERIZATION OF A LOW ILLITIC RAW CLAY AND WASTE BRICK MIXTURE. AN ALTERNATIVE TO TRADITIONAL CERAMICS

Applied Clay Science, 2022, Vol. 218, 106410.

Geopolymerization was investigated as an alternative to traditional ceramic products by developing a more sustainable approach that avoids thermal treatment. The study presents the first known alkali-activation of the raw clay and waste clay brick mixture using the solid to liquid ratios of 2.33 and 2.78. Several experimental sets were prepared to harden under varying conditions (2–4 days drying in 60 ◦C–70 ◦C and 3 h steam-curing). Non-activated and activated samples were analyzed for their physical and chemical properties after 14, 21, and 28 days. The tile-shaped specimens exhibited better initial drying behavior than the cubes and produced stronger materials with fewer cracks. Pre-curing in steam conditions induced higher flexural strength (13.7 MPa) and water absorption (13.13%) for the geopolymer tiles. The highest Si/Al molar ratio in the amorphous portion of 5.78 induced the best flexural strength. The geopolymerization process showed microstructural changes associated with the appearance of fibrous Na-zeolite nanocrystals. The degree of geopolymerization and zeolite formation was enhanced by steam-curing, but the microstructural stress and heterogeneity induced by the reactions resulted in higher water absorption. Ongoing reactions of amorphization in the bulk material and further crystallization at the surface are documented after 6 months of curing. This first detailed study reveals that the production of geopolymer ceramics from brick waste is possible, but further optimization of the activating solution and curing parameters is required.

Keywords: waste brick, low illitic raw clay, mineralogy, alkali-activation, geopolymer ceramics.

RAD U VRHUNSKOM MEĐUNARODNOM ČASOPISU (M21)

M. V. Vasić, L. Pezo, M. Vasić, N. Mijatovic, M. Mitric, Z. Radojević

WHAT IS THE MOST RELEVANT METHOD FOR WATER ABSORPTION DETERMINATION IN CERAMIC TILES PRODUCED BY ILLITIC-KAOLINITIC CLAYS? THE MYSTERY BEHIND THE GRESIFICATION DIAGRAM

Boletin de la Sociedad Espanola de Ceramica y Vidrio, 2022, Vol. 61, 241–251.

This study presents the 51 mixtures of ceramic clays characterized by using XRF, XRD, gran-ulometry, and dilatometry analyses. After firing in a 1000–1250°C range, water absorption (WA) according to EN standards by boiling in water, under vacuum, and by 24 h soaking is determined. The results indicated that there was a high and statistically significant cor-relation between the standard methods, but the testing under vacuum gave the highestsaturation of the samples fired at 1200°C and 1250°C. It is determined that these illitic-kaolinitic clays can be used to produce floor ceramic tiles belonging to the BIIa group (water absorption between 3% and 6%).The study also aimed to reveal which method of WA determination is suitable to read the sintering interval from the gresification diagrams, which is compared to the beginning of sintering as read from dilatometry curves.

Keywords: illitic-kaolinitic clays, ceramic tiles, water absorption, gresification diagram, sintering rang.

RAD U ISTAKNUTNOM MEĐUNARODNOM ČASOPISU (M22)

A. Terzić, M. V. Vasić, J. Stojanović, V. B. Pavlović, Z. Radojević

APPLICATION OF PYROPHYLLITE IN HIGH-TEMPERATURE TREATED BUILDING MATERIALS

Science of Sintering, 2022, Vol. 55.

Phyllosilicate mineral pyrophyllite is predominantly used in the ceramic industry because it exhibits high refractoriness. Due to its thermal transformation into mullite, pyrophyllite is stable at elevated temperatures, making it a suitable mineral additive for refractory non-shaped materials and various ceramic shaped products. In this study, pyrophyllite is employed as 50% clay replacement in the ceramics and up to 30% cement replacement in mortars. Physico-mechanical properties were investigated. The firing shrinkage in the ceramics treated at 1200 °C was reduced by pyrophyllite addition. Pyrophyllite acted as additional pozzolana during cement hydration. Within the microstructure, it formed micro-reinforcement in the shape of crystalline folia, which improves the mechanical properties of ordinary Portland cement, high aluminate cement, and blended cement mortars. The investigation proved the efficiency and suitability of pyrophyllite employed as a substitution for clay in ceramics and a cement replacement in mortars.

Keywords: mineral additives, sintering, sustainable raw materials, instrumental analyses.

M. V. Vasić, N. Mijatović, Z. Radojević

APLITIC GRANITE WASTE AS RAW MATERIAL FOR THE PRODUCTION OF OUTDOOR CERAMIC FLOOR TILES

Materials, 2022, Vol. 15, No. 1, 3145.

One of the significant problems in the production of ceramic tiles is the very high consumption of natural resources such as clay, feldspar, and quartz. The possibility of replacing part of the formulation of ceramic batches is of great importance. In this research, the possibility of using aplitic granite waste from

dimensional stone production was analyzed in detail. The waste is considered a low-cost substitute for feldspar in Serbia. The milled powdery waste was analytically tested to reveal its chemical and mineralogical contents, particle size distribution, and other important properties. The ceramic tiles containing aplitic granite waste (GW) and GW/raw clay mixture (CGW) were hydraulically pressed, and the ceramic and technological properties determined. This waste can act as a filler while forming, drying, and firing, since the high content of quartz helps to control the shrinkage and acts as a fluxing agent in high temperatures due to its feldspathic nature. The waste was found favorable in the production of ceramic tiles, as the gained values of modulus of rupture and water absorption were 28.68 MPa and 1.33%, respectively. The parameters defined in the series of standards EN ISO 10545 were tested on a semi-industrial probe, determining that this combination of materials (without the addition of quartz) may be efficiently used to produce ceramic floor tiles. The usage of what would otherwise be waste material contributes to sustainable management and environmentally friendly solutions by avoiding landfilling, while at the same time it enabling the conservation of scarce natural feldspar deposits.

Keywords: ceramic tile, aplitic granite waste, flux, recycling.

PREDAVANJE PO POZIVU SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M31)

M. Vasić

MONITORING AND ANALYZING THE CLASSICAL COUNTER CURRENT INDUSTRIAL TUNNEL DRYER FOR MASONRY CLAY UNITS

International Conference on Modern Technologies in Industrial Engineering *ModTech 2022*, Iasi, Romania, 2022, PID C4, 1–8.

The main goal of this paper was to increase the quality of the drying ware and to lower the drying scarp rate in one local brick facktory. The installed *KELLER* tunel dryer was classical counter current solution from mid 80, with four drying channels. The operation of each channel was monitored for one month. This has encluded the registration of drying air parameters (temperature, humidity and velocity) along the channels as well as the drying ware linear shrinkage and mass change. Material and Energy balances were also measured. The analyzed data has reveled two major things. The available quantities of drying air were lower than the recommended one and the drying air humidity and temperature were not evenly distributed along the height of the drying ware wagons (DWW). The ambient air breakthrough into the dryer was registered in each drying channel. It was found that 10 DWW were affected by *false* air in tunnel 4, while only 5 DWW were influenced in the tunnel 1. Since the hot air mass-flow rate with dry base, heat transfer coefficient, specific heat of wet air for the water–air system, the surface area of drying ware per unit length of dryer, saturated, critical and final humidity are known it is possible to clalculate the theoretical length of the constat drying zone inside the drying chanel. The registered critical parameters in lower, middle and upper part of the DWW were compared with the theoretical value. It was confirmed that the critical moisture content is not reached evenly in lower, middle and upper part of the DWW. This was the cause of trouble and the reason why the residual moisture in some of the products was larger than the desired one. In other words, the cause of the product quality deterioration at the beginning of the next (firing) production phase was finely quantified. Based on monitored data and mass and energy balances a solution was proposed for

preventing the *false* air breakthrough, upgrade of the existing dryer fans and installation of the novel, measuring equipment. A hypothetical solution for increasing the capacity of the dryer, which uses the registered material and energy balances as well as factory management expectation, that the production of 55.000 masonry units per day will be achieved soon, was given also.

Keywords: counter current tunnel dryer, mass and energy balances, masonry clay units.

PREDAVANJE PO POZIVU SA MEĐUNARODNOG SKUPA ŠTAMPANO U IZVODU (M32)

M. V. Vasić, L. L. Pezo, Z. M. Radojević

INFLUENCE OF COAL ASHES ON FIRED CLAY BRICK QUALITY USING RANDOM FOREST METHOD

CIMTEC 2022 15th International Ceramics Congress, Perugia, Italy, 2022.

Coal ashes have been extensively explored to be used in bricks. Some studies report the improvement of the quality while others claim the opposite. It is still unknown what are the factors that most affect the quality of the products. The database gathered 30_2 cases obtained from the literature containing the chemical composition of brick clays and the ashes and other relevant parameters like peak firing temperature and soaking time, to understand the quality of the fired bricks. The behavior of developed products is followed through bulk density, open porosity, water absorption, and compressive strength. The overall conclusions were that the compressive strengths were the highest after firing in tunnel kilns, and that class F ashes are highly suitable to be used in the brick industry as a replacement material for brick clay. The random forest method was employed and showed that the highest influence to the quality of coal-clay products was owed to the contents of Fe_2O_3 and K_2O coming from brick clays, and Na_2O, Fe_2O_3, and K_2O from the ashes. The comparison of different mathematical models was done, such as the support vector machine, random forest, boosted trees, and artificial neural network.

Keywords: coal ash, brick clay, random forest analysis.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

M. Vasić, M. V. Vasić

NOVEL AND RAPID DRYING CHARACTERIZATION TEST SUITABLE FOR THE BRICK AND TILE INDUSTRY

International Conference on Modern Technologies in Industrial Engineering *ModTech 2022,* Iasi, Romania, 2022, PID A15, 1–6.

Clays are primary raw materials used for the production of bricks or tiles. Within the raw material deposits several types of clays such as kaolin, hydrous mica (illite), kaloilite-hydrohlorite compositions and montmorillonite can be present. Presence of kaolin has a positive effect during drying while large quantities of montmorillonite can induce a negative *swelling* effect which can lead to cracking or deterioration of the dried ware mechanical characteristics. The industrial raw material compositions in brick or tile production are normally adapting from time to time with novel clays. The proper raw material change must be based on reliable raw material characterization testing. The established drying sensitivity criteria in commonly used tests (Bigot, Hartman, Beihl, Ratzenberger, Piltz, etc.) only allow the comparison of different raw materials and are not related with the mineral composition and mechanical nature of the clay. The XRD characterization of raw material is reliable only when orientated samples are prepared in other cases it is necessary to have additional characterization test such as DTA and TG in order to confirm the presence or absence of individual clay minerals. The quantity of the interlayer moisture present in different types of clays, can be easily qualified on the DTA/TGA curves, and is directly related with the mineralogical composition and the type of clays. This was a trigger for establishing the novel rapid drying sensitivity criteria. The value which represents the moisture loss read from TG curve at 200°C is used for classification. This value is respectively for insensitive raw materials less than 2.10 while for sensitive one is larger than 2.70. The analyze of more than 40 different raw materials have confirmed that the TG curves up to 350°C which are less sensitive to drying are delineated by less moisture loss as compared with the raw material which are more sensitive to drying. It is important to state that the proposed method is very simple rapid and reliable for application in brick and tile industry.

The second objective of this paper was to compare the results of the novel proposed method with the widely used Bigoth and Piltz tests. A good correlation was found.

Keywords: drying sensitivity, thermogravimetric analysis, clay, brick and tile industry.

T. Spasojević-Šantić, Z. Radojević

LIFE CYCLE ASSESSMENT (LCA) FOR CLAY MASONRY UNITS-CASE STUDY: ENVIRONMENTAL PRODUCT DECLARATION (EPD) FOR CLAY BLOCKS-PRODUCTION PLANT OF CLAY BLOCKS IN REPUBLIC OF SERBIA

XXVIII congress DIMK and IX congress SIGP with international symposium on research and application of modern achievements in civil engineering in the field of materials and structures, Divčibare, Serbia, 2022.

Life Cycle Assessment (LCA) analyses all phases of the life cycle of a construction product, takes into account the different impacts of these phases on the environment, evaluates, analyses and interprets the results. In life cycle assessment, the Environmental Product Declaration (EPD) is a standardized way of quantifying the impact of a product or system on the environment. This study evaluates the environmental impact of 1 tone of clay blocks produced in production plant in Republic of Serbia and grouped by use of Product Category Rules (PCR). The aim of this study is to determine the life cycle stages of the clay blocks that affect significantly to environment. LCA analysis for clay blocks has been conducted with the One Click LCA software, developed by One Click LCA Ltd, Finland. All processes have been modelled based on the inventory data given in the Ecoinvent database (v3.6). Based on the LCIA results in this study, product stage (modules A1-A3) contributes the most to the environmental impact. Taken as a whole, energy processes and raw material consumption dominate most impact categories.

Keywords: LCA, EPD, PCR, clay bricks.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U IZVODU (M34)

M. V. Vasić, A. Terzić, Z. Radojević

APPLICATION OF PYROPHYLLITE IN BUILDING AND REFRACTORY CERAMIC MATERIALS

Serbian Ceramic Society Conference *Advanced Ceramic and Application X – New frontiers in multifunctional material science and processing*, Belgrade, Serbia, 2022, 93.

Phyllosilicate mineral pyrophyllite possesses talc's characteristic softness and crystalline structure, but it also exhibits high refractoriness. Pyrophyllite is predominantly being used in the ceramic materials (tiles, porcelain) as a replacement of quartz, clay or feldspar. Due to its thermal transformation into mullite, pyrophyllite is stable at elevated temperatures. Its ion-exchanging properties are crucial for stabilization of the toxic elements in building materials. In this study pyrophyllite is used as a mineral additive for two types of construction products: traditional ceramic materials and refractory mortars. The experimental samples were prepared using 50% of pyrophyllite and 50% of refractory clay, ceramic clay, and carbonate brick clay, respectively. The samples were formed into discs or tiles using the compression method. The following characteristics have been investigated: resistance to firing (900 – 1300°C), carbonate content, plasticity coefficient, dimensional changes after drying at 105°C and upon firing, water absorption, and mechanical strength. Refractory samples were prepared using andalusite as aggregate, ordinary Portland cement and/or high aluminate cement as binder, and pyrophyllite as an additive (10%, 20%, and 30%). Compressive and flexural strength both at normal and at elevated temperature were tested on the samples, along with the refractoriness. The changes that pyrophyllite addition brings to the material's mineral composition, microstructure, as well as to bonding/sintering mechanisms were monitored using instrumental techniques (DTA, TGA, XRD). The aim of the investigation was to prove potential suitability of pyrophyllite as efficient and sustainable resource for the production of ceramic and refractory materials.

Key words: mineral additives, sintering, sustainable raw materials, construction materials.

M. V. Vasić, N. Mijatović, Z. Radojević

SUBSTITUTION OF FELDSPARS AND QUARTZ IN CERAMIC BATCHES BY THE GRANITIC WASTE IN THE PRODUCTION OF CERAMIC TILES

Serbian Ceramic Society Conference *Advanced Ceramic and Application X– New frontiers in multifunctional material science and processing*, Belgrade, Serbia, 2022, 68–69.

The urge of replacing part of the ceramic batches' formulation recipes is of great environmental importance. This study details the potential of using granitic waste in the production of ceramic tiles. This waste is found in the dimensional stone quarries, belongs to sediments younger than granite, decomposes, and lacks mechanical strength. The material mainly contains feldspar (especially albite) and quartz, a low quantity of micas, and a minor amount of kaolinite. Such materials are considered cost-effective alternatives because they are suitable as fillers and fluxes for ceramic batches. The study reveals the chemical and mineralogical composition of the granitic waste and composite materials (particle size distribution, XRF, XRD, FT-IR) containing 60% raw ceramic clay and 40% granitic waste. In addition, thermal behavior is followed by DTA/TGA/DTG and dilatometry analyses. Laboratory samples were hydraulically formed and calcined at 1100 and 1200°C. The microstructure of the samples is recorded by SEM-EDS. The important properties of the semi-industrial probes are tested according to the EN ISO 10545 set of standards, and the tiles are judged to belong to the group that absorbs 0.5and 3% of water in a vacuum. The samples were subjected to the standard-defined freeze-thaw tests and found insusceptible and were found to be free of lead and cadmium. Additionally, the L*a*b* color coordinates of the products obtained from clean waste and the composite are displayed. The convenience of using waste in other ways is sustainable management and an environmentally friendly solution by avoiding landfilling while ensuring the conservation and increased economic benefits of rare natural feldspar deposits.

Keywords: Ceramic batches, Granitic waste, Flux, Recycling.

RAD U NACIONALNOM ČASOPISU (M53)

M. Vasić

ESTIMATION OF THE DRYING BEHAVIOUR FOR DIFFERENT CLAY RAW MATERIALS – DRYING SENSITIVITY TECHNIQUES REVIEW

Journal of Silicate Based and Composite Materials, 2022, Vol. 74, No. 3, 88–92.

In order to rate the drying behavior of different clay raw materials it is necessary to establish the criteria for comparison. Mineralogical composition, clay minerals content, particle size distribution, packing, porosity, forming procedure, and raw material aging are known as intrinsic parameters. Due to the fact that these parameters are cross linked and are usually inter-dependently related to each other, the attempts to set up a criteria for correlation between intrinsic parameters and drying sensitivity has been limited. That was the reason why the estimation of the cracking tendency was linked with the easiness of the drying process in each reported method. The most applied methods for estimation of the drying sensitivity of clays in the ceramic industry were proposed by Bigot, Ratzenberger, Piltz, Hermansson and Varlamov. The fact that previously mentioned methods were not compared up till know has defined the main objective of this study. The only reported comparison was between Bigot and Ratzenberg drying sensitivity index. The second objective of this review was to present these methods and to estimate the drying behavior of tree different clay raw material. The results have confirmed that the most suitable conclusion about the drying behavior of the tested clays is obtained when results from Bigot, Piltz and Varlamov methods are available.

Keywords: drying sensitivity, heat transfer, masonry clay units, roofing tiles.

M. Vasić, M. V. Vasić

DECISION TO OPTIMIZE, UPGRADE OR INVEST IN NOVEL DRYER – A BRICK FACTORY CASE STUDY

International Journal of Manufacturing Economics and Management, 2021, Vol. 2 (1), 2784–1278.

doi.org/10.54684/ijmem.2021.1.2.60

Drying has enormeous impact on the quality of final masonary clay elements. The accumulated knowledge about modeling the drying process, as well as the registered progress in compauntig the coupling between haeat and mass transfer during the last decade has reached the applicative industrial level. The novel commercial drying solutis has dropped the drying cicle to 5 hours for hollow clay products and up to the 9 hours for clay blocks of large size and weight. The limitation of novel solutions is still directly linked with raw material porpertises. Even thoug the designers and vendors of the novel drying solutions are at the disposal for factory management's the decision about optimisation of the existing dryer, the upgrade or investmen in novel drying facility must be also experimentally validated. Results of the one month monitoring and analyzing of the production process in one Serbian brick factory including the material and energy blance were given in this paper. Based on these data, raw material limitations and costs of the novel dryer a proposal was to upgrade the existing dryer.

Key words: heavy clay dryers, mass and energy balances, masonray clay units, industrial monitoring.

SAOPŠTENJE SA SKUPA NACIONALNOG ZNAČAJA ŠTAMPANO U CELINI (M63)

M. Vasić, Z. Radojević

DODATNA VALIDACIJA TEORIJE TRANSPORTA VLAGE TOKOM IZOTERMSKOG SUŠENJA

XXVIII kongres DIMK i IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 319–326.

Program *GetData-Graph digitalizer* je korišćen za očitavanje koordinata tačaka sa dijagrama krivih sušenja i skupljanja preuzetih iz literature. Prikupljeni podaci su dalje obrađivani uskladu sa teorijom transporta vlage tokom izotermskog sušenja. Utvrđeno je da je oblik prognoznih krivi određen sa literaturno prikupljenim podacima sličan i uporediv sa teorijskom krivom Deff - MR. Karakteristične tačke koje definišu redosled i raspored međusobne interakcije mehanizama sušenja prikazane na teoriskoj prognoznoj krivi uočene su i na krivama preutzetim iz različitih naučnih radova, bezobzira na činjenicu što se metod proračuna zavisnosti Deff – MR prikazan u literaturi razlikovao od postupka na kome je zasnovana teorija transporta vlage tokom izotermskog sušenja. Upravo ova činjenica je potvrdila univerzalni karakter novorazvijene teorije sušenja.

Ključne reči: sušenje, efektivni koeficijent difuzije, keramički crepovi, skupljanje.

M. V. Vasić, M. Vasić, G. Goel, Z. Radojević

UGLJENA PRAŠINA U ENERGETSKI EFIKASNOJ PROIZVODNJI OPEKE: OD LABORATORIJSKIH DO INDUSTRIJSKIH PROBA

XXVIII kongres DIMK i IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 127–136.

U ovoj studiji utvrđena je optimalna mešavina opekarske gline i otpadne ugljene prašine u laboratorijskoj proizvodnji šupljih blokova sa ciljem promovisanja

održivog razvoja u smislu uštede resursa i energije. Glina koja sadrži karbonate može se koristiti uz dodatak do 3% visokokalorične otpadne ugljene prasine, što je ocenjeno kao optimalno. Šuplji blokovi industrijskih razmera pečeni su u tunelskoj peći i zabeležen je režim pečenja. Utvrđeno je da se režim mora korigovati u zoni pečenja i hlađenja jer su razlike bile do 180 °C. Industrijski prototip je bio zadovoljavajućeg kvaliteta koji ispunjava zahteve vezane za upijanju vode i čvrstoću na pritisak prema evropskim i drugim međunarodnim standardima.

Ključne reči: karbonatna glina, ugljena prašina, režim pečenja u tunelskoj peći, optimizacija.

M. V. Vasić, N. Mijatović, Z. Radojević

GRANITNI OTPAD KAO ZAMENA DELA PRIRODNE SIROVINE U MEŠAVINAMA ZA PROIZVODNJU KERAMIČKIH PLOČICA

XXVIII kongres DIMK i IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 107.

Značajan problem u proizvodnji keramičkih pločica je veoma velika potrošnja prirodnih resursa. U ovom radu je analizirana mogućnost korišćenja otpada od aplitskog granita kao zamena dela sirovine u mešavini, s obzirom na to da sadrži feldspate i kvarc. Keramičke pločice su hidraulički presovane i pečene do 1250 °C. Ovaj material se pokazao kao povoljan topitelj, ali i punilac, u proizvodnji keramičkih pločica. Parametri definisani u seriji standarda EN ISO 10545 testirani su na poluindustrijskoj probi, čime je utvrđeno da se mešavina granitnog otpada i ilitsko- kaolinitske gline (bez dodatka kvarca) može efikasno koristiti za proizvodnju podnih keramičkih pločica za spoljašenj oblaganje. Upotreba ovog otpadnog materijala u velikoj količini (40%) doprinosi održivom razvoju i ekološkim rešenjima, izbegavanjem njegovog odlaganja na deponiji uz očuvanje prirodnih resursa.

Ključne reči: Keramičke pločice, aplitski granitni otpad, reciklaža.

M.. R. Vasić, Z. Radojević, M. V. Vasić

POTENCIJALNA UPOTREBA BETONSKOG OTPADA KAO DODATKA U OPEKARSTVU

XXVIII kongres DIMK i IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 309–318.

U radu je ispitivana mogućnost korišćenja mlevenog betonskog otpada kao aditiva u proizvodnji opekarskih proizvoda. Uzorci betona, poznate klase izloženosti, klase čvrstoće pri pritisku, i klase konzistencije, su prvo sprašeni a zatim su formirani komoziti. Udeo zamene osnovne sirovine mlevenim betonskim otpadom se kretao od 10 do 30%. Karakterizacija sirovina je uključivala određivanje hemijskog, mineraloškog (XRD, DTA/TG) i granulometrijskog sastava. Izvršena su i dilatometrijska ispitivanja. Praćeno je ponašanje pri oblikovanju, sušenju i pečenju. Sa povećanjem sadržaja betonskog otpada vrednosti čvrstoće pri pritisku opadaju. Čak i kod uzoraka sa najvećim procentom betonskog dodatka nije zabeležena vrednost čvrstoće pri pritisku ispod 9 MPa. Rezultati su ukazali da mleveni betonski otpad može da ima primenu u opekarstvu.

Ključne reči: mleveni betonski otpad, reciklaža, glinene opeke, održivi razvoj.

NOVO TEHNIČKO REŠENJE PRIMENJENO NA NACIONALNOM NIVOU (M82)

M. V. Vasić, M. Vasić, N. Mijatović, Z. Radojević, L. Pezo

OPTIMIZACIJA KOMPOZITNE MEŠAVINE DOMAĆIH PRIRODNIH ILITSKO-KAOLINSKIH GLINA ZA PRIMENU U PROIZVODNJI KERAMIČKIH PLOČICA

Tehničko rešenje proizilazi iz objedinjenih obimnih istraživanja sastava, strukture i svojstava novih materijala na bazi domaćih prirodnih sirovina, u pravcu razvoja i primene novih proizvoda i energetski efikasnih tehnoloških postupaka u domaćim industrijskim kapacitetima. Ovo tehničko rešenje predstavlja karakterizaciju mešavina keramičkih glina XRF i XRD tehnikama, kao i granulometrijsku i dilatometrijsku analizu. Nakon pečenja hidraulički presovanih uzoraka u opsegu 1000–1250°C, određivano je upijanje vode prema EN standardima ključanjem u vodi, pod vakuumom i natapanjem u roku od 24 h. Rezultati su pokazali da postoji visoka i statistički značajna korelacija između standardima definisanih metoda, ali je ispitivanje pod vakuumom dalo najveću zasićenost uzoraka vodom. Utvrđeno je da se ispitivane ilitsko-kaolinitne gline mogu koristiti za proizvodnju podnih keramičkih pločica koje pripadaju BIIa grupi (upijanje vode između 3% i 6%).

Ključne reči: Ilitsko-kaolinitske gline, keramičke pločice, optimizacija kompozitne mešavine, tehnološka proba, kvalitet proizvoda.

Korisnik / naručilac: B.P.A. Mauman d.o.o., Šabac, 2022.

T 200
THERMAL ENGINEERING,
APPLIED
THERMODYNAMICS

T 200
TERMIČKI INŽENJERING,
PRIMENJENA
TERMODINAMIKA

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

A. Kijanović, M. Mirković Marjanović, S. Ilić

FIRE RESISTANCE TESTS FOR FIRE DAMPERS

30th International Congress on Process Engineering, Belgrade, Serbia, 2022.

This paper represents a methodology for testing fire - resistant dampers in a vertical furnace with a standard temprature curve in a test furnace. A fire-resistant damper has been installed in the wall of the vertical furnace, which function is to be an obstacle in the further spread of the fire to the rest of the ventilation system. The basic properties of fire resistant dampers are integrity and thermal insulation properties which are tested in accordance with the standard SRPS EN 1366-2. Integrity of fire dampers is determined by the occurrence of flame penetration on the non-exposed side of the damper and the limited volume flow reduced per unit cross-sectional area of the damper, while thermal insulation properties of the damper are determined by reaching the standard temperature limits on the non-exposed side of the damper. The time moment of falling of the integrity and thermal insulation properties of the damper is the fire resistance time of the tested damper. The tests were performed on fire-resistant dampers with the largest and smallest dimensions and there is shown test results of these tested dampers.

Keywords: passive fire protection; fire - resistant dampers; fire classification of fire - resistant dampers.

M. Laban, S. Ilić, I. Džolev, S. Draganić

EUROPEAN AND NATIONAL ASSESSMENT PROCEDURE FOR THE FIRE PERFORMANCE OF FAÇADES

19th International Symposium MASE, Ohrid, North Macedonia, 2022, 577–582.

Innovative construction systems, increasing use of combustible material in facades, less and less space between buildings, increased energy requirements; the transformation of facades in response to these changes requires the involvement of fire safety experts. As the fire incidents at Grenfell Tower, London and The Address in Dubai have demonstrated, use of combustible façade

elements and lack of fire spread measures resulted in massive loss of life and property. This fire spread through the various floors in double-quick time, primarily through the façade. We need to learn from these disasters. Other incidents prove that the use of non-combustible façade products can greatly inhibit the spread of fire and give both people and fire authorities' sufficient time for evacuation and fire suppression.

In the past years EU experts are working on development of common method for assessment of the fire performance of façade systems.The classification system should be transparent and should fit within the framework of existing national regulations. The common assessment method should be applicable to the wide range of façades systems available in the market including glazed façades, green façades and other emerging technologies.

There is a progress in developing legislation on façade fire safety in non-EU countries, due to emerging fire safety problems and harmonization of regulation with EU. Fire safety of facades in Serbia is defined through several rulebooks and standards, which significantly improved requirements. This paper presents the comparative analysis of legislation on facade fire safety in Serbia and other European countries.

Keywords: facade, fire safety, regulations, standards.

M. Mirković Marjanović A. Kijanović, S. Ilić, G. Todorović, R. Gospavić

EXPERIMENTAL AND NUMERICAL ANALYSIS OF WALS MADE FROM AERATED CONCRETE BLOCKS EXPOSED TO FIRE

19th International Symposium MASE, Ohrid, North Macedonia, 2022, 583–590.

In this paper solution of a non-stationary one dimensional (1D) heat conduction problem has been presented. The finite difference method, i.e. by applying energy balance has been used. The finite difference method has been applied and the partial differential equation of heat conduction has been reduced to an algebraic form. This procedure is also called discretization problem. By solving the system of algebraic equations, temperatures at discrete points - network nodes were obtained. Additional discretization was performed in non-stationary processes over time. Numerical 1D non-stationary calculation was performed on six walls of different thickness made of aerated concrete 50 mm, 75 mm, 100 mm, 120 mm, 150 mm and 250 mm thick are exposed to the developed fire. The developed

fire represents the logarithmic dependence of the temperature as a function of time according to the standard SRPS EN 834-1. The period of wall heating was analyzed, i.e. period until the moment when the temperature rise is observed on the non-exposed side of the wall. The paper compares the achieved experimental results with the obtained numerical results.

Keywords: numerical one-dimensional (1D) non-stationary calculation, fire condition, autoclaved aerated concrete, thermal behavior, different thicknesses of a wall.

M. Mirković Marjanović, A. Kijanović, S. Ilić, G. Todorović, R. Gospavić

THE COMPARATIVE ANALYSIS OF THERMAL BEHAVIOUR OF DIFFERENT THICKNESSES WALL MADE FROM AUTOCLAVED AERATED CONCRETE BLOCKS EXPOSED TO FIRE

19th International Symposium *MASE*, Ohrid, North Macedonia, 2022, 591–597.

In this paper a comparative analysis of thermal behavior of six partition walls with different thicknesses were presented. The walls were dimensions 3000 mm x 3000 mm made from autoclaved aerated concrete blocks with dimensions 625 mm x 200 mm and thicknesses 50 mm, 75 mm, 100 mm, 120 mm, 150 mm and 250 mm. All walls were exposed to standard fire test according the standard SRPS EN 834-1, non- combustibility test according the standard SRPS EN 1182 and surface spread of flame test according to SRPS U.J1.060. All walls were tested to fire resistance in vertical furnace with a data acquisition system, according to standard fire test. Standard furnace for testing construction consist of four two step burners in liquid fuel type „Major P25 AB HS TL V.C.“, heating power of 296 kW manufactured by ECO FLAM. Two transmitters of differential pressure type 6321 manufactured by TESTO (Germany), with range ±100 Pa installed inside the furnace were used for pressure measurement. Inside the furnace the temperature on six places with thermocouple type K were measures. The measure ranges of thermocouple type K were -270˚C to 1372˚C. The temperatures on unexposed fire side were measured in nine places with thermocouple type T with measure ranges -270˚C to 400˚C of according the national standard SRPS U.J1.090. The obtained temperature results depending of the time of reaching the critical temperature were presented for each wall thicknesses. The five identical cylindrical samples with high 50 mm and diameter 45 mm for non-combustibility

test has been used. All samples have been tested in standard furnace for non-combustibility test. The average temperature in furnace and specimens were presented. Surface spread of flame testing is carried out according to standard SRPS U.J1.060, if the coating material is based on organic or mixed materials. The samples for these test are with dimensions 900 x 230 mm.

Keywords: autoclaved aerated concrete, standard fire test, temperature measurement, thermal behavior, different thicknesses of a wall, non-combustibility test, surface spread of flame test.

M. Mirković Marjanović, S. Ilić, A. Kijanović, G. Todorović, R. Gospavić

EXPERIMENTAL ANALYSIS OF FIRE RESISTANCE OF CLAY HOLLOW-BRICK MASONRY NON-LOADBEARING WALL

8th International Conference *Civil Engineering – Science and Practice*, Kolašin, Montenegro, 2022.

Testing the clay hollow-brick masonry non-load-bearing wall helps us to understand the behaviour of this type of wall during a fire. It is important to know the fire resistance of hollow brick walls so that we can prevent the fire from spreading to other rooms. In this paper, the experimental analysis of fire resistance of non-load-bearing wall with dimensions 3000 mm x 3000 mm thickness 200 mm were presented. The wall was made from clay hollow-brick masonry blocks with dimensions 500 mm x 200 mm x 249 mm (L x D x H) with mortar on both side of wall of thickness 15 mm. The wall was exposed to a standard fire test according to SRPS EN 1363-1:2014. The temperatures on the unexposed side of the wall were measured in thirteen positions with thermocouples (K – type) according to the national standard SRPS EN 1364-1: 2014, and at the junction between mortar and clay hollow-brick. Deflection of the wall in five places was measured also. Obtained results depending on the time of reaching the critical temperature during the fire test were presented.

Keywords: clay hollow-brick masonry wall, standard fire test, temperature measurement, thermal behavior.

M. Mirković Marjanović, S. Ilić, A. Kijanović, G. Todorović, R. Gospavić

OVERVIEW OF THE NEW RULEBOOK ON TESTING FIRE RESISTANCE EXTERNAL FIRE PERFRMANCES AND REACTION TO FIRE IN THE REPUBLIC OF SERBIA

8th International Conference *Civil Engineering – Science and Practice*, Kolašin, Montenegro, 2022.

The growing expansion of construction and import of new, as well as existing materials from around the world, has led to a large number of tests materials and elements of constructions in the Republic of Serbia. Most of these materials and building constructions have test certificates obtained in foreign laboratories, which mostly refer to European standards. The currently valid Rulebook on mandatory attestation of elements of standard building structures for fire resistance and on working conditions that must be met by organizations of associated labour authorized to attest these products from 1990 requires testing of each product, or structural element, according to the domestic SRPS standards. The condition for accessing the European Union requires the harmonization of regulations related to the testing of construction products. Therefore, the IMS Institute, the Ministry of Interior - Sector for Emergency Situations and the Ministry of Construction of the Republic of Serbia have written a new draft Rulebook on Technical Requirements for construction products for which performance characteristics are important: reaction to fire, fire resistance and external fire performance. The plan is to publish the Rulebook, as valid, at the beginning of 2022, with a transitional period for implementation of two years. The paper presents a overview of the new Rulebook.

Keywords: the new rulebook, reaction to fire, fire resistance, behaviour of external fire, classification.

N. Božović, M. Krstić, G. Todorović, R. Gospavić, M. Mirković Marjanović, S. Ilić, A. Kijanović

MEASUREMENT AND MODELING OF THERMAL CONDUCTIVITY OF LOESS AT THE LOCATION OF THE AIRPORT NIKOLA TESLA IN SURČIN

5th Symposium of the Macedonian Association for Geotechnics, Ohrid, North Macedonia, 2022.

The thermal conductivity of a material is the parameter that is most reliably determined experimentally. The problem of determining the thermal conductivity in the soil is greater because the soil is heterogeneous, so for the same soil this parameter may be different depending on the their ohysical characteristics. Therefore, it is necessary to adopt an appropiate model for describing the thermal conductivity of the soil for a particular location after the necessary tests are performed. This paper is based on experimental measurements of soil thermal conductivity as a function of moisture content in the area of the ‚Nikola Tesla Airport construction site in Surčin and the adoption of one of the existing theoretical models that would satisfactorily describe changes in thermal consuctivity. Based on the obtained results of experimental reasearche, a two-parameter fitting of the measured values of thermal conductivity of the soil was performed in Cote-Konrad model, which proves to be reliable and the simplest to describe the thermal properties of loess in the area of Belgrade.

Keywords: thermal consuctivity, moisture content, loess.

S. Ilić, M. Laban, I. Džolev

FIRE RESISTANCE TESTING OF FIRE DOORS

8th International Scientific Conference *Safety Engineering*, Budva, Montenegro, 2022, 115–118.

Fire-resistant doors are widely used as part of passive fire protection systems, preventing the spread of fire and smoke beyond the fire compartment. Fire resistance is usually determined through standard fire tests in accredited laboratories, such as the Laboratory for thermal technique and fire protection in Institute IMS, Serbia. Current regulations in Serbia allow testing of fire doors according to two standards: Serbian national SRPS U.J1.160 and European SRPS EN 1634-1.

In the past five years, 236 samples of different fire doors were tested. Most of them were single-leaf, steel doors. Although almost one third (31%) of all samples (tested on 15, 20, 30, 45, 60, 90, 120, 180, 240 and 380 minutes) provided fire resistance of 120 minutes, which should be sufficient for the safe evacuation of people, as well as the protection of expensive equipment (hospitals, rooms with electrical devices, etc.). Samples usually fail the test when sustained flaming occurs on the unexposed side in the upper corner of the specimen (lock side), or

when the temperature measured by thermocouples exceeds the limitation given in the standard, usually at the top corner (lock side).

In this paper, both currently valid standard testing procedures are analysed and compared.

Keywords: fire-resistant door, fire resistance, standards, testing, single-leaf steel door.

S. Ilić, M. Malešev, M. Mirković Marjanović, A. Kijanović

DETERMINATION OF VENTILATION HEAT LOSSES THROUGH BUILDING ENVELOPE – A CASE STUDY

International Conference on Contemporary Theory and Practice in Construction XV, Banja Luka, Bosnia and Herzegovina, 2022, 552–558.

In this paper the experimental procedure for the determination of ventilation heat losses across building envelopes has been shown. The alternative name for this method is Blower Door Test or Fan Pressurization method. This text is a user manual for the determination of ventilation heat losses and parameters which is used to describe the air permeability of buildings. The experiment examination was performed at the office with old and after with new windows. The results were compared, and a significant contribution of new windows was shown.

Keywords: blower door test, experimental determination of ventilation heat losses, air change rate.

S. Ilić, M. Mirković Marjanović, A. Kijanović, M. Laban

TESTING OF BUILDING MATERIALS – REACTION TO FIRE

17th Conference with International Participation on Risk and Safety Engineering, Kopaonik, Serbia, 2022, 111–119.

To reduce occurrence of fires in buildings as efficiently as possible, it is necessary to take into account active and passive fire protection measures during construction of building. This paper will show more about passive fire protection measures related to the selection of adequate material to be used during construction, which contributes to the localization of fire and prevents it from spreading to other rooms and facilities.

All products, which are planned by project, must have adequate certificates not to contribute to the development of fire, as well as to meet the class of fire resistance. In the Republic of Serbia, only the Laboratory for Thermal Engineering and Fire Protection, within the IMS Institute, deals with this type of testing and issuing reports.

This paper will present test methods for obtaining a fire reaction class. After the tests, according to the standard SRPS EN 13501-1, a Classification Report is issued in which the final fire reaction class is given for the tested product whose validity lasts for 5 years.

Keywords: reaction to fire, classification, non-combustibility, heat of combustion, ignitability, SBI test, flooring test.

BITNO POBOLJŠANO TEHNIČKO REŠENJE NA NACIONALNOM NIVOU (M84)

D. Ivanišević, A. Kijanović, M. Mirković Marjanović, S. Ilić, K. Janković

GREJNA PLOČA ZA MERENJE TOPLOTNE PROVODLJIVOSTI GRAĐEVINSKIH MATERIJALA

Tehničko rešenje predstavlja poboljšanu konstrukciju zaštićene grejne ploče (hot-guarded plate) za merenje toplotne provodljivosti termoizolacionih materijala postavljanjem ispitnog uzorka iznad i ispod grejne ploče (standardna simetrična ispitna konfiguracija). Merenje toplotne provodljivosti vrši se u skladu sa standardom SRPS U.A2.020.

Ovim rešenjem toplotna provodljivost se proračunava na osnovu vrednosti izmerenog toplotnog fluksa korišćenjem dva tanka toplotna fluksmetra na toploj i hladnoj strani ispitivanih uzoraka. Prednost korišćenja fluksmetara na grejnoj i rashladnoj ploči u odnosu na uobičajen metod za određivanje toplotne provodljivosti (hot-guarded plate) je u periodu dostizanja stacionarnog stanja koji je znatno kraći. Na taj način bi se ostvarila sva zahtevana merenja toplotne provodljivsti termoizolacionih materijala usled povećane potražnje za ovakvom vrstom ispitivanja u Republici Srbiji.

Kod metoda merenja sa toplotnim fluksmetrima, uobičajeno je da se koristi jedan fluksmetar na zaštićenoj grejnoj ploči. Kod ovog tehničkog rešenja koriste se dva toplotna fluksmetra na površini uzorka. Na taj način se precizno može utvrditi srednja vrednost toplotnog fluksa kroz ispitivani uzorak tj. srednji toplotni fluks kroz sam uzorak je tačnije određen. Fluksmetri za ovakvu vrstu merenja su odabrani sa velikom mernom površinom da bi se dobile što merodavnije vrednosti raspodele toplotnog fluksa po mernoj površi, pri čemu uobičajeno korišćenje znatno manjih toplotnih fluksmetara.

Novi koncept grejne ploče ne odgovara uobičajenim grejnim pločama koje su opisane u standardima. Specifičnost ovog dizajna ploče je u smanjenom toplotnom prekidu – prostor između unutrašnje zaštićene (hot) i spoljašnje zaštitne (guard) ploče koje zajedno čine predmet ovog tehničkog rešenja. Veličinom toplotnog prekida od 1 mm popunjenog dvokomponentnim termoizolacionim lepkom, određena je i minimalna dozvoljena debljina uzorka.

Na taj način je omogućeno merenje tanjih termoizolacija, tj. povećan je merni opseg samog uređaja pri ovakvom načinu izrade grejne ploče.

Dodatna prednost u pogledu konstrukcije toplotnog prekida je u formiranju *stepenika* čija je osnovna svrha formiranje jednodelne konstrukcije koja se sastoji od zaštićene (hot) i spoljašnje zaštitne (guard) ploče. Uobičajeno se ovakve ploče izrađuju iz više segmenata dok je specifičnost ove konstrukcije da se sastoji iz jednog dela.

Temperaturska razlika između dve ploče se kontroliše korišćenjem termoparova u diferencijalnom spoju koji su raspoređeni po obimu kontakta dve ploče. Merenjem naponskog signala za praćenje temperaturne razlike između pomenute dve ploče mogu se proceniti lateralni gubici između zaštićene i zaštitne ploče i izmereni naponski signal se može koristiti u svrhe upravljanja.

Grejači zaštićene i zaštitne ploče su *ukopani* u materijal grejne ploče i napravljeni su korišćenjem žice za izradu termoparova K tipa. Grejači su vezani na standardni priključak za termoparove tipa K, koji je fiksiran za grejnu ploču. Preko fiksiranih priključaka ostvareno je napajanje grejača naponskim dvokanalnim nezavisnim izvorom. Korišćene su rashladne ploče koje su hlađene korišćem automatzovanog rashladnog kupatila sa propisanom površinskom fluktuacijom temperature rashladne površi od 0,1°C.

Validacija grejne ploče je izvršena učešćem u međulaboratorijskom poređenju.

Ključne reči: Ispitivanje termodinamičkih svojstava materijala, toplotna provodljivost, grejna ploča, metod sa zaštićenom grejnom pločom i fluksmetrima.

Korisnik / naručilac: Institut za ispitivanje materijala (Centralna laboratorija za ispitivanje materijala, Laboratorija za toplotnu tehniku i zaštitu od požara).

T 210
MECHANICAL ENGINEERING, HYDRAULICS, VACUUM TECHNOLOGY, VIBRATION AND ACOUSTIC ENGINEERING

T 210
MAŠINSTVO, HIDRAULIKA, VAKUUMSKA TEHNOLOGIJA I AKUSTIČKI INŽENJERING

SAOPŠTENJE SA SKUPA NACIONALNOG ZNAČAJA ŠTAMPANO U CELINI (M63)

A. Milenković, D. Boljević

ISPITIVANJA ZVUČNE IZOLACIJE SLOŽENIH ZIDNIH I KROVNIH KONSTRUKCIJA

XXVIII kongres DIMK I IX kongres SIGP sa međunarodnim simpozijumom o istraživanjima i primeni savremenih dostignuća u građevinarstvu u oblasti materijala i konstrukcija, Divčibare, Srbija, 2022, 183–189.

Za potrebe izgradnje filmskog studija projektovani su zid i krov visoke zvučne izolacije čije je vrednosti merodavne izolacione moći bilo potrebno potvrditi konkretnim ispitivanjem. U Laboratoriji za akustiku i vibracije Instituta IMS su i izvršena ispitivanja zvučne izolacije od vazdušnog zvuka i zida i krova radi dokazivanja projektovane zvučne izolacije. Ispitivanja su sprovedena u laboratorijskim uslovima, a izvršena su u serijama u toku instalacije zida odnosno krova kako bi se ispratile vrednosti merodavnih izolacionih moći u različitim fazama instalacije, a sve u cilju da se vidi koliki je doprinos zvučnoj izolaciji dodavanja različitih slojeva na osnovnu (betonsku) konstrukciju zida odnosno krova.

Ključne reči: Složena konstrukcija, zvučna izolacija, izolacija od vazdušnog zvuka, merodavna izolaciona moć, zid, krov.

T 220
CIVIL ENGINEERING,
HYDRAULIC ENGINEERING,
OFFSHORE TECHNOLOGY,
SOIL MECHANICS

T 220
GRAĐEVINARSTVO,
HIDRAULIKA,
PRIOBALNA
TEHNOLOGIJA,
MEHANIKA TLA

RAD U MEĐUNARODNOM ČASOPISU (M23)

M. Ćosić, N. Šušić, K. Đoković

STATIC-DYNAMIC TESTS OF BEARING CAPACITY OF WIND TURBINE PILES

Comptes rendus de l'Académie Bulgare des Sciences, 2022.

The paper presents the static load tests (SLT) and dynamic load tests (DLT) of the piles and numerical analyses of piles in interaction with the soil of wind turbines. Pile tests were conducted using the equipment with counterweights for SLT and an autonomous system for the control of DLT of the piles. Numerical DLT analyses were performed by the signal matching method. Tests proved that the design resistance of piles of SLT and mobilized static resistance of DLT are higher than the design forces obtained from the design of the wind turbine foundations. Also, the need to develop a plan for testing the bearing capacity of piles, concerning large and significant buildings was emphasized.

Keywords: pile, testing, bearing capacity.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

K. Đoković, N.Šušić, M. Drobnjaković

THE INFLUENCE OF MINERAL COMPOSITION ON THE PLASTIC PROPERTIES OF CLAY SOIL

XXVIII Congress DIMK and IX congress SIGP with International Symposium on Researching and Application of Contemporary Achievements in Civil Engineering in the Field of Materials and Structures, Divčibare, Serbia, 2022, 381–387.

The paper presents the results of testing the influence of mineralogical composition on the physical and mechanical properties of clayey soil, i.e. Atteberg consistency limits. The tests were conducted on samples of highly plastic clay soil with a high content of clay component in the granulometric composition (CF>80%). The results show that the liquid limit (LL) and the plasticity index (PI) increase with the increased content of clay minerals. High content of clay fraction, high values of Atteberg's consistency limits, analysis of colloidal activity, mineralogical and chemical analyzes showed that these are bentonite type clays containing montmorillonite and kaolinite minerals.

Keywords: clay, mineralogical composition, plasticity limit, liquid limit, plasticity index.

M. Ćosić, N. Šušić

COMPARATIVE ANALYSIS OF BEARING CAPACITY OF PILES TESTED BY DYNAMIC LOAD TEST (DLT) AND PRESSUREMETER TEST (PMT)

5th symposium of the Macedonian Association for Geotechnics, Ohrid, Macedonia, 2022, 344–354.

The paper presents the comparative analysis of several piles for different pier locations of a bridge by employing in-situ deep foundations tests and in-situ soil tests. The focus of the paper is on the presentation of the reliability of solutions obtained using the Dynamic Load Test (DLT) for in-situ tests of the bearing

capacity of deep foundations – piles. The DLT test was conducted in two stages: in-situ DLT of piles and pile bearing capacity analysis using the wave theory and the method of characteristics. The signals of upward traveling force waves, obtained by in-situ DLT of piles were signal matched with the signals of the numerical nonlinear model of the dynamic pile-soil interaction. The results of DLT of pile bearing capacity are presented as componential values (regarding the pile base and the pile shaft) and as a cumulative value (total bearing capacity), so that the comparison of DLT and pressuremeter test (PMT) was conducted both according to componential and cumulative bearing capacities. Since it is not possible to strictly conduct DLT and PMT for the same settlement level, it is not possible to directly compare the bearing capacity, however the comparison was performed taking into account the bearing capacities from PMTs according to Eurocode 7. DLTs provided bearing capacities which correlate well with the PMTs results. Also, DLTs determined the corresponding elastoplastic settlement for the designed resistance of piles, which is very useful to the designers in the analysis of serviceability (settlement) of both the pier locations and of the entire bridge.

Keywords: pile, testing, bearing capacity, dynamic load test, pressuremeter test.

M. Krstić, N. Božović, K. Đoković

STABILIZATION OF LOESS WITH FLY ASH

5th Symposium of the Macedonian Association for Geotechnics, Ohrid, Macedonia, 2022, 648–653.

To date, much research has been conducted in the field of the application of fly ash in road construction. Particular attention is paid to the effects of fly ash on soil stabilization. The results of the research show that self - binding fly ash is an efficient and economical stabilizing material for various applications in construction. The aim of this paper is to investigate the efficiency of stabilization of fine-grained soil with fly ash. This paper presents the results of the laboratory test for stabilization of loess with fly ash, which was conducted in August – September 2021 in the Laboratory for Roads and Geotechnics, at the IMS Institute in Belgrade. The materials used are ash from the heating plant Energetika Kragujevac and loess from the project Nikola Tesla airport in Surcin.

Keywords: fly ash, loess, stabilization.

S. Mitrović, G. Todorović, B. Kostić, M. Mirković Marjanović, N. Božović, M. Krstić, R. Gospavić, S. Ilić, A. Kijanović

UNIAXIAL COMPRESSIVE STRENGHT TEST BEFORE AND AFTER STANDARD FIRE TEST ON ROCK MASS

5th Symposium of the Macedonian Association for Geotechnics, Ohrid, North Macedonia, 2022.

The paper presents uniaxial compressive strength test according to the standard SRPS EN 1926. Uniaxial compressive strength test was performed on 12 identical cube-shaped specimens dimensions 70 mm x 70 mm x 70 mm, which are made of sandstone. Samples were brought form Laz tunnel and were divided into two groups of six samples. First group of samples consists of 6 samples tested for uniaxial compressive strength. Second group of samples consists of 6 samples exposed to standard fire test according SRPS EN 1363-1, with the intention to test uniaxial compressive strength after standard fire test. The aim of this study was to examine the uniaxial compressive strength of the rock, before and after standard fire test on the rock mass. The paper presents the strengths of the specimens tested before and after standard fire test.

Keywords: rock, uniaxial compressive strength, standard fire test.

T 230
BUILDING CONSTRUCTION

T 230
VISOKA GRADNJA

RAD U ISTAKNUTNOM MEĐUNARODNOM ČASOPISU (M22)

S. Živanović, B. Lin, H. Dang, S. Zhang, M. Ćosić, C. Caprani, Q. Zhang

EVALUATION OF INVERTED-PENDULUM-WITH-RIGID-LEGS WALKING LOCOMOTION MODELS FOR CIVIL ENGINEERING APPLICATIONS

Buildings, Vol. 12, No. 8, 2022, 1–19.

Bipedal models for walkers, originally developed in the research field of biomechanics, have been identified as potential candidates for modelling pedestrians in structural engineering applications. These models provide insight into both the kinetics and kinematics of walking locomotion and are considered to have a significant potential to improve the vibration serviceability assessment of civil engineering structures. Despite this notion, the ability of the bipedal models to represent the key features of the walking gait and natural variability within the pedestrian population are still under-researched. This paper critically evaluates the performance of two bipedal models with rigid legs to realistically both reproduce key features of an individual pedestrian's walking gait and represent a wide range of individuals. The evaluation is performed for walking on a rigid, rather than vibrating, structure due to the availability of experimental data and expectation that successful modelling on rigid surfaces is a necessary condition for progressing towards modelling on the vibrating structures. Ready-to-use equations are provided and the ability of the models to represent the kinematics and kinetics of individual pedestrians as well as the inter-subject variability typical of the human population is critically evaluated. It was found that the two models could generate realistic combinations of the gait parameters and their correlations, but are less successful in reproducing genuine kinetic and kinematics profiles.

Keywords: walking locomotion; bipedal inverted pendulum; ground reaction force; walking kinematics.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

B. Folić, A. Liolios, M. Ćosić, R. Folić

EFFECTS OF MAINTAINING A BUILDING CONSTRUCTED IN THE IMS SYSTEM (ŽEŽELJ) WITH AN APPROXIMATE ANALYSIS OF HYDRODYNAMICAL SHOCK AND THE ANALOGY WITH LATERAL SOIL EXPANSION WITH CAVERN EFFECTS DURING LIQUEFACTION

Assessment of the Condition, Maintenance and Rehabilitation of Buildings and Settlements, 12th International Conference, Vrnjačka Banja, Serbia, 2022.

The paper indicates the problems of maintaining buildings constructed in the IMS system, founded on piles with a basement floor. Also presented are the problems with the installations of buildings with a roof terrace, such as downpipe verticals that are extending through the building, or installations of water supply and sewerage that run through the technical floor at ground level. An approximate analysis of the hydrodynamic impact is presented. The analogy of the effects of caverns in sandy soil with lateral soil expansion during liquefaction was also used. Given the change in climatic conditions, it is necessary in some cases to analyze the influence of atmospheric conditions in the soil-structure interaction. The advantage of buildings built in the frame IMS system (Žeželj) in seismically active areas was also indicated. These buildings are also more resistant to problems that may arise later in construction of deep foundations.

Keywords: prestressed and reinforced concrete framed structures IMS, seismic strengthening system, soil pile structure interaction, earthquake resistant structures.

T 340	**T 340**
MINING	**RUDARSTVO**

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

Z. Ivković, D. Dramlić, B. Branković, D. Tošić, M, Ivković

THE IMPORTANCE OF COAL IN SERBIAN ENERGETICS

8th Balkan Mining Congress, Belgrade, Serbia, 2022, 232–240.

The dominant energy resource to produce electricity in the Republic of Serbia was, and still is coal, and such role should be kept in te following decades, since the determined reserves, built capacities for coal production and achieved technology processes with experienced and qualified workforce allow it. The present manuscript shows the basic sources of energy, the main guidelines of existing strategic documents on the development of energetics in the Republic of Serbia, as well as the analysed production of coal and electricity in the 2010-2020 period. It has been proven that in the following decades coal shall keep its role in the Serbian energetics, which is the main basis of implemented research, and this should be of help to state-level decision makers to see the future of coal in the production of electricity on a scientific level. As a separate section of research, the need for manitaining and developing underground exploitation, all within the scope of the industry system of EPS (Electric Power Industry of Serbia) has been pointed out.

Keywords: coal, electricity, coal production, coal reserves, thermal power plants.

SAOPŠTENJE SA SKUPA NACIONALNOG ZNAČAJA ŠTAMPANO U CELINI (M63)

Z. Ivković, D. Tošić, D. Dramlić

ANALYSIS OF COAL RESERVES WITH THE POTENTIAL FOR UNDERGROUND EXPLOITATION IN THE REPUBLIC OF SERBIA

13. Simpozijum sa međunaodnim učešćem *Rudarstvo 2022*, Vrnjačka Banja, Srbija, 2022, 183–189.

The issues addressed in this paper are dedicated to the balancing and analysis of coal reserves for the system of underground exploitation in the Republic of Serbia, both in active mines - deposits and in prospective deposits for activation in terms of production. The basic message emphasizes the importance of coal as the leading domestic energy source for the production of mainly electricity and thermal energy to a lesser extent. In addition to the balance of coal reserves in the deposits, importance was given to the quality of coal as an important thermal energy factor. For active mines-deposits, thermal values are given for assortments of piece, cube and fine coal, while for inactive deposits, quality values are shown for coal from coal seams. Based on the obtained research results, it is concluded that coal will maintain the leading position for electricity production in the energy sector of the Republic of Serbia in the coming decades, while coal from underground exploitation should increase its share in the energy balance.

Keywords: coal, coal reserves, mine, mine development, underground exploitation, energy production .

M. Ivković, V. Todorović, B. Branković, Z. Ivković, D. Dramlić

THE FUTURE OF COAL IN THE ENERGY SECTOR OF THE REPUBLIC OF SERBIA IN THE NEXT DECADES

13. Simpozijum sa međunaodnim učešćem *Rudarstvo 2022*, Vrnjačka Banja, Srbija, 2022, 161–171.

A country's energy policy should be largely based on domestic energy, stability and sufficiency, economy and be guided and directed. Sudden changes in the energy sector are not desirable because they can lead to more serious

consequences for the development of a society and the supply of energy to the population and economy.
In recent years, attempts have been made to marginalize the role of coal in the energy sector, without previously providing alternative sources of electricity production, or renewable sources in sufficient quantities. This has led to an energy crisis in some EU countries, and consequently an economic crisis.
In the Republic of Serbia, the main energy source for the production of electricity is coal, and the research conducted to produce this paper deals with the role of coal in the next few decades. The available reserves for surface and underground exploitation are presented, which shows that they can enable stable electricity production in the coming decades.
The negative impacts of this activity on the environment are evident, but they can be significantly reduced by appropriate solutions, and it should be noted that other energy sources have a detrimental impact on the environment to a greater or lesser extent. Work gives a brief overview of the impact of different energy sources on the environment.

Keywords: coal, mines, coal reserves, electricity, environment, surface exploitation, underground exploitation, energy balance.

T 350
CHEMICAL TECHNOLOGY
AND ENGINEERING

T 350
HEMIJSKA TEHNOLOGIJA
I INŽENJERING

RAD U VRHUNSKOM MEĐUNARODNOM ČASOPISU (M21)

N. Mijatović, M. Vasić, Lj. Miličić, M. Radomirović, Z. Radojević

FIRED PRESSED PELLET AS A SAMPLE PREPARATION TECHNIQUE OF CHOICE OR AN ENERGY DISPERSIVE X-RAY FLUORESCENCE ANALYSIS OF RAW CLAYS

Talanta, 2023, Vol. 252, 123844.

In this paper, the main subject concerns comparing different techniques to prepare raw clay samples for energy dispersive X-ray fluorescence spectrometry (EDXRF). Three kinds of sample preparation procedures are examined, such as loose powder, pressed pellet, and fired pressed pellet. The fired pressed pellet approach was observed as a part of universal sample preparation for physic, mechanical, and instrumental analysis, which has not been previously tested as a solution in chemical analysis by the EDXRF method. The observed sample preparation techniques were compared by calculating the parameters of validation (recoveries, limit of detection - LOD, limit of quantification - LOQ, precision, and expanded uncertainties of measurements) of 11 elements (Si, Al, Fe, Ca, Mg, K, Na, Ti, P, Mn, and S) using 15 certified reference materials (CRMs). Calibration curves were created and evaluated using 30 reference materials (RM) for all three approaches. Results proved that the fired pressed pellet is the most practical and precise approach for sample preparation of raw clays.

Keywords: chemical analysis, EDXRF, sample preparation, raw clays.

RAD U NACIONALNOM ČASOPISU MEĐUNARODNOG ZNAČAJA (M24)

A. Drpić, J. Popović; M. Popović; M. Điporović- Momčilović

ANALYSIS OF THE INFLUENCE OF PRE-TREATMENT WITH LIQUID HOT WATER (LHW) ON THE CHEMICAL COMPOSITION OF WOODEN CHIPS

Advanced technologies, Vol. 11 (2), 2022, 40–47.

doi: 10.5937/savteh2202040D

The goal of this paper is to analyze the chemical composition of untreated and treated wooden chips from the native narrow-leaved ash (Fraxinus angustifolia Vahl. ssp. Pannonica Soó & Simon). In order to determine the effect of pretreatment with liquid hot water (LHW) on changes in chemical composition, the content of moisture, cellulose, lignin, minerals (ash), extractives soluble in hot water, extractives soluble in organic solvents, for treated and for untreated wooden chips was determined. This was done in accordance with TAPPI and ASTM standard methods. The properties of wooden chips, treated for 30 min and 60 min at a temperature of 100°C, are compared to untreated wooden chips and changes in the chemical composition that occurred are defined as a result of the applied treatments. The research was performed under controlled conditions in a laboratory, and the results of treatments were the subject of comparative analysis. Applied treatments had a statistically significant effect on decreasing the content of extractives. The content of cellulose and hemicellulose increased in the treated wooden chips compared to untreated wooden chips, while the lignin content did not significantly change.

Keywords: native narrow-leaved ash, pretreatment with liquid hot water (LHW), analysis of the chemical composition of treated and untreated wooden chips.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U IZVODU (M34)

M. Radomirović, B. Tanaskovski, N. Mijatović, M. V. Vasić, L. Pezo, A. Onjia, S. Stanković

STATISTICAL ANALYSIS OF POLLUTION INDICES IN THE LAST TWO DECADES FOR THE BOKA KOTORSKA BAY, ADRIATIC SEA

XIV Conference of Chemists, Technologists and Environmentalists of Republic of Srpska, Banja Luka, Bosnia and Herzegovina, 2022, 184.

The surface sediments sampled from forty sampling sites in the Boka Kotorska Bay, starting from October 2005 to December 2019, were analysed for the content of ten heavy metals (As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn, Fe). Five complex indices (pollution load index (PLI), potential ecological risk index (RI), mean ERM quotient (MERMQ), toxic risk index (TRI), contamination severity index (CSI)) were determined for each site in the study period (2005, 2007, 2013, 2019), and statistically examined by principal component analysis (PCA) and cluster analysis (CA). In the semi-enclosed Bay, which consists of four smaller bays (Kotor, Risan, Tivat, Herceg Novi bays), a spatio-temporal comparison of sediment quality was carried out using PCA and CA analysis of the considered pollution indices. Statistical results revealed that the increased environmental risk in 2005 was observed in the bay of Kotor; in 2007 was in the bay of Tivat and Risan; in 2013 in the bay of Kotor and Tivat; and in 2019 was in the bay of Tivat, particularly at the shipyard site Bijela. The PCA and CA analysis highlighted that the sediment contamination in Kotor bay decreased from 2005 to 2019, while at the same time increased in Tivat bay, which is an indication of pollution due to urbanization and population growth in this part of the Bay. The results gave a statistical overview of the similarities between the pollution indices and the differences in the degree of sediment pollution in the Bay during the last two decades.

Keywords: surface sediments, pollution indices, statistical analysis, environmental risk, Adriatic Sea.

N. Antic, M. Stefanovic, N. Mijatovic, T. Tosti, C. Xie, M. Kašanin-Grubin

IS SNOW MORE DISTRUCTIVE AGENT THAN RAIN FROM THE PERSPECTIVE OF LAND DEGRADATION?

EGU General Assembly 2022, Vienna, Austria, 2022, EGU22-577, 2022.

doi.org/10.5194/egusphere-egu22-577

Badlands, between researcher also known as natural field laboratories, present areas formed in a wide range of lithologies and different climate conditions. Complex mineralogical and physico-chemical sediment composition make them suitable for numerous laboratory experiments that can replicate changes that occur in the field. As climate is one of the most significant factors in badlands forming and since climate changes are one of the biggest environmental concerns nowadays in this research badlands material was exposed to different conditions with the aim to monitor changes caused by extreme climate.

Three samples of badlands from China were organized in twelve sets and treated with rain, acid rain, ice (presenting snow) and acid ice (frozen acid rain). Six sets were treated with rain and acid rain of different intensity and under high and low temperatures during fifteen cycles, while the other six were treated with ice and acid ice during fifteen cycles, dried at 50°C for three cycles and then treated with ice and acid ice for additional five cycles. All of the samples were photographed after each cycle to follow physical change occurring on the sample surface Leachate was collected and volume, electrical conductivity, pH and ion concentration were measured.

Generally parameters did not oscillate much neither between samples, nor between treatments except electrical conductivity that was higher in the samples treated with ice and acid ice. Physical changes that occurred during the experiment present the main difference. In all of the samples high temperature caused the most noticeable decay, in samples treated with rain, sediment decay was minimal, while in samples treated with ice a noticeable decay occurred.

This experiment confirmed that high temperature/drought has great impact on land degradation, but interestingly pointed out that ice/snow and its thawing have greater impact on degradation then rain and its intensity. These kind of result opens up a new perspective on climate impact on forming and badlands evolution that should be further examined.

N. Antić, M. Stefanović, N. Mijatović, M. Kašanin-Grubin, G. Veselinović, S. Stojadinović, B. Jovančićević

ANTHROPOGENIC AND CLIMATE INFLUENCE ON LAND DEGRADATION

21st European Meeting on Environmental Chemistry *EMEC21*, 2021, Novi Sad, Serbia, 141.

Badlands are areas with scarce or completely absent vegetation formed in a wide range of lithologies in different climate conditions and exposed to a wide range of geomorphological processes. Generally, rapid evolution governed by erosion processes is a consequence of complex mineralogical and physico-chemical sediment composition and climate conditions. Because of that, badlands are often described as natural field laboratories and, furthermore, badland material is suitable for laboratory experiments that can, in controlled conditions, provide insight of changes that occur in the field. As indicated above, beside lithology, climate is one of the most significant factors in badlands forming. Since human activities have great impact on the environment and since climate changes present one of the biggest environmental pollution problems nowadays, in this research badland material was exposed to different conditions with the aim of monitoring changes caused by extreme climate conditions and acid ice. Three samples from badlands in China organized insix sets were treated with ice (representing snow) and acid ice (frozen acid rain) during fifteen cycles, dried in the oven for three cycles and afterwards again threated with ice and acid ice for additional five cycles. After each cycle samples were photographed, so that physical changes can be tracked, while leachate was collected and analyzed for monitoring changes in its volume, pH,electrical conductivity (EC) and cation concentration. Beside slight oscillations in parameters through cycles of samples treated with acid ice, extreme changes in observed parameters were not noticed neither between samples, nor between treatments. Leachate EC were a bit higher in samples treated with ice, leachate volume was higher for samples treated with acid ice, while pH was similar in both cases. Cation concentrations are similar in the leachate of all tested samples. In most of cases, the highest concentrations were measured at the beginning of the experiment, during the first two cycles or during the first *ice* cycles after drying. This indicates the high cation concentrations originate from the sediment surface or washing along the crack that appeared after drying. Physical changes that occurred through cycles implied that heat/drought is more aggressive agent of sediment decay. Decay caused by ice is slower, not

as aggressive as drought, but not negligible, causing no ticeable and significant cracks and fissures of fragments. This experiment confirmed that drought has high impact on sediment weathering, but more importantly, pointed out the impact of ice and its thawing, opening new questions about climate impact on forming, erosion processes and evolution of badlands which need to be further examined.

Keywords: chemical analysis, x-ray fluorescence, land degradation.

N. Mijatović, Lj. Miličić, I. Delić-Nikolić, E. Nikolić, M. Jovičić, B. Ilić

CHEMICAL ANALYSIS OF HISTORICAL MORTARS FROM THE ROMAN PERIOD IN SERBIA

Serbian Ceramic Society Conference *Advanced Ceramic and Application X– New frontiers in multifunctional material science and processing*, Belgrade, Serbia, 2022, 67.

This work is part of the MoDeCo2000 project research concerning the historical mortars from the Roman period in today's Serbia. It is focused on the chemical analysis of mortar samples selected from archaeological sites along the Danube River. The main compositional and technological features of the mortars were determined by chemical analyses with energy dispersive x-ray fluorescence (EDXRF) and inductively coupled plasma optical emission spectrometry (ICP-OES) with an HF resistant introductory system. The aim of this study is to present the analytical chemistry strategy used for the rapid and reliable characterisation of the relevant features of historical mortars. It is concluded that the EDXRF technique can be directly applied to solid samples, but ICP-OES still requires sample decomposition and dissolution to make full use of its analytical capabilities. However, in many cases, ICP-OES includes a quartz introductory system, and hydrofluoric acid removal by treatment with borates must be applied before measurement. Replacing the quartz introductory system with an HF resistant introductory system is achieved to eliminate the neutralisation step with borates, and still get very accurate boron and silicon results. After detailed research, standard reference certified materials of selected rocks, clays, and limestone (CRM NIST 688 (basalt rock), NCS DC CRM 60102 (clay), NCS DC CRM 60104 (clay), NCS DC CRM 60105 (clay), NCS DC CRM 60106 (clay), BCS-CRM 512 (dolomite), BCS-CRM 513 (limestone)) were analyzed with the same chemical techniques, sighting the identification of potential types of raw

materials employed for the production of mortars. Data analysis as a tool of statistics was applied to evaluate the characteristics of mortars, mutuallydifferentiating mortars from different sites, as well as typify updated samples. The analytical results showed that the EDXRF technique can be used together with other well-established techniques (ICP-OES) and presents a good potential as a reliable, cheap, and fast chemistry strategy to carry out the study of historical building materials. Elaboration of cheap and quick analytical methodology is an important aspect in the development of advanced steps in the research of historical mortars' production technology

Keywords: chemical analysis, EDXRF, ICP-OES, characterisation of historic mortars, Roman mortars, statistical verification of methodology, building materials.

N. Mijatović, Lj. Miličić, I. Delić-Nikolić, B. Ilić

ENERGY DISPERSIVE X-RAY FLUORESCENCE IN THE INVESTIGATION OF THE COMPOSITION OF HISTORICAL MORTARS

Science for Conservation of the Danube Limes Mortar Design for Conservation – Danube Roman Frontier 2000 Years After, Viminacium, Serbia, 2022, 49–51.

The use of X-ray fluorescence (XRF) spectrometers has increased in recent years due to its easy, rapid, non-destructive analysis and multiple element quantification. In this paper, XRF is proposed as a high-speed technique for classifying mortars from constructions of high historical value. Traditional wet chemistry methods for mineral dissolution in mortar are expensive and time-consuming. The current energy dispersive X-ray fluorescence (EDXRF) devices are able to provide a lot of data. There are a few different options for quantifying elements, such as developing an empirical calibration and using a method based on fundamental parameters.

For this purpose, in the scope of the project MoDeCo2000 research, the performance of an energy dispersive X-ray fluorescence spectrometer (Spectro Xepos (Germany)) was evaluated using data analysis of Roman mortars sampled from the buildings situated along the Danube River in Serbia.

The aim of this work is to compare results gained during the research of the samples of historical mortars using two different methodologies (empirical

calibration and fundamental parameters). Fundamental parameters are based on the physical theory of X-ray production rather than on empirical relations between observed X-ray count rates and concentrations of standards. This quantification methodology is not particularly reliable, especially when analyzing samples with very complex matrices, such as building materials. The methodology of empirical calibration based on used reference materials and eliminating matrix effects produces reliable results. The accuracy of the semi-quantitative results provided by the EDXRF spectrometer was compared with a previously validated and optimized EDXRF quantification method. Complete comparative research data treatment followed by an ANOVA and t test for method comparison results.

However, a method based on fundamental parameters is utilized for qualitative assessments in an unknown matrix of samples. The analytical method based on an empirical calibration gives better results for quantitative results.

Keywords: chemical analysis, x-ray fluorescence, characterisation of historical mortars; Roman mortars, statistical verification of methodology.

E. Nikolić, M. Jovičić, I. Delić-Nikolić, Lj. Miličić, S. Vučetić, J. Ranjogajec

OUR MODECO2000: RESULTS OVERVIEW OF THE SCIENTIFIC AND RESEARCH PROJECT

Science for Conservation of the Danube Limes Mortar Design for Conservation – Danube Roman Frontier 2000 Years After, Viminacium, Serbia, 2022, 34–39.

Project Mortar Design for Conservation - Danube Roman Frontier 2000 Years after (MoDeCo2000) deals with mortars used from the 1st to the 6th century AD along the part of the Danube frontier that is situated in the territory of today's Serbia and whose monuments form the UNESCO tentative list *Frontier of the Roman Empire - Danube Limes in Serbia*. The mentioned territory was a provincial area in the Roman period, and the construction activities that happened in this part of the empire were not particularly interesting to the international scientific community dealing with Roman architecture. The aim of this project is to gain knowledge of ancient mortar technology in this area, to allow conclusions to be made about building activities, the exploitation and use of raw materials, as well as the everyday life of the people on the frontier. After interpreting the results obtained in laboratories of testing historical materials, the project is making

compatible mixtures of mortars for the future conservation of the Limes monuments, using local raw materials, but also improving the properties of these mortars with different additions.

Mortar is a composite that can carry a large amount of information about the moment in which it was created, the skill of those who created it, and the conditions of the time during which it lasted. Different combinations of the same local raw materials have led to different mortar mixtures. The results of research during the project were often a surprise, and interesting findings were obtained not only where we expected them, as is the case with the famous Trajan's Bridge, but also in many other buildings. However, the landscape of Viminacium, as a unique cultural-historical and natural entity along the Danube River, which we can roughly observe from the mouth of the Morava River to the village Ram, is a space about which we have the most knowledge and from which we have gained the most research experience. Its value for this type of research is its wide time period of interactions humans developed with their surroundings, which left the remains of buildings in it. From the ancient and early Byzantine Viminacium, through the medieval fortresses, to monasteries and traditional village houses built using Roman building materials and later industrial facilities, this area provides us with material remains for a wide variety of research. The samples of mortar are some of the most interesting remnants of this kind, which can be connected with the life of this region through the centuries, through the exploitation and availability of raw materials and traces of their wider distribution. Targeted sampling of mortars from the 12th and 15th centuries and their comparison with samples from the period from the 1st to the 6th century during the project proved to be extremely important in this sense.

Will we be able to characterise all the components of the sampled mortars in the future? The answer is certainly no, but it is important to note that this project is a big step in the research of historical building materials in Serbia. Lime, river sand, crushed stone and brick have always been visually recognisable in mortars of this territory and, in most cases, they were probably the only mortar components. However, the possibility of using natural materials with pozzolanic properties on the territory of Serbia in the Roman period has not been fully investigated, and deposits of natural pozzolanic materials in Serbia have not been recognised as places of historic exploitation. Following this project, it would be justified to make an attempt to research this topic further but, first, it is necessary to investigate the role of these materials in mortars we have already sampled through

the project, and whose analysis led us to this idea, as well as to explore their reactions with other components of mortars, and the possibilities of the formation of different minerals in the mortars themselves due to different reactions and external conditions.

Today, one step away from the end of the project, the work on the research of Roman mortars of the Danube Limes has shown the exceptional scope and importance of the topic of ancient building materials for a large number of fields of science. Accordingly, to our satisfaction, the project covered a much larger number of research aspects than was originally conceived. The previous experience of the associates of the Institute of Archaeology in the research of Roman monuments of the Danube Limes was crucial in the selection of monuments for sampling, with great professional help from the associates of scientific and cultural institutions. However, although mostly humanities questions have guided and directed this multidisciplinary project, their answers depend entirely on properly selected and combined analyses of engineers and researchers in the natural sciences, in the "ocean" of possibilities offered by modern equipment and laboratory techniques.

After researching historical mortars and interpreting the results in order to make numerous trial conservation mixtures, the time will come when the selected, tested and proven ones will actually be applied during the conservation works on the monuments themselves. It is certain that then, through the contact of this material with the hands of modern masters, who will revive our research in that way, a new world of issues related to the technology of production and the methods of using mortars for the creation of Roman buildings on the territory of today's Serbia will be entered.

Keywords: Roman mortar, Danube Limes, raw materials, characterisation of materials, historical building.

S. Vučetić,J. Ranjogajec, I. Delić-Nikolić, Lj. Miličić, E. Nikolić, M. Jovičić

DESIGN OF COMPATIBLE MORTARS FOR CONSERVATION INTERVENTIONS

Science for Conservation of the Danube Limes Mortar Design for Conservation – Danube Roman Frontier 2000 Years After, Viminacium, Serbia, 2022, 52–54.

Architectural heritage suffers from many deterioration patterns among which mortar aging and degradation present a significant task for conservation practitioners and scientists. The functional requirements of compatible repair mortars strongly depend on the properties of historical mortars. In this sense, in-depth characterisation of historical mortars and technologies is crucial for the development and design of the repair mortars.

The main aim of our research, carried out in the PROMIS project MoDeCo2000, was design and laboratory and in-situ testing as well as monitoring of compatible mortars for conservation of the Roman military and residential objects along the Danube Limes in Serbia. This research covered: field architectural, archaeological, geological and technological investigation of historical technologies of mortar sample preparation and their comprehensive characterisation, as well as the characterisation of the available local raw materials. Moreover, laboratory design of conservation mortars, characterisation, testing and artificial ageing of the mortar models was also performed and promising recipes were applied and tested on the experimental walls and on the original structures. Laboratory characterisation of historical mortar samples and potential conservation mortars was performed using visual observations, stereo-optical and digital microscopy, spectrophotometry and colorimetry, mineralogical and petrological analyses, physicalmechanical tests, thermal characterisation, mechanical and chemical separation of aggregates and binders, and characterisation of samples, binders and aggregates using FTIR, RAMAN, XRF and XRD. The obtained results were used for the development of conservation mortars mixtures. The promising mortar mixtures were selected based on the compatibility of chemical, mineralogical, textural, visual and mechanical characteristics of the newly designed mortars with those of the old mortars and bricks/stones of the investigated building walls.

The characteristics of the tested materials and the recipes for conservation mortar design, along with an understanding of everyday life along the Danube Limes, represent the main results of the study. They prove the possibility of learning

about the past of this region and preserving procedure of the tangible cultural heritage objects.

Keywords: mortars, compatibility, laboratory and in-situ characterization.

Lj. Miličić., E. Nikolić, I. Delić-Nikolić, S Vučetić

COMPATIBLE MORTARS FOR THE ARCHITECTURAL CONSERVATION OF THE DANUBE LIMES IN SERBIA – IMPORTANCE OF THE RAW COMPONENT CHARACTERISATION

Science for Conservation of the Danube Limes Mortar Design for Conservation – Danube Roman Frontier 2000 Years After, Viminacium, Serbia, 2022, 55–59.

Recipes for compatible mortars for conservation must be based on raw materials whose presence was determined during the characterisation of historical mortars used on buildings on which we perform renewal or repairs. Additional materials are often used that improve the resistance of conservation mortars to various influences, while all the time ensuring that they do not have any negative effects on any part of the structure.

Within the MoDeCo2000 project, lime mortars for the conservation of monuments that belonged to the former Roman frontier in today's Serbia were prepared. The process was preceded by research into the materials used to make Roman mortars in the area. The selection of component materials, primarily binders, for the creation of conservation mortars included tests, in accordance with the methods prescribed by the relevant standards, of parameters that could adversely affect the properties of fresh or hardened mortar. In slaked lime, the content of free water required for the calculation of the optimal amount of water that will be used for the preparation of the mixture, in order to obtain a mortar of good consistency and workability, was tested. Examination of unextinguished lime particles and the stability of the volume was carried out in order to avoid the use of lime, which can lead to the appearance of microcracks in the mortar after hardening. When it came to choosing the quality of quicklime, it needed to have high reactivity, low content of inextinguishable particles, and high yield.

In accordance with the results of laboratory tests of historical mortars, many mixtures for conservation were prepared with the exclusive use of lime and river aggregate, in different interrelationships and different granulations of aggregates. In addition to river aggregate, crushed stone aggregate was added to some

mixtures. In the historical mortars used for plastering and flooring, a larger amount of brick was mostly used as an artificial material with pozzolanic properties and, thus, used for the compatible mixtures as well. Mineralogical testing of certain samples allowed consideration of the possible use of natural materials with pozzolanic properties for their preparation, so the use of zeolitised tuffs and kaolin clays in new mixtures was also tested, but carefully, in parallel with additional testing of historical samples.

The characteristics of mortars made exclusively of lime and river aggregate are lower mechanical properties, low resistance to atmospheric influences, primarily freezing and defrosting, as well as high water absorption. Although their good degree of compatibility with old mortars recommends their use in conservation, their application, depending on the climatic conditions of the environment, is generally suitable in structures protected from external influences. In accordance with the climate that is present in our territory, it was necessary to formulate preparations for conservation mortar with improved mechanical properties and greater resistance to external influences, which entailed the use of various additives. Natural and artificial materials with pozzolanic properties were added to a number of mortar mixtures prepared as compatible with pure lime mortars, including local clays, bricks, zeolitized tuffs, and kaolin clays, which were mechanically activated in the laboratory and whose use was expanded by using an industrial product created by their thermal activation, i.e., metakaolin. By applying these additives, in addition to a significant improvement in mechanical properties and durability, an attempt was made to achieve the desired appearance of the mortar, which included the colour of the mixture. In the phase of testing the suitability of applied recipes, in laboratory conditions, the appearance of cracks, fissures, flaking, discoloration due to drying or wetting, water absorption, volumetric mass, and mechanical properties, as well as their contact with samples of historical mortars were monitored.

Tests of the use of various components for the preservation of conservation mortars through the preparation of mixtures within the MoDeCo2000 project showed the possibility of using pure lime mortars for the conservation of Danube Limes monuments, but also the need to use different additives with pozzolanic properties in many cases. A large number of possibilities of combining these additives, in order to obtain more durable mortars for building conservation, while constantly adhering to the need to ensure the compatibility of old and new mortars and of existing built structures and new materials, raises the need for new

research, which needs to be directed to acquiring additional knowledge related to the composition of historical mortars, especially when it comes to the use of natural additives with pozzolanic properties.

Keywords: historical mortars, mortars for conservation, compatibility, Roman mortars, Danube Limes.

BITNO POBOLJŠANO TEHNIČKO REŠENJE NA NACIONALNOM NIVOU (M84)

N. Mijatović, A. Terzić, L. Pezo, Lj. Miličić, D. Živojinović

MODIFIKACIJA I UNAPREĐENJE ENERGETSKO-DISPERZIVNE RENDGENSKO FLUORESCENTNE METODE ZA ODREĐIVANJE SADRŽAJA DESET ELEMENATA U ELUATIMA CEMENTNIH VEZIVA

Inovacija u oblasti građevinskih materijala (veziva na bazi cementa), bitno unapređena metoda (bitno poboljšan metod, koji se koristi izvan predviđenog područja primene, proširen ili modifikovan metod ili poboljšan metod proizvođača opreme) za hemijsku analizu - određivanje sadržaja deset elemenata u eluatima cementnih veziva pomoću energetsko disperzivne rendgensko fluorescentne (EDXRF) tehnike.

Ključne reči: građevinski materijali, hemijska svojstva, instrumentalne metode za hemijsku analizu, cement, glineni resursi, pepeo, reciklaža, malter.

Korisnik / naručilac: Institut za ispitivanje materijala (Centralna laboratorija za ispitivanje materijala, Laboratorija za veziva, hemiju i maltere).

T 450
METAL TECHNOLOGY,
METALLURGY,
METAL PRODUCTS

T450
TEHNOLOGIJA METALA,
METALURGIJA,
PROIZVODI OD METALA

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

S. Bulatović, V. Aleksić, Lj. Milović, B. Zečević

DAMAGES THAT OCCUR AT VITAL COMPONENTS OF THE THERMAL POWER PLANT SYSTEM DETECTED BY NDT TESTING

ENERGETIKA 2022: Dugoročni i kratkoročni izazovi započete energetske tranzicije u Srbiji, Zlatibor, Srbija, 2022, 2.6.

Continuous exploitation in very harsh environmental conditions can lead to relatively frequent damages of steam line system. High place among the causes of these damages takes inadequate exploitation and maintenance. This paper describes damages and failures of steam line and provides an overview of NDT testing in order to determine the cause of steam lines failure in thermal power plants. This method may be applied to similar structures and its application in preventive maintenance would help extend the life of steam pipes. The results presented in this paper and conducted research projects allow us to analyze the behavior of supporting elements of steam line in order to determine changes in mechanical properties of materials.

Keywords: non-destructive testing (NDT), damages, steam line.

V. Aleksić, B. Zečević, S. Bulatović, A. Maksimović, Lj. Milović

THE ROLE OF DRAINAGE SYSTEMS IN THE PREVENTION OF MATERIAL DEGRADATION OF BRIDGE STRUCTURES

XXIII YuCorr: Stecište nauke i prakse u oblastima korozije, zaštite materijala i životne sredine, Divčibare, Srbija, 2022, 176–185.

The paper gives an illustrative presentation of damage to the material of bridge structures due to failure to maintain the system for drainage of bridges. Damage is caused by mechanical erosion and abrasion or by chemical means, corrosion or a combination of the above. The cause of the damage is related to the retention of salted water on the road and other surfaces of the bridge structure, as well as wetting of the side and ceiling surfaces by flooding due to the non-functionality

of the water drainage system from the bridge. The possibility of taking measures to prevent such phenomena and reduce them to a minimum is also considered.

Keywords: bridges, bridge drainage system, concrete, steel, asphalt, degradation.

V. Aleksić, Lj. Milović, S. Bulatović, B. Zečević, A. Maksimović

DETERMINATION OF LCF PLASTIC AND ELASTIC STRAIN COMPONENTS OF STEEL

Mechanisms and Machine Science, Vol. 109, Machine and Industrial Design in Mechanical Engineering, KOD 2021, Novi Sad, Serbia, Springer Nature Switzerland AG, 2022, Chapter 32, 341–349.

The behavior of steel in low-cycle fatigue (LCF) is tested experimentally, in accordance with ISO 12106:2017 (E) and/or ASTM E 606-04. For this purpose, smooth specimens which are exposed to low-cycle fatigue at several levels of regulated strains and/or loads at room, elevated or reduced temperatures are used. Stress–strain response at LCF has the shape of an ideal hysteresis loop. The strain range _ε corresponds to overall loop width, while the stress range Δσ corresponds to its overall height. The paper presents a method for determining the intersection of the idealized hysteresis loop and the positive part of the strain axis in order to determine the values of elastic, Δεe/2, and plastic, Δεp/2, components of the strain amplitude to characterize the behavior of steel under low cyclic fatigue. The values of elastic and plastic components of the strain amplitude are needed to determine the characteristic curves of low-cycle fatigue, which describe the behavior of steel under the loading of low-cycle fatigue.

Keywords: LCF – low cycle fatigue, strain.

RAD U VRHUNSKOM ČASOPISU NACIONALNOG ZNAČAJA (M51)

S. Bulatović, V. Aleksić, Lj. Milović, B. Zečević

DETERMINING OF THE FATIGUE CRACK GROWTH RATE OF HSLA STEEL AT ROOM TEMPERATURE

Advanced Technologies and Materials, 2022, Vol. 47, No. 1, 1–4.

DOI: 10.24867/ATM-2022-1-001

Welded joint is a critical region of a welded structure and fracture mechanics analysis is inevitable in the structural integrity assessment of all welded structures. This paper shows the determining of parameters of the fatigue crack for constituents of welded joints produced of high strength low alloyed steel. The applied methodology refers to the Paris relation where the link was established between the variable load quantity or the corresponding stress intensity factor range and crack growth per cycle. Results have shown that the position of the notch and crack initiation affect the values of the stress intensity range of fatigue threshold ΔKth and parameters in the Paris' equation. This is mostly expressed when determining growth parameters of the fatigue crack in heat affected zone of HSLA steel, where different changes of growth speed of the fatigue crack clearly express differences in structure of the crack pass.

Keywords: crack growth rate, welded joint, HSLA steel, welded joint.

NOVO TEHNIČKO REŠENJE PRIMENJENO NA NACIONALNOM NIVOU (M82)

V. Aleksić, Lj. Milović, S. Bulatović, B. Zečević, A. Maksimović

ODREĐIVANJA KARAKTERISTIČNIH STABILIZOVANIH HISTEREZA MATEMATIČKOM ZAVISNOŠĆU PODATAKA OPTEREĆENJA KOD LCF ISPITIVANJA ČELIKA

Razvijenom metodologijom sprovodi se određivanje matematičke zavisnosti maksimalne sile opterećenja i broja ciklusa opterećenja za određeni amplitudni nivo deformacije na podacima LCF ispitivanja čelika u svrhu određivanja područja stabilizovanih histereza i karakteristične histereze definisane standardima ISO 12106:2017(E) i/ili ASTM E 606-04.

Suština tehničkog rešenja je definisanje metodologije za određivanje karakterističnih stabilizovanih histereza, N_s, za svaki amplitudni nivo regulisane deformacije. Ovim tehničkim rešenjem se izbegava problem objektivnog i subjektivnog uticaja kod određivanja stabilizovane histereze. Svi podaci korišćeni za definisanje karakterističnih krivih niskocikličnog zamora su matematički ukalupljeni, pa objektivni i subjektivni uticaj praktično ne postoji.

Tehničko rešenje omogućava i brzo izračunavanje približne maksimalne sile opterećenja za bilo koji ciklus iz područja stabilizacije prema određenim formulama dobijenim iz podataka o ispitivanju LCF. Ukoliko nam je potrebna tačna vrednost maksimalnog opterećenja to očitavamo iz rezultata ispitivanja za konkretan ciklus opterećenja. Odstupanje vrednosti dobijene ovom približnom metodom ne odstupaju više od -1.15% i +1.46%.

Ključne reči: crack growth rate, welded joint, HSLA steel, welded joint.

Korisnik / naručilac: Univerzitet u Beogradu, Mašinski fakultet, Laboratorija za dinamička ispitivanja i TRCpro doo, Petrovaradin.

RAD U NEKATEGORISANOJ PUBLIKACIJI

M. Arsić, Ž. Flajs, A. Sedmak, E. Veg, S. Sedmak

DAMAGE OCCURENCE IN WELDED STRUCTURES OF THE BUCKET-WHEEL BOOM

Engineering Innovations, 2022, Vol. 2, 41–48.

Causes of damage occurrence in vital components of welded structures of the bucket-wheel excavator boom (DU1) at the coal landfill of the thermal power plant 'Nikola Tesla A' in Obrenovac (Serbia) are investigated. Bucket-wheel excavator was produced by French company 'Ameco' and it moves along the circular track. Taking into account lack of technical documentation, all tests and

were carried out under the assumption that welded structures were made of structural steels S355 and S235. Investigation of causes of damage occurrence are based on results of non-destructive tests (NDT) and tensometric measurements.

Keywords: bucket-wheel excavator boom, damage, NDT, tensometry.

P 430
MINERAL DEPOSITS,
ECONOMIC GEOLOGY

P 430
NALAZIŠTA MINERALA,
EKONOMSKA GEOLOGIJA

RAD U NEKATEGORISANOJ PUBLIKACIJI

L. Kurešević, M. Septfontaine, O. Vušović, I. Delić-Nikolić

CONTRIBUTION TO GEOLOGY AND GENETIC PATHWAY OF THE ROPOČEVO BRECCIA – AN ORPHAN OLISTOLITHIC BODY WITHIN THE UPPER CRETACEOUS FLYSCH NEAR SOPOT (CENTRAL SERBIA)

Geologica Macedonica, 2022, Vol. 36, No. 1, 5–18.

The Ropočevo breccia, a dimension stone highly prized in 20th century, has been examined by numerous prominent geologists of the time. It is revisited by researchers still intrigued by its perplexing provenance. Its position as a rigid exotic block of hard and completely metamorphosed carbonate breccia within the moderately lithified Upper Cretaceous flysch sequence remains unsolved due to absence of its source. Large bodies of a monomictic breccia suggest a relatively monotonous protolith carbonate sequence of significant thickness, such as those being formed in a calm marine environment with gradually sinking bottom due to epeirogenic movements. Varicoloured laminations indicate slight variations in the feeding material due to the epeirogenic oscillation of the basin bottom level. There is no regularity in clast distribution regarding size, colour or roundedness degree. This, paired with the occurrence of the "in-place brecciation" suggests a sudden fall of brecciated material due to a *catastrophic* event, such as earth-quake, collapse brecciation due to karst dissolution and a large sinkhole formation, or a graben/trench formation as in onset of the extensional processes.

Keywords: marble breccia, olistolith, Upper Cretaceous flysch.

DOCTORAL DISSERTATIONS | **DOKTORSKE DISERTACIJE**

ODBRANJENA DOKTORSKA DISERTACIJA (M 70)

N. Mijatović

HEMOMETRIJSKI PRISTUP ISPITIVANJU UTICAJA HEMIJSKIH SVOJSTAVA ELEKTROFILTERSKOG PEPELA, ZEOLITA I BENTONITA NA SVOJSTVA EKOLOŠKI PRIHVATLJIVIH GRAĐEVINSKIH MATERIJALA

Tehnološko-metalurški fakultet Univerziteta u Beogradu, 2022.

Intenzivna industrijalizacija i urbanizacija dovela je do sve veće potrebe za rešenjima koja će doprineti očuvanju životne sredine. Isto se dešava i u oblasti građevinske industrije, gde se čvrst neorganski otpad sve više koristi kao mineralna sirovina u cementoj industriji. U tom smislu nameću se novi izazovi za prilagođavanje hemijskih metoda za analizu sastava višekomponentnih materijala. U okviru ove doktorske disertacije razvijene su tri metode za hemijsku analizu višekomponentnih materijala i njihovih eluata od kojih se dve metode sprovode koristeći energetsko disperzivnu rendgensko fluoroscentnu spektrometriju (EDXRF), a treća metoda se zasniva na optičko emisionoj spektrometriji sa indukovano spregnutom plazmom (ICP-OES). Primenom eksperimentalnog dizajna koji uključuje sinteze maltera i cementnih veziva sa različitim udelima mineralnih dodataka (pepeo, zeolit i bentonit) pripremljeni su referentni materijali za razvijene metode. Prva od razvijenih metoda zasnovana je na primeni energetsko disperzivne rendgensko fluoroscentne spektrometrije (EDXRF) i primenjena je za ispitivanje veziva na bazi cementa sa dodatkom mineralnih sirovina (pepela, zeolita i bentonita). U tu svrhu analizirano je osamnaest elemenata prisutnih u sastavu materijala: deset glavnih elemenata (Si, Al, Fe, Ca, Mg, S, Na, K, Ti, P) i osam elemenata u tragovima (Cr, Zn, Cu, As, Ni, Pb, Sr, Mn). Trideset pet uzoraka od kojih su tri sertifikovani referentni materijali i trideset dva referentna materijala napravljena od cementa, pepela, zeolita i bentonita korišćeni su tokom validacije i optimizacije ispitivane EDXRF metode. Metoda je potvrđena u smislu selektivnosti, preciznosti, radnog opsega, linearnosti, tačnosti, robusnosti, granice detekcije i kvantifikacije. Trideset pet uzoraka, istovremeno su analizirani pomoću EDXRF i optičke-emisione spektrometrije sa induktivno spregnutom plazmom (ICP-OES). Poređenja

rezultata dobijenih primenomovih metoda su pokazala minimalno male razlike, jer su koeficijenti korelacije bili izuzetno dobri (≈1), što ističe EDXRF tehniku kao dobru alternativu ICP-OES tehnici za hemijsku analizu cementnih veziva. Druga metoda, takođe zasnovana na tehnici energetsko disperzivne rendgensko fluorescentne spektrometrije (EDXRF) je razvijena za deset hemijskih elemenata (As, Ba, Cd, Co, Cr, Cu, Mo, Ni, Pb, Zn) u eluatima dobijenim iz cementnih veziva. U eksperimentu je korišćeno 29 uzoraka. Svi uzorci su napravljeni na bazi portland cementa. Leteći pepeo različitog porekla, zeoliti bentonit su korišćeni kao mineralni dodaci u cementnim vezivima. Destilovana voda je korišćena za izluživanje. Validacija ove EDXRF metode je sprovedena određivanjem granica detekcije i kvantifikacije, radnog opsega, linearnosti, selektivnosti, preciznosti, istinitosti i robusnosti. Sledljivost je uspostavljena korišćenjem sertifikovanih referentnih materijala. Merna nesigurnost je potvrđena internim laboratorijskim pristupom validacije. Proširene nesigurnosti za deset analiziranih elemenata dobijene su za sve radne opsege EDXRF metode. Robusnost EDXRF metode je procenjena pomoću hemometrijskog internog pristupa koji uključuje analizu glavnih komponenti (PCA) i klastersku analizu (CA). Rezultati dobijeni rendgenskom fluorescentnom metodom su dodatno poređeni sa rezultatima dobijenim pomoću optičko emisione spektrometrije sa induktivno spregnutom plazmom (ICP-OES) kako bi se potvrdilo da se EDXRF može koristiti kao efikasana i pouzdana alternativna metoda za analizu eluata cementnih veziva. Treća metoda je razvijena primenom optičko emisione spektrometrije sa induktivno spregnutom plazmom (ICP-OES). Metoda je razvijena i potvrđena za hemijsku analizu (35 elemenata: Al, Be, Cd, So, Cr, Cu, Fe, Mn, Mo, Ni, V, Mo, Zn, Pb, Bi, Si, Zr, V, As, Se, Sb, Sn, Ti, Ba, B, Ag, Mg, Ca, K, Na, S, P, Ga, In, Li) u eluatu letećeg pepela i eluatima u vezivima i malterima sa i bez dodatka letećeg pepela. Određene su performance validacije i nesigurnost merenja. Nesigurnost merenja izračunata je na tri načina: postupak validacije, učešće u šemama testiranja osposobljenosti (PT) i pomoću podataka datih u standardnoj metodi. Da bi se dokazala tačnosti preciznost, korišćena je razvijena metodana laboratorijskim uzorcima cementnih veziva i maltera. Multivarijacione analize, tj. klaster analiza (CA) i analiza glavnih komponenti (PCA), primenjene su za uspostavljanje međusobnih odnosa između analiziranih uzoraka, i za potvrdu razvijene ICP-OES metode. Pored razvijenih metoda za ispitivanje cementnih veziva sa mineralnim dodacima (pepeo, zeolit i bentonit) u ovoj doktorskoj disertaciji ispitana je sposobnost imobilizacije toksičnih elemenata u okviru samih cementnih veziva sa pomenutim mineralnim dodacima. Istražene su

adsorptivne sposobnosti dve sirovine (zeolit i bentonit), odnosno njihov afinitet za imobilizaciju jona teških metala Zn^{2+}, Ni^{2+}, Pb^{2+} i Cu^{2+} pomoću pripremljenih pojedinačnih i multi-elementarnih rastvora Zn^{2+}, Ni^{2+}, Pb^{2+} i Cu^{2+}. Dobijeni rezultati su podvrgnuti analizi putem modela pseudo-prvog i pseudo-drugog reda kinetičkih reakcija. Analizirane su Langmuirove i Freundlichove izoterme. Bentonit je pokazao bolji afinitet adsorpcije od zeolita prema sva četiri ispitivana katjona. Kao dokaz, test izluživanja je sproveden na sedam različitih cementnih veziva sa različitim mineralnim aditivima (leteći pepeo, zeolit, bentonit). Eluat dobijen na uzorcima cementa sa dodatkom letećeg pepela i glina (bilo zeolit ili bentonit) sadržavao je niže koncentracije jona Zn^{2+}, Ni^{2+}, Pb^{2+} i Cu^{2+} nego eluati dobijeni na uzorcima cementnog veziva sa letećim pepelom isključivo kao rezultat mehanizma adsorpcije i hidratacije koji Imobilizuju teške metale u cementnoj masi kompozita.

Ključne reči: ICP-OES, EDXRF, mineralni dodaci, hemometrija, izluživanje.

ORGANIZATION
OF CONFERENCES

ORGANIZACIJA
STRUČNIH SKUPOVA

XXVIII KONGRES DIMK I IX KONGRES SIGP

SA MEĐUNARODNIM SIMPOZIJUMOM O ISTRAŽIVANJIMA I PRIMENI SAVREMENIH DOSTIGNUĆA U GRAĐEVINARSTVU U OBLASTI MATERIJALA I KONSTRUKCIJA

Divčibare, 19–21.10.2022.

Organizatori

Društvo za ispitivanje i istraživanje materijala i konstrukcija (DIMK) Srbije

Udruženje savremene industrije glinenih proizvoda Srbije

Institut IMS, Beograd

Ograničene mogućnosti nametnute aktuelnom pandemijskom situacijom su osnovni razlog koji je uslovio istovremeno održavanje dva Kongresa.

Kongres DIMK sa Međunarodnim simpozijumom predstavljao je priliku da se inženjeri i istraživači iz zemlje i šireg okruženja okupe i prikažu rezultate svojih istraživanja u proteklom periodu.

S druge strane, izražena je i potreba proizvođača glinenih proizvoda da se na Kongresu okupe, razmene iskustva u pogledu savremene proizvodnje i novih tehnoloških procesa, mogućnosti šire primene proizvoda od gline kao i zaštite životne sredine i energetske efikasnosti. Kongresom su obuhvaćene teme vezane za geološka istraživanja sirovinske baze, eksploataciju, preradu sirovine, tehnološke procese oblikovanja, sušenja i pečenja i automatizaciju procesa. Posebna oblast je primena građevinskih materijala na bazi gline.

Oba Kongresa i Međunarodni simpozijum su prilika za razmenu iskustava, kao i za analizu ostvarenih rezultata u prethodnom periodu i definisanje budućih pravaca razvoja - u cilju unapređenja našeg građevinarstva na području materijala i konstrukcija. Simpozijum je ukazao na glavne pravce razvoja u predmetnim oblastima i stanje naše regulative u ovim oblastima, kao i potrebu njenog daljeg usaglašavanja sa evropskim normama.

STRUČNI SKUP

ŠTA SMO URADILI I ŠTA NAS ČEKA PRELASKOM NA PRAVILNIK O PASIVNOJ ZAŠTITI OD POŽARA

Institut IMS, Beograd, 27.5.2022.

Organizator

Institut IMS, Centar za materijale, Centralna laboratorija za ispitivanje materijala, Laboratorija za toplotnu tehniku i zaštitu od požara

Institut IMS je organizovao stručni skup povodom novog pravilnika iz oblasti protivpožarne zaštite koji je usvojen u februaru 2022. godine: Pravilnik o načinu iskazivanja performansi građevinskih proizvoda i elemenata zgrade u vezi sa bitnim karakteristikama – reakcija na požar, otpornost na požar i ponašanje pri spoljašnjem požaru („Sl. glasnik RS", br. 21/2022).

Na skupu su predstavljeni ispitni kapaciteti Laboratorije za toplotnu tehniku i zaštitu od požara Instituta IMS, kao i pravni i inženjerski aspekti novog pravilnika i ispitne metode koje sprovodi ova laboratorija, a koje su obuhvaćene pravilnikom – otpornost na požar vrata, zidova, servisnih instalacija, klase reakcije na požar.

Aktuelni zakonski okvir za GP sa osvrtom na pasivnu zaštitu od požara prikazala je predstavnica Ministarstva građevinarstva, saobraćaja i infrastrukture, član radne grupe koja je izradila pravilnik, Nina Vukosavljević.

SCIENTIFIC RESEARCH PROJECTS | **NAUČNO-ISTRAŽIVAČKI PROJEKTI**

NAUČNO-ISTRAŽIVAČKI RAD FINANSIRAN OD STRANE MINISTARSTVA PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA

Institut IMS sklopio je sa Ministarstvom prosvete, nauke i tehnološkog razvoja Republike Srbije ugovor o realizaciji i finansiranju naučnoistraživačkog rada NIO u 2022. godini, evidencioni broj: 451-03-68/2022-14/ 200012.

Ovim ugovorom obezbeđeno je projektno finansiranje za sledeće istraživače Instituta IMS:

Broj	**Ime i Prezime**	**Naučno ili stručno zvanje**
1	Dr Zagorka Radojević	Naučni savetnik
2	Dr Nenad Šušić	Naučni savetnik
3	Dr Ksenija Janković	Naučni savetnik
4	Dr Anja Terzić	Naučni savetnik
5	Dr Milica Vasić	Viši naučni saradnik
6	Dr Biljana Ilić	Viši naučni saradnik
7	Dr Miloš Vasić	Naučni saradnik
8	Dr Dragan Bojović	Naučni saradnik
9	Dr Dejan Momčilović	Naučni saradnik
10	Dr Ksenija Đoković	Naučni saradnik
11	Dr Jelena Ćirilović	Naučni saradnik
12	Dr Vujadin Aleksić	Naučni saradnik
13	Dr Srđan Bulatović	Naučni saradnik

14	Dr Nevenka Mijatović	Naučni saradnik
15	Nikola Božović	Istraživač pripravnik
16	Dr Mladen Ćosić	Stručni savetnik
17	Ljiljana Miličić	Stručni savetnik
18	Marko Stojanović	Stručni savetnik
19	Ljiljana Lončar	Stručni savetnik
20	Željko Flajs	Viši stručni saradnik
21	Ivana Delić-Nikolić	Stručni saradnik

NAUČNO-ISTRAŽIVAČKI PROJEKAT

U OKVIRU PROGRAMA ZA IZVRSNE PROJEKTE MLADIH ISTRAŽIVAČA – PROMIS FONDA ZA NAUKU REPUBLIKE SRBIJE

MORTAR DESIGN FOR CONSERVATION – DANUBE ROMAN FRONTIER 2000 YEARS AFTER

Institut IMS je učestvovao u projektu *MORTAR DESIGN FOR CONSERVATION – DANUBE ROMAN FRONTIER 2000 YEARS AFTER (MoDeCo2000)* u saradnji sa Tehnološkim fakultetom Univerziteta u Novom Sadu i Arheološkim institutom iz Beograda. Ovaj projekat, u kome su učestvovali istraživači Instituta IMS Ljiljana Miličić, Ivana Delić-Nikolić, dr Biljana Ilić i dr Nevenka Mijatović, je realizovan u okviru Programa za izvrsne projekte mladih istraživača – Promis Fonda za nauku Republike Srbije, pod evidencionim brojem 6067004.

Tokom završnog projektnog perioda sprovođenja aktivnosti planiranih u okviru projekta *MoDeCo2000*, sprovedena su laboratorijska istraživanja vezana za arheološke, arhitektonske, geološke i tehnološke aspekte arheoloških nalazišta, lokaliteta i pojedinačnih spomenika na nekadašnjoj rimskoj dunavskoj granici – limesu, tim projekta *MoDeCo2000* je obradio uzorke sa 23 istorijske lokacije.

Reka Dunav kroz Srbiju protiče u ukupnoj dužini od 588 km, a projektna ekspedicija je ispitala rimske ostatke duž njenih 484 km. Tim koji čine arhitekta, arheolog, inženjeri materijala, geolog i hemičari posetio je 32 građevine i tom prilikom prikupio uzorke 99 različitih maltera koji potiču iz dve jedine legionarske tvrđave na teritoriji današnje Srbije, Singidunuma i Viminaciuma, drugih rimskih utvrđenja i osmatračnica, nekropola, manjih naselja i gradova, kao i usamljenih građevina.

Uzorkovani malteri pripadaju građevinama čije vremensko određenje pokriva dugačak period od I do VI veka, tako pružajući mogućnost analize razvoja tehnologije izrade maltera tokom celokupne rimske dominacije na našoj teritoriji, dok će malteri tvrđava na Dunavu iz XII i XV veka dati važne podatke o daljim građevinskim aktivnostima nakon pada rimskog limesa. Za Limes kao serijsko kulturno dobro se trenutno priprema nominacioni dosije za upis na Uneskovu Listu svetskog nasleđa, a njegov važan segment će biti upravo rezultati istraživanja maltera u okviru projekta *MoDeCo2000*.

Proces uzorkovanja i ispitivanja je detaljno dokumentovan (fotografije, pozicioniranje i tekstualni opis uzoraka). Laboratorije učesnika projekta, Tehnološkog fakulteta u Novom Sadu i Instituta IMS, su uzorke za dalje ispitivanje odabrale uz podršku članova tima iz Arheološkog instituta, a prema dosadašnjem iskustvu svakog pojedinačnog člana tima, kao i dogovorima tokom projektnih sastanaka. Uzorci su foto dokumentovani uz kreiranje njhovih dosijea preko novoformirane baze koju danas čini preko 8.000 snimaka iz laboratorije i preko 3.500 fotografija sa terena. Digitalna optička mikroskopija je urađena na 73 uzorka, mineraloško-petrografske analize su sprovedene na preko 50 uzoraka, ispitivanja hemijskog sastava na preko 40 uzoraka i fizičko – mehanička svojstava na oko 15 uzoraka. Sprovedene laboratorijske analize su pokazale međusobnu raznolikost uzoraka, izdvojile one koje je projektni tim ocenio kao važne za buduću pripremu maltera za konzervaciju spomenika na limesu, i navele na prve zaključke o antičkom graditeljstvu uz reku Dunav, ali i drugim aspektima života na granici tokom rimskog i ranovizantijskog perioda.

Analize su projektnom timu pružile dobar uvid u kolekciju uzoraka maltera i ponudile relevatne ulazne podatke za dalje laboratorijske analize i pripremu novih maltera, kompatibilniih sa istorijskim, koji bi se mogli koristiti u fazama konzervacije, restauracije i popravke ovih kulturno istorijskih spomenika. Akcenat kompatibilnosti maltera je bio pre svega na sastavu, odnosu komponenata veziva i agregata, mehaničkim svojstvima, fizičkim osobinama i konačno vizuelnoj kompatibilnosti. Na taj način je pripremljeno oko 40 noviih mešavina maltera, sa učešćem različitih agregata i veziva na bazi živog kreča i krečnog testa koje su ispitivane u laboratorijskim uslovima. Rezultati ovih ispitivanja su bili osnov za izbor nekih malterskih mešavina za primenu na objektu (in situ) kako bi se pratilo ponašanje maltera u realnim uslovima.

Aktivnosti na diseminaciji projekta su sprovedene kroz medije (tv, radio, štampa, internet, društvene mreže), komunikaciju sa nadležnim institucijama i profesionalcima koji se bave zaštitom graditeljskog nasleđa, ali i studentima iz relvantnih oblasti projekta, kao i preko predavanja na nacionalnom naučno-stručnom skupu o očuvanju kulutrnog nasleđa. Kao rezultat istraživanja u okviru projekta objavljen je veliki broj naučnih radova na skupovima ncionalnog i međunarodnog značaja, u časopisima kategorije M22 i M21, kao i poglavlja u knjigama.

NAUČNO-ISTRAŽIVAČKI PROJEKAT

U OKVIRU PROGRAMA NAUČNO-TEHNOLOŠKE SARADNJE MINISTARSTVA PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA REPUBLIKE SRBIJE I SAVETA ZA NAUČNOTEHNOLOŠKA ISTRAŽIVANJA TURSKE

TAILOR MADE SELF-COMPACTING HEAVYWEIGHT CONCRETE WITH WASTE MATERIALS

Na osnovu Protokola o saradnji u oblasti nauke i tehnologije između Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije (MPNTR) i Saveta za naučnotehnološka istraživanja Turske (TUBITAK), potpisanog u Beogradu, 7. oktobra 2019. i na osnovu Konkursa za podnošenje zajedničkih predloga projekata, usaglašena je i 5. maja 2021. potpisana Odluka o odobrenim projektima naučno-tehnološke saradnje (2021–2023).

Nakon razmatranja 79 administrativno korektnih predloga projekata sa obe strane, a u skladu sa prioritetima definisanim u tekstu Konkursa i na osnovu sprovedenih procedura ocene projekata u obe države, odobreno je za finansiranje 10 predloga projekata.

Među odobrenim projektima je i *Tailor made self-compacting heavyweight concrete with waste materials*, kojim rukovode dr Ksenija Janković iz Instituta IMS i dr Kambiz Ramyar, Ege University, Engineering Faculty, Izmir. Na projektu učestvuju i sledeći istraživaći iz Instituta IMS: dr Anja Terzić, dr Dragan Bojović, dr Miloš Vasić i Marko Stojanović.

SELECTED
BUSINESS REFERENCES

ODABRANE
STRUČNE REFERENCE

U ovom odeljku dat je pregled ključnih usluga koje je Institut IMS izvršio u 2022. godini.

U skladu sa multidisciplinarnom organizacijom Instituta, usluge obuhvataju izradu investiciono-tehničke dokumentacije, ispitivanja na terenu i u laboratorijama, stručni nadzor nad izvođenjem radova, studije, ekspertize i drugo u praktično svim oblastima građevinarstva, mašinske industrije i energetike.

Pregled referenci je dat po organizacionim celinama.

THE CENTRE
FOR MATERIALS

CENTAR
ZA MATERIJALE

CENTAR ZA MATERIJALE

	Laboratorija za građevinsku keramiku	
R.b.	**Referenca**	**Investitor**
1.	Elaborat o rezultatima ispitivanja reprezentativnih uzoraka sirovina sa deponije ciglane, sa preporukama kriterijuma za prihvatanje sirovina za proizvodnju opekarskih proizvoda	Univerzum ciglana d.o.o. Aranđelovac
2.	Izveštaj o rezultatima ispitivanja uzoraka keramičkih glina	Polet keramika d.o.o. Novi Bečej, Nexe grupa
3.	Elaborat o oceni kvaliteta opekarskih glina	Dilj d.o.o. Vinkovci, Hrvatska Nexe grupa
4.	Izveštaj o rezultatima ispitivanja keramičkih glina	Polet keramika d.o.o. Novi Bečej, Nexe grupa
5.	Elaborat o rezultatima ispitivanja uzoraka opekarske sirovine iz istražnih bušotina potencijalnog ležišta Zalužnje kod Leskovca sa ocenom primenljivosti sirovine za proizvodnju crepa	IGM Mladost d.o.o. Leskovac
6.	Izveštaj o rezultatima ispitivanja uzoraka opekarske sirovine iz ciglane DOO Neimar – Zrenjanin sa preporukama kriterijuma za prihvatanje sirovina za proizvodnju opekarskih proizvoda	DOO Neimar Zrenjanin

7.	Elaborat o rezultatima ispitivanja uzoraka keramičkih glina sa lokaliteta Damnjanovića Brdo u Donjem Crniljevu (kompozitni uzorci) sa ocenom primenljivosti sirovine za proizvodnju keramičkih pločica	Zorka-keramika d.o.o. Beograd
8.	Elaborat o rezultatima ispitivanja uzoraka keremičkih glina sa lokaliteta Damnjanovića brdo – sever u Donjem Crniljevu, pojedinačni uzorci	Zorka-keramika d.o.o. Beograd
9.	Elaborat o rezultatima ispitivanja uzoraka keremičkih glina sa lokaliteta Damnjanovića brdo – sever u Donjem Crniljevu, (kompozitni uzorci) sa ocenom primenljivosti sirovine za proizvodnju keramičkih pločica	Zorka-keramika d.o.o. Beograd
10.	Elaborat o rezultatima ispitivanja uzoraka opekarske sirovine iz istražnih bušotina ležišta PK Obriježˇ (staro ležište) sa ocenom primenljivosti sirovine za proizvodnju opekarskih proizvoda	IGM Drina Bijeljina
11.	Izveštaj o rezultatima ispitivanja uzorka opekarske sirovine iz ciglane Mašinac NM84 d.o.o. Svilajnac sa preporukama kriterijuma za prihvatanje sirovina za proizvodnju opekarskih proizvoda	Mašinac NM84 d.o.o. Svilajnac

12.	Početni pregled proizvodnog pogona i fabričke kontrole proizvodnje elemenata za zidanje u skladu sa Pravilnikom o tehničkim zahtevima za elemente za zidanje od gline, elemente za zidanje od kalcijum-silikata i blokove od gline za polumontažne sitnorebraste tavanice i relevantnim standardima.	IGK POLET a.d. Novi Bečej Lepojević d.o.o. Novo Orahovo Z.R. DACKO Čurug SZR INOSLAV Vlasotince Z.R. Batica Kocić, Vlasotince Lepojević d.o.o. Novo Orahovo IGM Opeka d.o.o. Smederevska Palanka IGK Polet a.d. Novi Bečej, Pogon Stražilovo Sremski Karlovci IGM Mladost d.o.o. Leskovac, Ogranak Vlasotince Wienerberger d.o.o. Karlovac, Hrvatska Wienerberger d.o.o. Ormož, Slovenija

13.	Stalni nadzor fabričke kontrole proizvodnje elemenata za zidanje u skladu sa Pravilnikom o tehničkim zahtevima za elemente za zidanje od gline, elemente za zidanje od kalcijum-silikata i blokove od gline za polumontažne sitnorebraste tavanice i relevantnim standardima	PGP Rapid a.d. Apatin IGM Mladost d.o.o. Leskovac, Ogranak Mala Plana Neimar, d.o.o. Zrenjanin IGM Opeka d.o.o. Smederevska Palanka IGM Mladost d.o.o. Leskovac, Ogranak Stalać IGK Polet a.d. Novi Bečej, Pogon Stražilovo, Sremski Karlovci Univerzum ciglana d.o.o. Aranđelovac Univerzum Export-Import d.o.o. Aranđelovac, Ogranak proizvodni pogon Inđija Ciglana Vasa Kuzmin IGM Mladost d.o.o. Leskovac, Ogranak Vlasotince Zorka opeka d.o.o. Šabac, Pogon Donje Crniljevo Koceljeva

	Laboratorija za akustiku i vibracije	
R.b.	**Referenca**	**Investitor**
1.	Monitoring buke na području Grada Valjeva	Grad Valjevo Gradska uprava
2.	Merenja buke većeg broja objekata Maxi i Shop and Go na teritoriji Srbije	Delhaize Serbia
3.	Zvučna zaštita objekata u Beogradu na vodi	Belgrade Waterfront
4.	Kontrolna merenja buke po nalogu inspektora	Grad Beograd Sekretarijat za inspekcijske poslove

	Odeljenje za zaštitu životne sredine	
R.b.	**Referenca**	**Investitor**
1.	Deklaracija proizvoda o zaštiti životne sredine prema SRPS ISO 14025:2007 i SRPS EN 15804:2020 za elemente za zidanje od gline – grupa proizvoda – blokovi od gline i fasadna opeka od gline	Zorka-opeka d.o.o. Šabac

	Laboratorija za toplotnu tehniku i zaštitu od požara	
R.b.	**Referenca**	**Investitor**
1.	Ne postoji značajniji objekat u Republici Srbiji za čiji su tehnički prijem nisu bili potrebni dokumenti izdati od Laboratorije za toplotnu tehniku i zaštitu od požara.	
2.	Direktna merenja (terenske metode iz oblasti energetske efikasnosti)	Belgrade Waterfront Grundfos Inđija Građevinska direkcija Srbije
3.	Termička i protivpožarna merenja	Aerodrom Nikola Tesla Termolelektrana Kostolac B Vojnotehnički institut
4.	Ispitivanje toplotne otpornosti tla na gotovo svim elektroenergetskim objektima u Srbiji i Crnoj Gori	
5.	Ispitavanja prema reakciji na požar za fasadne sisteme za većinu proizvođača i uvoznika fasadnih sistema u Srbiji	

	Laboratorija za kamen i agregat
R.b.	**Referenca**
1.	Laboratorijska ispitivanja tehničkog i arhitektonskog kamena, šljunka i peska u cilju realizacije geoloških istraživanja ležišta, na više od 15 istraženih ležišta
2.	Ispitivanje tehničkog i arhitektonskog prirodnog kamena, dimenzionisanih elemenata izrađenih od prirodnog kamena, kamenih agregata i sl.
3.	Ispitivanje agregata za beton i asfalt u cilju sertifikacije u skladu sa Pravilnikom o tehničkim zahtevima za frakcionisani agregat za beton i asfalt
4.	Početni pregledi i stalni nadzori proizvodnih pogona i fabričke kontrole proizvodnje u skladu sa Pravilnikom o tehničkim zahtevima za frakcionisani agregat za beton i asfalt
5.	Laboratorijska ispitivanja za potrebe projekta PROMIS, Mortar Design for Conservation – Danube Roman Frontier 2,000 Years After
6.	Ispitivanje materijala sa kulturno-istorijskih spomenika: Zindan Kapija, Kapija Karla VI, Rimokatolička crkva Snežne gospe u Žablju, original bareljefa sa Spomenika zahvalnosti Francuskoj i dr.

	Laboratorija za drvo i sintetičke materijale	
R.b.	**Referenca**	**Investitor**
1.	Ispitivanje cevi i elemenata cevovoda za potrebe nadzora fabričke kontrole proizvodnje, prema Pravilniku o tehničkim i drugim zahtevima za elemente sistema cevovoda od plasičnih masa za snabdevanje vodom namenjenom za ljudsku upotrebu, transport zaprljane i kanalizacione vode, transport gasovitih goriva i instalacija za grejanje	Krušik - Plasika, Osečina AkvaPanInženjering, Čačak Peštan, Aranđelovac Tubi di plastica, Vranje
2.	Ispitivanje fasadne građevinske stolarije (prozori, vrata, zid zavese), u laboratoriji i na objektu, za značajne objekte i potrebe izvoza na inostrano tržište	Exing element, Beograd ASC, Beograd Tester Al, Jagodina Sunce Marinković, Kragujevac
3.	Ispitivanje termoizolacionih proizvoda (XPS, EPS, PUR, PIR, kamena i mineralna vuna, prema Pravilniku o tehničkim i drugim zahtevima za termoizolacione materijale	Austrotherm, Valjevo Maxima, Lučani Bekament, Aranđelovac Ravago, Grčka Ursa, Slovenija Saint Gobain
4.	Ispitivanja iz oblasti drveta, gume, adheziva, za potrebe provere kvaliteta proizvoda i učešću na tenderima za značajne objekte u zemlji i inostranstvu	

	Laboratorija za veziva, hemiju i maltere	
R.b.	**Referenca**	**Investitor**
1.	Početni pregled proizvodnog pogona i fabričke kontrole proizvodnje cementa u skladu sa izdatim STO, a prema Srpskom dokumentu za ocenjivanje Portland-kompozitnih cemenata sa smanjenim sadržajem klinkera SDO 15 001:2021	Lafarge BFC d.o.o. Moravacem d.o.o. Titan cementara Kosjerić d.o.o.
2.	Stalni nadzor fabričke kontrole proizvodnje hemijskih dodataka u skladu sa Pravilnikom o tehničkim zahtevima za hemijske dodatke betonu, mlaznom betonu, malteru i injekcionoj masi za kablove za prethodno naprezanje	Sika Srbija d.o.o. Isomat d.o.o. Ading a.d. S. Makedonija TKK Srpenica Slovenija BCF Inđija BT3 Austrija Master Builders Italija MC Bauchemie Mađarska Penetron SAD
3.	Laboratorijska ispitivanja hemijskih, fizičkih i mehaničkih karakteristika uzoraka cementa, maltera, lepka, kreča, gipsa, pepela, šljake itd.	
4.	Ispitivanja na terenu pull-off metodom	Lidl Srbija Vinci Terna Srbijaautoput PCCC Antikor
5.	Ispitovanja na terenu, tekuća kontrola smese za injektiranje	CRBC

	Laboratorija za za hidroizolaciju i anti-korozivnu zaštitu	
R.b.	**Referenca**	**Investitor**
1.	Prianjanje izvedene hidroizolacije na mostovima i nadvožnjacima na deonicama Merošina – Prokuplje i Beloljin – Rudare, Projekat: Pojačano održavanje puta IB 3 i Pojačano održavanje puta IA reda	Srbijaautoput Beograd
2.	Prianjanje izvedene hidroizolacije i zaštite od korozije Projekat: Rehabilitacija starog Ostružničkog mosta preko reke Save	Antikor Beograd Strabag Beograd JP Putevi Srbije Beograd
3.	Prianjanje izvedene hidroizolacije u tunelu Straževica i na mostovima i nadvožnjacima Obilaznica oko Beograda, Bubanj Potok	PCCC Beograd
4.	Merenje debljine protivpožarnog sistema Aerodrom Nikola Tesla, Beograd	Vinci Terna Beograd
5.	Merenje debljine protivpožarnog sistema Spalionica Vinča, Beograd	Energogroup Beograd
6.	Ispitivanje geotekstila Pojekat: Izgradnja državnog puta Novi Beograd – Surčin	CCCC, Beograd
7.	Ispitivanje postojeće zaštite od korozije na čeličnoj konstrukciji krune kotla u TE Nikola Tesla Blok A2, Obrenovac	Institut IMS, Centar za konstrukcije i prednaprezanje
8.	Ispitivanje izvedene zaštite od korozije na čeličnoj konstrukciji za TE-KO B3, Kostolac	China Machinery Engineering Corporation Ogranak Beograd

9.	Laboratorijska ispitivanja: hidroizolacioni proizvodi na bazi bitumena i polimernih materijala, boje za zaštitu metala od korozije, boje za horizontalnu signalizaciju na kolovozu, kompozitni materijali, samorazlivajući podovi, geomreže i geotekstili.	Maxima Bekament Mapei Sika Busscher Hoffmann FIM Kanjiža Knauf Matox Fibran

	Laboratorija za beton	
R.b.	**Referenca**	**Investitor**
1.	Kontrola kvaliteta betona na gradilištu brze saobraćajnice DP Ib 27 Loznica – Valjevo – Lazarevac, deonica Iverak – Lajkovac	China Shandong International Economic & Technical Cooperation Group
2.	Kontrola kvaliteta betona na gradilištu auto-puta E-763, deonica Surčin – Novi Beograd	CCCC Ogranak Beograd
3.	Kontrola kvaliteta betona na gradilištu mosta preko reke Save kod Šapca na putu Ruma – Šabac – Loznica	Azvirt
4.	Kontrola kvaliteta betona na gradilištu DP Ib 26 brza saobraćajnica Novi Sad – Ruma (Fruškogorski koridor)	CRBC
5.	Kontrola kvaliteta betona prilikom izgradnje i rekonstrukcije Aerodroma Nikola Tesla – Beograd, Surčin	Vinci Terna
6.	Kontrola kvaliteta betona na gradilištu: E-763 od Preljine do Požege	CCCC Ogranak Beograd
7.	Kontrola kvaliteta na izvođenju radova na izgradnji brane i akumulacije Arilje – profil Svračkovo	Hidrotehnika – Hidroenergetika Beograd
8.	Kontrola kvaliteta betona prilikom izvođenja radova na projektu VE Krivača faza 2 Golubac	Hanput Plus
9.	Kontrola kvaliteta betona prilikom izgradnje auto-puta E-761, Pojate - Preljina	Cemprom
10.	Kontrola kvaliteta betona prilikom izvođenja radova na projektu pojačanog održavanja puta IA 1, deonica: Petlja Paraćin – Petlja Ražanj	Srbijaautoput

THE CENTRE
FOR METALS
AND ENERGETICS

CENTAR
ZA METALE
I ENERGETIKU

CENTAR ZA METALE I ENERGETIKU

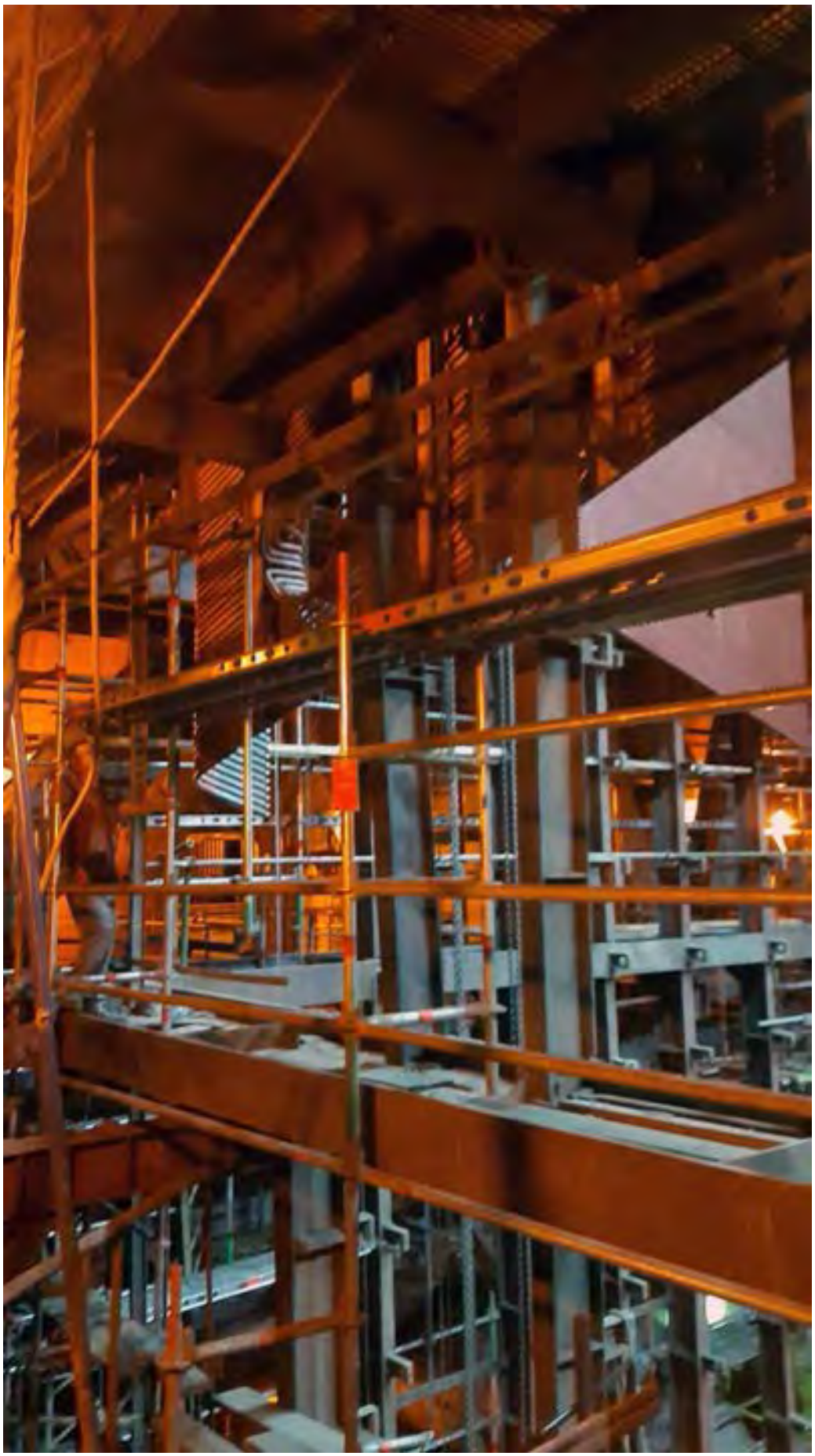
Laboratorija za ispitivanje metala,

Kontrolno telo,

Sertifikaciono telo za sertifikaciju osoba

Laboratorija za etaloniranje mehaničkih veličina

R.b.	Referenca	Investitor
1.	Ispitivanje mašinske opreme za potrebe revitalizacije	JP EPS BEOGRAD Ogranak HE Đerdap HE ĐERDAP 1, Kladovo
2.	Kontrola tehničke dokumentacije za prijem i ispitivanje mašinske opreme za sanaciju RHE BB	JP EPS BEOGRAD Ogranak Drinsko-Limske HE RHE Bajina Bašta
3.	Ispitivanje opreme bez razaranja HMO – HE PIROT	JP EPS BEOGRAD Ogranak HE Đerdap Kladovo
4.	Ispitivanje glavnih parovodnih linija – Ra, RB i RC, prestrujnih parovoda i cevovoda, kotlovskih komora metodama bez razaranja na blokovima A1, A2 i A6	JP EPS BEOGRAD Ogranak TE Nikola Tesla Obrenovac
5.	Kontrola kvaliteta mašinskih elemenata na isporučenoj novoj osnovnoj rudarskoj mehanizaciji	JP EPS BEOGRAD Ogranak TE – KO Kostolac
6.	Tehnička kontrola delova i sklopova osnovne rudarske mehanizacije na PK Drmno u zemlji i inostranstvu	JP EPS BEOGRAD Ogranak TE – KO Kostolac
7.	Ispitivanje opreme bez razaranja (usluge kontrole i ispitivanja hidromehaničke opreme i drugih čeličnih konstrukcija)	JP EPS BEOGRAD Ogranak HE Đerdap HE ĐERDAP 1 Kladovo



8.	Angažovanje ekspertskih laboratorija u cilju kontrole kvaliteta materijala, delova i opreme – ispitivanja bez razaranja (MT, UT, PT, RT)	JP EPS BEOGRAD Ogranak RB KOLUBARA Lazarevac
9.	Ispitivanje hemijskog sastava i mehaničkih osobina materijala	GP Nikolić DOO Kraljevo STRABAG DOO Beograd ASAIBELIK DOO Beograd AZVIRT, Ogranak Beograd INSTITUT GOŠA DOO Beograd PROLETER AD METALSKA INDUSTRIJA, Arilje METALING DOO Beograd TANKMONT DOO Beograd RUDNIK OLOVA I CINKA VELIKI MAJDAN DOO Ljubovija JP EPS BEOGRAD, Ogranak RB Kolubara Lazarevac MONTESINO DOO Beograd NBA - COMMERCE Beograd MARKANT Valjevo TVIK DIV Valjevo SHANDONG FOREIGN ECONOMIC & TECHNICAL COOPERATION CO. LTD. Ogranak Beograd TASYAPI INSAAT TAAHHUT SANAYI VE TICARET A.S. Ogranak Beograd
10.	Sertifikacija betonskog čelika	KÜRÜM International Sh.A.Ish-Kombinati Metalurgjik Elbasan/Albania TRGOVIR DOO Gračanica, BIH ARCELOR MITTAL Zenica, BIH ALSIKO DOO Beograd FERRIERE NORD Udine, Italija METALFER STEEL MILL Sremska Mitrovica

		ARMAKO Prnjavor KOMERC - MALI Prnjavor SIDENOR STEEL INDUSTRY S.A. Thessaloniki, Greece SOVEL SA HELLENIC STEEL PROCESSING COMPANY Athens, Greece DUCTIL STEEL SA Buzau, Romania DOJRAN STEEL DOOEL Nov Dojran, Makedonia COLAKOGLU METALURJI A.S. Beykoz, Turska MAKSTIL AD Skopje, Makedonija SIDERPOTENZA, Potenza, Italy ALFA ACCIAI S.p.A. , Brescia - Italy
11.	Sertifikacija osoba u oblasti zavarivanja	ĐERDAP USLUGE A.D., Kladovo; SANACIJA I ISPITIVANJE MATERIJALA D.O.O., Beograd; SRBIJA KARGO A.D., Beograd; SILOS – TECH D.O.O, Senta; ENERGETIKA D.O.O., Kragujevac; JP ELEKTROPRIVREDA SRBIJE Ogranak „Drinsko–Limske HE“ Bajina Bašta INFRASTRUKTURA ŽELEZNICE SRBIJE MINEL SERVIS TERMOMONTAŽA
12.	Etaloniranje uređaja za merenje mehaničkih veličina	AD CRNAGORA PUT AG INSTITUT NOVI SAD AGENA TECHNOLOGY BET CCCC COMEX SABAC CPL Barajevo CPL Veternik CSI SUPPORT - YANFENG Kragujevac

ENERGOPROJEKT NISOGRADNJA Beograd
FIN - Novi Sad
GAF NIS
GEZE - Zrenjanin
GLOBAL MAITENANCE
GOSA INSTITUT - Smederevska Palanka
GR PJEVIC OBUDOJEVICA - Cajetina
GRADJEVINSKI FAKULTET - Beograd
HBIS Smederevo
HEMOMET LAB - METALFER - Sremska Mitrovica
HIDROTEHINIKA
HIDROENERGETIKA Beograd (Arilje)
HK KRUSIK - Valjevo
IGM MLADOST - Leskovac
IMW INSTITUT LUZNICE-Kragujevac
INSTITUT ZA BEZBEDNOST I SIGURNOST NA RADU AD - Novi Sad
INSTITUT ZA PUTEVE - Beograd
INSTITUT ZA ZASTITU EKOLOGIJU I OBRAZOVANJE - Tuzla
INSTRUMENTI MB - Beograd
JAT TEHNIKA
KOMPRESOR ING - Valjevo
KONSTRUKTOR
KOPEX MIN LIV NIS
I LAFARGE - Beocin
LETAC PREFABRIKACIA
MONUS - Inđija
NEXE - Batajnica
NEXE - Becej
NEXE POLET OPEKA - Novi Becej
NOVI PAZAR PUT
PPT TMO AD Trstenik
PUT INZENJERING
RD DUAGNOSTIKA Beograd

	SHANDONG LIQIAO GROUP LTD Subotica
	SIGMA LAB
	SIGURA SISTEM DOO PIROT
	SIKA SIMANOVCI
	TATRAVAGONKA BRATSTVO DOO SUBOTICA
	TEHNOGRADNJA KRUSEVAC
	TERMOMETAL MBM INDJUA
	TPA Cacak
	UNIVERZUM Arandjelovac
	VATROINZENJERING DOO Zrenjanin
	VUKMIR DOO
	WEST PHARMACEUTICAL
	WIENERBERGER DOO Kanjiza
	I ZASTAVA ORUZIE Kragujevac
	ZAVOD ZA ISP MAT I KONS Suborica
	ZAVOD ZA ZAVARIVANJE

THE CENTRE
FOR ROADS
AND GEOTECHNICS

CENTAR
ZA PUTEVE
I GEOTEHNIKU

CENTAR ZA PUTEVE I GEOTEHNIKU

	Odeljenje za geotehniku	
R.b.	**Referenca**	**Investitor**
1.	Ispitivanje šipova dinamičkim probnim opterećenjem DLT za potrebe izgradnje Brza pruga Beograd – Budimpešta deonica Novi Sad - Subotica – državna granica	Shandong Karin Komerc MD
2.	Ispitivanje šipova dinamičkim probnim opterećenjem DLT za potrebe izgradnje autoputa na koridoru Vc kroz Republiku Srpsku - „Obilaznica Doboj“, Bosna i Hercegovina	Integral Inženjering
3.	Ispitivanje šipova dinamičkim probnim opterećenjem DLT za potrebe izgradnje Luke Brčko, Bosna i Hercegovina	Bijeljina put BiH
4.	Ispitivanje šipova dinamičkim probnim opterećenjem DLT za potrebe izgradnje mostova za državni put IB reda Iverak - Lajkovac	Shandong
5.	Ispitivanje šipova dinamičkim probnim opterećenjem DLT za potrebe izgradnja i rekonstrukcija Luke Novi Sad	AQUA MONT SERVICE
6.	Ispitivanje šipova dinamičkim probnim opterećenjem DLT za potrebe izgradnje mostova za brzu saobraćajnicu Ruma-Šabac – Loznica	Azvirt
7.	Ispitivanje šipova dinamičkim probnim opterećenjem DLT za potrebe izgradnje TENT B Nikola Tesla	Ex ing

8.	Ispitivanje šipova metodom SIT i DLT za PLOT 25, Beograd na vodi	STRABAG DOO
9.	Ispitivanje integriteta šipova metodom SIT za potrebe izgradnje brze pruge Beograd – Budimpešta deonica Novi Sad - Subotica – državna granica	Karin Komerc MD OBW
10.	Ispitivanje integriteta šipova metodom SIT za potrebe izgradnje državnog put IB br.21 Novi Sad – Ruma Tunel Iriški venac	CHINA ROAD
11.	Ispitivanje integriteta šipova metodom SIT za potrebe izgradnje: - Mostovi za državni put Ib reda Iverak Lajkovac -Mostovi za brzu saobraćajnicu Ruma-Šabac – Loznica	Shandong Azvirt
12.	Ispitivanje integriteta šipova metodom SIT za potrebe izgradnje: - PLOT 25, Beograd na vodi - Brana Svračkovo, Arilje - TENT B Nikola Tesla	STRABAG Hidrotehnika-Hidroenergetika Ex ing
13.	Ispitivanje šipova opitom statičkog probnog opterećenja za potrebe izgradnje nadvožnjaka na km:5+214.94, autoput E-80, Niš-Merdare, Merošina	STRABAG DOO
14.	Ispitivanje šipova opitom statičkog probnog opterećenja za potrebe izgradnje brze pruge Beograd – Budimpešta deonica Novi Sad - Subotica – državna granica	China Civil Engineering, OBW, Shandong, LHR, Karin Komerc MD

15.	Ispitivanje šipova opitom statičkog probnog opterećenja za potrebe izgradnje železničke stanice Beograd centar, Prokop, u Beogradu	Elita Cop
16.	Ispitivanje šipova opitom statičkog probnog opterećenja za potrebe izgradnje TENT B Nikola Tesla	LHR
17.	Geotehnički elaborat o uslovima izgradnje toplovoda za daljinsko grejanje duž trase Novi Beograd – Obrenovac	POWER CONSTRUCTION
18.	Geotehnički elaborat o uslovima izgradnje 4 pumpne stanice: PSHEPS „Novi Beograd“ , PS „Ostružnica“ , PS HEPS „Sava - Obrenovac“ i PS „Boljevci“ na toplovodu za daljinsko grejanje duž trase Novi Beograd – Obrenovac	POWER CONSTRUCTION
19.	Geotehnički Elaborat o uslovima rekonstrukcije i dogradnje Kalenić pijace u Beogradu - celina 3	Gradska uprava grada Beograda
20.	Elaborat o geotehničkim uslovima fundiranja stambeno-poslovnog kompleksa „B40“ na katastarskoj parceli 1222 / 21 u bloku 40 – Omladinskih brigada - Novi Beograd	PFB

21.	ISPITIVANJA Standardnim penetracionim opitom (Standard Penetration Test – SPT) u bazi šipa za potrebe: - izgradnje autoputa KUZMIN – SREMSKA RAČA - izgradnje Morava Koridor -izgradnje brze saobraćajnice deonica: Iverak-Lajkovac - izgradnje autoputa E-763 deonica: Preljina – Požega	TASYAPI Bechtel Enka UK Limited Shandong CCCC LTD
22.	Stručni geodetski nadzor na autoputu Sremska Rača-Kuzmin, deonica: čelični most preko reke Save	TASYAPI
23.	Projektno - tehnička dokumentacija sanacije oštećenja kolovoza –klizišta ″Beljina″ na državnom putu IIA-147, Deonica br. 14703, Barajevo (Lisović) – Dučina (Sibnica), km: 16+630	SRBIJAPUT A.D
24.	Projektno - tehnička dokumentacija sanacije oštećenja kolovoza i nasipa na državnom putu IIA-176, deonica br. 17601, Valjevo (Brežđe) – Brežđe, km: 5+790	PZP VALJEVO
25.	Projektno - tehnička dokumentacija sanacije oštećenja kolovoza i nasipa ″Bumbarevo brdo 2 ″ i ″Gružansko jezero″ na državnom putu IB-46, deonica br. 04602, Knić – Mrčajevci, km: 9+695 i 14+000	PZP KRAGUJEVAC DOO


KONTROLA
SIGNALIZACIJE

26.	Projektno-tehnička dokumentacija za sanaciju klizišta "Gornja Sabanta " - oštećenje kolovoza i nasipa na državnom putu IIA-183, oznaka deonice 18301, Kragujevac-Gornja Sabanta, km:13+645	PZP KRAGUJEVAC DOO
27.	Projektno - tehnička dokumentacija sanacije oštećenja kolovoza i nasipa ″Knić″ na državnom putu IB-46, deonica Br. 04602, Knić – Mrčajevci, km: 5+690	PZP KRAGUJEVAC DOO
28.	Projektno –tehnička dokumentacija sanacije oštećenja kolovoza-klizišta na državnom putu IB-22, deonica br.02234, Novi Pazar (Brđani) Ribariće u mestu ″KOMINJE″, km: 274+560	AD NOVI PAZAR PUT
29.	Projektno tehnička dokumentacija sanacije nasipa ispod objekta manastira Preradovac na teritoriji Opštine Rekovac	PZP KRAGUJEVAC DOO
30.	Projekat sanacije nasipa trupa puta na državnom putu IIA-100 oznaka deonice 02101, Novi Sad (Sirig)-Petrovaradin (Račkog) km:130+647 – km:131+025	JP Putevi Srbije
31.	Izmena i dopuna projektno-tehničke dokumentacije za sanaciju odrona– nestabilne kamene kosine na državnom putu IB-23, deonica br. 02332, Mijoska – granica SRB/CG (Gostun),km: 259+570 - 259+760, Galerija 1, Galerija 2, Galerija 3, Galerija 4 i potporni zid	SRBIJAPUT AD

THE CENTRE FOR
STRUCTURES
AND PRESTRESSING

CENTAR ZA
KONSTRUKCIJE
I PREDNAPREZANJE

CENTAR ZA KONSTRUKCIJE I PREDNAPREZANJE

	Odeljenje za prednaprezanje	
R.b.	**Referenca**	**Investitor**
1.	Testiranje prednapregnutih geotehničkih sidara prema testu granične nosovosti, za potrebe projektovanja i izgradnje visećeg pešačkog mosta na tvrđavi u Užicu	Zajača ING d.o.o. Loznica
2.	Izvođenje utezačkih radova na konstrukciji za statičko ispitivanje šipova, projekta izgradnje železničke pruge Beograd – Budimpešta, deonica Novi Sad – Subotica, kod Subotice	Karin Komerc MD d.o.o. Veternik
3.	Ispitivanje sile u kablovima stambeno – poslovne zgrade u Smederevu, izgrađene u IMS sistemu gradnje, za potrebe ocene stanja objekta	Odeljenje za projektovanje, nadzor i sanacije
4.	Kalibracija opreme za prednaprezanje	Više naručilaca
5.	Obuka kadrova za rad sa opremom za prednaprezanje	Shangdong Luiqiao Group Co. Ltd Ogranak Beograd Ratko Mitrović Construction d.o.o. Čačak; AŠA IBELIK d.o.o. Beograd, pogon Velika Plana Tehna d.o.o. Gračanica, BIH

	Odeljenje za projektovanje nadzor i sanacije	
R.b.	**Referenca**	**Investitor**
1.	Elaborat o stanju konstrukcije i Projekat sanacije taložnika i neutralizacione jame	Elixir Prahovo
2.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta OŠ Lazar Savatić	OŠ Lazar Savatić Zemun
3.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta izvedenog u IMS sistemu u Smederevu	Morava Gas d.o.o. Ljig
4.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta hotela Splendid u Beogradu	DT Properties d.o.o. Beograd
5.	Pregled i Izveštaj o stanju objekta upravne zgrade MIND Park kod Kragujevca	MIND Real Estate d.o.o. Kragujevac
6.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta Mlečne hale na Kalenić pijaci sa predlogom sanacionih mera	Uprava Grada Beograda Sekretarijat za investicije
7.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta BIGZ sa predlogom sanacionih mera	MPP BIGZ d.o.o. Beograd
8.	Stručno mišljenje o razlozima nastanka prslina na fasadi objekta Porsche SCG u Krnjači	Fermax d.o.o. Beograd
9.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta Centralne kule Starog sajmišta na Novom Beogradu	KOTO d.o.o. Beograd
10.	Pregled, ispitivanje i Elaborat o stanju jarbola na Beogradskom Sajmu	DP Beogradski sajam Beograd


ФНПЭ
1931

11.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta Mlin sirovine	Titan cementara Kosijerić
12.	Pregled, ispitivanje i Elaborat o stanju konstrukcije objekta Toranj predgrejača	Titan cementara Kosijerić


VOLVO
VOLVO

	Laboratorija za ispitivanje konstrukcija	
R.b.	**Referenca**	**Investitor**
1.	Ispitivanje železničkih mostova probnim opterećenjem, deonica: Stara Pazova - Novi Sad (40 mostova)	RŽD International Infrastruktura Železnice Srbije a.d.
2.	Ispitivanje nosivosti stenskih ankera – tuneli Laz i Munjino brdo, Izgradnja autoputa E-763, deonica: Preljina – Požega	China Communications Construction Company Ltd.
3.	Ispitivanje nosivosti stenskih ankera - tunel Iriški venac, Izgradnja državnog puta IB reda br.21, Novi Sad - Ruma	China Road & Bridge Corporation Serbia Ogranak Beograd
4.	Istražne usluge na nosećim čeličnim i betonskim konstrukcijama GPO - Noseća čelična konstrukcija konstrukcija kotla na bloku A1	JP Elektroprivreda Srbije Beograd Ogranak TENT Beograd – Obrenovac
5.	Istražne usluge na nosećim čeličnim i betonskim konstrukcijama GPO - Noseća čelična konstrukcija konstrukcija kotla na bloku A2	JP Elektroprivreda Srbije Beograd Ogranak TENT Beograd – Obrenovac

CERTIFICATION BODY | **SERTIFIKACIONO TELO**

SERTIFIKACIONO TELO

Institut IMS je akreditovan kod Akreditacionog tela Srbije kao sertifikaciono telo za obavljanje poslova sertifikacije građevinskih proizvoda prema standardu SRPS ISO/IEC 17065:2016, Opšti zahtevi za tela koja sprovode sisteme sertifikacije proizvoda, rešenje broj 04-003.

Na osnovu Rešenja Ministarstva građevinarstva, saobraćaja i infrastrukture, Institut IMS je imenovan kao telo za sprovođenje:

ocenjivanja usaglašenosti cementa opšte namene i cementa za specijalnu namenu u skladu sa zahtevima Pravilnika o kvalitetu cementa (Sl. glasnik RS, br. 34/13 i 44/14)

ocenjivanja usaglašenosti čelika za armiranje betona u skladu sa zahtevima Uredbe o tehničkim i drugim zahtevima za čelik za armiranje betona (Sl. glasnik RS, br. 35/2015 i 44/2016)

ocenjivanja i verifikacije stalnosti performansi hemijskih dodataka betonu, mlaznom betonu, malteru i injekcionoj masi za kablove za prethodno naprezanje u skladu sa zahtevima Pravilnika o tehničkim zahtevima za hemijske dodatke betonu, mlaznom betonu, malteru i injekcionoj masi za kablove za prethodno naprezanje (Sl. glasnik RS, br. 39/2019)

ocenjivanja i verifikacije stalnosti performansi elemenata za zidanje od gline, elemenata za zidanje od kalcijum-silikata i blokova od gline za polumontažne sitnorebraste tavanice u skladu sa zahtevima Pravilnika o o tehničkim zahtevima za elemente za zidanje od gline, elemente za zidanje od kalcijum-silikata i blokove od gline za polumontažne sitnorebraste tavanice (Sl. glasnik RS, br. 90/2019)

ocenjivanja i verifikacije stalnosti performansi elemenata sistema cevovoda od plastičnih masa za snabdevanje vodom namenjenom za ljudsku upotrebu, transport zaprljane i kanalizacione vode, transport gasovitih goriva i instalacije za grejanje u skladu sa zahtevima Pravilnika o tehničkim zahtevima za elemente sistema cevovoda od plastičnih masa za snabdevanje vodom namenjenom za ljudsku upotrebu, transport zaprljane i kanalizacione vode, transport gasovitih goriva i instalacije za grejanje (Sl. glasnik RS, br. 6/2020)

ocenjivanja i verifikacije stalnosti performansi frakcionisanog agregata za beton i asfalt u skladu sa zahtevima Pravilnika o tehničkim zahtevima za frakcionisani agregat za beton i asfalt (Sl. glasnik RS, br. 78/2020)

ocenjivanja i verifikacije stalnosti performansi Portland-kompozitnog cementa sa smanjenim sadržajem klinkera u skladu sa zahtevima Srpskog dokumenta za ocenjivanje - Portland-kompozitnih cemenata sa smanjenim sadržajem klinkera SDO 15 001:2021 (Sl. glasnik RS, br. 120/21).

Institut IMS ad je upisan u registar imenovanih tela za ocenjivanje usaglašenosti pod jedinstvenim registarskim brojem И 030.

R.b.	Referenca	Investitor
1.	Sertifikacija cementa	Lafarge BFC d.o.o. Beočin
		Moravacem d.o.o. Popovac
		Titan cementara, Kosjerić
		NEXE d.d., Našice
		CEMEX Hrvatska d.d. Kaštel Sućurac
		Fushe Kruje Cement Factory SH.P.K. Albanija
		Lukavac cement d.o.o. Lukavac
		Tvornica cementa Kakanj d.d. Kakanj
		Traçim Çimento Sanayi Ve Ticaret A.Ş. Turska
		OYAK Çimento Fabrikaları Anonim Şirketi Turska
		LIMAK Turska
		ANTEA Grčka
2.	Sertifikacija hemijskih dodataka	SIKA Srbija d.o.o. Šimanovci
		Ading a.d. Skoplje
		TKK Proizvodnja kemičnih izdelkov d.o.o. Srpenica Slovenija
		Master Builders Solutions Spa Treviso Italija
		BT3 Betontechnik GmbH Theresienfeld Austria
		MC-Bauchemie Kft. Mađarska
		Isomat d.o.o. Šimanovci Srbija
		BCF Inđija
		Penetron International Ltd. USA

3.	Sertifikacija čelika za armiranje betona	Alfa Acciai S.P.A. Italija Alsiko d.o.o. Beograd Arcelor Mittal Zenica d.o.o. Zenica BIH Armako d.o.o. Prnjavor BIH Dojran Steel Dooel Dojran Severna Makedonija Ferriere Nord S.p.A. Udine,Italija Komerc Mali d.o.o. Prnjavor BIH Kurum Albanija Metalfer Steel Mill d.o.o. Sremska Mitrovica Sidenor Steel Industry S.A. Thessaloniki Grčka Siderpotenza Via della Siderurgica Italija Sovel Hellenic Steel Processing Company S.A, Almyros Greece Çolakoğlu Metalurji A.Ş,Istanbul Turkey

4.	Sertifikacija elemenata za zidanje	IGM Mladost Leskovac Ogranak Stalać Ogranak Vlasotince Ogranak Mala Plana AD Polet IGK Novi Bečej Zorka opeka d.o.o. Šabac PGP Rapid AD Apatin Univerzum ciglana d.o.o. Aranđelovac UNIVERZUM export-import d.o.o. Aranđelovac DOO Neimar Zrenjanin IGM Opeka d.o.o. Smederevska Palanka Gold Ceramics LLC, Prokeram Ukrajina Wienerberger d.o.o. Hrvatska Wienerberger d.o.o. Slovenija

CERTIFICATION BODY
FOR THE CERTIFICATION
OF PERSONS

SERTIFIKACIONO TELO
ZA SERTIFIKACIJU
OSOBA

SERTIFIKACIONO TELO ZA SERTIFIKACIJU OSOBA

Sertifikaciono telo za sertifikaciju osoba IMS (STSO) je organizaciona celina koja se nalazi u sastavu Instituta za ispitivanje materijala a.d. kao pravnog entiteta. Sertifikaciono telo za sertifikaciju osoba je većinom svog obima rada okrenuta ka Centru za metale i energetiku, u vidu sertifikacije zavarivača za sledeće kategorije sertifikacije osoba:

Zavarivanje čelika topljenjem prema šemi sertifikacije IMS-01 koja je usklađena sa standardom SRPS EN ISO 9606-1:2017.

Aluminotermijsko zavarivanje šina prema šemi sertifikacije IMS-02 koja je usklađena sa standardom SRPS EN 14730-2:2021.

Sistem menadžmenta unutar Sertifikacionog tela za sertifikaciju osoba IMS (STSO) je usklađen sa zahtevima standarda SRPS ISO/IEC 17024:2012 – Ocenjivanje usaglašenosti – Opšti zahtevi za tela koja obavljaju sertifikaciju osoba.

CONTROL BODY | **KONTROLNO TELO**

KONTROLNO TELO INSTITUTA IMS

Akreditacija kontrolnog tela Instituta IMS obuhvata oblasti kontrolisanja koje se sprovode u Centru za metale i energetiku.

Kontrolisanje delova postrojenja i objekata pri izgradnji, rekonstrukciji, revitalizaciji i remontu – procesnih, hidroenergetskih, hidromašinske opreme, hidromehaničke opreme, termoenergetskih, turboenergetskih). Kvalifikacija tehnologija zavarivanja metalnih materijala (elektrolučno zavarivanje, gasno zavarivanje, navarivanje). Kontrolisanje proizvoda od gvožđa i čelika – pljosnati proizvodi, limovi, trake, profili, cevi, šipke, žice, odlivci, otkovci, liveno gvožđe. Kontrolisanje metalnih konstrukcija – čeličnih i aluminijumskih. Kontrolisanje nove opreme pod pritiskom. Ocenjivanje usaglašenosti nove opreme pod pritiskom primenom modula B i F prema odredbama Pravilnika o tehničkim zahtevima za projektovanje, izradu i ocenjivanje usaglašenosti opreme pod pritiskom (Sl. glasnik RS 87/2011) i relevantnih harmonizovanih standarda.

R.b.	Referenca	Investitor
1.	Kontrola tehničke dokumentacije za prijem i ispitivanje mašinske opreme za potrebe sanacije RHE BB	JP EPS beograd Ogranak Drinsko-Limske HE RHE Bajina Bašta
2.	Kontrola kvaliteta mašinskih elemenata na isporučenoj novoj osnovnoj rudarskoj mehanizaciji	JP EPS Beograd Ogranak TE – KO Kostolac
3.	Kontrola mašinske opreme na HE Đerdap 1 i HE Đerdap 2	JP EPS Beograd Ogranak HE Đerdap Kladovo
4.	Ispitivanje opreme bez razaranja (kontrola i ispitivanje hidromehaničke opreme i drugih čeličnih konstrukcija na HE Đerdap 1)	JP EPS BEOGRAD Ogranak HE Đerdap Kladovo

PT PROVIDER | **PT PROVAJDER**

PIMS - PROVAJDER ZA ISPITIVANJE OSPOSOBLJENOSTI INSTITUT IMS

Provajder za ispitivanje osposobljenosti Instituta IMS (PIMS) je od 5. 12. 2018. godine akreditovan od strane Akreditacionog tela Srbije u skladu sa referentnim standardom SRPS ISO/IEC 17043:2011 (akreditacioni broj 09-001), a ove godine je i obnovio akreditaciju (5. 12. 2022.).

Provajder za ispitivanje osposobljenosti Institut IMS (PIMS) godišnje realizuje u proseku 12 krugova–ciklusa šema ispitivanja osposobljenosti ispitnih laboratorija u svrhu ocene njihove kompetentnosti, kako iz akreditovanih oblasti i metoda, tako i za oblasti i metoda koje nisu akreditovane, a postoji interesovanje potencijalnih participanata.

Obim akreditacije PIMS se odnosi na ispitivanja osposobljenosti iz oblasti:

- fizičkih, hemijskih i mehaničkih ispitivanja cementa,
- akustičkih ispitivanja buke,
- akustičkih ispitivanja zvučne izolacije,
- fizičkih i mehaničkih ispitivanja keramičkih pločica,
- fizičkih i mehaničkih ispitivanja elemenata za zidanje i crepova od gline,
- fizičkih i mehaničkih ispitivanja kamenog agregata,
- fizičkih ispitivanja bitumena,
- fizičkih i mehaničkih ispitivanja termoizolacionih materijala.

Ispitivanja osposobljenosti koja nisu akreditovana odnose se na oblasti:

- hemijskih ispitivanja čvrstog otpada,
- požarnih ispitivanja termoizolacionih materijala,
- fizičkih ispitivanja vezdušne propustljivosti stanova,
- fizičkih i mehaničkih ispitivanja sintetičkih materijala.

Učešće u realizaciji šema do sada je uzelo oko 500 pravnih lica iz oko 50 zemalja iz Evrope, Azije i Afrike.

U 2022. godini realizovani su sledeći krugovi – ciklusi:

R.b.	Predmet ispitivanja osposobljenosti	Broj učesnika
1.	Cement	
	ciklus hemijskih svojstava portland cementa	12
	ciklus fizičkih i mehaničkih svojstava portland cementa	19
2.	Kameni agregat	
	ciklus fizičkih i mehaničkih svojstava kamenog agregata 8/16	13
	ciklus fizičkih svojstava kamenog agregata 4/16	18
3.	Bitumen	
	ciklus fizičkih svojstava putnog bitumena	10
4.	Buka	
	ciklus zvučne snage izvora buke	9
	ciklus u životnoj sredini na otvorenom prostoru	22
	ciklus u životnoj sredini u zatvorenom prostoru	12
5.	Keramičke pločice	
	ciklus fizičkih i mehaničkih svojstava glaziranih pločica	12
6.	Elementi za zidanje	
	ciklus fizičkih i mehaničkih svojstava šuplje opeke	12
7.	Termoizolacioni materijali	
	ciklus fizičkih i mehaničkih svojstava ekspandiranog polistirena	9
	ciklus požarnih svojstava mineralne vune	20
	ciklus požarnih svojstava ekspandiranog polistirena	12
8.	Vazdušna propustljivost stanova	
	ciklus fizičkih svojstava stana	26