REVIEW
OF RESEARCH
AND BUSINESS RESULTS
OF THE IMS INSTITUTE
IN 2019

PREGLED
NAUČNIH I STRUČNIH
REZULTATA
INSTITUTA IMS
U 2019. GODINI

Institut za ispitivanje materijala a.d.

Beograd, decembar 2019.

PREGLED NAUČNIH I STRUČNIH REZULTATA INSTITUTA IMS U 2019. GODINI

REVIEW OF RESEARCH AND BUSINESS RESULTS OF THE IMS INSTITUTE IN 2019

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Institut za ispitivanje materijala, kao naučno-istraživačka instituciju sa najdužom tradicijom u Srbiji, u 2019. obeležava 90 godina od kada je pri Ministarstvu građevina kraljevine Jugoslavije osnovan Zavod za ispitivanje materijala.

Institut za ispitivanje materijala je i ove godine poslovao veoma uspešno i učestvovao u najznačajnijim projektima u zemlji i regionu. U skladu sa višedecenijskom tradicijom i ugledom, kao i širokim spektrom usluga koje pružamo, bili smo angažovani na kontroli i nadzoru, projektovanju, ispitivanjima i istraživanjima građevinskih i mašinskih objekata i konstrukcija, materijala i proizvoda, na geotehničkim istražnim radovima, kao i primeni različitih tehnologija i sistema razvijenih u Institutu IMS.

Kao najznačajnije, izdvajamo izgradnju gasovoda Turski tok, nastavak rada na koridorima X i XI, na pregledu, obnovi i izgradnji putnih objekata duž autoputeva i magistralnih i regionalnih puteva u Srbiji, na revitalizaciji HE Đerdap 1 u Kostolcu i na drugim hidro i termo-elektranama, na sanaciji brojnih klizišta, obnovi graditeljskog nasleđa, primeni sistema prednaprezanja i drugim specijalističkim inženjerskim uslugama.

Nastavljeno je učešće naših saradnika na realizaciji sedam projekata tehnološkog razvoja, jednog projekta integralnih i interdisciplinarnih istraživanja i dva projekta iz programa osnovnih istraživanja.

I ove godine Institut IMS može da se pohvali priloženim pregledom apstrakata, koji svedoči o održanom kontinuitetu objavljivanja naučnih radova na uglednim skupovima i u istaknutim publikacijama.

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MONOGRAFSKA STUDIJA / POGLAVLJE U KNJIZI M11 ILI RAD U TEMATSKOM ZBORNIKU VODEĆEG MEĐUNARODNOG ZNAČAJA (M13)

K. Janković, D. Bojović, M. Stojanović

INFLUENCE OF NANOPARTICLES ON THE STRENGTH OF ULTRA-HIGH PERFORMANCE CONCRETE

Nanotechnology in Eco-efficient Construction, Materials, Processes and Applications, Second Edition, Woodhead Publishing Series in Civil and Structural Engineering, 2019, 13-42

Ultra high performance concrete (UHPC) is a modern composite material with extremely good mechanical characteristics. The application of nano-particles in concrete is one of the possibilities for improving its properties. Nanoparticles such as nano-SiO_2 (NS), nano-Al_2O_3 (NA), nano-TiO_2 (NT), nano-Fe_2O_3 (NF), nano-ZnO_2, nano-clay (NC), carbon nano-tubes (CNT) and carbon nano-fibers (CNF) can be used in cementitious materials. Nanomaterial in UHPC accelerates the hydration of cement, densifies microstructure, improves strength and thus contributes to its durability. Component materials and curing regimes significantly affect the properties of UHPC. For this reason, the influence of various supplementary cementitious materials such as metakaolin and fine ground fly ash and curing regimes (in water, steam and autoclave curing) on the properties of UHPC has been analyzed. The influence of the nano-silica as the most frequently applied nanomaterial and the curing regimes on the strength of UHPC is studied. Nanomaterial dispersion and distribution has significant influence on the properties of cement based materials. Techniques for better homogenization of nanoparticles are listed.

Keywords: Ultra-high performance concrete, nano-particles, curing regimes, strength.

RAD U VRHUNSKOM MEĐUNARODNOM ČASOPISU (M21)

S. Stojanović, V. Bikić, Lj. Miličić, I. Radosavljević Evans, N. V.Y. Scarlett, H. E.A. Brand, Lj. Damjanović-Vasilić

EVIDENCE OF CONTINUOUS POTTERY PRODUCTION DURING THE LATE BYZANTINE PERIOD IN THE STUDENICA MONASTERY, A UNESCO WORLD HERITAGE SITE

Microchemical Journal, 2019, Vol. 146, 557-567.

A collection of 63 pottery shards excavated at the Studenica Monastery, Serbia, originating from two distinct cultural strata (late 12th until the late 13th century, and the 14th and the first half of 15th century) was subject of this work. Mineralogical and chemical composition of body and glaze and production technology of investigated pottery were determined combining optical microscopy, inductively coupled plasma-optical emission and wavelength dispersive X-ray fluorescence spectrometry, Fourier transform infrared and micro-Raman spectroscopy, high-resolution synchrotron powder X-ray diffraction and multivariate statistical analysis. In addition, clay rod with traces of glaze from the kiln found within the Monastery complex was investigated. The firing temperature was estimated at 600–700 °C for the most of cookware and at 800–1000 °C for tableware. Pottery, made of non-calcareous clay, was covered with transparent lead based glaze and copper and iron were used as colorants. Combining results of all used techniques no significant differences in mineralogical and chemical composition among samples from two cultural strata were identified indicating continuous pottery production process from 13th until 15th century in Studenica.

Keywords: medieval pottery, production technology, FTIR spectroscopy, raman spectroscopy, synchrotron PXRD, multivariate statistical analysis.

RAD U MEĐUNARODNOM ČASOPISU (M23)

A. Terzić, L. Pezo, Lj. Miličić, N. Mijatović, Z. Radojević, D. Radulović, Lj. Andrić

THERMAL AND MECHANICAL BEHAVIOR OF COMPOSITE MORTARS CONTAINING NATURAL SORPTIVE CLAYS AND FLY ASH

Science of Sintering, 2019, Vol. 51, 39-56.

Mineral additives are extensively applied as cement replacement materials in both construction concrete and mortar. Fly ash is one of the most commonly utilized additives which improves rheological properties, as well as thermal and mechanical behavior of mortar, and as such it has been widely investigated. This industrial byproduct comprises heavy metals in its composition; therefore further research is needed to optimize its effective dosage. Moreover, certain sorptive clays, such as natural zeolite and bentonite, can prevent migration of toxic elements from fly ash by immobilizing them in their structure. Ten experimental mortars are prepared with Portland cement, river sand and addition of fly ash, zeolite and/or bentonite in accordance with chemometric experimental design rules. The aim of the study was to investigate the effect of mineral additives on thermal and mechanical performances of mortar. Thermal characteristics were monitored via dilatometric analysis and DTA method. Principal component analysis was used on the results of physico-mechanical testing (workability, bulk density, water absorption, shrinkage, compressive and flexural strength) to enable the divisions of the observed samples into groups in the factor space. The performance of Artificial Neural Network was compared with the experimental data in order to develop rapid and accurate method for prediction of mechanical parameters of mortar. The ANN model showed high overall prediction accuracy ($r^2 = 0.989$, during training cycle). The test results indicate that incorporation of the mineral additives gave cost effective mortars with sufficiently good properties. However, tools of analytical modeling highlighted mortar with zeolite and fly ash as the optimal composition regarding its mechanical performance.

Keywords: dilatometry, DTA; analytical modeling; SEM; construction composites.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

A. Drpić, J. Smiljanić

MECHANICAL PROPERTIES OF WOOD PLASTIC COMPOSITES (WPC)

Science and higher education in function of sustainable development SED 2019, Mokra Gora, 2019, Session 3 – Civil engineering and architecture, 1-7.

WPC are composite materials with a wide range of applications in a number of market sectors. WPC are composites made of wood and plastic component. Some applications, such as outdoor products (decking, fancing and garden/outdoor furniture), doorframe profiles and window profiles, require production with appropriate proportion of recycled plastics and secondary wood processing waste and feedstocks. The selection of raw materials, composition, production method and parameters of the process will efect on the final WPC properties. The influence of wood component application on the WPC mechanical properties will be disscussed in this work and the typical cases will also be presented.

Keywords: wood plastic composites (WPC), application of wood plastic composites, influence of wood component on the mechanical properties of WPC.

B. Ilić, A.Mitrović, Lj. Miličić

MECHANIKALLY ACTIVATED KAOLIN AS SUPPLEMENTARY CEMENTITIOUS MATERIAL

15th International Congress on the Chemistry of Cement *ICCC 2019*, Prague, Czech Republic, 2019.

Two types of kaolin, with high content of impurities, mainly mica and quartz, were mechanically activated in the same milling equipment, under the same conditions. Pozzolanic activities of activated kaolin (AK), determined as the 7-day compressive strength on the lime mortars, were high and similar (~14 MPa).

Kaolinite and mica contributed to the pozzolanic activity through the amorphization. Quartz grains acted as an additional milling media and facilitated

mechanical activation of kaolinite. Additionally, in the presence of calcium hydroxide, quartz grains dissolved in the alkaline solution and generated reactive silica, which contributed to pozzolanic reaction.

The effect of AK on the compressive strength of cement composites was investigated. Composites, prepared with 10%, 20%, 30%, 40% and 50% of AK, were cured under different conditions - ordinary (28 days) and autoclave. In the composites with higher content of AK (30%-50%), hydrated lime was added, to secure enough calcium hydroxide (CH) for pozzolanic reaction.

Results showed that only composite with 10% of AK with higher content of quartz, achieved strength equal to the reference. For all cement replacement levels, under both curing conditions, higher compressive strengths were obtained for composites with AK, containing higher amount of quartz.

Keywords: mechanically activated kaolin, pozzolanic activity, cement-based composites; compressive strength.

I. Despotović, K. Janković, D. Bojović, M. Stojanović

SELF-COMPACTING CONCRETE WITH TAILINGS AND FLY ASH AS ECOLOGICAL MATERIAL

International Conference on Sustainable Materials, Systems and Structures *SMSS 2019: New Generation of Construction Materials*, Rovinj, Croatia, 2019, RILEM PRO 128, Vol. 1, 494-499.

Concept of sustainable development, which beside sociological and economic aspects, includes saving of energy, environment protection and preservation of restorable natural resources, presents strategic determination of various economic sectors. During the ore flotation in the mine large amounts of flotation tailings are generated and as waste material disposed in the specially determined areas. With the increase in metal production, the amount of tailings also increases, which is a major environmental problem because it takes up large areas. Great production of fly ash, which is the main residue from combustion of coal, also "managed" by landfilling, is a huge risk and danger for environment. Unlike vibrated concrete, self-compacting concrete contains significant amounts of fine particles, i.e. a mineral additive that greatly affects its performance, where potential use of fly ash is very important ecological aim. Tailing test results showed no pozzolanic activity and so its application in concrete can be only a

partial replacement of aggregate.This paper presents the possibility of using tailings and fly ash, which are waste products, in Self – Compacting Concrete. The obtained results indicate that these materials can successfully be used.

Keywords: self-compacting concrete, tailings, fly ash, compressive strength.

I. Despotović, K. Janković, S. Stanković

POSSIBILITIES OF RECYCLED CONCRETE AGGREGATE IMPROVEMENT

11th International Scientific Conference *Contemporary Materials 2018*, Banja Luka, BIH, 2019, 65-74.

Concept of sustainable development, which beside sociological and economic aspects, includes saving of energy, environment protection and preservation of restorable natural resources, presents strategic determination of various economic sectors. In that way great contribution is expected from construction industry. Self-compacting concrete has significant environmental advantages in comparison to the vibrated concrete: absence of noise and vibrations during installing provides a healthier working environment. Unlike vibrated concrete, self-compacting concrete contains significant amounts of fine particles, i.e. a mineral additive that greatly affects its performance, where potential use of fly ash is very important ecological aim. Tailing test results showed no pozzolanic activity and so its application in concrete can be only a partial replacement of aggregate.This paper presents the possibility of using tailings and fly ash, which are waste products, in Self – Compacting Concrete. The obtained results indicate that these materials can successfully be used.

Keywords: self-compacting concrete, tailings, fly ash, compressive strength.

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

THE INFLUENCE OF THE METHOD OF SPECIMEN PREPARATION ON THE DEPTH OF WATER PENETRATION UNDER PRESSURE

18th International symposium of MASE, Ohrid, Macedonia, 2019, 887-881.

Samples are often delivered to the laboratory, with a requirement to test the depth of penetration of water under pressure according to SRPS EN 12390-8:2010,

which calls for the preparation of samples immediately after their removal from the mold, at the age of one day. Often, these samples are not adequately prepared. As the preparation of the specimens by roughening with a steel brush, in the moment when the concrete is already approximately 28 days old, is very difficult, we tested how the results of the test of the depth of water penetration under pressure would be affected by the testing of the specimens without prior preparation (in the condition in which they were received), and what the results would be if the specimens were prepared by roughening with a hammer.

The paper presents the influence of the method of preparation of the surface of concrete specimens on the depth of water penetration under pressure. Three groups of nine specimens were created. From each group, three series of three specimens were examined: the first series of specimens without surface preparation, the second series whose surfaces were roughened with a wire brush immediately after removal from the molds and the third series whose surfaces were roughened right before the test. All specimens were exposed to water pressure, according to SRPS EN 12390-8:2010. Tests have shown that the method of surface preparation affects the depth of water penetration under pressure in concrete specimens.

Keywords: concrete, surface preparation, water pressure, water penetration.

K. Janković, D. Bojović, M. Stojanović

THE INFLUENCE OF NANO SiO_2 AND CURING REGIMES ON MECHANICAL PROPERTIES OF UHPFRC

International Conference on Sustainable Materials, Systems and Structures *SMSS 2019: New Generation of Construction Materials*, Rovinj, Croatia, 2019, RILEM PRO 128, Vol. 1, 202-209

One of the latest advances in concrete technology is Ultra High Performance Fibre Reinforced Concrete (UHPFRC). It is a fiber-reinforced, densely-packed concrete material that exhibits increased mechanical performance and superior durability to normal and high strength concretes. Nano SiO_2 can also accelerate cement hydration through a nucleation and growth mechanism, stimulate the formation of additional calcium silicate hydrates (C-S-H) through possible pozzolanic reactions, and reduce calcium leaching and weak zones of calcium hydroxide. Furthermore, curing on high temperature has a positive effect on the

pozzolanic reactions between CH from the hydration of cement and Nano silica. The aim of this study was to examine the effects of curing regimes on the mechanical properties of UHPFRC with different content of nano silica (1 and 2%). Standard curing regime in water, steam curing and autoclaving were applied. Comparative test results of concrete in fresh and hardened state are shown.

Keywords: UHPFRC, nano SiO_2, compressive strength, flexural strength, curing regime.

M. Aškrabić, D. Zakić, A. Savić., Lj. Miličić

EFFECTS OF NATURAL ZEOLITE ADDITION TO LIME BASED RENDER LAYERS FOR RESTORATION OF HISTORICAL BUILDINGS

5th Historic Mortars Conference, Pamplona, Spain, RILEM PRO 130, 1087-1098.

Renders, as the most exposed elements of historical buildings, have limited durability therefore their periodical inspection and replacements are necessary. Various studies have been made with a purpose to develop renders with improved resistance to environmental conditions, yet compatible with originally used materials (mortars and masonry). Although traditional renders were applied in several layers with different properties, most of the studies are based on only one layer production and testing. Natural zeolites are crystalline hydrated alumnosilicates with a specific three-dimensional framework structure. They have been used as a pozzolanic addition in lime mortars since ancient times. This paper presents the effects of natural zeolite addition on physical and mechanical properties of lime-based historical mortars, representing both base and superficial layer of traditional renders. Only locally available materials were used in the mix design. Capillary water absorption coefficient, water absorption after 48 hours, open porosity, flexural and compressive strength were measured on prismatic samples after 14, 28 and 60 days, and compared with the recommended properties for each render layer. The results demonstrate positive effects of zeolite addition to lime based render layers for restoration of historical buildings.

Keywords: natural zeolite, lime renders, compatibility, historical mortars.

M. Stojanović, K. Janković, D. Lukić, D. Bojović, L. Antić

THE INFLUENCE OF REINFORCEMENT TYPE ON SHOTCRETE PROPERTIES FOR TUNNEL LINING

7th International Conference *Contemporary Achievements in Civil Engineering 2019*, Subotica, 2019, 445-453.

This paper presents the possibility of using synthetic (polyolefin) and steel fibers in shotcrete to be used in tunnels in the production of primary coatings. In the experimental work, shotcrete slabs with and without the content of polyolefin and steel fibers, as well as slabs with constructive reinforcing mesh were made. Shotcrete slabs were tested for punching (absorption energy). Based on the results of the test it is assumed that it is possible to apply the fibers in the shotcrete during the production of the primary tunnel liner. The obtained values of the shotcrete test with the content of polyolefin fibers, have met the favorable mechanical properties.

Keywords: shotcrete, fiber reinforcement, energy absorption.

M. Stojanović, Ž. Flajs, K. Janković, D. Bojović, L. Antić Aranđelović

NATURAL FREQUENCIES OF UHPFRC BEAM WITH DIFFERENT PERCENTAGES OF STEEL FIBER CONTENT

18th International symposium of MASE, Ohrid, Macedonia, 2019, 1443-1450.

UHPFRC (Ultra High Performance Fiber Reinforced Concrete) mixes have been designed and made with 1 and 3 steel fiber percentages. Basic tests of compressive strength at different ages were performed and the secant modulus of elasticity in compression was determined on standard samples. Compressive strength values at 28 days of age were obtained with a steel fiber content of 1% - 150 MPa and a steel fiber content of 3% - 160 MPa. Based on the values obtained by testing on standard samples, it was concluded that with the increase in the steel fiber content, the mechanical properties of UHPFRC also increase. UHPFRC beams with 1% and 3% of steel fibers were built. The simply supported beams have a constant cross-section of 60 x 60 x 2000 mm and 100 x 100 x 2000 mm. In the middle of the span, the samples were loaded with a mass of 30 kg and 40 kg. The excitation of the beam was carried out with hammers weighing 2 kg and 3 kg. The measured values of the accelerations and displacements were obtained

with accelerometer and displacement transducer, and natural frequencies were calculated from acceleration and displacement data. Based on the obtained values, by examining the oscillation frequency of beams with a cross section of 60 x 60mm, it can be concluded that with the increase of the content of steel fibers, the oscillation frequency also increases. This behavior was not observed for beams with a cross-section of 100 x 100 mm, where the same test values were obtained with a steel fiber content of 1% and 3%.

Keywords: natural frequency, steel fibers, UHPFRC.

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

VALIDATION OF ICP–OES PROCEDURE FOR MAJOR AND TRACE ELEMENTS DETERMINATION IN THE LEACHATES OF FLY ASH AND FLY ASH BASED COMPOSITES

XIII International Mineral Processing and Recycling Conference, Belgrade, 2019, 70-76.

The novel global trends for waste materials processing and recycling, as well as new European standards for sampling and testing of these materials, require better performances of analytical methods for the chemical analysis and improvements regarding their matrices. In this study, a new method for optical emission spectrometry with inductively coupled plasma (ICP-OES) has been developed and subsequently validated for determination of 35 elements comprised in leachates of fly ash and composites based on fly ash, i.e. cement pastes and mortars. Validation performances and the uncertainty measurement were determined and calculated via three different routes: validation method, participation in proficiency testing schemes and standard method. It is proved that this method is acceptable for the determination of all 35 elements in this matrix. The obtained results highlight a new simple and effective analyzing route for quantity determination of undesired trace elements in fluids upon conducted leaching test.

Keywords: analytical procedures, waste materials, industrial byproducts, leaching test, environmental safety.

S. Stanković, K. Janković, I. Despotović

NUMERICAL CALCULATION OF IONIZING RADIATION ATTENUATION CHARACTERISTICS FOR CONCRETE

7th International Conference *Contemporary Achievements in Civil Engineering 2019*, Subotica, 2019, 455-460.

This paper presents a method of numerical calculations of the total mass attenuation coefficient as one of the basic radiation characteristics of materials used for produced of concrete for a special purpose. Using the XCOM software, numerical calculations were made, and then the results between the mass attenuation coefficient values for the selected type of concrete with barite, for concrete which are a combination of steel with magnetite and steel with limonite, and for UHPC concrete with barite and nanosilica, are compared.

Keywords: concrete barite, concrete steel magnetite limonite, UHPC concrete nanosilica, gamma X radiation, total mass attenuation coefficients.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U IZVODU (M34)

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

CORRELATION OF ED-XRF AND ICP-OES METHODS APPLIED IN CHEMICAL CHARACTERIZATION OF CEMENTITIOUS MATERIALS

1st International Conference on Advanced Production and Processing, Novi Sad, 2019, 157.

Rare earth elements (REE) are often referred to as “the secret ingredients of modern industry”, as they are extensively applied in many branches of contemporary industry. These elements found their end applications as catalysts, battery alloys, magnets, and most importantly as dopants in ceramic materials. The quantity of RRE (i.e. specifically the fifteen lanthanides, as well as scandium and yttrium) is scarce, as they usually appear as companion elements of other ores in their deposits. Therefore, the unconventional REEs-containing resources have to be assessed. REE can be found in acid mine drainage, produced water, coal and most importantly coal byproducts. Fly ash, as a byproduct of coal combustion in thermal plants, often comprises REE concentrations that vary between 200 and 1500 ppm. This quantity of REEs can be isolated, even though the extraction can be challenging. In this study, the five phase extraction has been conducted on fly ash obtained from the five different landfill sites. The extraction of thirty two elements (As, Ga, Ce, Be, Ge, Nd, Cr, Zr, Eu, Cu, Nb, Gd,Co, Mo, Dy, Li, Ag, W, Mn, Cd, Au, Ni, In, Hg, Pb, Sn, Ti, V, Sb, Th, Zn, La) has been conveyed. The complexity of the obtained data was also examined by principal component analysis (PCA) and cluster analysis (CA) in the identifying chemical composition of each coal ash sample. The recovery of mentioned elements from fly ash was assessed by means of techno-economic analysis.

Keywords: extraction, chemical analysis, ICP, analytical modeling, reapplication, ceramic materials.

N. Mijatović, Lj. Miličić, Z. Radojević, A. Terzić

ANALYTICAL MODELING OF ICP-OES AND XRF PROCEDURES FOR DETECTION OF THE MAIN ELEMENTS IN TRADITIONAL BRICK CLAYS

Advanced Ceramic and Application VII – New frontiers in multifunctional material science and processing, Belgrade, 2019, 66.

Comparison of two instrumental analytical techniques, i.e. X-ray fluorescence (XRF) and inductively coupled plasma-optical emission spectrometry (ICP-OES), for measuring of the concentrations of major elements (Si, Al, and Fe) found in the traditional brick clay was conducted. Sixty-nine samples of clays from various Serbian deposits were analyzed and characterized in order to evaluate the possibility of their employment as a raw material in the ceramic industry. Concentrations of Si, Al and Fe in clays were primarily determined using ED XRF analyzer. ICP-OES analysis on digested clays (using a microwave-assisted combination of nitric, hydrochloric and hydrofluoric acids digestion) was applied to confirm XRF data. The analytical modeling of the obtained results showed that concentrations of Si, Al and Fe determined via XRF method correlated with high linearity with concentrations of Si, Al and Fe acquired by ICP-OES measurements. Statistical F-test and t- test applied on the data of both methods showed very small differences between results obtained by these two techniques. Namely, the results of ICP-OES analysis confirmed XRF measurement of concentrations of Si, Al and Fe in investigated clays, which suggests that XRF is a quick and good alternative for the chemical analysis that allows much larger sampling regimes in relatively shorter times.

Keywords: chemical analysis, traditional ceramics, brick production, construction materials.

RAD U VRHUNSKOM ČASOPISU NACIONALNOG ZNAČAJA (M51)

T. Spasojević-Šantić, Z. Radojević

ANALIZA POSTUPKA OCENJIVANJA ŽIVOTNOG CIKLUSA OPEKARSKIH PROIZVODA

Izgradnja, 2019, Vol. 3-4, 197-201.

Poznato je da se u proizvodnji opekarskih proizvoda koriste velike količine sirovina koje takođe uključuju visoku potrošnju energije što se negativno odražava na kvalitet životne sredine. Ocenjivanje životnog ciklusa (eng. *Life Cycle Assessment-LCA*) je metod za analizu i kvantifikaciju mogućih uticaja proizvoda na životnu sredinu tokom celokupnog životnog veka proizvoda, od ekstrakcije sirovina, preko proizvodnje, upotrebe, postupanja na kraju životnog veka proizvoda, recikliranja i konačnog odlaganja. Shodno tome, u radu je predstavljena analiza postupka ocenjivanja životnog ciklusa opekarskih proizvoda u cilju proizvodnje održivih građevinskih proizvoda.

Ključne reči: LCA, opekarski proizvodi, životna sredina.

BITNO POBOLJŠANO TEHNIČKO REŠENJE NA NACIONALNOM NIVOU (M84)

Z. Radojević, A. Terzić, Lj. Vasić, Lj. Santo

OPTIMIZACIJA SASTAVA I SVOJSTAVA GLINENIH KOMPOZITA U CILJU DOBIJANJA OPEKARSKIH PROIZVODA NAPREDNIH PERFORMANSI

Tehničko rešenje pripada oblasti konstrukcione keramike sa primenom u građevinarstvu. Tehničko rešenje se bavi razvojem i optimizacijom bitno poboljšanih opekarskih proizvoda (energetskih blokova) na bazi različitih vrsta glina i mineralnog aditiva - ugljene prašine, kao sirovine sekundarnog porekla iz procesa sagorevanja uglja. Rešenje doprinosi modifikaciji tehnološkog procesa proizvodnje opekarskih proizvoda u smislu dobijanja proizvoda poboljšanih svojstava, ali i povećanju energetske efikasnosti pogona.

Ključne reči: glina, optimizacija, industrijski nus-produkti, energetska efikasnost.

Korisnik/naručilac: IGM MLADOST-TMP D.O.O, Mala Plana, 2019.

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CIVIL ENGINEERING,
HYDRAULIC ENGINEERING,
OFFSHORE TECHNOLOGY,
SOIL MECHANICS

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GRAĐEVINARSTVO,
HIDRAULIKA,
PRIOBALNA
TEHNOLOGIJA,
MEHANIKA TLA

RAD U MEĐUNARODNOM ČASOPISU (M23)

K. Đoković, S. Tošović, K. Janković, N. Šušić

PHYSICAL-MECHANICAL PROPERTIES OF CEMENT STABILIZED RAP/CRUSHED STONE AGGREGATE MIXTURES

Technical Gazette, Vol. 26, No. 2, 385-390.

The paper presents and analyzes the results of testing the properties of cement stabilized mixtures of reclaimed asphalt pavement (RAP) and crushed stone aggregate (CSA). Tests were carried out on reclaimed asphalt pavement and crushed stone aggregate mixtures with varying RAP content (0%, 20%, 40%, 60% and 80%), as well as with a varying addition of cement (3%, 5% and 7%). The purpose of these tests was to determine the optimal proportion of recycled asphalt pavement in a mixture with crushed stone aggregate, and the optimal addition of cement as a hydraulic binder. Furthermore, the aim was to determine physical-mechanical parameters: the indirect tensile strength (Rt) and the dynamic modulus of elasticity (E), which are applied in pavement design during the process of cold recycling. On the basis of the obtained values, categorization of the stabilized mixture was carried out according to the standard EN 14227-10: 2006, which continues to be applied in the design of pavements. The maximum proportion of recycled asphalt in the stabilized mixture was determined as being up to 60%; the stabilized mixture was categorized into the "T1" and "T2" categories - gravelly soils.

Keywords: cold recycling, cement stabilized mixtures, dynamic modulus of elasticity, indirect tensile strength, reclaimed asphalt pavement.

M. Ćosić, N. Šušić, R. Folić, B. Folić

MODEL OF PROBABILISTIC ANALYSIS OF PILE CAPACITY BASED ON THE EXTRAPOLATION OF FORCE-SETTLEMENT CURVES

Soil Mechanics and Foundation Engineering, 2019.

This paper formulates a mathematical model using the extrapolation of load-settlement curves with a rational function for analyzing the capacity of piles

obtained from the Static Load Test (SLT). In preliminary analyzes extrapolation was based on the application of a number of mathematical functions that were gradually eliminated by iterative selection and filtering. The solution was obtained by extrapolation with a rational function. Using a rational function in the extrapolation of the load-settlement curve, a clearly identifiable part is obtained in which the asymptote is vertical, indicating reached limit state of capacity in the soil and/or in the pile. The probabilistic analysis showed that no unique value for pile capacity was obtained, and that the spectrum of capacity values depends on the probability of occurrence of the corresponding event.

Keywords: pile, static load test, bearing capacity, rational function, probability theory.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

B. Folić, M. Ćosić, S. Brčić, M. Čokić, S. Sedmak

THE EFFECT OF AFTERSHOCK ON 2D RC FRAME FOUNDED ON PILES WITH P-Y CURVES

Assessment of the Condition, Maintenance and Rehabilitation of Buildings and Settlements, Zlatibor, 2019, 375-386.

This paper presents the manner of modeling the aftershock (in an earthquake), the phenomenon whose significance has been noted in the second half of the 20th century. It lists the constructional systems in which the consideration of the aftershock is important. It shows in more detail the model of the skeletal RC construction, i.e. the 2D RC facade frame constructed on the 60cm-diameter drilled RC piles. The dynamic interaction soil-pile, i.e. the non-linear behaviour of the soil is modelled with the horizontal p-y curves for sand, applying multiplastic link elements. For the accelerogram El Centro during time history (TH) the global and (local) drift, the condition of plastic hinges were considered.

Keywords: soil-pile-structure interaction, p-y curve, dissipation of seismic energy, after shock.

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

SOME ASPECTS OF THE ANALYSIS OF PILE FONDATIONS BEHAVIOUR UNDER SEISMIC ACTION

Geotechnics in Civil Engineering, Vrnjačka Banja, 2019.

The paper presents a seismic analysis of the structure-pile-soil system, of a 2D RC frame. The analysis of individual system elements and some potential damage on two Vrancea accelerograms, VR77NS and VRfoc86NS are presented. The impact of the response spectra is provided for VR77NS, because the structure enters the resonant area and the damage increase considerably. Local drift diagrams during the earthquake, and the model damage featured as plastic hinges condition at the end of accelerograms are provided. It is indicated that it is necessary to introduce a dynamic interaction of the structural system, which

includes not only the piles, but soil as well, because it became possible at the present level of scientific and technological progress of the human kind.

Keywords: seismic analysis, piles, dynamics SPSI, plastic hinges, response spectra.

K. Đoković, G. Hadži-Niković, N. Šušić

ASSESSMENT CLASS OF DISPERSIVITY OF FLY ASH-SOIL MIXTURE

7th International Symposium of Mining and Environmental Protection *MEP 2019*, Vrdnik, 2019.

The need for construction of earth embankments has increased in Serbia in the last years. For these purposes, clay materials from numerous natural deposits are often used. Using pure natural fine-grained materials for earth embankments could be inconvenient and may cause serious engineering problems, because some of them could be dispersive. However, dispersive natural materials can be improved significantly by adding fly ash from thermal power plants. In that case, adding of fly ash greatly reduced dispersivity of natural soil materials; fly ash-soil mixture becomes then nondispersive material and can be successfully used for embankments. Assessment class of dispersivity for fly ash – soil mixtures cannot be performed using standard laboratory testings: the grain-size distribution and plasticity test. For the first time in Serbia, tests of dispersion of fly ash-soil mixture were carried out. The paper presents the methods and materials of recent testing dispersivity of fly ash – soil mixture, using other classification tests.

Keywords: dispersivity, fly ash - soil mixture, identification, crumb test, double hydrometer test, pinhole test.

RAD U ISTAKNUTOM NACIONALNOM ČASOPISU (M52)

M. Ćosić, K. Božić-Tomić, N. Šušić

PILE INTEGRITY TESTING: TESTING AND RESULTS ANALYSIS

Building Materials and Structures, 2019, Vol. 62, No. 3, 39-59.

The paper presents typical examples of pile integrity testing and the results analysis, whereby the testing methodology relies on existing ASTM standards, as well as on the testing methodology presented in the scientific paper Pile Integrity and Load Testing: Methodology and Classification, published in this journal. The pile tests were conducted using licensed equipment for Sonic Integrity Test (SIT) and Crosshole Sonic Logging (CSL). The tests have shown the correct and problematic situations that arise when analyzing pile integrity. Some aspects of the wave theory implementation, but also of signal processing and numerical analysis have been indicated. Also, the need to develop a plan for testing the integrity of piles in structures with a large number of piles has been emphasized.

Keywords: pile, testing, integrity, reflectogram, SIT, ultrasonic profile, CSL

M. Ćosić, K. Božić-Tomić, N. Šušić

PILE INTEGRITY AND LOAD TESTING: METHODOLOGY AND CLASSIFICATION

Building Materials and Structures, 2019, Vol. 62, No. 1, 43-68.

The paper presents the methodology and classification of pile integrity and load testing, in compliance with current foreign standards, as well as our own defined segments of standard improvement and our own definitions of certain key elements. The classification has been conducted according to the test types which clearly define the pile testing process, analysis methods, and test results processing. Beside the basic division of pile testing to integrity tests and load tests, there is also an additionally defined group of shaft control tests in the case of bored piles, since for the proper shaft formation, when it comes to bored piles, certain qualitative-quantitative criteria must be fulfilled beforehand. Presented in this way, the methodology and classification of pile integrity and load tests

serves, primarily, an educational purpose for civil and geotechnics engineers who deal with this issue, to additionally introduce innovations in this field of testing and and clarify all the elements of the testing since contradictory opinions and disagreements regarding the testing details are quite common in practice.

Keywords: pile, testing, standards, classification, integrity, load.

SAOPŠTENJE SA SKUPA NACIONALNOG ZNAČAJA ŠTAMPANO U CELINI (M63)

G. Hadži-Niković, K. Đoković

PARAMETRI SWRC I DISPERZIVNOSTI LESNIH SEDIMENATA

Geotehnički aspekti građevinarstva, Vrnjačka banja, 2019.

U radu je analizirana mogućnost uspostavljanja zavisnost između disperzivnosti i parametara retenzione krive SWRC za lesne naslage Zemunskog platoa. Retenzione SWRC krive određene su eksperimentalno, dreniranjem uzoraka pod pritiskom u 15-barnom ekstraktoru, prema ASTM standardima. Ispitivanja disperzivnosti vršena su metodom grudvice, metodom dvostrukog hidrometrisanja i pin-hol opitom, prema BS i ASTM standardima. Ispitivanja su izvedena na prirodnim i veštački pripremljenim uzorcima lesnih sedimenata. Disperzivnost lesnih sediemenata povećava se sa povećanjem pritiska prodiranja vazduha $(u_a\text{-}u_w)_b$ i rezidulanog stepena zasićenja S_{rez}, a opada sa smanjenjem koeficijenta λ. Zbijenost utiče na parametre retenzione krive, a manje utiče na disperzivnost.

Ključne reči: lesni sedimenti, retenziona kriva, disperzivnost, gustina, zbijanje.

T 230
BUILDING CONSTRUCTION

T 230
VISOKA GRADNJA

RAD U VRHUNSKOM MEĐUNARODNOM ČASOPISU (M21)

M. Mirković Marjanović, R. Gospavić , G. Todorović

AN ANALYTICAL APPROACH BASED ON GREEN'S FUNCTION TO THERMAL RESPONSE FACTORS FOR COMPOSITE PLANAR STRUCTURE WITH EXPERIMENTAL VALIDATION

International Journal of Thermal Sciences, 2019, No. 139,129-143.

The unsteady heat conduction in composite planar structure, with arbitrary number of layers, using analytical approach based on Green's Functions (GF) is analyzed. The analytical solution for spatial and temporal temperature distribution is evaluated in the general form and expressed in the terms of the convolution integrals. The GF are employed in the novel approach for calculation of Thermal Response Factors (TRF) with arbitrary shape functions for unsteady heat conduction in composite planar structure. The two pairs of TRF for spatial and temporal distribution of the temperature and the thermal flux are obtained. The whole analysis is performed in the time domain. A numerical scheme for efficient evaluation of convolution integral suitable for practical application in the case of the long term measurements with lower sampling rates is developed. The in-situ measurements of inside and outside surface temperatures and outside heat flux for a building wall under real dynamical environmental conditions during the period of then days are used for validation of the presented results and to demonstrate the possible practical application. Using developed approach and recorded surface temperatures as inputs the temporal and spatial distributions of the temperature and the thermal flux are obtained. These results are compared with experimental data and numerical simulations obtained by the Finite Volume Method (FVM).

Keywords: Green's functions, heat conduction, composite structure, thermal response factors.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

A. Kijanović, M. Mirković Marjanović, M. Bjekić, R. Gospavić, G. Todorović

PREFABRICATED FERROCEMENT SANDWICH ELEMENTS IN FIRE CONDITIONS

Contemporary achievements in civil engineering, Subotica, 2019, 437-444.

In this paper the experimental results of two-dimensional non-stationary temperature fields of prefabricated ferrocement sandwich panels in fire condition, were presented. In order to determine resistance to fire, the temperature fields of two walls dimensions of 3000 mm × 3000 mm and a thickness of 190 mm made from precast ferrocement sandwich panels, were analyzed. The first panel has been insulated with styro-concrete, and the second with styro-concrete and expanded polystyrene. The panels were exposed to conditions of real fire corresponding to the standard fire curve defined by the standard SRPS EN ISO 834-1. The tests have shown that, due to the detonations that occur when the panels are exposed to fire, these panels have unpredictable behavior.

Keywords: prefabricated ferrocement sandwich element, heat transport, fire test.

D. Boljević, M. Maričić, N. Maričić

APPROACH AND OVERVIEW OF THE PT SCHEME IN ACOUSTIC FIELD

7th International Proficiency Testing Conference, Oradea, Romania, 2019, 41-48.

During 2015 IMS Institute constituted the Proficiency Testing Provider (PIMS), accredited in 2018 by Accreditation Body of Serbia. Among a large number of subjects of testing (primarily building materials), PIMS organizes inter-laboratory comparisons in the field of acoustical testing, primarily in the field of environmental noise level measurement (outdoors and/or indoors), sound power measurements of noise sources and field measurements of building elements sound insulation. These measurements are designed in a manner that the subject of testing is the same for all participants. Implemented PT cycles were conducted

in Belgrade, except sequential scheme for sound power measurement of a noise source, where the same sample travels from participant to participant. In the previous years, PIMS conducted four PT cycles of environmental noise measurements (two outdoors and two indoors), two cycles of field measurement of building elements sound insulation and one cycle of sound power measurements of noise sources. An overview of the participant results, robust statistics analysis (assigned value, its uncertainty, and cycle standard deviation) as well as the conclusions for one conducted cycle will be presented in this paper.

Keywords: PT scheme, environmental noise, robust statistics, uncertainty.

RAD U ISTAKNUTOM NACIONALNOM ČASOPISU (M52)

A. Drpić, Z. Radojević

APPLICATION OF PROCEDURES FOR ISSUING ECO-DECLARATIONS FOR CONSTRUCTION PRODUCTS

Izgradnja, 2018, Vol. 72, No. 11-12, 637-643.

Procedures for preparing of the eko-declarations for construction products and buildings are based on the standardized methods. Environmental Product Declarations (EPDs) belong to the type III eco-declarations. The EPD contains verified, precise and unambiguous information about the environmental impact of products and the potential for improvement based on the scientifically proven facts. On the basis of the EPD, the data given by the manufacturer are verified, i.e. their accuracy is confirmed and it is assessed that they are in accordance with the applicable regulations and standards. EPD provides information on how emissions of individual elements and compounds affect air, soil and water during use of a building facility. The aim is to evaluate the sustainability of buildings in relation to the environment.

Keywords: eco-declaration, construction product, building, EPD, sustainability, environment.

T 350
CHEMICAL TECHNOLOGY
AND ENGINEERING

T 350
HEMIJSKA TEHNOLOGIJA
I INŽENJERING

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

M. Vasić, Z. Radojević

METHOD FOR AVOIDING CRACKS DURING DRYING OF MASONRY UNITS MADE OF ILLITE RAW MATERIAL

International Conference on Modern Technologies in Industrial Engineering *ModTech 2019*, Iasi, Romania, 2019, IOP Conf. Series: *Materials Science and Engineering*, 2019, 591, 012101.

Drying is one of the most important steps in the production process of masonry units. In order to prevent the formation of cracks during drying information's about the moisture migration rate variability as well as the material strength variability through drying are necessary. The main goal of this paper was to find a solution how to prevent the crack formation at the beginning (during the first hour) of the drying for the drying sensitive illite raw material. The first step was to record a series of isothermal Deff – MR curves at different drying air temperatures and constant drying air velocity and humidity. As it was already reported all moisture transport mechanisms during isothermal drying are visible on those curves. Characteristic spots registered on these curves were then transposed on the experimentally registered figure material strength us moisture content. It was found that the material strength for the cracked masonry units at the beginning of drying was around 0.09 MPa and that the time of cracking was near the characteristic spot B. Registered material strength and the crack time position (spot B) has additionally confirmed that the drying sensitivity of the raw material are obviously related with the present clay mineral constituents structure and the initial moisture content of the green heavy clay units. Using the Deff values registered for each experiment in the spot B we were able to calculate the maximal moisture transport rate and consequently the proper drying air parameters which are safe and which will not initialize the formation of the cracks at the beginning of the drying.

Keywords: drying process, drying regime, effective diffusion coefficient, clay roofing tile, clay raw material.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U IZVODU (M34)

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

INFLUENCE OF BRICK CLAY CHARACTERISTICS TO THE QUALITY OF ADOBE CLAY BRICKS

1th International Conference On Advanced Production and Porcessing *ICAPP 2019*, Novi Sad, Serbia, 2019, 143.

In this study, 139 heavy clay samples from Serbia are tested. The effects of macro-oxides content, granulometry analysis (contents of sand-, alevrolite-, and clay-sized particles), remains on the 0.063 mm sieve, and contents of total carbonates on the characteristics of raw and adobe clay bricks were mathematically analysed in this research. The observed parameters were characteristics of wet raw material (shaping moist, plasticity coefficient according to the method by Pfefferkorn, and drying sensitivity following Bigot) and adobe clay bricks (drying shrinkage and compressive strength). Correlations and principal component analysis were done to sum the important effects of inputs over the outputs. It was revealed that Al_2O_3 mostly influenced shaping moist, Na_2O and K_2O were influential to dry compressive strength and drying until the critical point. Increase in clay-sized particles induced higher shrinkage and compressive strength. A rise in the quantity of allevrolite-sized particles decreased drying sensitivity, drying shrinkage and compressive strength.

The analysis is done as the preliminary check of the data, before building Artificial neural networks.

Keywords: Adobe clay brick, correlations, plasticity, drying sensitivity.

M.Vasić, Z. Radojević

MEASURING THE DRYING SENSITIVITY OF CLAYS: A REVIEW

1st International conference on advanced production and processing *ICAPP 2019*, Novi Sad, 2019, 144.

It is well known that intrinsic parameters such as mineralogical composition, clay minerals content, grain distribution, packing, porosity, as well as forming method and raw material aging are affecting on the easiness of the drying process. Often many of previously mentioned parameters are inter-dependently related to each other. That is the reason why attempts to relate the drying sensitivity to one or more of the above mentioned intrinsic parameters have encountered limited success. A logical solution was to relate the drying crack with the term "drying sensitivity". By doing that the evaluation of the cracking tendency is linked with the easiness of the drying process in each proposed method. The main objective of this review was to present five methods (Bigot, Ratzenberger, Piltz, Hermansson and Varlamov) which are usually used for qualitatively estimation of the drying sensitivity of clays and consequently the prediction of the drying behavior. After a literature check it was found that only Bigot and Ratzenberg drying sensitivity index were compared. The second task was to estimate the clay drying behavior using all five methods. The results have confirmed that the most suitable conclusion about the drying behavior of the tested clay is obtained when results from Bigot, Piltz and Varlamov method are available.

Keywords: drying sensitivity, clays, Bigot, Varlamov, Piltz, TG curve.

T 450
METAL TECHNOLOGY,
METALLURGY,
METAL PRODUCTS

T450
TEHNOLOGIJA METALA,
METALURGIJA,
PROIZVODI OD METALA

RAD U ISTAKNUTOM MEĐUNARODNOM ČASOPISU (M22)

B. Aleksić, A. Grbović, Lj. Milović, A. Hemer, V. Aleksić

NUMERICAL SIMULATION OF FATIGUE CRACK PROPAGATION: A CASE STUDY OF DEFECTED STEAM PIPELINE

Engineering Failure Analysis, 2019, Vol. 106, 104-165.

In order to prevent the premature failure of steam pipeline produced of molybdenum-vanadium steel, the experimental tests were performed to measure fracture toughness and to determine the mechanical behaviour of cracked pipes. A finite element method was used to calculate the fracture behavior of the pressurized pipeline made of 14MoV6-3 steel based on the J-integral computation. The J-R curves were experimentally obtained by the elastic unloading compliance method for the single edge notched bend specimens and compared with those obtained using finite element method.

A two dimensional finite element analysis was performed in Ansys Workbench software to determine the stress distribution and calculate J-integral values for the selected specimen geometry. Special attention was paid to the influence of applied boundary conditions on the accuracy of J-integral values, as well as to the influence of mesh density. It is shown that numerically obtained J-values significantly depend on the number of nodes used to apply displacements. However, if recommendations proposed in this paper are implemented, the accuracy of calculated values is satisfactory and successful failure analysis can be carried out. This approach can be use ful in engineering applications where time saving and costs reducing are required.

Keywords: Steam pipelines failures, J-integral, J-Rcurve, finite element method.

M. Mrdak, B. Međo, D. Veljić, M. Arsić, M. Rakin

THE INFLUENCE OF POWDER FEED RATE ON MECHANICAL PROPERTIES OF ATMOSPHERIC PLASMA SPRAY (APS) AL-12SI COATING

Reviews on Advanced Materials Science, 2019, Vol. 58, No. 1, 75-81.

In this paper, structural and mechanical properties of APS - atmospheric plasma spray coating Al-12Si are presented. The aim of the research was the optimisation of the flow of powder to produce layers with optimal mechanical and structural properties that will be applied to the worn out parts of airplanes. Three groups of samples were produced, by utilising three powder feed rates: 30 g/min, 45 g/min and 60 g/min. Evaluation of layers' microhardness was done using HV0.3 method and the bond strengthwas determined by testing of tensile strength. Surface morphology of the deposited powder particles was examined on SEM (Scanning Electron Microscope). The microstructure of the coating with the best measured mechanical properties was subsequently examined in etched condition on optical microscope and SEM (in accordance with the standard PN 585005, Pratt & Whitney). Also, fracture morphology of this coating in deposited state was examined using SEM. It was found that powder feed control with atmospheric plasma spraying can produce dense layers of Al-12Si coating with good bond strength.

Keywords: atmospheric plasma spraying (APS), Al-12Si alloy microstructure, hardness, bond strength.

V. Aleksić, Lj. Milović, I. Blačić, T. Vuherer, S. Bulatović

EFFECT OF LCF ON BEHAVIOR AND MICROSTRUCTURE OF MICROALLOYED HSLA STEEL AND ITS SIMULATED CGHAZ

Engineering Failure Analysis, 2019, Vol. 104, 1094-1106.

Numerous structural components made of high strength low-alloyed steels are often exposed to low-cycle fatigue loading during their exploitation life. In order to study the fatigue behavior of one grade of structural steels produced in Yugoslavia during the eighties of the last century, a push-pull constant amplitude strain-controlled fatigue tests were conducted at room temperatures. This paper analyses behavior of two different materials, parent steel (PM) and its

coarsegrained (CG) simulated heat-affected zone (SHAZ) exposed to the action of low-cycle fatigue (LCF) loading performed in the range from 1 to 104 cycles. LCF tests were conducted at strain ratio R=-1 at strain amplitude range from 0.3% to 0.8%. The materials' Coffin-Manson parameters appearing in the strain-life and cyclic stress-strain curves were calculated. Fracture surface analysis of both materials was done. The results showed that plasticity under dynamic load conditions is satisfactory for both materials which give them good resistance to crack initiation and propagation.

Keywords: Low-cycle fatigue, High strength low-alloyed steels, Cyclic test, Simulated weld CGHAZ, Microstructure.

RAD U MEĐUNARODNOM ČASOPISU (M23)

M. Savković, M. Dedić, G. Pavlović, M Arsić, Z. Stamenić

ANALYSIS OF THE DRIVE SHAFT FRACTURE OF THE CONVEYOR BELT FOR TRANSPORT OF COAL

Technical Gazette, 2019, Vol. 26, No. 5, 1333-1338.

The conveyor belt for slag and coal transport in the open mine pit "Kolubara" – Serbia is driven by means of two drive drums, attached on separate shafts. Each shaft is driven by two electric motors on both sides. During exploitation, the conveyor belt drive shafts are subjected to torques and transverse forces due to belt tension. The gearboxes and the bearing units on both sides of the drive drum support each shaft. A fracture of one of the drive shafts of the conveyor belt occurred at its connection point with the gearbox. The first part of the paper defines the loads relevant for shaft calculation, based on measurements in different phases of operation and the manufacturer's data. It is followed by the FEM analysis and fatigue analysis, for the most unfavourable load case. It has been established that the critical stress value has occurred near the connection point between the shaft and the gearbox, in the fracture zone. The second part of the paper presents experimental testing of the chemical composition and mechanical properties of the shaft material as well as metallographic inspection of the fracture surface. The experimental test procedure shows that the fracture has occurred not because of an error in the material but as a consequence of the ineadequate heat treatment. Superposition of two negative influences: material fatigue and inadequate heat treatment, expressed in the cross section at the point of fracture is the main case of the conveyor belt shaft fracture.

Keywords: conveyor belt, drive shaft of the conveyor belt, fracture analysis, experimental testing.

RAD U NACIONALNOM ČASOPISU MEĐUNARODNOG ZNAČAJA (M24)

M. Arsić, S. Bošnjak, V. Grabulov, M. Mladenović, Z. Savić

REPAIR OF DAMAGES THAT OCCURRED ON THE WELDED JOINTS AT THE BODY OF GUIDE VANE APPARATUS VANES OF THE VERTICAL KAPLAN TURBINE

Advanced Materials Research, 2019, Vol. 1153, 1-6.

Vertical kaplan turbines, with nominal power of 178 mw and manufactured in russia, have been installed in 6 hydroelectric generating units of hydro power plant 'djerdap 1'. Experimental tests were carried out by non-destructive methods in order to determine the turbine condition during the rehabilitation of the hydro power plant. Lack of root penetration was detected in v40 welded joints between upper and lower sleeves and bodies of guide vane apparatus vanes. Height of the lack of root penetration was in the range between 5 and 15 mm, while the allowable height of the lack of root penetration is 3 mm, according to the technical conditions. The upper sleeves were made of cast steel 25l (in accordance with gost 977), while lower sleeves were made of steel forging st 25 (in accordance with standards gost 1050 for chemical composition and gost 8479 for forgings). Methodology for the repair of non-penetrated welded joints between the sleeves and body of the guide vane apparatus vane was composed taking into account the results of ultrasonic testing. By repair methodology it is necessary to, due to the structural solution and service function of guide vane apparatus vanes, specify a large number of details, consider them carefully and carry them out in order to improve safety, because if some of them get overlooked, underestimated or incorrectly perceived, significant problems in turbine operation may occur.

Keywords: sleeve, guide vane apparatus vane, lack of root penetration, repair of damages.

SAOPŠTENJE SA MEĐUNARODNOG SKUPA ŠTAMPANO U CELINI (M33)

M Arsić, V. Grabulov, S. Bošnjak, M. Mladenović, Z. Savić

LAMELLAR TEARING OF PARENT MATERIAL AND DEGRADATION OF WELDED JOINTS AT VITAL WELDED STRUCTURES

10th International Scientific Professional Conference *Engineering Technologies in Manufacturing of Welded Constructions and Products SBW 2019*, Slavonski Brod, Croatia, 2019, CD, 61-68.

Vertical Kaplan turbines, manufactured in Russia, are installed in 6 hydroelectric generating units at 'Djerdap 1', with nominal power of 176 MW each. Because of the structural solution and inability of performing periodic inspections and state analyses, 40 years long service life of the turbine and upper ring of guide vane apparatus was predicted. Welded structures of the turbine cover and upper ring of guide vane apparatus consist of 4 segments made of steel St 3, in accordance with GOST 380-94. Flux-cored arc welding was used in order to merge the segments. Non-destructive and destructive tests were performed on parent material and welded joints during the rehabilitation of the hydroelectric generating set A4, in order to carry out the condition analysis and assessment of the level and cause of eventual degradation of structures of the turbine cover and upper ring of guide vane apparatus at hydro power plant 'Djerdap 1'. In this paper the analyses that refer to determination of the cause of lamellar tearing of parent material in the area of welded joints based on results of magnetic particle testing and ultrasonic testing are presented.

Keywords: welded structure, non-destructive test, lamellar tearing of parent material, degradation of the welded joint.

M Arsić, V. Grabulov, S. Bošnjak, M. Mladenović, Z. Savić

INTEGRITY OF WELDED JOINTS BETWEEN PIPES FOR PRESSURE VESSELS MADE OF HOT ROLLED FINE-GRAINED STEEL P460NL1

10th International Scientific Professional Conference *Engineering Technologies in Manufacturing of Welded Constructions and Products SBW 2019*, Slavonski Brod, Croatia, 2019, CD, 109-118.

This paper contains results of tests performed in order to determine mechanical properties of steel P460NL1, meant for production of pressure vessels. Arc welding of samples from which the specimens were taken was carried out through the application of welding process 111, because it is one of the processes for the execution of pipelines for the transport of oil or gas. Microspecimens with diameter of 1,5 mm were tested in order to determine tensile properties of material taken from the heat-affected zone and weld metal, while specimens with diameter of 6 mm were tested in order to determine tensile properties of parent material. Standard Charpy V-notch specimens were used in order to determine impact energy. Results of metallographic tests which refer to the structure of a pipe welded joint are also presented. On the basis of results of tensile tests carried out on specimens taken from parent material, heat-affected zone and weld metal it was determined that mean values of yield strength and tensile strength of parent material and weld metal are practically equal, while these values for heat-affected zone are more than 20% lower. The situation is similar regarding the value of elongation.Mean values of overall impact energy for parent material and weld metal are practically equal, while in comparison with results obtained for material taken from the heat-affected zone they are more than 2 times lower. Through the analysis of energy necessary for initiation and propagation of cracks it was determined that the ratio of those energies is very good when it comes to parent material and weld metal, while it was also determined that the critical location for crack initiation is the heat-affected zone. Integrity evaluation of the air tank during exploitation was carried out through the analytical calculation of strength of the shell and upper bottom based on their technical properties after the completion of reparatory welding/surface welding.

Keywords: steel P460NL1, welded joint, mechanical properties, integrity evaluation.

M. Arsić , S. Bošnjak, V. Grabulov, N. Gnjatović, I. Milenović

REPAIR METHODOLOGY FOR THE CARRYING STRUCTURE OF THE REJECTING DRUM OF THE BUCKET-WHEEL RECLAIMER STACKER CONVEYOR AT COAL LANDFILL

XXIII International Conference on material handling, constructions and logistics *MHCL19*, Vienna, Austria, 2019, 117-122.

Damaging of the carrying steel structure and embedding of the rejecting drum of the stacker conveyor occurred during the exploitation of the bucket-wheel reclaimer with the belonging stacker. The analysis of the cause and level of damaging led to the conclusion that damaged parts should be replaced by new ones and that methodology of repair should be based on the application of a suitable welding technology. This paper presents the methodology of repair welding performed during the replacement of the damaged carrying structure and embedding of the rejecting drum of the stacker conveyor which consist of steel sheets and profiles that's based on the conceptual solution for damage repair through the use of program package 'Catia' – V5 that enabled the creation of models and graphic documentation of structural parts that should be replaced by new ones. It should also be noted that geodetic survey of the lower belt of the stacker structure was performed after the substitution of damaged parts of the structure.

Keywords: spreader, open pit surface mine, welded structure, damage, repair.

M. Arsić, S. Bulatović, M. Mladenović, Ž. Šarkočević, Z. Savić

BUCKET-WHEEL EXCAVATOR GEARBOX FAILURE ANALYSIS AND RELIABILITY ASSESSMENT

XXIII International Conference on material handling, constructions and logistics *MHCL19*, Vienna, Austria, 2019, 161-164.

This paper presents the analysis of failure causes and reliability assessment executed for the gearbox of the bucket-wheel excavator SRs 470.20/3 "TAKRAF" (produced by "Lauhhammer", Germany), which is engaged in overburden excavation at the surface mine 'Kostolac' (in Serbia). In order to determine during which phase the error was made (during the design process, production or exploitation), failure analyses and assessments of reliability have

been performed for gearbox elements through the use of Pareto analysis, FTA - Fault Tree Analysis, reliability allocation and failure intensity. For the calculation of reliability allocation and failure intensity an adequate program package was developed. Through the use of the above mentioned procedures data necessary for the identification of most important elements for the analysis regarding the maintenance process and failure prevention measures have been collected.

Keywords: bucket-wheel excavator, bucket-wheel drive gearbox, failure analysis, reliability.

M. Arsić., S. Bošnjak, V. Grabulov, D. Arsić, Z. Savić

PREDICTION OF SERVICE LIFE OF COMPONENTS AND STRUCTURES OF HYDRO POWER PLANTS DURING THE DESIGN, PROTOTYPING AND SERVICE PERIOD

International Conference on Accomplisments in Electrical and Mechanical Engineering and Information Technology *DEMI 2019*, Banja Luka, Bosnia and Herzegovina, 2019, CD, 183-188.

During the rehabilitation of turbine and hydromechanical equipment at hydro power plant 'Djerdap 1' results of tests and researches carried out in order to analyze the condition of vital components and structures during service led to the conclusion that the components and structures could be made only if parameters of fracture mechanics were applied during the design and prototyping phase, because by doing so the occurrence of fatigue fracture and/or degradation of parent material and welded joints due to variable loading, corrosion, erosion and cavitation would be prevented, therefore the integrity of material would be maintained. Experimental determination of the fatigue crack propagation rate as an important property of development of the fatigue process during the action of the variable load, from the initial to the critical length, enables the prediction of the stable crack propagation period, or in other words of the service life of vital components and structures of turbine and hydromechanical equipment. Taking into account the fact that cracks are most severe of all defects, the results obtained for cracks could safely be applied for other types of defects which often occur in welded joints. This paper contains the methodological approaches for the assessment of integrity and evaluation of service life of components and structures of turbine and hydromechanical equipment during the design,

prototyping and service period based on history of fatigue loading and application of fracture mechanics parameters.

Keywords: hydro power plant, fracture mechanics parameters, service life prediction.

S. Cvetkovski, V. Grabulov, N. Jashari

INVESTIGATION OF MICROSTRUCTURAL AND MECHANICAL PROPERTIES OF SUBMITTED WELDED PARTS - PULLING PIPES

10th International Scientific Professional Conference *Engineering Technologies in Manufacturing of Welded Constructions and Products SBW 2019*, Slavonski Brod, Croatia, 2019, CD, 275-282.

The results of investigations presented in this research work are result of the practical task performed for the welding company. The request for investigation was submitted as result of the existence suspection for using wrong material for production of welded parts.

Performed investigation had to confirm or deny this statement. And finally, if wrong filler and base material were used, could these welded parts satisfy in the exploratory conditions.

To answer these questions some basic investigations were performed: determination of chemical composition, tensile testing, hardness measurement and macro and micro metallography. Generally mechanical testing was much higher than required. But it was decided to replace wrong pieces and continue welding as was prescribed by the welding technology.

Keywords: Pulling pipe, P92 steel pipe, TIG welding, microstructure, hardness, forged part.

DOCTORAL DISSERTATIONS | **DOKTORSKE DISERTACIJE**

V. Aleksić

NISKOCIKLIČNI ZAMOR NISKOLEGIRANIH ČELIKA POVIŠENE ČVRSTOĆE

Univerzitet u Beogradu, Tehnološko-metalurški fakultet, Beograd, 2019.

Imajući u vidu heterogenost svojstava zavarenog spoja, a naročito uske zone pod uticajem toplote, u ovoj disertaciji je eksperimentalno ispitivano i analizirano ponašanje niskolegiranog čelika povišene čvrstoće (HSLA) u uslovima niskocikličnog zamora, na glatkim okruglim epruvetama iz osnovnog metala i epruvetama dobijenim termičkom simulacijom zone pod uticajem toplote. Takođe je ispitivano ponašanje osnovnog metala i simulirane zone pod uticajem toplote u uslovima dejstva kavitacije.

Čelik, Nionikral 70 (NN-70), odabran u ovoj disertaciji za istraživanje ponašanja pri zamornom opterećenju i dejstvu kavitacije, spada u grupu niskolegiranih čelika povišene čvrstoće koji se, između ostalog, primenjuju u brodogradnji kao i za izradu posuda pod pritiskom.

Ciljevi istraživanja su da se, u odsustvu pouzdanijih teorija o zamaranju i kavitaciji, pogodnom metodom ispitivanja, tj. simuliranjem strukture materijala i dejstva opterećenja odnosno deformacija, u laboratorijskim uslovima na odgovarajućim uzorcima - epruvetama, dođe do rezultata koji su posredno ili neposredno primenljivi u proračunima i da se dobijeni rezultati eventualno iskoriste i za fundamentalna proučavanja tokova procesa zamaranja i kavitacije kako osnovnog metala, tako i zone uticaja toplote zavarenih spojeva.

Ključne reči: niskolegirani čelici povišene čvrstoće, simulirana zona uticaja toplote, niskociklični zamor, stabilizovana histereza, zamorna prslina, kavitacija.

CERIF: T 450 Metal technology, Metallurgy, Metal Products.

ORGANIZATION
OF CONFERENCES

ORGANIZACIJA
STRUČNIH SKUPOVA

STRUČNI SKUP

NOVE TENDENCIJE U PROJEKTOVANJU, PROIZVODNJI I KONTROLI KVALITETA BETONA I BETONSKIH KONSTRUKCIJA

Beograd, Institut IMS, 17.4.2019.

Organizatori

Institut IMS Beograd

Društvo za ispitivanje i istraživanje materijala i konstrukcija Srbije

Susreti naučnika, stručnjaka i predstavnika privrede koji se bave problematikom materijala i konstrukcija se prevashodno organizuju u cilju razmene informacija i saradnje na područjima teorijskih i eksperimentalnih istraživanja, a posebno u segmentu metodologija ispitivanja i istraživanja koje se primenjuju na tim područjima.

Na ovom stručnom skupu su prezentovani stanje i perspektive u projektovanju betonskih konstrukcija i odredbe aktuelne regulative koja se odnosi na proizvodnju i kontrolu kvaliteta svežeg i očvrslog betona. Dužna pažnja je posvećena sanaciji betonskih konstrukcija.

Osnovne teme konferencije su:

1. Ocenjivanje in-situ čvrstoće pri pritisku betona ugrađenog u konstrukcije i prefabrikovane betonske elemente prema SRPS EN 13791:2008
2. Metode za ocenjivanje čvrstoće pri pritisku betona in-situ prema odredbama serije standarda SRPS EN 12504
3. Ispitivanje betonskih prefabrikovanih elemenata prema EN standardima
4. Sertifikacija fabričke kontrole proizvodnje betona u skladu sa SRPS EN 206:2017
5. Sanacija i zaštita betonskih konstrukcija u skladu sa standardom EN 1504
6. Projektovanje betonskih konstrukcija – stanje i perspektive
7. Metode ispitivanja svežeg betona prema odredbanma serije standarda SRPS EN12350
8. Metode ispitivanja očvrslog betona prema odredbanma serije standarda SRPS EN12390

OSMO MEĐUNARODNO NAUČNO-STRUČNO SAVETOVANJE GEOTEHNIČKI ASPEKTI GRAĐEVINARSTVA

Vrnjačka Banja, 13-15.11.2019.

Organizatori

Srpsko društvo za mehaniku tla i geotehničko inženjerstvo

Institut IMS Beograd

Opština Vrnjačka Banja

Bijenalna savetovanja o geotehničkim aspektima građevinarstva su redovno organizovana od 2005. godine. Uspešno održanih predhodnih sedam savetovanja podstaklo je organizatore da organizuju osmo savetovanje sa istom osnovnom tematikom. Raznolikost geotehničkih uslova u našoj zemlji i socio-ekonomski odnosi u društvu, kao i položaj naše zemlje u svetu tokom poslednjih dvadeset godina, doveli su do zaostajanja za razvijenijim zemljama sveta u oblasti građevinske geotehnike. Zbog toga postoji potreba da se rezimiraju dosadašnji rezultati i dostignuća u ovoj važnoj oblasti u širokom spektru segmenata i to od metoda primenjenih geotehničkih terenskih istražnih radova, laboratorijskih ispitivanja, primene savremenih teorijskih i numeričkih postupaka, metodologije analize i projektovanja, kao i u oblasti praktične građevinske operative. Očekuje se da se ovom prilikom razmene iskustva stručnjaka različitih profila i specijalnosti koji se bave geotehnikom kao što su: građevinski inženjeri - geotehničari, inženjerski geolozi, konstruktori, hidroinženjeri i inženjeri koji se bave saobraćajnicama.

Savetovanje treba da ukaže na orijentaciju glavnih pravaca razvoja ove struke koji bi odgovarali uslovima i potrebama u ovoj fazi izgradnje naše zemlje. Pored toga, to je prilika da se razmotri i stanje naše regulative u ovoj oblasti i potreba njenog usaglašaanja sa najnovijim dokumentima Evrokodova koji se od nedavno primenjuju u zemljama Evropske Unije.

Teme savetovanja

1. Normativi – tehnički propisi u građevinskoj geotehnici, EN i drugi standardi i preporuke
2. Geotehnika u projektovanju i izvođenju objekata infrastrukture
3. Geotehnički aspekti građenja u urbanim sredinama
4. Istražni radovi, karakteristike tla i stena, karakterizacija i klasifikacija terena
5. Modeli u geotehnici i numeričke metode
6. Opservacije i predviđanje sleganja i ponašanja objekata
7. Poboljšanje tla, armiranje, injektiranje, drenaže i drugo
8. Stabilnost kosina i klizišta
9. Hidrotehnički nasipi i brane
10. Duboki temelji - šipovi, dijafragme i druge tehnologije fundiranja
11. Geotehnika saobraćajnica: putevi, železnice i aerodromi
12. Deponije čvrstog otpada, ekološki aspekti geotehnike
13. Mikrozoniranje i seizmički rizik
14. Ostale teme

RESEARCH PROJECTS FINANCED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGICAL DEVELOPMENT

NAUČNI PROJEKTI FINANSIRANI OD STRANE MINISTARSTVA PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA

NAUČNI PROJEKTI
FINANSIRANI OD STRANE MINISTARSTVA PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA

	TEHNOLOŠKI RAZVOJ	
Ev. broj	**Naziv projekta**	
35002	Razvoj novih metodologija revitalizacje turbinske i hidromehaničke opreme hidroelektrana u zavisnosti od uzroka degradacije materijala	Dr Miodrag Arsić, rukovodilac projekta Dr Vencislav Grabulov Dr Zoran Odanović
36014	Geotehnički aspekti istraživanja i razvoja savremenih tehnologija građenja i sanacija deponija komunalnog otpada	Dr Nenad Šušić, rukovodilac projekta Dr Ksenija Đoković Dr Jelena Ćirilović Dr Mladen Ćosić
36017	Istraživanje mogućnosti primene otpadnih i recikliranih materijala u betonskim kompozitima, sa ocenom uticaja na životnu sredinu, u cilju promocije održivog građevinarstva u Srbiji	Dr Ksenija Janković Dr Dragan Bojović Dr Biljana Ilić Ljiljana Lončar Marko Stojanović
35011	Integritet opreme pod pritiskom pri istovremenom delovanju zamarajućeg opterećenja i temperature	Dr Dejan Momčilović Dr Vujadin Aleksić

35006	Održivost i unapređenje mašinskih sistema u energetici i transportu primenom forenzičkog inženjerstva, eko i robust dizajna	Dr Miodrag Arsić
35029	Razvoj metodologija za povećanje radne sposobnosti, pouzdanosti i energetske efikasnosti mašinskih sistema u energetici	Dr Dejan Momčilović
35040	Razvoj savremenih metoda dijagnostike i ispitivanja mašinskih struktura	Željko Flajs

	INTEGRALNA I INTERDISCIPLINARNA ISTRAŽIVANJA	
Ev. broj	**Naziv projekta**	
45008	Razvoj i primena multifunkcionalnih materijala na bazi domaćih sirovina modernizacijom tradicionalnih tehnologija	Dr Zagorka Radojević Dr Anja Terzić Dr Milica V. Vasić Dr Miloš Vasić Ljiljana Miličić Ivana Delić

	OSNOVNA ISTRAŽIVANJA	
Ev. broj	**Naziv projekta**	
172005	Uticaj nano i mikrostrukturnih konstituenata na sintezu i karakteristike savremenih kompozitnih materijala sa metalnom osnovom	Dr Zoran Odanović
172057	Usmerena sinteza, struktura i svojstva multifunkcionalnih materijala	Dr Anja Terzić

SELECTED
BUSINESS REFERENCES

ODABRANE
STRUČNE REFERENCE

U ovom odeljku dat je pregled ključnih usluga koje je Institut IMS izvršio u 2019. 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 oceni kvaliteta opekarskih sirovina sa različitih lokacija sa preporukama za primenu u proizvodnji crepa i blokova	DILJ d.o.o. Vinkovci, Hrvatska
2.	Elaborat o oceni kvaliteta opekarske sirovine sa lokacije Novo naselje sa preporukama receptura za primenu u ciglani u Molu kod Ade	GEOSTIM d.o.o. Beograd
3.	Elaborat o oceni kvaliteta opekarske sirovine sa lokacije Stalać sa preporukama receptura za primenu u ciglani IGM MLADOST, Leskovac, pogon u Stalaću	MLADOST, Leskovac, Pogon u Stalaću
4.	Elaborat o oceni kvaliteta opekarske sirovine sa lokacije Stražilovo sa preporukama receptura za primenu u ciglani PD AD POLET IGK, Novi Bečej, pogon Stražilovo, Sremski Karlovci	PD AD POLET IGK, Novi Bečej, Pogon Stražilovo, Sremski Karlovci
5.	Elaborat o oceni kvaliteta opekarske sirovine sa ležišta koje eksploatiše Tvornica opeke Sarajevo sa preporukama receptura za primenu u proizvodnji termo blokova	Tvornica opeke doo, Sarajevo, BiH
6.	Elaborat o oceni kvaliteta keramičkih glina sa ležišta Gornje Crniljevo i preporukama za primenu u proizvodnji keramičkih pločica	B.P.A. MAUMAN d.o.o. Šabac
7.	Elaborat o oceni kvaliteta opekarske sirovine sa ležišta Jabuka – Skrobara 2 kod Pančeva	OM COMPANY d.o.o. Novi Beograd


11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

	Laboratorija za beton	
R.b.	**Referenca**	**Investitor**
1.	Završne ocene kvaliteta betona za objekte izvedene u Srbiji za firmu Širbegović grupa – GMT Konstrukcije, Gračanica, BiH	Širbegović Inženjering, Gračanica, BiH
2.	Nezavisna kontrolna ispitivanja za betonske radove, Koridor X	Ogranak Aktor A.T.E., Beograd
3.	Tekuća kontrola kvaliteta betona na gradilištu: Autoput E-763, deo 3:Obrenovac –Ub	China Shandong International Economic & Technical, Ogranak Beograd,
4.	Kontrola kvaliteta materijala na građevinskom objektu: izgradnja autoputa E-75, deonica LOT 3 – tunel Predejane i LOT 4 – TUNEL Manajle	Euro Alliance Tunnels JSC, Ogranak Beograd
5.	Kontrola kvaliteta na deonici autoputa E-75 Grdelica – Caričina Dolina	Azvi S.A. Ogranak Novi Sad
6.	Angažovanje laboratorije za beton na poslovima vršenja kontrole kvaliteta materijala na izgradnji Autoputa E-763, deonica Surčin – Obrenovac	DEVIX, Lazarevac
7.	LOT B3.2 Izgradnja Ostružničkog mosta u konzorcijumu sa UTIBER, Mađarska	JP Putevi Srbije, Beograd
8.	Završne ocene kvaliteta betona za objekte izvedene u Srbiji za firmu Baupartner, Lukavac, BiH	Baupartner, Lukavac, BIH

9.	Nezavisna laboratorija za ispitivanje betona na izgradnji Auto-putnog pravca E-75, Deonica: Grdelica(gornje Polje) – Caričina Dolina, LOT2: Put i mostovi od Tunela Predejane do Caričine Doline	TRACE GROUP HOLD PLC, Ogranak Beograd
10.	Ispitivanje betona na mostu preko reke Save od stacionaže km22+516 do km 24+097	China communications Construction Company LTD. Ogranak Beograd
11.	Studija primenljivosti upotrebljenih agregata za spravljanje betona sa cementom CEM II/A-L 42.5 R, CRH	CRH (Srbija), Popovac
12.	Tekuća kontrola kvaliteta betonskih radova na izgradnji mostova na deonici Auto-puta Surčin – Obrenovac	Freyssinet, Ogranak Beograd
13.	Izvođenje radova na izgradnji brane i akumulacije Arilje – profil Svračkovo	Hidrotehnika – Hidroenergetika, Beograd
14.	Vršenje stručnog nadzora za kontrolu projekata i izvođenje građevinskih radova na obilaznici oko Beograda, sektori 4, 5 i 6	JP Putevi Srbije, Beograd
15.	Nezavisna laboratorijska kontrola kvaliteta betona prilokom izvođenja građevinskih radova na izgradnji Autoputa E-75, LOT 1-Put i mostovi od Grdelice do tunela Predejane	Integral Inženjering, Niš
16.	Kontrola kvaliteta betona na fabrici tokom izvođenja radova na deonicama autoputa E-75 LOT 6 i tunela Manajle i Predejane	5D, Vranje

17.	Uzorkovanje, ispitivanje i koordinacija na izgradnji objekata za organe bezbednosti u Vranju	Tasyapi Insaat Taahhut Sanayi Ve Ticaret A.S. Ogranak Beograd
18.	Kontrola kvaliteta betona na rekonstrukciji ulica 27. marta, Kraljice Natalije, Džordža Vašingtona i Cara Dušana	Bauwesen, Lazarevac
19.	Kontrola kvaliteta materijala na izgradnji objekta Kula Beograd St. Regis, BW u Beogradu	Pizzaroti Millennium, Beograd

THE CENTRE
FOR METALS
AND ENERGETICS

CENTAR
ZA METALE
I ENERGETIKU

CENTAR ZA METALE I ENERGETIKU

Laboratorija za ispitivanje metala,
Kontrolno telo,
Laboratorija za etaloniranje mehaničkih veličina

R.b.	Referenca	Investitor
1.	Superkontrola nad izvođenjem radova na transmisionom gasovodu (interkonektor) granica Bugarske – granica Mađarske na teritoriji republike Srbije	Bureau Veritas d.o.o. Beograd
2.	Fabrički prijem opreme od strane instituta pri izradi i sanaciji delova hidroagregata u fabrikama LMZ, Silovie Mašini, Rusija	JP EPS Beograd, Ogranak HE Đerdap, HE Đerdap 1, Kladovo
3.	Prijemna kontrola opreme i tehnički nadzor u kapitalnom remontu B2 u TE Kostolac B	JP EPS Beograd, Ogranak TE KO Kostolac
4.	Ispitivanje mašinske opreme	JP EPS Beograd, Ogranak HE Đerdap, HE Đerdap 1, Kladovo
5.	Ispitivanje opreme za potrebe revitalizacije HE Đerdap 2	JP EPS Beograd
6.	Ispitivanje opreme bez razaranja HMO – HE PIROT, HE Vlasina	JP EPS Beograd, Ogranak HE Đerdap, Kladovo
7.	Ispitivanje glavnih parovodnih linija RA, RB i RC i ispitivanje prestrujnih parovoda metodama bez razaranja za 2019. god. TENT A, blokovi A1 i A2	JP EPS Beograd, Ogranak TE Nikola Tesla A, Obrenovac

8.	Ispitivanje turbinske opreme Ispitivanje NDT metodama (lopatice, vretena, ležajevi, ...) za remont 2019. god., blokovi A1 i A2	JP EPS BEOGRAD, Ogranak TE Nikola Tesla A, Obrenovac
9.	Ispitivanje metala sa i bez razaranja	JP EPS BEOGRAD Ogranak TE KO Kostolac
10.	Ispitivanje preostalog radnog veka ventila koji rade u kritičnim uslovima – TENT A	JP EPS BEOGRAD Ogranak TE Nikola Tesla A, Obrenovac
11.	Ispitivanje hemijskog sastava i mehaničkih osobina materijala	Thyssenkrupp Materials d.o.o. Inđija Proleter a.d. Metalska industrija, Arilje Paffoni d.o.o. Mladenovac Manet d.o.o. Beograd Aqua Mont Service d.o.o. Beograd KRONOS SRB, Lapovo RD Dijagnostika, Beograd AZVI S.A., Beograd Kolubara Metal, Lazarevac TE KO Kostolac Izoprogres, Beograd Tehnorad, Valjevo

12.	Sertifikacija betonskog čelika	KÜRÜM International Sh.A.Ish Kombinati Metalurgjik Elbasan, Albania Trgovir d.o.o. Gračanica, BIH Arcelor Mittal, Zenica, BIH Alsiko d.o.o. Beograd Ferriere Nord, Udine, Italija Metalfer Steel Mill, Sremska Mitrovica Armako, Prnjavor
13.	Ispitivanje mehaničko-tehnoloških osobina vijaka, navrtki i podloški	Markant, Valjevo DIV betonski pragovi, Svrljig TVIK DIV, Valjevo Kolektor Etra, Beograd Dunex, Beograd

14.	Ispitivanja proizvoda od gvožđa i čelika (armatura, užad za prednaprezanje, cevi...)	Ogranak Terna S.A. Serbia, Beograd JP za podzemnu eksploataciju uglja, Resavica Aktor A.T.E, Ogranak Beograd AD Putevi, Užice BEMAX, Podgorica, Crna Gora ASA IBELIK, Beograd Rudnik olova i cinka Veliki Majdan, Ljubovija
15.	Etaloniranje uređaja za merenje mehaničkih veličina	EPS Beograd, Ogranak RB Kolubara, Poliester, Priboj Lafarge BFC, Beočin AZVI S.A. Beograd, Železara Smederevo, JAT Tehnika, Beograd, Lasta, Beograd, Energoprojekt Niskogradnja, Beograd ELITA – COP d.o.o. Beograd Hemofarm a.d. Vršac GP Mostogradnja a.d. Beograd


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THE CENTRE
FOR ROADS
AND GEOTECHNICS

CENTAR
ZA PUTEVE
I GEOTEHNIKU

CENTAR ZA PUTEVE I GEOTEHNIKU

	Odeljenje za geotehniku	
R.b.	**Referenca**	**Investitor**
	Dinamičko ispitivanje šipova metodom DLT	
1.	Mostovi na autoputu E-763, obilaznica oko Beograda, deonica Surčin – Obrenovac	Unogradnja Westgradnja
2.	Postrojenje za sinterovanje u okviru Železare Smederevo	LHR d.o.o.
3.	Izgradnja Vijadukta Donja Gračanica, BIH	Univerzitet Džemal Bijedić, Građevinski fakultet u Mostaru
4.	Sakura park u Novom Beogradu	Goldberg Real Estate d.o.o.
5.	Termoeletrana Toplana Pančevo, faza 1 i 2	China Energy

	Ispitivanje integriteta šipova metodom SIT	
1.	Vijadukt na km 59+159 za potrebe izgradnje brze pruge Beograd – Stara Pazova – Novi Sad – Subotica – državna granica	Karin Komerc MD
2.	Vetrogeneratori u Izbištu	Prenecon
3.	Na Koridoru 10	Integral Inženjering Aktor
4.	Mostovi na autoputu E-763, obilaznica oko Beograda, na deonici Surčin – Obrenovac	Unogradnja
5.	Autoput Bar – Boljare	ABG Test
6.	Most između tunela Lipak i Železnik	Azvirt Ogranak Beograd
7.	Postrojenje za sinterovanje u okviru Železare Smederevo	LHR doo
8.	Termoeletrana Toplana Pančevo, faza 1 i 2	China Energy
9.	Mostovi na levoj traci državnog puta Ia reda A1 i A3 (7-70/E-75), deonica Dobanovci – Bubanj potok	Power Construction Corporation of China
10.	Most na Begeju, u sklopu izgradnje obilaznog puta oko Zrenjanina	Bauwesen d.o.o.
11.	Institut za kardiovaskularne bolesti Dedinje	WD Concord West d.o.o.
12.	Izgradnja Vijadukta Donja Gračanica, BIH	Univerzitet Džemal Bijedić Građevinski fakultet u Mostaru, Euroasfalt Sarajevo

	Statičko ispitivanje šipova - SLT metoda	
1.	Vijadukt na km 59+159 za potrebe izgradnje brze pruge Beograd – Stara Pazova – Novi Sad – Subotica – državna granica	Karin Komerc MD, Mostogradnja, Starting, Ingrap Omni
2.	Institut za kardiovaskularne bolesti Dedinje	WD Concord West d.o.o.
3.	Postrojenje za sinterovanje u okviru Železare Smederevo	LHR doo
4.	Postrojenje za ODG Nikola Tesla A, Obrenovac	MPP Jedinstvo
5.	Termoeletrana Toplana Pančevo, faza 1 i 2	China Energy

4.	**Geotehnički elaborati**	
	Geotehnički Elaborat za potrebe dogradnje proizvodne hale za proizvodnju mesinganih elemenata spratnosti (SU+P) na kat. parceli 9836/38 K.O. Užice	PRVI PARTIZAN a.d.
	Tehnička dokumentacija za potrebe utvrđivanja i digitalizaciju stanja stabilnosti kamenih putnih kosina u zasecima i usecima u zoni državnog puta IB-34, deonica: Golubac – Brana HE Đerdap I, km: 55+922 – km: 164+024, ukupne dužine L=109 km Đerdapska magistrala), za celine LOT 1 – LOT 7	JP Putevi Srbije
	Geotehnički Elaborat o uslovima fundiranja pešačkog mosta preko reke Đetinje, od magistralnog puta M-19/1 do Starog grada u Užicu	UŽICE RAZVOJ
	Projekat inženjerskogeoloških istraživanja za potrebe formiranja tehničke dokumentacije za izvođenje radova na izgradnji saobraćajnice i javnih površina sa infrastrukturom na području priobalja reke save u granici projekta Beograd Na Vodi, Novi Beograd: Faza – Bulevar Zorana Đinđića, l ≈ 435 m Faza – ulica Vladimira Popovića, l ≈ 650 m	Grad Beograd Gradska uprava
	Izvođenje istražnih radova u svrhu ocene stanja autoputa E-763, Beograd – Požega, Sektor I: Beograd – Ljig, deonica IV: Ub – Lajkovac, od km 40+645,28 do km 53-139,91	Saobraćajni institut CIP

5.	**Projekti sanacije klizišta**	
	Projektno-tehnička dokumentacija za sanaciju klizišta Pecka 2, na državnom putu IIA-143, deonica puta br. 14301, Pričević – Pecka, km: 21+294,00	PZP VALJEVO
	Projektno-tehnička dokumentacija sanacije klizišta na državnom putu IB-21, deonica puta br. 02126, Valjevo (Brežđe) – Kaona, km: 142+085	PZP VALJEVO
	Projektno - tehnička dokumentacija za sanaciju oštećenja kolovoza i nasipa trupa puta na državnom putu IB-21, deonica puta br. 02117, Draginje (Kamenica) – Koceljeva, km: 98+050 – km: 98+200	PZP VALJEVO
	Projektno-tehnička dokumentacija sanacije klizišta na državnom putu IIA-227, deonica puta br. 22706, Vlase – petlja Vranje jug, km: 58+700	SRBIJAPUT a.d.
	Projektno-tehnička dokumentacija sanacije klizišta na državnom putu IIA-227, deonica puta br. 22706, Vlase – petlja Vranje jug, km: 53+100	SRBIJAPUT a.d.
	Izvođenje istražnih radova i izrada projekta sanacije oštećenja na autoputu E-763 Beograd – Požega, sektor 1	PANPRO TEAM d.o.o.

THE CENTRE FOR
STRUCTURES
AND PRESTRESSING

CENTAR ZA
KONSTRUKCIJE
I PREDNAPREZANJE

CENTAR ZA KONSTRUKCIJE I PREDNAPREZANJE

	Odeljenje za prednaprezanje	
R.b.	**Referenca**	**Investitor**
1.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju prilazne konstrukcije desne obale (polja od S6 do D3) mosta preko reke Save kod Ostružnice, na autoputu E70/E75: Dobanovci – Bubanj Potok, Obilaznica oko Beograda	Strabag d.o.o Beograd Udarnik Gradnja d.o.o. Beograd
2.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju konstrukcije za statičko ispitivanje šipova na Vijaduktu Čortanovci i Vijaduktu Beška, projekat izgradnje železničke pruge Beograd – Budimpešta	Karin Komerc d.o.o. Veternik
3.	Inženjerig usluge prilikom bušenja, ugradnje, injektiranja i prednaprezanja geotehničkih sidara i testiranje nosivosti geotehničkih sidara za potrebe stabilizacije kosine, na autoputu E-75, deonica Gornje polje – Tunel Predejane, LOT 1, usek 5, usek 2	Integral Inženjering Ogranak Niš
4.	Inženjerig usluge prilikom prednaprezanja geotehničkih sidara i ispitivanje geotehničkih sidara, za potrebe stabilizacije kosina i potpornih zidova na autoputa E-75, deonica Gornje Polje – Caričina dolina, LOT 2	TRACE GROUP HOLD PLC Ogranak Beograd F. HYČA S.R.O. MAKS PRO d.o.o. Zemun

5.	Inženjerig usluge prilikom prednaprezanja geotehničkih sidara i ispitivanje geotehničkih sidara, za potrebe stabilizacije kosina na autoputu E-75, deonica Gornje polje – Tunel Predejane, LOT 1, usek 2, 3 i 4	AZVI S.A. Ogranak Novi Sad
6.	Testiranje nosivosti geotehničkih sidara i prednaprezanje geotehničkih sidara na potpornoj konstrukciji Useka 23, na autoputu E-80 Niš – Dimitrovgrad, lot 2: Bancarevo – Crvena Reka	AKTOR A.T.E. Ogranak Beograd
7.	Testiranje nosivosti geotehničkih sidara i prednaprezanje geotehničkih sidara na AB potpornom zidu za potrebe statičkog frekventnog pretvarača – treća faza, na RHE Bajina Bašta	Hidrotehnika – Hidroenergetika a.d. Beograd
8.	Testiranje nosivosti geotehničkih sidara i prednaprezanje geotehničkih sidara za potrebe izgradnje MNE Pavlica na reci Ibar kod Raške	HIDRO TAN d.o.o. Beograd
9.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju mosta preko Podrvške reke, na državnom puti IB reda br. 35, deonica Milutinovac – Brza Palanka	INGRAP-OMNI d.o.o Beograd
10.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju mosta br. 9, na km 580+401 – leva traka, na autoputu E70/E75 – obilaznica oko Beograda – deonica Dobanovci – Bubanj Potok	ASA IBELIK d.o.o Beograd FERBILD d.o.o. Beograd
11.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju mosta preko reke Ibar kod Raške	GPD Nikolić d.o.o. Kraljevo

12.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju drumsko-pešačkog mosta preko Mijajlovačke reke u Medveđi kod Kruševca	GPD Nikolić d.o.o. Kraljevo
13.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju mosta na km 0+252 industrijskog koloseka na kompleksu nove luke Smederevo.	STRABAG d.o.o. Beograd
14.	Primena sistema prednaprezanja SPB i SPB SUPER i radovi na prednaprezanju mosta na Banjskoj reci u Novom Pazaru, na državnom putu IB reda Raška – Novi Pazar	Novi Pazar - Put d.o.o. Novi Pazar
15.	Specijalistički stručni nadzor rada pogona za adheziono prednaprezanje elemenata Martini Gradnja	Martini Gradnja d.o.o. Inđija

	Odeljenje za projektovanje, nadzor i sanacije	
R.b.	**Referenca**	**Investitor**
1.	Izveštaj o redovnom pregledu stanja mostova na teritoriji 17 gradskih opština, partija 1	JP Putevi Beograd
2.	Veštačenje po predmetu P1716/15 Osnovnog suda u Kotoru	Osnovni sud u Kotoru
3.	Vršenje stručnog nadzora na izgradnji tri objekta u sklopu sajamskog kompleksa	DP Beogradski Sajam
4.	Elaborat o stanju konstrukcije objekta Muzej grada Beograda, Resavska 40b	Grad Beograd, Sekretarijat za investicije
5.	Projekat sanacije konstrukcije objekta Dom vazduhoplovstva u Zemunu	Zavod za zaštitu spomenika kulture grada Beograda
6.	Izveštaj o ekspertizi građevinske konstrukcije na seriji S300 u sklopu rafinerije Pančevo.	NIS a.d. Novi Sad
7.	Tehnički izveštaj o stanju kolektora u Karađorđevoj ulici u Beogradu	Bauwesen d.o.o. Lazarevac

	Laboratorija za ispitivanje konstrukcija	
R.b.	**Referenca**	**Investitor**
1.	Specijalni pregled mosta preko reke Dunav na državnom putu IB reda br. 14, deonica: Smederevo – Kovin	JP Putevi Srbije
2.	Ispitivanje probnim opterećenjem drumskog mosta – Nadvožnjak u ulici Zelena gora u Kraljevu	ŽGP GP Beograd
3.	Ispitivanje stenskih ankera probnim opterećenjem na Obilaznici Beograd, tunel Straževica	Power Construction Coorporation of China Limited Ogranak Beograd

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 ad 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) i 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).

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

Registar izdatih sertifikata: http://www.institutims.rs/sertifikacija/registar.html

R.b.	Referenca	Investitor
1.	Sertifikacija cementa	Lafarge BFC d.o.o., Beočin CRH (Srbija) d.o.o., Popovac Titan cementara Kosjerić d.o.o., Kosjerić NAŠICECEMENT d.d., Našice, Hrvatska CEMEX Hrvatska d.d., Kaštel Sućurac, Hrvatska FUSHE KRUJE CEMENT FACTORY SH.P.K., Albanija TRAÇIM ÇIMENTO SANAYI VE TICARET A. Ş., Turska TITAN CEMENTARNICA USJE a.d., Skopje, Severna Makedonija FABRIKA CEMENTA LUKAVAC d.d., Lukavac, BIH Tvornica cementa Kakanj d.d., Kakanj, BIH

2.	Sertifikacija dodataka betonu	SIKA SRBIJA d.o.o., Šimanovci, ADING a.d., Skopje, Severna Makedonija TKK Proizvodnja kemičnih izdelkov d.o.o., Srpenica, Slovenija BASF Construction Chemicals Italia Spa, Treviso, Italija ISOMAT d.o.o., Šimanovci, Srbija BT3 Betontechnik GmbH, Theresienfeld, Austria MC - BAUCHEMIE MÜLLER, GmbH & Co. KG, Bottrop, Nemačka
3.	Sertifikacija čelika za armiranje betona	METALFER STEEL MILL d.o.o., Sremska Mitrovica ALSIKO d.o.o., Beograd KOMERC MALI d.o.o., Prnjavor, BIH ArcelorMittal Zenica d.o.o., Zenica, BIH Armako d.o.o., Prnjavor, BIH FERRIERE NORD S.p.A., Udine, Italija ÇOLAKOĞLU METALURJI A.Ş, Istanbul, Turska SIDENOR STEEL INDYSTRY S.A., Thessaloniki, Grčka SOVEL HELLENIC STEEL PROCESSING COMPANY S.A, Almyros, Greece DOJRAN STEEL DOOEL, Dojran, Severna Makedonija DUCTIL STEEL, Rumunija

CONTROL BODY | **KONTROLNO TELO**

KONTROLNO TELO INSTITUTA IMS

Akreditacija kontrolnog tela obuhvata oblasti kontrolisanja koje se sprovode u Centru za metale i energetiku:

Kontrolisanje posuda pod pritiskom i cevovoda prema Pravilniku o tehničkim zahtevima za projektovanje, izradu i ocenjivanje usaglašenosti opreme pod pritiskom (Sl. glasnik RS 87/2011) – modula B i F .

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 delova postrojenja i objekata pri izgradnji, rekonstrukciji, revitalizaciji i remontu (procesnih, hidroenergetskih, termoenergetskih, turboenergetskih postrojenja, hidromašinske i hidromehaničke opreme).

Kontrolisanje tehnologija zavarivanja metalnih materijala (elektrolučno zavarivanje, gasno zavarivanje, elektrootporno zavarivanje, navarivanje).

Kontrolno telo		
R.b.	**Referenca**	**Investitor**
1.	Superkontrola nad izvođenjem radova na transmisionom gasovodu (interkonektor) granica Bugarske – granica Mađarske na teritoriji republike Srbije	Bureau Veritas d.o.o. Beograd
2.	Fabrički prijem opreme od strane instituta pri izradi i sanaciji delova hidroagregata u fabrici LMZ, Silovie Mašini, Rusija	JP EPS Beograd, Ogranak HE Đerdap, HE Đerdap 1, Kladovo
3.	Prijemna kontrola opreme i tehnički nadzor u kapitalnom remontu B2 u TE Kostolac B	JP EPS Beograd, Ogranak TE KO Kostolac
4.	Specijalna ispitivanja i ekspertize materijala u TE Kostolac B	JP EPS Beograd, Ogranak TE KO Kostolac

PT PROVIDER | **PT PROVAJDER**

PIMS - PROVAJDER ZA ISPITIVANJE OSPOSOBLJENOSTI INSTITUT IMS

Provajder za ispitivanje osposobljenosti Institut IMS (PIMS) tokom 2019. godine realizuje 14 šema ispitivanja osposobljenosti ispitnih laboratorija (ocenu njihove kompetentnosti), sa predmetima ispitivanja prikazanih tabelom. Učešće u realizaciji ovih šema uzelo je 179 učesnika iz 33 zemlje Evrope, Azije i Afrike.

Od 11.01.2018. godine PIMS se nalazi na EPTIS kalendaru i bazi podataka svetskih PT Provajdera.

Provajder Institut IMS je od 05.12.2018. godine akreditovan od strane Akreditacionog tela Srbije u skladu sa referentnim standardom SRPS ISO 17043:2011, pod brojem 09-001.

R.b.	Predmet ispitivanja osposobljenosti	Broj učesnika
1.	Cement	
	ciklus hemijskih svojstava	12
	ciklus fizičko-mehaničkih svojstava	27
2.	Kameni agregat	
	ciklus fizičkih i mehaničkih svojstava	16
	ciklus fizičkih svojstava (u toku)	21
3.	Bitumen	
	ciklus fizičkih svojstava	16
4.	Buka	
	ciklus u zatvorenom prostoru	8
	ciklus na otvorenom prostoru	23
	ciklus u radnoj sredini	7
	ciklus nivo zvučne snage	12
5.	Toplotni izolatori u zgradarstvu	
	ciklus fizičkih svojstava	7
6.	Elementi za zidanje od gline	
	ciklus fizičkih svojstava (u toku)	5
7.	Energetska efikasnost	
	ciklus vazdušna propustljivost stana	10

8.	Keramičke pločice ciklus fizičkih svojstava	6
9.	Vrata i prozori ciklus fizičkih svojstava (u toku)	9
	Ukupno:	179