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Editor-in-Chief
Diana Bajare, Dr. sc. ing., Professor, Riga Technical University
diana.bajare@rtu.lv

Secretaries:
Laura Vitola, Mg. sc. ing., Riga Technical University
laura.vitola_1@rtu.lv
Daira Erdmane, Mg. soc., Riga Technical University
daira.erdmane@rtu.lv

Contacts:
Faculty of Civil Engineering
Riga Technical University
6A Kipsalas Str.
LV-1658, Riga, Latvia
Phone: +371 67089123
E-mail: imst.conference@gmail.com

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Chairman of Local Organizing Committee:
Bajare Diana, Dr. sc. ing., Professor, Riga Technical University
diana.bajare@rtu.lv

The 4th International Conference on Innovative Materials, Structures and Technologies (IMST 2019) takes place on 25-27 September 2019 in Riga, Latvia. The conference is organised by the Faculty of Civil Engineering of the Riga Technical University in cooperation with Brno University of Technology in Czech Republic. Following the established tradition, the aim of the conference is to promote and discuss the latest results of industrial and academic research carried out in the following engineering fields: analysis and design of advanced structures and buildings; innovative, ecological and energy efficient building materials; inspection, assessment and monitoring methods; construction technology and project management; sustainable and safe transport infrastructure; waste management; civil engineering education and BIM.
The conference provides an excellent opportunity for researchers, representatives of the industrial community, engineers, managers and students to share the latest achievements, discuss recent advances and highlight the current challenges. IMST 2019 attracts over 120 scientists from 22 countries. After rigorous reviewing, over 70 technical papers are accepted for publication in the conference proceedings. On behalf of the organizing committee I would like to thank all the speakers, authors, session chairs and reviewers for their efficient and timely effort.

Finally, I would like to thank all those who helped to make this event happen. Special thanks go to prof. Diana Bajare, Daira Toma and Laura Vitola for their major contribution to organizing the conference.

Dr. Sandris Rucevskis
Chairman of International Scientific Committee
Faculty of Civil Engineering
Riga Technical University

Dear participants!

In 2019, the Faculty of Civil Engineering can proudly reflect on hundred and fifty six years of its work. In the long period of more than one and a half century names of the countries and the language of industry standards have changed, but the essence of education has remained the same – to educate and train knowledgeable specialists for the construction industry, who, literally speaking, are building Latvia. We can be proud of our alumni, who have taken part in the implementation of every important construction project in Latvia.

Our conference is offering a wide spectrum of interrelated topics that illustrates the achievements of construction science. I would like to wish all participants interesting presentations and fruitful discussions.

Juris Smirnovs
Dean of Faculty of Civil Engineering

The innovation-driven economy should be priority on the Baltic states. The greatest innovation is to find ways how to convert knowledge generated in the universities into high-value technologies and products to serve society needs. EIT is proposing an unique way by capitalising on human resources in universities. The leading universities of the Baltic states cooperate closely with EIT by establishing hubs in climate technology, health and food domains. This year RTU, KTU and TalTech has agreed to work together in areas of raw materials to add value to waste generated from industry. We will focus on joint engagement of students in business development, promoting cooperation between industry and universities, and supporting doctoral students.

I am looking forward to this conference and Raw Material endeavours in general as we expect this initiative will allow to facilitate the development of new high-tech industries in the Baltics region.

Talis Juhna
RTU Vice-rector for research

As a part of the EIT Regional Innovation Scheme (RIS), EIT RawMaterials will focus mostly on those EU regions where there is a natural opportunity for the raw materials sector activity (primarily driven by endowment of primary and secondary raw materials). Our strategy for delivering maximum impact in the Baltic Countries is aligned with the EIT RawMaterials overall RIS Strategy. The main actions include:
Engage key partners in the Baltic countries to enable outreach to the local stakeholders;
Carry out activities in Innovation and Education with Partners in the Baltic countries;
Grow participation from non-partners (and potential partners) from the Baltic region by securing a strong presence and targeted outreach;
Engage idea holders, entrepreneurs and start-up's from the Baltic countries into Business Creation and Support programs offered by EIT RawMaterials.

To further support the development of innovation capacity in the Baltic region, EIT RawMaterials has decided to open a new regional innovation centre - the RIS Hub Baltic. This Hub aims to invigorate and mobilize the stakeholders in the Baltic Countries (Estonia, Latvia, Lithuania) to be engaged in EIT RawMaterials' activities. We particularly see that the modest participation rate in current activities is not revealing the true potential of these countries in innovation activities. The Hub activities focus on student entrepreneurship training (especially PhD), technology transfer from research to commercialization, and support of early stage or emerging start-ups in the raw materials sector. The founding partners of the Hub are three universities: Riga Technical University (RTU), Kaunas University of Technology (KTU) and TalTech, all partners of EIT RawMaterials. The Hub is coordinated out of RTU in Riga, where also a small office space will be established for the Hub activities. In its initial phase, the Hub focuses on four key activities: Marketing and Communication, PhD Summer School, Technology Transfer Conference, and a pre-accelerator (jointly with the EIT RawMaterials JumpStarter where applicable).

Dr. Olli Salmi
Managing Director
EIT RawMaterials Baltic Sea Innovation Hub CLC

eit | RawMaterials Hub
Regional Center Baltic

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EFFECT OF MODIFIED LIQUID GLASS ON ABSORPTION HUMIDITY AND THERMAL CONDUCTIVITY OF FLAX FIBER SLABS

SERGEI ROMANOVSKIY, ALIAXANDR BAKATOVICH

Department of Construction Industry, Polotsk State University, Novopolotsk, Belarus
E-mail: s.romanovskiy@psu.by

Thermal insulation materials based on vegetable fibers are considered. The results of studies on the microstructure of flax fiber noils using a light microscope and flax fibers using electron microscopy are presented. A complex of studies on the selection of the composition of thermal insulation slabs from flax fibers and flax noils has been conducted to determine the process of absorption of humidity from the air. The humidity absorption of insulants based on flax fibers and flax noils has been determined at a relative humidity of 40 – 97 % using sodium liquid glass, and modified liquid glass, as well as «Akotherm flaks» slabs. The thermal insulation slabs water vapor absorption kinetics has also been investigated, taking into account the time parameter. The effect of absorption humidity on the thermal conductivity of the studied materials has been examined; for this purpose, the coefficients of thermal conductivity of materials with the maximum humidity content of insulators were determined. The results of the tests indicate the highest efficiency of thermal insulation slabs made of flax fiber tow compared with insulation materials based on flax fibers and «Akotherm flaks» slabs.

CONDUCTIVE EPOXY POLYMER COMPOSITES FILLED WITH CARBON NANOTUBES

EVGENI OVODOK[1], SERGEY POZNYAK[1], HANNA MALTANAVA[1], VLADIMIR KURILO[2], ANDREY ANISKEVICH[3]

[1]Research Institute for Physical Chemical Problems, Belarusian State University, Minsk, Belarus
[2]Belarusian State University, Minsk, Belarus
[3]University of Latvia, Riga, Latvia
E-mail: ovodok@bsu.by

Conductive nanofiller/polymer composites have been widely investigated in academia and industry because of their outstanding multifunctional properties compared to conventional conductive polymer materials [1]. The present work is focused on preparation of epoxy based polymer composites filled with carbon nanotubes and characterization of their conductivity and electromagnetic interference shielding efficiency (EMI SE).

The epoxy resin Biresin CR122 and hardener CH122-5 were provided by SIKA. Multiwall carbon nanotubes (MCNTs) NC7000™, which have an average diameter of 9.5 nm and an average length of 1.5 μm. were supplied by Nanocyl S.A. (Belgium). MCNTs were dispersed in the epoxy resin by two methods. According to the first method, the as-received MCNTs were mechanically dispersed directly in the epoxy resin without any pre-treatment. In the second method, the MCNTs were preliminarily dispersed in hexane by sonication. Then, the obtained dispersion was mixed with epoxy resin and the MCNTs were spontaneously transferred from hexane phase into the epoxy resin. After removing the residual hexane under vacuum, a hardener was added during mechanical stirring, and the composite was cured further at room temperature overnight. The electrical conductivity of the epoxy/MCNTs composites was measured on cylindrical samples by standard two-point contact method. Thin films with an average thickness of 120 μm were prepared by casting blade method for EMI SE measurements. The EMI shielding efficiency was measured with an Agilent 8722ET transmission/reflection network analyser at 10 GHz.

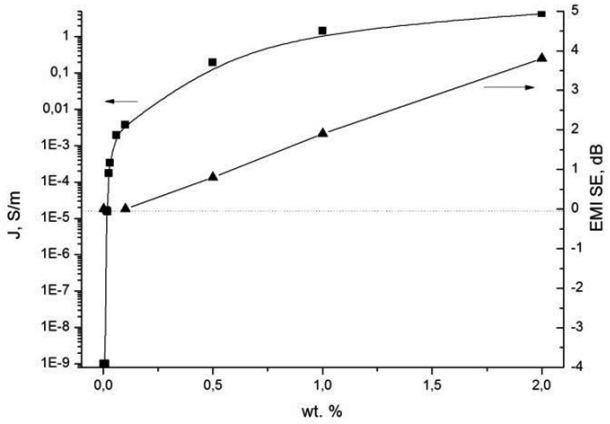

Fig. 1. Conductivity and EMI SE of the epoxy based composite filled with different amount of split MCNTs

Electrical conductivity study showed that the percolation threshold for the composite prepared by second method was 0.013 wt. % (Fig. 1). At the same time, the composite with 0.5 wt. % of MCNTs prepared by first method is characterized by a very low electrical conductivity (about 1.4×10^{-6} S/m). The dispersion of the MCNTs directly in the epoxy resin does not allow splitting the MCNTs agglomerates. As a result, the absence of continuous percolating CNT network leads to a low electrical conductivity. Predispersion of the MCNTs by sonication in hexane results in swelling and splitting of the MCNTs agglomerates. The prepared epoxy composites with split MCNTs are characterized by a uniform distribution of the MCNTs and their excellent connection with each other, forming an efficient conducting pathway for electron transport in the epoxy matrix. EMI shielding efficiency measurements showed that thin film composite samples with split MCNTs absorb electromagnetic waves (10 GHz) when the MCNTs loading was higher than 0.1 wt. % (Fig. 1). A rise of the content of MCNTs in the composite leads to a proportional increase in the EMI SE. Thin composite films with 2 wt. % MCNTs are characterized by EMI SE of 3.8 dB.

Epoxy based composites with a uniform distribution of the MCNTs were prepared. It was shown that pre-dispersion of the MCNTs in hexane allows creating an efficient conductive network within the polymer matrix with a lower content of the MCNTs. Percolation threshold for these composites was 0.013 wt. % of the MCNTs. 120 μm thick films of the composite with 2 wt. % of the MCNTs demonstrated EMI shielding efficiency of 3.8 dB measured at 10 GHz.

Acknowledgments

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OCCURRENCES IN CZECH RAILWAY INFRASTRUCTURE AND THEIR RELATION TO THE ECONOMIC EFFICIENCY OF INVESTMENTS

VIT HROMADKA, JANA KORYTAROVA, EVA VITKOVI

Brno University of Technology, Faculty of Civil Engineering, Brno, Czech Republic
E-mail: hromadka.v@fce.vutbr.cz

The paper is focused on the evaluation of the economic and the financial efficiency of investment projects on railways. The evaluation of the financial and the economic efficiency of investment projects financed from funds of the European Union is based on the Guide to Cost-Benefit Analysis of investment Projects by European Commission from 2014. In the Czech Republic is this Guide for purposes of the economic and the financial evaluation of projects in transport infrastructure completed by the Departmental Guideline for the Evaluation of Economic Effectiveness of Transport Construction Projects by Ministry of Transport of the Czech Republic, which specifies in the economic evaluation of projects of roads and highways, railways and trafficly important water structures. The Departmental guideline defines benefits, which it is possible to include into the economic evaluation, e.g. savings from operation costs, the decreasing of costs connected with accidents, the decreasing of costs connected with the travel time or negative externalities usually related to impacts on the environment. However, in the case of the railway infrastructure they are not taken into account benefits connected with the increasing of the safety and fluency of the transport due to the carrying out of security and information systems, even these investments are standard part of the most of investment projects in the railway infrastructure. The objective of the paper is to identify the amount and the structure of accidents and incidents on railways, which can influence the effective working of the railway transport, for the possibility of their next research in order to take into account their decrease in the economic analysis. The methodology of the work is based on the detailed analysis of specific accidents and incidents, which happened on Czech railways during last three years. The output of the paper is the detailed statistics of accidents and incidents including caused detriments and formulated recommendations for next steps leading to the quantification of relevant benefits.

Acknowledgements

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SHRINKAGE OF THE ALKALI-ACTIVATED SLAG MORTARS CONTAINING ALTERNATIVE ACTIVATOR

BARBARA KUCHARCZYKOVA, VLASTIMIL BILEK, HANA SIMONOVA

Brno University of Technology, Faculty of Civil Engineering, Brno, Czech Republic
E-mail: barbara.kucharczykova@vutbr.cz

The paper deals with the experimental determination of the shrinkage process of the alkali-activated-slag mortars (AASM).

Two mortars which differed especially in the type of used aggregate were mixed for the purpose of experiment. First mortar was prepared using the standard sand EN-196-1 with the maximum grain size of 2 mm. Natural sand with the maximum grain size of 4 mm was used for preparing the second mortar. The rest of mortars' components was the same. The slag-aggregate ratio was 1:3 for both mortars. The waste sludge, containing the Na_2O in amount of 4.1 %, obtained from the water glass production was used as an activator. Its dose for mixtures preparation was adjusted to the amount which corresponded to the 8 % of Na_2O by mass of slag. The sand contained in the waste sludge was included into a total amount of aggregate in the case of both mortars. The desired workability of the fresh mixtures was reached by addition of water. Because of the high water demand of waste sludge used for mortars production the water-slag coefficient (w/s) was relatively high – 0.98 for the mortar with the natural sand and 0.73 for the mortar with the standard sand.

The fresh mixtures were prepared in a laboratory mixer and poured into polypropylene moulds with dimensions of 40 mm × 40 mm × 160 mm. The moulds were covered with a polyethylene foil for 24 hours. After that, all test specimens were removed from the moulds and left to dry freely in the laboratory conditions with a temperature of 21 ± 2 °C and relative humidity of 50 ± 10 % during the whole time of measurement. The changes in length and mass were measured in pre-defined intervals.

The results show that AASMs which contain waste sludge exhibit rapid shrinkage with a high magnitude independent on the type of aggregate. During the first 40 hours of ageing, both mortars reached approx. 50 % of the final value of shrinkage. The high shrinkage was strengthened by a high w/s coefficient needed to maintain the workability of the fresh mixtures.

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WASTE GLASS AS A REPLACEMENT FOR FINE FRACTION IN HIGH-PERFORMANCE CONCRETE

DIANA MARIAKOVA[1,2], ZUZANA JIRKALOVA[1,2], LENKA LAIBLOVA[1,2]

[1]*University Centre for Energy Efficient Buildings of CTU in Prague, Bustehrad, Czech Republic*
[2]*Czech Technical University, Prague, Czech Republic*
E-mail: diana.mariakova@fsv.cvut.cz

Research project is focused on the experimental verification of high-performance concrete (HPC) with full replacement of fine fraction. This paper deals with HPC mixtures containing recycled glass materials (waste glass powder from municipal waste, waste glass powder from photovoltaic panels, grinding waste glass from jewellery). The research is based on the results of previous student grant. A recipe that was made during 2017 is used and optimized according to the waste glass powder properties. The influence of different local sources is monitored. The HPC mixtures are tested for mechanical properties (flexural strength, compressive strength) and compared with the results from the previous research. Flowability is tested and all the mixtures are workable. The mixture with grinding glass (GG) showed the highest results in flexural and compressive strength compared to the reference sample, the use as a substitute for fine fraction in HPC is conceivably attitude. The municipal waste glass mixture and the mixture with the waste glass from photovoltaic panels is not usable as HPC.

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INFLUENCE OF CURING CONDITIONS ON MECHANICAL AND FRACTURE PROPERTIES OF ALKALI ACTIVATED SLAG CONCRETE

HANA SIMONOVA, BARBARA KUCHARCZYKOVA, VLASTIMIL BILEK, LIBOR TOPOLAR, DALIBOR KOCAB

Brno University of Technology, Faculty of Civil Engineering, Brno, Czech Republic
E-mail: simonova.h@vutbr.cz

The aim of this work is the determination of the physical, mechanical and fracture characteristics of concrete specimens with alkali activated binder cured at the different conditions. The concrete mixture with alkali activated ground granulated blast furnace slag was selected for the purpose of the experiment. The binder was activated by the liquid sodium silicate with the silicate modulus of 2.0. Its amount was adjusted to provide 8 % Na_2O by mass of the binder. Natural sand and gravel were used as a fine and coarse aggregate, respectively. Maximum aggregate size was 16 mm. Binder: aggregate: water ratio was 1 : 3 : 0.46.

The concrete mixture was mixed in a laboratory mixer and then was cast into the polypropylene moulds with dimensions of 100 mm × 100 mm × 400 mm to prepare prismatic specimens intended for the fracture test. The moulds were covered with a thin PE foil and stored in laboratory with ambient temperature of 21 ± 2 °C and relative humidity of 50 ± 10 % for 24 hours. After that, all specimens were demoulded and left to dry freely in the same laboratory conditions for another 24 hours. At the age of 48 hours of concrete hardening, the specimens were divided into two groups. One group was immersed in the water-bath for a predetermined curing time, after which the specimens were again removed from the bath and left to dry freely until the testing time. The second group of the test specimens was left to dry freely for the whole time of curing.

During the specimens ageing, the dynamic modulus of elasticity was determined using resonance method according to the standard ČSN 73 1372. The fracture characteristics were determined based on the results of the three-point bending test of specimens provided with an initial central edge notch. The fracture experiments were conducted at the age of 3 and 38 days. The loading force (F), the displacement measured in the middle of the span length (d), and the crack mouth opening displacement (CMOD) were continuously recorded during the test. The F–d diagrams were then used for calculation of the elastic modulus from the initial part of the diagram, effective fracture toughness using the Effective Crack Model (Karihaloo, 1995) and the specific fracture energy using work-of-fracture method (RILEM, 1985). The F–CMOD diagrams were subsequently evaluated using the Double-K fracture model (Kumar and Barrai, 2011). This model allows the quantification of two different levels of crack propagation: initiation, which corresponds to the beginning of stable crack growth, and the level

of unstable crack propagation. The fracture tests were also accompanied by the monitoring of acoustic responses using the acoustic emission method (Grosse and Ohtsu, 2008). The informative value of compressive strength was determined on the specimens' fragments after the fracture tests were finished.

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CHARACTERIZATION OF CRACK FORMATION AND DEVELOPMENT IN THE OIL&GAS WELL CASING CEMENT SHEATH

IEVA PAEGLE, VICTOR MARCOS-MESON, GREGOR FISCHER

Department of Civil Engineering, Technical University of Denmark, Lyngby, Denmark.
E-mail: vicmes@byg.dtu.dk

The oil industry relies on the use of cement as a primary barrier, to isolate the steel casing from the surrounding formations and provide overall stability on the bored structure. There has been extensive technological development on the physical and mechanical properties of the materials from the cement and cementing industry, in order to produce and install effective cement barriers, capable of withstanding both physical and chemical loads under extreme wellbore conditions. In particular, the formation of cracks and interfacial damage at the primary cement sheath is a largely discussed issue. However, there is still a limited understanding about the crack formation and propagation processes in well-cements, due to the particular geometric and boundary conditions of the structural system, such as: pressure, temperature, and confinement conditions. This paper is focused on the crack formation and propagation processes on cement systems under wellbore-like geometrical conditions, and proposes a test-setup to evaluate cracking and localized damage at the casing-cement interface.

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VARIATION OF BENDING STRENGTH OF FIBER REINFORCED CONCRETE BEAMS DUE TO FIBER DISTRIBUTION AND ORIENTATION AND ANALYSIS OF MICROSTRUCTURE

HEIKO HERRMANN[1], RENATA BORIS[2], OKSANA GOIDYK[1], ANDRES BRAUNBRUCK[1]

[1]Tallinn University of Technology, Department of Cybernetics, Tallinn, Estonia
[2]Vilnius Gediminas Technical University, Faculty of Civil Engineering, Vilnius, Lithuania
E-mail: hh@cens.ioc.ee

Fiber concrete is becoming increasingly popular as a construction material, as it can potentially form a ductile concrete. The properties of the fiber concrete depend on the concrete recipe, the flow of the fresh concrete into the formwork, possible vibrating of the concrete and the fiber orientations.

The talk will present the results of bending tests performed on steel fiber concrete beam specimen, which have been cut out of a larger plate (Herrmann, 2019). These beams have different fiber orientation distributions, due to being taken from different parts of the plate and with different orientation with respect to the flow of the fresh concrete. The outcomes of these bending tests show a large variation in the post-cracked bending strength from strain-hardening to strain softening. The talk discusses different possible reasons for this and reasons that the differences in the post-cracking behaviour are due to different fiber orientations, because the microstructure analysis shows that the samples are otherwise equal.

Acknowledgments

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NATURAL VIBRATION OF STEPPED NANOPLATE WITH CRACK ON AN ELASTIC FOUNDATION

MAINUL HOSSAIN, JAAN LELLEP

Institute of Mathematics and Statistics, University of Tartu, Tartu, Estonia
E-mail: mainul.hossain@ut.ee

The small-scale effect on the vibrational characteristic of isotropic, rectangular nanoplate embedded in an elastic medium is investigated. The formulation is based on the plate theory on aggregate with the nonlocal elasticity theory. The solution procedure is derived using the governing differential equations of physical phase that are converted into set of linear algebraic equations. Latter is solved by computer code. The effects of aspect ratio, step, crack and rotatory inertia on the different modal vibrations of nanoplate are explored. The results show the significant effect of different physical and geometrical parameters on the vibration of nanoplate.

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EFFECT OF WETTING/DRYING ON THE PROPERTIES OF OSB/3 AND BIRCH PLYWOOD

REGINO KASK[1], HARRI LILLE[1], MIHKEL KIVISTE[1], RENEE TAMM[1], JOHANN OLAF LAANE[2]

[1]*Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia,*
[2]*Institute of Technology, Estonian University of Life Sciences, Tartu, Estonia*
E-mail: mihkel.kiviste@emu.ee

In this study the thickness swelling (TS), restore dimensions (RD) and density after ten cycles of wetting over/drying of commercial boards, 3-layered OSB/3 ("SWISS KRONO" of 12 mm thickness) and 9-layered birch (betula sp) plywood with phenol-formaldehyde (UPM-Kymmene, Otepää, Estonia) were investigated [1,2].

Test samples (dimensions of 290 mm × 50 mm × 12 mm) for determination of change in the investigated parameters, according to standard EVS EN 326-1:2002, were cut from the boards in the parallel (|| - major axis) direction to the face (outer layer) strand. The cutting forehead and the facet edges of the test samples were coated with the water repellent mastic Kiilto Fibergum ("KIILTO OY"). The specimens were altered by soaking in a tank with water (22 ± 1 °C) for 24 hours and dried for 48 hours in a ventilated drying box at 65 ± 1 °C. Before testing the samples were conditioned in a climatic chamber at a relative humidity of 65 % at 21 °C.

The investigated parameters were arranged in accordance with standards TS (EN 312-4 (1996)), moisture content (EN 322:2002) and density (EN 323:1993). Also, the modulus of rupture (MOR) and the modulus of elasticity (MOE) of particleboard and plywood were compared. MOR and MOE were determined by the three-point bending test conducted in accordance with EN 310 (1993b), using the computer-controlled mechanically actuated universal testing machine Instron 3369. Deflection for calculating the modulus of elasticity was measured by an optical gauge (Advanced Video Extensometer 2663-821).

The surfaces and cross-sections of the initial dry samples after the first, second and third wetting/oven-drying cycles were studied using the X-ray technique (Yxlon FF35 CT).

The analytical exponent- and linear-fractional equations were used to approximate the obtained experimental data depending on the number of cycles.

The retention values vs initial values of MOR and MOE recorded after the first wetting/oven-drying cycle were 81.6 %; 79.8 % and 93.2 %; 89.4 % for plywood and particleboards, respectively. The retention values of MOR of both studied materials decreased more significantly than MOE. The density of particleboard was 87.8 % and TS was 120.7 %. The initial dimensions of plywood have decreased after wetting/oven-drying as the RD of thickness of the dried samples was 98.5 ± 0.5 %.

The results of X-ray studies revealed a manipulation of OSB/3 boards with a large increase

in TS and a decrease in density and MOR even after the first wetting/oven-drying cycle. A small amount of phenol formaldehyde resin (matrix) tended to segregate along the wood strand boundaries forming an amorphous matrix in which the individual strands are embedded. The wood strands swelled during wetting and their increasing volume created stresses in the embedded boundaries of the matrix, resulting in plastic deformations. Next, as the volume of the wetted strands decreased during oven-drying, the strands consequently (partially or fully) ripped off from the embedded boundaries of the matrix or were fractured parallel or perpendicular to the grain. Because of voids generated between the fracture surfaces of strands and the embedded boundaries of their matrix, the dimensions of the samples did not restore after drying. Also, comparison of the TS of the wetted and dry samples indicated that the plastic deformations of the matrix had not recovered. Due to frequent precipitation in the practice of construction sites, wetting of OSB/3 boards before assembly or as a sheathing material (before installation of external cladding) results in air voids even after repetitive drying. These air voids also significantly increase the air permeability of OSB/3 boards [3], which as a consequence of which the requirements for nearly zero-energy buildings were not satisfied. The presented analysis is limited to the methodology and is based on the data obtained from the above described experiments of the investigated panels.

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COMPOSITION OF ENGINEERING DRAWING THROUGH COMMUNICATION SKILLS AND SOCIAL/MATERIAL INTERACTIONS FROM THE SEMIOTICS ASPECT

HARRI LILLE[1], AIME RUUS[2]

[1]*Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia*
[2]*School of Engineering, Tartu College, Tallinn University of Technology, Tartu, Estonia*
E-mail: harri.lille@emu.ee

The idea of technical engineering (product identification), i.e. the internal representation, is usually generated in the head of the engineer, serendipitously. It means that through spatial thinking in the process of visualization (sketching) and implementation (conceptual design) of engineering ideas. That is, identification of the product is understood and its function and form (solid and surface modelling, design analysis) are planned, which ends up with the manufacturing (technical drawings and documentation, manufacturing simulation, rapid prototypes) of real technical products and marketing [1]. In order that the design idea is unambiguously transmitted (communicated), usually by means of the engineering drawing, the external representation or the so-called design (intercultural) language is acquired within Descriptive Geometry - the theory of geometric shaping whose aim is to study and understand objects in three-dimensional space (3D) from their two-dimensional representations (2D) in one or more planes; and within Engineering Graphics – creation of technical documentation whose aim is forming principles and methods of expression of engineering drawing. Within this course engineering students grasp the fundamentals of graphics: sketching; graphics projection, sectioning and dimensioning, engineering drawing. They learn the correct expression of engineering drawing in order to achieve standards related to working and assembly drawings so that after passing the course they will be able to read and design professional drawings using traditional or modern technology. Concisely: forming, testing and modifying of ideas, and communication of the design result (conceptual design). It means that the designer works within a spectrum of signs. Parts of these signs are depictions, i.e. pictorial – representational images; others are scriptorial, i.e. involving words – verbal images. The development of Engineering Graphics is influenced (besides other theories) by semiotics - the study of signs and symbols, as well as to some degree the making of meaning. Therefore, it is not a pure theory as it includes also representational modes other than language and, as such, it only becomes useful when applied to specific contexts, particularly visual design – art, film and naturally engineering drawing as a specialized branch of it. Hence, wherever meaning is made semiotics can be applied and its models and

methods can be use when working in the field of Engineering Graphics.

Peirce's triadic model can to help encode and decode signs – in our case (subject) various type engineering drawing, for which there international agreement that excludes different interpretations and includes the study of how meaning is constructed and understood [2]. However, in the case of different social groups (for whom the language of instruction in the classroom is a foreign or a second language); they create the meaning of the idea and its representations differently. Culture determines both the meaning of concepts and utterances, which can coordinate the existing internationally accepted pattern of meanings. As noted above, engineering drawings as a visual language (for us characteristically, a graphically standardized language) can be interpreted as signs. Yet drawings should not be interpreted differently by different people, but should be focused on conveying information in a simple manner. According to the semiotician Y. Lotman, the basic issues in semiotics are the following. What did the author want to convey? Did you understand it [3]? The same applies to the graphic language: "one can draw" and "one can understand a technical drawing" [4], it means, that "I" language and "you" language coincide. The activity of composing engineering drawings involves also the semiotic activity of classroom participants – the activity which is continually transformed through the interpretative collaboration and elaboration by teacher and students (communication), through listening to their feedback and sharing their views (according to teacher's verbal instructions regardless of linguistic limitations, i.e. so-called visual/verbal learning) and explanations.

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3D COMPUTER DRAWING COMPETITION CADRINA

AURIKA NOMM[1], REIN MAGI[2], KULLI MEISTER[1]

[1] Academy of Architecture and Urban Studies, Tallinn University of Technology, Tallinn, Estonia
[2] Estonian Maritime Academy, Tallinn University of Technology, Tallinn, Estonia
E-mail: aurika.nomm@taltech.ee

CADrina is IT-festival, where takes place 3D computer drawing competition, which has been organized for 9 years by Kadrina Secondary School. In this competition AutoCAD program is used. Participants will create 3D objects in AutoCAD during a given period according to the specifications that will be provided. They will be judged on accuracy and speed. The competition took place in several rounds - the preliminary round and the final round. The event provides opportunities to showcase students' knowledge and skills as well as to be a role model and inspiration for the future choice of young people. 3D computer drawing competition is a good chance to develop team-working skills under pressure among students.

EXPERIMENTAL ASSESSMENT OF BIO-BASED EARTH BRICKS DURABILITY

AURELIE LABOREL-PRENERON[1], MARIE GIROUDON [1], JEAN-EMMANUEL AUBERT[1], CAMILLE MAGNIONT[1], PAULINA FARIA[2]

[1] LMDC, University of Toulouse, INSA, UPS, Toulouse, France
[2] CERIS and NOVA, University of Lisbon, Department of Civil Engineering, Caparica, Portugal
Email: alaborel@insa-toulouse.fr

Construction is one of the most polluting industrial sectors that is the reason why developing sustainable building materials is a world-wide interest. Earth bricks have recently been more and more studied, mainly regarding their mechanical and hygrothermal properties. The interest in adding plant aggregates in an earth matrix, notably to improve the thermal behaviour, has also been shown. However, durability of the materials is a major concern to sustain performance levels, to limit maintenance and to ensure the comfort and safety of the occupants. Although earth construction seems to be durable, with the various examples of the vernacular heritage in France and all over the world, unstabilised earth is quite sensitive to environmental factors (weather, occupants, micro-organisms). The resistance of an earth material to liquid water is particularly low, and the addition of plant fibres may decrease its resistance even more. Moreover, the incorporation of organic matter, containing cellulose, raises questions about the composite resistance to moulds. Investigations are thus needed to assess several durability properties.

The present paper studies and compares durability of earth bricks containing 0 % and 3 % weight content of barley straw, lavender straw and rice husk. Some durability tests corresponding to weathering or occupants' actions are conducted: a wet erosion test is performed to simulate rain or accidental water droplets and the resistances to dry abrasion and to impact are also appraised. The resistance to fungal growth is also investigated.

Results show a considerable interest in adding lavender straw in earth bricks. Indeed, a very good compromise has been found concerning properties of weathering durability and to microorganisms. The addition of lavender straw improves the dry abrasion resistance of earth bricks whereas rice husk and barley straw additions decrease it. The two types of straw greatly increase the resistance to wet erosion of earth bricks while rice husk only in a smaller extent. Concerning the brick resistance to impact, its behaviour is considerably improved by the addition of the three kinds of plant aggregates, particularly rice husk. Finally, as expected, the bricks made of earth alone are the more resistant to fungal growth. However, the addition of rice husk maintains a very high resistance with the first mould observed after only 10 weeks of incubation at 93 % of relative humidity and 30 °C.

DEVELOPMENT OF A HIGH CLAY CONTENT EARTH PLASTER

MERYL LAGOUIN, AURELIE LABOREL-PRENERON, CAMILLE MAGNIONT, JEAN-EMMANUEL AUBERT

LMDC, Université de Toulouse, INSA, UPS, Toulouse, France
E-mail: lagouin@insa-toulouse.fr

The building sector is a major contributor to resources' consumption, such as energy and raw materials, as well as greenhouse gas and pollutant emissions. This industry is the largest consumer of energy (with about 40 % of the total energy consumption), of non-renewable raw materials and is responsible for approximately 36 % of greenhouse gas emissions in European Union (European Commission, 2018). Hence, building industry has to drive efforts to reduce its environmental footprint. This situation has contributed to the growing interest in locally available resources for the development of sustainable building materials. Earthen materials fit in with this perspective.

Moreover, earth is known to be a natural humidity regulator and to improve comfort inside buildings, making it a good choice for indoor plastering. The clayey phase is responsible for the dry strength, the water vapor permeability and the sorption capacity of earthen plasters. However, clay also induces the drying shrinkage of the soil material. So, to limit this phenomena and prevent the cracking of the plaster, earth is admixed with sand. Clay gives the global cohesion of the material by acting as a binder for the sand grain skeleton.

The objective of this work is to improve the moisture buffer capacity of earthen plaster. The impact of different design parameters was studied: sand to earth ratio, nature of clay and addition of organic admixtures.

For each formulation, the water content is defined to ensure similar consistency between the materials. Tests are conducted to validate the composition of plasters by means of a shrinkage test followed by a shear test. An earth plaster is of acceptable mechanical quality if, after shrinkage, there are no cracks through which water can penetrate into the wall, and the plaster has a sufficient bond with its wall. Then, its hygric regulator potential is evaluated through the Moisture Buffer Value (MBV) test.

As expected, results have shown that, to maintain a standard level of consistency, an increase in the clay content leads to a greater amount of mixing water. Consequently, the plaster shrinkage is more important and the cracks induced by the restrained shrinkage are more extensive. Furthermore, it affects the plaster/wall bonds, resulting in lower breaking strength for the shear test.

Outcomes also provide information about the maximum earth content with the soil used to prevent shrinkage cracks: below 25 % of earth, the plaster surface area remains smooth and does not lift away from the wall. Shear tests highlight the high mechanical resistance of the studied plaster as all mixes meet the re-

quirements set for indoor application.
This first campaign also evidenced the impact of organic admixtures on the water demand, the shrinkage and the mechanical performances of earth plaster.
Finally, earthen plasters can be considered as good hygric regulators that improve indoor hygrothermal comfort. To enhance the MBV, the highest possible earth content must be used without jeoperdizing the aestethic and mechanical aspects of plaster.

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INVESTIGATIONS ON THE FOAM CONCRETE PRODUCTION TECHNIQUES SUITABLE FOR 3D-PRINTING WITH FOAM CONCRETE

VIACHESLAV MARKIN[1], GENADIJS SAHMENKO[2], VENKATESH NAIDU NERELLA[1], MATHIAS NATHER[1], VIKTOR MECHTCHERINE[1]

[1]Institute for Construction Materials, Technical University of Dresden, Dresden, Germany.
[2]Department of Building Materials and Products, Institute of Materials and Structures, Riga Technical University, Riga, Latvia
Correspondence: mechtcherine@tu-dresden.de

With high thermal insulating property and low-density foam concrete has high potential in 3D-printing applications such as residential buildings. The synergy of the foam concrete and 3D-printing process pre-requisites research and optimization of foam concrete production. This paper presents investigations on the appropriateness of two different methods for production of foam concrete: 1) mixed foaming method in turbulence (colloidal) mixer; 2) mixed foaming method in cavitation disintegrator. Performance of synthetic and protein based foaming agents were examined. The dosage of the foaming agent was varied from 0.7 % to 1.2 % by weight of cement to produce foam concretes with densities ranging between 800 kg/m^3 and 1500 kg/m^3. The study shows that foaming ability of the designed mix compositions depends primarily on the w/b ratio. Whereby foaming with lesser dosage of foaming agent is possible when turbulence mixer is used. Furthermore, mechanical and physical properties of foam concrete, including compressive strength, bending strength and water absorption were reported.

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DEVIATING (MELTING) ENTHALPY VALUES OF SALT HYDRATES IN LITERATURE: ORIGINS INVESTIGATED WITH CALCIUM CHLORIDE HEXAHYDRATE

HENRI SCHMIT, DOVILE RUDALEVICIENE, CHRISTOPH RATHGEBER, STEFAN HIEBLER

ZAE Bayern, Garching, Germany
E-mail: henri.schmit@zae-bayern.de

Latent heat storages with phase change materials (PCM) are attractive for thermal energy storage (TES). In the process of designing a system containing a latent heat storage, the enthalpy that can be stored over a certain temperature range has to be known. Reviews on PCM containing (melting) enthalpy values can thereby be a valuable source. However, especially for salt hydrates, reviews often contain differing (melting) enthalpy values for the same material (e.g. [1], [2]), which makes it difficult to choose a reliable value for the design. Although salt hydrates are generally more cost effective than organic PCM and offer high volumetric melting enthalpies, they are often regarded as problematic. However, this view can arise from a lack of knowledge on how to correctly handle salt hydrates, from the measurement of the basic thermophysical properties to their application in latent heat storages. In this work, the origin of deviating (melting) enthalpy values of salt hydrates in literature is investigated with the example of $CaCl_2 \cdot 6H_2O$. The focus lies on two aspects: the influence of deviations from the stoichiometrically correct water content and of different basic raw materials on the enthalpy difference.

$CaCl_2 \cdot 6H_2O$ is hygroscopic and does not melt congruently, i.e. upon reaching the melting temperature, $CaCl_2 \cdot 6H_2O$ does not become completely liquid but rather separates into the lower hydrate $CaCl_2 \cdot 6H_2O$ and a liquid solution. A liquid solution with the same composition as $CaCl_2 \cdot 6H_2O$ can be obtained by further raising the temperature and simultaneous mixing [3]. This behaviour leads to difficulties when performing calorimetric measurements on $CaCl_2 \cdot 6H_2O$, especially in the case of small sample sizes as is typical with differential scanning calorimetry (DSC) instruments [4]. In our previous work, we have shown that this difficulty can be overcome by adding a small amount of a nucleating agent, 0.1 wt% $Ba(OH)_2$ [5]. Therefore, the combination of DSC and 0.1 wt% $Ba(OH)_2$ added to $CaCl_2 \cdot 6H_2O$ is also used in this work. Additionally, the maximum storage capacity in a temperature range of 15 K is used as a measure to evaluate $CaCl_2 \cdot 6H_2O$ samples of different compositions. The maximum storage capacity represents the enthalpy difference over a certain temperature range containing the phase change and is thus a pure material property.

Six different $CaCl_2 + H_2O$ samples with differing water content in a range of around 1.75 wt% were prepared and

measured via DSC. The sample corresponding to $CaCl_2 \cdot 6H_2O$ has the highest maximum storage capacity in the temperature range between 25 and 40 °C with 232 ± 9 J g^{-1}. The sample with the highest water content, i.e. around 1.75 wt% more than $CaCl_2 \cdot 6H_2O$, has a maximum storage capacity of 171 ± 7 J g^{-1}, and thus -26 % lower than $CaCl_2 \cdot 6H_2O$. This shows, that rather small differences in the water content of $CaCl_2 \cdot 6H_2O$ can have a considerable influence on the maximum storage capacity.

For the investigation of the influence of different basic raw materials on the maximum storage capacity, four different $CaCl_2 \cdot 6H_2O$ were prepared: one sample from grown crystals, which serves as a reference, two samples from laboratory grade basic raw materials, and one sample from a technical grade basic raw material. The samples were again measured via DSC and the difference in maximum storage capacity was evaluated. The $CaCl_2 \cdot 6H_2O$ reference sample has a maximum storage capacity of 235 ± 9 J g^{-1} while the value for the sample from the technical grade basic raw material is 204 ± 8 J g^{-1}. A difference of -13 % thus results between reference and technical grade $CaCl_2 \cdot 6H_2O$ sample.

The investigation of both influence factors on the maximum storage capacity of $CaCl_2 \cdot 6H_2O$ has shown that considerable differences can arise due to seemingly small composition differences. Thus, two possible explanations for differing (melting) enthalpy values for $CaCl_2 \cdot 6H_2O$ in literature and hence for other salt hydrates are provided.

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AXIAL STRENGTHENING OF RC COLUMNS BY STEEL ENCASEMENT WITH DIRECT FASTENING CONNECTIONS

RAY KAI-LEUNG SU, ZHIWEI SHAN

Department of Civil Engineering, The University of Hong Kong, Hong Kong, China
E-mail: klsu@hku.hk

Reinforced concrete (RC) columns are crucial structural members that sustain vertical loads. Their strength may deteriorate due to fire, corrosion of the reinforcements or design errors. In response, a new strengthening method that uses a steel encasement to increase the axial capacity and ductility of RC columns is proposed in this paper. This method is quick and convenient because direct fastening [1] is used to assemble the system. Four columns including one control column and three strengthened columns have been tested to examine the reliability and effectiveness of the proposed method. Although direct fastening plays a crucial role in the structural performance of the proposed method, current design guidelines [2-5] have not incorporated this new connection technique. Hence, extensive connection tests have been conducted to evaluate the key factors (e.g. fastener type, fastener spacing, protuberance, etc.) that affect the strength of the connections. New design equations are subsequently proposed based on the test results for shear connections that use direct fastening.

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USE OF ARTIFICIAL NEURAL NETWORK IN DESIGN OF STEEL STRUCTURES

HARSHADA MOTE, S. R. SATISH KUMAR

Indian Institute of Technology Madras, Chennai, India
E-mail: moteharshada2@gmail.com

Design of steel structures is an iterative process that often turns complicated when requires initial guess. A good initial design guess can considerably reduce the number of subsequent analysis and design cycles. The good initial guess comes from past design experience. It is difficult to form declarative rules to express human intuitions and past experience. Another problem in design process is arriving at optimal solution, where optimization process in most cases is computationally expensive and time consuming. Artificial Neural Network (ANN) is a promising computational model that can perform cognitive tasks, such as learning and optimization, and is thereby rapidly gaining interest in applications to structural engineering problems. It has the ability to capture experts' knowledge, intuitions and past experience in a generalized form by storing it in the form of network parameters. Data used for training neural network can be theoretical, experimental, and empirical based on reliable past experience, or combination of these. Based on the training data provided ANN predicts relevant solution. Owing to its parallel processing it can generate good design much faster than a mathematical optimizer.

This paper focuses on application of ANN in various levels of design so as to make design process more efficient. The aim is to train ANN to arrive at optimal solution by considering design constraints along with practical constraints like material availability, ease in construction and economy. This is achieved by training neural network with suitable input-output training set that reflects these constraints. This is illustrated with an example of design of compression member which primarily requires an initial guess. The economy in design is obtained by providing a training set of optimal solutions to a multilayer neural network. The design process followed to generate the training set is in accordance with Indian code for steel design (IS: 800-2007). The procedure followed to arrive neural network size using learning curve is explained. The solutions given by ANN are approximate but have a reasonable agreement with the expected solutions.

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EFFECT OF SODIUM LIGNOSULFONATE SUPERPLASTICIZER ON THE EARLY HYDRATION OF CEMENT WITH DIFFERENT CONTENTS OF CUBIC C_3A

ALEXANDER MEZHOV, KONSTANTIN KOVLER

National Building Research Institute, Faculty of Civil and Environmental Engineering, Technion - Israel Institute of Technology, Haifa, Israel
E-mail: alexander.m@technion.ac.il

In this research, the influence of the sodium lignosulfonate superplasticizer (LS) on the early hydration of two types of cements containing different amount of cubic C_3A was studied. It is shown that at 0.1 % addition of LS has no significant influence on the hydration, while at higher dosages LS contributes to the additional formation of ettringite. This phenomenon is observed for both types of cement. The higher ettringite formation was found for the cement containing higher C_3A amount. However, LS addition retards the hydration, which is indicated by the reduction of the portlandite amount formed.

FEATURES OF GEOMETRIC SHAPES IN ARCHITECTURE

TATIGUL SAMURATOVA

L. N. Gumilyov Eurasian National University, Astana, Kazakhstan
E-mail: samyratovatk@mail.ru

Disclose the meaning of the features of geometric shapes in architecture; explore the relationship of architecture with geometry and explore the concept of geometric shapes and architectural styles and the history of geometry in architecture. Explore how geometric forms were combined in the projects of the architects of the modern world. Identify how the combination of basic geometric forms contributes to the development of architecture. Identify the practical application of geometry in the architecture of Kazakhstan. Having studied the scientific works, we realized that geometry is a wonderful tool that helps to establish order and harmony in our life. The author claims that Oriental traditions and an audacious flight of artistic thought of leading Western architects have bizarrely and harmoniously merged in the architectural appearance of Astana. In architecture, almost all geometric shapes are used. The most interesting architectural structures and geometric bodies underlying them, as well as geometric transformations are considered on the example of the architecture of the Capital of Kazakhstan.

EFFECT OF THE PHASE CHANGE MATERIALS (PCM) APPLICATION IN BUILDINGS FOR LATVIA CLIMATE

DIANA BAJARE[1], ALEKSANDRS KORJAKINS[1], ANDRIS JAKOVICS[2]

[2]Institute of Materials and Structure, Riga Technical University, Riga, Latvia
[2]Laboratory for Mathematical Modelling of Environmental and Technological Processes, Department of Physics University of Latvia, Latvia

Reduction of the CO_2 emissions in the atmosphere is one of the goals set forth by the European Union, hence various directives have been adopted, such as the European directive 2012/27/EU on energy efficiency, i.e. ensuring from 2019 the construction of the near-zero energy buildings (nZEB). Increased usage of air conditioning in the building environment, is directly related to the demand for higher thermal comfort as well as global warming, involves higher electricity consumption and CO_2 emissions and provides new challenges for designers of cooling systems. Thermal energy storage, which plays an important role in building energy conservation, can be achieved by using PCM in the building constructions. Phase change materials (PCM) are materials that can be considered to tackle these new challenges. It has been proven that PCMs can be passively used to improve the thermal mass of lightweight structures, which improves thermal comfort and reduces cooling and heating loads and therefore provides energy savings.

Two types of commercial materials containing PCM ("DuPont Energain" and "BioPCM" sheets) were used to carry out the experiments in-situ, as well as modelling and validation of the obtained data.

Evaluation of the PCM effect on temperature regime indoors has been performed by software WUFI+ and tested in real test buildings by using an integrated system of sensors.

In the preliminary study of PCM effectiveness, PCM containing sheets were placed on the walls and ceiling in the test building. The amount of PCM was about 3.5 kg/m^2. It was observed that, if free temperature mode with mechanical ventilation of 0.45 1/h that was used in the test building, the phase change material will not be effective in ensuring optimum indoor climate. In order to facilitate the complete phase transition of the PCM in a 24 hour cycle under free temperature conditions, additional ventilation with a vertically opened window in the ventilation mode from 7 PM to 9 AM was provided.

In addition to the experiments in-situ, the WUFI+ modelling program was used with real-time climatic data from a given time period, in order to analyse the efficiency of PCM containing materials in ensuring an optimal indoor microclimate. Like in experiments in-situ, increased air exchange over time is necessary according to obtained data by WUFI+ modelling program to allow the phase change material to become solid at night thus can decrease air temperatures for 2–3 °C in the day time.

The results showed the advantages and disadvantages of PCM using in Latvian

climatic conditions. Satisfying results have been obtained for passive cooling of indoor air in the summertime. PCM usage significantly improves the thermal inertia of the walls in the building.

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NUMERICAL MODELS FOR LONG-TERM PERFORMANCE ASSESSMENT OF LIGHTWEIGHT INSULATING ASSEMBLIES

MIHAILS BIRJUKOVS[1], INGA APINE[2], ANDRIS JAKOVICS[1]

[1]Department of Physics, University of Latvia, Riga, Latvia
[2]Botanical garden, University of Latvia, Riga, Latvia
E-mail: mihails.birjukovs@lu.lv

This paper describes the details of numerical modelling of hygrothermal processes in test buildings situated in the Botanical garden of the University of Latvia. Long-terms performance of wall, floor and ceiling insulating assemblies for five different buildings was simulated using WUFI Pro 5.3, a finite volume method (FVM) based software package that solves coupled heat and moisture transport equations. The authors utilized climate data (temperature, relative humidity, solar radiation intensity) generated by the Botanical garden meteostation, and internal building climate was prescribed by standards. On the experimental side, measurements of temperature and relative humidity at key points of assembles have been accumulated over a period of five years and mould samples were gathered and analysed, enabling the validation of numerical models. Similarities and discrepancies between numerically obtained forecasts and experimental data were analysed and reliability of both was assessed. Mould growth risk models were checked for consistency using analysed mould samples from test sited.

A REVIEW STUDY ON SPECIFIC REQUIREMENTS FOR REFURBISHMENT OF MILITARY BUILDINGS IN COLD CLIMATES

ALEKSEJS PROZUMENTS, ANATOLIJS BORODINECS, MAIJA KRIZMANE

Institute of Heat, Gas and Water Technology, Riga Technical University, Latvia
E-mail: anatolijs.borodinecs@rtu.lv

In most cases there are no specific and clear design requirements defined in local building codes, the responsibility for appropriate design of military buildings therefore lies primarily on third party design service contractors that are hired upon a short term agreement, whereas government is primarily involved in financing stages and military personnel is solely involved in long term exploitation of these structures. Authors of this paper focus on analyzing and isolating specific requirements for refurbishment of military buildings with regards to their structural reliability, safety, endurance, fire and explosion-resistance, heating, ventilation and air-condition systems performance and efficiency, as well as adding energy efficiency, building performance optimization recommendations and measures in moderate and cold climate conditions.

ENERGY PERFORMANCE OF TEMPORARY SHELTERS

ANATOLIJS BORODINECS[1], ALEKSANDRS GEIKINS[1], SERGEJ SMIRNOV[2]

[1]*Institute of Heat, Gas and Water Technology, Riga Technical University, Latvia*
[2]*Institute of Mathematics and Computer Science, University of Latvia, Riga, Latvia*
E-mail: anatolijs.borodinecs@rtu.lv

This paper analyzes methods for calculating energy consumption of temporary shelters for the purpose of reducing energy consumption for heating and improving the level of comfort. Mobile shelters are widely used by rescue emergency teams. Often such type of buildings has a limited access to reliable source of energy supply. Thus it is vitally important to make correct heat losses analysis to select proper capacity of energy source. The paper presents analysis of heat losses of rubber/fabric shelters without extra thermal insulation.

NUMERICAL COMPARISON OF HPSFRC AND HPC RIBBED SLABS

KARINA BUKA-VAIVADE[1], JANIS SLISERIS[1], DMITRIJS SERDJUKS[1], GENADIJS SAHMENKO[2], LEONIDS PAKRASTINS[1]

[1]Institute of Structural Engineering and Reconstruction, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia,
[2] Institute of Materials and Structures, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: karina.buka-vaivade@rtu.lv

The problem of limited resources is actual nowadays. One of the ways for solving this problem can be the use of high-performance steel fibre reinforced concrete as a structural material for elements subjected to the flexure. The dispersive reinforcement improves the properties of the concrete and allows reducing the required dimensions of cross-section and ratio of longitudinal reinforcement for members subjected to flexure. This research includes the numerical comparison of ultimate limit state and serviceability limit state of ribbed slabs from high-performance concrete (HPC) and high-performance steel fibre reinforced concrete (HPSFRC) behaviour, taking into account the different deformative properties of these materials. The effective use of these materials has been studied using a nonlinear finite element model. This model is created by using a beam type element with a multilayer cross-section, where each layer has a non-linear stress-deformation relationship, according to the layer materials such as HPC, HPSFRC, or steel bars. The finite element model used for the limited plates is validated. Results of experiment showed, that used calculation model describes with sufficient accuracy the behaviour of the ribbed slabs. The difference between design and experimentally determined breaking load is less than 6 % for ribbed slab. The use of HPSFRC for ribbed slabs with the spans from 6 to 12 m is justified so as using of HPSFRC instead of HPC enables to increase 42-26 % the intensity uniformly distributed load for the ribbed slabs with the same cross-sections and allowed deflections.

BEHAVIOUR OF TIMBER-CONCRETE JOINTS IN HYBRID MEMBERS SUBJECTED TO FLEXURE

ROMANS VASILJEVS, DMITRIJS SERDJUKS, JANA GERASIMOVA, KARINA BUKA-VAIVADE, ALPER ORHUN ERUZ

Institute of Structural Engineering and Reconstruction, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: karina.buka-vaivade@rtu.lv

Possibility to develop rigid timber-concrete joint for hybrid timber-concrete specimens was stated. Behaviour of timber-concrete rigid and compliant joints were evaluated numerically and by experiment for the members subjected to flexure. Small scale hybrid timber-concrete specimens with the length, width and thickness equal to 400, 95 and 43 mm were investigated for case of three points bending. The small-scale hybrid timber-concrete specimens consists from the layers of cement base finishing mass Sacret BAM and timber boards of strength class C24 with thicknesses equal to 25 and 18 mm, correspondingly. The rigid timber-concrete joint was provided by the pieces of crushed granite, which were strengthened on the surface of the timber boards by epoxy glue Sica Dur 330. Dimensions of the crushed granite pieces changes within the limits from 2 to 25 mm. The compliant timber-concrete joint was provided by the screws with diameter and length equal to 4 and 40 mm, correspondingly. The screws were placed under the angles equal to 45 and 90 degrees relatively to the direction of fibres of the timber layers. Load-carrying capacity and maximum vertical displacements were gotten for groups of small-scale hybrid timber-concrete specimens with rigid and compliant timber-concrete joints. It was shown that providing of rigid timber-concrete joint enables to decrease 1.86 - 3.50 times the maximum vertical displacements of hybrid timber-concrete specimens. Load-carrying capacity of the specimens grows by 16.5 – 50.0 % at the same moment.

EFFECT OF WATER-BINDER RATIO ON PROPERTIES OF PHOSPHOGYPSUM BINDER

GIRTS BUMANIS, JELIZAVETA ZORICA, DIANA BAJARE, ALEKSANDRS KORJAKINS

Department of Building Materials and Products, Institute of Materials and Structures, Riga Technical University, Riga, Latvia
E-mail: girts.bumanis@rtu.lv

The technological, physical and mechanical properties of mineral binders are often defined by the amount of water add to the binder (W/B ratio). The role of water is contributed to the workability of fresh paste, hydration processes, porosity, mechanical performance and durability of the material. Present research summarizes the relationship between gypsum based binder W/B ratio in mixture composition to properties of hardened gypsum binder, giving a marginal borders of properties affected by W/B. The W/B ratios evaluated were from 0.3 to 1.15. Dihydrate phosphogypsum (PG), which is a waste of phosphorus fertilizer industry and commercial gypsum binder were used as a raw material for production of gypsum samples and results compared to commercial gypsum binder. At the beginning PG was dried at 60 °C and afterwards homogenised by milling it in ball mill or by collision milling in disintegrator. Samples were made with plasticizers, mineral additives and foam forming additive. In this work 26 dense and 9 porous mixture compositions was summarized, from which 18 compositions were made from commercial binder for comparison. A series of performance properties of the binders were investigated, such as density, porosity and 14 d compression strength regarding to W/B ratio used to prepare the samples. The chemical and mineralogical composition of PG used was determined by XRF and XRD. The results indicate that plasticizers in PG based gypsum binder could reduce W/B ratio from 1.15 down to 0.4. The PG binder bulk density for samples without pore forming admixture was in range from 726 – 1600 kg/m^3, total porosity 35 – 71 vol.% and compressive strength from 1.4 to 28.7 MPa at the age of 14 d. Ultra porous gypsum material was obtained with the pore forming agent, which allowed to obtain gypsum based material with bulk density from 213 – 726 kg/m^3, total porosity from 67.9 – 90.6 % and strength from 0.2 – 0.8 MPa. Results show that the material density and strength decreases while porosity tends to increases with the increase of W/B ratio. These tendencies are true both for dense and porous specimens. It was concluded, that lowest W/B of dense PG specimens was 0.43, otherwise the workability of a binder decreased dramatically and decrease of strength was observed. With the same W/B ratio the technological properties of PG binder may be affected by gypsum treatment parameters and selected mixture composition, allowing to improve the properties of gypsum binder obtained from same raw material.

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PRELIMINARY TEST RESULTS OF BACTERIA-BASED CONCRETE WITH LIGHTWEIGHT AGGREGATES

LAURA DEMBOVSKA, DIANA BAJARE, ALEKSANDRS KORJAKINS, EVIJA JAKUBOVICA

Department of Building Materials and Products, Institute of Materials and Structures, Riga Technical University, Riga, Latvia
E-mail: laura.dembovska@rtu.lv

A typical phenomenon in concrete constructions is crack formation. Shrinkage cracks may appear in early stage of concrete and in late age - in process of serviceability and external weather conditions. Larger cracks interfere structural integrity, smaller micro-meter sized cracks may result in durability problems as increase of water absorption, which results in material degradation and reinforcement corrosion. Manual maintenance of the concrete structure is costly and labour consuming, therefore functionality of self-healing phenomenon of concrete structures has been inspected.

In this study bacteria-based self-healing has been investigated. Calcium lactate and yeast medium with spore-forming alkaliphilic bacteria Bacillus Lentus have been chosen. Bacillus Lentus spores with inoculum were integrated into expanded clay granules with a size of 2 - 4 mm by using vacuum technique. Expanded clay granules not only represent the internal Bacilus Lentus storage, but also form the structural element of the concrete, as well as the protective matrix for the self-healing medium with spores. Such system increase the viability of bacteria and thus the time-related functionality of biochemical self-healing agents.

Results from optical microscope in combination with permeability tests showed that self-healing phenomenon has happened and cracks in concrete were partly healed.

The mechanism of crack healing in bacterial concrete presumably occurs through metabolic conversion of calcium lactate to calcium carbonate what results in crack-sealing.

The influence of biochemicals on the mechanical and physical properties of samples was estimated after 28 days and after 6 years.

From the results obtained, it can be concluded that concrete samples with self-healing bacteria showed an increase of 22 % in compressive strength compared to the 28 days old reference sample. Material density was in the range of 1736 – 1777 kg/m^3.

HOW TO BOOST THE STUDENTS' INTEREST TO BIM AND PLM STUDIES IN UNDERGRADUATE COURSES?

MODRIS DOBELIS[1], MONIKA SROKA-BIZON[2], TED BRANOFF[3]

[1]Riga Technical University, Riga, Latvia
[2]Silesian University of Technology, Gliwice, Poland
[3]Illinois State University, Normal, IL, USA
E-mail: modris.dobelis@rtu.lv

Any project development involves several stages, such as conceptual design, further development, detailed design, analysis, feedback and iterative re-design, development of tools, manufacturing, assembling, testing, management, etc. Both during a typical engineering product development and building industry scenarios, most stages are performed using internal or commercial third-party Computer Aided Design (CAD) systems. Vast amount of new Information Technology (IT) tools and media appear every year with a new version of CAD software. However, the links between individual stages very often are still scheduled manually. Considerable progress has been made in software industry in general and in CAD technology in particular over the past few decades. Evident boost in Architecture, Engineering and Construction (AEC) industry now is possible through the use of BIM concept – Building Information Modelling. For the design of industrial and consumer products, a similar workflow under a common term Product Lifecycle Management (PLM) is known for quite time. Many associations have been established to take care of faster and more productive BIM and PLM concept implementation into life. Successful introduction of these technologies will determine the future growth rate in any society and will allow applying them more efficiently, consistently and in a more automated way than a traditional CAD approach used until recent. Advances in the cloud storage of information and Internet of Things (IOT) possibilities will facilitate another boost in the BIM and PLM industries. However, there are significant challenges for these technologies and software tools how to bring them into service as fast as possible to replace the traditional use of CAD/CAE applications for engineering organizations. Universities are also considered as major player in the process of faster implementation of these technologies into life. A common background knowledge required to tackle this problem is a development of visualization skills since both of the concepts are based on a shared three-dimensional (3D) geometric model or database. The former classic university courses like descriptive geometry and engineering graphics used in the last century have undergone considerable reduction in credit points and decent content changes dictated by IT achievements and sometimes by administrative orders, however, its role should not be under estimated in the syllabuses. A development of the spatial comprehension and visual-

ization skills are necessary to effectively use solid modelling software in wide range of engineering applications. Therefore, in the era of further advancement of concurrent engineering achievements it is important to revise a course content with caution. A quick feedback has to be provided how to assess as fast as possible and quantitatively the effect of new adopted and tested teaching methods of engineering graphics literacy. The paper will share an experience about recent research and findings about teaching spatial comprehension, 3D visualization and CAD communication skills in technical universities of Latvia and Poland. Results from a 2011 Fulbright Scholarship research project will also be covered.

SHRINKAGE DEFORMATION COMPARISON BETWEEN FOAM CONCRETE, GEOPOLYMER CONCRETE, DISINTEGRATED AND NON-DISINTEGRATED CEMENT MORTAR

RIHARDS GAILITIS[1], ANDINA SPRINCE[1], LEONIDS PAKRASTINS[1], GENADIJS SAHMENKO[1]

[1]*Department of Structural Engineering, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia*
[2]*Department of Materials and Structures, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia*
E-mail: rihards.gailitis@rtu.lv

Foamed concrete has been used as a building material since early 1920. In the beginning, it was used as an insulation material with very low density. Since then there has been attempts to make this material more load-bearing and structural. In present-day foamed concrete is being used in soil reinforcement, building blocks and other shorts of building materials. [1]

Geopolymer concrete has been around for more than 40 years. It is being used in all sorts of buildings such as railroads, reservoirs, and houses.

In past few decades there has been considerable amount of researches regarding partial replacement of cement using disintegrated cement in cement mortar or concrete. As it is known to obtain powder mineral filler material planetary ball milling is applied, but it is ineffective. Grinding by collision is found out to be more effective method for refining brittle material. One of ways to refine is to disintegrate with disintegrator. [2] This raises the questions whether old cement disintegration together with sand can improve its long-term properties.

The aim of this article is to determine difference of shrinkage deformation difference for foam concrete and disintegrated cement mortar which are Portland cement based cement composites and geopolymer concrete which represents alkali activated cement composites. The size of all shrinkage specimens was 47 mm in the diameter and 190 mm in height. The shrinkage deformations of the specimen were determined by consistently measuring specimen deformation displacement. [3]

Shrinkage deformation values for foam concrete in 30th day did reach 10.88 $mm \cdot 10^{-2}$, disintegrated cement mortar 3.44 $mm \cdot 10^{-2}$ but for geopolymer concrete on the 30th day it was 3.16 $mm \cdot 10^{-2}$.

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CALCULATION OF INITIAL AND HEATING COSTS FOR NEARLY ZERO ENERGY SINGLE-FAMILY BUILDING OVER 30 YEARS

STANISLAVS GENDELIS[1], MIKUS MIKELSONS[2], ANDRIS JAKOVICS[3]

[1]*The Faculty of Physics, Mathematics and Optometry, University of Latvia, Rīga, Latvia*
[2]*Department of Infrastructure, University of Latvia, Latvia,*
E-mail: mikus.mikelsons@lu.lv

In practice, during design stage of a single-family building, only initial costs are taken into account, they are also discussed with the customer and optimized with the aim to reduce them. At the same time, the calculation of operational costs should be made to see the real difference in expenses while living in this house. It should be emphasized that in the case of nZEB building the global cost calculation approach, which includes all the expenses over long time period, becomes especially useful because of the strict requirements of heating and primary energy, as well as compulsory use of renewable energy sources, requiring more detailed and comprehensive calculations of cost-optimal set of solutions.

In this study, one newly built nZEB single-family house is studied in detail using comparative global cost calculation methodology [1]. The most popular in Latvia typical insulation materials (loose cellulose wool, mineral wool, EPS/XPS), construction types (wooden frame construction and masonry construction), two types of windows and two types of floor construction (slab-on-ground and strip foundation) are include in research to calculate initial and global costs. On the other hand, different heating systems are included in analysis to calculate the difference in heating expenses and compare them over 30 years. The economic calculations are carried out, taking into account expected energy price increase, discount rate, maintenance and operating costs during the calculation period of 30 years.

Calculations (see Figure) show that the difference in initial costs for considered variants due to change of materials, constructions and heating systems are relatively small and they are comparable with the difference in replacement costs for different materials/constructions. At the same time, the total energy (mainly heating) costs are practically negligible compared to the total costs, but this this statement is valid only for nZEB buildings with very low energy consumption.

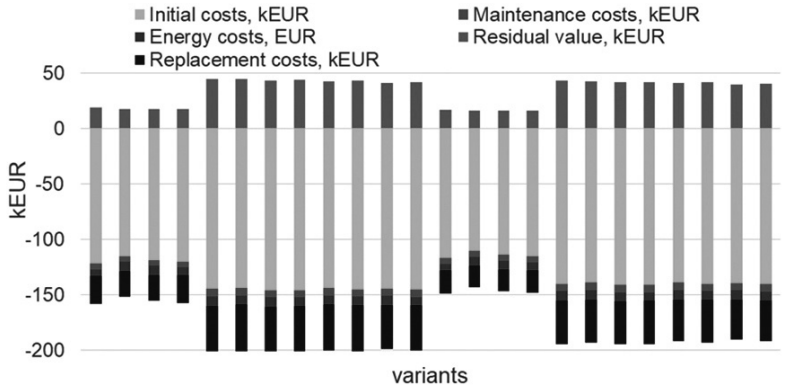

Fig. 1. Comparison of all the costs for different variants of nZEB building over 30 years.

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VELOCITY MODIFICATION AT THE BRIDGE ABUTMENTS BECAUSE SCOUR

BORISS GJUNSBURGS[1], MARTINS VILNITIS[2]

[1]*Water Engineering and Technology Department, Riga Technical University, Riga, Latvia*
[2]*Construction Technology Department, Riga Technical University, Riga, Latvia*
E-mail: boriss.gjunsburgs@rtu.lv

The contraction flow by the bridge structures at low-land rivers, such as abutments, piers, as well as guide banks, and spur dikes, leads to the flow and velocities modification in the vicinity of the abutment and is one among another reasons for scouring. Approaching the bridge contraction, the streamlines are bended by an embankment, and the flow goes parallel to it. The flow velocities along the extreme streamline drop almost to minimum values and then gradually increase, which is accompanied by circulation and development of different vortex structures. At the corner of the abutment, is streamline concentration, sharp water level drop, rapid local increase of the velocity and local scour. Currently, in formulas or methods for scour calculation near structures in flow is used approach flow velocity, instead of local one, which presence is confirmed in nature and in tests at the bridge abutments at the flow. According to tests results relative local and critical velocities are depending on open flow parameters, backwater value, rate of contraction by bridge crossings, depth of scour, steady or unsteady flow, floods events, uniform or stratified river bed Studded changes of the relative local and critical velocities in time at steady and unsteady flow, uniform and stratified river bed model. The local velocity V_{lt} is reducing and the critical velocity V_{0t} is increasing because of the scour within the time step at steady and unsteady flow. For the next time step of the flow local and critical velocities are different because of the increased discharge and the scour depth developed in the previous step. Formula for local velocity for plain and scoured river bed is presented in paper and comparison of the local velocity with approach flow for different contraction rate of the flow is made.

Dependence relative velocities $V_l/V_{apr.}$, $V_l/\beta V_0$ from contraction rate Q/Q_b and F_r number is presented, where V_l is local velocity and $V_{apr.}$ is approach flow velocity. The ratio V_l/V_{ap}. (local to approach velocity) is depending on contraction rate and of the flow Froude number of the flow. With increase contraction rate of the flow the difference between local and approach velocity of the flow is increasing and with increase the Froude number is decreasing. Among another factors which impact on scour at the abutments, local velocity, but not approach velocity, is forming the scour hole.

Velocities at any stage of scour at uniform and bed layering V_{lt}, V_{0t} and relative ones V_l/V_{lt}, V_{0t}/V_0, $\beta V_{0t}/V_{lt}$ in time at steady and unsteady flow, as well relative velocity $\beta V_{0t}/V_{lt}$ impact on relative depth of scour h_s/h_f at unsteady flow and stratified bed model is studied. Tests

were made for fixed and sand bed of the model. Tests with fixed bed of the model were made for different contraction of the flow to investigate velocity and water level changes in approach to the embankment, along to it and near the model of the abutment. With sand bed – to study scour process, velocity changes in time, influence of hydraulic parameters, rate of contraction of the flow, grain size, uniform and stratified bed and time on the scour.

SPECTROPHOTOMETRIC EVALUATION OF PIGMENTED URETHANEACRYLATE COATING COLOUR STABILITY

ZANE GRIGALE-SOROCINA[1,2], INGMARS BIRKS[1], RASA PILIPAVICA[1]

[1]R&D, Kinetics Nail Systems, Riga, Latvia,
[2]Institute of Polymer Materials, Faculty of Material Science and Applied Chemistry, Riga Technical University, Riga, Latvia
E-mail: zane.grigale@kineticsbeauty.com

The research was carried out testing two red pigment dispersion colour stability in UV light-curing urethane acrylate composition. The given urethane acrylate composition was pigmented with a pigment content of 0.1 % to 5 %. Coating colour change were evaluated at room temperature and at 50 °C over a 28 day period. For all prepared pigment samples, spectrometric colour difference measurements were performed using CIEL*a*b* and CIEL*C*h* colour systems and FTIR-ATR to evaluate their stability over time. It was found that increasing pigment concentration improves the colour stability. There was found the difference between tested red pigments and can be concluded that one of them are more stable for use in pigmented coatings.

CRACK-HEALING BY CRYSTALLINE ADDMIXTURE IN CONCRETE

SANDRA GUZLENA[1], GITA SAKALE[1], DIANA BAJARE[2]

[1]Institute of Technical Physics, Faculty of Material science and Applied Chemistry, Riga Technical University, Riga, Latvia
[2]Institute of Materials and Structures, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: sandra.guzlena@gmail.com

Different types of defects can be seen on every construction facade material. Defects in material enhances due to aggressive factors in outdoor which reduces material properties over a longer period. Mainly defects on facades are from mechanical impacts, environmental exposure or due to impropriate maintenance [1]. Every materials properties can be predict. In concrete material through cracks aggressive agents, as chlorides, sulphides and carbonates penetrate trough material surface and service life of concrete structures decreases [2]. To improve service life many methods can be used. One of them is self-healing materials, like bacteria, crystalline additives, incapsulated healing agents and other. Self-healing material use have many advantages, like, less people work and money saving due to inspection, monitoring and repair. Crystalline admixtures have many advantages due to other self-healing techniques. No need for encapsulation, contrary bacteria or liquid healing agents, which reduces sample preparation time. Crystalline admixtures have positive effect not only on cracks healing but also on permeability reduction.

In this work crystalline admixture WT-200 from SIKA have been used. Crystalline admixture has been mixed in concrete mass during mixing process. Samples were cut and cured in air for 28 days. Samples were pre-cracked after 28 days. After pre-cracking samples were cured in water. Cured samples were analysed by microscope and scanning electron microscope (SEM).

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ALKALI-AGGREGATE REACTION IN ALKALI-ACTIVATED CEMENT CONCRETES

PAVEL KRIVENKO[1], OLEKSANDR GELEVERA[1], OLEKSANDR KOVALCHUK[1], GIRTS BUMANIS[2], ALEKSANDRS KORJAKINS[2]

[1]Kyiv National University of Construction and Architecture, Scientific research institute for binders and materials named after V.D. Glukhovskii, Kyiv, Ukraine
[2]Department of Building Materials and Products, Institute of Materials and Constructions, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: aleksandrs.korjakins@rtu.lv

The paper discloses the results of a study on structure formation processes in the interfacial transition zone "cement stone – aggregate" of the alkali-activated cement concretes. The results indicate the importance of the content of Al_2O_3 in the cement and aggregate. Together with components that are able to interact actively with alkalis in the presence of reactive SiO_2, the processes taking place during the alkali-aggregate reaction can have weather destructive or constructive effect. The constructive effect is caused by incorporating the corrosion products into alkaline aluminosilicate compounds, thus retarding the internal corrosion of the concrete and providing the higher durability even in case of alkali-activated cements and alkali-susceptible aggregates with relatively high alkali content.

EFFECT OF PCM ON THE PROPERTIES OF CEMENT COMPOSITES

DIANA BAJARE, ALEKSANDRS KORJAKINS

Department of building materials and products, Institute of Materials and Structures, Riga Technical University, Latvia
E-mail: aleksandrs.korjakins@rtu.lv

Rapid economic development worldwide and a high standard of living lead to increasing demand for energy and its consumption is increasing significantly. Manufacturers of construction materials and the construction industry as a whole are among the largest consumers of the World's materials and energy resources, so the development of new, efficient and environmentally friendly materials is one of the industry's priorities to reduce energy consumption during buildings construction and operation. Passive heat storage systems (PHSS) containing phase change materials (PCM) are an advanced option for improving thermal mass and heat comfort for buildings.

As concrete is widely used as building material for residential and commercial buildings around the world, PCM's integration technology in the concrete and cement composite structure has great potential to improve the energy performance of buildings and indoor microclimate.

A self-compacting mixture (SCC) was created in order to prevent PCM microcapsules from being exposed to deformation and damaged during the casting of the cement composite. The excretion of hydration heat is delayed by 5 - 10 min and reduce the maximum hydration temperature by 5.6 °C, depending on the amount of PCM microcapsules added to the composition. From this point of view, the use of PCM microcapsules in the manufacture of cement composites can be considered an advanced method.

By increasing the proportion of PCM microcapsules in the composition (1, 3 and 5 %), the self-compacting properties of the cement composite is not significantly affected, but the compressive strength and density of the cement composite are decreased and porosity is increased.

Preliminary study shows that PCM microcapsules are not long-lasting in alkaline environments and therefore effective action in the cement composite structure could be significantly diminish over time. The study of that phenomena should be continued.

Acknowledgements

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COMPETENCE OF LOCAL GOVERNMENT BUILDING BOARD IN ELIMINATION OF THE CONSEQUENCES OF ARBITRARY CONSTRUCTION

INTRA LUCE[1], IVETA PUKITE[2]

[1]College of Law, Riga, Latvia
[2] Riga Technical University, Riga, Latvia
E-mail: intra@jk.lv

In accordance with the provisions of regulatory enactments of the Republic of Latvia, the law obliges the local governments to establish a Building Board within their administrative territory or, in co-operation with other local governments to develop joint Building Boards and ensure the resources required for the operation of a Building Board, thus providing for the legality of construction process in their administrative territory. Building Board is an institution of special status, established at the local government and it is one of the municipal structures that has been delegated to control the legality of the building process in the administrative territory of local government, therefore, the Building Board is an intermediate administration institution that is bound by external regulatory enactments that are binding on derivative public entity, and, therefore the administrative procedure is binding on them as well. The objective of the article is to study the competence of Building Board in the elimination of the consequences of arbitrary building by determining the principal functions of the Building Board, signs of the detection of the arbitrary building and the competence of the personnel of the Building Board and the competences of the Building Board personnel in the review of arbitrary construction cases. The article evaluates the administrative acts of the Building Board that impose the duty of the addressee of the administrative act to eliminate the consequences of arbitrary building.

LAMINA PROPERTIES NON-DESTRUCTIVE CHARACTERISATION OF ASYMMETRIC CARBON FIBER REINFORCED LAMINATES

ENDIJA NAMSONE[1], DENIS ERMAKOV[2]

[1]*Institute of Materials and Structures, Riga Technical University, Riga, Latvia*
[2]*Department of Mechanics of Composite Materials and Structures, Perm National Research Polytechnic University, Perm, Russia*
E-mail: endija.namsone@rtu.lv

A non-destructive technique – numerical-experimental method, based on vibration tests is applied for the characterization of lamina properties of asymmetric carbon fiber reinforced laminates. Carbon fiber reinforced plastics are widely used now in different lightweight constructions requiring high stiffness-to-weight and strength-to-weight ratios. The technical data of such materials are estimated in the research laboratories by using conventional fracture methods [1], ultrasonics [2] or inverse technique based on low-frequency vibrations [3-5].

The inverse technique in the present work is realised by using vibration tests and includes physical experiments, numerical modelling and identification procedure, consisting of planning of experiments, response surface methodology and minimization of error functional that describes the residuals between the experimental and numerical natural frequencies. The main idea of this procedure is the determination of simple mathematical models (response surfaces), using the finite element analysis at the reference points of experimental design.

The vibration testing is fast and low-cost method for an identification of elastic properties. To study the behaviour of specimens, one of the common used procedure - experimental modal analysis - is applied. During this analysis, consequent modal parameters, like modal frequency and shape of mode, are determinated. The experimental set-up for vibration tests in the present work is based on Scanning Laser Vibrometer POLYTEC.

The finite element method is used for the modelling and dynamic analysis of laminated composite specimens. The finite element code ANSYS 19.2 is applied for modelling the composite specimens using the first order shear deformation theory.

For the purpose of characterization, two asymmetric carbon fiber laminated specimens were prepared, using the prepreg manual layout technology. The technology of prepreg molding has the following characteristics: low complexity of laminate laying, clean process, high quality composite material, increased requirements for tooling and support materials (high polymerization temperature). The specimens consist of four anisotropic layers with the following reinforcement schemes [0°/90°/0°/90°] and [-45°/45°/-45°/45°]. During the physical experiments, 14 first eigeinfrequencies are measured for the specimen 1 and 13 first eigenfrequencies – for the specimen 2.

An inverse technique, based on vibration tests and response surface methodology, was successfully applied for an identification of the elastic material properties of asymmetric carbon fiber reinforced composite specimens. The main advantage of the identification procedure, based on non-direct optimization methodology, was the reduction of computational efforts. To evaluate the elastic material properties obtained, the numerical eigenfrequencies, determinated by using identified material properties, were successfully compared with experimentally measured and high accuracy with average relative error less than 1% was reached. It is necessary to note that out-of-plate material properties could be identified also using the present methodology. However, in this case the thickness of tested samples should be increased (not less than 4 mm).

Acknowledgements

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BIODEGRADATION STUDIES OF SAPROPEL-BASED COMPOSITE MATERIALS

VAIRA OBUKA[1], OLGA MUTER[2], MARIS SINKA[3], MARIS KLAVINS[1]

[1]*Department of Environmental Science, University of Latvia, Riga, Latvia*
[2]*Institute of Microbiology and Biotechnology, University of Latvia, Riga, Latvia*
[3]*Riga Technical University, Faculty of Civil Engineering, Institute of Materials and Structures, Latvia*
E-mail: vaira.obuka@lu.lv

Traditional composite materials used for construction purposes currently face many questions regarding their sustainability – mainly because they do not come from renewable sources and due to the problems related to their end-of-life management. These challenges motivate companies and researchers to look at the natural fiber composite materials with increased interest. Usually natural fiber materials in construction are used together with mineral binders, but in this research new organic binder – sapropel (organic rich lake sediments) is used as a binder for natural fiber composite materials with various fillers. In previous research these composite materials have proven their applicability in construction industry due to their sufficient mechanical strength and low thermal conductivity. Thus, in this research evaluation of the biodegradability of composite materials were done, comparing them to natural fiber materials with mineral binders. As a methods respiration intensity of microorganisms in soil and enzyme activity of microorganisms were used.

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IDENTIFICATION AND MONITORING OF DEGRADED REAL ESTATE IN THE CONTEXT OF URBAN ENVIRONMENTAL ANALYSIS AND DEVELOPMENT PLANNING IN THE CITY OF RIGA

IVETA PUKITE[2], MARA ZIRA[1], INETA GEIPELE[2]

[1]College of Law, Riga, Latvia
[2]Riga Technical University, Riga, Latvia
E-mail: iveta.pukite@rtu.lv

Nowadays real estate plays an important role in the life of a person: it is one of the important elements of the quality of life (dwelling, workplace), as well as of public spaces, especially the outdoor space, i.e., the elements that make up the image of the city and the aesthetic enjoyment of the city. The topical issue under consideration is directly related to the physically deteriorated real estate that falls into the category of degraded or even dangerous buildings and structures. The article aims at investigating the problems of identifying, assessing and monitoring the degraded real estate in the context of urban development. The topicality of degraded objects is also observed in the main national and municipal development planning documents. The quality of real estate is assessed by different institutions according to the specificity and necessity of their activity, for example, planning and monitoring of territory development, application of real estate tax, as well as determination of the value of real estate. However, according to the research conducted within the article, information on real estate is not always up to date, available or linked between different holders of information sources. Different institutions evaluate the same thing at different levels of detail, but there is currently no fast, efficient and accurate exchange of information. This can be explained by disorganized administrative and legal issues, as well as the inefficiency of mutual communication.

ASPHALT RECYCLING TECHNOLOGIES: A REVIEW ON LIMITATIONS AND BENEFITS

MUKUL RATHORE, MARTINS ZAUMANIS, VIKTORS HARITONOVS

Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: mukul.rathore@rtu.lv

Recycling of asphalt pavements gained popularity in 1970s due to the rapidly increasing cost and reducing supply of oil and hence - bitumen. However, presently there are other reasons to develop this technology, the main being the ability to utilize non-renewable resources. Sustainability of asphalt pavement construction can only be ensured if we are able to utilize the available reclaimed asphalt pavement (RAP) material completely in the new construction. Another potential advantage is the mutual benefit of using RAP in conjunction with warm mix asphalt (WMA). This is due to compensation of hardened binder from RAP with softer binder of WMA. For such mixes, significant energy savings can be realized due to the lower mixing and compaction temperature as well as due to lesser efforts required for compaction. This paper summarises several approaches that can be adopted to maximize the amount of RAP material in asphalt mixtures. In addition, the current recycling practices implemented in the industry are discussed to identify the main reason behind the lacking confidence in using high RAP content in mixes. The environmental and economical benefits of high rate of recycling are also discussed. Finally, the possible research directions that will allow to incorporate high proportion of RAP without compromising the performance of pavement are discussed.

EVALUATION OF ADHESION BETWEEN BITUMEN AND AGGREGATE WITH THE DIGITAL IMAGE PROCESSING METHOD

ARTURS RIEKSTINS[1,2], VIKTORS HARITONOVS[2], ANDRIS BALODIS[12]

[1]Riga Technical University, Department of Roads and Bridges, Latvia
[2] SJSC "Latvian State Roads", Latvia
E-mail: riekstins.arturs@gmail.com

Although adhesion between bitumen and aggregates is one of the most important properties, it is still evaluated visually. European Standard EN 12697-11 provides 3 test methods for the preparation of samples for evaluation - rolling-bottle method, static method and boiling water stripping method. The method used in Latvia is different from EN 12697-11, but with similarities. Bitumen coating is evaluated visually for all methods. The result is the average value of two parallel operators. This principle of evaluation is much criticized as inaccurate and subjective. Today's technologies are evolving and in lot of fields they are more reliable than a human. The goal of this study is to determine whether a visual assessment method can be replaced by a photo processing method. To evaluate accuracy of photo processing method, 4 different mineral materials - granite, dolomite, quartz diorite, gravel, were selected. Samples obtained during the test procedure were tested visually and using a photo processing method. For photo evaluation, a mini photo studio was created, where the necessary pictures were taken using a professional camera and budget smartphone. The smartphone was used to determine if it is possible to get high quality pictures and results using budget smartphones in our pockets. The "ImageJ 2" program was used for the photo processing method. The obtained results showed a dispersion in the 10 % range between the operators when used visual evaluation method. Comparing the results of photo processing with pictures from a professional camera and the Huawei P9 lite smartphone, the difference was 4 – 8 % on average. Comparing the results of the visual assessment method with photo processing results (professional photo camera) they did not differ more than 10 %.

EVALUATION OF BRIDGE AND LANDSCAPE INTERACTIONS

ILZE ROZENTALE, AINARS PAEGLITIS, JURIS SMIRNOVS

Department of Road and Bridges, Riga Technical University, Riga, Latvia
E-mail: ilze.rozentale@rtu.lv

In recent years, the community has become more and more focused on the preserving the natural landscape that is an essential part of a quality of human life. Every member of society wants to enjoy a high - quality landscape. This is evidenced by the documents adopted in recent years, which set out how to evaluate the interaction between structures and landscape. The European Landscape Convention covers all areas with both natural and human-changed landscape. This paper analyses methods and criteria for assessment of bridges as a component of the landscape, focusing on the possibilities and experiences of applying multi - criteria methods. Particular attention is paid to the interaction between the bridge and the environment, the criteria and methods for its assessment, which is one of the stages of the visual (technical and visual) and aesthetic (separate elements and overall design) of the bridges, which includes both landscape and bridge impact assessment. Paper analysis the possible application of criteria and methods for evaluation of existing and new bridges as a part of the landscape.

APPLICATION OF PCM FOR PASSIVE AND ACTIVE TES SYSTEM FOR SPACE COOLING OF NEARLY ZERO-ENERGY RESIDENTIAL BUILDINGS

SANDRIS RUCEVSKIS, PAVEL AKISHIN, ALEKSANDRS KORJAKINS

Institute of Materials and Structures, Riga Technical University, Kipsalas iela 6A, Riga, LV-1048, Latvia

According to the data form the European Commission, building sector is the dominant energy consumer in the EU and accounts for approximately 40 % of total energy consumption and over 36 % of greenhouse gas emissions. Conventional heating, ventilating, and air conditioning systems are responsible for most of the energy use in buildings. Therefore, there is a need for alternative energy technologies that can reduce the energy consumption in buildings. Latent heat thermal energy storage systems with the application of phase change materials (PCM) has received considerable attention due to their ability to provide high volumetric heat capacity and their ability to store thermal energy at relatively constant temperatures. PCM incorporated thermal energy storage (TES) systems for buildings can generally be categorized into two main application methods - active and passive.

In this study, application of PCM for passive and active TES system for space cooling of multi - storey nearly zero-energy residential buildings is investigate numerically. TES system composed of stand-alone PCM storage units is integrated into the building interior between the concrete ceiling slab and the ceiling finishing layer. In the passive application, PCM is incorporated into a building envelope to increase thermal mass and the system operates without the external supply of energy. PCM melts during the daytime thus absorbing the heat and solidifies during the night by dissipating the stored energy. In the active application, regeneration of the PCM is achieved by means of cold water flowing within a capillary pipe system incorporated in the storage unit. Effectiveness of the TES systems under the typical summer conditions of the Baltic States is analysed by using computational fluid dynamics (CFD) software Ansys Fluent. The obtained results showed that the active cooling application is superior in reducing the indoor air temperature of the studied room compared to the passive one. The main reason is that in the passive application, the PCM suffers from a poor solidification rate during the night not allowing using the full storage capacity of the PCM during the day.

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CONCRETE SENSITIVE THERMAL ENERGY STORAGE DESIGN AND APPLICATION

DMITRIJS RUSOVS, SIGURDS JAUNDALDERS, PETERIS STANKA

Riga Technical University, Latvia
E-mail: dmitrijs.rusovs@rtu.lv

The need for energy storage is created by the intensive use of renewable energy resources. The waver energy generation requires storage in order to provide stable supply in grid and network. Because the energy consumption of today is also fluctuating, energy is no longer used when it is produced. Nowadays production gear and load gear are no longer the same. This means that there is a surplus at sometimes and a lack at other times. It is the job of storage to restore the balance between these two. The term "load gear" refers to the time course of the power consumption by the end users.

Another reasons for energy storages is energy price high volatility (in network like Nordpool) and reduction of feed-in-tariff for "green" energy. Furthermore, more heat accumulators are used to reduce the emission of carbon dioxide in the heat sector. In particular, heat-and-power coupling systems lead the market here.

Limitation of wide adopted water sensitive energy storage for district heating systems include: existing system are designed for operation at water saturation temperature at ambient pressure and below. Due to that water heat accumulator had season bounding and restricted in thermal energy conversation to electrical power.

Recent development of renewable energy by concentrated solar power creates high temperature concrete (HTC) for passive solid storage system. Combination of average specific heat of 916 J/(kg K) and density around 2750 kg/m^3 provide heat capacity for HTC at 350 °C up to 100 – 150 kWh/m^3 which is very close to energy density in water storage. However, the cracking due to hoop stress of concrete need to be limited at high temperature application. A balanced innovative concrete mixture casted according module sizing technology also interface layer for piping in concrete had to be used.

The main objectives of the authors' current paper include thermal sizing of a regenerative concrete heat exchanger for coupling of the biomass plants and the heat engine like ORC (Organic Rankine Cycles). The main challenge for regenerators is the temperature difference between charging and discharging process. Therefore, during discharge temperature decrease and heat transfer is relatively small.

Heat energy charging can be done by hot flue gas or high temperature fluid (HTF) circulation through solid modules of storage. Optionally heat supply can be obtained by using of electrical energy. The concrete modules contain embedded piping for charging and discharging and definition of the geometric parameters like piping size and distance represented in current work. The design of unsteady heat-transfer in regenerative

heat exchanger done for small size plant with peak power of 1 – 2 MWe and heat capacity of 5 – 8 MWht.

The combination of concrete modules and piping size together with charge and discharge rate and methods are used to benchmark computer modelling. Status of key issues remaining to be addressed to total efficiency of power generator – storage system performance.

PROPERTIES OF THIN WALL CEMENT COMPOSITES REINFORCED WITH AR GLASS, CARBON AND PVA FIBRES

RIMVYDAS MOCEIKIS[1], ASTA KICAITE[1], GENADIJS SAHMENKO[2], ALEKSANDRS KORJAKINS[2]

[1] Department of Building Materials and Fire Safety, Vilnius Gediminas Technical University, Vilnius
[2]Department of Building Materials and Products, Institute of Materials and Structures, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: rimvydas.moceikis@vgtu.lt

Thin wall cement composites find a wide range of special applications for making light weight façade exterior wall and urban decorative elements, as well as a part of load bearing constructions. AR glass fibre is the most popular reinforcing material for producing glass fibre reinforced concrete (GRC). Possibilities for use alternative Carbon and PVA fibres are analysed in this work. The study is focused on investigation of technological and mechanical properties of thin wall (15 mm) cement composite plates reinforced by tree types of fibres.

FIRE PROTECTION, THERMAL AND STRENGTH COMPARISON OF HEMP BASED BIOCOMPOSITES WITH MAGNESIUM AND LIME BINDERS

MARIS SINKA[1], DIANA BAJARE[1], EDGARS BUKSANS[2], ANDRIS JAKOVICS[3]

[1]Institute of Materials and Structures, Riga Technical University, Riga, Latvia
[2]Forest and Wood Products Research and Development Institute, Jelgava, Latvia
[3] Faculty of Physics and Mathematics, University of Latvia, Riga, Latvia

Bio-based building materials for thermal insulation purposes are biocomposites with a wide range of potential application and they comply with the modern requirements – low environmental impact and high energy efficiency. One of the ways to widen their possible use is to overcome the issues of low strength and fire resistance. This paper focuses on testing hemp-based building material where traditional lime based binder is substituted with two types of magnesium based binders – magnesium oxychloride and magnesium phosphate cements – as these binders should provide higher strength and fire resistance properties than lime binders. Magnesium binder biocomposites are tested to assess their compressive strength in correlation with density and thermal conductivity, as the aim is to achieve higher strength at lower thermal conductivity, as well as compared to traditional lime binder biocomposites. Fire resistance of all materials is also evaluated according to LVS ISO 5660-1: 2015. The results achieved indicate that using both magnesium-based binders biocomposites with 4 – 5 times higher compressive strength at the same density can be produced which allows to significantly decrease binder amount and thermal conductivity at the same compressive strength. During fire resistance tests magnesium binder biocomposites showed lower heat release rate but higher loss of mass which is linked to the fact that the magnesium-based biocomposites have chemically bound water, which is released under the impact of elevated temperatures. Overall results show that magnesium based biocomposites display promising properties to widen their use in construction.

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NUMERICAL MODELLING OF HIGH STRENGTH FIBRE-CONCRETE'S COLUMNS IN MULTI-STOREY BUILDING

JANIS SLISERIS, KARINA BUKA-VAIVADE

Riga Technical University, Riga, Latvia
E-mail: janis.sliseris@gmail.com

The complexity of architecture is continuously growing. Therefore, it is necessary to develop a new construction systems with complicated topology using less human work. A fiber – concrete is very promising material to solve those problems. However, design methods of fiber – concrete load bearing structures such as slabs, columns and walls are not well developed. Therefore, a new numerical simulation framework is proposed for analysis of fiber – concrete structures on meso, macro and giga scale. The method can take into account non-linear post-cracking behaviour of fiber – concrete. This includes local fiber orientation in thin elements, anisotropic continuum damage models on different scales, efficient meso – scale fiber orientation prediction tools and others.

The proposed method is used to analyse multi-scale buildings where part of structural elements are made from fiber – concrete. The effectiveness of fiber – concrete is estimated and proposed a guidelines for optimal design using fiber – concrete.

PREDICTION OF STRENGTH IN SINTERED METAL-CERAMIC COMPOSITES WITH ADDED HOLLOW PARTICLES BY ULTRASOUND VELOCITY AND DENSITY

ALEXEY TATARINOV, ANDREY SHISHKIN, VIKTORS MIRONOVS

[1]Laboratory of Powder Materials, Riga Technical University, Riga, Latvia
E-mail: aleksejs.tatarinovs@rtu.lv

Ultrasound velocity is known as a good predictor of strength in some construction materials like concrete. In multi-phase materials, where the physical properties of components differ by orders, the strength prediction becomes more ambiguous due to more complicated interactions between the components. As an example of such material, sintered metal-ceramic composites with added hollow particles were taken.

The matrix was sintered mixture of powdered iron and clay, and hollow inclusions were admixed cenospheres or microsphreres of fly ash. By varying the iron – to – clay ratio, sintering temperature and cenospheres content, 17.4 % variation of the bulk density ρ and 35.3 % variation of the compression strength σ of cylindrical specimens were achieved. Ultrasound velocity C was measured by the though transition of the specimens and showed 8.6 % variation.

The results showed that all the mentioned parameters positively correlated with each other. The relationship between C and σ was of an expressed non-linear character. Normalization of the relationship by ρ helped to improve C-σ correlation. The best ones were obtained between C and the ρ·σ product, for Spearman rank correlation (0.942) where the dependency between the correlated values may be described by a non-linear monotonous function, and C and ρ-2·σ-4, for Pearson linear correlation (0.943). Density ρ in this case has as a quantitative measure of the hollow particles content.

PHYSICAL AND MECHANICAL PROPERTIES OF HIGH PERFORMANCE CONCRETE REINFORCED BY SHORT NON-METALLIC FIBRES

DAIRA TOMA, LAURA DEMBOVSKA, DIANA BAJARE, VITALIJS LUSIS, GENADIJS SAHMENKO, ALEKSANDRA KORJAKINS

Department of Building Materials and Products, Institute of Materials and Structures, Riga Technical University, Riga, Latvia
E-mail: daira.toma@rtu.lv

This study is focused on the physical and mechanical properties of the Fibre Reinforced High Performance Concrete (FRHPC). The most important benefits of addition of fibres to the concrete mix are the hindrance of the development of microcracks, the delay of the propagation of microcracks to macroscopic cracks and the better ductility after microcracks occurs. To evaluate the impact of fibres, firstly, plain reference matrix was defined using HPC with extra fine fillers and then six types of non-metallic fibres were chosen to reinforce the HPC matrix. In this paper, the efficiency of different type of fibres with equal volume dosage in the mix on the physical and mechanical properties of FRHPC was evaluated, including compressive strength the tensile cracking strength is discussed through the analysis of experimental results. Results and conclusions presented in the paper give valuable information on type of non-metallic fibres to choose for HPC reinforcement.

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INTERACTIVE LEARNING MEDIUM IN CONTEMPORARY ENGINEERING EDUCATION ACCENTED FOR PRACTICAL TRAINING OF HIGH SKILLED PERSONNEL

ZOJA VEIDE, VERONIKA STROZHEVA

Department of Computer Aided Engineering Graphics, Riga Technical University Riga, Latvia
E-mail: zoja.veide@rtu.lv

The contemporary generation of students reluctantly uses traditional teaching tools such as textbooks, which makes it necessary to create interactive training materials using modern technologies. This article presents the experience of creation of interactive educational materials for graphical engineering disciplines, which is aimed for students of colleges and vocational schools. In the material developing, the didactic experience of technical universities teachers from five countries has been summarized. Elaborators of this course have got joint goals of improvement of quality of education and solving similar problems of fast and efficient presentation of educational material acceptable to the modern generation of students.

ENERGY SAVING POTENTIAL OF VENTILATION SYSTEMS WITH EXHAUST AIR HEAT RECOVERY

JURGIS ZEMITIS, ANATOLIJS BORODINECS

Heat, Gas and Water technology institute; Riga Technical University; Riga, Latvia
E-mail: Jurgis.Zemitis@rtu.lv

The paper presents the results of data gathering regarding the heat recovery efficiencies of different heat recovery types at various air flows supplied by some of the most common manufacturers. The study showed that the average heat recovery efficiency of modern, commonly used rotary heat exchangers is around 83 % while for counter-flow exchangers around 86 %. Also, in the paper, the simulation results of heat energy consumption and recovered heat potential for the single-family house are presented. The simulations are performed in IDA-ICE software and show that for the specific building it is possible to reduce the heating energy up to 84 % if ventilation with heat recovery is used. The results also showed that in case the internal heat loads decrease, then it slightly affects the heat recovery potential. In the case of no internal gains, this value decreases by 4 %.

LIFE CYCLE ASSESSMENT FOR MASONRY EXTERIOR WALL MODELS MADE OF TRADITIONAL BUILDING MATERIALS

ZINTA ZIMELE[1], MARIS SINKA[1], DIANA BAJARE[1], ANDRIS JAKOVICS[2]

[1]*Institute of Materials and Structures, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia*
[2]*Faculty of Physics and Mathematics, University of Latvia, Riga, Latvia*
E-mail: zinta.zimele@rtu.lv

Building materials contributes significant amounts of CO_2 to overall greenhouse gas emissions and this environmental impact should be reduced to improve the sustainability of construction industry. Although new and low-carbon materials are emerging, still the majority of the materials used are traditionally produced and highly carbon intensive, such as masonry blocks and insulation slabs – rock wool or expanded polystyrene. To assess which of the traditionally used building materials are more sustainable, in this paper, wall models of the most widely used masonry blocks and insulation materials were analysed using life cycle assessment. The wall models were created to fulfil the requirements of nearly - zero energy buildings. The assessment showed that the lowest impact on the environment is from aerated concrete blocks and expanded polystyrene insulation that is mostly due to low weight and raw materials consumption compared to other materials. On the other hand, expanded polystyrene insulation poses more danger to humans and environment in its use phase as other materials due to emissions during fire and degradation, thus should be used with caution.

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SHEAR FAILURE OF SANDWICH PANELS SUBJECTED IN BENDING

MYKOLAS DAUGEVICIUS[1], TOMAS SKUTURNA[1], JUOZAS VALIVONIS[1], ANTANAS PATAPAVIČIUS[2]

[1]Department of Reinforced Concrete Structures and Geotechnics, Vilnius Gediminas Technical University, Vilnius, Lithuania
[2]Department of Applied Mechanics, Vilnius Gediminas Technical University, Vilnius, Lithuania
E-mail: mykolas.daugevicius@vgtu.lt

The paper describes the behaviour of the sandwich panels in bending. Two panels of the same dimensions are tested. The panels differ only in the layout of the inner thermal insulation layer. The thermal insulation layer is made of separate mineral wool slabs. The graphs of the strain development in the external sheets, the displacement between the layers and mid-span displacement are presented in the paper. The nature of the failure shows that only separate internal thermal insulation slabs resist the shear force. Therefore, the complete width resistance cannot be evaluated. The views of the failure are also presented.

EFFECT OF MWCNT AND PCE PLASTICIZER ON THE PROPERTIES OF CEMENT PASTES

GINTAUTAS SKRIPKIUNAS[1], EKATERINA KARPOVA[1], JOANA BENDORAITIENE[2], IRMANTAS BARAUSKAS[3]

[1]Department of Building Materials and Fire Safety, Vilnius Gediminas Technical University, Vilnius, Lithuania
[2]Department of Polymer Chemistry and Technology, Kaunas University of Technology, Kaunas, Lithuania
[3]Department of Silicate Technology, Kaunas University of Technology, Kaunas, Lithuania
E-mail: ekaterina.karpova@vgtu.lt

Polycarboxylate ether (PCE) plasticizer possesses by high water-reduction capability of about 30 – 40 %. Despite the superior water reduction capability, the high dosages of PCE may cause the bleeding in cement systems, which is not suitable for high workability and self- compacting concrete. The current research is devoted to the studying of multi-walled carbon nanotubes (MWCNT) suspension prepared in combination with PCE plasticizer on the rheological properties of cement pastes. The bleeding of cement pastes modified by different dosages of MWCNT was estimated as well. The increase of yield stress in 3.7 and 3.5 times was obtained for cement paste modified by MWCNT suspension in dosage of 0.12 % by weight of cement (bwoc) in 5 and 120 min after cement paste mixing, respectively. The increase of plastic viscosity in 2.95 and 1.55 times was obtained for cement paste modified by MWCNT suspension in dosage of 0.12 % bwoc in 5 and 120 min after cement paste mixing, respectively. Modification of cement pastes by MWCNT suspension in the dosage of 0.24 % bwoc led to the decrease of bleeding water volume by 21.7 % in comparison with cement pastes modified only by PCE plasticizer.

THE IMPACT OF EXPANDED POLYSTYRENE WASTE OF DIFFERENT FINENESS ON THE PROPERTIES OF LIGHTWEIGHT COMPOSITE

DAINIUS LEONAVICIUS, INA PUNDIENE, JOLANTA PRANCKEVICIENE, MODESTAS KLIGYS

Vilnius Gediminas Technical University, Faculty of Civil Engineering, Institute of Building Materials, Vilnius, Lithuania
E-mail: dainius.leonavicius@vgtu.lt

Expanded polystyrene is one of the well-known wastes, which has been widely used for many years in various applications. Due to its inert, closed-cell and ultralight (up to 95 % air by volume) structure expanded polystyrene is widely used as a packaging material for many types of goods. However, once the material is used, it is disposed of in landfills, where it can remain intact for the lifetime of several generations. Large amounts of expanded polystyrene require decisions regarding its reuse. Recycling of disposed expanded polystyrene packaging is of high relevance worldwide. Concretes with higher strength values must be developed in order to increase the reuse of expanded polystyrene waste in construction industry. The main objective of this study is to make a more detailed research into the effect of expanded polystyrene aggregate waste of different fineness and shape on physical and mechanical properties of lightweight concrete with porous aggregates.

Tests were done with cement CEM I 42.5 R, expanded polystyrene waste of different fractions (crushed and cut), metakaolin, superplasticizer and air entraining additive. Six batches of porous lightweight aggregates concrete (PLWAC) specimens were formed with different ratios of crushed (EPR) and cut (EPU) expanded polystyrene waste, ranging from 0.5 to 3 (EPR/EPU). The following characteristics of tested specimens were measured: water absorption of EPR and EPU aggregates, density of PLWAC samples after curing and drying, compressive strength, ultrasonic pulse velocity (UPV). The tests revealed that the change in EPR/EPU ratio in PLWAC with porous aggregates leads to density reduction from 700 – 490 kg/m^3 after curing and from 550 to 410 kg/m^3 after drying. When EPR/EPU ratio in the composite is increased to 2, the compressive strength of the specimens drops from 2.3 to 1.75 MPa, the density drops from 700 to 530 kg/m^3. The increase of EPR/EPU ratio up to 3 causes a slight drop in density down to 490 kg/m^3, and a significant drop in compressive strength down to 0.55 MPa. It can be concluded that the increase of EPR/EPU ratio in PLWAC sample with porous aggregates from 0.5 to 3 causes the compressive strength after 28 days of curing to drop from 2.3 to 0.55 MPa. It happens due to varying W/C and structural changes in composite, which are recorded by UPV tests. When EPR/EPU ratio reaches 3, UPV drops to 40 % compared to the specimens where EPR/EPU ratio is 0.5.

THE EFFECT OF SILICA FUME ADDITIVE ON THE RESISTANCE OF CONCRETE TO ALKALI SILICA REACTION

DZIGITA NAGROCKIENE[1], AURIMAS RUTKAUSKAS[1], INA PUNDIENE[2], INGRIDA GIRNIENE[1]

[1]Department of Building Materials and Fire Safety, Faculty of Civil Engineering, Vilnius Gediminas Technical University, Vilnius, Lithuania
[2]Institute of Building Materials, Faculty of Civil Engineering, Vilnius Gediminas Technical University, Vilnius, Lithuania
E-mail: dzigita.nagrockiene@vgtu.lt

Alkali silica reaction in concrete is one of the most deleterious type of chemical corrosion that slowly, however irreversibly, damages concrete structures. The processes of alkali silica reaction can cause cracking, pop-outs, and destruction of concrete surface. Modification of concrete composition with silica fume additive is one of the ways to retard and prevent alkali silica reaction in concrete.

The aim of the paper is to analyse the effect of silica fume additive on alkali silica reaction in concrete mixture containing aggregates contaminated with reactive particles.

Concrete mix made of cement CEM I 42.5 R, silica fume, fine aggregate sand of 0 / 4 fraction and superplasticizer was tested. 5 batches of specimens were made with different silica fume content, where up to 10 % of binding material was replaced with silica fume. Compressive strength, absorption, density, ultrasonic pulse velocity, and resistance to alkali silica reaction were tested in concretes modified with different amounts of silica fume additive. The effect of silica fume additive on the expansion of modified concrete conditioned in 1 M NaOH solution for 56 days was tested. Concrete modified with silica fume at 10 % by weight of cement was found to be the most appropriate for structures exposed to alkaline environment. The control specimen without mineral additives had the expansion of 0.113 %, which exceeds the limit value by 0.1 %, whereas the expansion of specimens modified with 2.5 % of silica fume was equal to the limit value, i.e. 0.1 %. The expansion values reduced in specimens modified with 5 % and 7.5 % of mineral additive. After 56 days of testing, the expansion values of these specimens were 0.093 % and 0.082 % respectively. The lowest expansion value was obtained in specimens with the highest content of silica fume, i.e. 10 %. The expansion of these specimens was 0.07 % after 56 days of conditioning in 1 M NaOH solution at 80 °C temperature. The tests revealed that concrete modified with silica fume replacing 10 % of cement had better resistance to alkali silica reaction and better durability characteristics and thus can be used as structural concrete.

RECYCLING MSWI FA AS ADDITION FOR CLAY BRICK

VIOLETA VOISNIENE[1], OLGA KIZINIEVIC[2], VIKTOR KIZINIEVIC[2]

[1]*Department of Building Materials and Fire Safety, Faculty of Civil Engineering, Vilnius Gediminas Technical University, Vilnius, Lithuania*
[2]*Laboratory of Composite Materials, Institute of Building Materials, Faculty of Civil Engineering, Vilnius Gediminas Technical University, Vilnius, Lithuania*
E-mail: olga.kizinievic@vgtu.lt

The paper analyses the possibilities of recycling municipal solid waste incineration (MSWI) fly ash in clay brick manufacture. The paper analyses the effect of MWSI fly ash (FA) on physical-mechanical characteristics, environmental toxicity of clay bricks. The clay bricks were prepared by adding 2.5 – 7.5 % of FA and firing them at 1000 °C temperature. Physical and mechanical characteristics of clay bodies change depending on the content of FA added: shrinkage, density and compressive strength reduce, water absorption and effective porosity increase. Clay bricks containing 2.5 – 5 % FA do not exceed the limit values of inert substances according to the Waste Directive 2003/33/EC. According to the test results and taking into consideration clay brick physical - mechanical characteristics and environmental toxicity, the recommended content of the addition to the moulding compound is 2.5 – 5 % FA.

ENVIRONMENTAL STUDY AND VALORIZATION OF AN ASHY WASTE: CASE OF PYRRHOTITE ASH

MARYAM ACHIK[1], ABDELLAH OULMEKKI[1], MUSTAPHA IJJAALI[1], HAYAT BENMOUSSA[1,2], NOUREDDINE EL MOUDDEN[2]

[1]*Laboratory of Condensed Matter Chemistry, Faculty of Sciences and technologies, University of Sidi Mohammed Ben Abdellah, Fez, Morocco*
[2]*Campus of Innovation, University of Sidi Mohammed Ben Abdellah, Fez, Morocco*
E-mail: maryam.achik@usmba.ac.ma

Pyrrhotite ash is an industrial waste from an old sulfuric acid process that was based on the roasting of pyrrhotite ore from the Kettara mine. It has been generated since 1965 until 1982, when the mine was closed because of the difficulties associated with the extraction of the ore and the roasting process [1]. This ashy waste is currently stored in large quantities in a large area in southwest of Morocco. The literature review revealed that this waste has been used by some cement industries and has not been the subject of any environmental study or valuation in another area.

In order to fill the lack of information in the literature around pyrrhotite ash, we first realized the physicochemical characterization of pyrrhotite ash [2]. The results showed the presence of iron oxides Fe_2O_3 (64.9 %) and silicon dioxide SiO_2 (13 %) as major constituents in addition to low levels of other oxides.

This work focuses on the environmental study of pyrrhotite ash. This study consists of a dynamic test with renewing lixiviate more particularly the leaching tank test [3]. The protocol used is extracted from the Dutch standard NEN 7345 [4] with modification of the volume of water used and the number of extraction. Quantitative analysis by ICP has shown that pyrrhotite ash releases heavy metals in aqueous aqueous medium. However, the concentration of these is very low compared to the limits estimated by the Dutch standard adapted to the Moroccan hydrological context (MBMD) [5], this result encouraged us to find a way to valorise this waste and to make it a raw material for the manufacture of terracotta bricks made of clay.

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COMPARISON OF BOND EFFICIENCY OF VARIOUS COATING MATERIALS

KEHINDE B. OSIFALA[1], TIMOTHY A. I. AKEJU[2]

[1]*Department of Civil Engineering, Yaba College of Technology, Yaba, Lagos, Nigeria*
[2]*Department of Civil & Environmental Engineering, University of Lagos, Nigeria*
E-mail: kosifala@yahoo.com

The paper reports an experimental research investigation carried out to compare the bond resistance and efficiency of various coating materials, including epoxy, which were sourced locally. Thirty four full size beams of varying lengths and sectional dimensions, with lap spliced bars in constant moment region were cast and tested in a four point bending system. Three varying high yield diameter bars 16 mm, 20 mm and 28 mm were coated with various coating materials such as epoxy, chlorinated rubber, tyrolin, vinyl chloride and zinc ethyl silicate in an attempt to find a cheaper but effective coating material than epoxy.
The ultimate moment from the tests were used to determine the stress developed in the steel rods. The bond efficiency, i.e. the ratio of test bond stresses and the theoretical bond stresses was used for the comparison of bond efficiency of the various coating materials. The bond resistance and efficiency of Vinyl Chloride coated bars were found to be higher than that of Epoxy and other materials, in all the bars tested.

EFFECT OF THE CURING CONDITIONS ON THE COMPRESSIVE STRENGTH OF SPENT FLUID CATALYTIC CRACKING (FCC) CATALYST-BASED GEOPOLYMERS

GABY RUIZ[1,2], RAFAEL AGUILAR[2], JAVIER NAKAMATSU[3], SUYEON KIM[4]

[1]*Department of Civil Engineering, Universidad de Piura, Piura, Peru*
[2]*Civil Engineering Division, Department of Engineering, Pontificia Universidad Católica del Peru – PUCP, Lima, Peru*
[3]*Chemistry Division, Department of Science, Pontificia Universidad Catolica del Peru– PUCP, Lima, Peru*
[4]*Department of Engineering, Pontificia Universidad Catolica del Peru – PUCP, Lima, Peru*
E-mail: raguilar@pucp.pe

This research evaluates the effect of the curing conditions on the mechanical properties of geopolymers containing spent fluid catalytic cracking (FCC) catalyst generated as a waste by the Peruvian oil – refinery industry. For this purpose, three curing conditions were evaluated: i) the curing temperature, ii) the time before curing (pre - curing time or delay time, before heating), and iii) covering during curing to avoid water loss. The performance of samples was assessed measuring the compressive strengths and bulk densities of samples. The results reveal that there is an optimal temperature associated to the higher compressive strength of the FCC – based geopolymers, when water loss was reduced, and samples were allowing to rest before curing (pre - curing). These two conditions of the curing process assure not only a higher compressive strength but also a denser and more homogeneous product. The effect of the curing process is less significant for the bulk density. The higher values of bulk density are associated to a homogeneous material and were obtained when mixtures were sealed with plastic bags to avoid moisture loss and samples were subjected to a pre - curing time before heating in an oven. However, the lack of dependency of the compressive strength on the bulk density is confirmed in this research.

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SYNTHESIS OF A GEOPOLYMER BINDER USING SPENT FLUID CATALYTIC CRACKING (FCC) CATALYST

GABY RUIZ[1,2], RAFAEL AGUILAR[2], JAVIER NAKAMATSU[3], SUYEON KIM[4]

[1]*Department of Civil Engineering, Universidad de Piura, Piura, Peru*
[2]*Civil Engineering Division, Department of Engineering, Pontificia Universidad Católica del Peru – PUCP, Lima, Peru*
[3]*Chemistry Division, Department of Science, Pontificia Universidad Catolica del Peru– PUCP, Lima, Peru*
[4]*Department of Engineering, Pontificia Universidad Catolica del Peru – PUCP, Lima, Peru*
E-mail: raguilar@pucp.pe

A synthesis of a geopolymer binder using spent fluid catalytic cracking (FCC) catalyst is evaluated in this research. Spent FCC is a solid waste product from the oil refining industry worldwide. This waste material is composed mainly by aluminium and silicon oxides. Final ratios of SiO_2/Al_2O_3, N_2O/SiO_2, and H_2O / total solids were evaluated as key factors of the polymerization additive composition on the compressive strength and bulk density of geopolymers. The silica modulus (MS), NaOH concentration, and liquid/solid weight ratio were varied to obtain a range of final ratios. Results indicate that there is an optimum value for each Ms, NaOH concentration and liquid/solid weight ratio that produces the maximum compressive strength. The liquid/solid ratio is of great importance to develop a homogeneous mixture but it does not depend on the NaOH concentration. Optimized final ratios of SiO_2/Al_2O_3, N_2O/SiO_2 and H_2O/total solids in the range of 2.5, 0.30 – 0.32, 0.50 – 0.60, respectively, assure to produce the maximum compressive strengths. These parameters can be considered as key control composition parameters of the mixture and its final compressive strength. On the other hand, no significative effect of these three factors on the bulk density was observed. As expected, a lack of dependency of the compressive strength on the bulk density is confirmed with this results. In this geopolymer binder, bulk density keeps constant unless the compressive strength varies in a wide range of values. A geopolymer block with a compressive strength of 24.7 MPa after curing for one day at 65 °C and six days at room temperature was produced using this spent FCC waste.

Acknowledgements

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A STUDY ON THE PHYSICOCHEMICAL PROPERTIES OF DIFFERENT POST-PROCESS WASTES FROM THERMAL PROCESSES

MICHAL LACH, KINGA KORNIEJENKO, NORBERT KOMAR, JANUSZ MIKULA

Institute of Materials Engineering, Faculty of Mechanical Engineering, Cracow University of Technology, Cracow, Poland,
E-mail: michal.lach@pk.edu.pl

The main aim of the article is determinate the safety for use the anthropogenic raw materials such as ashes and slags produced in waste incineration plants and possibilities of they using for manufacturing building materials. The article presents the results of research on physicochemical properties of ashes and slags produced in waste incineration plants. The research methods used were: water leaching, radioactivity, dioxins and furans content, oxide and phase composition.

The major treatment for investigated waste is a high level of leaching of harmful substances and the content of dioxins and furans. It is necessary to take appropriate measures to develop procedures for safe processing and storage of this type of materials. As shown in the research, ashes from the two investigated waste incinerators do not meet the requirements for leaching levels for hazardous waste landfills. These wastes must undergo processing to reduce to an appropriate level of leaching. Referring to the sum of dioxins in soils in urban areas, which is from 5 to 10 ng/kg, it can be stated that the waste tested contains very high dioxin contents and is hazardous waste. Working with this kind of waste requires special precautions. The ashes from waste incineration plants exceed this limit several dozen times (eg 221 ng I-TEQ/kg). Due to very high values of leaching and dioxin content in the raw materials, even the rinsing process does not guarantee the possibility of obtaining waste that could be stored in hazardous waste landfills. The article suggests the further way of safety processing this kind of materials.

Acknowledgements

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2. This work has been supported by the ERANet-LAC 2nd Joint Call (http://www.eranet-lac.eu) funded by the National Centre for Research and Development in Poland, within the framework of the grant: 'Development of eco-friendly composite materials based on geopolymer matrix and reinforced with waste fibers'.

A COMPARATIVE STUDY OF MECHANICAL PROPERTIES OF FLY ASH-BASED GEOPOLYMER MADE BY CASTED AND 3D PRINTING METHODS

KINGA KORNIEJNEKO[1], SHIH-YU CHOU[2], WEI-TING LIN[2], MICHAL LACH[1], MAREK HEBDA[1], JANUSZ MIKULA[1], DARIUSZ MIERZWINSKI[1], AN CHENG[2]

[1]*Institute of Materials Engineering, Faculty of Mechanical Engineering, Cracow University of Technology, Cracow, Poland*
[2]*Department of Civil Engineering, National Ilan University, Yilan, Taiwan*
E-mail: kinga@mech.pk.edu.pl

3D printing is a rapidly developing industrial sector and, potentially, a disruptive technology that have a lot of advantages such as resources saving, energy efficiency and sustainable compared to subtractive technologies (Tay et al. 2017). Unfortunately, the full exploitation of 3D printing technology for ceramic is currently limited due to the in-process and in-service performance of the available materials' sets, especially in application in construction industry: 'While 3D printing techniques have been successfully applied in a wide range of industries such as aerospace and automotive, its application in concrete construction industry is still in its infancy' (Nematollahi et al. 2017).
The further development of this technology required improvements to design new materials, to assess materials performance and to improve processing strategies. The some research in the area in case of concreates have been done, but the investigation connected with other ceramic materials such as geopolymers are still new area (Panda et. al. 2017 a, b). Contemporary only some prototype solution in the area of geopolymers material were designed in Australia, China and Russia (Xia and Sanjayan 2016).
The main aim of the article is comparison mechanical properties between mechanical properties such as compressive and flexural strength for casted and injected samples (simulation for 3D printing process). The same geopolymer mix based of fly ash class F was casted and cured in the same temperature prior to its mechanical test with printed samples. The properties has been compared not only between casted and injected samples, but also anisotropy has been taken under consideration.

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MEASUREMENT OF THERMAL, HYGRIC AND PHYSICAL PROPERTIES OF BRICKS AND MORTAR FROM POLISH MARKET

KAROL PIETRAK, MICHAL KUBIS, LUKASZ CIESLIKIEWICZ, PIOTR FURMANSKI, MIROSLAW SEREDYNSKI, MICHAL WASIK, TOMASZ WISNIEWSKI, PIOTR LAPKA

Institute of Heat Engineering, Faculty of Power and Aeronautical Engineering, Warsaw University of Technology, Warsaw, Poland
E-mail: piotr.lapka@itc.pw.edu.pl

Hygric, thermal and physical properties have been determined for building materials typical for Polish market. The study included one type of mortar and three types of masonry bricks. Thermal diffusivity and specific heat of dry materials were obtained using flash and differential scanning calorimetry methods, respectively. Distinct anisotropy of thermal diffusivity in one type of bricks had been detected and later connected with microstructure texturing observed using SEM. The orientations of principal axes of the thermal diffusivity tensor were found using infrared thermography. Dependence of thermal conductivity of building materials on moisture content was investigated using the guarded hotplate (Bock) apparatus. In these measurements, samples were wrapped with vapour-resistant polypropylene foil to prevent moisture loss. Water vapour permeability was tested using the cup method for one temperature (23 °C) and two kinds of air humidity conditions (relative humidity from 0 to 50 % and from 50 to 94 %). The test was performed according to ISO 12572:2016. The measurements of sorption isotherms were done using the environmental chamber method, according to ISO 12571:2013. The measurements of apparent and true density of considered materials were used to determine their porosity. Presented measurements concerned materials involved in physical and numerical experiments aimed at quantitative and qualitative analyses of heat and moisture transport during drying of building materials and walls.

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NEW NUMERCAL MODEL OF HEAT AND MOISTURE TRANSFER IN THE WET BRICK

MIROSLAW SEREDYNSKI, PIOTR FURMANSKI, PIOTR LAPKA, MICHAL WASIK, LUKASZ CIESLIKIEWICZ, KAROL PIETRAK, MICHAL KUBIS, TOMASZ WISNIEWSKI

Warsaw University of Technology, Institute of Heat Engineering, Warsaw, Poland
E-mail: msered@itc.pw.edu.pl

The topic of this study is numerical modelling of the fully coupled heat and moisture transfer in the building material, i.e., in a brick. The new mathematical model of equilibrium transport of heat and moisture in the form of continuous liquid medium (funicular region), discontinuous liquid medium (pendular region) and gaseous phase with dry air present is proposed. As independent variables, the total mass moisture content and temperature are chosen. Both energy and moisture balance equations are mutually coupled. It is due to dependence of capillary and vapor pressures on the moisture content and temperature. Additionally, vaporization and condensation phenomena are also accounted for in the energy balance equation. Both transport equations are supplemented with boundary conditions expressing the coupled heat and moisture transfer at the dried wall or heat transfer at the impermeable walls. Balance equations are discretized on the rectangular control volume grid in the framework of the in-house computational code. A grid-based method of generation of the control volume mesh is proposed, with 'half' and 'quarter' control volumes related to boundary grid nodes created at the domain walls. This approach enables deeper insight into implemented code as well as simplifies analysis of influence of selected terms in balance equations and implementation of complex hygro-thermal boundary conditions. The computational model is verified and validated with experimental data available in literature.

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EXPERIMENTAL INVESTIGATION OF INFLUENCE OF RELATIVE HUMIDITY OF AIR ON THE DRYING PROCESS OF POROUS BUILDING MATERIALS

LUKASZ CIESLIKIEWICZ, MICHAL KUBIS, MICHAL WASIK, PIOTR LAPKA, KAROL PIETRAK, PIOTR FURMANSKI, MIROSLAW SEREDYNSKI, TOMASZ WISNIEWSKI

Warsaw University of Technology, Faculty of Power and Aeronautical Engineering, Institute of Heat Engineering, Warsaw, Poland
E-mail: piotr.lapka@itc.pw.edu.pl

The paper presents an experimental analysis of influence of air relative humidity on the drying process of porous building materials. Investigations were conducted applying the stand working in a closed-loop flow duct and equipped with the following elements: the cooler (humidity condenser), fan with variable rotation speed, throttle, humidifier and heater (see Fig. 1). During experiments fixed temperature and velocity of air were maintained at the level of 40 °C and 3 m/s, respectively. The specimen was placed in the duct and had one (top) surface exposed to the flowing air. The relative humidity of air used for drying was varied in the ranged from 20 % to 80 % every 10 %. Four different materials were investigated, i.e., two types of red ceramic brick, sandlime brick and mortar. Variations of moisture content in the building materials were measured by system of two force meters and then thoroughly analysed.

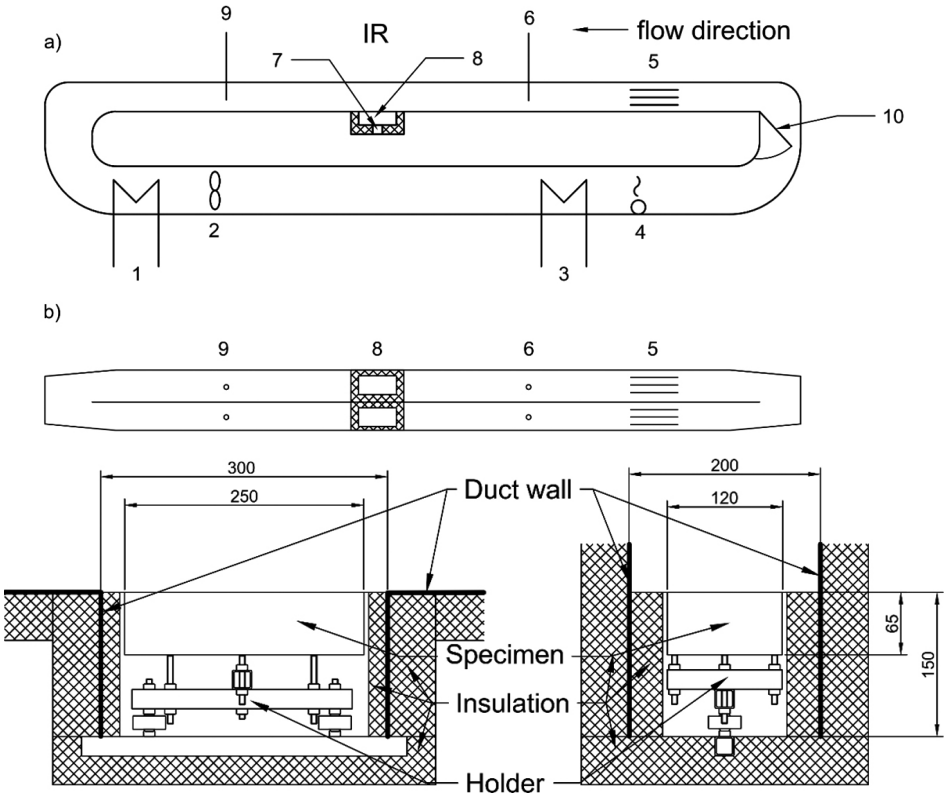

Fig. 1. Schematic of the closed-loop flow experimental stand: a) side and b) top view as well as cross-section of the specimen pocket with main dimensions: c) side and d) perpendicular to the flow direction view (where: 1 – cooler/condenser; 2 – fan; 3 – heater; 4 – humidifier; 5 – flow stabilizer; 6 – integrated velocity, temperature and humidity transmitter; 7 – force meter; 8 – sample; 9 – integrated temperature and humidity transmitter; 10 – throttle).

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DEVELOPMENT OF AN EXPERIMENTAL STAND FOR INVESTIGATION OF THE DRYING PROCESS IN BUILDING STRUCTURES

LUKASZ CIESLIKIEWICZ, MICHAL KUBIS, MICHAL WASIK, PIOTR LAPKA, KAROL PIETRAK, PIOTR FURMALSKI, MIROSLAW SEREDYNSKI7, TOMASZ WISNIEWSKI

Warsaw University of Technology, Faculty of Power and Aeronautical Engineering, Institute of Heat Engineering, Warsaw, Poland
E-mail: lukasz.cieslikiewicz@itc.pw.edu.pl

Existence of excessive moisture in the construction made of porous building materials should be avoided because it increases heat exchange with the surroundings as well as decays and weakens its structure. Moreover, presence of water in the masonry walls may lead to growth of mildew and microorganisms which cause health problems of occupants. Study of the drying process in whole building structures is extremely important to develop effective techniques of moisture removing and preventing it from re-penetration of water. The paper presents development of the experimental stand for investigation of drying process of building structures, e.g., in a part of a wall which consists of about thirty bricks joined by a mortar. The stand based on a platform balance applied to measure the variation of the global moisture content in the whole structure. The temperature measurements were carried out using K-type thermocouples which were placed in different locations in the structure. Additionally, the thermography method was applied to register temperature field on the specimen surface. In order to decrease the impact of the surroundings the stand was closed in a chamber made of vapour impermeable foil and heat insulation. Several holes were drilled in the specimen and were used to mount special heating probes. These probes heated up and supplied air close to the bottom of the hole. Then the hot air left the hole flowing along its boundaries and at the same time heating and drying the wall. The paper contains the exemplary results of measurements which test and verify operation of the stand.

Acknowledgments

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NUMERICAL INVESTIGATION OF INFLUENCE OF RELATIVE HUMIDITY OF AIR ON THE DRYING PROCESS OF POROUS BUILDING MATERIALS

MICHAL WASIK, PIOTR LAPKA, LUKASZ CIESLIKIEWICZ, PIOTR FURMANSKI4, MICHAL KUBIS, KAROL PIETRAK, MIROSLAW SEREDYNSKI, TOMASZ WISNIEWSKI, MACIEJ JAWORSKI

Warsaw University of Technology, Faculty of Power and Aeronautical Engineering, Institute of Heat Engineering, Warsaw, Poland
E-mail: piotr.lapka@itc.pw.edu.pl

Moisture have a large impact on the building structure durability, thermal insulation properties of walls and indoor micro-climate. A method of improvement of energy efficiency of buildings with damp walls based on drying walls and protecting them against water re-penetration. The effectiveness of drying techniques may be improved by using numerical modelling. Heat and moisture phenomena in the porous building material are complicated. The convective drying rate depends on temperature, relative humidity and velocity of air applied in the drying process. The paper presents a numerical analysis of influence of the air relative humidity on the drying process of porous building materials. Numerical simulations were conducted by applying the developed non-equilibrium mathematical model which was implemented in the commercial software (ANSYS Fluent) by using its advance customisation interface and user-defined functions (UDFs). A 2D case with a fluid (flowing air) and solid porous (building material) zones was considered – see Fig. 1. The solid zone had one (top) surface exposed to the flowing air, while the other walls were assumed adiabatic and impermeable for moisture transfer. During simulations the inlet temperature and average air velocity were fixed and equal to 40 °C and 3 m/s, respectively. The relative humidity of the inlet air was varied in the ranged from 20 % to 80 % every 10 %. The obtained results shown influence of the relative humidity of air on the drying time of the specimen.

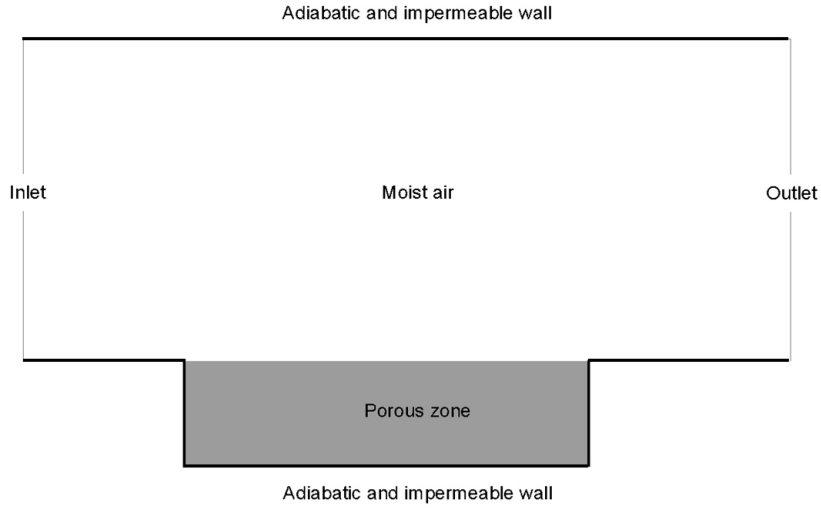

Fig. 1. Schematic of computational domain.

Acknowledgments

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MECHANICAL PROPERTIES OF GEOPOLYMER CONCRETES REINFORCED WITH WASTE STEEL FIBERS

JANUSZ MIKULA[1], MICHAL LACH[1], KINGA KORNIEJENKO[1], RIHARDS GAILITIS[2], JANIS SLISERIS[2], JUAN MORAN[3], EXEQUIEL RODRIGUEZ[3]

[1]Institute of Materials Engineering, Faculty of Mechanical Engineering, Cracow University of Technology, Cracow, Poland
[2]Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
[3]Area de Materiales Compuestos Estructurales (CET), Instituto de Investigaciones en Ciencia y Tecnologia de Materiales (INTEMA), Facultad de Ingenieria, UNMDdP-Conicet, Mar del Plata, Argentina
E-mail: jamikula@pk.edu.pl

In comparison to the traditional materials, such as Portland concrete, geopolymers have a number of advantages, especially connected with reduction of footprint and eco-friendly character. Manufacturing of this class of materials compared to the traditional concretes is economically more beneficial including the low energy consumption. Additional environmental benefit is connected with using to production process waste materials: for example, fly ashes and mine tailings. Moreover, the positive environmental influence can be even higher if the waste materials will be applied to production this composites as reinforcement or filler. Some of the attempting will be conducted with natural and synthetic reinforcement. The natural additives came from mainly plant production such as abaca coir and coffee grounds. The synthetic waste came from production carbon and glass fibres, waste Rockwool, waste form used tires and other plastic waste.

The article presents the research that try to determinate the possibilities of utilization the waste came from used tires to create the composites based on geopolymer matrix. The tire is multicomponent construction. It mainly consists of elastomer (rubber), metal and textile fibres such called textile cord. A lot of components cause difficulties in the tire recycling process.

The main aim of the research was determinate the possibilities of recycling the waste steel from used tires in geopolymer composites and develop the eco-friendly material for construction industry. The matrix based on fly ash from power station located in city named Skawina (Poland) and fine sand at a ratio of 1:1. The process of activation was made by 12M sodium hydroxide solution combined with the sodium silicate solution. In order to manufacture the composites the addition of 1% of waste steel fibres by mass was applied. The waste steel fibres came from two different recycling company form Argentina and Poland. The specimens were prepared according to the methodology described in the standard EN 12390-1. The research methods used were: microstructure research, density, flexural strength and compressive strength tests as well as analysis of breakthroughs.

Acknowledgments

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2. This work has been supported by the ERANet-LAC 2nd Joint Call (http://www.eranet-lac.eu) and funded by Ministry of Science, Technology and Productive Innovation (MINCYT) in Argentina and the National Centre for Research and Development in Poland, within the framework of the grant: 'Development of eco-friendly composite materials based on geopolymer matrix and reinforced with waste fibers'.

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APPLICATION OF MUTLI-CRITERIA METHOD TO ASSESS THE USEFULNESS OF A HYDROTECHNICAL OBJECT FOR FLOATING HOUSING

EMILIA MISZEWSKA, MACIEJ NIEDOSTATKIEWICZ

Faculty of Civil Engineering and Environment, Gdansk University of Technology, Gdansk, Poland
E-mail: emiurban@pg.edu.pl

Floating housing has long tradition not only in Europe, but in Asia and North America as well. On each latitude it derves from different rationale [1]. Floating housing is developed to meet the year-round housing requirements of its owners and users. It is possible provided that a convenient space for mooring can be found, guaranteeing not only safety, but also access to facilities such as disposal of waste, utility networks and parking spaces. It has to be noted that a Floating House is a floating object, whereas its further classification will require some additional findings.

This publication presents the results of several years' analysis of three hydrotechnical objects located in Gdansk with a view of mooring Floating Houses. The research has been conducted applying multi- criteria analysis of decision - making problems AHP (Analytic Hierarchy Process). This method was developed by Saaty [2] and is used, above all, to support the analysis connected with selecting a decision option. Numerous applications of this method in endorsing economic decisions, technical developments and social activities confirm its usefulness, especially in the cases when some assessment criteria are qualitative and the experience and knowledge of the assessor constitue the basic source of subjective evaluation [3].

Criteria adopted for the analysis, which is the subject of this article, are as follows: the mooring systems that can be applied, a form of communication with land, availability of utility networks, municipal waste disposal and location of parking areas. On the basis of the studies carried out and the calculation using AHP method, it has been indicated that hydrotechnical object no 1 - is the most adapted to mooring of Floating Houses.

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VOLUME OPTIMIZATION OF SOLID WASTE LANDFILL USING VORONOI DIAGRAM GEOMETRY

EDWIN KOZNIEWSKI, MARCIN ORLOWSKI

Faculty of Civil and Environmental Engineering, Bialystok University of Technology, Poland
E-mail: m.orlowski@pb.edu.pl

The work uses the geometry of Voronoi diagrams to create a solid waste landfill with a given area of the base and inclination angle. A considerable enlargement of the volume of the previous shape of the solid has been obtained. The authors applied in detail the theory of geometric embankments developed as a generalization of roof geometry. They used the standard version of AutoCAD software and built a 3D model of the landfill based on solid operations. This approach enables the rapid determination of the volume and surface area of the designed solids.

DAMPING IDENTIFICATION AND PREDICTION FOR LAMINATED COMPOSITE PLATES

MIROSLAW WESOLOWSKI[1], EVGENY BARKANOV[2]

[1]*Department of Structural Mechanics, Koszalin University of Technology, Koszalin, Poland*
[2]*Institute of Materials and Structures, Riga Technical University, Riga, Latvia*
E-mail: miroslaw.wesolowski@tu.koszalin.pl

Laminate composite structures are widely used in the form of plates, beams, or cylindrical shells. Besides their exceptional stiffness properties, the composites structures exhibit highly preferable damping characteristics. The damping identification as well as damping prediction have been intensively studied considering laminated composite plates and beams. As these two procedures are mutually dependent on each other, the identification procedure seems to be more crucial in this relation. It is so, because the identification procedure delivers the necessary information on the damping coefficients which are further used to predict the damping of structures composed of material in question. Among the methods for damping coefficients identification, the inverse technique based on dynamic response has been appreciated the most. The inverse technique combines the experimental and numerical analyses. In the numerical analysis, a proper selection of the applied damping model is the core issue since it is used for the both, identification and prediction of damping.

In the present work the damping model based on the strain energy method was used for damping coefficients identification and for loss factor prediction. The damping model was combined with the finite element solutions. The study concerns with the damping coefficients identification of a single layer of a unidirectionally laminated plate. The identification is performed using the inverse technique which is based on the design of experiments and the response surface methodology. The reliability of the identification method is validated by numerical loss factor prediction for a plate made of the same material but having different geometric characteristics. Further the prediction of the loss factor is also validated by vibration test. The vibration tests necessary for the current study were performed in a non-contact manner using a laser vibrometer.

CONSIDERATIONS ON TRANSIENTS IN A WATER SUPPLY DISTRIBUTION NETWORK

ANCA CONSTANTIN, NITESCU CLAUDIU STEFAN

Faculty of Civil Engineering, Ovidius University from Constanta, Romania
E-mail: aconstantina@univ-ovidius.ro

In Constanta County, Romania, apart from the large interconnected water supply system that delivers drinkable water to the cities and resorts on the Black Sea coast, there are many independent systems which provide water from their own underground sources, especially in the rural area. One of them is the water system of Lipnita, a village situated in a hilly region, in the South West of the county.

The groundwater is pumped from the source, which is placed in the middle of the village at a low elevation of 63.99 m, to a storage tank placed at an elevation of 123.03 m at the end of the main street in the village, in the highest point. The adduction duct is 850m in length. From the storage tank water flows by gravity to the consumers. The distribution network is a branched one and follows the direction of the streets, therefore, there are two long mains that intersect in a manifold situated at 60.83 m of elevation, close to the water facility that comprises the source. The manifold hosts the isolation valves. This topology of the system shows high static head for the adduction duct that conveys water from the source to the storage tank and high elevation differences between the end consumers and the consumers in the centre of the village.

The distribution network is being under modernization process. Therefore, an investigation on the safety and reliability of the system is imposed.

Mechanical failures including pipe breaks, or abnormal operation generated by wrong valve manoeuvres may put into jeopardy the whole pipeline. Isolation valves play an important role in the system reliability and security by providing a shutoff function, therefore we analysed, by numerical simulation, the transients on two different segments of the system:

- the first branch of the network downstream the storage tank to the isolation valve, in case of a quick closure of the valve;
- the adduction duct, in case of a power failure and shut down of the pump.

The simulation was performed for the original steel made pipelines aiming at identifying the vulnerable cross sections and extreme pressure values. In the first node, close to the valve, pressure rises from 49mwc to 100mwc which is on the limit of danger to the pipe. But cavitation occurs along the pipe, which can be dangerous. The same simulation was carried out for the new PEHD pipes. A slight increase in diameter of the new pipes showed better results regarding pressure variation during transients. Cavitation is avoided.

Numerical simulation proved to be a reliable tool for investigation of different transient operation scenarios helping the designers to make an optimal choice. The adopted diameters for the pipes are 160 mm instead of 150 mm for the adduction duct, respectively 110 mm instead of 80 mm for the network pipes.

THE PROCEDURE FOR DETERMINATION OF THE DEPENDENCE OF THE COST OF INSULATION MATERIALS ON THEIR THERMOPHYSICAL CHARACTERISTICS

OLGA GAMAYUNOVA, ANTON RADAEV, MIKHAIL PETRICHENKO

Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russia
E-mail gamayunova@inbox.ru

Optimal insulation for the walls of the house is selected based on the material of construction and must meet several requirements. The article describes the procedure for determination of the dependence of the cost of insulation on parameters such as thickness, coefficient of thermal conductivity, average density, water absorption and combustibility group. The quality of the mathematical model was assessed for reliability by means of regression analysis.

LIGHTWEIGHT CONCRETE WITH EXPANDED AGGREGATE FROM SILICEOUS ROCKS

LUBOV ZAKREVSKAYA, ANDREW GANDELSMAN, IGOR GAVRILENKO, PETR LUBIN

Department of Construction Industry, Vladimir State University, Vladimir, 600000, Russia
E-mail: lvzak@mail.ru

The purpose of this study is to develop technology for the production of a new building composite made of silicon-containing rocks. An aggregate is foamed granules obtained on the basis of diatomite with the addition of caustic soda, dolomite, water and liquid glass. The material composition, materials processing, physical and mechanical properties have been observed. The problem of alkali-silicate interaction typical for traditional Portland cement and glass phase is solved through the use of magnesia binder. Samples on Portland cement and magnesia binder were obtained, the aggregate content was varied. Some aggregate fractions were used to obtain high packing density in the composite. Concrete was estimated according to density, compressive strength and tensile strength, water absorption and thermal conductivity. Analysis of the material structure was made. The results of the study of the microstructure of synthesized concrete indicate the presence of a cement matrix in which granules of various sizes are tightly packed. The results of X-ray phase analysis of synthesized concrete indicates that the cement matrix consists of forsterite crystals. Approximate savings in the use of concrete with the developed aggregate is about 10 - 20 %. Such savings are possible due to the fact the surface occurrence of siliceous rocks allows them to be mined in an open way with minimal costs compared to other rocks, with a lower calcination temperature during material creation.

BIOACTIVATED SELF-HEALING PHENOMENON OF HISTORICAL MORTARS

BOJAN MILJEVIC[1], SNEZANA VUCETIC[1], OLJA SOVLJANSKI[1], SINISA MARKOV[1], EMILIJA FIDANCEVSKA[2], JONJAUA RANOGAJEC[1]

[1]Faculty of Technology, University of Novi Sad, Novi Sad, Serbia
[2]Faculty of Technology and Metallurgy, Ss. Cyril and Methodius University, Skopje, Macedonia
E-mail: miljevic@uns.ac.rs

In recent years, extensive studies have been conducted on application of carbonate precipitating bacteria for approaching a self-healing effect in cements materials [1], but there are only few publications dealing with autogenous capacity of historical lime-based mortars [2 - 4].
The presented research enables the efficiency evaluation of the external bacteria-based repair healing method in/on the samples of high alkalinity. The main aim of our work was to acquire more deep knowledge on the self-healing phenomenon of historical lime-based mortars. In order to achieve the mentioned goal, characterization of bio-based self-healing agent, bacterial culture Sporosarcina pasteurii was performed. In the main focus of the proposed research are models of "historical" lime mortar, cement-based mortars and medieval historical mortars from the Franciscan monastery, Bac, Serbia. The model samples of interest were prepared and artificially weathered according to the characteristics of the medieval historical mortars [5]. The detailed study of the cracks inside the prepared models and the bacterial suspension penetration was done by comparison of the results obtained by different complementary imaging techniques (optical and scanning electron microscopy), followed by the mechanical properties characterization according to the procedure for cement based bio-mortars [6].
The obtained results support the development of the external repair healing method by using bacterial culture (Sporosarcina pasteurii) as a bio-activator of self-healing phenomena.

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ENERGY AND MOISTURE IN HISTORIC MASONRY WALLS RETROFITTED WITH HEMP-LIME

PAULIEN STRANDBERG-DE BRUIJN[1], KRISTIN BALKSTEN[2]

[1]*Division of Building Materials, Lund University, Lund, Sweden*
[2]*Conservation, Uppsala University Campus Gotland, Visby, Sweden*
E-mail: paulien.strandberg@byggtek.lth.se

Thermally insulating existing buildings is imperative in order to reduce energy demands of the existing building stock. Thermally insulating historical masonry walls can be challenging. Adding internal insulation on a masonry façade can change the hygrothermal properties of the wall while adding external insulation affects a building's architectural and heritage values. An insulation material is needed that improves energy efficiency while being both compatible with the masonry from a hygrothermal perspective and compatible with lime plaster from an aesthetic and cultural heritage perspective.

Hemp-lime is a building material that consists of on a combination of hemp shiv, the woody core part of the hemp stem, and building limes. As hemp-lime is a thermally insulating and diffusion open material it has potential to work very well as an insulating material for retrofitting historic buildings.

This paper explores the use of hemp-lime as an insulation material for historic masonry walls. The aim of this study was to determine if hemp-lime could be a feasible option for thermally insulating historic masonry walls in Sweden. The objectives were to measure energy performance of full-scale masonry façades insulated with hemp-lime, for an external insulation as well as internal insulation scenario, and to monitor moisture levels inside the masonry walls.

Three small half-leaf masonry façades were constructed at the campus of Lund Faculty of Engineering, each façade had a small room behind it that was heated to room temperature. One façade was uninsulated, the other had internal hemp-lime insulation and a third had external hemp-lime insulation. Energy use for space heating as well as temperature and relative humidity in the rooms behind these facades was monitored. Also, moisture levels inside the masonry were monitored.

Results show that thermally insulating historic masonry walls with hemp-lime can lead to substantial improvement in energy performance. Energy use for space heating was 44 – 53 % lower for the rooms insulated with hemp-lime than for the room with an uninsulated masonry façade.

However, moisture levels in the masonry were higher in the façades that were insulated with hemp-lime. In the façade with internal hemp-lime insulation high moisture levels occurred in the masonry in combination with low temperatures, increasing the risk for frost damage. Nevertheless, no frost scaling was observed during the first winter.

DEFINING ADAPTIVE FACADES: CHARACTERIZATION, CLASSIFICATION, TECHNOLOGY TRENDS

BAHAR BASARIR

Mimar Sinan Fine Arts University, Istanbul, Turkey
E-mail: bahar.basarir@msgsu.edu.tr

An adaptive facade has the ability to repeatedly and reversibly change some of its functions, features or behavior over time in response to changing performance requirements and variable boundary conditions (Loonen et al., 2013). Due to these features they are considered to be an important step in the development of facade technology and receiving increasing attention from researchers and professionals in the building sector. However, covering a wide range of technologies from smart materials, passive systems to artificial intelligence, adaptive facade technology is not a well-defined field in architectural research. Although there are many attempts to define adaptive facades (Struck et al., 2015; Gosztonyi, 2015, Aelenei et al., 2016; Romano et al., 2018; Aelenei et al., 2018), a holistic approach has not been revealed which combines them. The disorganized knowledge of adaptive facade is making it difficult to understand its dynamics. This constitutes a barrier to widespread adoption and development of adaptive facades.

From this point of view, this study aims to determine the characteristics, classification criteria which also present the design variables and technology trends of adaptive facades. For this purpose, a comprehensive literature study is conducted, covering more than fifty articles. First, terms used for facades that adapt to environmental conditions and user requirements, such as smart, multifunctional, responsive and adaptive, are compiled. It is determined that although these expressions have somewhat different meanings, they are often used interchangeably. Then the characteristics and classification criteria of the facades defined in these terms are compiled. Characteristics are analyzed according to the frequency of use in the literature. Qualitative and quantitative properties of adaptive facades that are effective in the adaptation process are revealed. Classification criteria are rearranged to classify the system according to the change event which can be characterized with three elements: agent of change, mechanism of change and the effect of change (Ross et al., 2008). The reviews of case studies are analyzed to determine the technology trends. Thus, an approach is developed to define adaptive facades which is enabled some understanding of the design variables. However, the study is also shown that there is still space for different technologies. Variables that define the adaptation or adaptation criteria can vary over time.

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GREEN BUILDINGS: AN ENVIRONMENTAL AND SUSTAINABLE APPROACH

FEHİMAN CİNER, NESLİHAN DOGAN-SAGLAMTİMUR

Department of Environmental Engineering, Nigde Omer Halisdemir University, Nigde, Turkey
E-mail: neslihandogansaglamtimur@gmail.com

Occupant experience and satisfaction are affected by several environmental factors such as thermal, visual, acoustics and air quality, as well as workplace features such as privacy, furniture, needs, cleanliness, and environmental controls (Khoshbakht et al., 2018). Indoor comfort plays an important role and poses a huge impact to preserve health, morale, working efficiency, productivity and satisfaction of inhabitants (Sant'Anna et al., 2018). Apart from energy consumption, conventional buildings involve the consumption of natural resources, greenhouse gas emission, production of noise and other pollutants (e.g. light pollution, waste disposal) as well. These pressures influence climate change and global warming with demand driving further environmental impacts associated with all relevant industry supply chains (He et al., 2018). The growing public interest of the potential of sustainable construction and increased concern about environment is pushing green building to the forefront (Lstiburek and Lukachko, 2008, Sharma, 2018). Therefore, the global awareness and importance of sustainability in building sector is on rise and various other issues like climate change, rising population, rapid urbanization therefore increased the demand for green buildings for sustainable development (Butera, 2010; Gou and Xie, 2016, Sharma, 2018). The philosophy of green building is originated from "Arcology", a combination of architecture and ecology (Zhao et al., 2015; He et al., 2018). Green buildings point out an application in the construction sector that priorities environmental responsibility and resource efficiency in a whole building life cycle (Khoshbakht et al., 2018).

It was pointed out green buildings as a global response to raise awareness of the human activity role in global climate change, with maximum expression in LEED Certification and its five basic requirements: Sustainable Space (SS); Materials and Resources (MR); Energy and Atmosphere (EA), Environmental Quality (EQ), and Water Efficiency (WE). The EQ requirement is based on users perceptions focus on temperature, acoustics, indoor air quality, lighting and cleanliness. Green building must be not only energy-saving, emission reduction or land-saving, but also means as the key part to provide a comfortable working or living environment for human activities (Sant'Anna et al., 2018).

When assessing how green or sustainable a building is, a yardstick for measuring environmental performance is needed (Crawley and Aho, 1999). LEED, BREEAM, GBL, Comprehensive Assessment System for Built Environment Efficiency, GS, Green Mark Scheme, ASGB, DGNB and Pearl Rating System for Estidama are listed as worldwide green building rating systems (GBRSs) (Ret-

zlaff, 2008) to accelerate the transformation of the building sector towards an environmentally friendly model.

Energy efficient buildings lessen the energy demanded by 40 %, decreases associated costs and workers retention, enhances/boosts workers productivity and health, reduce risk and is valuable for developers, tenants and owners (Sharma, 2018). It has been found that adoption of energy-efficient measures can reduce greenhouse gas (GHG) emissions by 142 mega tonnes (Mt) a year by 2020 and by 296 Mt a year by 2030 (Darko et al., 2013; Sharma, 2018).

In this study, as an environmental and sustainable approach, green buildings and the issues related to their origin, eco-friendly properties, benefits and rating tools/systems are discussed.

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THE EFFECT OF DIFFERENT ALKALINE RATIOS ON GEOPOLYMER COMPOSITE MATERIALS

HATİCE OZNUR OZ[1], NESLİHAN DOGAN-SAGLAMTİMUR[2], AHMET BİLGİL[1], TURKAN VURAL[2], ELİF SUZGEC[2]

[1]*Department of Civil Engineering, Nigde Omer Halisdemir University, Nigde, Turkey*
[2]*Department of Environmental Engineering, Nigde Omer Halisdemir University, Nigde, Turkey*
E-mail: neslihandogansaglamtimur@gmail.com

Increasing use of cement raises the CO_2 emission in the atmosphere and is responsible for air pollution and global warming. At the same time, raw materials used for the production of cement diminish the natural rock deposits. Therefore, it is necessary to use the substitute binding material for the sustainable environment which can reduce air and land pollution as well as reduce degradation of valuable natural resources (Patel and Shah, 2018). Geopolymer is termed as a polymer as it can transform, polymerize and harden at low temperature (Bakharev, 2005). Geopolymerization of fly ash (FA) occurs through a conjoined reaction of destruction and condensation of the largely amorphous aluminosilicate phase (Deb et al., 2015). Utilization of geopolymer as an alternative binder to ordinary Portland cement adds sustainability to concrete by reducing the CO_2 emission associated with cement production (Duxson et al., 2007, Davidovits, 2008, Doğan-Sağlamtimur et al., 2016).

In this study, geopolymer matrix was made from the FA supplied from İsken Sugözü Thermal Power Plant (ISTPP) located in Zonguldak, Turkey. FA and standard (CEN reference, as fine aggregate) sand were used together with the amount of 1200 kg/m^3. At first, two different alkaline solution/material ratio (fly ash + standard sand) (L/M) were selected as 0.2 and 0.4 for the design parameters. In the production of geopolymer composite material, sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) were used together within the ratio of 1:1, 1:1.5, 1:2, 1:2.5 and 1:3, respectively. A totally of 10 mixes were cured at 70 and 100 °C at 24 hrs, respectively and thereafter kept in room temperature until testing age. Physical characteristics of hardened mortar were determined via the bulk density, water absorption and porosity values at 28 days while the strength of geopolymers was obtained on the results of compressive strength and flexural strength tests conducted at 7, 28 and 90 days. Considering the testing parameters, the geopolymer mixture with the highest compressive strength was produced with L/M ratio of 20 % by weight; the alkaline solution consisted of a mixture of NaOH and Na_2SiO_3 in volume ratio of 1:1.5 by curing 70 °C at 24 hrs. This conclusion was supported by the study of Van Jaarsveld et al. (2002) showed that the optimum curing temperature for the geopolymer material changed between 60 and 90 °C. However, test results showed that there was an optimum limit for the alkaline solution, such that exceeding this limit gave the reverse effect for the strength characteristics (Khale and Chaudhar, 2007).

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GLOBAL 3D CONCRETE PRINTING: WELCOME TO THE FUTURE OF EMERGING INDUSTRY TRENDS, CHALLENGES, ECONOMIC POTENTIALS, AND OPPORTUNITIES

MOHAMMED SONEBI

Queens' University Belfast, Belfast, UK
E-mail: m.sonebi@qub.ac.uk

3D printing methods using polymeric materials developed since the 90's, this additive manufacturing is on rise nowadays. As formworks represent 35 to 60 % of the global cost of a concrete construction, this innovation embodies an important financial benefit, in addition to improving the construction rate and architectural liberties. The pioneers of this novelty have developed the "Contour Crafting" method aiming to construct buildings and houses on Earth and they are even envisaging applying this new technique on the moon. 3D concrete printing is a technologically advanced and innovative method used for constructing predesigned building components with the help of 3D concrete printers. The technology holds the promise of substantially optimising the construction industry in terms of construction cost, time, error reduction, flexibility in design, and environmental impact. The field of 3D concrete printing is receiving increased focus from construction companies across the globe. These companies mainly focus on experimenting with different concrete mixes and printing machines to bring about further developments in this construction technique. With construction companies making continuous efforts to bring 3D concrete printing in mainstream construction, the global 3D concrete printing market is projected to gather significant momentum in the next few years. Global 3D concrete printing market is projected to grow from $ 30 million in 2018 to $ 58 million by 2024.

The rate at which construction companies, researchers, and technologists are coming together in the development of 3D concrete printing techniques is commendable. The market is expected to receive a healthy boost from developing regions such as Asia, Asia Pacific and some parts of Latin America in the near future. The construction sector in these regions is projected to lead to an increased demand for cost - effective building elements fabricated through 3D concrete printing techniques to complement the several new infrastructure development and building construction projects. The fresh and rheological properties of 3D printing of concrete are discussed.

PARAMETRIC IDENTIFICATION OF MULTY-STOREY BUILDING MODEL BASED ON VIBRATION TESTING RESULTS

VIKTORIYA VOLKOVA[1], LIGA GAILE[2], LEONIDS PAKRASTINSH[3]

[1]Dnipro University of Technoligy, Dnipro, Ukraine
[2]Riga Technical University, Riga, Latvia
E-mail: drvev09@gmail.com

Buildings and structures are complex systems having predetermined parameters, which should be controlled in the process of manufacturing structures, construction and installation. Vibrations are the most dangerous effects on the builadings and structures. Significant alternate stresses caused by vibrational actions leads to accumulation of damage in the material. It causes the appearance of fatigue cracks and destruction. In addition to fatigue failure in mechanical systems there are other phenomena that cause changes in the structure of the surface layers of the parts to be joined and consequently the reduction of the frictional force in the joint.

Dynamic structural health monitoring methods allow us to assess the state of the whole building and subsequently to localize and detect defects that can be specified by non-destructive methods. These methods can more accurately identify the risk of collapse, estimate the residual lifetime of buildings and structures. Therefore, the development of methodology for assessing the technical condition of buildings based on dynamic criteria, which allows to increase the objectivity and reliability of the obtained results and reduce the time of the structural health monitoring is an actual scientific task.

The purpose of the study is to develop a methodology for evaluating the parameters of a construction model based on dynamic criteria, namely, the period and frequency of the eigenoscillations. The object of the study is a multi-storey building havinga rectangular shape in plane. Strucutral scheme of the building is a two spans frame. The frame of the building consists of monolithic reinforced concrete structures. It is including monolithic ribbed slabs of floors and roof which connected with monolithic columns. The stability of the structure is provided by a rigid disks of monolithic reinforced concrete floors and roof, as well as a rigid conections of columns with main beams of floors and roof.

According to the analysis of the basic diagnostic parameters of the technical condition of buildings and structures, affect their stability and reliability are geometrical parameters of buildings and structures, and their main structural elements, as well as physical and mechanical parameters of structural elements of building and dynamic parameters of buildings and structures.

An analysis of methods for determining the dynamic parameters of buildings has shown that the main criteria for assessing the technical condition of bearing structures, using the dynamic method, is the

period and frequency building vibration. It is known that the main dynamic parameter is the period of eigenoscillations of a structures system due to its rigidity. Therefore, the results of dynamic tests of the period of their eigenoscillations of the structure give the value of reducing the generalized stiffness of the structure. Thus, for any strucutral system, the period of its eigenoscillations characterizes the rigidity of the system. It can be assumed that the mass of the building is approximately constant, then the decrease in the moment of inertia, shows the presence of possible defects in the intersections of structural elements of the structure. The decrease of the elastic modulus shows that there is a decrease in the strength of structural elements. Therefore, by changing the period and frequency of the own fluctuations of the bearing systems, it is possible to evaluate the change in their structural stiffness and give a quantitative assessment of their technical condition.

Dynamic tests were conducted to determine the dynamic and rigid characteristics of bearing structural elements of the building and structures, detection of hidden defects.

According to the method of measuring the dynamic parameters, the degree of damage to a building or structure, is determined by the comparison of the design values of dynamic parameters, periods of eigenoscillations, and the decrement of oscillations with experimentally obtained data. The analysis of the forms of oscillation makes it possible to find out the localization of possible defects in height and on the plan of a building or structure.

USE OF CARRIER MATERIALS TO IMMOBILISE AND SUPPLY CEMENTATION MEDIUM FOR MICROBIALLY MEDIATED SELF-HEALING IN BIOCEMENT

CHRISTINE ANN SPENCER[1], HENRIK SASS[2]

[1]*School of Engineering, Cardiff University, Cardiff, UK*
[2]*School of Ocean and Earth Sciences, Cardiff University, Cardiff, UK*
E-mail: SpencerCA1@Cardiff.ac.uk

Microbially induced calcium carbonate precipitation (MICP) has been attracting growing interest in respect of its use for biocementation, as a means of improving the engineering properties of granular soil. Recent studies have demonstrated the potential of MICP to enable self-healing of biocement [1, 2]. Self-healing has previously been achieved by injecting the nutrients and precursor chemicals required for MICP into degraded biocement. To enable a truly autonomous healing process, the nutrients and precursor chemicals will need to be readily available within the biocement matrix. This research explores the use of carrier materials for the storage and supply of cementation medium within biocement, to enable self-healing. This system has the potential to improve the durability and sustainability of geotechnical structures.

The effectiveness of a variety of carrier materials for the immobilisation and release of the nutrients and precursor chemicals, also referred to as the cementation medium, has been explored. Materials tested include expanded perlite (EP), diatomaceous earth (DE) and natural fibres such as jute and coir. Studies have subsequently been undertaken to investigate the effect of these carrier materials on the MICP process, in aqueous solutions and within the biocement matrix, and thus the potential to enable self-healing. Ureolytic, spore forming Sporosarcina ureae has been utilised to induce the precipitation of calcium carbonate.

Jute fibres were found to be the most absorbent of the materials tested, with the capacity to immobilise at least three times their mass of solid cementation medium constituents. In comparison, expanded perlite and diatomaceous earth powders absorbed just under half of this amount per gram of material tested. The immobilisation capacity of coir was low in comparison to other materials tested and this material was not used for later tests. When placed in deionised water, almost all of the immobilised cementation medium was released from EP and DE after 50 hours. Over the same period, just over fifty percent of the immobilised cementation medium was released from Jute. Solutions containing cementation medium released from the carrier materials facilitated the production of calcium carbonate following inoculation with S. ureae. After three days of incubation at 30 °C, 150 rpm, the calcium ion depletion, determined using ICP-0ES, was highest in samples containing cementation medium released from DE. This level of calcium ion depletion was higher than

in the control samples that contained the standard cementation medium.

A biocementation study was conducted using EP loaded with cementation medium and premixed with sand. The results from this showed that much of the immobilised cementation medium had leached from the EP after five treatments of the sand columns with the standard cementation medium. This had the effect however of accelerating the biocementation process.

Results obtained demonstrate that diatomaceous earth, expanded perlite and jute fibres have the potential to be utilised for the immobilisation and supply of the required nutrients and precursor chemicals to enable self-healing of biocement via MICP. Furthermore, diatomaceous earth has been shown to have a beneficial effect on the MICP process by increasing calcium carbonate precipitation. Coir was deemed unsuitable due to the low capacity for immobilisation of cementation medium when compared to other carriers tested. More tests are required, to include biocementation studies using jute fibres and DE, to further test the suitability of these carrier materials for the storage and supply of cementation medium for self-healing. Results obtained suggest that the jute fibres may be able to retain cementation medium during biocementation. Coatings would need to be applied to EP and DE to reduce leaching of immobilised cementation medium during biocementation.

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GREEN INTEGRATED STRUCTURAL ELEMENTS FOR RETROFITTING AND NEW CONSTRUCTION OF BUILDINGS

GEDIMINAS KASTIUKAS, XIANGMING ZHOU

Brunel University London, London, United Kingdom
E-mail: Gediminas.kastiukas@brunel.ac.uk

With the development of urbanization in Europe and particularly in the developing countries, building construction, renovation and demolition have produced an enormously huge amount of construction and demolition waste (C&DW). For example, in 2017, disposal of C&DW in China exceeded three billion tons and accounted for 30% to 40% of the total amount of waste. C&DW is not only dauntingly huge, but is often unsorted with different and complex components. Therefore, effective disposal and recycling has become a demanding task for every country. At the same time, we are facing an increasing shortage of natural materials such as sandstone, which is another impetus to reduce our dependence on fresh resources and allow for the use of waste, which would otherwise be deposited to landfill. The 'circular economy' (CE) concept is fast becoming a new model for resilient growth. Creating and optimizing resource 'loops' along value chains in the construction industry will help meet the needs of growing and urbanizing populations while mitigating against a continued rise in primary resource use, associated emissions and environmental pollution. The CE is now a core component of the EU's 2050 Long-Term Strategy to achieve a climate-neutral Europe, with the aim to 'implement a plan for guiding circular development, encourage the circular use of resources between production and society, and accelerate efforts to recycle resources from refuse'.

Our project 'Green Integrated Structural Elements for Retrofitting and New Construction of Buildings' (Green INSTRUCT) is part of the EU research and innovation initiative to work on 'New technologies and strategies for the development of pre-fabricated elements through the reuse and recycling of construction materials and structures'. The core aim of the project is to seamlessly combine four integrated layers with high structural performance, which would provide high levels of insulation, a healthy indoor environment, high aesthetic value, along with CO2 capture, and greywater management. The competitive advantage of the Green INSTRUCT panel is (1) sustainable and cost effective - using more than 70 % wt. C&DW including concrete, bricks, plastic, metals; (2) safety and energy efficiency - meeting Eurocode standards for fire safety, thermal insulation with U-value of 0.14 W/m2·K and acoustic insulation coefficient under 60dB and (3) Customisation potential -multi-layered, modular & prefabricated building block for new and old building.

This paper will discuss the most recent project achievements in terms of material development, demonstration activities and future work.

IMPACT FLOW AND BED LAYERING ON EQUILIBRIUM DEPTH OF SCOUR AT ELLIPTICAL GUIDE BANKS

BORISS GJUNSBURGS[1], MARITE BIZANE[1], MARTINS VILNITIS[2], JANA PARILKOVA[3]

[1]*Department of Water Engineering and Technology, Riga Technical University, Riga, Latvia*
[2]*Department of Construction Management, Riga Technical University, Riga, Latvia*
[3]*Department of Water Structures, Brno University of Technology, Brno, Czech Republic*
E-mail: boriss.gjunsburgs@rtu.lv

In the paper is present study the equilibrium scour at elliptical guide banks with uniform sands and stratified bed, with two layers, of different grain sizes and different sequence and thickness, different flow parameters, flow contraction. A new approach for determination equilibrium depth of scour at elliptical guide banks is made and method for calculation equilibrium depth of scour at uniform and stratified river bed at elliptical guide banks is presented.

Analysis of the test, calculation and computer modelling results is made to estimate impact on relative equilibrium depth of scour: thickness and sequence of the layers, Fr number of the flow, local Froude number - Fr_{Vl}, flow contraction, relative time and bed model layering. Test, calculation and comparison results are presented in tables and figures.

Local Froude number is depending from flow contraction, with increase of the local Froude number relative equilibrium depth of scour is increasing. Relative equilibrium depth of scour is depending on flow contraction and relative time of scour.

Stratification of the river bed, flow parameters considerably affects the value of equilibrium depth of scour. When the depth of scour is greater than thickness of the bed layer $h_{equil} > H_{d1}$, the scour develops in the second layer with a grain size d_2 and with modified local flow parameters. If the depth of scour is greater than thickness of the second bed layer $h_{equil} > H_{d1} + H_{d2}$, the scour develops in the third layer with a grain size d_3, and so on.

Depth of scour is depending from thickness and sequence of the layers with different grain size, when the depth of scour is greater than thickness of the bed layer $h_{equil} > H_{d1}$, the scour develops in the second layer with a grain size d_2.

According to the results obtained in test and calculation by method presented, in case of river bed layering, for example, the depth of scour is always greater when a fine-sand layer is under a coarse-sand layer (s). Calculations equilibrium depth of scour at river bed stratification using the grain size on the top of the river bed or in for next layer grain size with the same flow data, using approach flow parameters, as it excepted nowadays in formulas and methods for calculation depth of scour, and neglecting bed layering, changes of the flow parameters during the scour can lead to wrong results and possible damages and losses.

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THE IMPACT OF INNER GAS PIPELINES BUILT INTO THE CONSTRUCTION TO THE SAFETY OF INHABITANTS AND ENERGY EFFECTIVENESS FACTORS OF THE BUILDING

ALEKSANDRS ROMANOVS, JELENA TIHANA, ANATOLIJS BORODINECS

Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: aleksandrs.romanovslg@gmail.com

The article describes mathematical and simulation models of inner gas pipelines systems, built into the construction of different types of buildings: in newly built or existing blocks of flats or private houses.

The article analyses outside and inner gas pipelines operating problems and offers some solutions to solve these problems. Building the houses, construction workers regularly face with the problems of gas pipelines inner or outer systems operation. According to statistics, among 400 000 Latvian households, each third contains some defects or shortcoming. They are caused by ignoring the safety measures when using the gas.

The article in details describes the processes which happen in the gas pipelines of the built constructions. In cases of gas pipelines placement in special channels with air vents, it is important to estimate the impact of basic parameters of the air exchange process on the sites' safety indicators. Air permeability, air flow and speed impact on the possible air flow stuck effect in the gas ventilating channels. Also the time of air flow speed in the room (with different ventilation systems) in case of the gas leakages was calculated and described. Theoretical calculations and simulations will be accomplished in TRNSY program.

The developed methodology of gasified objects can let us use the gas pipelines safely, not losing energy efficiency of building and its functionality.

PRODUCTION OF FOAM PHOSPHOGYPSUM IN LABORATORY CONDITIONS

JELIZAVETA ZORICA, GIRTS BUMANIS

Department of Building Materials and Products, Institute of Materials and Structures, Riga Technical University, Riga, Latvia
E-mail: girts.bumanis@rtu.lv

The construction industry is developing through the implementation of global trends, such as problem of conservation of the earth resources, which with each passing day becomes more relevant. Reduction of waste and its harmfulness from extractive industries and amending is set goal of European Parliament and the Council by directive 2006/21/EC, which can be carried out by using waste in production of building materials. A promising example is phosphogypsum (PG) – gypsum waste material from fertilizer production plant, which could be used as replacement of natural gypsum. Gypsum-based filling materials are one of the major components of lightweight construction throughout the world. Thus, aim of the work was to produce foam PG with density less than 600 kg/m^3 in laboratory conditions, which is beyond the traditional boundaries defined in LVS EN 12859 (characterizing gypsum products > 600 kg/m^3). Foam PG considered to be used as alternative thermal and sound insulation of building interiors.

At the moment there is no reliable methodology of producing foam gypsum, because many factors influence output material: raw material characteristics, type and mineralogical composition of the binder, chemical nature of the foaming agent, foaming method, etc. For this reason, the trial and error method was applied as a result of the study. First foam gypsum production tests carried out with commercial gypsum (CG), then it was substituted with PG – which was obtained from open stacks of fertilizer production plant (AB Lifosa, Lithuania), homogenised by collision milling in disintegrator and heat treated at 180 ^{0}C. In manufacturing process gypsum slurry and foam were homogenized with a mixer separately, then combined. Foaming agents PB-lux and Sika Schaumbiltner SB22 were used for foam creation. Foaming tool differed regarding production volume: for a small batch up to 1 litre was used double-shaft electrical hand mixer; up to 10 litres – one-shaft electrical hand mixer.

Physical properties of gypsum binder and foam gypsum were analysed. Samples bulk density was from 213 – 685 kg/m^3, total porosity from 67.9 – 90.6 %. Density of foam gypsum was regulated by slurry / foam ratio. The estimated strength of obtained foam gypsum was from 0.1 – 0.8 MPa.

According to the results, PG is a possible substitute of CG. Therefore, produced samples lack strength and could not be straightforward used as construction material, production technology or composition of presented foam gypsum needs improvement. Goal of producing

material with density < 600 kg/m^3 was accomplished.

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THE IMPACT OF NANO SILICA AND ADMIXTURES ON CEMENT HYDRATION AND PHYSICAL MECHANICAL PROPERTIES

JURGITA MALAISKIENE[1], VILMA BANEVICIENE[1], MARIJA VAICIENE[2]

[1]*Laboratory of Composite Materials, Institute of Building Materials, Vilnius Gediminas technical university, Vilnius, Lithuania*
[2]*Civil Engineering Faculty, Vilnius College of Technologies and Design, Vilnius, Lithuania*

Currently, an analysis of the impact of various nano - additives (nano - TiO_2, nano - $CaCO_3$, nano - Al_2O_3, carbon nano - tubes, nano silica (NS), etc.) on the properties of cementitious materials gains the popularity. One of the most effective nano - additives is NS which fills the cavities between cement particles and has high reactivity with calcium hydroxide of the cement. Moreover, it increases the density of cementitious materials, reduces drying shrinkage, capillary absorption and water demand [1 - 3]. However, different NS in scientific studies of cementitious materials is used in various amounts – from 0.01 % to 0.5 % [4, 5].

The aim of our work is to determine the lowest and effective NS amount for cementitious paste and identify the complex impact of NS and chemical admixtures on cement hydration and physical-mechanical properties. In order to achieve the aim, cementitious specimens with different types and amounts of NS were formed. Further, after the selection of NS and its amount, specimens were formed with various superplasticizers. The work analysis the following properties of cementitious mixtures and hardened cement stone: flow diameter, exothermal temperature, density, ultrasound pulse velocity, flexural and compressive strengths, microstructure and mineralogical composition. It was determined that the greatest strength of cementitious specimens was obtained when 0.02 wt. % of NS was used, and, compared to control specimens, it increased by ~ 15 %. Additionally, the greatest increment in strength was observed for specimens with melamine-based superplasticizer. Compared to control specimens, the strength increased up to 23 % and the obtained density and ultrasound pulse velocity were the greatest. XRD analysis showed that all specimens had analogue crystal hydrates formed but their amounts differed. SEM research showed that 0.02 wt. % of NS determined denser structure of the material. Additionally, superplasticizers led to a smaller size of minerals identified. One of the used superplasticizers increased the porosity of cement stone.

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EFFICIENT HEAT-INSULATING MATERIAL BASED ON TECHNOGENIC ANHYDRITEG

GRIGORIY IVANOVICH YAKOVLEV[1], DARYA ALEKSEEVNA KALABINA[1], GRIGORIY NIKOLAEVICH PERVUSHIN[1], ROSTISLAV DROCHYTKA[2], KIRILL ALEKSEEVICH. BAZHENOV[1], ANASTASIYA FEDOROVNA GORDINA[1], JYULIA NIKOLAEVNA GINCHITSKAYA[1]

[1] Kalashnikov Izhevsk State Technical University, Russia
[2] Brno University of Technology, Brno, Czech Republic
E-mail: 4450539@gmail.com

Physical and mechanical properties of the heat-insulating composition based on high-strength anhydrite binder with expanded perlite sand as a lightweight aggregate have been studied. The study has evaluated the influence of two poring components, air-entraining additives and aluminum powder suspension, on the main characteristics of the composition: the compressive strength of the sample, its average density, thermal conductivity, and water absorption. The studies have shown that adding an air-entraining agent in an amount of 1.2 % by the weight of dry fluoroanhydrite significantly influenced the decrease in the average density (up to 37 %) of the material. The developed composition with a lightweight aggregate based on expanded perlite sand and an air-entraining additive can be used in construction as an efficient heat-insulating material, including for filling cavity walls during frame construction.

THE IMPACT OF CHEMICAL COMPOUNDS RELEASED BY NATURAL HEMP AGGREGATES ON THE PROPERTIES OF DIFFERENT TYPE OF MINERAL BINDERS

LAURA VITOLA, MARIS SINKA, DIANA BAJARE, ALEKSANDRS KORJAKINS

Department of Building Materials and Products, Institute of Materials and Constructions, Riga Technical University, Riga, Latvia
E-mail: laura.vitola_1@rtu.lv

Scientists have been focused on development of ecological building products with low impact on the environment as well as with enhanced technical properties like long term durability, mechanical, physical and thermal properties, recyclability etc. The use of natural plant origin aggregates as a replacement of conventionally used aggregates seems to be a feasible solution to reduce the problem of pollution and amount of CO2 emissions and to develop energy efficient and cost - effective building materials. On the other hand, these new aggregates also pose new challenges as, for example, they are affecting the properties of mineral binders used in the production of bio-based building materials.

Some components of natural plant origin aggregates like hemicellulose is unstable in reaction with alkaline binders. Alkalis readily react with extractives and hemicellulose, but effects on lignin at low concentration and ambient temperature is low. However, lignin can react with alkalis in the elevated temperature in general giving a number of

Results revealed that natural hemp aggregates` infusion retards silicate hydrate-based binder setting time and decrease the main reaction product formation in the material (C-S-H and M-S-H). For the first week organic chemical compounds released by natural hemp shives retards formation of C3S, thus the compressive strength decreases. On the 28th day, the effect of the organic compounds released by natural hemp shives on compression strength has decreased due to the onset of C2S formation. Meanwhile, they improve carbonate-based binder properties, during 28 - day period polysaccharides and reduced sugars provide a denser structure of the binder matrix and so the strength index comparing to the reference increases twice higher. As it was already expected after studying the available literature natural hemp aggregates` infusion has not noteworthy impact on MOC and MPC based binders.

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