RIGA TECHNICAL UNIVERSITY
Faculty of Civil Engineering

2nd International Conference

Innovative Materials, Structures and Technologies

Organised by the Faculty of Civil Engineering

Riga, Latvia, 30 September – 2 October 2015

Book of Abstracts

RTU PRESS
Riga – 2015

Editor-in-Chief

Diana Bajare, Dr. sc. ing., Professor, Riga Technical University

E-mail: diana.bajare@rtu.lv

Secretaries

Liga Radina, Mg. sc. ing., Riga Technical University

E-mail: liga.radina@rtu.lv

Daira Erdmane, Mg. soc., Riga Technical University

E-mail: daira.erdmane@rtu.lv

Laura Sele, B. sc. ing., Riga Technical University

E-mail: laura.sele_2@rtu.lv

Editorial Board address

Faculty of Civil Engineering

Riga Technical University

Kipsala Str. 6A/6B

LV-1658, Riga, Latvia

Phone: +371 67089123

E-mail: conference@imst-rtu.com

ISBN 978-9934-10-742-9

Published by RTU Press, Riga Technical University, 1 Kalku street, Riga, LV-1658, Latvia
Printed by RTU Printing House

Chairman of Conference Scientific Committee

Sandris Rucevskis, Riga Technical University (Latvia)

Members of Conference Scientific Committee

Andrus Aavik, Tallinn University of Technology (Estonia)

Hakim Abdelgader, Tripoli University (Libya)

Diana Bajare, Riga Technical University (Latvia)

Kaspars Bondars, Riga Technical University (Latvia)

Andris Chate, Riga Technical University (Latvia)

Donatas Cigas, Vilnius Gediminas Technical University (Lithuania)

Nele De Belie, Ghent University (Belgium)

Raimonds Eizensmits, Chairman of the Board, Latvian Association of Consulting Engineers (Latvia)

Gregor Fischer, Technical University of Denmark (Denmark)

Boriss Gjunsburgs, Riga Technical University (Latvia)

Reiner Jager, Hochschule Karlsruhe (HSKA) (Germany)

Talis Juhna, Riga Technical University (Latvia)

Tomas Hanak, Brno University of Technology (Czech Republic)

Viktors Haritonovs, Riga Technical University (Latvia)

Aleksander Kozlowski, Rzeszow University of Technology (Poland)

Gintaris Kaklauskas, Vilnius Gediminas Technical University (Lithuania)

Miroslav Komljenovic, University of Belgrade (Serbia)

Aleksandrs Korjakins, Riga Technical University (Latvia)

Jana Korytárová, Brno University of Technology (Czech Republic)

Jarek Kurnitski, Tallinn University of Technology (Estonia)

Joao Labrincha, University of Aveiro (Portugal)

Stephen O. Ekolu, University of Johannesburg (South Africa)

Ainars Paeglitis, Riga Technical University (Latvia)

Leonids Pakrastins, Riga Technical University (Latvia)

Ina Pundiene, Vilnius Gediminas Technical University (Lithuania)

Karlis Rocens, Riga Technical University (Latvia)

Dmitrijs Serdjuks, Riga Technical University (Latvia)

Juris Smirnovs, Riga Technical University (Latvia)

Genadijs Sahmenko, Riga Technical University (Latvia)

Renars Spade, Ministry of Economics (Latvia)

Rimvydas Stonys, Vilnius Gediminas Technical University (Lithuania)

Sigitas Tamulevicius, Kaunas University of Technology (Lithuania)

Ralejs Tepfers, Chalmers University of Technology (Sweden)

Nikolay Vatin, Saint-Petersburg State Polytechnical University (Russia)

Viktorija Volkova, Dnepropetrovsk State Higher Educational Institution “National Mining University” (Ukraine)

Miroslaw Wesolowski, Koszalin University of Technology (Poland)

Dear participants,

In 2015 the Faculty of Civil Engineering can proudly reflect on hundred and fifty two 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

Dear participants and guests,

On behalf of Riga Technical University I welcome you to the second International Conference "Innovative Materials, Structures and Technologies". The growing need for higher safety and living quality standards without compromising the environment, urges civil engineering to become more and more integrated with other sciences such as information technology, materials science and mechatronics. It appears that truly innovative solutions and technologies can emerge only on the borderline. This conference is serving as a forum for exchanging state-of-the-art knowledge and practice. We invite scientists, students, practitioners and entrepreneurs to use this opportunity to join the conference and share their experience, gain new insight and find partners for future collaboration.
Looking forward to meet you in Riga!

Talis Juhna
Vice-Rector for Research

Dear Colleagues,

It is my great pleasure to welcome you to the International Conference „Innovative Materials, Structures and Technologies", held in Riga, Latvia, on 30 September – 2 October, 2015.
Innovative materials, structures and technologies are the driving force in all sectors of economy. The research results are significant for improving transport and ensuring the safety, healthy environment, and communication. In addition to having the impact on the economy the created innovative materials and structures have to be environmentally friendly. The materials used in infrastructure projects have to be safe of potential chemical and biological hazards during all life cycle. The safety of material structure is of high importance for all objects, especially taking into account the rising demand for the innovative composites/structures and nanostructured materials to be used with modern technologies. The National Research Programme has five priority directions in financing fundamental and applied research in Latvia in 2014 – 2017 and synergy with these priorities can be observed. Participants from academia and industry are both welcome. Young scientists are especially encouraged to come.
The conference will take place in the main campus of Riga Technical University, which is the first technical university in the Baltic countries – its history dates back to 1862 when Riga Polytechnic was founded. The historical centre of Riga is a UNESCO World Heritage

Site, noted for its Art Nouveau architecture and the 19th century wooden architecture. Major attractions and sightseeing places are within a walking distance from the conference venue and hotels convenient for accommodation.
I am looking forward to seeing you in Riga!

Andris Chate,
Manager of
National Research Programme "INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH"

Dear conference guests, dear scientists and practicing engineers,

It is great honour to have you as participants in our annual scientific conference. I solemnly declare the conference open.
To start with, I would like to remind you one simple truth. What does a scientist produce? Scientist produces and discovers new information and knowledge. On the one hand there are fundamental sciences studying nature objects, such as animals, human beings, minerals, universe and many other miracles of nature. On the other hand there are technical sciences studying man-made objects, equipment, devices, building constructions and technological processes. But what is then technique? It is the ability to use the information, both – new and already known to achieve the set goals. In Greek language "τεχνη" means "art". Ancient Greeks did not separate artists from engineers – both professions were considered to be equally creative. In ancient times everyone who created something new and never seen before, was considered to be an artist.
However, pure scientific information without any implementation in industry gives less contribution. That is the main reason why new knowledge and obtained information in research, especially in the field of technical sciences should be aimed at solving the existing problems with the technical sources. Our construction sciences should have essential novelty and high value in practical use and application after some years and in near future.

Videvuds-Arijs Lapsa
Chairman of the Board, Latvian Concrete Association

TABLE OF CONTENTS

EFFECT OF SILICA FUME ON TWO-STAGE CONCRETE STRENGTH

HAKIM ABDELGADER[1], ALI EL-BADEN[1]
[1] Civil Engineering Dept., Faculty of Engineering, Tripoli University, Tripoli, Libya
E-mail: hakimsa@poczta.onet.pl, elbadenpool@gmail.com

Two-stage concrete (TSC) is an innovative concrete that does not require vibration for placing and compaction. TSC is a simple concept; it is made using the same basic constituents as the traditional concrete: cement, coarse aggregate, sand and water as well as mineral and chemical admixtures. As the name suggests it is produced through a two-stage process. Firstly, the washed coarse aggregate is placed into the formwork in-situ. Later, a specifically designed self-compacting grout is introduced into the form from the lowest point under gravity pressure to fill the voids, cementing the aggregate into a monolith. The hardened concrete is dense, homogeneous and has in general improved engineering properties and durability. This paper presents the results of the research work aiming to study the effect of silica fume (SF) and superplasticizer admixtures (SP) on the compressive and tensile strength of TSC using various combinations of water to cement ratio (w/c) and sand to cement ratio (s/c). Thirty six concrete mixes were tested with different grout constituents. From each mix twenty four standard cylinder samples of size (150 mm x 300 mm) of concrete containing crushed aggregate were produced. The tested samples were made from the combinations of w/c equal to: 0.45, 0.55 and 0.85, and three c/s of values: 0.5, 1 and 1.5. Silica fume was added at a dosage of 6% of weight of cement, while the superplasticizer was added at a dosage of 2% of cement weight. The results indicated that both tensile and compressive strength of TSC can be statistically derived as a function of w/c and s/c with good correlation coefficients. The basic principle of the traditional concrete which states that an increase in water/cement ratio leads to the reduction in compressive strength was proved to be true for TSC specimens tested. Using both silica fume and superplasticisers caused significant increase in strength relative to control mixes.

FINITE ELEMENT MODELLING AND ANALYSIS OF CONVENTIONAL PULTRUSION PROCESSES

PAVEL AKISHIN[1], EVGENY BARKANOV[1], ALEKSEY BONDARCHUK[2]
[1]Institute of Materials and Structures, Riga Technical University, Riga, Latvia
[2]Department of Theoretical and Computational Fluid Dynamics, Southern Federal University, Rostov-on-Don, Russia
E-mail: pavels.akisins@rtu.lv

Pultrusion process is a continuous and efficient process producing composite profiles with a constant cross-section. During pultrusion the fibre reinforcements are saturated with resin in a resin tank and then continuously pulled through a heated die by a puller. External electrical heaters are used for the heating of the die in conventional pultrusion technology. Inside the die, the resin gradually cures and solidifies to form a composite part with the same cross-section profile as in the die.

Curing process is exothermal chemical reaction (vulcanization) of polymer thermoset resins. Traditionally the degree of cure is approximated using the Arrhenius relationship and simple resin kinetic models. The curing rate depends on the resin properties and applied temperature.

Two numerical techniques based on the finite element method have been developed for the simulation of conventional pultrusion processes. The first one uses the general purpose finite element software ANSYS Mechanical, the second one is quite new and specialized on the fluid dynamic finite element software ANSYS CFX. The movement of resin-saturated composite is simulated as a semi steady process by using the general purpose finite element software. ANSYS Mechanical allows the obtaining of temperature distribution for the current time step by solving the remaining transient heat conduction problem. Within each time step, the species equation is solved outside the software using the control volume method to obtain the degree of cure at each nodal point. The effect of the convection and exothermic terms on temperature is computed from the known temperatures of the previous time step. The movement of the cured material is simulated by shifting the temperature and degree of cure fields after each calculation step. In pultrusion simulation made by the specialized fluid dynamic finite element software, the process is simulated as transient and the cure reaction is implemented as an additional variable.

The developed techniques have been validated by using the experimental and numerical results demonstrating the distribution of thbae temperature and degree of cure along the control line of pultured profile and published in open literature. Three test examples have been analysed: pultrusion of cylindrical rod [1]–[3], flat plate [3], [4] and I-beam [5]. The first test was chosen to validate the simulation of the exothermal curing reaction under constant external thermal conditions. To avoid the influence of other factors on the result of calculations only the pultruded composite material has been simulated in this test. 3-D model of pultured composite profile and steel pultrusion die was prepared for the simulation of the flat plate pultrusion in the second test. This test allowed the validation of the curing simulation techniques when an interaction of the pultured material with the heated die was observed. An important simplification used in this test was the simulation of zones with constant temperatures on the die surfaces instead of the applied heaters. This simplification was not used in the third test where the heaters were modelled as aluminium bodies with a heat generation equal to the electrical power of heaters. The temperature in the die was controlled by turning the heaters ON and OFF during the remaining transient solution.

Good agreement between the present finite element results and published numerical-experimental results showed that the developed techniques can be used successfully for an accurate simulation of the conventional pultrusion processes with different initial data, boundary conditions and new technological requirements.

ACKNOWLEDGEMENT
The authors gratefully acknowledge the support of European Commission, FRAMEWORK 7 program, contract No. NMP2-SL-2013-609149, project “Development of an Innovative Manufacturing Process for the In-Line Coating of Pultruded Composites (COALINE)”.

[1] Valliappan M., Roux J.A., Vaughan J.G., Arafat E.S., Die and post-die temperature and cure in graphite/epoxy composites. Composites: Part B, 1996, Vol. 27, pp. 1-9
[2] Suranto B.R.,Ye L.,Mai Y.W., Simulation of temperature and curing profiles in pultruded composite rods. Composite Science and Technology, 1998, Vol. 58, pp. 191-7
[3] Liu X.L., Crouch I.G., Lam Y.C. Simulation of heat transfer and cure in pultrusion with a general-purpose finite element package. Composites Science and Technology, 2000, Vol. 60, pp. 857-64
[4] Chachad Y.R., Roux J.A., Vaughan J.G., Three-dimensional characterization of pultruded fiberglass-epoxy composite materials. Journal of Reinforced Plastics and Composites, 1995, Vol. 14, pp. 495-512
[5] Liu X.-L., Numerical modelling on pultrusion of composite I beam. Composites: Part A, 2001, Vol. 32, pp. 663-81

FIBRE REINFORCED POLYMERS (FRP) AS REINFORCEMENT FOR CONCRETE ACCORDING TO GERMAN APPROVALS

ROLF ALEX[1]
[1]*German Institute of Construction Technology, Berlin, Germany*
E-mail: ral@dibt.de

Since more than 20 years that in Germany FRPs have been used as reinforcement for concrete.
The first application was for the strengthening of concrete constructions which are reinforced with reinforcement steel or pre-stressed steel. The first approvals in Germany for FRPs with Carbon Fibres were issued in mid-nineties of the last century. In most cases FRPs are used in the form of prefabricated Carbon Fibre Strips which are bonded with epoxy adhesives on the surfaces of the concrete parts for strengthening them. Since the beginning of 2000 there are also approvals for the strengthening with prefabricated Carbon Fibre Strips which are bonded in slits of the concrete.
Soon after that first applications for the strengthening of concrete constructions with Carbon Fibre Sheets began. The difference is that with Carbon Fibre Strips on site only the bond between the strips and the concrete is realised while with Carbon Fibre Sheets the bond between the fibres as well as the concrete is realised on site.
Since 2000, a lot of research for such strengthening kits has been done in Germany. The result of this development is the directive from DAfStb (German Committee for Reinforced Concrete) at the national level which considers the latest scientific investigations in this field. This directive has four parts.

Part 1: Design and Construction;
Part 2: Products and Systems for Strengthening;
Part 3: Execution;
Part 4: Supplementary Rules for the Planning of Strengthening Measures.

It is not foreseen to introduce the directive legally in the design practice. The first national approvals of this new type are expected to be issued in 2014.
Part 1 of this directive has been translated into English and is being discussed in CEN/TC 250/SC 2/WG 1/TG 1.
The national approval for the second type of FRP reinforcement was issued in 2008. It is the approval for the so called Schöck-ComBar which is a reinforcing bar of Glass Fibre Reinforced Polymers. This reinforcement bar is mainly used for new buildings not for the strengthening.
The third type of FRP reinforcement is the so called Textile-Reinforcement. The first approval for such a type of reinforcement was issued in July 2014 for the applicant TUDAG (Technical University Dresden Joint-Stock Company). After sewing the textile is coated to realise the bond between the single fibres of multifilament yarns. The first approval for such a type of reinforcement was issued in July 2014 for the applicant TUDAG (Technical University Dresden Joint-Stock Company). The approval has been issued for strengthening but this type of reinforcement also may be used for new concrete elements.
During the presentation the possibility of joint principles to develop the test programmes for national approvals or European Technical Assessments will be demonstrated and the limits of the different systems will be shown, which until now have been approved in Germany.

PREDICTION OF CORROSION RESISTANCE OF CONCRETE CONTAINING NATURAL POZZOLANS FROM COMPRESSIVE STRENGTH

AREF MOHAMAD AL-SWAIDANI[1], RASSIN ISMAT[3], EID DIYAB[3]
SAMIRA DIB ALIYAN[2]
[1]Faculty of Architectural Engineering, Arab International University (AIU), Damascus, Syria
[2]Syria Arab Organization for Standardization and Metrology (SASMO), Damascus, Syria
[3]Order of the Syrian Engineers, Syrian Code Committee, Damascus, Syria
E-mail: aydlswaidani@yahoo.fr

Corrosion of reinforcing steel is an important problem facing the construction sector in Syria, especially in industrial and marine environments. A lot of RC structures have suffered from this phenomenon which shortened significantly their service lives. It is widely accepted that any increase in the durability of reinforced concrete structures increases the sustainability of the construction industry. In order to make the concrete industry much more sustainable, it is imperative to take some effective approaches to concrete mix design. Probably, one of the most effective approaches is to substitute pozzolans with a portion of Portland cement. Syria is relatively rich in natural pozzolans (volcanic scoria). Compressive strength of concrete is commonly considered to be its most valuable property, although, in many practical cases, other characteristics, such as durability and permeability, may in fact be more important. Compressive strength measurements are easy from an experimental point of view. By contrast, evaluation of reinforcement corrosion resistance is time consuming and difficult to deal with. During the study, in order to predict the corrosion resistance from compressive strength, concrete specimens were produced with seven cement types: one plain Portland cement (control) and six natural pozzolans-based cements with replacement levels ranging from 10 to 35%. The development of the compressive strengths of concrete cube specimens with curing time has been investigated. Chloride penetrability has also been evaluated for all concrete mixes after three curing times of 7, 28 and 90 days. The effect on the resistance of concrete against the damage caused by corrosion of the embedded reinforcing steel has been investigated using an accelerated corrosion test by impressing a constant anodic potential for 7, 28 and 90 days curing. The results of the test were statistically analysed and the correlation equations relating compressive strength and corrosion performance were developed. Significant correlations were noted between the compressive strength and both of rapid chloride penetrability and corrosion initiation times. So, this prediction could be reliable in the concrete mix design when using natural pozzolans as cement replacement.
The study is of particular importance not only for the country but also for other countries of similar geology, e.g. Harrat Al-Shaam, a volcanic field covering a total area of about 45 000 km^2, one third of which is located in Syria. The rest is covering parts of Jordan and Saudi Arabia.

COLOURED REACTIONS AND EMISSION OF ELECTRONS TOWARDS EARLY DIAGNOSTICS OF POLYMER MATERIALS OVERLOADING

ANDREY ANISKEVICH[1], OLGA BULDERBERGA[1], YURI DEKHTYAR[2], VIKTORIJA DENISOVA[3], KAMILA GRUSKEVICA[3], TALIS JUHNA[3], IGOR KOZAK[2], MARINA ROMANOVA[2]

[1]Institute of Polymer Mechanics, University of Latvia, Riga, Latvia
[2]Institute of Biomedical Engineering and Nanotechnologies, Riga Technical University, Riga, Latvia
[3]Department of Water Engineering and Technology, Riga Technical University, Riga, Latvia
E-mail: andrey.aniskevich@pmi.lv, dekhtyar@latnet.lv, kamila.gruskevica@rtu.lv

Fibre-reinforced composites with epoxy matrix and polymers are of wide applications in engineering.
The early undetected damage of these materials could be a reason of the constructions catastrophic destruction.
The polymer pipes (polyvinylchloride or polyethylene) have extensive applications in drinking water distribution systems. The polymer materials have a long lifetime and are not susceptible to corrosion, organic and inorganic additives being in use to improve material durability and lifetime. Polyethylene, polyvinylchloride and the above mentioned additives tend to leach biodegradable organic compounds. These compounds serve as a nutrient source for bacteria; they may react with disinfection agents (like chlorine, chloramine and ozone) and are capable to form carcinogenic substances, water organoleptic properties (taste and smell) are influenced. The leach could be promoted due to mechanical loading of the pipe (thermal and soil shift induced deformations, etc.). Therefore early diagnostics of the materials overload is of high importance in practical application.
The following approaches were employed towards early diagnostics of the materials overload: (1) coloured visualization of the overloaded area of the material; (2) detection of the emission of electrons as a result of loading of the material.
For coloured visualization the encapsulated leuco dyes and colour developer were used. Overloading ruptures, the capsules and dyes react with colour developer. Such a reaction develops the colour at the location of the overload. The embedded encapsulated components are well incorporated with the fibre reinforced composite with epoxy matrix. Because the overloading at the bulk of the material is invisible, only its surface layer is available for such diagnostics.
The detection of the electron emission was employed during the loading of both composites and polymers that are in use for water pipes.
The experiments were provided with the dog-bone shaped specimens. Both the coloured reaction and emission of electrons were detected for the loaded specimens *in situ*.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

FIBRE-REINFORCED ADHESIVE FOR STRUCTURE ANCHORING

JAN BARNAT[1], MIROSLAV BAJER[1]
[1] *Department of Metal and Timber Structures, Faculty of Civil Engineering, Brno University of Technology, Brno, Czech Republic*
E-mail: barnat.j@fce.vutbr.cz, bajer.m@fce.vutbr.cz

The topic of this paper is the glue-concrete interface of bonded anchors loaded by tension force. The paper is closely focused on bond strength experiments using high strength concrete up to class C50/60 or higher together with pure epoxy resin and fibre-reinforced resin. The goal of this research is to find the limits of the effective use of such glue types in high performance concrete, and also to verify the most commonly used design methods for bonded anchors.

The base line of this analysis deals with one of the typical failure type of bonded anchor loaded by static tension force. According to widely spread ETAG documents [1] and also new EC standard [2], the failure type implied by adhesive compound is in general defined by Bond strength value.

The bond strength is defined as the peak value of tangential stress on defined contact area in most cases. Contact area is given by effective anchoring length and diameter. In principle, the correct diameter should be used according to the failure position. However, it is very difficult to determine the correct failure mode for specific anchoring conditions. Using the anchor bolt diameter leads to complete neglecting of a thickness of the adhesive layer. This is acceptable model of problem simplification because the layer thickness is for most bonded anchors systems equal to several millimetres (according to anchor bolt diameter 1 or 2 mm). The bond strength as material parameter defined by this way does not represent real material characteristic in many cases. If the failure on the steel anchor bolt and adhesive compound occurs the tangential stress on the contact area is not a Bond stress (or Bond strength in peak value) but the shear strength of the adhesive itself.

It is possible to assume that there is no adhesion failure on concrete-glue contact either. The surface of drilled hole (at least in usual case of hammer drilling procedure) is very rough/bumpy. Failure on this contact means the failure of concrete or glue or both materials. The weaker from both materials affects the failure in major scale. This simple assumption means that anchor resistance cannot be increased by use of high strength concrete without use of high performance adhesive as well.

Glues based on epoxy resin usually give the best values of bond strength. The disadvantage of this type of glues is the long hardening time at normal temperatures (it takes several hours to reach significant values of strength and several days to reach full strength). The glue used in presented experiments was also based on epoxy resin but it was produced with respect to reach maximum shear strength.

Presented research includes experimental analysis of the glue-concrete interface and the influence of its parameters on anchor behaviour. The presented analysis shows some problems of the ‘separated failure modes’ approach and also presents experimentally verified bond strength values obtained for the currently most widespread glue types. Results of fibre reinforced epoxy resin are also presented in this paper.

[1] ETAG 001 Anchoring design methods, EOTA-European Organisation for Technical Approvals, Avenue des Arts 40, Kunstlaan, 1040 Brusel, 2011
[2] ČSN P CEN/TS 1992-4-5, Design of fastenings for use in concrete – Part 4-5: Post-installed fasteners – Chemical systems, CEN, 2 Avenue Marnix 17, B-1000 Brusel, 2009

USAGE OF ALTERNATIVE, ENVIRONMENTALLY ACCEPTABLE MATERIALS-EXPERIENCE FORM EASTERN CROATIA

IVANA BARISIC[1], MARTINA ZAGVOZDA[1], SANJA DIMTER[1]
[1]Faculty of Civil Engineering, Osijek, Croatia
E-mail: mzagvozda@gfos.hr

The concept of sustainability should be the main guiding principle in the construction industry today. It mandates conservation of natural resources and thus lower impact on environment. In road construction, part of construction industry that consumes the largest amount of natural materials, sustainable building and maintenance of roads is possible trough application of secondary materials. Usage of industrial and construction waste saves energy and is an ecologically and financially effective alternative. Republic of Croatia, even as a new member of European Union, is still lagging behind well-established practices of alternative materials applications in different European countries. Reasons for this can be found in current state of legal and technical regulations for alternative materials. In this paper, existing regulations for alternative materials and how it reflects on application of this materials in practice for region of eastern Croatia will be shown.

PORE DISTRIBUTION AND WATER UPTAKE IN A CENOSPHERE–CEMENT PASTE COMPOSITE MATERIAL

JANIS BARONINS[1], JANINA SETINA[2], GENADIJS SAHMENKO[3], SANTA LAGZDINA[4], ANDREI SHISHKIN[5]

[1] Department of Materials Engineering, Tallinn University of Technology, Tallinn, Estonia
[2] Institute of Silicate Materials, Riga Technical University, Riga, Latvia
[3] Institute of Materials and Structures, Riga Technical University, Riga, Latvia
[4] Testing Laboratory of Silicate Materials, Riga Technical University, Riga, Latvia
[5] Laboratory of Powder Materials, Riga Technical University, Riga, Latvia
E-mail: genadijs.sahmenko@rtu.lv

The application of alumina silicate cenospheres (CS) is one of the discussed topics nowadays. As a significant waste material from power plants using coal, CS should be utilized in other industries to avoid the pollution of nature with ashes. The use of CS as Portland cement replacement material can control physical and mechanical properties and make a product lighter and cost-effective. In the frame of this study Portland cement paste samples were produced by adding CS in the range of concentration from 0 to 40 volume %. The water uptake of hardened samples was checked and pore size distribution by using the mercury porosimetry was determined. In cold climate where the temperature is often below 0 °C, it is important to avoid the amount of micrometer sized pores in the final structure and to decrease water absorption capacity of the material. In winter conditions water is filling such pores and causing additional stress to their walls when expanding while freezing. It was found that generally water uptake capacity for cement paste samples decreased up to 20 % by increasing the concentration of CS up to 40 volume %, at the same time the volume of micrometer sized opened pores increases.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

THE EFFECTS OF AGGRESSIVE ENVIRONMENTS ON THE PROPERTIES OF FLY ASH BASED GEOPOLYMER

ZVEZDANA BASCAREVIC[1], MIROSLAV KOMLJENOVIC[1],
VIOLETA NIKOLIC[1], NATASA MARJANOVIC[1]
[1]Department of Materials Science, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia
E-mail: zvezdana@imsi.bg.ac.rs

This paper analyses the effect of two different aggressive environments, concentrated ammonium nitrate solution (480 g/dm^3) and sodium sulphate solution (50 g/dm^3), on the structure and mechanical strength of fly ash-based geopolymer.

Ammonium salt solutions are very aggressive to Portland cement structure [1]. NH_4NO_3 is often used as a fertilizer and concrete structures in contact with surface water from the processed agricultural soil can suffer serious damage. The concentrated NH_4NO_3 solution is frequently used for accelerated decalcification test of Portland cement [1]. Sulphate ions present in groundwater or soils surrounding a concrete structure also represent a threat to long-term durability of concrete. Sulphate attack on binders is most often studied in Na_2SO_4 solutions in concentrations of 44–50 g/dm^3 [2].

In this work, fly ash-based geopolymer samples were subjected to aggressive $NH_4NO_3$and Na_2SO_4 solutions over a period of 365 days. It was found that the major changes in the geopolymer structure were associated with the changes in the pH values of aggressive solutions during the testing. Concentrated NH_4NO_3 solution used in this investigation had initial pH value of about 4, while starting pH of Na_2SO_4 solution was about 6. After immersion of the geopolymer samples into the aggressive solutions, leaching of alkalis from the geopolymer pore solution caused increase in pH values of both of the solutions. The pH value of the NH_4NO_3solution increased up to ~8.3 after the first 28 days of testing, while at the same time the pH value of the Na_2SO_4 solution reached the value of ~12.

The most valuable insight into the structural changes caused by testing of the geopolymer samples in the NH_4NO_3 and Na_2SO_4 solutions was provided by means of 29Si MAS NMR. It was found that immersion of geopolymer samples in the NH_4NO_3 solution caused breaking of Si-O-Al bonds in the aluminosilicate geopolymer gel structure [3]. The observed degradation mechanism represents the first step of the dealumination reaction, the process that is usually observed in the case of acid attack on geopolymer binder [2]. On the other hand, treatment of the geopolymer samples with the Na_2SO_4 solution resulted in breaking of Si-O-Si bonds in geopolymer gel structure and leaching of Si [4]. This type of degradation mechanism has already been observed in geopolymer samples exposed to moderately alkaline solutions [2].

Testing of the geopolymer samples in aggressive NH_4NO_3 and Na_2SO_4 solutions caused small decrease in geopolymer strength (10–20 %). The strength decrease was due to the formation of the structural defects, caused by breaking of Si-O-Al and Si-O-Si bonds in the aluminosilicate geopolymer gel structure. Testing of Portland cement samples in the same aggressive solutions usually results in a more notable decrease in mechanical properties [1], [2]. The results obtained in this work suggest that, compared to the traditional Portland cement, fly ash-based geopolymers show better resistance to some types of aggressive environments.

[1] Alexander M., Bertron A., De Belie N. (Eds.), Performance of Cement-Based Materials in Aggressive Aqueous Environments, State-of-the-Art Report, RILEM TC 211 – PAE, Series: RILEM State-of-the-Art Reports, 2013, Vol. 10, Springer, ISBN 978-94-007-5413-3

[2] Baščarević Z., Chapter 14 - The resistance of alkali-activated cement-based binders to chemical attack, in:F. Pacheco-Torgal, J. Labrincha, C. Leonelli, A. Palomo and P. Chindaprasit(Editors) Handbook of

Alkali-activated Cements, Mortars and Concretes, Woodhead Publishing, ISBN 978-1-78242-276-1, 2015, pp. 373-396
[3] Baščarević Z., Komljenović M., Miladinović Z., Nikolić V., Marjanović N., Žujović. Z., Petrović R., Effects of the concentrated NH_4NO_3 solution on mechanical properties and structure of the fly ash based geopolymers. Construction and Building Materials, 2013, Vol. 41, pp. 570-579
[4] Baščarević Z., Komljenović M., Miladinović Z., Nikolić V., Marjanović N., Petrović R., Impact of sodium sulfate solution on mechanical properties and structure of fly ash based geopolymers. Materials and Structures, DOI 10.1617/s11527-014-0325-4

EXPERIMENTAL STUDY ON TENSILE CRACK PROPAGATION OF HIGH STRENGTH CONCRETE

BRUNO BASKERS[1], ANDINA SPRINCE[1], LEONIDS PAKRASTINSH[1]
[1]Riga Technical University, Riga, Latvia
E-mail: bruno.baskers_2@edu.rtu.lv, andina.sprince@rtu.lv, leonids.pakrastins@rtu.lv

High strength concrete is a comparatively new type of cement composite with poorly studied tensile crack propagation [1]−[5]. This research deals with experimentally and analytically studied tensile crack propagation of high strength concrete. Several kinds of concrete mix were made by abardding microsilica, nanosilica and cocktail of polyvinyl alcohol (PVA) fibres. Compact tension (CT) testing method and compact tension specimens have been used. Specimens with dimensions of 150 x 150 x 12 mm were prepared. The compression and tensile strength, modulus of elasticity, crack mouth opening were experimentally determined. Fracture intensity factor, fracture toughness, stress distribution at crack tip (see Fig. 1), fracture energy, fracture energy ratio, length of fracture process zone (FPZ), critical crack opening and the described crack tip zone were analytically determined. The results demonstrated that the behaviour of both mixes significantly differed. The specimens with nanosilica had better resistance to tension caused cracking, 19% higher crack resistance and needed 47% more energy to form a new area of crack. This research shows that high strength cement composite homogeneity is affecting fracture processes − reducing fracture possibility and making it more durable, thus prolonging the construction lifetime.

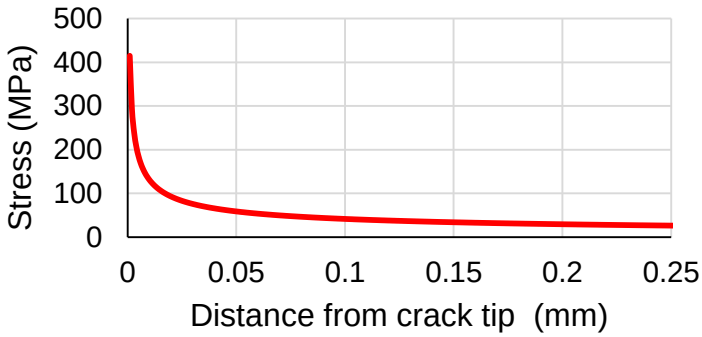


Fig.1. Distribution of stress

ACKNOWLEDGEMENT
We would like to thank Gregor Fischer, Associate Professor of Technical University of Denmark, and Ieva Paegle, Research Assistant of Riga Technical University for their assistance and cooperation and the Department of Civil Engineering of RTU for providing the lab equipment to carry out the necessary tests related to the crack propagation study.

[1] Prisco M., Plizzari G., Vandewalle L., Fibre reinforced concrete: new design perspectives, Materials and Structures, 2009, Vol. 42, pp. 1261-1281
[2] Fischer G., Li V., Effect of fiber reinforcement on the response of structural members, Engineering Fracture Mechanics, 2007, Vol. 74, pp. 258-272
[3] Pereira E.B., Fischer G., Barros J.A.O., Effect of hybrid fiber reinforcement on the cracking process in fiber reinforced cementitious composites, Cement and Concrete Composites, 2012, Vol. 34, Issue 10, pp. 1114-1123
[4] ASTM-E647 Standard test method for measurement of fatigue crack growth rates, ASTM Standard, US, 2005, Vol.03.01
[5] Pereira E.B, Fischer G., Barros J.A.O., Lepech M., Crack formation and tensile stress-crack opening behavior of fiber reinforced cementitious composites (FRCC), Proceedings of Fra MCoS-7, 2010, pp.1638-1647

THE RHEOLOGY OF SELF COMPACTING PASTE AND MORTAR INCORPORATING WASTE LIMESTONE FILLER AND RECYCLED AGGREGATE

RUBEN PAUL BORGA[1], LIBERATO FERRARA[2], CYRIL LYNSDALE[3]
[1] *Department of Construction & Property Management, University of Malta, Malta*
[2] *Department of Civil and Environmental Engineering, Politecnico di Milano, Italy*
[3] *Department of Civil and Structural Engineering, University of Sheffield, United Kingdom*
Email: ruben.p.borg@um.edu.mt

Waste materials lead to significant challenges with regards waste management; recycling these in mortar and concrete provide an effective solution. This paper addresses the Rheological properties of self compacting paste and mortar incorporating quarry waste limestone and waste recycled aggregate. The aim of the paper is to assess the rheology of self compacting paste and mortar mixtures produced with industrial grade filler (Betocarb) and waste limestone filler (Globigerina Limestone). Self compacting mortar mixtures with un-crushed fine aggregate, crushed industrial grade limestone fine aggregate and with crushed recycled concrete fine aggregate were also analysed.

The fresh characteristics of the mixes were obtained through empirical tests carried out using the mini-cone slump flow test, and the mini V- funnel flow test. The paste and mortar were also analysed using a MARS Rotational Rheometer. The single point test results were compared to the rotational Rheometer results, in order to obtain an understanding of the rheology of the self compacting pastes and mortar specimen, with respect to changing water / powder ratio, superplasticiser dosage, filler replacement content of cement and type of fine aggregate (uncrushed, crushed limestone or crushed recycled concrete) in the mixes.

The invesitgation led to a better understanding of the performance of self compacting paste and mortar using waste materials. The rebuilding rate strongly depends on the content of superplasticiser in the mix, with a lower rebuilding rate obtained for high dosages of superplasticiers. It was concluded that the industrial grade filler improves the workability (fluidity) of the mix, leads to an improved stability but does not effectively prevent segregation. Lower superplasticiser dosages were required to reach the target yield stress. Industrial filler mixes had a higher rebuilding rate for target yield stress as the control mix. The waste limestone filler does not improve the workability (fluidity) of the mix nor does it lead to a higher rebuilding rate. However the waste limestone improves the mix stability and provides a significant contribution towards the prevention of segregation, even for mixes with high superplasticiser dosage. The fine aggregate increased the rebuilding rate for un-crushed rounded aggregate in comparison with the crushed limestone and waste recycled aggregate mixes. The research indicates that when used in the right form and right proportions, waste limestone filler and recycled aggregates can effectively be incorporated in self compacting paste and mortar.

STRUCTURAL INVESTIGATION OF ALKALI ACTIVATED CLAY MINERALS FOR APPLICATION IN WATER TREATMENT SYSTEMS

GIRTS BUMANIS[1], DIANA BAJARE[1], LAURA DEMBOVSKA[1]
[1] Department of Building Materials and Products, Riga Technical University, Riga, Latvia
E-mail: girts.bumanis@rtu.lv

Alkali activation technology can be applied for wide range of alumo-silicate materials to produce innovative materials with wide range of application. The most of researches focus on material application in building industry as cement binder replacement to produce mortar and concrete [1]. However alkali activation technology provides high potential in biotechnologies [2]. In the processes where certain pH level, especially alkaline environment, must be ensured, alkali activated materials can be applied. One of such fields is water treatment systems where certain high level of pH (up to pH 10.5) ensures efficient removal of such water pollutant as manganese [3]. The formation process of alkali activated materials contains the restructuring of alumina and silica rich minerals under highly alkaline conditions by using sodium, calcium or potassium hydroxides, sodium silicates or mixed alkaline solutions as activators. Most of alkalis remain in the material structure as a non-load bearing material which usually is available for leaching. In building material application this quality is estimated as a disadvantage due to the risk of efflorescence while in water treatment technologies this feature can be used as an advantage to increase the pH level in water environment. This effect can be intensified if porous material structure is created with increased porosity. Previous investigations have shown that alkali activation technology can be applied to calcined clay powder and aluminium scrap recycling waste as a foam forming agent to create porous alkali activated materials. This investigation focuses on structural investigation of calcined kaolin and illite clay alkali activation processes. Chemical and mineralogical composition of both clays were determined and structural investigation of alkali activated materials were made by using XRD, DTA, FTIR analysis and microstructure of hardened specimens was observed by SEM. Physical properties of the obtained material was determined. Investigation indicates the essential role of chemical composition of clay used in the alkali activation process and the potential use of the obtained material in water treatment systems.

ACKNOWLEDGEMENT
The research work was carried out in the frame of the project of Latvian Council of Science: "Smart Biofilters" (No.Z12.0491)

[1] Bajare D., Bumanis G.,Korjakins A., Sele L., Reuse of non-metallic residues from aluminium recycling industry in production of porous building materials, Construction Materials and Structures, 2014, pp. 136-144
[2] Rugele K., Bumanis G., Bajare D., Lakevics V., Rubulis J., Alkaline Activated Material for pH Control in Biotechnologies, Key Engineering Materials, 2014, Vol.604, pp. 223-226
[3] Bajare D., Bumanis G., Alkali diffusion in porous alkali activated materials, NTCC2014, International Conference on Non-Traditional Cement and Concrete, 2014, pp. 1-9

ROAD SAFETY BARRIERS, THE NEED AND THE IMPACT ON ROAD TRAFFIC ACCIDENT MECHANISM

ZANS BUTANS[1], KARLIS-AGRIS GROSS[1],
ARTJONS GRIDNEVS[2], ELINA KARZUBOVA[2]
[1]Riga Technical University, Riga, Latvia
[2]SIA "Tilts", Riga, Latvia
E-mail: zans.butans@gmail.ocm

Constantly increasing intensity of road traffic and the authorized speed limits seem to impose more stringent requirements on road infrastructure and application of road safety systems. One of the ways to improve the road safety is the use of road restraint systems. Road safety barriers not only reduce number of road traffic accidents, but are also of great importance to the accident severity reduction.
The paper provides information on the technical requirements applied on the road safety barriers, as well as the places where the barriers should be installed. Various types of the road safety barriers and their selection criteria, basing on the specific road section characteristic, are discussed.
The article views an example of a road traffic accident, which is also modelled by PC-Crash computer programme. The given example reflects a road accident mechanism in case of a car-to-barrier collision, and provides information about the typical damage to the car and the barrier.
The paper describes an impact of the road safety barrier type and its presence on the road traffic accident mechanism. Implementation and maintenance costs of different barrier types are viewed. The article draws discussion on necessity to use the road safety barriers, as well as its optimal choice.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement "INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH".

CEMENT BASED BATTERIES AND THEIR POTENTIAL FOR USE IN LOW POWER OPERATIONS

AIMEE BYRNE[1], NIALL HOLMES[1], BRIAN NORTON[2]
[1]School of Civil & Structural Engineering, Dublin Institute of Technology, Dublin 1, Ireland
[2]Presidents Office, Dublin Institute of Technology, Dublin 1, Ireland
E-mail: aimee.byrne@dit.ie

This paper presents the development of innovative cement-based batteries for low power operations such as cathodic protection of reinforced concrete. Initial electrical outputs of 1.5 V and 23 mA have been found which is sufficient to polarise prescribed corrosion currents of 20 mA per m^2 of embedded steel. This paper focuses on increasing the voltage and current outputs, lifespan and recharge-ability. This is achieved by comparing ways to enhance the ionic conductivity of the solution in the cement pores and increase the porosity of the cement, examining ways of sealing moisture into the cement, comparing different electrode materials and treatments, and connecting batteries in series and parallel. The batteries presented consist of different combinations of Portland cement, water, carbon black and salt solutions with embedded copper acting as the cathode and magnesium, aluminium or zinc cast as the anode.
The preliminary findings demonstrate that cement-based batteries can produce sufficient sustainable electrical outputs with the correct materials and arrangement of components. Work is ongoing to determine how these batteries can be recharged using photovoltaics which will further enhance their sustainability properties.

EUROPEAN VERTICAL REFERENCE SYSTEM IN LATVIA

ARMANDS CELMS[1], ILONA REKE[1], AIVARS RATKEVICS[2]
[1]Faculty of Land Management and Geodesy, Latvia University of Agriculture, Latvia
[2]Faculty of Rural Engineering, Latvia University of Agriculture, Latvia
E-mail: armands.celms@llu.lv, ilona.reke@gmail.com

Until 1st of December, 2014 the heights in Latvia were determined in Baltic Normal Heights System of 1977. The national height system is determined by the Cabinet of Ministers and the legislation of the Republic of Latvia. Now in order to change the national height system amendments to the laws and regulations are being developed, but just the amendment for the Law of Geospatial Information is in force, whereas the amendment to the regulation of Cabinet of Ministers is still not valid.

From 1st of December the national height system is. European Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services. Article 1.3.3. „Compound Coordinate Reference Systems" of Annex II determines that the European Vertical Reference System shall be used to express gravity-related heights within unit's geographical scope.

For transformation from Baltic Normal Height System 1977 to European Vertical Reference System Federal Agency for Cartography and Geodesy (BKG – Bundesamt fűr Kartographie und Geodesie) in Germany and Reference Frame Sub-Commission for Europe (EUREF) has made the transformation formula for EVRF2007 realization in the territory of Latvia.

According to the transformation formula height difference between Baltic Normal Height System 1977 and European Vertical Reference System is not a constant value in the whole territory of Latvia but differs from 135 mm to 165 mm and depends on the point location in territory (coordinates).

The Amendment to the regulations of Cabinet of Ministers determines the Latvia Height System LAS-2000.5 and the parameters for it, which are different from the parameters for EVRF2007 for the territory of Latvia. The height differences between Baltic Normal Height System 1977 and Latvia Height System LAS-2000.5 are from 125 mm to 173 mm. The difference is 48 mm, which is higher than previously determined by EVRF2007.

SYNTHESIS AND CHARACTERIZATION OF REACTIVE POWDER CONCRETE FOR ITS APPLICATION ON THERMAL INSULATION PANELS

VALLE CHOZAS[1], INIGO LARRAZA[1], JOSE VERA-AGULLO[1],
NATALIE WILLIAMS-PORTAL[2], URS MUELLER[2], MATHIAS FLANSBJER[3]
[1]ACCIONA Technological Centre, Valportillo II 8, Alcobendas, Spain
[2]CBI Cement and Concrete Research Institute, 501 15 Boras, Sweden
[3]SP Technical Research Institute of Sweden, 501 15 Boras, Sweden
E-mail: inigo.larraza.alvarez.ext@acciona.com, jurs.mueller@cbi.se

There is a vastly growing demand for increased energy efficiency of the buildings we live and work in, which is one of the great challenges of the European construction sector, including materials and processes. The EU has set ambitious energy-saving goals: to achieve a reduction 20% of total energy consumption, a 20% reduction of Green House Gases (GHG) (below the level in 2005) in 2050; to ensure that most buildings and districts are energy-neutral and have zero CO2 emissions (Energy Policy set by the European Council in March 2007).

The presented work was developed within the SESBE project [1], which aims at developing façade elements (sandwich and half sandwich) with high insulation ability and at the same time a reduced thickness and great mechanical properties. In order to enable a significantly reduced thickness of these elements, layers of reactive powder concrete reinforced with carbon fibre grids have been developed.

Reactive powder concrete (RPG) is a cement-based type of material characterized by the fact that its microstructure is optimized by a precise gradation of all particles in the mix to yield maximum compactness. It uses extensively the pozzolanic properties of highly refined silica fume and alternative cement additions and optimization of the Portland cement chemistry to produce the highest strength hydrates and should be more appropriately seen as a cold ceramic rather than a concrete [2].

The present paper reports the synthesis and characterization of different formulations of RPC with a high compressive strength (~140 MPa) and good rheology and at the same time a reduced carbon footprint achieved by adding high concentrations of alternative cement additions.

[1] This project has received funding from the European Community's Seventh Framework Programme NMP.2013-1 under Grant agreement no: 608950

[2] Richard P., Cheyrezy M., Composition of reactive powder concretes. Cement and Concrete Research, 1995, Vol. 25 (7), pp.1501-11.

INSPECTION OF CONSTRUCTION WORKS ACCORDING TO POLISH CONSTRUCTION LAW

ANDRZEJ CZEMPLIK[1]
[1]Wroclaw University of Technology, Wroclaw, Poland
E-mail: andrzej.czemplik@pwr.edu.pl

Construction regulations are still different in many European countries even though the European Union directives did unify many acts for construction works and construction products in the member countries. The scheme of the construction process organized as per Polish construction regulations are presented and commented on in the paper. In particular, duties and responsibilities, as far as formally required qualifications of all engineers officially registered for the given construction process, are shown. Systematic supervision and inspection methodology of construction works are presented extensively. Finally, the formal requirements that foreign designers and foreign site engineers have to fulfil in order to be allowed to take official roles in Polish construction sites in the same way as Polish engineers are discussed.
The paper meets the demand for presented information package from foreign designers, contractors, investors and project managers, since many international construction projects are being developed in Poland, now.

ALKALI-ACTIVATED ALUMINIUM-SILICATE COMPOSITES AS INSULATION MATERIALS FOR INDUSTRIAL APPLICATION

LAURA DEMBOVSKA[1], DIANA BAJARE[1], INA PUNDIENE[2], GIRTS BUMANIS[1]
[1]Department of Building Materials and Products, Institute of Materials and Structures, Riga Technical University, Riga, Latvia
[2]Vilnius GediminasTechnical University, Sauletekio Str. 11, 10223, Vilnius, Lithuania
E-mail: laura.dembovska@rtu.lv

The paper presents a study of thermal stability of alkali-activated aluminium-silicate composites (ASC) at temperature 800–1100 °C. ASC were prepared by using calcined kaolinite clay, aluminium scrap recycling waste, lead-silicate glass waste and quartz sand. As alkali activator commercial sodium silicate solution modified with an addition of sodium hydroxide was used. The obtained alkali activation solution had silica modulus Ms = 1.67. The components of aluminium scrap recycling waste (aluminum nitride (AlN) and iron sulphite ($FeSO_3$) react in the alkali media and create gas – ammonia and sulfur dioxide, which provide the porous structure in the material [1]. The production of different types of ASC results in a close to zero-carbon dioxide emission, which is significant compared to the production of refractories from alumina cement.
Changes in the chemical composition of ASC during heating were identified and quantitatively analysed by using DTA/TG, dimension changes during the heating process were determined by using HTOM, pore microstructure was examined by SEM, and mineralogical composition of ASC was determined by XRD. The density of ASC was measured in accordance with EN 1097-7.
ASC with density around 560 kg/m^3 were obtained with heat resistance up to 1100 °C with shrinkage less than 5%.The intended use of this material is as insulation material for industrial purposes at elevated temperatures.

ACKNOWLEDGEMENT
The research work was carried out in the frame of the project of Latvian Council of Science:”Development of sustainable effective lightweight construction materials based on industrial waste and local resources” (No.Z12.0412).

[1] Bajare D., Bumanis G., Korjakins A., New Porous Material Made from Industrial and Municipal Waste for Building Application, Materials Science, 2014, Vol. 20, No. 3, pp. 333-338

ENERGY EFFICIENCY OF HEAT PUMPS IN COLD CLIMATE

ILZE DIMDINA[1], ARTURS LESINSKIS[1], ANDRIS JAKOVICS[2],
STANISLAVS GENDELIS[2], GATIS PLAVENIEKS[1]
[1]Riga Technical University, Riga, Latvia
[2]University of Latvia, Riga, Latvia
E-mail: ilze.dimdina@gmail.com

As a result of the increasing requirements for energy efficiency of buildings, the heating consumption of the buildings decreases. This contributes to the increasing role of heat pumps for heating in colder climates. European standards describe how to make tests and calculate the Coefficient of Performance (COP) and Seasonal Coefficient of Performance (SCOP) for the heat pumps in defined climate conditions. In practice the achieved energy efficiency of a heat pump highly depends on the selected heat pump capacity in relation to the local climate and its variations, specific heat consumption of the building under certain operation conditions and taking into account the building's thermal inertia, density and other characteristics. An important criterion for the selection of the heat pump is the heating solution – as the only heat source or as an additional heat source equipment to operate under favorable conditions.

STATISTICAL ANALYSIS OF CONCRETE COVER IN NEW HIGHWAY BRIDGES

STEPHEN O. EKOLU[1], FITSUM SOLOMON[1]
[1]Department of Civil Engineering Science, University of Johannesburg, Auckland Park 2006, Johannesburg, South Africa
E-mail: sekolu@uj.ac.za; sekolu@gmail.com

Quality control is one of the important aspects of any major construction works that is to be undertaken to ensure work execution according to design requirements. The work presented in this paper involved measurement of cover thickness in three newly constructed highway bridges. Testing was conducted to ensure that specified requirements were attained prior to commissioning of the structures; otherwise, the quality control survey would identify problem areas for consideration of corrective measures.
A total of 328 data sets were obtained during cover measurements. In this paper, the results obtained are discussed and evaluated. Data are characterised on the basis of statistical quantities.

TOWARDS PRACTICAL CARBONATION PREDICTION AND MODELLING FOR SERVICE LIFE DESIGN OF REINFORCED CONCRETE STRUCTURES

STEPHEN O. EKOLU[1]
[1]*Department of Civil Engineering Science, University of Johannesburg, Auckland Park 2006, Johannesburg, South Africa*
E-mail: sekolu@uj.ac.za; sekolu@gmail.com

The interest about durability of concrete structures has been high amongst the scientific community for over 40 years. Of the various causes of degradation of concrete structures corrosion is the most widespread durability problem and carbonation is one of the two causes of steel reinforcement corrosion. While a lot of scientific understanding has been gained from the numerous carbonation studies undertaken over the past years, it is still presently not possible to accurately predict carbonation and to apply it in the design of structures. This underscores the complex nature of the mechanisms as influenced by several interactive factors. Based on critical literature and some experience of the author, it is found that there still exist major challenges in establishing a mathematical constitutive relation for realistic carbonation prediction. While most current models employ permeability/diffusion as the main model property, analysis shows that the most practical material property would be compressive strength which has a low coefficient of variation of 20% compared to 30% to 50% for permeability. This important characteristic of compressive strength, combined with its merit of simplicity and data availability at all stages of a structure's life, promotes its potential use in modelling over permeability. By using compressive strength in carbonation prediction, the need for accelerated testing and permeability measurement can be avoided.
This paper attempts to examine the issues associated with carbonation prediction, which could underlie the current lack of sound established prediction method. Suggestions are then made for possible employment of different or alternative approaches.

DURABILITY OF ALKALI ACTIVATED BLAST FURNACE SLAG

KATHLEEN ELLIS[1], NAJAT ALHARBI [2], PABLO SANTIZO MATHEU [3],
BENJAMIN VARELA[4] RICHARD HAILSTONE[5]
[1]Industrial and Systems Engineering Department, Rochester Institute of Technology, Rochester NY, USA,
[2] Center for Imaging Sciences, Rochester Institute of Technology, Rochester NY, USA
[3] Mechanical Engineering Department, Rochester Institute of Technology, Rochester NY, USA
E-mail: ke4861@rit.edu, naa4271@g.rit.edu, pxs3517@g.rit.edu, bxveme@rit.edu, hailstone@cis.rit.edu

The alkali activation of blast furnace slag has the potential to reduce the environmental impact of cementatious materials and to be applied in geographic zones where weather is a factor that negatively affects performance of materials based on Ordinary Portland Cement. The scientific literature provides many examples of alkali activated slag with high compressive strengths; however, research into the durability and resistance to aggressive environments is still necessary for applications in harsh weather conditions. In this study two design mixes of blast furnace slag with mine tailings were activated with a potassium based solution. The design mixes were characterized by scanning electron microscopy, BET analysis, shrinkage and compressive strength testing. Freeze-thaw testing up to 100 freeze-thaw cycles was performed in 10% road salt solution. Our findings included compressive strength of up to 100 MPa after 28 days of curing and 120 MPa after freeze-thaw testing. The microstructure of the materials and pore size distributions were correlated with variations in the compressive strength.

DEVELOPMENT OF NEW CEMENTITIOUS MATERIALS BY ALKALINE ACTIVATING INDUSTRIAL BY-PRODUCTS

ANA. FERNANDEZ-JIMENEZ[1], INES GARCIA-LODEIRO[1], ANGEL PALOMO[1]
[1]Instituto Eduardo Torroja, Madrid, Spain
E-mail: anafj@ietcc.csic.es, iglodiero@ietcc.csic.es, palomo@ietcc.csic.es

The alkaline activation of aluminosiliceous industrial by-products such as blast furnace slag and fly ash is widely known to yield binders whose properties make them comparable to or even stronger and more durable than ordinary Portland cement.
The present paper discusses activation fundamentals (such as type and concentration of alkaline activator and curing conditions) as well as the structure of the cementitious gels formed (C-A-S-H, N-A-S-H).The durability and strength of these systems make these materials apt for use in many industrial applications, such as precast concrete elements (masonry blocks, railroad sleepers), protective coatings for materials with low fire ratings and lightweight elements.

ANALYSIS OF YEARLY TRAFFIC FLUCTUATION ON LATVIAN HIGHWAYS

ANDRIS FREIMANIS[1], AINARS PAEGLITIS[1]
[1]Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: andris.freimanis_1@edu.rtu.lv

Average annual daily traffic and average annual truck traffic are two most used metrics for road management decisions. They are calculated from the data gathered by continuous counting stations embedded in road pavement, manual counting sessions or mobile counting devices. The two latter ones usually do not take longer than a couple of weeks so the information gathered is influenced by yearly traffic fluctuations.
Data containing a total of 8'186'871 vehicles or 1989 days from 4 WIM stations installed on highways in Latvia were used in this study. Each of the files was supposed to contain the data of only 1 day, additional data were deleted. No other data cleaning steps were performed, which increased the number of vehicles as counting systems sometimes split vehicles in two. Weekly traffic and weekly truck traffic was normalized against the respective average values. Each weekly value was then plotted against its number in a year for better visual perception.
Weekly traffic amplitudes were used to assess the differences between different locations and standard deviations for comparing the fluctuation of truck and regular traffic at the same location.
The results show that the truck traffic fluctuates more than regular traffic during a year, especially around holidays. Differences between the counting locations were larger for regular traffic than the truck traffic. These results show that the average annual daily traffic could be influenced more if short term counting results were adjusted by the factors derived from unsuitable continuous counting stations, but the truck traffic is more influenced by the time of the year in which the counting is done.

ACKNOWLEDGMENT
The authors would like to thank Latvian Road Administration for providing WIM data. The research leading to these results has received the funding from Latvia state research programme under grant agreement "INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH".

GLUED JOINT BEHAVIOR OF COMPOSITE PLYWOOD PLATES

GIRTS FROLOVS[1], KARLIS ROCENS[1], JANIS SLISERIS[1]
[1] Faculty of Building and Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: girts.frolovs@rtu.lv

This article shows experimental investigations of composite sandwich plywood plates with skin layers of birch plywood and a core of straight and curved plywood honeycomb-type ribs.
The shape of core ribs provides several improvements for these plates in manufacturing process as well as mechanical properties of plywood plates.
The influence of core element shapes on stiffness in longitudinal direction of the plate is insignificant although it is possible to vary the stiffness in transverse direction of these plates by changing the form of the plate's ribs. The results are describable as specific strength or stiffness (stiffness to mass or strength to mass ratio etc.). This specific form of ribs allows simplify the manufacturing of these plates although it should be detailed and improved.
Various results depending on the chosen variables (according to strength-stiffness criteria) of plywood composite macrostructure were obtained for one span plate according to EN789 standard. The most typical cases (series of specimens) were compared to the results obtained from FEM (ANSYS) simulations and validated.
All thicknesses of elements were chosen according to the assortment of the plywood supplier.
Various thicknesses of plywood sheets (0/90/0+90/0•*n*) were taken for straight ribs as well as various plates coverings for the waved part of ribs. The 3 layer plywood was taken (90/0/90) due to the simplification of manufacturing process.
For all parts of plate Birch plywood plates were used and as reference plywood Standard Birch plywood plates were chosen.

ACKNOWLEDGMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement "INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH".

STUDY ON PROPERTIES OF ENVIRONMENT-FRIENDLY CONCRETE CONTAINING LARGE AMOUNT OF INDUSTRIAL BY-PRODUCTS

HIROMI FUJIWARA[1], MASANORI MARUOKA[1], CHIHIRO SADAYAMA[1], MASATOSHI NEMOTO[1], MAMI YAMAJI[1]
[1]Utsunomiya University, Utsunomiya, Japan
E-mail: fhiromi@cc.utsunomiya-u.ac.jp

In recent years, the use of high strength concrete has been on the increase. However, such high-strength concrete usually requires markedly high cement content of concrete and it means that significantly large quantities of CO_2 from the cement industry are emitted.
This study aims to reduce CO_2 discharged from the cement and concrete industries by effective use of industrial by-products, such as fly ash, blast furnace slag, and so on. In this paper, the properties of concrete containing large amount of industrial by-products and very small amount of cement, as well as those of clinker free concrete were investigated. The effects of some kinds of accelerating admixture including industrial waste such as sludge from ready mixed concrete plant on the properties were also evaluated.
As a result, it was confirmed that the concrete containing large amount of industrial by-products and clinker free concrete can achieve enough compressive strength of more than 60 N/mm2 through suitable combination of industrial by-products and superplasticizer. However, this concrete showed poor frost resistance. It was thought that their air void system is coarsening which causes their poor frost resistance. Therefore, in order to micronize the air void system and improve the frost resistance, the combination of air entraining agent and antifoaming agent was applied. By this method it was confirmed that the frost resistance of this concrete is improved.
In this study other properties of this concrete, such as fresh properties and durability were evaluated and it was confirmed that this concrete has sufficient properties.

CEMENTS WITH LOW CLINKER CONTENT

INES GARCIA-LODEIRO[1], ANA FERNANDEZ-JIMENEZ[1], ANGEL PALOMO[1]
[1]Instituto Eduardo Torroja, Madrid, Spain
E-mail: iglodiero@ietcc.csic.es, anafj@ietcc.csic.es, palomo@ietcc.csic.es

Hybrid alkaline cements are multi-component systems containing high percentage of mineral additions (fly ash, blast furnace slag), low proportions (<30 %) of Portland clinker and moderate amount of alkaline activators. The substantially lower amount of clinker needed to manufacture these binders than the ordinary Portland cement is both economically and ecologically beneficial. Their enormous versatility in terms of raw materials used has made them an object of considerable interest.
The presented study explored the mechanical strength of binary blends: mixes of 20 % clinker (CK) and 80 % fly ash (FA) and 20 % clinker and 80 % blast furnace slag (BFS), hydrated in the presence and absence of an alkaline activator designed for this purpose. The use of the activator enhanced the development of early age strength considerably. All the hydrated matrices were characterised with XRD, SEM/EDX and (^{29}Si and ^{27}Al) NMR. The use of the alkaline activator generated reaction products consisting primarily of the mix of gels [(N,C)-A-S-H and C-A-S-H] whose respective proportions were found to depend on the system composition and initial reactivity.

INFLUENCE OF BUILDING ENVELOPE THERMAL MASS ON HEATING DESIGN TEMPERATURE

BAIBA GAUJENA[1], ANATOLIJS BORODINECS[2], JURGIS ZEMITIS[2], ALEKSEJS PROZUMENTS[2]

[1] Department of Civil Engineering, Institute of Building Production, Riga Technical University, Latvia
[2]Department of Heat and Gas technology, Institute of Heat, Gas and Water technology, Riga Technical University, Latvia
E-mail: baiba.gaujena@rtu.lv, anatolijs.borodinecs@rtu.lv, jurgis.zemitis@rtu.lv

The stability of indoor air parameters is very important factor, essential for such institution as museums, schools and hospitals. Nowadays use of renewable energy for space heating became one of top priorities in modern building design. The active and passive solar energy as well as heat pumps are widely used nowadays. However such technologies have a limitation in cold climates and often are not able to cover maximal heating loads. This paper is devoted to analysis of influence of building envelope's properties and outdoor air parameters on indoor air thermodynamic parameters stability in winter time. It presents analysis of thermal mass impact on buildings energy performance and indoor air parameters stability in cold climate. The results show that the thermal mass of building envelope is able to cover extreme winter temperatures as well as in case of emergency heat supply break.

EARTH'S SURFACE DISPLACEMENTS FROM THE GPS TIME SERIES

DIANA HARITONOVA[1,2], JANIS BALODIS[1], INESE JANPAULE[2],
KATERINA MOROZOVA[2]
[1]Institute of Geodesy and Geoinformatics, Riga, Latvia
[2]Riga Technical University, Riga, Latvia
E-mail: diana.haritonova@rtu.lv, janis.balodis@lu.lv

The GPS observations of both Latvian permanent networks – EUPOS®-Riga and LatPos, have been collected for the period of 8 years – from 2007 to 2014. The Bernese software version 5.0, developed at the University of Bern, was used to process the GPS data in the Institute of Geodesy and Geoinformatics of the University of Latvia. The EUREF Permanent Network (EPN) stations in the surroundings of Latvia were used as fiducial stations.
The purpose of this study is to analyse the GPS time series obtained using both data processing strategies: Precise Point Positioning (PPP) and estimation of station coordinates in relation to the positions of fiducial stations also known as differential GNSS.
The impact of station selection for the network solution and influence of reference station problems on the quality of post-processing results were under discussion as well.
Local surface displacements were derived from the obtained GPS time series eliminating different impact sources. The results showed a positive tendency of vertical displacements in the western part of Latvia – station heights are increasing, and negative velocities are observed in the eastern part. Station vertical velocities are ranging from – 2 mm/year to +2 mm/year. In the case of horizontal displacements GPS station velocities are up to 1 mm/year and mostly oriented to the south.
Comparing the obtained results with the data from the deformation model NKG_RF03vel the horizontal velocities of the Latvian GPS stations are in good agreement, but concerning the vertical velocities for the territory of Latvia the data range is two times greater.

[1] Beutler G., Bock H., Dach R., Fridez P., Gäde A., Hugentobler U., Jäggi A., Meindl M., Mervart L., Prange L., Schaer S., Springer T., Urschl C., Walser P., User manual of the Bernese GPS Software Version 5.0. Astronomical Institute, University of Bern, 2007
[2] Kenyeres A., European dense velocity field based on the integration of EPN and the national active GNSS network products Presented at REFAG2014 Symposium, Luxembourg, 2014
[3] Milne G.A., Davis J.L., Mitrovica J.X., Scherneck H.-G., Johansson J.M., Vermeer M., Koivula H., Space-Geodetic Constraints on Glacial Isostatic Adjustments in Fennoscandia, Science, 2001, Vol. 291, pp. 2381-2385
[4] Ågren J., Svensson R., Land Uplift Model and System Definition Used for the RH 2000 Adjustment of the Baltic Levelling Ring, Presented at NKG General Assembly, Copenhagen, 2006

HIGH MODULUS ASPHALT CONCRETE WITH DOLOMITE AGGREGATES

VIKTORS HARITONOVS[1], JANIS TIHONOVS[1], JURIS SMIRNOVS[1],
[1] Department of Roads and Bridges, Institute of Transportation, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: Janis.tihonovs@rtu.lv

Dolomite is one of the most available sedimentary rocks in the territory of Latvia. Dolomite quarries contain about 1000 million tons of this material. However, according to Latvian Road Specifications this dolomite cannot be used for average and high intensity roads because of its low quality (mainly, LA index). Therefore, mostly imported magmatic rocks (granite, diabase, gabbro, basalt) or imported dolomite are used which makes asphalt expensive. However, practical experience shows that even with these high quality materials roads exhibit rutting, fatigue and thermal cracks. The aim of the research is to develop a high performance asphalt concrete for base and binder courses using only locally available aggregates. In order to achieve resistance against deformations at a high ambient temperature, a hard grade binder was used. Workability, fatigue and thermal cracking resistance, as well as sufficient water resistance is achieved by low porosity (3–5%) and higher binder content compared to traditional asphalt mixtures. The design of the asphalt includes a combination of empirical and performance based tests, which in laboratory circumstances allow simulating traffic and environmental loads. High performance AC 16 base asphalt concrete was created using local dolomite aggregate with polymer modified (PMB 10/40-65) and hard grade (B20/30) bitumen. The mixtures were specified based on fundamental properties in accordance with EN 13108-1 standard.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

POSSIBILITIES OF USING CELLULOSE FIBRES IN BUILDING MATERIALS

VIOLA HOSPODAROVA[1], NADEZDA STEVULOVA[1], ALENA SICAKOVA[1]
[1] Institute of Environmental Engineering, Faculty of Civil Engineering, Technical University of Kosice, Kosice, Slovakia
E-mail: viola.hospodarova@tuke.sk, nadezda.stevulova@tuke.sk, alena.sicakova@tuke.sk

Nowadays, utilization of wastes from agriculture, paper production and building construction is becoming increasingly important due to the concerns about environmental impact. The material recycling is a growing trend in the development of building materials and some waste materials can be used in construction as secondary raw materials. The demand for natural non-renewable raw materials is increasing rapidly, therefore wastes as a resource for secondary raw materials can be a good substitute in production processes. In this way, the shortage of natural raw materials can be supplemented. Construction industry uses secondary raw materials very effectively thereby substituting virgin materials. One of interesting secondary raw materials is the waste coming from natural plant fibres.

An alternative to more expensive steel fibre, glass fibre, and synthetic polymer fibre-reinforced cement products, wood fibres and recycled cellulose fibres of waste paper are well-suited for reinforcing cement-based materials because of their high strength-to-cost ratio, availability, renewability and recyclability, and non-hazardous nature. The increasing regulations surrounding the use of asbestos fibre reinforced materials have also prompted the growing interest in wood fibre-cement composites for construction. The growing worldwide acceptance and use of fibre-cement products in residential construction and the continuing development of new products have caused the industry to describe fibre-cement materials as "tomorrow's growth product" [1]. The primary advantages of using lignocellulosic fibres as additives in cement are low density, low cost, nonabrasive nature, high filling levels possible, low energy consumption, and wide variety of fibres available throughout the world. With an increasing worldwide shortage of wood resources, there has been a strong trend to produce composite products using recycled paper, non-wood plant materials and agricultural residues. Among the possible alternatives, the development of pulp and paper industries and bio-composites using recycled paper is currently in the centre of attention [2].

In this paper, characterization of cellulose fibres from waste paper and their use in cement composites are presented. Technically important parameters of hardened composites are determined and tested (density, water absorbability, coefficient of thermal conductivity and compressive strength).

[1] El-Ashkar N.H., Mohr B., Nanko H., Kurtis K.E., Durability of pulp fiber-cement composites to wet/dry cycling, Advances in Building Technology, 2002, pp. 233-237
[2] Ashori A., Tabarsa T., Valizadeh I., Fiber reinforced cement boards made from recycled newsprint paper, Material Science and Engineering A, 2011, pp. 7801-7804

EVALUATION OF STRENGTH CHARACTERISTICS OF LATERIZED CONCRETE WITH CORN COB ASH (CCA) BLENDED CEMENT

EFE E. IKPONMWOSA[1], MUSBAU A. SALAU[1], WAFUNDA B. KAIGAMA[1]
[1]Department of Civil and Environmental Engineering, University of Lagos, Lagos State, Nigeria
E-mail: efe_ewaen@yahoo.com

Agricultural wastes are dumped in landfills or left on the land in which they constitute nuisance. This study presents the results of investigation of strength characteristics of laterized concrete beams with cement partially replaced with corn cob (agricultural wastes) ash (CCA). Laterized Concrete specimen of 25% laterite and 75% sharp sand was made by blending cement with Corn Cob Ash at 0 to 40% in steps of 10%. A concrete mix ratio of 1:2:4 was used to cast 54 Nos. 150 mm cubes and 54 Nos. 750 x 150 x 150 mm beams.

The results showed that the consistency and setting time of cement increased as the percentage replacement of cement with CCA increased while the workability and density of concrete decreased as the percentage of CCA increased. There was a decrease in compressive strength when laterite was introduced to the concrete from 25.04 to 22.96 N/mm^2 after 28 days and a continual reduction in strength when CCA was further added from 10% to 40% at steps of 10%. The corresponding central deflection in beams, due to two points loading, increased as the laterite was added to the concrete mix but reduced and almost approaching that of the control as 10% CCA was added. The deflection then increased as the CCA content further increased to 20%, 30% and 40% in the mix. It was also noted that the deflection of all percentage replacement including 40% CCA is less than the standard recommended maximum deflection of the beam.

VALIDATION OF FINITE ELEMENT UPADTED MODELS OF THE DEVELOPED FACADE SCAFFOLD ANCHOR

JIRI ILCIK[1], VIKAS ARORA[2], JAKUB DOLEJS[1]
[1]Faculty of Civil Engineering, Czech Technical University, Prague, Czech Republic
[2]Department of Technology and Innovation, University of Southern Denmark, Odense, Denmark
E-mail: jiri.ilcik@fsv.cvut.cz

The paper focuses on the updating of the finite element models of the newly developed facade scaffold anchor in the light of the experimental results. The experiments (force-displacement curves) have been carried out on the anchor. The facade scaffold anchor overcomes the problems connected with the joining into the facades through the thermal insulation layers, in current methods the wind load cannot be effectively transferred into the façade and scaffolding stability is decreased [1]. Experimental results are presented and the finite element models of the anchor are developed using non-linear beam and solid elements. It has been observed that the predictions of finite element models do not match with the experiment results. Subsequently the finite element models of the developed anchor have been updated in the light of experimental result by using the parameter-based finite element model updating method. In the case of an anchor, modelling of stiffness of the joints and values of the materials are expected to be dominant sources of inaccuracy in the FE model, assuming that the geometric parameters are correctly known [2], [3]. After updating joint stiffness of the anchor joints and material properties, the finite element predictions match with experimental results. The outcomes showing that there is a good correlation between the updated finite element models and the experimental data can be seen in Fig. 1. The accuracy of updated finite element models is demonstrated by overlaying force-displacement curves with the curve from the experiment and it can be concluded with confidence that the updated finite element models of the anchor represent the reality.

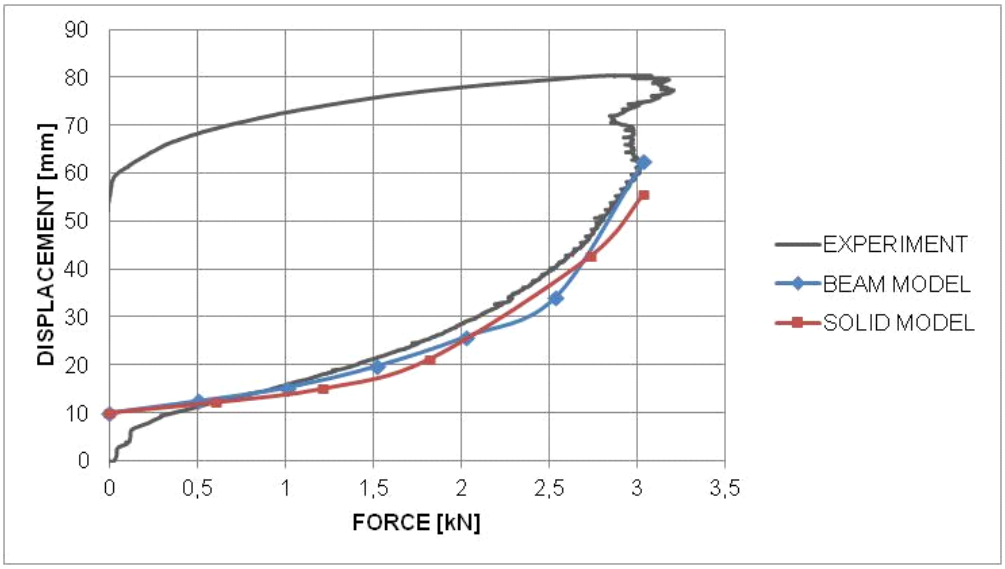


Fig.1. Final overlay of the Force-Displacement curves.

[1] Dolejs J., Spatial coactions of facade scaffolds elements and components. Habilitation thesis, 2013, pp. 14-16
[2] Arora V., Singh V., Kundra T.K., Damped FE model updating using complex updating parameters: its use for dynamic design, Sound Vib, 2009, Vol. 324, pp. 350-364
[3] Arora V., Singh V., Kundra T.K., Finite element model updating with damping identification, Sound Vib, 2009, Vol. 324, pp. 1111-1123

ENERGY EFFICIENCY AND SUSTAINABILITY OF DIFFERENT BUILDING STRUCTURES IN LATVIAN CLIMATE

ANDRIS JAKOVICS[1], STANISLAVS GENDELIS[1], LIENE BANDENIECE[1]
[1]Department of Physics, University of Latvia, Riga, Latvia
E-mail: Andris.Jakovics@lu.lv

Five experimental test buildings (stands) have been built in Riga (Fig. 1). They are identical except for the external walls for which different mainly regional building materials are used. The basic materials used for the ventilated facade exterior wall construction are:

- perforated ceramic blocks (440 mm) with flexible stone wool insulation outside (type CER);
- aerated concrete blocks (375 mm) with flexible stone wool layer outside (type AER);
- modular plywood panels with flexible stone wool filling (200 mm) and fibrolite (70 mm) inside (type PLY);
- perforated ceramic blocks (500 mm) filled with insulating granules (type EXP);
- wooden beams (200 mm) with flexible stone wool insulation layer and wood paneling inside (type LOG).

However, the projected heat transmittance (U-value) of the walls, floor and ceiling is the same for each test building. All the test stands are equipped with the same set of more than 40 different sensors:
1) temperature and humidity (T/H) sensors; 2) air velocity flow sensors; 3) solar radiation sensor; 4) energy meter; 5) differential pressure sensor; 6) heat flow sensor. To collect meteorological data a weather station is installed on the top of the test stand with a separate data logger. The web server and the FTP server are installed in each data logger providing remote access to the stored data for each sensor and to the software's parameters. The measurement data file from loggers is sent to the main FTP server once a day, where the data is collected and post-processed for detailed analysis.
Initial moisture of materials influences the relative humidity of indoor air, which can be higher at the initial time period of 2–3 years. As a result the U-values are also very different and cause different heating/cooling energy consumption.

Fig. 1. Experimental test buildings.

Measurements show that a critical situation is observed for two test houses where initial moisture is high and the drying process of external walls is slow. One external wall consists of aerated concrete (AER) and insulation layer from the outer side. The second external wall is created from one clay block with insulation filling (EXP). The results show that the heat demand in cold period for these two test houses is significantly higher than

for the other 3 test stands. Moreover, overheating risk for the two “critical” test houses is significantly lower in summer. However, the situation is not normal in that case. Both summer and heating seasons have been analysed and differences between the five test houses are discussed in details.

Long-term monitoring of various physical parameters in test buildings in Latvian climate show, that calculated and measured heat transmittance for building structures may vary mainly due to the different moisture content. Therefore, heating energy consumption for such buildings differs up to 35%.

After two years of operation wet constructions dry out and the air humidity in the room decreases; it means a decrease in heating energy consumption for the next heating seasons.

Thermal mass of the building structure is a very important factor, which reduces the overheating of rooms without cooling in summer time.

DAMAGE IDENTIFICATION IN BEAM STRUCTURE USING SPATIAL CONTINUOUS WAVELET TRANSFORM

RIMS JANELIUKSTIS[1], SANDRIS RUCEVSKIS[1], MIROSLAW WESOLOWSKI[2], ANDREJS KOVALOVS[1], ANDRIS CHATE[1]
[1]Institute of Materials and Structures, Riga Technical University, Riga, Latvia
[2]Department of Structural Mechanics, Faculty of Civil Engineering, Environment and Geodesy, Koszalin University of Technology, Koszalin, Poland.
E-mail: Rims.Janeliukstis_1@rtu.lv

Modern engineering structures, including but not limited to buildings, bridges, dams, automotive and aerospace facilities, have to maintain their integrity and functionality under severe environmental conditions. Their failure can lead to tragic consequences, therefore the structures have regular inspections. Rigorous inspection of structures on regular bases is usually a time-consuming and costly procedure; therefore non-destructive structural health monitoring (SHM) methods have become an important research area for civil, mechanical, and aerospace engineering communities.
In recent years, various vibration-based damage detection methods have been proposed for SHM. Many of them use various transformations of measured dynamic response of structure. Dynamic responses, which in many cases can be easily obtained, offer damage information such as the location and severity. One of the most promising techniques of processing dynamic response for damage identification is a wavelet transform. A wavelet transform technique, which originated in 1990s and was mainly used for signal noise reduction, image compression and discontinuity localization of signals, has become one of the latest trends in SHM.
In this paper the applicability of spatial continuous wavelet transform (CWT) technique for damage identification in an aluminium beam with a mill-cut damage is analysed by application of different types of wavelet transform and scaling factors. The proposed method uses exclusively mode shape data from the damaged structure for wavelet transform. To examine limitations of the method and to ascertain the sensitivity of the method to noisy experimental data, several sets of simulated data are applied. Simulated test cases include numerical mode shapes corrupted by different levels of random noise as well as mode shapes with different number of measurement points used for wavelet transform. The validity of the proposed method is assessed by comparing the damage identification results of the simulated test cases to the results obtained from the experimental test case. The modal frequencies and the corresponding mode shapes are obtained via finite element models for numerical simulations and by using a scanning laser vibrometer SLV with PZT actuator as a vibration excitation source for the experimental study.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

EVALUATION OF THE HYDROPHILIC/HYDROKPHOBIC PROPERTIES OF MODIFIED LIGNOCELLULOSIC FILLER

JEVGENIJS JAUNSLAVIETIS[1], GALIA SHULGA[1], JURIJS OZOLINS[2], BRIGITA NEIBERTE[1], ANRIJS VEROVKINS[1], SANDRA LIVCHA[1]

[1]Latvian State Institute of Wood Chemistry, Riga, Latvia

[2] Riga Technical University, Riga, Latvia

E-mail: shulga@junik.lv, juris-oz@inbox.lv

The different nature of a hydrophilic lignocellulosic filler and a hydrophobic thermoplastic polymer matrix is the main reason for their limited compatibility in wood-polymer composites. To increase the compatibility and decrease the free energy at the polymer matrix – wood filler interface, various methods of chemical modification of the filler are used. Recently, hydrophilic/hydrophobic properties of the lignocellulosic filler and its affinity to the polymer matrix have been evaluated in terms of wettability, which is characterised by the contact angle [1], [2]. Contact angle measuring is a very sensitive method for quantifying the wettability and surface energy of a solid material.

The aim of the work was to evaluate the hydrophilic/hydrophobic properties of the initial and modified aspen wood microparticles as potential filler using contact angle and water sorption measuring as well as Z potential determination. The contact angles were measured with a tensiometer Kruss 100M (Kruss, Germany) using the Washburn and Wilhelmy balance methods. The capillary constant for each wood sample was determined in *n*-hexane, the contact angle of which was 0. Zeta potential of the microparticles was measured with a dynamic light scattering device Zetasizer Nano SZ (Malvern, UK). For modification, the aspen microparticles <100 mk were, at first, activated with low temperature acid hydrolysis under mild conditions [3]. The activated microparticles were modified by introducing new functional groups at their surface. It was found that the activation and modification of lignocellulosic particles were directed in the opposite sides in terms of “wettability”. While the activation of wood microparticles led to an increase in their negative Z potential values and a decrease in their contact angles, the modification essentially decreased the negative charge of particles and remarkably enhanced their contact angles in water. Moreover, water vapour sorption of the modified lignocellulosic particles was 1.5–2 times lower compared with the cases of the initial and activated microparticles.

The composite samples for contact angle measuring were prepared from a raw blend composed of the 50% recycled polypropylene and the 50% lignocellulosic filler in a wide range of filling degree (10–50%) by the extrusion and the moulding method using HAAKE MiniLab II and MiniJet II (ThermoScientific, Germany). It was shown that for the composite samples filled with both the initial and activated aspen microparticles the contact angle values in water remarkably diminished with increasing the filling degree. At the same time, in comparison with the previous samples the composites containing the modified aspen microparticles were characterised by enhanced advancing and receding contact angles, which did not dramatically decrease with the variation of the filling degree, as well as by a smaller contact angle hysteresis. All the factors indicated the improvement of the wettability of the modified filler to the polymer matrix. This conclusion was supported by better physico-mechanical properties of the composites filled with the modified microparticles in comparison with those of the composites containing the initial and activated aspen fillers.

[1] Kirdponpattara S., Phisalaphong M., Newby B.M.Z., Applicability of Washburn capillary rise for determining contact angles of powders/porous materials, Journal of Colloid and Interface Science, 2014, Vol. 397, pp. 169-176

[2] Della Volpe C., Maniglo D., Siboni S., Morra M., An Experimental Procedure to Obtain the Equilibrium Contact Angle from the Wilhelmy Method, Oil & Gas Science Technology, Rev. IFP, 2001, Vol. 56, pp. 9-22

[3] Shulga G., Vitolina S., Neiberte B., Verovkins A., Jaunslavietis J., Ozolins J., Obtaining lignocellulosic microparticles using energy saving pre-treatment method, Proceedings of the 13th European Workshop on Lignocellulosics and Pulp (EWLP-2014), Seville, Spain, 2014, pp. 779-782

ANALYSIS OF LAND COVER CHANGE IN A COASTAL AREA USING REMOTELY SENSED DATA

INESE JAUNZEME[1], MARIS KALINKA[1], MARTINS REINIKS[1], JANIS KAMINSKIS[2]
[1] Department of Geomatics, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia,
[2]ETH Zurich, Zurich, Switzerland
E-mail: inese.jaunzeme@rtu.lv

Coastal area monitoring is a significant task in national development and environmental protection. The study area of this work is the Baltic Sea region, with particular focus on the land cover changes in the coastal area from Cape Kolka to Lithuania boundary.
The aim of this research is to estimate and illustrate different case examples of monitoring and mapping the land cover changes in coastal area using remotely sensed data – orthophoto, multispectral data and radar data. The Synthetic Aperture Radar (SAR) images may be acquired under most climate conditions especially in cloudy areas [1].

[1] Trebossen H., Deffontaines B., Classeau N., Kouame J., Rudant J., Monitoring coastal evolution and associated littoral hazards of French Guiana shoreline with radar images, C. R. Geoscience 337, 2005, pp. 1140-1153

MOISTURE AND THERMAL CONDUCTIVITY OF LIGHTWEIGHT BLOCK WALLS

RAGNAR JOOSEP[1]
[1] *Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia*
E-mail: ragnar@disainprojekt.ee

Evaluating of energy efficiency has become an important factor in building sector. More attention is paid to thermal properties of walls and insulation materials. The article examines thermal transmittance, moisture condensation and moisture drying out speed in insulated lightweight block walls and changes of those properties during 500 days [2], [4], [5], [15]–[17].Three different types of lightweight blocks mostly used in Estonia for building small dwelling houses: Aeroc (autoclaved aerated concrete blocks), compacted LECA (lightweight expanded clay aggregate FIBO), Silbet (blocks produced from oil shale ash) and two types of heat insulation: expanded Thermisol EPS60F polystyrene plates and glass wool Isover OL-P plates, were investigated. Wall fragments were built into the window openings of the laboratory and plastered inside and outside to obtain the situation more true to life [8] – [13].

Thermal transmittance U and moisture content RH of the test walls were measured on site and those values were compared with the results based on calculations [6], [7]. Four tested wall structures fulfilled the requirements set for the thermal properties of external walls in 2009 [1], but care must be taken during construction time, especially using polystyrene insulation boards. Drying out of blocks behind EPS is lasting, especially in winter. The results showed also that thermal transmittance of walls differs about 15 – 20% when comparing U values of real walls with the results of calculations. Attention should be paid to the moisture content of the blocks used and climate conditions during the bricklaying work, because the drying out speed is unexpectedly slow. For instance, the measured RH between the insulation layer and AEROC blocks of the test wall A2 (both sides plastered) was more than 99% over a year since constructing.

[1] Energiatõhususe miinimumnõuded, Vabariigi valitsuse, 2014 Vol. 68, §12
[2] de Gracia A., Castell A., Medrano M., Cabeza L.F., Dynamic thermal performance of alveolar brick construction system, Energy Conversion and Management, 2011
[3] Skujans J., Vulans A., Iljins U., Aboltins A., Measurements of heat transfer of multi-layered wall construction with foam gypsum, Applied Thermal Engineering, 2007, Vol. 27, Issue 7, pp. 1219–1224
[4] Skujans J., Iljins U., Ziemelis I., Gross U., Ositis N., Brencis R., Veinbergs A., Experimental research of foam gypsum acoustic absorption and heat flow, Chemical Engineering Transactions, 2010, Vol. 19, pp. 79–84
[5] EVS-EN ISO 13788:2012, Hydrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and interstitial condensation – Calculation methods
[6] EVS-EN ISO 6946:2008, Building components and building elements – Thermal resistance and thermal transmittance – Calculation methods
[7] ISOVER OL-P product information, according to EN 28301, EN 28302 www.isover.fi
[8] Sertifikaatin nro 129/00, 30.03.2000, www.thermisol.fi.
[9] Vastavussertifikaat, 1403-CPD-0027, www.aeroc.ee.
[10] EÜ vastavusdeklaratsioon Fibo3 kergplokile (EN 771-3), www.maxit.ee
[11] RT RakMK-21217, LÄMMÖNERISTYS Ohjeet, 2003
[12] Iila R., Kas soojustatud välissein peaks ka hingama, Keskkonnatehnika, 2008, Vol. 2, Issue 8, pp. 52–53
[13] Matiašovský P., Bagel L., Correlation between thermal conductivity and elastic modulus of porous building materials – power law functions of porosity, Institute of Construction and Architecture, Slovak Academy of Sciences, Slovakia
[14] Pavlík Z., Žumár J., Pavlíková M., Jerman M., Černý R., A transient method for determination of water vapor diffusion coefficient of building materials as function of relative humidity, Czech Technical University in Prague, Czech Republic
[15] Janssen H., Thermal diffusion of water vapor in porous materials: true or false?, Department of Civil Engineering, Technical University of Denmark, Denmark

LOAD BEARING INNOVATIVE CONSTRUCTION FROM GLASS

ROMAN KALAMAR[1], MARTINA ELIASOVA[1]
[1] *Faculty of Civil Engineering, Czech Technical University in Prague, Prague*
E-mail: roman.kalamar@fsv.cvut.cz, eliasova@fsv.cvut.cz

When looking at the current architecture, there are a lot of examples of supporting glass structures, such as, beams, ribs stairs, railings or glass columns. These elements are designed to transfer dead and imposed load as well as the wind and snow load. The design of these structures requires sufficient knowledge of structural behaviour.
Load bearing glass columns are relatively rare despite the compressive strength of glass being significantly higher than its tensile strength. This opens up new applications of glass panels in structures such as transparent columns loaded by normal force. The place of transmission from slabs to the columns is the most important detail for these load bearing glass structures. Any local irregularities may cause stress concentration or additional bending moments and thereby cause early failure of the element. The design concept should consider the possibility of an alternative load transfer from horizontal structures to other structures to prevent progressive collapse based on the breakage of one glass pillar.
Glass columns subjected to the compression have sufficient strength, stiffness and residual load bearing capacity to be able to transfer loads and to be safe even after the first breakage. The design methods for other materials cannot be taken into account and used for glass elements without any modifications because it is necessary to consider the effect of manufacturing tolerances (glass thickness), initial deformation, PVB layers for laminated glass, glass elastic behaviour without hardening effect, the effect of load duration, damage of the glass surface and the impact strength of glass, which is not necessary for other materials (e.g. steel).
This paper is focused on experimental research of the hollow glass column subjected to compression. The column has a squarecross-section and is composed of four float glass panes glued together with polymer adhesive. The performed experiments proved the structural behaviour of the element and verified the numerical and analytical models developed by the first author.

ACKNOWLEDGEMENT
This paper has been written with support by the GAČR 14-17950S project.

THE NEAR REAL TIME IONOSPHERIC MODEL OF LATVIA

MARIS KALINKA[1, 2], JANIS ZVIRGZDS[1, 2], DIDZIS DOBELIS[2], ERNSTS LAZDANS[2], MARTINS REINIKS[2],

[1] Institute of Geodesy and Geoinformatics, University of Latvia, Riga, Latvia

[2] Department of Geomatics, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia

E-mail: maris.kalinka@rtu.lv

There is a necessity for a highly accurate ionosphere model to enable fast and reliable coordinate determination with GNSS in real time. It is partially ionized atmospheric region ranging up to 1000 km height affected by spatial variations, space weather, seasonal and solar cycle dependence. New approach and algorithms of modelling techniques were used to seek for better solution in the territory of Latvia. The ionospheric TEC value differs in Western Latvia from that of the Eastern part of Latvia. Actual ionospheric map should be calculated and delivered to surveyors near real time. Results of simulation close to real time are being prepared for publication in the WEB and for sending to mobile devices in a field to help surveyors see conditions and make geodetic measurements with higher accuracy.

THE METHOD OF ICE FIELD STRENGTH REDUCTION IN PORT SABETTA ON YAMAL PENINSULA

IVAN KAZUNIN[1], MARK KREYNUK[2]
[1]*St. Petersburg State Polytechnical University, St. Petersburg, Russia,*
[2]*"Morstroytechnology" Ltd, St. Petersburg, Russia,*
E-mail: ivk07@mail.ru

On the Yamal peninsula the construction of sea-port Sabetta has begun. It is designed for the transloading of hydrocarbon crude from Yamal gas condensate field to provide the transfer of natural gas and oil by sea transport to other countries. The Arctic area conditions where port Sabetta is located cause difficulties for navigation due to the problem of icing [1].

One of the associated problems in port construction is providing optimal conditions for ship navigation and berthing. Nowadays there are two ways of solving this problem: mechanical destruction of the ice sheet (by means of ice-breakers), heat exposure (using bubbler devices in combination with warm water) [2], [3].

The paper gives the analysis of ice formation taking into account peculiar features of port Sabetta and presents a new method of ice sheet destruction, which suggests the decreasing of heat conductivity of upper water layers. To achieve this it is possible to use a "blanket" made of separate polyethylene cylinders closely located to each other covering the harbour area and to allow their shift during ship passage. In addition, these cylinders will make pores in ice field to reduce its strength allowing the ship to break ice easily.

Using the "blanket" as an isolation covering to protect the harbour area from low temperatures will allow to significantly save energy and consequently to cut the costs of pilotage in northern conditions.

[1] Alhimenko, A.I., et al. Gidrotehnicheskiye soorugeniya morskih portov. LAN, 2014, p. 427
[2] Bogorodskiy V.V., Gavrilo V.P., Nedoshivin O.A., Razrushenie lda. Metodi, tehnicheskie sredstva. Leningrad: Gidrometeoizdat, 1983, p. 232
[3] Kozlov D.V., Led presnovodnih vodoemov I vodotocov. M.: MGUP, 2000, p. 263

NUMERICAL METHOD TO FIND FRICTION COEFFICIENT OF STEEL FIBRE IN CONCRETE

AMJAD KHABAZ[1]
[1]*Majmaah University, Riyadh, Kingdom of Saudi Arabia*
E-mail: a.khabaz@mu.edu.sa

The friction forces between steel fibre and the concrete in the case of Straight Steel Fibre Reinforced Concrete (SSFRC) are considered as the main factor to generate the bonding between these two building construction materials. Three types of steel fibre are usually used in Fibre Reinforced Concrete (FRC) Straight, Dramix and Tabix. In the case of using straight steel fibre as reinforcement material to improve the resistance capacity of plain concrete under axial or flexural tension forces to obtain Steel Fibre Reinforced Concrete (SFRC), bonding forces at the interface between the steel fibre and the concrete matrix must be satisfactory. The bonding forces between these two materials are generated due to the friction forces at the interface; therefore the final evaluation of the bonding forces is related with the real value of the friction forces, consequently the friction coefficient value between the straight steel fibre and the concrete is important to evaluate and calculate the real value of the friction forces. This paper is devoted to introducing an experimental study about the mechanism of removing straight steel fibre from concrete matrix which is named as (pull-out test) as well as programming simulations prepared to represent this mechanism too, these laboratory experiment and computer simulations have been used in the determination process of friction coefficient value between the straight steel fibre and the concrete $Fri_{(SSF.C)}$.

PERFORMANCE OF PLAIN AND BLENDED CEMENTS EXPOSED TO MARINE ENVIRONMENT

ASAD-UR-REHMAN KHAN[1]
[1]Department of Civil Engineering, NED University of Engineering and Technology, Karachi, Pakistan
E-mail: asadkhan@neduet.edu.pk

Cement based materials when exposed to aggressive environments, like the one near the shore, deteriorate due to ingress of moisture and other harmful chemicals. This study presents the performance of cements blended with pozolanic materials in extreme marine environment. An experimental study was conducted for this purpose in which mortar cubes of different cements including OPC, SRC, Slag cement and Blended OPC and SRC cements (varying percentages of 30%. Fly Ash and 15% Silica Fume) were cast. Compressive strength of each was measured at 28 days initially. Samples were then immersed in sea water for 180 days to observe the impact of marine environment. The testing was done to determine the strength of the immersed samples after 90 days and 180 days. OPC samples showed the highest compressive strength after 28 days of curing but when exposed to extreme environment, strength degradation was observed and reduction was more as compared to OPC blended cements and slag cement. Maximum strength reduction was observed in SR blended cements. In addition to mortar cubes concrete cylinders were also prepared from all the cement types mentioned above to compare the pH resistance of each. All the cylinders were first cured in normal water for 28 days and pH values were noted after 28 days of curing. The samples were then exposed to marine environment for 28 days and pH values noted after 28 days of exposure. The least change in pH was observed in samples cast with OPC blended with fly ash while maximum change in pH was found in the samples cast with OPC blended with silica fume. The results of OPC, Slag cement and SR blended cement samples were not found significantly different in terms of change in pH. Overall performance of samples cast with fly ash blended OPC cement was found to be the best.

DIMENSIONAL INTERVAL AND CRITICAL SIZES OF NON-LEGAND NANO- AND MICRO- PARTICLES

ANATOLI KHARKHARDIN[1], VALERIA STROKOVA[1], NATALIA KOZHUKHOVA[1], VICTORIA NELUBOVA[1]

[1]Belgorod State Technological University named after V.G. Shoukhov, Belgorod, Russia
E-mail: s-nsm@mail.ru, vvstrokova@gmail.com, kozhuhovanata@yandex.ru, nelubova@list.ru

It is known that packing density of spherical particles (steel and plumbeous balls) in spherical bottles of 0.64, at the same time, theoretical packing density equals 0.64976. The packing density of particles depends on several factors. More influential of them is the size factor, which is considered as a ratio of container size to particle size filling in the container, that influences the packing density of particles in surfacial layers of bulk dispersed (grained) material that is in near-wall layers of the container.

From the analysis of size distribution of pores in monodispersed material while filling them with grains of appropriate diameter, the diameter of the grains providing the most compacted filling of volume was determined. This allowed developing a formula to calculate critical sizes of tridimensional formations under the critical condition of substance and dimensional interval of particles in dispersed material, where changing in properties of nano- and microparticles and critical condition of dispersed layer occur.

The principles of close packing of atoms and Coulombic uniformity of their distribution around the central atom, forming in such a way icosahedral or closest packing in small polyhedrons are considered in this work. Critical packing densities of atoms of elementary substances depending on their packing density in a crystal phase were calculated.

Herein was determined the first critical packing density of particles for dispersed materials ($\eta c1 \leq 0.2549$) during their milling with dry mechanical way, which is characterized by microparticles aggregation.

The second critical packing density ($\eta c2 \leq 0.1$) when unusual changing in properties occur was calculated during wet milling of mineral dispersed materials up to obtaining nano- and microsized particles.

Based on this data the formulas for calculating of critical sizes of nano- and mocroparticles as well as discreteness levels of a substance determining canonical sizes of the particles were developed. The work has a continuation in argumentation of wave-corpuscle duality of discrete systems.

CHEMICAL CHARACTERIZATION OF LIME-BASED BINDERS IN HISTORIC BUILDINGS OF LATVIA

INTA KIRILOVICA[1], LIENE GULBE[1], INTA VITINA[1], SILVIJA IGAUNE-BLUMBERGA[1]
[1]Institute of Silicate Materials, Riga Technical University, Riga, Latvia
E-mail: inta.kirilovica@rtu.lv

The aim of this research was the investigation of the chemical composition of stone materials of several local historic buildings with the purpose of elaboration of restoration strategy, including the choice of restoration materials. Most of the examined mortars are lime-based hydraulic mortars, characteristic to the architecture of the 19th/20th century. Pure aerial lime binders show reduced compatibility with historic materials, that is why lime binders with pozzolan additive (cement) are an appropriate choice for restoration. In order to examine the changes of hydraulicity (i.e., the property of binders to harden when exposed to water) of perspective restoration binders, series of blended lime-cement mixtures were synthesized with a growing content of cement (up to 10 % by weight). A significant relationship between the cement content and hydraulic properties has been shown.

APPLICATION OF GRANULATED BLAST FURNACE SLAG IN CEMENT COMPOSITES EXPOSED TO BIOGENIC ACID ATTACK

MARTINA KOVALCIKOVA[1], ADRIANA ESTOKOVA[1], ALENA LUPTAKOVA[2]
[1] Institute of Environmental Engineering, Faculty of Civil Engineering,
Technical University of Kosice, Kosice, Slovakia
[2]Slovak Academy of Sciences, Institute of Geotechnics, Kosice, Slovak Republic
E-mail: martina.kovalcikova@tuke.sk, adriana.estokova@tuke.sk, luptakal@saske.sk

The deterioration of cement-based materials used for the civil infrastructure has led to the realization that cement-based materials, such as concrete, must be improved in terms of their properties and durability. Leaching of calcium ions increases the porosity of cement-based materials consequently resulting in a negative effect on durability since it provides an entry for aggressive harmful ions causing corrosion of concrete. The use supplementary cementing composite materials have been reported to improve the resistance of concrete to deterioration by aggressive chemicals.
The paper is focused on the investigation of the influence of biogenic acid attack on the cement composites affected with bacteria Acidithiobacillus thiooxidans. The concrete specimens with 65% wt. addition of antimicrobial activated granulated blast furnace slag as durability increasing factor as well as without any addition were studied. The experiments proceeded during 150 days under model laboratory conditions. The pH values and chemical composition of leachates were measured after each 30-day cycle. The calcium and silicon contents in leachates were evaluated using X–ray fluorescence method (XRF).

INFLUENCE OF MECHANO- AND CHEMOACTIVATION PROCESSES ON OPERATIONAL CHARACTERISTICS OF GEOPOLYMER BINDERS

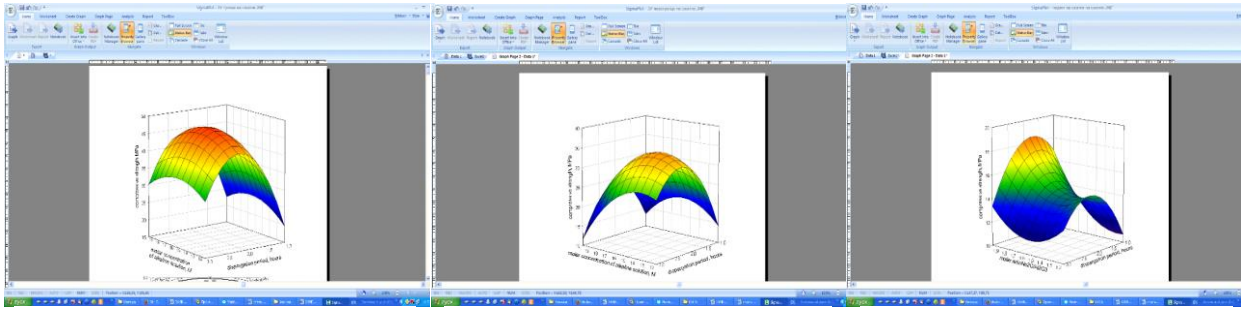
NATALIA KOZHUKHOVA[1], IGOR ZHERNOVSKY[1], VALERYA STROKOVA[1], VICTORIA KALASHNIKOVA[1]
[1]Belgorod State Technological University named after V.G. Shoukhov, Belgorod, Russia
E-mail: kozhuhovanata@yandex.ru, zhernovsky.igor@mail.ru, vvstrokova@gmail.com, nikasz@mail.ru

It should be pointed out that among the existent representatives of resource and energy efficient binders geopolymer binders (or geopolymers) are produced by alkaline activation of natural and industrial raw components with aluminosilicate composition. However, efficiency of alkaline activation of given raw materials and subsequent formation of physical, mechanical and other operational properties of obtained composites depends on a set of factors, including dispersity of used aluminosilicates.

According to the contemporary idea of reaction activity of mineral raw materials with increasing in dispersity of aluminosilicate component due to mechanical activation, the tendency of increasing in amorphous phase concentration is observed. It is important to know that the amorphous substance is a more active component in geopolymerization process, which favourably effects operational properties of the final product.

In order to confirm a given hypothesis of reaction activity of raw materials some of natural and industrial alumosilicate components were studied. Perlite from Mukhor-Talinsk deposit was studies as a natural aluminosilicate material. Fly-ashes of Novotroitsk and Troitsk power stations were used as industrial aluminosilicates.

In the frame of the work the planning matrix for the experiment "type of raw materials vs. activation method" was developed for different geopolymer binder mixes (Fig.1).



a b c

Fig. 1. Dependence of compressive strength on dispersion time and molar concentration of alkaline solution based on a) Troitsk fly ash; b) Novotroitsk fly ash; c) from Mukhor-Talinsk perlite

From the obtained dependences, the parameters for optimal binder mixes were determined where, dispersion time was 2 hours; molar concentration of alkaline solution was 16M for fly-ashes and 13M for perlite. With these parameters the highest compression strength for the studied binders can be achieved.

A regularity of behaviour of properties of geopolymer binder depending on chemical and mechanical activation of aluminosilicate raw materials was found. A mathematical relation strength performance of geopolymer binders vs. activation parameters of aluminosilicate raw materials was developed.

ACKNOWLEDGEMENT

The research work was accomplished with the financial support from the Ministry of Education and Science of Russian Federation in the framework of State Assignment with using of the equipment based on the High-Technology Centre, BSTU named after V.G. Shoukhov.

[1] Fomina, E.V., Strokova, V.V., Kozukhova, N.I., Application of natural aluminosilicates in autoclave cellular concrete, World Applied Sciences Journal, 2013, № 25 (1), pp. 347–354
[2] Zhernovsky I.V., Osadchaya M.S., Cherevatova A.V., Strokova V.V., Aluminosilicate nanostructured binder based on granite raw materials, Construction Materials Journal,2014, № 1–2, pp. 38–41. 2014.
[3] Alfimova N.I., Shapovalov N.A., Abrosimova O.S., Operational characteristics of lime bricks made of industrial aluminosilicate raw materials, Bulletin of BSTU named after V.G. Shoukhov, 2013, № 3, pp. 11–14
[4] Davidovits, J., Geopolymers and Geopolymeric Materials, Journal of Thermal Analysis,1989, Vol. 35, № 2, pp. 429–441
[5] Kozhukhova N.I., Zhernovsky I.V., Strokova V.V., Evaluation of biopositivity of geopolymer binders based on low-calcium fly-ash, Construction Materials Journal, 2012, № 9, pp. 84–85
[6] Kalashnikov V.I., Khvastunov N.I., Maktridin A.A., Kartashov V.L., New geopolymer materials based on rocks and modified with small amount of slakes and alkalies. Construction Materials Journal, 2006, № 6, pp. 93–95
[7] Fomina E.V., Kozhukhova M.I., Kozhukhova N.I., Assessment of efficiency in application of aluminosilicates as a component of composite binders, Bulletin of BSTU named after V.G. Shoukhov. 2013, № 5, pp. 31–35
[8] Kozhukhova N.I., Zhernovsky I.V., Sobolev K.G., The effect of Silica Polymerization in Fly Ash on the Strength of Geopolymer, XXII International Material Research Congress MRS, Cancun, 2013

POROUS CERAMIC MATERIAL ELABORATION UTILISING SEWAGE SLUDGE

DACE KRIVANE[1], KASPARS BONDARS[1], JEKATERINA SAVIKINA[1], ALEKSANDRS KORJAKINS[2],
[1] Technical University of Riga, Department of Civil Engineering, Riga, Latvia
[2]Technical University of Riga, Department of Building Materials and products, Riga, Latvia
E-mail: kaspars.bondars@rtu.lv, aleksandrs.korjakins@rtu.lv

Producers of building materials are urged to think about the usage of more effective resources, which are available and necessary for production, as well as to find possibilities and solutions for the decrease of primary energy resource depletion by producing ecological materials. Clay is one of local raw materials that can provide successful solution of growing problems in the production of ceramic materials and their products. For the production of porous ceramics there are various types of porous creating materials, such as waste obtained from agricultural or metal industries. Sewage sludge has been applied as porous creating row material for producing light ceramics [1]. Devonian clay from the Latvian clay deposit Ane and Liepa has been used as a matrix and saw dust as burnable fillers. The mentioned clay has high content of carbonate compounds that improve the insulation properties of ready product after burning. Sewage sludge from Jelgava municipality waste water treatment plant was used after water content reduction by centrifugal and coagulant processing and one year anaerobic storage. Additional dewatering was performed by freezing method [2]. To reduce pathogenic activity of mixtures CaO+MgO component was added in dosages 5, 10 and 20% from sewage sludge dry weight. CaO+MgO dosage effect on elasticity and strength parameters of ceramics was defined. Pathogenic treatment efficiency test was performed to evaluate PH rise efficiency [3]. Evaluation of sewage sludge utilization possibilities in producing porous building ceramics partial replacement of saw dust with sewage sludge was performed. During the investigation four compositions were elaborated. One control composition with saw dust as burnable component in building ceramic block traditional technology and three compositions of mixtures were performed with replacement of 15%, 30% and 45% of saw dust by sewage sludge. Shrinkage average value of specimens was 6% after drying and burning. Porosity increased by 5–15% for the specimens with sewage sludge in comparison with control specimen. The replacement of the composition of 20% saw dust with the sewage sludge showed similar strengths (12.7MPa) and deformability (152 MPa) parameters as the existing porous ceramic. Applying CaO+MgO treated waste and replacing by this one 30% of saw dust in the production of porous ceramic blocks allows utilization of 10% of annual sewage sludge amount produce in Latvia.

ACKNOWLEDGEMENT
The research was financially supported by the Latvian Science Council project Nr. 12.412 „Development of sustainable effective lightweight construction materials based on industrial waste and local resources”.

[1] Rozenštrauha I., Krāģe L., Notekūdeņu dūņas saturoši poraini kompozītmateriāli, Rīgas Tehniskā universitāte, Rīga, 2012
[2] Vesilind P. A., Martel C. J., Freezing of water and wastewater sludges., Environmental Engineering, 1990, Vol. 116, pp. 854-862
[3] Cusido J.A., Cremades L.V., Gonzalez M., Gaseous emissions from ceramics manufactured with urban sewage sludge during firing processes, Elesevier Science Ltd., Barcelona, Spain, 2002

THE INVESTIGATION OF PROPERTIES OF INSULATING REFRACTORY CONCRETE WITH PORTLAND CEMENT BINDER

ANDRIUS KUDZMA[1], VALENTIN ANTONOVIC[1], RIMVYDAS STONYS[1], JELENA SKAMAT[1]

[1]Vilnius Gediminas Technical University, Vilnius, Lithuania,
E-mail: andrius.kudzma@vgtu.lt

The companies which produce concrete for high temperatures (> 1100 ºC) generally offer compositions with calcium aluminate cement (CAC). Refractory concrete with Portland cement binder practically is not made. Nevertheless the development of new compositions of refractory concrete with Portland cement have not lost certain value since the cost of it is 6–10 times lower in comparison with the cost of CAC.

In this work the impact of high temperatures on the properties of Portland cement based insulating refractory concrete including microsilica additives, expanded clay and vermiculite fillers was investigated. It was established that microsilica intensify the interaction between disperse components of concrete and therefore increases strength values, density and thermal shock resistance.

BEHAVIOUR OF MECHANICALLY LAMINATED CLT MEMBERS

PETR KUKLIK[1], LUKAS VELEBIL[1],
[1]Czech Technical University in Prague – University Centre of Energy Efficient Buildings, Prague, Czech Republic
E-mail: kuklik@fsv.cvut.cz,lukas.velebil@fsv.cvut.cz,

The cross laminated timber (CLT) is one of the structural systems that can be used for buildings. It completes structural systems like the light and heavy timber frame formed by mechanically connected rod elements. It is becoming more and more favourite because of its properties.
The cross laminated timber consists of uneven number of plank layers of plate element. They are oriented at a 90° angle to each other. The most common method of joining the layers is an allover gluing. Recently, there is a requirement of development of an alternative process based on the mechanical joining of layers. This way of connecting will be more economical and accessible for many producers.
As a result of the perpendicular layer orientation and their connection with screws, there is a different behaviour of strength and stiffness properties compared with current design approaches to determine the carrying capacity of the wall.
This paper is focused on the experimental research of wall panels made from mechanically joined cross laminated timber subjected to the shear stress in the plane. The shear resistance of mechanically joined CLT is ensured by layer connection with screws. The number and parameter of screws significantly influences the final shear resistance of the wall. The performed experiments examined the torsional stiffness and the slip modulus of individual crossing areas for two orthogonally connected boards. The specimens are placed to the test setup. The torsional rotation and slip are measured. These experiments are used to validate the numerical model created by the author.

PREDICTION OF MOISTURE DISTRIBUTION IN CLOSED RIBBED PANEL FOR ROOF

AIVA KUKULE[1], KARLIS ROCENS[1]
[1]*Institute of Structural Engineering and Reconstruction, Riga Technical University, Riga, Latvia*
E-mail: aiva.kukule@rtu.lv, rocensk@latnet.lv

Nowadays one of the possibilities to improve energy efficiency is the use of building elements with low air permeability, for example, sandwich panels. However, these panels used as part of combined roof structure may have insufficient load-bearing capacity required for covering the span. The load-bearing capacity can be increased by placing ribs into the insulation layer of the panel. One of the most economic solutions is the use of wood ribs impregnated with antiseptics.
Durability of the wood ribs can be adversely affected by the condensate that may appear due to high temperature difference of the panel surfaces. Currently methodology of ISO 13788:2012 is widely used to verify hygrothermal performance of building components. Whereas this method assumes that moisture flow is passing through the structure, this calculation model does not reflect the actual situation in a closed structure. Therefore, in order to predict the distribution of moisture in such structure with surfaces exposed to different temperatures and to assess the hazards of moisture distribution in the wood ribs, it is necessary to develop an appropriate method of calculation.
As the panel is a closed construction, ambient humidity does not affect vapour pressure distribution in the inner layers of structure. Thus the amount of moisture that can concentrate in the part of construction is limited. The temperature gradient promotes moisture flow in the direction from the warmest layers to the coldest. This results in moisture gradient that induces reversal moisture flow. Therefore in contrast to the data obtained according to ISO 13788:2012 methodology condensation may not be detected.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

SLENDER COMPRESSED PLATE IN COMPONENT BASED FINITE ELEMENT MODEL

MARTA KUREJKOVA[1], FRANTISEK WALD[1], JAROMIR KABELAC[2], LUBOMIR SABATKA[2]

[1] Department of Steel and Timber Structures, Faculty of Civil Engineering, Czech Technical University in Prague, Prague, Czech Republic

[2]IDEA RS, U vodarby 2a, 616 00 Brno, Czech Republic

E-mail: marta.kurejkova@fsv.cvut.cz, wald@fsv.cvut.cz, kabelac@idea-rs.com, sabatka@idea-rs.com

For the design of joints in steel structures it is common to use the component method (CM) which is described in standard EN 1993-1-8. However, this method can be used only for the joints with specific geometry and specific loading. This method gives reliable results for common joints. Connections for which due to the complicated geometry and lack of knowledge about the components this method cannot be used are analysed by finite element method FEM. The finite element method can be used for the design of the joints with any geometry and any loading. However many works have been published on the modelling of joints using finite element method. This research is focused on creating the most accurate numerical models for practical design. The research finite element model (RFEM) which is based on materially and geometrically nonlinear analysis with imperfections (GMNIA) is not suitable for the design of common joints, especially because of time-consuming modelling, difficulties with entering of imperfections and the definition of the ultimate limit state. Design finite element model (DFEM) and Component based finite element model (CBFEM) are getting common for design of joints as an alternative solution. The design model with material nonlinear analysis without imperfections with the assessment of component of bolts, welds and slender compressed plates becomes an alternative approach for the design of joints. In the design of stiffened joints in steel structures local buckling of slender compressed plates, shear buckling of slender web panels and local buckling of compressed plate between the bolts are taken into account. The method is evaluated during performed experiments of triangular stiffeners for better understanding of the behaviour. The data from analytical models and experiments are used to verify and valorise the recommended advanced design model. The paper provides guidance, recommendations and limits of application for efficient modelling of stiffeners and correct interpretation of the results of the numerical design model.

PLASTOMETRY FOR THE SELF-COMPACTING CONCRETE MIXES

VIDEVUDS ARIJS LAPSA[1], ANDREJS KRASNIKOVS[1], VITALIJS LUSIS[1], ARTURS LUKASENOKS[1,2]

[1]Concrete Mechanics Laboratory, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
[2]Intitute of Mechanics, RTU Concrete Mechanics Laboratory, Riga Technical University, Riga, Latvia
E-mail: andrejs.krasnikovs@rtu.lv

Traditionally, for prompt rheological consistence determination of self-compacting concrete mixes the Abram's cone, the Vebe's device, the U-box siphon as well as L-box or funnel tests are used. At the same time is worth mentioning that these field methods are determining some indirect mechanical characteristics of such very complicated paste-like material as concrete mix. These are the slump of the conical sample or the spread (diameter) of the diffluent concrete pancake, degree of the self-leveling in siphon, the time of the flow-out through the funnel or the Vebe time. All these parameters cannot be observed as direct mechanical parameters may be included into rheological equations describing fresh concrete as a non-linear liquid.

The main rheological parameter that differentiates the usual concrete mixes from the self-compacting mixes is the yield stress. Self-compacting concrete mixes are behaving liquid-like and in consistency equation they are characterized by yield stress.

For the yield stress measurement conical plastometer can be used [1]. Previously, this device and measuring methods were used for determining forsmall of paste-like materials (pastes and concretes). It can be used for liquid like materials, too. At the same time, for field tests, where the concrete volumes are greater and the observed self-compacting mixes can show liquid- like rheological behaviour, the well known method of calculation is not precise enough, because the conical indentor is small (15 cm) and the buoyancy force of the liquid mix also is not taken into consideration.

Taking into account the above mentioned obstacles a conical plastometer having higher precision and less sensitivity to the inaccuracy during tests in a field condition was elaborated in the Concrete Mechanics Laboratory of RTU. A new method was also elaborated for the yield stress calculation, taking into account the buoyancy of the liquid (or paste like) concrete mix [2]:

where $F\Sigma$ is the total axial force acting on the indentor;
$F\mathrm{Arch}$ is the buoyancy force;
h is the depth of the immersion of the indentor into concrete mix;
k is the coefficient depending of the angle α of the pointed end of the indentor;
ρc is the density of the concrete mix.

In such a way these rheological tests of the concrete mix by use of the proposed plastometer and the said methodic could give an answer to three questions:

Is the real mix self-compatible or not?

If yes, we can calculate the real value of the yield stress of the mix.

We can follow these measurements for further determination of the time of appearance and increase of the mix plasticity and for further investigation all kinetics of the early processes of the setting and formation of the new microstructure in the concrete mix, too.

[1] Valjamae G.H., Gordon V.I., etc., Tallinn Technical University, Conical plastometer. Patent of the former USSR Nr,748190, publ. June 15, 1980

[2] Lapsa V.A. , Krasnikovs A., Lusis V., Rheological testing process for paste-like materials, Latvian patent Nr.14530, publ. June 20, 2012

EVALUATION OF TIME OF SCOUR AT GUIDE BANKS IN PLAIN RIVERS

OSKARS LAUVA[1], GUNTIS KLIVE[1], BORISS GJUNSBURGS[1]
[1]Water Engineering and Technology Department, Riga Technical University, Riga, Latvia
E-mail: oskars.lauva@rtu.lv

One of the reasons of the bridge crossings failure or damage in flow is the unpredicted depth of scour near foundations. The aim of this study is to find the equilibrium time near elliptical guide banks. The literature analysis shows that there are no methods or formulas to calculate equilibrium time of scour near elliptical guide banks. In the formulas used in calculating equilibrium time at piers or abutments different parameters are not taken into consideration. These parameters include: contraction rate of the flow, Froude number, bed layering, sediment movement parameters, local flow modification, ratio relative local and critical velocities, and relative depth. The differential equation of the bed sediment movement in clear water was used and method for computing equilibrium time of scour near elliptical guide banks was elaborated. New hydraulic threshold criterion is proposed for the calculation of equilibrium time of scour. Computer modelling results were compared with equilibrium time of scour which were calculated by the presented method and they were in good agreement.

ACCURACY OF ORTHOMOSAIC GENERATED BY DIFFERENT METHODS IN EXAMPLE OF UAV PLATFORM MUST Q

NATALJA LIBA[1], JAANO BERG-JURGENS[1]
[1]Institute of Forestry and Rural Engineering, Estonian University of Land Science, Tartu, Estonia
E-mail: natalja.liba@emu.ee

The development of photogrammetry has reached a new level due to the use of unmanned aerial vehicles (UAV). Compared to life-size airplanes low-cost UAVs are easier to handle and because of that many companies are able to procure an aerial vehicle to perform photogrammetric work. In addition software opportunities have changed, which means that software, specially designed for UAV image correlation, makes UAV project preparation and processing much easier to handle. Worldwide the UAVs are used in comprehensive ways starting with different purposes in military, pack delivery, estimation of forest health and ending with wide use in entertainment business. In Estonia the main areas of use of UAVs are monitoring overhead power lines for energy companies, fields in agriculture and estimating the use of stockpile in mining. This research was carried out as UAVs have become common but the accuracy of the work performed has not yet been studied. So there is a situation where there are a number of service providers but the estimation of quality of projects and orthomosaics is unkonown. The project was carried out to satisfy the demand of City of Tartu for the future road construction. It was accomplished by ELI OÜ in collaboration with Estonian Mapping Center and it was used as UAV platform MUST Q. In this research automation of UAV image processing and reduction of time spent on the use of ground control points (GCP) is studied. For that 3 projects were developed with programs Pix4D and Photomod 5.1. The first one was processed automatically without GCP, the second one – automatically with GCP, but the third project was processed fully manually.
The result of the project is orthomosaic with GSD 12.5 cm. The most accurate project turned out to be the one with manual image processing, but the most important is that accuracy of automatic project with the GCPs turned out to remain in the error limit and the accuracy of the project without GCP exceeded the limit.

STRUCTURAL ENGINEERING MANAGERS – INNOVATION CHALLENGES FOR THEIR SKILLS

DANA LINKESCHOVA[1], ALENA TICHA[1]
[1] *Institute of Structural Economics and Management, Faculty of Civil Engineering, Brno University of Technology, Veveří 331/95, Brno, 602 00 Czech Republic*
E-mail: linkeschova.d@fce.vutbr.cz

The profession of a structural engineer is highly responsible because the consequences of a structural engineer's errors result not only in economic damage of property and often irreversible damage of the environment, but also can lead to direct loss of lives. In the current turbulent, dynamically developing society it is not possible that the managerial methods of structural engineers stagnate at the level of the last century.
This paper deals with challenges which the present century brings to structural engineers and managers. It compares the results of research regarding the current state of managerial skills of structural engineers in Czech building companies to the skills defined for managers of the 21st century according to the global research programme ITL Research and according to the Vision for the Future of Structural Engineering, drawn up by Structural Engineering Institute – SEI ASCE.

CALCULATION OF PERFORATED METALLIC MATERIAL ELEMENT USING FINITE ELEMENT ANALYSIS

MIHAILS LISICINS[1], VJACESLAVS LAPKOVSKIS[1]
[1] *Laboratory of Powder Materials, Riga Technical University, Riga, Latvia*
E-mail: mihails.lisicins@rtu.lv

Finite element analysis (FEA) software such as Ansys® or Solidworks® can be effectively used for prediction and determination of physico-mechanical characteristics of material with variable cross-sectional area. The mathematical model obtained by means of FEA numerical analysis can also be applied for further forecasting of structural design and performance, which significantly facilitates the selection of materials, reducing the labour intensive experimental activities, allowing a great prospects for design optimizations.
In the presented paper an experimentally determined tensile strength for perforated steel tape specimen is compared to theoretical calculations and developed FEA mathematical model. The most important issue of FEA modelling is a proper choice of the finite element system. In the current case two finite element types SHELL and SOLID were chosen. Recommendations for type of FEA element which gives more accurate simulation results are presented.

SHEAR ADHESIVE CONNECTIONS FOR GLASS STRUCTURES

KLARA MACHALICKA[1], IVA HORCICKOVA[2], MARTINA ELIASOVA[2]
[1] *University Centre for Energy Efficient Buildings, Czech Technical University in Prague, Czech Republic*
[2] *Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic*
E-mail: klara.machalicka@fsv.cvut.cz

Unique aesthetical properties of glass – not only transparency but also smooth, glossy and primarily reflective surface – give this material special importance for contemporary architecture. Every structural application of glass needs to solve connections between the glass pane and another part from different material or between two glass elements. Moreover, there are many types of hybrid structures that combine glass and metals [1], timber [2], glass fibres (GFRP) or carbon fibres (CFRP) to improve loadbearing capacity of glass, to achieve safe failure behaviour and high degree of transparency at the same time. The connection of brittle glass and reinforcing material is an essential part of these structures, where composite action between the two parts is beneficially ensured by glued joint.

The reliability of the bond is influenced by many factors, starting with the selection of the appropriate adhesive for a particular joint. The shear strength of connection may be also influenced by adhesion of glue to the substrate, cohesion of glue, joint dimensions and geometry, environmental factors (relative humidity, UV radiation, temperature), thermal expansion coefficients of joining elements, duration of load, rate of load application, surface preparation and surface roughness, workmanship and curing. Missing data about the behaviour of adhesive in the joint and missing standards or guidelines are some of the problems which have to be solved before the correct and safe design of the adhesive connection.

The current paper deals with the experimental analysis focused on the determination of mechanical characteristics of adhesives applied in planar connections under shear loading. Since wide range of adhesives is produced, six glues with different properties (polyurethanes, acrylates and UV-curing metacrylates) were chosen for the research. The research also compares two similar adhesives (the older type and the new one) produced by the same manufacturer in the case of glass-to-steel connection. Specimens of all adhesives were prepared for various substrates and their surface treatment (smooth glass, roughened glass, steel, stainless steel and aluminium). As joint dimensions and thickness play the crucial role, adhesives were tested in several thickness according to the type of adhesive. Firstly, small-scale test specimens were carried out. In the following stage the most appropriate transparent adhesive was selected for full-scale specimens of glass beam to evaluate the influence of the size-effect.

ACKNOWLEDGEMENT
This paper has been written with support by the European Union, OP RDI project No. CZ.1.05/2.1.00/03.0091 - University Centre for Energy Efficient Buildings and by the GAČR 14 17950S project.

[1] Netusil M., Eliasova M., Structural Design of Composite Steel-Glass Elements, proceeding of Challenging Glass 3 – Conference on Architectural and Structural Applications of Glass, IOS Press, 2012
[2] Blyberg L., Serrano E., Timber/Glass adhesively bonded I-beams, proceeding of Glass Performance Days, 2011, pp. 507-512

RICE HUSK ASH AND DIATOMACEOUS SPENT EARTH AS A SILICA SOURCE TO FABRICATE A GEOPOLYMER BINDER BASED ON FLY ASH AND METAKAOLIN

JOHANNA M. MEJIA[1], RUBY MEJIA DE GUTIERREZ[1]
[1]Materials Engineering School, Universidad del Valle, Cali, Colombia
E-mail: johanna.mejia@correounivalle.edu.co

Colombian industrial and agro-industrial by-products were valued by using alkaline activation process to manufacture a cementitious material. The aim of this research is to propose the use of two by-products as a solid silica source instead of the silica from the commercial sodium silicate (SS) which often is used as alkaline solution. This approach will introduce an eco-material that could be used in the civil construction field, this will provide a beneficial effect on the environment.

The first silica source is a rice husk ash (RHA) obtained directly from a Colombian rice milling factory which they use as a bio-combustion material in a combustor, and the second one is a diatomaceous spent earth (DSE) used in a Colombian brewing Company as a filter during the beer filtering stage. Both by-products were subjected to different conditioning processes such as milling and thermal treatment, in order to reduce particle size of the rice husk ash and remove organic traces from the diatomaceous spent earth respectively.

Three geopolymer systems were produced based on the blend of Colombian fly ash (FA) and commercial metakaolin (MK), as alkaline solutions were used a mix of the different silica source with sodium hydroxide. FA/MK-SS, FA/MK-FA, and FA/MK-DSE had a FA/MK proportion of 70/30 and a SiO2/Al2O3 and Na2O/SiO2 molar ratio values of 4.4 and 0.2 respectively, those ratios were kept constant during the activation process. Mechanical and micro-structural analysis were conducted on the three systems, compressive strength was assessed on three ages 28, 180 and 360 days and raw materials and hydrated products were characterized by using Fourier transformed Infrarred spectroscopy (FTIR), X-Ray diffraction (XRD) and Scanning electronic microscopy (SEM).

It was found that the mechanical strength does not change with time, it keeps constant from 28 days to 360 days for all the above systems. FA/MK-SS reached the strength of 75 MPa in 360 days, on the other hand at the same age FA/MK-DSE and FA/MK –RN both got values around 38 MPa which is the half of the strength of FA/MK-SS system, however with that value it is feasible to use the binder as a cementitious material for being applied ion the civil construction field. It was also was noticed by XRD and FTIR that the hydrated gel is a typical sodium aluminosilicate hydrate (N-A-S-H), on the other hand it was found on both silica sources that some crystalline compounds remain after the alkali activation process, which make inferring that the amorphous and an amount of the crystalline phases from both RHA and DSE reacts as a part of the hydrated product.

SHRUB DETECTION ON AGRICULTURAL LAND BY USING AIRBORNE LASER SCANNING (ALS) DATA

MERIT MANDEL[1], MAARJA-CHRIS TAMM[1], NATALJA LIBA[1],
ANTS VAIN[1,2], SIIM MAASIKAMAE[1]
[1]Department of Geomatics, Estonian University of Life Sciences, Tartu, Estonia
[2]The Land Board, Tallinn, Estonia
E-mail: merit.mandel@emu.ee

During the last decades the issue of land use change has caught many scientists' interest all over the world and the factors and causes of land use change vary by regions and countries. In order to start the analysis of land use change causes and factors, the land use change must be detected. One option to identify land use change is through land cover change detection. The good indicator of land use change on agricultural land is the appearance of shrubs and brushes. Different remote sensing techniques and data are used to monitor the land cover changes [1–7]: orthophotos, satellite images and airborne laser scanning data and their combinations.

The aim of this paper is to evaluate the suitability of airborne laser scanning (ALS) data for identifying shrubs and bushes on agricultural land in Ahja parish, Estonia by using the data obtained from the Estonian Land Board and the Estonian Agricultural Register and Information Board database (EARIB). The research is based on quantitative methodology and includes two research methods. At first, through the digitalisation process shrubs are visually identified on the orthophotos. Secondly, airborne laser scanning data are processed and normalised canopy height model is constructed. The model is divided into five height categories for analysing purposes. Two different databases are used for the basis of arable land in Ahja parish: Estonian National Topographic Database (ENTD) and from EARIB database.

Therefore data analysis is carried out in three steps: firstly, general analysis of arable land information; secondly, airborne laser scanning data analysis; and thirdly, comparison of normalised canopy height model with digitalised areas from ortophotos. Three different groups of data were analysed from arable land perspective: data of arable land from ENTD and from EARIB. The latter was divided into two: arable land with agricultural support and without agricultural support. The results of ALS detection are showing that shrubs and bushes are covering 9.3% of arable land areas registered in ENTD and 3.2% of EARIB's agricultural land with support and 6.0% of EARIB's agricultural land without support. Based on visual inspection: 10.13%, 3.05% and 6.98%, respectively. The results are revealing that the area of brushwood obtained from the digitalisation process is larger than that obtained obtained from ALS data processing.

In conclusion, the difference is quite small, less than 1% in every case and one of the reasons why the area of brushwood is larger in digitalisation case may be that during the digitalisation process the whole area of shrubs and bushes was digitalised including the space between the shrubs and bushes, but ALS is detecting bushes and trees at their real location and space between them is excluded. ALS data usage in agricultural land cover change detection is a promising method and its advantage is the lower cost of time.

[1] Bujan S., Gonzalez-Ferreiro E., Reyes-Bueno F., Barreiro-Fernandez L., Crecente R., Miranda D., Land use classification from LIDAR data and ortho-images in a rural area - The Photogrammetric Record, 2012, Vol. 27(140), pp. 401–422

[2] Hellesen T., Matikainen L., An Object-Based Approach for Mapping Shrub and Tree Cover on Grassland Habitats by Use of LiDAR and CIR Orthoimages – Remote Sensing, 2013, Vol. 5, pp. 558-583

[3] Lang M., A simple method for mapping woody plant cover in agricultural fields using airborne lidar, Forestry Studies, 2013, Vol. 58, pp. 5–11

[4] Szostak M., Wezyk P., Tomplski P., Aerial Orthophoto and Airborne Laser Scanning as Monitoring Tools for Land Cover Dynamics: A Case Study from the Milicz Forest District (Poland), Pure and Applied Geophysics, 2013, pp. 1-10

[5] Zhang C., Xie Z., Selch D., Fusing lidar and digital aerial photography for object-based Forest mapping in the Florida Everglades, GIScience & Remote Sensing, 2013, Vol. 50, Issue 5, pp. 562-573
[6] Tsui O. W., Coops N. C., Wulder M. A., Marshall P. L., Integrating airborne LiDAR and space-borne radar via multivariate kriging to estimate above-ground biomass, Remote Sensing of Environment2013, Vol. 139, pp. 340–352
[7] Valbuena R., Mauro F., Arjonilla F. J., Manzanera J. A., Comparing airborne laser scanning-imagery fusion methods based on geometric accuracy in forested areas, Remote Sensing of Environment, 2011, Vol. 115, pp. 1942–1954

THERMAL TRANSMITTANCE AND THE EMBODIED ENERGY OF TIMBER FRAME LIGHTWEIGHT WALLS INSULATED WITH STRAW AND REED

MATIS MILJAN[1], JAAN MILJAN[1]
[1] *Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia*
E-mail: matis.miljan@emu.ee

Sustainable energy use has become actual in the whole world [1]–[6]. Energy gives us comfort we are used to. EU regulations determine energy efficiency of the buildings, too. One side of the problem is energy efficiency of houses during exploitation but the other side is primary energy content of used materials and more rational use of resources during the whole life cycle of a building [13]. The mentioned value constitutes about 8–20% of the whole energy content [7]. Calculations of energy efficiency of materials leads us to energy efficiency of insulation materials and to comparison of natural and industrial materials taking into account their thermal conductivity as well as their primary energy content.

Our first aim was to find the smallest primary energy content comparing five mostly used wall structures for small dwelling houses in Estonia. The best was the timber frame wall insulated with glass wool [8].

The second aim was to find out whether the natural insulation materials are competitive with industrial ones considering their thermal conductivity and the primary energy content as well.

Tests have shown that thermal conductivity of natural materials (mainly waste, like reed and straw) is not so good as of the artificial ones [10], [11], [14] but we may compensate this by building thicker walls and using materials with less primary energy content .

The measurements of the test wall insulated with straw bales gave the possibility to design a house using the measured value for designing the wall according to the minimum energy efficiency requirements set in Estonia. The thermal transmittance of outer walls should be $U = 0.12 – 0.22$ W/m^{2}K (for walls) [12]. The house was built in November 2012. Heat flow plate and thermocouples were placed on and inside the wall to measure heat flow and temperature during 500 days beginning from exploitation.

The measured values and calculations performed showed that straw is a considerable insulation. The thermal transmittance of the straw bale wall was in the rate of $U \approx 0.12 – 0.22$ W/m^{2}K.

[1] International Energy Agency, FAQs: Renewable energy, www.iea.org/aboutus/faqs/renweableenergy/, accessed in January 2015
[2] International Energy Agency, www.iea.org/aboutus/faqs/renweableenergy/, Key World: Energy Statistics, accessed in January 2015
[3] Analysis of the Life Cycle Impacts and Potential for Avoided Impacts Associated with Single-Family Homes, www.epa.gov/epawaste/conserve/imr/cdm/pdfs/sfhomes.pdf, assessed in January 2015
[4] Sustainable Building, Design Manual, ICAEN, The Energy and Resources Institute, India, printed by Multiplexus, 2004, Vol. 2, p. 299
[5] Zhu L., Yong G., Soeren L., Hongyan Z., Tsyushi F., Dabo G., Embodied energy in Chinaś Industrial sectors. Energy Policy, 2012, Vol. 49, pp. 751-758
[6] Hammond G.P, Jones C.I., Embodied energy and carbon in construction materials, Proceedings of the Institution of Civil Engineers – Energy, 2008, pp. 87-98
[7] Berge B., Henley F., The Ecology of Building Materials, Architectural Press, 2009, p. 435
[8] Miljan J., Kukka E., Eestis enamkasutatud välispiirete primaarenergia sisaldus (in Estonian), 2009, Vol. 9, pp. 72-75
[9] Miljan M., Miljan J., Pilliroost toodete energiamahukus (in Estonian) Compendium Pilliroog ja selle kasutamise võimalused, 2013, pp. 72-78
[10] Miljan M.J., Miljan J., Thermal Transmittance of Enclosures of the Test Hopuse, compendium Guidebook of Reed Business, 2013, pp. 38-40

[11] State Gazette RT I 06.01.2015, Minimum energy performance requirement. The Government of the Republic of Estonia, 2015
[12] Inventoy of Carbon and Energy (ICE) version 16.a www.bath.ac.uk/mech-eng/sert/embodied, assessed in December 2014
[13] Lawrence, M., Shea A., Walker P., De Wilde P., Hygrothermal performance of bio-based insulation materials. Proceedings of the Institution of Civil Engineers: Construction Materials, 2013, Vol. 166 (4). pp. 257-263, ISSN 1747-650X

MECHANICAL AND ACOUSTICAL PROPERTIES OF BUSHINGS MADE OF LOW-ALLOYED MATERIALS AND USED IN BRAKE SYSTEMS OF TRANSPORT VEHICLES

VIKTORS MIRONOVS[1,3], PAVEL STANKEVICH[1], ALEKSEJ TATARINOV[1], VJACHESLAV ZEMCHENKOV[3], IRINA BOYKO[2],

[1] Laboratory of Powder Materials, Riga Technical University, Riga, Latvia
[2] Institute of Mechanical Engineering, Riga Technical University, Riga, Latvia,
[3] Institute of Aeronautics, Riga Technical University, Riga, Latvia
E-mail: viktors.mironovs@gmail.com, mail020580@gmail.com, irinaboyko@inbox.lv, v.zemchenkov@gmail.com

Bearing assemblies is one of the most important elements in the braking system of railway rolling stock. Due to the intensification of passenger and freight rail traffic, as well as the increase of the traffic speed, the development of new anti-friction materials is an urgent task. The paper considers peculiarities of manufacturing bushes for the braking system of railway rolling stock made of low-alloy metal powder materials based on Fe-C compound with content of Ni and Mo up to 0.3%. The studies on physical and mechanical properties and microstructure of sintered samples, as well as metrological and tribological studies were carried out.

To assess the material homogeneity of the bushes and possibility to locate cracks upon its volume, the method of ultrasonic testing called “time-of-flight” (TOF), typically demonstrated for effective detection of cracks in welds, was applied. The TOF method based on sounding the zone between the transmitter and the receiver and the analysis of signals generated by direct transmission of ultrasound and diffraction reflections has shown the ability to form a pseudo-image of a crack in the cylindrical bush with the crack. The distribution of ultrasound velocity in a few sample bushes indicated a significant variation of the velocity (from 3.75 to 4.54 km/s) that was pronounced in the height of bushes rather than in the cross section zones. The effect is explained by a higher degree of technological compaction of metal powder in the marginal zones of height. The results showed that the TOF scanning of the bushes surface can reveal cracks and assess heterogeneity of the material during the same test.

The analysis of the data on physical and mechanical properties and microstructure of the sintered samples confirmed the possibility of using low-alloy metal powder materials for the production of bushes for braking systems despite the slight decrease of strength (5–10%) and the larger density of the used powder materials. The metrological studies applied 2D and 3D roughness approach and the tribological studies were performed under the “ball-on-disk” mode. 2D and 3D roughness parameters, the friction coefficient and the volumetric wear of the investigated samples confirmed the predicted wear resistance, which is only slightly inferior to the same of more expensive known materials. The effect of surface texture parameters on tribological characteristics of the bushes material was shown.

Thus, the use of low-alloy metal powder on the iron base for producing sintered bushes for braking systems reduces the product cost with almost no reducing its wear resistance and durability.

CELLULAR COMPOSITES OF NATURAL AND AUTOCLAVED HARDENING WITH APPLICATION OF NANOSTRUCTURED BINDER

VIKTORIA NELYUBOVA[1], NATALIA PAVLENKO[1], DARIA NETSVET[1]
[1]*Department of Materials Science and Technology, Belgorod State Technological University named after V.G. Shoukhov, Belgorod, Russia*
E-mail: vvnelubova@gmail.com

The paper presents the results of the development of natural hardening foam concrete and aerated autoclaved concrete for heat insulating and construction and heat insulating purposes. Thus nanostructured binder (NB) in the composites was used as a primary binder and as a high activity binder as a modifier.

Because of more detailed knowledge of structure and performance of natural objects at molecular scale there is a visible tendency in the development of basic approach to producing and application of synthetic materials with nanosized structure.

An actual trend, however, is the development of physical-chemical and technological principles to design new nonmetallic materials on the basis of nanotechnological way by oriented structure formation, optimization of physical and chemical principles in manufacture. The principle of structure formation of materials obtained with high concentrated binder system (HCBS) technology underlies the conception of design of one such technology. In the given system it is near 10% of nanosized particles that form in the result of mechanochemical activation of raw materials.

The binders studied in this work are produced by wet milling process at temperature 60–80 °C in optimal pH level. All these conditions provide the milling process with critical concentration (max dilution) followed by suspension stabilization on the rheological principal, which is a mechanical gravitation mixing. At these conditions polydispersed granular composition as well as a low amount of bonded liquid is achieved. It is a determining factor if we speak about density (porosity), strength and shrinkage of the binder.

It was established that the application of nanostructured binder as a modifying agent for autoclaved gas concretes results in the improvement of macro- and microstructure of gas concrete before the autoclave treatment and intensification of phase formation under hydrothermal conditions. NB optimizes the rheotehnologycal properties of cellular concrete mix that provides: a smooth intense process of gas evolution by the increase of the mixture volume, reduction of swelling time, decrease of the thickness of interporous partitions while maintaining the required strength characteristics of the finished products. As a result of the research compositions of autoclaved gas concrete for heat insulating and construction and heat insulating purposes with density brands D350-D500 and classes for strength B0.75, B2.5 – B5.5 were proposed.

The specificity of nanostructured binder allows recommending it as a basic binder for the production of heat insulating and construction and heat insulating cellular nonautoclaved concretes obtained by foaming. Foam concrete on the basis of NB has a density of 300 – 900 kg/m3, compressive strength of 3–12 MPa, coefficient of thermal conductivity of 0.08 – 0.12 W/(m·°C), coefficient of water vapor permeability of 0.23 – 0.14 mg/(m·h·Pa), moisture sorption of 6 – 10% respectively. The use of NB in the manufacture of foam concrete allows to improve technological and economic efficiency of the process due to the significant reduction of time of manufacturing of foam concrete products with improved technical performance and thermal characteristics.

The application of NB allows to obtain materials with optimum cellular structure which is characterized by evenly distributed, polydispersed, locked, deformed in the correct polyhedrons porous, with a glossy surface of the near-porous layer, divided by thin dense interporous partitions-walls. The reduction of porosity of an interporous partition-wall is proved by the existence of nanodispersed particles in NB and in moulding systems on its basis. Using NB the particles of the minimum size, located in the gaps between relatively

large particles of matrix system promotes the creation of a thin film of the binder on a surface of an air bubble.
Thus, at the expense of the development and application of new type nanostructured binder and technology during the production of construction materials it is possible to reduce energy demand of production of synthetic composites significantly, i.e. to receive raw mixes with qualitatively new energy state that will provide objective conditions for introduction of nanomaterials in industrial and civil engineering.

SAPROPEL AS A BINDER: PROPERTIES AND APPLICATION POSSIBILITIES FOR COMPOSITE MATERIALS

VAIRA OBUKA[1], MARIS SINKA[2], MARIS KLAVINS[1], KARINA STANKEVICA[1], ALEKSANDRS KORJAKINS[2]

[1] Department of Environmental Science, University of Latvia, Riga, Latvia

[2] Institute of Materials and Structures, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia

E-mail: vaira_obuka@outlook.com

Recent trends of development largely look for possibilities of a wider use of natural materials and local resources. In this perspective the use of organic rich lake sediments – sapropel as a binding material in line with other environmentally friendly filling materials can be considered as a challenge. Sapropel itself is a valuable resource with multiple areas of application, for example, medicine, veterinary, agriculture, livestock farming, balneology, cosmetic applications, construction and such application options has been widely studied in the 20th century in the Baltic countries, Ukraine and Russia. Birch wood fibre and sanding dust, hemp shives, "Aerosil" as a filler are used with three types of sapropel as a binder and taken to make composites. After material's preparation and curing, physical and mechanical properties - density, thermal conductivity, compressive and flexural strength were determined and compared to data in literature, as well as opportunities to use them in the ecological construction. The obtained results give insight into the possibilities to use sapropel as a raw material and can be considered as a prospective material for construction materials and design products.

ACKNOWLEDGEMENT

The research leading to these results has received the funding from Latvia state research programme under grant agreement "INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH".

EFFECT OF WASTE PLASTIC SHREDS ON BOND RESISTANCE BETWEEN CONCRETE AND STEEL REINFORCEMENT

KEHINDE BABAJIDE OSIFALA[1], MUSIBAU AJIBADE SALAU [1],
ADEBOLA ADEWALE ADENIYI [1]
[1]Department of Civil Engineering, Yaba College of Technology, Yaba, Lagos, Nigeria
E-mail: akosifala@yahoo.com, bajibsalau@yahoo.co.uk, bola_niyi2003@yahoo.com

This paper investigates the effect of waste plastic shreds on steel-concrete bond. Forty (40) RILEM test specimens with 16mm and 20mm diameter high-yield reinforcing bars were cast and tested. Fifteen (15) specimens with 16mm and 20 mm diameter each were cast with the addition of waste plastic shreds at varying percentages of 1%, 1.5% and 2%; another ten (10) RILEM specimens with 16mm and 20 mm diameter bars at 0% of waste plastic shreds were cast as reference. Nine (9) 150 mm cubes, with three taken from each batch of the various percentages of waste plastic shreds, were used to monitor the concrete strength. From the test results and analysis, the compressive strength of concrete was found to reduce with increased percentages of waste plastic shreds, while the waste plastic shreds material was found not to improve the bond resistance between the concrete and steel. However, though lower than normal concrete, there was an increase in the bond resistance with increase in the % of the plastic shreds. The bond resistance of 16mm was also found to be higher than that of the 20 mm in all the specimens tested.

TRAFFIC LOAD EFFECT ON BRIDGE DYNAMIC RESPONSE

ILZE PAEGLITE[1], JURIS SMIRNOVS[1]
[1] Department of Roads and Bridges, Riga Technical University, Riga, Latvia.
E-mail: ilze.paeglite@rtu.lv

The paper presents the research on traffic load effect on a bridge structure. The structural condition of a bridge is affected by the operational loads including – dead load, live load and wind load. The moving vehicular axle load has a large effect on the structural condition of the bridge, especially for the medium span bridges. A moving truck generates a dynamic response which is greater than the static one because of the interaction between the moving vehicle and bridge structure, hence it can accelerate deterioration process of the bridge. To evaluate the influence of the passing truck on a bridge design, structural codes require that static live load is multiplied by the dynamic amplification factor (DAF) or is a built-in value of a live load model.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

INFLUENCE OF CARBON NANOTUBES ON THE STRUCTURE FORMATION OF CEMENT MATRIX

SERGEY PETRUNIN[1], VIKTOR VAGANOV[2], VIKTOR RESHETNIAK[2], LUBOV ZAKREVSKAYA[2]

[1]Limited Liability Company "Macromer", Vladimir, Russia
[2]Vladimir State University, Vladimir, Russia
E-mail: ser-petru@yandex.ru, vaganov-viktor-1953@ya.ru

The perspective of application of CNTs as a reinforcing agent in cement composites is governed by the presence of their unique mechanical and electronic properties [1]–[3]. The analysis of concrete strength changes upon introduction of CNTs shows non-uniformity and sometimes inconsistency of results. Due to the fact that CNTs influence the hydration kinetics, structure and phase composition of concrete it has been suggested that it is important to have interaction between the surface of MWCNTs and hydrate ions that are formed by the dissolution of the clinker phases.

In this case the theoretical and experimental study of interaction between hydrate ions and CNT surface is discussed. Reference nanotubes and nanotubes functionalized by carboxylic groups are used in this research. The phase composition was determined by X-Ray analysis according to the Rietveld method. It was found that the presence of oxygen-containing functional groups on CNTs surface leads to the intensification of the hydration process and an increase in concentration of C-S-H gel from 65.9% to 74.4%. Special attention is usually paid to the interactions between Ca2+ ions and MWCNT, because the hardening rate and structure of cement stone are determined by principle of Ca2+ localization in the solution [4]. Theoretic calculations were performed by GGA (PBE)-DFT method, using Quantum Espresso program [5]. According to the computation results there is a binding between Ca2+ ions and CNT surface with the Ca-C bond. Based on the experimental results the hypothesis of formation of cement composite structure for different CNTs surface functionalizations is described. According to this hypothesis, the CNTs act as the centers of crystallization for hydration products contributing to the acceleration of hydration, increase of the concentration of C-S-H gel and strength improvement of CNTs based composites.

[1] Li G.Y., Wang P.M., Zhao X., Mechanical behavior and microstructure of cement composites incorporating surface-treated multi-walled carbon nanotubes, Carbon. P., 2005, pp. 1239-1245
[2] Sobolkina A., Mechtcherine V., Khavrus V., Maier D., Mende M., Ritschel M., Leonhardt A., Dispersion of carbon nanotubes and its influence on the mechanical properties of the cement matrix, Journal of colloid and interface science, 2014, pp. 43-53
[3] Petrunin S., Vaganov V., Sobolev K., Cement Composites Reinforced with Functionalized Carbon Nanotubes. Materials Research Society Symposium Proceedings, 2014, pp. 133 – 138
[4] Kondofersky-Mintova I., Plank J., Fundamental Interactions between Multi-Walled Carbon Nanotubes (MWCNT), Ca2+ and Polycarboxylate Superplasticizers in Cementitious Systems, 10th CANMET/ACI Conference on Superplasticizers and Other Chemical Admixtures in Concrete (Proceedings), Prague, 2012, pp. 423-434
[5] Giannozzi P., Baroni S., et. al. J. Phys.: Condens. Matter, 2009, Vol.21, 395502

ANALYSIS OF REED CANARY GRASS CHEMICAL CONTENT

RASMA PLATACE[1], ALEKSANDRS ADAMOVICS[1], LIENA POISA[1],
SKAIDRITE BUMANE[2], EDGARS CUBARS[3]
[1]Latvian University of Agriculture, Jelgava, Latvia, LV 3000
[2]Institute for Regional Studies, Rezekne Higher Education Institution
[3]Institute of Food Safety, Animal Health and Environment BIOR
E-mail: rasmins@inbox.lv

The energy plant quality parameters are defined by various standards. They are different for each biofuel variety and for each country. At the same time it is difficult to define the ideal plant quality requirements as they will be different for various users; for example the owners of large and small furnaces. In the same way the increase in crop qualitative and quantitative indices is an urgent matter, without increasing the sown areas at the same time. With that in mind there is a large role for environment – friendly growing technologies, which guarantee qualitative soil tillage, suitable variety cultivation and the use of fertilizers according to agrochemical parameters. In order to assess the suitability of various power plants to produce the energy the analysis of chemical content of plants and factors that affect it was performed.

The reasons for the harvest yield increase or decrease were evaluated: the chemical content, the energy parameters, the morphologic parameters for the yield – length of correlation connections.

In the research for hemp dry matter harvested, a fundamental correlation was observed between the yield and silicon (Si) content (n = 15; r = 0.53; $P < 0.05$). According to the results of the three-year study there is a following conclusion: the carbon content in the reeds varies from 42.41 ± 0.18%. Changes of the carbon content in different years are explained by the fact that there are stalks of the previous year in the current annual biomass. The stalks have begun to decompose consequently reducing the carbon content. The carbon content is similar to various tall fescue (*Festuca arundinacea* Schreb.) – 47.55 ± 0.09%, festulolium (× *Festulolium*) 47.14 ± 0.14%, reed canary grass (*Phalaris arundinacea* L.) variety ("Marathon", "Bamse", "Pedja") – 47.24 ± 0.09%. The carbon yield for one hectare was within the range of 1.09–3.89 t ha-1. It was dependent on the variety, plant age and nitrogen fertilizer norms.

PERFORMANCE OF LIGHTWEIGHT CONCRETE BASED ON GRANULATED FOAMGLASS

MAXIM POPOV[1], LYUBOV ZAKREVSKAYA[1], VIKTOR VAGANOV[2]
[1]Department of Construction Production, Vladimir State University, Vladimir, Russia
[2]Department of Physics and Applied Mathematics, Vladimir State University, Vladimir, Russia
E-mail: popov.maxim.1989@gmail.com

The paper presents the investigation of properties of lightweight concretes based on granulated foamglass (GFG-concrete) aggregates. The application of granulated foamglass (GFG) to concrete might significantly reduce the volume of waste glass and enhance the recycling industry in order to improve environmental performance. The conducted experiments showed high strength and thermal properties for GFG–concrete. However, the use of GFG in concrete is associated with the risk of harmful alkali-silica reactions (ASR). Thus, one of the main aims was the study of ASR manifestation in GFG-concrete.

The consequences of ASR in GFG-concrete were investigated. The results indicate that the lightweight concrete based on porous aggregates and ordinary concrete have different mechanism of ASR. In GFG-concrete, the structural changes and partial destruction of granules with the accumulation of silica hydro-gel in its pores was observed. According to the existing methods for the analysis of ASR manifestation in concrete, the measurement of sample expansion was used, but the results showed that it is not the determining factor of ASR in concrete with porous aggregates. Microstructural analysis and testing of the concrete strength is needed to evaluate the degree of ASR. Low-alkali cement and different pozzolanic additives as preventive measures against ASR were performed. The efficacy of measures depends on the operating conditions of the concrete. The final composition of the GFG-concrete provides high strength, thermal and durability characteristics. On the whole, the potential for GFG-concrete has been identified.

IMPACT OF EXTERNAL HEAT INSULATION ON DRYING PROCESS OF AUTOCLAVED AERATED CONCRETE MASONRY CONSTRUCTIONS

SANITA RUBENE[1], MARTINS VILNITIS[1], JURIS NOVIKS[1]
[1]Riga Technical University, Riga, Latvia
E-mail: sanita.rubene@inbox.lv, martins.vilnitis@rtu.lv

In time when one of the most important construction trends is sustainable construction as well as cost saving on heating and cooling of buildings, it is important to acknowledge the possibilities of application of construction materials with high heat parameters and the ways in which these parameters can be obtained. Aerated concrete is a load bearing construction material, which has high heat insulation parameters, although it has one significant problem. If the autoclaved aerated masonry construction has high relative humidity rate it loses its heat insulation properties. This is the reason why it is important to detect the humidity distribution throughout the cross section of the masonry elements in order to conduct the drying process of the aerated concrete construction.
Therefore the question about non-destructive detection of humidity distribution throughout the cross section of the material arises. Humidity distribution throughout the cross section of autoclaved aerated concrete masonry constructions has significant impact on its performance of heat resistivity properties. An application of electrical impedance spectrometry (EIS) method for determination of humidity distribution throughout the cross section of autoclaved aerated concrete constructions has been a subject of research recently. The EIS method is an easily applicable non-destructive testing method for the detection of humidity distribution throughout the cross section of the construction.
The research of the impact of external heat insulation layer on the speed of humidity distribution changes is described in this paper.

ALKALINE ACTIVATION OF ILLITE-BASED CLAYS OF LATVIA

MARIS RUNDANS[1], INGUNDA SPERBERGA[1], GAIDA SEDMALE[1], POLINA SPELA[1]
[1] Institute of Silicate Materials, Faculty of Materials Science and Applied Chemistry, Riga Technical University, Riga, Latvia
E-mail: maris.rundans@rtu.lv

Alkaline activation is a chemical process in which the powder material of an alumosilicate nature is mixed with an alkaline activator to produce a paste that is able to set and harden in a short time [1], [2]. The reaction process of this system is characterized by dissolution of alumino-silicate oxides and followed by the polymerization reaction of those dissolved species in the presence of alkali ions for charge balancing in framework cavities nearby AlO4 constituents. Such type of materials, i.e. geopolymers possess excellent mechanical properties, including fire and acid resistance [3]. Due to these such materials are viewed as alternative materials for certain industrial applications in the areas of construction, transportation, road building, aerospace, mining and metallurgy. The most common geopolymeric reactants in the past decades are kaolinite and metakaolinite. The search for alternative low cost and easily available materials have led among other materials to illite based clays. The aim of this work is the study of alkaline dissolution and geopolymerization of natural illite based clays of Latvia. The traditional subdivision of clay deposits in Latvia is based on geological age with specific attention to beds with industrial importance – Devonian and Quaternary deposits. From geological point of view – Latvia is rich in clay resources to be used for material production currently and at least for centuries [4], [5].

Illite based geopolymer products via activating of Quaternary and Devonian clays of Latvia with KOH and NaOH solution were investigated. It is important to note that the mechanical strength of the materials obtained from clays via activation process depends on many factors such as mineralogical and chemical composition and dominating particle size of the clay as well as activation temperature, the type and concentration of the activator.

It was stated that the type of cation (Na+ or K+) involved in the activation reaction differently affected the microstructural development of the obtained material. The presence of alkali metal cation plays a catalytic role, controlling all stages of material formation, in particular gel hardening and crystallisation and enables an appropriate structure formation. The factor that plays an important role during the activation process is the calcium content in clays. Quaternary (calcite containing) clays showed higher mechanical strength than those of Devonian clays (calcite content is very low) obviously due to the formation of Ca-Al-Si amorphous structures. There was found (in samples cured at low temperatures) also the development of calcium silicate hydrate CSH and possibly coexistence with geopolymeric gel reinforcing the geopolymeric structure and as a result the increasing of mechanical strength.

XRD results confirmed the differences between the activated clays developing the diverse final strength of the obtained samples. FTIR spectra differences of the used activated and unactivated clays were a good indication of transformations taking place during synthesis. The general trends observed were: compressive strength of alkali activated clays are greatly dependent on the used clay and curing conditions. Compressive strength measurements due to the low cost and simplicity were widely used as an indicator to assess the success of the used technology. The obtained results showed that chemically activated illite-based clays could be a source material for the obtaining of new products.

[1] Duxson P., Fernández-Jiménez A., Lukey G.C., Palomo A., Geopolymer technology: the current state of the art. Journal of Material Sciences, 2007, Vol. 42, pp. 2917-2933
[2] Steins P., Poulesquen A., Diat O., Frizon F., Structural evolution during geopolymerization from an early age to consolidated material. Langmuir, 2012, Vol. 28, pp. 8502-8510
[3] Kuenzel C., Vandeperre L.J., Donatello S., Boccaccini A., Cheeseman, C., Ambient temperature drying shrinkage and cracking in metakaolin-based geopolymers, Journal of American Ceramic Society, 2012, Vol. 95, pp. 3270-3277
[4] Seglins V., Stinkule A., Stinkulis G., Mineral raw materials in Latvia, 2013, p. 184
[5] Stinkule A., Latvian clay subsoil, 2014, p. 169

INVESTIGATION OF MECHANICAL PROPERTIES OF THE STEEL FIBRE-REINFORCED CONCRETE

ALEXANDER RYABCHIKOV[1], VALDEK TAMME[1], MATI LAURSON[3]
[1] Department of Rural Building, Estonian University of Life Sciences, Tartu, Estonia
[3] Savekate OÜ, Tartu, Estonia
E-mail: alexander.ryabchikov@emu.ee

Fibres considerably reduce the brittleness of concrete and improve its mechanical properties. Fibre-reinforced concrete is widely used in structural slabs [1]. These slabs can be used, for example in structural ceilings, pedestrian bridges and industrial floors. When a load is applied to a fibre-reinforced composite consisting of a low-modulus matrix reinforced with high-strength, high-modulus fibers, the plastic flow of the matrix under stress transfers the load to the fibre; this results in high-strength, high-modulus material which determines the stiffness and stress of the composite [2].

The main benefits of including fibres in hardened cement-based products occur in the post-cracking state, where the fibres bridging the cracks contribute to the increase in stress, failure strain and toughness of the composite. In concrete the fibre volume is usually less than 2%, often with low-modulus fibres being included. The efficiency of fibre reinforcement depends on fibre shape, fibre aspect ratio, orientation and dosage [3], [4].

In this study the equivalent flexural strength, equivalent flexural ratio $R_{e,3}$ and the compressing strength of steel fibre-reinforced concrete is investigated. Notched test specimens with five different dosage of steel fibres (20, 25, 30, 35, 40 kg/m3) were prepared using industrial concrete. The determination of the flexural tension strength was carried out according to the EU norm prEN 14651.

The equivalent flexural strength and subsequently equivalent flexural ratio Re,3 of steel fibre-reinforced concrete with dosage of 20, 25, 30, 35 kg/m3 was similar and with dosage of 40 kg/m3 was 31% higher compared to their average values. This effect can be explained by non-uniform distribution of steel fibres in the cross-section of fracture. The compressing strength of the steel fibre-reinforced concrete was approximately 12% higher compared to plain concrete.

[1] Khaloo A.R., Afshari M., Flexural behaviour of small steel fibre reinforced concrete slabs, Cement&Concrete Composites, 2005, Vol. 27, pp. 141-149
[2] Illston J.M., Construction materials: Their nature and behavior, Chapman & Hall, London, 1994
[3] Banthia N., MacDonald C., Tatnall P., Structural applications of fiber reinforced concrete, ACI International, SP-182, 1999
[4] Hameed R., Turatsinze A., Duprat F., Sellier A., Metallic fiber reinforced concrete: effect of fiber aspectratio on the flexural properties, ARPN Journal of Engineering and Applied Sciences, 2009, Vol. 4, pp. 5, 67-72

THE BEHAVIOUR OF THE EMBEDDED RAIL IN INTERACTION WITH BRIDGES

PAVEL RYJACEK[1], MD MOHASIN HOWLADER[1], MIROSLAV VOKAC[2]
[1]Department of Seel and Timber Structure, Faculty of Civil Engineering, Czech Technical University, Prague, Czech Republic
[2] Klokner institute, Czech Technical University. Prague, Czech Republic
E-mail: pavel.ryjacek@fsv.cvut.cz

Nowadays there is need for higher speed as well as the demand to accommodate the extremely growing traffic which in the last few decades has brought about major changes in different solutions to railway track systems. Since the beginning of the direct fastening system in railways, probably Embedded Rail System (ERS) is one of the most spectacular one of the developments. Especially, the easy and low maintenance requirement along with the capability to revive the existing low strength bridge structures has given a new dimension to this system contributing towards environmental as well as economic sustainability. But with the increasing demand, the demand for detail characteristics behaviour of this type of fastening has to be met. Since the inception of modern fastening system, numerous analysis and experiments have been made to establish the behaviour of those particular systems. And, there exist established codes of practice for traditional ballasted tracks (UIC 774-3, EN 1991-2 or DIN Fb-10). But there is still lack of specific interaction model, especially when it comes to bridges with ERS system.

Therefore, the primary purpose of the paper was to investigate the response of bridges with Embedded Rail System (ERS) under different combinations of vertical and longitudinal load. With a view to find the response, at first a small scale test was conducted in the laboratory on a sample of ERS mounted on an asymmetric steel I girder. One of the important finding from the test results is that the resistance of ERS is not varying significantly for loaded and unloaded case. The results of the test are discussed in the paper.

Subsequently a Finite Element Model (FEM) was developed to simulate the test. The specific objectives of the simulation were to find out the longitudinal resistance of the ERS and to investigate its influence on the bridge system. Therefore, the model was verified and validated (V&V) prior to determining the effects of ERS. The Finite Element Analysis (FEA) results for the unloaded track condition were found fairly close to the experimental results and the results for the loaded track conditions have also been found of similar nature but varying gradually with the increment of vertical load. The pattern of transverse and longitudinal distribution of the vertical pressure due to a loaded train was established from the FEA, which would eventually lead to important design parameters for the railway bridges installed with ERS. Significant improvement on stress generation magnitude for top and bottom fibre of girder was also found as compared to the fastening system without ERS. The effect of debonding of physical parts in the ERS sample has also been considered during the study and an infinitesimal effect was observed. Stress softening characteristics of the embedding material under short term repetitive load was considered as the principle reason behind the result variation.

The results from the paper are given in the conclusion. The suggestions for further research are also given. The results will be valuable for researchers and also for practical application of ERS on bridges.

THERMAL INSULATION FROM HARDWOOD RESIDUES

INESE SABLE[1], ULDIS GRINFELDS[1], LAURA VIKELE[1], LINDA ROZENBERGA[1]
[1] Latvian State Institute of Wood Chemistry, Riga, Latvia
E-mail: inese.sable@inbox.lv

Adequate heat is one of the prerequisites for human survival; therefore building insulation is required in places where the outside temperature is not suitable for living. For thousands of years people have used nature materials for that purpose – moss, clay, straw, wool, herbs etc. In the last century, however, a lot of synthetic materials have taken place in this application area, but considering the global tendency to reduce CO_2 emissions, humanity comes again to green-thinking. In addition to this reason, natural materials in construction create pleasant microclimate for living. Modern thermal insulation material should have air permeability together with good thermal insulation properties and easy handling.

Thermal insulation boards from soft wood fibres are part of global market nowadays. The climate change with its rising temperatures and longer dry periods enlarges the regions with conditions more convenient for hardwood species than for the softwood species [1]. Manufacturers can change the focus on hardwood products. Birch (*Betula pendula*) is the most common hardwood species in Latvia – its stock was 160 million m^3 in 2014 and that is 24% of total wood stock of our country.

The aim of this work was to obtain birch fibres from wood residues of plywood production and to form low-density thermal insulation boards. Also impact of additives on density, transportability and thermal conductivity was investigated.

Fibres were obtained from birch chips in thermo-mechanical pulping process. Board formation and production was done in the presence of water; natural binder, fire retardant and fungicide were added in different concentrations. Board properties were investigated: density, transportability or resistance to particulate loss, thermal conductivity, reaction to fire and surface-water contact angle.

This study includes thermal insulation boards with density 60–120 kg/m^3, a strong correlation between the density and binder amount was found. Transportability also improved with addition of binder and other additives and 0.1–0.5 % of binder was the most appropriate amount for this purpose. The measured thermal conductivity was in the range of 0.040–0.043 W/(m·K) and a good correlation with density of fibre-board was found. Fire resistance increased with the increase of the amount of fire retardant.

We concluded that the birch fibres from thermo-mechanical process are applicable for thermal insulation board production. It is possible to diversify the board properties by changing the amount of different additives. It is a good opportunity to obtain a product of high added value from wood residues instead of burning them to produce only energy.

[1] De Borst K., Bader T.K., Structure–function relationships in hardwood – Insight from micromechanical modelling, Journal of Theoretical Biology, 2014, Vol. 345, pp. 78-91

EVALUATION OF BEHAVIOURS OF LAMINATED GLASS

LIENE SABLE[1], GUNTIS JAPINS[1], KASPARS KALNINS[1]
[1]Institute of Materials and Structures, Riga Technical University, Riga, Latvia
E-mail: lienesable@gmail.com

Traditionally glass was just a simple window or door component. This has changed over the time. Currently glass enables both light and unique interior design. In particularly laminated glass has become one of the trend materials capable for load carrying capacity and transparent appearance. Mechanically glass has high mechanical strength and medium density, however sudden brittle failure like concrete or other ceramics restricts the efficient design of glass structures. This should be changed as consumers requirements evolve without a safe and reliable design methodology. The design methodology for glass and glass laminates should be rapidly developed and included as a chapter in Eurocode.

Laminated glass consists of two or more glass sheets bonded together by Ethyl Vinyl Acetate (EVA) layers. In the composition of this laminate all types (annealed, heat-strengthened and tempered glass) could be employed exploring the potential and fulfilling the condition defined by the construction safety class. A specific safety feature is embedded in such a design – when a laminated panel under load collapses all shards stay at EVA layer and do not cause hazard for humans.

The current research aims to extend the existing knowledge about all glass types by evaluating the mechanical properties of layers of several different thicknesses and to compare the obtained results with the product data sheets partly available from manufacturers. This will serve as a starting point for further investigations of the laminated glass bending behaviour (Fig. 1.) by finite element commercial code ANSYS.

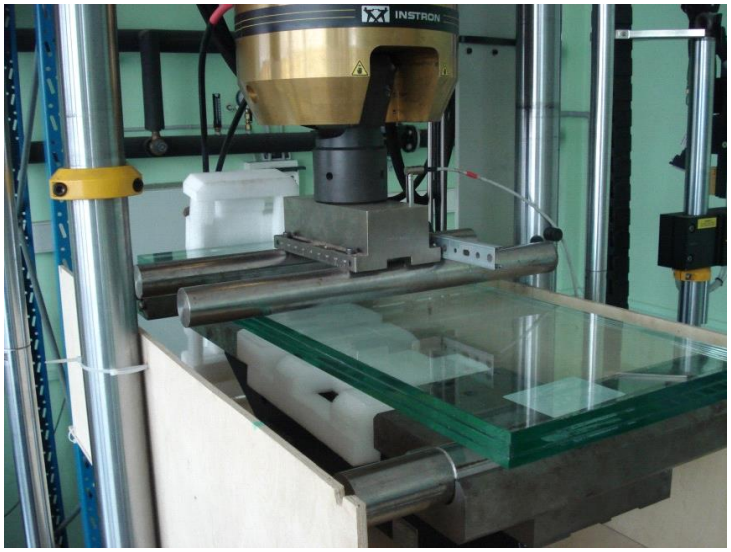


Fig.1. A laminate glass sample tested in bending (INSTRON 8802)

EFFECTIVE USE OF DOLOMITE BY-PRODUCT IN CONCRETE TECHNOLOGY

GENADIJS SAHMENKO[1], NIKLAVS PLEIKO[1], GIRTS BUMANIS[1], DIANA BAJARE[1]
[1]Department of Building Materials and Products, Institute of Materials and Structures,
Riga Technical University, Riga, Latvia,
E-mail: genadijs.sahmenko@rtu.lv

By-products of dolomite carrier are a multi-fraction mix (range of sizes up to 8 mm) containing a large amount of fine particles. The goal of this research is to elaborate effective concrete mixes with maximum content of dolomite by-products. The experimental mixes are based on pure dolomite aggregate as well as its combination with traditional aggregate and special admixtures. The produced concrete is characterized by compressive strength of up to 60 MPa and good freeze-thaw resistance. Small fractions of dolomite improve the mix workability and allow to achieve self-compacting properties of concrete mixes.
In the frame of experimental work some variants of practical use were elaborated, such as architectural exterior panels and composite blocks with incorporated additional heat insulation. Utilizing of dolomite by-products allow to use local resources more rationally and to produce high performance concrete with high added value.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

EFFECT OF DIFFERENT COARSE AGGREGATE SIZES ON THE STRENGTH CHARACTERISTICS OF LATERIZED CONCRETE

MUSBAU A. SALAU[1], AKIM O. BUSARI[1]
[1]*Department of Civil and Environmental Engineering, University of Lagos, Lagos State, Nigeria*
E-mail: ajibsalau@yahoo.com

The high cost of conventional concrete materials is a major factor affecting the housing delivery in developing countries such as Nigeria. Since Nigeria is blessed with abundant locally available materials like laterite, researchers have studied the use of laterite to replace river sand partially or fully in the concrete. However, the studies did not consider the optimum use of coarse aggregate to possibly improve the strength of the laterized concrete, since it is usually lower than that of the normal.

The results of the tests showed that workability, density and compressive strength at constant water- cement ratio increase with the increase in coarse aggregate particle size and also with curing age. However, as the percentage of laterite increases, there was reduction in all these characteristics even with the particle size of coarse aggregate reduction due to the loss from the aggregate-paste interface zone.

Also, when the sand was replaced by 25% of laterite, the 19.5 mm and 12.5 mm coarse aggregate particle sizes gave satisfactory results in terms of workability and compressive strength respectively at 28 days of curing age, compared to normal concrete. However, in the case of 50% up to 100% laterite contents, the workability and compressive strength values were very low.

EFFECTS OF ELEVATED TEMPERATURE ON CONCRETE WITH RECYCLED COARSE AGGREGATES

MUSBAU A. SALAU[1], OSEAFIANA J. OSEMEKE[1], OYEGOKE O. TANITOLUWA[1]
[1]Department of Civil and Environmental Engineering, University of Lagos, Lagos State, Nigeria
E-mail: ajibsalau@yahoo.com

This paper discusses the effect of heat on concrete with partially replaced content of Natural Coarse Aggregates (NCA) with Recycled Coarse Aggregates (RCA), obtained from a demolished building in the ratio of 0%, 15% and 30%. The concrete mix ratio adopted throughout the experiment was 1:1.7:2.5 with w/c of 0.5. The effect of heating temperatures of 200 °C, 400 °C and 600 °C for 2 hours each at a heating rate of 2.5 °C/min on these concrete samples were determined.

On heating the concrete samples, no noticeable changes took place until the temperature was considerably above 100 °C. There was an initial drop in strength from 100 °C to 200 °C which is suspected to be due to the relatively weak interfacial bond between the RCA and hardened paste within the concrete matrix, a gradual increase in strength continued from 200 °C to 450 °C and a steady drop occurred again as it approached 600 °C.

Further, the compressive test results showed that Recycled Aggregate Concrete (RAC) with 15% NCA replacement when exposed to optimum temperature of 450 °C yielded high compressive strength comparable to that of control specimen (normal concrete). With the replacement proportion of 0%, 15% and 30% of NCA and exposure to peak temperature of 600 °C, a relative concrete strength of 23.6 MPa, 25.3 MPa and 22.2 MPa respectively for 28days curing age can be achieved.

In addition, all concrete samples exhibited similar strain behaviour as only slight surface hairline cracks were noticed as the temperature approached 600 °C, thus making the Recycled Aggregate Concrete fit for structural use.

COMPARING THE ENVIRONMENTAL IMPACTS OF ALKALI ACTIVATED MORTAR AND TRADITIONAL PORTLAND CEMENT MORTAR USING LIFE CYCLE ASSESSMENT

PABLO SANTIZO MATHEU[1], KATHLEEN ELLIS [2], BENJAMIN VARELA[3]
[1]Industrial and Systems Engineering Department, Rochester Institute of Technology, Rochester NY, USA
[2]Mechanical Engineering Department, Rochester Institute of Technology, Rochester NY, USA
E-mail: pxs3517@g.rit.edu, ke4861@rit.edu, bxveme@rit.edu

Since 1908 there has been research into the use of alkali activated materials (AAM) in order to develop cementitious materials with similar properties to Ordinary Portland Cement. AAMs are considered a green material since their production and synthesis is not energy intensive. Even though AAMs have a high compressive strength, the average cost of production among other issues limits its feasibility. Previous research by the author yielded a low cost AAM that uses mine tailings, wollastonite and ground granulated blast furnace slag (GGBFS). This mortar has an average compressive strength of 50MPa after 28 days of curing. In this paper the software SimaPro was used to create a product base cradle to gate Life Cycle Assessment (LCA). This compared the environmental impact of the AAM mortar to an Ordinary Portland Cement mortar (PCHM) with similar compressive strength. The main motivation for this research is the environmental impact of producing Ordinary Portland Cement as compared to alkali activated slag materials. Approximately one ton of CO2 is emitted to the atmosphere for producing one ton of traditional Portland cement. The results of this LCA show that the Alkali activated design mix has a lower environmental impact, compared to PCHM, in 10 out of 12 categories including Global Warming Potential, Ecotoxicity, and Smog.

MECHANICAL PROPERTIES OF HEAT AFFECTED ZONE OF HIGH STRENGTH STEELS

KATERINA SEFCIKOVA[1], TOMAS BRTNIK[1], JAKUB DOLEJS[1],
KIMMO KELTAMAKI[2], RAUNO TOPPILA[2]
[1]Department of Steel and Timber Structures, Faculty of Civil Engineering,
Czech Technical University in Prague, Czech Republic
[2]Lapin AMK – Lapland University of Applied Science, Finland
E-mail: katerina.sefcikova@fsv.cvut.cz

High Strength Steels became more popular as construction material during the last decade because of their increased availability and affordability. On the other hand even though general use of Advanced High Strength Steels (AHSS) is rising, wide utilization is limited because of insufficient information about their behaviour in structures.
Fusion welding is the most widely used technique for joining steels. The welding process has an influence not only on the welded connection but on the area near this connection, the so called Heat Affected Zone (HAZ), as well. For that reason it is very important to be able to determine the properties in HAZ. This area of investigation is being continuously developed dependent on the significant progress in material production, especially on new types of steels available. There are currently several types of AHSS on the market. The two most widely used processes for AHSS production are ThermoMechanically Controlled Processing (TMCP) and Quenching in connection with Tempering.
In the presented study, TMCP and QC steels grade S960 were investigated. The study is focused on the changes of strength, ductility, hardness and impact strength in HAZ based on the used amount of heat input. AHSS are most widely used in machine industry where almost all work can be done in workshop. High strength is achieved by fine grain structure of the steel. This brings steel a lot of strength, however, it also makes steel more sensitive to higher heat brought in the weld area. High temperatures can decrease the strength of base material in HAZ and thus make HAZ the weakest part of the welded connection.

DETERMINATION OF LOAD BEARING CAPACITY FOR SPATIAL JOINT WITH STEEL ANGLE BRACKETS

PETR SEJKOT[1,2], SIGURDUR ORMARSSON[3], JOHAN VESSBY[3], PETR KUKLÍK[1,2]
[1]Department of Steel and Timer Structures, CTU in Prague, Czech Republic
[2]UCEEB of CTU in Prague, Czech Republic
[3]Linnaeus University, Vaxjo, Sweden
E-mail: petr.sejkot@gmail.com

There is a significant possibility to improve the calculated load bearing capacities of spatial connections using thin walled metal nailing plates making them more consistent with the results from tests. The reason is that the design of these connecting elements has inadequate support in the existing Standards. Therefore, it is the intention of the research to improve this state of knowledge. This paper describes the whole process of the research which consists of full scale experiments, 3D FEM models in Abaqus CAE and the developing of the existing analytic solution.

Timber connections using thin-walled metal elements gradually supplant traditional carpentry joints. Their main advantage is that they do not weaken the connected timber elements. Other advantages include the possibility of in-situ implementing or possibility of direct connection of timber elements to steel and concrete structures. The most common thin-walled metal connector is the steel angle bracket with a rib connected to the structure by annular ring nails or by bolts.

The connections by thin walled metal elements are very ductile. This is favourable, because the over-loaded structure can be easily identified by sight. The load bearing capacity of these connections can be generally determined by three possible forms of collapse: failure of steel element, splitting of timber element caused by tension and failure of nails. Nevertheless, it has been proved by experiments [1], that the failure of nails is predominant. The splitting of timber element is eliminated by the check according to Eurocode 5 [2], which should be a part of every static design. Also the angle brackets have predefined places for connectors by holes in the steel plate to avoid inappropriate stresses in them.

The Standards and the specialized literature are essential information source about the issue. In Eurocode 3 [3] there is the calculation procedure for steel membrane that can be used to determine the stresses in steel plate. In Eurocode 5 [2] there is a table of minimum spacing and edge and end distances for nails. The structural Timber Education Programme (STEP) [4] contains general knowledge about the static schema of spatial joints by thin walled metal elements and a few worked examples of their calculations. In Technical Report 17 (TR17) [5] published by European Organisation for Technical Approvals (EOTA) there is an example of calculation of a spatial joint of timber elements by steel angle bracket loaded in the direction opening to the angle, but the example is very simplified and uses many experimentally based inputs. Nevertheless, neither using any of the listed sources nor combining them gives us enough knowledge for calculating the load-bearing capacity of any angle bracket with a rib.

Therefore the research at the Czech Technical University in Prague started. The research was carried out in cooperation with the Czech producer of thin-walled three-dimensional metal plates BOVA Březnice and Czech civil engineering software company FINE. The fundamental steps of the whole research project are described as follows.

A simplified calculation model of the whole connection was made to calculate its load-bearing capacity. Then full scale experiments were performed to determine the real load-bearing capacity. After that the connecting elements were numerically analysed in Abaqus FEM software and the performance of these elements was improved. Finally the improved elements were tested in full scale experiments to compare the behaviour of the

improved and not improved versions of the connecting elements. Detailed description, results and analysis will be presented in the subsequent paper.

ACKNOWLEDGEMENT
Besides the support of companies BOVA and FINE, the work has been supported by the European Union, OP RDI project No. CZ.1.05/2.1.00/03.0091 – University Centre for Energy Efficient Buildings and the experimental research was supported by the grant SGS13/171/OHK1/3T/11.

[1] Šťastný R., Tenkostěnné ocelové tvarované element používané v dřevařském inženýrství, Disertační práce ČVUT, 2005
[2] EN 1995-1 -1 Eurocode 5: Design of Timber structures – Part 1 -1: General – Common rules and rules for buildings
[3] EN 1993-1 -1 Eurocode 3: Design of steel structures – Part 1 -1: General rules and rules for buildings
[4] Koželouh B., Dřevěné konstrukce podle Eurokódu 5 – STEP1 , 1998
[5] EOTA TR17: Worked example calculation of characteristic load-carrying capacities of 90°angle bracket with a rib. Technical report 17, European organisation for technical approvals, Amended October 2012

INFLUENCE OF PLASTICIZER AMOUNT ON RHEOLOGICAL AND HYDRATION PROPERTIES OF CEM II TYPE PORTLAND CEMENTS

JURGA SEPUTYTE-JUCIKE[1], INA PUNDIENE[1], ASTA KICAITE[2], JOLANTA PRANCKEVICIENE[1]
[1]*Scientific Institute of Thermal Insulation, Vilnius GediminasTechnical University, Lithuania*
[2]*Vilnius GediminasTechnical University, Vilnius, Lithuania*
E-mail: jurga.seputyte@vgtu.lt

Concrete is a universal, reliable and one of the oldest materials used in construction. Despite this fact, the manufacturing and properties of concrete are constantly changing due to the occurrence of new additive and admixture, energy prices and increasingly stringent environmental requirements. Some of the most promising additives both technologically and economically, are limestone and slag. CEM II blended Portland cements, in comparison with ordinary CEM I Portland cements have ecologic advantages, since the use of admixtures reduces fuel costs and CO_2 emissions into the atmosphere during Portland cement production and somewhat solve waste utilization problems [1], [2]. That is why it is expected that the future world production of CEM II blended Portland cement will be continuously increasing. Various plasticizers have been widely offered to the users, therefore choosing an option and amount of plasticizer in blended cements is essential [3]–[5].

The article analyzes the effect of plasticizer (based on polycarboxilates) amount (0.3% – 1.2%) on the rheological and hydration properties of two Portland cement pastes: CEM II/A-S 42,5N and CEM II/A-LL 42,5N. The increase of plasticizer amount (from 0.3 to 1.2 %) reduces viscosity of the CEM II/A-LL 42,5N cement paste 3 to 12 times, where viscosity of CEM II/A-S 42,5N cement paste reduces 5 to 20 times. The optimum plasticizer dose (0.3%) in the case of CEM II/A-S 42,5N and (1.2%) in the case of CEM II/A-LL 42,5N was established. Calorimetry studies have shown that the plasticizer reduces the wetting heat release rate in CEM II/A-LL 42,5N cement twice and in CEM II/A-S 42,5N cement – by one fourth. The plasticizer prolongs the maximum heat release rate time by 16 h in CEM II/A-LL 42,5N samples and reduces the heat release rate by 19%. In CEM II/A-S 42,5N cement samples the plasticizer prolongs maximum heat release rate time by 14.5 h and increases the heat release rate by 15%. The results of investigations can help to select the appropriate CEM II type Portland cements for the use with polycarboxilates plasticizer.

ACKNOWLEDGEMENT
The research work was carried out in the frame of the Lithuanian Agency of Science project Innovation and Technology Eureka Project: E!8790 Enclosure waste concrete.

[1] Zhang X., Han J., The effect of ultra-fine admixture on the rheological property of cement paste, Cement and Concrete Research, 2000, Vol. 30, pp. 827-833
[2] Menendez G., Bonavetti V., Irassa E., Strength development of ternary blended cement with limestone filler and blast-furnace slag, Cement and Concrete Composites, 2003, Vol. 25, pp. 61-67
[3] Golaszewski J., Szwabowski J., Influence of superplasticizers on the rheological behaviour of fresh cement mortars, Cement and Concrete Research, 2004, Vol. 34, pp. 235-248
[4] Justs J., Wyrzykowski M., Winnefeld F., Bajare D., Lura P., Influence of superabsorbent polymers on hydration of cement pastes with low water-to-binder ratio, Journal of Thermal Analysis and Calorimetry, 2014, Vol. 115, pp. 425–432
[5] Hallal A., Kadri E., Ezziane K., Kadri A., Khelafi H., Combined effect of mineral admixtures with superplasticizers on the fluidity of the blended cement paste, Construction and Building Materials, 2010, Vol. 24, pp. 1418-1423

DEVELOPMENT OF THE ONE CENTIMETER ACCURACE GEOID MODEL OF LATVIA FOR GNSS MEASUREMENTS

JANIS BALODIS[1], GUNARS SILABRIEDIS[1], DIANA HARITONOVA[1,2], MARIS KALINKA[1,2], INESE JAUNPAULE[1], KATERINA MOROZOVA[1] , IZOLDE JUMARE[1], INGUS MITROFANOVS [1,2], JANIS ZVIRGZDS[1,3], JANIS KAMINSKIS, [1,2], IVARS LIEPINS [1,3],

[1]Institute of Geodesy and Geoinformatics, University of Latvia

[2]Department of Geomatics, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia,

[3] Latvian Agency of Geospatial Information

E-mail: Janis.balodis@lu.lv

The necessity for a highly accurate and reliable geoid model to enable a prompt determination of normal height with the use of GNSS coordinate determination is needed due to the high precision requirements in geodesy, building and high precision road construction development and in other industries [1], [2]. Several Latvian geoid models have been developed [3]–[5], however, maximum precision and reliability is still needed to be proved in order to strive towards the compliance with the requirements of European Vertical Reference System (EVRS). Currently, the Latvian height system is in the process of transition from BAS-77 (Baltic Height System) to EVRS2007 system. The accuracy of the geoid model must be of about ~1 cm. The use of all the available software [5], [6] and verified data sources is planned including the enlarged set of GNSS/levelling data, gravimetric measurement data and, additionally, the vertical deflection measurements over the territory of Latvia. Digital Zenith Camera has been developed recently at the Institute of Geodesy and Geoinformatics.

ACKNOWLEDGEMENT

The research was carried out in the frame of ERAF activity 2.1.1.1. „Support science and research”. Project "One centimeter accuracy Latvian geoid model for GNSS measurements" Nr.2014/0039/2DP/2.1.1.1.0/14/APIA/VIAA/012.

[1] Ellmann A., Considerations on the further improvements of regional geoid modeling over the Baltic countries, Geodezija ir Kartografija, 2012, Vol. 36, Issue 1, pp. 5-15

[2] Hirt C., RTM Gravity Forward-Modelling Using Topography/Bathymetry Data To Improve High-Degree Global Geopotential Models In The Coastal Zone,Marine Geodesy, 2013, Vol. 36, Issue 2, pp. 1-20

[3] Janpaule I., Methods for the determination of high precision Latvian geoid model, Summary of the Doctoral Thesis, RTU, 2013, p. 24

[4] Jäger R., Kaminskis J., Strauhmanis J., Younis G., Determination of Quasi-geoid as Height Component of the Geodetic Infrastructure for GNSS Positioning Services in the Baltic States, Latvian Journal of Physics and Technical Sciences, 2012, Vol. 3, pp. 5-15

[5] Jäger R., DFHRS (Digital FEM Height Reference Surface), A Rigorous Approach for the Integrated Adjustment and Fitting of Height Reference Surfaces, Forschung aktuell, Karlsruhe: Hochschule Karlsruhe Technik und Wirtschaft, 2007, pp. 78-82

[6] Sjöberg L.E., Hunegnaw A., Some modifications of Stokes' formula that account for truncation and potential coefficient errors, Journal of Geodesy, 2000, Vol. 74, Issue 2, pp. 232-238

HEMP THERMAL INSULATION CONCRETE WITH ALTERNATIVE BINDERS, ANALYSIS OF THEIR THERMAL AND MECHANICAL PROPERTIES

MARIS SINKA[1], GENADIJS SAHMENKO[1], ALEKSANDRS KORJAKINS[1], LIGA RADINA[1], DIANA BAJARE[1]

[1]Institute of Materials and Structures, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
E-mail: maris.sinka@rtu.lv

As the construction industry produces one of the highest CO_2 amounts among all sectors, it is necessary to develop more sustainable building materials – with a lot less embodied CO_2 in their manufacturing process. These materials also need to have sufficiently high thermal properties as the energy used in heating of poor thermal performance buildings also contributes to the rising amounts of CO_2. The material that fits both these descriptions is hemp-lime concrete.

Hemp-lime concrete consists of filler – hemp shives – the core of the hemp stalk that is an industrial by-product of hemp fibre production and of binder – usually natural or artificial hydraulic lime. It is used as self-bearing thermal insulation material usually together with the structural timber frame. It can be installed and used in various forms – blocks, slabs, prefabricated panels, in-situ moulding or spraying, loose for horizontal surfaces.

Hemp-lime concrete is a carbon negative material due to the fact that both the filler and the binder take up CO_2. Hemp shives take up carbon dioxide in the growing process of the hemp stalk and lime takes up the CO_2 in the hardening process – carbonization. 1 m^3 of hemp-lime concrete wall takes up about 120 kg of CO_2 and requires 1480 MJ of energy to produce, while the cellular Portland cement concrete wall releases about 192 kg of CO_2 and needs 2200 MJ of energy [1].

Another main advantage is the hygrothermal performance of the material. It has low thermal conductivity – 0.06 to 0.1 W/(m*K) depending mainly on the density – which reduces the heat diffusion through the building envelope. The material has also high moisture buffering capacity which can improve the indoor hygrothermal comfort – high moisture transfer – about $2.5 * 10^{-11}$ kg/(m*s*Pa) and high moisture buffer value – 2.15 g/(m^2 %RH). It has been shown that the material reduces daily indoor relative humidity variations [2].

The scope of this paper is to research the effect of hardening conditions on hemp-lime concrete chemical composition, mechanical and thermal properties. The hardening conditions in question are moisture, temperature and CO_2 amount, as it has been spotted during the previous tests that by hardening the sample in high moisture and low CO_2 concentration environment, the mechanical properties are weaker than of those samples that cured in relatively lower moisture conditions. This does not match other authors' conclusions [3] and the knowledge that hydraulic material should harden under increased moisture.

A series of tests that included various hardening conditions were performed, thermal conductivity, compressive and flexural strength were tested, as well as the chemical composition of the samples was acquired. After the tests the conclusions about most suitable hardening conditions were given.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement “INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH”.

[1] Walker N., Pavia S., Moisture transfer and thermal properties of hemp–lime concretes. Construction and Building Materials, 2014, pp. 270–276
[2] Rahima M., Douzanea O., et al., Characterization of flax lime and hemp lime concretes: Hygric properties and moisture buffer capacity, Energy and Buildings, 2015, pp. 91–99
[3] Arizzia A., Cultroneb G., Brümmerc M., Vilesa H., A chemical, morphological and mineralogical study on the interaction between hemp hurds and aerial and natural hydraulic lime particles: Implications for mortar manufacturing, Construction and Building Materials, 2015, pp. 375–384

CONSOLIDAITON PROPERTIES OF SLUDGE FROM LIEPAJA'S KARAOSTAS CHANNEL

PETERIS SKELS[1], KASPARS BONDARS[1], JANIS TERAUDS[2]
[1]Department of Civil Engineering, Riga Technical University, Riga, Latvia
[2]SIA "BGS", Riga, Latvia
E-mail: peteris.skels@gmail.com, kaspars.bondars@rtu.lv

HELCOM recognised Liepaja' Karaosta (Warport) as one of the most polluted place in the Baltic Sea region already in 1992. The waterway's bed is covered with 0.1 to 2 meter thick layer of polluted sludge with heavy metals, hydrocarbons, oil products and other chemical substances. The canal area is 780000 m², and the approximate volume of the polluted sludge is 700000 m^3.
Therefore, already in 2001 the sheet pile wall was constructed in the Eastern part of canal as a planned deposition area of about 6 ha territory. There has been an extensive consolidation properties testing of the sludge specimens both in SIA "UNICONE" and "GEOS constructive testing" laboratories in 2011. Series of oedometer tests were conducted giving remarkable amount of data about the sludge consolidation properties. However, the test data has been used incompletely and this study focuses on data interpretation and usage in consolidation modelling software such as GGU-Consolidate and PLAXIS.

WAVE PHASE-SENSITIVE TRANSFORMATION OF 3D-STRAINING OF MECHANICAL FIELDS

ILYA SMIRNOV [1,2], ANATOLY SPERANSKIY[1]
[1]Advanced Vector Analytics SIA, Riga, Latvia
[2]Lomonosov Moscow State University, Moscow, Russia
E-mail: ilyas@ava-labs.com, isminov@cs.msu.ru, vibro-vector@yandex.ru

The area of the research is oscillatory processes in elastic mechanical systems. Technical result of innovation is the creation of spectral set of multidimensional images which reflect time-correlated three-dimensional vector parameters of metrological, and/or estimated, and/or design parameters of oscillations in mechanical systems. Reconstructed images of different dimensionality integrated in various combinations depending on their objective function can be used as homeostatic profile or cybernetic image of oscillatory processes in mechanical systems for an objective estimation of current operational conditions in real time.

Our presentation will give the mathematical basis of a new method of measurement and processing of trajectory data, using the approach trajectory profiles in the example experiment of wave propagation in construction, placed on two supports, as well as analytical expected results and confirmation of the results obtained by the experiment.

The innovation can be widely used to enhance the efficiency of monitoring and research of oscillation processes in mechanical systems (objects) in construction, mechanical engineering, acoustics, etc.

APPLICATION OF HEMP HURDS FOR PREPARING OF BIOCOMPOSITES

JULIA CIGASOVA[1], NADEZDA STEVULOVA[1], IVANA SCHWARZOVA[1], ALENA SICAKOVA[1], JOZEF JUNAK[1]

[1]Institute of Environmental Engineering, Faculty of Civil Engineering, Technical University of Kosice, Kosice, Slovakia

E-mail: nadezda.stevulova@tuke.sk

Hemp is a controversial bio product with promising performance as a sustainable building material. The fact that hemp is an organic, natural product makes it highly relevant in the present reality of global pollution and struggle for coping with planetary warming. The construction sector is among the leading industries when it comes to energy consumption and release of CO_2 and is responsible for great amounts of waste and pollution. The researching and implementation of sustainable building materials is a crucial necessity in modern times. Hemp (Cannabis sativa) is an agricultural crop that can be used as a building material in combination with conventional or alternative binders. Hemp composites have many advantages as a building material but it is not load-bearing and must be used in combination with a load-bearing wooden frame. Despite this disadvantage the hemp composite materials offer several of appropriate properties, namely: low density, good thermal insulation, antiseptic and breathability.

This paper studies the possibility of preparing the lightweight composites based on hemp hurds. The properties of hemp composites are characterized by mechanical and physical methods

COMPOSITION AND PROPERTIES OF THE HIGH-PERFORMANCE CONCRETE FOR RAILWAY SLEEPERS

OLGA SMIRNOVA[1]
[1]Department of Building Materials and Technology, Petersburg State Transport University, Saint-Petersburg, Russia
E-mail: smirnovaolgam@rambler.ru

The paper presents the recommendations on the production of precast prestressed reinforced concrete constructions (railway sleepers) with double turnover forms per day by using the integrated approach, involving the use of ordinary raw materials, effective modifiers of concrete structure, low-temperature of heat-steaming treatment. Such concretes should provide the required transfer strength (strength at the moment of release tension bars) in the relatively short time of 10–12 hours. The obtaining of high-performance concrete for sleepers in the conditions of the existing technological equipment of domestic plants requires the implementation of the following measures: increasing the density of cement stone due to the use of water-reducing admixtures, improving the structure of concrete due to the use of low heat-steaming treatment, the account of activity of Portland cement at low temperature of heat-steaming treatment, use of active mineral component.
The paper presents the recommendations on the quantity of polycarboxylate-based water-reducing admixtures, the activity of Portland cement after the low-steaming treatment, the compatibility of cement with admixtures, the mode and temperature of the low-steaming treatment, the type and quantity of active mineral component.

MODIFICATION IN CLAY CONCRETE PROPERTIES DURING FLUID FLOW PERMEABILITY MEASUREMENT

FITSUM SOLOMON[1], STEPHEN O. EKOLU[1]
[1]Department of Civil Engineering Science, University of Johannesburg, Auckland Park 2006, Johannesburg, South Africa
E-mail: fitsummoa@gmail.com

In this paper, two methods consisting of triaxial water permeability and water penetration were used to evaluate changes occurring in the pores of clay concretes, during the tests. Triaxial permeability is generally used for the concrete with higher permeability while the concrete with very low permeability is suited for the penetration method.
Clay concrete specimens of 0 to 40% clay content were used in the study. The concrete mixes had water-to-cementitious ratios (w/cc) of 0.70, 0.75, 0.80, 0.85, and cementitious content 380 and 450 Kg/m^3. The results show that the concrete gains moisture during wetting at a much faster rate than it loses during subsequent drying. This could be explained by the contribution of suction pressure created upon drying. When water penetration pressure is applied, more water is driven into pore space than could be responsible for changing the network of the voids. The pore structure during drying may certainly be different in size and shape than its form during wetting, leading to a consequent effect on the permeability of the clay concretes. The modification could be one reason that the moisture gain percentage in clay concretes was higher than in normal concretes.

PERMEABILITY OF CLAY CONCRETES

FITSUM SOLOMON[1], STEPHEN O. EKOLU[1]
[1]Department of Civil Engineering Science, University of Johannesburg, Auckland Park 2006, Johannesburg, South Africa
E-mail: fitsummoa@gmail.com

This paper presents an investigation on the effect of clay addition on water permeability and air permeability of concretes. Clay concrete mixes consisted of 0 to 40% clay content incorporated as cement replacement. Flows methods using triaxial cells and air permeameters were used for measuring the injected water and air flows under pressure. It was found that, the higher the clay content in the mixture, the greater the permeability. At higher water-cementitious ratios, the paste matrix is less dense and easily allows water to ingress into concrete. But at high clay contents of 30 to 40% clay, the variation in permeability was significantly diminished among different concrete mixtures. The obtained results also show that water permeability was higher than air permeability. However, further work is needed to determine the causes of the observed differences in air and water permeability results.

IMPACT OF WETTING/OVEN-DRYING CYCLES ON THE MECHANICAL AND PHYSICAL PROPERTIES OF BIRCH (BETULA SPP.) PLYWOOD

MARKO SOORU[1], KAIDO KASEPUU[1], REGINO KASK[1], HARRI LILLE[1]
[1]Institute of Forestry and Rural Engineering, Estonian University of Life Sciences, Tartu, Estonia
E-mail: harri.lille@emu.ee

The objective of this study was to explore some physical and mechanical properties of the moisture resistant birch (Betula spp.) plywood after 7 cycles of soaking/oven-drying. The experiments were made with 8 series (minimum numbers of specimens in a series were twelve). The specimens were cut from the board with the thickness of 12 mm in the following directions: one in the longitudinal (major) axis and the other in the transversal (minor) axis.

The properties to be determined were BS (bending strength), MOE (modulus of elasticity in bending), JH (Janka hardness). The moisture content of specimens was altered by soaking during 24 hours and drying in a climate chamber. The study consisted of 3-point bending tests and static hardness tests carried out with the INSTRON Universal Testing System 3369; the optical gauge (Advanced Video Extensometer 2663-821) measured deflection.

The sensitivity of the measured data was studied and the expanded uncertainties of the computed mean values are presented. An analytical equation was used for approximation of the change in the physical and mechanical properties of the specimens depending on the number of cycles. It was shown that the number of soaking and drying cycles affected BS, MOE and JH values and they decreased from 4% to 10% from the initial ones.

SURFACE TREATED NATURAL FIBRES AS FILLER IN BIOCOMPOSITES

IVANA SCHWARZOVA[1], NADEZDA STEVULOVA[1], EVA SINGOVSZKA[1], EVA TERPAKOVA[1]

[1]Department of Material Engineering, Institute of Environmental Engineering, Faculty of Civil Engineering, Technical University of Kosice, Slovakia

E-mail: ivana.schwarzova@tuke.sk

Biocomposites based on natural fibres as organic filler have been studied for several years because traditional building material such as concrete is increasingly being replaced by advanced composite materials. Natural fibres are a potential replacement of glass fibres in composite materials. SInherent advantages such as low density, biodegradability and comparable specific mechanical properties make natural fibres an attractive option. However, limitations such as poor thermal stability, moisture absorption and poor compatibility with matrix are challenges that need to be resolved.

The primary objective of this research was to study the effect of surface treatment on the properties of natural fibres and composite materials made thereof. Industrial hemp fibre is one of the most suitable fibres for use in composite materials because of its good specific properties, as well as it being biologically degradable and CO_2 neutral. However, improving interfacial bonding between fibres and matrix is an important factor in using hemp fibres as reinforcement in composites. In order to improve the interfacial bonding, modifications can be made to the hemp fibres to remove non-cellulosic compounds, separate hemp fibres from their bundles, and modify the fibre surface.

FEASIBILITY OF INTEGRATED INSULATION IN RAMMED EARTH

CLAYTON STONE[1], MAGDALENA BALINTOVA[1], MARIAN HOLUB[1]
[1] Institute of Environmental Engineering, Civil Engineering Faculty, Technical University of Kosice, Kosice, Slovakia
E-mail: marian.holub@tuke.sk

The Building Codes in Europe stipulate strict thermal performance criteria which any traditional rammed earth recipe cannot meet. This does not infer that the material itself is inferior – it has many other face saving attributes such as low embodied energy, high workability, sound insulation, fire resistance, aesthetics, high diffusivity and thermal accumulation properties. The paper experiments with the notion of testing integrated insulation, to achieve the 0.22 ($W.m^{-2}$) overall coefficient of heat transfer for the walls required by the Slovak standards of 2015, without covering the wall with thermal insulation or using technologically complex interstitial insulation. This has the added aesthetic benefit of leaving the earth wall exposed to the external environment. The results evaluate the feasibility of this traditional approach.

INTRINSIC HYDROPHOBICITY OF RAMMED EARTH

MARIAN HOLUB[1], CLAYTON STONE[2], MAGDALENA BALINTOVA[1], RATISLAV GRUL[3]

[1] Institute of Environmental Engineering, Civil Engineering Faculty, Technical University of Kosice, Kosice, Slovakia
[2]Building Construction Laboratory, Faculty of Civil Engineering, Technical University of Kosice, Kosice, Slovakia
[3]External relation and marketing office, Faculty of Civil Engineering, Technical University of Kosice, Kosice, Slovakia
E-mail: marian.holub@tuke.sk

Rammed earth is well known for its vapour diffusion properties, its ability to regulate humidity within the built environment. Rammed earth is also an aesthetically iconic material such as marble or granite and therefore is preferably left exposed. However exposed rammed earth is often coated with silane/siloxane water repellents or the structure is modified architecturally (large roof overhangs) to accommodate for the hydrophilic nature of the material. This paper sets out to find an optimal hydrophobicity for rammed earth based on natural composite fibres without adversely affecting the vapour diffusivity of the material. The material is not required to be waterproof, but should resist driving rain. The results evaluate the feasibility of this approach.

BEHAVIOUR OF STEEL ARCH STABILIZED BY A TEXTILE MEMBRANE

ONDREJ SVOBODA[1], JOSEF MACHACEK[1]
[1]Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic
E-mail: ondrej.svoboda.4@fsv.cvut.cz

Behaviour of the slender steel arch supporting textile membranes in a membrane structure with respect to in-plane and out-of plane stability is investigated. In the last decades the textile membranes are widely used to cover both common and exclusive structures due to the progress of new membrane materials with eminent properties. Nevertheless, complex analysis of such membranes in interaction with steel structure (carbon/stainless steel perimeter or supporting elements) is rather demanding, even with specialized software.

Laboratory model of a large membrane structure simulating a shelter roof of a concert stage was tested and the resulting stress/deflection values are presented. The model of a reasonable size was provided with prestressed membrane of PVC coated polyester fabric Ferrari® Précontraint 702S and tested under various loadings. The supporting steel structure consisted of two steel arch tubes from S355 grade steel and perimeter prestressed cables.

The stability behaviour of the inner tube was the primary interest of the investigation. The SOFiSTiK software was used to analyze the structural behaviour in 3D. Numerical non-linear analysis of deflections and internal forces of the structure under symmetrical and asymmetrical loadings covers various membrane prestressing and specific boundary conditions. The numerical results are validated using the test results.

Finally, the preliminary recommendations for appropriate numerical modelling and stability design of the supporting structure are presented.

MODELLING FLOOD LOSSES TO BUILDINGS: RELATIONSHIP BETWEEN ROOM DIMENSIONS AND DEPTH OF FLOODING

MARTIN TUSCHER[1], TOMAS HANAK[1]
[1] *Faculty of Civil Engineering, Brno University of Technology, Brno, Czech Republic*
E-mail: tuscher.m@fce.vutbr.cz, hanak.t@fce.vutbr.cz

This paper discusses the evaluation of flood losses to buildings using loss curves. The objective of the research was to ascertain whether there is a relationship between the depth of flooding and the amount of unit loss set with regard to the impact of room dimensions. The research was conducted on a sample of 154 model situations for two different room shapes. The results confirm that the depth of flooding, considered in the context of the impact of room dimensions, has an influence over the accuracy of setting the amount of loss, and that the significance of this influence increases with increasing depth. These results can help achieve a more accurate evaluation of flood losses using loss curves or indicators when settling, for example, insurance claims filed in consequence of large-scale flooding.

EVALUATION OF SAFETY, QUALITY AND PRODUCTIVITY IN CONSTRUCTION

MUMTAZ USMEN[1], MARTINS VILNITIS[2]
[1]Wayne State University, Detroit, USA
[2]Riga Technical University, Latvia
E-mail: musmen@eng.wayne.edu, martins.vilnitis@rtu.lv

The proposed paper examines the success indicators of construction projects, and covers safety, quality and productivity in terms of their implications and impacts during and after construction. Safety is first considered during construction with a focus on hazard recognition and the prevention of occupational accidents and injuries on work sites. The legislation mandating safety programs, training and compliance with safety standards is presented and discussed. Consideration of safety at the design stage is emphasized. Building safety and the roles of building codes in prevention of structural failures are also covered in the paper together with factors affecting building failures and methods for their prevention.
Quality is introduced in the paper from the perspective of modern total quality management. Concepts of quality management, quality control, quality assurance and six sigma and how they relate to building quality and structural integrity are discussed with examples. Finally, productivity concepts are presented with emphasis on effective project management to minimize loss of productivity, complemented by lean construction and lean six sigma principles. The paper synthesizes the relationships between safety, quality and productivity.

STRENGTHENING UNDER LOAD: EXPERIMENTAL AND NUMERICAL RESEARCH

MARTIN VILD[1], MIROSLAV BAJER[1]
[1] *Institute of Metal and Timber Structures, Faculty of Civil Engineering, Brno University of Technology, Brno, Czech Republic*
E-mail: vild.m@fce.vutbr.cz

The paper presents experimental and numerical research of strengthening of columns under load using welded plates. The experiments were conducted at the laboratory of Institute of Metal and Timber Structures at Brno University of Technology in December 2014. Three sets of three columns each were tested. All columns were 3 m long and loaded by the loading cylinder. The load was transmitted through knife-edge bearings, which ensured pinned boundary condition perpendicular to the weaker axis and fixed perpendicular to the stronger axis. Set (A) were columns with T shaped cross-section welded from flange with dimensions of 140 x 8 mm and web with dimensions of 200 x 6 mm. According to the EN 1993-1-1 [1] classification of cross sections, the columns of set (A) were class 4. Set (B) comprised columns with monosymmetric I shaped cross-section. The flanges had dimensions of 140 x 8 mm and 80 x 8 mm and the web of 200 x 6 mm. This cross-section was class 2. Both sets (A) and (B) had been loaded monotonically until the collapse occurred. Set (C) contained T shaped columns with the same dimensions as the columns in set (A). The columns from set (C) were first inserted into the loading set-up and loaded to 70 kN. The force was held roughly constant and the second flange with dimensions of 80 x 8 mm was welded to the web under the load. The temperature of the column was monitored with thermal imager. After the welding process was finished and the specimen cooled, the column was unloaded to 10 kN and then loaded to failure. The vertical deflection and force at the bottom and the horizontal deflection and strains in the middle of the height were measured in case of all specimens.
The average forces at the collapse of the column sets (A), (B) and (C) were 142 kN, 308 kN and 323 kN, respectively. It was unexpected that the columns strengthened under load (C) had higher resistance than the columns welded without the preload (B). It could be caused by the residual stress and distortion caused by welding. The columns in set (C) started to deflect under the preload but the distortion caused by welding slightly returned the column to the original shape. In addition, the residual stress reduced the compression in the most stressed fibres. Similar behaviour and favourable residual stress distribution caused by welding under the load was observed, among others, at Lehigh University in Pennsylvania [2].
The study includes the results of finite element models of the problem created in ANSYS software [3]. The steel plates were modelled with SHELL 181 element type. Transient analysis case was used and birth and death of elements was used for the strengthening plates. The column was loaded on nodes at the presumed position of knife-edge bearings. First, the whole member with strengthening plates was modelled, modal analysis was performed and the amplitude and shape of initial imperfection were chosen. Then the elements simulating the strengthening flange were killed and the base section was loaded to the preload 70 kN. Then the elements of the strengthening flange were born and the column was loaded by temperature simulating the residual stress and distortion caused by welding. Then the column was unloaded to determine the initial imperfections and then loaded to failure. The force when the yield stress was reached in the most stressed fibres was considered as the elastic resistance and the highest force reached before collapse (last converged load increment) was considered as the plastic resistance.
The results from the experiments and numerical simulations were compared. The numerical simulation serves especially for determining the values, which had not been

measured or are unclear in the experiment. The validated numerical model will serve for the behaviour analysis of members strengthened under the load in the future research.

[1] ČSN EN 1993-1-1 Eurokód 3: Navrhování ocelových konstrukcí – Část 1-1: Obecná pravidla a pravidla pro pozemní stavby. Praha: ČNI, 2006
[2] Nagaraj Rao N. R., Tall L., Columns reinforced under load Welding Journal, 1963, Vol 42, p. 54
[3] ANSYS® Academic Research, Release 15.0, Help System, ANSYS Parametric Design Language Guide, ANSYS, Inc.

DESIGN METHODS FOR LOAD-BEARING ELEMENTS FROM CROSS-LAMINATED TIMBER

AIVARS VILGUTS[1], DMITRIJS SERDJUKS[1], VADIMS GOREMIKINS[2]
[1]Institute of Structural Engineering and Reconstruction, Faculty of Civil Engineering, Riga Technical University, Riga, Latvia
[2] Department of Steel and Timber Structures, Czech Technical University in Prague, Czech Republic
E-mail: aivars.vilguts@gmail.com

Cross-laminated timber is a structural material which during the last years is used for several load-bearing elements. Cross-laminated timber is an environmentally friendly material which possesses a decreased level of anisotropy in comparison with the solid and glued timber. Cross-laminated timber is used for load-bearing walls and plates in multi-storey timber buildings. Cross-laminated timber plates are used for span structures of pedestrian and road bridges.

Design methodology of cross-laminated timber elements subjected to bending and compression with bending is considered. The methodology is based on LVS EN 1995-1-1 and transformed sections method. The presented methodology was checked by the experiment and analytically. Two cross-laminated timber plates with the total thickness of 95 mm were tested at the action of static load. Dimensions of the boards cross-sections for outer and middle layers were equal to 25 x 50 and 45 x 195 mm, correspondingly. All layers were joined together by the polyurethane glue under the pressure of 400 kg/m^2. Pine wood with strength class C18 was chosen as a board's material. The fibre directions of outer layers of boards coincided with the longitudinal axis of the plates. The fibre direction of the middle layer was perpendicular to the longitudinal axis of the plates. Freely supported beam with the span equal to 1.9 m, which was loaded by the uniformly distributed load, was a design scheme of the considered plates. The width of the plates was equal to 1m. Intensities of uniformly distributed loads changed within the limits from 1 to 7.5 kN/m^2. The load was added by the steel pieces with approximate weight of 20 kg each.

The considered cross-laminated timber plates were analysed by FEM method, which is based on using of computational program ANSYSv14. The comparison of stresses acting in the edge fibres of the plate and the maximum vertical displacements showed that the suggested methodology can be used for engineering calculations as the difference between the experimentally and analytically obtained results did not exceeds 20%.

ACKNOWLEDGEMENT
The research leading to these results has received the funding from Latvia state research programme under grant agreement "INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH".

MONITORING TECHNICAL CONDITIONS OF ENGINEERING STRUCTURES USING THE NON-LINEAR APPROACH

VIKTORIJA VOLKOVA[1],
[1]*Construction Department, SHEI National Mining University, Dnepropetrovsk, Ukraine*
E-mail: drvev@mail.ru

Monitoring technical conditions of structural elements in engineering structures, buildings and facilities is one of the ways to improve their reliability and safety. The main objectives of monitoring are to anticipate possible development of damage, occurrence of emergency conditions or to specify emergency modes of operation for investigated objects. With these objectives in view, at the beginning, the responses of the object to permanent and temporary, operational and/or testing effects are recorded. Further, using regression methods, assessment of the characteristics of the object is carried out by numerical simulation.

Conventional methods of monitoring technical conditions are based on the detection of damage in the structure of buildings or facilities during the entire period of their operation. In spite of considerable interest displayed in this issue and a significant number of publications, there is no unity of opinions [1], [3]. These methods differ from each other in sets of values fixed for investigations, the techniques of their recording, transfer and further processing.

Non-linearity of dynamic models of structures stems from geometrical non-linearity, non-linear functioning of construction materials, non-linearity of dissipative forces. Today's rules and regulations for building design expand the scope of application of structures operating in the elastic-plastic stage. Such structures having no damage originally, posses non-linear properties and can be adequately described by non-linear models only. Cracks are one of the most common types of such damage; they can open and then close under operational loads. This type of damage includes: fatigue cracks, which occur near the bolt holes in truss joints; cracks caused by destruction of fragile structural materials; cracks resulting from significant deformation of the structure.

Traditionally, monitoring technical condition of structural elements in buildings and facilities is based on the application of measuring instruments for the survey of deformations and displacement of building structures and ground. The set of the recording equipment, the points of location of individual sensors and the methods of data transmission are assigned individually. According to the experimental data, the basic natural frequency ranges and eigenvibration modes are determined. The next step is to calibrate the initial finite-element model. This approach has gained widespread acceptance. There are, however, a number of significant limitations to its successful application.

The survey of properties of an actual structure is feasible only with a certain degree of approximation. In such cases, one of the major tasks while creating a mathematical model for the supporting structure with the use of modern software is to ensure the possibility to introduce into the model the parameters and characteristics, which would substantiate the results of the field experiments. In this research [2], the authors suggest a method for automatic image classification of a phase-plane portrait to one of the standard classes, as applied to dynamic systems with a small parameter. Particular attention was paid to the behaviour of the integral curves in the vicinity of singular points. Of main interest is the phase trajectory on the plane (y, $\ddot{y}$). In addition, dependence of $\ddot{y}(y)$ is antisymmetrical to the curve of elastic properties in relation to axis $\ddot{y}$. Particularly, phase trajectories $\ddot{y}(y)$ allow for identification of type and degree of non-linearity of the system. It is known that accelerations of points are more sensitive towards deviations from harmonic vibration [2].

Phase trajectories allow to detect the whole set of motions occurring in the dynamic system. The finding of stationary solutions, singular points and limit cycles, investigating their stability, location of areas of attraction of stable stationary modes in the phase space is an issue of the qualitative theory of dynamic systems.

[1] Kerschen G., Past, present and future of nonlinear system identification in structural dynamics, Mechanical Systems, Signal Process, 2006, Vol. 20, Issue 3, pp. 505–592
[2] Volkova V. E., Schneider K., Qualitative theory and identification of dynamic system with one degree of freedom, Applied mechanics, 2005, Vol. 41,Issue 6, pp. 134–139
[3] Worden K., Tomlinson G.R., Nonlinearity in Structural Dynamics: Detection, Identification and Modelling, New-York: Institute of Physics Publications, 2001, p. 678

NATURAL OSCILLATIONS IN WELDED STEEL BEAMS IN THE SPAN STRUTURES OF CONVEYOR GALLERIES

VIKTORIJA VOLKOVA[1], ILLIA SMOLII[1]
[1]Departament of Construction, Geotechnics and Geomechanics,
SHEI "National Mining University", Dnepropetrovsk, Ukraine
E-mail: drvev@mail.ru

The objects of this research are conveyor gallery span structures. These structures are the facilities of the first criticality level. The principal function of the span structures is to provide adequate conditions for transportation of bulk cargoes with the belt conveyors supported by them.

Beam systems are widely used in span structures. They have higher reliability and require less operating expenditures as compared to trusses. Depending on technological requirements, the span structures of conveyor galleries can be installed either even or inclined (10–15°).

Technological loads acting on the structural elements of conveyor galleries are dynamic in nature due to the induced vibrations of the conveyor belt transporting bulk material at various stages of operation. Due to this fact, investigations into dynamic characteristics of the span structures of conveyor galleries are of great significance.

Formerly, when calculating the conveyor gallery structures, the most commonly used method was based on the flat cross-section hypothesis. However, as far as the dynamic behaviour of beams in the span structures is concerned, such approach is rather approximate. The models suggested by Timoshenko and Vlasov have also found wide application.

This article presents the results of numerical simulation of dynamic behaviour of welded metal beams in conveyor galleries. Investigations were carried out for the beams having symmetrical cross-sections and evenly-spaced transversal ribs with various spacing between the ribs in different beams. A simulation was performed for simply supported pin-ended beams. The results were obtained with the use of the SCAD software package and implementation of Lanczos method for dynamic analysis. Rectangular finite element mesh was used in research. The finite elements represented the plates of 100 x 100 mm in size and 20–40 mm thick. According to the standards, it is recommended to analyze 3 to 5 principal modes of vibration. In order to avoid building-up of errors in integration, simulation was carried out for 10 modes of vibration. In further investigations the first 5 modes were used. The obtained results were compared to the available approximate solutions.

BEARING CAPACITY ASSESSMENT ON LOW VOLUME ROADS

ATIS ZARINS[1]
[1]*Department of Roads and Bridges, Riga Technical University, Riga, Latvia*
E-mail: atis.zarins@rtu.lv

A large part of Latvian road network consists of low traffic volume roads and in particular – roads without hard pavement. Unbounded pavements show serious problems in the form of rutting and other deformations which finally lead to weak serviceability and damage of the road structure after intensive exploitation periods. Traditionally these problems have been associated with heavy goods transport, overloaded vehicles and their impact. The study is carried out to find the specific damaging factors causing road pavement deformations and evaluate their prevention possibilities, and to establish conditions that will allow to do it. As the main factor of load, the tire pressure has been set. Two different tire pressures have been used in tests and their impact compared. The comparison is done using the deflection measurements with LWD together with dielectric constant measurements in a road structure using percometer. Measurements were taken in the upper pavement structure layers and in different depths during full-scale loading and in different moisture/temperature conditions. Advisable load intensity and load factors for heavy traffic according to road conditions were set based on the study results.

DRILLING SOIL-CEMENT PILES, WHICH ARE PERFORMED BY DRILLING-MIXING METHOD

NIKOLAI ZOTSENKO[1], YURIY VYNNYKOV[1], VASILIY ZOTSENKO[2]
[1] *Poltava National Technical Yuriy Kondratyk University, Poltava, Ukraine*
[2] *«Fundamentbud – 3», Poltava, Ukraine*
E-mail: zotcenco@mail.ru, vynnykov@yandex.ru, vasnz@rambler.ru

Drilling piles are replacing precast from the construction market. Their advantage is the absence of impact on the existing buildings during construction, wide range of sizes, depth and diameter. Such piles have all advantages of monolithic structures. The greatest effect is achieved when they are used in stable soils above the water table, when elements are based on the incompressible soil. Problems occur if piles are performing in unstable dispersed soils under the water table. During drilling and concreting it is necessary to provide the stability of the well walls. It is possible in two ways: 1) to apply cased pipes during well drilling – pipes are removed and used repeatedly; but it is impossible to remove pipes often; 2) drilling with drilling-mixture and underwater concreting. Those factors are increasing the cost and the time of construction.

The development of the drilling-mixing technology leads to the appearance of the soil-cement piles. It has all advantages of the drilling piles, but it eliminates the problem of the well walls stability. Drilling-mixing technology means that the machine with drilling-mixing head loosens the soil, impregnates it by laitance and mixes. The piles are created from the excavation bottom until the design depth. The movable soil-cement mixture fills wells during all the process. The pile has a cylindrical form with set sizes as the result of the hardness in 28 days. Soil-cement prism strength is reaching σ = 2 MPa in clay loam and σ = 4 MPa in sand (in clay soil strength is lower) with the amount of cement 20% of the amount of the dry soil. The soil-cement strength increases twice after one year. The cost of 1m^3 of such pile is 100$ ± 25% according to the size and conditions of the performance. The feature of the soil-cement pile is that its bearing capacity by the soil is much higher than by the pile material. This is reducing the efficiency of piles. So the main purpose of the research of such piles is to find methods for increasing the strength of the soil cement. During the last 10 years we have made extensive field and laboratory researches. The factors are identified that determine the strength of the soil cement, manufactured by drilling-mixing technology [1].

1. Composition of soils, on which the pile is cut. Classical clay loam and sandy loam are researched; alluvial quartz sand small and dusty; alluvial floodplain sediments (sand, loam peat). At the age 28 days with the amount of cement 20% from the amount of the dry soil, higher strength has soil cement manufactured from small sand (up σ = 6 MPa), and lower – from heavy clay loam (σ = 1,5 MPa).
2. Cement content. Value of the loosened soil in well could take cement less than 20% by weight of dry soil. Soil-cement strength with constant content of cement increase cements of the high grades, but it is irrational. Increase strength to the σ=10 MPa is possibly by preliminary soil removing from leading borehole.
3. Steel reinforcement increases the strength of the piles material up to 2 times.
4. Soil-cement piles manufacturing lower than the ground water table lead to the high water-cement ratio of the mixture. It is much increasing material porosity and reducing its strength. Additional water are removing by the mixture vibrating by the deep vibrators. It is increasing soil-cement strength up twice, accordingly to the vibration time and frequency.
5. In the heavy clay loam, soil-cement strength is increasing up to 30-40% if added sand in the laitance. There are no studies on the impact of chemical reagents on the soil-cement strength.

6. Soil-cement strength is increasing with time, especially if it is manufacturing lower than the ground water table. If it is manufacturing in the dry-air environment part of the strength could be lost.
7. Soil-cement as abnormally high water resistance. Without any additives, its water resistance is W8 - W12, and for small sand - W6.
Dependence "strength – deformability" of the soil-cement is investigated by the “Concrete deformability theory” [2]. There is present practice of using of the soil-cement piles in Ukraine, including the results of long-term geodetic observations for the buildings based on them.

[1] Zotsenko M., Vynnykov Yu., Lartseva I., Shokarev V., Krysan V., Characteristics of manmade stiff grounds improved by drill-mixing method, Proc. of the 15th European Conf. on Soil Mechanics and Geotechnical Engineering “Geothechnics of Hard Soils – Weak Rocks”, Athens, 2011, pp. 1097–1102
[2] Zotsenko M., Vynnykov Yu., Doubrovsky M., Innovative solutions in the field of geotechnical construction and coastal geotechnical engineering under difficult engineering-geological conditions of Ukraine, Proc. of the 18th International Conf. on Soil Mechanics and Geotechnical Engineering, Paris., 2013, Vol. 3, pp. 2645–2648

DAMPING PROPERTIES OF SANDWICH TRUSS CORE STRUCTURES BY STRAIN ENERGY METHOD

MIROSLAW WESOLOWSKI[1], SANDRIS RUCEVSKIS[2],
PAVEL AKISHIN[2], MAREK POLANSKI[3]
[1]Department of Structural Mechanics, Faculty of Civil Engineering, Environment and Geodesy, Koszalin University of Technology, Koszalin, Poland
[2]Institute of Materials and Structures, Riga Technical University, Riga, Latvia
[3]Department of Advanced Materials and Technologies, Military University of Technology, Warsaw, Poland
E-mail: miroslaw.wesolowski@tu.koszalin.pl

Sandwich panel structures having stiff, strong face sheets and low density cores are widely used to support dynamic loads. Assembling light carbon fibre reinforced polymer (CFRP) composite materials with structurally efficient cores offers novel opportunities for lightweight structure development. Sandwich structures with a pyramidal truss core have found many advantages in several branches of industry, including civil engineering, aerospace and automotive. An engineering oriented application of truss core sandwich structures is not limited to their high specific strength and stiffness but also due to superior heat dissipation, vibration control and energy dissipation characteristics. The efficiency of the energy dissipation may be considerably increased by the combination of different constituent materials used in manufacture process. Combining CFRP face layers with an aluminium pyramidal truss core improves the damping performance due to viscoelastic character of carbon fibre composites.

To predict the damping characteristics of pyramidal truss core sandwich panel with CFRP face layers, the strain energy method (SEM) is adopted [1].The measure of the damping is given by the specific damping capacity defined as the ratio of the energy dissipated to the maximum strain energy stored in one cycle of vibration. The SEM is applicable if principles of linear dynamics hold and therefore can be used for low stress amplitudes and moderate damping levels. The limitation of the SEM method is that it uses the undamped mode shapes of the structure to evaluate the energy stored in the vibration cycle. This makes the method approximate but rather accurate for structures with damping less than 2% [2]. The application of the SEM gives the opportunity to include the directional material behaviour of CFRP and also combine energy losses of different constituents. It is so because the SEM assumes that the energy dissipation of the structure is the sum of separable energy dissipations due to individual stress components. The specific damping capacity of the whole sandwich panel is expressed as the sum of energy losses in the carbon face layers and aluminium pyramidal truss core.

Two types of constituent materials were used to manufacture the sandwich panel: unidirectional carbon fibre/epoxy tape and aluminium alloy PA6. The unidirectional carbon fibre tape was used for face layers and the aluminium alloy for the truss core. The truss core members were cut out from an aluminium sheet by means of the water-jet cutting and assembled to form a pyramidal truss. The joints of the pyramidal truss were treated with epoxy thermo set adhesive. The face layers and the pyramidal truss core were connected with the epoxy adhesive and cured in hot press jig. Prior numerical prediction of specific damping capacity of the sandwich panel, the damping properties of the constituent materials were estimated experimentally. A resonance method was applied for free-free flexural and torsion vibration of beams capons cut out from the constituent materials. A scanning laser vibrometer was used for vibration sensing and the Frequency Response Functions (FRFs) preserving. A modal parameters extraction method was applied on FRFs for the damping estimation of constitutive materials.

The procedure for evaluating the damping of the truss core sandwich panel was performed using the commercial finite element software NASTRAN. The natural

frequencies, mode shapes and element properties, such as stresses, strains and volumes were obtained from the Real Eigenvalue Analysis using Lanczos eigensolver. The numerical modal data and the stored element properties were combined with the damping values of constituent materials and post processed using MATLAB software to estimate the specific damping capacity of the whole sandwich panel. The experimental modal analysis was performed on the sandwich panel in order to extract the modal characteristics of the real panel and compare them with the numerical predictions.

[1] Maheri M. R., Adams R. D., Hugon J., Vibration damping in sandwich panels, Journal of Materials Science, Vol. 43, 2008, pp. 6604–6618
[2] Hu B., Finite element analysis of damped vibrations of laminated composite plates, PhD Thesis, McMaster University, 1992