

## PART 2: PROGRAMME PROJECT INFORMATION

### 2.1. Project No. 1

Title	<i>Innovative and Multifunctional Composite Materials from Local Resources for Sustainable Structures</i>		
Project leader's name, surname	Diana Bajare		
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### 2.2. Tasks and deliverables

*(List all tasks and deliverables that were planned for reporting period, list responsible partner organizations, give status, e.g. delivered/not delivered)*

**Target:** *Create and investigate multifunctional materials and composites, including composite materials for sustainable buildings, and bio-materials such as CO<sub>2</sub> neutral or negative fibre composite.*

The Project consists of research divided in three parts each having its own core task to be completed in the framework of NRP IMATEH:

**Core task 1:** *To develop high performance concrete composite materials for infrastructure projects and public buildings, focusing on their permanence (freeze resistance, corrosion resistance, etc.) and sustainability in the local climate in Latvia, which differs from the climate in other European countries with high level of relative humidity and swift temperature fluctuations around 0 °C in winter and autumn, etc.;*

**Core task 2:** *To develop compositions of bitumen composites characterised by economy, environmental friendliness and permanence using lower quality local aggregates, recycled asphalt concrete as well as warm-mix asphalt concrete technologies;*

**Core task 3:** *To develop CO<sub>2</sub> neutral composite materials made from textile plants for use in energoeffective buildings, thus contributing to a comfortable and healthy climate inside the building.*

**Time frame for the core tasks is given in Annexes 1-A, 1-B and 1-C.**

In addition, specific tasks related to completing core tasks of each Project parts are defined in every Period of the Project corresponding to the calendar year.

No.	Tasks	Deliverable	Responsible partner	Status
1.1.	To create production method of high	Production method for innovative and	D. Bajare, Department of	In progress

	performance concrete composites (compression strength >100MPa) for use in infrastructure and public buildings, partly replacing concrete with microfillers having local origin.	advanced cement composite with microfillers materials for infrastructure projects and public buildings (30.09.2015) Annex 1-A	Building materials and Technologies, Institute of Materials and Structures, RTU	
1.2.	To develop recommendation on increase of the corrosion and freeze resistance properties for the concrete produced from the Latvian cement.	Recommendation on increase of the corrosion and freeze resistance properties for the concrete produced from the Latvian cement (31.12.2016) Annex 1-A	D. Bajare, Department of Building materials and Technologies, Institute of Materials and Structures, RTU	In beginning
2.1.	To create production method for high performance asphalt concrete mixes from local low quality components.	Production method for high performance asphalt concrete mixes from low quality components (30.09.2015) Annex 1-B	V. Haritonovs, Centre of Construction Science, RTU	In progress
3.1.	To develop method for production of ecological composite materials from textile plants and local mineral binders.	Method for production of ecological composite materials from textile plants and local mineral binders (30.03.2016) Annex 1-C	G. Sahmenko, Department of Building materials and Technologies, Institute of Materials and Structures, RTU	In beginning
3.2.	To develop and write guidelines for data collection system, which is suitable for heat and humidity migration control in energy-efficient buildings	Guidelines for data collection system (30.12.2017) Annex 1-C	G. Sahmenko, Department of Building materials and Technologies, Institute of Materials and Structures, RTU	In progress

*In case of non-fulfilment provide justification and describe further steps planned to achieve set targets and results*

The planned targets of the NRP IMATEH Project 1 „Innovative and Multifunctional Composite Materials from Local Resources for Sustainable Structures” were fully achieved in the reporting period from 01.11.2014 till 31.03.2015. The planned tasks are completed and the main results obtained.

### **2.3. Description of gained scientific results**

*(Describe scientific results achieved during reporting period, give their scientific importance)*

**Target of Project 1: *Create and investigate multifunctional materials and composites, including composite materials for sustainable buildings, and bio-materials such as CO<sub>2</sub> neutral or negative fibre composite.***

Target of the national programme and this project is to create innovative and sustainable materials (cement, bitumen and fibrous composites) by using local raw materials. Targets set for this reporting period are fully achieved.

**Core task 1:** *Perform research about high performance composite materials for use in infrastructure and public buildings stressing their durability in the Latvian climate.*

**Time frame for the Core task 1 is given in Appendix 1-A.**

**Task for the Period 1:** *To develop production method of high performance cement composite materials (compressive strength >100MPa) for use in infrastructure and public buildings by using local raw materials.*

In Latvia, as well as in Europe and worldwide, one of the most important topicalities in the civil engineering is development of innovative technologies for using in concrete production that help reducing cement consumption in the construction sector not reducing production volume in the same time, namely, sparing cement and other natural resources.

Although since 2008 CEMEX Latvija, introducing the latest technologies that allow to increase amount of alternative fuel up to 45% from total amount of fuel, will reduce amount of CO<sub>2</sub> emission significantly, environmental quality in Latvia will not increase significantly, if the cement consumption will grow proportionally by producing high performance and high-strength concrete with higher cement ration in concrete mix. Therefore, in order to achieve project targets, it has been decided to create high performance concrete mixes with perfect packaging of aggregates.

Cement, which is produced in Latvia, and dolomite aggregates with the local origin are used conducting research on high performance cement composite materials for use in infrastructure and public buildings. In order to obtain high strength (up to 100 MPa) concrete products, one of the methods should be used in concrete mix development: use high strength aggregate (CEM 52.5) and increase its ratio in concrete mix or ensure optimum filler packaging by using not only traditional fillers but microfillers as well.

Aggregate constitutes 60 to 85% from the total volume of concrete mix and it plays an important role ensuring physical and mechanical properties and durability of the concrete. Optimum packaging of aggregate particles including microfillers also ensures desirable rheological properties of concrete (workability, self-compacting properties, etc.) as well as strength and durability of hardened concrete. Modern high performance concrete is nano-material with the properties in macro level determined by extremely dense packaging of C-S-H nano-particles in micro level. Direct connection between packaging of material microstructure and elasticity modulus, mechanical properties and durability of the material has been proven. Two groups of properties can be determined characterising concrete aggregates: granulometric composition and morphological indices of the particles (form, surface roughness, etc.). Well known methods are used for tests of aggregates and fillers, for example, sieving to determine granulometric composition, etc.; methods giving more complete picture about particle form and geometrical sizes are used for microfiller description

in their turn, and they are based on use of optical technique and computer technologies.

Microfillers accumulated as waste of by-products in the production process in the Baltic region are used in research conducted in the framework of this project but the main focus is on research and use of the local materials. One of the main important scientific conclusions in the Period 1 of the project is possibility to increase microfiller reactivity (in relation to pozzolanic reactions) as a result of thermal and/or mechanical processing. The obtained initial data show that sand, which is grinded in disintegrator, is active first 72 h and increase the compressive strength of concrete after 28 day hardening by 10-15%. Processes during the grinding can be related to the changes in the crystalline structure of the materials, which can be completely different for the initial. Changes in the physical and chemical properties of the materials can be observed consequently. Grinding in the disintegrator activates the grinded product by breaking molecular bonds and increasing the specific surface area significantly.

Microfillers in high performance cement composite materials for use in infrastructure and public buildings not only ensure the decrease of necessary amount of cement in order to obtain the planned strength of the concrete but also increase its durability. It is related not only to the optimum filler packaging but also pozzolanic reactions between reactive microfillers and free CaO in the cement, which ensures formation of dense cement matrix. As a result concrete becomes more resistant to the negative impact from the environment. It is also important because CEMEX cement has high content of Na<sub>2</sub>O eq., and the hydrated cement paste of this kind usually is not resistant to alkali silica reactions and therefore is exposed to intense corrosion risks. Therefore one of the main tasks in the Period 2 of the project is to perform durability tests for high performance cement composite materials (compressive strength >100MPa) for use in infrastructure and public buildings from the local raw materials.

In order to develop economically reasonable and technologically applicable production methods for high performance cement composite materials (compressive strength >100MPa) for use in infrastructure and public buildings from local raw materials, information has been collected on the microfillers available in the Baltic region and especially Latvia; the most promising among them were selected with volume and availability corresponding to the needs of sustainable construction.

Aim of the microfiller use is to ensure the reduction of costs per concrete unit, by replacing some determined amount of cement with microfillers in the same time improving physical and mechanical properties of the concrete and increasing its longevity. In addition, benefits in the environment protection are important because decreased cement consumption on the production of cement unit contributes to the decrease of CO<sub>2</sub> emissions and use of non-renewable natural resources for the cement production.

Microfillers of various origin and types were used in the research within this project. Some of the filler, for example, industrial waste such as fly ash or biomass ash, have large specific surface and high reactivity even without pre-treatment of the material, while others, for example, calcined clay, natural aluminosilicates, furnace slag, glass waster, etc., need pre-treatment to use this material as efficient microfiller for concrete. The following technologies are used for efficient microfillers: thermal treatment of the material, grinding of the material (for decreasing the size of particles), thermal treatment and grinding of the material. Based on the obtained results, raw material preparation methods have been developed for the concrete production.

Depending on the type, origin and chemical composition of the material, one of the processing types of their combination was used.

A/S CEMEX Latvija cement and local aggregates were used in the research conducted within this project. 8 different series of concrete mix were prepared, physical and mechanical properties of the mix were determined and longevity tests were started.

***Core task 2:** To conduct a research compositions of bitumen composites, where lower quality local mineral materials, recycled asphalt concrete as well as warm-mix asphalt concrete technologies were used.*

**Time frame for the Core task 2 activities is given in Appendix 1-B.**

***Task for the Period 1:** To develop production method of cost-efficient, ecological and durable bitumen composite mixes by using lower quality local mineral materials.*

As the target of project is rational use of local resources, completion of the Core task 2 is related to the creation of new materials by using raw materials that are not very well known in the production. For example, dolomite is one of the most common sedimentary rocks in the territory of Latvia. Register of construction raw materials deposits currently consists of 2265 deposits and fields of the projected stocks, including 1265 explored fields with the majority (980) being sand and gravel deposits [[http://mapx.map.vgd.gov.lv/geo3/atradnu\\_kadastrs.htm](http://mapx.map.vgd.gov.lv/geo3/atradnu_kadastrs.htm)]. The total explored (A category) deposit volumes for dolomite are about 367 million m<sup>3</sup>, while the unexplored are 1200 million m<sup>3</sup>. Seven biggest among the explored dolomite deposits are *Aiviekstes kreisais krasts, Birzi-Puteli, Darzciems, Iecava, Kranciems, Pertnieki and Turkalne*. [[http://mapx.map.vgd.gov.lv/geo3/PDF\\_faili/Atradnes\\_2004\\_makets\\_1daja.pdf](http://mapx.map.vgd.gov.lv/geo3/PDF_faili/Atradnes_2004_makets_1daja.pdf)].

Although, according to the demands of "Road specifications 2014" this mineral resource as well as crushed gravel have the quality that is too low for use in the asphalt concrete mix for the high intensity roads. For this reason imported and expensive igneous rocks (such as granite, diabase, gabbro and basalt) as well as high strength dolomite are often used as aggregates in the asphalt concrete mixes. According to the existing practical experience, even these high quality aggregates are not fully effective in asphalt concrete mixes and roads exhibit rutting, fatigue cracking and thermal cracking.

Foreign experience on development of bitumen mixes with high exploitation properties by using mineral materials with lower quality was analysed within this project. Based on the information obtained, suitable raw materials for the bitumen composite materials have been selected - Latvian dolomite with lower resistance to crushing and hard bitumen B20/30. Raw materials within this part of research was delivered from SIA „Pļaviņu DM” and Grupa LOTOSS. A (Poland).

Composition (recipe) of composite material was created in laboratory setting using lower quality shiver and hard bitumen B20/30. In addition, the traditional asphalt concrete mix (reference mix) was created from the imported shiver and bitumen B50/70 as well as mechanical and physical properties were determined for the traditional and untraditional (prepared from lower quality mineral materials) mixes.

Technology High Modulus Asphalt Concrete - HMAc, also known as (*Enrobé Modulus Élevé (EME)*) in France and *WMC (Betonasfaltowy o wysokim modulus*

ztywności) in Poland, was selected for the production of bitumen composite materials from lower quality local mineral materials. In order to ensure the resistance of asphalt concrete deformative properties in elevated exploitation temperatures, harder bitumen (B10/20; B15/25; B20/30; B35/50), modified bitumen of highly modified bitumen was used in the mixes. It is planned to ensure workability, fatigue resistance, thermal cracking resistance and appropriate water sensitivity with low pore content (2-5%) and higher bitumen content compared to the traditional mixes. Exploitation property testing methods or „*performance based testing*”, allowing to ensure laboratory setting similar to the real loading conditions on the road r street, were used in the development of asphalt concrete mix (to determine deformative properties and optimize concrete mix). Mixes were developed according to the demands of standard LVS EN 13108-1, allowing to specify mixes with fundamental, performance-based properties.

HMAC type asphalt is intended for use in the lower layers of asphalt concrete pavement and/or binding layers on medium to high intensity roads, airports and other transport areas, where high resistance of the asphalt concrete pavement to deformation and significant fatigue resistance is necessary, for example, on crossroads, public transport stops, etc.

Local dolomite shiver and siftings coming from company SIA „Pļaviņu DM” were selected for production of bitumen composite material with high exploitation properties. Physical and mechanical properties as well as class of properties according to the standard LVS EN 13043 were determined for the dolomite shiver in the laboratory setting. According to the obtained testing results, design of asphalt concrete mix (optimisation of granulometric composition and content of bitumen) were performed in the laboratory setting with Marshall method.

Economic assessment and recommendations for the design, production and laying of bitumen composite in the framework of the project were prepared, based on the obtained results.

***Core task 3: To develop CO<sub>2</sub> neutral composite materials made from textile plants for use in energoeffective buildings, thus contributing to a comfortable and healthy climate inside the building.***

**Time frame of the Core task 3 activities is included in Appendix 1-C.**

***Task for the Period 1:***

*To develop data collection system, which is suitable for heat and humidity migration control in energy-efficient buildings.*

Data collection system, which is suitable for heat and humidity migration control in energy-efficient building, has been developed and created in the Period 1 of the Project to complete the Core task 3.

The developed system of sensors allows to control temperature of constructions and humidity migration control, thus it will be possible to assess the role of the above mentioned factors in the energy-efficiency in the typical Latvian climate (characterised by the wide temperate range during the day and high relative air humidity). It will offer new possibilities to improve the existing and develop new solutions for the use of fibre composite materials as well as recommend them for the wider use in construction sector.

Before starting tasks set for the reporting Period 1, information from the literature sources and internet resources about fibre composite material creation, properties of materials and their control has been summarised. By analysing the obtained information it has been concluded that the existing fibre composite materials, which are made by using hem or flax shives and lime binder, have insufficient insulation characteristics compared to the classic insulation materials, such as mineral wool, extruded polyester, etc. The optimum layer of fibre composite materials layer to ensure the necessary insulation demands is up to two times thicker compared to other, traditional insulation materials. The second negative aspect is the high dependency of the fresh fibre composite material mix on the proportion of shives and binder – higher proportion of binder leads to more durable and heavier materials but its insulation properties are lower.

If the amount of shives is increased, lighter material is obtained that provides better insulation of the building; however, its application possibilities decrease due to the low bearing capacity. Significant disadvantage for the use of textile plants in composite materials intended for construction of energy-efficient buildings in Latvia is its seasonal character. Only 6 months per year the Latvian climate and air humidity are suitable for production of the fibre composite materials on the construction site, over the rest of the year air humidity is high, material does not harden and therefore appropriate strength is not obtained.

Taking into account this information, basic mixes for the production of composite materials, which are suitable for the Latvian climate, were designed by using binders based on lime and special additives. Specimens were produced and hardened in various conditions of controlled environment (temperature, air humidity), their of binding dynamics was detected as well as mechanical and thermal properties were tested. The obtained research data were summarized and presented in conferences and conference proceedings.

In order to determine, what impact the climate has on hardening dynamics of fibre composite materials, data collection system was developed, which is useful for temperature and humidity migration control in buildings constructed from the hem fibre composite materials, its tender and technical specification was prepared and the call for tenders was announced (ID Nr. RTU-2014/202). The procurement resulted in purchase of the necessary system, which was inspected, tested and aprobed in the laboratory setting. Data collection system was installed in the one storey demonstration building located in Ikšķile in cooperation with SIA „ESCO Būve” by the end of the reporting period. Hem composite blocks are produced in the construction site and built-in, their thickness is 500 mm. The obtained data will allow to assess and improve the properties of new fibre composite material.

Taking into account the initial data and the collected information about parameters of temperature and humidity movement in the demonstration building, as well as the existing demands of the Latvian Construction Standard LBN 002-01 „Thermotechnics of Building Envelopes”, development of recommendations and method for the composite material production was started. Demands of LBN 002-01 were analysed to develop recommendations for the standard improvement.

<b>Tasks for Period 1</b>	<b>Main results</b>
1. To create production method of high performance concrete composites (compression strength >100MPa) for use	Production methods. Development of composition, method of preparation of raw materials for concrete production.

<p>in infrastructure and public buildings, partly replacing concrete with microfillers having local origin.</p>	<p>Deliverable: Preparation method for innovative and advanced cement composite with microfillers materials or infrastructure projects and public buildings (in progress).</p>
<p>Efficiency of microfillers and their impact on the physical and mechanical properties of the concrete were determined in the report period (durability parameters will be tested in Period 2). It has been concluded that microfillers (calcined clay and kaolin clay, microsilica, fly ash, etc.) can be used to replace up to 15% of cement mass, thus not decreasing or even increasing compressive strength of the concrete.</p> <p>Each microfiller was processed depending on the physical/chemical properties of the material and its origin. For the microfillers obtained from the raw materials based on aluminum silicates, the optimum curing regime is 700-800° C but the optimum grinding time in planetary mill is 20 min. The above mentioned processing of the material results in maximum reactivity (for values of active SiO<sub>2</sub> and R<sub>2</sub>O<sub>3</sub> content – 1.85 un 32.19% respectively) and the largest specific surface – 16 m<sup>2</sup>/g. Quartz sand grinded in disintegrator lose their reactivity within 72 h, therefore it is important to grind them shortly before adding to mortar. The longer the grinding time of TPP coal ash, the higher is the reactivity of the obtained microfiller; among all tested grinding regimes optimum grinding time was 45 min. Similar results were obtained grinding glass waste. Some of the microfillers do not require specific processing, for example, metakaolin, which is a byproduct coming from production of glass granules in STIKLAPORAS factory, Lithuania.</p> <p>In the Period 1 of the project 8 series with concrete specimens were prepared, replacing 5, 10 un 15% of the cement mass with the prepared microfillers. Each of the series has reference mix, where cement was not replaced with microfillers. Amount of aggregates and fillers and water/cement ration is identical in all tested concrete compositions but constant cone flow was ensured by different amount of plastificator added. Average compressive strength for reference mixes was 72 MPa after 28 day curing in standard conditions. If the amount of cement is decreased by 15%, replacing it with byproducts containing matakaoline, compressive strength does not change; however, replacing 15% of the cement with microsilica, compressive strength of concrete reached 90 MPa, after 28 days thus improving the compressive strength of concrete by 25%. Use of calcined illite clay, coal and biomass ash in the concrete composition decreases the concrete strength. It is planned to continue research in the next period with pozzolanic microfillers coming form A/S CEMEX Latvia.</p> <p>In the second research period it is planned to perform durability tests for the created concrete mixes in order to assess the impact of microfillers on structural changes in material. Research in this fields has been already started in the first period.</p>	
<p>2. To create production method for high performance asphalt concrete mixes from local low quality.</p>	<p>Production methods. Method for high performance asphalt concrete mixes using local components was developed based on High Modulus Asphalt Concrete (HMAC) technology.</p> <p>Deliverable: Production method for high performance asphalt concrete mixes from low quality components (in progress).</p>
<p>Study of High Modulus Asphalt Concrete (HMAC) production and building technology was performed on reporting Period 1. Scientific and practical experience of several European countries (*Belgium, France, Poland, etc.) with regard to the use</p>	



of HMAC technology with low quality mineral materials has been analysed as well as specifications (HMAC technical rules) in these countries. It has been concluded that this technology has proven its efficiency in several countries, which do not have significant resources of high quality mineral materials, like Latvia.

A raw material corresponding to the HMAC technology - dolomite shiver and siftings coming from SIA „Pļaviņu DM” and hard bitumen B20/30 aggregate - was used in the Period 1. Physical and mechanical properties of the raw materials - bitumen and mineral materials - were tested. Bitumen was tested with regard to its softening temperature, needle penetration, brittleness temperature as well as changes in these properties after short-term (imitating production of bitumen composite) and long-term (imitating continuous exploitation) ageing. Mineral material was tested with regard to its granulometry, form, surface roughness (texture), resistance to crushing (abrasiveness), freeze resistance and water absorption. It has been concluded that local dolomite shiver has 1.5-2.5 times lower resistance to crushing compared to imported magmatic or metamorphic mineral material. However, in spite of its low resistance to crushing, local dolomite shiver meets the HMAC standards. Therefore a method, which is based on HMAC production technology, has been developed involving use of local dolomite shiver and siftings as well as hard bitumen B20/30 aggregate for using local mineral material in production of high performance bitumen composite. Calculation of granulometric composition for mineral material was performed. Theoretical composition of bitumen composite was determined consisting of bitumen, aggregate and fractioned mineral materials (development of production method). Experimental mixes have been prepared in laboratory setting. Volume parameters (pores, porosity of mineral frame and pores filled with bitumen) were tested using Marshall method.

In the Period 2 of the project it is planned to perform experimental tests of the deformative properties using exploitation testing methods - wheel tracking test, rigidity and fatigue tests, thermocracking tests as well as water-sensitivity (adhesion of bitumen and mineral material).

3. To develop data collection system, which is suitable for heat and humidity migration control in energy-efficient buildings; guidelines..

Data collection system has been developed.

Deliverable: Method for production of ecological composite materials from textile plants and local mineral binders (in progress).

To reach the target of the project, the necessary data collection system has been developed, tender and technical specification has been prepared in the reporting Period 1. The system, which has been purchased in the tender, has been tested and approved in the laboratory setting, then installed in the demonstration building located in Ikskile thus allowing to assess and improve properties of fibrous composite material.

**The developed and approved device consists of:**

- 5 temperature sensors (temperature measurement range being at least - 50...+50°, ensuring temperature reaction time not exceeding 8 seconds);
- 5 humidity sensors (measurement range being 0...100% humidity, ensuring temperature reaction time not exceeding 8 seconds);
- 1 thermal conductivity sensor (plate with minimum dimensions 180x180, temperature range of work conditions – 40...+80°C);
- set of cables ensuring connecting of all sensors to the data collector sockets;
- data collector/storage which ensures control of the connected temperature,

humidity and heat conductivity sensors, data collection from 11 sensors and sending of the obtained data to the data storage, processing and sending device;

- data storage, processing and sending devices ensuring receiving of the sensor data from the data collector, which stores the data and sends them to the FTP server;
- power source with direct current, stabilized with output current +5V, 3A and input alternating current 230 V, input noise voltage does not exceed 80mV p-p. Power source work temperature range is -20...+70°C;
- structural frame made of plastic, which is shock-resistant and with removable cover. Structural frame is designed for installation of data collector, data storage and power source.

The developed system allows multi-level data collection and transmission - it ensures transmission in mobile network as well as sending to FTP server, where data can be viewed online with an option of visual representation. Data collection, transmission and storage in the FTP server proceeds automatically.

Basic mixes for production of composite materials, which are suitable for the Latvian climate, using binders based on hydraulic lime and special additives, were developed in parallel during the Period 1 of the project. Specimens were prepared, hardened in various controlled environmental conditions (temperature, humidity), binding dynamics was detected as well as mechanical and thermal properties were tested. The obtained research data were summarized and presented in conferences and conference proceedings.

#### **2.4. Further research and practical exploitation of the results**

*(Describe further research activities that are planned, describe possibilities to practically exploit results)*

##### **To achieve the project target, it is planned during the Period 2 of the project:**

- continue durability tests with the high performance cement composite materials (compressive strength >100Mpa) for the infrastructure and public buildings from local raw materials.
- continue developing method for bitumen composite mixes with increased viscosity by using lower quality local mineral materials (production method, method, 1 publication submitted).
- To develop and create data collection system, which is suitable for heat and humidity migration control in energy-efficient buildings.

Within the research Period 2 of the project it is planned to perform durability tests of the cement composite materials - to determine alkali silica reaction resistance, sulphate resistance, freeze resistance, resistance to the destructive impact of chlorides, etc.

Freeze resistance of the concrete specimens was determined according to the Annex of Standard LV 206. Concrete which passed the standard 400 freeze-thaw cycles was tested in 5% NaCl solution; it is characterised as high-quality concrete being able to withstand impact of temperature changes, which is characteristic for the Latvian climate in winters.

Deepness of chloride penetration will be determined according to NT BUILD 492 methods. Ability of the concrete to withstand chloride penetration in the structure of concrete will be detected; it is important in the Latvian climate, especially in areas, where de-icing is used and salty solutions contact concrete surface, thus contributing to the reinforcement corrosion, concrete crumbling and loadbearing capacity loss of the construction. Ability of the concrete to withstand migration of chloride ions is characterised by chloride migration coefficient.

Impact of alkali silica reaction on concrete mixes was determined according to the standard RILEMAAR-2 – method of ultra accelerated mortar prism testing. Alkali silica reaction is based on reaction between alkalis (Na and K ions) in the content of cement and certain SiO<sub>2</sub> minerals, which can be present in the concrete aggregates. The specimens hardened for 24 h are immersed in the 80°C water media for 24 h, then the base length of the specimens was determined. In the next 14 days specimens are exposed to 1MNaOH solution in 80°C. Changes in the specimen dimensions are determined in the test. Test criteria determines the linear expansion limit 0.054% from the initial length of 40x40x160 mm prisms, which is related to the cracking of material structure and can have negative impact on the concrete durability.

Sulphate resistance will be determined according to Annex D of the Standard SIA 262/1 D: "Sulphate resistance". Prismatic specimens (40x40x160 mm) were tested in Na<sub>2</sub>SO<sub>4</sub> solution and changes in mass and length of the specimens was determined after their immersion in the sulphate solution. Under the impact of sulphate solution concrete can increase its volume, crack, lose bonding between aggregate and cement stone, changes in the chemical composition of cement stone can be observed having negative impact on the concrete strength.

In order to conduct a research on bitumen composites, in the Period 2 of the project it is planned to perform experimental tests of the deformative properties of bitumen composite material using exploitation testing methods - wheel tracking test, rigidity and fatigue tests, thermocracking tests as well as water-sensitivity (adhesion of bitumen and mineral material). In addition it is planned to design innovative mixes of bitumen composite material by using the local gravel shiver as well as dolomite shiver from other quarries in order to compare their properties with the traditional types of asphalt concrete;

Designing mixes of bitumen composite material with both various types of local mineral materials and imported traditional mineral materials, it will be possible to compare their properties with traditional types of asphalt concrete and to design bitumen composite material mixes (production methods) by using polymer modified bitumen.

Based on data, which were previously obtained in the laboratory, it is planned to produce high strength bitumen mixes with high RAP (*recycled asphalt pavement*) content (RAP is partially replaced with traditional aggregates used in Latvia);

Summarising the obtained results, it is planned to prepare the economical assessment and recommendations for the designing, production and laying of bitumen composite in the Period 2 of the project.

Core task 3 of the Project Period 2 is to develop data collection system, which is suitable for heat and humidity migration control in energy-efficient buildings.

According to the planned task, after the collection of necessary data from the literature sources and internet resources and its demonstration, studying the requirements related to the installation of temperature and humidity migration control system as well as testing operation of the system in laboratory and making sure that the system performs its measurements correctly, by making measurements, collecting

and sending the data, system of sensors was installed in the demonstration building. Installation of the sensor system in the demonstration building was performed according to the developed methodology and paying attention to the fact that flow of warm air is not changed thus having negative impact on precision of the measurements. Further research direction is related to the testing of data correctness in order to make sure that the chosen sensor installation methodology is correct. As this type of sensor system is installed in the textile plant composite material building constructions in Latvia, it is possible that there are mistakes in the work of the sensor system, humidity penetrates in the sensors if they are installed incorrectly. In this case the system will be repaired by installing it in the conditions that are more suitable and secure for exploitation. In case if the measurements will not be correct due to the humidity in the walls of the composite material, it will be changed by producing walls with lower humidity level; it will be possible by producing constructions in the laboratory setting, not in the construction site; thus decreasing the amount of water necessary for production.

After making sure that the system of sensors work well, it will be possible to use it in other buildings as well, which are constructed using hemp shives with different technology. In the same time, taking into account the obtained data, new hemp composite materials will be designed, by improving the existing physical and mechanical properties.

As it was mentioned previously, the biggest problem in the production of textile plant composites is its slow and insufficient strength improvement over time. It can be related to the fact that fibres release sugar thus delaying hardening of the binder. It is possible to limit sugar release and increase the hardening of binder by limiting humidity in the material or by shortening time of water impact. Thus one of the tasks in the next period is to continue research on the hardening processes of composite materials with textile plants in various humidity and temperature conditions as well as an impact of various additives, delaying release of sugar, on the hardening conditions.

## **2.5. Dissemination and outreach activities**

*(Describe activities that were performed during reporting period to disseminate project results)*

In the project Period 1 of the Project „Innovative and Multifunctional Composite Materials from Local Resources for Sustainable Structures” 11 conference abstracts or publications were prepared:

1. Bumanis, G., Bajare, D., Korjajins, A. Durability of High Strength Self Compacting Concrete with Metakaolin Containing Waste, [24th International Baltic Conference Baltmatrib](#), Tallinn, Estonia, 5.11-6.11.2015;
2. Bumanis, G., Toropovs, N., Dembovska, L., Bajare, D., Korjajins, A. The Effect of Heat Treatment on the Properties of Ultra High Strength Concrete, 10th International Conference Environment. Technologies. Recourses, Rezekne, Latvia, 18.-20.06.2015.
3. G. Sahmenko, N. Pleiko, G. Bumanis, D. Bajare, Effective use of dolomite by-production concrete technology, 2<sup>nd</sup> International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015.
4. V. Haritonovs, M. Zaumanis, R. Izaks, J. Tihonovs, Hot Mix Asphalt with High RAP Content, Funchal, Portugal, 1.09-4.09.2015;
5. V. Haritonovs, J. Tihonovs, J. Smirnovs. Use of low quality aggregates in hot mix asphalt concrete, 6th Eurasphaltand Eurobitume Congress, Prague, Czech Republic, 1.06.-3.06.2016;

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8. M. Sinka, L. Radina, G. Sahmenko, A. Korjakins, D. Bajare, Enhancement of lime-hemp concrete properties using different manufacture technologies, 1st International Conference on Bio-based Building Materials (ICBBM), Clermont-Ferrand, France, 21.06-24.06.2015;
9. M. Sinka, L. Radina, G. Sahmenko, A. Korjakins, D. Bajare, Hemp Thermal insulation Concrete with Alternative Binders, Analysis of their Thermal and Mechanical Properties, 2<sup>nd</sup> International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015;
10. S. Pleiksnis, M. Sinka, G. Sahmenko, Experimental justification for spropel and hemp shives use as thermal insulation material in Latvia, Environment. Technology. Resources, Rezekne, Latvia, 18.06-20.06.2015.
11. V. Obuka, M. Sinka, M. Klavins, K. Stankevics, A. Korjakins, Spropel as Binder: Properties and Application Possibilities for Composite Materials, 2<sup>nd</sup> International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015.
12. J. Baronins, J. Setina, G. Sahmenko, S. Lagzdina, A. Shiskin, Pore Distribution and Water uptake in a Cenosphere – Cement Paste Composite Material, 2nd International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015

#### **Participation in conferences:**

1. D. Bajare participated in the "International Conference on Construction Materials and Structures", **Johannesburg, South Africa, 24-26 November 2014 with an oral presentation.**

#### **5 master's thesis and 2 bachelor's thesis were prepared and defended within Project 1. Master's thesis:**

1. L. Lavnika, „High strength concrete corrosion resistance”;
2. R. Latkovska, „Concrete deterioration in reinforced concrete structures exposed to aggressive environments”;
3. Ofkante, „Hemp fibre composite with clay-lime binder”;
4. Aleksejeva, „Nanodispersed additives in the production of concrete”;
5. J. Jankovskis „The impact of composition and microstructure of high-performance cellular concrete on material properties”.

#### **Bachelor's thesis:**

1. M. Demenkovs, „Design of concrete for protection against radiation”;
2. G. Balahovcs, „Available on the market micro-size composition of cement”.

#### **The following doctoral thesis were written:**

1. U. Lencis „Methodology for use of ultra sound impulse method in assessment of construction strength”, supervisor A. Korjakins, planned to defend in 2015

2. J. Justs „Ultra high performance concrete with diminished autogenous shrinkage technology”, supervisor D. Bajare, planned to defend in 2016
3. J. Tihonovs „Aphalt concrete mixes from the local mineral material with high exploitation properties” supervisor J. Smirnovs, V. Haritonovs, planned to defend in 2017
4. M. Shinka „Natural fibre insulation materials”, supervisor G. Shahmenko, planned to defend in 2017
5. N. Toropovs „Fire resistance of high performance concrete”, supervisor G. Shahmenko, planned to defend in 2016

### **The performance indicators of the programme and project promotion**

Project representatives participated in the NRP IMATEH meetings on the Project progress and implementation on 8.11.2014 and 26.05.2015.

A seminar for students was organised on 27.01.2015 in order to present aims, tasks and benefits related to the NRP Project 1.

In addition, the Project members was working actively organising two scientific conferences in 2015 - IMST „Innovative Materials, Structures and Technologies” on 30.09.2015-02.10.2015 as well as scientific conference for students on 28.04.2015.

To promote the programme, Concrete Contest (Stage 1, concrete preparation competition) will take place on 16.04.2015. Teams of 3 participants will prepare concrete specimens, which will be tested on compression strength after 28 days, determining teams having the strongest specimens. Aim of the concrete contest is to encourage students to practical application of the knowledge obtained in the university and technological development.

Stage 2 of Concrete competition will take place on 12.05.2015, when the winner will be determined among 7 teams testing the specimens on compression strength.

Upon launching the NRP programme IMATEH website was created, where information on programme achievements and activities is constantly updated. On IMATEH website <http://imateh.rtu.lv/> detailed information on projects 1-6 is available as well as information on NRP IMATEH activities and updates.