Scientific report for Period 1

PART 1 – INFORMATION ON PROGRAM

1.1. Title of the program	**Innovative Materials and Smart Technologies for Environmental Safety**
1.2. Program acronym:	**IMATEH**
1.3. Program web page address:	http://imateh.rtu.lv
1.4. Program manager (name, surname, phone, e-mail)**:**	Dr.sc.ing. Andris Cate, +371 26416672, and_cate@latnet.lv
1.5. Contact person (name, surname, phone, e-mail)**:**	Dr.sc.ing. Diana Bajare, +371 29687085, diana.bajare@rtu.lv
1.6. Report for a period	from 01.11.2014 till 31.03.2015

1.7. The aim of the program and objectives:

The aim of the National Research Programme:

> ***Contribute to the creation of world class knowledge base, which would be wide and deep enough for innovation-based economic development involving innovative materials, smart technologies and safe human living environment, by using interdisciplinary approach in solving of scientific, technologic and social problems.***

National Research Programme (NRP) has a practical orientation; each of its tasks will contribute to the important sectors of the Latvian economy - Construction, Transport, Material Processing. In the same time, the main target of the research programme is to create new knowledge about use of innovative materials to ensure safe living environment, to facilitate technology transfer to the economy by contributing to the restructuration of the national economy according to the smart specialisation strategy for the long-term development in Latvia. In the framework of this programme innovative materials, technologies, recommendations and guidelines will be developed in order to build higher safety level of living environments and to raise competency of the scientists in this area as well as to improve normative acts and standards.

The following tasks have been set to achieve the target:

1. *Create and investigate multifunctional materials and composites, including composite materials for sustainable buildings, and bio-materials such as CO_2 neutral or negative fibre composite;*

2. *Create and investigate multifunctional materials and composites, including modified materials for plywood sandwich panels;*
3. *Develop new methods of risk assessment for buildings and structures to ensure their safe, efficient and sustainable operation.*
4. *Create a layered wood composite with rational structure that provides increased specific bending load-carrying capacity, reduced cost of materials and energy consumption compared to traditional wood-based materials used.*
5. *Develop methods for materials, micro-, nano-scale features and improve the quality of diagnosis;*
6. *Develop a methodology and criteria for optimization of metallic material properties to improve the surface treatment and coating to reduce friction and wear of friction pairs including interaction with metal surfaces and ice.*

The accumulated knowledge in a form of publications, recommendations, technologies, methodology and other scientific documents will be available to producers of construction materials, civil engineers, planners, as well as legislative and supervisory institutions resulting in economic development and direct improvement of human living environment safety for the existing and future infrastructure.

Highly qualified scientific staff from the Riga Technical University (RTU) and the Latvian University (LU) is involved in the NRP. High qualifications of the Programme executors are attested by scientific publications (CVs of the main executors were included in Programme proposal, Annex 1), previous, active and submitted projects (were included in Programme proposal, Annex 2), as well as membership in professional associations and other professional activities (were included in Programme proposal).

Interdisciplinary research is included in the Programme. Main executors come from various scientific directions, such as: Construction Science (Construction Materials and Technologies, Structures); Mechanics (Construction Mechanics); Material Engineering and Mechatronics, Transport (Land Transport and Infrastructure); Material Science (Wood Materials and Technology, High Temperature Materials); Mechanics of Solids, Mechanical Engineering, Chemical Engineering (High Temperature Materials and Plasma Technology).

In order to facilitate development and sustainability of the sector, 11 young scientists, 11 doctoral students and 6 master's students are involved in the NRP, the total number of young scientists being up to 70%. Part of the young researchers has performed their research in the scientific institutions abroad.

In order to increase scientific capacity of the NRP, highly qualified scientific personnel of SIA „D un D centrs" and SIA „Evopipes" is attracted. "D un D centrs" was founded by scientists and engineers coming from the former Riga Aviation University specializing in monitoring and diagnosis systems for civil aviation. The approach of "D un D centrs" to R&D includes three main components: advanced investigation techniques, integrated models of both vibration and other machine's parameters and malfunction tests. Modern data processing techniques provide high effectiveness of measurement and analysis but the testing allows to adopt the diagnosis model and to determine the limits of measured parameters' alterations. „Evopipes" was founded in 2005 for the implementation of the polymer pipe production project in Jelgava, Latvia. At the end of 2008 the company began mass production offering wide range of products. „Evopipes" is the most advanced polymer pipe production complex in Europe, which uses the latest technology achievements, with annual production capacity of 14,000 tons of pipes. The products are tested and verification of their conformity to certain criteria is done in the laboratories of the Riga Technical University and Lithuanian Institute of Power Engineering. Company collaborates with the Riga Technical University, Faculty of Civil Engineering, Institute of Heat, Gas and Water Technology.

Strategic Management Group is established for the scientific monitoring of the Programme. Strategic Management Group consists of the Programme leader and project leaders and at least two internationally renowned scientists who are assessed according to h-index, WoS, SCOPUS or publications in journals of the respective sector validated by the ministry as well as two experts from the respective industry. Two scientists (Professor and Head of Department of Bridges and Special Structures **Gintaris Kaklauskas** from the Vilnius Gediminas Technical University (VGTU) and Director of the Institute of Materials Science, Professor of the Physics Department **Sigitas Tamulevicius**, Kaunas University of Technology (KTU)) and two experts (**Raimonds Eizensmits** Chairman of the LIKA (Latvian Association of Consulting Engineers) Board (Latvia) and **Renars Spade**, Expert of the Ministry of Economics (Latvia) have agreed to be included in the group and their CVs are included in Annex 4 of programme proposal.

The main responsibilities of the Programme leader and project leaders are to plan the cash flow and prepare progress reports and payment requests as well as to demand accounting documents and to summarise data on the activities and results. An option of mutual replacement among the project members is foreseen. Regular communication among the project members is planned to achieve this, especially with the cooperation partners, as well as regular control of the execution of tasks.

Programme leader and project leaders are responsible for time frame completion control, analysis of reasons causing delay and suggestions for improvement, corrections in time frame if necessary as well as timely planning of tenders, monitoring of the document exchange system.

Programme leader is responsible for conclusion of detailed Cooperation agreement with the cooperation partners, coordination and control of performance of the contract as well as respecting of work plan and time frame, timely preparation of progress reports.

Projects leaders (Programme consists of 6 projects) are responsible for achievement of the project targets, development of relevant methodology, detailed assessment of the experimental and theoretical data and corrections in work plan if necessary. Projects leaders are also responsible for timely planning of equipment maintenance and repair works as well as purchases of spare parts.

Executors of the NRP have modern and well equipped laboratories with the exploitation period of equipment being up to 7 years, for example, some of the project executors have participated in the project "Infrastructure Development in the National Research Centre for Nanostructured and Multifunctional Materials, Structures and Technologies", where one of the activities was purchase and installation of the scientific equipment in the Riga Technical University. Involvement of the executors of the Programme in various projects with national and international funding as well as research volume and publications in scientific journals points out the suitability of the existing infrastructure for needs of the NRP. To be able to ensure research sustainability, participants of the NRP have submitted several project proposals to the EU funded project Horizon 2020 *(Apvārsnis 2020)*, for example, in call H2020-

COMPET-2014, COMPET-02-2014, activity RIA, project No. SEP-210135862, acronym FUCOLAS; in call H2020-COMPET-2014, COMPET-11-2014, activity CSA, project No. SEP-210137040, acronym COSMOS2020 etc. Currently information is being gathered and possible partners being identified for submitting proposals to the new Calls for proposals, such as M-ERA.NET, which are open every year, etc.

1.8. Executive summary of the Programme

(max. two A4 pages. Summary of scientific results achieved during reporting period, their scientific and applicational significance)

The planned targets of the NRP IMATEH in general as well as for each project in the framework of the programme 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. Detailed information on the scientific achievements of each Project is given in the Section 2 of this Report,

In the framework of this Programme 29 conference abstracts or full length papers were prepared and accepted during the Period 1 (performance indicators for Project 1 are 12 full length papers, performance indicators for Project 2 are 2 full length papers, for Project 3 − 10 papers or abstracts, for Project 4 – 3 full length paper or abstracts, for Project 5 – 1 abstract, for Project 6 – 1 full length paper or abstracts).

Two papers have been published:

1. I. Paeglite, A. Paeglitis, Dynamic Amplification Factors of Some City Bridges, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol 8, No 12, 2014, 1190-1194;
2. E. Labans, K. Kalnins, Experimental Validation Of The Stiffness Optimisation For Plywood Sandwich Panels With Rib-Stiffened Core, Wood Research, 59 (5), 2014, 793-802.

Programme IMATEH members have participated in the following conferences:

1. Paeglite, International Conference on Structural and Construction Engineering (ICSCE), London, United Kingdom, 22.12-23.12.2014;
2. D.Bajare, "International Conference on Construction Materials and Structures", Johannesburg, South Africa**,** 24-26 November 2014.

In the framework of programme 10 master's thesis and 5 bachelor's thesis have been defended in the Period 1.

As planned, doctoral researchers are involved in the Period 1 of NRP IMATEH. The following theses were prepared in addition to the research planned in the Period 1

1. U. Lencis „Methodology for application of the method of ultrasonic pulses to evaluate the strength of concrete in structures**",** 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 „Asphalt 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 2016I. Paeglite "Impact of moving load on the dynamic properties of bridges", supervisor professor, Dr.sc.ing. J. Smirnovs, planned to defend in 2017;
6. A. Freimanis „Risk assessment of secure, efficient and sustainable bridge constructions", supervisor professor, Dr.sc.ing. A. Paeglitis, planned to defend in 2018;
7. R. Janeliukshtis „Development of damage identification method for the monitoring of technical condition of constructions", supervisor professor, Dr.sc.ing. A. Cate, planned to defend in 2018A. Vilguts "Rational structures of multistorey buildings made of layered glued wood composite", supervisor professor, Dr.sc.ing. D. Serdjuks, planned to defend in 2018
8. G. Frolovs "Calculations of rational structures and elements of structures from wood composite materials", supervisor professor, Dr.sc.ing. K.Rocens, planned to defend in 2017;
9. A. Kukule "Work of plywood board ribs in the conditions with humidity changes", supervisor, professor, Dr.sc.ing. K.Rocens, planned to defend in 2017;
10. O. Bulderberga "Function of mechanical damage detection in polymer composite material: development and study of properties", supervisor A. Aniskevics, planned to defend in 2017
11. E. Labans "Development and improvement of multifunctional properties for sandwich structures with plywood components", scientific supervisor Dr.sc.ing. K. Kalniņš.
12. M. Ķirpļuks "Bio-based rigid polyurethane foam and nano size filler composite properties", scientific supervisor Dr.sc.ing. U. Cābulis.

Patent application P-14-103 „Production method of rib boards" is submitted.

In addition programme members were working actively on organising two scientific conferences taking place in 2015 - IMST „Innovative Materials, Structures and Technologies" 2015, 30.09.-02.10.2015, as well as 56th Scientific and Technical Conference for Students, 28.04.2015 (more information on: http://imateh.rtu.lv/konferences/).

Project representatives have participated in the NRP IMATEH meeting on project progress and implementation on 08.10.2014 as well as attended Innovate UK2014 meeting in London on 04.11.2014 giving an insight/ideas on methods of metal modification in order to improve its slipperiness.

Two seminars were organised on implementation of the programme tasks in the framework of IMATEH: seminar focused on the topics related to the research planned in Project 4 on 19.12.2014, where all interested stakeholders could find out about the conducted research and achievement as well as in order to reach new stakeholders and inform about the upcoming tasks; seminar for students on 27.01.2015 in order to present aims, tasks and benefits related to the NRP Project 1.

To promote the programme, Concrete Contest (Stage 1, concrete preparation competition) will take place on16.04.2015. 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 projects1-6 is available as well as information on NRP IMATEH activities and updates.

Co-funding of the private sector for the projects included in the programmes reaches EUR 185 146.8 in the Period 1. (01.07.2014 - 1.03.2015).

1.9. Results of the programme

Performance indicator	Results	
	Planned	Achieved
Scientific performance indicators		
1. Scientific publications:	2	2
number of original scientific articles (*SCOPUS*)(SNIP>1)	0	0
number of original scientific articles enclosed in magazines of the database *ERIH (A and B)* or in proceeding of conference articles	2	2
number of reviewed scientific monographs	0	0
2. In the framework of the programme:	0	15
number of defended doctoral thesis	0	0
number of defended master's thesis	0	10
number of defended bachelors'	2	5
3. Elaborated methods for establishment of epigenetic effects of selected species under certain biotic and abiotic conditions	0	0
4. Developed in vitro system for cultures in order to conserve protected species	0	0
Performance indicators of the promotion of the programme		
1. Interactive events to promote the process and results of the programme. Target groups should include students and the number of:	5	6
conferences	2	2
seminars	1	1
organized seminars	2	2
popular-science publications	0	1
exhibitions	0	0
2. Press releases	0	29
Economic performance indicators		
1. Amount of private funding attracted to the scientific institution in the framework of the programme, including:	151 000.0	185146.8
1.1. co-funding from the private sector to implement the projects of the programme	115 000.0	37321.0
1.2. income from commercializing the intellectual property created in the framework of the programme (alienation of industrial property rights, licensing,	0	0

conferring exclusive rights or rights to use on a fee)		
1.3. income from contractual jobs that are based on results and experience acquired in the framework of the programme	36 000	147826.0
2. Number of applied for, registered, and valid patents or plant varieties in the framework of the programme:	0	1
in the territory of Latvia	0	1
abroad	0	0
3. Number of new technologies, methods, prototypes or services that have been elaborated in the framework of the programme and approbated in enterprises	0	0
4. Number of new technologies, methods, prototypes, products or services that have been submitted for implementation (signed contracts on transfer of intellectual property)	0	0

In case of deviation from planned justification of deviation and planned activities to mitigate deviation.

The planned targets of the NRP IMATEH in general as well as for each project in the framework of the programme were fully achieved in the reporting period from 01.07.2014 till 31.03.2015. The planned tasks are completed and the main results obtained. Detailed information on the scientific achievements of each Project is given in the Section 2 of this Report,

1.10. List of results of the programme

(*List of publications, conference thesis, etc.)*

Two papers have been published:

1. Paeglite, A. Paeglitis, Dynamic Amplification Factors of Some City Bridges, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol 8, No 12, 2014, 1190-1194.
2. E. Labans, K. Kalnins, Experimental Validation Of The Stiffness Optimisation For Plywood Sandwich Panels With Rib-Stiffened Core, Wood Research, 59 (5), 2014, 793-802.

Programme IMATEH members have participated in the following conferences:

1. Paeglite, International Conference on Structural and Construction Engineering (ICSCE), London, United Kingdom, 22.12-23.12.2014;
2. D.Bajare, "International Conference on Construction Materials and Structures", Johannesburg, South Africa**,** 24-26 November 2014.

List of accepted abstracts or full text papers:

1. Bumanis, G., Bajare, D., Korjakins, A. Durability of High Strength Self Compacting Concrete with Metakaolin Containing Waste, 24th International Baltic Conference Baltmattrib, Tallinn, Estonia, 5.11-6.11.2015;
2. Bumanis, G., Toropovs, N., Dembovska, L., Bajare, D., Korjakins, 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-productin concrete technology, 2nd International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015.
4. 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
5. V. Haritonovs, M. Zaumanis, R. Izaks, J. Tihonovs, Hot Mix Asphalt with High RAP Content, Funchal, Portugal, 1.09-4.09.2015;
6. V. Haritonovs, J. Tihonovs, J. Smirnovs. High Modulus Asphalt Concrete With Dolomite Aggregates, Transport Research Arena Conference -TRA 2016, Warsaw, Poland, 18.04-21.04.2016
7. 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;
8. V. Haritonovs, J. Tihonovs, J. Smirnovs. High Modulus Asphalt Concrete With Dolomite Aggregates, 2nd International Conference „Innovative Materials, Structures and Technologies" IMST 2015, Riga, Latvia, 30.09-02.10.2015.
9. 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;
10. M. Sinka, L. Radina, G. Sahmenko, A. Korjakins, D. Bajare, Hemp Thermal insulation Concrete with Alternative Binders, Analysis of their Thermal and Mechanical Properties, 2nd International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015;
11. S. Pleiksnis, M. Sinka, G. Sahmenko, Experimental justification for sapropel and hemp shives use as thermal insulation material in Latvia, Environment. Technology. Resources, Rezekne, Latvia, 18.06-20.06.2015.
12. V.Obuka, M. Sinka, M. Klavins, K. Stankevics, A. Korjakins, Sapropel as Binder: Properties and Application Possibilities for Composite Materials, 2nd International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015.
13. Labans, E., Kalniņš, K. Experimental Validation of the Stiffness Optimisation for Plywood Sandwich Panels with Rib-Stiffened Core. Wood Research (SNIP 0.764), 2014, Vol.59, Iss.4, pp.793-802. ISSN 1336-4561
14. Kirpluks, U.Cabulis, A.A.Avots, I.Sevastjanova. Flammability of Rigid PU/PIR Foam Insulation from Renewable Resources. European COST MP1105 Workshop of Advances in Flame Retardancy of Polymeric Materials, February 4-6, 2015, Madrid, Spain.
15. Paeglite I., Paeglitis A., Smirnovs J. (2015) The Dynamic Amplification Factor for bridges with span length from 10 to 35 meters. // Journal Engineering Structures and Technologies, 2015, pp.1-8 10.3846/2029882X.2014.996254
16. Paeglite I., Paeglitis A. (2014) Dynamic Amplification factors of some city bridges, ICSCE 2014: XII Interantional Conference on Structural and Construction Engineering, London, United Kingdom, 22-23 December 2014.

17. Freimanis, A., Paeglītis A. (2015) Modeling of traffic loads for bridge spans from 200 to 600 meters.// The Baltic Journal of Road and Bridge Engineering 10 (3)
18. R. Janeliukstis, S. Rucevskis, M. Wesolowski, A. Kovalovs, A. Chate, Damage identification in beam structure using spatial continuous wavelet transform dalībai IMST 2015 - 2nd International Conference „Innovative Materials, Structures and Technologies", 30. septembris – 2. oktobris, 2015, Rīga, Latvija;
19. R. Janeliukstis, S. Rucevskis, M. Wesolowski, A. Kovalovs, A. Chate, Damage identification in beam structure using mode shape data: from spatial continuous wavelet transform to mode shape curvature methods dalībai ICoEV 2015 - IFTOMM International Conference on Engineering Vibration 2015, 7.-10. septembris, Ļubļana, Slovēnija;
20. R. Janeliukstis, S. Rucevskis, M. Wesolowski, A. Kovalovs, A. Chate, Damage identification in polymer composite beams using spatial continuous wavelet transform dalībai BPS 2015 – Baltic Polymer Symposium 2015,16.-18. Septembris, Sigulda, Latvija.
21. A.Vilguts, D.Serdjuks, L.Pakrastins "Design Methods of Elements from Cross-Laminated Timber Subjected to Flexure". Raksts pieņemts publicēšanai starptautiskas konferences "International Scientific Conference - Urban Civil Engineering and Municipal Facilities", 2015, 18.03.15. – 20.03.15., Sanktpēterburga, Krievija.
22. A.Stuklis, D.Serdjuks, V.Goremikins „Materials Consumption Decrease for Long-span Prestressed Cable Roof". Raksts iesniegts publicēšanai 10. starptautiskās zinātniski praktiskās konferences „Vide. Tehnoloģija. Resursi" (Rēzeknes Augstskola, Rēzekne, Latvija, 2015. gada 18. – 20. jūnijs) rakstu krājumā.
23. A.Vilguts, D.Serdjuks, V.Goremikins "Design Methods for Load-bearing Elements from Cross-laminated Timber", 2nd International Conference „Innovative Materials, Structures and Technologies", 30. septembris – 2. oktobris, 2015, Rīga, Latvija;
24. A. Hirkovskis, D.Serdjuks, V.Goremikins, L.Pakrastins "Behaviour analysis of load-bearing aluminium members "Инженерно-строительный журнал", 5 (57), 2015.
25. G.Frolovs, K.Rocēns, J.Šliseris "Comparison of a load bearing capacity for composite sandwich plywood plates" 10. starptautiskā zinātniski praktiskajā konference "Vide. Tehnoloģija. Resursi" Rēzekne, 18.06. – 20.06.2015.
26. G.Frolovs, K.Rocēns, J.Šliseris "Bending Behavior Of Composite Plywood Plates With Cell Type Core" 2nd International Conference „Innovative Materials, Structures and Technologies", Riga, Latvia, 30.09-02.10.2015.
27. A.Kukule, K. Rocēns "Prediction Of Moisture Distribution In Closed Ribbed Panel For Roof" 2nd International Conference „Innovative Materials, Structures and Technologies", Riga, Latvia, 30.09-02.10.2015.
28. Aniskevich, A., Bulderberga, O., Dekhtyar, Yu., Denisova, V., Gruskevica, K., Juhna, T., Kozak, I., Romanova, M. Coloured Reactions and Emission of Electrons towards Early Diagnostics of Polymer Materials Overloading. 2nd International Conference „Innovative Materials, Structures and Technologies, September 30 – October 2, 2015, Riga, Latvia

29. Ž. Butāns, K.A. Gross, A. Gridnevs, E. Karzubova „Road safety barriers, the need and the impact on road traffic accident mechanism" IOP ConferenceSeries: Materials Science and Engineering (MSE)

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 1

Title	***Innovative and Multifunctional Composite Materials from Local Resources for Sustainable Structures***		
Project leader's name, surname	Diana Bajare		
Degree	Dr.sc.ing.		
Institution	Riga Technical University, Institute of Materials and Structures		
Position	Professor		
Contacts	*Phone number*		+371 29687085
	E-mail		diana.bajare@rtu.lv

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_2 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 ^{o}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_2 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 performance concrete composites (compression strength >100MPa) for use in infrastructure and public buildings, partly replacing concrete with microfillers having local origin.	Production method for innovative and advanced cement composite with microfillers materials for infrastructure projects and public buildings (30.09.2015) Annex 1-A	D. Bajare, Department of Building materials and Technologies, Institute of Materials and Structures, RTU	In progress
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 CO2 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_2 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 no 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_2O 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_2 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 alumosilicates, 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]. The total explored (A category) deposit volumes for dolomite are about 367 million m^3, while the unexplored are 1200 million ^{m3}. 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]*. 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 form 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 modules ztywnošci*) 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_2 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 Ikskile 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.

<table>
<tr><th>Tasks for Period 1</th><th>Main results</th></tr>
<tr><td>1. To create production method of high performance concrete composites (compression strength >100MPa) for use in infrastructure and public buildings, partly replacing concrete with microfillers having local origin.</td><td>Production methods. Development of composition, method of preparation of raw materials for concrete production.
Deliverable: Preparation method for innovative and advanced cement composite with microfillers materials or infrastructure projects and public buildings (in progress).</td></tr>
<tr><td colspan="2">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.
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^{o} 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_2 and R_2O_3 content – 1.85 un 32.19% respectively) and the largest specific surface – 16 m^2/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.
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.
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.</td></tr>
<tr><td>2. To create production method for high performance asphalt concrete mixes from local low quality.</td><td>Production methods. Method for high performance asphalt concrete mixes using local components was developed</td></tr>
</table>

<table>
<tr><td></td><td>based on High Modulus Asphalt Concrete (HMAC) technology.
Deliverable: Production method for high performance asphalt concrete mixes from low quality components (in progress).</td></tr>
<tr><td colspan="2">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 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 texting methods - wheel tracking test, rigidity and fatigue tests, thermocracking tests as well as water-sensitivity (adhesion of bitumen and mineral material).</td></tr>
<tr><td>3. To develop data collection system, which is suitable for heat and humidity migration control in energy-efficient buildings; guidelines..</td><td>Data collection system has been developed.
Deliverable: Method for production of ecological composite materials form textile plants and local mineral binders (in progress).</td></tr>
<tr><td colspan="2">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 approbated in the laboratory setting, then installed in the demonstration building located in Ikskile thus allowing to assess and improve properties of fibrous composite material.</td></tr>
</table>

The developed and approbated device consists of:

- 5 temperature sensors (temperature measurement range being at least -50...+50º, 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...+80ºC);
- 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...+70ºC;
- 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_2 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_2SO_4 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 texting 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 form other quarries un 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 of 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 if 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 hep 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., Korjakins, A. Durability of High Strength Self Compacting Concrete with Metakaolin Containing Waste, 24th International Baltic Conference Baltmattrib, Tallinn, Estonia, 5.11-6.11.2015;
2. Bumanis, G., Toropovs, N., Dembovska, L., Bajare, D., Korjakins, 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, 2nd 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;
6. V. Haritonovs, J. Tihonovs, J. Smirnovs. High Modulus Asphalt Concrete With Dolomite Aggregates, Transport Research Arena Conference -TRA 2016, Warsaw, Poland, 18.04-21.04.2016
7. V. Haritonovs, J. Tihonovs, J. Smirnovs, High Modulus Asphalt Concrete With Dolomite Aggregates, 2nd International Conference „Innovative Materials, Structures and Technologies" IMST 2015, Riga, Latvia, 30.09-02.10.2015.
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, 2nd International Conference Innovative Materials, Structures and Technologies, Riga, Latvia, 30.09-02.10.2015;
10. S.Pleiksnis, M. Sinka, G. Sahmenko, Experimental justification for sapropel 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, Sapropel as Binder: Properties and Application Possibilities for Composite Materials, 2nd 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 on16.04.2015. 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 projects1-6 is available as well as information on NRP IMATEH activities and updates.

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 2

Title	***Innovative and multifunctional composite materials for sustainable buildings***	
Project leader's name, surname	Kaspars Kalnins	
Degree	Dr.sc.ing.	
Institution	Institute of Materials and Structures, RTU	
Position	Senior reseacher	
Contacts	*Phone number*	+371 26751614
	E-mail	kaspars.kalnins@rtu.lv

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)

The aim: Development of I-core type birch plywood panels with relative stiffness/strength matching conventional solid plywood. At the same time integrating and improving multifunctionality of sandwich structure in terms of heat /vibration and impact abortion properties.

Time frame for the WP is given in Annexes 2-A.

Work package 1 (Testing of physical properties): Elaboration of physical properties of polyurethane foam for determination of thermal conductivity/vibration and impact absorption for multifunctionality of sandwich I-core panels.

Work package 2 (Virtual simulations): Extension of design methodology for sandwich panel design based on simulations of finite element method and optimisation of obtained physical results. Initial verification of test results and validation of produced prototypes and scale up structures.

Work package 3 (Prototyping and scaling ***up):*** Laboratory scale-up prototyping of developed sandwich panels, extension of chemical composition of polyurethane foam composition for improved adhesion and workability.

Nr	Tasks	Deliverable	Responsible partner	Status
1	1.1 and 1.4 Identification of foam and sandwich mechanical properties up to ultimate failure	Report on material properties	**RTU and KĶI**	In progress
2	2.1 Development of finite element model for sandwich optimum design	Methodology and publications	**RTU**	In progress/ publication in SNIP 0.764
3	3.1 Extension of chemical composition of polyurethane foam	Report on improvement of chemical composition of foams / presentation in scientific workshop.	**KĶI**	In progress/communication at COST action workshop

Tasks allocated for 1st reporting period	Core achievements
WP-1: Elaboration of physical properties of polyurethane foam for determination of thermal conductivity/vibration and impact absorption for multifunctionality of sandwich I-core panels.	Identification of polyurethane mechanical properties up to the ultimate failure.

Initial phase of project focused on extraction of mechanical properties up to failure to be implemented in finite element modelling (FEM). Series of specimens with foam density from 80 to 250 kg/m^3 has been processed by KĶI and mechanically tested (fig.1.) at RTU. Current testing practice limits total compression up to 80% of initial geometry, thus more knowledge of ultimate failure was required for numerical simulations. In order to verify the linear and geometrically/physically non-linear behaviour of polyurethane foams a simple FEM model has been elaborated as shown in fig.2.

Fig.1. Obtained stress strain curves for foams with density of (80 – 250 g/m^3).

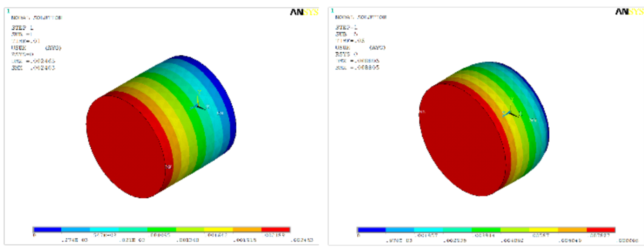

Fig.2. Verification of simplified foam specimen material model by FEM.

WP-2: Extension of design methodology for sandwich panel design based on simulations of finite element method and optimisation of obtained physical results. Initial verification of test results and validation of produced prototypes and scale up structures.	Improved ANSYS numerical model for further analysis of sandwich thermal conductivity vibration and impact absorption properties. Initial verification of concept for design methodology (originally with no foam filling material) with scientific publication.

Throughout the first phase of the project a finite element model in commercially available software ANSYS has been developed (fig.3.) and extended implementation of multiphysical (thermal conductivity / vibration damping / impact resistance) properties of foam. Initial validation of proposed optimum design methodology has been performed by setting a design reference. Obtained results are summarised in article: Labans, E., Kalniņš, K. Experimental Validation of the Stiffness Optimisation for Plywood Sandwich Panels with Rib-Stiffened Core. ***Wood Research*** (SNIP 0.764), 2014, Vol.59, Iss.4, pp.793-802. ISSN 1336-4561

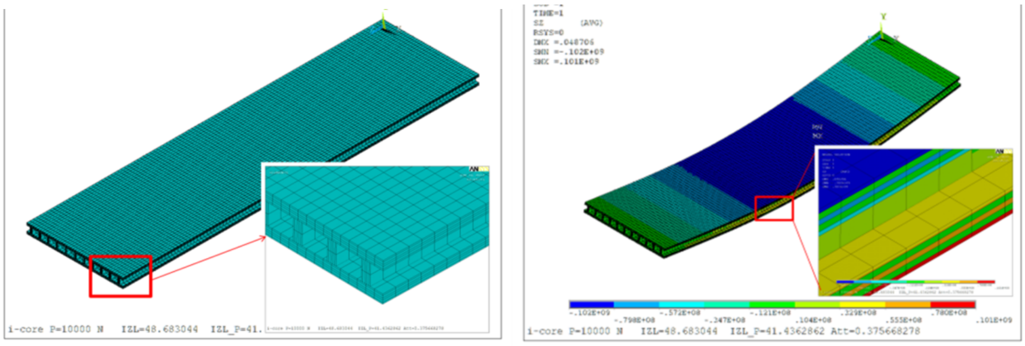

Fig.3. I-core plywood sandwich panel numerical model.

WP-3: Laboratory scale-up prototyping of developed sandwich panels, extension of chemical composition of polyurethane foam composition for improved adhesion and workability.	A series of polyurethane foam specimens have been produced for mechanical testing up to failure. Obtained results presented at COST MP1105 workshop.

Initially in order to systemise polyurethane foam mechanical properties a series of different density (80-150m^3) foams has been elaborated for further tests up to failure. Scientific achievements on improvement of polyurethane foam chemical composition on thermal conductivity has been presented: M. Kirpluks, U.Cabulis, A.A.Avots, I.Sevastjanova. Flammability of Rigid PU/PIR Foam Insulation from Renewable Resources. European COST MP1105 Workshop of Advances in Flame Retardancy of Polymeric Materials, February 4-6, 2015, Madrid, Spain.

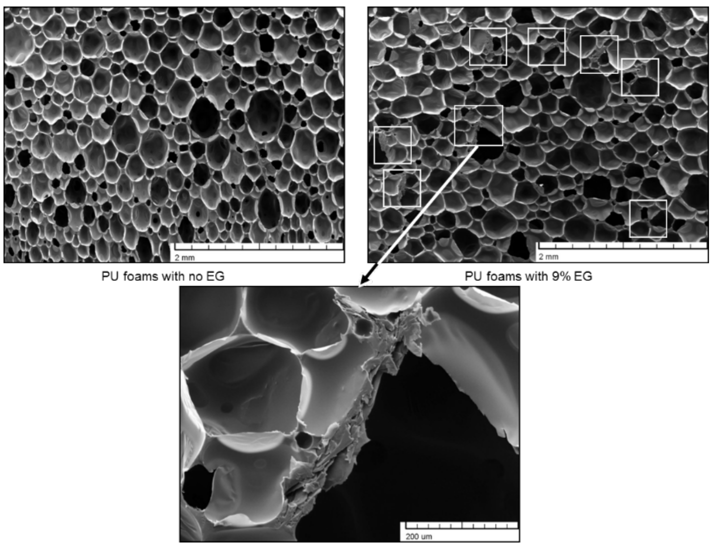

Fig.4. Obtained polyurethane foam with modified chemical composition.

2.3. Description of gained scientific results

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

WP-1: Elaboration of physical properties of polyurethane foam for determination of thermal conductivity/vibration and impact absorption for multifunctionality of sandwich I-core panels.

- Series of various density foam specimens produced exclusively for mechanical tests up to ultimate failure.
- Verification of simplified numerical foam model including linear/ non-linear behaviour.
- Improved FEM based foam mechanical model transferred for I-core sandwich panel design methodology development.

WP-2: Extension of design methodology for sandwich panel design based on simulations of finite element method and optimisation of obtained physical results. Initial verification of test results and validation of produced prototypes and scale up structures.

- Improved finite element commercial code ANSYS model for further simulation of thermal conductivity/ vibration damping and impact resistance models.
- Verification and benchmarking of reference I-core sandwich panel design methodology.
- The concept of design methodology summarised and published in scientific article: Labans, E., Kalniņš, K. Experimental Validation of the Stiffness Optimisation for Plywood Sandwich Panels with Rib-Stiffened Core. Wood Research, 2014, Vol.59, Iss.4, pp.793-802. ISSN 1336-4561

WP-3: Laboratory scale-up prototyping of developed sandwich panels, extension of chemical composition of polyurethane foam composition for improved adhesion and workability.

- Produces a series of various density foam specimens exclusively for mechanical tests up to ultimate failure.
- Initial results on bio-based foam chemical composition influence over thermal properties presented at workshop: M. Kirpluks, U.Cabulis, A.A.Avots, I.Sevastjanova. Flammability of Rigid PU/PIR Foam Insulation from Renewable Resources. European COST MP1105 Workshop of Advances in Flame Retardancy of Polymeric Materials, February 4-6, 2015, Madrid, Spain.

2.4. Further research and practical exploitation of the results

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

WP-1: Elaboration of physical properties of polyurethane foam for determination of thermal conductivity/vibration and impact absorption for multifunctionality of sandwich I-core panels.

- Extraction from series of polyurethane specimens an impact resistance and thermal conductivity properties.

WP-2: Extension of design methodology for sandwich panel design based on simulations of finite element method and optimisation of obtained physical results. Initial verification of test results and validation of produced prototypes and scale up structures.

- Further improvement of finite element I-core sandwich panel design model, implementing material failure criteria.
- Further development of design methodology, based on metamodelling and Pareto optimality – implementing thermal/impact/vibration damping properties
- Numerical model validation with scaled prototype.

WP-3: Laboratory scale-up prototyping of developed sandwich panels, extension of chemical composition of polyurethane foam composition for improved adhesion and workability.

- Extension of knowledge for polyurethane chemical composition – for production of sandwich panel prototype.
- Production of various density specimen series for determination of thermal/impact/vibration properties.
- First prototype production.

2.5. Dissemination and outreach activities

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

Scientific dissemination:

1. Labans, E., Kalniņš, K. Experimental Validation of the Stiffness Optimisation for Plywood Sandwich Panels with Rib-Stiffened Core. ***Wood Research***, 2014 (SNIP 0.764), Vol.59, Iss.4, pp.793-802. ISSN 1336-4561
2. M. Kirpluks, U.Cabulis, A.A.Avots, I.Sevastjanova. Flammability of Rigid PU/PIR Foam Insulation from Renewable Resources. European COST MP1105 Workshop of Advances in Flame Retardancy of Polymeric Materials, February 4-6, 2015, Madrid, Spain.

Designed poster for upcoming major conferences – WIRE 2015 and EuroNanoForum 2015

Incorporation in doctoral thesis research:

1. E. Labans "Development and improvement of multifunctional properties for sandwich structures with plywood components". Scientific supervisor – K. Kalniņš.
2. M. Ķirpļuks "Bio-based rigid polyurethane foam and nano size filler composite properties". Scientifical supervisor – U. Cābulis.

Incorporation in study process:

1. Obtained results and detailed prototyping procedure incorporated in building engineering master study programme subject: modern materials RTU/BKA700.

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 3

Title	***Risk consideration for safe, effective and sustainable structures***		
Project leader's name, surname	Ainārs Paeglītis		
Degree	Dr.sc.ing.		
Institution	Riga Technical University		
Position	Professor		
Contacts	*Phone number*		+371 29269448
	E-mail		ainars.paeglitis@rtu.lv

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: ***Develop new methods of risk assessment for buildings and structures to ensure their safe, efficient and sustainable operation.***

The Project is divided in three parts where each part have its own core task:

Core task 1: *Investigation of the dynamic characteristics of Latvian road bridges and determination of their impact on construction reliability, to develop the new methods for assessment of structural risk, reliability and robustnes;*

Core task 2: *Development of the methodology for experimental acquisition of dynamic characteristics (modal frequencies, mode shapes, modal damping) of structural elements with the presence of damage (different failure modes) for structural health monitoring;*

Core task 3: *To develop innovative smart structure with using of removable natural resources with the increased durability and reliability for structural and infrastructural purposes.*

Time frame for the core tasks is given in Annexes 3-A, 3-B and 3-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.	Modeling of bridge and vehicle interaction, taking into account the type of the vehicle, type of the span structure, and pavement eveness	Method for investigation of vehicle and bridge interaction	A.Paeglitis, Department of Roads and bridges, Institute of Transport infrastructure engineering, RTU	In progress

1.2	Approbation of theoretical probability distribution models of bridge loads in Latvia. Analysis of traffic load data	Method of traffic data analysis	A.Paeglitis, Department of Roads and bridges, Institute of Transport infrastructure engineering, RTU	In progress
2.1	To develop method for localization of damage site and evaluation of damage size in various structural elements by using appropriate signal processing techniques experimentally measured dynamic parameter changes.	Methodology of damage identification in different type of structural elements (beam, plate, sandwich)	S. Rucevskis, Department of Composite Materials, Institute of Materials and Structures, RTU	In progress
2.2	To develop new technologies for monitoring and diagnostics of aviation engines and various elements of rotary machines.	Recommendation on monitoring and diagnostics of dynamic systems.	S. Rucevskis, Department of Composite Materials, Institute of Materials and Structures, RTU	In progress
2.3	To develop method for pre-stress loss estimation in pre-stressed steel reinforced concrete structural elements.	Method for pre-stress loss estimation in pre-stressed steel reinforced concrete structural elements.	S. Rucevskis, Department of Composite Materials, Institute of Materials and Structures, RTU	In beginning
3.1	Data generalization for development of design procedure for load-bearing elements from cross-laminated timber.	The data were generalized for development of design procedure for load-bearing elements from cross-laminated timber during the Period 1. The considered procedures are based on the LVS EN 1995-1-1, effective strength and stifness method and transformed section method.	D.Serdjuks Department of Building Constructions Institute of Structural Engineering and Reconstruction	In progress

Tasks for Period 1	**Main results**
1.1. Modeling of bridge and vehicle interaction, taking into account the type of the vehicle, type of the span structure, and pavement eveness	Method for investigation of vehicle and bridge interaction
1.2. Development of method for	Method for prediction of traffic load

prediction of live load action combinations	combinations

In the first period was caried out the analysis of the dynamic characteristics of the bridges obtained from the bridge load tests with dynamic loads during the last 20 years. The traffic load cause not only a static, but also a dynamic action on the bridge that affect the structural performance. These effects can be indicated by different dynamic parameters like – natural frequency, bridge logarithmical decrement, bridge acceleration and dynamic amplification factor (DAF). Dynamic amplification factor is the most widely used parameter, because it shows amplification of the static effects on the bridge structure. Results show that for bridges road surface condition is a very important factor. If road surface has ice in the winter or potholes then heavy traffic driving with low speed can decrease load carrying capacity of a bridge. In the Eurocode 1 (EN 1991-2:2003 Actions on structures. Traffic loads on bridges) a generalized DAF value should be applied to the worst static load case.

Obtained results show that DAF values for reinforced concrete and pre-stressed concrete bridges does not depend only on span length but there are many other factors that influence DAF. Results show that for bridges road surface condition is a very important factor. If road surface has ice in the winter or potholes then heavy traffic driving with low speed can cause a lot of damage.

Bridge natural frequency did not correlate with the bridge span length for pre-stressed concrete bridges, however for simple concrete bridges there was a tendency for natural frequency to decrease when span length increased. However there were correlation between natural frequency and DAF - for higher natural frequency values DAF values were smaller.

Overall DAF values for even pavement were within range 1,0 to 1,4 and are in the range proposed in the Eurocode 1. Hence proposed values are reasonable for good pavement condition.

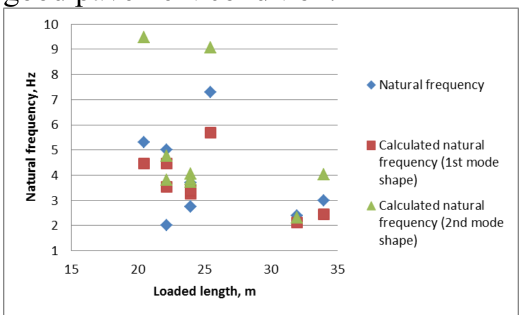

Fig.1 Natural frequency dependence on loaded length

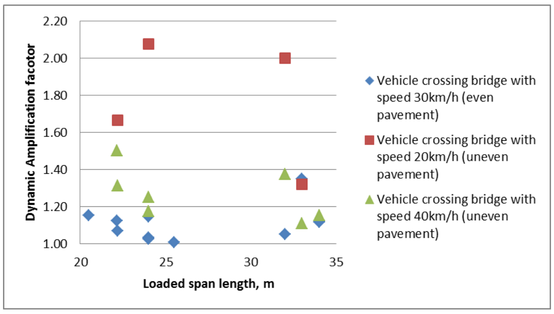

Fig.2 DAF dependence on loaded length

Because of the DAF value correlation with evenness of the bridge pavement, there should be regular bridge maintenance to assure good pavement conditions of all time hence significantly large DAF values can decrease load carrying capacity of the bridge.

Traffic weight data used in this study were collected from two WIM systems installed on highway A1 and A3 in Latvia where truck traffic is one of the highest in country. Vehicles were measured with piezo-electric sensors installed in the surface of the pavement.

In this study comprehensive WIM data cleaning was performed based on four different types of filters. Then cleaned data were used to calculate uniformly distributed loads for 200, 300, 400, 500, 600 meters long bridges spans were calculated.

Load values decrease with an increase in bridge span and a decrease in amount of trucks in traffic flow, although there are some exceptions. They could have arisen because cars that were included in the traffic flow was selected randomly but chronological order was preserved, it is therefore possible that cars have been included in the middle of a long truck platoon, that has been preserved in other scenarios.

If compared to UDL of the most loaded lane in LM1. even the loads calculated from first traffic scenario where traffic flow consists of only trucks in traffic flow are lower than 27 kN/m, the only exception here is A3 Lane1 200 meter span, but that has been addressed in conclusion 2. But it has to be noted that calculated loads have not been increased to provide room for future increase in truck weights.

If load calculated from 7th traffic scenario that simulates traffic flow with only cars in it is compared to the load model's 1 remaining lane loads (7.5 kN/m), it can be seen that calculated load is much lower than the ones currently used, however it would be unreasonable to assume that there would be a lane without any trucks.

These calculated loads still must be compared to loads calculated from specific bridge's influence lines as currently they are only for a case when maximum stresses are achieved with whole deck.

For each highway and lane combination 35 loads were calculated. Loads calculated from A1 data are presented in Figure 2 and Figure 2, loads from A3 – in Figure 15 and Figure 16, also Table 5 shows all of the loads. Scenario 7 was omitted from all figures due to visibility reasons.

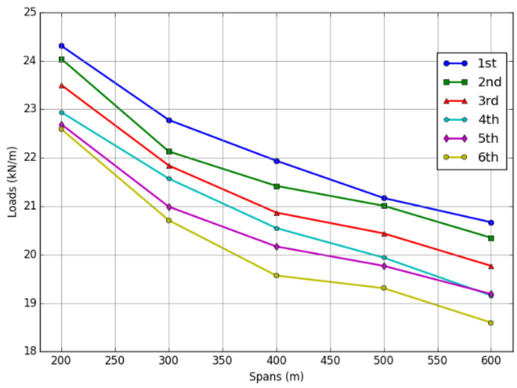

Figure 12. Calculated loads for highway's A1 Lane 1.

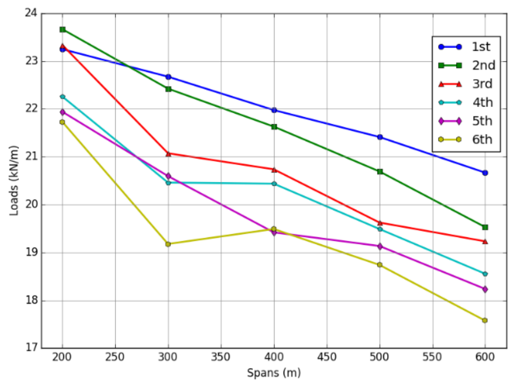

Figure 15. Calculated loads for highway's A3 Lane 2

In this study comprehensive WIM data cleaning was performed based on four different types of filters. Then cleaned data were used to calculate uniformly distributed loads for 200, 300, 400, 500, 600 meters long bridges spans were calculated.

Load values decrease with an increase in bridge span and a decrease in amount of trucks in traffic flow, although there are some exceptions. They could have arisen because cars that were included in the traffic flow was selected randomly but chronological order was preserved, it is therefore possible that cars have been included in the middle of a long truck platoon, that has been preserved in other scenarios.

If compared to UDL of the most loaded lane in LM1. even the loads calculated from first traffic scenario where traffic flow consists of only trucks in traffic flow are lower than 27 kN/m, the only exception here is A3 Lane1 200 meter span, but that has been addressed in conclusion 2. But it has to be noted that calculated loads have

not been increased to provide room for future increase in truck weights.

If load calculated from 7th traffic scenario that simulates traffic flow with only cars in it is compared to the load model's 1 remaining lane loads (7.5 kN/m), it can be seen that calculated load is much lower than the ones currently used, however it would be unreasonable to assume that there would be a lane without any trucks.

These calculated loads still must be compared to loads calculated from specific bridge's influence lines as currently they are only for a case when maximum stresses are achieved with whole deck.

2. To develop damage localization methods for structural elements	Method for damage localization in beam-type structural elements

In the report period studies of experimental evaluation of dynamic parameters (vibration frequencies, modes, damping etc.) for beam-type structural elements and their application to structural health monitoring were carried out. By using appropriate signal processing techniques, dynamic parameters were used for identification of damage – related parameters, such as localization and size of damage, in structural elements. A Wavelet Transform (WT) technique is proposed as a solution to this problem. WT is a mathematical transformation, which represents a correlation between a tested signal and a wavelet function. In case of large correlation, large magnitude WT coefficients are obtained. Largest peaks in plots of WT coefficients vs coordinate of a structure reveal the location of damage. To improve the confidence of algorithm proposed above, a large set of combinations was tested, including all possible wavelet functions at different scale parameters.

In the frame of damage identification algorithm, WT method was compared to the well-known Mode Shape Curvature Squares (MSCS) method, which is based on the fact that a mode shape curvature of a healthy structure is smooth. This smooth surface is obtained through damaged structure's mode shape curvature approximation with a Fourier series functions. The identification of damage was characterized with a so-called Damage Index (DI), which, in case of WT, is equal to the value of WT coefficients, but, in case of MSCS – with an absolute value of difference between squares of mode shape curvature of a damaged structure and its approximation with a Fourier series function. After calculation of DI for every mode shape, this result was normalized to the largest value of DI and summed up for all modes considered in the study. By using the statistical hypothesis approach, DI was standardized, thus yielding a Standardized Damage Index (SDI) and a threshold of 1.28, 2 and 3, corresponding to damage detection confidence of 90%, 95 % and 99%, respectively, was applied. Thresholding of SDI was performed in order to truncate smaller SDI peaks that are misleading in terms of damage location. To quantify the goodness of damage identification for every wavelet, an additional term, called Damage Estimate Reliability (DER) was calculated. DER represents the average cumulative SDI value in the zone of damage divided by this value in 3 zones – zone before damage, zone of damage and zone after damage. DER result is expressed in percentage. WT method requires the analysis of wavelet function performance (in terms of DER) at every scale, thus finding the optimum scale that yields the best damage identification results, therefore an extensive study of DER vs scale behaviour for different wavelets was conducted. An additional study of the influence of number of mode shape input data points on DER values was performed. This was done in order to estimate the density of embedded sensor grid in a real time situation if structure was equipped with one.

Mode shapes were also numerically simulated in FEM commercial software ANSYS. Geometry and material properties of tested samples were taken onto account. Zone of damage was simulated by reducing the thickness of the sample. Experimentally measured signals naturally contain some level of noise, therefore, in order to assess the sensitivity of methods to noisy experimental data, numerical mode shapes were corrupted with an artificial noise of different intensity levels.

WT and MSCS methods were tested on the following samples:

1. two aluminium beams of different length, containing single mill-cut damage;
2. the same two aluminium beams, containing 2 sites of mill-cut damage;
3. two polymer composite beams of different length, containing single low-velocity impact damage.

All calculations, including DI, SDI, DER, etc. for both methods were performed using MATLAB software.

Task for Period 1	Main results
3. Data generalization for development of design procedure for load-bearing elements from cross-laminated timber.	The data were generalized for the plates from cross-laminated timber subjected to flexure and compression with the bending. The model of initial member of transversal load-bearing timber walls was developed.

The data were generalized for the plates from cross-laminated timber subjected to flexure and compression with the bending to obtain necessary information for the development of design procedure for load-bearing elements. Efective strength and stifness method and transformed sections method were considered for the purposes. The both methods were compared analytical and by the experiment. Two cross-laminated timber plates with the dimensions 2X1 m and total thickness in 95 mm were considered. External and internal layers were made from the timber boards with the dimensions 25x50 and 45x195 mm, correspondingly. Fiber direction of the external layers is parallel to the longitudinal axis of the plate. Fiber direction of the internall layer is oriented under the angle equal to 90° to the longitudinal axis of the plate. The layers were glued together by the polyurethane glue under the pressure in 400 kg/m^2. Pine wood with the strength class C18 is considered as a board material. A freely supported beam, which is loaded by the uniformly distributed load, was chosen as a design scheme for both plates, because this statical scheme is widely used for CLT plates in practice. A span of freely supported beam was equal to 1.9 m. the both plates were statically loaded by the uniformly distributed load, which changed within the limites from 1 to 7.5kN/m^2. Considered pannels were analysed by the programs REFM 5.0 and ANSYS v14.

Investigation of rational structure of multy-storey timber buildings was started. Behaviour of light timber framework of three-storey buildings were analysed by the procedure of LVS EN 1995-1-1. Procedure for evaluation of stifness of timber multystorey framework in case of transversal load-bearing wall using was suggested. Framework of initial member of transversal load-bearing timber walls, which is made of pine wood with the strength class C24, was considered as an example. Dimensions of the framework elements are 70X195 mm and 45X195 mm.

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 3 „ *Risk consideration for safe, effective and 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 3: *Develop new methods of risk assessment for buildings and structures to ensure their safe, efficient and sustainable operation.*

Target of the national programme and this project is to develop new methods of risk assessment for buildings and structures to ensure their safe, efficient and sustainable operation. Targets set for this reporting period are fully achieved.

***Core task 1:** Investigation of the dynamic characteristics of Latvian road bridges and determination of their impact on construction reliability, to develop the new methods for assessment of structural risk, reliability and robustness.*

Tasks for the Period 1:

1.1. Modeling of bridge and vehicle interaction, taking into account the type of the vehicle, type of the span structure, and pavement eveness.
1.2. Development of method for prediction of live load action combinations.

Investigation presents analysis of dynamic effects obtained from dynamic load testing of city highway bridges in Latvia carried out from 2005 to 2012. 9 prestressed concrete bridges and 4 composite bridges were considered. 11 of 13 bridges were designed according to Eurocodes but two according to SNIP codes. The dynamic properties of bridges were obtained by heavy vehicles passing the bridge roadway with different driving speeds and with or without even pavement. The obtained values of DAF and bridge natural frequency were analyzed and compared to the values of built-in traffic load models provided in Eurocode 1. The actual DAF values for even bridge deck in most cases are smaller than the value adopted in Eurocode 1. Vehicle speed for uneven pavements significantly influence DAF values.

Obtained results show that for bridges road surface condition is a very important factor. If road condition is very bad and with many bumps, then heavy traffic driving with low speed can cause a lot of damage.

Overall DAF values for even pavement were within 1,0 and 1,4 and are smaller than assumed in Eurocode 1.

Bridge natural frequency did not correlate with bridge span and vehicle weight, however for higher natural frequency values DAF values were smaller.

Traffic load models available in structural codes are most often developed for short or medium span bridges, but most unfavorable traffic situations for long span bridges are very different from the ones considered in them. For this reason, funds may be used irrationally, if inappropriate traffic load models are used for long span bridge design.

Weigh – in – Motion (WIM) data from WIM station installed on 72. kilometer of highway A1, have been used in these paper. First data cleaning was performed, then data were split into two lanes. Long span bridge loads were calculated by using information about vehicles found in traffic flow from the cleaned WIM data. Load model calculations were done for 200, 300, 400, 500 and 600 meter long spans.

Traffic flow was simulated using seven different traffic scenarios, out of which first six simulates traffic with varying percentage of trucks. The seventh scenario simulates traffic flow consisting entirely out of cars. For each lane, span, traffic scenario combination Gumbel's distributions were fitted to the highest 30% of the calculated loads, by using the maximum probability estimates for left truncated data; loads were extrapolated to the probability of exceedance of 10% in hundred years period. Results show that Eurocode 1 part 2 load model 1 load is too conservative for use in long span bridge design even when the very unlikely scenario of only trucks in the leftmost lane is considered.

Core task 2: *Development of the methodology for experimental acquisition of dynamic characteristics (modal frequencies, mode shapes, modal damping) of structural elements with the presence of damage (different failure modes) for structural health monitoring;*

Task for the Period 1: *To develop damage localization methods for structural elements.*

According to the Core task 2 of the project: "The development of methodology for experimentally measured dynamic parameters (vibration frequencies, vibration modes, vibration damping coefficients) of healthy or damaged (various forms of material degradation) structural elements and its application to structural health monitoring", the planned objectives are fully met.

A damage identification method, based on vibrational response of a structure, is meant for practical applications. The proposed methodology implies the localization of damage site, which is not seen with a naked eye in homogeneous, as well as in composite materials. Damage Indices were calculated for 1-dimensional and 2-dimensional space to ensure the identification in damage for beam-type and plate-type structures, respectively. It is possible to extend the method to large scale structures, for example, automotive and aerospace structural elements by using the appropriate experimental equipment.

Core task 3: *To develop innovative smart structure with using of removable natural resources with the increased durability and reliability for structural and infrastructural purposes.*

Task for the period 1: Data generalization for development of design procedure for load-bearing elements from cross-laminated timber.

The data and information were generalized to develop design procedure for load bearing elements from cross-laminated timber subjected to flexure and compression with the bending.

The considered design procedure is based on the LVS EN 1995-1-1, effective strength and stifness and transformed section methods. The effective strength and stifness and transformed section methods were checked analytical and by the experiment. Two cross-laminated timber plates were analysed by the FEM, which was realised by the programs REFM 5.0 and ANSYS v14. It was stated, that the diference between the effective strength and stifness and transformed section methods does not exceeds 20%.

Behaviour of light timber framework of three-storey buildings were analysed by the procedure of LVS EN 1995-1-1. Procedure for evaluation of stifness of timber multystorey framework in case of transversal load-bearing wall using was suggested and checked analytical by the program ANSYS v15.

2.4. Further research and practical exploitation of the results

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

For the 2nd period are planned following activities:

Core task 1:

1. Development of method for assessment of new bridge dynamic characteristics;
2. Development of method for prediction of traffic load action combinations.

In the development of the method will be used a computer software to simulate the dynamic behavior of the bridge. Results will be compared to the live-scale dynamic test results. Frequencies of traffic load actions will be analysed and mathematical basis of combination probability will be developed based on obtained theoretical probability models.

Core task 2:

The task for the Period 2 is "Study of damage zone configuration and localization method", which is directly related to studies of the Period 1. A submitted paper to internationally indexed journal is defined as a result of the Period 2. The Period 2 of the project will be devoted to development of dynamic parameter identification experimental methodology in plate-type structures, as well as development of corresponding damage identification algorithm in MATLAB: it is intended to use a 2-dimensional Wavelet Transform algorithm for damage identification over plate coordinates of length (X) of and width (Y). The result is a 3-dimensional map, where Z axis depicts a Standardized Damage Index, obtained from Wavelet Transform coefficients.

Core task 3:

The following activities are planned during the period 2 of the project to achieve the core task 3 targets,

- Development of design procedure for load-bearing elements from cross-laminated timber.
- Experimental check of developed design procedure for load-bearing elements from cross-laminated timber.

Using of transformed section method for load bearing elements from cross-laminated timber, subjected to flexure and compression with the bending, with the different design schemes, must be checked analytical and by the experiment during the period 2 of the project. Cross-laminated timber plates which are suspended in the corners and freely supported by two sides, should be considered under the statical load

Investigations of rational structural solution of innovative smart structure should be started during the period 2 of the project. Rational parameters of prestressing of load bearing cable structure must be evaluated to improve the distribution of internal forces and decrease materials consumption. Saddle-shaped cable roof with the rigid support contour and dimensions 60X60 in the plan must be considered for the purpose.

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 „ Develop new methods of risk assessment for buildings and structures to ensure their safe, efficient and sustainable operation" were prepared:

Conference abstracts or publications submitted:

1. Paeglite I., Paeglitis A., Smirnovs J. (2015) The Dynamic Amplification Factor for bridges with span length from 10 to 35 meters. // Journal Engineering Structures and Technologies, 2015, pp.1-8 10.3846/2029882X.2014.996254;
2. Paeglite I., Paeglitis A. (2014) Dynamic Amplification factors of some city bridges, ICSCE 2014: XII Interantional Conference on Structural and Construction Engineering, London, United Kingdom, 22-23 December 2014;
3. Freimanis, A., Paeglītis A. (2015) Modeling of traffic loads for bridge spans from 200 to 600 meters.// The Baltic Journal of Road and Bridge Engineering 10 (3);
4. R. Janeliukstis, S. Rucevskis, M. Wesolowski, A. Kovalovs, A. Chate, Damage identification in beam structure using spatial continuous wavelet transform, IOP Conference Series: Materials Science and Engineering;
5. R. Janeliukstis, S. Rucevskis, M. Wesolowski, A. Kovalovs, A. Chate, Damage identification in beam structure using mode shape data: from spatial continuous wavelet transform to mode shape curvature methods, International Journal of Mechanical Sciences;
6. R. Janeliukstis, S. Rucevskis, M. Wesolowski, A. Kovalovs, A. Chate, Damage identification in polymer composite beams using spatial continuous wavelet transform, Key Engineering Materials;
7. A.Vilguts, D.Serdjuks, L.Pakrastins "Design Methods of Elements from Cross-Laminated Timber Subjected to Flexure". Raksts pieņemts publicēšanai starptautiskas konferences "International Scientific Conference - Urban Civil Engineering and Municipal Facilities", 2015, 18.03.15. – 20.03.15., Sanktpēterburga, Krievija;
8. A.Stuklis, D.Serdjuks, V.Goremikins „Materials Consumption Decrease for Long-span Prestressed Cable Roof". Raksts iesniegts publicēšanai 10. starptautiskās zinātniski praktiskās konferences „Vide. Tehnoloģija. Resursi" (Rēzeknes Augstskola, Rēzekne, Latvija, 2015. gada 18. – 20. jūnijs) rakstu krājumā;
9. A.Vilguts, D.Serdjuks, V.Goremikins "Design Methods for Load-bearing Elements from Cross-laminated Timber", 2nd International Conference „Innovative Materials, Structures and Technologies", 30. septembris – 2. oktobris, 2015, Rīga, Latvija;
10. A. Hirkovskis, D.Serdjuks, V.Goremikins, L.Pakrastins "Behaviour analysis of load-bearing aluminium members "Инженерно-строительный журнал", 5 (57), 2015.

Finished bachelor theses:

1. R.Ruža "Stīgbetona siju nestspējas izpēte" (supervisor Prof. A.Paeglītis);

2. R.Martinsons “Ilgtspējīgas koka tiltu laiduma konstrukcijas” (supervisor Prof. A.Paeglītis);
3. M.Jansons “Ceļa zīmju un apzīmējumu izmantošanas efektivitātes analīze” (supervisor Prof. J.Smirnovs).

Finished master these:

1. Virbule, „Load-bearing elements' behaviour analyse for three-storey timber framework buildings”(supervisor Dr.sc.ing. prof. D.Serdjuks).

Preparation of a doctoral thesis:

1. Ilze Paeglīte “The influence of traffic load on on the bridge the dynamic properties”, scientific supervisor – prof. Dr.sc.ing. Juris Smirnovs, planned to defend in 2017.
2. Andris Freimanis „ Risk consideration for safe, effective and sustainable bridge structures”, scientific supervisor – prof. Dr.sc.ing. Ainārs Paeglītis, planned to defend in 2018.
3. A.Vilguts „Rational structure of multy-storey buildings from cross-laminated timber”, supervisor D.Serdjuks, planned to defend in 2018.
4. Rims Janeliukštis „ The develpment of the damage indentification methods for monitoring of the technical condition of the structure”, scientific supervisor – prof. Dr.sc.ing. Andris Čate, planned to defend in 2018.

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 4

Title	**Layered wooden composite with rational structure and increased specific bending strength**	
Project leader's name, surname	Kārlis Rocēns	
Degree	Dr. habil. sc. ing.	
Institution	Institute of Structural Engineering and Reconstruction	
Position	Leading researcher	
Contacts	*Mobile phone*	22023321
	E-mail	rocensk@latnet.lv

2.2. Tasks and deliverables

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

Nr.	Tasks	Deliverable	Responsible partner	Status
1	Methodology work-out for determination of bending strength and conceptual design of plates with cell type hollow ribs	1 Methodology (31.06.2016) Annex 4-A	K. Rocēns, Institute of Structural Engineering and Reconstruction, RTU	In beginning

Development of load bearing layered wood composite with rational structure (Standard plywood plates do not have rational placement of material by its height and structure of layered material gives a chance to vary with placement of material at plates height), that provides increased specific bending stiffness (stiffness to weight ratio), reduced costs, consumption of materials and energy comparing to traditionally used materials. (LV Patent No. 14519)

A new type of composite-construction will be proposed with cell type hollow ribs and skins of plywood or other material. This type of ribs let us vary the stiffness of wood composites unlike it is for Standard plywood or existing sandwich constructions.

Particular solution of ribs will be achieved; absolute and specific strength will be given and compared to standard type of constructions (plywood sheets, sandwich panels). A new method of calculations will be developed for designing and using plates with proposed structure.

This solution offers to adjust with bending carrying capacity and reduce consumption of material in less loaded areas of cross section. This leads to a new design methodology for structural design which harmonize section stress field with resistance field of the developed structure. This material could be used in furniture production, and structural applications. At the same time it will give an opportunity to use of the proposed plates in multi-storey wood building industry.

Task 1: Development of the methodology for determination of bending strength and conceptual experimental investigations of plates with cell type hollow ribs (task ends 2 quarter of year 2016)

Time frame for the core tasks is given in Annexes 4-A.

Results are stated with three submitted and accepted abstracts for international scientific conferences. It will be possible to inform the interested engineers and scientists with the latest scientific results in the full paper for Conference full text proceedings.

In the first phase, the main required materials for plates forming experimental equipment and experimental models and equipment for research process of the plates with cell type hollow ribs are selected, ordered and procured.

Results of the project in period 1:

The representatives of involved IMATEH projects have been participated in the meeting of State Research program IMATEH about the process and state of art of projects and program on 8.10.2014.

In framework of project on 19.12.2014 was organized the seminar in which the topics that are related to planned researches were presented. The interested participants can find out about researches, achievements and next things to do in the Project.

In the IMATEH home page http://imateh.rtu.lv/ detailed information about activities and actualities of 4th Project and State Research Program IMATEH.

Tasks of the Project	The main results
1.Development of methodology for determination of bending strength and	Basics of the methodology and technological principles of

conceptual experimental investigations of plates with cell type hollow ribs (task ends 2nd quarter of year 2016)	manufacturing. Results show that for the constant thickness of a plate for ribbed plates the specific strength increases significantly in allows to reduce material consumption for up to 20%.

ANSYS finite element code was chosen for methodology of calculations that takes into account geometrical parameters, material properties and other factors that influence load bearing capacity. For these type of plates serviceability limit state (SLS) is crucial. The mathematical relationships for specific stiffness (stiffness-to-mass) depending on plate's thickness and the geometrical parameters are obtained. Results show that load bearing capacity increases significant for ribbed plates with the same height of a plate. Furthermore it decreases consumption of wood material up to 20%.

This approach provides required information for optimization of structural parameters to provide design rational structures. Meanwhile the plate with reduced consumption of wood and necessary bending load bearing capacity.

The method of calculations will give an algorithm to design the structure of material for required bending load bearing capacity with reduced consumption of wood.

In this reporting period a conceptual variant of experimental equipment for hollow rib manufacturing is proposed. For the manufacturing equipment the required materials are selected, ordered and procured.

This equipment will consist of vertical supporting frame and horizontal compressing frame (movable and immovable). With two hydro cylinders the movable horizontal frame will be compressed together with immovable horizontal frame. In specified distances the heatable compressive elements will be placed for faster hardening. The load bearing frame will be made of rolled steel profiles joined with screw or welded joints.

Master degree students will do their research that provides evaluating and rational use of wood materials in constructions as carrying elements.

The main results can be summarized in a following way:

Analytically approved that it is possible to achieve material consumption reduction up to 20% and increase efficient use of wood material;

The method of production and conceptual prototype of production equipment equipment's conception variant for hollow rib production are worked out;

At the moment it is almost checked and proofed that methods of plate's production. The new solutions for plates with cell type hollow ribs and testified with patent application:

- P-14-103 "Method for producing ribbed plates" K.Rocēns, A.Kukule, Ģ.Frolovs, J.Šliseris, Ģ.Bērziņš;

As well as in preparation stage existing:

- "Method and equipment of production for ribbed composite plate with goffered wood-based core" K.Rocēns, Ģ. Frolovs, A. Kukule, J. Šliseris;

The size for specimen of a plate for determination of mechanical properties are chosen according to EN 789 Timber structures. Test methods. Determination of mechanical properties of wood based panels and coherence to geometry of real size ribbed plate are carried out.

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

All planned activities were completed.

2.3. Description of gained scientific results

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

Development of the methodology for determination of bending strength and conceptual experimental investigations of plates with cell type hollow ribs (task ends 2 quarter of year 2016)). First part of the first task is successfully done.

The first phase of the development of methodology workout is started for bending bearing capacity for plates with cell type hollow ribs (LV Patent No. 14519) for longitudinal direction with taking into account the geometrical parameters of ribs.

Results approve 20% decrease of material consumption in comparison to standard massive plywood – material consumption decreases up to 20%. Although for plates with the height of 100mm and more, also the specific bending bearing capacity is increasing up to 20% comparing to previously known ribbed plates with straight ribs. For the plates with straight ribs only the large local deformations between the ribs occurs but by using newly provided plates with cell type hollow ribs these deformations are limited in that way it is possible to save material for plate's skins.

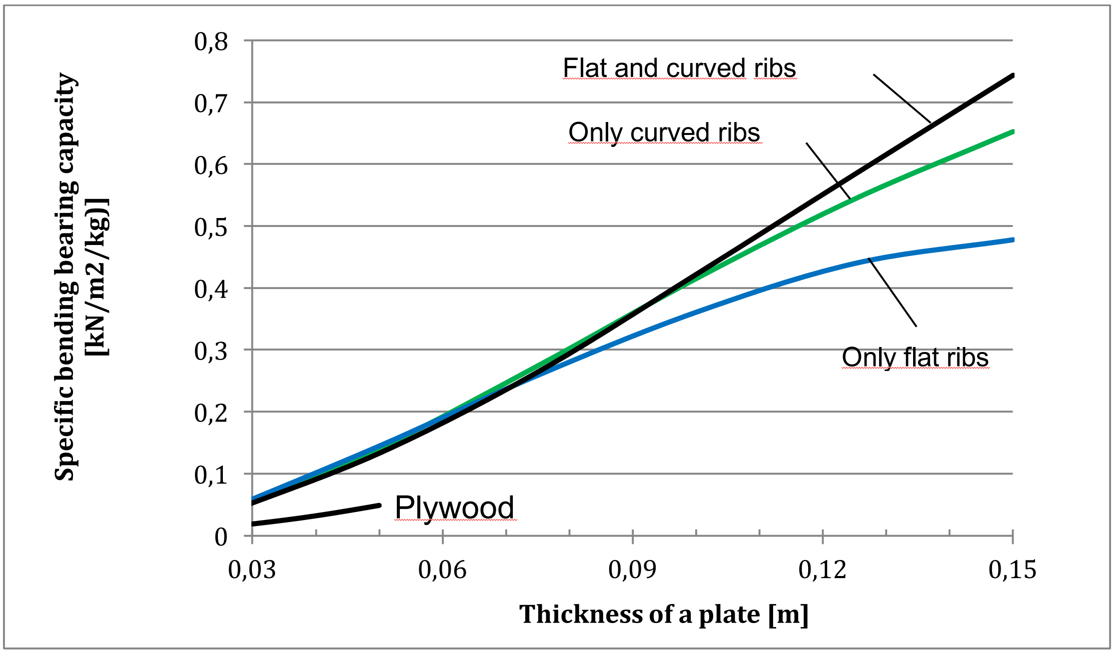

fig. 1. Ultimate Service load (SL) and dead weight (DW) ratio comparing plywood and related ribbed (straight and waved) plates in longitudinal direction.

For all elements (plywood for ribs and skins) 3 layer plywood with total thickness of 4 mm and density approx. 700 kg/m^3. Legends: **PW** – plywood; **r** – only with straight ribs in longitudinal direction of a plate; **r̃**I,⊥ - with straight and waved ribs (waved ribs' outer layer ply direction perpendicular to plate's plane) **r̃**I,ǁ - with straight and waved ribs (waved ribs' outer layer ply direction parallel to plate's plane); **r̃**II,⊥ - **r̃**I,ǁ - only with waved ribs (waved ribs' outer layer ply direction perpendicular to plate's plane); **r̃**II,ǁ - only with waved ribs (waved ribs' outer layer ply direction parallel to plate's plane);

Scientific publication is written and submitted (will be assigned in 2nd quarter of 2015) based on achieved results. Influence of height of a plate, geometrical parameteres and dimensions of plywood sheets on the stiffness of a plate.

Obtained results allow to make detailed investigated of a plate with evaluation the influence of given factors to bearing capacity and could be taken as optimization basis for some specific use or load combination.

In addition to the planned results, application for patent P-14-103 „ Method for producing ribbed plates" (authors: K. Rocēns, A. Kukule, Ģ. Frolovs, J. Šliseris, Ģ. Bērziņš) is submitted.

In which the method for producing ribbed plates with work-in the foam plastic insulating layer between the ribs. In addition, a concept is worked out for hollow ribs' manufacturing.

The development of basic technological principles allow producing plates with such ribs and thereby making experimental investigations for these plates. In first phase the main materials and tools for manufacturing of the plates to produce these plates in second phase are developed in order to do accurate experimental investigations. The influence of plate's geometrical parameters was investigated and evaluated according to EN789 for determination of plates' properties. Relating to private sector participation the cooperation between RTU Institute of Building and Reconstruction, Fraunhofer ITWM institute and The Baltic-German University Liaison Office was made.

The beginning part of the methodology is made for numerical investigations with multiparametric numerical model for the design of structure for composite with cell type hollow ribs.

The mechanical behaviour of these plates is highly dependent of joint between ribs and skins. Therefore it is needed to make the strength tests for glued joint when there are joined skin surface to rib's edge – determination of shear properties. As a result the bearing capacity of glued layer and the influence of general load bearing capacity of plate are achieved. These results will take into consideration the researchers of similar constructions as well as glue producers in taking the consideration for load bearing capacity of this type of connections.

In the first phase, materials (different thickness birch plywood, PVA and epoxy glue, polyurethane foam plastics and other materials and tools) for plates and materials (steel angle profiles U profiles and I profiles and other materials and tools) for manufacturing equipment are selected and ordered. Digital indicators for experimental measurement of deformations as well as other tools and materials which are required in the project are obtained. The project personal salary makes 6348 EUR (bruto salaries – 5137 EUR + social taxes – 1211 EUR) in reporting period.

The prediction conceptual prototype will be made and used for making plate's specimens with different thickness and other geometrical parameters of plates. The experimental investigations will be carried out to validate the methodology of calculations.

2.4. Further research and practical exploitation of the results

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

Task for second phase – to continue first phase started task Methodology work-out for determination of bending strength and conceptual experimental investigations of plates with cell type hollow ribs (task ends 2 quarter of year 2016)).

In next phase the methodology for shear resistance of glued joint for plywood surface and edge will be developed and validate with experimental investigations with particularly chosen specimens as well as beginning experimental investigations of deformability and strength of plates with cell type hollow ribs in bending.

In the same time the second task (Methodology work-out for determination of specific bending strength for plates with cell type hollow ribs and determination of values for the most typical geometrical parameters.) and the third task (Work-out plate models with most typical types of hollow cell type ribs and experimental investigations to get specific strength in bending, consumption of materials, energy consumption and costs.) with continue till end of 2016 are done.

2.5. Dissemination and outreach activities

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

Three conference abstracts are accepted:

1. G.Frolovs, K.Rocēns, J.Šliseris «Comparison of a load bearing capacity for composite sandwich plywood plates» 10th International Scientific Practical Conference "Environment. Technology. Resources" Rēzekne, 18.06. – 20.06.2015.
2. G.Frolovs, K.Rocēns, J.Šliseris «Bending Behavior of Composite Plywood Plates with Cell Type Core» 2nd International Conference „Innovative Materials, Structures and Technologies", Riga, Latvia, 30.09-02.10.2015.
3. A.Kukule, K. Rocēns «Prediction of Moisture Distribution in Closed Ribbed Panel for Roof» 2nd International Conference „Innovative Materials, Structures and Technologies", Riga, Latvia, 30.09-02.10.2015.

Submitted one patent application P-14-103 „ Method for producing ribbed plates".

The following theses were prepared in the Period 1 of project 4:

Doctoral thesis:

1. Ģ.Frolovs " Calculations of Rational wooden composite structures and their elements";
2. A. Kukule "Behaviour or plywood ribs in various conditions of moisture"

Master thesis:

1. I. Ucelnciece "Impact of snow loads on different types of roof shapes"; (Supv. D. Serdjuks, Ģ. Frolovs)
2. A. Žukovska-Kečedži, „ Wind load action depending on the roof's shape"; (Supv. D. Serdjuks, A. Kukule)

The planned seminar took place on 19.12.2014. with reports of participants involved in project (9 listeners – project involved people and leading scientists of Institute of Building and Reconstruction) The topics related to the research were discussed with such oral presentations:

1. Advantages of plates with cell type hollow ribs (Ģirts Frolovs)
2. Methodology for determination of insulated plates moisture distribution in case with different surface temperatures (Aiva Kukule)

3. New solution for multi-storey buildings made of cross laminated timber elements. (Aivars Vilguts)

In the seminar interested scientists and other participants were able to get information about these plates and the possibilities of their applications as well as initiate a discussion about wood extended use in constructions.

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 5

Title	***Material mechanical micro - nano- scaled features and their impact on human safety***		
Project leader's name, surname	Jurijs Dehtjars		
Degree	Dr. hab. phys		
Institution	Riga Technical University, Institute of Biomedical Engineering and Nanotechnologies		
Position	Head of the Institute, Professor		
Contacts	*Phone number*		+371 29469104
	E-mail		jurijs.dehtjars@rtu.lv

2.2. Tasks and deliverables

(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)

Project goal: To research early destruction of surface of polymer composite materials, to develop methods of early diagnostics and analyze application of the methods in enterprises.

Task 1 of the 1st Period: *Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research influence of aquatic microorganisms on early destruction of materials* (the task ends in the IV quarter of 2015).

The following was planned in order to accomplish the Task: (1) to develop sample preparation methods and fabricate the samples; (2) to find optimal parameters for optical stimulation of photoelectron emission in order to achieve the maximum signal to noise ratio depending on a type of studied material; (3) to adjust a method for detection of leaching of organic substances from walls of polymeric pipes.

Task 2 of the 1st Period: *Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research visual recognition of early destruction using destruction-induced staining* (the task ends in the IV quarter of 2015).

The following was planned in order to accomplish the Task: (1) to develop sample fabrication methods and fabricate the samples; (2) to develop a method of applying dye containing microcapsules onto the surface of the samples.

Time frame for the tasks is given in Annex 5-A.

The goal and tasks of the 1st Period of the Project were fully achieved. Methods of preparation of fiberglass polymer composites (FPC), polymer composites filled with carbon nanotubes and samples of polymeric pipes were developed. Automatic sheet cutting CNC technique was adjusted for preparation of FPC samples. The developed method of preparation of polymer composites filled with carbon nanotubes consists of component mixing, shaping and drying stages. A special technological device was developed and manufactured for the shaping stage. In order to prepare samples of polymeric pipes, mechanical cutting method was developed. For each type of the material a specific shape was optimized in order to perform mechanical loading experiments and electron emission measurements. A method of applying dye containing microcapsules onto the surface of composite materials was developed. Spectroscopic method for detection of leaching of organic substances from walls of polymeric pipes was adjusted.

For each type of the material increments of photoemission current during the mechanical loading were studied depending on wavelengths used for photostimulation. A range of wavelengths was chosen which ensures the greatest increment of the current.

The following Deliverables are expected upon the completion of the tasks in the IV quarter of 2015:

Nr.	Task	Deliverable	Responsible partner	Status
1.	Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research influence of aquatic microorganisms on early destruction of materials	Research method for development of diagnostics of early destruction of surface of polymer composite materials using *in situ* electron emission spectroscopy (31.12.2015)	J. Dehtjars, Institute of Biomedical Engineering and Nanotechnologies, RTU	In progress
2.	Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research visual recognition of early destruction using destruction-induced staining	Research method for development of diagnostics of early destruction of surface of polymer composite materials using destruction-induced staining (31.12.2015)	A. Aņiskevičs, The Institute of Polymer Mechanics of the University of Latvia	In progress

2.3. Description of gained scientific results

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

Tasks of the Project	The main results
1. Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research influence of aquatic microorganisms on early destruction of materials.	Concept of the method developed

The following results were achieved during the report period:

1. A method for sample fabrication was developed and the samples were prepared for loading experiments:
    a. epoxy resin samples with different concentrations of carbon nanotubes (0%; 0,2%; 0,5%, 1,0%);
    b. samples of polymeric pipes (rough cutting using bandsaw, fine cutting using vertical milling machine);
    c. samples of fiberglass polymer composite (rough cutting using bandsaw, fine cutting using vertical milling machine).
2. Equipment for measurement of electron emission was adjusted for measurements in a single electron counting mode during mechanical loading of the samples. Optical stimulation modes have been optimized for measurements of photoelectron emission (PE) from the samples.
3. Initial experiments were performed that demonstrated possibility to detect PE during quasielastic deformation. The experiments have provided evidence that the concept of the method of early diagnostics of destruction can be employed when observing destruction of the surface during quasielastic deformation (Fig.1).

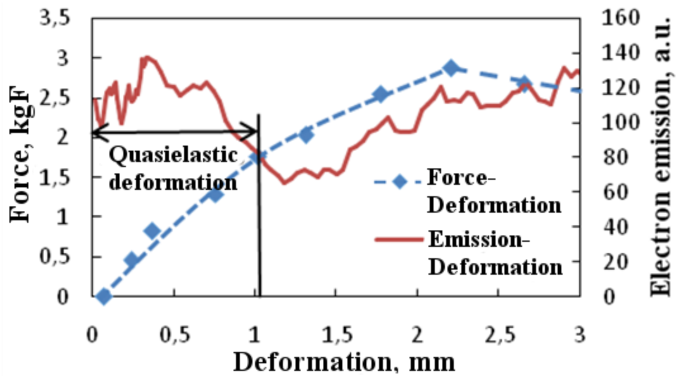

Fig. 1. Changes of photoelectron emission from a polymeric pipe PE-80 during quasielastic deformation

4. Possibility to determine leaching of organic substances (TOC – total organic carbon) which serve as nutrients for microorganisms from Evoaqua HDPE (high-density polyethylene) pipes into water was tested. The experiments were performed with different water samples (tap water, tap water with added Cl_2 (0.5 mg/L), ultra-clean deionised water). The results showed that during the observed period the pipes did not leach enough organic substances that could be used as the nutrients by bacteria.

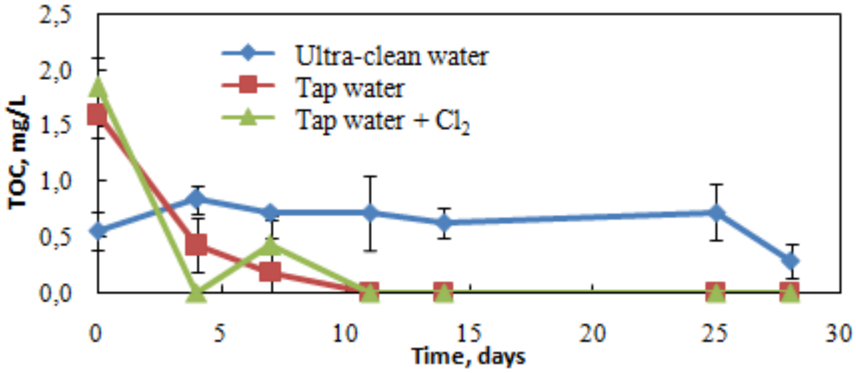

Fig. 2. Changes in TOC concentration using different water samples

5. The experiments have been launched to determine the influence of concentration of the leached TOC on multiplication of natural (*Pseudomonas Fluorescens*) and faecal (*Escherichia Coli*) microorganisms found in water.

2. Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research visual recognition of early destruction using destruction-induced staining.	Concept of the method developed

The following results were achieved during the report period:

1. A method of applying dye containing microcapsules onto the surface of polymer composite materials was developed. PVA (polyvinyl acetate) glue was used as a binding water-based agent, the filler consisted of dye-filled microcapsules and microcapsules filled with color developer mixed in a ratio of 1:1 in aqueous suspension. Concentration of the filler was 0 – 50% by weight in a liquid state.
2. Concentration of the filler in the sample was determined after complete drying of the sample (Fig. 3).

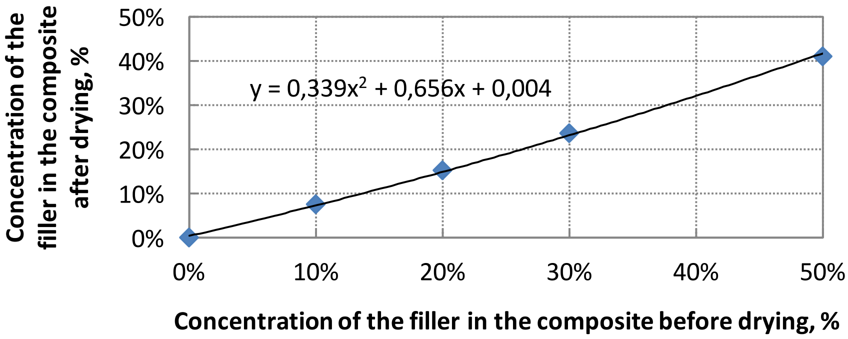

Fig. 3. Concentration of the filler in the composite after drying of water

3. Tension test of the samples was done (elastic modulus depending on concentration of the filler, stress-strain diagram). Staining of the samples using microcapsules was achieved on reaching the critical local deformation. The experiment demonstrated possibility of early diagnostics of destruction.

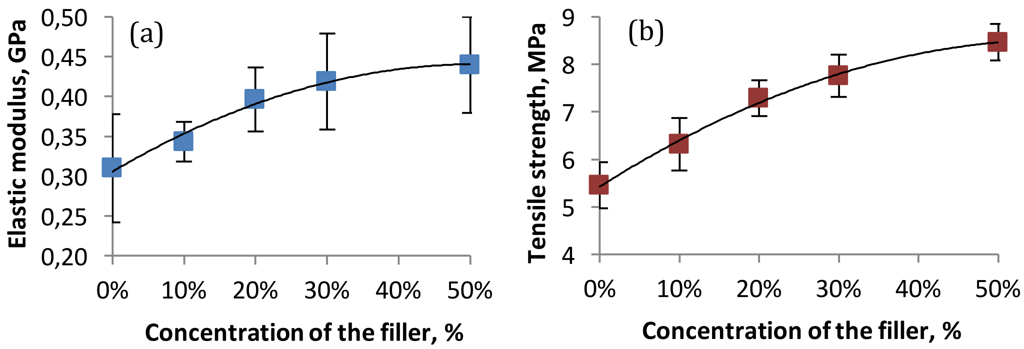

Fig. 4. (a) Elastic modulus of the samples depending of the filler concentration; (b) tensile strength of the samples depending of the filler concentration

4. Compression test of the polymer material with 2 types of shells of microcapsules was done with and without indentor. Stress-strain diagram was plotted, elastic modulus and compressive strength were determined.

The achieved results have the following scientific importance:

1. It has been demonstrated that organic substances leach into water from walls of polymeric pipes, however further studies are required in order to determine whether concentration of organic substances is sufficient to influence multiplication of aquatic microorganisms.
2. Possibility to develop a method for diagnostics of early destruction of polymer composite materials has been confirmed:
   a) it is possible to observe destruction of the materials already at a stage of quasielastic deformation;
   b) it is possible to adjust mechanical properties of dye containing microcapsules in order to visualise early destruction of polymer composite materials.

The achieved results of the 1st Period of the Project will promote development of methods of diagnostics of early destruction of surface of polymer composite materials during the next Periods of the Project.

2.4. Further research and practical exploitation of the results

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

Technological readiness has been achieved for the implementation of the 2nd Period of the Project. The achieved results demonstrate ability to continue implementation of the Project in accordance with the original application. **Therefore, the following two tasks are planned for the 2nd Period:**

1. Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research influence of aquatic microorganisms on early destruction of materials.

   a) TOC leaching and microorganisms counting experiments will be performed using aging acceleration of polymeric pipes (at 60 °C temperature). Natural bacteria found in Evian water (these bacteria do not multiply without addition of the substrate unlike the bacteria present in tap water) and *E.Coli* bacteria will be used.

b) The research method for development of diagnostics of early destruction of surface of polymer composite materials using *in situ* electron emission spectroscopy will be developed (the Deliverable).

2. Development of research methods for diagnostics of early destruction of surface of polymer composite materials: the method to research visual recognition of early destruction using destruction-induced staining.

   a) Damage indication coating changes mechanical properties of a composite material. Therefore it is necessary to take into account mechanical properties of the dye-containing microcapsules when designing constructions made from composite materials. By performing experimental measurements and simulations, mechanical properties of microcapsules embedded in an elastic matrix will be determined. Polymeric matrix with different concentration of microcapsules (0–50%) will be fabricated and tested. The obtained results will allow modelling mechanical behaviour of a matrix with embedded microcapsules.
   b) The research method for development of diagnostics of early destruction of surface of polymer composite materials using destruction-induced staining will be developed (the Deliverable).

Practical exploitation of the achieved results:

Possibility to develop a method for diagnostics of early destruction of polymer composite materials has been confirmed. The experiments give evidence that the method will allow to observe the destruction already at a stage of quasielastic deformation. As a result:

a) The knowledge about destruction processes taking place in polymer composite materials and water-supply polymeric pipes at nano and micro scale will be developed.
b) Quality and safety of polymer composite materials and corresponding constructions, as well as sustainability and safety of water supply systems will be improved.

2.5. Dissemination and outreach activities

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

Conference abstract was submitted and accepted:

Aniskevich, A., Bulderberga, O, Dekhtyar, Yu.,Denisova, V., Gruskevica, K., Juhna, T., Kozak, I., Romanova, M. Coloured Reactions and Emission of Electrons towards Early Diagnostics of Polymer Materials Overloading. 2nd International Conference „Innovative Materials, Structures and Technologies, September 30 – October 2, 2015, Riga, Latvia

Development of master theses was lauched, the defence is in June, 2015:

1. Inguna Krista Anspoka. Influence of destruction of composite material on electron emission from composite material surface, supervisor Prof. A.Balodis

2. Irina Golovko. Influence of plastic water supply material on quality of drinking water, supervisor Asoc. Prof. K. Tihomirova

Development of bachelor theses was lauched, the defence is in June, 2015:

1. Anna Korvena-Kosakovska. Early failure of composite material under mechanical load, supervisor Prof. A. Balodis
2. Ēriks Dombrovskis. Diagnostic method for early collapse of polymer pipes under mechanical load, supervisor Prof. J.Dehtjars
3. Toms Vāvere. Indirect determination of mechanical properties of polymer matrix spherical fillers, supervisors Dr. Sc. Ing. Andrejs Aņiskevičs, Msc. Olga Bulderberga

The doctoral thesis is being developed:

O. Bulderberga. Polymer composite with damage indication ability: development and determination of properties. Supervisor A. Aņiskevičs, the defence is planned in 2017.

Dissimination of results:

Project participants held three meetings to discuss the results of the Project (07.11.2014, 19.12.2014, 13.02.2015). The meetings were announced to all the stuff of the departments involved in the implementation of the Project as well as for students who participated in the research developing their bachelor and master theses.

PART 2: PROGRAMME PROJECT INFORMATION

2.1. Project No. 6

Title	***Processing of metal surfaces to lower friction and wear***	
Project leader's name, surname	Karlis Agris Gross	
Degree	PhD	
Institution	Riga Technical University	
Position	Assoc. Prof./ lead researcher	
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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: ***Develop a methodology and criteria for optimization of metallic material properties to improve the surface treatment and coating to reduce friction and wear of friction pairs including interaction with metal surfaces and ice.***

Time frame for the core tasks is given in Annexes 6-A.

Nr.	Tasks	Deliverable	Responsible partner	Status
1	Develop a method for measuring slip under laboratory conditions	Report (method) 31.12.2015.	K.A. Gross, Biomaterials research laboratory, RTU	In progress
2	Develop a method for determining the slip under real track conditions, in comparison with laboratory equipment	Report (method) 30.06.2017.	K.A. Gross, Biomaterials research laboratory, RTU	In beginning
3	Optimise metal surface for increased gliding on ice	Report 30.06.2017.	K.A. Gross, Biomaterials research laboratory, RTU	In progress
4	Determine the relationship of gliding between the metal surfaces and ice (report)	Report 30.09.2017.	K.A. Gross, Biomaterials research laboratory, RTU	In progress
5	A recommendation for a modification of metal surface to improve gliding in track conditions, application of the materia	Report 30.12.2017.	K.A. Gross, Biomaterials research laboratory, RTU	In beginning

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

The planned task of the Project 6 „ Processing of metal surfaces to lower friction and wear" were fully achieved in the reporting period from 01.11.2014 till 31.03.2015. The first phase of work has given valuable screening results that will be evaluated in more detail. This will allow more accurate assessment of sliding metal on ice.

2.3. Description of gained scientific results

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

The first phase of the project has been completed. A measuring device, equipped with a number of high-precision optical sensors, has been created and will provide precise information about the material sliding speed in different sections of the route. This is a very important starting point to optimize the metal surface and determine the effect of modification on the sliding ability of metal samples.

The first phase of the project involves the development of the climate simulator. In cooperation with the Faculty of Building and Civil Engineering at RTU, the Energy Performance of Buildings simulator microclimate camera will be modified to operate at low temperatures (as low as -10°C). Setting and maintaining a temperature is important because the ice temperature is highly influenced by gliding.

The conference Innovation 2014, on November 4, 2014, in London, provided non-traditional ways of thinking. The main point taken from the visit is to abandon the traditional way of thinking and to change the properties of the metal surface by quickly applying the coating. An alternative approach is to pay particular attention to the surface, thereby improving the sliding.

<table>
<tr><th>Tasks for Period 1</th><th>Main results</th></tr>
<tr><td>Develop testing apparatus (simulation of bobsled track) and software to detect movement of the sample at a certain angle</td><td>Laboratory track development</td></tr>
<tr><td colspan="2">To verify how the sliding ability of the metallic surface responds to different treatment methods, an experimental apparatus or slip stand must be developed to measure metallic slip properties on different surfaces. This is the first phase of the project. The resulting apparatus consists of sloped planes (with different inclination angles, an adjustable U-shaped aluminium profile, and an iced surface). Four retro-reflective optical sensors will ensure a fixed distance for sliding of a metallic specimen from the top of the slope to the bottom of the slope.
The four optical sensors will provide detailed information about the sliding process of the sample. The sensors will be placed at intervals (one on each end of the inclined plane and two between the end sensors) to provide information on average speed and acceleration of the inclined plane at three stages - at the beginning, the middle and the end.
To collect and properly assess the signals generated by the optical sensors, a circuit consisting of a data collection module was developed. This module operates on a 24V DC signal, which powers the optical sensors and signal converter, and sends the signals to a computer. A data processing program, automatically converts the information from the sensors into examinable values of the sample speed. The slip stand actuators provide a time measurement with an accuracy of 0.01s.
The data processing program will ensure a shorter calculation time period allowing a greater number of experimental runs, which will provide statistically reliable data. The slip stand assembly is designed so that the plane tilt, the size of the sample, and the applied force can be varied. The possibility to change all the above parameters provides great opportunities to simulate a variety of real life situations.
The operation slip stand has been tested using a metallic inclined plane (stainless steel base), which showed successful results as the test ran smoothly. In the next tests, the metallic base will be replaced with an ice tray.</td></tr>
</table>

2.4. Further research and practical exploitation of the results

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

The second phase of the project will be to compare the different surface test methods to find the best method for metal surface analysis. The chosen method will be fast, easy to use, have high accuracy, provide good quality topography and microstructure images. These results will then be used to analyse the metal surface and the impact of modifications on sliding. Meanwhile, work will continue on the first phase of the project, which concerns the development of a laboratory track and a low temperature simulator.

2nd phase tasks:

1. Characterize the metal surface and determine the best test methods (deliverable - scientific publication submitted for publication in a journal).

2. Modify the slip measuring equipment for use in the laboratory, and develop the climate simulator to work at appropriate temperatures (deliverables - anti-slip measuring device which is suitable for custom work in a cold chamber).
3. Modify the metal surface, to determine the slip dependence of the modifications (deliverables - complete report, submitted abstract, and participation in the European Materials Research Society conference).

Problems may arise due to the high number of parameters concerning metal gliding; this may affect the accuracy of the results. To improve the outcome, it is planned to stay in close contact with the bobsled and skeleton federation, ensuring the opinion of experts on the factors that have a greater impact on the metal.

2.5. Dissemination and outreach activities

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

The Innovate UK 2014 meeting in London, which occurred on November 4, 2014, gave new insight and ideas for metal modification techniques for improving sliding properties.

The abstract "Road safety barriers, the need and influence on road traffic accidents" (Ž Butans, KA Gross, A Gridnevs, E Karzubova) will be submitted to the international conference "Innovative Materials, Structures and Technologies", which will take place in Latvia from 30/09/2015 to 02/10/2015. Conference abstracts will be published as a full-length research paper in the journal open access "IOP Conference Series: Materials Science and Engineering (MSE)".

The project is part of the master's thesis: "Tribological property assessment method of surfaces made with a lower wear and material removal" (author - Jānis Lungevičs, head - Prof. Jānis Rudzītis), which is expected to be completed in June 2016.

The research article on the characterization of metal surfaces by comparing analytical methods is the 2nd phase of the project which is planned to be published in the journal "Materials and Design" (impact factor 3.1) or the journal "Materials Characterization" (impact factor 1.9).

Project representatives participated in PPP IMATEH meetings (08/10/2014 and 26/05/2015) on the progress and implementation of the project.

Two meetings were held during the first stage of the project (02/10/2014 and 31/10/2014), where project staff and representatives of the profession attended. Project tasks and deliverables were discussed.

The IMATEH website (http://imateh.rtu.lv/) provides information on the activities of the project and current events.

PART 3: INFORMATION ABOUT PROGRAM FINANCE

The short information about the use of program finance

		Planned	Used
1000–9000*	EXPENSES - IN TOTAL	**175 654.00**	**175475.88**
1000	**Remuneration**	**102 853.00**	**107764.41**
2000	**Goods and services** (2100+2200+2300)	**48 360.00**	**49839.77**
2100	Study, work and official missions, official and work trips	9 217.00	5878.70
2200	Services	26 373.00	20700.43
2300	Stock, materials, energy resources, goods, office supplies and inventory	12 770.00	23260.64
5000	**Establishment of core capital**	**24 441.00**	**17871.70**

Programm leader ________________________ /A. Čate/

(signature[1]) (name, surname) (date[1])

Annex 1-A

Time frame the Core task 1 activities of the Project 1

	2014		2015				2016				2017			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. To create production method of high performance concrete composites (compression strength >100MPa) for use in infrastructure and public buildings, partly replacing concrete with microfillers having local origin.	x	x	x	x	x									
1.1.1. To design high strength concrete mixes	x	x	x	x	x									
1.2. To determine mechanical and physical properties.	x	x	x	x	x									
1.3. Preparation method for innovative and advanced cement composite with microfillers materials for infrastructure projects and public buildings (deliverable)					x									
2. To develop recommendation on increase of the corrosion and freeze resistance properties for the concrete produced from the Latvian cement.			x	x	x	x	x	x	x	x				
2.1. To assess sulphate resistance of the developed concrete mixes			x	x	x	x	x	x						
2.2. To determine alkali silica reaction resistance of the developed concrete mixes							x	x	x	x				
2.3. To assess carbonisation resistance of the developed concrete mixes			x	x	x	x	x	x	x	x				
2.4. To assess resistance to the impact of chloride of the developed concrete mixes					x	x	x	x						
2.5. To assess freeze resistance of the developed concrete mixes			x	x	x	x	x	x	x					
2.6. Recommendation on increase of the corrosion										x				

and freeze resistance properties for the concrete produced from the Latvian cement (deliverable)														
3. To develop methods for innovative reinforced cement composite material production for infrastructure and public buildings											x	x	x	x
3.1. To design mixes for glass fibre reinforced concrete composites											x			
3.2. To determine mechanical and physical properties of the designed mixes											x	x	x	
3.3. To assess alkali silica reactions by using pozzolanic additives in glass fibre reinforced concrete composites												x	x	
3.4. Method for innovative reinforced cement composite material production (deliverable)														x
4. Parameter optimisation of cement composite mixing process											x	x		
2.1. Recommendation for parameter optimisation of cement composite mixing process (deliverable)												x		
4. Publications, Scopus										1				
5. Conferences				2	1			1				1		
6. Supervision of doctoral thesis and master's thesis	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Annex 1-B

Time frame the Core task 2 activities of the Project 1

	2014		2015				2016				2017			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. To create production method for high performance asphalt concrete mixes from local low quality components.	x	x	x	x	x	x								
1.1.To select raw materials, to deliver them, to assess their properties	x	x	x	x	x	x								
1.2. To design high performance asphalt concrete mixes by using local dolomite shiver and bitumen B20/30			x	x	x	x								
1.3. Production method for high performance asphalt concrete mixes from low quality components (deliverable)						x								
2. To develop recommendations for parameter optimisation of mixing process for asphalt concrete mixes					x	x	x	x	x	x				
2.1. To design high performance asphalt concrete mixes by using local gravel shiver and bitumen B20/30					x	x	x	x						
2.2. To design high performance asphalt concrete mixes by using local gravel and dolomite shiver and polymer-modified bitumen PMB							x	x	x	x				
2.3. Recommendation for parameter optimisation of mixing process for asphalt concrete mixes (deliverable)										x				
3. To develop recommendations for transportation and incorporation of asphalt concrete mix											x	x		
3.1. Recommendation for transportation and incorporation of asphalt concrete mix (deliverable)												x		
4. To develop methodology for use of									x	x	x	x	x	x

recycled asphalt concrete														
4.1. To select raw materials, to deliver them, to assess their properties									x	x				
4.2. To determine design and exploitation properties of the designed mixes									x	x	x			
4.2.1 To restore properties of asphalt concrete mix recovered from recycled material with traditional bitumen having lower viscosity									x	x				
4.2.2 To restore properties of asphalt concrete mix recovered from recycled material with warm asphalt concrete production additives											x	x		
4.3. M**ethodology for use of recycled asphalt concrete** (deliverable)														x
4.4. Recommendation for use of high-viscosity bitumen using warm asphalt concrete production additives														x
5. To prepare economic assessment of high performance asphalt concrete exploitation											x	x	x	x
5.1.To assess external factors – transport load and temperature											x	x		
5.2.To select forecasting model (based on results of laboratory experiments) and to determine parameters for functions of the model												x	x	
5.3. Economic assessment of high performance asphalt concrete exploitation (deliverable)														1
6. Recommendations for improvement of road technical rules													x	x
4. Publications, Scopus										1				
5. Conferences					2			2				1		
6. Supervision of doctoral thesis and master's thesis					x	x	x	x	x	x	x	x	x	x

Annex 1-C

Time frame the Core task 3 activities of the Project 1

	2014		2015				2016				2017			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. To develop method for production of ecological composite materials from textile plants and local mineral binders.		x	x	x	x	x	x							
1.1. To design fibre composite materials mix		x	x	x										
1.2. To determine mechanical and physical properties		x	x	x	x	x								
1.3. To create method for production of ecological composite materials from textile plants and local mineral binders (deliverable)							x							
2. To develop and write guidelines for data collection system, which is suitable for heat and humidity migration control in energy-efficient buildings.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2.1.To develop plan for sensor installation in real stand (in cooperation with producer)	x	x												
2.2. To install sensors		x	x											
2.3.To collect data (humidity, temperature, etc.)			x	x	x	x	x	x	x	x	x	x	x	x
2.4. To develop model based on the collected data								x	x	x	x	x	x	x
2.5. To create guidelines for data collection system (deliverable)														x
3. Life-cycle calculations of natural fibre composite materials						x	x	x	x	x				
3.1. To collect and process data						x	x	x	x	x				
3.2.To create method for life-cycle calculations of natural fibre composite materials (deliverable)										x				
4. Recommendations for information about thermal properties of natural fibre composite materials to be added to LBN 002-01											x	x	x	x
4.1. To prepare recommendations for information about thermal properties of natural fibre														x

composite materials to be added to LBN 002-01 (deliverable)														
4. Publications, Scopus													1	
5. Conferences				2	1							1		
6. Supervision of doctoral thesis and master’s thesis	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Annex 2-A

Time frame the Core task 2 activities of the Project 3

	2014	2015				2016				2017			
	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. Experimental research on component scale specimens. Additional investigation damping and impact properties on finalised panels with vertical stiffeners	**X**	**X**	**X**	**X**	**X**	**X**	**X**						
1.1 Identification of material mechanical properties	X	X	X										
1.2. Identification of material thermal properties	X	X	X	X	X	X							
1.3. Identification of vibration damping properties		X	X	X	X								
1.4. Identification of impact properties					X	X	X						
2. Virtual modelling and optimisation by numerical methods	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
2.1 Updating of the Finite Element numerical model	X	X	X	X	X	X	X						
2.2 Optimisation of the product/process				X	X	X	X	X	X				
2.3 Validation of numerical model with experimental results					X	X	X	X	X	X			
2.4 Development of design methodology									X	X	X	X	
3. Prototyping at laboratory scale. Development of design guidelines	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
3.1. Upgrading of the chemical coposition of foam material	X	X	X	X	X								
3.2. Laboratory scale prototyping				X	X	X	X	X	X	X			
3.3 Scale-up of industrial manufacturing								X	X	X	X	X	X
4. Dissemination	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Annex 3-A

Time frame the Core task 1 activities of the Project 3

	2014		**2015**				**2016**				**2017**			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. Develop method for assesment of bridge dynamic characteristics.	X	X	X	X	X	X	X	X	X	X				
1.1. Studie about vehicle weight and speed impact on the bridge structure dynamic characteristics.			X	X	X	X	X	X	X	X				
1.2. Develop a method to asess heavy and very heavy vehicle dynamic effects on the bridge structure.							X	X	X	X				
1.3. Determine and justify limit values of the bridge dynamic characteristics based on the developed methods for assesment of bridge dynamic characteristics.											X	X	X	X
2. Analyse traffic load influence on bridge structure using theoretical probability distribution models.	X	X	X	X	X	X	X	X	X	X				
2.1. Develop a method for external action correlation forecasting.	X	X	X	X	X	X	X							
2.1. Study about properties range of materials used in bridge construction.	X	X	X	X	X	X	X							
2.2. Develop theoretical probabilistic distribution models for in construction used materials property variation.				X	X	X	X	X	X					
2.3. Analysis about ageing process influence on the construction material properties and its variation for existing structures.			X	X	X	X	X	X	X	X				
2.4. Develop a probabilistic model for building accuracy and description of other "human factor" induced structural properties variation and their impact on load–carrying capacity.							X	X	X	X				

2.5. Comparison of resulting action and material resistance probabilistic modes using limit state method defined in Eurocode, it will allow to determine existing bridge safety and robustness (with appropriate safety factors).									X	X	X	X	X	X
4. Publications, Scopus		1				3				2				2
5. Conferences		1				3				2				2
6.PhD and Master theses	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Annex 3-B

Time frame the Core task 2 activities of the Project 3

	2014		2015				2016				2017			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. Develop of method for localization of damage site and evaluation of damage size in various structural elements by using appropriate signal processing techniques experimentally measured dynamic parameter changes.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1.1. identification of damage in beam-type structural elements	X	X	X	X	X									
1.2. identification of damage in plate-type structural elements				X	X	X	X	X	X					
1.3. identification damage in sandwich-type structural elements							X	X	X	X	X	X		
1.4. methodology for exploitation damage identification in various structural elements											X	X	X	X
2. Development of new technologies for monitoring and diagnostics of aviation engines and various elements of rotary machines.			X	X	X	X	X	X	X	X	X	X		
2.1. investigation of aviation structural element health monitoring and diagnostics			X	X	X									
2.2. experimental investigation of dynamics parameters of aviation structural elements				X	X	X	X	X						
2.3. exploitation damage identification in aviation structural elements						X	X	X	X	X				
2.4. recommendation for health monitoring and diagnostics of aviation structural elements										X	X	X		
3. Development of method for pre-stress loss estimation in pre-stressed steel reinforced concrete structural elements.							X	X	X	X	X	X	X	X

3.1. investigation of methods, based on analysis of loss of pre-stress in pre-stressed steel-reinforced concrete structural elements							X	X	X	X				
3.2. numerical modelling and simulations of pre-stressed steel-reinforced concrete structural elements									X	X	X	X	X	
3.3. experimental estimation of dynamic parameters of pre-stressed steel-reinforced concrete											X	X	X	
3.4. method for evaluation of pre-stress loss in prestressed steel-reinforced concrete structural elements												X	X	X
4. Publications, Scopus						2	1	1				1	1	
5. Conferences					3				1			1	1	
6. Supervision of doctoral thesis and master’s thesis	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Annex 3-C

Time frame the Core task 3 activities of the Project 3

	2014		2015				2016			
	1	2	1	2	3	4	1	2	3	4
1. Development of design procedure for load-bearing elements from cross-laminated timber	x	x	x	x	x	x	x	x	x	x
1.1. Data generalization for development of design procedure for load-bearing elements from cross-laminated timber	x	x	x							
1.2. Development of design procedure for load-bearing elements from cross-laminated timber			x	x	x	x	x	x		
1.3. Experimental testing of design procedure for load-bearing elements from cross-laminated timber				x	x	x	x	x	x	x
2. Topology optimization for structure from cross-laminated timber and evaluation of it rational, from the point of view of it materials expenditure, parameters							x	x	x	x
2.1. Model of behaviour for structure from cross-laminated timber							x	x	x	x
2.2. Development of optimization algoritme for structure from cross-laminated timber							x	x	x	x
2.3. Evaluation of it rational parameters for structure from cross-laminated timber							x	x	x	x
3. Conferences, papers		1	2							
4. Supervision of doctoral and masters thesis	x	x	x	x	x	x	x	x	x	x

Appendix 4-A

Time schedule for project 4.

	2014		2015				2016				2017			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. Methodology work-out for determination of bending strength and conceptual design of plates with cell type hollow ribs	x	x	x	x	x	x	x	X						
1.1. work-out of calculation methodology	x	x	x	x	x	x	x	X						
1.2. determination of specimens' mechanical properties				x	x	x	X							
1.2.1 Developement of shear Resistance determination methodology for glued joint joint between plywood surface and edge.				x	x	X								
1.2.2 Determination of deformability and strength of plates in bending					x	x	X							
2. Methodology work-out for determination of specific bending strength for plates with cell type hollow ribs and determination of values for the most typical geometrical parameters.					x	x	x	x	X					
2.1. work-out of calculation methodology					x	x	x	X						
2.2. determination of specific bearing capacity							x	x	X					
3. Work-out plate models with most typical types of hollow cell type ribs and experimental investigations to get specific strength in bending, consumption of materials, energy consumption and costs.				x	x	x	x	x	x	x	x	X		
4. Recommendations work out for design of geometrical parameters of plates with hollow cell type ribs.									x	x	x	x	X	
5. Recommendations' work out manufacturing and 'work							x	x	x	x	x	x	x	X

in' technology principles and produce plates' demonstration models.														
6. Publications, Scopus										1			1	
7. Conferences				1		1		1	1			1	1	
8. Supervision of doctoral thesis and master's thesis	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Annex 5-A

Time frame of the Project 5

	2014		2015				2016				2017			
	III	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**II**	**IV**	**I**	**II**	**III**	**IV**
1. Development of research methods for early diagnostics of destruction of surface of polymer composite materials	**X**	**X**	**X**	**X**	**X**	**X**								
1.1. a method to study the influence of aquatic microorganisms on early destruction of materials	X	X	X	X	X	X								
1.2. a method to study visual recognition of early destruction using destruction-induced staining	X	X	X	X	X	X								
2. Development of methods for early diagnostics of destruction of polymer composite materials							**X**	**X**	**X**	**X**				
2.1. the method for early diagnostics of destruction using *in situ* electron emission spectroscopy							X	X	X	X				
2.2. the method for early diagnostics of destruction, based on the influence of aquatic microorganisms							X	X	X	X				
2.3. the method of visual recognition of early destruction using destruction-induced staining							X	X	X	X				
3. Application of methods for early diagnostics of destruction of surface of polymer composite materials in enterprises											**X**	**X**	**X**	**X**
3.1. Application of diagnostic methods in machinery manufacturing and constructions (development of recommendations)											X	X	X	X
3.2. Application of diagnostic methods in manufacturing of polymeric pipes for drinking water (development of recommendations)											X	X	X	X
4. Number of scientific publications						**1**				**2**				**2**
4.1. Scopus										1				1
4.2. Proceedings of conferences						1				1				1
5. Conferences						**1**				**1**				**1**
6. Development of doctoral and master theses	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
7. Registered Latvian patent														**1**

Annex 6-A

Time frame of the Project 6

	2014		2015				2016				2017			
	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
1. To characterize the metal surface and determine the best test methods	X	X	X	X	X	X								
1.1. Develop a method for the preparation of the metal surface of the samples - cutting, rough polishing, fine polishing	X	X		X	X									
1.2. Develop a method for full sample surface analysis (optical microscopy, atomic force microscopy, scanning electron microscopy, profilometry)			X	X	X	X								
2. To develop a test apparatus to simulates an ice track and a climate simulator to test metal surface friction and wear reduction	X	X	X	X	X	X								
2.1. Develop testing apparatus (simulation of bobsled track) and software to detect movement of the sample at a certain angle	X	X												
2.2. Develop a climate simulator which can be adjusted to work at low temperatures		X	X	X	X									
2.3. Develop a method for measuring slip under laboratory conditions	X	X	X	X	X	1								
3. To modify the metal surface, and calculate the new slip determined by any modifications made					X	X	X	X	X	X	X	X		
3.1. Develop a method for metal surface modification to increase slip (surface roughness, hardness, chemical modification)					X	X	X	X	X	X	X			
3.2. Optimise metal surface for increased gliding on ice (report)										X	X	1		
4. Determine the relationship of gliding between the metal surfaces and ice (report)											X	X	1	
5. To develop methods for the optimisation for the gliding surface with real track conditions						X	X		X	X	X	X	X	X
5.1. Develop a method for determining the slip under real track conditions, in comparison with laboratory equipment (report)						X	X			X	X	1		
5.2. Develop a method for surface modification of a larger metal sample									X	X	X	X		
5.3. Make a modification recommendation for the metal													X	1

surface to improve gliding in track conditions (report)														
6. Publications						1				1				1
7. Conference					1				1				1	
8. Science publications									1					
9. Seminars										1				1
10.Master's thesis	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11. Patent results in Latvia														1
12. New methods for exploitation														1