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.	
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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)

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).

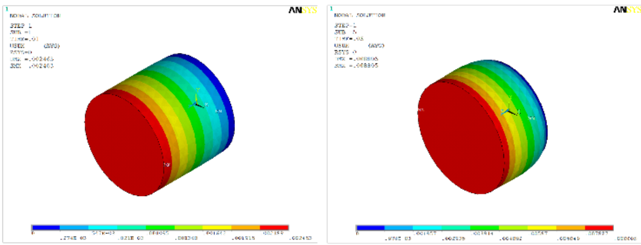

Fig.2. Verification of simplified foam specimen material model by FEM.

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

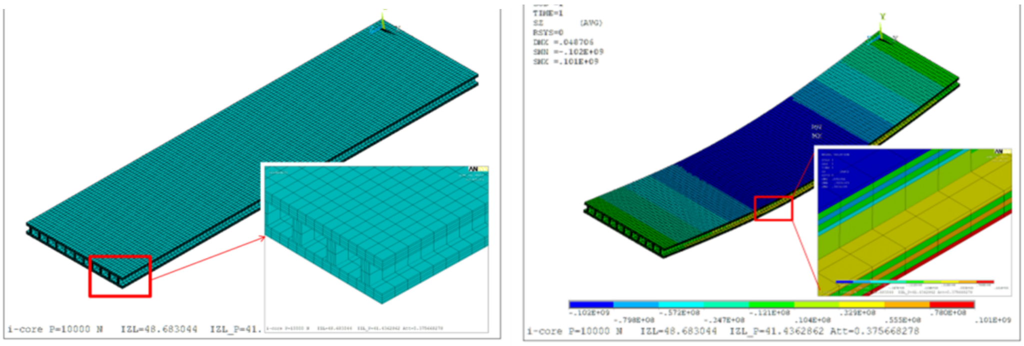

Fig.3. I-core plywood sandwich panel numerical model.

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.

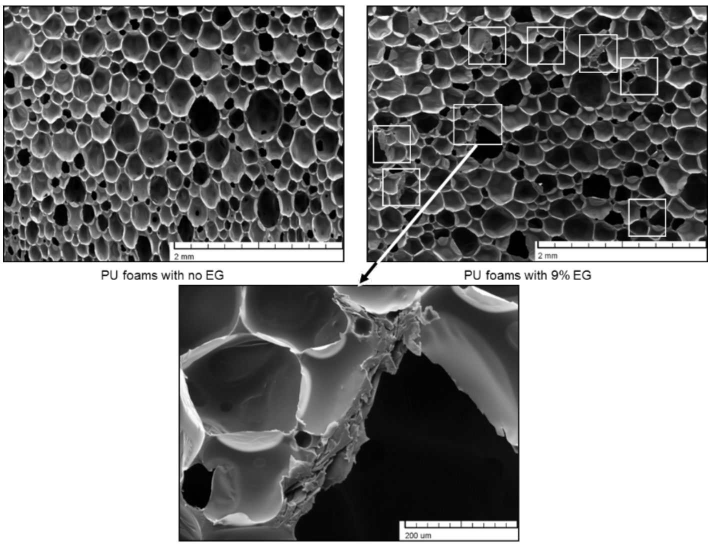

Fig.4. Obtained polyurethane foam with modified chemical composition.

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.