

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

(Phase 1 05.12.2014 – 31.03.2015)

Degree

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2.2. The aim of the Project

Outwork of Rational wooden composite with rational structure

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 1 quarter of year 2016)

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.

Three conference abstracts are accepted:

1. G.Frolovs, K.Rocēns, J.Šlisieris «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”.

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.

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 of 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)

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.

2.3. 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)

<p>1. Development of methodology for determination of bending strength and conceptual experimental investigations of plates with cell type hollow ribs (task ends 1st quarter of year 2016)</p>	<p>Basics of the methodology and technological principles of 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%.</p>
<p>ANSYS finite element code was chosen for methodology of calculations that takes into account geometrical parameters, material properties and other factors that influence load</p>	

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:

1. Analytically approved that it is possible to achieve material consumption reduction up to 20% and increase efficient use of wood material;
2. The method of production and conceptual prototype of production equipment equipment's conception variant for hollow rib production are worked out;
3. 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.
4. 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

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2.4. 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 1 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.

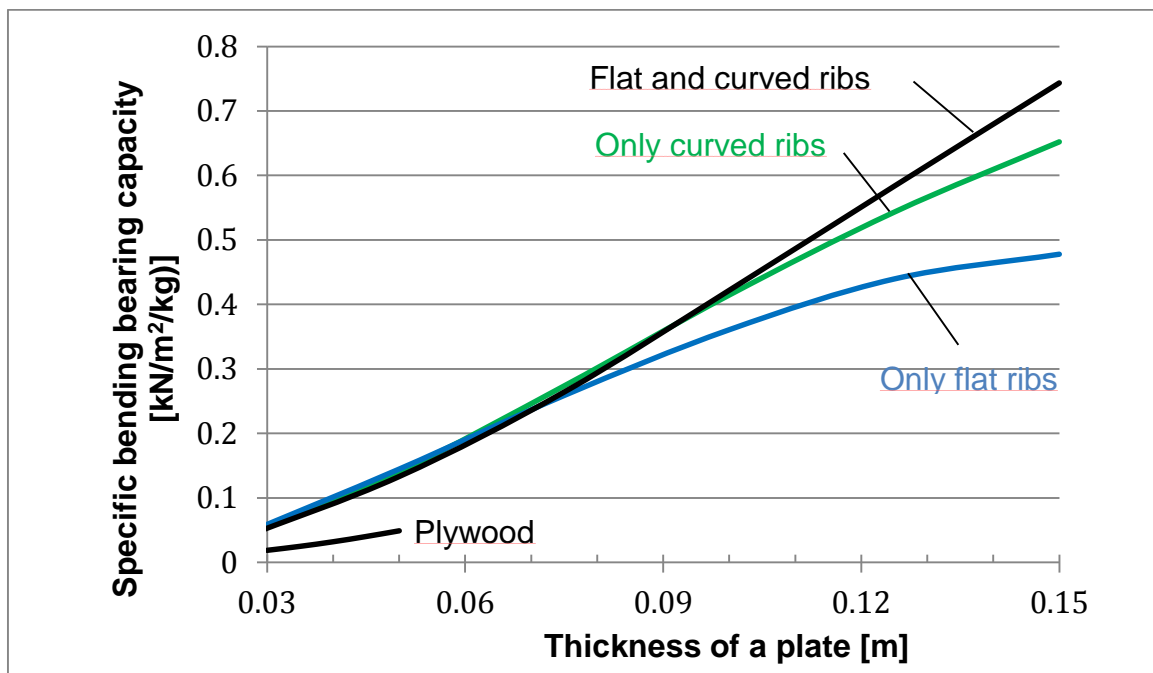


fig. 1. Ultimate Service load (SL) and dead weight (DW) ratio comparing plywood and related ribbed (straight and waved) plates in longitudinal direction.

For all elements (plywood for ribs and skins) 3 layer plywood with total thickness of 4 mm and density approx. 700 kg/m³.

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 + social taxes - 1211) 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.

2.5. 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.

2.6. Dissemination and outreach activities

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

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:

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

PART 3: INFORMATION ABOUT PROGRAM FINANCE

