Riga Technical University 53rd International Scientific Conference dedicated to the 150th anniversary and
The 1st Congress of World Engineers and Riga Polytechnical Institute / RTU Alumni

"Bending stiffness and weight optimization of plywood sandwich panels"

Edgars Labans (*Riga Technical University, Institute of Materials and Structures*)
Kaspars Kalniņš (*Riga Technical University, Institute of Materials and Structures*)

***Keywords* – numerical modeling, ANSYS, rib stiffened plywood structures, Pareto optimality.**

I. Introduction

Sandwich structures and rib stiffened panels from metal, fiber materials and plastics has been recognized as efficient and material saving solutions for applications requiring lightweight design elements, like ships, trains and aircrafts[1]. In addition to weight reduction, sandwich structures also allow to integrate addition properties for the panel like insulation and wave damping layers.

Wood is now widely used in sandwich design for building walls and floors, where insulation properties is most important than weight reduction. However excellent mechanical properties of plywood are suitable for manufacturing of lightweight sandwich panels for heavy duty load applications like floors in passenger transport. Mechanical properties of single plywood layer (veneer) in longitudinal direction are close to GFRP fabric ~ 17 GPa. Changing orientation of layers is possible to create tailored solutions for specific load conditions. Plywood sandwich panels with rib stiffener cores are not widely studied, thus there is potential to create more weight efficient solution than traditional plywood boards.

The aim of current research is to find most effective cross section design for plywood sandwich panels with rib stiffened and corrugated core as well as to develop overall methodology for assessing efficiency of sandwich panel, taking stiffness and volume of full plywood board as reference.

II. Numerical modeling

The optimization work conducted in present research is based on approximation of mechanical response values of sandwich panels acquired numerically from ANSYS computer code. Sandwich panels have been made of multilayered shell elements with transverse isotropic wood properties. Numerical sandwich structures with rib and corrugated plywood core has been virtually loaded in 4-point bending. Extended description of numerical modelling and validation with experimental tests provided in previous study [2].

III. Metamodeling technique

In current research metamodeling (surrogate modeling) were used to reduce number of numerical experiment runs. Design variables for panels with rib stiffened core are cross section parameters: overall cross-section height, distance between stiffeners, thicknesses of skins and stiffeners expressed by odd layers count. For panels with corrugated plywood core, additional parameters characterizing core is corrugated plywood thickness and angle, bonding area length. Partial polynomial approximation functions created by Adaptive Basis Function Creation (ABFC) technique (implemented in VariReg software). Metamodelling accuracy was measured using Relative Root Mean Square Error (*RRMSE).*

IV. Pareto optimization for sandwich panels

Overall efficiency of plywood sandwich panels has been demonstrated by formulating Pareto optimization problem where maximization of relative stiffness ΔK is done simultaneously by minimizing the relative volume ΔV of the panel. Relative stiffness is acquired dividing numerically calculated conventional plywood board deflection with calculated deflection of sandwich panel with same length and thickness, under the same loading conditions. Relative volume is acquired by dividing sandwich panel volume with full plywood panel volume.

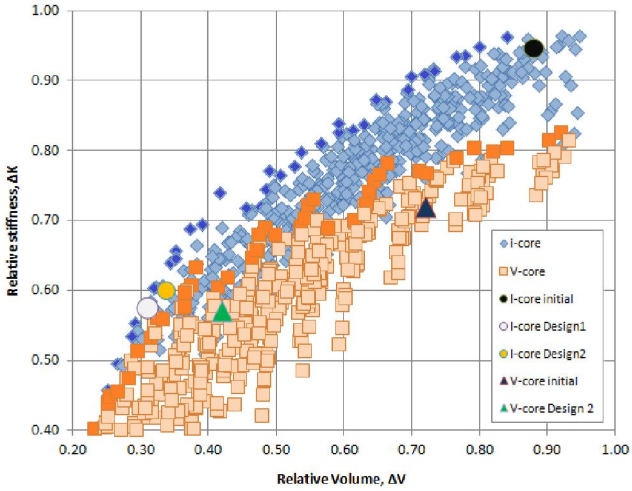

Fig. 1. Pareto optimality plots for I-core and V-core sandwich panels

Overall tendency could be observed that panels with rib stiffened core (I-core) has better stiffness ratio than panels with corrugated core (Figure 1). Using these results future decisions about direction of sandwich panels performance improvement could be done.

V. Conclusions

Comparing Pareto fronts of sandwich panels with different core types, has been find out that panels with rib stiffened core have better relative stiffness, consequently better optimization capacity. Variable sets on Pareto fronts in relative volume region from 0.3 to 0.7 could be recommended as optimal solutions for further panel manufacturing. In these cases difference between relative volume and stiffness is more than 20 %. It is also noticeable that initial designs for both panels are outside these bounds. Improved cross-section topology design drives sandwich panels closer to the optimal front.

V. References

[1] J.R. Vinson, Sandwich structures: past, present and future Sandwich Structures 7: Advancing with Sandwich Structures and Materials. Proceedings of the 7th International Conference on Sandwich Structures, Aalborg University, Aalborg, Denmark, 29–31 August, 2005, pp. 3-12.

[2] E. Labans, K. Kalniņš, Numerical versus experimental investigation of plywood sandwich panels with corrugated core, Proceedings of the Civil engineering `11, Jelgava, 2011. - pp 159-165.