Universitatea *Transilvania* din Braşov

# HABILITATION THESIS

# SUMMARY

**Title: MODELING, TESTING AND OPTIMIZATION OF THE STRUCTURES MADE OF COMPOSITE MATERIALS REINFORCED WITH FABRICS AND NATURAL FIBERS**

**Domain: MECHANICAL ENGINEERING**

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## SUMMARY

The habilitation thesis approaches a research theme in the *mechanical engineering* field, which refers to the modeling, simulation, testing and optimization of the parts and structures made of hybrid composite materials reinforced both with glass woven fabrics and with natural fibers (flax woven fabrics, wood flour). One presents the results of the reasearches conducted after obtaining of the scientific title of *doctor* (*PhD*), in the field of the *mechanical engineering (June, 2006)*.

The reasons for choosing of the theme are based on: requirements imposed by the economic environment related to the design of innovative lightweight structures, with minimum costs of manufacturing, which corresponds to the applications both in terms of the mechanical strength and in terms of durability under the action of the environmental factors (humidity, temperature variations, UV, etc.); necessity of the using of the natural fibers, especially those that are easily renewable (flax, jute, hemp, etc.), as sustainable source of raw materials for reinforcement of the composites; ecological requirements related to the use of recyclable waste (e.g. wood waste).

In *chapter 1*, one presents both the theoretical results (obtained with analytical model and with finite element analysis) and the experimental results (obtained by tensile testing and bending testing) concerning the mechanical behavior, in case of three kinds of composite materials based on epoxy resin, differently reinforced: one composite material reinforced only with flax woven fabric; two hybrid composites reinforced both with glass woven fabric and with flax woven fabric that are different by layouts of the layers. Finally, one comparatively presents the results and one establishes the optimal structure of the hybrid composite of type glass / flax / epoxy.

In *chapter 2*, one presents the experimental researches concerning the mechanical behavior of the hybrid composite materials reinforced both with glass fabric and with wood flour, researches that are gradually approached to finding an optimal structure both in terms of the mechanical properties and in terms of durability under the action of the effects of water absorbed after 6572 hours of immersion. It was analyzed the effects of the wood fiber type (different species), the effects of the glass fabric type, the effects of the immersion environment and of the immersion time on the mechanical characteristics. The causes of the degradation of the mechanical characteristics are justified by data related to the water absorption and by analysis of the material structure with digital microscope: micro-cracks at the interface between glass fibers and epoxy resin; oxidation of the resin; degradation of the wood fibers. The results were compared with the results obtained by other researchers in the case of composites based on wood chips, hot pressed.

The experimental researches presented in *chapter 3*, were imposed as a necessity in terms of

knowledge of the transverse contraction coefficient $\nu_{12}$ (*Poisson*'s ratio) within the reinforcing plane 12, in the purpose of the accurately modeling of the material in case of the structures made of composite materials. The effects of the reinforcing with wood fibers on *Poisson*'s ratio $\nu_{12}$, are presented. Four kinds of composite materials were tested: one reinforced only with oak wood flour; one reinforced only with glass fabric; two hybrid composite materials reinforced both with glass woven fabric and with oak wood flour or fir wood flour, respectively. In order to concurrently determine both the longitudinal strain $\varepsilon_x$ in the direction of the tensile force and the transverse strain $\varepsilon_y$, it was combined the tensile testing and the method of digital image correlation by using the *Aramis 2M* (Polytechnic University of Bucharest) for the acquisition and for the post-processing of the images. The experimental data $\left(\varepsilon_x, \left|\varepsilon_y\right|\right)$ were approximated by linear regression and the slope of the linear function represents *Poisson*'s ratio $\nu_{12}$. It was proved that the reinforcing with wood leads to the increasing of *Poisson*'s ratio $\nu_{12}$.

In the chapter 4, one presents the theoretical and experimental researches concerning the stress and strain states developed in the chair seat-backrest component made of composite material of the glass / fir wood flour / epoxy type that is analyzed in chapters 2 and 3.

The research results presented in *chapter 1* are obtained in recent years (2014-2015) and these were published in the journal *Advances in Mechanical Engineering* (*SAGE Journals*, SRI: 0.787 / 2014) and *Procedia Technology* (*Elsevier*). Part of the research results presented in *chapters 2...4* constituted the research objectives of the grants which the author of the present habilitation thesis, had coordinated as project manager since 2007 and these results were published in 10 papers indexed ISI (5 papers in ISI quoted journals) and 16 papers indexed in BDI. Referring to the career development plans, it was proposed projects that are in evaluation process, in order to attract funds, which continue the research themes approached in the present habilitation thesis and extend the research methodology for other types of structures made of sandwich composite materials reinforced with natural fibers. The results will be disseminated in: ISI quoted papers and ISI / BDI indexed papers. In terms of didactic activities, it aims regular updating of the courses, with results of own researches. Professional development plan is sustainable considering the competences and abilities proved by: coordinating of three (3) research grants gained through national competition, as director; collaborating as a team member in 11 contracts; one (1) patent application; 13 ISI indexed papers; 20 papers indexed in international databases (BDI); publication of two monographies (1-single author, 1 -coautor); 4 course supports as main author.