HABILITATION THESIS

"Buckling analysis of thin-walled members and vibration analysis of civil engineering structures"

a) ABSTRACT

Present thesis summarises the scientific activity of the candidate after defending the PhD Thesis at The Technical University of Cluj-Napoca, confirmed by The Ministry of Education and Research, on the basis of Order no. 6026, dated 27.11.2009. The scientific activity and achievements presented here are developed in two thematic directions.

The first one entitled "*Buckling analysis of thin-walled members*" represents the dominant part of the candidate's research activity, it started with the scientific work developed during the candidate's PhD programme entitled "Stability aspects for metallic structures", supervisor: prof. Cornel BIA, and since then it has significantly evolved by new theoretical formulations in the field of thin-walled structures. In this area, the candidate's work is related to the Generalised Beam Theory (GBT), a specialised theory for the analysis of thin-walled members, which is thoroughly presented in this thesis. The candidate extended GBT for special cases of thin-walled members and analysis types, and his personal contributions of theoretical nature, published in ISI and conference papers, can be summarised as follows:

a. *GBT formulation to analyse the behaviour of thin-walled members with variable cross-section.* This formulation added new equations to GBT in order to handle tapered thin-walled members with small tapering slopes.
b. *GBT formulation to analyse the buckling behaviour of isotropic conical shells.* GBT was already developed for cylindrical shells and tubes and through the candidate's work, that formulation was extended for conical shells, yielding very promising results even for large values of the tapering slope.
c. *Buckling mode decomposition from Finite Element Analysis (FEA) of thin-walled members.* The candidate proposed a method capable to quantify the modal participation of the pure deformation modes (of Global, Distortional and Local nature) in a general buckling mode. Even if similar methods were very recently reported by other researches, the method developed by the candidate is, at present time, the fastest and the most stable, due to a special algorithm based on the orthogonality features of the pure deformation modes.

The second scientific direction entitled "*Vibration analysis of civil engineering structures*" contains theoretical and also experimental work. The theoretical work started under the topic "Vibration mode decomposition from FEA of thin-walled members" and is mainly concentrated on the applicability of the modal decomposition method (briefly described above, at point *c.*) to the modal shapes derived from FEA, associated with the natural frequencies of thin-walled members. The topics of the experimental work are (i) *Experimental modal analysis,* and (ii) *Tension estimation of cables based on vibration analysis*. The candidate was recently (2011) nominated as coordinator of the laboratory „Actions in Buildings and Structures", Department of Structural Mechanics, Faculty of Civil Engineering, Technical University of Cluj-Napoca. The laboratory contains Bruel&Kjaer and PCB Piezotronics equipment and dedicated software suited to perform experimental vibration analyses. At present time, under the candidate supervision, successful experimental modal analyses were performed on real-world structures (beam and suspension bridges, metallic structures, tall concrete buildings, hollow-core slabs etc.) and also on small elements inside laboratory. The candidate conducted many vibrations measurements and analyses in

time/frequency domain for bridges and other civil engineering structures (acceleration, velocity, displacement, level of vibrations) with the purpose of: optimisation of structure's dynamic characteristics (mass, stiffness, damping), risk assessment of having the resonance phenomenon, prediction of dynamic behaviour, evaluating the damping for inclusion in FE models, correlation of FE models with real structures, damage detection and assessment, long term building monitoring, experimental assessment of traffic or other human activities induced vibrations.
The tension estimation of cables by means of vibration response is another recent scientific area in which the candidate obtained very promising results. The vibration method uses the experimental modal analysis to extract the natural frequencies of the cable and next, the tension force is determined by using appropriate analytical closed-form or numerical algorithm-form relationship between natural frequencies and the cable tension. The cable response is mainly affected by its flexural stiffness, sag-extensibility and the rotational stiffness of the end-supports. Until present time, the candidate considered hinged supports for his experiments, and the "sag" effect was neglected, but all the influencing terms were analysed in numerical studies.
The main achievements and results are presented in detail in Chapter (b-i): *Scientific, professional and academic achievements*.

In what concerns the future research and development plans of the candidate, related to the fields of research presented above, the following research topics will continue or will be developed:
Analysis of thin-walled members
- buckling/vibration analysis of tapered thin-walled members with arbitrary cross-sectional variation
- buckling/vibration analysis of conical shells based on GBT
- improving the modal decomposition method
- buckling/vibration mode decomposition for tapered thin-walled members, cylindrical and conical shells
- buckling/vibration mode decomposition for thin-walled members with arbitrary holes
- the effect of imperfections in non-linear analysis of thin-walled members

Experimental vibration analyses:
- perform new experimental modal analyses on real complex structures such as civil and industrial constructions and also on small structures and scale models inside laboratory
- tension estimation of cables by means of vibration response taking into consideration the "sag" effect and the real rotational stiffness of the end-supports

A short description of each topic has been done in Chapter (b-ii): *Scientific, professional and academic future development plans*.

Finally, it have to be underlined that the active role of the candidate will continuously increase by participation with new research topics to international conferences and papers published in specialised journals.