Axiomatic-Asymptotic Analyses of Composite Plates and Shells

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The development of beam (1D), plate and shell (2D) models is one of the most important topics of the theory of structures. From a mathematical standpoint, the development of structural models requires the reduction of a 3D problem to a 2D or 1D one. In other words, the 3D unknown variables become 2D or 1D. In the former, the variables usually lie on a reference surface, in the latter, on a reference axis. The axiomatic and the asymptotic methods are the main techniques to build 2D and 1D models. An axiomatic model is based on assumptions regarding the mechanical behavior of a structure. In a 1D case, for instance, the behavior of the structure above the cross-section may be assumed and translated in a displacement field expanded over the cross-section coordinates. Similarly, in a 2D case, assumptions deal with the mechanical behavior along the thickness direction and expansions over the thickness coordinate can be employed. The asymptotic method makes use of characteristic parameters, e.g. the thickness ratio, to build a 1D or 2D series that approximates the 3D energy. Those variables that exhibit the same order of magnitude as the parameter when it vanishes are retained. While axiomatic models are easier to build, asymptotic ones allow the accuracy of the models with respect to the exact solution to be evaluated.

The axiomatic-asymptotic method (AAM) has been recently proposed by the authors as an attempt to retain the advantages of both methods. In the AAM, in fact, a starting model is used with a full expansion of variables. Then, the influence of each variable, or groups of variables, on a given problem is evaluated by deactivating it. Only those variables exhibiting an influence are retained and reduced models are built in which the number of unknown variables are less or equal to the starting, full model. The method can be iterated to evaluate the influence of characteristics parameter such as thickness or orthotropic ratios. The Carrera Unified Formulation (CUF) is used to generate any full and reduced model. The systematic use of CUF and AAM has then led to the definition of Best Theory Diagrams (BTD) in which, for a given accuracy and problem, the minimum number of required unknown variables can be read. This paper presents the latest development of AAM with particular attention paid to plate and shell models.

Keywords: CUF; AAM, BTD