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A best theory diagram for metallic and laminated shells

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Abstract

Among the various problems related to design and analysis of metallic and layered shells this paper focuses on the development of appropriate shell theories for a given geometry, loadings, boundary conditions as well as metallic and layered wall. It is known that classical plate theories, such as classical Theory based on Kirchhoff-Love postulates are not capable to trace accurately local stress/strain response of metallic thick structures and anisotropoic shells. Laminated structures, in fact, due their intrinsic trough-the-thickness anisotropy, show the so called zig-zag ZZ form of displacement field as well as interlaminar continuous IC transverse shear and normal stress fields at layers interfaces. These peculiarities of multilayered construction where summarized as C^0_z-requirements in [1] and cannot be considered by classical plate theories. Many studies have been proposed to overcome limitation of classical theories. Higher order theories with unknown variables whose numbers is independent by the number of the constitutive layers N_l have been denoted as Equivalent Single layer models ESLM; others which kinematic is independent in each layer have been denoted as Layer-Wise models LWM. Zig-zag effect is naturally accounted for by LWM while possibilities to include ZZ effetc and IC have been extensively discussed in the review papers by Carrera [1], [2]. Most of the practical problems related to composite structures demand the use of computational models, that is 3D solution as well as closed form analysis are restricted to very few cases.
By using refined computational models for layered structures the following question arise to the users:
Is there any possibility to establish the most accurate and less expensive computational model/theory for a given shell problem?
If we restrict the attention to shell case we can look at the problem by considering the diagram in Fig. 1. The x-axis shows accuracy (measured for a given stress/displacement/strain/failure variable) and the y-axis computational costs (ndof) of a given plate theory. For a given problems, geometries, lamination lay-out, loadings and boundary conditions, the theory under considera-

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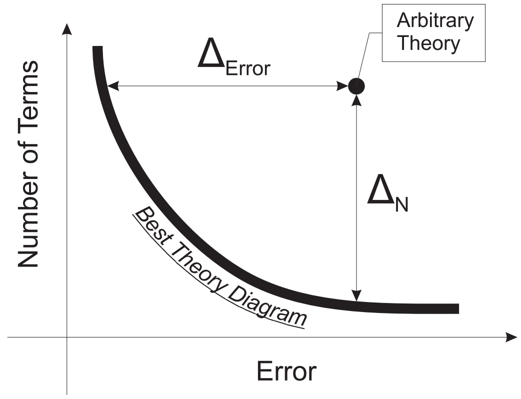

Figure 1: Best Theory Diagram: costs vs accuracy.

tion can be represented by a point in that diagram. The following two equations can be made:

1. Is it possible to reduce the error with the same computational costs?
2. is it possible to reduce the computational costs with the same error?

To provide answer to the above questions appears extremely relevant to shell-theory users. It appears clear by Fig. 1 that to provide answer to questions 1 and 2 means to find the two corresponding points at constant error and constant computational costs, respectively. By doing that for any possible plate-model it appear clear that a Best Theory Diagram can be build which gives for each accuracy the minimum dof required or viceversa. It is concluded that BTD is a tool that provide answer to questions 1 and 2. On the basis of Carrera Unified Formulation [1], [2] and recent works [3],[4] BTD has been introduced in [5] for the case of theory for isotropic one-layer plates. This work extend the construction of BTD to shell geometry.

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