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EVALUATION OF SHELL THEORY PERFORMANCES VIA NEURAL NETWORKS

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This paper presents a methodology to evaluate the performances of shell theories concerning the accuracy and computational cost. The approach has three components, i.e., the Carrera Unified Formulation (CUF), Axiomatic/Asymptotic Method (AMM), and Artificial Neural Networks (NN). CUF provides governing equations, e.g., for dynamic cases,

$$\mathbf{u}(x,y,z) = F_\tau N_i(z)\mathbf{u}_{\tau i}(x,y) =>$$
$$\int_{\Omega_k A_k} \int (\delta\epsilon^{kT}\sigma^k + \rho^k \delta u^{kT}\ddot{u}^k)H_\alpha^k H_\beta^k d\Omega_k dz = 0 \quad => \quad m_{\tau i s j}^k \ddot{u}_{\tau i}^k + k_{\tau s i j}^k u_{\tau i}^k = 0 \quad (1)$$

The AAM leads to the Best Theory Diagram (BTD) by measuring the relevance of generalized displacement variables, see 1. On the BTD, a structural theory is identified by its degrees of freedom (DOF) and the error concerning a given output, e.g., natural frequencies, the transverse displacement, and stress values. The BTD theories provide the best accuracy for a given number of DOF and the minimum computational cost for a given accuracy. The performance of any other structural theory can be evaluated against the BTD. The computation of the BTD can be cumbersome as thousands of static or dynamic
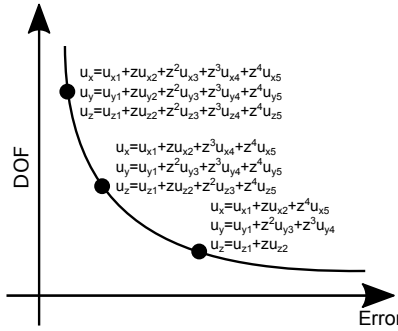

Figure 1: Best Theory Diagram.

analyses are necessary. This paper overcomes this problem by using NN. The NN training makes use of the data from CUF-AAM. The inputs of the NN are combinations of the fifteen generalized displacement variables of a fourth-order model and the thickness ratio,

$$\begin{aligned} u_x &= u_{x_1} + z u_{x_2} + z^4 u_{x_5} \\ u_y &= u_{y_1} + z u_{y_2} + z^3 u_{y_4}, \quad h/a = 0.1, \quad => \quad [1\,1\,1\,1\,1\,0\,0\,1\,0\,1\,0\,1\,0\,0\,0.1] \quad (2) \\ u_z &= u_{z_1} + z u_{z_2} + z^2 u_{z_3} \end{aligned}$$

Where '1' indicates an active variable and '0' a deactivated one, the targets for the NN training are the errors over the first natural frequencies or static responses. The use of NN leads to the BTD with some 10% of the analyses required by the full run case.