ICMAMS 2019
Second International Conference on Mechanics of Advanced Materials and Structures
Nanjing, 19-22 October 2019
www.icmams.com

EVALUATION OF SHELL THEORY PERFORMANCES VIA NEURAL NETWORKS

M. Petrolo

MUL[2] Group, Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Italy.

Keywords: *Structural Mechanics, Composite Materials, Computational Mechanics*

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,

$$\begin{aligned} &\mathbf{u}(x,y,z) = F_\tau N_i(z)\mathbf{u}_{\tau i}(x,y) => \\ &\int_{\Omega_k}\int_{A_k} (\delta \boldsymbol{\epsilon}^{k^T} \boldsymbol{\sigma}^k + \rho^k \delta \boldsymbol{u}^{k^T} \ddot{\boldsymbol{u}}^k) H_\alpha^k H_\beta^k d\Omega_k dz = 0 \quad => \quad \boldsymbol{m}_{\tau isj}^k \ddot{\boldsymbol{u}}_{\tau i}^k + \boldsymbol{k}_{\tau sij}^k \boldsymbol{u}_{\tau i}^k = 0 \end{aligned} \tag{1}$$

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

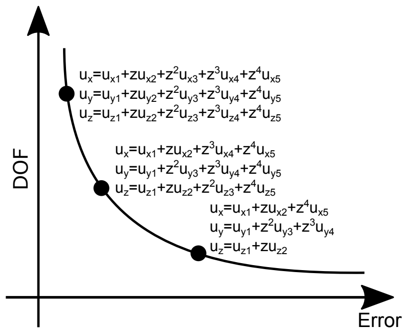

Figure 1: Best Theory Diagram.

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,

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

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.