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Computational model validation of structural components by full-field optical measurements

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Key Words: *I-beam, Digital Image Correlation, Model Validation, Decomposition.*

The primary objective of the present work is to demonstrate the full field validation methodology proposed in [1], for the comparison of simulation and experimental displacement and strain results acquired by simulation and Digital Image Correlation (DIC). Three-point bending of an I-beam with open holes in the web has been selected for the investigation. Perforated I-beams are widely used in light-weight structures e.g. as aircraft wing spars, in civil engineering e.g. in metallic building frames, as well as in other civilian applications . The I-beam deformation was captured with by a three-dimensional DIC optical system, deployed for this purpose. A detailed Finite Element model was also developed in order to predict the stress / strain and displacement fields under three-point bending loading.
In Figure 1 (left), the three-point bending experimental set-up of the aluminum I-beam is shown. A finite element model of the aluminum beam under three-point bending is generated using 23136 Ansys type 'shell181' elements (Figure 1-right). A finer mesh is generated around the open holes. An elastoplastic material model with kinematic hardening is used. The numerical post-processing includes the acquisition of beam full-field displacement and strain contour plots, such as comparisons to the respective experimental results on the selected regions of interests of the beam web is performed (Figure 2).

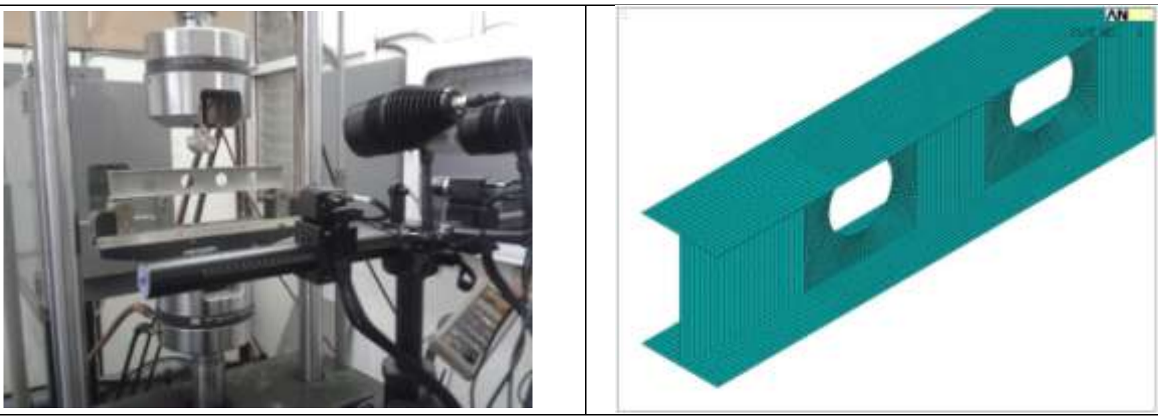

Figure 1: I-beam experimental testing setup (left) and Computational I-beam model (right)

Before a comparison between modelling and experimental data is performed. a radical reduction of the dimensionality of data fields from a matrix consisting of million values to a feature vector with, ideally between twenty and hundred elements is required. An efficient means for performing this task is the application of image decomposition techniques based on

e.g. orthogonal polynomials. Zernike polynomials were used for data decomposition of displacement and strain data fields in the present case.
Once DIC and FE displacement and strain images are decomposed, feature vectors are available from both experimental and numerical results, which are compared against one another, in the form of the plot shown in Figure 3.

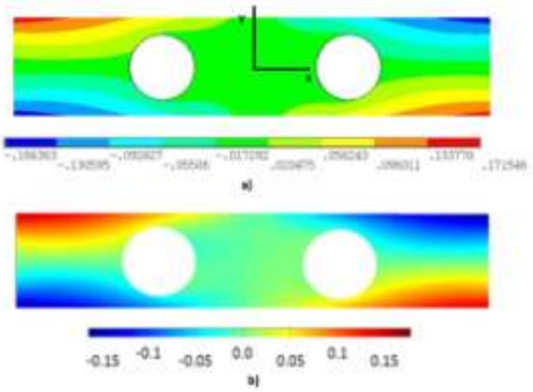

Figure 2: Displacement plots (mm) along x-axis, a) FE model b) DIC measurements

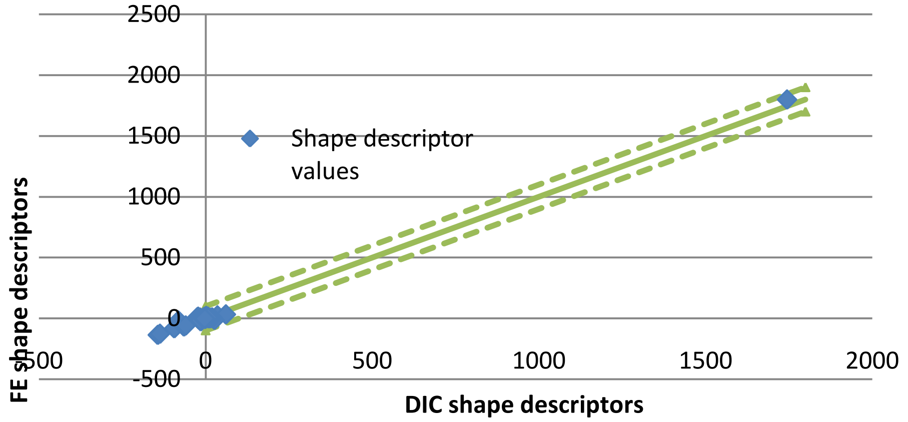

Figure 3: FEM–DIC comparison of in-plane displacement field

Concluding, a quantitative comparison between DIC displacement / strain maps and the respective FE data by exploiting the capabilities of Zernike moment decomposition was performed and the validity of simulation was assessed. A reliable validation methodology of computational solid mechanics models has been successfully demonstrated in the case of a common structural element of many engineering applications.

ACKNOWLEDGMENTS

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