Special session - Supporting simulations with strain measurement (CEN WS71)

190 Round robin results for CWA16799:2014 – Validation of computational solid mechanics models

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Abstract. Round robin results of a CEN guideline describing a validation methodology for computational solid mechanics models is currently being taken into account into the research activities of the H2020 Clean Sky 2 project MOTIVATE. The main research developments include the introduction of a quantitative validation metric, the development of generalised data decomposition methodologies, as well as the maturing of the CEN guideline implementation practices.

Introduction

The CEN guideline CWA16799:2014 entitled 'Validation of computational solid mechanics models' [1] recommends the use of full-field measurement data for the purpose of validating a numerical model. The guideline demonstrated its usefulness in laboratory environments on different representative test objects [2]. The results and experiences from an international Inter Laboratory Study – ILS, similar to a round robin exercise, performed in the frame of the EC supporting action VANESSA [3] have been taken into account in increasing the Technology Readiness Level of the validation methodology from 4 to at least 6.

Round Robin Results

The Inter Laboratory Study (ILS) protocol used to derive the round robin results included an overview of the methodology for validation of computational solid mechanics models, as well as a procedure for the step-by-step application of the validation process and recording of results. The participants in the ILS were provided with a choice of three exemplars to which the validation methodology could be applied. These three exemplars (shown in Figure 1) comprised a thermomechanical analysis of an antenna reflector, a wedge indenter deforming a rubber block and an I-beam with open holes in the web under three-point bending loading. A strong emphasis was placed on selecting industrially relevant components as ILS exemplars. The protocol provided step-by-step guidance for the application of the CEN guideline validation methodology. Displacement and / or strain plots were provided for use in the validation process. A software package, which could be used for the image decomposition, together with an excel file for the visualization of the results were also made available to the ILS participants. The Validation ILS was formally launched at the second CEN workshop on September 4th, 2013, in Cardiff, Wales, followed by a promotional campaign to the international engineering community and especially to engineers and researchers involved in computational solid mechanics simulations, mainly from the industrial sector, via the VANESSA project website, as well as at conferences, related project meetings and other relevant occasions. The collection of the completed validation ILS protocols was followed, by collation, interpretation and dissemination of the results.

The feedback from the engineering community revealed that the CEN guideline includes a novel validation methodology, which requires some refinements for use in the different industrial sectors.

The main round robin results referring to the implementation of the guideline were:

a. The criticality of the data decomposition and reconstruction processes and the selection of appropriate decomposition processes to generate sets of shape descriptors that are invariant to scale, rotation and translation. In response to this result, a generalised decomposition methodology of strain fields more suitable for complex components is under development in MOTIVATE project [4].
b. The importance of a perfect match between the Regions of Interest (ROIs) and data fields or images in the experiment and the simulation. In particular it was highlighted that, while for straight and easy test setups it is quite easy to match the images, for more complex set-ups with different view angles and rotations, references have to be established on the test subject to facilitate ROIs adjustment. Furthermore, the need that both the experimental and computational images to be in the same format, i.e. either in the deformed or in the undeformed state, was highlighted.
c. The requirement to assess the model quality, i.e. the degree to which the model matches the experiment, via an appropriate validation metric. The CEN guideline approach included only a simple comparison of data fields by plotting the elements of the feature vectors representing the data from

experiment and model as a function of one another in a linear plot and the acceptability of the comparison was discussed in the context of the uncertainties associated with the data from the experiment; for a valid model, all points of the plot should fall within a zone on either side of the line of unit gradient with bandwidth defined by the uncertainty in the feature vectors representing the data from the experiment, i.e. in a go-no-go basis.
To fulfil this requirement, in the frame of MOTIVATE project [4], a quantitative comparison methodology has been integrated in the validation process, by developing a validation metric, mapping the discrepancy between the computational response relative to the experimental data.

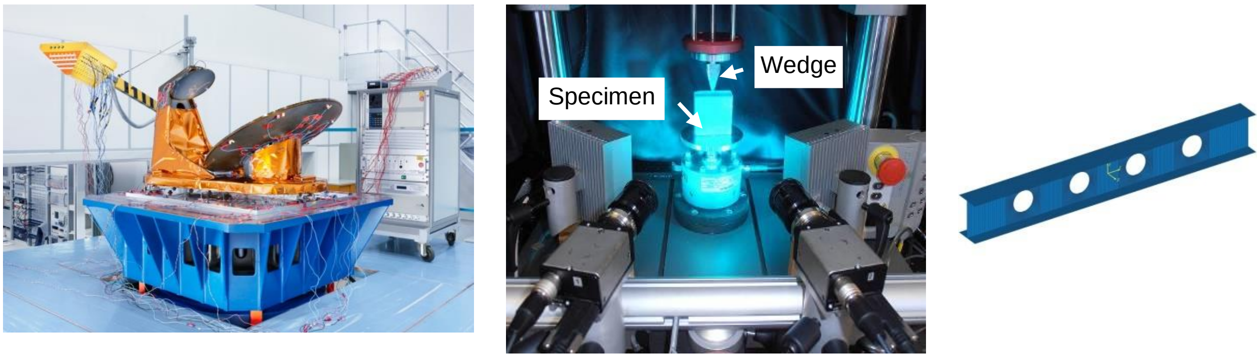

Figure 1: Exemplars of the validation ILS: a full CFRP space antenna reflector (left); wedge indenter deforming a rubber block (experimental arrangement) (centre); and an I-beam with holes under 3-point bending (simulation model) (right).

Conclusion

The round robin feedback to the CEN guideline approach has proven the effectiveness of the proposed methodology enshrined in the CEN Workshop Agreement 'Validation of computational solid mechanics models'. Evidence has been provided that the validation protocol forms a solid base for standardisation. The incorporation of the round robin comments are being undertaken in the activities of MOTIVATE project.

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