Engineering Stress Analysis using PhotoStress and Computational Techniques

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Currently industry relies on computational techniques to perform stress analysis of structures under loading conditions. However the solution is highly dependent on how correctly the loading and boundary conditions are defined. Computational techniques may thus require experimental validation.

The boundary and loading conditions are themselves more realistic in experimental stress analysis, hence the reason why the PhotoStress experimental technique was studied.

The research concentrated mainly on building up knowledge on the use of the PhotoStress method for experimental stress analysis. The research aimed at identifying areas in which the PhotoStress method augments the simulation process. The overall goal of the study was to examine the effectiveness of the PhotoStress technique and to serve as a guide to determine qualitatively and quantitatively strain/stress measurements using the PhotoStress technique.

The PhotoStress technique is a non-contact full-field experimental method which uses light rays and optical techniques to determine stresses on any structural component under different loading and boundary conditions through surface strain measurements.

The performance, reliability and accuracy of the PhotoStress coating method was evaluated by applying this technique to benchmark problems whose solutions for stress distribution is known. The benchmark problems include end-loaded SS304L cantilever beams, circular discs and annular rings loaded in diametral compression and a flat plate with hole under uniaxial tensile loading. An investigation of the stress/strain state of these two-dimensional benchmark problems was carried out to verify and validate the experimental PhotoStress coating technique by analysing and comparing the PhotoStress’ difference in principal strains and stresses with
the results obtained from experimental strain gauges, FEM and analytical solutions. The viability of the PhotoStress technique was evaluated via three-dimensional case studies.

The PhotoStress technique, as such, is not a complicated procedure, but in order to attain the required skills for this technique, one would require experience with regards to setting up of equipment, correct load application and most importantly, correct analysis of the qualitative stress distribution and of the quantitative data before reliable solutions can be obtained. It is only by analysing the benchmark problems that one can truly appreciate the method’s versatility when solving problems of a complex nature.

Results from the analyses of the stress/strain state of two-dimensional benchmark problems and case studies led to several positive conclusions regarding the use of the PhotoStress technique, and have also brought to light some limitations experienced by this experimental technique. Despite all the advantages that the PhotoStress coating technique entails, the PhotoStress technique is not suitable on medium-to-high modulus structures under low load conditions.

This study can serve as a useful guide to users still unexperienced in optics stress analysis who intend to use the PhotoStress technique as a strain/stress measuring tool, by understanding the different PhotoStress material coatings available, the experimental procedure and what to expect from such an experimental technique.

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