ASME

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METHODOLOGY FOR VALIDATION OF FINITE ELEMENT ANALYSIS UTILIZING STRAIN GAUGE MEASUREMENTS

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• Motivation and objectives
• Strain gauges
• Measurement methodology
• Post-processing methodology
• Results comparison
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Motivation and objectives

• Finite Element Analysis (FEA) has become widely adopted in engineering practice

• Various simplifications and assumptions are made while setting up models

• Significant errors, which are not obvious, may be introduced to the results
Motivation and objectives

• In order to validate simulations, physical testing must be performed

• Physical testing using strain gauges allows the collection of raw strain data from the structure

• Raw strain data can be processed and compared directly with FEA results
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Strain gauges

• Three-axis pattern is required for general stress analysis

• Tee strain gauges can be accurate only if the principal directions are known in advance

• Linear gauges can indicate strain only in one direction
Strain gauges

• Three-axis pattern is required for general stress analysis
  • Structures having complex shapes
  • Structures exposed to a combination of loads
  • Magnitudes of principal strains and their directions can be obtained
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Measurement methodology

• Determine strain gauge locations

• Select appropriate gauges, bonding adhesives and protective coatings for gauge installation

• Surface preparation
Measurement methodology

• Gauge installation
• Installation verification
• Capture data – record strain data together with environmental data and driving forces
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• **Post-processing methodology**
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Post-processing methodology

• Three normal strains can be converted into other meaningful information

• Three principal strains

• Direction of principal strains

• Equivalent strain

• Maximum shear strain
Post-processing methodology

- Strains can be converted into stresses
- Formulas provided for linear elastic and isotropic materials
- Proportionality stress is important
- Principal stresses
- Equivalent stress
- Maximum shear stress
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Results comparison

- Location where the strain gauge was installed during physical testing has been probed in the FEA
- Various strain and stress quantities extracted from the FEA
- Directions of the principal strains were extracted as well
Results comparison

- Percentage difference calculated for quantities of interest
- Best match occurs for the absolute maximum engineering shear strain (0.7%)
- Biggest percentage difference occurs for the second principal stress (6.7%)
- Principal strain angle (difference 2.2°)
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Conclusion

• Straightforward and repeatable methodology provided in the paper

• Validity of FEA assumptions and simplifications can be confirmed

• Strain and stress tensor visualization via 3D Mohr’s circles

• Percentage difference between the test case and FEA is below 5% for most quantities