Structures Bulletin

ASC/ENFS
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Subject: Structural Analysis Data Requirements

Background:

ASC/ENFS frequently receives requests to review structural analysis reports, and many times these reports have been submitted with limited or incomplete information. Some technical reports inadequately describe the structure, show assumptions without justification, and provide results without showing how they were obtained. Inability to portray a complete technical picture of the structural analysis makes a review difficult to accomplish and increases the time required to provide a response to the program office. To improve the effectiveness of the ASC/ENFS review process, this bulletin is provided to define representative data required when submitting a structural analysis for review. Submittal of technical information described in this bulletin will allow ASC/ENFS to conduct a thorough review and document any findings or recommendations in a technical evaluation. These same data requirements are recommended for use by all programs for all structural analysis reports.

Discussion:

In general, structural analysis reports need to include all relevant data (drawings, materials, loads, etc.), list all assumptions, show relevant computations, etc., in order to fully justify the analysis. These reports must be completed for every Model Design Series (MDS). An analysis that stands on its own and portrays the full extent of the work accomplished is the ideal for a complete review.

The data provided below outlines the basic representative requirements of a structural analysis report. ***Note that not all items will be required for every analysis report.*** However, all analyses need to be able to stand alone and should include basic report sections (introduction, background/purpose, work completed, results, and conclusions).

Representative Structural Analysis Data:

- Description of Structure:
    - Drawings, sketches, etc.
    - Sufficient geometric views, provide multiple views when possible
    - Orientation and location within aircraft, short description/title for part
    - Dimensions, tolerances, etc.
    - Joining methods (fasteners, adhesives, etc.)

- Materials:
    - Property data from an approved reference
    - Material description (alloy, heat-treatment, production method, etc.)
    - Material allowables (yield strength, ultimate strength, modulus, etc.)
        - - Account for environmental conditions, including temperature
        - - Use “A Basis” allowables for primary structures, single load path, and secondary metallic structures
        - - Use “B Basis” allowables for all other structures and composites

- Design Criteria:
    - State all design criteria pertinent to the structure
        - - Federal Aviation Administration/Federal Acquisition Regulations
        - - Military Handbook 516 sections
        - - Performance driven criteria

- External Loads:
    - Loads analysis: document all design conditions considered (maneuver, gust, ground loading, etc.). Provide reason why certain conditions were chosen for analysis. Loads to be considered in the analysis include:
        - - Aerodynamic, inertial, and thermal loading
        - - Fatigue loads
        - - Fuselage Pressurization
        - - Bird Strikes
    - Document magnitudes and distributions of all ~~aero, inertial, and thermal~~ loads used for design of the system in its operational environment. Provide a free body diagram showing loads and reactions when applicable
    - Show selection (down-select) of worst case conditions, and include shear, bending moment, and torsion data for all conditions
    - Detailed presentation of the analysis method along with sample calculations for determining loads

- Stress analysis:
    - Clearly define and display all mathematical variables used
    - Provide reference for analysis method (including equations) unless very simple or repetitious
    - Internal loads
        - - Applied loads

- - Computer program inputs/outputs
- - Finite element model description (constraints, assumptions, nodes, degrees of freedom, etc.)
- Critical load cases (if structure is repetitive use most critical case)
- Types of applied stresses
- Include special factors (fitting, bearing, casting, etc.)
- Account for all eccentricities
- Realistic load paths that properly account for structure (holes, cutouts, etc.)
- Calculations of stresses. Provide a detailed reasoning on why certain conditions were chosen for analysis
- Examine stability of structure through crippling and buckling (free flange, inter rivet, column, lateral, torsional, panel, etc.)
- Include calculations for fastened joints (bearing, pullout, tear out, etc.)
- Consider secondary effects (compression wrinkling of sheets, diagonal tension in shear webs causing increased fastener loads, etc.)
- Perform yield checks at limit load for structures made from materials which yield strength is less than two-thirds of its ultimate strength
- Margins of safety at limit load and at ultimate load. Ensure minimum margin of safety of 25% is used for critical structures that are not tested

- Durability and Damage Tolerance Analysis:
  - Life requirements
  - Classification of parts (safety-of-flight, fracture critical, mission critical, etc.)
  - Durability analysis
    - - S-N curves
    - - da/dN data
    - - Durability analysis spectrum description
    - - Fatigue or crack growth analysis
  - Damage tolerance analysis
    - - Model validation
    - - Damage Tolerance analysis spectrum description
    - - da/dN data and fracture toughness data
    - - Crack growth analysis
  - Inspection Requirements
    - - Provide inspection schedule and inspection methods

- Dynamic Analysis:
  - Vibrations/Aeroacoustics / Sonic Fatigue
    - - Design usage segments
    - - Define all noise/vibration sources and assumptions
    - - Define / reference methodology assumptions and limitations
  - Aeroelastic/Aeroservoelastic Analysis
    - - Define modeling methodology (FEM, and Aero), assumptions, and limitations
    - - Justify any limiting scope of analysis – store similarities, probable failure modes, etc.

- - Document modal properties for all retained modes; identify rationale for truncated modes.
- - Document any mass / stiffness parametric analyses for design sensitive components (store mass/c.g., actuator stiffness, etc.)

- Weight and Balance Analysis:
  - Mass distribution
  - Center of gravity
  - Area
  - Moment of inertias

- Analysis Validation:
  - Description of any testing performed (proof, static, flight, fatigue, etc.)
  - Associated test plans and procedures
  - Correlation of test results with predictions

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