Information regarding the requirements for writing a FEA report.

Dovre Sertifisering AS

GUIDELINE

GL-DSE-2020-003 Requirements for writing a FEA report

Information regarding the requirement for writing a FEA report

Last Revision date: November 25th 2020.

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Versjon: 1	**Sist revidert:** 25.12.2020	**Neste revisjon:**

Introduction

The focus of this note is on what is required when you are using a FEA to assist in the justification of the design.

It is preferred that a design is justified using Design by Rule. If you are working with the design of pressure equipment (piping or pressure vessels) it is preferred to use the requirements as laid down in the according standards (ex. EN13445-3 or EN13480-3).

There are situations where these standards are not applicable or do not cover your specific model, geometry or loads.

In this case it may be necessary to perform other calculations. This can be manual calculations or a Design by analysis route (ex. EN13445-3 Annex B or Annex C).

In this case we focus on the Finite Element Analysis (FEA).

What is Finite element analysis (FEA)

The finite element method (FEM) or finite element analysis (FEA) is a numerical method to predict the behaviour of a construction and for solving problems of engineering and mathematical physics.

Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The finite element method formulation of the problem results in a system of algebraic equations.

The method yields approximate values of the unknowns at discrete number of points over the domain *(Logan, 2011)*.

To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem.

Requirements FEA submission

If the standard rules are not sufficient to cover the design a FEA could be applicable.

The following items should be a part of the FEA report.

- The scope of the FEA.
  - Reason and explanation why the FEA is used.
  - Technical description of the structure
  - Description of the loads

- The software used for the FEA.
- Executive summary.
  - Describing how the FEA was used to support the design
  - FEA model used
  - The results of the FEA
  - Conclusions of the FEA for the model

- Type of analysis (linear, plastic).
  - Model description and generation
  - Refer to the drawings used (correct number and revision).
  - If simplifications or changes of the model are needed to perform a FEA, these must be explained and justified
  - Explain meshing (mesh type and size) and refinement
    - Explain h.
    - Explain p.
    - Shape.
    - Order (1^{st}, 2^{nd}).
- Chosen mesh size and local refinement.
  - Element type and number of elements
  - Forces on the model
  - Contact elements (how 2 areas/ faces are connected, ex. Flange faces that are connected)
  - Describe and show supports
  - Describe and show forces
  - Describe and show restraints
  - Describe the method to prevent rigid body movement
    - Models can translate or rotate freely if they are not correctly restrained.
    - An object has 3 translational and 3 rotational rigid body modes.
    - You can prevent rigid body movement by:
      - Restraints to the displacement
      - Study settings (soft spring)

    - Contacts
    - Connections
  - Describe and explain boundary conditions to compensate for missing model parts. This is typically when you are performing an analysis based on symmetry

- Material properties.
  - A complete description should be provided
  - All of the material properties used must be presented in the report (do not refer to separate documentation)
  - Use tables and graphical data
  - Be aware of material properties as function of the temperature
  - Youngs modulus and Poisson's ratio

- Results of the FEA.
  - Include a validation of convergence (it is allowed to refer to earlier models if applicable)
    Ex: Do the values "converge" toward a finite value as the mesh is refined and run repeatedly.
  - Displacements of the model
  - Deformed and un-deformed shapes (superimposed, shows the 2 models as layered).
  - Mesh plots
  - Stress plots
  - Reaction forces on the model (compare with the forces applied)
  - Check incorrect boundary conditions (temperatures, pressures, forces etc).

- Analysis of the results.
  - Accuracy of the model should reflect that the results are also applicable for the physical equipment being built
  - Allowable stresses
  - Element stress, nodal stress and compare the results
  - Results are explained
  - If results are excluded this should be explained/ justified
  - Of all used results / plots it should be explained why the results are included and its purpose.
  - Explain stress concentrations

- Conclusion based on the results.
  - Relate the results to the applicable standard
  - Uncertainties of the results

Remember:

An FEA program allows an engineer to make mistakes at a rapid rate of speed (R. miller).

FEA is a versatile tool, but not the best analytical tool for every problem. (Cook)