

## Tata Steel Technical Directive

**R1 60 01 01 FEM calculations**

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## Revisions

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1.1	Febr 2022	Yvonne Adelaar ADM	Link to HSSE website changed

## Abbreviations

Afkorting	Verklaring
CAD	Computer Aided Design
FEM	Finite Element Method / Eindige elementen methode

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# 1 Preface

The purpose of this FEM Technical Directive is to give guidance and minimum content of a FEM report. The FEM report must have a clear overview of the calculation and must give the reviewer enough information to review the calculation without being in possession of the 3D FEM model.

This FEM Technical Directive must be used for, but is not limited to the following FEM analyses:

- Static and dynamic structural calculations
- Refractory heat transfer calculations
- Flow calculations for fluids and gasses
- Piping Mechanical / thermal calculations

## 2 Requirements for FEM calculations

FEM reports requested by TATA STEEL must include, but will not be limited to the information and requirements as specified in this chapter.

### 2.1 Basis of calculation

- Purpose of the analysis
- Explanation what does the constructor want to validate with the analysis
- Approach and followed course of the calculation
- Scope: On which part of the model is the focus, and which part of the model shall be ignored?
- Legal requirements and specifications
  - Applicable standards
  - Design codes (NEN-EN)
  - EC directives
- Additional User Requirement Specifications
  - Maximum allowed permanent deformation (usability)
  - Stability requirements
  - Maximum allowable stress in material at specific location (strength/integrity)
- Assumptions made
- Scope and battery limits
- Analytical calculation for verification (e.g. hand calculation with free body diagram)

### 2.2 Materials

- Material parameters (for each part)  
(Young's modulus, Poisson ratio, yield stress, tensile stress, tensile strain, etc.)
- In case of non-linear material behaviour indication if engineering stress and strain or true stress and strain is used

If non-linear material calculations are expected to be required for static structural calculations this needs to be motivated in writing to TATA STEEL for approval.

### 2.3 Loads and Boundary Conditions

- Boundary conditions and loads
- Description of load cases (Boundary Conditions, point loads, moments, pressure, location, direction, degrees of freedom, symmetry, contact bodies, friction coefficients, etc.)
- Load case combinations

### 2.4 Finite element model

- Applied software and software version

## 2.5 Mesh

### 2.5.1 Required information in report

- Used element type(s)
- Indicate location of transition if multiple types in one model are used
- Explanation why certain element types are used
- Thickness for shell elements for the complete model
- Orientation for each part in case of direction sensitive elements

### 2.5.2 Meshing assessment criteria

- Application of sufficiently detailed mesh. The stress gradient within a single element must be acceptable
- Avoid unnecessary detail or overly fine grained mesh
- Discontinuities in the mesh must be avoided and shall be described
- 4 node tetrahedrons must not be used in solid models.  
3 node triangles in 2D models must be avoided.  
If these elements have been used prove why these elements do not influence the calculations results.
- FEM Software supplier guidance on shape limits must be followed

## 2.6 Results

- Clear visualisation of deformations and displacements (including 1:1 scale deformation plot)
- For elastic and non-elastic analysis of materials the following results:
  - Von Mises stress
  - maximal principle tensile stress in X, Y and Z direction
  - shear stress
- In case of elastic-plastic analysis of materials the result must also show plastic strain
- In case peak stresses occur but are deemed acceptable, an explanation must be given which is supported by independent external references or projects
- Extrapolation method of element results during post processing is to be available if used
- Make element edges visible in plots

## 2.7 Conclusions and recommendations

### 2.7.1 Conclusions

- Statement whether the analysis satisfies the requirements stated in this document
- Describe if the analysed design meets the stated requirements
- Summary of load cases and safety margins
- Limitations of the result, e.g. validity of (non)linear assumptions
- Conclusions must be unambiguous and definite

### 2.7.2 Recommendations

- Recommendations must be specific

## 2.8 Attachments

- Analytical calculations to support the FEM calculations
- Drawings (if applicable)
- Prior calculation reports (if applicable)
- Verification of results

### 3 Deliverables

The following items must be delivered:

- Calculation report (pdf format) for review
- Final calculation report (pdf format) with TATA STEEL cover sheet, completed with meta-data and TATA STEEL document number

### 4 Archiving

All digital data used for the FEM calculations must be available to be verified, if requested.