

ITER Project Management and Quality Program

Standard TOC For Analysis Reports

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1 Introduction

Writing a document about the analysis performed in the form of a report is essential, and can be considered as the last step of an analysis, either a finite element analysis or analytical analyses. The report describes the work performed and presents the input data for the analysis and the results obtained from the analyses, as well as the conclusions and (if possible) recommendations. The proposal for the layout of a report, as described in this document, is only made to reach some kind of consensus how the analyst should describe what has been done. Because every analysis is different, a large amount of flexibility in writing is necessary and allowed. However, the report should provide at least the information which is required 'to repeat' the analysis. First some general suggestions are given. After the "Table of Contents for Analysis Report" an explanation is given of what should be included in the different chapter/sections.

2 Table of Contents for Analysis Report

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Title Page

The title page should contain the title of the report and all kinds of other (administrative) information such as: date, name and affiliation of author, controller/checker and approver.

Summary

The report should start with a summary or abstract of what can be expected to be found in this report. This summary should consist of a short introduction (why the analysis is made), how the analysis is done and what the main conclusions and achievements are. This summary should be similar to an abstract for a conference or symposium. A rule of thumb: when the reader reads the summary (and conclusions) he should be informed such that he knows what has been done and what the results are.

1 Introduction

The section gives a brief description of the analyzed structure and specifies the objectives of the analysis, the issues being addressed, and the required (or expected) answers. Information about the purpose of the structure and geometry can also be given here.

2 Finite Element Model(s) or other Numerical Model(s)

This chapter should contain a description of the finite element model(s) or analytical model(s) and which (if any) assumptions/simplifications, have been made during the generation of the model. It should also contain a reference of the drawings used, or (even better) include the drawings in the report. Mention should be made of the main coordinate systems and dimensions used. It is strongly recommended to use (only) the International System (SI).

In general a structure can be broken into different components and sub-components or parts. It is practical to define different real constant, material identifications, and element type identification numbers to each of these parts to facilitate the region selection and the result post processing. Such a breakdown of the numerical model(s) into sections occurs often when a workplan is made by the analyst. If this approach is chosen (recommended), a certain amount of flexibility (changing input values) can be achieved. In this case it is advised to include in the report a description, in tabular form or equivalent, of every region of the structure and its attributes (element type, real constant, and material identification numbers). Nowadays many programs allow the definition of so-called 'components'. However, these 'components' represent user-defined sections of the FE-model and do not allow changing of element type(s), real constant etc.

Units used in the analysis.

All analysis must be done in S.I. units. This is decided because all official governmental institutes, codes, etc. have adopted the use of the S.I. units. It is a fundamental and convenient feature of the International System (SI) that the base units, supplementary units and derived units form a coherent system. Derived units are algebraic expressions in terms of power of the base units, and all numerical factors are unity. In the inch-pound system (and also in the U.S. Customary Units), by contrast, a great many numerical factors come into play when units are derived from each other, or even when they are compared with one another. This can be a source for errors, especially for those who are not familiar with these systems.

In the table below the seven base units are defined as well as the two supplementary units. The last unit (solid angle) will probably be never used in the ITER Project.

Quantity	Unit Name	Unit Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric Current	Ampere	A

Thermodynamic Temperature	Kelvin	K
Amount of Substance	Mole	mol
Luminous Intensity	candela	cd
Plane angle	radian	rad
Solid angle	steradian	sr

Based on the seven base units and two supplementary units many derived quantities can be defined. The table that follows shows some of these derived units with their names, symbols, and formulas.

Quantity	Name	Symbol	Formula
Acceleration	--	--	m/s^2
Angular acceleration	--	--	rad/s^2
Angular velocity	--	--	rad/s
Conductance	siemens	S	A/V
Density	--	--	kg/m^3
Electric charge	coulomb	C	$A.s$
Electric potential	volt	V	W/A
Electric resistance	ohm		V/A
Energy, Work	joule	J	$N.m$
Entropy	--	--	J/K
Force	newton	N	$m.kg.s^{-2}$
Frequency	hertz	Hz	$1/s$ or s^{-1}
Inductance	henry	H	Wb/A
Magnetic flux	weber	Wb	$V.s$
Magnetic flux density	tesla	T	Wb/m^2
Moment of a force	--	--	$N.m$
Moment of Section	--	--	m^4
Power	watt	W	J/s
Pressure	pascal	Pa	N/m^2
Stress	pascal	Pa	N/m^2
Thermal flux density	--	--	W/m^2
Velocity	--	--	m/s
Young's Modulus	--	--	N/m^2

The use of decimal multiples and submultiples of the SI units are allowed to be used within the analysis and are formed by means of the prefixes as shown in the table below.

Multiples and Submultiples	Prefixes	Symbols
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^1	hecto	h

10	deka	da
10 ⁻¹	deci	d
10 ⁻²	centi	c
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p
10 ⁻¹⁵	femto	f
10 ⁻¹⁸	atto	a

It is up to the analysts if he wants to do the analysis in Mega-Newton (MN) and meter (m) or in Newton (N) and millimetre (mm). In both cases the calculated stresses are in Mega-Pascal (MPa). It also strongly depends of other important factors. For example; because the geometry designed with a CAD-system is described in millimetres, the analyst prefers the use of millimetres. Another possibility could be that the used analysis program 'demands' the use of certain dimension. Magnetic analysis in ANSYS must be done in the unit's meter-kilogram-seconds, or MKS units.

Use of Tables and Pictures

In reports describing numerical analyses the use of tables and figures, wherever applicable, is encouraged. However, these tables and figures should be used to give the reader the required information. In general figures are used to illustrate things and should not be used to subtract data from(except if there is no other possibility). Numerical data should be presented in tables.

Clear and bright figures showing the finite element model, showing sections with different material properties, geometrical sections of interest, showing the boundary conditions used, and the loads applied are almost compulsory to analysis reports and are therefore strongly recommended. The same is applicable for the presentation of the results. Wherever possible and appropriate, the use of figures is encouraged and should be considered as much as possible.

2.1 Element Types

Description of the element types used. Specifications of the element key-options and/or other element parameters, which are not equal to the default values. Even mentioning the default values can be very illustrating.

2.2 Material Properties

Overview of the isotropic, orthotropic and/or anisotropic (temperature dependant) material properties for the element types used. A table, or if not possible a readable graph, presenting the properties values and their dependencies, must be included. A reference for the material properties is also required.

2.3 Real Constants

Overview of which real constants are required and specified for the element types and their meaning.

In addition sub-chapters can be added which can contain an overview of other input values, so called analysis option commands. For example:

- a) which non-linearity's are included and how do they behave,
- b) which commands are used to influence the convergence of a non-linear analyses,

- c) what is the convergence criteria used

3 Loading and Boundary Conditions

3.1 Load definition

Overview and explanation of the loads on the structure, i.e. which loads (defined in load cases) and where they have been defined. A description of how the loads have been applied onto the FE-model should be included. Each “type” of loading condition should be described in a separate sub-section such as:

- Thermal loads
- Mechanical loads
- Electromagnetic loads

3.2 Boundary Conditions

Overview of the boundary conditions, such as symmetry or a-symmetry conditions, restraints, prescribed displacements, coupled degrees of freedom, constraint equations, master degree of freedom, initial strains, pre-stresses, multi point constraints, etc. This section is important for the reader to judge the quality and accuracy of the analysis.

3.3 Load cases and load case combinations

This chapter includes a summary list of the load cases (combination of loads and boundary conditions previously defined) and the load case combinations that are analyzed. The definition of the load cycles and the number of cycles have to be defined in this chapter if necessary.

3.4 Design code and allowable values

One comment only in section 3.4 Design code and allowable values should a statement be added about using validated software or ITER approved software. If its validated software how was it done and if some independent approval needs to be done by ITER or others. This chapter describes the design code used (if any) for the assessment of the analysed structure or components. It also included:

- the definition of the load categories and load service level of each load case and load combination;
- the allowable stress values (based on the design code) and any other design limit value.
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3.5 Used Software

The software used for the analysis should be validated commercial software (which has in many cases its own QA procedures) or in case the software is an ‘in-house’ product the validation of the software shall be made available.

4 Results

This is the main body of the document. The layout of this chapter depends strongly on the type of analysis, i.e. thermal analysis, structural analysis, modal analysis, etc. When applicable a kind of overview of the results, for example the displacements of the whole analysed structure should be given at the beginning of this chapter. Also a check by using the reaction loads should be made and presented in here.

After presentation of the ‘global’ behaviour or results, sub-sections can be made in which the results are presented and discussed at the component level. Where applicable an assessment should be performed at which the results are compared with the allowable values.

5 Comparison with other analyses and with hand calculations

If relevant, comparison should be made, for cross-reference, with other similar analyses. If the results do not agree, the report should include a discussion of possible causes for the disagreement.

Hand calculations should be performed on simplified models to verify the results or some of them. The calculations and comparison should be presented in this chapter. This chapter should be considered as part of the QA.

6 Conclusions

The conclusion should contain a summary of the information obtained with the analysis and should provide the elements addressing the issues identified in the introduction. Suggestions for possible solution(s) to still existing problems are appreciated but the analysis of these possible solutions is beyond the scope of the report and work performed.

7 References

Does not need any explanation

List of Figures

List of Tables

Annexes

- Listing of all input files and software used to perform the analyses and to produce the information presented in the report as well as the information required to retrieve them.