E2. Model validation using self-checking

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Before exploiting the model results, several verifications should be carried out on:

- input data;
- the behavior of the model under elementary stresses and kinematic conditions;
- the potential of the model and the software to provide satisfactory and exploitable results.

If some of these points prove to be redundant for the person who carried out the modeling himself or herself (see previous paragraph), they are essential in the case of the exploitation of a modeling carried out by a third person.

If the final objective of the global study is to perform non-linear calculations (geometrical non-linearities, non-linear material behavior law...), this validation is essential because it can avoid the unnecessary execution of long calculations. This is really important because obtaining an acceptable solution for a complex problem to be solved is rarely immediate.

In general, the realization of a small simplified model using bars allows to quickly validate some rough estimates for values from an FE model. See the example of the High-rise building tower (skewer model): Example A - High-rise building (part C).

It is also necessary to verify the model as the model progresses, especially in the case of dead weight load. All too often, we see engineers starting a model for several weeks and then stumbling over multiple error messages. It is also possible to save intermediate data files throughout the day, by incrementing the file name, so that you can return to a previous version very easily (the one that worked before the last updates).

This approach will also make it possible to evaluate the time required to generate the model, calculate and display the results.

Some important checkpoints are presented below. This list is neither limitative nor exhaustive. For specific problems, other checkpoints may be considered.

E.2.1 Initial model verifications

Before any calculations are carried out, it is necessary to carry out some basic verifications.

These verifications may seem tedious, but the detection of errors, often basic, can save a lot of time in the end.

a) Model geometry control

Simple graphical controls usually reveal inconsistencies in the geometric features of the elements.

Some software allows you to visualize the elements with their real section. This possibility is particularly interesting for beam type elements because it allows to control visually the correct orientation of the main axes and the adequate position of the longitudinal axis which will be used as reference for the loading for example.

The connection of the elements, the correct connection of the shells and the boundary conditions are an integral part of the geometric verification. The visual inspection of local coordinate systems before applying local loads is also part of the geometric verification.

b) Element features

For beam type elements, some software can propose predefined profiles. The very first time you use one of those elements, you should verify that the features displayed by the software correspond to the geometry; compare these features with those provided by the catalogs in the case of standard sections, or make approximate manual calculations of the features for non-standard sections.

For a section defined by its contour, the surfaces and inertias calculated by the software must be verified.

For curved problems or with eccentric loads, it is important to verify the position of the torsional center of the beams and to verify whether or not the software takes into account a possible offset between the center of gravity and the torsional center.

c) For material features, a proofreading of the data is necessary.

In the case of a mono-material model, an error on the Young's modulus can affect the results of the deformations without having an impact on the stresses. Whereas in the case of a multi-material model, an error on one of the modules will influence all the results.

d) Comparison with previous versions

When we have a simplified model from a previous phase, or when we make a modification on a model, we must systematically recheck certain main measures to detect possible errors.

e) Load features

For loads, a proofreading of the data is also necessary.

It is a question of visualizing all the loads applied to the model and this for each of the defined load cases.

The load values must be correctly identified; characteristic values or pondered values. The orientation and direction of these loads must also be verified.

If the model contains several load cases, it should be observed whether they are independent or successive load cases.

For dynamic studies, a verification of the masses of the model in all directions is essential.

E.2.2 Basic verification of calculation results

This step is based on simplified linear static approaches.

For each calculation performed, basic verifications must be made. These verifications, in addition to participating in the model validation, will also allow a beginner to become familiar with the post-processor of the software used and to verify that the different options of the elements and/or calculations have been activated correctly.

a) Deformation – Rough estimate of results

The general pattern of the deformation is very explicit because it gives an immediate response on the structure's behavior to a given load or stress. It allows to validate the hypotheses on the static scheme (simple support, fixed, ...) and on the modeling of the assemblies.

Beware of graphic amplification factors, which can be misleading on local displacements (impose a factor of 1 to verify possible inconsistencies).

In linear elasticity, the displacement rough estimates must be satisfactory. Their amplitude must be small in relation to the dimensions of the structure.

b) Vertical loads calculation

Static equilibrium must be verified. The results of the loads applied in the model can be calculated manually and compared with the components of the sum of the support reactions displayed by the software.

The distribution and direction of the reactions on the different supports must be analyzed in relation to the blocked degrees of freedom.

The presence of a null reaction for a blocked degree of freedom must be analyzed. This will generally be a symmetry effect.

E.2.3 Tests on connections and assemblies

a) Null or non-zero support reactions

The support reactions must correspond to the static diagram.

The sign must also be verified and allows the detection of referential errors for load cases.

b) Modeling an assembly

The general calculation does not eliminate the need for a local (and manual) analysis, for example with a load close to an assembly to verify that the force transfers are made in the expected way.

E.2.4 Sensitivity tests on specific modeling points

We must question when modeling produces an effect (global or local) that varies a lot as input data changes. This would be a case of model instability.

Révision #2
★Créé 21 September 2023 10:27:58 par Paul Terrasson Duvernon
✎Mis à jour 10 October 2023 10:01:05 par Paul Terrasson Duvernon