Revisiting Stress Singularity / Concentration Examples With COMSOL Multiphysics®

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Abstract

Numerical stress singularities (SS) and "true" stress concentration (SC) are regularly encountered in structural analysis and need to be acknowledged with care, such to obtain sustainable models.

By following Tony ABBEY's interesting and free Talk-Events over the last months (https://www.fettraining.net & https://www.nafems.org/community/talking-shop-with-tony-abbey) and comparing some of his examples to the results obtained with COMSOL Multiphysics® I notice quite some differences, and wondered why. Here I present a few thoughts, and some simple test models to compare an example of Shell Point Load stress singularity and a flexible slender beam attachment stress concentration issue with an elliptic fillet optimisation for Fx, Fy and Mz loadings.

Numeric SS are mostly non-physical, but appear frequently for poor loading definitions or at sharp corners from the CAD, particularly in complex models, and very often with welded structures. Such SS stress hot-spots are seldom accepted as such and are often difficult to explain to your clients, and I do not recommend that you just make them disappear by limiting the stress level of your plots. SS must be closely studied and mostly you may only use your engineering judgment to tell if they might be a problem, or not.

While stress concentrations are true physical effects that might be minimised by adapting the geometry, and for that may be handled by geometrical shape optimisation, easily applied in COMSOL.
Stress is not always correctly resolved for structural FEM models, as it relates to the strain that relates again to the spatial derivative of the displacements vector field "u" solved for. Mesh optimisation on the strain energy "Ws" might be used to adapt the mesh to the SC regions for a more precise analysis.

These important subjects are worth a few PhD works each, so only a short preview and two simple examples may be described on the poster, but related models with applications are provided to allow you to build further on these examples.

Figures used in the abstract

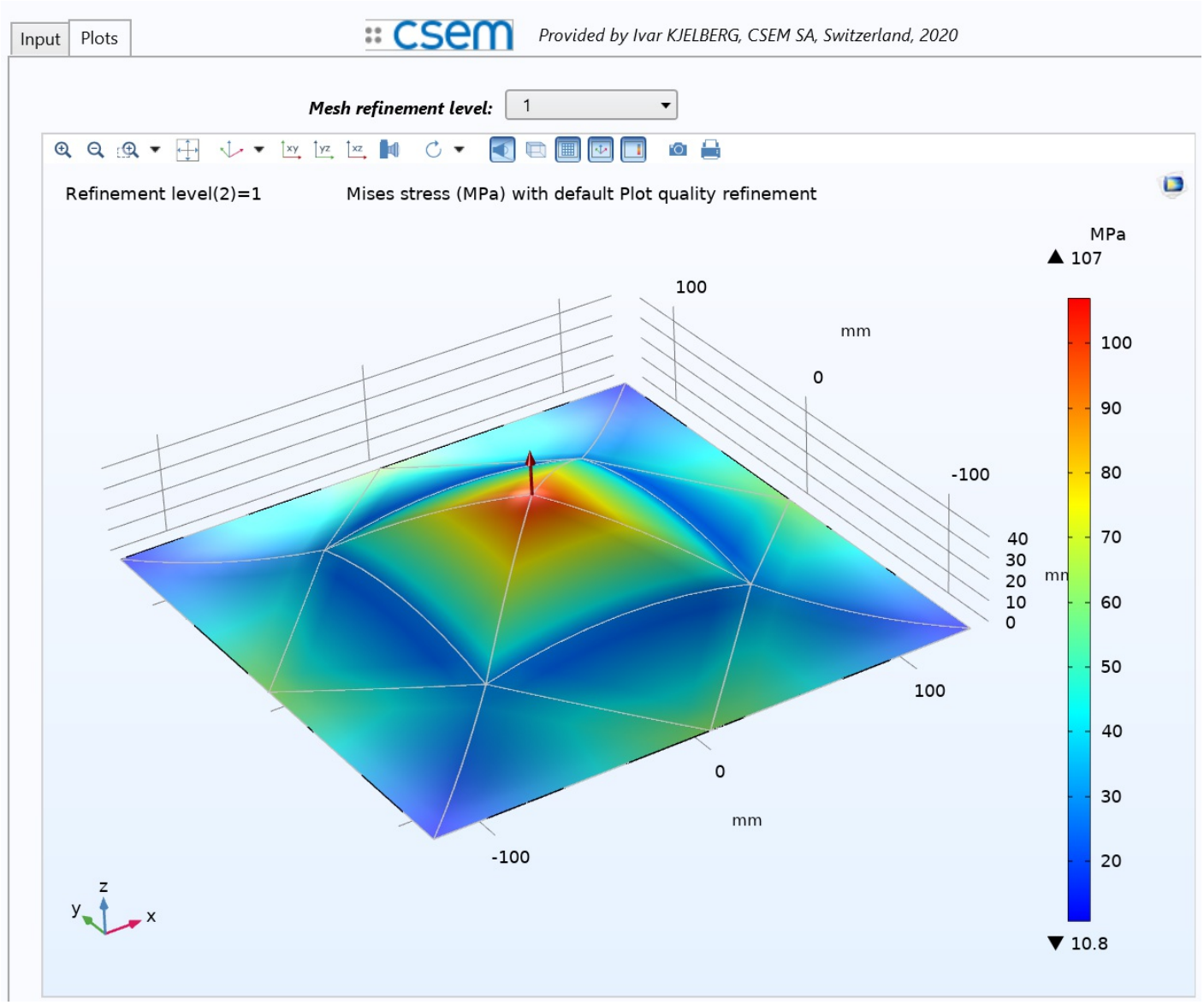

Figure 1 : Central Point load singularity on a Shell with increasing mesh elements.