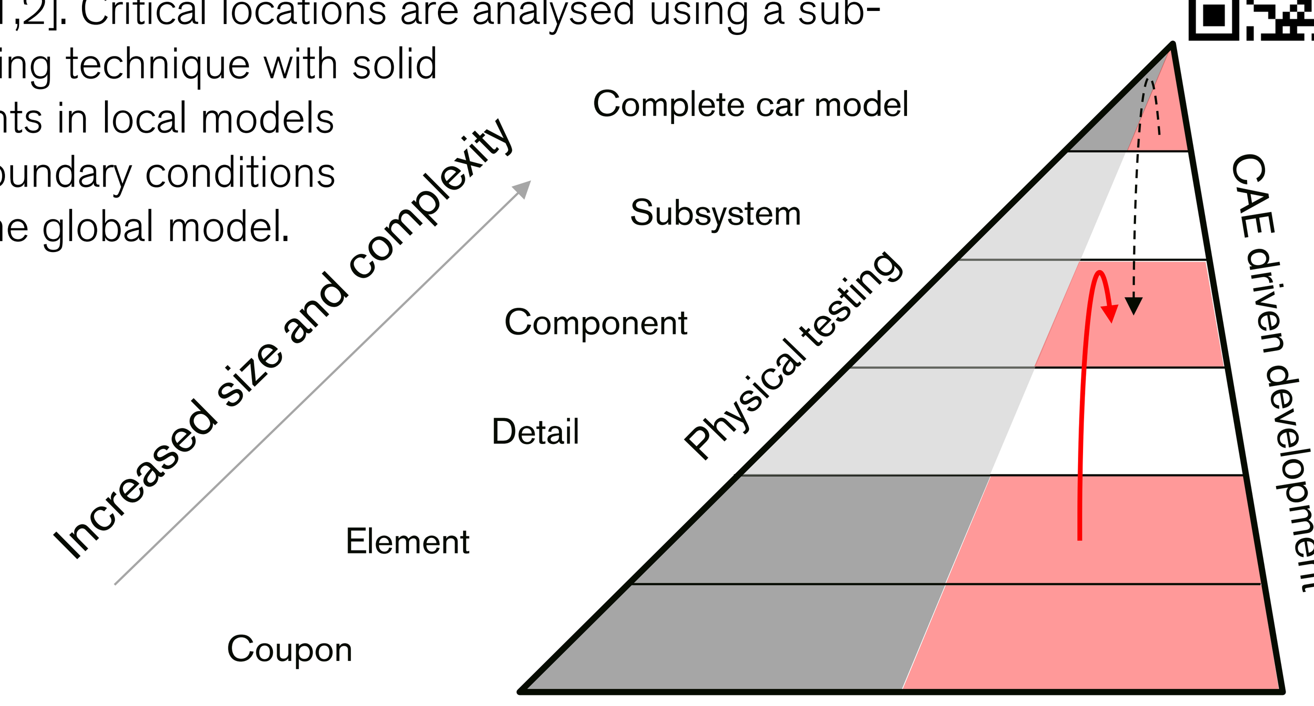
VERIFICATION OF HOT-SPOT IN COMPLEX COMPOSITE STRUCTURES USING DETAILED FEA

Motivation Current shell-element based design tools used in the automotive industry do not allow for failure prediction in complex composite structures. An automated method to identify and analyse structural hot-spots for all potential failure modes is therefore needed.

Conclusion A methodology for automated analysis of structural hot-spots in complex composite structures is developed. The method's key feature is that it allows for fast and efficient analysis of multiple hot-spots. The process is readily applicable for industry as it is built with the commercial tools Ansa, Metapost and Abaqus.

1. Multiscale approach

High fidelity models used at coupon and element levels cannot be used on a global level. Instead, at the global level more efficient models to predict critical locations, capturing all failure modes are used [1,2]. Critical locations are analysed using a sub-modelling technique with solid elements in local models with boundary conditions from the global model.

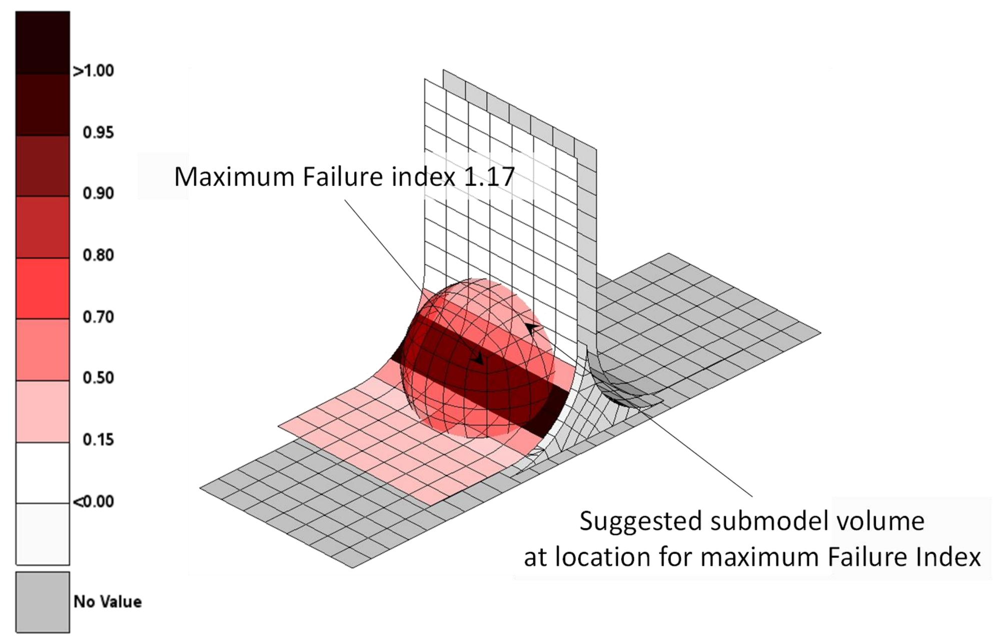


The proposed process is built on earlier work for isotropic materials [3]. However, the modelling of the composite laminates is more complex and uses tools available for laminate modelling. Different parts are then joined together.

2. Global analysis – Hot spot identifcation

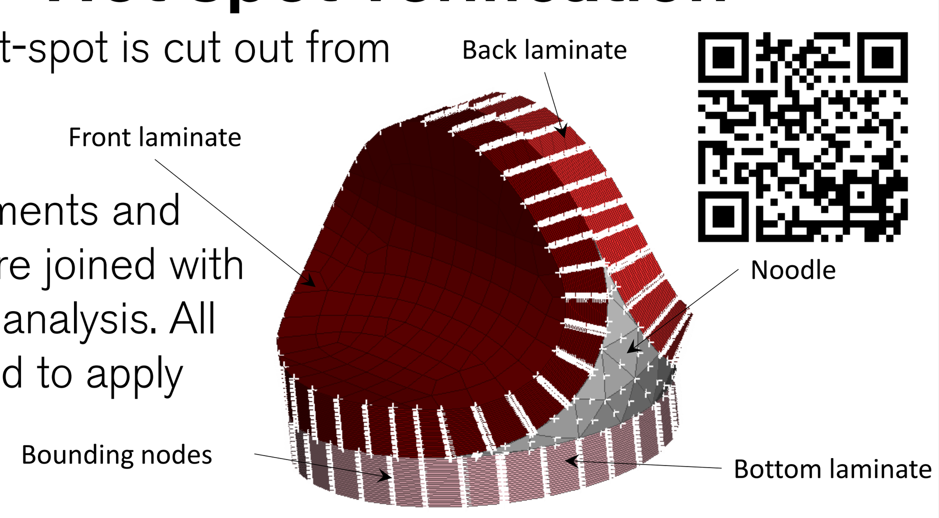
Global models and most analyses within the automotive industry use either complete car models, or large assemblies from these. The models are built using shell elements. In order to capture all failure modes that may be active, the full stress tensor is needed. This is achieved using the post-processing method Extended 2D FEM approach [4]. The added cost for this is the need for 2^{nd} order elements in the composite parts.

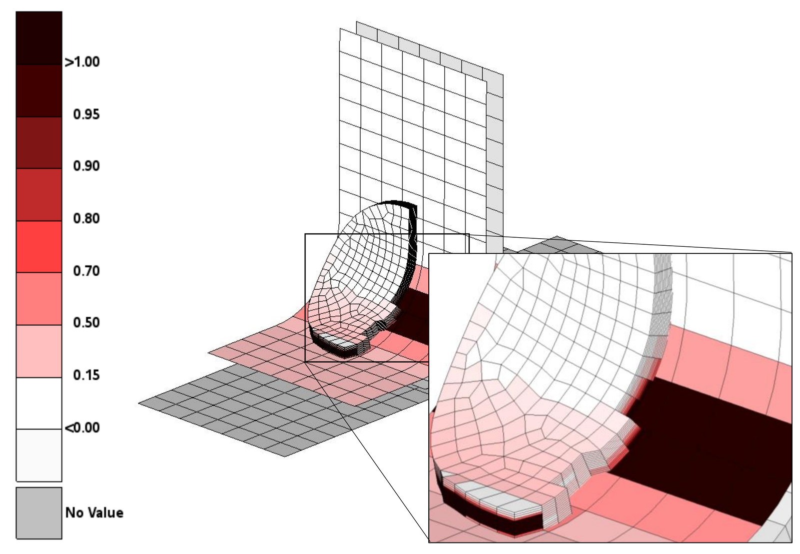
Potential hot-spots are identified [2] and retrieved. The locations are presented for the analyst to judge whether they should be analysed in detail and if so to decide the size of the local model.



3. Local analysis - Hot spot verification

The critical location for each hot-spot is cut out from the structure in the global database. The composite parts are meshed with finer shell elements and volumized. The different parts are joined with TIE-constraints as in the global analysis. All nodes on the perimeter are used to apply the displacement field from the global model.

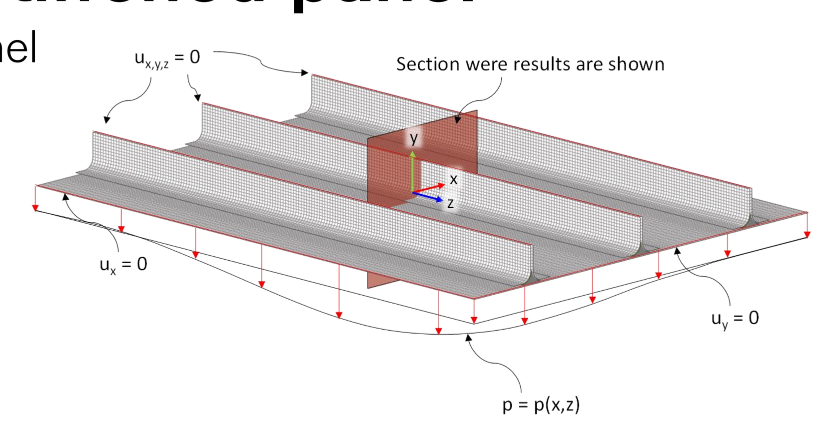




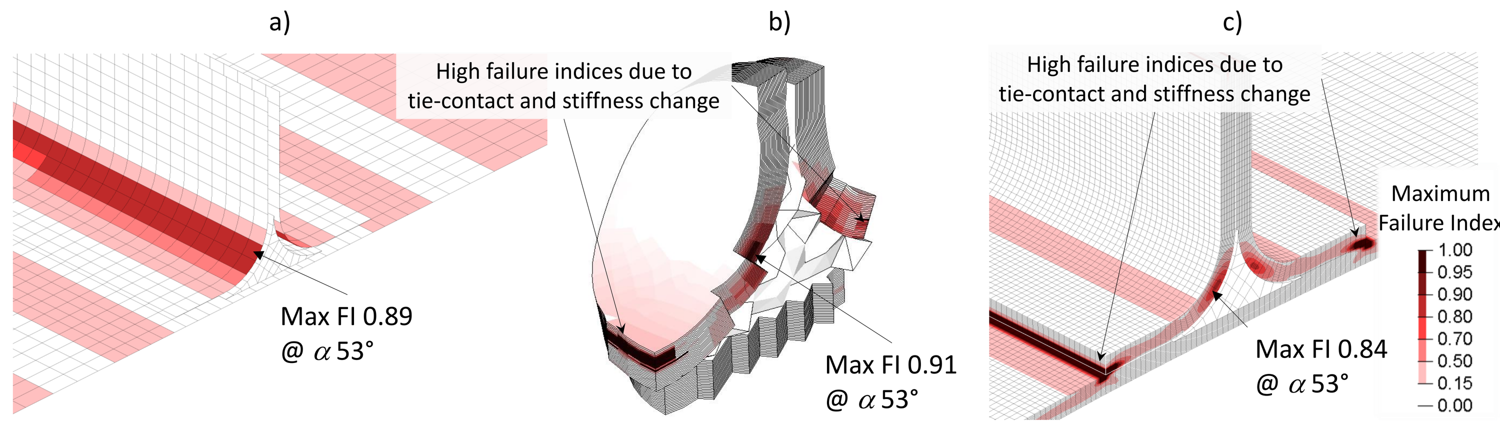
The detailed sub-model analyses either classify the hot-spot as critical or non-critical. The global database in the build stage of the local model makes it possible to use all composite definitions that are created.

4. Case study on stiffened panel

The methodology is applied to a panel stiffened with stringers. The panel is subjected to a varying external pressure.



Three different modelling approaches are compared. (a) A global 2^{nd} order shell model, (b) a local sub-model (following the procedure described) and (c) a 3D solid reference model.



References

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