Best Practice Application between AVEVA Hull Finite Element Modeler and ANSYS Workbench for Detailed Design Phase in Shipbuilding Industry

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Summary

A process for CAD – FEM interface of shipbuilding design program AVEVA Hull Finite Element Modeler to ANSYS workbench was developed. An application was developed for mapping missing attributes of geometry in ANSYS workbench.

Keywords

Shipbuilding, CAD-FEM Interface, Application, AVEVA Hull Finite Element Modeler, AVEVA Marine

1. Structural design process in shipbuilding industry

The process of structural design in ship-building industry is simplified divided in five design phases (Fig. 1).

- In Pre-contract phase a 2D structural design concept will be carried out based on general arrangement plan, technical specification, rules and regulations. Quantity structure, mass and center of gravity will be calculated
- In Basic design phase a class approval drawings and a global 3D FEM model for longitudinal strength calculation will be carried out. Main components, hydrodynamic-model tests, routing and manufacturing concepts are taken into consideration.
- Detailed design phase is focused on local structural assessment like foundations, integration of equipment, reinforcements after receiving load data from suppliers.
- In Production phase solution are requested for change orders caused by late design evolutions.
- Finally in Delivery phase non conformance like exceeding of vibration or noise limits found during sea trials have to be fixed.

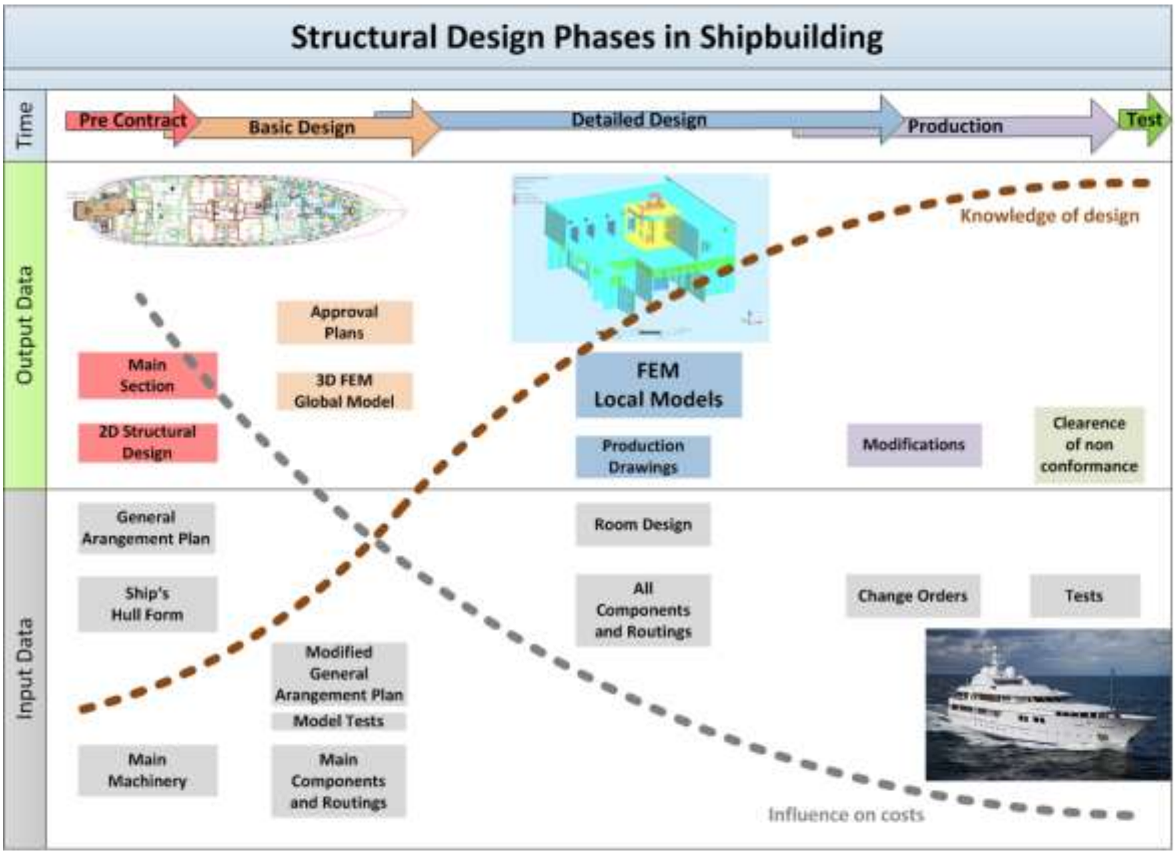

Fig. 1: Structural Design Phases in Ship-Building industry

The knowledge of the structural engineering increases steep during basic and detailed design while the influence on costs decreases over project time. The earlier assessment is available, the valuable it is. This is the driver to accelerate and improve the FEA process.

During detailed design phase a lot of local analyses are requested for foundations and implementation of aggregates and further for pipe-routing and design changes.

2. Shipbuilding design software AVEVA Marine

This paper is focused on the detailed design phase. In this phase the 3D CAD data is available in AVEVA Marine. This software handles the entire ship design process, from hull design to parts manufacture and block assembly, creating drawings, parts lists and all necessary shipyard production information and documentation [AVEVA].

3. Workflow for integration of AVEVA Hull Finite Element Modeler and ANSYS APDL

3.1 Idealisation in AVEVA Hull Finite Element Modeller

AVEVA Marine is the well distributed integrated software for shipbuilding. Part of the software package is the CAD tool for detailed design. For this CAD geometry AVEVA Hull Finite Element Modeller™ (FEM Modeler) was developed for a rules-based idealization of 3D volume data to 3D shell and beam data [1], [2], [3].

In the first step the user chose the idealization settings in for different part groups like panel, pillar, stiffener, flange or hole. Fig. 2 shows idealizers setting interface with tabs for the single part-groups of a crane column integration (Fig. 3) . A part of the deck is unselected for inside view.

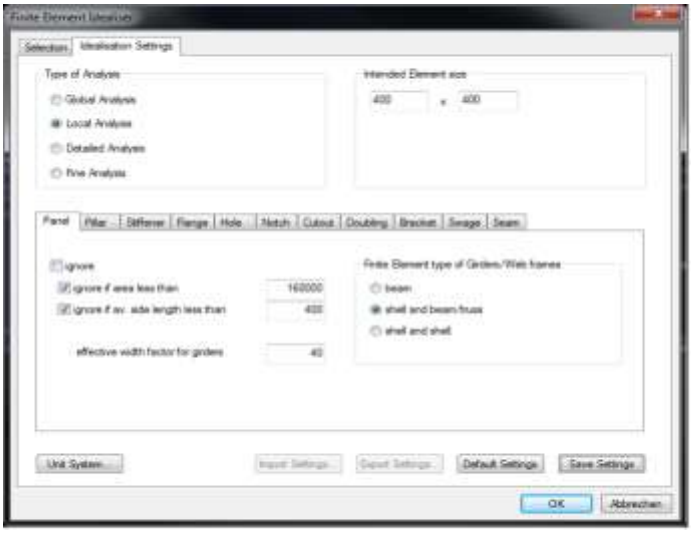

Fig. 2: Graphic user interface of AVEVA Hull Finite Element modeler

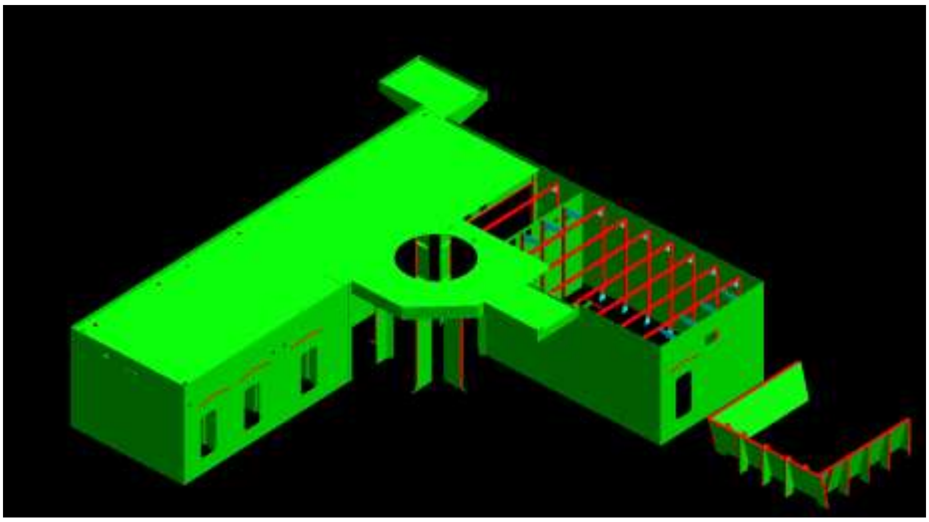

Fig. 3: AVEVA CAD model of crane column integration

In the second step the volume geometry will be transformed into an intermediate shell part model. Plate volumes will be reduced to areas (Fig. 4). Shape of parts will be simplified. An idealized geometry is result of this step. The geometry is completely in shell elements with zero thickness. The location of the shell plates is on there design coordinates. The shell plates at T-joints have probably a gap depending on the reference locations. The shell plates of the decks and walls are not divided at the T-joints to other walls and profiles.

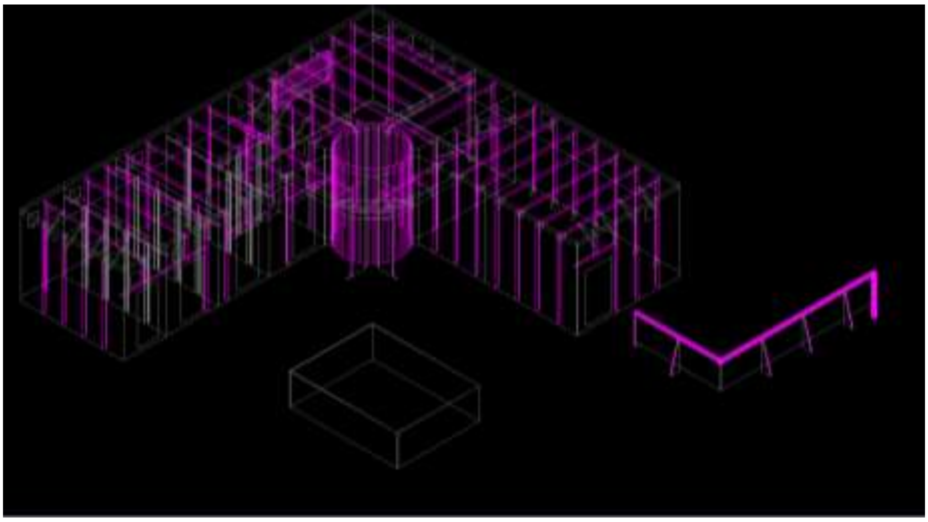

Fig. 4: AVEVA CAD idealized geometry

Third and final step deals with a pre-divided model of the geometry and generation of an APDL file (Fig. 5). Pre-division means a subdivision of the geometry according to settings. In this step small cutouts, holes, brackets and notches will be suppressed according the idealization input data. Gaps between T-joints of plates will be closed. Shell plates of profiles will be transferred to beam element if requested. The shell plates of the decks and walls are in this step divided at the T-joints to other walls and profiles. This model in AVEVA is no more a geometry model and can not be exported by e.g. STEP format. It is only an image of the idealization.

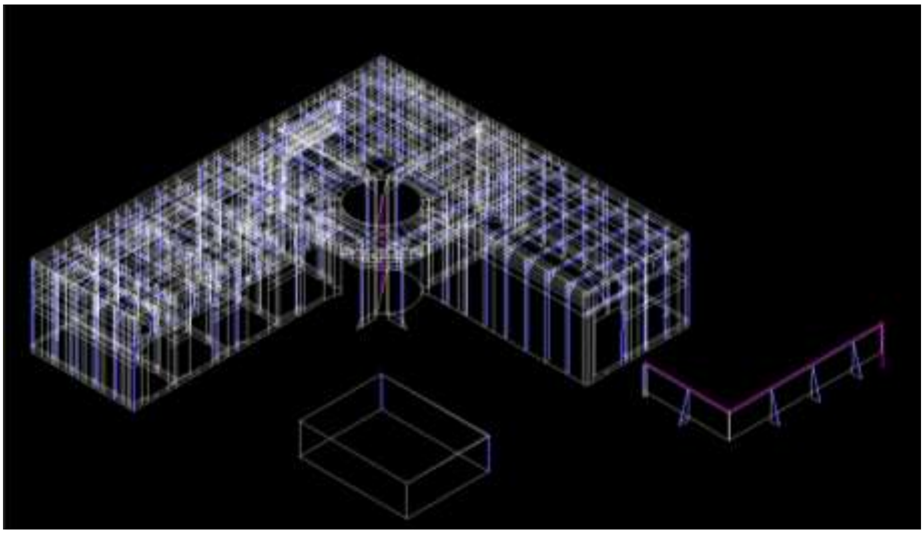

Fig. 5: AVEVA FEM idealization of CAD geometry

3.2 Export of idealized structure to ANSYS APDL

AVEVA Hull Finite Element Modeler generates an input file for ANSYS classic (Fig. 6). The geometry is pre-divided and connected. It contains area and line geometry with shell and beam attributes. The geometry is connected with shared lines. The mesh in Fig. 7 shows a detail of the connected mesh.

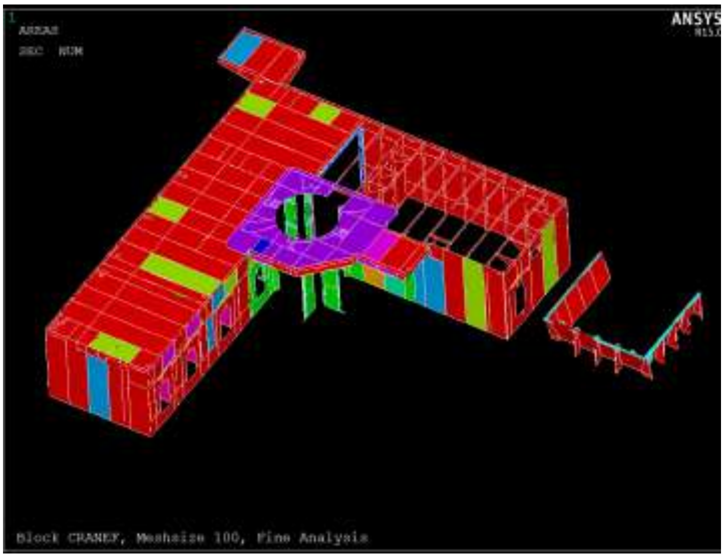

Fig. 6: AVEVA idealized model imported in ANSYS APDL

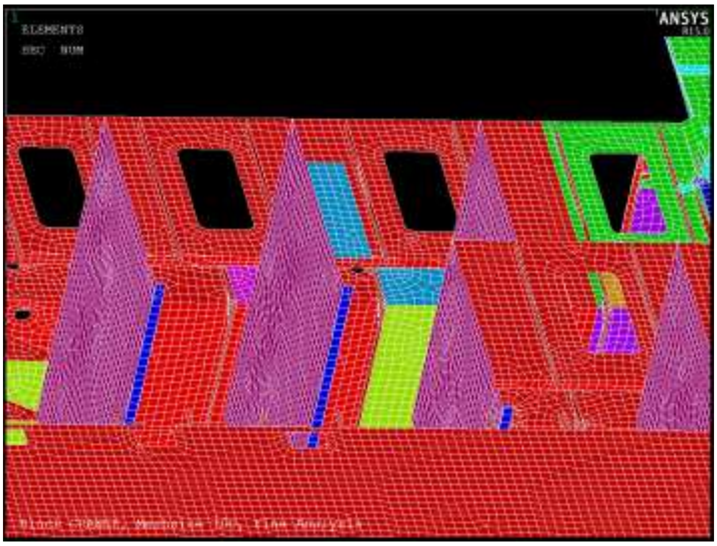

Fig. 7: AVEVA idealized model meshed in ANSYS APDL (Detail)

Advantages of the idealization for ANSYS classic:

+ The process is developed by AVEVA an supported for this application
+ Idealization in shell/beam structures
+ Consistent CAD and FEA models
+ Parts are widely connected
+ Attributes mapped on idealized parts
+ No gaps between parts after idealization

Disadvantages of the idealization for ANSYS classic:

- Process only developed for ANSYS classic
- Reparation of model can be time consuming in ANSYS classic if an implementation in an surrounding structure is needed
- The creation of idealization file is sometimes time consuming for special components like corrugated bulkheads.
- During final transfer to APDL geometry bugs can occur, especially around cut outs

The bugs can be reduced by idealization settings but the setting can be chosen only for the all parts together of the idealized structure and not different for single parts. In some cases bugs occur around holes and parts of the structure are not completely modeled (Fig. 8). These defects can be easily fixed because only parts of areas are missing not the keypoints.

Fig. 8: Defects in some ADPL model with uncomplete areas with cut outs

4. Integration of AVEVA Hull Finite Element Modeler and ANSYS workbench with VBS application

To unfold the full capacity of ANSYS for pre- and post-processing, a method for the FEM Modeler to ANSYS Workbench was developed.

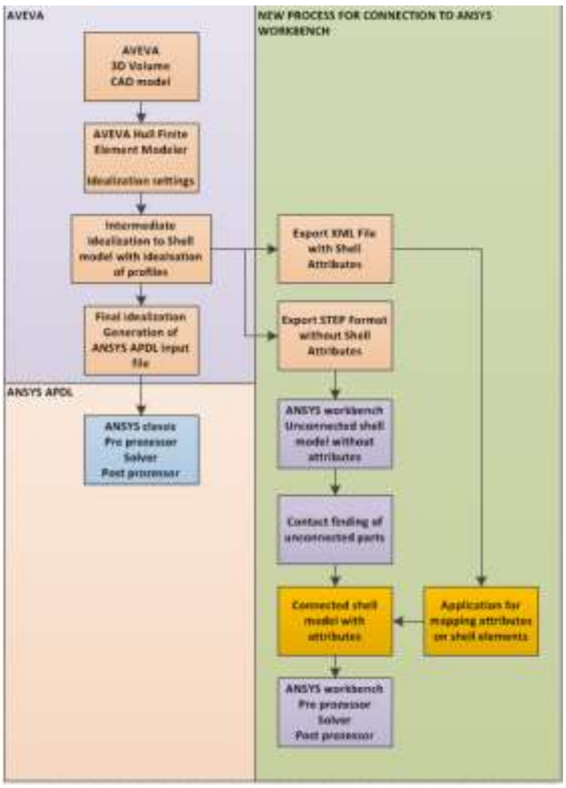

Fig. 9: Original workflow of AVEVA–ANSYS APDL interface vs. New workflow for AVEVA–ANSYS WB

The principle of this method is to export the intermediate model in FEM Modeler via STEP format without carrying out the final step in the FEM modeler (Fig. 9). After this step it is possible in AVEVA to export the intermediate model via STEP format. At this stage a model without final idealization exist e.g. small notches and cutouts are still in the model but profiles and brackets are idealized. This geometry can be imported in ANSYS workbench (Fig. 10).

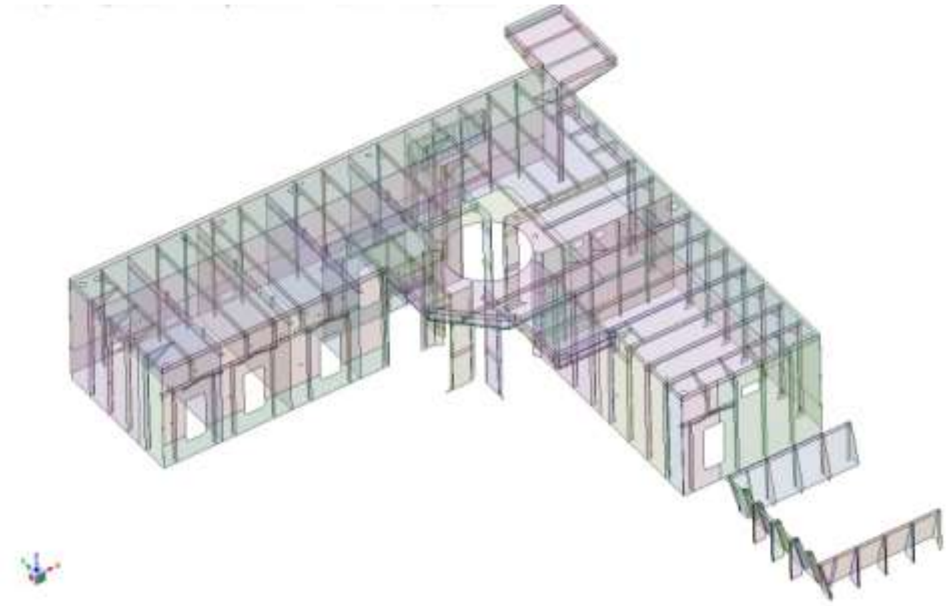

Fig. 10: Idealized AVEVA model imported in ANSYS workbench

T-joints parts are not extended to each other in the model (Fig. 11). A gap can occur after reduction the volume model to a shell model. In ANSYS workbench the gap will be closed by contact elements.

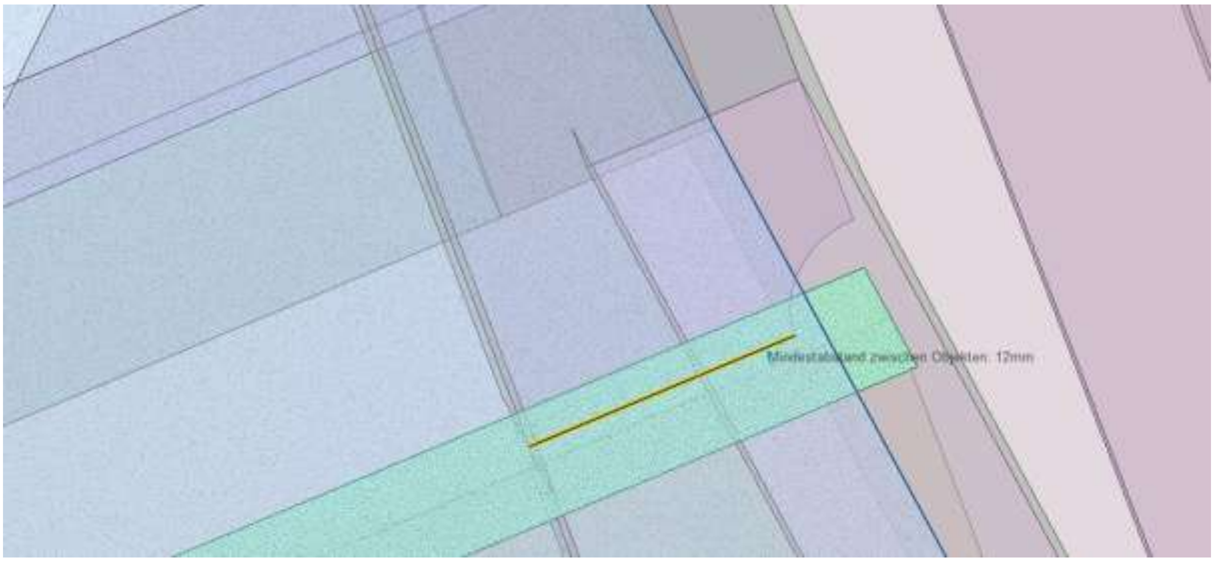

Fig. 11: Gap between T-joint parts

In STEP format the attributes of the shell thickness are missing. This information is stored in an exported XML file. The part names in the XML and STEP files are similar (apart from a prefix) so that a correlation between these parts is possible.

A VBS script was developed to map the thickness information on the imported STEP model in ANSYS workbench. For profiles the thickness information of the web and the flange is not written in the XML file but the type of the profile. E.g. the Holland profile HP 100x6 given in AVEVA as 1 (one) volume, is idealized as an unsymmetrical L-bar with 2 (two) areas. For both legs of the L-bar the thickness properties will be read from an extended digital profile catalogue containing geometry information of substitute profiles. The attributes of the substitute profile are chosen that the inertia moment is identically to the Holland profile (Fig. 12).

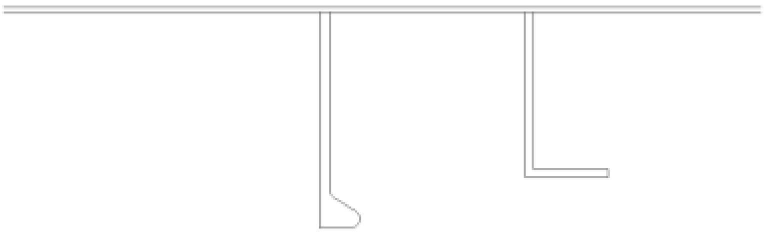

Fig. 12: Holland profile idealised as L-bar (principle)

The connection of the geometry is realized by contact elements. Fig. 13 shows the contact areas on left side and the unshared mesh on right side.

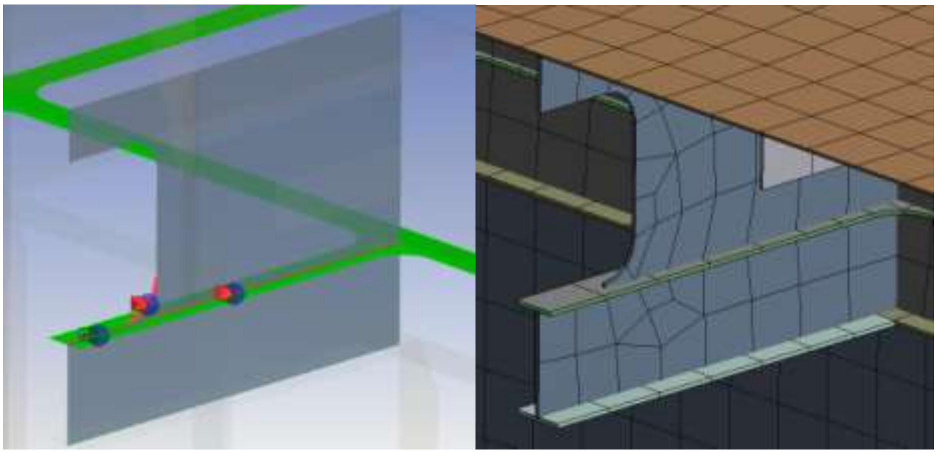

Fig. 13: Detail of contact joints and unshared mesh in ANSYS workbench

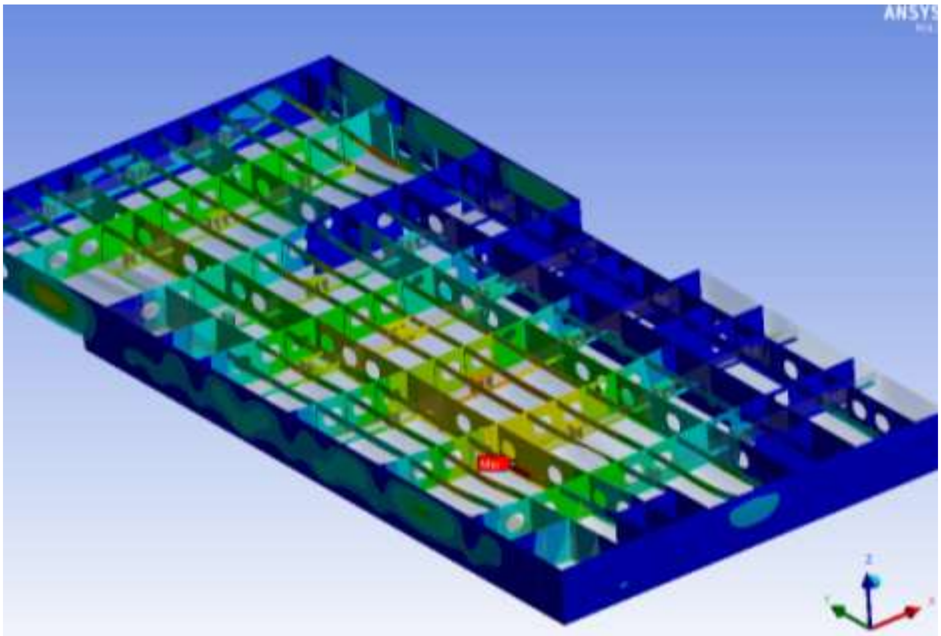

Fig. 14: AVEVA idealized model imported in ANSYS workbench (Detail)

Advantages of the idealization for ANSYS workbench:

+ Analysis in ANSYS workbench
+ Idealization in shell structures
+ Bug-free geometry
+ Time saving model pre-processing by ANSYS workbench tools
+ Consistent CAD and FEA models

Dis-advantages of the idealization for ANSYS classic:

- The process is customized and not fully supported by AVEVA
- Not all simplifications of the idealized geometry are in the model. Geometry details like notches and small cut outs are still in.
- Parts are not connected. Connection in ANSYS Workbench by bonded contact required

Current limits of this process:

- Global models and bigger section models with many parts are currently insufficient slow in handling.
- Due to many contacts which are all rigid connected bigger models are also slow in solving.
- The search radius for automatically contact finding must be set at least to the maximum plate thickness to ensure, that all contact pairs will be found.
- The control of the contacts is time consuming for huge models

Goals for improving the process:

- Goal is the export of the final pre-meshed model in STEP format. Currently the final model in AVEVA is only generated for APDL. Advantage of further development will be the connection of the parts and the closing of the gaps in between.
- Further it will be investigated how a scripted connection of the parts can be realized in AVEVA.
- Goal is a contact free ANSYS model. With a gap free model the powerful ANSYS tool for mesh connections can be used.

4. Conclusions

This process and application is a powerful solution in detailed design stage for local models, when AVEVA CAD model is available. The advantage of the changes in the original CAD-FEM interface process is the access to ANSYS workbench with its efficient pre- and post-processing tools in comparison to ANSYS APDL.

5. References

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