

# Ensuring conformity and high level productivity between ANSA and LS-DYNA during model and load case development

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## 1 Abstract

Simulations have been playing an increasingly significant role in developing Computer-Aided Engineering (CAE) models over the last decades. Virtual testing has become standard practice in the design process, with analysts striving to establish robust procedures to validate the final products. ANSYS LS-DYNA has become a leading solution in CAE simulations, proving indispensable for engineers. Simultaneously, the BETA CAE pre-processor ANSA offers a comprehensive solution for model building, load case definition, and generating the deck file for ANSYS LS-DYNA. This ensures full conformity with ANSYS LS-DYNA standards, facilitating easy setup and high-quality results.

This presentation demonstrates ANSA's capability to handle all needs of a CAE engineer in a broad spectrum of use cases ranging from ID handling and solver deck file conformity up to high level inspection and editing of a complex crash model.

Handling simulation requirements for IDs can be challenging. ANSA has evolved to adapt the numbering scheme to any custom scheme, ensuring compatibility with other solvers and modeling environments, or to a fully LS-DYNA compatible scheme, ensuring compatibility between different suppliers of LS-DYNA models.

Moreover, specialized handling of Include files is crucial for the modular setup of a CAE model. ANSA enables easy loading and unloading of such files at will. It also provides advanced integration functions to ensure an Include file can fit with the loaded model by avoiding ID space conflicts and resolving missing keywords.

Regarding the complete setup of CAE models, a suite of additional tools has been incorporated, including comparison utilities for different entities and complete deck files, as well as a comprehensive LS-DYNA check template that guarantees proper execution. These features collectively contribute to a user-friendly and robust model and load case setup.

## 2 Introduction

Simulations play a crucial role in the vehicle design process, serving as an essential tool for engineers and designers to visualize, analyze, and optimize components before creating physical prototypes. This iterative approach not only accelerates the development timeline but also significantly reduces costs by identifying potential issues early in the design phase. However, the process can be complex, as it requires coordination among various departments and different model suppliers to achieve a proper final digital model. Therefore, analysts need sophisticated tools that provide the flexibility and accuracy required to model real-world conditions.

ANSYS LS-DYNA is a powerful simulation software widely used in the automotive industry for its robust capabilities in performing complex nonlinear analysis, particularly in crashworthiness and impact simulations. ANSA, the BETA CAE pre-processor, offers a wide array of tools to ensure smooth and effective LS-DYNA workflow. ID management during model creation, whether from scratch or sourced from different suppliers, is supported by custom ID schemas and the LS-DYNA standard. During the model merging process, analysts can examine any ID conflicts between the working and incoming models and take necessary actions. The modular model setup allows reading and previewing the Include hierarchy of a master file, while individual Include files can be loaded and merged according to the analyst's requirements. Additionally, an easy-to-use "cookbook" manager facilitates the production of different configurations of a model variant. Comparison capabilities enable users to identify differences in keywords or at the file level across various Include files and versions. Finally, a fully configurable check machine ensures proper execution of LS-DYNA runs.

### 3 IDs schema

ANSYS LS-DYNA has a specific way of IDs sharing among the different keywords. There are different types of entities that can share the same IDs resulting to free ID ranges that are available for use for the model creation. This becomes essential with digital models of electric vehicles where there is big increase in the element numbers that are used. ANSA over the latest versions supports fully the LS-DYNA numbering IDs schema offering additional flexibility to the users.

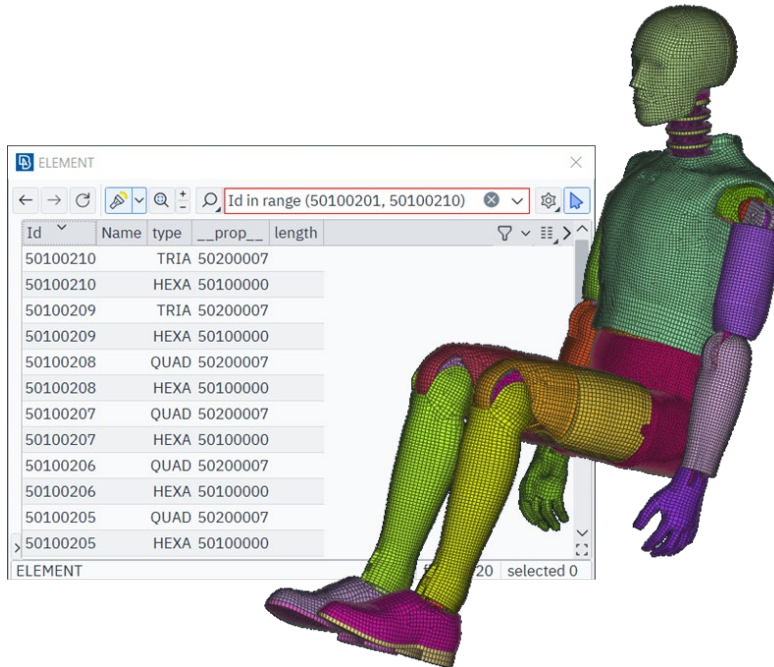


Fig.1: Shells and solids sharing the same IDs in ANSA for a LSTC.H3\_50

Despite this, ANSA holds true to its multi-solver pre-processor identity by offering multiple settings to cover both industry standard and user-defined ID schemas, providing extra flexibility to CAE engineers.

### 4 Merge Models

During the model build process, the ability to identify potential ID clashes between a currently working model and an incoming file is critical. This is particularly evident in the case of assembling a master model consisting of multiple include files. The ability to check per keyword for potential conflicts between two models offers a complete and clear overview of any model issues and where they can be located, thus deeming this option incredibly important. Moreover, different options should be available in order for the analyst to apply the proper action if any renumbering or offset is needed during the merge of two files. 'Model Merge' function of ANSA offers a complete overview of the ID clashes per keyword and provides different renumbering options to guide the merge process of the files. The tool offers a first level summary to inform the user if there are conflicts, and if there is need one can proceed to check the detailed view to notice exactly where clashes exist. The tool's intuitiveness can recognize the existence of clashes between defined and undefined entities, eliminating output of unnecessary warning messages, whilst informing users by displaying in the detailed view entity status definition during the merge process.

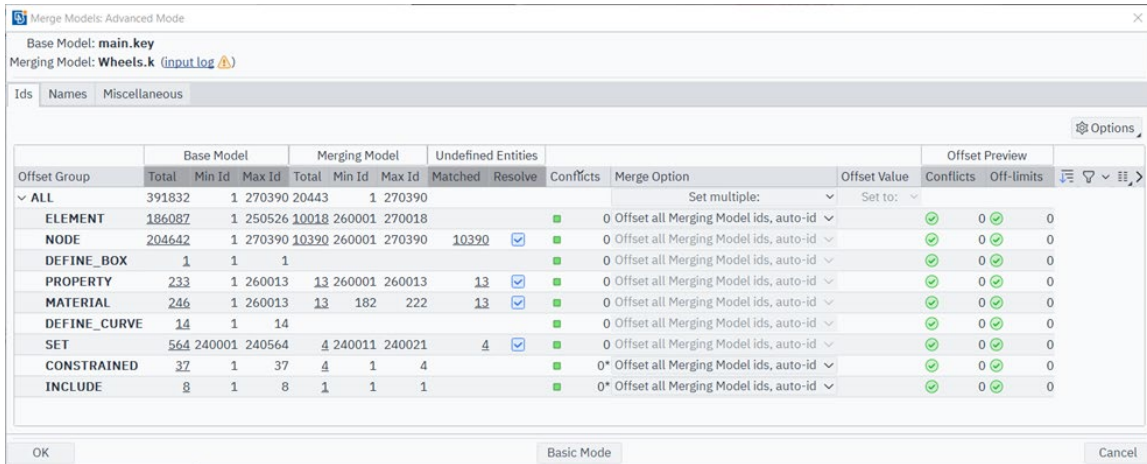


Fig.2: Advanced view of the ANSA Merge Models tool

## 5 Includes handling

Modular modelling is a practical approach for managing the complexity of full vehicle crash simulations and optimizing the development process. The use of **\*INCLUDE** under one master/main file has several advantages in the design process of a virtual model, particularly in crashworthiness simulations. It offers scalability and flexibility since individual components can be developed and tested in parallel, and changes and updates can take place in specific files without the necessity to update the entire system. Added value to the use of **\*INCLUDE** gives the reusability. Several parts among different vehicle models and configurations are the same and can be directly used reducing this way the redundancy.

### 5.1 Includes list

It is vital for crash and safety engineers to be able to import in the pre-processor and check the **\*INCLUDE** hierarchy without having anything loaded. ANSA provides a functionality where one can optionally load either all the **\*INCLUDE** keywords that could be met in the definition of a full crash model or just the first level ones, avoiding to call the nested include files that follow in a second or even deeper to the model definition.

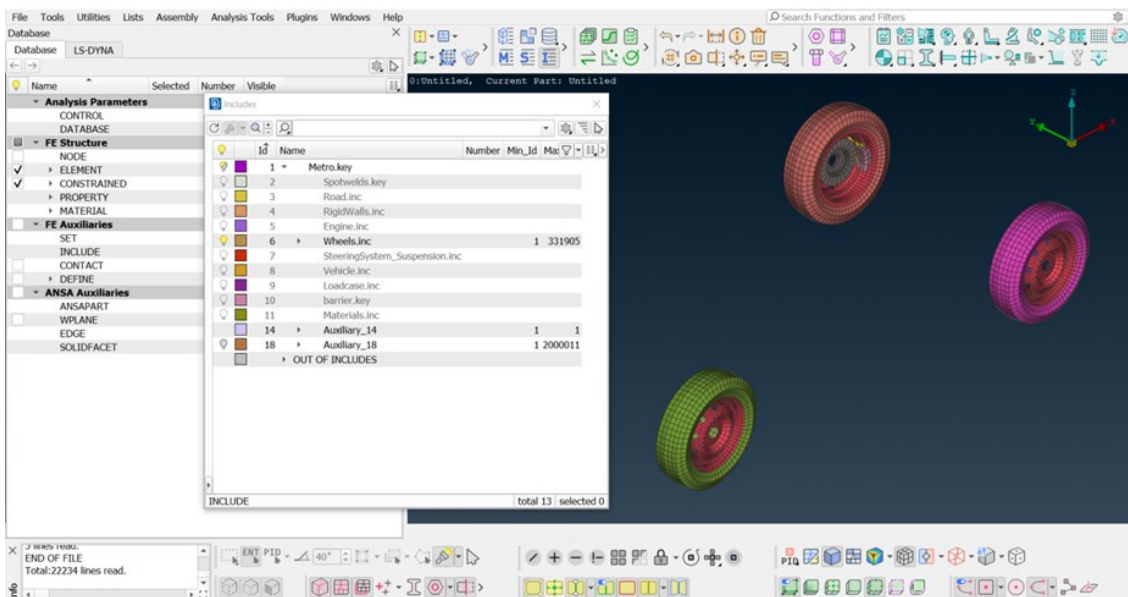


Fig.3: **\*INCLUDE** hierarchy imported in ANSA Includes list – single include loaded.

Effortless loading and unloading of individual and/or consecutively different include files is also provided by the ANSA include list, further facilitating the modular model built process. During this process, ANSA silently takes into account specific numbering settings to protect the user from any error that could make during the model merge by renumbering entities from their definition ID space but also treating the undefined properly to get their definition avoiding any undesirable numbering actions.

## 5.2 Includes Manager

As previously reestablished, one of the main advantages of the modular model built is that several parts can be reused in the definition of different variants and versions of a digital crash model. Analysts mainly have the need of an easy way to view all the include files that are placed in a specific place of a disk or a server and make combinations of those to produce different model configurations. ANSA offers a tool to preview all the include files either within a master file or in any place of a disk/server and through an easy interface to build different configurations and output them without the need to load anything within it. This way ANSA acts like a “cookbook” in a more easy and user friendly way.

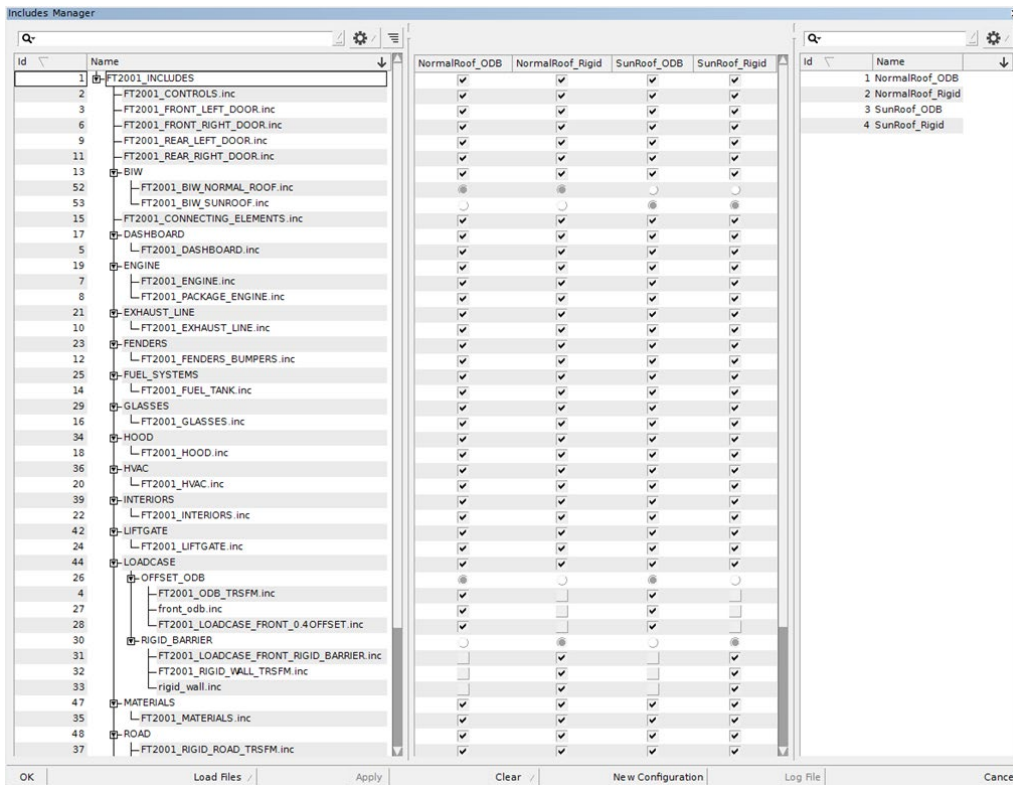


Fig.4: Model configuration creation through Includes Manager

## 5.3 Find Changes

Loading several includes within the pre-processor files during the model setup, can cause unintended or mistaken updates which may wrongly affect parts of the model. ANSA offers the ability to identify which of the existing include files have been modified at any time during the working process. This way one can see not only the added or deleted entities, but also check for any change that an include file has undergone in keyword level and parallelly examining both initial and current status, performing

all necessary comparisons. All changes can be directly output so as to have an accurate model update.

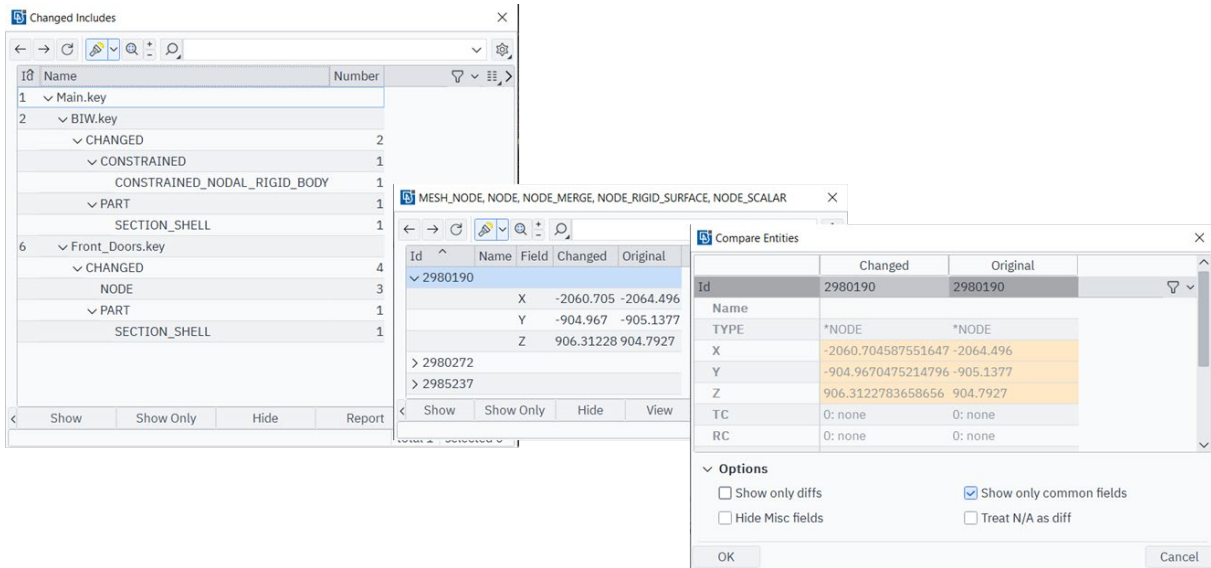


Fig.5: Check modified keywords within Includes through Find Changes

## 6 Compare

It is a common practice in the crash simulation workflow to compare not only complete Include files, but also different entities of the same type within the same include. ANSYS the pre-processor provides a suite of tools that enable the users to apply comparison of entities at different levels. Engineers often work with multiple versions of Include files especially during the modular model build. Comparing those, helps identify changes, improvements, or potential issues across different iterations. Moreover, comparing include files ensures that the components are consistent and compatible with the overall model. This is crucial for maintaining the integrity of simulations.

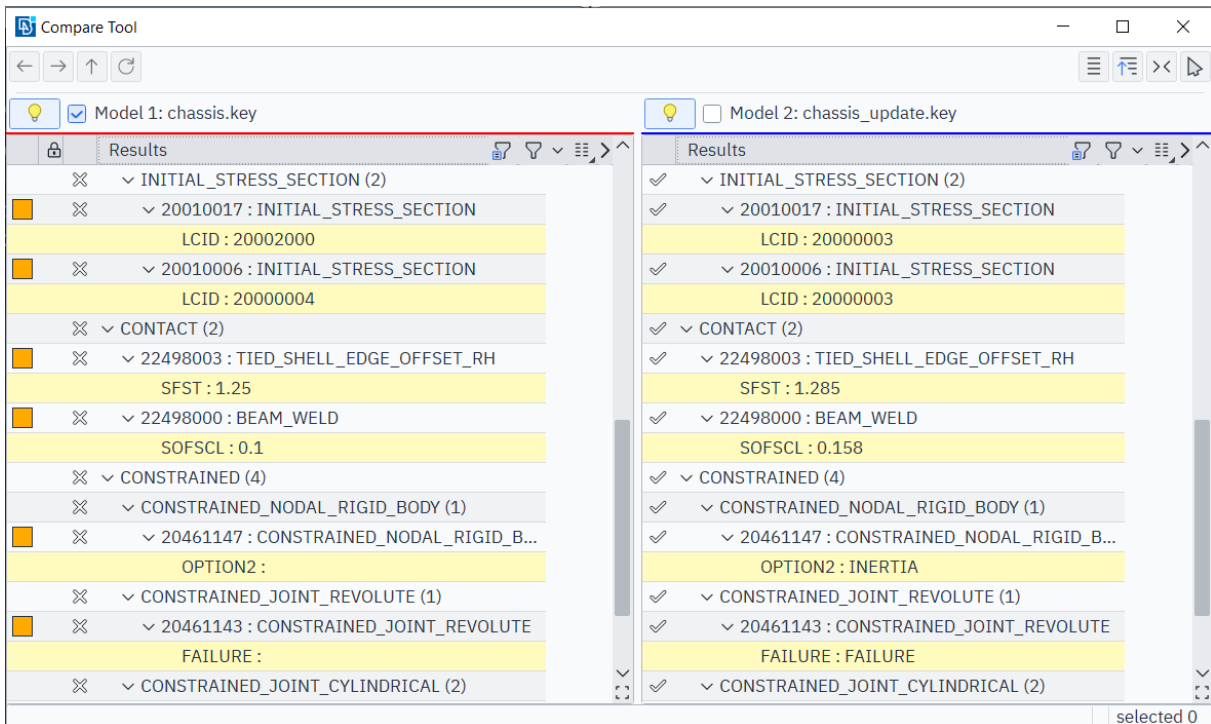


Fig.6: Comparison of two compete files through ANSA compare tool

Differences in keywords, parameters, or configurations can lead to errors in simulations. A thorough comparison either within the same file among keywords or between two complete files helps detect these discrepancies early in the process. Keeping track of changes between or within Include files provides valuable documentation, aiding communication among team members and facilitating better project management. By analysing differences, engineers can identify opportunities for optimization or improvements in the model setup process.

Types	24 MAT_PIECEWISE_LINEAR_PLASTI	24 MAT_PIECEWISE_LINEAR_PLASTI
<b>Id</b>	80000054	80000071
<b>Name</b>	DP 500-800	BH 260/370
<b>SIGY</b>	520.	260.
<b>FAIL</b>	0.	1.E21
<b>&gt; LCSS</b>	80000200	80000007
<b>VP</b>	1.	0.

**Options**

- Show only diffs
- Show only common fields
- Hide Misc fields
- Treat N/A as diff

Fig.7: Material cards comparison in ANSA

## 7 Checks Manager

The LS-DYNA run submission is probably the most crucial part of the crash simulation set up. At this point crash and safety engineers should rest assured of a proper run in LS-DYNA after the submission of the file they have prepared in the pre-processor. This demands not only a deeper understanding of the model but also a complete, proper check of it, standing up to the LS-DYNA's standards. These standards are rules that have to be followed either per keyword in its definition or in a combination of keywords definition. Alas, a check mechanism that harnessing the "know how" of LS-DYNA's rules is elementary.

Over the years, BETA CAE has developed a check manager consisting of a huge number of individual checks to validate that all the important keywords have the proper definition. These checks have been meticulously collected under a single template called 'LS-DYNA checks', granting fast access to easily identify any malformations in one's model. Customizing personalized templates grouping together the checks one would like to run is also available. Furthermore, each template could be further customized by having different settings depending on the level of quality that one would like to offer to one's model. Thus, multiple levels of criteria strictness can be achieved, even on the same check template.

Active	Name	Execute on	Status	Errors	Warnings	Info	Execution
<input checked="" type="checkbox"/>	Connections	All Entities	✔	0	0	0	0:00.004
<input checked="" type="checkbox"/>	Constraint Rigid Body PIDM - I	All Entities	✔	0	0	0	0:00.018
<input checked="" type="checkbox"/>	Constraint Rigid Bodies Long (	All Entities	✔	0	0	0	0:00.021
<input checked="" type="checkbox"/>	Contacts	All Entities	✘	5	2	0	0:04.890
<input checked="" type="checkbox"/>	Contacts Overlap	All Entities	✘	4	0	0	0:03.544
<input checked="" type="checkbox"/>	Curves:Axes	All Entities	⚠	0	10	0	0:00.006
<input checked="" type="checkbox"/>	Curves:End Time	All Entities	✔	0	0	0	0:00.002
<input checked="" type="checkbox"/>	Database: Check CS	All Entities	✔	0	0	0	0:00.004
<input checked="" type="checkbox"/>	Database: Check Part Set	All Entities	✔	0	0	0	0:00.015
<input checked="" type="checkbox"/>	Database: Cross Section	All Entities	✔	0	0	0	0:00.002
<input checked="" type="checkbox"/>	DB Histories	All Entities	⚠	0	12	0	0:00.002
<input checked="" type="checkbox"/>	Ex.Nodes Connectivity	All Entities	⚠	0	2177	0	0:00.139
<input checked="" type="checkbox"/>	Free	All Entities	⚠	0	208	0	0:01.831
<input checked="" type="checkbox"/>	IDs-Numbering Rules	All Entities	✔	0	0	0	0:00.220
<input checked="" type="checkbox"/>	Include Self Contained	All Entities	⚠	0	2	0	0:07.158
<input checked="" type="checkbox"/>	Include Transform Range IDs	All Entities	✔	0	0	0	0:00.004
<input checked="" type="checkbox"/>	Initial Velocity	All Entities	✘	5845	0	0	0:00.850

total 34 selected 0

Fig.8: Individual ANSA checks for LS-DYNA

After having run LS-DYNA checks, ANSA provides a clear overview of the model validation in a list that contains items separated by keyword definition (optionally). This way the user has a first categorization of which keywords have problems. Once the overview makes clear of actions needed, ANSA then provides automated fixation to the majority of the errors according to the LS-DYNA standards to bring the keyword definition to the proper setup. Of course the manual interaction with the model is applicable at any time for one to make any correction is needed. Then a re-run of the single check is applicable to validate the correction but also the complete check template could run. This way the user concludes in a clear and robust way to a file that is ready to be submitted to the solver.

## 7.1 Checks Manager List

It is important to highlight the results list generated by the Checks Manager. The interface provides a powerful and flexible overview of errors and warnings within the model. By default, results are clearly categorized into errors and warnings, distinguishing those that could lead to an "Error termination" in LS-DYNA from standard warnings.

Users can further refine their analysis by viewing results grouped by keyword. The system conveniently displays a detailed list of erroneous definitions for each keyword, allowing for quick identification and resolution of issues. This structured approach enhances the efficiency of the troubleshooting process, ensuring that users can effectively manage model validation.

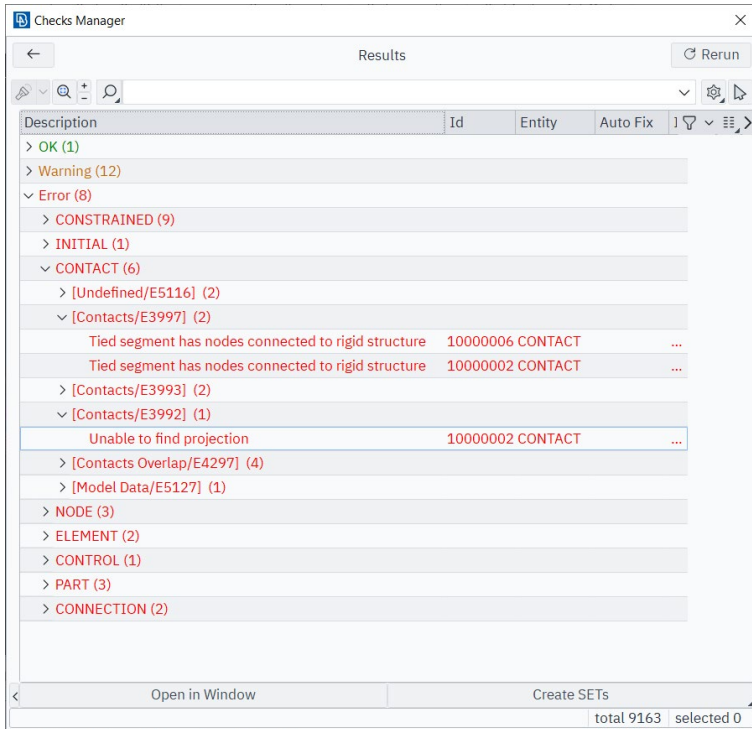


Fig.9: Errors per LS-DYNA keyword in ANSA Checks Manager list

Additionally, the check template comprises multiple individual checks that run consecutively, allowing users to view the model validation results categorized by each specific check. Importantly, this list allows for interaction, distinguishing between errors, warnings, and items that successfully pass validation. This interactive feature empowers users to customize the displayed results, tailoring the information to their specific needs and enhancing the overall efficiency of the validation process.

## 7.2 Live check

A special functionality that ANSA offers to its users is the live keyword check. When performing any modification or editing a keyword and its ANSA card pops up, a real time check when the card is to be confirmed by 'OK' takes place. If an erroneous definition is identified in the keyword's card, ANSA does not close the card highlighting the error and printing a relative message, to properly signal it to the user.

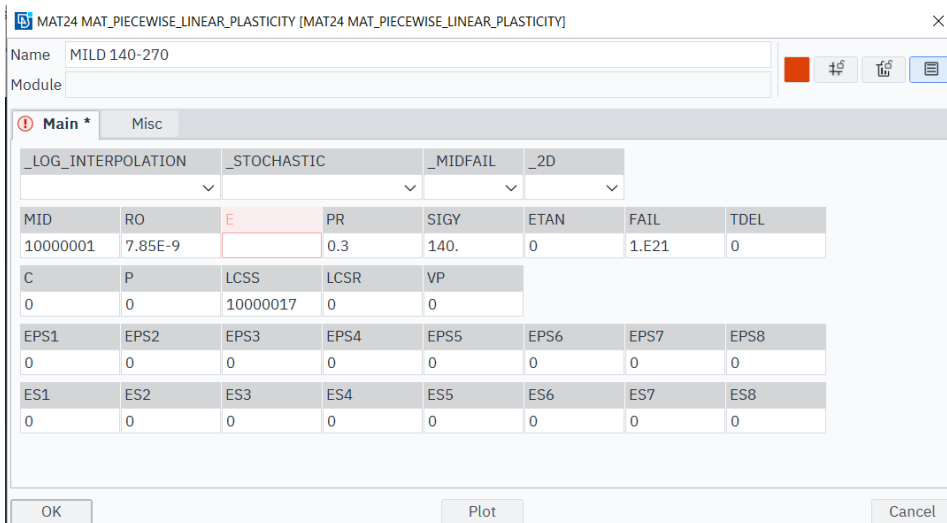


Fig.10: \*MAT24 card cannot close due to young modulus erroneous definition



### 7.3 Custom model check

Apart from executing build-in checks for validating the model, ANSA provides the capability to define custom checks. One can use python ANSA API to create any user defined check one would like to impose on one's model and can include it inside the desired template. Furthermore the user is provided with the ability to create and run a series of custom checks during the confirmation, by pressing "Ok" button on a keywords card. Thus, a live check on a keyword can also be customized.

## 8 Summary

ANSYS LS-DYNA employs a specific ID-sharing system among various keywords, allowing different entities to share IDs, which is crucial for digital models, especially in electric vehicles with increased element counts. ANSA supports the LS-DYNA ID schema and offers additional flexibility due to its multi-solver capabilities, accommodating both standard and user-defined ID schemas.

During model assembly, it's essential to identify ID clashes between the current model and incoming files. The 'Model Merge' function provides an overview of these clashes, offering renumbering options and detailed views to help analysts address conflicts.

Modular modeling simplifies complex crash simulations, allowing for parallel development and updates without affecting the entire system. The \*INCLUDE functionality enhances reusability, making it easier to manage component changes. The Includes Manager enables users to preview and manage Include files from disk or server locations, facilitating easy combinations to create various model configurations, acting as a "cookbook" for users.

Modification tracking is a key feature that allows identification of modified Include files during the setup process, enabling engineers to track changes at the keyword level for accurate updates. In ANSA, comparing Include files is essential for maintaining simulation integrity, with tools available for analyzing complete files and specific entities to identify discrepancies and document changes.

Ensuring a successful LS-DYNA run involves thorough checks against LS-DYNA standards. The Checks Manager offers numerous validation checks and allows the creation of custom templates for specific needs. The system provides a clear overview of errors and warnings, facilitates automated fixes, and allows for manual corrections.

A live keyword check highlights errors in real time during modifications. Additionally, users can define custom checks using the Python API, enabling tailored validation processes.

Overall, the software enhances workflow efficiency and model reliability through comprehensive ID management, modular handling, comparison tools, and robust validation mechanisms.

## 9 Literature

[1] ANSA version 25.0.0 ANSA Documentation, BETA CAE Systems International AG, August 2024

[2] LS-DYNA Keyword Users' Manual Version R14, ANSYS, Copyright© 1992-2023 ANSYS, Inc ("ANSYS"). All Rights Reserved.