GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 18.0

May 2019

1 Executive Summary

This document describes new and enhanced features included in *GENESIS* version 18.0. Following is a summary of the key new features and enhancements:

Analysis of Lattice Structures: Solid elements in *GENESIS* can now be used to simulate lattice structures. Now *GENESIS* can use homegenized material properties that represent either some new built-in lattice patterns or user-supplied lattice patterns. This new functionality allows simple solid meshes produce answers equivalent to more complex lattice models.

Optimization of Lattice Structures: Sizing and Topometry optimization of lattices can now be performed. Sizing and/or topometry can be applied to the solid element properties that specify lattice homogenization. Design variables can be associated to the diameter of the lattice structures.

Interior Acoustic Optimization: Fluid pressures calculated by either a direct or a modal frequency response analysis can now be used in optimization with coupled fluid-structure interaction problems. Fluid pressure calculated at any fluid grid can be used as objective or constraints using the new FPRESS response type. FPRESS is available for DRESP1 and TRESP1. FPRESS can be used in topology and other types of optimization.

New Fabrication Constraints for Topology to Support Additve Manufacturing (Overhang Constraints): Overhang angle constraints can now be defined uising new TSYM1/TSYM2/TSYM3 options: ABX, ABY, ABZ, ATX, ATY, and ATZ. This helps to reduce or eliminate the need for non-structural supports when parts are designed for additive manufacturing (3D printing).

Maximum Member Size Result Improvements: Existing methods have been tuned up to produce better results for topology optimziation with maximum member size constraints.

Tolerance for Badly Shaped Solid Elements: First-order elements that are flat or nearly flat are allowed in the model. When finding such elements, the software will ignore them. This complements the improvent in 17.0 where second-order elements with flat shapes were accepted.

Coordinate System Input Alternatives: New data entries CORD3R and CORD4R define local coordinate systems by specifying the x-axis and the x-y plane.

New properties on PTUBE and PROD: Tube and rod elements can now have torsional stifness. The J stiffness is now available on PROD data entries. PTUBE will automatically calculate J based on the tube dimensions.

Nodal Thickness in Shell elements: CTRIA3, CTRIA6, CQUAD4 and CQUAD8 now accept nodal thinkness data. This helps improve compatibility with input data generated by some third-party preprocessors.

2 Analysis Enhancements

1. Analysis of lattice structures: Solid elements in *GENESIS* can now be used to simulate lattice strucutres. Now *GENESIS* can use homegenized materials that represent either some new built-in lattice patterns or user supplied lattice patterns. This new functionality allows simple meshes produce answers equivalent to more complex lattice meshes.

   Bulk Data Entries - PSOLID, LATMAT, TABLAT1

2. New data entries available for analysis: New data entries CORD3R and CORD4R define local coordinate systems by specifying the x-axis and the x-y plane. These complement the existing coordinate system entries, which all define local systems by specifying the z-axis and the x-z plane.

   Bulk Data Entries - CORD3R and CORD4R

3. Tube and rod element can now have torsional stifness. The J stiffness is now available for PROD data entries. PTUBE entries will automatically calculate a J value.

   Bulk Data Entries - PTUBE and PROD

4. Nodal thickness in shell elements. This helps improve compatibility with input data generated by some third-party preprocessors.

   Bulk Data Entries - CTRIA3, CTRIA6, CQUAD4 and CQUAD8

5. Bar and beam element input vector flexibility. The bar and beam elements now support options for choosing which coordinate system is used to define the orientation vector and the offset vectors of the two endpoints. The OFFT field specifies a code for choosing between two options for each of the three vectors.

   Bulk Data Entries - CBAR, CBEAM

6. New rigid option for PBUSH. The bush element property now accepts the word RIGID for any of the Ki values. If RIGID is used, an appropriate penalty stiffness is calculated for each referencing CBUSH element such that it approximates a rigid connection in the specified direction.

   Bulk Data Entry - PBUSH

7. New option for CGLUE1. The CGLUE1 entry supports a new field to choose whether to use only translation dofs for the independent dofs (the default) or to use both translations and rotations. Adding the rotations helps improve results for certain modelling situations where the end of a relatively thick flat shell is to be glued to the surface of another flat shell.

   Bulk Data Entry - CGLUE1

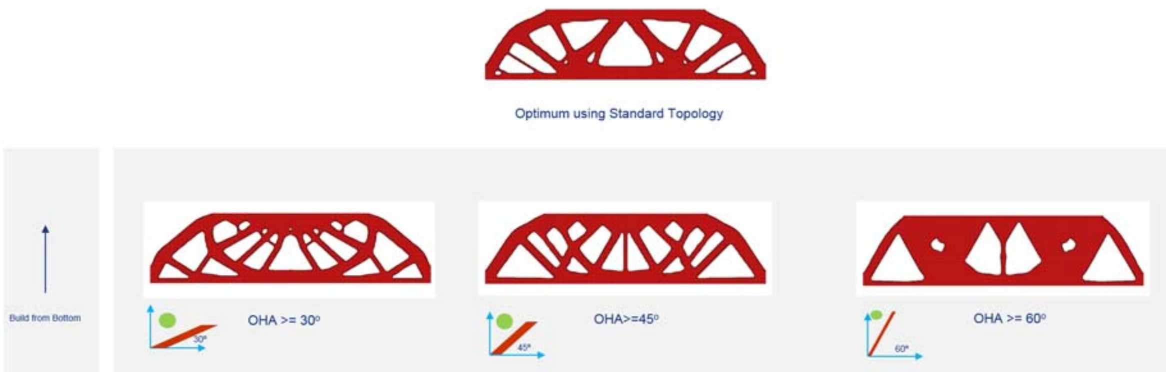
3 Structural Optimization Enhancements

1. Interior acoustic optimization: Fluid pressures calculated at fluid grids in a coupled fluid-structure frequency responses analysis can now be used in optimization. The new FPRESS response is now available with DRESP1 and TRESP. Fluid-pressure constraints or objectives can be used for for topology and other types of optimization.

   Bulk Data Statements - DRESP1/TRESP1, new RTYPE=FPRESS

2. Overhang constraints:

   Bulk Data Statements - TSYM1,TSYM2,TSYM3, new TYPE=ATX, ATY, ATZ or ABX, ABY or ABZ



Topology Optimization results with overhang angle constraints

The figure above shows a comparson between stadard topology and 3 alternarive answers using different overhang angle constraints limits (30, 45 and 60 degrees)

3. Maximum member size improvements: The existing method to impose maximum menber size has been tune-up to get better answers,.

   Bulk Data Statements - TSYM1,TSYM2,TSYM3, existing types SYMV3 and SYMV4

4. User mode tracking: Now a user-supplied shared library can be loaded and used for reordering modes.

   Executiive Control Command - UMODTRK

4 Output Enhancements

1. Optimal sensitivity graph can now be printed. With the aid of a provided lua script, one can now obtain a graph in a spreedsheet that visualizes how much the objective changes when an active constraint bound changes by 1%. Check Design Studio Example SZDSG012 for more details.

2. Graph file enhancement. The optimization summary *.html file is now printed at the end of every design cycle. This enables easy visualization of results “in progress”. Note that there is only one *.html file for the entire job, not one per design cycle. This means that the file will be overwritten each design cycle.
   Solution Control Command - GRAPH

3. Update file enhancement. PBAR/PBARL properties designed with DVPROP3 will now be written as PBARL with approproate dimensions in the *UPDATExx.dat file. This will enable easier visualization of bar element design results.
   Solution Control Command - UPRINT

5 Post Processing File Enhancements

1. The format of optimization post-processing files that contain results for sizing, topometry, shape and topology can now be individually specified to be PUNCH or OUTPUT2. This format can be different from the format specified by the POST executive control command. This feature enables, for example, printing optimization post processing files in the easily parsable PUNCH format, while still using the space-saving OUTPUT2 format for the typically larger analysis post-processing files.

   Solution Control Commands - DENSITY, SHAPE, SIZING and THICKNESS

2. Printing of CRMS results can now be optionally skipped when only RMS results are needed in random response analysis. This capability allows for more compact post-processing files in many typical use cases.

   Bulk Data Statements - PARAM, new parameter name is PCRMS

6 New Input Data

6.1 Executive Control

UMODTRK	Define a shared library to load for performing mode tracking

6.2 Bulk Data

CORD3R	Alternative format for defining a rectangular local coordinate system
CORD4R	Alternative format for defining a rectangular local coordinate system
LATMAT	References TABLAT1 data entries to define material properties of user provided lattice profiles. This data is referenced by PSOLID.
TABLAT1	Defines material properties of lattices as a tabular function of lattice diameter fraction or volume fraction.

6.3 Analysis PARAMeters

PCRMS	Parameter to allow skipping the printing of cumulative root mean square results, while still printing RMS and N0.

6.4 DOPT Parameters used in Topology Optimization

OHADEF	Parameter to select where to measure the overhang angle. A value of 0 will measure the angle from the build plate. A value of 1 will measure the angle from the build direction.
OHASPM	Parameter to select which method is used to define the support condition. A value of 1 will use a “strict” condition to decide whether a layer above a support can be built or not. A value of 2 will use a “lenient” condition to decide how much densitiy is allowed above a support.
OHASPA	Parameter to select method to calculate overhang-sensitivities. A value of 0 will use the direct method with approximations. A value of 1 will use overhang-adjoint sensitivities. Overhang-adjoint sensitivities are only calculated when OHASPM is 1.

OHASPV	Controls the treatment of unsupported poles. A value of 0.0 will cause poles located in areas that do not have mesh below to them to have a zero density. This value will cause the program to optimize for full self-supported answers. A value of 1.0 will cause poles located on areas that do not have mesh below to them to have a density of 1.0. This value will cause the program to optimize for interor parts to be self-supported answer. This assume that elements in bottom regions will have an external non-strucural support. Note: This parameter does not effect on poles located on the build platform as such poles are by definition supported.
OHASPRI	Radius Factor Influence. Used to define the support influence. Large value should produce more accurate results but at a larger cost. The extreme case 1.0E30 would use most resolution. A value of 1.0 will still work fine for problems where overhang features that are not naturally shallow or short. This parameter is not used when OHASPM=2 and OHASPA=1.
HSBETA	Beta value used to polarize element densities. Currently, this is only used with densitiy of elements on topoogy regions with overhang angle constraints. Higher values of HSBETA will polarize answers faster. Shell meshes might require higher values than default.
OHASPS	Parameter to select shape of internal support region used with overhang angle constraints. A value of 0 will use a “CONE” shape. A value of 1 will use a “FLAT” shape. Initial testing indicates that the FLAT shape is best for solids, whereas the CONE shape is best for shell meshes. Note: This selection is valid only when OHASPM=1. For OHASPM=2 the FLAT shape is used.
OHASPRF	Radius Factor. Used to define the support depth for “CONE” shapes option. Most useful values are between 1.0 and 2.0
OHASPB	BetaT value used to calculate the polarized density of supports. Higher values of BetaT produce shorter transition zone between near 0.0 to near 1.0 values. This value is used in a Heavyside Thresholding function.
OHASPT	Thresholding cut-off value used to calculate polarized density of supports. A value of -1.0 or -2.0 will use internal methods to calculate location dependent values of T. This value is used with the BetaT parameter. It is also used with the NHUT parameter for the shape “FLAT”.
OHASPN	Thresholding scale value NHUT used to calculate polarized density of supports. This value is used toghether with the BetaT and T parameters a Heavyside Thresholding function. Values between 1.5 and 2.0 seems to good choices to improve convergence. This parameter is only used with shape support regions of the type “FLAT”.

7 Enhanced Input Data

7.1 Solution Control

DENSITY	Can now directly specify PUNCH or OUTPUT2 format, and can be different from the format on the POST executive control command
SHAPE	Can now directly specify PUNCH or OUTPUT2 format, and can be different from the format on the POST executive control command
SIZING	Can now directly specify PUNCH or OUTPUT2 format, and can be different from the format on the POST executive control command
THICKNESS	Can now directly specify PUNCH or OUTPUT2 format, and can be different from the format on the POST executive control command

7.2 Analysis Bulk Data

CBAR	Allows OFFT options
CBEAM	Allows OFFT options
CGLUE1	Now has an option to specify independent components
CTRIA3	Now has optional nodal thickness
CTRIA6	Now has optional nodal thickness
CQUAD4	Now has optional nodal thickness
CQUAD8	Now has optional nodal thickness
CHEXA	Can now reference lattice-properties
CHEX20	Can now reference lattice-properties
CPENTA	Can now reference lattice-properties
CPYRA	Can now reference lattice-properties
CTETRA	Can now reference lattice-properties
PBUSH	Now has rigid option for K
PSOLID	Can now reference lattice property information, PSOLID can now reference the new LATMAT entry and can accept lattice diameter and cell size.
PROD	Can now use torsional stiffness (J term)
PTUBE	Now includes torsional stiffness

7.3 Topology Optimization Bulk Data

TCYCLE	Can now be used in a master file for multi-model optimization.
TSYM1	New overhang angle constraints filling from bottom: ABX, ABY and ABZ New overhang angle constraints filling from bottom: ATX, ATY and ATZ These types of filling allow to reduce shallow overhangs to avoid or reduce non-structrural support for additive manufacturing designs
TSYM2	New overhang angle constraints filling from bottom: ABX, ABY and ABZ New overhang angle constraints filling from bottom: ATX, ATY and ATZ These types of filling allow to reduce shallow overhangs to avoid or reduce non-structrural support for additive manufacturing designs
TSYM3	New overhang angle constraints filling from bottom: ABX, ABY and ABZ New overhang angle constraints filling from bottom: ATX, ATY and ATZ These types of filling allow to reduce shallow overhangs to avoid or reduce non-structrural support for additive manufacturing designs

7.4 Sizing/Topometry Optimization Bulk Data

DVPROP1	Can now be used to link a design variable and a diameter of lattice associated to PSOLID
DVPROP2	Can now be used to link a design variable and a diameter of lattice associated to PSOLID

7.5 DRESP1/TRESP1- New response types RTYPE

FPRESS	Fluid Pressure at fluid grids. Now available in TRESP1 and DRESP1

8 *GENESIS* Manual Updates

All *GENESIS* manuals have been updated to reflect the new features, as well as the new and modified data entries.

Manual Title	Filename	Status
GENESIS: Analysis Manual	volume1.pdf	Updated to reflect all enhanced and new features.
GENESIS: Design Manual	volume2.pdf	Updated to reflect all enhanced and new features.
GENESIS: Analysis Examples	volume3.pdf	Updated.
GENESIS: Design Examples	volume4.pdf	Updated.
GENESIS: Quick Reference Manual	quickref.pdf	Updated to reflect all changes and new data entries
GENESIS: New Features and Enhancements	newfeat.pdf	This document which describes the changes between *GENESIS* versions 17.0 and 18.0

9 Changes in Version 18.0 with Respect to Version 17.0

GENESIS 18.0 should run any problem that was successfully running in version 17.0 with no changes.

A 64-bit operating system is required to run *GENESIS* 18.0. 32-bit operating systems are no longer supported.

PTUBE now automatically calculates a torsional stiffness. Input models with CTUBE elements may now give slightly different results than previous versions.