GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 12.1

September 2011

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1 Introduction

This document describes the new and enhanced features added to Genesis in version 12.1. Key enhancements include the following:

The 15-node CPENTA element has been added: The new element can be used for any type of analysis. The new element is supported in all types of optimization. Stress and strain are recovered for statics, frequency response and random response. Grid stresses are recovered for statics and frequency response. The results can be printed in the output file and/or post processing files.

The stress and strain of the 10-node CTETRA element has been improved: A new procedure that results in more accurate element results has been added.

Stress and force results for the CWELD element are now available: These results are available for statics, frequency response and random response analysis. The results can be printed in the output file and/or post processing files.

Forces results for the CGAP element are now available: These results are available for statics analysis. The results can be printed in the output file and/or post processing files.

Interlaminar shear results for the composite elements are now available: The responses are available for statics analysis and for optmization. The results can be printed in the output file and/or post processing files.

The topology preprocessor has been improved: The memory requirement for geometry-based fabrication constraint preprocessing has been dramatically reduced for solid structures. The overall preprocessor calculation has been improved resulting in lower memory usage and a speedier process.

Uniform fabrication constraints have been enhanced: The existing uniform fabrication constraints, UXY, UYZ and UZX, can now be used as geometry-based constraints. Previously these were only available for element-based topology optimization.

The anti-checkerboard filter controls for topology have been enhanced: New options for the filtering allow control over which neighbor shell elements will participate within a single filter region.

New shifted response types have been added: Shifted responses allow easy creation of constraints which have bounds that are frequency dependent. Shifted response are now available for random response power spectral density displacements, velocities, accelerations.

New built-in functions are now available: New types for DRESP3 and TRESP3 are SDEV and PNORM2.

New topography options are now available: New perturbation method FFORM and shape type UNIF add flexibility to topography problem setup.

Nested include files are now allowed: Included bulk data files are now allowed include other files to give users greater flexibility in organizing their input data.

2 Execution Enhancements

1. Shape, Topography and Freeform Optimization Restart. When restarting, the *.SHP shape optimization post-processing file will be appended starting at the restart cycle, preserving result from previous cycles. In previous versions, the *.SHP file was completely overwritten, destroying previous run results. In addition, if mesh smoothing is used, the smoothed mesh from the restart cycle is recovered from the *.SHP file, if available. This change can prevent restart errors due to failure of the mesh smoothing.

   Executive Control Command - RESTART
   Solution Control Command - SHAPE

2. Nested Include Files. Now bulk data INCLUDE files may themselves include other files. If a file includes itself directly or indirectly, Genesis will detect that situation and generate a fatal error.

   Bulk Data Statement - INCLUDE

3. Input Data Generation. A new facility allows dynamic generation of input data. The new PROCESS command will execute a given command line to run a user program, and any output from that program will be included as input data.

   Solution Control Command - PROCESS
   Bulk Data Statement - PROCESS

4. New Runtime Control Mechanism. Genesis now includes the ability to accept signals sent by a control program while running a job. These signals can modify certain input data parameters. This can be used, for example, to change the printing frequency of analysis results or to reduce or increase the maximum allowed design cycles based on observed progress. Signals are sent from the command line using the new `-cntl` option to the `genesis` script on Unix/Linux or using the `gencntl.exe` program on Windows as follows:

   (Unix/Linux) `genesis -cntl`

   (Windows) `gencntl.exe`

   List the *jobid*s of currently running jobs

   (Unix/Linux) `genesis -cntl` *`jobid action`* `[`*`action ...`*`]`

   (Windows) `gencntl.exe` *`jobid action`* `[`*`action ...`*`]`

   Send *action* signals to job *jobid*

   Available *actions*:

   DESMAX=n

   DIAG=n

   APRINT={NONE | ALL | LAST | n}

   DPRINT={NONE | ALL | LAST | n}

   UPRINT={NONE | ALL | LAST | n}

3 Analysis Enhancements

1. Fifteen-Node Pentahedral Element. This new second order element can be used for all types of analysis. Stress and strain results for this new element type are available for statics, frequency response and random response. Grid stresses are recovered for statics and frequency response. These results can be printed in the output file and/or post processing files.

   Solution Control Commands - STRESS, FORCE, GSTRESS
   Bulk Data Statement - CPENTA

2. Improved 10-Node Tetrahedral Element Stress/Strain Recovery. A new procedure that results in more accurate stress and strain results for the second order tetra element has been added.

   Solution Control Commands - STRESS, FORCE, GSTRESS
   Bulk Data Statement - CTETRA

3. Improved Solid Element Connections. Models that directly connect solid elements to 1- and 2-D elements can create singularities due to the fact that solid elements do not connect to the rotation degrees of freedom of grids (i.e., components 456). Genesis now includes special preprocessing to detect these situations and fix the connections. This results in a more robust solver by eliminating potential singularities.

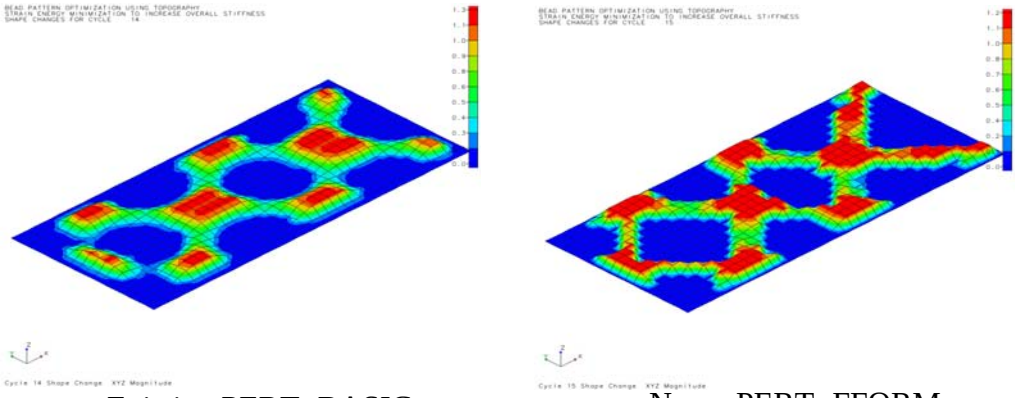
4 Shape, Sizing, Topometry and Topography Optimization Enhancements

1. Freeform Topography. A new method to automatically generate perturbation vectors in topography optimization has been added. The method is activated using word “FFORM” in field PERTM of the DTGRID data entry.

   Bulk Data Statement - DTGRID

   Example:

   The following example shows topography optimization of a initially flat plate assembled with shell elements. The structure is subjected to torsional loads. The picture below shows two results. The result on the left corresponds to one of the existing topography optimization methods. The result on the right corresponds to the new method which is activated using PERTM=FFROM



Existing PERT=BASIC New - PERT=FFORM

2. Uniform Topography. A new shape type has been added to topography optimization. This type creates a uniform shape change pattern in the topography region. The method is activated using word “UNIF” in field STYPE of the DTGRID data entry.

   Bulk Data Statement - DTGRID

3. Shifted Random Responses. Shifted responses associated to power spectral density functions of displacement, velocity and acceleration are now available to be used as objectives or constraints. Shifted responses allow easy creation of constraints which have bounds that are frequency dependent. The new response types for DRESP1 are: PSDDS, PSDVS and PSDAS.

   Bulk Data Statements - DSHIFT, DRESP1

4. Fifteen-Node Pentahedral Element. The new 15-node penta element (CPENTA) can be designed with shape and freeform optimization, and has several response types that can used in an optimization problem. Available element response types include: STRESS, DSTRESS, STRAIN, DSTRAIN, GSTRESS and DGSTRESS. These responses can be selected with DRESP1.

   Bulk Data Statements - DVGRID, DSHAPE, DRESP1.

5. New DRESP3 Built-in Functions. New built-in functions were added to DRESP3 to calculate the standard deviation (SDEV) or the one-sided distance (PNORM2).

   Bulk Data Statements - DRESP3

6. Composite Element Interlaminar Shear. New option for FINDEX was added to DRESP1. With FINDEX item code = 2, Genesis will use interlaminar shear as a response.

   Bulk Data Statements - DRESP1

7. Enhanced Output Summaries. A table showing the mass associated with each topometry regions is now printed for each design cycle.

5 Topology Optimization Enhancements

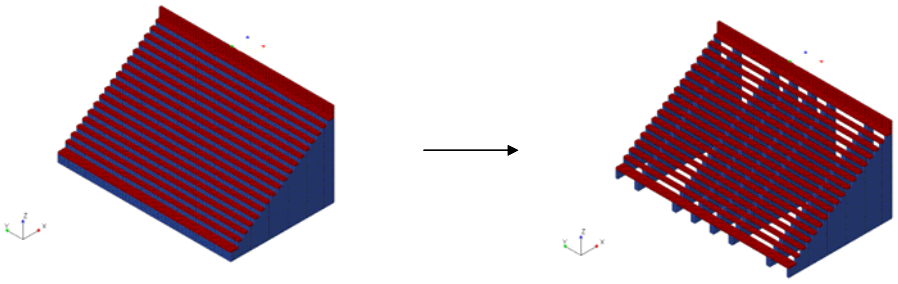
1. Improved Topology Preprocessor. The memory requirement for geometry-based fabrication constraint preprocessing has been dramatically reduced for solid structures. The overall preprocessor calculation has been improved resulting in lower memory usage and a speedier process.

2. Enhanced Fabrication Constraints. The existing uniform fabrication constraints, UXY, UYZ and UZX, can now be used as geometry-based constraints. This allows enforcement of these constraints even for irregular meshes. In addition, this change allows enforcement of minimum member sizes with these fabrication constraints.

   Bulk Data Statements - TSYM1, TSYM2, TSYM3

   Example: Uniform fabrication constraint (UXZ) and minimum member size

   The following example shows the design of the support of spectator bleachers. Notice that the support are uniform and are suitable to be built as a standard wall. Standard topology optimization without the uniform manufacturing constraint produces a truss like structure.



Original Design Final Design

3. Shifted Random Responses. Shifted responses associated to power spectral density functions of displacement, velocity and acceleration are now available to be used as objectives or constraints. Shifted responses allow easy creation of constraints which have bounds that are frequency dependent. The new response types for TRESP1 are: PSDDS, PSDVS and PSDAS.

   Bulk Data Statements - DSHIFT, TRESP1

4. Fifteen-Node Pentahedral Element. The new 15-node penta element (CPENTA) can be designed with topology optimization.

   Bulk Data Statements - TPROP.

5. New TRESP3 Built-in Functions. New built-in functions were added to TRESP3 to calculate the standard deviation (SDEV) or the one-sided distance (PNORM2).

   Bulk Data Statements - TRESP3

6. Topology Variable Selection. The TSELECT can now select among design variables associated with topology designed properties. The variables are selected indirectly by referencing the property that they design.

   Bulk Data Statements - TSELECT

7. Enhanced Output. The optional topology quality information report now prints a table showing individual results for each designed property. In previous versions, only global results were printed.

   Executive Control Command - DIAG=631

6 Output Enhancements

1. Weld Element Stress and Force. Element stresses and forces from CWELD elements are available for statics, frequency response and random response analysis. These results can be printed in the output file and/or post processing files.

   Solution Control Command- STRESS, FORCE

2. Gap Element Force Recovery. Element forces (but called stresses for compatibility with other software) from CGAP elements are available for statics analysis. These results can be printed in the output file and/or post processing files.

   Solution Control Command - STRESS

3. Composite Element Interlaminar Shear. Interlaminar shear failure indices from PCOMP elements are available for statics analysis. These results can be printed in the output file and/or post processing files.

   Solution Control Command - STRESS

7 New Input Data

7.1 Solution Control

PROCESS	Can run an external user program to generate input data.

7.2 Bulk Data

PROCESS	Can run an external user program to generate input data.

7.3 DOPT Parameter

FILTNRM	Cutoff angle to exclude neighbor shell elements from participating in anti-checkerboard filtering. Shell elements whose norms make an angle greater than FILTNRM will not be considered as part of the same anti-checkerboard filter region. A value of 0.0 will force Genesis to create anti-checkerboard filter regions containing only elements that are in the same plane. A value of 90.0 will allow Genesis to include all neighbor elements with an anti-checkerboard filter region (however elements close to 90 degree will have little influence as a result of using FILTER=-2). This parameter is only used when FILTER=-2 and is ignored with other FILTER values.

8 Enhanced Input Data

8.1 Executive Control

RESTART	The restart procedure has been enhanced for problem with shape optimization with mesh smoothing. Now, the smoothed mesh from the restart cycle is recovered from the *.SHP file, if available. This change can prevent restart errors due to failure of the mesh smoothing.

8.2 Solution Control

FORCE	The forces of CWELD elements can now be printed.
STRESS	The stresses of 15 node CPENTA elements and CWELD elements can now be printed. The forces of CGAP elements can now be printed.
STRAIN	The strains of 15 node CPENTA elements can now be printed.
GSTRESS	Then grid stress of 15 node CPENTA elements can now be printed.
SHAPE	When used with RESTART, the *.SHP result file will now be appended to rather than overwritten.

8.3 Bulk Data

INCLUDE	Included files may now also contain INCLUDE statements.
CPENTA	Connectivity information for the 15 node pentahedral element.
CQUAD4->PCOMP	Interlaminar shear is now calculated.
CQUAD8->PCOMP	Interlaminar shear is now calculated.
CTRIA3->PCOMP	Interlaminar shear is now calculated.
CTRIA6->PCOMP	Interlaminar shear is now calculated.
PCOMP	SB field specifies the interlaminar shear stress limit.
DRESP1	Can now accept new shifted responses (PSDDS, PSDVS and PSDAS).
TRESP1	Can now accept new shifted responses (PSDDS, PSDVS and PSDAS).
DRESP3	Can now use new built-in functions (SDEV and PNORM2)
TRESP3	Can now use new built-in functions (SDEV and PNORM2).
DTGRID	Now accept new shape type, UNIF, and new perturbation method, FFORM.

TSELECT	Can now select among internally created topology design variables using the PROP continuation form.
TSYM1	Now accept mixing minimum member size with uniform fabrications constrains (UXY, UYZ, UZX).
TSYM2	Now accept mixing minimum member size with uniform fabrication constraints (UXY, UYZ, UZX).
TSYM3	Now accept mixing minimum member size with uniform fabrication constraints (UXY, UYZ, UZX).
DOPT	Now can use new DOPT parameter FILTNRM. The existing DOPT parameter FILTER can now take values 0, 1, -1 and -2.

8.4 DRESP1- RTYPE Improvements

FINDEX	Now can be used to select interlaminar shear.
STRESS	Now can be used to select stress of new 15 node penta.
STRAIN	Now can be used to select strain of new 15 node penta.
GSTRESS	Now can be used to select grid stress of new 15 node penta.

8.5 DOPT- Parameter Improvements

FILTER	New value -1 causes Genesis to use property-by-property anti-checkerboard filter regions instead of global regions. New value -2: causes Genesis to use norm-dependent anti-checkerboard filter regioning. In this case, elements whose norms are more closely aligned interact more strongly within the filter.

9 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 improved and new features
GENESIS: Design Manual	volume2.pdf	Updated to reflect all improved and new features
GENESIS: Analysis Examples	volume3.pdf	Updated. Two new examples was added
GENESIS: Design Examples	volume4.pdf	Updated. One new example was added
GENESIS: Quick Reference Manual	quickref.pdf	Updated to reflect all changes and new data entries
GENESIS: New Features and Enhancements	newfeat.pdf	This document

10 Changes in Version 12.1 with Respect to Version 12.0

Genesis 12.1 should run any problem that was successfully running in version 12.0 with no changes.