GENESIS

Structural Analysis and Optimization

New Features and Enhancements

Version 12.0

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1 Introduction

This document describes the new and enhanced features added to Genesis in version 12.0. Key enhancements include the following:

New nonlinear analysis capability. Now, the CGAP element can be used for simulating nonlinear static contact analysis.

New second order elements added. Two new elements were added: CQUAD8 and CTRIA6. The new elements can be uses for simple shell/plate analysis or for modeling composites. The new elements are supported in all types of optimization.

Reusable eigenvectors. Eigenvectors can optionally be saved to a special database file so that subsequent modal frequency response runs do not have to recalculate the modes.

Performance improvement in the optimization process. Results of certain calculations from the analysis solver of design cycle 0 are now saved for reuse in later cycles, making later cycles faster.

New random response available for all types of optimization. Power spectral density functions of displacement, velocity and acceleration are now available to be used as objectives or constraints.

New shifted responses available for all types of optimization. Shifted responses allow easy creation of constraints which have bounds that are frequency dependent. Shifted respones are avaiable for displacements, velocities, accelerations and corresponding user function responses.

User function of dynamic responses now available for topology. UFDATA now can be used with topology optimization through new TRESP1 response types: UFDISP, UFVELO and UFACCE. In previous versions, UFDATA could only be used with parametric optimization.

New fabrication constraints for topography, topometry, topology and freeform optimization. New fabrication constraints enforce designs that are uniform throughout a specified plane using symmetry type: UXY, UYZ and UZX. In addition, the new symmetry type UXYZ forces a completely uniform design.

Topology extra variable selection. A new data entry, TSELECT, tells the optimizer to select the best set of toplogy extra variables to move to their upper bound while forcing the rest to their lower bound. This new capability allows easy formulation of optimization problems such as selecting the best among a set of candidates to keep in component designs.

2   Execution Enhancements

1. The SOL executive control command has been changed to have no default. Previously, the default was COMPAT0, which specifies the traditional Genesis interpretation of data on PSHELL and PBAR. However, most user data contains PSHELL and PBAR entries written for a Nastran interpretation (SOL COMPAT1). To avoid erroneous answers caused by interpreting the input data wrongly, now the SOL command must be specified. An alternative to putting the SOL command in the input data is to use the `-sol` command line option. In a future version, the default for SOL will be changed to COMPAT1.

    Executive Control - SOL

2. The history file used for a restart run can now be selected from different directory. If the HIS command is given, then the specified file will be copied to *pname*.HIS at the start of the run, where *pname* is the project name for the run.

    Executive Control - HIS

3. The restart file required for certain restart runs can now be selected from different directory. If the RST command is given, then the specified file will be copied to *pname*.RST at the start of the run, where *pname* is the project name for the run.

    Executive Control - RST

4. The performance for optimization runs has been improved. Now, results from certain calculations for the analysis solver of cycle 0 are saved and reused in later cycles. This reduces the time required for later cycles, frequently by 10% or more.

5. Input data containing only DMIG data for the stiffness matrix can now be run. This makes it convenient to test superelements. Previously, Genesis required at least one element entry and at least one property entry in the input data.

3 Analysis Enhancements

1. The CGAP element can now be used for simulating nonlinear static contact analysis. To trigger nonlinear analysis, the NLPARM solution control statement must be used to point to a NLPARM bulk data entry. This entry specifies the maximum solver iterations allowed per design cycle. For non-static loadcases, or for for static loadcases that do not specify the NLPARM solution control command, the CGAP elements will behave as linear spring elements.

    Solution Control Statement - NLPARM.
    Bulk Data Statements - CGAP, PGAP, NLPARM.

2. Two new elements were added: CQUAD8 and CTRIA6. These second order elements can be uses for simple shell/plate analysis or for modeling composites.

    Bulk Data Statements - CQUAD8, CTRIA6.

3. Eigenvectors can optionally be saved to a special database file so that subsequent modal frequency response runs do not have to recalculate the modes. Setting analysis parameter MODERST to WRITE will cause Genesis to write the eigen database file after performing an eigenanalysis. Setting MODERST to READ will cause Genesis to read in the eigenvalues and eigenvectors from a previously written eigen database file instead of doing the eigenanalysis.

    Bulk Data Statement - PARAM (MODERST).

4. Improvements have been made to the module that eliminates dependent degrees from freedom on rigid/interpolation elements and MPC. Now if near-singularities (i.e., redundant dependencies) are detected, Genesis will print a message reporting the grid/components to aid the user in fixing the model.

5. The EIGRL data entry has been modified to select the SMS eigenvalue method if the EIGRL is used for natural frequency analysis and an upper bound frequency (V2) is specified. Previously, the EIGRL entry always selected the Lanczos method.

    Bulk Data Statements - EIGRL.

6. The modal matrix solver for modal frequency response has been completely rewritten. The new solver is much more efficient for problems with viscous or structural damping.

4 Shape, Sizing, Topometry and Topography Optimization Enhancements

1. Power spectral density functions of displacement, velocity and acceleration are now available to be used as objectives or constraints. The new response types for DRESP1 are: PSDDISP, PSDVELO and PSDACCE.

   Bulk Data Statement - DRESP1.

2. Shifted responses allow easy creation of constraints which have bounds that are frequency dependent. Shifted respones are available for displacements, velocities, accelerations and corresponding user function responses. New response types for DRESP1 are: DDISPS, DVELOS, DACCES, MDISPS, MVELOS, MACCES, UFDISPS, UFVELOS, UFACCES. The new DSHIFT data entry defines the shift type and references a TABLEDi that provides the function of the loading frequency.

   Bulk Data Statements - DSHIFT, DRESP1.

3. The mesh smoothing has been improved to be more robust. Now the untangling phase will pass the best untangled mesh to to mesh optimization phase. The previous version simply passed the last untangled mesh, which may not have been the best.

4. The CQUAD8 and CTRIA6 elements are designable with shape, sizing, topometry and topography optimization, and have several response types that can used in an optimization problem. Available element responses include: stress, strain, force and composite failure index.

5. The DEQATN data entry has been enhanced to a) allow long variable names and b) allow arbitrary length equations. Variable names up to 31 characters are now allowed, whereas previous versions limited variables to 8 characters. Now there is no fixed limit to the length of an equation (as long as LENVEC is large enough). Previously, there was a 20,000 character limit on the total length of a DEQATN entry. In addition, the equation parsing module has been enhanced to provide more detailed feedback when errors are encountered while parsing equations. New detailed error messages will help users to quickly correct invalid equation data.

6. The DOT optimizer has been upgraded to version 6.0. For many problems, this new version reduces the number of design cycles required.

7. Support for loading multiple DRESP3 and DLIB shared objects has been added. This allows sites to easily build up a library of custom response calculations by putting each function in a separate shared object. Site users then need only select the custom functions needed for a given optimization job.

8. New fabrication constraints enforce designs that are uniform throughout a specified plane using symmetry type: UXY, UYZ and UZX. In addition, the new symmetry type UXYZ forces a completely uniform design.

   Bulk Data Statements - DTGRID, DSPLIT, DSHAPE.

9. The response regioning process for frequency response results has been enhanced. Previously, each loading frequency was always placed in a different response region, which could lead to many unnecessary constraints being retained, creating more work for the sensitivity and approximate optimization modules. Now, the user can optionally group different loading frequencies into the same region, which may reduce the total run time of the optimization.

    Bulk Data Statement - DOPT (FREQREG).

5 Topology Optimization Enhancements

1. New fabrication constraints enforce designs that are uniform throughout a specified plane using symmetry type: UXY, UYZ and UZX. In addition, the new symmetry type UXYZ forces a completely uniform design.

   Bulk Data Statements - TSYM1, TSYM2, TSYM3.

2. A new data entry, TSELECT, tells the optimizer to select the best set of toplogy extra variables to move to their upper bound while forcing the rest to their lower bound. This new capability allows easy formulation of optimization problems such as selecting the best among a set of candidates to keep in component designs.

   Bulk Data Statement - TSELECT.

3. UFDATA can now be used with topology optimization through new TRESP1 response types: UFDISP, UFVELO and UFACCE. In previous versions, UFDATA could only be used with parametric optimization

   Bulk Data Statement - TRESP1.

4. Power spectral density functions of displacement, velocity and acceleration are now available to be used as objectives or constraints. The new response types for DRESP1 are: PSDDISP, PSDVELO and PSDACCE.

   Bulk Data Statement - TRESP1.

5. Shifted responses allow easy creation of constraints which have bounds that are frequency dependent. Shifted respones are available for displacements, velocities, accelerations and corresponding user function responses. New response types for DRESP1 are: DDISPS, DVELOS, DAACES, MDISPS, MVELOS, MACCES, UFDISPS, UFVELOS, UFACCES. The new DSHIFT data entry defines the shift type and references a TABLEDi that provides the function of the loading frequency.

   Bulk Data Statements - DSHIFT, TRESP1.

6. The new CQUAD8 and CTRIA6 elements are designable with topology optimization.

6 Output Enhancements

1. The optimization post processing file (pnameOPOST??.xxx) has been enhanced. SIZING=POST will now include the total thickness of composites. Previously the total thinckeness of composite was only printed with the THICKNESS=POST command. Now SIZING =POST can do all that THICKESS=POST does. Default for SIZING=POST remains the same. In other words, by default, only design dimensions are printed.

2. Output requests for random results (i.e., using the RPUNCH or RPRINT keyword) no longer also always select the corresponding non-random frequency response result printing. Add the PRINT, PUNCH or PLOT keyword to the output request to also output the non-random results to the output or post-processing file.

   Solution Control Statements - DISP, VELO, ACCE, STRESS, STRAIN, FORCE.

7   New Input Data

7.1   Executive Control

HIS   Specifies the full path of the history file. This command is optional.

RST   Specifies the full path of the restart file. This command is optional.

7.2   Solution Control

NLPARM   Activate nonlinear static analysis

7.3   Bulk Data

CQUAD8   Connectivity information for the 8 node quadrilateral element.

CTRIA6   Connectivity information for the 6 node triangular element.

DSHIFT   Controls the type and shifting values for shifting responses. DSHIFT is referenced by DRESP1 and TRESP1. DSHIFT works with the new response types DDISPS, DVELOS, DACCES, MDDISP, MVELOS, MACCES, UFDISPS, UFVELOS and UFACCE.

NLPARM   Controls the number of iterations for the nonlinear static solution using CGAP elements.

TSELECT   Select fraction of listed topology extra variables to move to their upper bound. The rest of the listed variables in TSELECT will be moved to their lower bound.

7.4   New Analysis Parameters

MODERST   Control the reading/writting of eigenvectors. This allows reuse of eigenvectors to save computation time.

7.5   New Design Parameters

DSHIFT   Parameter to turn on and off values associated to DSHIFT.

FREQREG   Control the regioning of loading frequencies for frequency response results. A positive value defines the number of loading frequencies per region used in screening process. A negative value defines the total number of regions per DRESP1 or TRESP1 entry.

8   Enhanced Data

8.1   Executive Control

SOL
:   The default value for this command is no longer COMPAT0. The compatibility mode must be specified either with this command or with the -sol command line option.

DRESP3
:   Multiple user supplied dresp3 libraries are now allowed. DRESP3 defines the name of an external shared object (DLL) that will calculate external user-defined responses for the DRESP3 or TRESP3 bulk data entry.

DLIB
:   Multiple user supplied dlib libraries allowed. DLIB provides the name of an external shared object (DLL) that will calculate user-defined properties and stresses for the DVPROP3 bulk data entry.

8.2   Solution Control

SIZING
:   The total thickness of composite elements are now printed to the OPOST file.

8.3   Bulk Data

CGAP
:   Can now act as a nonlinear contact element.

DRESP1
:   Can now be used with the new DSHIFT entries.
    Can now be used with new shifted responses (DDISPS, DVELOS, DACCES, NDISPS, MVELOS, MACCES, UFDISPS, UFVELOS and UFACCES), and UFACCE) and new random respones (PSDDISP, PSDVELO and PSDACCE).

TRESP1
:   Can now be used with the new DSHIFT entries.
    Can now accept new shifted respones (DDISPS, DVELOS, DACCES, NDISPS, MVELOS, MACCES, UFDISPS, UFVELOS and UFACCES), new user function of nodal dynamic respones (UFDISP, UFVELO and UFACCE) and new random respones (PSDDISP, PSDVELO and PSDACCE).

DSHAPE
:   Now accept new fabrication constraints for sheet forming. The new fabrications constrains are UXY, UYZ, UZX and UXYZ. The first three new fabrication constraints can be combined with the existing mirror symetries.

DSPLIT
:   Now accept new fabrication constraints for sheet forming. The new fabrications constrains are UXY, UYZ, UZX and UXYZ. The first three new fabrication constraints can be combined with the existing mirror symetries.

DTGRID | Now accept new fabrication constraints for sheet forming. The new fabrications constrains are UXY, UYZ, UZX and UXYZ. The first three new fabrication constraints can be combined with the existing mirror symetries.

EIGRL | Now selects the SMS method if V2 is specified and the entry is referenced by a natural frequency loadcase.

PGAP | Can now select properties for a nonlinear contact element.

TSYM1 | Now accept new fabrication constraints for sheet forming. The new fabrications constrains are UXY, UYZ, UZX and UXYZ. The first three new fabrication constraints can be combined with the existing mirror symetries.

TSYM2 | Now accept new fabrication constraints for sheet forming. The new fabrications constrains are UXY, UYZ, UZX and UXYZ. The first three new fabrication constraints can be combined with the existing mirror symetries.

TSYM3 | Now accept new fabrication constraints for sheet forming. The new fabrications constrains are UXY, UYZ, UZX and UXYZ. The first three new fabrication constraints can be combined with the existing mirror symetries.

8.4 RTYPE Improvements

STRESS | Then stresses of new elements TRIA6-PSHELL and QUAD4-PSHELL can be selected in DRESP1-STRESS for parametric optimization.

STRAIN | Then strains of new elements TRIA6-PSHELL and QUAD4-PSHELL can be selected in DRESP1-STRESS for parametric optimization.

FINDEX | Then failure index of new elements TRIA6-PCOMP and QUAD4-PCOMP can be selected in DRESP1-STRESS for parametric optimization.

9   Changes in Version 12.0 with Respect to Version 11.0

Genesis version 12.0 no longer defines a default value for the SOL executive control command. To run input data for previous versions that does not have the SOL executive control command, specify the previous default compatibility mode using one of the following methods: add SOL COMPAT0 to the executive control; or use the `-sol=0` command line option.

Version 12.0 performs stricter checking of variable names in DEQATN data than previous versions. The only allowed characters in variable names are (case-insensitive) letters ('A'-'Z'), numbers ('0'-'9') and underscore ('_'). In addition, names must begin with a letter. Input data for previous versions with illegal variable names must be corrected before it will run successfully in version 12.0.

Except for the above, Genesis 12.0 should run any problem that was successfully running in version 11.0 with no changes.

On Unix/Linux systems, the installation script no longer sets a default value for LENVEC. When Genesis runs, a default value will be chosen such that Genesis uses approximately 50% of the physical memory on the machine. If this is not desired (e.g., on servers), the system administrator can manually edit the `vrand/bin/genesis-12.0` script to set a different default value. As always, any user can use the LENVEC executive control command or the `-lenvec` command line option to specify a desired value.