
# GENESIS

Structural Analysis and Optimization

## New Features and Enhancements

**Versions 14.0**

December 2014

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# 1 Introduction

This document describes the new and enhanced features added to *GENESIS* in version 14.0. Key enhancements include the following:

**Glue-like Connections:** BCONTACT entries now can be used in natural frequency and/or frequency response loadcases to connect surfaces. Unlike CGLUE connections, this new type of connection is applied in individual loadcases only. This allows surfaces to have nonlinear contact in static loadcases, while being linearly bonded in dynamic loadcases. By omitting a friction coefficient on the referenced BCPAIR, these connnections allow for optional tangential slip while still tying the surfaces together in the normal direction.

**CPYRA Element:** A new five-sided pyramid solid element connecting 5 or 13 grids can be used for any type of analysis. This 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. Stress and strain of pyramid elements can be used in optimization throught the DRESP1 entry.

**Radial Filling Fabrication Constraints for Topology:** New radial filling manufactring constraints can be used to enforce designs to have radial members: RGX, RGY, RGZ, RBX, RBY, RBZ, and RTX, RTY and RTZ.

**Spoke Fabrication Constraints for Topology:** New manufactring constraints can be used to enforce designs to have spoke-like members: KX, KY and KZ. These new types are cylindrical counterparts to the existing linear extrusions EX, EY and EZ.

**Reference Plane Filling Fabrication Constraints for Topology:** New manufacturing constraints can be used to force material to fill symmetrically up and down with respect to a specified parting plane: F0X, F0Y and F0Z.

**Maximum Member Size for Topology:** This is a new fabrication constraint available for any type of element designable with topology optimization. It is used in conjunction with a minimum gap size to force the optimizer to eliminate large chunky regions in the final design.

**Anisotropic Topology:** Now topology optimization can be performed on solid elements that reference anisotropic materials. Topology optimization can also now be performed on composite elements.

**Solver Enhacements:** Numerous enhancements in the analysis solver improve performance and robustness for many cases. Duplicate SPC sets are now detected, potentially reducing the number of factorizations performed. Surface pairing algorithms for BCPAIR and CGLUE have been refined, greatly improving cases with distorted meshes. Solver methods have been retuned for modern CPUs, leading to improved performance.

# 2 Analysis Enhancements

1. Linear surface-to-surface connections can now be included in natural frequency and/or frequency responses loadcases. Like nonlinear contact, this new capabilities uses BCONTACT, BCPAIR and BCPADD data entries. Unlike nonlinear contact, this new capabilitiy does not use NLPARM. Unlike CGLUE connections, this new type of connection is applied in individual loadcases only. This allows surfaces to have nonlinear contact in static loadcases, while being linearly bonded in dynamic loadcases.

   Solution Control Commands - BCONTACT

   Bulk Data Statements - BCPAIR, BCPADD

2. A new five-sided pyramid solid element connecting 5 or 13 grids can be used for any type 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.This element references PSOLID and works with MAT1, MAT9 and/or MAT11 material properties.

   Solution Control Commands - STRESS, STRAIN, GSTRESS

   Bulk Data Statement - CPYRA

3. A new bulk data entry allows the definition of orthotropic material properties for solid elements. MAT11 can be referenced by PSOLID. The MAT11 data will be converted into equivalent MAT9 data. The sorted echo will show the generated MAT9.

   Bulk Data Statement - MAT11

# 3 Shape, Sizing, Topometry, Topography and Freeform Optimization Enhancements

1. Shape, freeform and topography optimization can now be used to design the new pyramid solid element.

   Bulk Data Statement - DOMAIN, DSHAPE and DTGRID

2. Stress, strain and grid stresses components from the new pyramid solid element may now be selected as responses for use in constraints or objectives. These are specified using response types STRESS, STRAIN, GSTRESS, DSTRESS, DSTRAIN or DGSTRESS on DRESP1.

   Bulk Data Statement - DRESP1

3. The approximate problem has beem improved to perform certain computations in parallel. In some cases, performance has been measured to be up to six times faster when using 8 cores.

   Bulk Data Statement - DOPT parameter LINAPR

# 4 Topology Optimization Enhancements

1. Topology optimization now supports of orthotropic and anisotropic solid elements. Solid elements that reference MAT9 and new MAT11 material can now be designed in topology optimization.

   Bulk Data Statement - TPROP

2. Topology optimization now supports composite elements. Triangular and quadrilateral elements that reference PCOMP/PCOMPG properties can now be designed in topology optimization.

   Bulk Data Statement - TPROP

3. New radial filling manufactring constraints can be used to force material to fill in a radial direction. These new types are cylindrical counterparts to the existing filling types FGx, FBx and FTx.

   Bulk Data Statement - TSYM1, TSYM2 and TSYM3

   Types - RGX, RGY, RGZ, RBX, RBY, RBZ, RTX, RTY and RTZ

4. New manufactring constraints can be used to enforce designs to have spoke-like members. These new types are cylindrical counterparts to the existing linear extrusions EX, EY and EZ.

   Bulk Data Statement - TSYM1, TSYM2 and TSYM3

   Types - KX, KY and KZ

5. New manufacturing constraints can be used to force material to fill symmetrically up and down with respect to a specified parting plane.

   Bulk Data Statement - TSYM1, TSYM2 and TSYM3

   Types - F0X, F0Y and F0Z

6. Maximum member size a new fabrication constraint available for any type of element designable with topology optimization. It is used in conjunction with a minimum gap size to force the optimizer to eliminate large chunky regions in the final design.

   Bulk Data Statement - TSYM1, TSYM2 and TSYM3

   Types - SVM3 and SVM4

# 5 Output Enhancements

1. The stress, strain and grid stress associated to new pyramid solid elements are now available for post-processing.

   Solution Control Command - STRESS, STRAIN, GSTRESS

2. The stress, strain and grid stress associated to new pyramid solid elements are now available for post-processing.

   Executive Control Command - POST

   Solution Control Command - STRESS, STRAIN, GSTRESS

# 6 New Input Data

## 6.1 Bulk Data

| | |
|---|---|
| CPYRA | Connectivity information for the 5 and 13 node pyramidal element. |
| MAT11 | Material information for the orthotropic properties of solid elements. |

## 6.2 New DOPT Parameter

| | |
|---|---|
| DESMIN | Minimum number of design cycles. A value n, greater than zero, will force the program to perfom at least n design cycles before stopping. |
| LINAPR | Approximation Optimization Method Control<br>LINAPR = 0 will cause the program to use the “fast” linear approximations method when all approximations are linear. If one or more approximation are nonlinear, then the program will use its standard hybrid approximations.<br>LINAPR = 1 will force the program to use the “fast” linear approximations method for all responses. This will result in faster times in each design cycle, but it might lower the quality of approximations which in some cases might cause the program to need more design cycles to converge.<br>LINAPR = -1 will cause to use its standard linear and hybrid approximations. |

# 7 Enhanced Input Data

## 7.1 Executive Control

| | |
|---|---|
| RESTART | New alternative format, RESTART = LAST, k allows restart from the last design cycle available in the HIS file, specifying the maximum number of additional design cycles to allow. |

## 7.2 Solution Control

| | |
|---|---|
| BCONTACT | Can now be used in natural frequency and frequency response loadcases. This will trigger a linear (glue-like) conection that bonds together surfaces only for the selected loadcase. |
| LOAD | Can now reference RFORCE bulk data. |
| STRESS | Now can print to the output file and to the post-processing files the stresses of the new CPYRA elements. |
| STRAIN | Now can print to the output file and to the post-processing files the strains of the new CPYRA elements. |
| GTRESS | Now can print to the output file and to the post-processing files the grid stresses of the new CPYRA elements. |

## 7.3 Bulk Data

| | |
|---|---|
| CGLUE | Field 8 now specifies the shear behavior of the connection. If field 8 is SLIP, then connection will allow relative displacement in the tangential direction, and only bond in the normal direction. The default, STICK, bonds in all directions. |
| DSCREEN | Can control the number of retained response associate to composite thickness responses LTHICK and CTHICK. |
| LOAD | Can now reference RFORCE bulk data |
| PSOLID | Can reference MAT11 |
| TPROP | Can reference PSOLID that reference MAT9 - Enables topology optimization of solids with anistropic material.<br>Can reference PSOLID that reference MAT11- Enables topology optimization of solids with orthotropic material.<br>Can reference PCOMP- Enables topology optimization of composites |

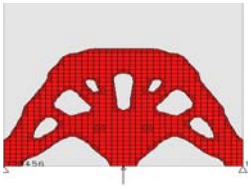
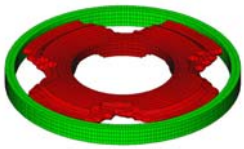
| | |
|---|---|
| TSYM1 | Now accept new fabrication constraints:<br>Radial filling from general plane: RGX, RGY and RGZ<br>Radial filling from bottom: RBX, RBY and RBZ<br>Radial filling from top:RTX, RTY and RTZ<br>Spoke filling: KX, KY, and KZ<br>Symmetric fillings from parting plane: F0X, F0Y and F0Z<br>Maximum member size: SYMV3<br>Minimum gap between members: SYMV4 |
| TSYM2 | Now accept new fabrication constraints:<br>Radial filling from general plane: RGX, RGY and RGZ<br>Radial filling from bottom: RBX, RBY and RBZ<br>Radial filling from top:RTX, RTY and RTZ<br>Spoke filling: KX, KY, and KZ<br>Symmetric fillings from parting plane: F0X, F0Y and F0Z<br>Maximum member size: SYMV3<br>Minimum gap between members: SYMV4 |
| TSYM3 | Now accept new fabrication constraints:<br>Radial filling from general plane: RGX, RGY and RGZ<br>Radial filling from bottom: RBX, RBY and RBZ<br>Radial filling from top:RTX, RTY and RTZ<br>Spoke filling: KX, KY, and KZ<br>Symmetric fillings from parting plane: F0X, F0Y and F0Z<br>Maximum member size: SYMV3<br>Minimum gap between members: SYMV4 |

## 7.4 DRESP1- RTYPE Enhancements

| | |
|---|---|
| STRESS | The stresses of the new elements CPYRA-PSOLID can be selected in DRESP1-STRESS. |
| STRAIN | The strain of the new elements CPYRA-PSOLID can be selected in DRESP1-STRAIN. |
| GSTRESS | The grid stresses of the new elements CPYRA-PSOLID can be selected in DRESP1-STRAIN. |

# 8 New Example Problems

The following table describes new examples and their corresponding input file names. The listed files are provided with the installation

| Name | Problem | Special Features | Figure |
|---|---|---|---|
| T028.dat | Topology Optimization with Maximum Member Size Constraints | Maximum member Size and minimum member gap constraints |  |
| T029.dat | Topology Optimization with Radial Fillings from the General Plane Fabriccations Constraints | Use RGZ |  |
| T030.dat | Topology Optimization with Radial Fillings from the bottom Plane Fabrications Constraints | Uses RBZ |  |

The first example is also provided with the step-by-step sample manual of Design Studio.

# 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. |
| 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 |

# 10 Changes in Version 14.0 with Respect to Version 13.1

*GENESIS* 14.0 should run any problem that was successfully running in version 13.1 with no changes, except for the following:

DRESP1 response type FORCE responses for CQUAD4, CQUAD8, CTRIA3 and CTRIA6 elements that reference PCOMP/PCOMPG are now computed in the material coordinate system. Previously, these were computed in the element coordinate system.

Due to changes allowing LOAD to reference RFORCE, RFORCE must now have a unique identification number with respect to all static loading (FORCEi, MOMENTi, PLOADi).