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GENESIS Structural Optimization Software: Current and Upcoming New Features

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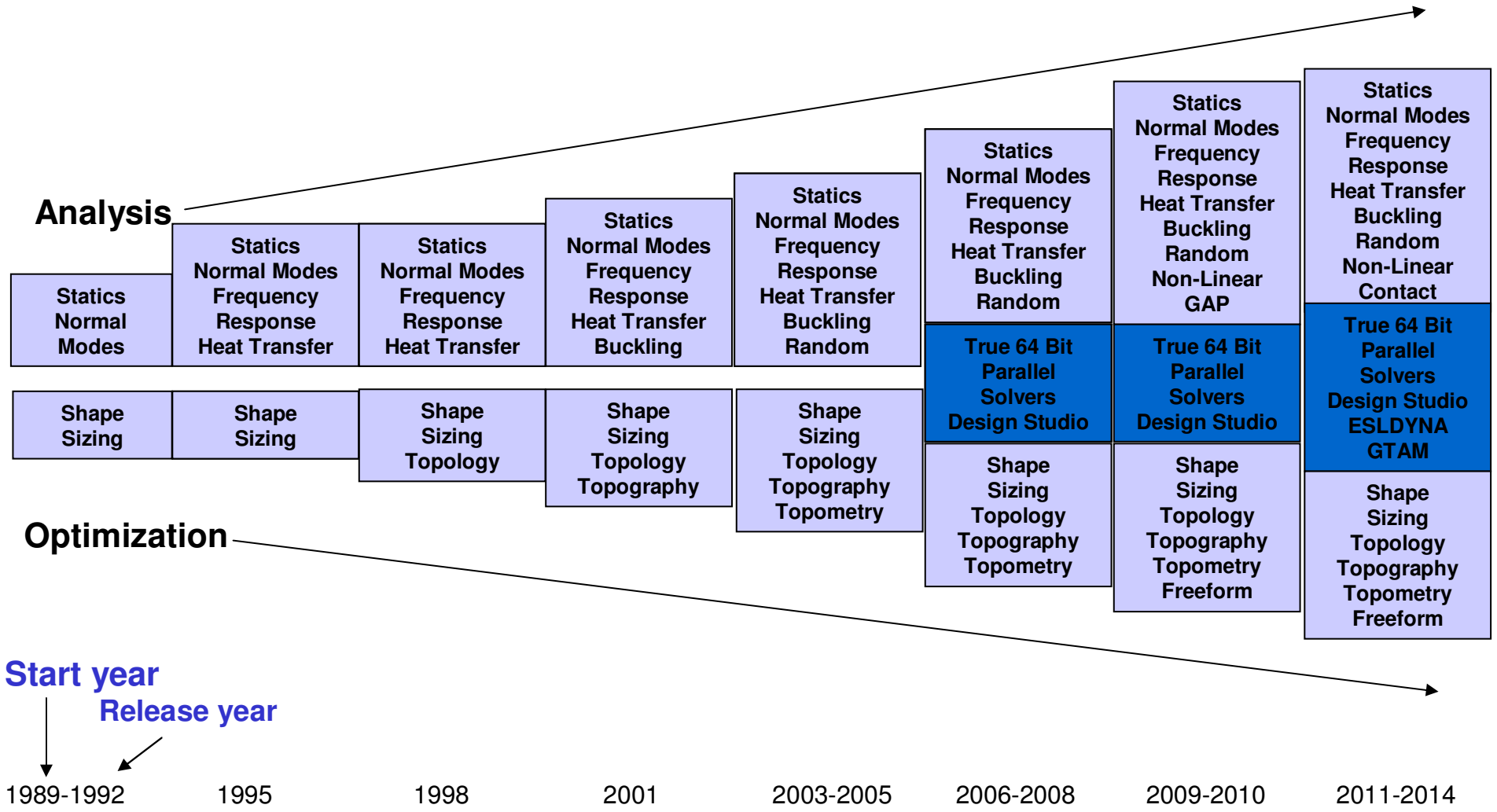
Outline

- **GENESIS Evolution**
- **Enhancements in GENESIS 13 and 13.1**
  - Finite Element Enhancements
  - Optimization Enhancements
- **Upcoming Features in GENESIS 14**
  - Finite Element Enhancements
  - Optimization Enhancements
- **Concluding Remarks**

GENESIS Evolution



Finite Element Enhancements in 13.0 and 13.1

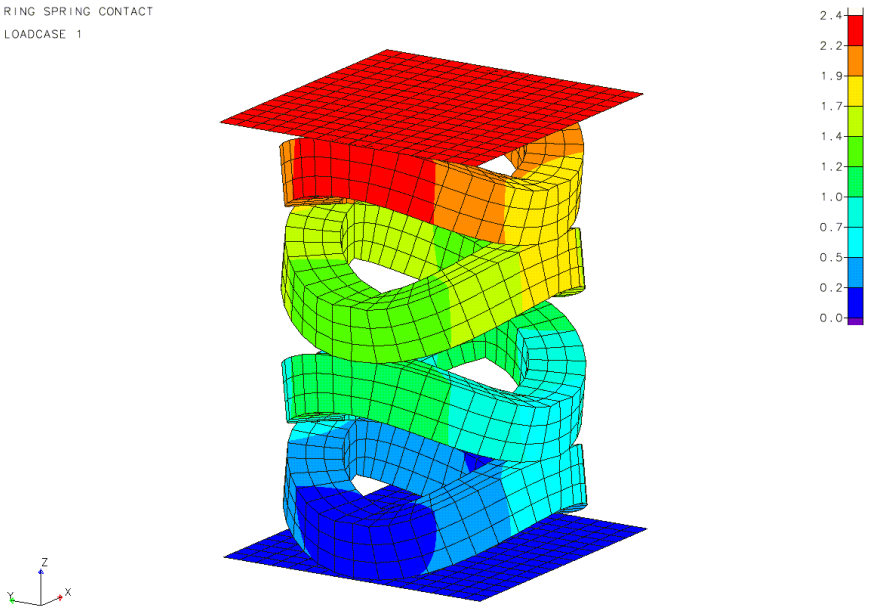
Finite Elements Improvements

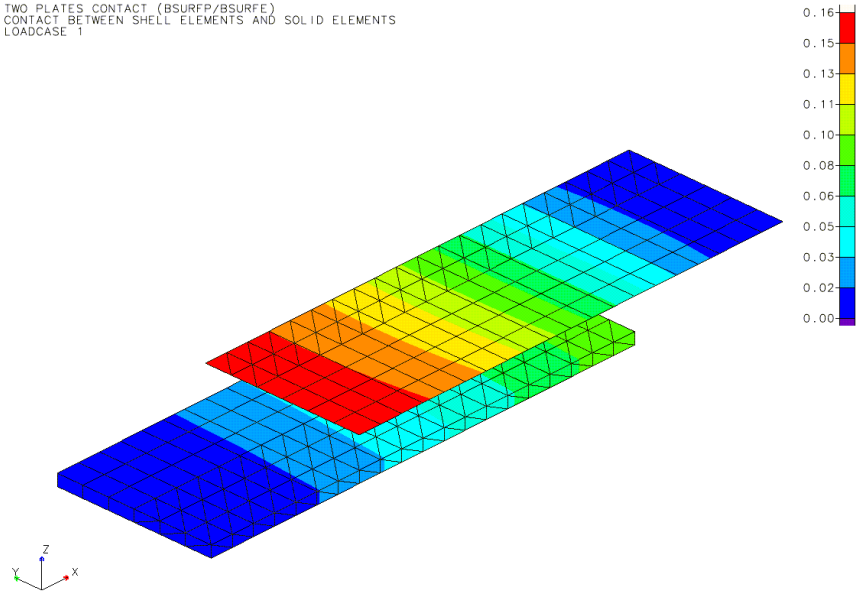
- **Non-Linear Contact Analysis**
  - Automatically generates potential contact points from surface definitions
  - Works with static load cases
  - Different static load case can have different contact conditions in the same run
  - Much easier than using CGAP elements
  - Accurate contact pressure results

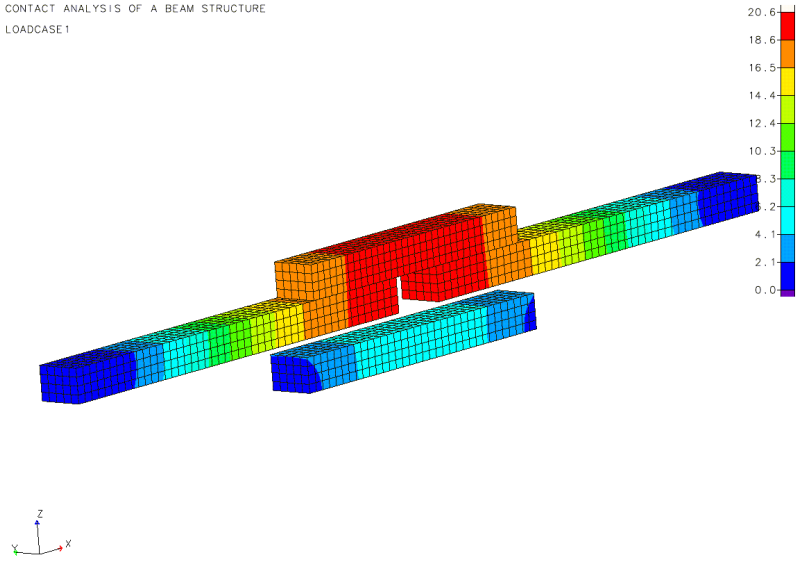
Contact Analysis

- **Surface to surface contact**
  - Solid surface to solid surface
  - Solid surface to shell surface
  - Shell surface to shell surface
- **Contact surface definition by**
  - Material ID's (BSURFM)
  - Element properties (BSURFP)
  - Element ID's (BSURFE)
- **Post-processing output**
  - Contact pressure
  - Contact force
  - Contact clearance

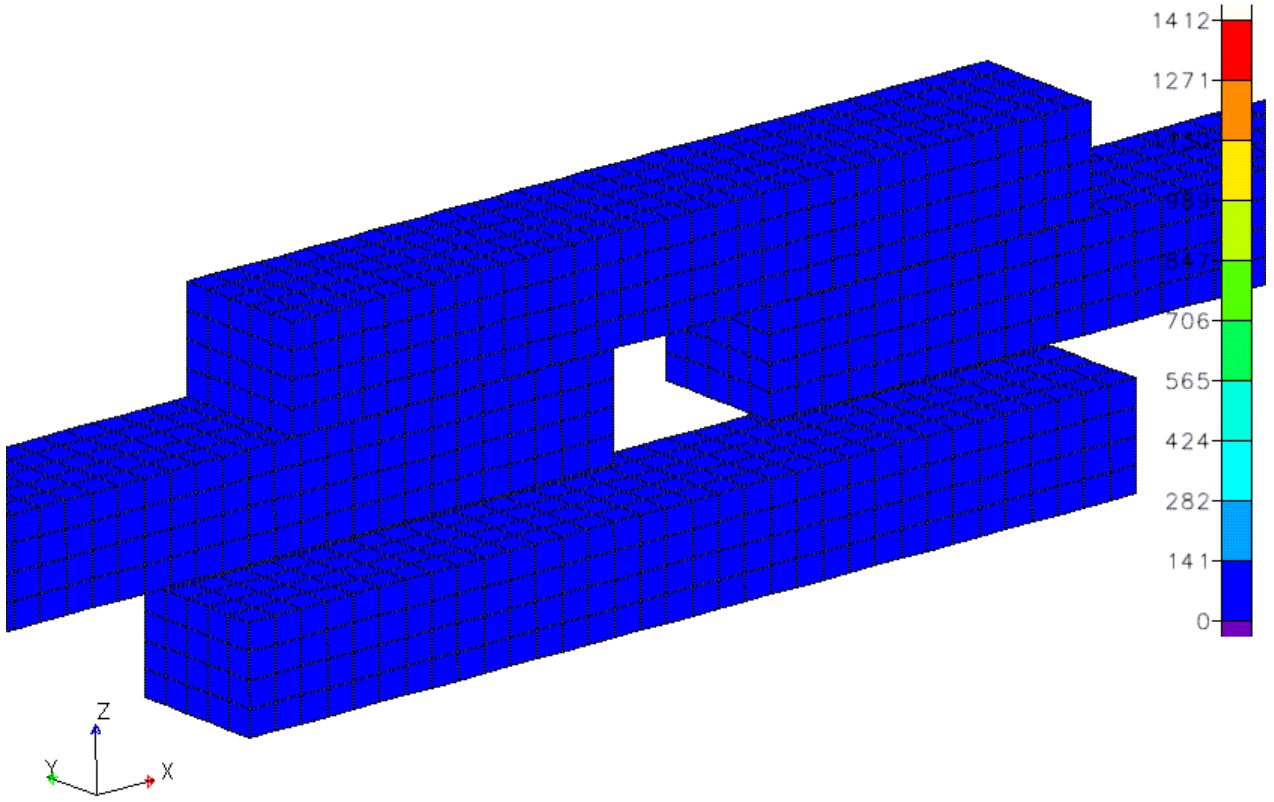
Contact Analysis Examples







Contact Analysis Examples



Equivalent Radiated Power

- **ERP Assumption:**

  The pressure at the structure-fluid interface is proportional to the normal velocity times the fluid density times the speed of sound in the fluid.

$$ERP = \frac{1}{2}\rho c \iint_A v_n^* v_n dA$$

where:

r is the fluid density

c is the speed of sound in the fluid

v_n is the component of the velocity normal to the structural panel

v_n * is the complex conjugate velocity

A is the panel area

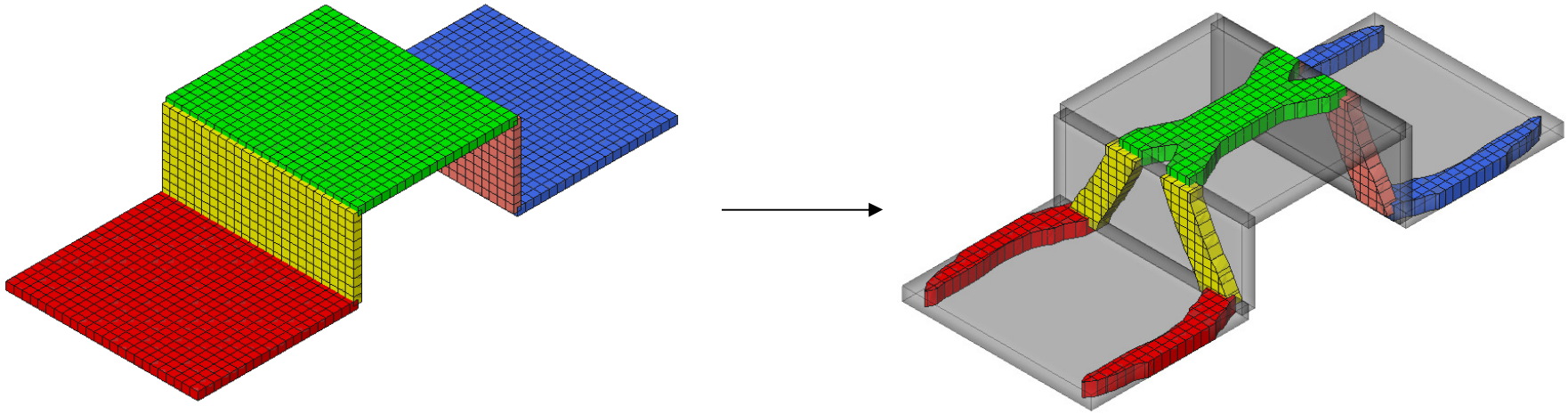
•Note that ERP is an implicit function of the loading frequency, W

Optimization Enhancements in 13.0 and 13.1

Optimization Enhancements

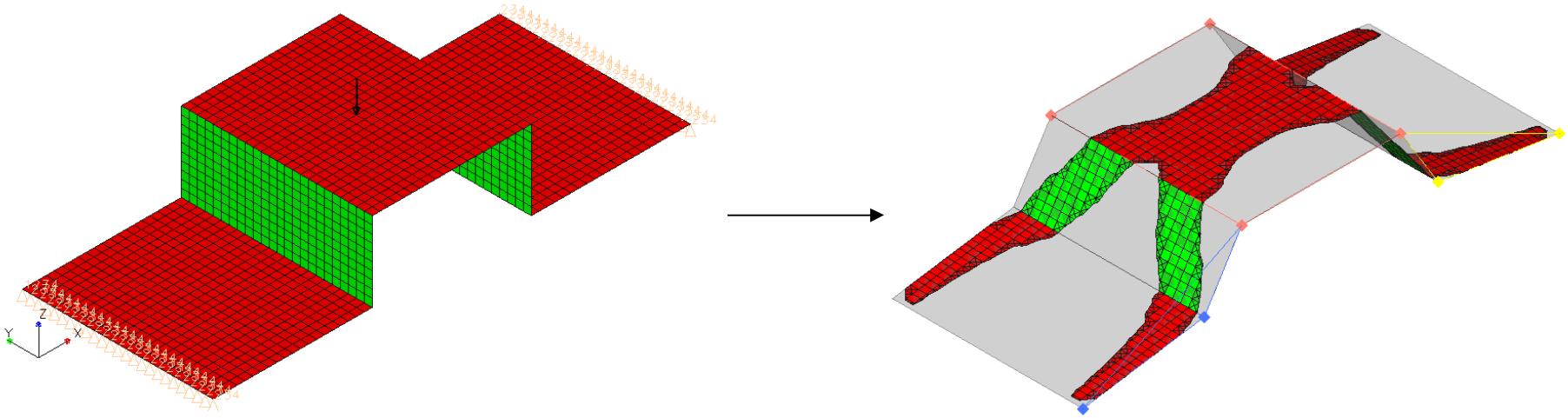
- **Topology Optimization is now Integrated with Parametric Optimization**
  - Topology can be mixed with Sizing, Shape, Topometry, Topography and/or Freeform
  - DRESP1 and other Parametric entries can be used simultaneously with TRESP1 and other Topology entries

Mixed Topology and Sizing



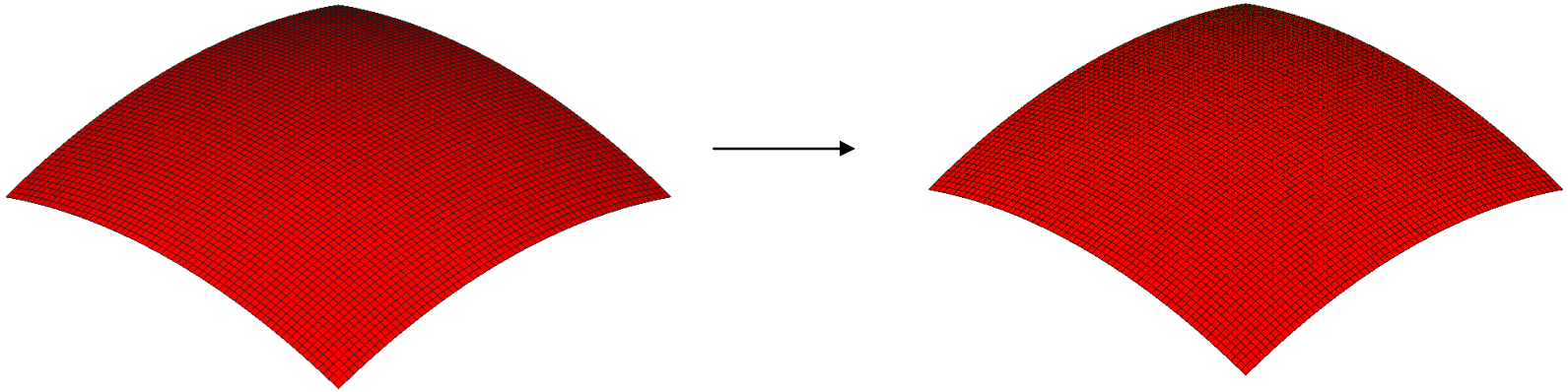
Topology & Sizing Optimization

Mixed Topology and Shape



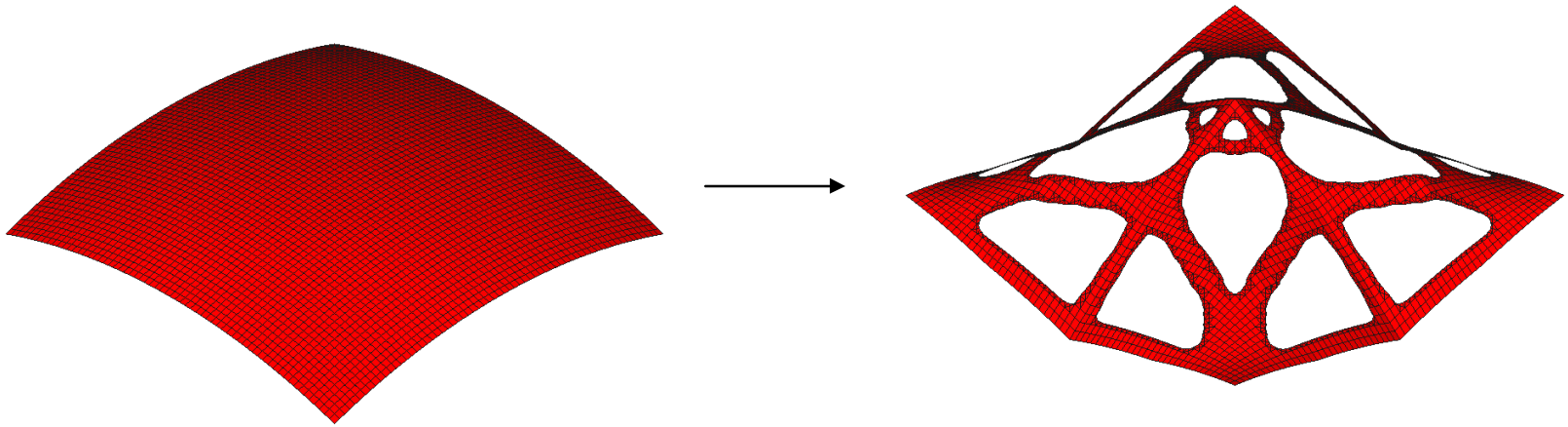
Topology & Shape Optimization

Mixed Topology and Shape



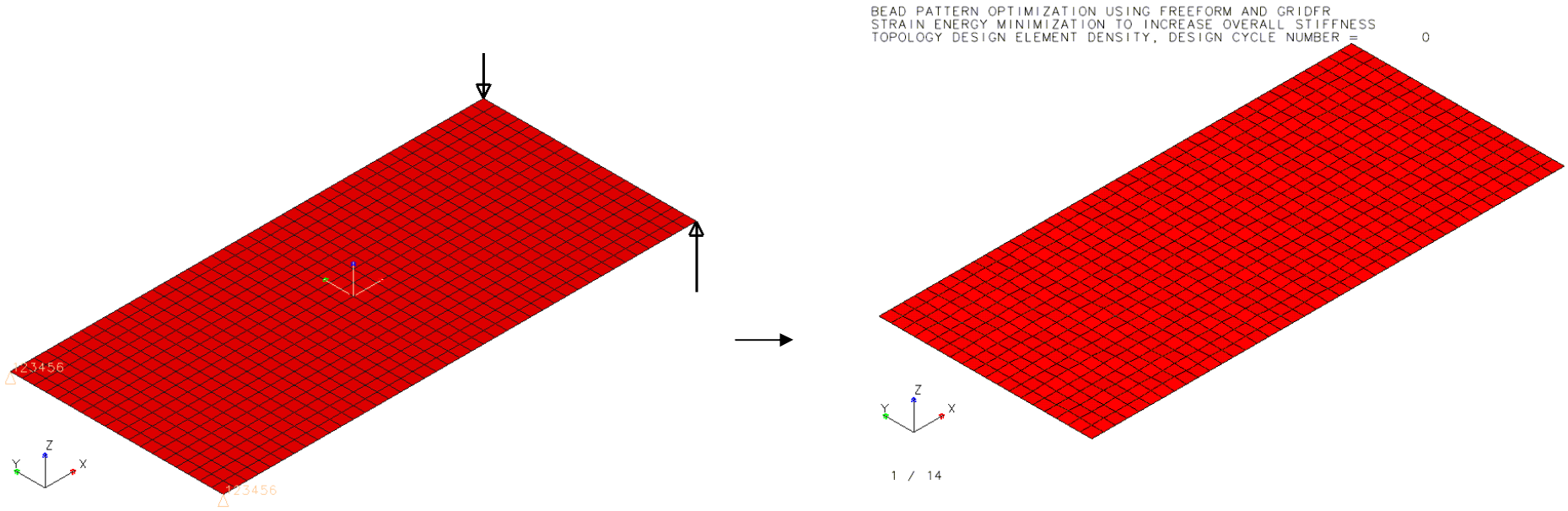
Topology & Shape Optimization

Mixed Topology and Shape



Topology & Shape Optimization

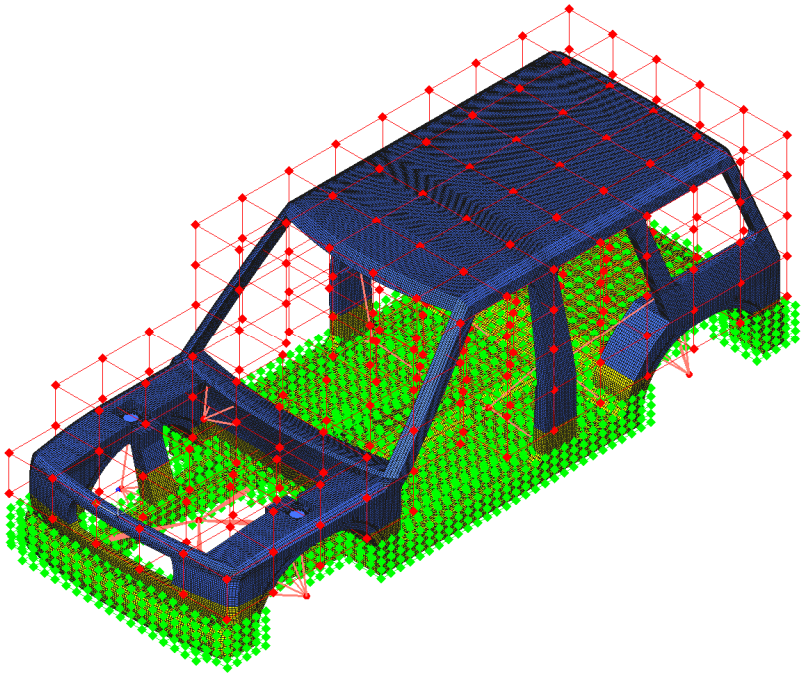
Mixed Topology and Freeform

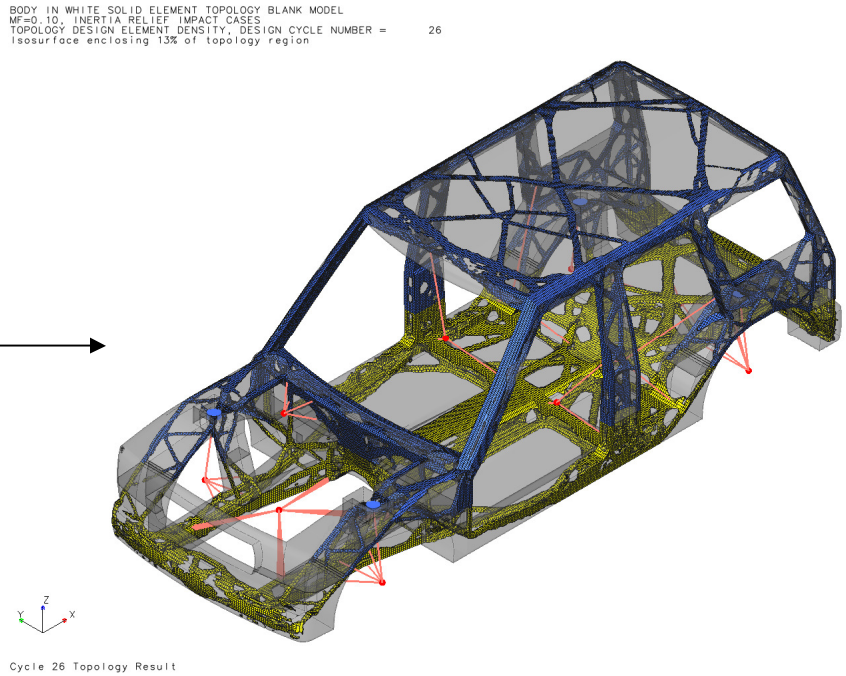


Topology & Freeform Optimization

Mixed Topology and Freeform

- Minimize SE with mass fraction of 0.1
- 10 static loadcases
- 737,836 Topology design variables
- 1,477 shape design variables
- Mass constraint <= Initial mass*.01

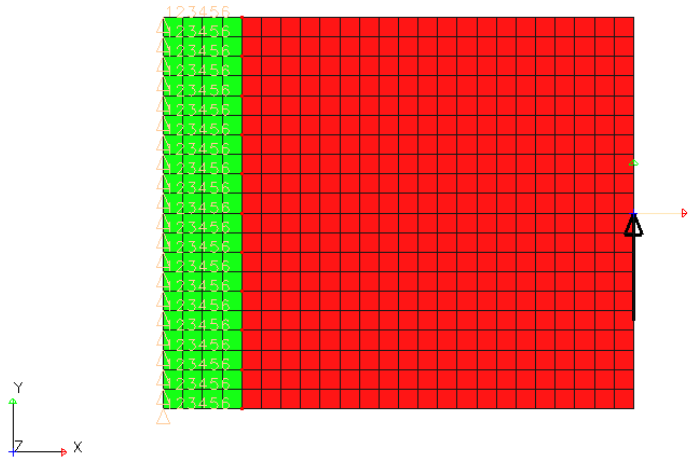


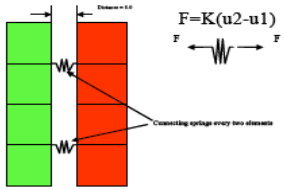


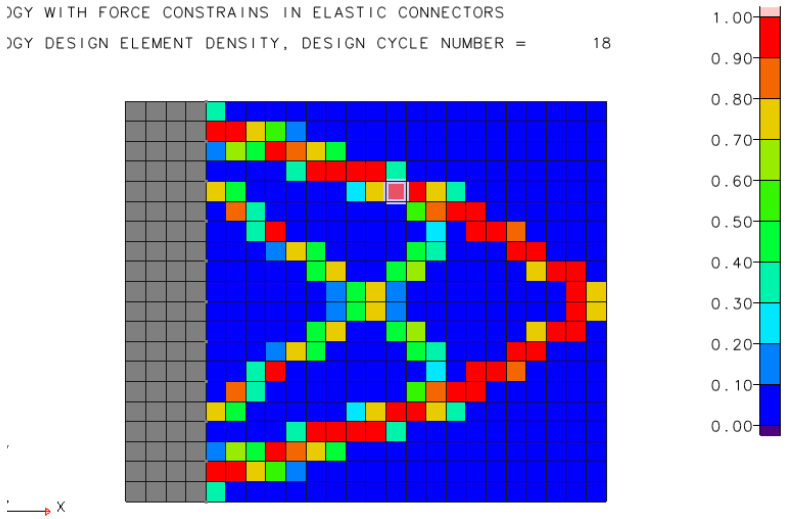
Topology & Freeform Optimization

Topology with DRESP1

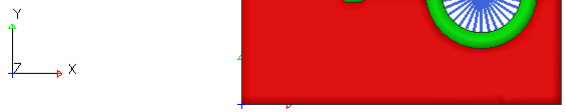
Topology with Forces Constraints in CELAS Connectors





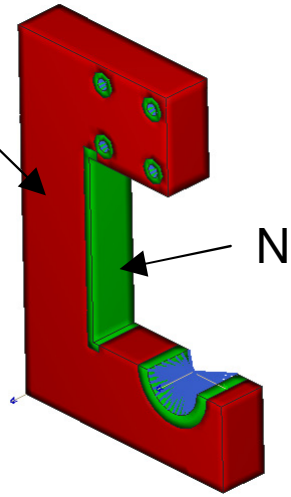


Topology with Stress Constraints

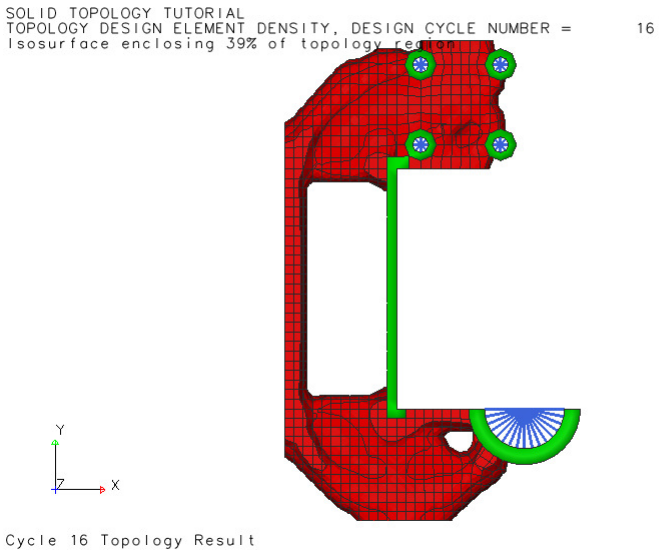


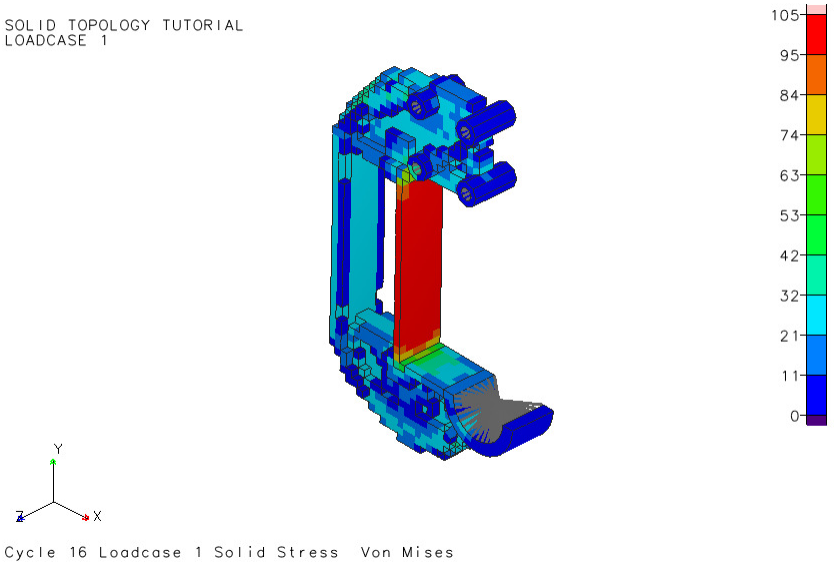
Designable

Nondesignable



Topology with Stress Constraints





Reference Answer

Without stress constraints

Max Stress = 105 MPa

Finite Element Enhancements in 14.0

Finite Element Improvements

- **Glue-Like Connections**
  - Automatically generates glue connection from surface definitions
  - Works with Natural frequency loadcases and Frequency responses
  - Different loadcases can have different glue-like conditions in the same run

Finite Element Improvements

- **Non-Linear Contact Improvements**
  - Internal algorithm that calculates contact areas has been refined. This help to produce better answers on problems with bad meshes
  - Convergence history now is output so that users can see the progress in solving the non-linear problem

Finite Element Improvements

- **Status and Progress on Contact and Glue Connections**

	V12.0	V12.2	V13.0	V14.0
Non-Linear Gap	yes	yes	yes	yes
Glue Connections	no	yes	yes	yes
Non-Linear Contact	no	no	yes	yes
Axisymmetric Glue-Connections	no	no	yes	yes
Glue-Like Connections	no	no	no	yes

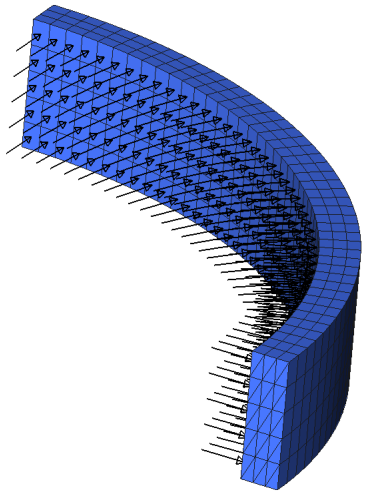
Finite Element Improvements

- **New 5-Node and 13-Node Pyramidal Elements**

CPYRA → PSOLID

Analysis Updates

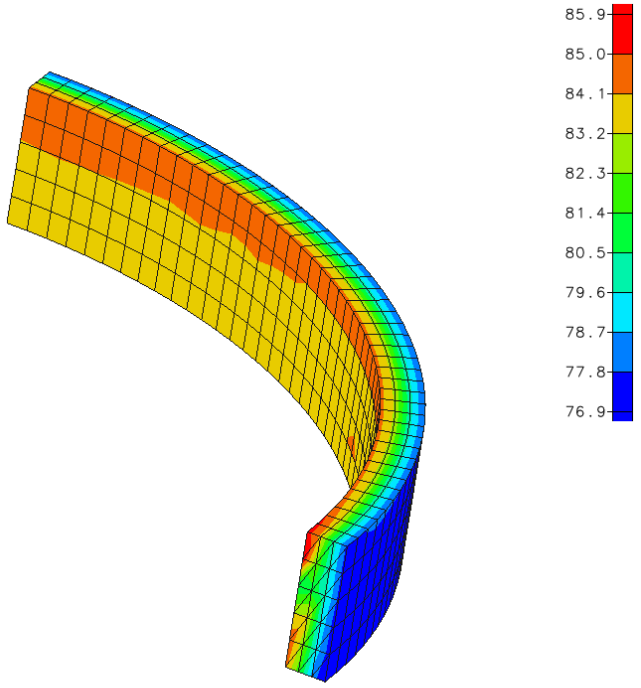
- Element stiffness matrices
- Lumped and Consistent mass matrices
- Conductivity matrices
- Geometric stiffness
- Damping matrices



New Finite Element Results

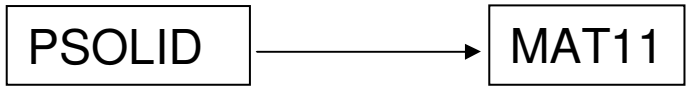
- **Statics, Freq. Resp. and Random Stress/Strain Recovery for the new 5-node and 13-Node CPYRA element**
- **Static and Freq. Resp. GSTRESS for the new 5-node and 13-Node CPYRA element**

STRESS=ALL
STRAIN=ALL
GSTRESS=ALL



Finite Element Improvements

- **New orthotropic Material: MAT11**

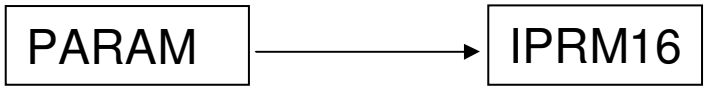


Analysis Updates

- Any solid element can now use orthotropic material

Finite Element Improvements

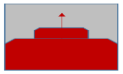
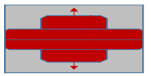
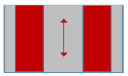
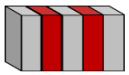
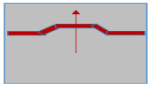
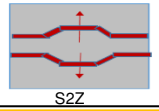
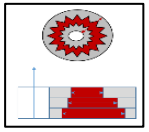
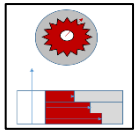
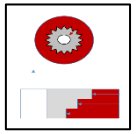
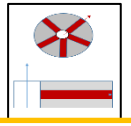
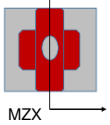
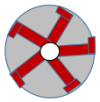
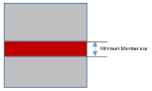
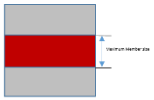
- **Output Element Stiffness Matrix and Mass Matrix to DMIG format**



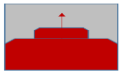
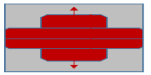
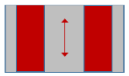
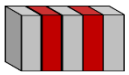
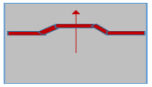
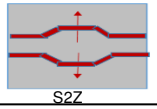
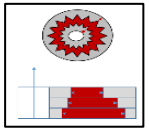
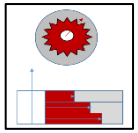
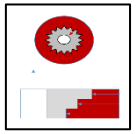
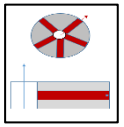
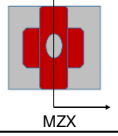
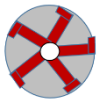
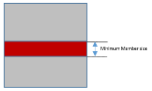
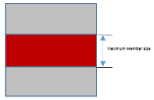
IPRM16=10 → output K matrices
IPRM16=20 → output M matrices
IPRM16=30 → output K and M matrices

Optimization Enhancements in 14.0

Families of Manufacturing Constraints

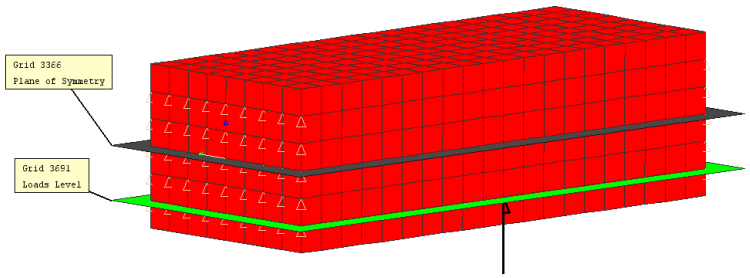
Castings	 FGZ	 FBZ	 FTZ	 FSZ	 F0Z New
Extrusion and Uniforms	 EZ	 UZX	 UXYZ		
Stamping	 S1Z	 S2Z			
Radial Filling	 RGZ	 RBZ	 RTZ New		
Radial Spokes	 KZ New				
Mirror & Cyclic Symmetry	 MZX	 CX			
Minimum& Maximum Member Size		 New			

Family of Manufacturing Constraints

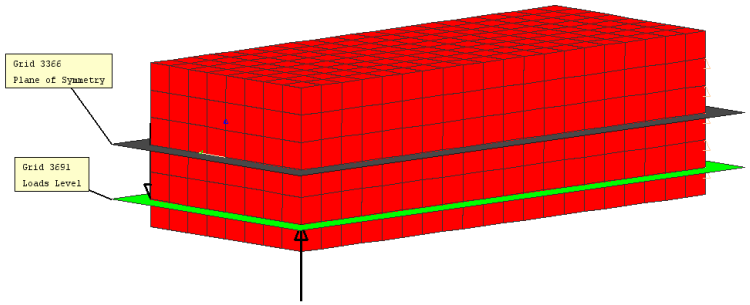
Castings	 FGZ	 FBZ	 FTZ	 FSZ	 F0Z
Extrusion and Uniforms	 EZ	 UZX	 UXYZ		
Stamping	 S1Z	 S2Z			
Radial Filling	 RGZ	 RBZ	 RTZ		
Radial Spokes	 KZ				
Mirror and Cyclic Symmetry	 MZX	 CX			
Minimum & Maximum Member Size					

Design of Structure Subject to 3 Torsion Loadcases

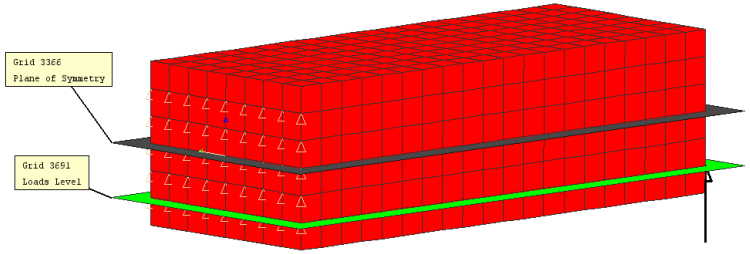
Example: new F0Z



Loadcase 1: Torsion Center



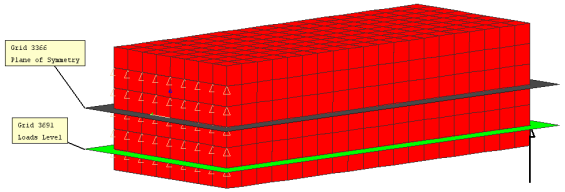
Loadcase 2: Torsion End A

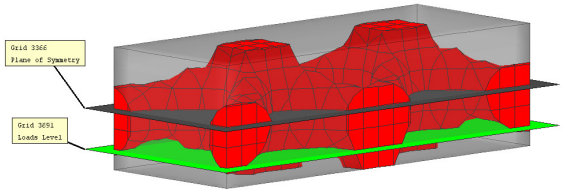


Loadcase 3: Torsion End B

Design of Structure Subject to 3 Torsion Loadcases

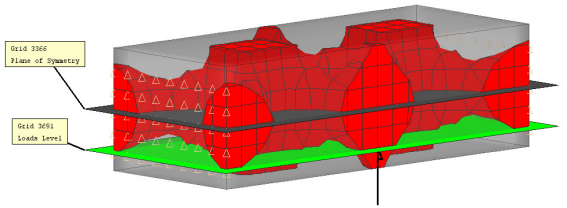
Example: new F0Z





Optimum using Existing FGZ

Answer is not Symmetric
w/r to Parting Plane

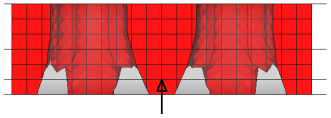
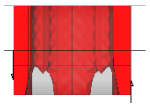
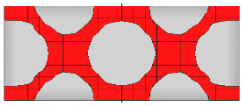
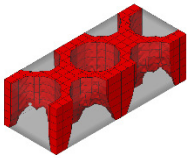
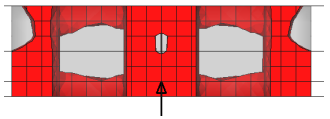
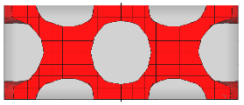
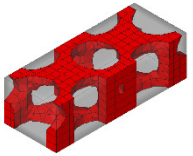
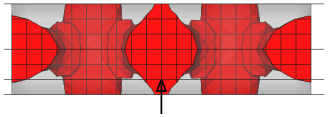
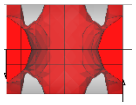
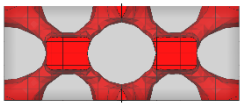
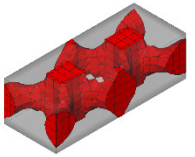
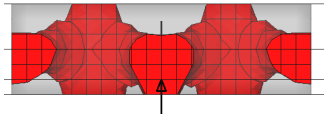
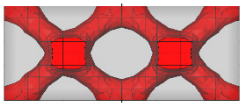
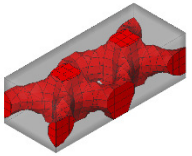
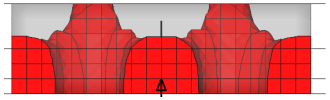
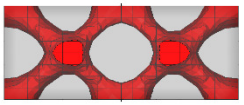
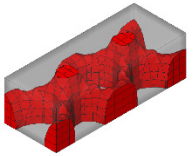


Optimum using New F0Z

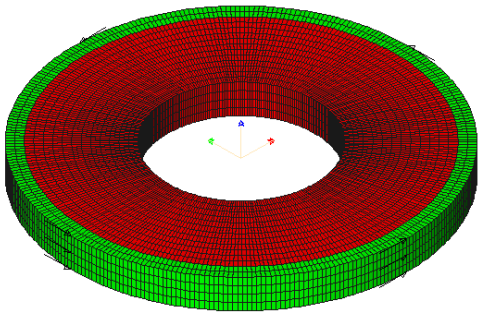
Answer is Symmetric
w/r to Parting Plane

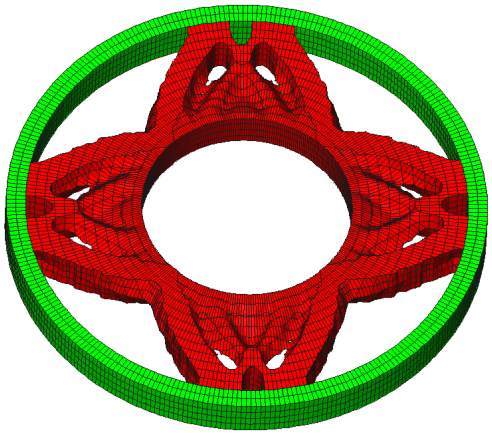
Design of Structure Subject to 3 Torsion Loadcases

Four Views of Five Alternative Designs using Different Filling Fabrication Constraints

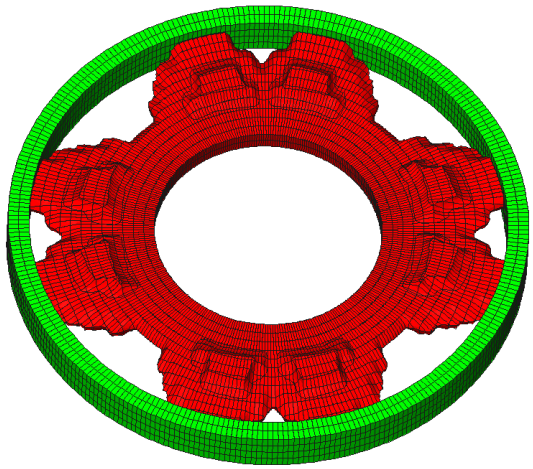
Type	Filling Direction	Side View	Front View	Top View	ISO View
FTZ					
FSZ					
F0Z					
FGZ					
FBZ					

New Manufacturing Constraints: RGZ



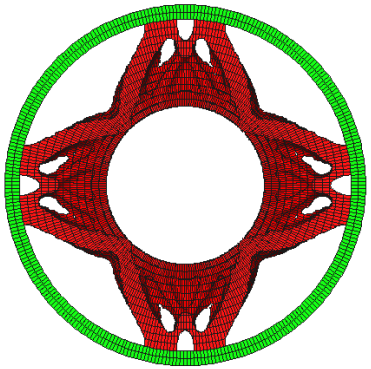


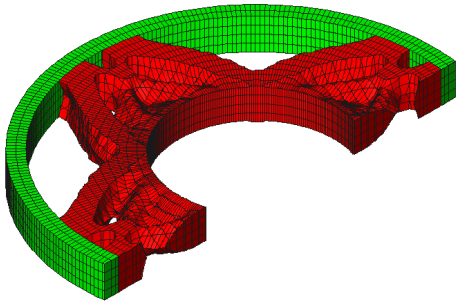
Free Topology: Reference Answer

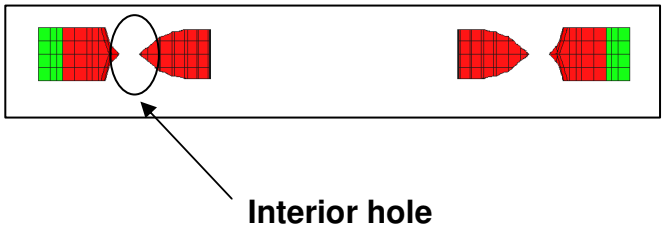


Topology with Radial Filling: RGZ

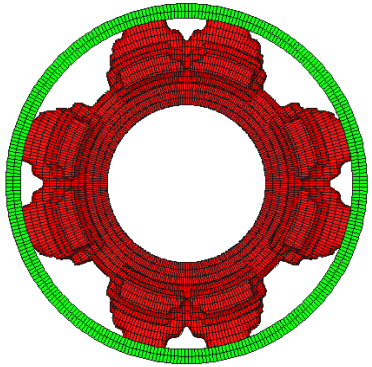
New Manufacturing Constraints: RGZ

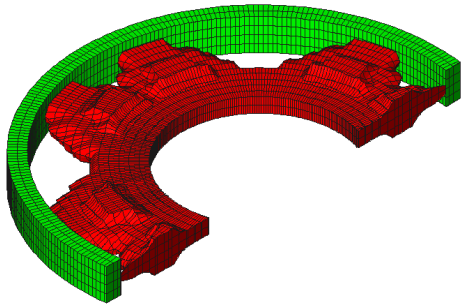






Free Topology: Reference Answer

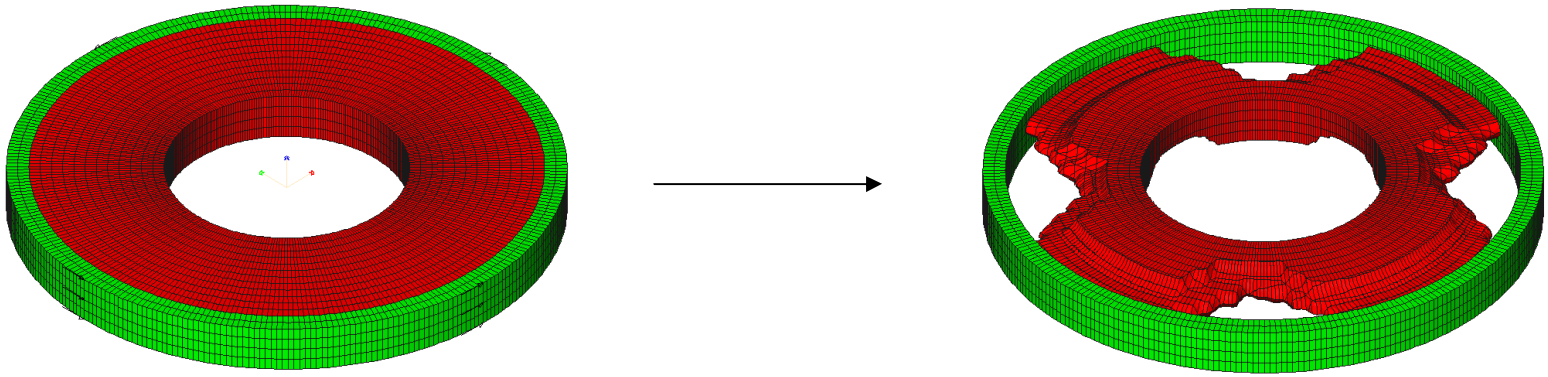




Topology with Radial Filling: RGZ

New Manufacturing Constraints: RBZ

Topology with Radial Filling from Bottom: RBZ

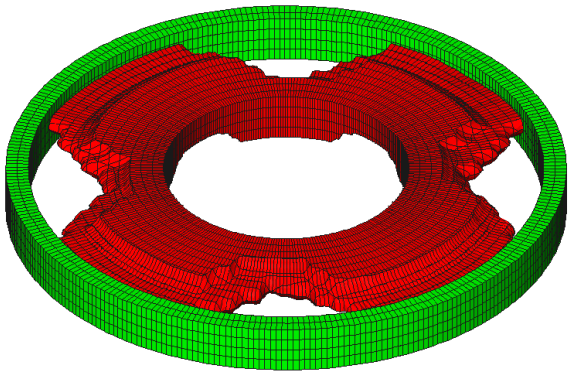


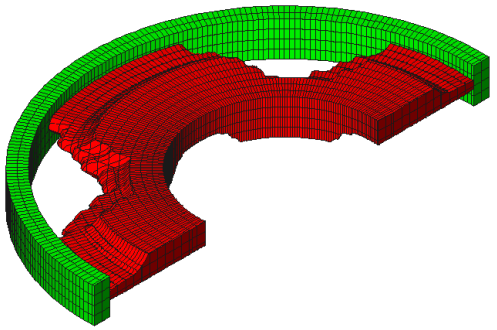
Initial Design

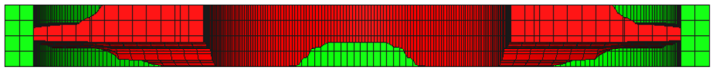
Topology with Radial Filling from Bottom: RBZ

New Manufacturing Constraints: RBZ

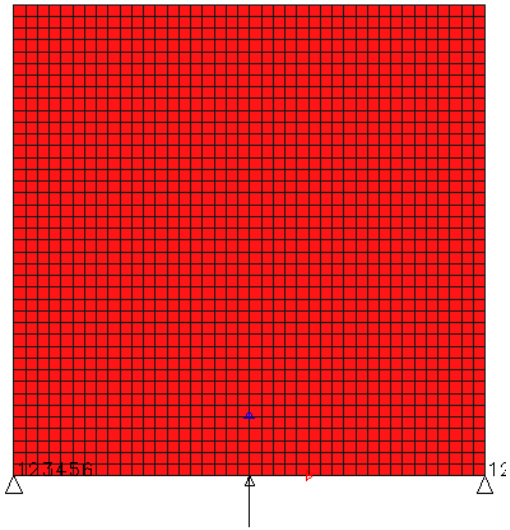
Topology with Radial Filling from Bottom: RBZ





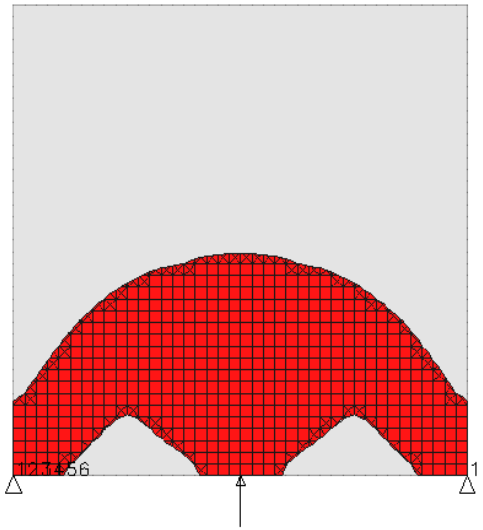


Shell Structure with Maximum Member Size



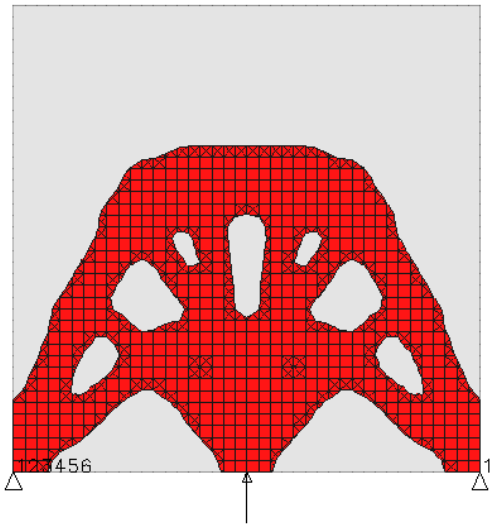
Initial Design

Topology Optimization



W/O Maximum Member Size Control

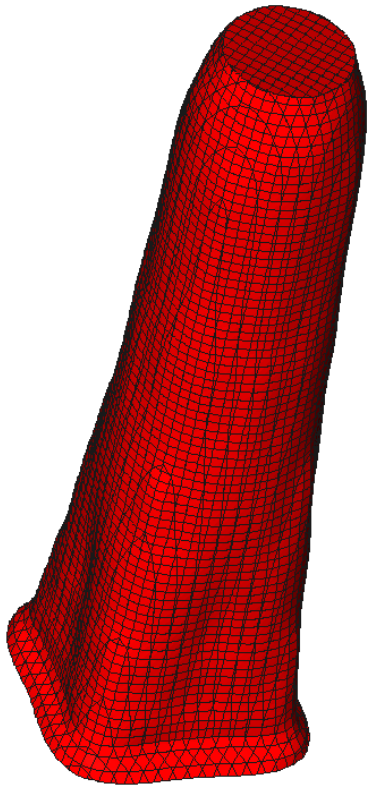
Topology Optimization



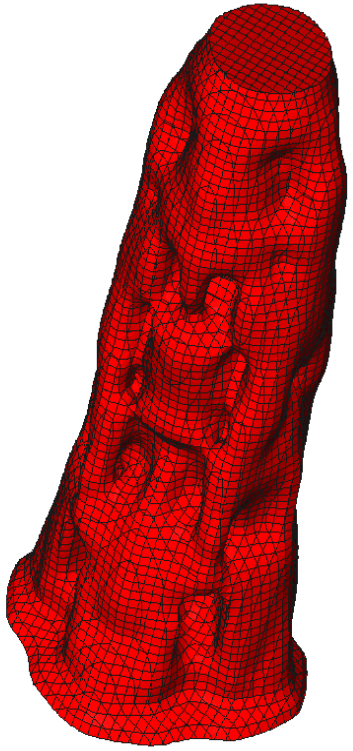
With Maximum Member Size Control

Solid Structure with Maximum Member Size

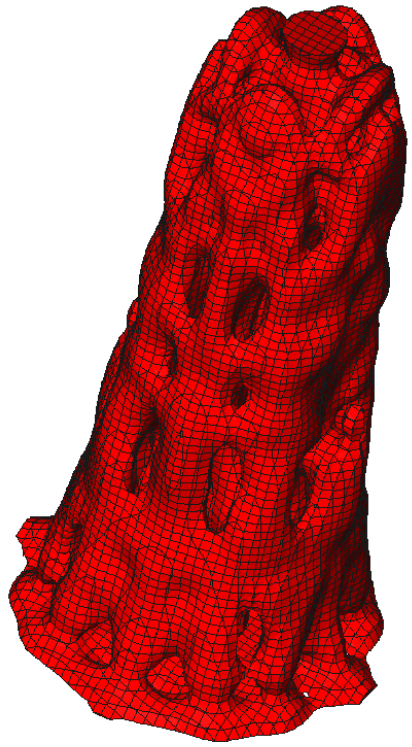
Three Alternative Topology Designs



Free Topology
W/O Max. Size Control

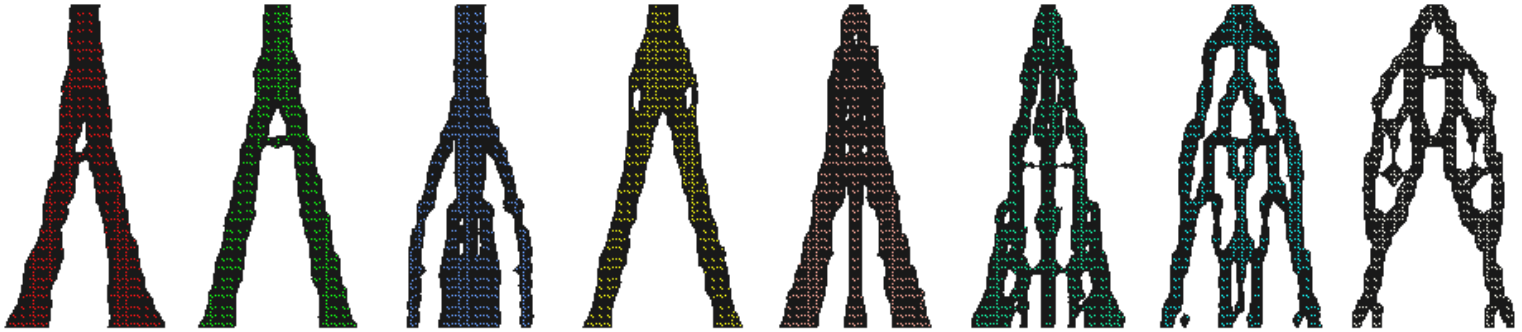


Max Member Size=1.0
Minimum GAP=1.0



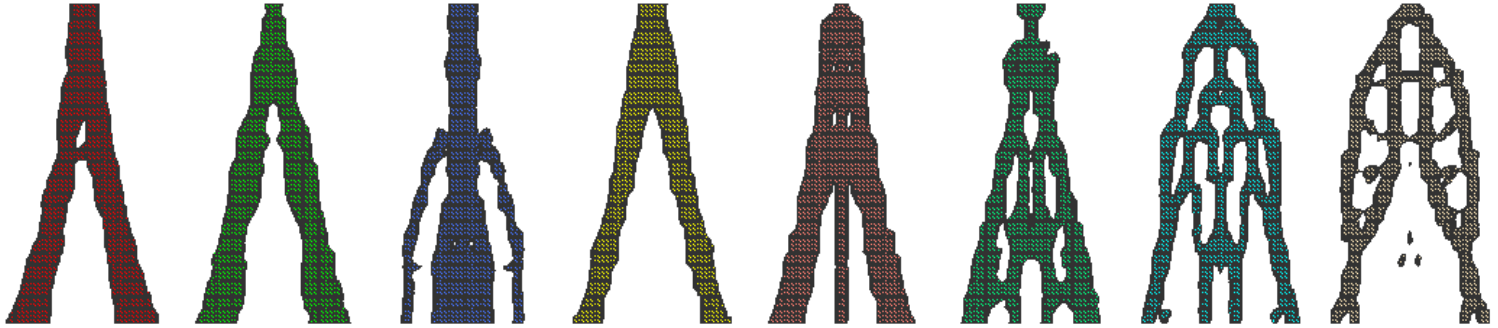
Max Member Size=0.5
Minimum GAP=0.5

Alternative Designs Using Different Values for Maximum Member Size and Minimum Gap



MMS=1.0 MG = 1.0 | MMS=1.0 MG = 2.0 | MMS=1.0 MG = 3.0 | MMS=1.0 MG = 4.0 | MMS=0.5 MG = 0.5 | MMS=0.5 MG = 1.0 | MMS=0.5 MG = 1.5 | MMS=0.5 MG = 2.0

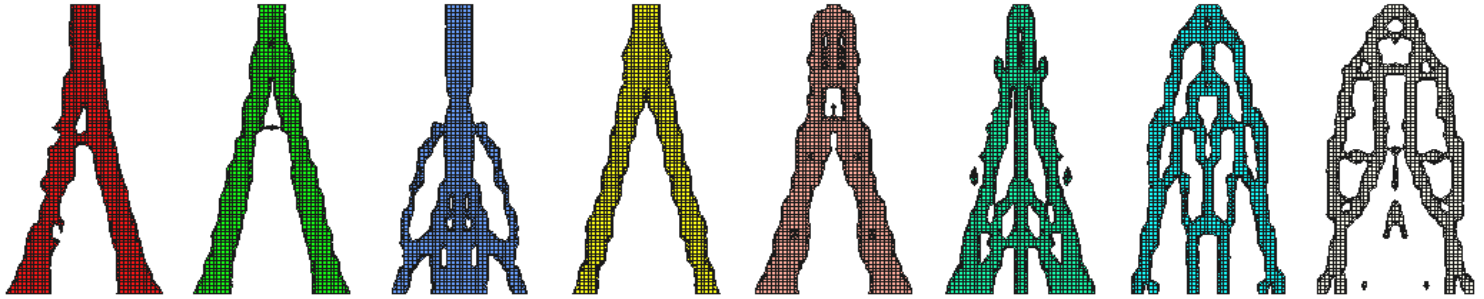
TRIA3



MMS=1.0 MG = 1.0 | MMS=1.0 MG = 2.0 | MMS=1.0 MG = 3.0 | MMS=1.0 MG = 4.0 | MMS=0.5 MG = 0.5 | MMS=0.5 MG = 1.0 | MMS=0.5 MG = 1.5 | MMS=0.5 MG = 2.0

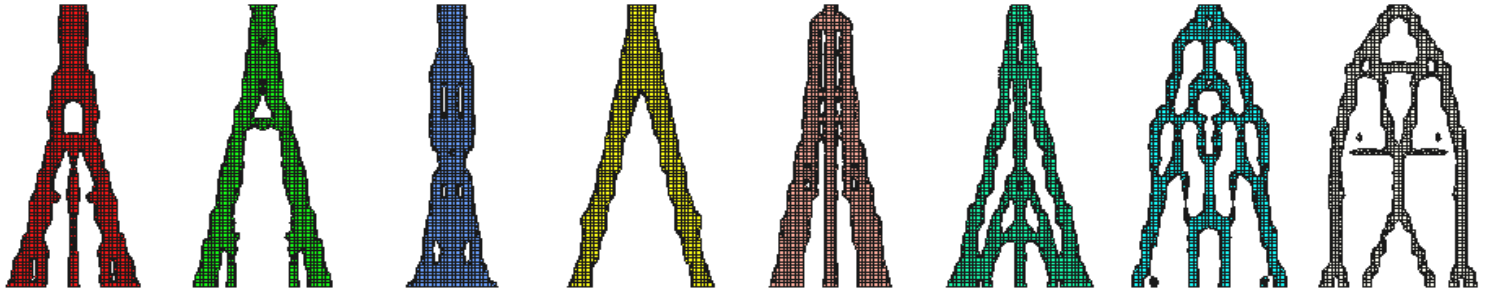
TRIA6

Alternative Designs Using Different Values for Maximum Member Size and Minimum Gap



QUAD4

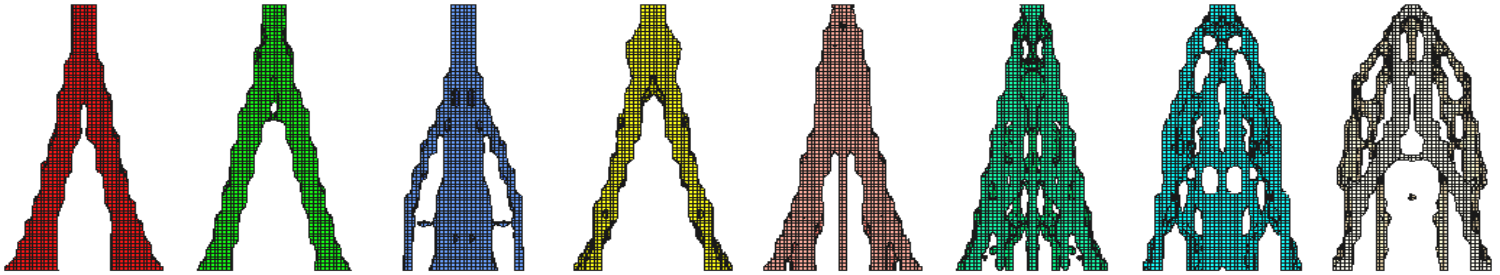
MMS=1.0 MG = 1.0	MMS=1.0 MG = 2.0	MMS=1.0 MG = 3.0	MMS=1.0 MG = 4.0	MMS=0.5 MG = 0.5	MMS=0.5 MG = 1.0	MMS=0.5 MG = 1.5	MMS=0.5 MG = 2.0



QUAD8

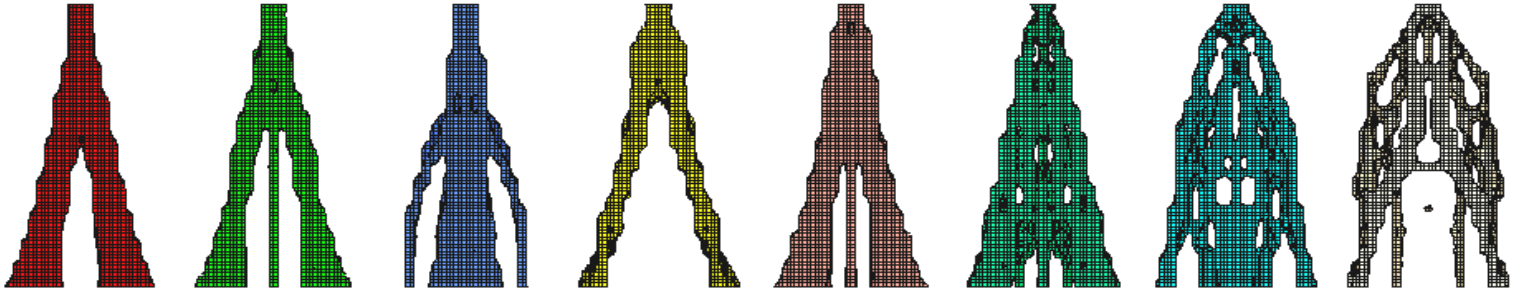
MMS=1.0 MG = 1.0	MMS=1.0 MG = 2.0	MMS=1.0 MG = 3.0	MMS=1.0 MG = 4.0	MMS=0.5 MG = 0.5	MMS=0.5 MG = 1.0	MMS=0.5 MG = 1.5	MMS=0.5 MG = 2.0

Alternative Designs Using Different Values for Maximum Member Size and Minimum Gap



MMS=1.0 MG = 1.0	MMS=1.0 MG = 2.0	MMS=1.0 MG = 3.0	MMS=1.0 MG = 4.0	MMS=0.5 MG = 0.5	MMS=0.5 MG = 1.0	MMS=0.5 MG = 1.5	MMS=0.5 MG = 2.0

HEXA



MMS=1.0 MG = 1.0	MMS=1.0 MG = 2.0	MMS=1.0 MG = 3.0	MMS=1.0 MG = 4.0	MMS=0.5 MG = 0.5	MMS=0.5 MG = 1.0	MMS=0.5 MG = 1.5	MMS=0.5 MG = 2.0

HEX20

Additional Enhancements in 14.0

- Topology Optimization now supports solid anisotropic (MAT9) and orthotropic (MAT11) materials
- Topology Optimization now supports composite (PCOMP) elements
- The approximate problem now is much faster for problems with linear constraints

Conclusions

- *GENESIS* is Continuously Being Improved for Functionality
- Numerous User-Requested Features have been Added

Conclusions

- **Design Studio Has Been Upgraded to Support *GENESIS* 14.0**

Questions?

Thanks for Attending