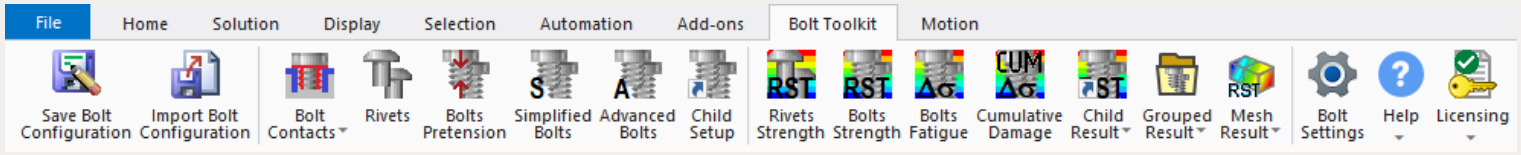
EDRMedeso Bolt Toolkit

Ansys Mechanical 2024 R1

Bolt Toolkit



- Main Features:
  - Optimization and automation of bolt contacts and contact imprints.
  - Build parametric rivets and bolts without CAD geometry in Mechanical including pre-tension.
  - Add your own custom bolt geometries including automatic pretension calculation.
  - Evaluate rivet and bolt forces, utilization and fatigue according to Eurocode 3/AISC-360-16.
- Business Value:
  - Ansys unique automatic bolt creation replaces manual CAD work, meshing & contact setup.
  - Ease of use and speedup. Create and evaluate hundreds of bolts in minutes instead of days.
  - Automatic bolt report for each selected analysis.

Advanced Bolt LC2

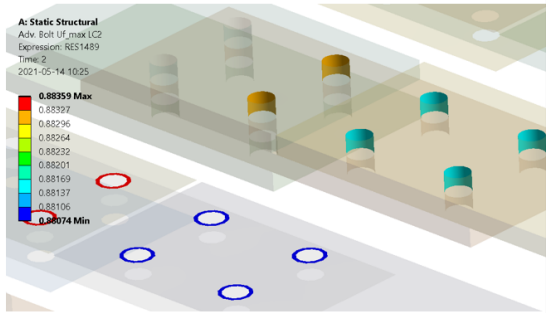


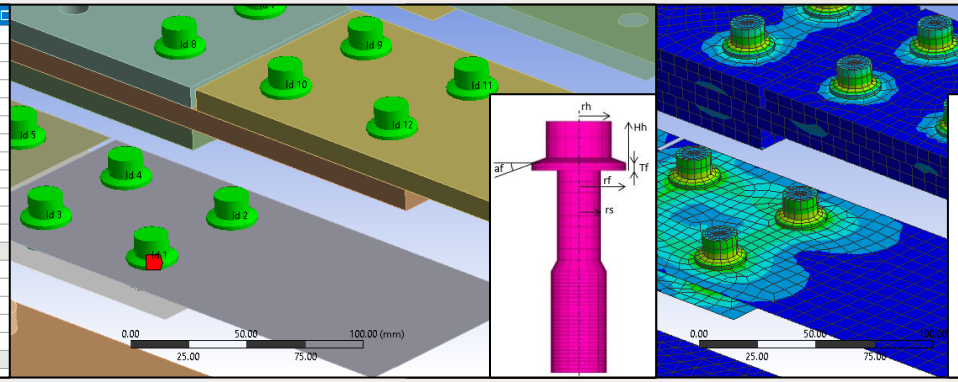
Figure 8. Adv. Bolt Uf_max LC2

Result Name	Advanced Bolt LC2	
Bolt Geometry		
Bolt Group	Advanced Bolts M12	
Nominal Diameter, d	12.0 mm	Head Diameter, d_m
Stress Diameter, d_s	10.4 mm	Hole Diameter, d_0
Bolt Evaluation		
Bolt Code	Eurocode 3	Bolt material class
Bolt yield strength, f_{yb}	640.0 MPa	Bolt ultimate strength, f_{ub}
Design bolt preload, $F_{p,Cd}$	42865.0 N	Applied Pretension Force, F_p
Connection Category	F shear and tension	Cut thread comply with EN 1090
Plate ultimate strength, f_u	400.0 MPa	Plate thickness, t_p
Safety factor, γ_{M2}	1.25	Safety factor, γ_{M3}
Shear resistance factor, α_v	0.5	Design shear resistance per plane an $F_{v,Rd}$
Bolt hole type	Normal	Bearing resistance factor, k_b
End distance (parallel), e_1	30.0 mm	Inner distance (parallel), p_1
End distance (perpendicular), e_2	25.0 mm	Inner distance (perpendicular), p_2
Bearing resistance factor, α_b	0.769	Bearing resistance factor, k_1
Design bearing resistance per hole, $F_{b,Rd}$	57600.0 N	
Class of friction surface	None	Plate slip factor, μ
Slip resistance factor, k_s	1.0	Design slip resistance per plane and $F_{s,Rd}$
Countersunk bolt	No	Countersunk bolt factor, k_2
Design tension resistance, $F_{t,Rd}$	48499.0 N	Design punching resistance, $B_{p,Rd}$
Bolt Result		
Result Item	Uf_{max}	Scale Factor Value
Definition		
By	Time	Display Time

Table 11. Advanced Bolt LC2 property list

Details of "Advanced Bolts M12"

Bolt Head	
Scoping Method	Named Selection
Named Selection	Adv head Solid
Nut/Thread	
Scoping Method	Named Selection
Named Selection	Adv nut Solid
General	
Bolt Geometry File	FlangeBolt_ISO15071
Material	Steel bolt 8.8
Nonlinear Effects	Yes
Element Order	Linear
Bolt Dimension [mm]	12
Head Diameter	22.5 mm
Bolt Length	0 mm
Nominal Diameter Length	15 mm
Head friction	0.14
Thread friction	0.14
Pretension from Code	Eurocode 3
Pretension Force	42865 N



Bolt Id	$F_{t,Ed}$ [N]	$F_{v,Ed}$ [N]	Uf_{max}	Uf_{shear}	$Uf_{bearing}$	$Uf_{tension}$	Uf_{punch}	Uf_{comb}	Uf_{slip}
1	4.272e+04	2.008e+03	0.881	0.087	0.035	0.881	0.315	0.716	0.368
2	4.272e+04	1.993e+03	0.881	0.086	0.035	0.881	0.315	0.715	0.365
3	4.271e+04	6.834e+02	0.881	0.030	0.012	0.881	0.315	0.659	0.125
4	4.271e+04	7.071e+02	0.881	0.031	0.012	0.881	0.315	0.660	0.130
5	4.285e+04	3.199e+03	0.884	0.139	0.056	0.884	0.316	0.770	0.586
6	4.285e+04	3.278e+03	0.884	0.142	0.057	0.884	0.316	0.773	0.601
7	4.283e+04	1.645e+03	0.883	0.071	0.029	0.883	0.316	0.702	0.302
8	4.283e+04	1.643e+03	0.883	0.071	0.029	0.883	0.316	0.702	0.301
9	4.275e+04	7.444e+02	0.881	0.032	0.013	0.881	0.315	0.662	0.136
10	4.275e+04	7.417e+02	0.881	0.032	0.013	0.881	0.315	0.662	0.136
11	4.276e+04	2.220e+03	0.882	0.096	0.039	0.882	0.315	0.726	0.407
12	4.276e+04	2.192e+03	0.882	0.095	0.038	0.882	0.315	0.725	0.402

Table 13. Advanced Bolt LC2 Results summary

Save and Import Bolt Configuration

- Rivet, bolt and result objects can be reused between models and projects to speed up preparation and post processing. By using “Named Selections” the scooping is applied automatic.

- Save Bolt Configuration writes a text file in the current solution folder.
  All or selected rivet, bolt and result objects from the current analysis are exported.
  The file can be used as a template for creating user defined bolt configurations.

- Import Bolt Configuration reads a bolt configuration file and creates all objects in the file unless an object with the same name already exists.

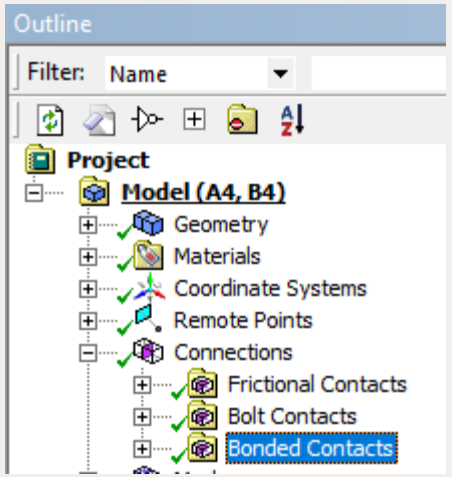
- The Save/Import option can be used to copy the bolt setup from a Structural analysis to a Thermal analysis or from one analysis to another.
  It can also be used if the bolt configuration is defined outside of Mechanical or by another automation app/Wizard.

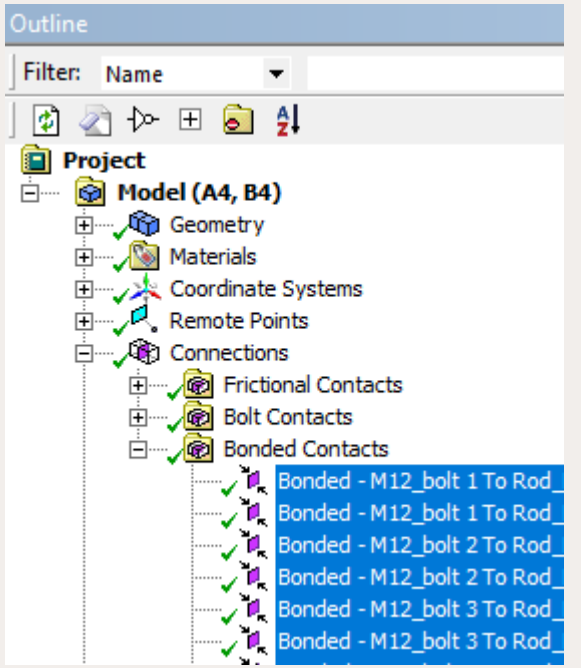
Optimize Bonded Contacts

- Bonded face to face contacts can be optimized for bolt analysis by setting the smaller face as “Contact” and the larger face as “Target” and change behavior to “Asymmetric”.

- Select the “Connections” folder, “Contacts” folders or individual “Contacts” and click the button “Optimize Bonded Contacts” to update all selected objects.

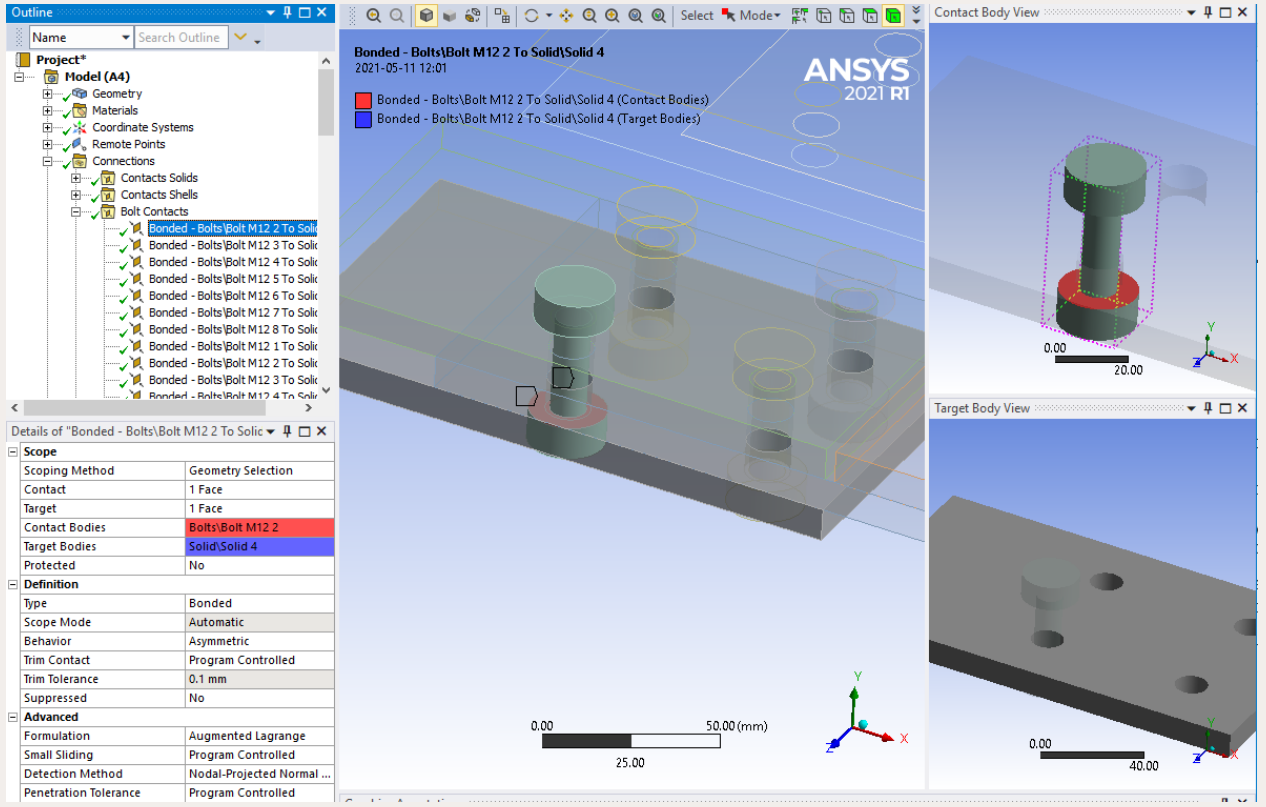
- An info message will show the number of selected contacts to optimize and how many that was updated.





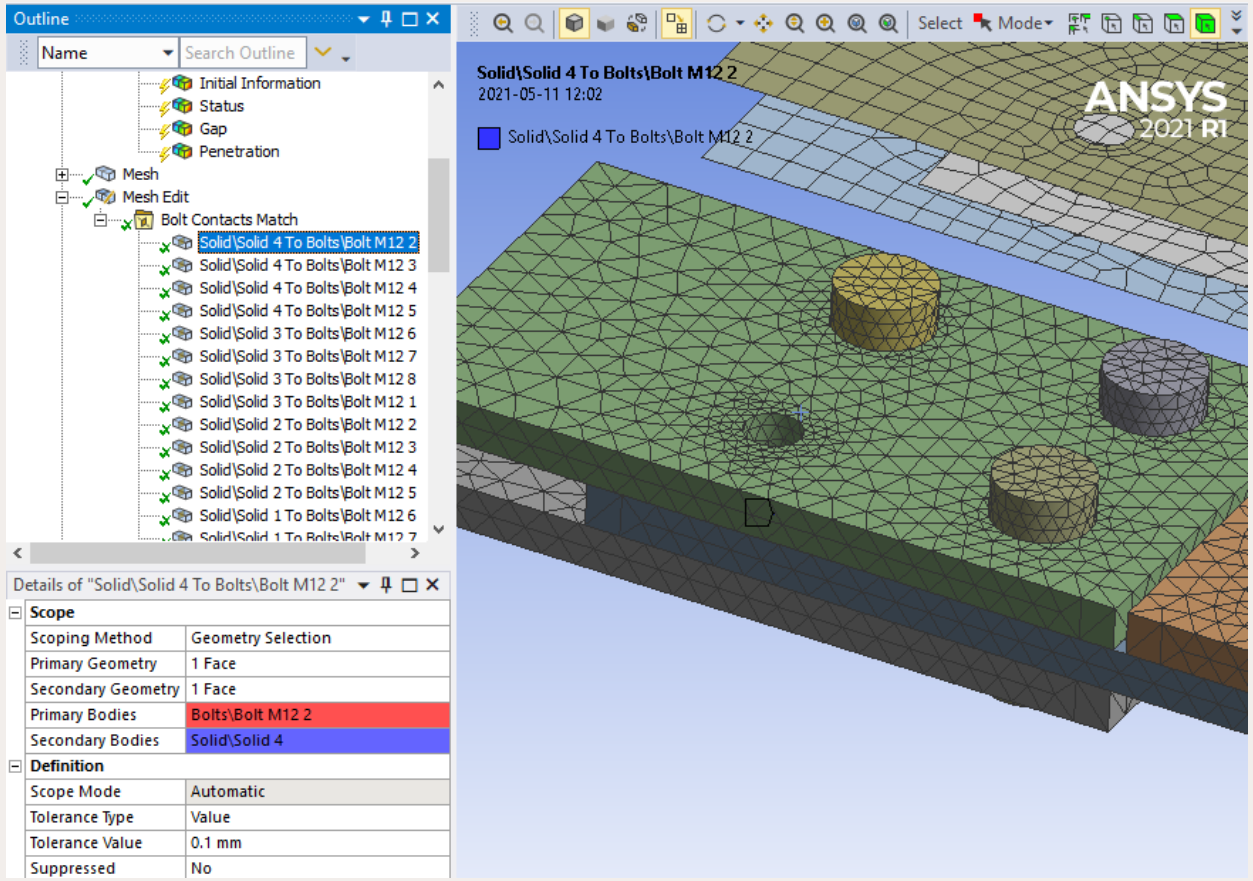
Create Bolt Contacts

- Managing contacts for large assemblies with many bolts is important to get consistent results.
- “Create Bolt Contacts” will create a “Bolt Contacts” Connection folder and create bonded contacts for all parts containing “bolt” in the name.
- Delete any existing duplicate bolt contacts in other contacts folders.
- The created contacts can be edited, e.g. changed to frictional contact.
- Tip: Multi-select parts in Geometry group and press “F2” to rename.



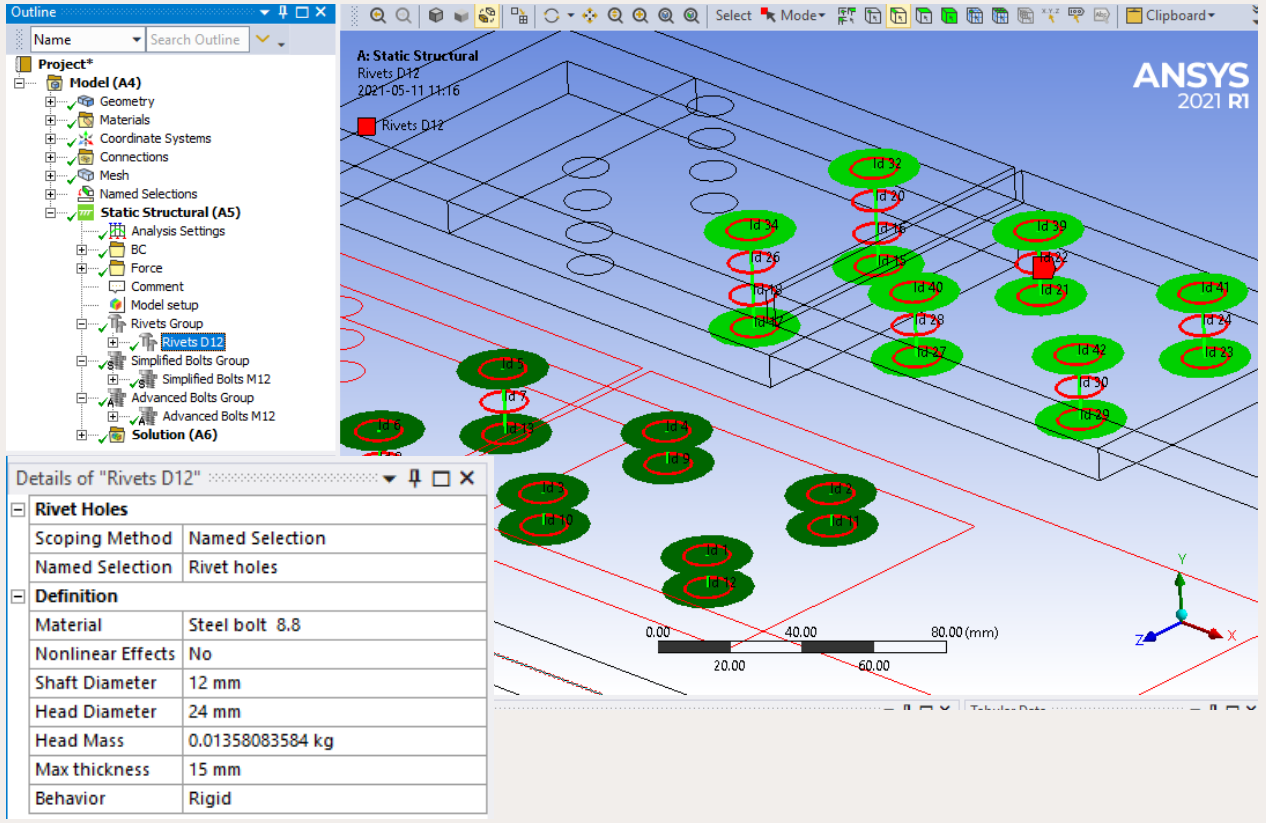
Bolt Contacts Match

- For tetrahedron meshed parts the bolt contacts match can be used to create a “Bolt Contacts Match” folder in Mesh Edit and create corresponding mesh imprint for the bolt contacts.
- The mesh imprint will improve the contact calculation as the contact and target mesh will match.
- This is an easy alternative instead of using “Inflation” around the bolt holes.



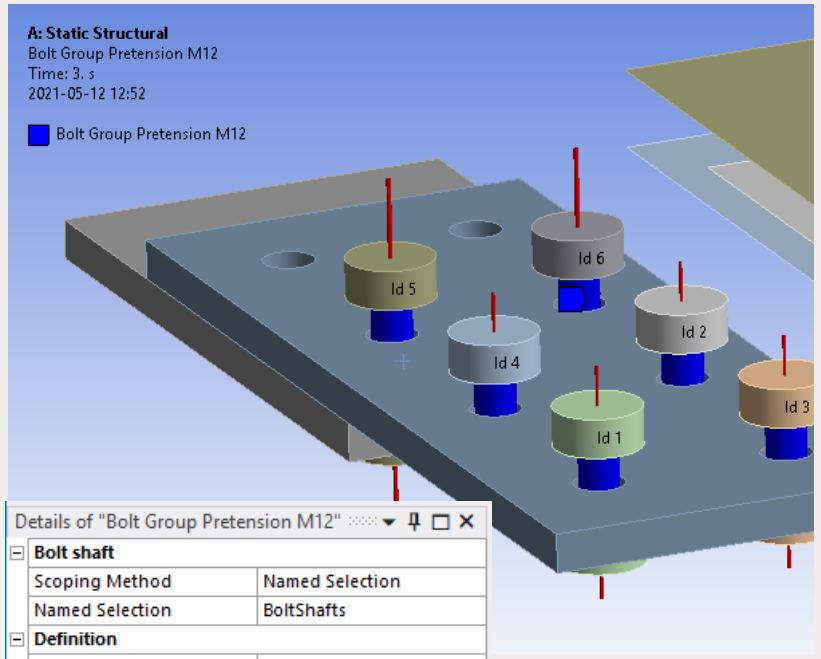
Rivets

- A rivet is a simplified joint element that can connect parts without pretension and can take both forces and moments.
- Rivets can be used instead of bolts and contacts to connect parts locally at each bolt hole.
- To create rivets, select a group of hole edges, select a material, shaft/head diameter and max thickness.
- The rivets are visualized with a disc for the head and a green line for the shaft and an id number at each interface.
- The head behavior can be “Rigid”, “Deformable” or “User”.



Special Pretension Features

- Recommended Pretension Force
  - Based on the selected materials “Tensile Yield Strength” or “Tensile Ultimate Strength” from Engineering Data the recommended pretension force can be automatically calculated based on the selected bolt shaft diameter and code.
  - This feature allows you to easily change bolt dimension and have the correct pretension applied automatically.
- Sequential Bolt Pretension
  - For detailed pretension analysis the order of bolt pretension can easily be studied with the sequential bolt pretension feature without needing to create several bolt pretension objects.
  - To set up sequential pretension define the geometry scoping in the order you want them to be pretensioned. The selected scoping order is the same as the bolt “Id” displayed on each bolt in the graphics window.
  - The “Load Step Apply, Lock and Embedding” is then defined using a list syntax for incrementing the load step number when the load is applied.
- Pretension Type
  - For large deformation analysis the pretension type must be changed to “MPC184” to avoid constraint forces and moments in the bolt shaft due to global rotations.



Details of "Bolt Group Pretension M12"

Bolt shaft	
Scoping Method	Named Selection
Named Selection	BoltShafts
Definition	
Material	Steel bolt 8.8
Nonlinear Effects	No
Shaft Diameter	10.354 mm
Pretension from Code	Eurocode 3
Pretension Force	42865 N
Increment (Embedding)	-0.02 mm
Load Step Apply	1
Load Step Lock	2
Load Step Increment	3
Pretension Type	PRETS179
Contact Slip Radius	25 mm

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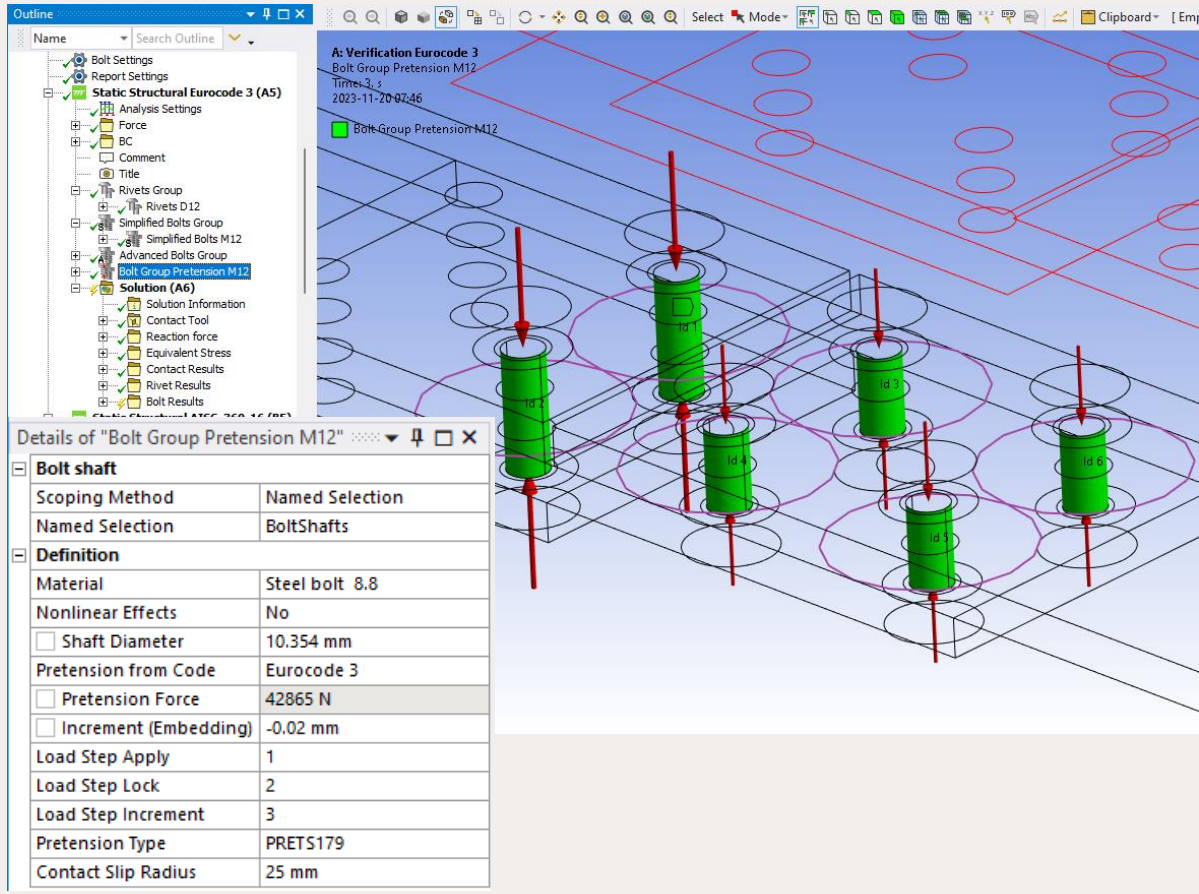
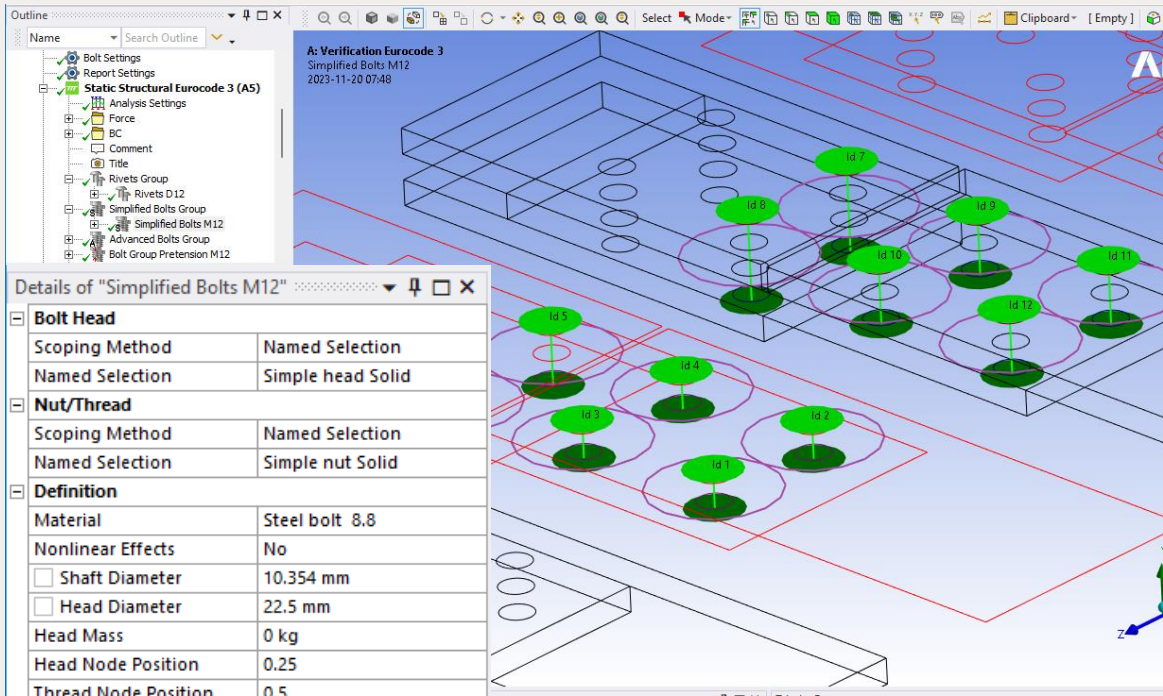
Bolts Pretension

- For custom bolt geometries the “Bolts Pretension” can be used to apply material, pretension force and post process according to Eurocode 3.
- Select a group of cylindrical faces to apply the pretension. The shaft diameter is retrieved.
- The material can be modified by selecting from the material list of standard bolt materials and available Engineering Data materials.
- The pretension can be calculated based on the shaft diameter and selected code.
- The pretension force normal and bolt id number is plotted on the geometry.



Simplified Bolts

- Simplified bolts can model bolt joints with pretension with a minimum of added degrees of freedom (DOF).
- The bolts uses beam elements and constraint equations at the head/thread to connect to the parts.
- The head/thread behavior can be “Rigid”, “Deformable” or “User”.
- To create simplified bolts, select a group of hole edges for the head and group of edges/faces for the nut/thread. Select a material, shaft/head diameter and define the pretension.
- The bolts are visualized with a disc for the head and a green line for the shaft.
- Both solid and shell parts can be used.

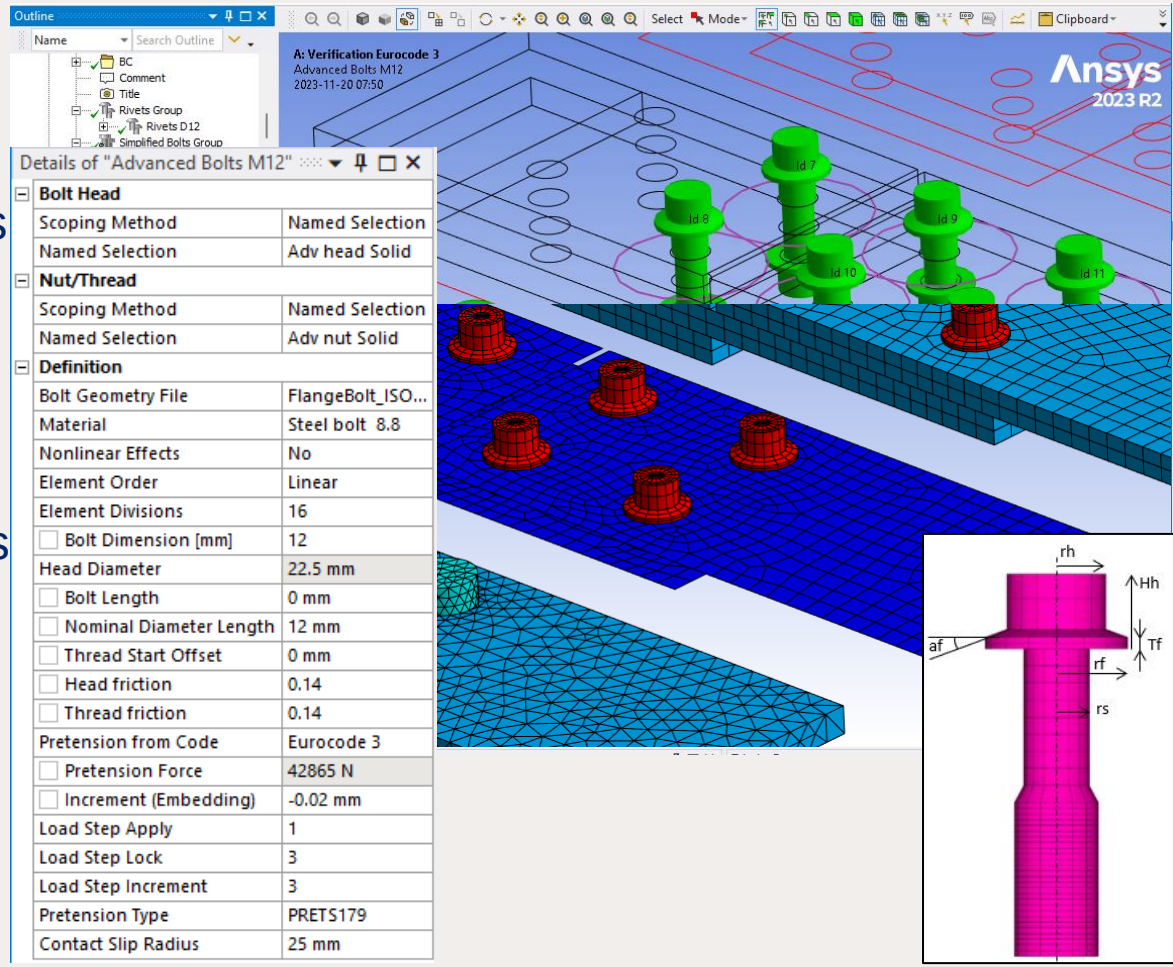


Details of "Simplified Bolts M12"

Bolt Head	
Scoping Method	Named Selection
Named Selection	Simple head Solid
Nut/Thread	
Scoping Method	Named Selection
Named Selection	Simple nut Solid
Definition	
Material	Steel bolt 8.8
Nonlinear Effects	No
Shaft Diameter	10.354 mm
Head Diameter	22.5 mm
Head Mass	0 kg
Head Node Position	0.25
Thread Node Position	0.5
Thread Length	0 mm
Behavior	Rigid
Pretension from Code	Eurocode 3
Pretension Force	42865 N
Increment (Embedding)	-0.02 mm
Load Step Apply	1
Load Step Lock	2
Load Step Increment	3
Pretension Type	PRETS179
Contact Slip Radius	25 mm

Advanced Bolts

- Advanced bolts can model bolt joints with pretension with best possible accuracy including frictional contacts, thread interaction and non-linear material.
- The bolt geometry is based on parameter tables and is visualized as a green solids.
  Additional bolt tables can be added by the user.
- The bolts uses solid elements and contacts at the head/thread to connect to the parts.
- To create advanced bolts, select a group of hole edges for the head and group of edges/faces for the nut/thread. Select a material, bolt dimension and define the pretension.
- The bolt pretension can be calculated from bolt torque based on the friction coefficients and bolt geometry.
- Both solid and shell parts can be used.

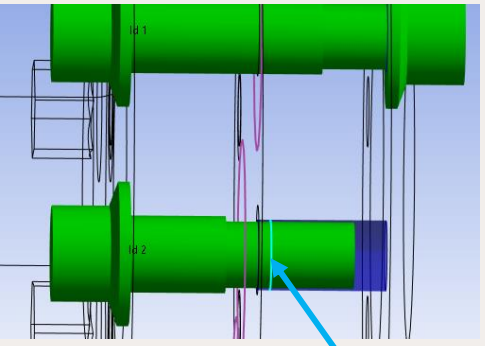


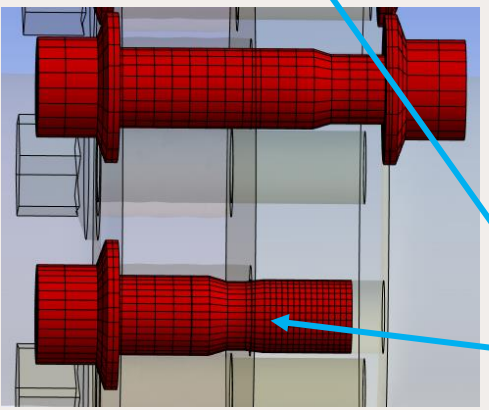
Details of "Advanced Bolts M12"

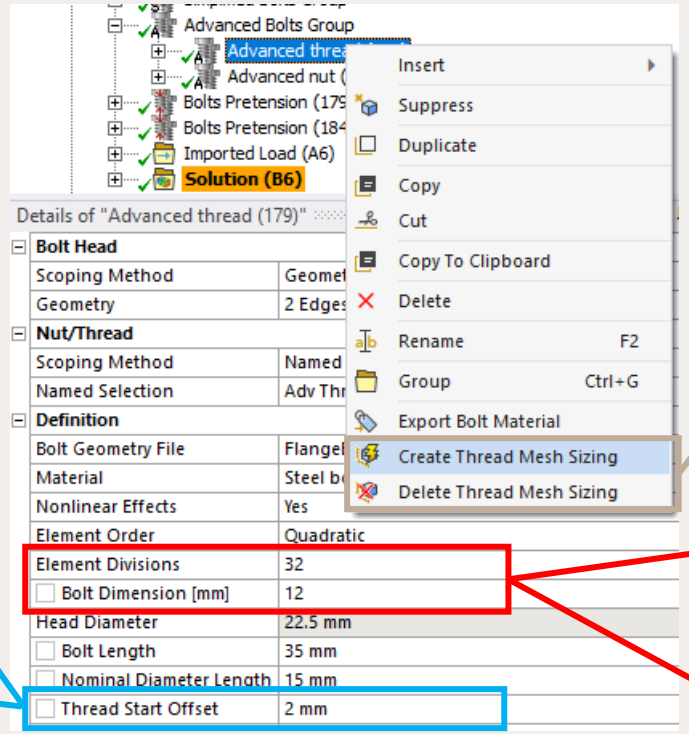
Bolt Head	
Scoping Method	Named Selection
Named Selection	Adv head Solid
Nut/Thread	
Scoping Method	Named Selection
Named Selection	Adv nut Solid
Definition	
Bolt Geometry File	FlangeBolt_ISO...
Material	Steel bolt 8.8
Nonlinear Effects	No
Element Order	Linear
Element Divisions	16
Bolt Dimension [mm]	12
Head Diameter	22.5 mm
Bolt Length	0 mm
Nominal Diameter Length	12 mm
Thread Start Offset	0 mm
Head friction	0.14
Thread friction	0.14
Pretension from Code	Eurocode 3
Pretension Force	42865 N
Increment (Embedding)	-0.02 mm
Load Step Apply	1
Load Step Lock	3
Load Step Increment	3
Pretension Type	PRETS179
Contact Slip Radius	25 mm

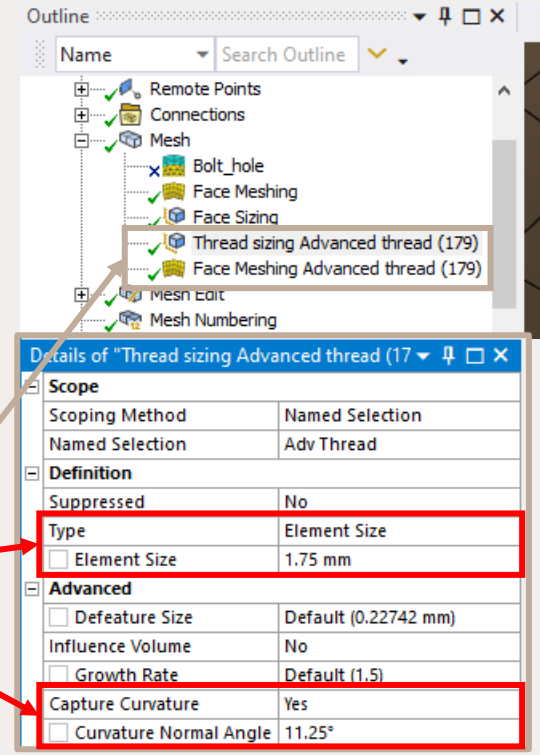
Advanced Bolts, Thread Mesh Sizing

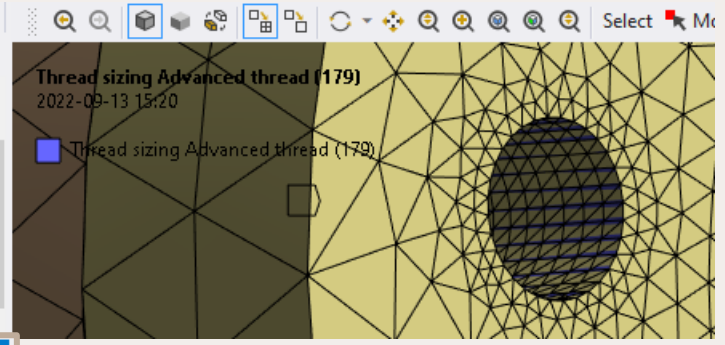
- The number of element divisions can be defined for advanced bolts in the range from 16 to 48.
- A thread mesh sizing can be defined that is linked to the element divisions and thread pitch size, P.
- A thread start offset can be defined to elongate the bolt shaft into the thread hole.









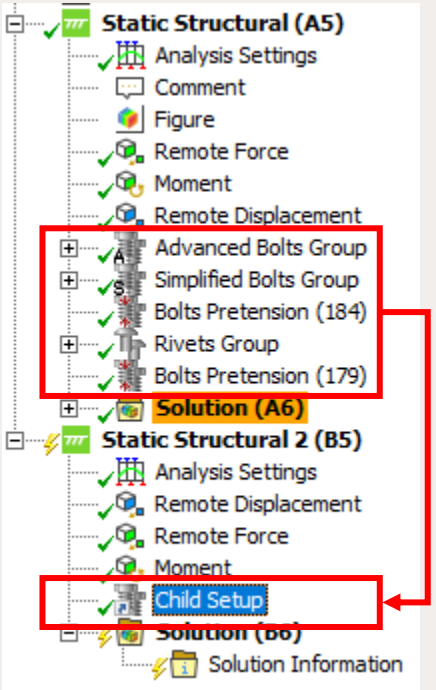


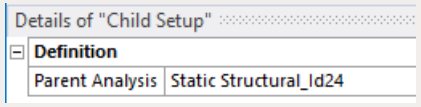
P(D=12mm) = 1.75mm

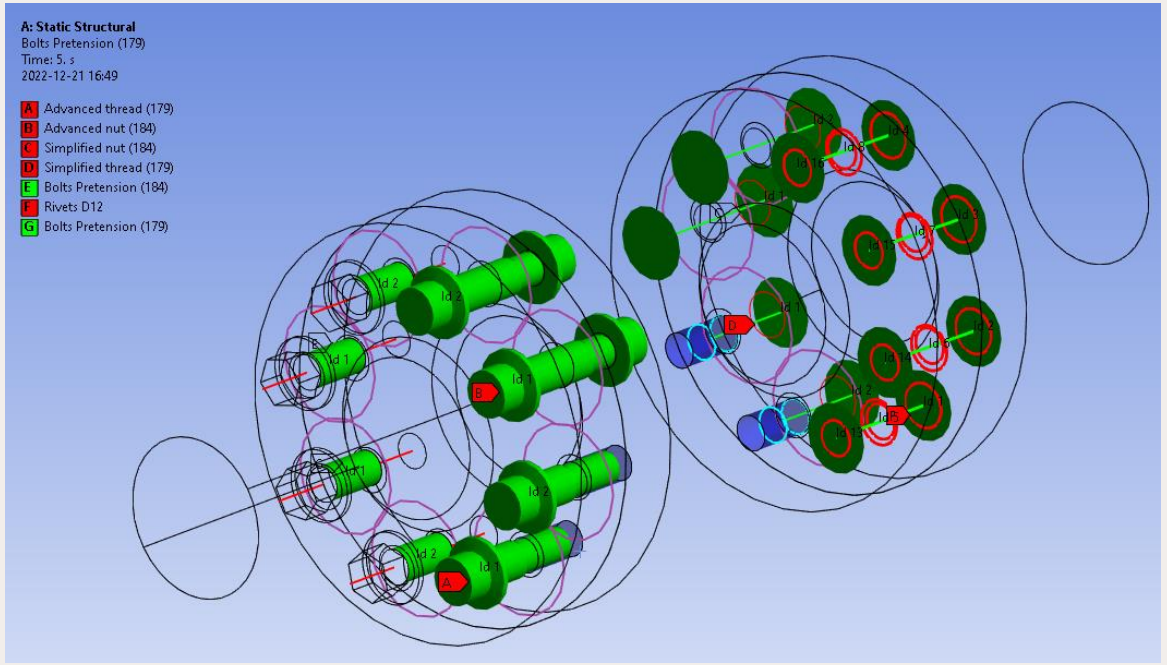
Δphi = 360/32 = 11.25°

Child Setup

- The Child Setup let you re-use the rivet and bolt setup from one linked parent analysis.
- This will make solution combination of bolt results possible both for “Grouped Results” and fatigue loads using “Solution Combination” or “Solution Scanning”.







Rivets Result

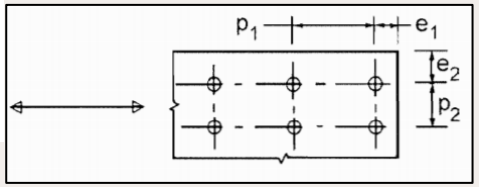
- Rivets results evaluate forces and moments in each rivet section.
- Rivet utilization factor, *Uf*, can be post processed according to Eurocode 3.
- Results are plotted on the geometry and listed in csv files used by the “Bolt Report” feature.

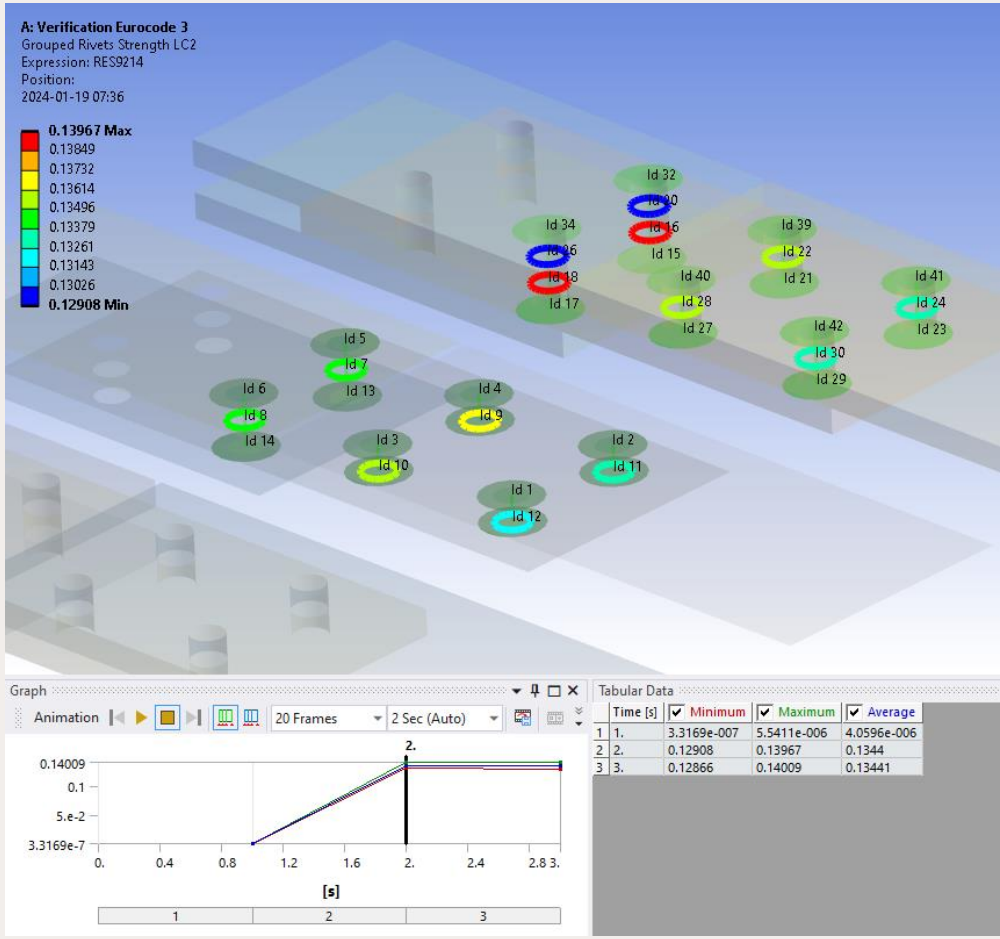
Result Name	Rivet LC2		
Rivet Geometry			
Rivet Group	Rivets D12		
Shaft Diameter, d	12.0 mm	Head Diameter, d_m	24.0 mm
Stress Diameter, d_s	12.0 mm	Hole Diameter, d_0	12.0 mm
Rivet Evaluation			
Rivet Code	Eurocode 3	Rivet material	S235
Rivet yield strength, f_{yb}	235.0 MPa	Rivet ultimate strength, f_{ub}	400.0 MPa
Connection Category	A bearing		
Plate ultimate strength, f_u	400.0 MPa	Plate thickness, t_p	10.0 mm
Safety factor, γ_{M2}	1.25		
Shear resistance factor, α_v	0.6	Design shear resistance per plane and rivet, $F_{v,Rd}$	21715.0 N
End distance (parallel), e_1	30.0 mm	Inner distance (parallel), p_1	63.0 mm
End distance (perpendicular), e_2	25.0 mm	Inner distance (perpendicular), p_2	50.0 mm
Bearing resistance factor, α_b	0.833	Bearing resistance factor, k_1	2.5
Design bearing resistance per hole, $F_{b,Rd}$	80000.0 N		
Rivet Result			
Result Item	Uf_{max}	Scale Factor Value	1.0
Definition			
By	Time	Display Time	2.0

Table 4. Rivet LC2 property list

Rivet Id	$F_{t,Ed}$ [N]	$F_{v,Ed}$ [N]	Uf_{max}	Uf_{shear}	$Uf_{bearing}$
7	0.000e+00	2.500e+03	0.115	0.115	0.031
8	0.000e+00	2.501e+03	0.115	0.115	0.031
9	0.000e+00	2.599e+03	0.120	0.120	0.032
10	0.000e+00	2.600e+03	0.120	0.120	0.032
11	1.355e+01	2.405e+03	0.111	0.111	0.030
12	6.874e+00	2.404e+03	0.111	0.111	0.030
16	0.000e+00	2.897e+03	0.133	0.133	0.036
18	0.000e+00	2.931e+03	0.135	0.135	0.037
20	0.000e+00	2.101e+03	0.097	0.097	0.026
22	0.000e+00	2.736e+03	0.126	0.126	0.034
24	0.000e+00	2.263e+03	0.104	0.104	0.028
26	0.000e+00	2.076e+03	0.096	0.096	0.026
28	0.000e+00	2.704e+03	0.125	0.125	0.034
30	0.000e+00	2.305e+03	0.106	0.106	0.029

Table 6. Rivet LC2 Results summary





Bolts Result

- Bolts results evaluate forces and moments at head, mid or thread shaft section in all bolts.
- Bolt utilization factor, *Uf*, can be post processed according to Eurocode 3 or AISC 360-16.
- Results are plotted on the geometry and listed in csv files used by the “Bolt Report” feature.

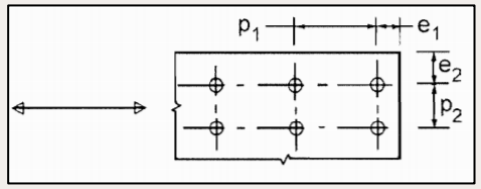
Result Name		Advanced Bolt LC2 no packing plate	
Bolt Geometry			
Bolt Group	Advanced Bolts M12		
Nominal Diameter, d	12.0 mm	Nominal Diameter Length	0.0 mm
Stress Diameter, d_s	10.4 mm		
Head Diameter, d_m	22.5 mm	Hole Diameter, d_0	13.0 mm
Bolt Evaluation			
Bolt Code	Eurocode 3	Bolt material class	8.8
Bolt yield strength, f_{yb}	640.0 MPa	Bolt ultimate strength, f_{ub}	800.0 MPa
Design bolt preload, $F_{p,Cd}$	42865.0 N	Applied Pretension Force, F_p	42865.0 N
Connection Category	F shear and tension	Cut thread comply with EN 1090, k_{tv}	1.0 (Yes)
Plate ultimate strength, f_u	400.0 MPa	Plate thickness, t_p	10.0 mm
Safety factor, γ_{M2}	1.25	Safety factor, γ_{M3}	1.1
Shear resistance factor, α_v	0.6	Packing plate thickness, t_{pp}	0.0 mm
Design shear resistance per plane and bolt, $F_{v,Rd}$	32332.0 N		
Bolt hole type	Normal		
End distance (parallel), e_1	30.0 mm	Inner distance (parallel), p_1	63.0 mm
End distance (perpendicular), e_2	25.0 mm	Inner distance (perpendicular), p_2	50.0 mm
Bearing resistance factor, α_b	0.769	Bearing resistance factor, k_1	2.5
Bearing resistance factor, k_b	1.0	Design bearing resistance per hole, $F_{b,Rd}$	57600.0 N
Class of friction surface	None	Plate slip factor, μ	0.14
Slip resistance factor, k_s	1.0	Design slip resistance per plane and bolt, $F_{s,Rd}$	5456.0 N
Countersunk bolt	No	Countersunk bolt factor, k_2	0.9
Design tension resistance, $F_{t,Rd}$	48499.0 N	Design punching resistance, $B_{p,Rd}$	135717.0 N
Bolt Result Item	Uf_{max}	Scale Factor Value, γ_L	1.0
Result averaging	Individual	Result Location	Mid
Definition By	Time	Display Time	2.0

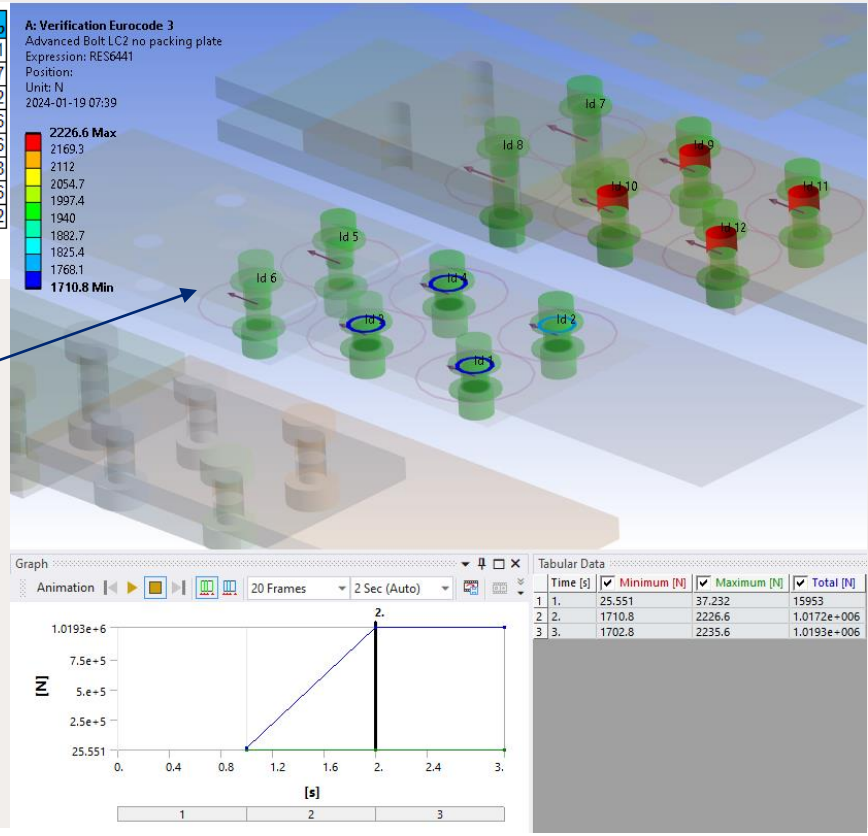
Table 26. Advanced Bolt LC2 no packing plate property list

Bolt Id	$F_{t,Ed}$ [kN]	$F_{v,Ed}$ [kN]	Uf_{max}	Uf_{shear}	$Uf_{bearing}$	$Uf_{tension}$	Uf_{punch}	Uf_{comb}	Uf_{slip}
1	42.865	1.719	0.884	0.053	0.030	0.884	0.316	0.684	0.331
2	42.865	1.787	0.884	0.055	0.031	0.884	0.316	0.687	0.337
3	42.865	1.711	0.884	0.053	0.030	0.884	0.316	0.684	0.332
4	42.865	1.758	0.884	0.054	0.031	0.884	0.316	0.686	0.336
9	42.865	2.207	0.884	0.068	0.038	0.884	0.316	0.700	0.406
10	42.865	2.213	0.884	0.068	0.038	0.884	0.316	0.700	0.408
11	42.865	2.227	0.884	0.069	0.039	0.884	0.316	0.700	0.406
12	42.865	2.206	0.884	0.068	0.038	0.884	0.316	0.700	0.402

Table 28. Advanced Bolt LC2 no packing plate Results summary

Shear/Sliding Force vectors





Bolts Fatigue

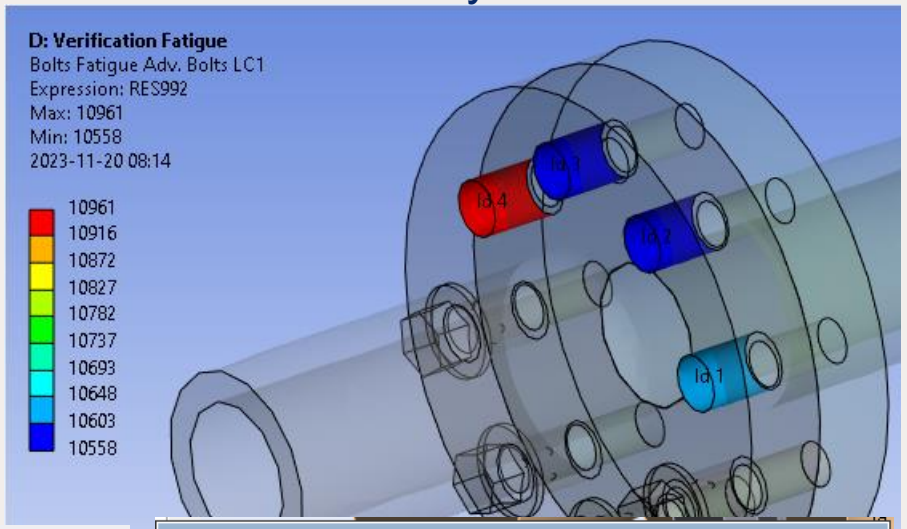
- Bolt fatigue life and damage can be post processed according to Eurocode 3 or user defined S-N curves.
- Results are plotted on the geometry and listed in csv files used by the “Bolt Report” feature.
- If using the “Child Setup” the load case can be defined from results in linked analyses.

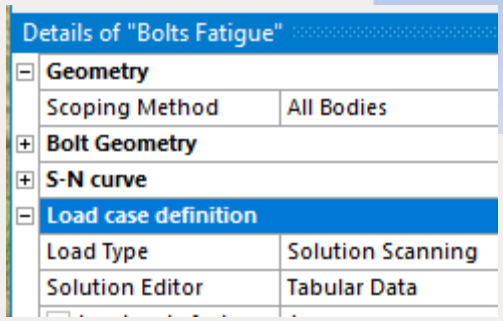
Result Name		Bolts Fatigue Adv. Bolts LC1	Id 227
Bolt Geometry			
Bolt Group	Advanced Bolts		
Nominal Diameter, *d*	12.0 mm	Nominal Diameter Length	15.0 mm
Stress Diameter, d_s	11.0 mm	Stress Type	Structural
S-N curve			
FAT Class	EC3 FAT50 vari	N_{cutoff}	1.0e+08
FAT (@ N_{fat} cycles)	50 [MPa]	FAT factor	1.0
N_{fat}	2000000.0	N_c	5000000.0
Slope m_1	3	Slope m_2	5
Load case definition			
Load Type	Load Scanning		
First time	1.0	Last time	3.0
Cycles per block	10000.0	Load scale factor	1.0
Bolt Result Item	Life [N]	Result Location	Thread

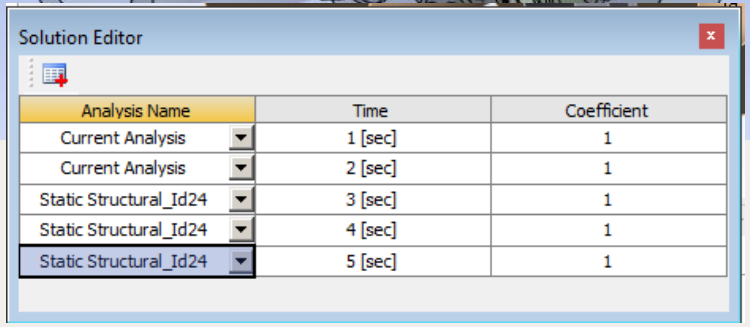
Table 26. Bolts Fatigue Adv. Bolts LC1 property list

Bolt Id	Life [N]	Damage per block [-]	SF life [#blocks]	Stress range [MPa]	SF stress [-]	Stress util. [-]
1	1.0629e+04	0.9408	1.0629	286.51	1.0206	0.9799
2	1.0558e+04	0.9471	1.0558	287.16	1.0183	0.9821
3	1.0570e+04	0.9461	1.0570	287.05	1.0186	0.9817
4	1.0961e+04	0.9123	1.0961	283.59	1.0311	0.9699

Table 27. Bolts Fatigue Adv. Bolts LC1 Results summary

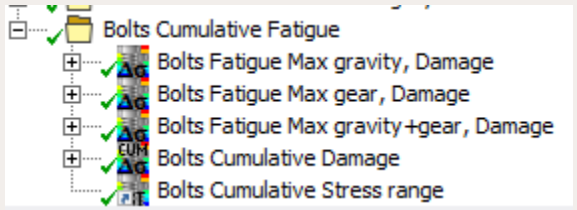


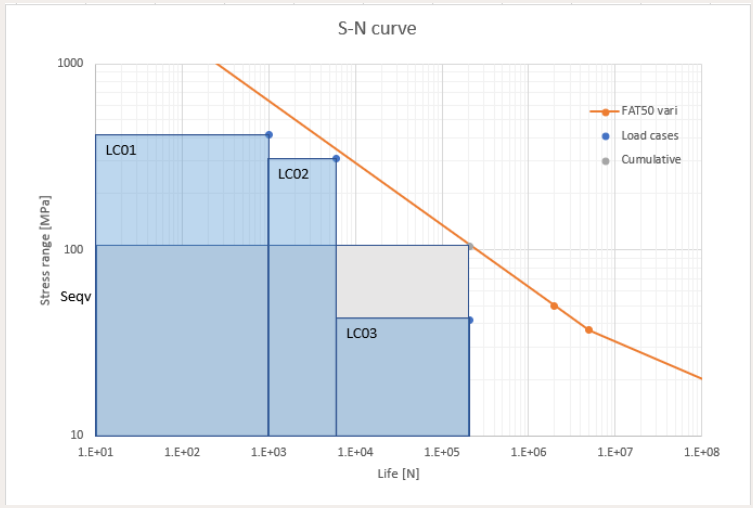




Bolts Cumulative Fatigue

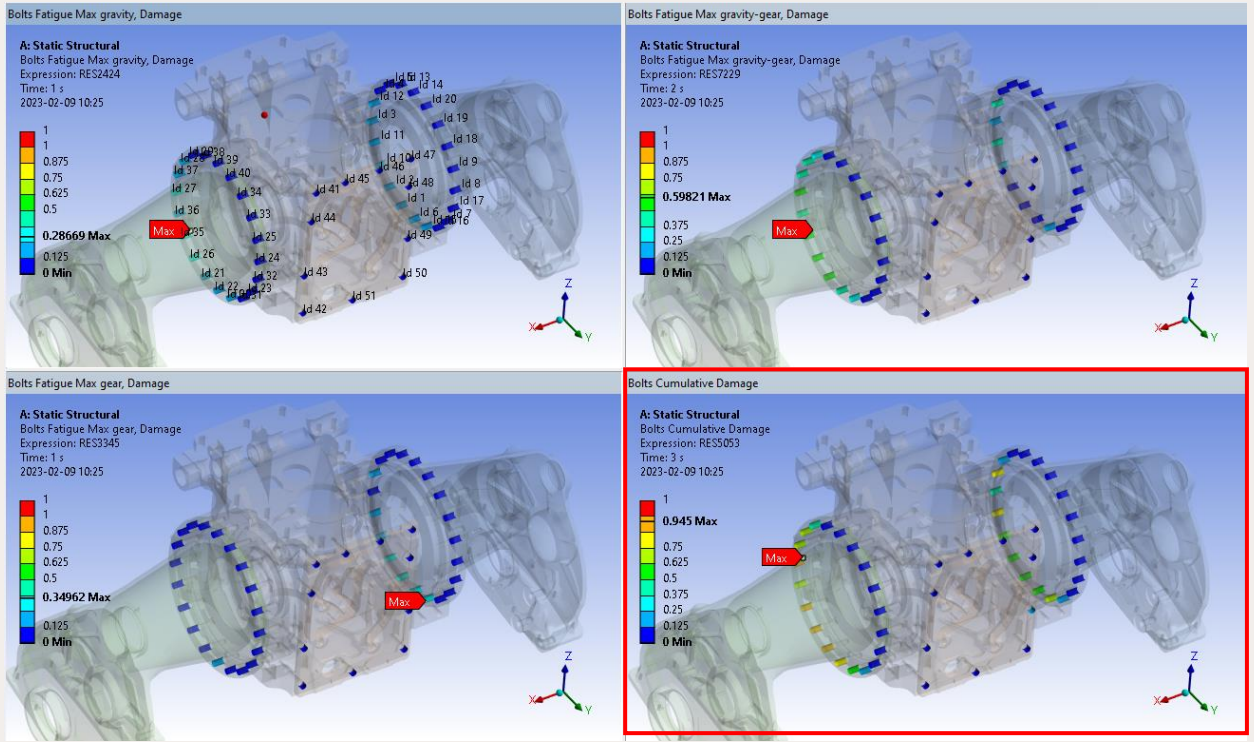
- The total damage from a duty cycle can be evaluated using Bolts Cumulative Fatigue.
- Each individual event (load case with number of cycles) is defined using the Bolts Fatigue object and then grouped in the model tree together with the Bolts Cumulative Damage result object.





Details of "Bolts Cumulative Damage"

Geometry	
Scoping Method	All Bodies
Load Case Definition	
Load Case Grouping	Grouped Results
Load Group Properties	Loaded
Bolt Object	M12 Flange bolt ISO-15071
Pretension Force Fp	42865 N
Nominal Diameter d	12 mm
Stress Diameter ds	10.354 mm
Stress Type	Structural
Total #Cycles	206000
S-N curve	
FAT Class	EC3 FAT50 vari
FAT (@ Nfat cycles)	50 MPa
FAT factor	1
Nfat	2000000
Nc	5000000
Slope m1	3
Slope m2	5
Ncutoff	100000000
Fatigue Result	
Result Item	Cumulative Damage [-]



Child Result

- The Rivets/Bolts Child Result let you select a parent result and plot a different result item (and/or time/set number) while keeping all other settings the same as in the parent result.
- This result object does not output any summary tables to the bolt report since they are listed for the parent result object. When clearing and edit the parent the children are updated as well.

Model Tree

- Bolt Results Parent-Child
  - Bolts Result Uf_max
  - Bolts Result Child Fn LC1
  - Bolts Result Child Fn LC2
  - Bolts Result Child Fn LC3

Parent Result

Details of "Bolts Result Uf_max"

Geometry	
Scoping Method	All Bodies
Bolt Geometry	
Bolt Object	Advanced thread (179)...
Pretension Force, Fp	42865 N
Nominal Diameter, d	12 mm
Nominal Diameter Length	15 mm
Stress Diameter, ds	10.354 mm
Head Diameter, dm	22.5 mm
Hole Diameter, d0	14 mm
Bolt Evaluation	
Bolt Code	Eurocode 3
Bolt Material Class	8.8
Bolt Yield Strength, fyb	640 MPa
Bolt Ultimate Strength, fub	800 MPa
Connection Category	E preloaded
Cut thread comply with EN 1090, ktv	Yes
Plate Ultimate Strength, fu	400 MPa
Plate thickness, tp	20 mm
Safety factor, gammaM2	1.25
Countersunk bolt factor, k2	No
Bolt Result	
Result Item	Uf_max
Result averaging	Individual
Result Location	Mid
Calculate Time History	Yes
Scale Factor Value	1
Definition	
By	Maximum Over Time

Children

Details of "Bolts Result Child Fn LC1"

Geometry	
Scoping Method	All Bodies
Bolt Geometry	
Parent Result	Bolts Result Uf_max_Id7276
Bolt Result	
Result Item	Normal Force
Result averaging	Individual
Result Location	Mid
Calculate Time History	No
Definition	
By	Time
Display Time	1. s

Details of "Bolts Result Child Fn LC2"

Geometry	
Scoping Method	All Bodies
Bolt Geometry	
Parent Result	Bolts Result Uf_max_Id7276
Bolt Result	
Result Item	Normal Force
Result averaging	Individual
Result Location	Mid
Calculate Time History	No
Definition	
By	Time
Display Time	2. s

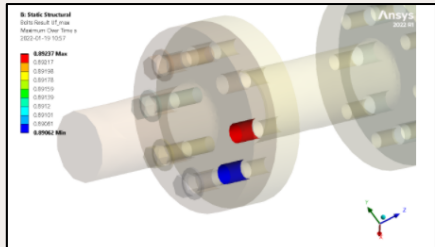


Figure 18. Bolts Result Uf_max

Table 35. Bolts Result Uf_max property list

Result Name		Bolts Result Uf_max	
Bolt Geometry			
Bolt Group	Advanced thread (179)		
Nominal Diameter, d	12.0 mm	Head Diameter, d_m	22.5 mm
Stress Diameter, d_s	10.4 mm	Hole Diameter, d_0	14.0 mm
Bolt Evaluation			
Bolt Code	Eurocode 3	Bolt material class	8.8
Bolt yield strength, f_{yb}	640.0 MPa	Bolt ultimate strength, f_{ub}	800.0 MPa
Design bolt preload, $F_{p,Cd}$	42865.0 N	Applied Pretension Force, F_p	42865.0 N
Connection Category	E preloaded	Cut thread comply with EN 1090	Yes
Plate ultimate strength, f_u	400.0 MPa	Plate thickness, t_p	20.0 mm
Safety factor, γ_{M2}	1.25		
Countersunk bolt	No	Countersunk bolt factor, k_2	0.9
Design tension resistance, $F_{t,Rd}$	48499.0 N	Design punching resistance, $B_{p,Rd}$	271434.0 N
Bolt Result Item	Uf_{max}	Scale Factor Value	1.0
Definition By	Maximum Over Time		

Table 36. Bolts Result Uf_max Results summary

Bolt Id	F_x [kN]	F_y [kN]	M_z [Nm]	δ_{Adj} [mm]	P_{Head} [MPa]	F_s [kN]	F_n [kN]
1	33.937	0.184	1.487	7.121e-02	139.3	0.797	38.025
2	33.801	0.153	1.578	7.150e-02	138.7	0.809	43.978

Table 37. Bolts Result Uf_max Results summary

Bolt Id	$F_{t,Ed}$ [kN]	$F_{v,Ed}$ [kN]	Uf_{max}	$Uf_{tension}$	Uf_{punch}
1	33.937	0.797	0.700	0.700	0.125
2	33.801	0.809	0.697	0.697	0.125

Bolts Result Child Fn LC1

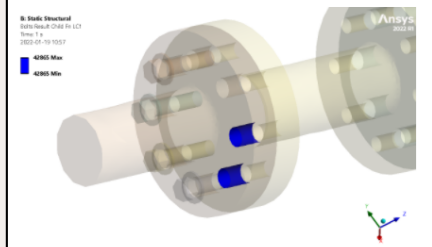


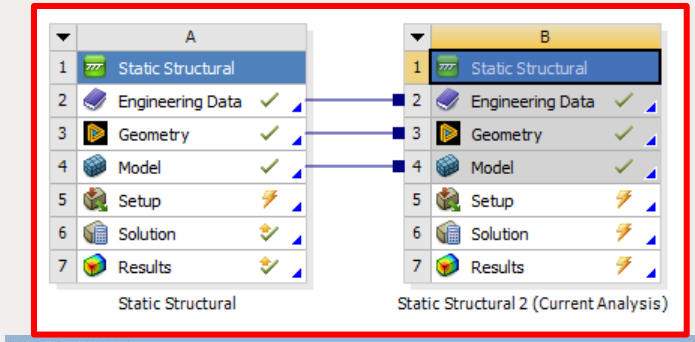
Figure 19. Bolts Result Child Fn LC1

Table 38. Bolts Result Child Fn LC1 property list

Result Name		Bolts Result Child Fn LC1	
Parent Result	Bolts Result Uf_max_Id7276		
Bolt Result Item	Normal Force	Scale Factor Value	1.0
Definition By	Time	Display Time	1.0

Grouped Result

- *Grouped Rivet/Bolt Strength/Fatigue* result combine many results within the same group in the model tree or from selected results from different analyses using the Solution Editor into one plot.
- The results *absMax*, *Max* or *Min* results can be evaluated to see the overall max from several load cases.



Details of "Grouped Bolts Strength"

Geometry	
Scoping Method	Geometry Selection
Geometry	7 Bodies
Bolt Result	
Load Group Results	Loaded (Click to re-load)
Solution Editor	Apply / Cancel
Result Max Min	Max
Result Item	Uf_max
Calculate Time History	No
Definition	
By	Time
Display Time	2. s

Solution Editor

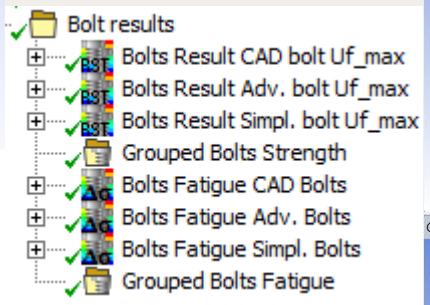
Analysis Name	Result Object
Current Analysis	Bolts Result CAD bolt Uf_max_Id188
Current Analysis	Bolts Result Adv. bolt Uf_max_Id189
Current Analysis	Bolts Result Simpl. bolt Uf_max_Id190

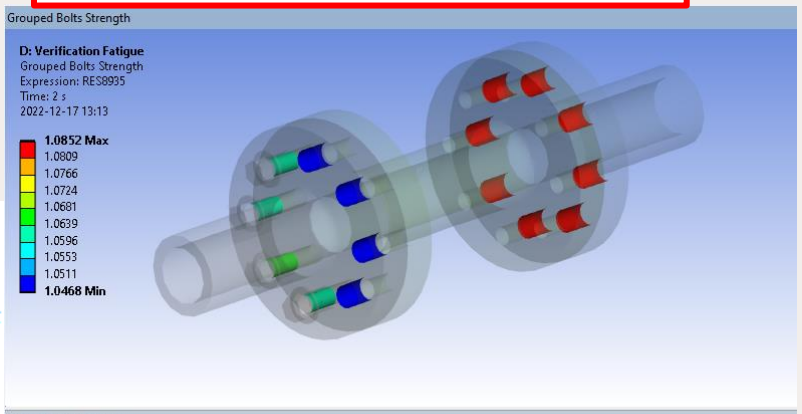
Details of "Grouped Bolts Fatigue"

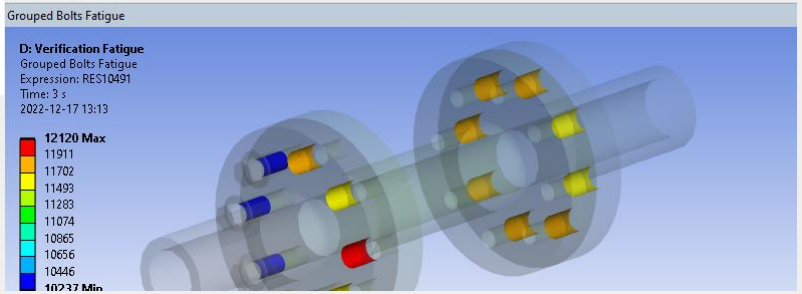
Geometry	
Scoping Method	Geometry Selection
Geometry	7 Bodies
Bolt Result	
Load Group Results	Loaded (Click to re-load)
Solution Editor	Apply / Cancel
Result Max Min	Min
Result Item	Life [N]
Definition	
By	Time
Display Time	Last

Solution Editor

Analysis Name	Result Object
Current Analysis	Bolts Fatigue Adv. Bolts_Id227
Current Analysis	Bolts Fatigue Simpl. Bolts_Id297
Current Analysis	Bolts Fatigue CAD Bolts_Id226

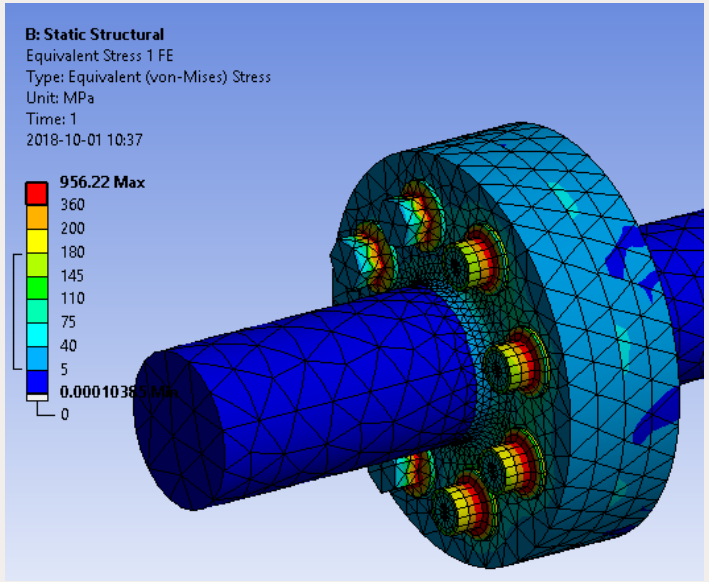


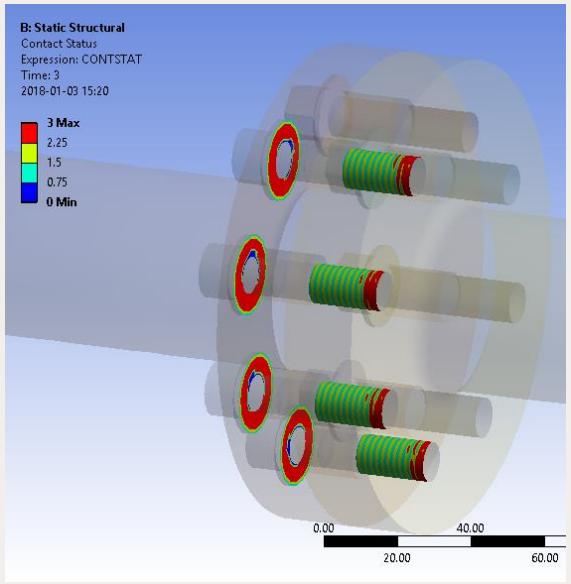


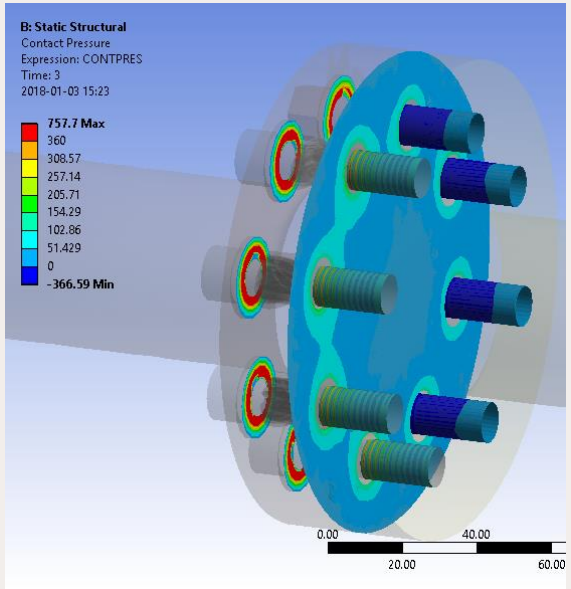


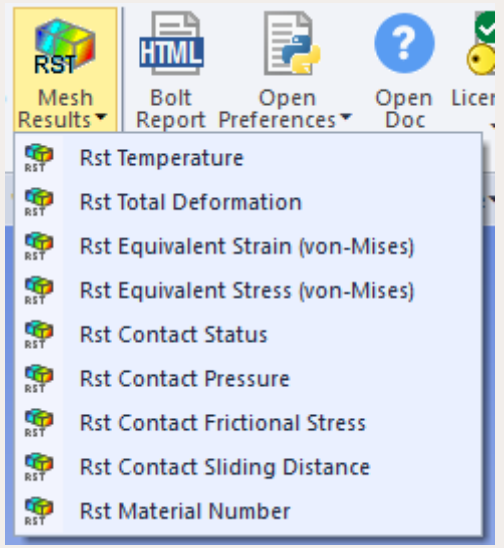
Mesh Result

- FE-based results for rivets and bolts can be easily plotted using the predefined items in the drop-down menu “Mesh Results” (since there is no geometry associated with the bolt and rivet objects).



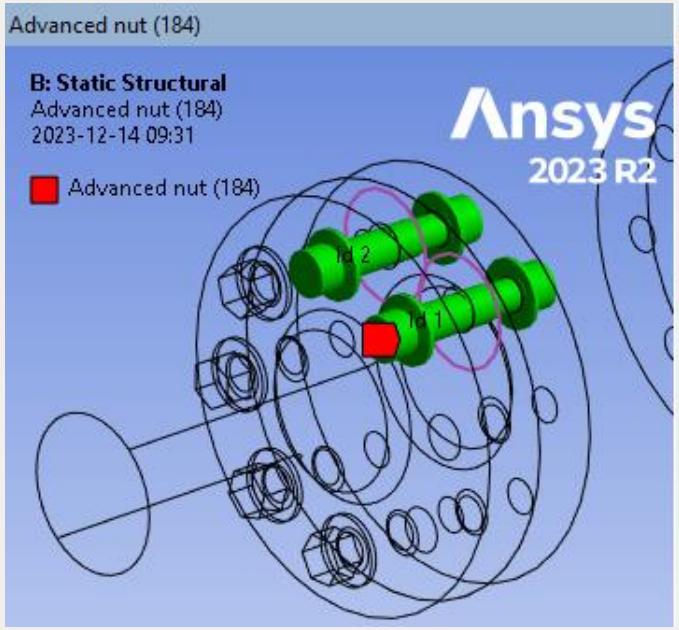


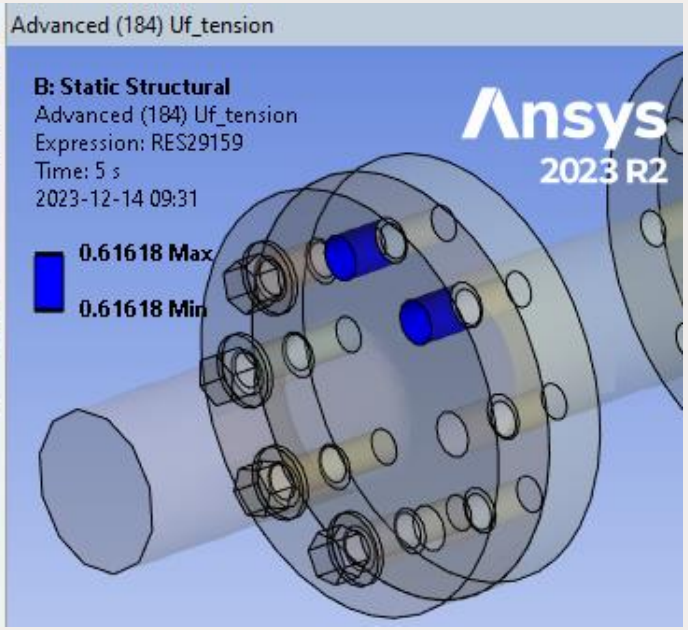




Worksheet Preview

- The “Worksheet Preview” is a feature in the *Report Generator* app that displays all details of a bolt object including the result summary tables in the “Worksheet” window. (Report Generator license is not needed.)
- This feature is useful to look at the design values and different result items in the summary tables.





Advanced (184) Uf_tension Preview

Table 1. Advanced (184) Uf_tension property list

Result Name		**Advanced (184) Uf_tension**	
Bolt Geometry			
Bolt Group	Advanced nut (184)		
Nominal Diameter, d	12.0 mm	Nominal Diameter Length	30.0 mm
Stress Diameter, d_s	12.0 mm		
Head Diameter, d_m	22.5 mm	Hole Diameter, d_0	14.0 mm
Bolt Evaluation			
Bolt Code	Eurocode 3	Bolt material class	8.8
Bolt yield strength, f_{yb}	640.0 MPa	Bolt ultimate strength, f_{ub}	800.0 MPa
Design bolt preload, $F_{p,Cd}$	57577.0 N	Applied Pretension Force, F_p	42865.0 N
Connection Category	E preloaded	Cut thread comply with EN 1090, k_{tv}	1.0 (Yes)
Plate ultimate strength, f_u	400.0 MPa	Plate thickness, t_p	20.0 mm
Safety factor, γ_{M2}	1.25		
Countersunk bolt	No	Countersunk bolt factor, k_2	0.9
Design tension resistance, $F_{t,Rd}$	65144.0 N	Design punching resistance, $B_{p,Rd}$	271434.0 N
Bolt Result Item	$Uf_{tension}$	Scale Factor Value, γ_L	1.0
Result averaging	Individual	Result Location	Mid
Definition By	Time	Display Time	5.0

Table 2. Advanced (184) Uf_tension Results summary

Bolt Id	F_n [kN]	F_v [kN]	M_b [Nm]	δ_{Adj} [mm]	P_{head} [MPa]	F_s [kN]	F_c [kN]
1	40.133	0.152	3.243	2.936e-01	164.7	0.314	35.594
2	40.140	0.122	2.602	2.938e-01	164.7	0.415	35.927

Table 3. Advanced (184) Uf_tension Results summary

Bolt Id	$F_{t.Ed}$ [kN]	$F_{v.Ed}$ [kN]	Uf_{max}	$Uf_{tension}$	Uf_{punch}
1	40.133	0.314	0.616	0.616	0.148
2	40.140	0.415	0.616	0.616	0.148

Geometry | Worksheet

Bolt Report

- A HTML formatted report of all rivets, bolts and results including any comments, figures and images is created with a click on “Bolt Report” using the *Report Generator* app. (Report Generator license is not needed.)
- The report can be imported to Microsoft Word (Insert>Text from File…).

EDR MEDESO

Bolt Toolkit report

Project details

Project: Bolt Toolkit
Subject: Verification analysis Eurocode 3
Author: Magnus Gustafsson
Prepared for: End User
Ansys version: 2021 R2
Project file: C:\MagnusG\ANSYS_ACT_temp\Bolt_Toolkit_Verification_V212.1.wbpj
Project Last saved: Thursday, October 28, 2021
Report created date: 2021-10-29 10:10
Report created by app: Bolt Toolkit V212.1

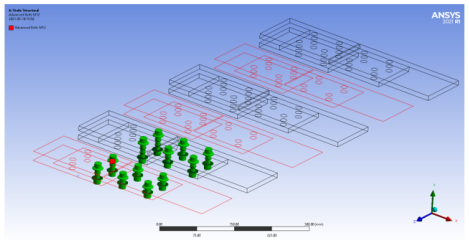
Static Structural

Verification analysis for bolt results.

Shell and solid geometry is used with rivets, simplified bolts, advanced bolts and CAD bolts with bolt group pretension.

LC 1: Bolt pretension force: $F_{p,Cd} = F_{p,Cd} = 42865$ N
LC 2: Bolt pretension lock. Shear force: $F_X = 10000$ N
LC 3: Bolt pretension increment: -0.02 mm. Shear force: $F_X = 10000$ N

Figure 1. Model setup



Advanced Bolts Group

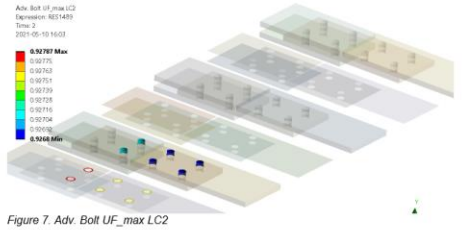
Advanced Bolts M12

Note that surface normal for shell parts must be outward facing the bolt head/nut (the green side of face)

Figure 4. Advanced Bolts M12

Advanced Bolt Connection Name	Advanced Bolts M12		
Bolt Geometry File	FlangeBolt_ISO15071	Element Order	Linear
Material Name	Steel bolt 8.8	Nonlinear Effects	No
Bolt Dimension, d	12.0 mm	Head Diameter, d_m	22.5 mm
Bolt Length	Through All	Nominal Shaft Length	15.0 mm
Head Friction, μ_H	0.14	Thread Friction, μ_G	0.14
Pretension Torque, M	107953.018 N mm	Tightening Factor, α_A	1.0
Pretension Force, F_p	45000.0 N	Pretension Type	PRETS179
Load Step Apply	1	Load Step Lock	2

Table 3. Advanced Bolts M12 property list



Adv. Bolt LC2

Figure 7. Adv. Bolt UF_max LC2

Result Name	Adv. Bolt LC2		
Bolt Geometry			
Bolt Group	Advanced Bolts M12		
Nominal Diameter, d	12.0 mm	Head Diameter, d_m	22.5 mm
Stress Diameter, d_s	10.4 mm	Hole Diameter, d_0	13.0 mm
Bolt Evaluation			
Bolt Code	Eurocode 3	Bolt material class	8.8
Bolt yield strength, f_{yb}	640.0 MPa	Bolt ultimate strength, f_{ub}	800.0 MPa
Design bolt preload, $F_{p,Cd}$	42865.0 N	Applied Pretension Force, F_p	45000.0 N
Connection Category	F shear and tension	Cut thread comply with EN 1090	Yes
Plate ultimate strength, f_u	400.0 MPa	Plate thickness, t_p	10.0 mm
Safety factor, γ_{M2}	1.25	Safety factor, γ_{M3}	1.1
Shear resistance factor, α_v	0.5	Design shear resistance per plane and bolt, $F_{v,Rd}$	23095.0 N
Bolt hole type	Normal	Bearing resistance factor, k_b	1.0
End distance (parallel), e_1	30.0 mm	Inner distance (parallel), p_1	63.0 mm
End distance (perpendicular), e_2	25.0 mm	Inner distance (perpendicular), p_2	50.0 mm
Bearing resistance factor, α_b	0.769	Bearing resistance factor, k_1	2.5
Design bearing resistance per hole, $F_{b,Rd}$	57600.0 N		
Class of friction surface	None	Plate slip factor, μ	0.14
Slip resistance factor, k_s	1.0	Design slip-resistans per plane and bolt, $F_{s,Rd}$	5727.0 N
Countersunk bolt	No	Countersunk bolt factor, k_2	0.9
Design tension resistance, $F_{t,Rd}$	48499.0 N	Design punching resistance, $B_{p,Rd}$	135717.0 N
Bolt Result			
Result Item	UF_{max}	Scale Factor Value	1.0
Definition			
By	Time	Display Time	2.0

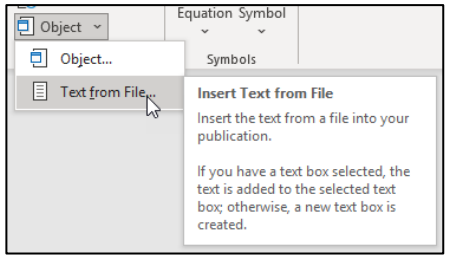
Table 10. Adv. Bolt LC2 property list

Bolt Id	X [mm]	Y [mm]	Z [mm]	F_{vy} [N]	F_{vz} [N]	F_x [N]	δ_{Ug} [mm]	α_A [-]	P_{head} [MPa]
1	2.190e+02	2.000e+01	7.250e+02	4.499e+04	2.618e+02	2.490e+03	3.291e-01	1.000	169.8
2	2.190e+02	2.000e+01	6.750e+02	4.499e+04	2.620e+02	2.486e+03	3.290e-01	1.000	169.8
3	1.560e+02	2.000e+01	7.250e+02	4.499e+04	3.022e+02	9.856e+02	3.289e-01	1.000	169.8
4	1.560e+02	2.000e+01	6.750e+02	4.499e+04	3.037e+02	1.394e+03	3.291e-01	1.000	169.8
5	9.300e+01	1.643e+01	6.750e+02	4.500e+04	1.130e+02	3.253e+03	3.906e-01	1.000	169.9
6	9.300e+01	1.643e+01	7.250e+02	4.500e+04	7.407e+01	3.390e+03	3.923e-01	1.000	169.9
7	9.300e+01	1.636e+01	5.250e+02	4.496e+04	1.337e+01	1.660e+03	3.252e-01	1.000	169.8
8	9.300e+01	1.636e+01	5.750e+02	4.497e+04	1.232e+01	1.653e+03	3.252e-01	1.000	169.8
9	1.560e+02	2.143e+01	5.250e+02	4.495e+04	2.578e+02	7.296e+02	2.911e-01	1.000	169.7
10	1.560e+02	2.143e+01	5.750e+02	4.495e+04	2.564e+02	7.326e+02	2.911e-01	1.000	169.7
11	2.190e+02	2.143e+01	5.250e+02	4.495e+04	2.607e+02	2.283e+03	2.911e-01	1.000	169.7
12	2.190e+02	2.143e+01	5.750e+02	4.495e+04	2.572e+02	2.344e+03	2.911e-01	1.000	169.7

Table 11. Adv. Bolt LC2 Results summary

Bolt Id	F_{LEd} [N]	$F_{t,Ed}$ [N]	UF_{max}	UF_{shear}	$UF_{bearing}$	$UF_{tension}$	UF_{punch}	UF_{comb}	UF_{slip}
1	4.499e+04	2.490e+03	0.928	0.108	0.043	0.928	0.331	0.770	0.435
2	4.499e+04	2.486e+03	0.928	0.108	0.043	0.928	0.331	0.770	0.434
3	4.499e+04	9.856e+02	0.928	0.043	0.017	0.928	0.331	0.705	0.172
4	4.499e+04	1.394e+03	0.928	0.060	0.024	0.928	0.331	0.723	0.243
5	4.500e+04	3.253e+03	0.928	0.141	0.056	0.928	0.332	0.804	0.568
6	4.500e+04	3.390e+03	0.928	0.147	0.059	0.928	0.332	0.810	0.592
7	4.496e+04	1.660e+03	0.927	0.072	0.029	0.927	0.331	0.734	0.290
8	4.497e+04	1.653e+03	0.927	0.072	0.029	0.927	0.331	0.734	0.289
9	4.495e+04	7.296e+02	0.927	0.032	0.013	0.927	0.331	0.694	0.127
10	4.495e+04	7.326e+02	0.927	0.032	0.013	0.927	0.331	0.694	0.128
11	4.495e+04	2.283e+03	0.927	0.099	0.040	0.927	0.331	0.761	0.399
12	4.495e+04	2.344e+03	0.927	0.101	0.041	0.927	0.331	0.763	0.409

Table 12. Adv. Bolt LC2 Results summary



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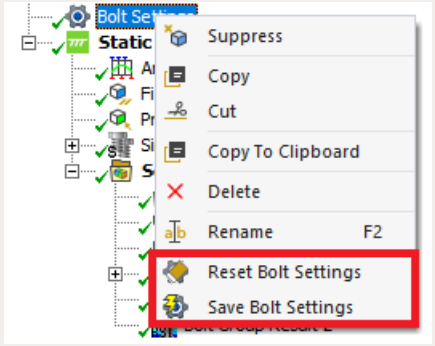
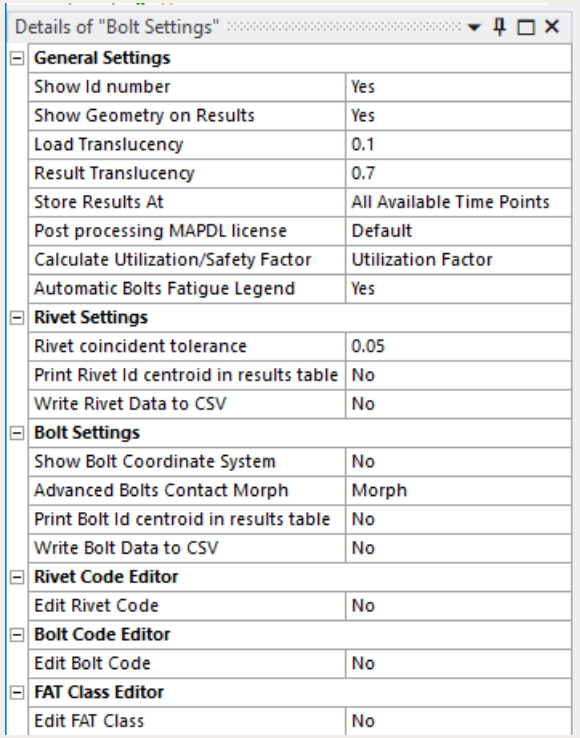
Bolt Settings

- The *Bolt Toolkit* has a new easy to use “Bolt Settings” object to customize general settings in the app.
- Bolt/Rivet codes and FAT-class S-N curves are also fully editable.
- Changes made can be saved as new app default values.





FAT Class List

FAT Class	FAT (@ Nfat cycles)	Nfat	N0	Nc	Ncutoff	Slope, m0	Slope, m1	Slope, m2
EC3 FAT160	160 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT140	140 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT125	125 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT112	112 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT100	100 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT90	90 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT80	80 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT71	71 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT63	63 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT56	56 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT50	50 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT45	45 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT40	40 [MPa]	2000000	0	5000000	100000000	3	3	1000000
EC3 FAT36	36 [MPa]	2000000	0	5000000	100000000	3	3	1000000

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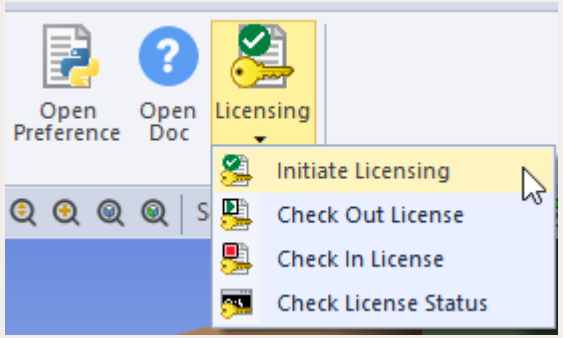
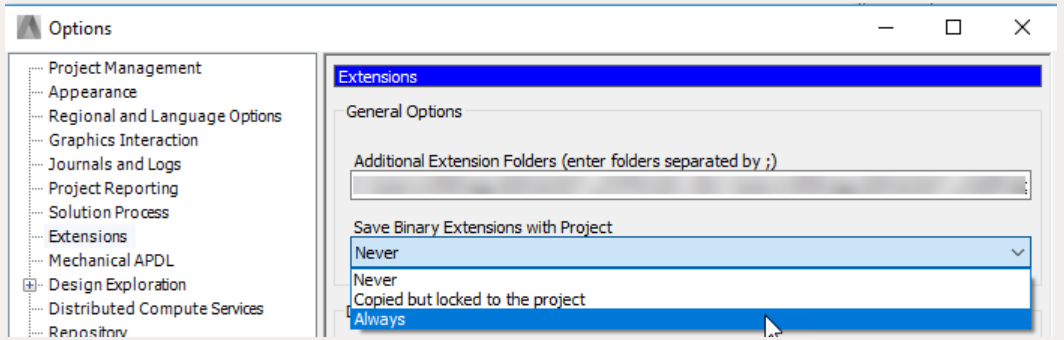
- You may also open Mechanical without the app license being checked out.
(This allows the model to be shared with people without access to the app or license.
Just make sure to *“Save Binary Extension with Project”*, see *“WB>Tools>Options…>Extensions”* below.)
- You may activate the app license to reserve it for your continuous use. *“Check Out License”*
- You may release the app license from the current Mechanical session to use it in another session within the same project or a different project or by a different user. *“Check In License”*
- You may check the status of available licenses and who is using the license. *“Check License Status”*
- The app license is automatically checked out when evaluating a feature during solve or post processing.
- If the license is not available a warning message is displayed in Mechanical.





References

- Bolt and rivet utilization calculation according to:

  Eurocode 3: EN 1993-1-8:2005. Design of steel structures - Part 1-8: Design of joints [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

  AISC 360-16: Specification for Structural Steel Builds, July 7 2016. American Institute of Steel Construction, 130 East Randolph Street, Suite 2000, Chicago, Illinois 60601-6204

- Bolt fatigue calculation according to:

  Eurocode 3: EN 1993-1-9:2005. Design of steel structures - Part 1-9: Fatigue [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]

Thank You!

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