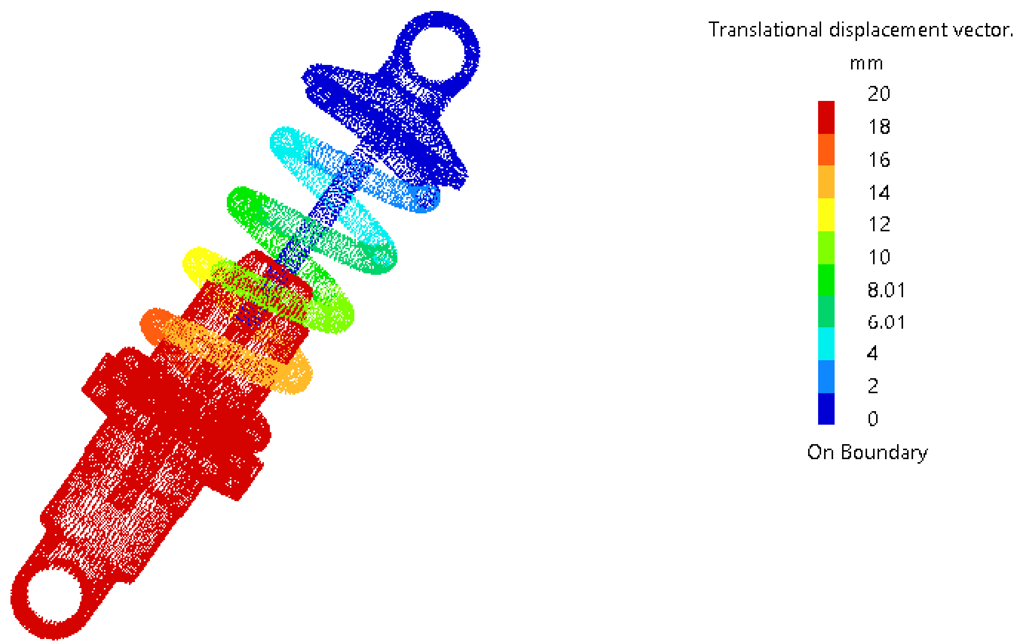
Shock Absorber Preload Analysis using CATIA Generative Structural Analysis (FEA)



- The following licenses are required to create the Shock Absorber Preload Simulation:
  - Generative Shape Design
  - Mechanical Part Design
  - Generative Structural Analysis

- Issues to prove with this coil over shock absorber FEA analysis:

1. The spring rate will be linear when the spring has a consistent (evenly spaced) pitch and a constant diameter.

2. Preloading the spring on the coil over assembly will NOT change the rate of the spring.

3. Preloading the spring on the coil over assembly WILL affect the deflection at load (length at load) of the shock absorber.

1.1) Calculate the spring values.

From CATIA				C3 Project Front Spring Calculation													
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L_f]			Total coils [N_t]	Active coils [N_a]	Select End Types:
	(psi x 10^6)	(MPa x	contraction	(psi x 10^6)	(MPa x 10^3)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	10.000	0.254	254	8.650	6.650	Squared or closed (Ground)
				11501494	79300000000												

$$k = \frac{d^4 G}{8 D^3 N_a}$$

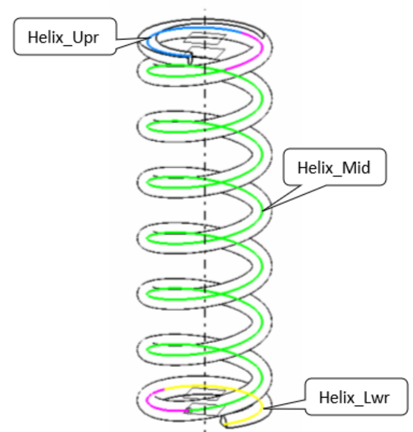
$$\nu = \frac{E}{G \cdot 2} - 1$$

G = E / (2*(1+ν))

Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]	
inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm
1.475	0.0375	37.475	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64

Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

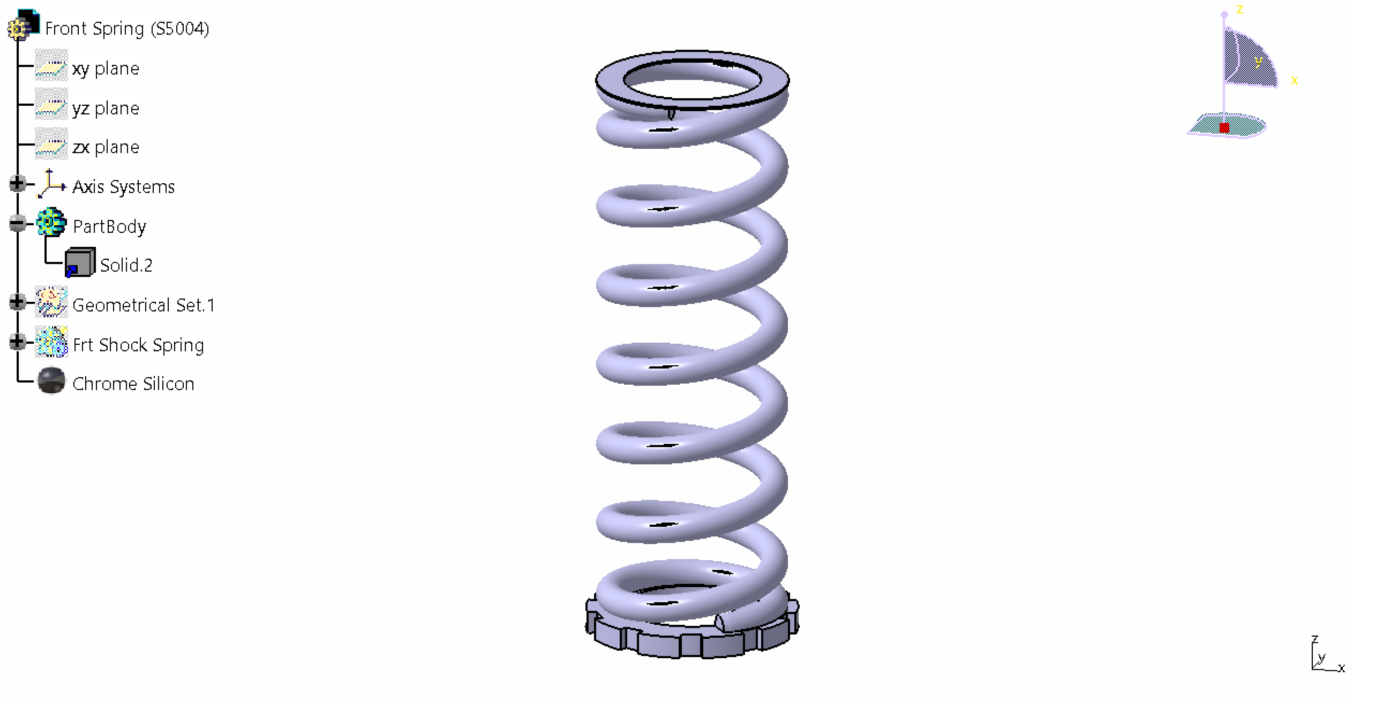
in	lb	in	lb/in
3.000	197.03	0.394	500.4



Adjusted for CATIA FEA	
38.195	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
232.992	= Height in Helix_Mid
21.01	= Δ Free Length to Helix_Mid Ht.
10.504	= Height of Helix_Mid Start Plane
0.77	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
8.088	= Pitch in Helix_Upr&Lwr
5.252	= Height in Helix_Upr&Lwr

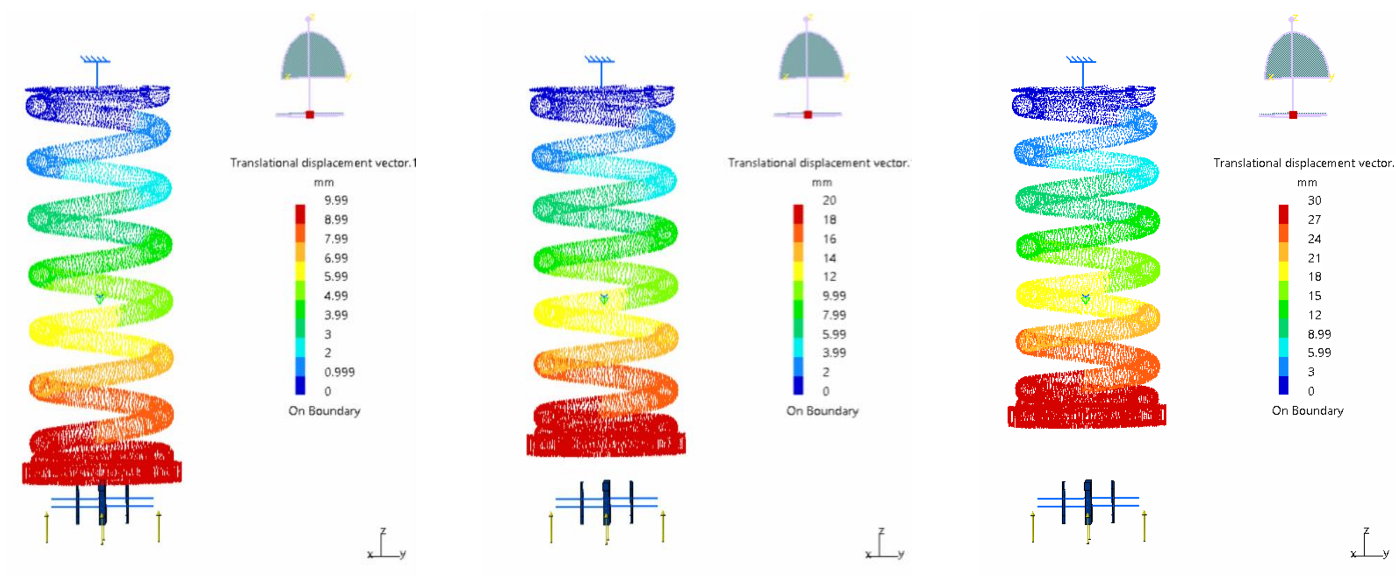
1.2) Create a CATIA Part model of the Spring.

- Since this is an FEA simulation analysis of a coil over shock absorber assembly, we will assume the user has created all the parts within the assembly.



BND TechSource

1.3) Create an FEA analysis of the Spring which correlates the Spring Rate of the CATIA Part model and proves the rate to be Linear.



Load = 10X the Spring Rate ➔ 10mm Defl.

Load = 20X the Spring Rate ➔ 20mm Defl.

Load = 30X the Spring Rate ➔ 30mm Defl.

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2.1) Change the Free Length of the Spring on the Calculation sheet to remove the deflection caused by the Preload value.

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Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L_f]			Total coils [N_t]	Active coils [N_a]	Select End Types:
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Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]	
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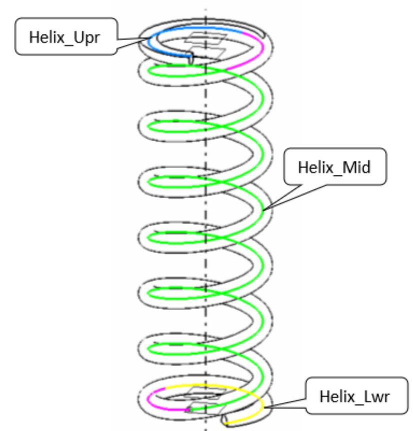

Adjusted for CATIA FEA	
36.692	= Pitch in Helix_Mid
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223.820	= Height in Helix_Mid
20.18	= Δ Free Length to Helix_Mid Ht.
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7.769	= Pitch in Helix_Upr&Lwr
5.045	= Height in Helix_Upr&Lwr

2.2) Update the CATIA Part for the Spring using the new values from the calculations sheet.

Adjusted for CATIA FEA	
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6.10	= Coils in Helix_Mid
223.820	= Height in Helix_Mid
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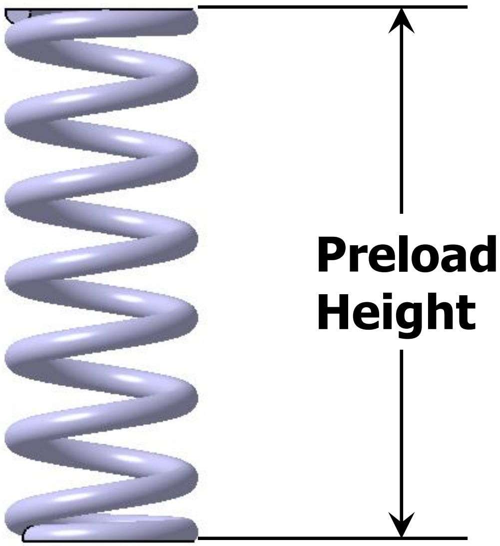

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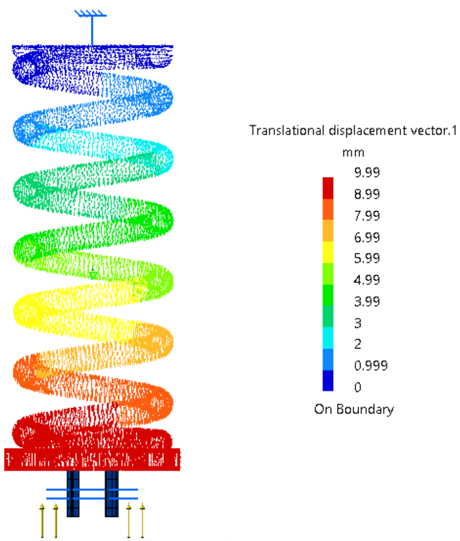
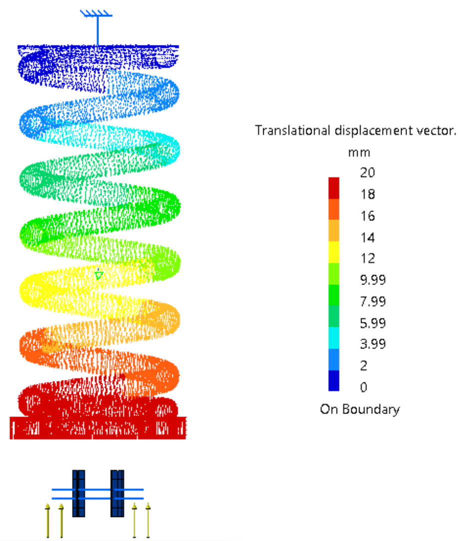
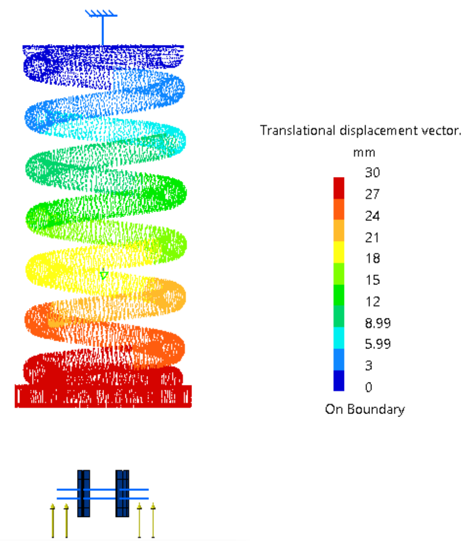
2.3) Create an FEA analysis of the Preloaded Spring to correlate the Spring Rate from the CATIA Part model and prove the rate remains Linear.



Load = 20X the Spring Rate – the Preload ➔ 10mm Defl.

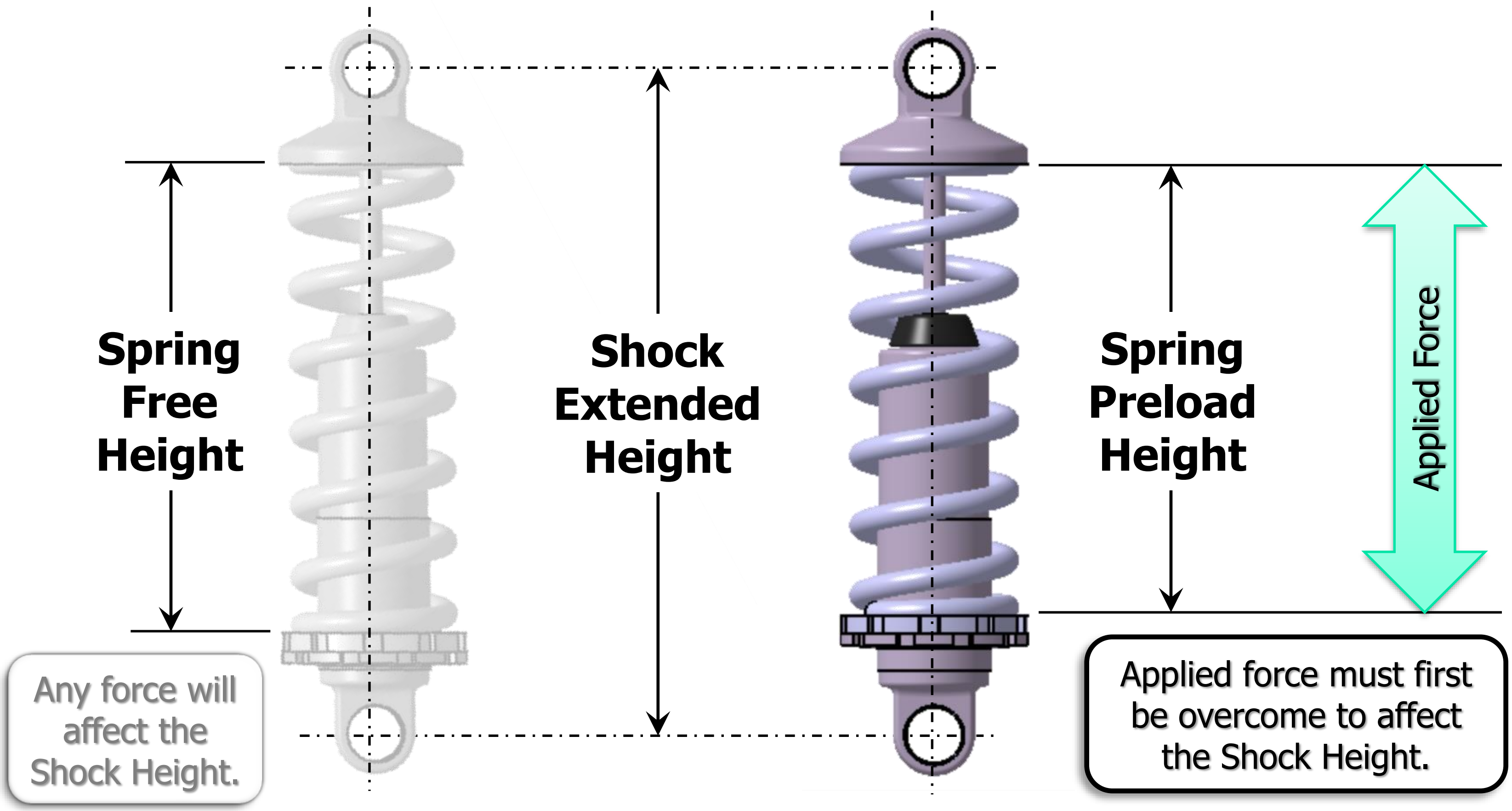


Load = 30X the Spring Rate – the Preload ➔ 20mm Defl.



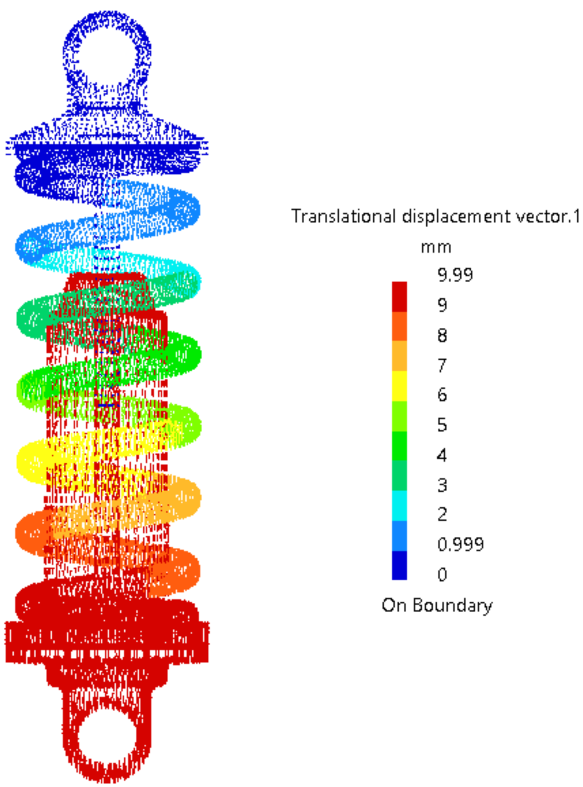
Load = 40X the Spring Rate – the Preload ➔ 30mm Defl.

3.1) Create a CATIA Product model of the Coil Over Shock Absorber Assembly in the Preloaded condition.



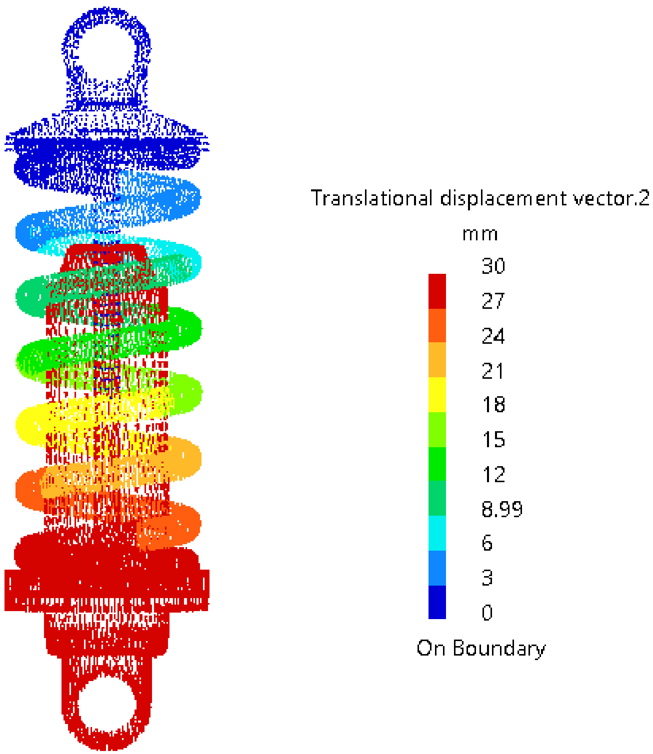
3.2) Create an FEA analysis (Static Case.Preload) of the Coil Over Assembly applying the proper restraints and loads.

(10x rate = 10mm deflection)



Static Case.Preload will be used as the **Preload** for this simulation.

3.3) Create an FEA analysis (Static Case.Shock Load) of the Coil Over Assembly applying the proper restraints and loads.
(30x rate = 30mm deflection)



Static Case. Shock Load will be used as the **Shock Load** for this simulation.

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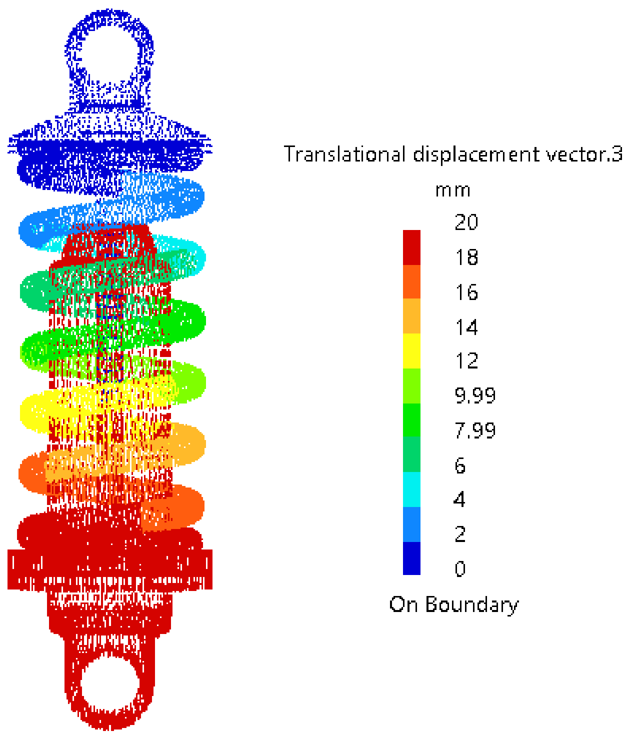
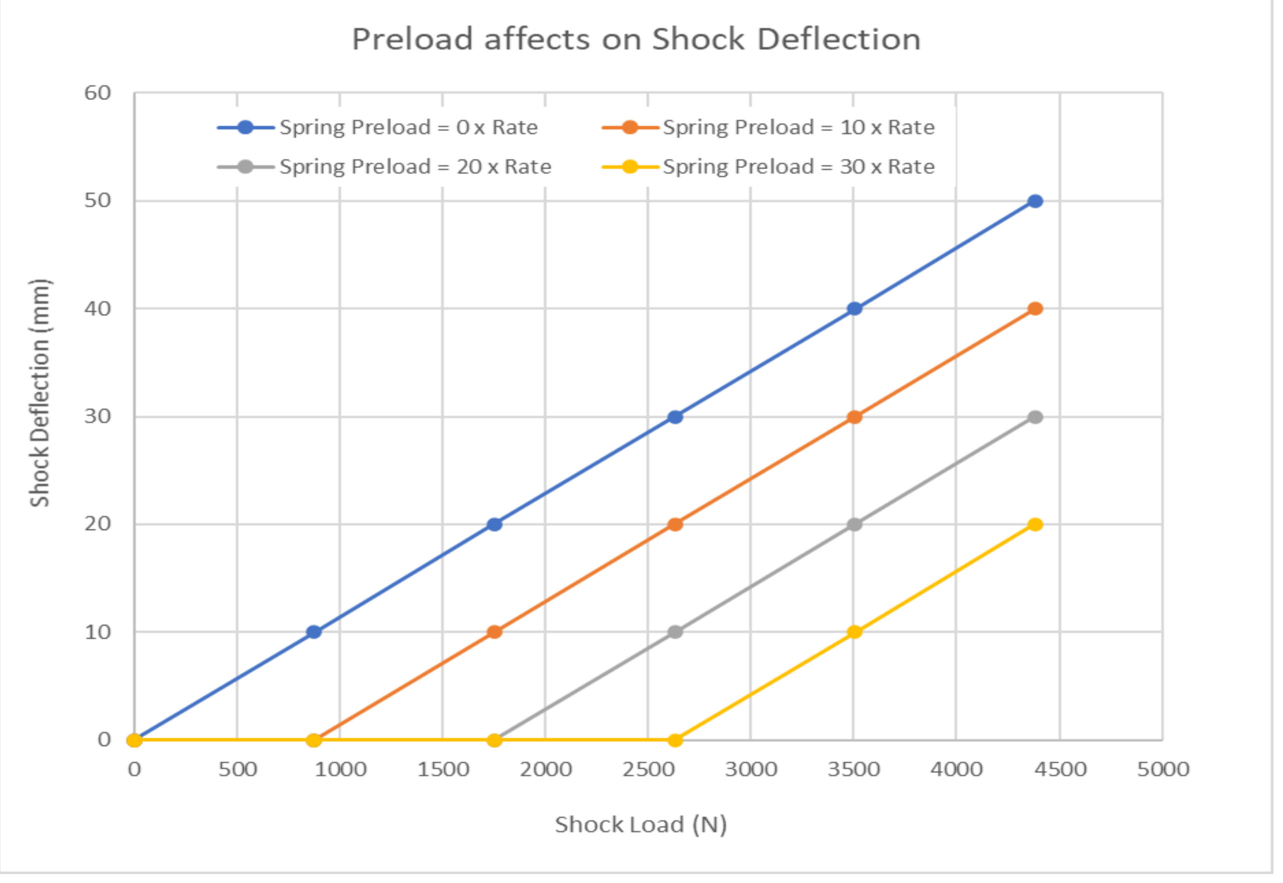
3.4) Create an FEA analysis (Combined Case.Shock Load) of the Coil Over Assembly applying the proper restraints and loads.
(Shock Load – Preload = Resultant Shock Load ➔ Shock Deflection)



Combined Case. Shock Load will be used as the **Resultant Shock Load** for this simulation.

3.5) Graph below shows the Shock Deflection based on Shock Load at various Preload conditions.



Create the Free Length Spring FEA

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- Create an Excel spreadsheet to calculate the spring values.

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Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction]	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L_f]			Total coils [N_t]	Active coils [N_a]	Select End Types:
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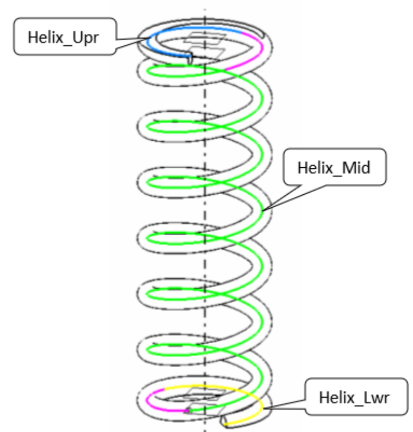

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8.088	= Pitch in Helix_Upr&Lwr
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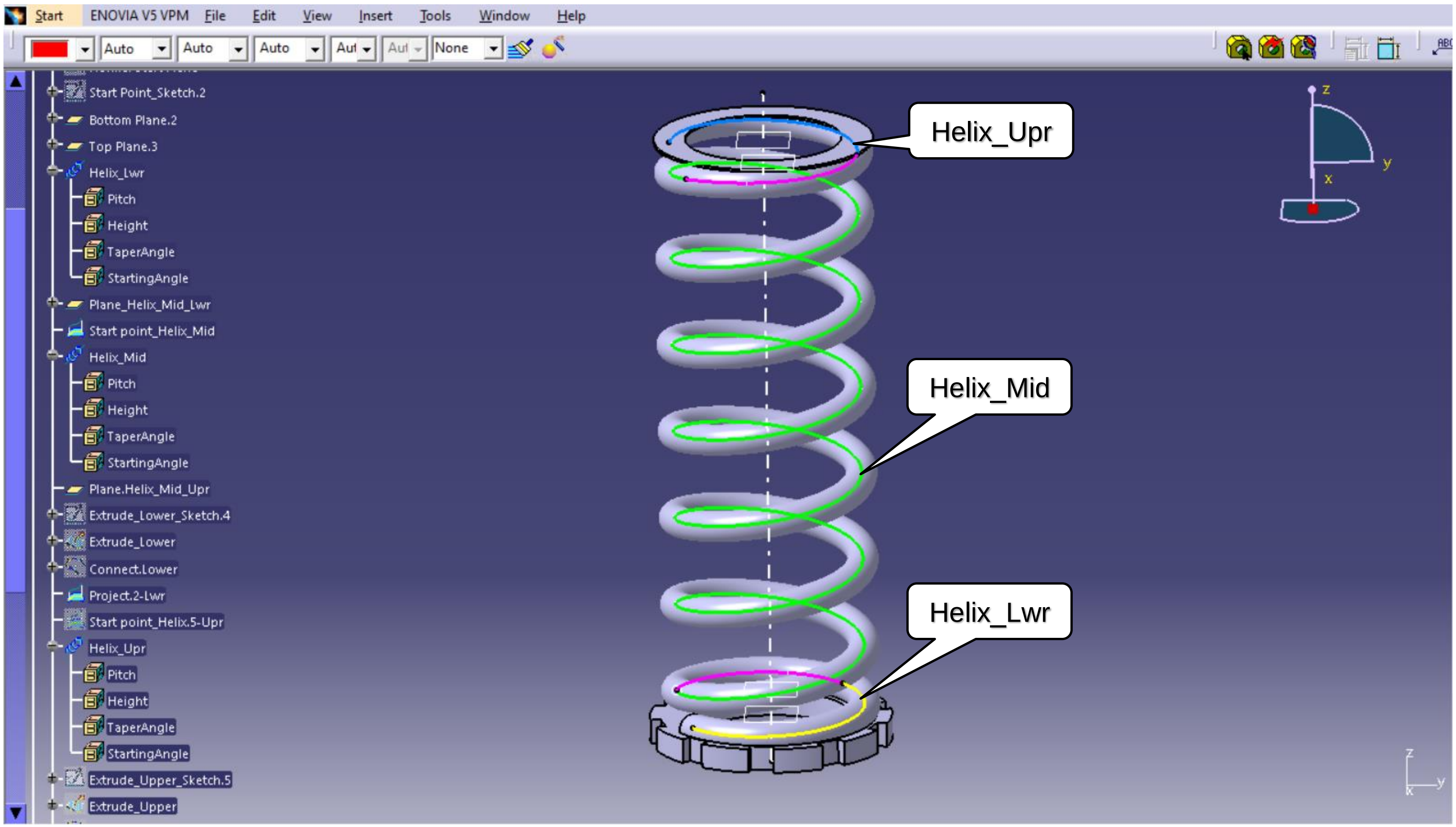
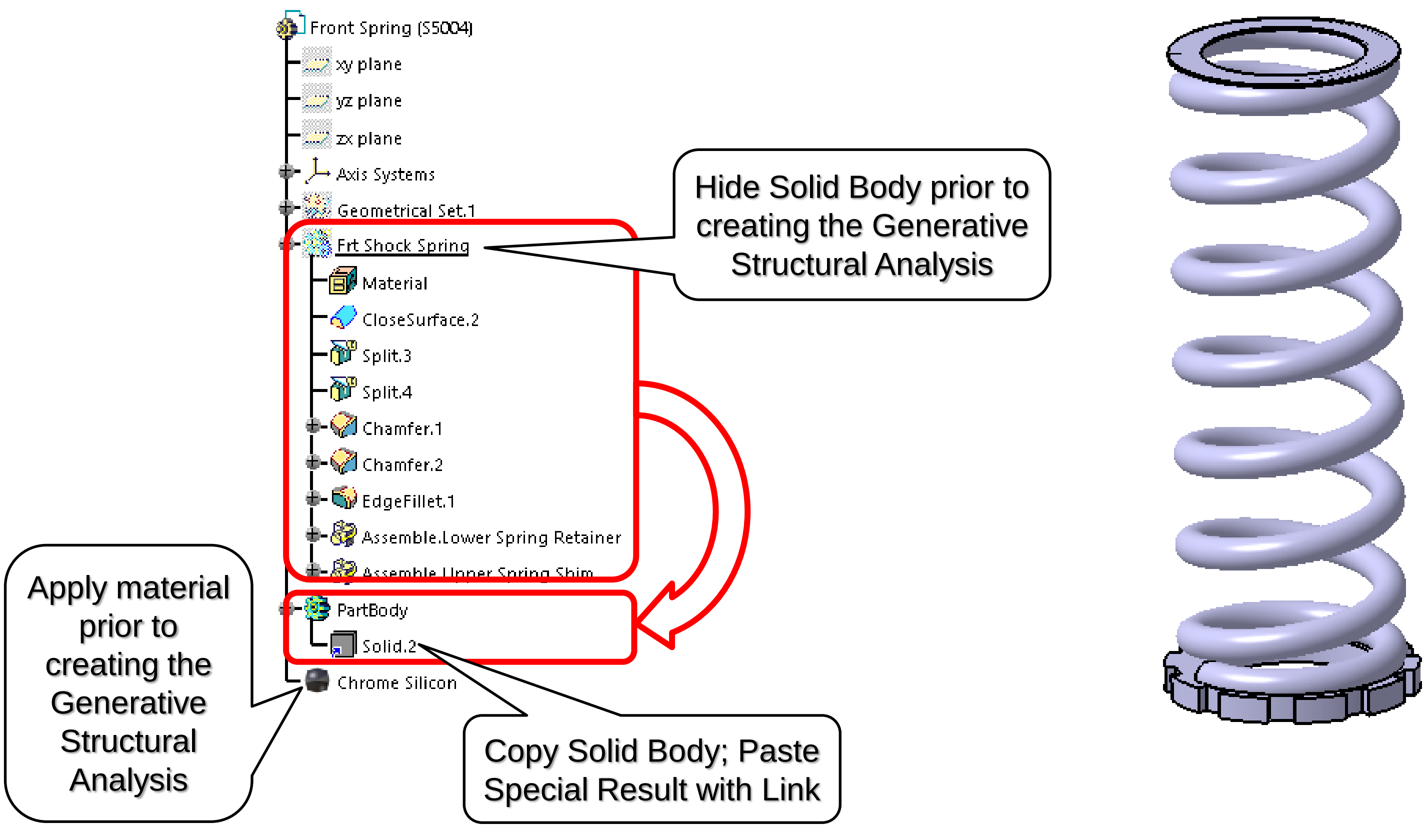
BND TechSource

- Create the Spring based on calculated the spring values.

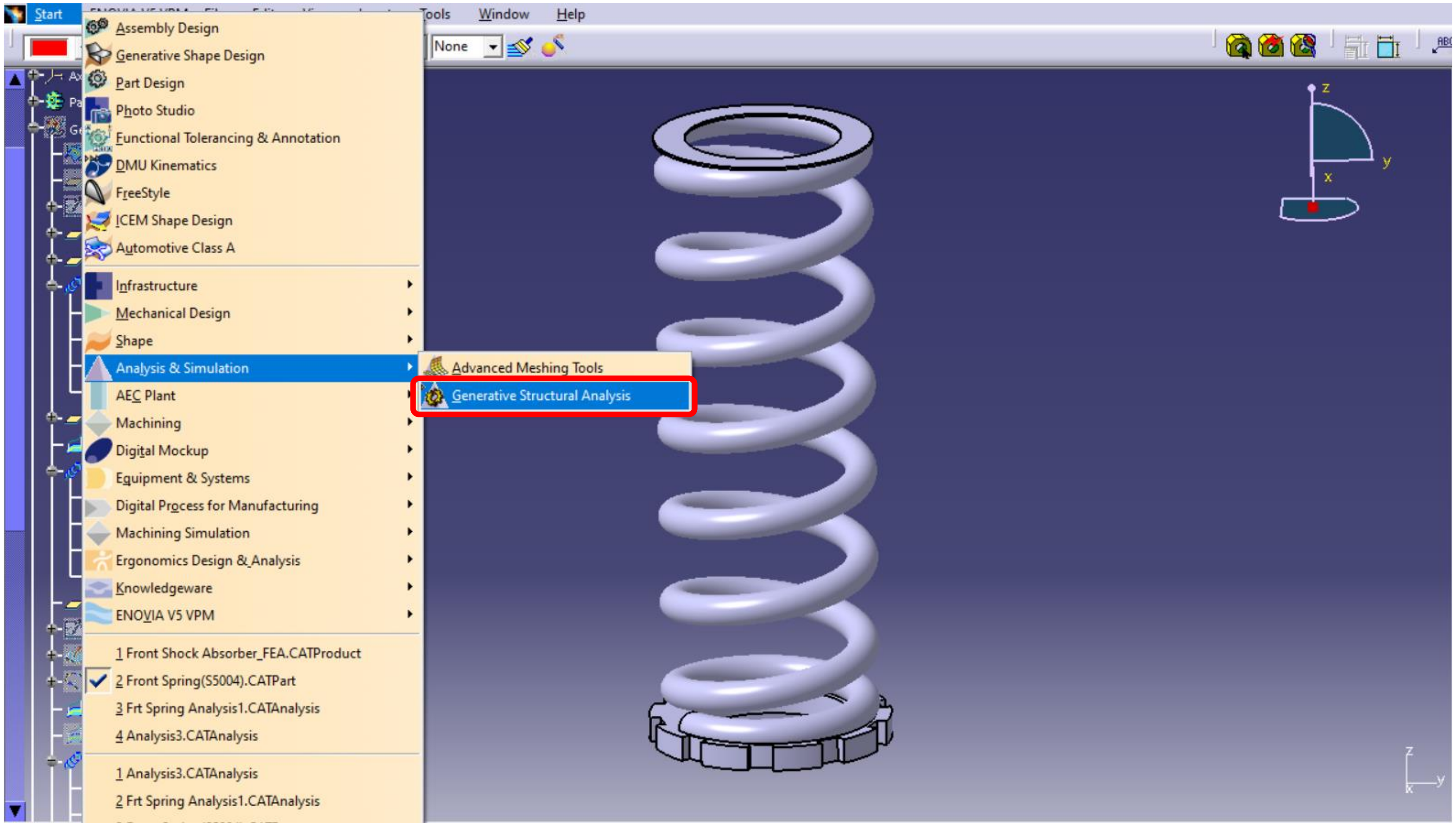


- Generative Structural Analysis only works with the geometry inside the PartBody!



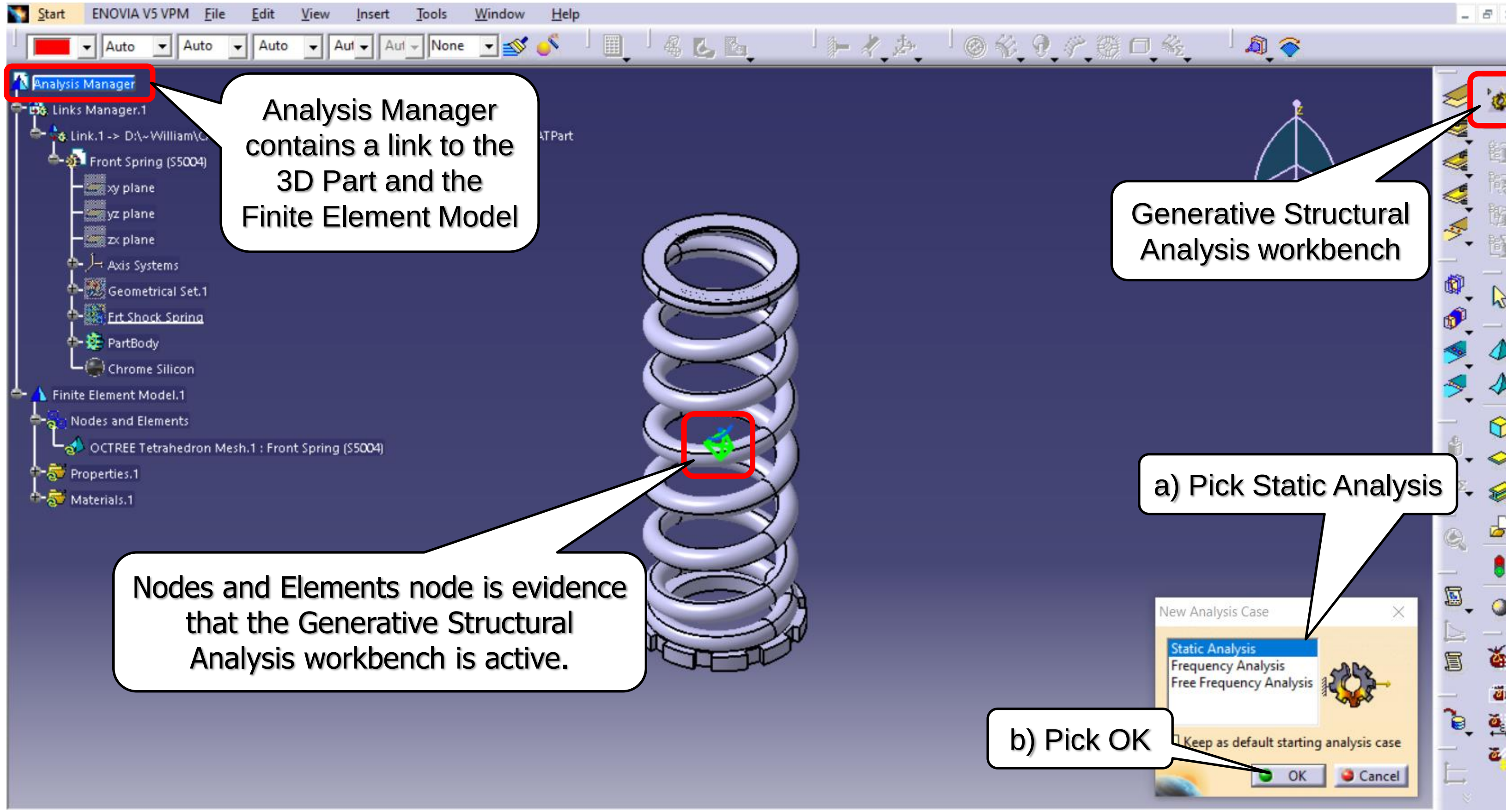
BND TechSource

- While inside the CatPart, call the Generative Structural Analysis workbench.

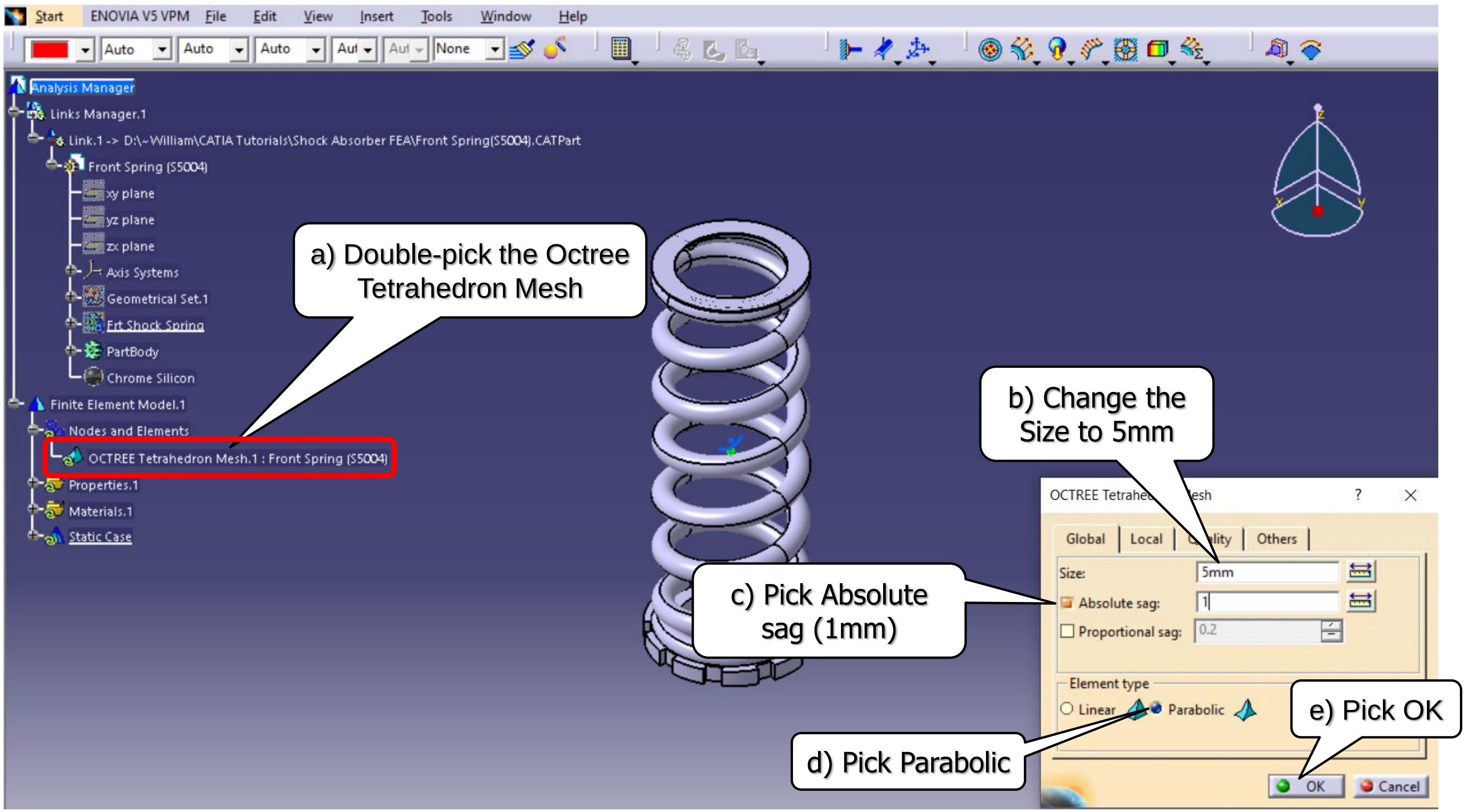


BND TechSource

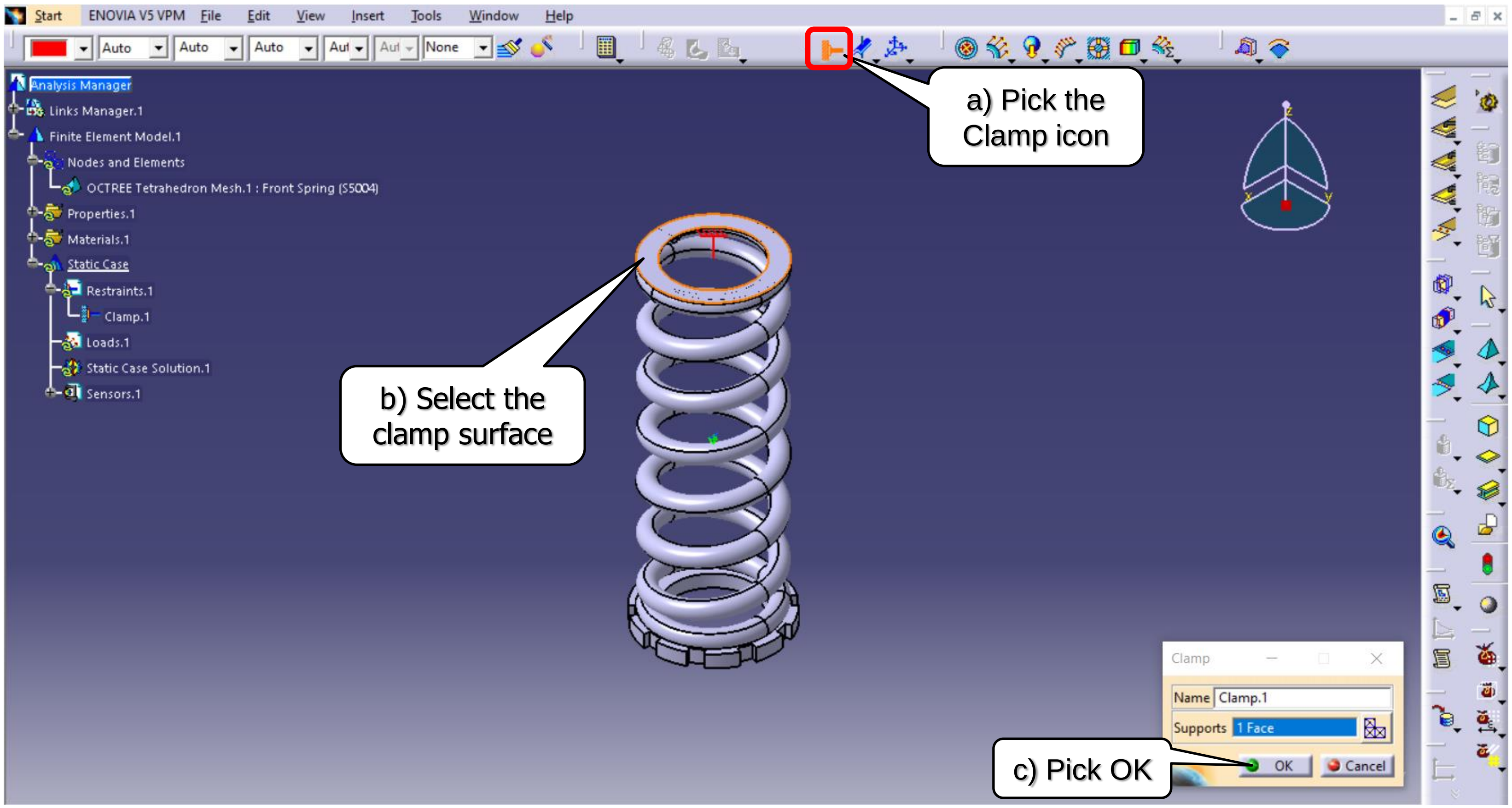
- Generative Structural Analysis workbench creates the Analysis Manager.



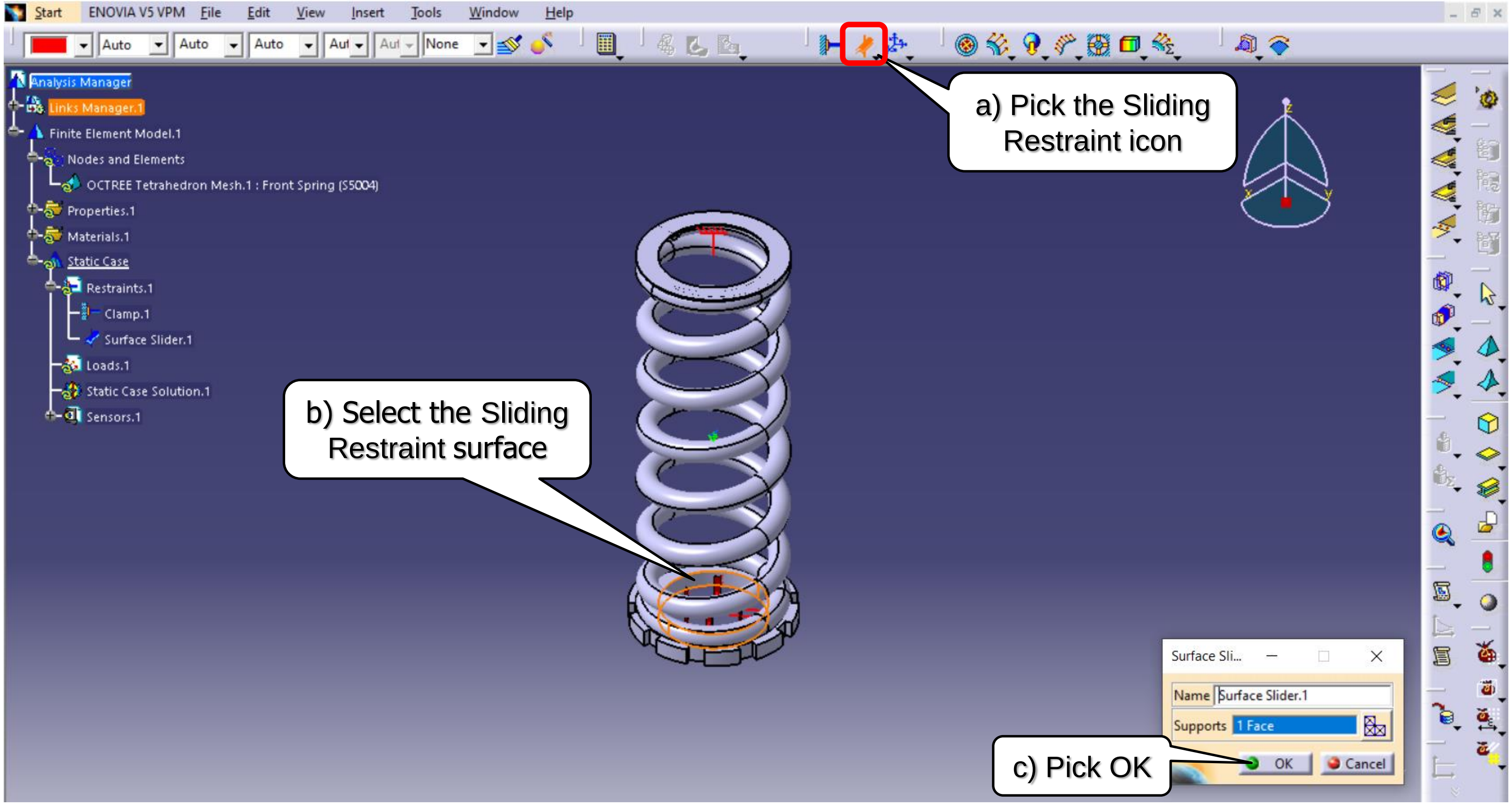
- Optimize the Mesh for the Spring.



- Create the Clamp Restraint.



- Create the Sliding Restraint.



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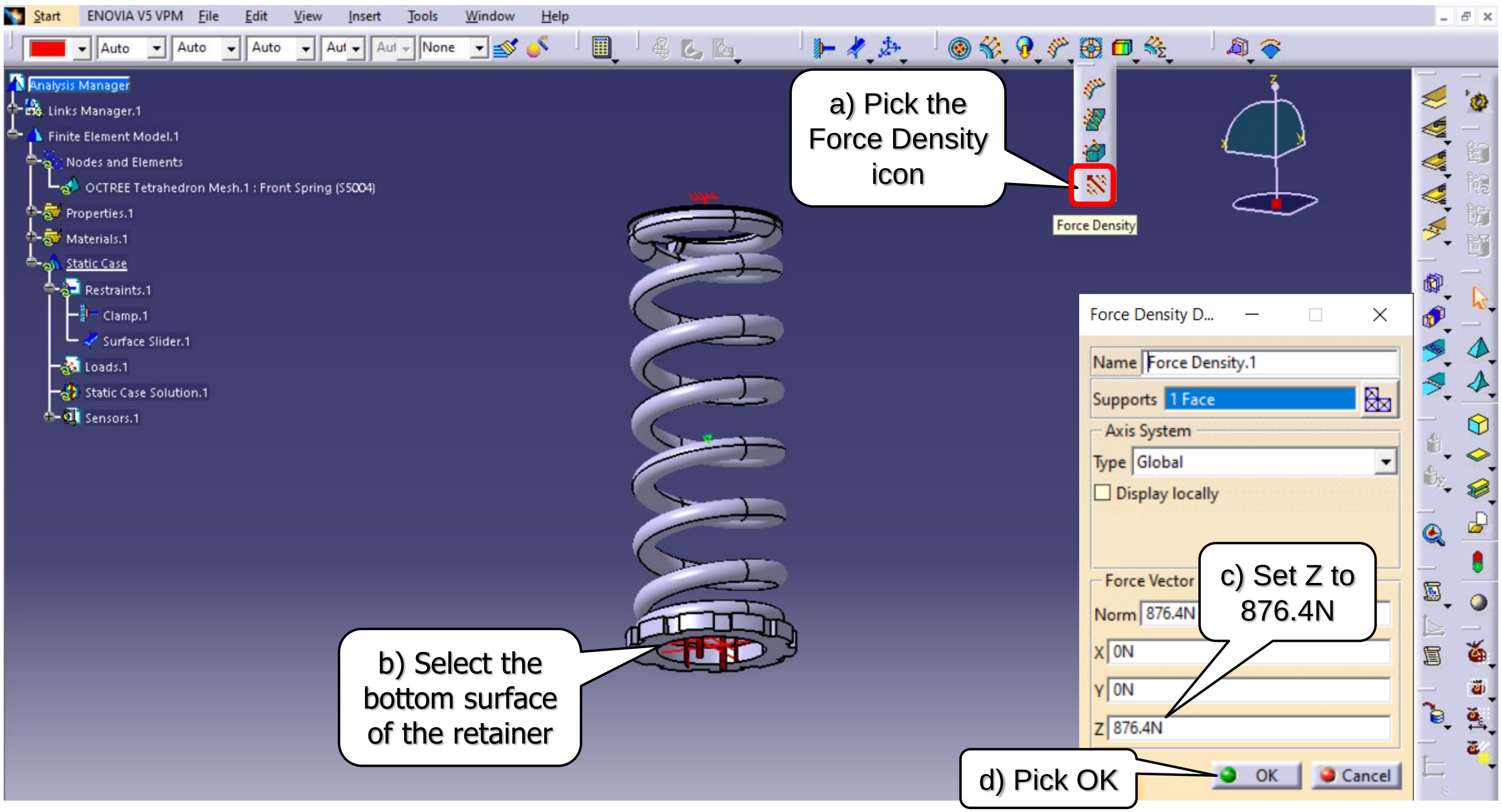
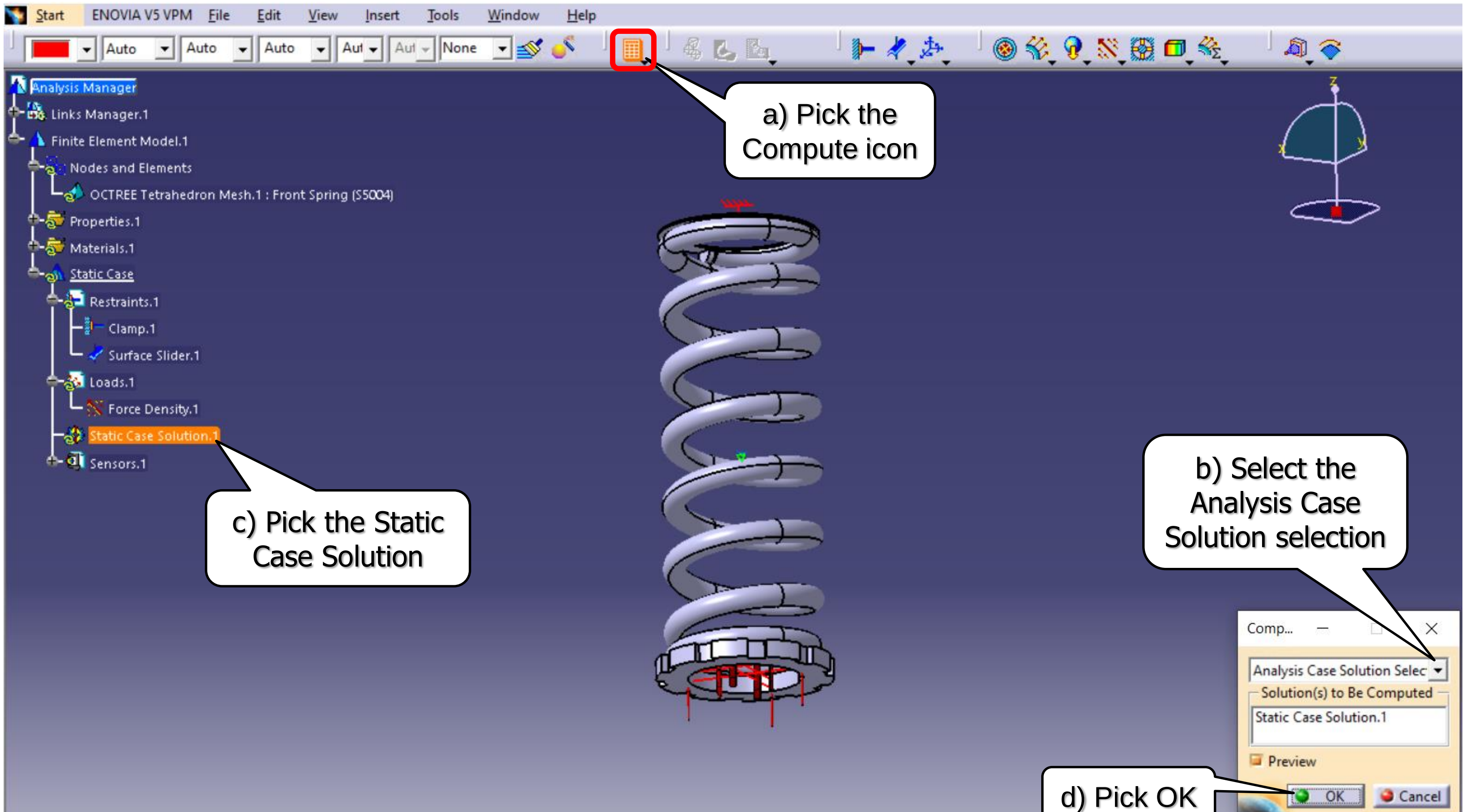
- Create the Load (10 x rate ➔ 876.4N).



BND TechSource

- Compute the analysis of the Free Length Spring.



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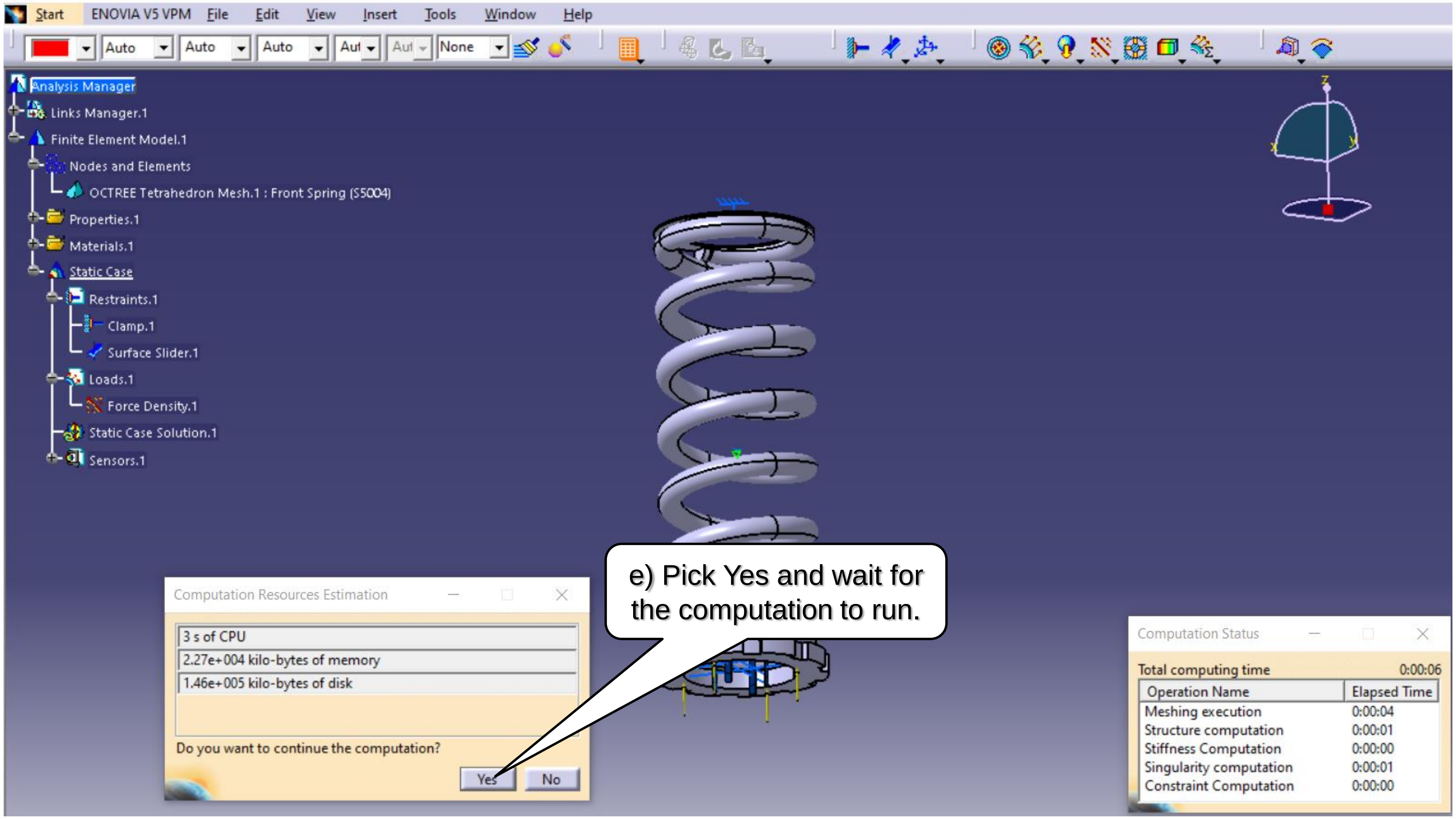
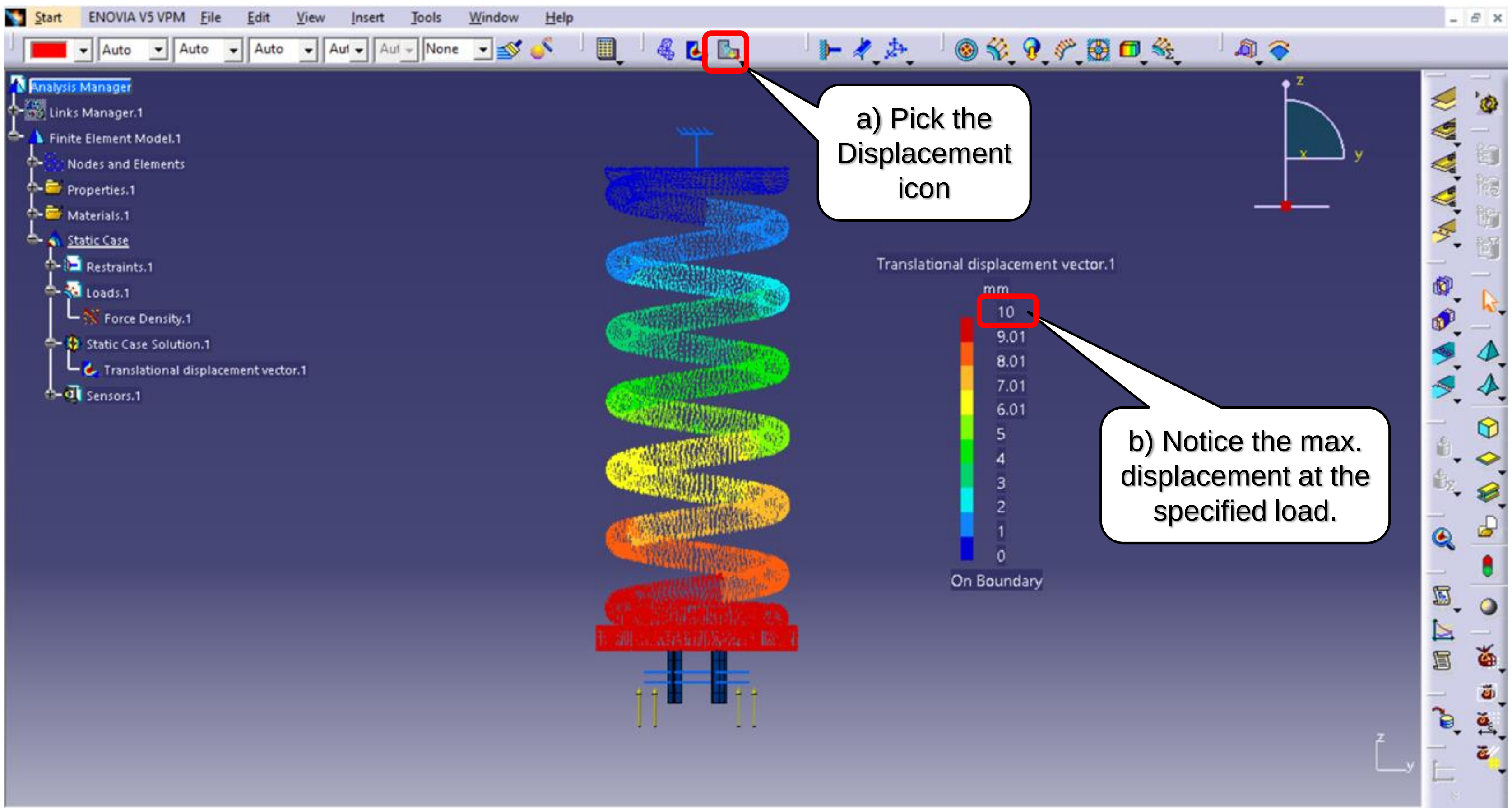


BND TechSource

- Show results of the analysis.



- Adjust Factors to "dial in" the FEA correlation if required.

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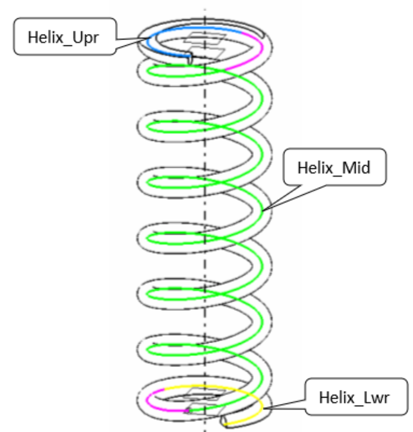

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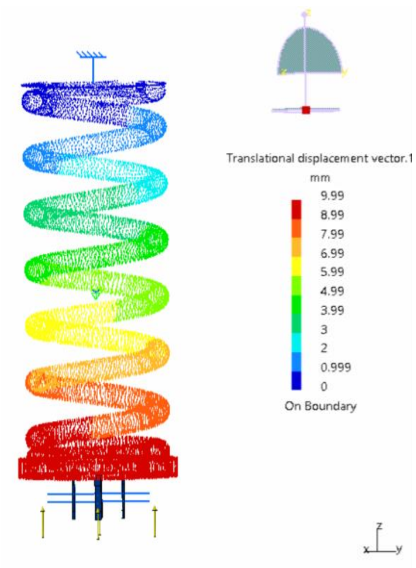
- The FEA analysis of the Free Length Spring correlates with the Spring Rate of the CATIA Part model and proves the rate to be Linear.



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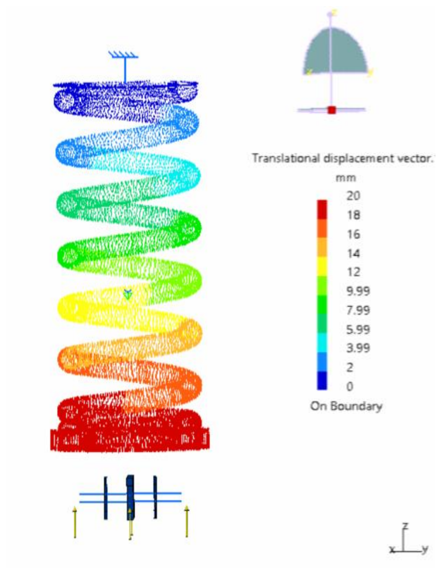

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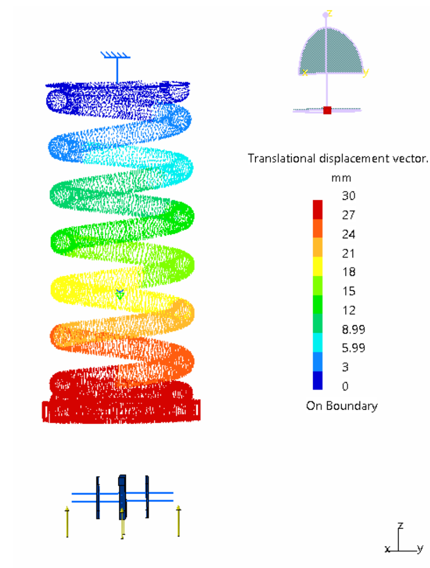

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BND TechSource

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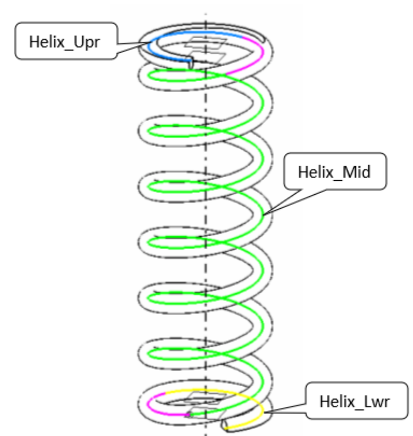

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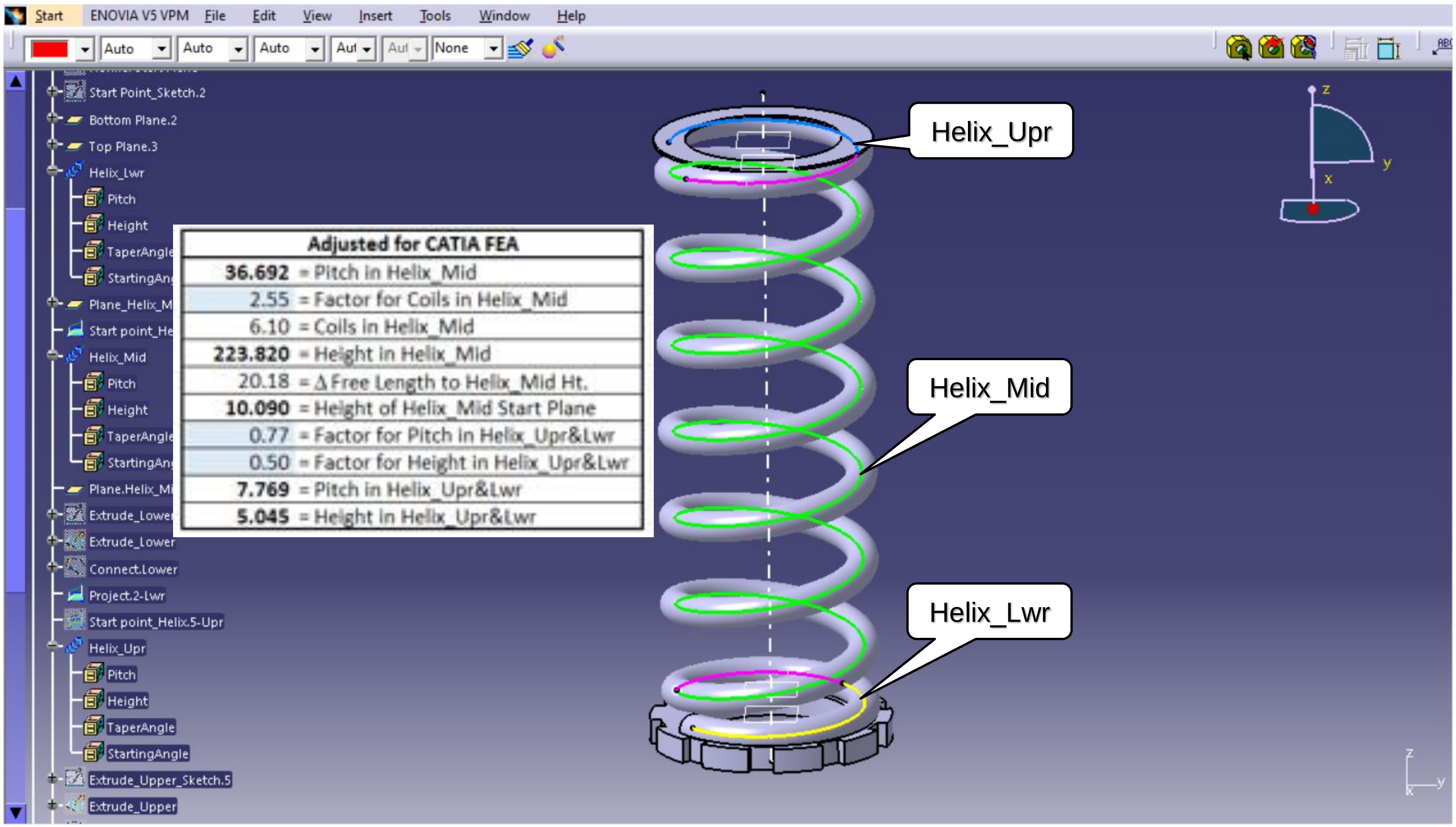
- Adjust the Spring based on Preload calculated the spring values.



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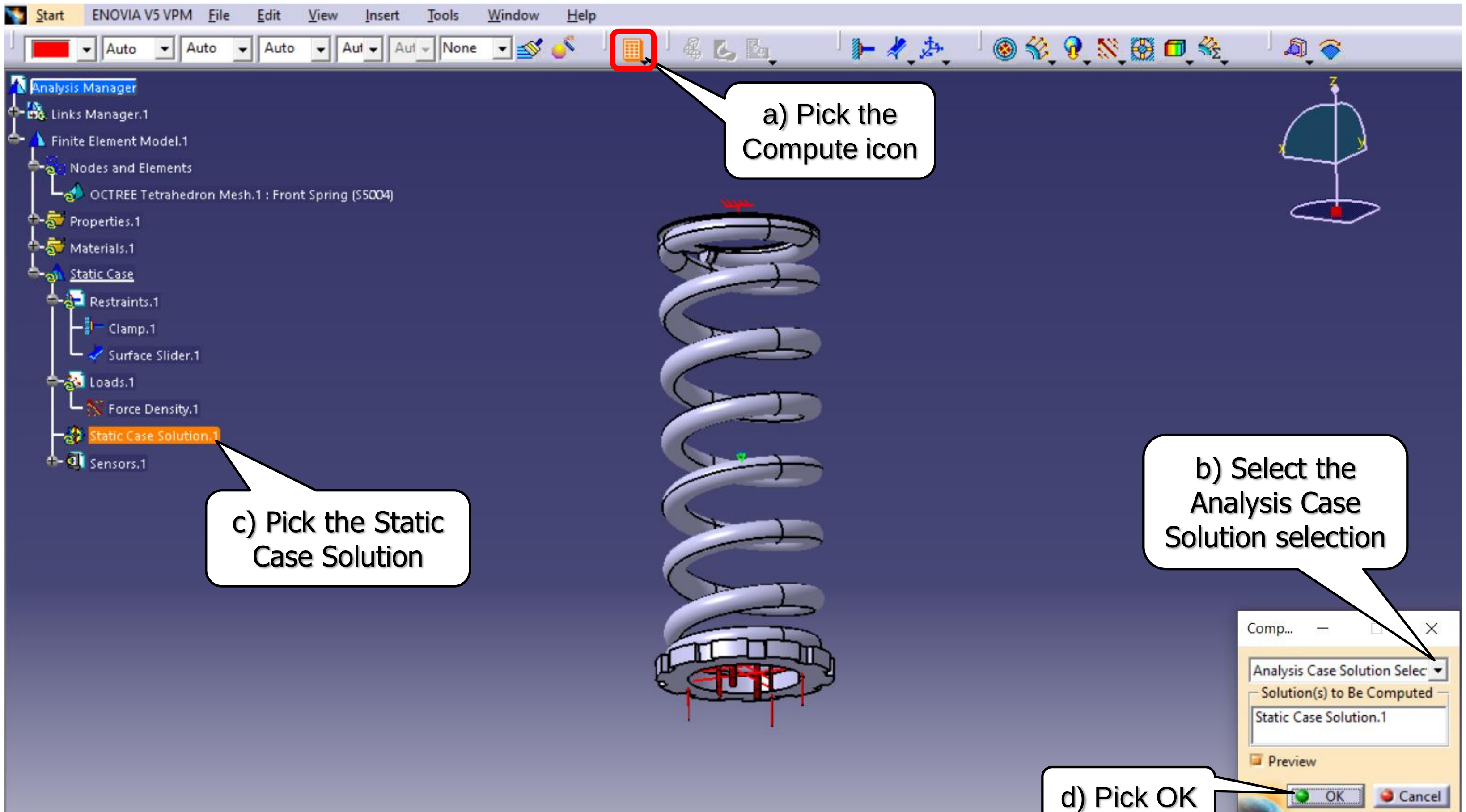
5.045	= Height in Helix_Upr&Lwr

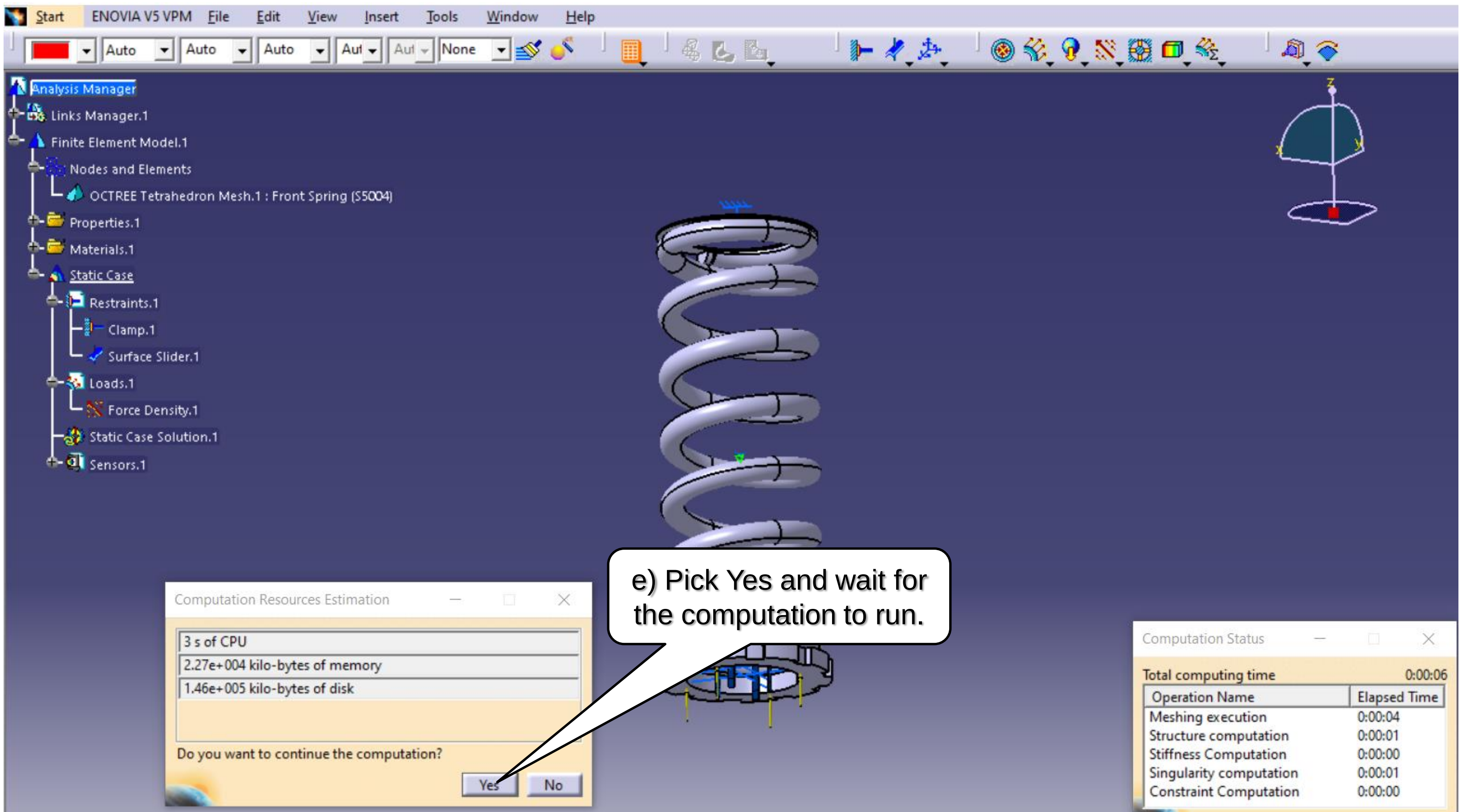
BND TechSource

- Compute the analysis of the Preloaded Spring.



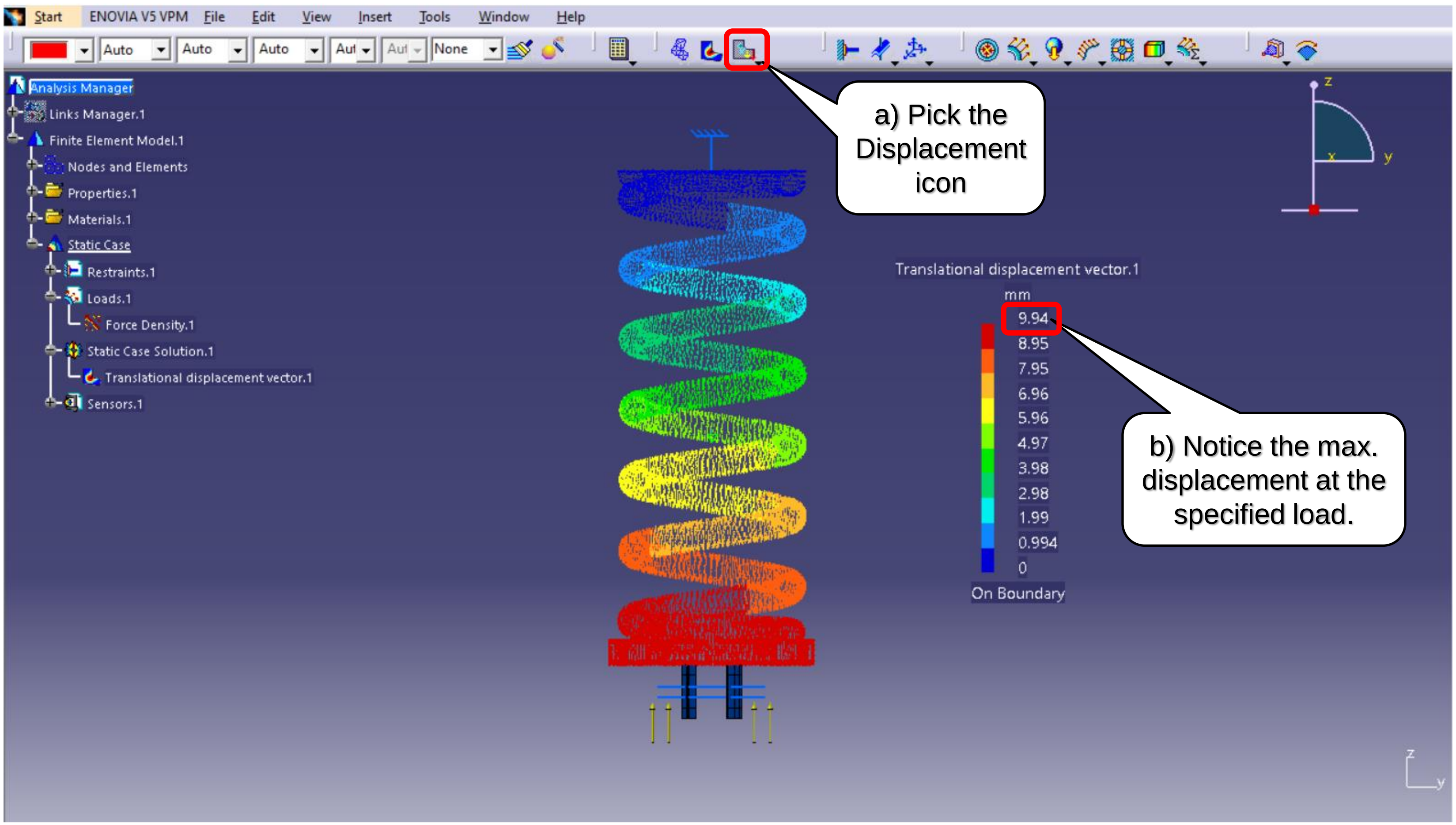
BND TechSource

- Compute the analysis of the Preloaded Spring.



BND TechSource

- Show results of the analysis.



BND TechSource

- Adjust Factors to “dial in” the FEA correlation if required.

From CATIA				C3 Project Front Spring Calculation													
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L_f]			Total coils [N_t]	Active coils [N_a]	Select End Types:
	(psi x 10^6)	(MPa x	contraction	(psi x 10^6)	(MPa x 10^3)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	9.606	0.244	244	8.650	6.650	Squared or closed (Ground)
				11501494	79300000000												

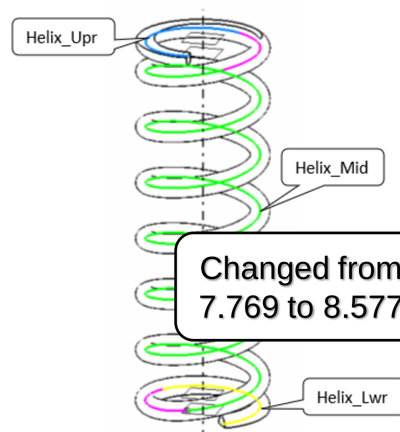
$$k = \frac{d^4 G}{8 D^3 N_a} \qquad v = \frac{E}{G \cdot 2} - 1$$

G = E / (2*(1+ν))

Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]	
inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm
1.411	0.0358	35.836	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64

Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

in	lb	in	lb/in
3.000	197.03	0.394	500.4



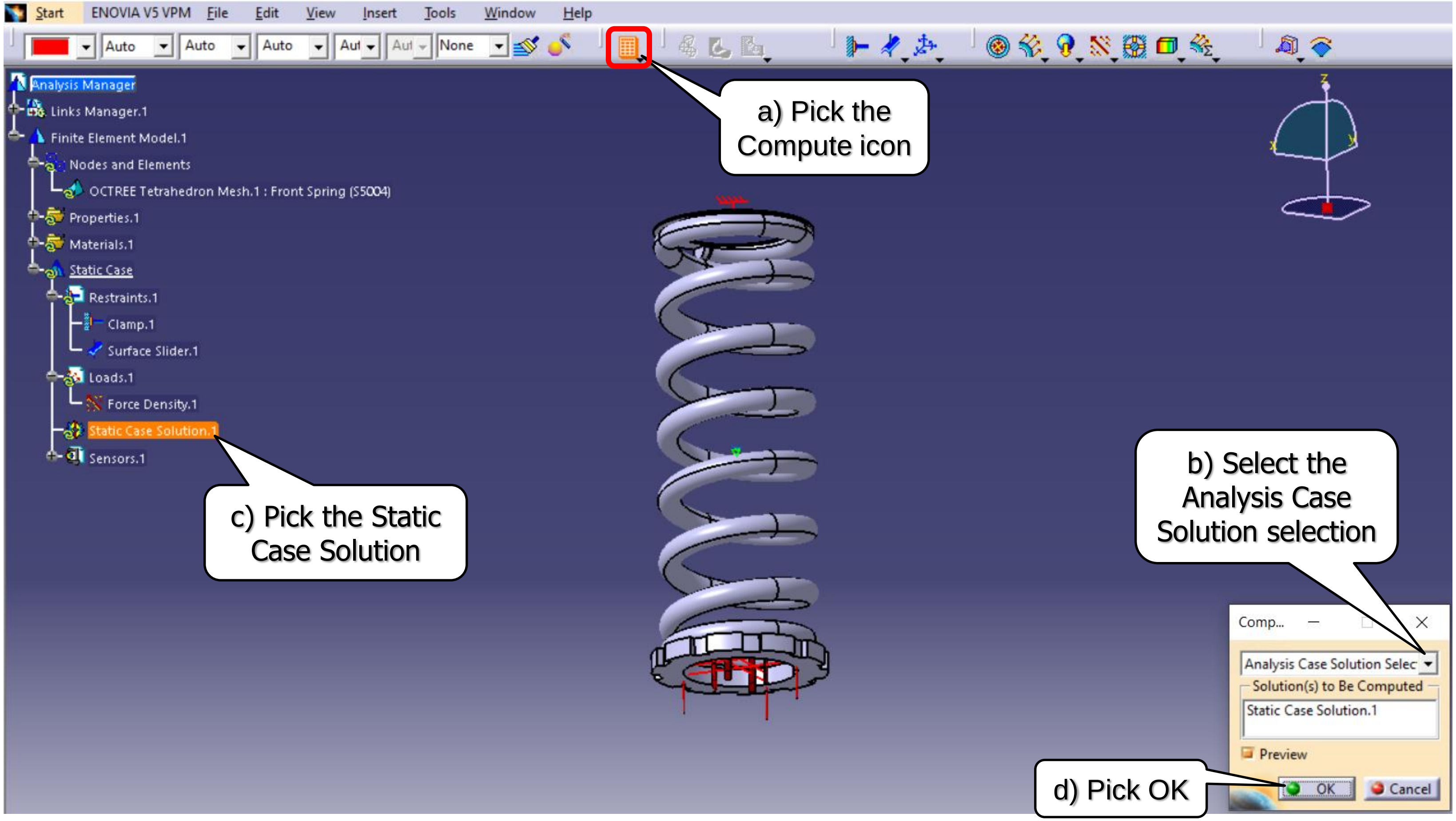
Adjusted for CATIA FEA	
36.692	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
223.820	= Height in Helix_Mid
20.18	= Δ Free Length to Helix_Mid Ht.
10.090	= Height of Helix_Mid Start Plane
0.85	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Fa... for Height in Helix_Upr&Lwr
8.577	= Pitch ... lix_Upr&Lwr
5.045	= Height in ... r&Lwr

Changed from 7.769 to 8.577

Changed from 0.77 to 0.85

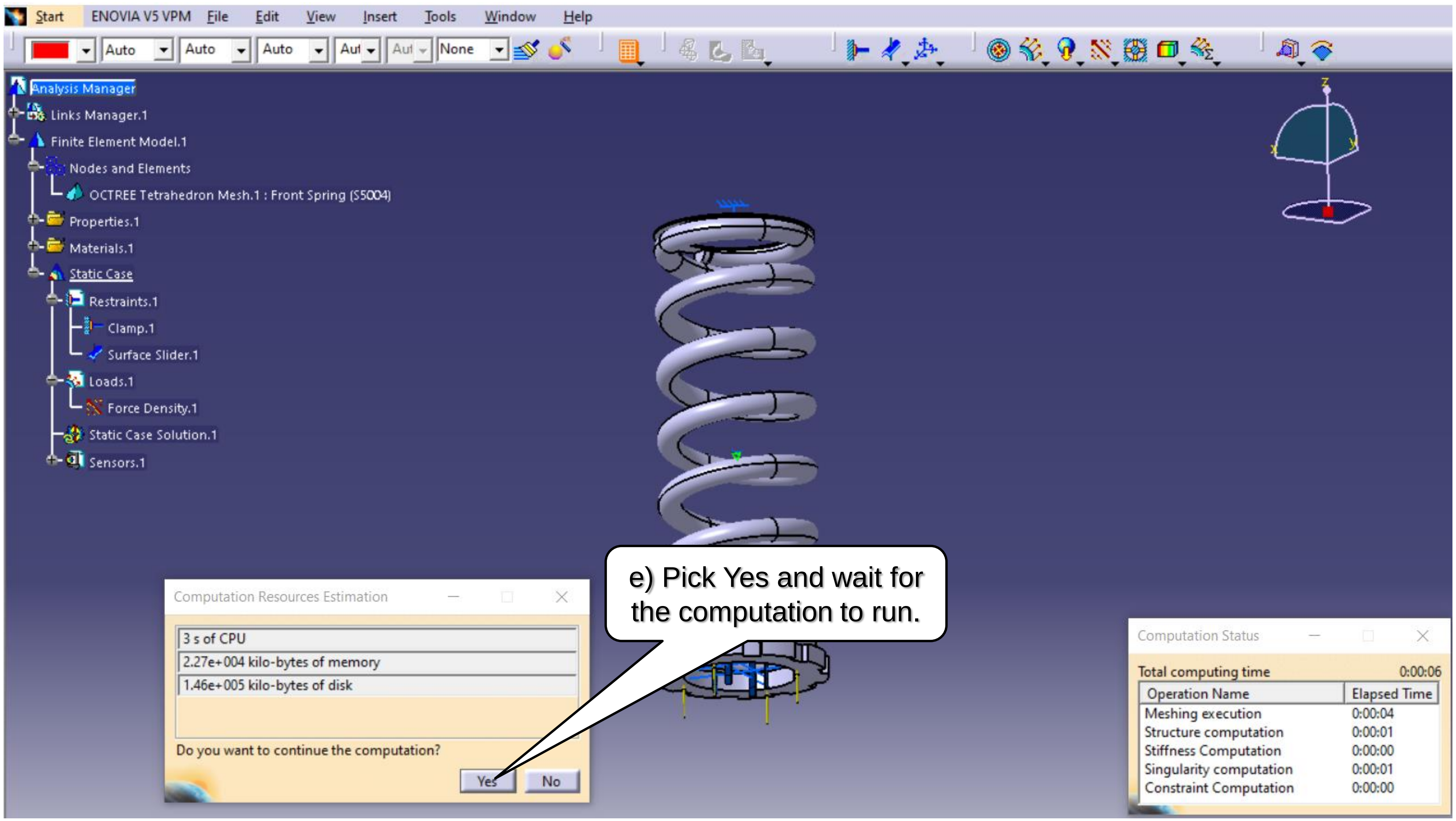
BND TechSource

- Re-compute the analysis of the Preloaded Spring.



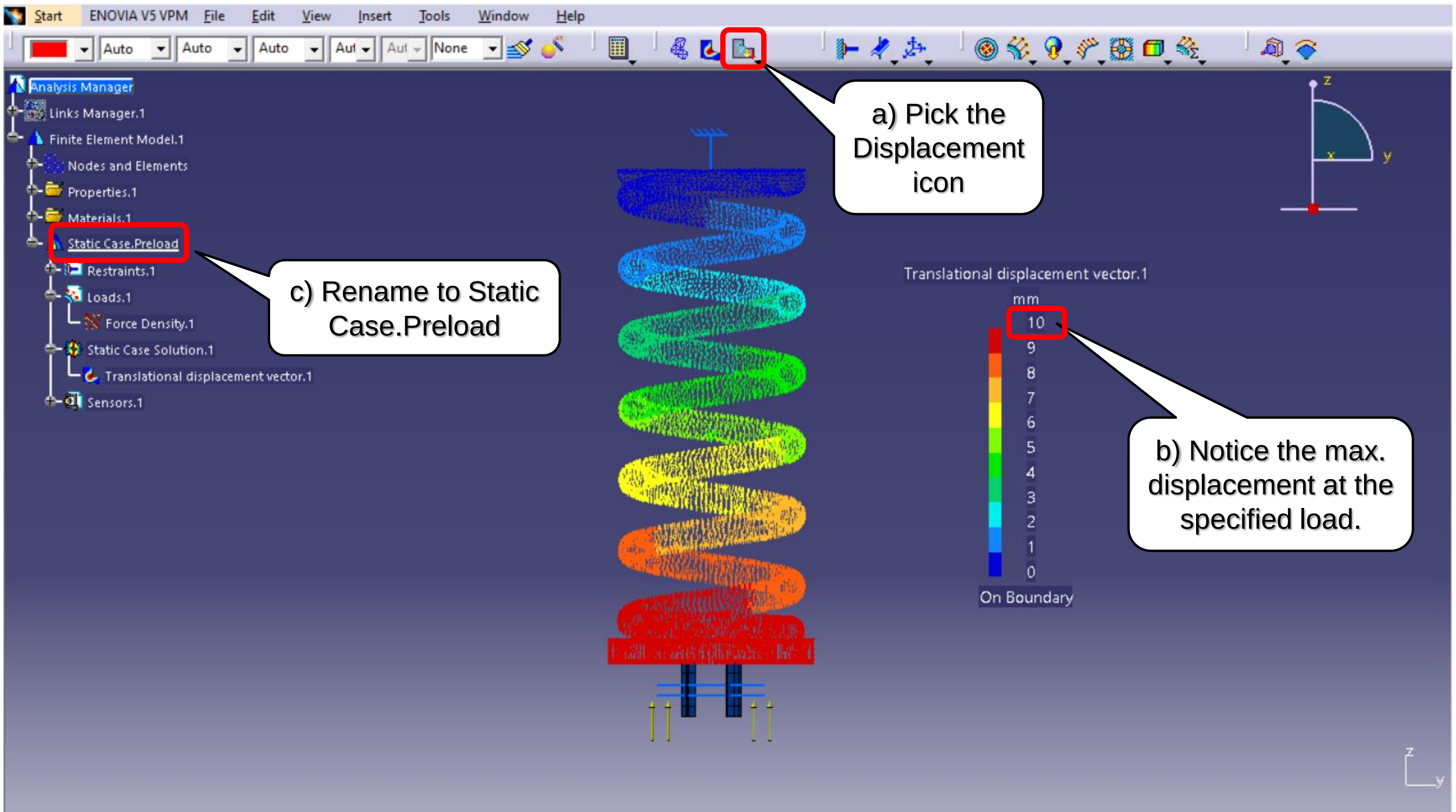
BND TechSource

- Re-compute the analysis of the Preloaded Spring.



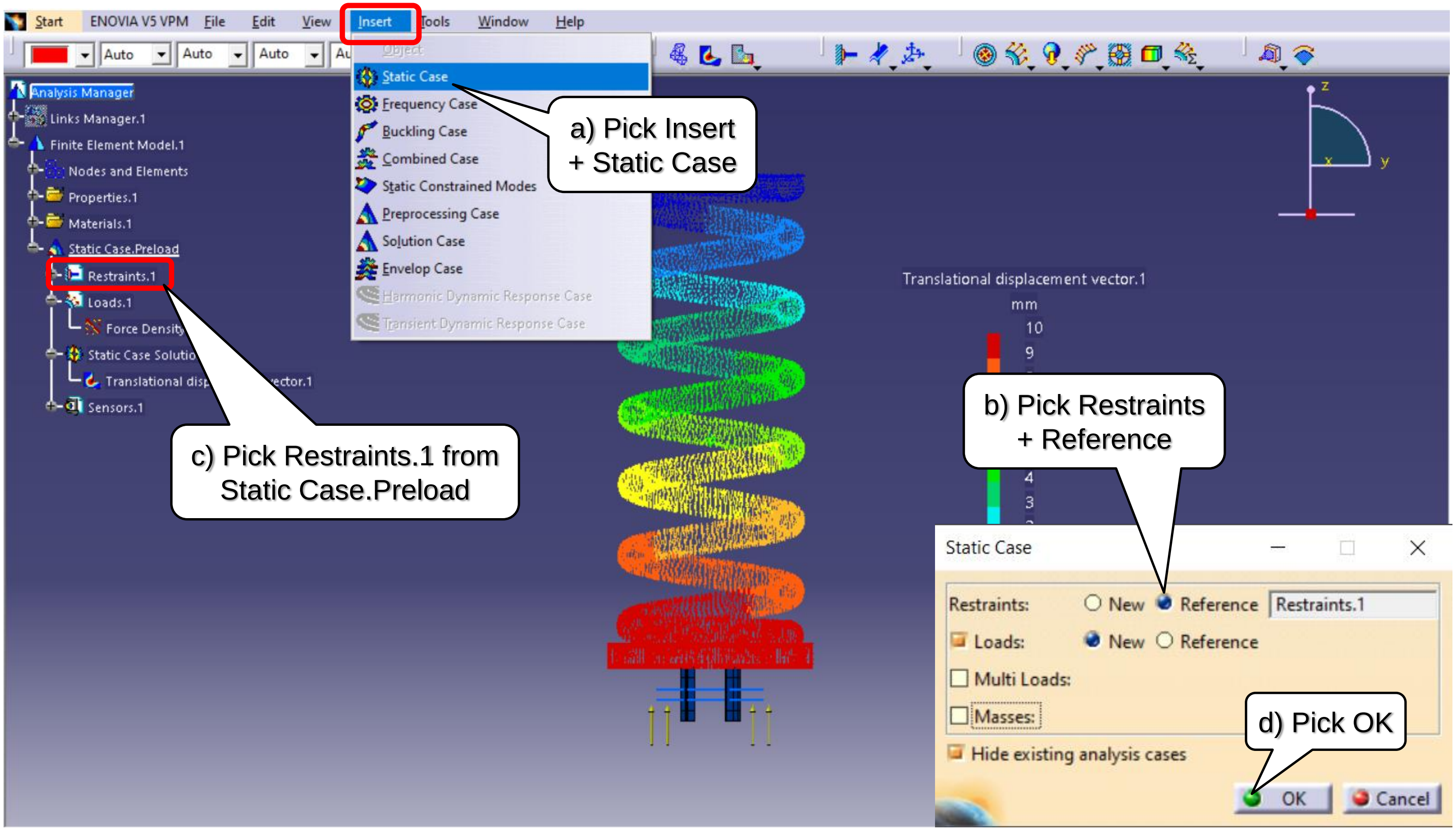
BND TechSource

- Show results of the Preload analysis.

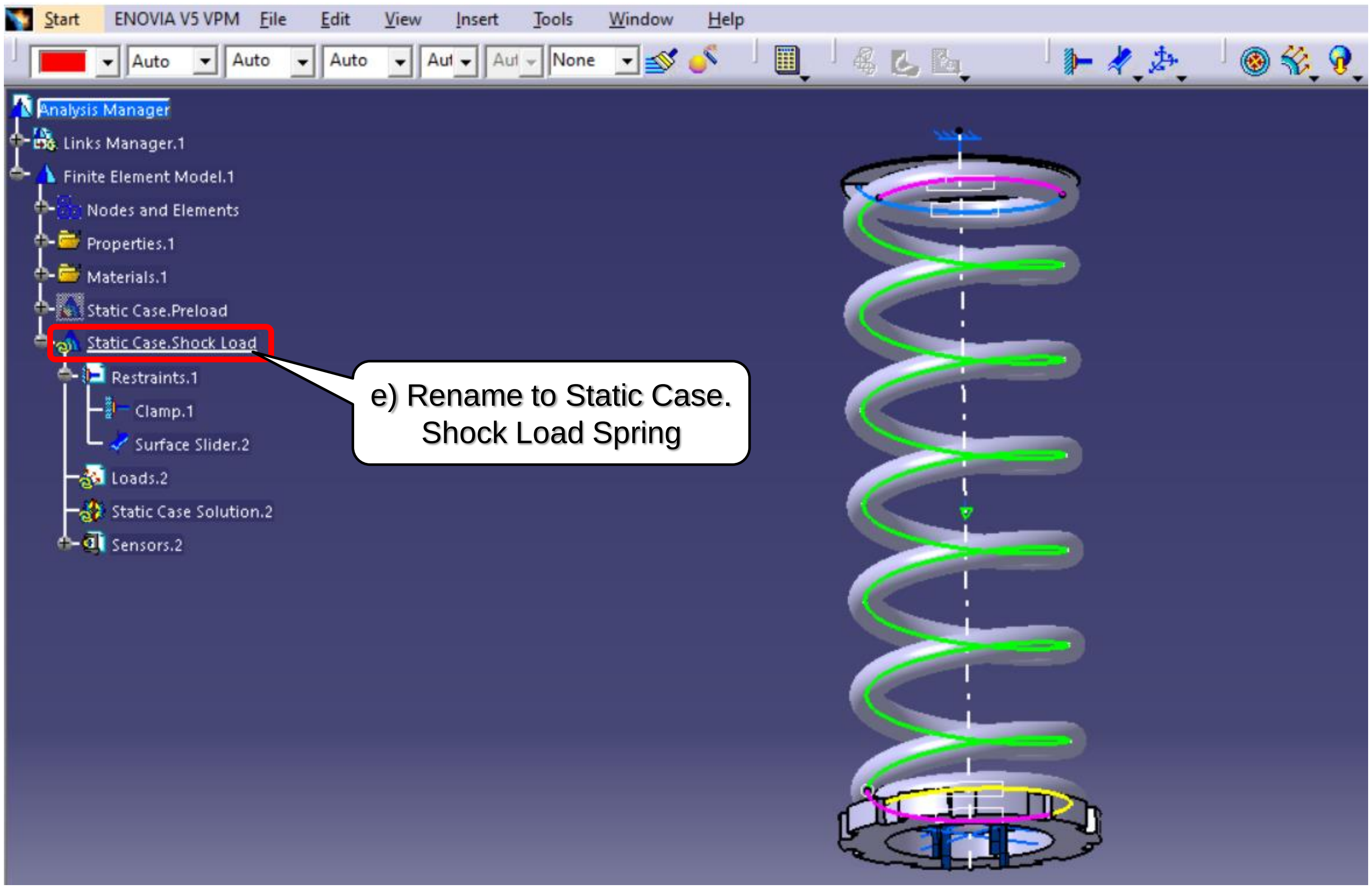


BND TechSource

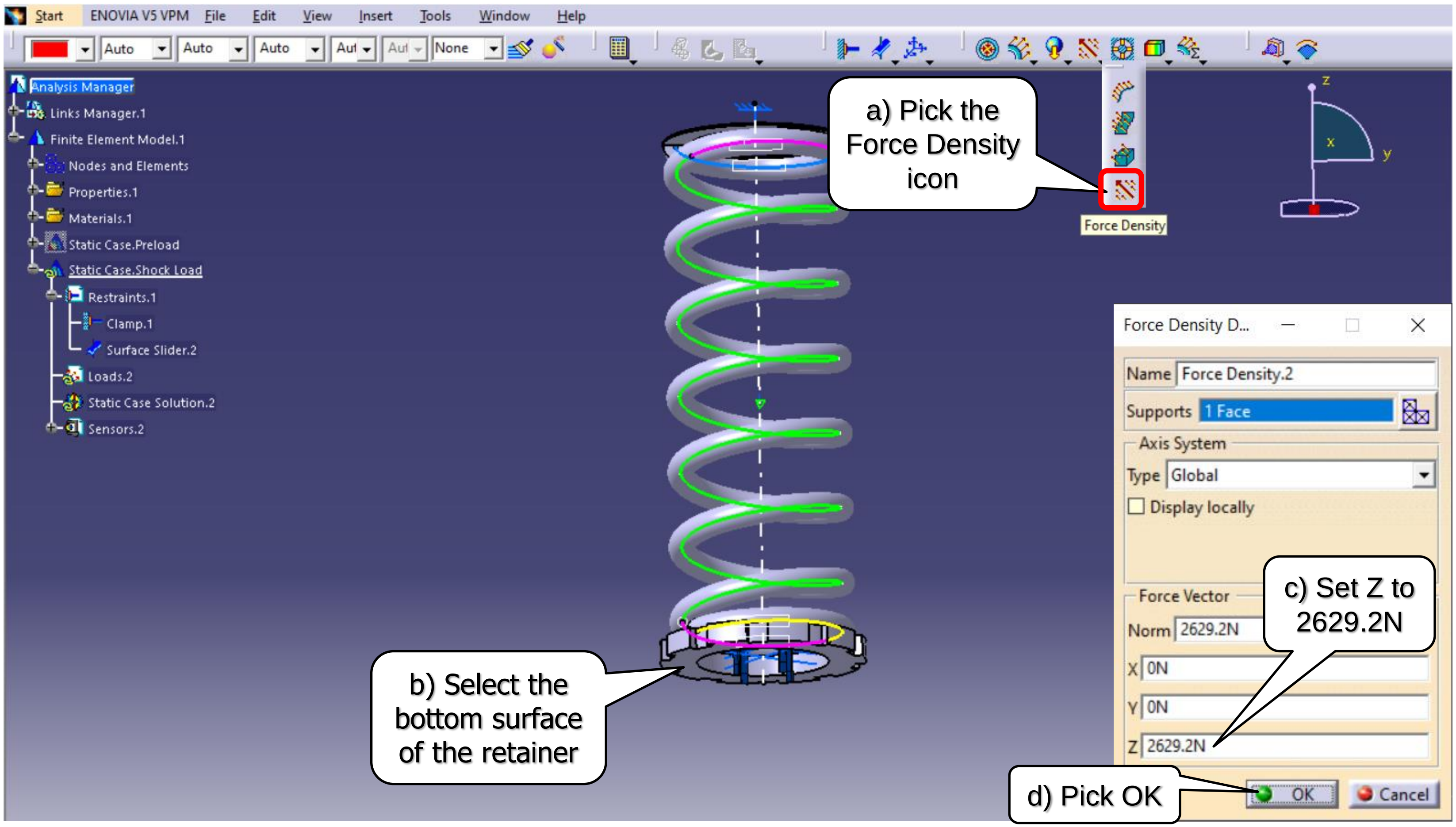
- Create a new Static Case.Shock Load Spring.



- Create a new Static Case.Shock Load Spring.

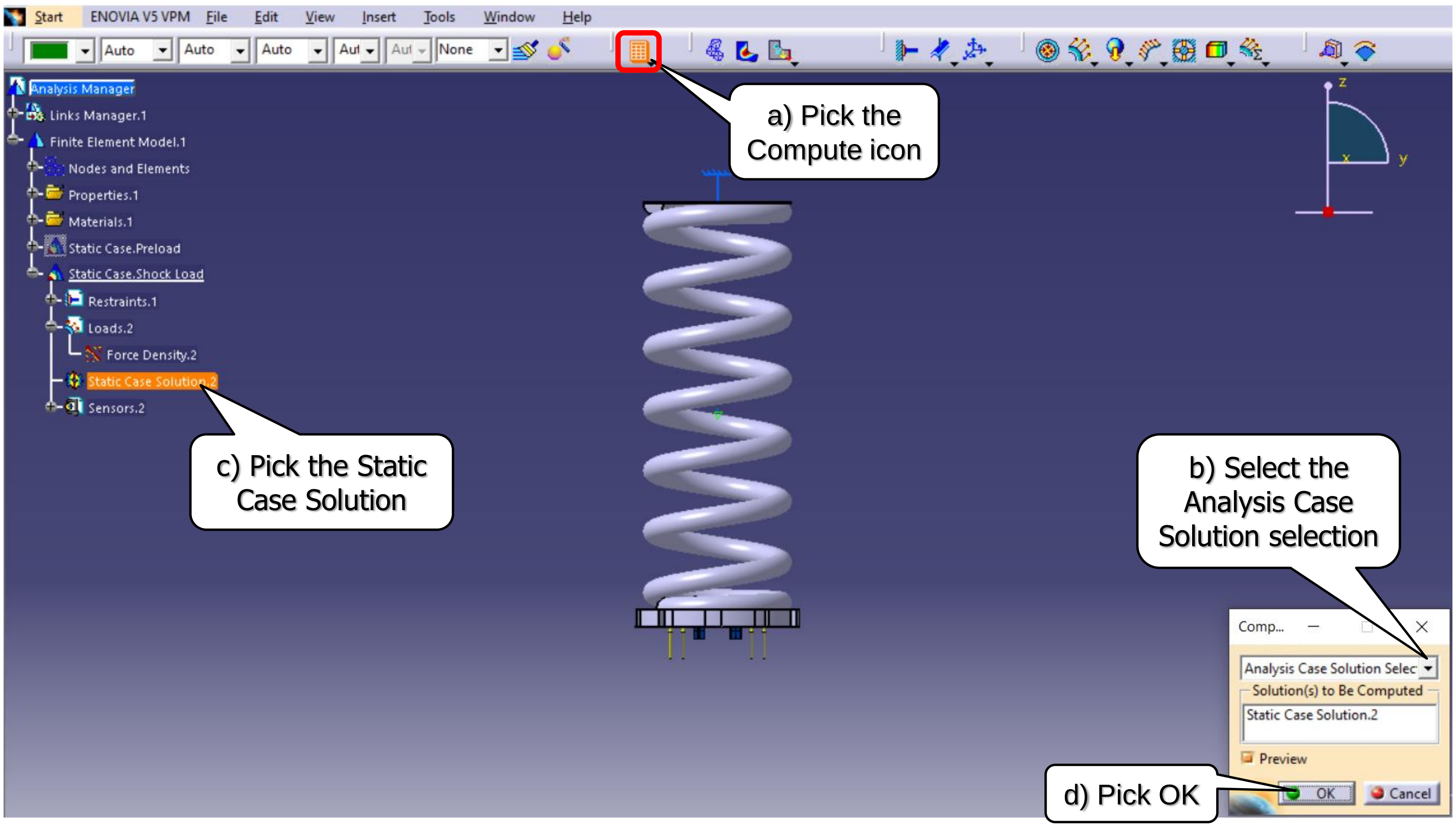


- Create the new Shock Spring Load (30 x rate ➔ 2629.2N).



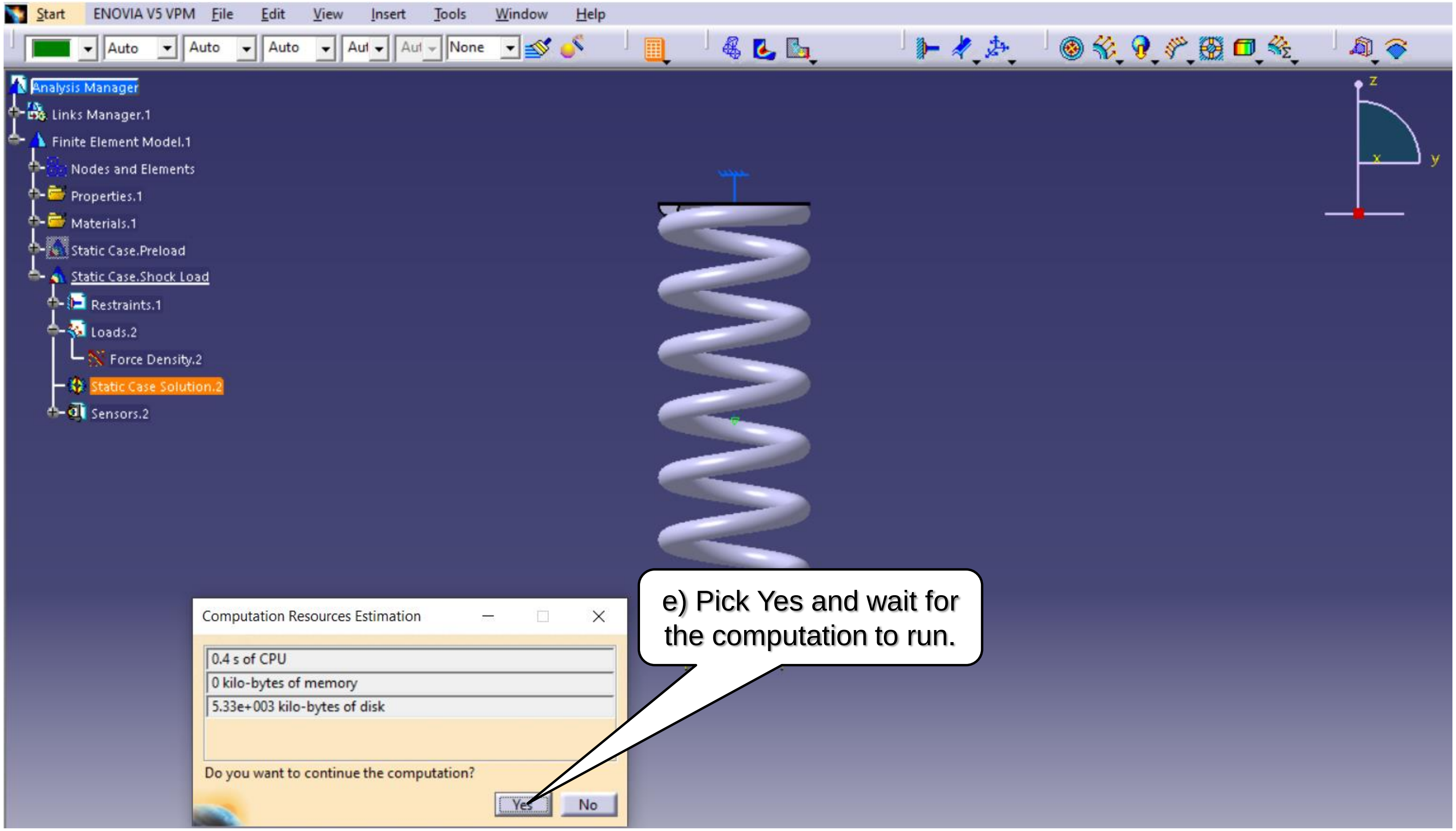
BND TechSource

- Compute the analysis of the Shock Load Spring.



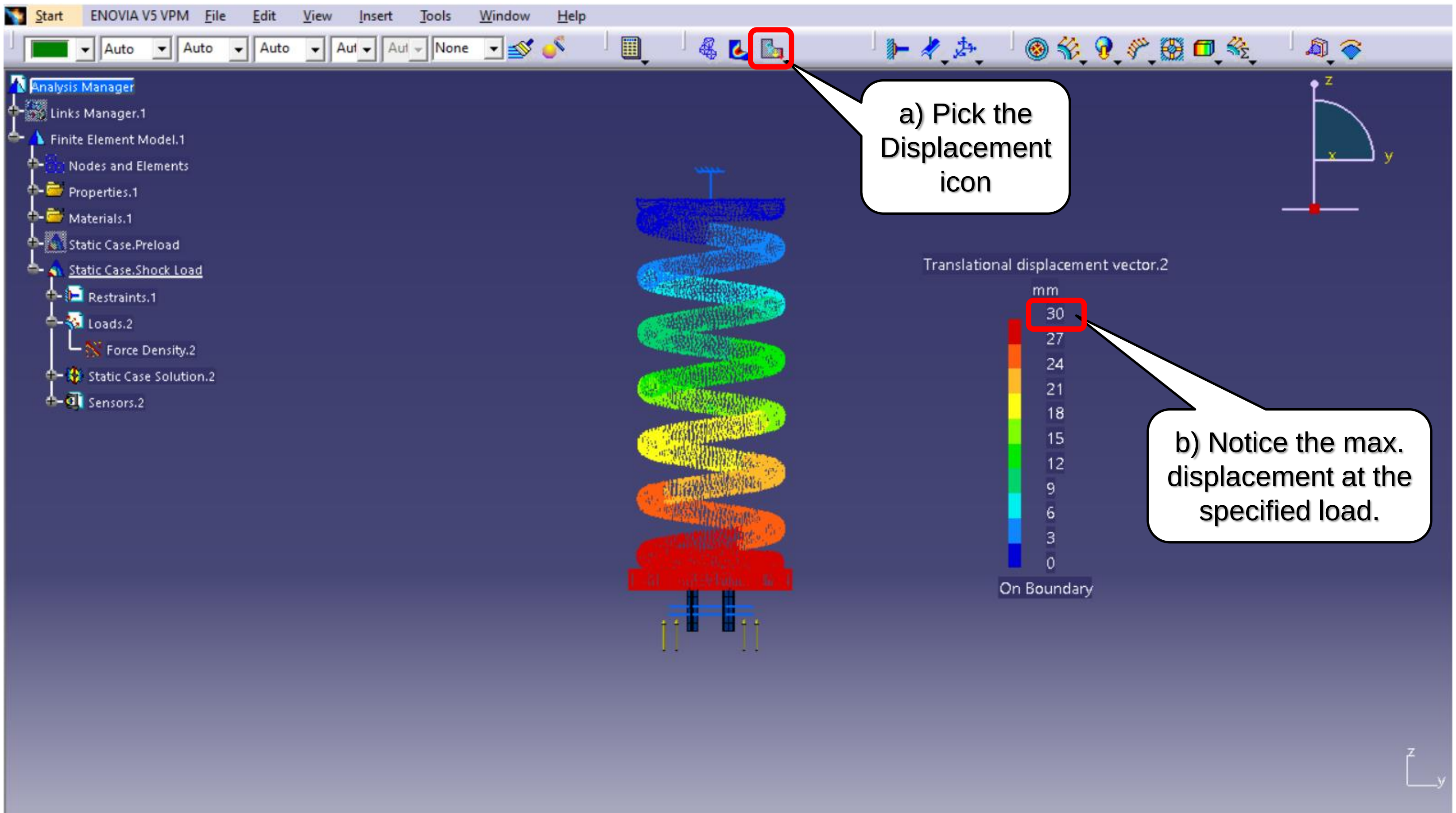
BND TechSource

- Compute the analysis of the Shock Load Spring.



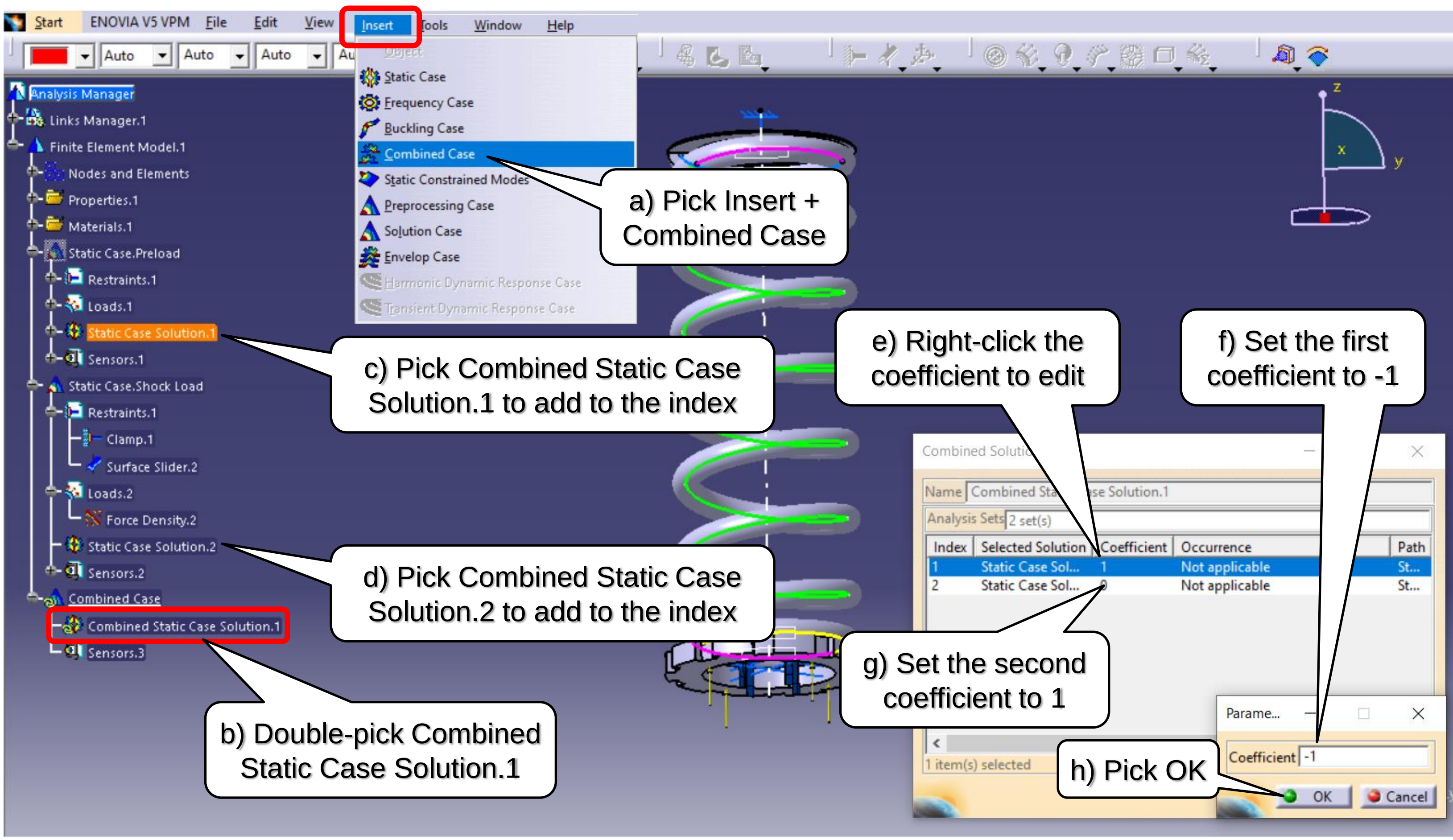
BND TechSource

- Show results of the Shock Load Spring analysis.

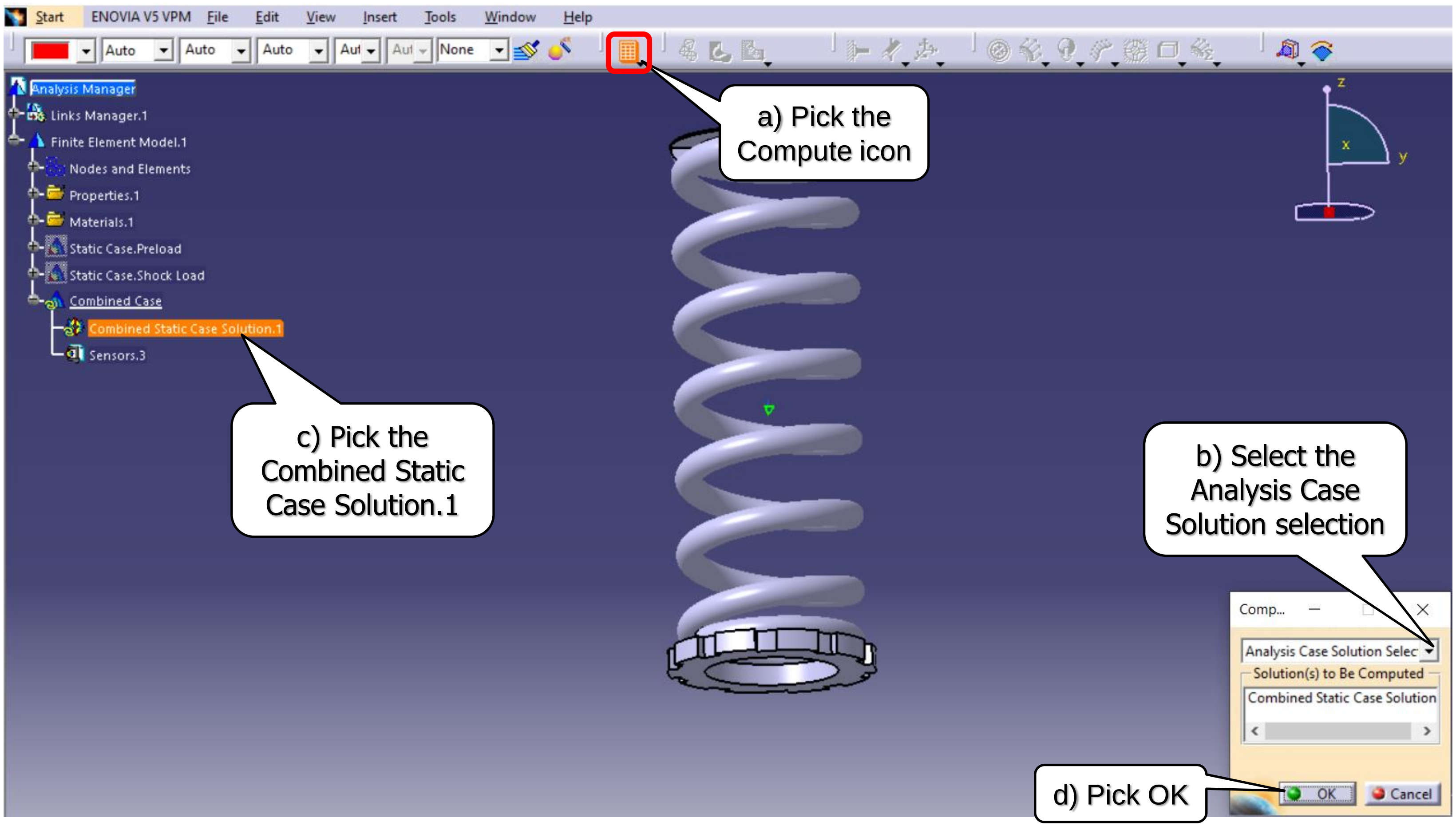


BND TechSource

- Create a new Combined Case.Shock Spring Deflection.

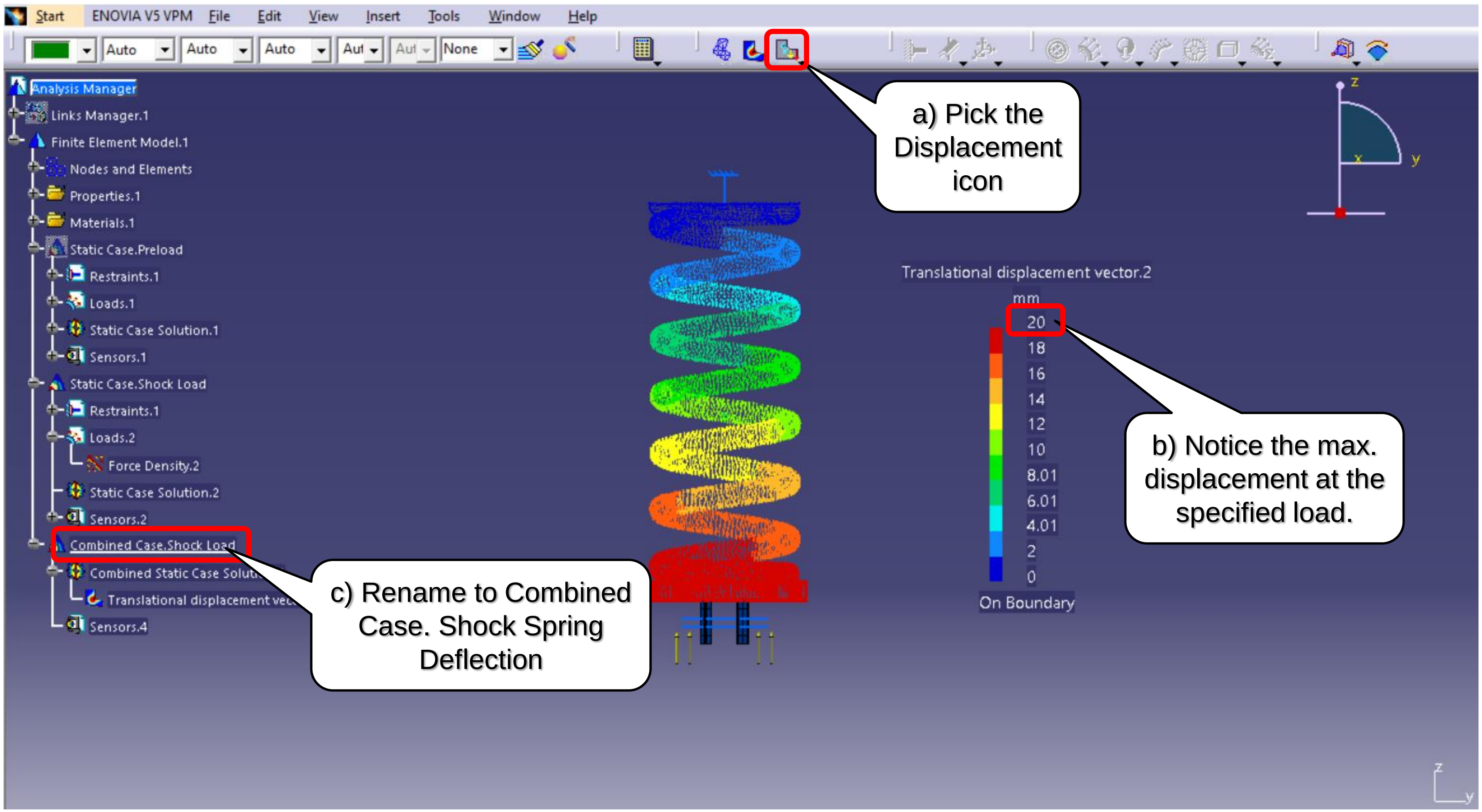


- Compute the analysis of the Combined Static Case Solution.1



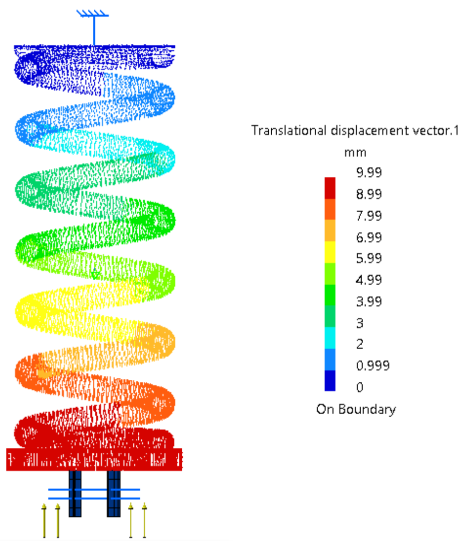
BND TechSource

- Show analysis results of the Combined Case.Shock Spring Deflection.

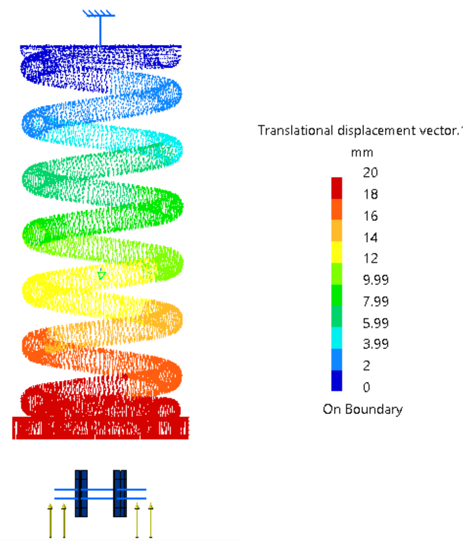


BND TechSource

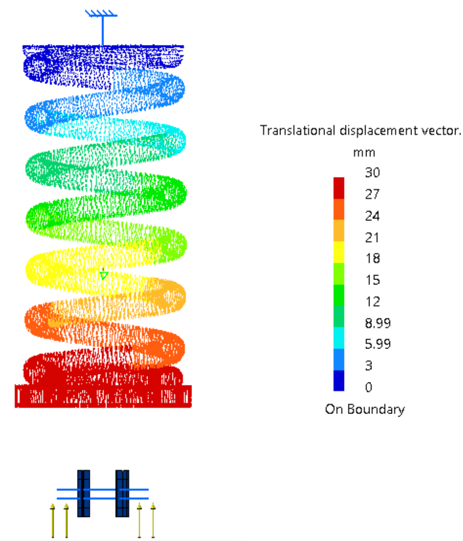
- The FEA analysis of the Preloaded Spring correlates with the Spring Rate from the CATIA Part model and proves the rate remains Linear.



Load = 20X the Spring Rate – the Preload ➔ 10mm Defl.



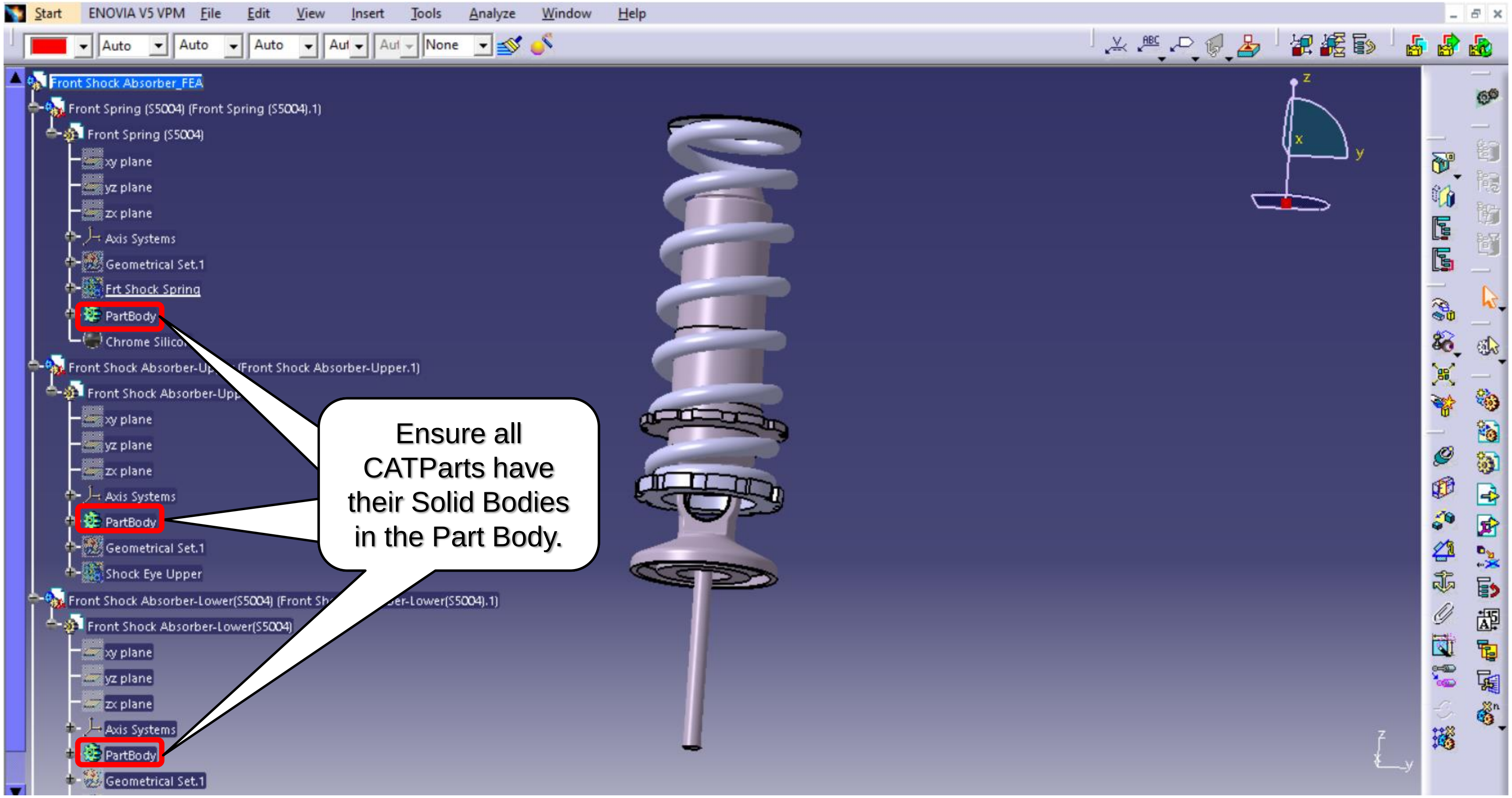
Load = 30X the Spring Rate – the Preload ➔ 20mm Defl.



Load = 40X the Spring Rate – the Preload ➔ 30mm Defl.

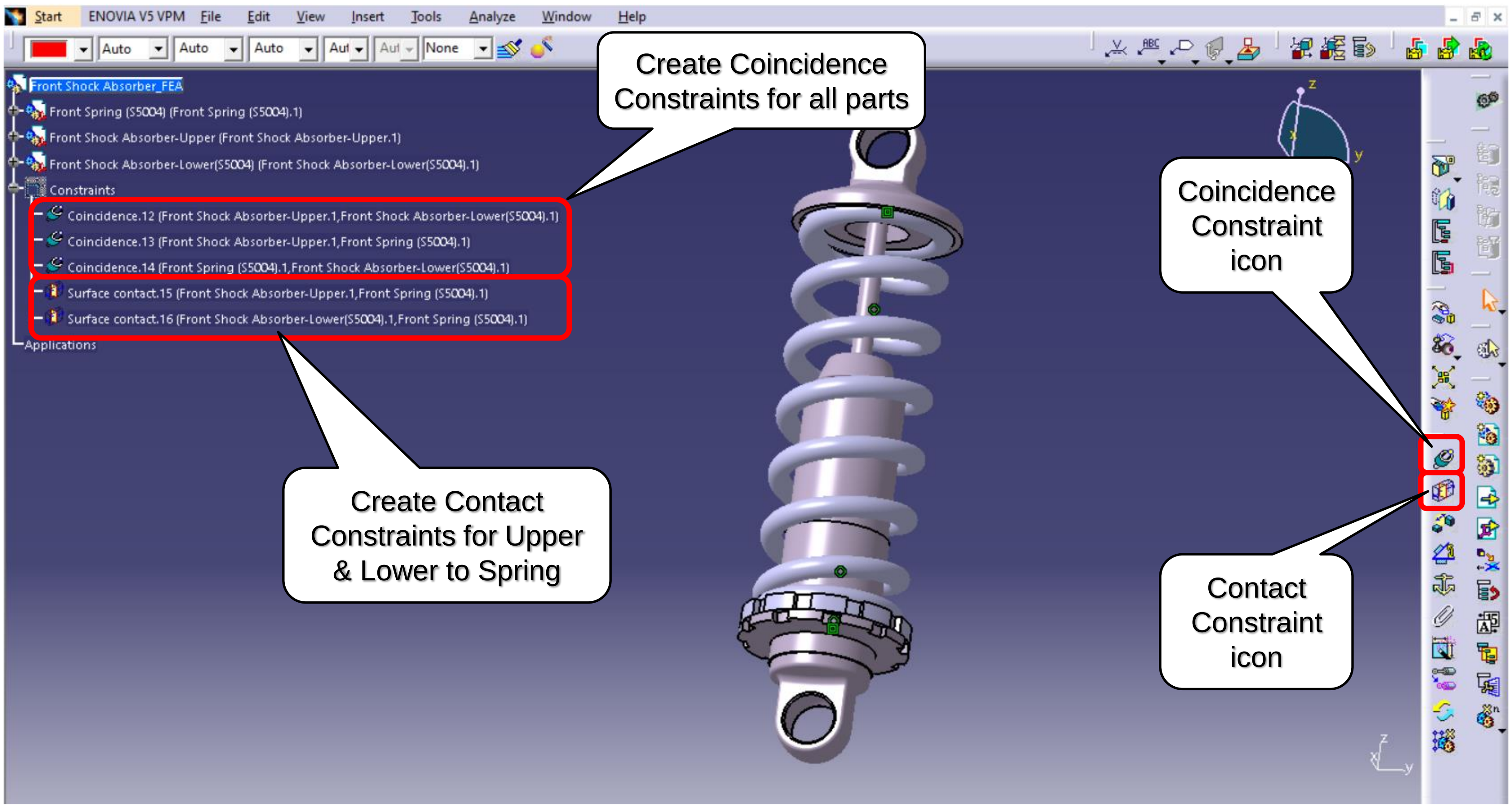
Create the Preloaded Coil-over Shock Assembly FEA

- Create a CATProduct for the Coil-over Shock Assy.



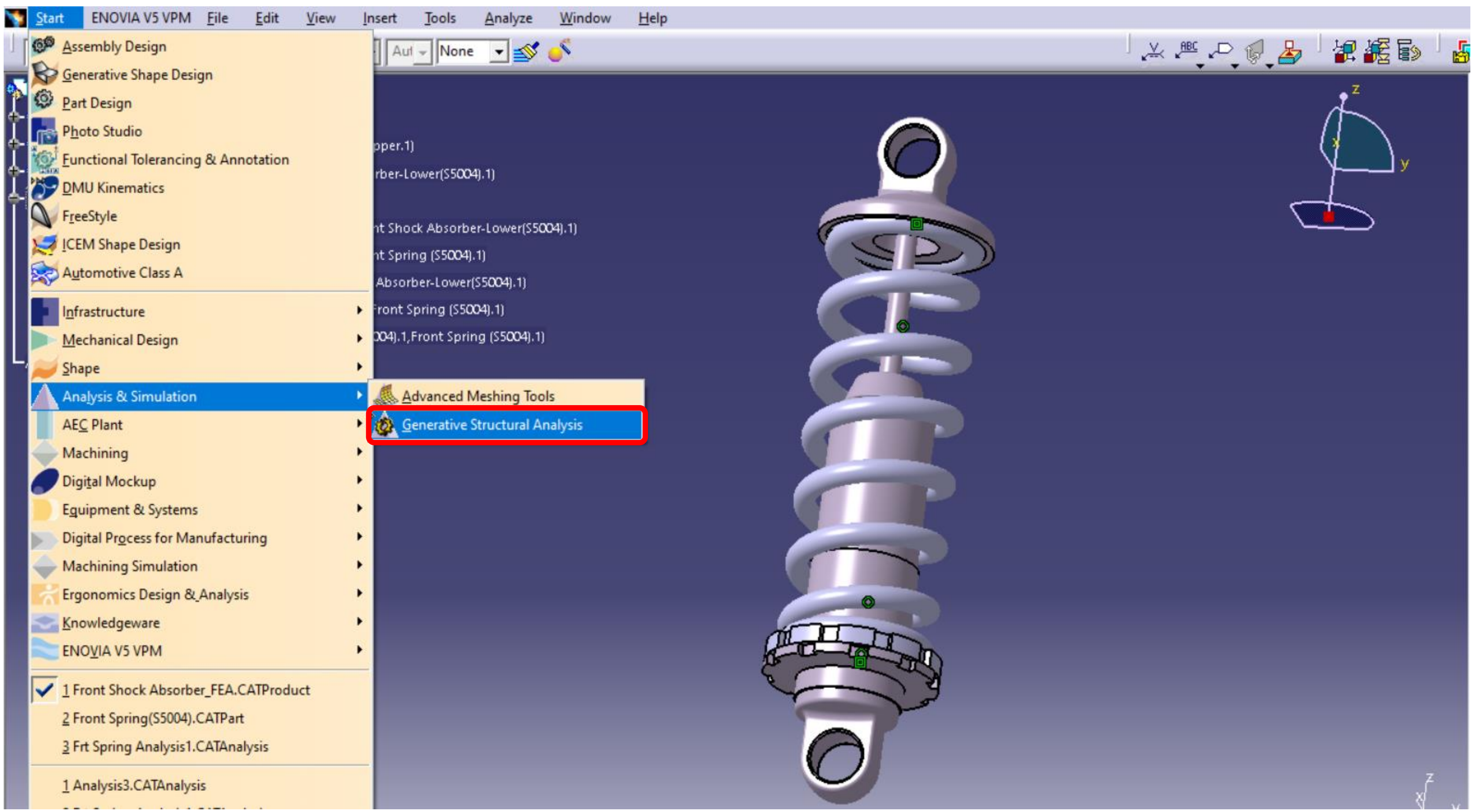
BND TechSource

- Create Constraints for all parts within the Coil-over Shock Assy.



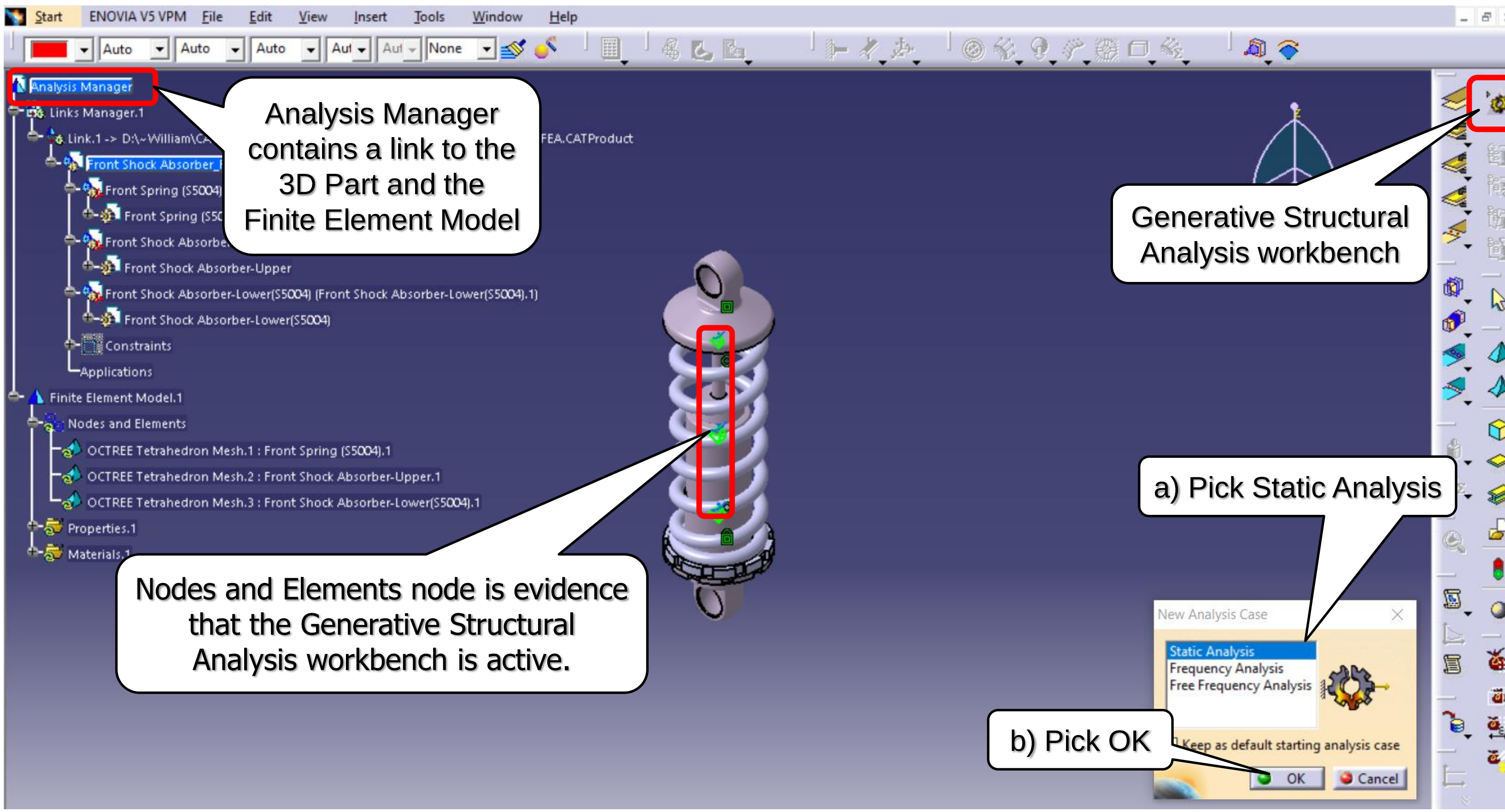
BND TechSource

- While inside the CatPart, call the Generative Structural Analysis workbench.

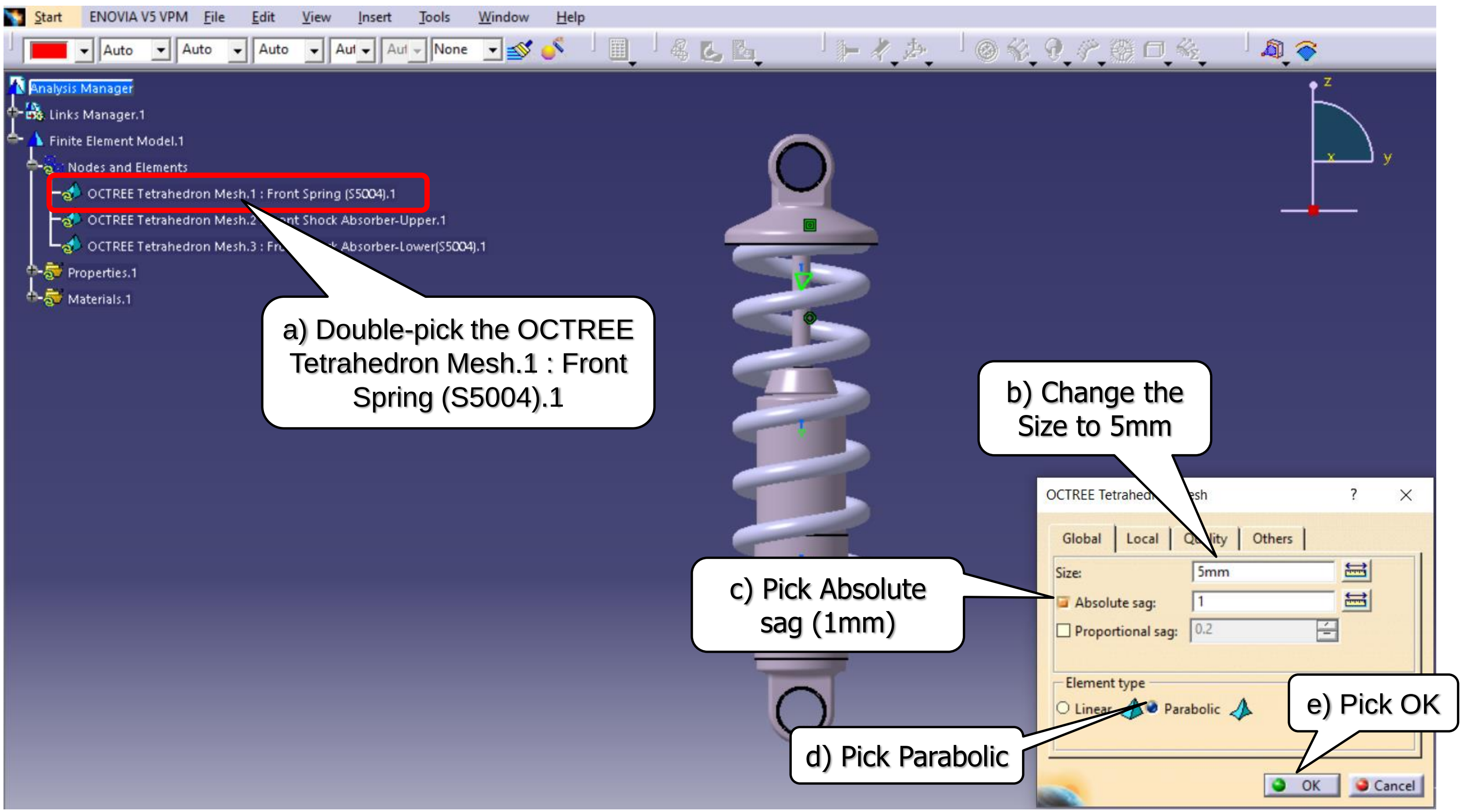


BND TechSource

- Generative Structural Analysis workbench creates the Analysis Manager.

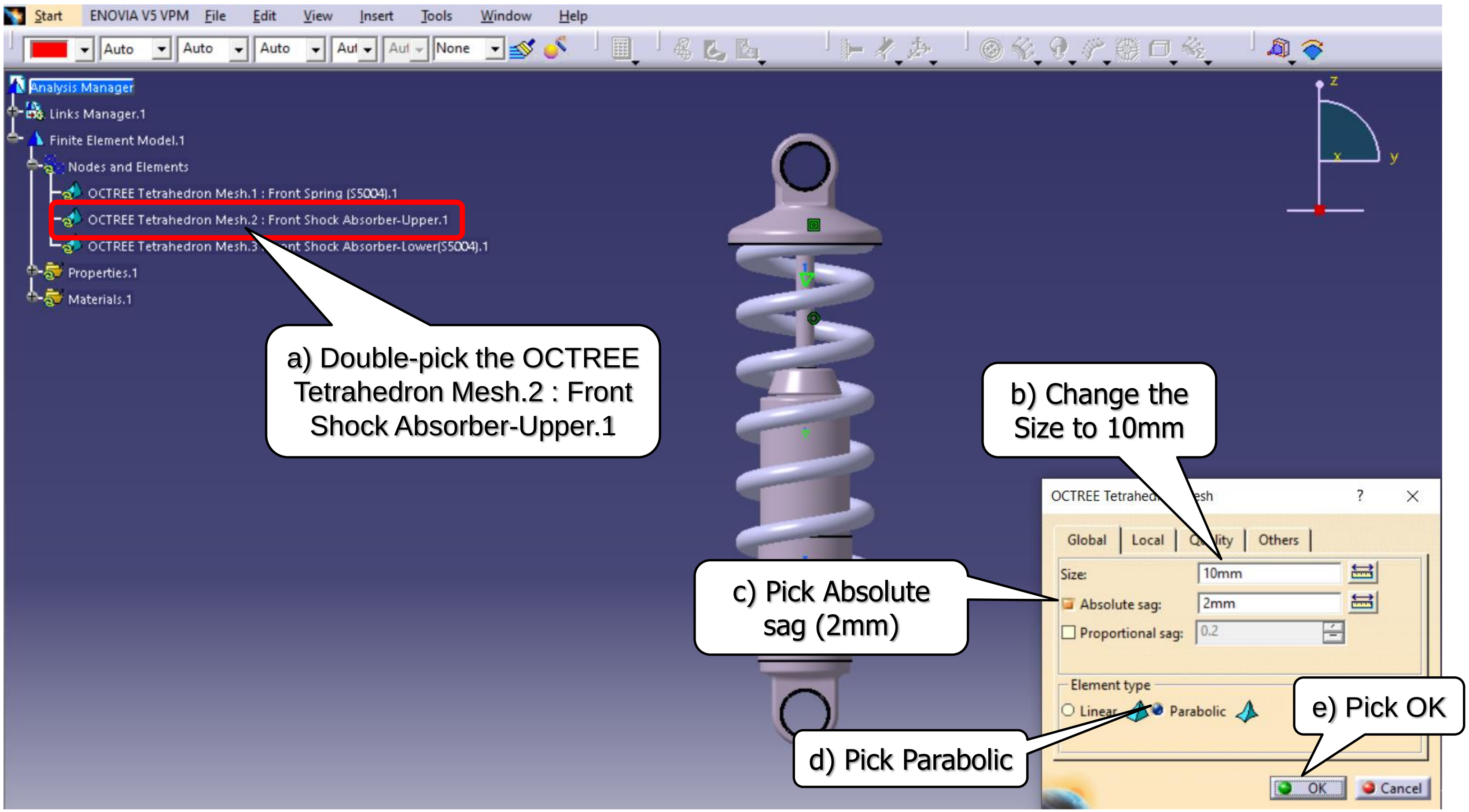


- Optimize the Mesh for the Spring.



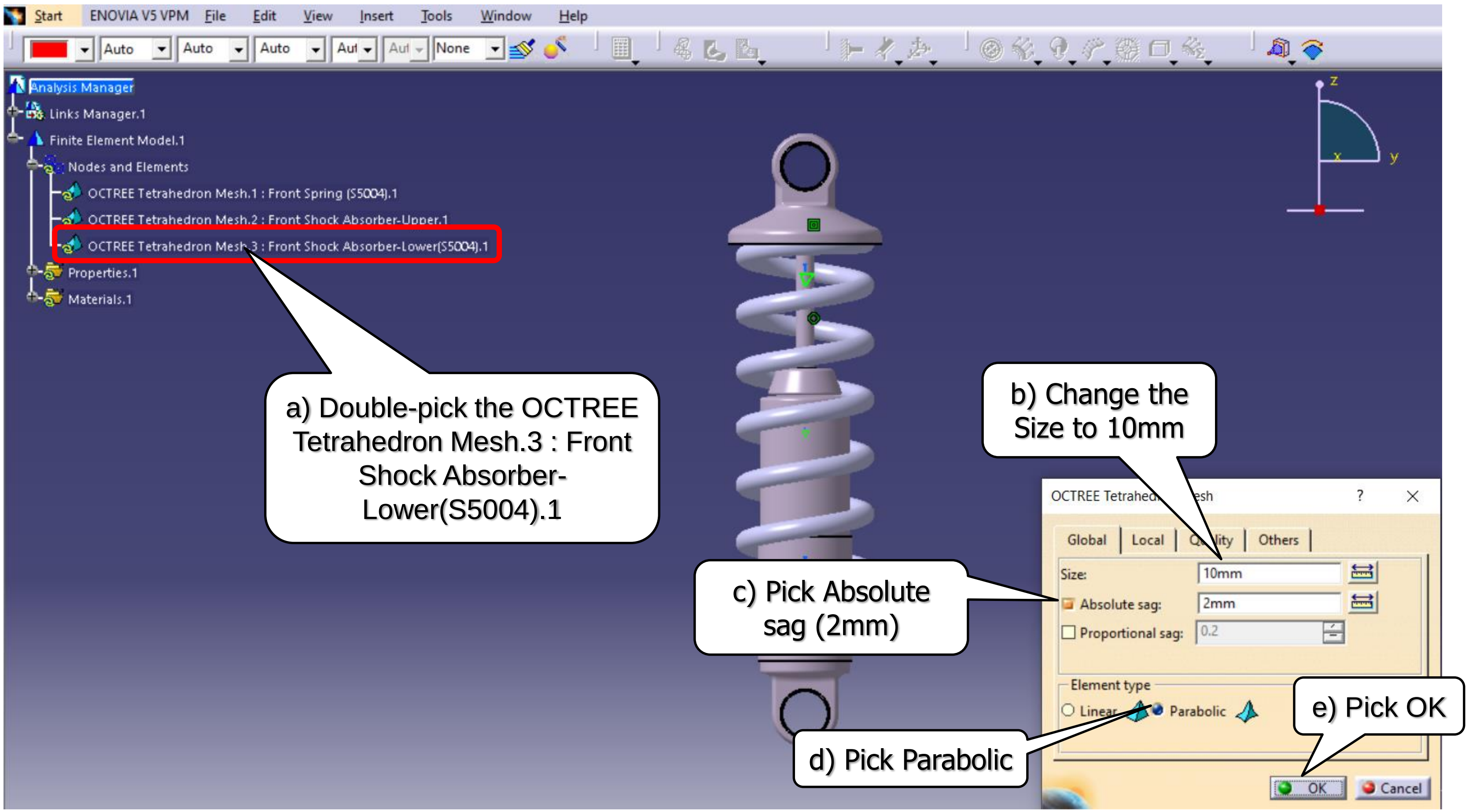
BND TechSource

- Optimize the Mesh for the Upper Shock.



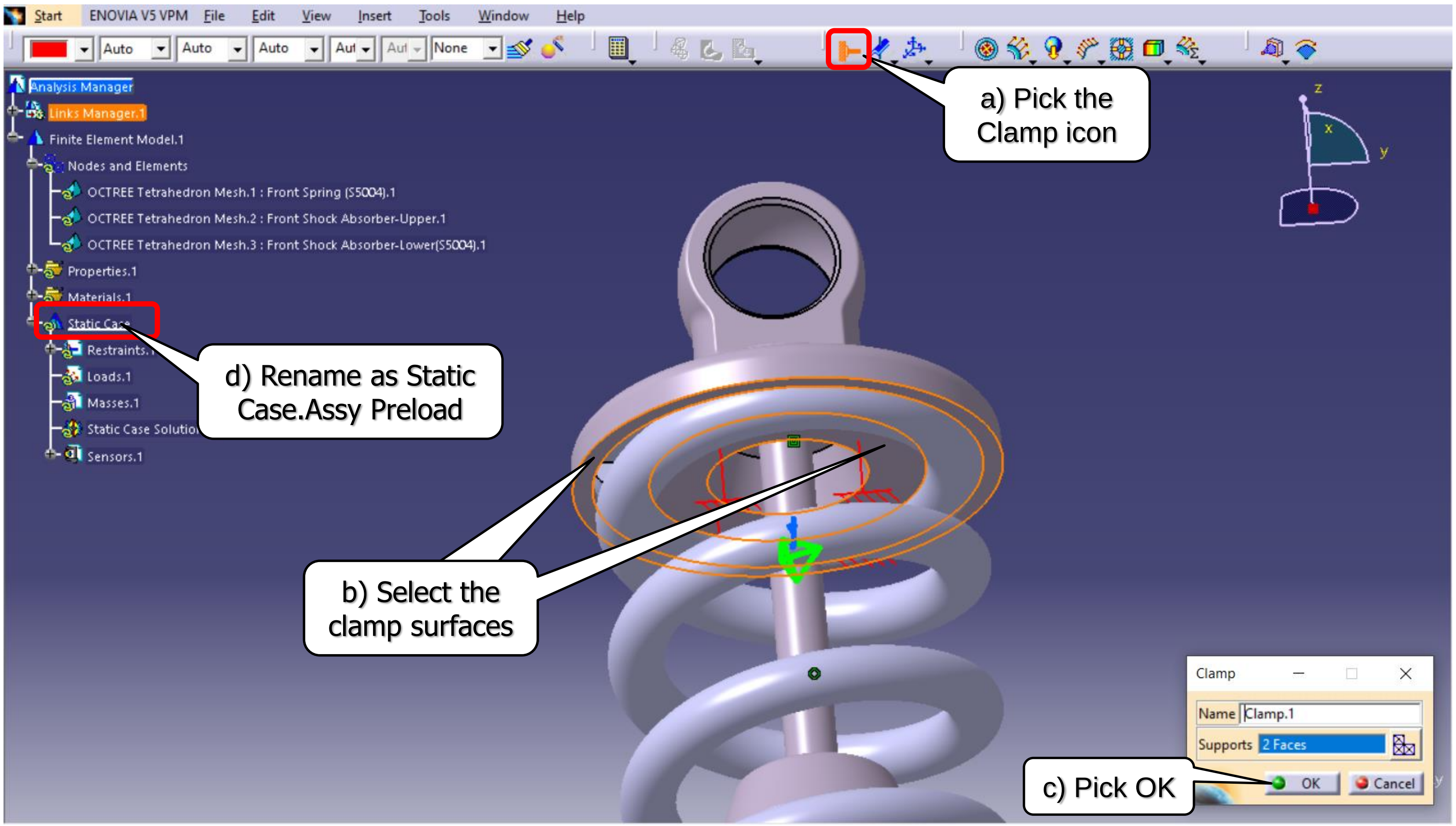
BND TechSource

- Optimize the Mesh for the Lower Shock.



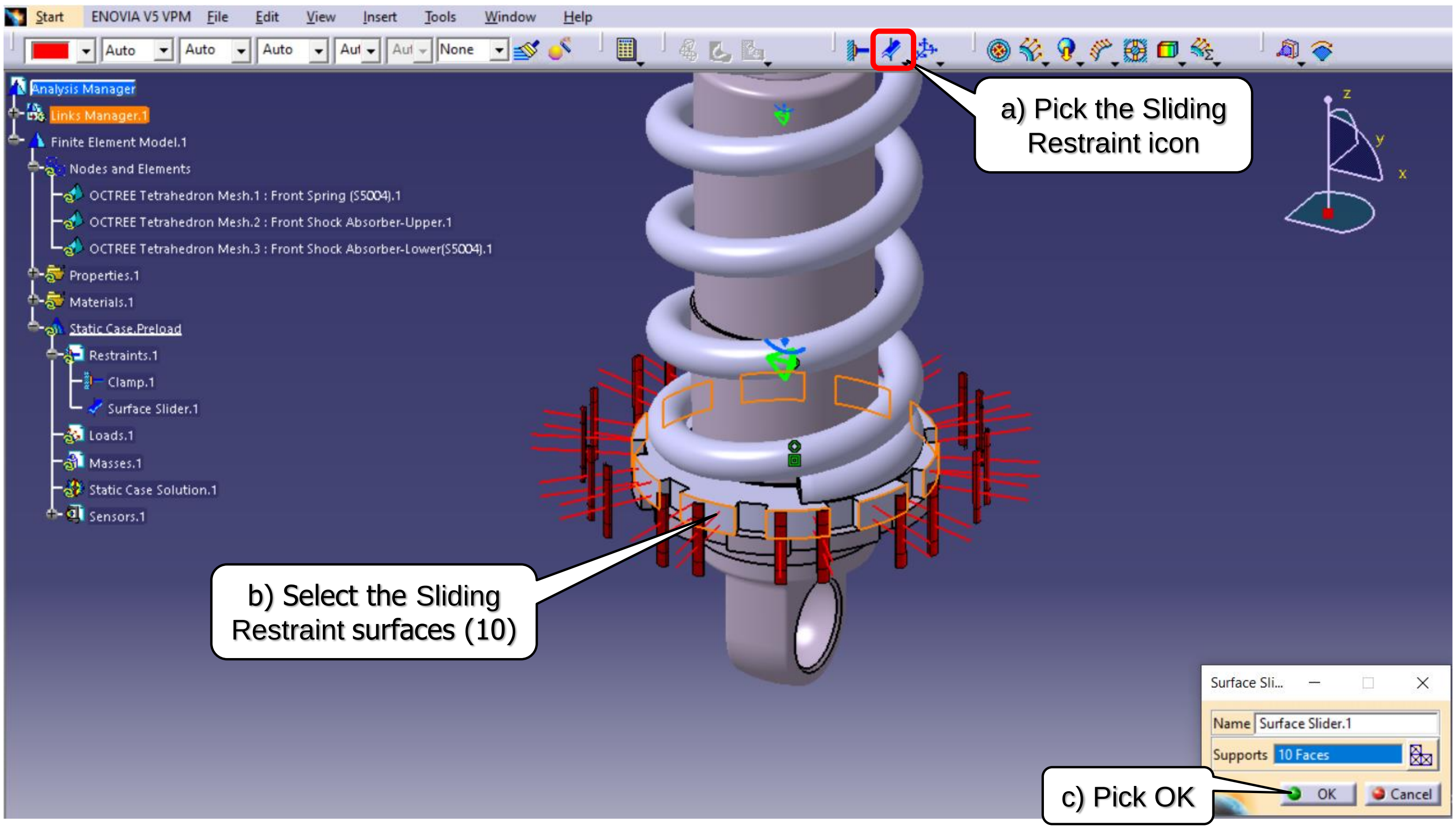
BND TechSource

- Create the Clamp Restraint and rename Static Case.

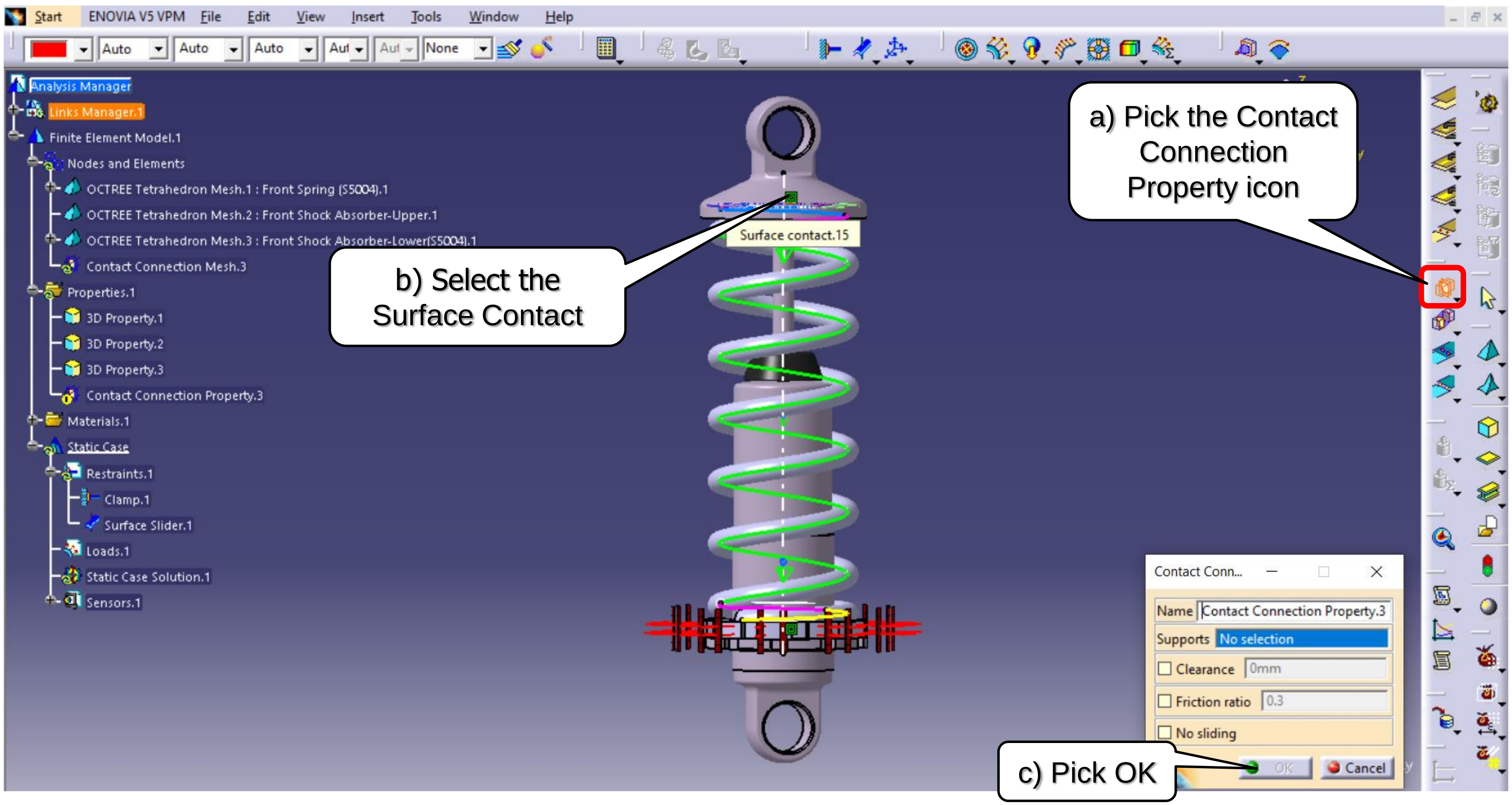


BND TechSource

- Create the Sliding Restraint.

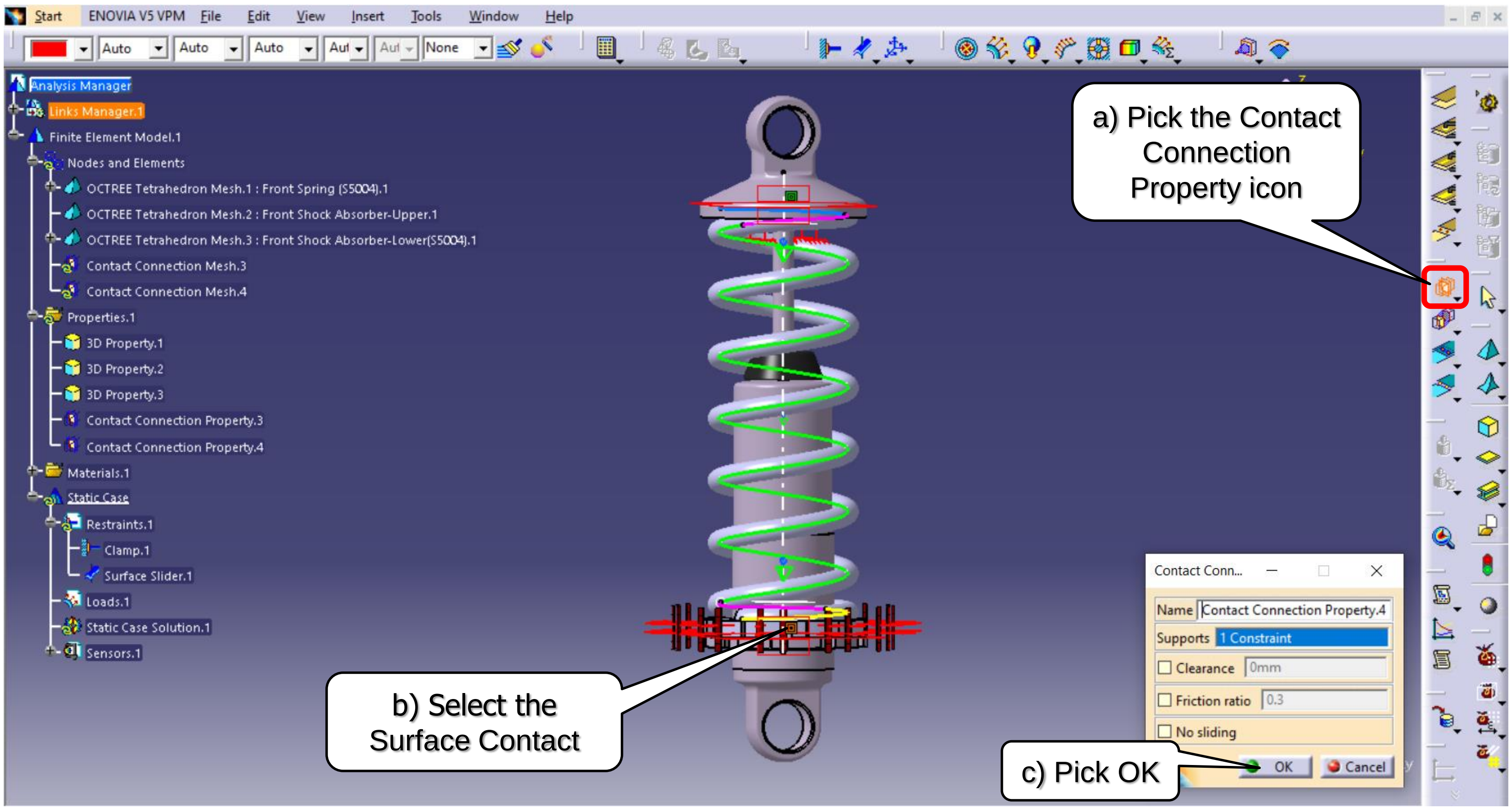


- Create the Contact Connection Property.1



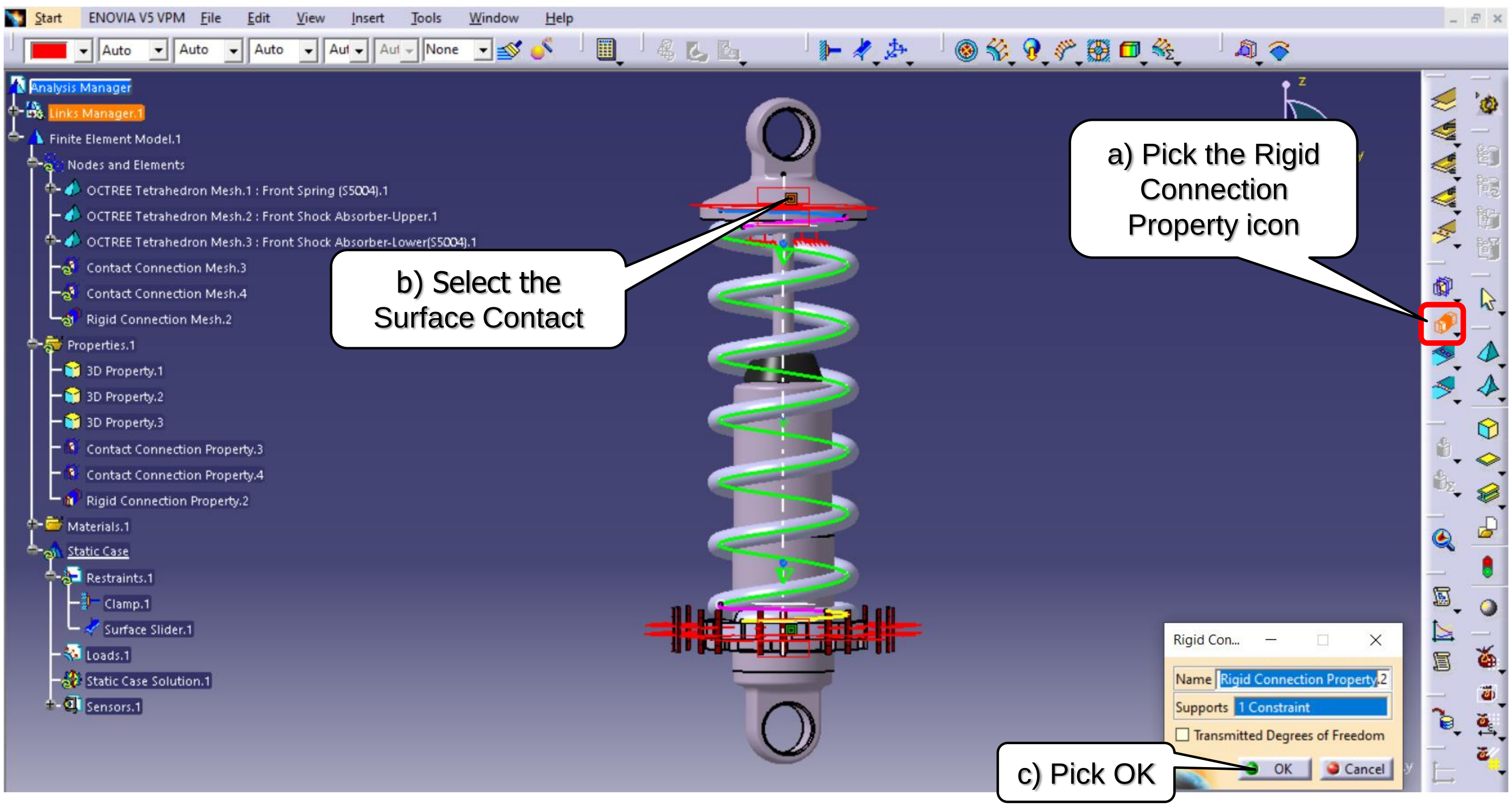
BND TechSource

- Create the Contact Connection Property.2

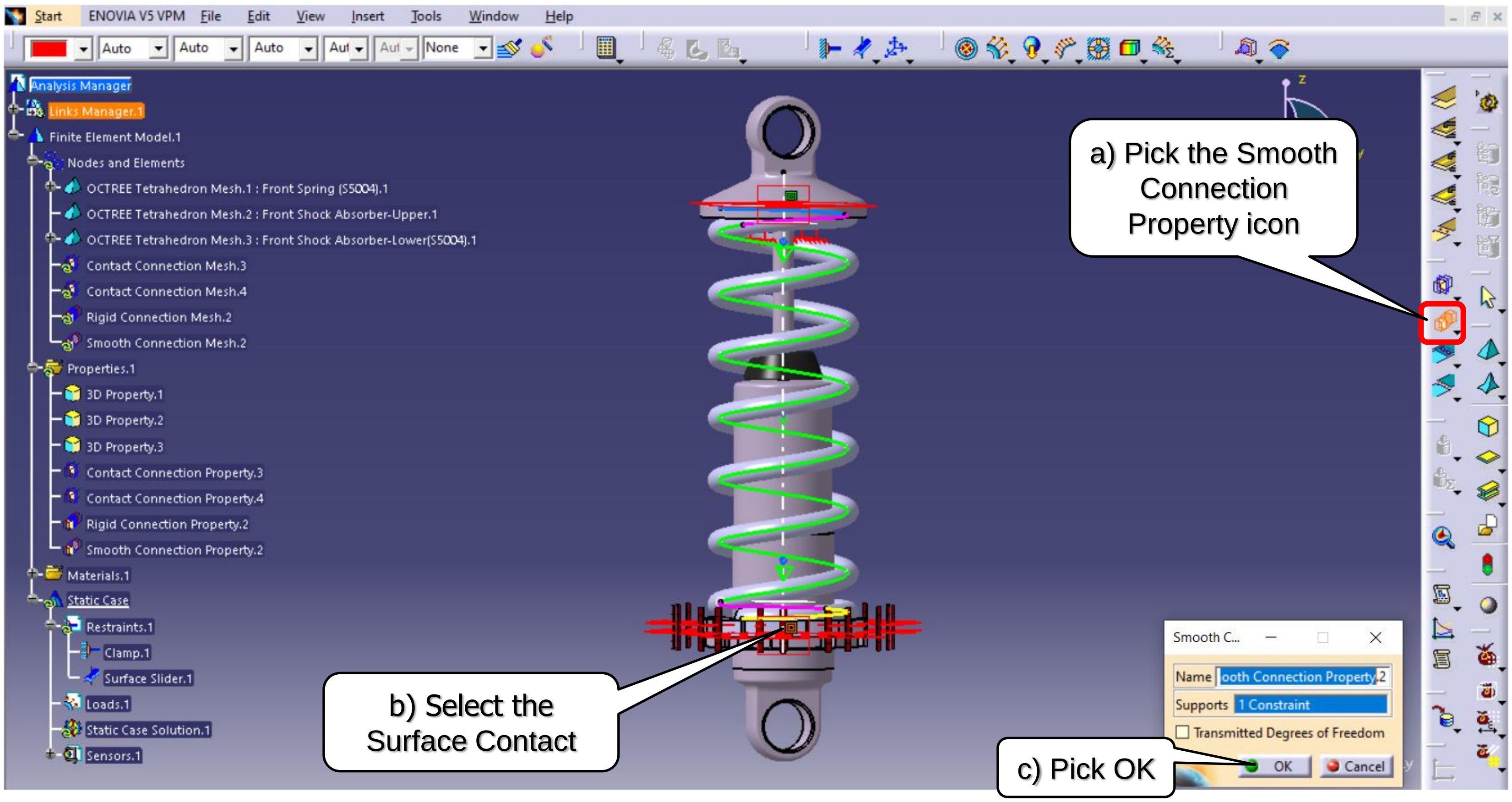


BND TechSource

- Create the Rigid Connection Property.

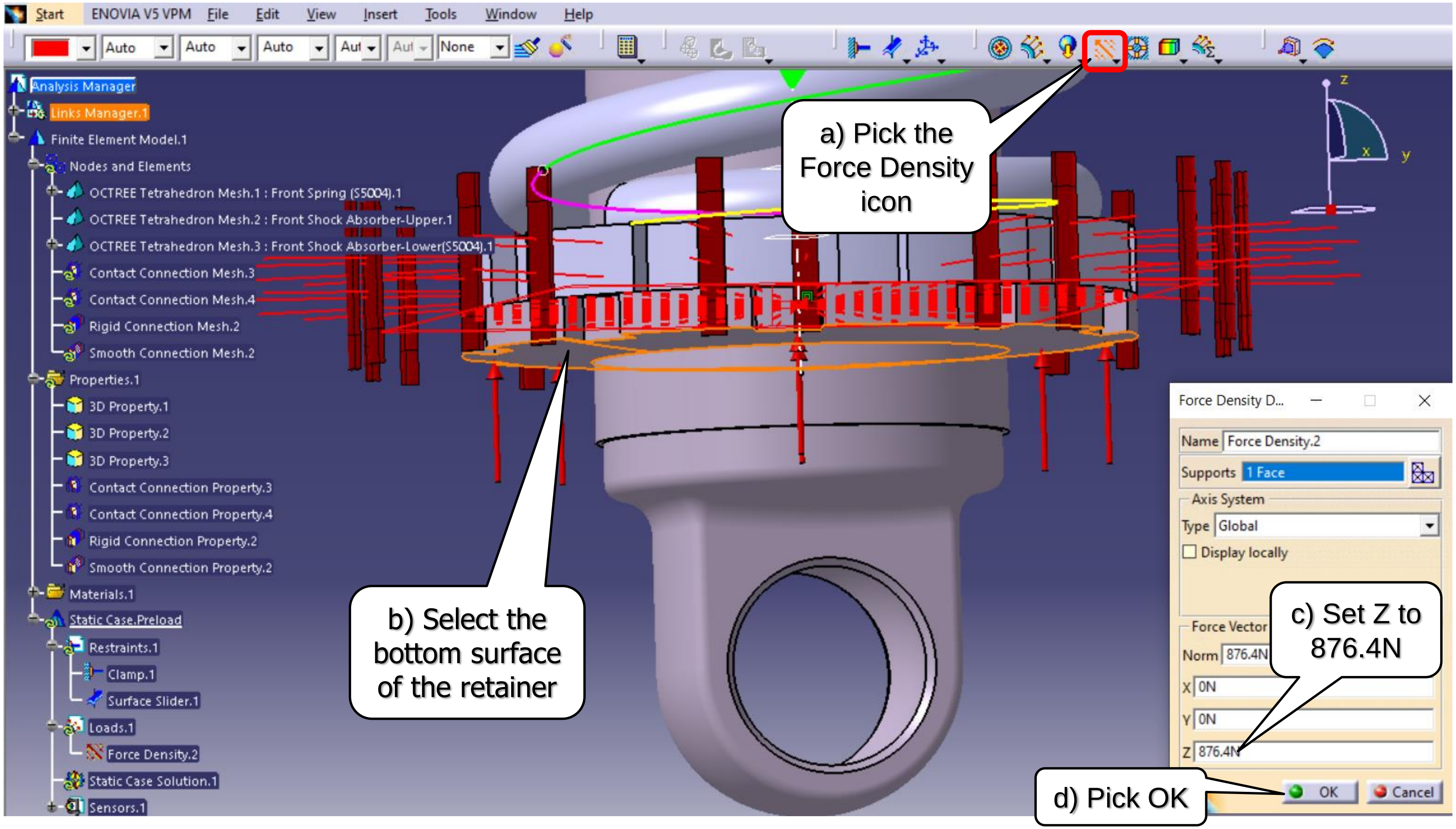


- Create the Smooth Connection Property.



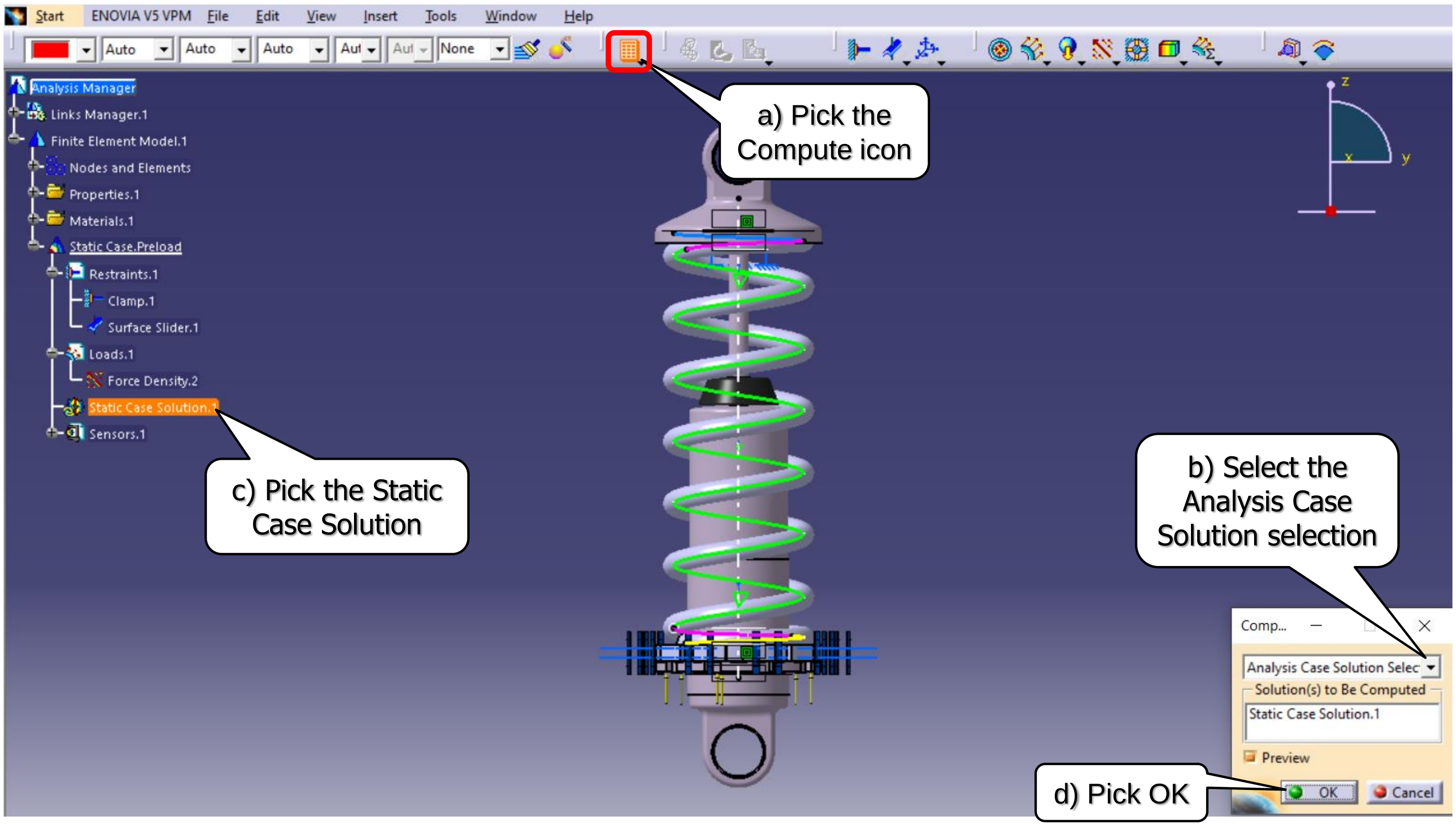
BND TechSource

- Create the Preload (10 x rate ➔ 876.4N).



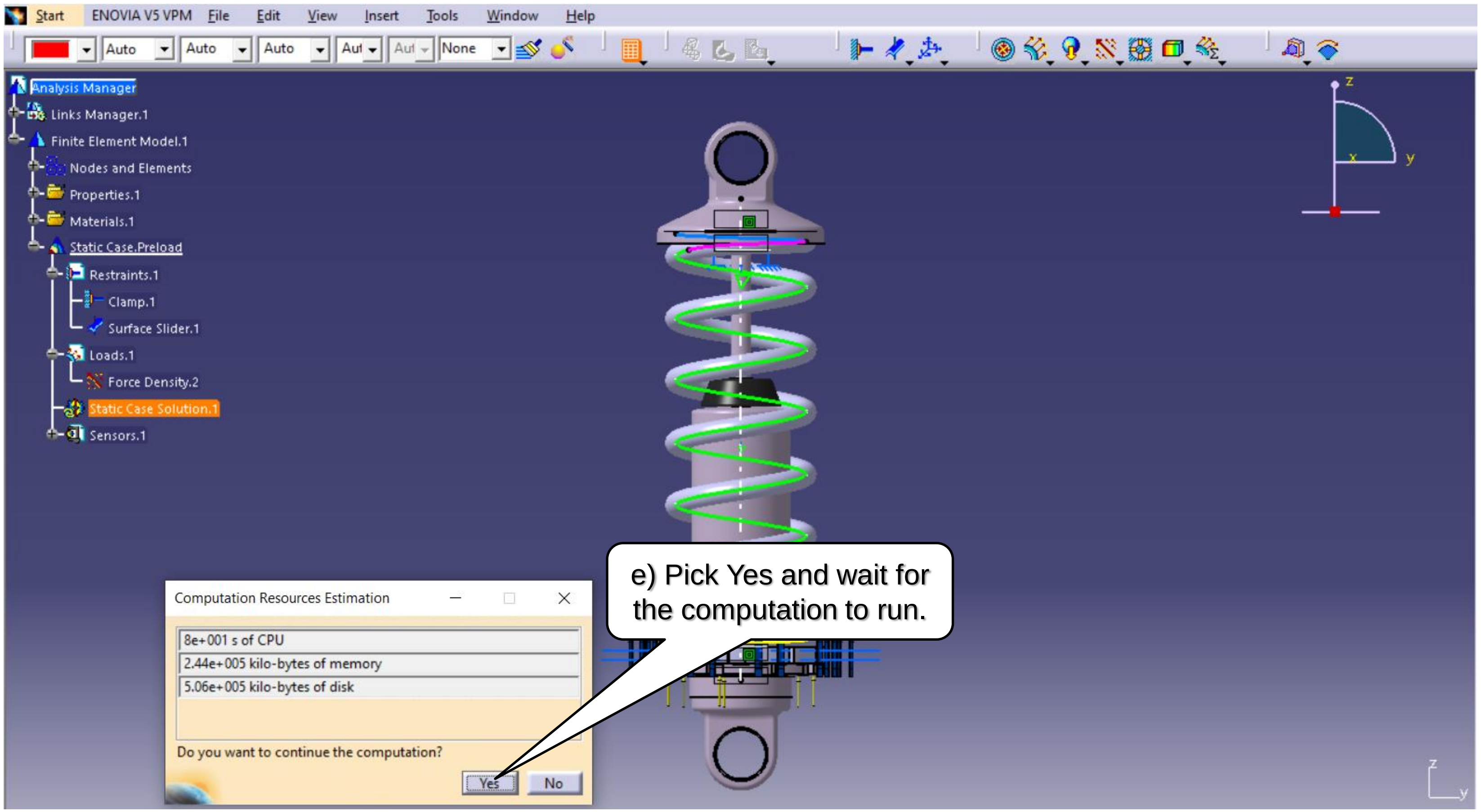
BND TechSource

- Compute the Assy Preload analysis.

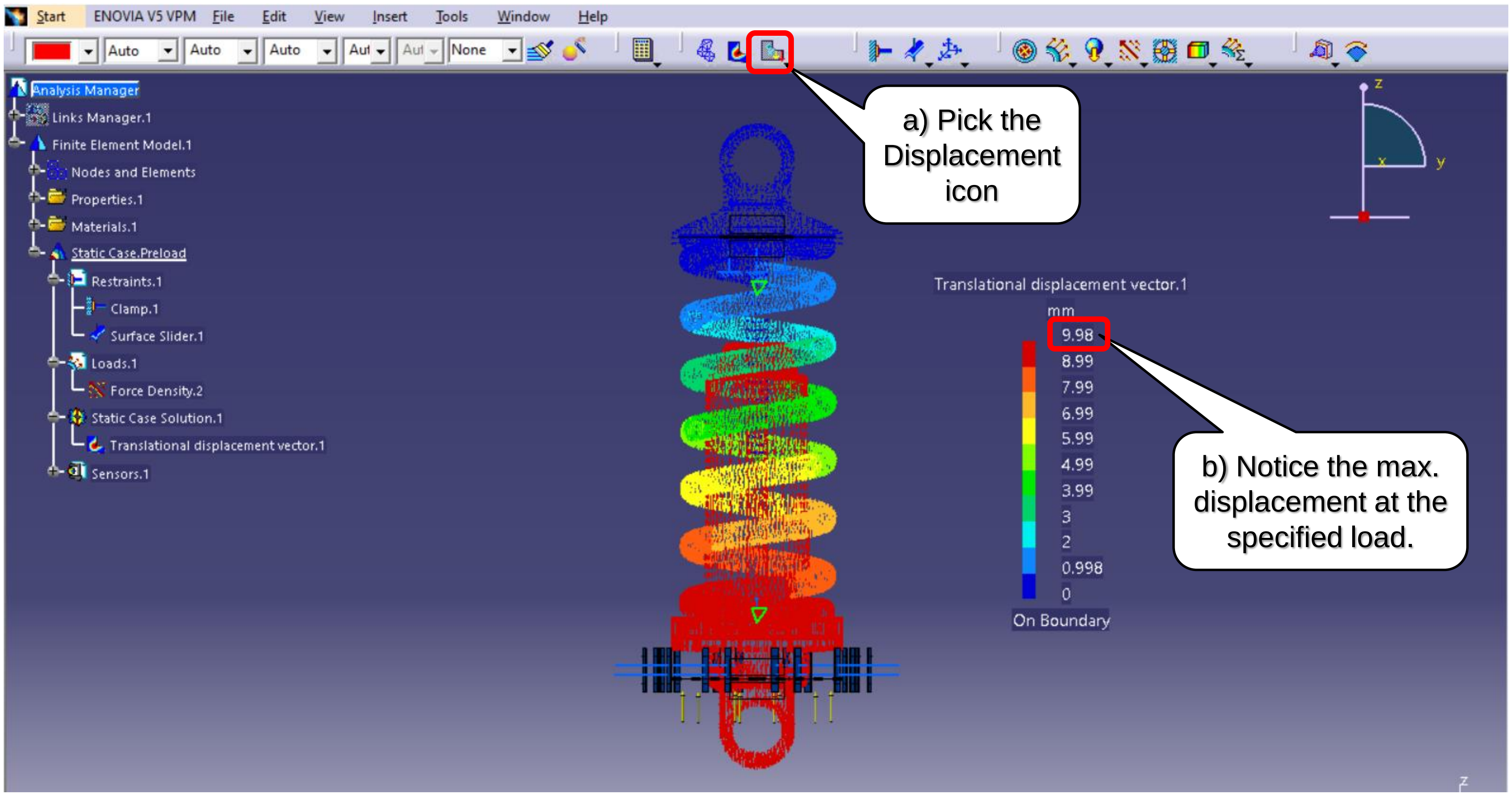


BND TechSource

- Compute the Assy Preload analysis.



- Show results of the Assy Preload analysis.



BND TechSource

- Adjust Factors to “dial in” the FEA correlation if required.

From CATIA				C3 Project Front Spring Calculation													
Material	Young's Modulus (E) [modulus of elasticity]		Poisson's ratio (ν) [transverse contraction	Modulus of Rigidity (G)		Wire Diameter [d]			Spring Mean Diameter [D]			Free Length [L_f]			Total coils [N_t]	Active coils [N_a]	Select End Types:
	(psi x 10^6)	(MPa x		(psi x 10^6)	(MPa x 10^3)	inch	m	mm	inch	m	mm	inch	m	mm	value	value	Choice
Chrome Silicon	30.0	207.0	0.305	11.5	79.3	0.500	0.0127	12.7	3.000	0.0762	76.2	9.606	0.244	244	8.650	6.650	Squared or closed (Ground)
				11501494	79300000000												

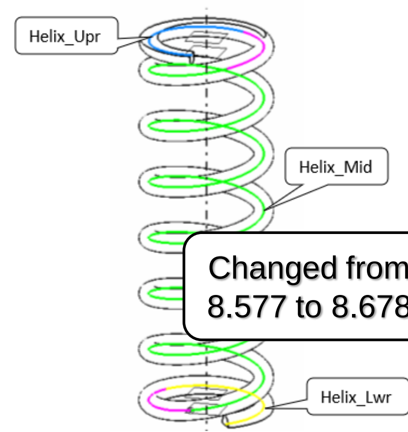
$$k = \frac{d^4 G}{8 D^3 N_a} \qquad \nu = \frac{E}{G \cdot 2} - 1$$

G = E / (2*(1+ν))

Calculated Pitch [P]			Spring Outer Diameter [OD]			Spring Inner Diameter [ID]			Spring rate [k]	
inch	m	mm	inch	m	mm	inch	m	mm	lb/in	N/mm
1.411	0.0358	35.836	3.500	0.0889	88.9	2.500	0.0635	63.5	500.45	87.64

Spring Results (FEA)			
Mean Dia.	Force	defl	Rate
mm	N	δ (mm)	(k) N/mm
76.2	876.4	10	87.6

in	lb	in	lb/in
3.000	197.03	0.394	500.4



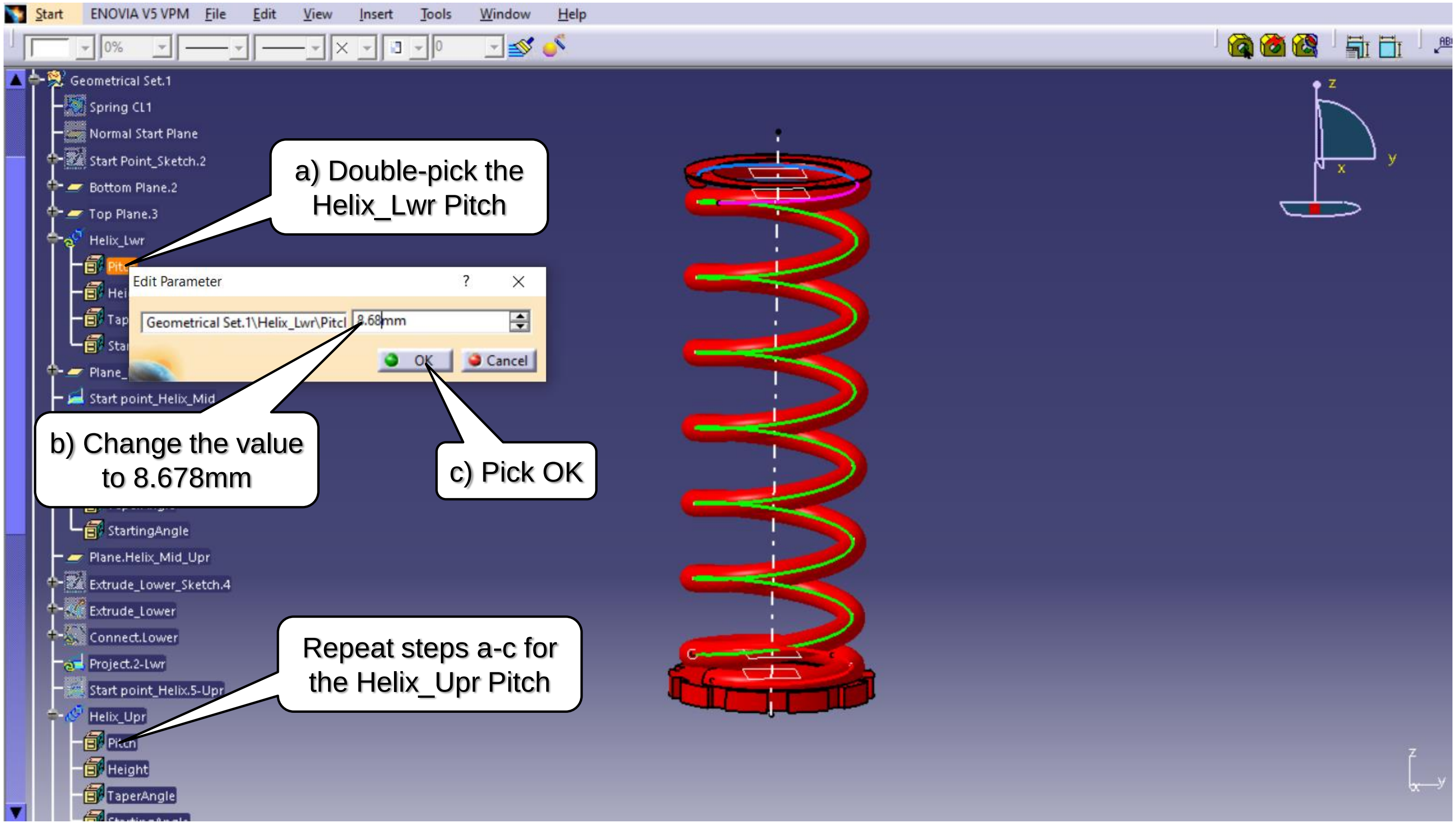
Adjusted for CATIA FEA	
36.692	= Pitch in Helix_Mid
2.55	= Factor for Coils in Helix_Mid
6.10	= Coils in Helix_Mid
223.820	= Height in Helix_Mid
20.18	= Δ Free Length to Helix_Mid Ht.
10.09	= Height of Helix_Mid Start Plane
0.86	= Factor for Pitch in Helix_Upr&Lwr
0.50	= Factor for Height in Helix_Upr&Lwr
8.68	= Pitch in Helix_Upr&Lwr
5.05	= Height in Helix_Upr&Lwr

Changed from 8.577 to 8.678

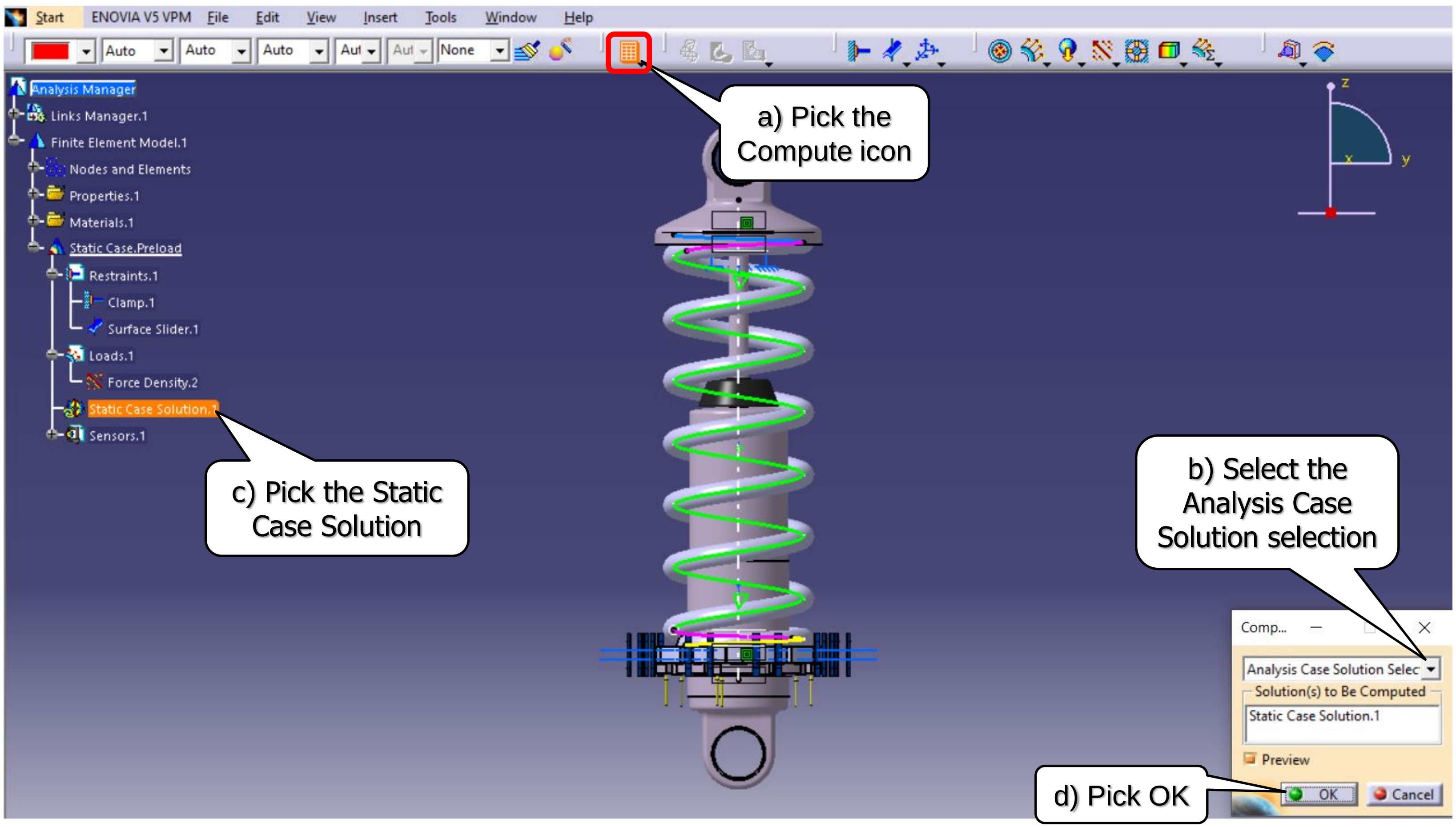
Changed from 0.85 to 0.86

BND TechSource

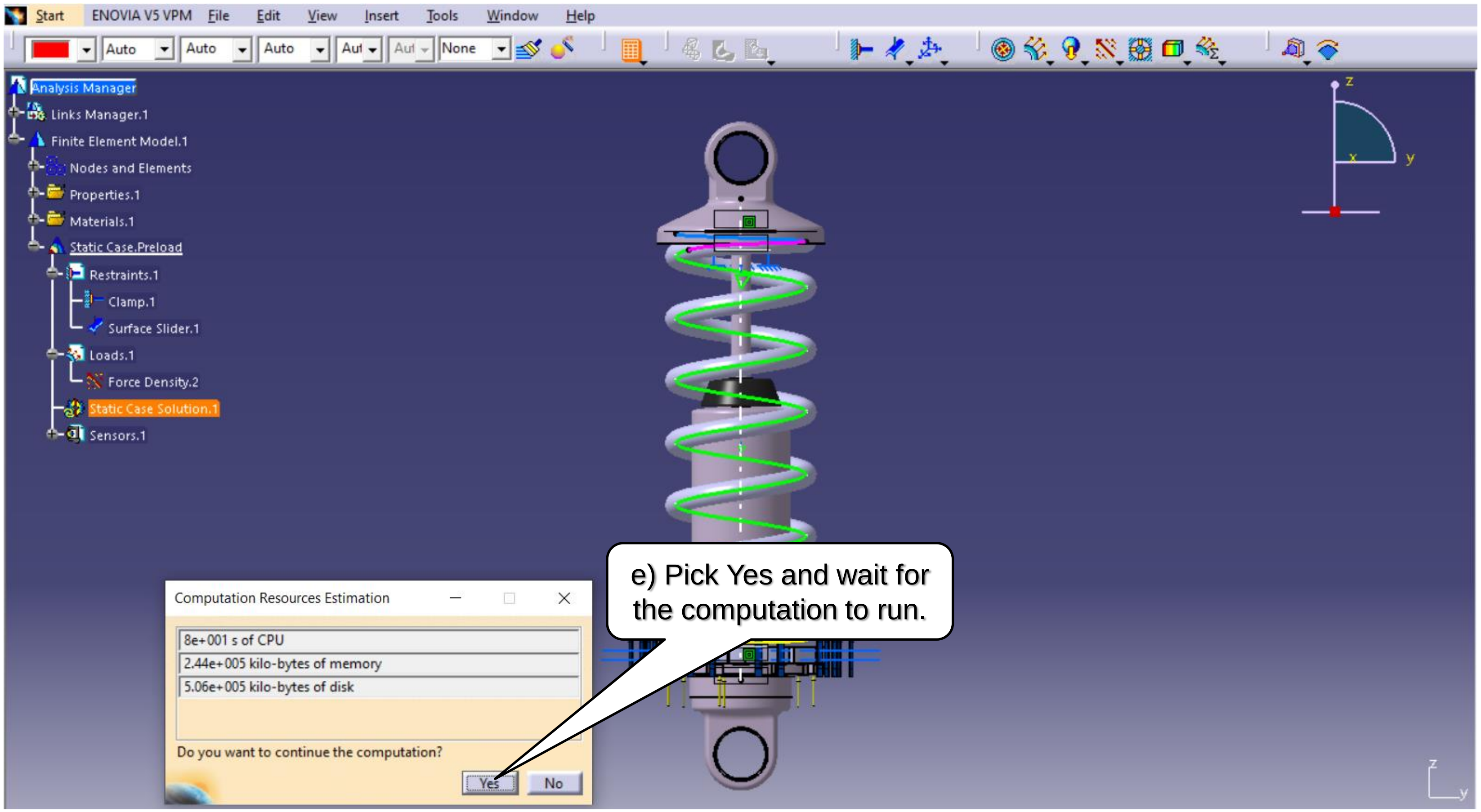
- Adjust the Spring CATPart Upr & Lwr Helix.



- Re-compute the Assy Preload analysis.

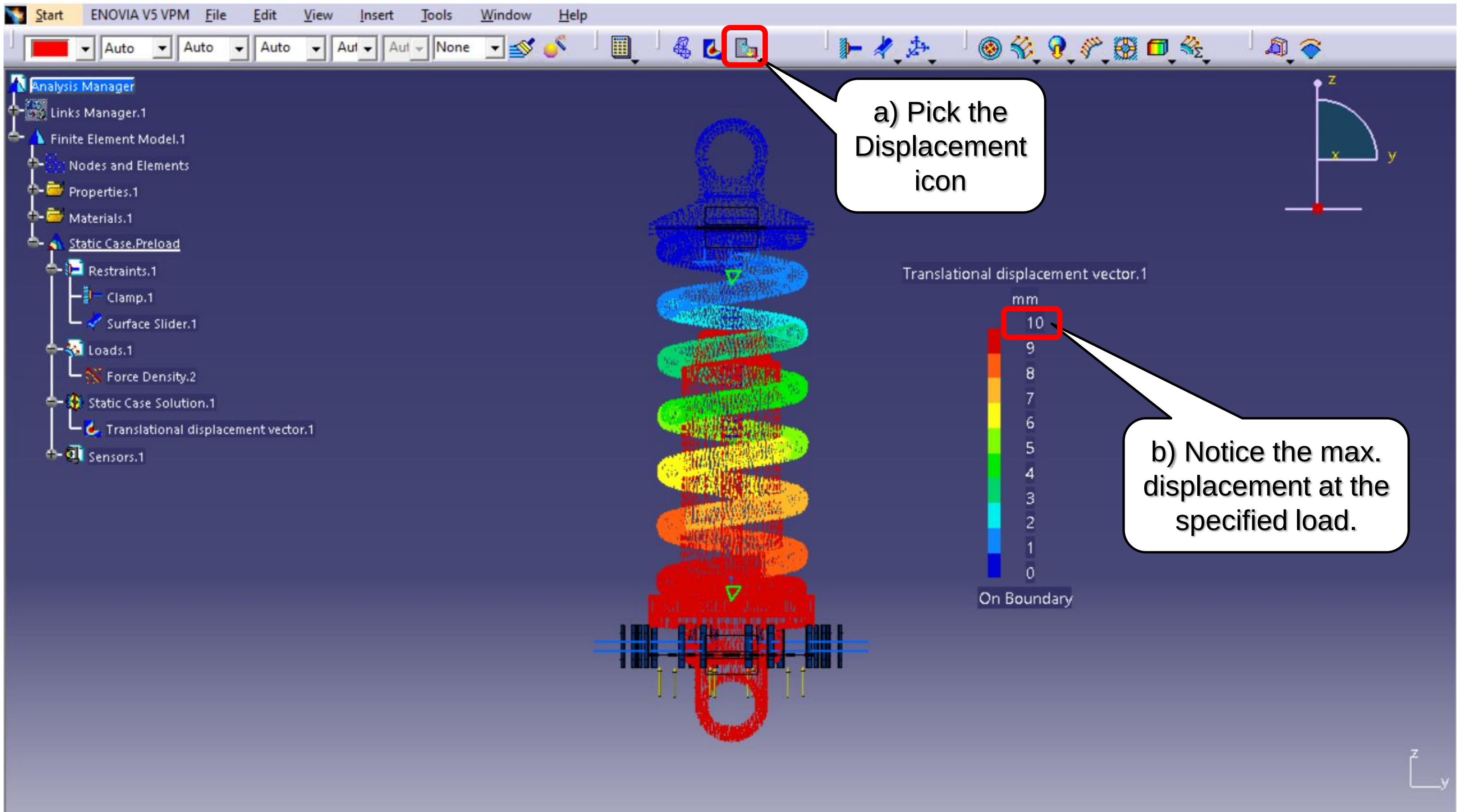


- Re-compute the Assy Preload analysis.

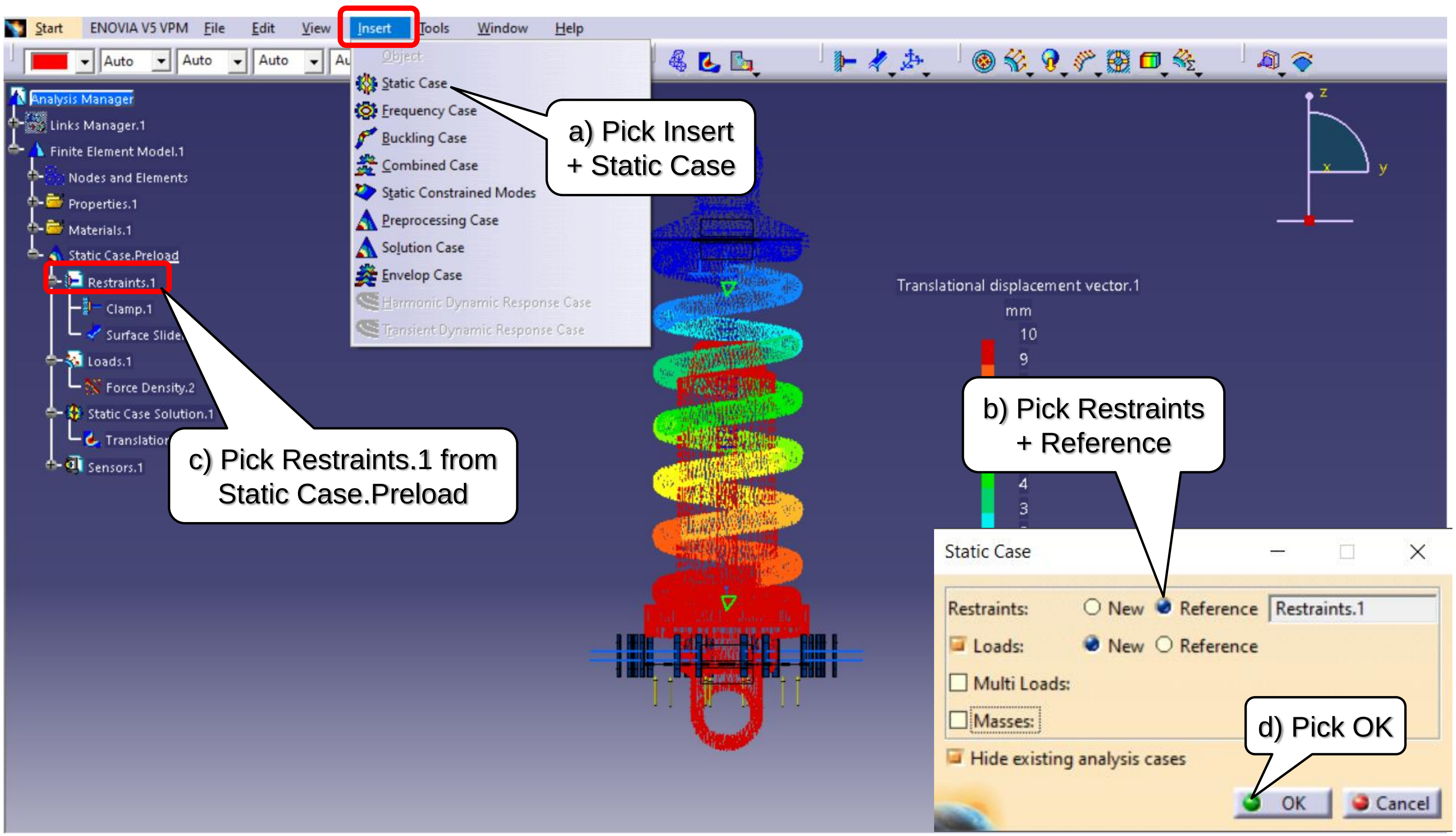


BND TechSource

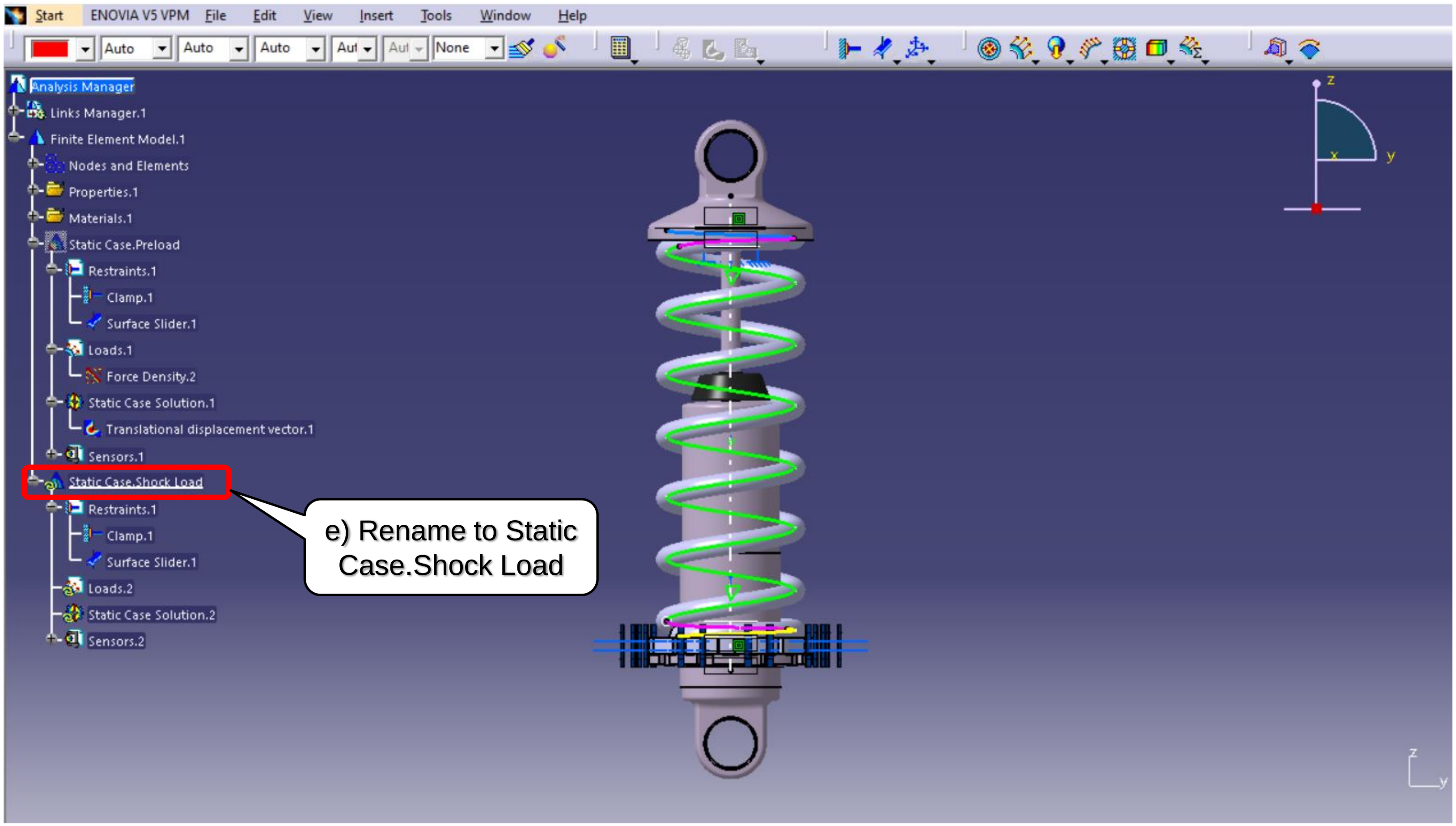
- Show results of the Assy Preload analysis.



- Create a new Static Case.Assy Shock Deflection.

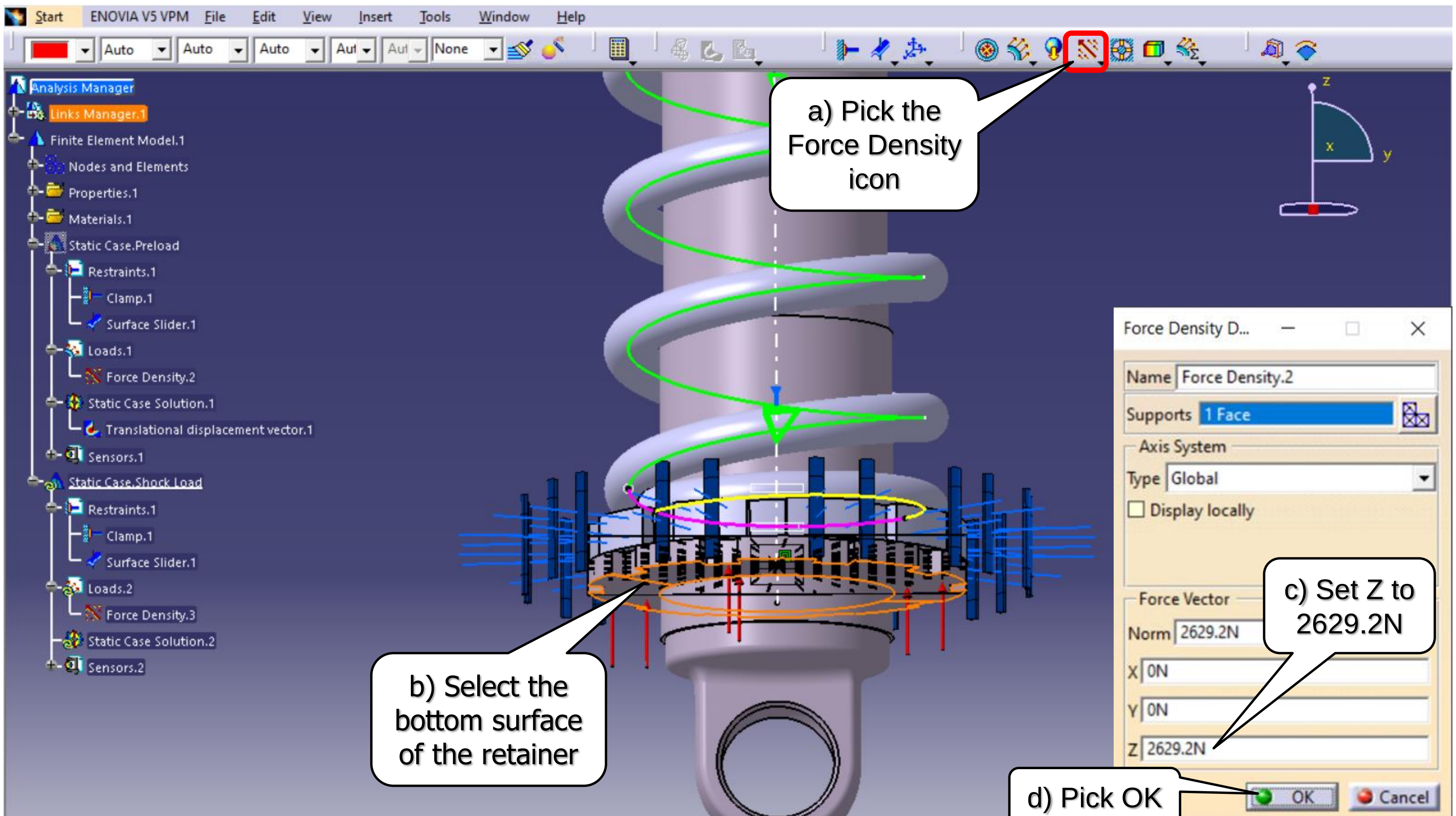


- Create a new Static Case.Assy Shock Deflection.



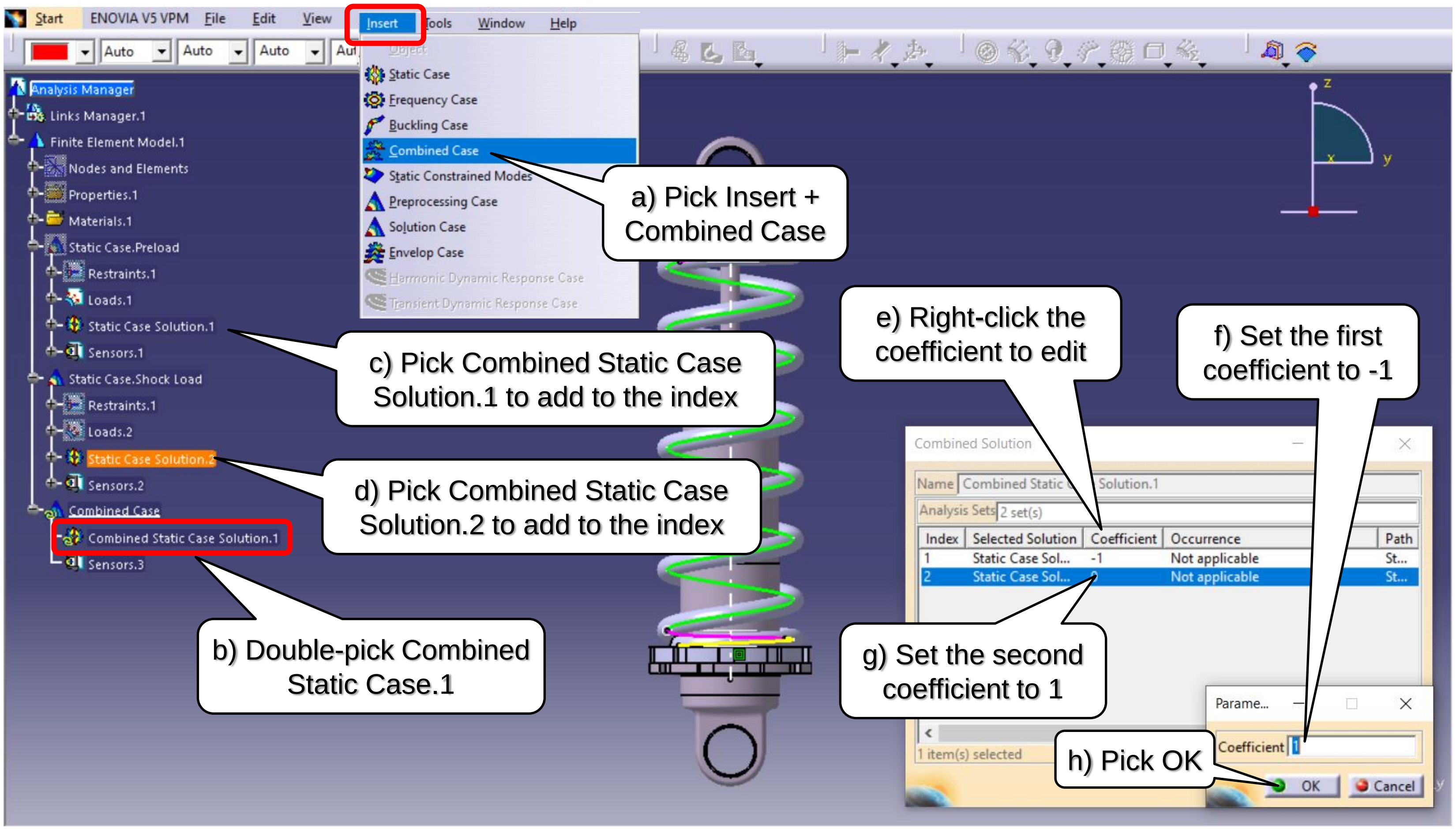
BND TechSource

- Create the new Shock Load (30 x rate ➔ 2629.2N).



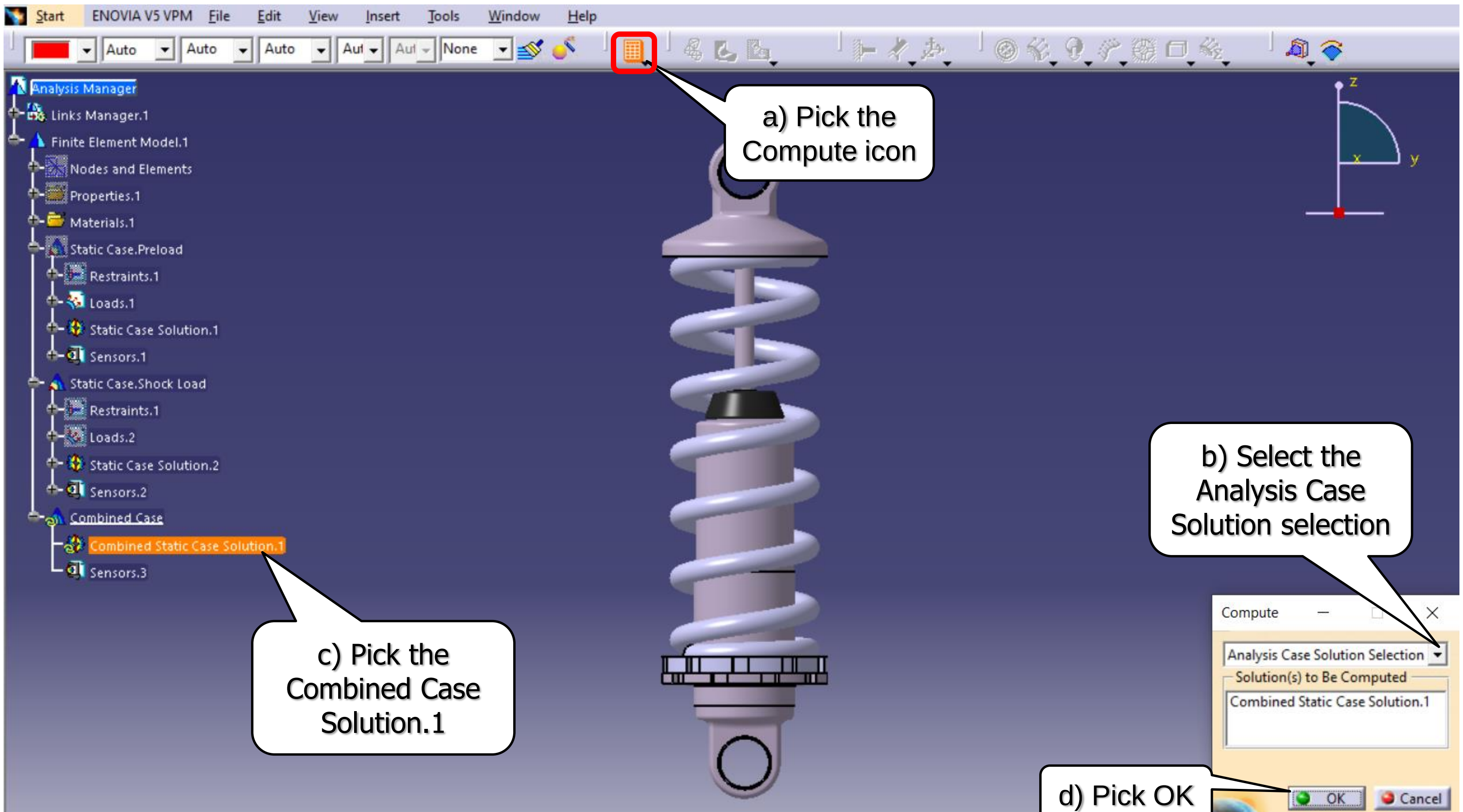
BND TechSource

- Create a new Combined Case.Assy Shock Deflection.

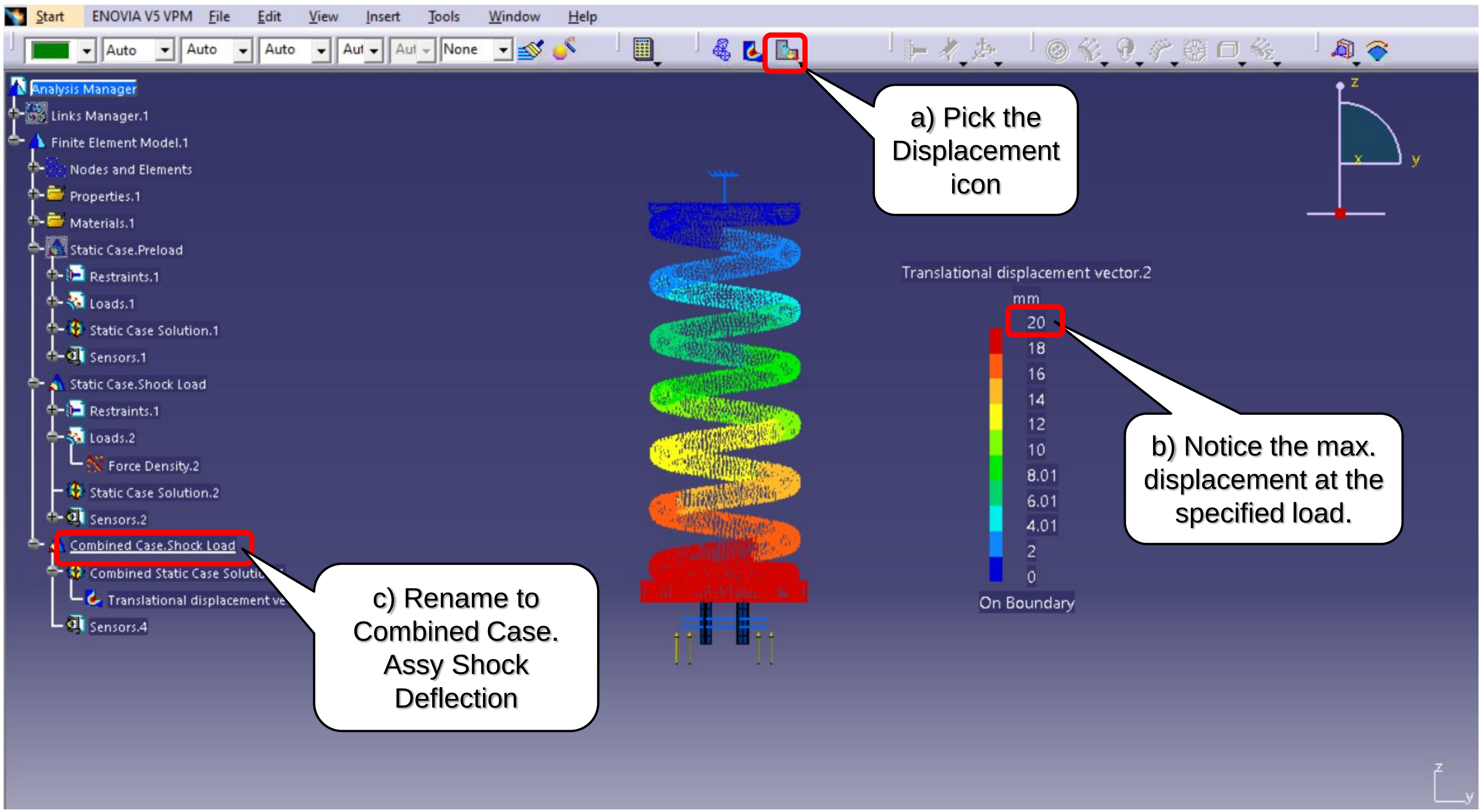


BND TechSource

- Compute the analysis for the Combined Case.

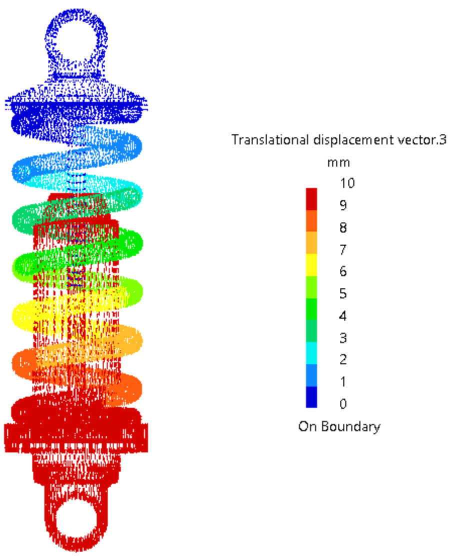


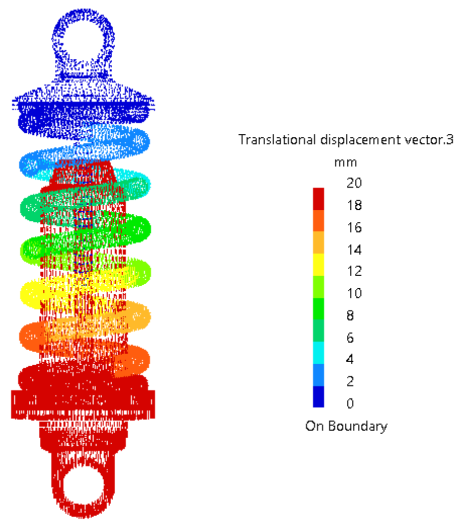
- Show results of the analysis of the Combined Case.Assy Shock Deflection.

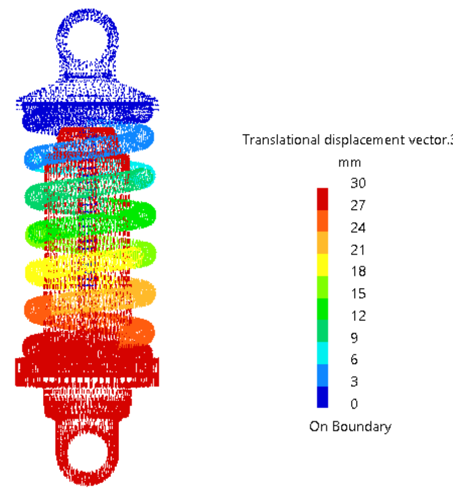


BND TechSource

- The FEA analysis of the Preloaded Shock Assy correlates with the Spring Rate from the CATIA Part model and proves the rate remains Linear.





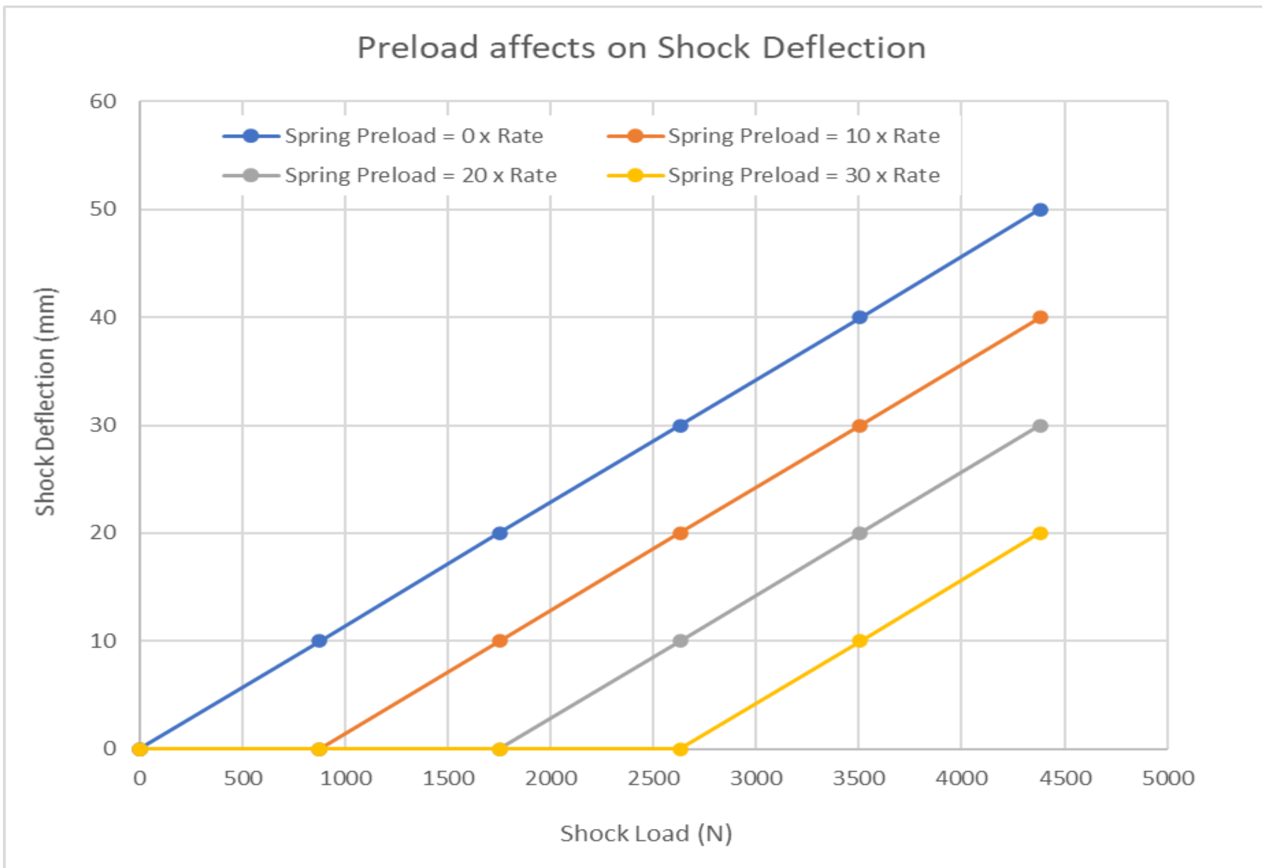


Load = 20X the Spring Rate – the Preload ➔ 10mm Defl.

Load = 30X the Spring Rate – the Preload ➔ 20mm Defl.

Load = 40X the Spring Rate – the Preload ➔ 30mm Defl.

- Graph below shows the Shock Deflection based on Shock Load at various Preload conditions.



- In this Shock Absorber Preload Analysis, we have proven the following:

1. The spring rate will be linear when the spring has a consistent (evenly spaced) pitch and a constant diameter.

2. Preloading the spring on the coil over assembly will NOT change the rate of the spring.

3. Preloading the spring on the coil over assembly WILL affect the deflection at load (length at load) of the shock absorber.

- Conclusion:

This is an example of how to use CATIA Generative Structural Analysis to prove the affects of Preload within the coil over shock absorber.

We hope this analysis proves useful for those who need to show a Torsion Bar Analysis.

As always, we are open to any discussions this may bring.

Please ***subscribe*** to our YouTube channel!