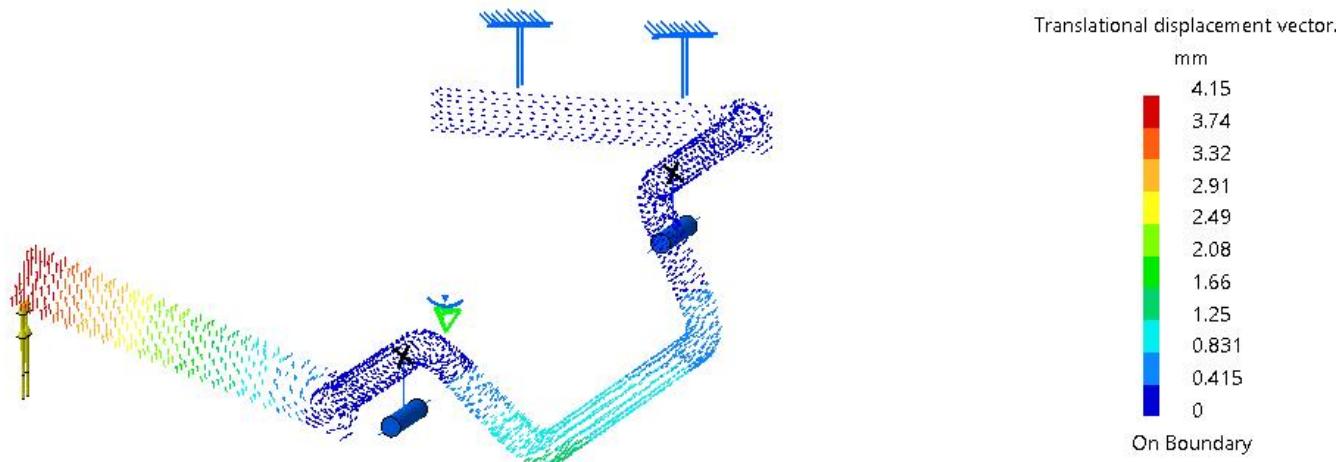
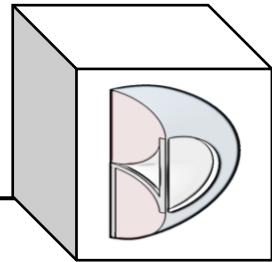


BND TechSource

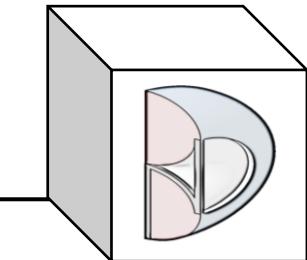


Torsion Bar Analysis using CATIA Generative Structural Analysis (FEA)





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



- Anti-roll bars perform in torsion.

The deflection rate (k) at the free end of a torsion spring is:

$$\frac{F}{\delta} = \frac{\pi d^4 G}{32 L r^2} = k$$

Where:

G = Modulus of Rigidity

δ = Deflection

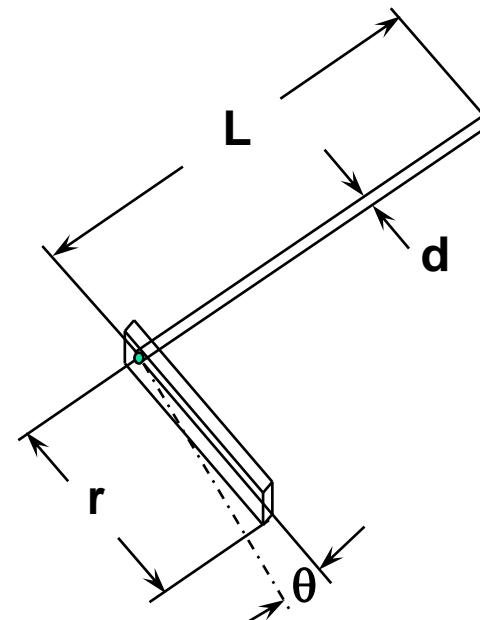
E = Young's Modulus

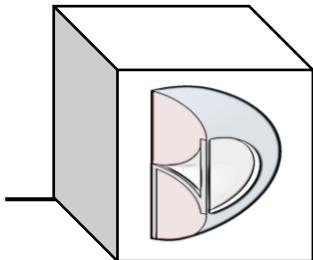
ν = Poisson's ratio

Deflection at end = δ

$\delta = r * \theta$ (radians)

$G = E / (2*(1+\nu))$





- 25mm dia. torsion bar torsional rate and force.

From CATIA			For Torsion Bar calculation													Deflection angle (θ)		Deflection (δ)			
Material	Young's Modulus (E) [modulus of elasticity] (psi x 10 ⁶)	Poisson's ratio (v) [transverse contraction coeff.]	Modulus of Rigidity (G)		Outer Diameter (d ₁)			Inner Diameter (d ₂) (if hollow)			Length (L)			Radius (r)			Deflection angle (θ)		Deflection (δ)		
	(MPa x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	inch	m	mm	radians	degrees	inch	m	mm
Steel	29.0	0.266	11.5	79.0	0.984	0.025	25	0.000	0	0	39.370	1	1000	9.843	0.25	250	0.0175	1.0	0.172	0.0044	4.36
			11456378	78988941548																	

$$\frac{F}{\delta} = \frac{\pi(d_1^4 - d_2^4)G}{32 L r^2} = k$$

211.48 Newtons/deg
47.542 Pounds/deg

$$F = \delta * \frac{\pi(d_1^4 - d_2^4)G}{32 L r^2}$$

211.48 Newtons
47.542 Pounds

Where:

Diameter d = 0.025m (25mm), 0.030m (30mm)

Length L = 1.0m (1000mm)

Modulus of Rigidity G = 79 MPa x 10³

Radius r = 0.25m (250mm)

θ (radians) = 0.03491 (1 deg)

Deflection δ = 0.0087m (4.36mm)

Young's Modulus E = 200 MPa x 10³

Poisson's ratio v = 0.266

Deflection at end = δ

δ = r * θ (radians)

G = E / (2*(1+v))

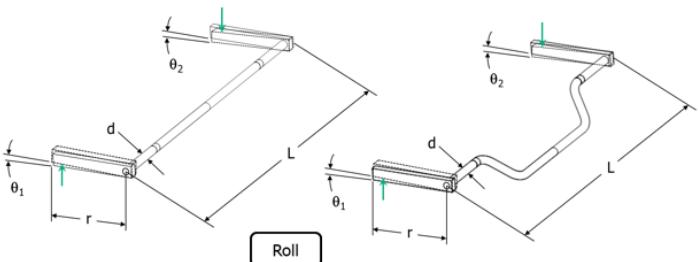
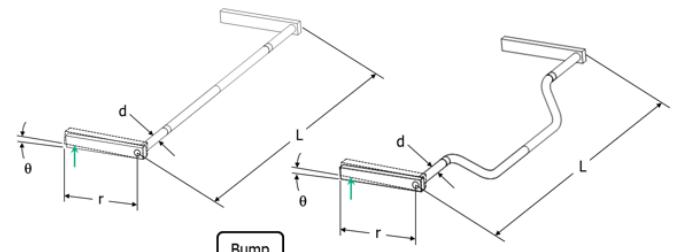
Prove: Shape change affects the spring rate of a torsion bar

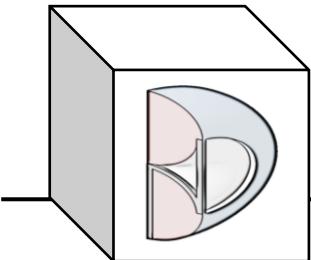
$$\delta = \frac{F 32 L r^2}{\pi(d_1^4 - d_2^4)G}$$

F =	211.5	N
inch	47.547	lb
0.172	0.0044	4.36

	Dia.	Force	Spring Rate (k)	
			straight	bent
Bump	mm	N	δ (mm) N/mm	δ (mm) N/mm
	25	211.5	4.36	48.5
	30	438.5	4.36	100.6
	in	lb	in	lb/in
	0.984	47.55	0.980	1.9
	1.181	98.58	0.980	4.0
			0.162	609.2

	Dia.	Force	Spring Rate (k)	
			straight	bent
Roll	mm	N	δ (mm) N/mm	δ (mm) N/mm
	25	423	4.54	93.2
	30	877	4.52	194.0
	in	lb	in	lb/in
	0.984	95.09	1.021	3.7
	1.181	197.16	1.016	7.6
			0.169	1167.3





- 30mm dia. torsion bar torsional rate and force.

Material	From CATIA			For Torsion Bar calculation																		
	Young's Modulus (E) [modulus of elasticity] (psi x 10 ⁶)		Poisson's ratio (ν) [transverse contraction coeff.]	Modulus of Rigidity (G)			Outer Diameter (d ₁)			Inner Diameter (d ₂) (if hollow)			Length (L)			Radius (r)			Deflection angle (θ)		Deflection (δ)	
	(MPa x 10 ³)	(psi x 10 ³)		(psi x 10 ⁶)	(MPa x 10 ³)	inch	m	mm	inch	m	mm	inch	m	mm	inch	m	mm	radians	degrees	inch	m	mm
Steel	29.0	200.0	0.266	11.5	79.0	1.181	0.03	30	0.000	0	0	39.370	1	1000	9.843	0.25	250	0.0175	1.0	0.172	0.0044	4.36

$$\frac{F}{\delta} = \frac{\pi(d_1^4 - d_2^4)G}{32 L r^2} = k$$

438.52 Newtons/deg
98.583 Pounds/deg

$$F = \delta * \frac{\pi(d_1^4 - d_2^4)G}{32 L r^2}$$

438.52 Newtons
98.583 Pounds

Where:

Diameter d = 0.025m (25mm), 0.030m (30mm)

Length L = 1.0m (1000mm)

Modulus of Rigidity G = 79 MPa x 10³

Radius r = 0.25m (250mm)

θ (radians) = 0.03491 (1 deg)

Deflection δ = 0.0087m (4.36mm)

Young's Modulus E = 200 MPa x 10³

Poisson's ratio ν = 0.266

Deflection at end = δ

δ = r * θ (radians)

G = E / (2*(1+ν))

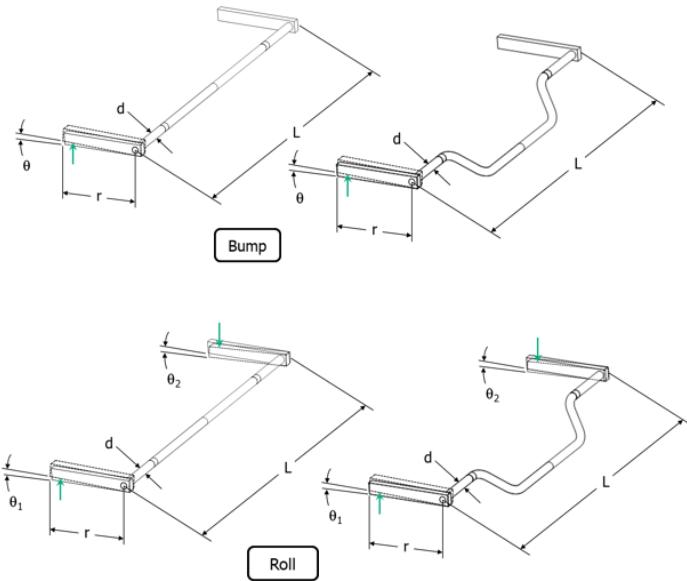
Prove: Shape change affects the spring rate of a torsion bar

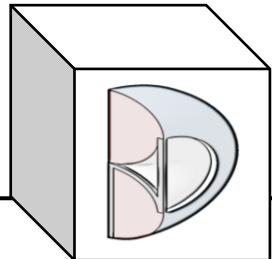
$$\delta = \frac{F 32 L r^2}{\pi(d_1^4 - d_2^4)G}$$

F =	438.5	N
inch	98.579	lb
0.172	0.0044	4.36

Bump	Spring Rate (k)					
	straight		bent			
	Dia.	Force	δ (mm)	N/mm	δ (mm)	N/mm
25	211.5	4.36	48.5	4.15	51.0	
30	438.5	4.36	100.6	4.11	106.7	
in	lb	in	lb/in	in	lb/in	
0.984	47.55	0.980	1.9	0.163	291.0	
1.181	98.58	0.980	4.0	0.162	609.2	

Roll	Spring Rate (k)					
	straight		bent			
	Dia.	Force	δ (mm)	N/mm	δ (mm)	N/mm
25	423	4.54	93.2	4.32	97.9	
30	877	4.52	194.0	4.29	204.4	
in	lb	in	lb/in	in	lb/in	
0.984	95.09	1.021	3.7	0.170	559.1	
1.181	197.16	1.016	7.6	0.169	1167.3	

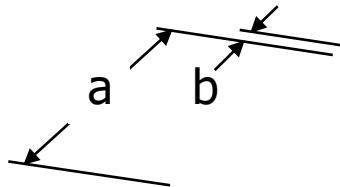




BND TechSource



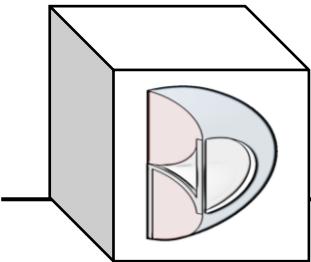
- Positions of the clamp/pivot surfaces on the Torsion Bar.



The position of these clamp/pivot surfaces are important to the *correlation* of the Equations to the FEA.



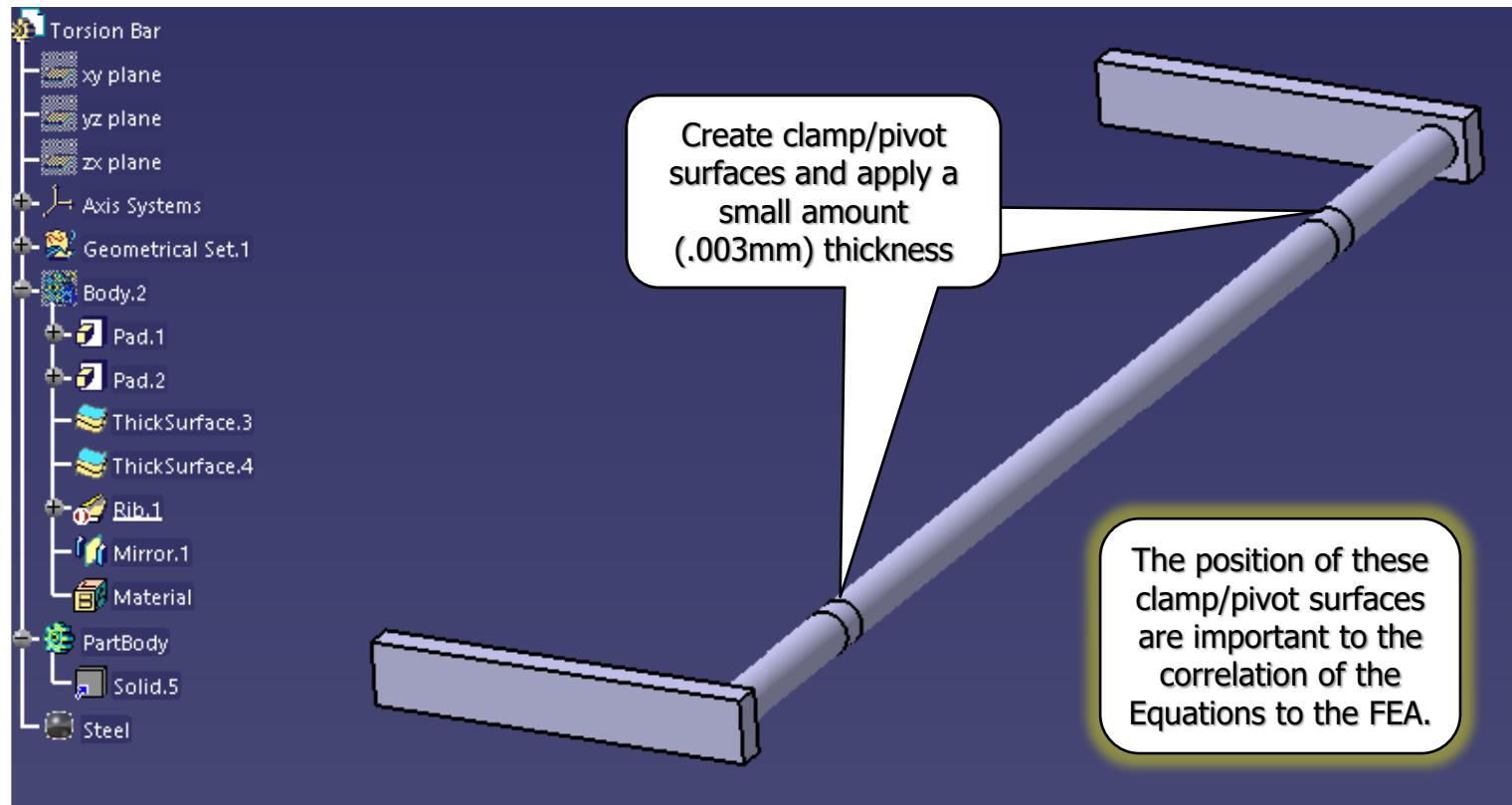
Diameter (mm)	a (mm)	b (mm)
25	295	50 (2^*d)
30	295	60 (2^*d)

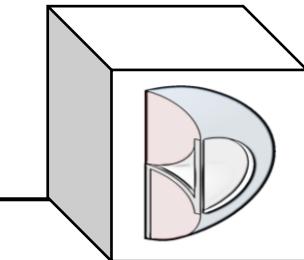


BND TechSource



- Create the straight Torsion Bar solid geometry in a CatPart.

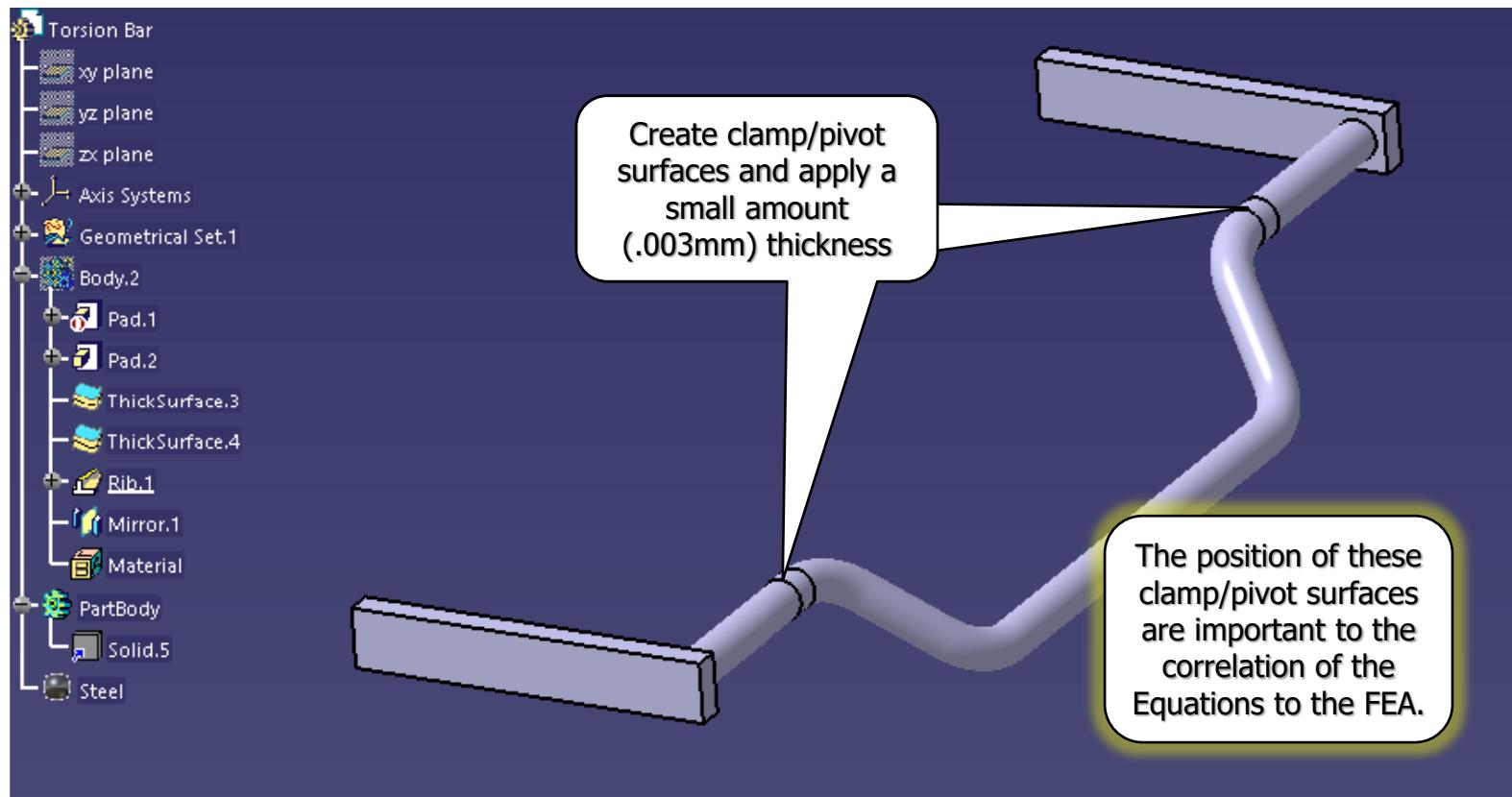


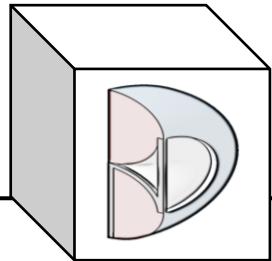


BND TechSource



- Create the bent Torsion Bar solid geometry in a CatPart.

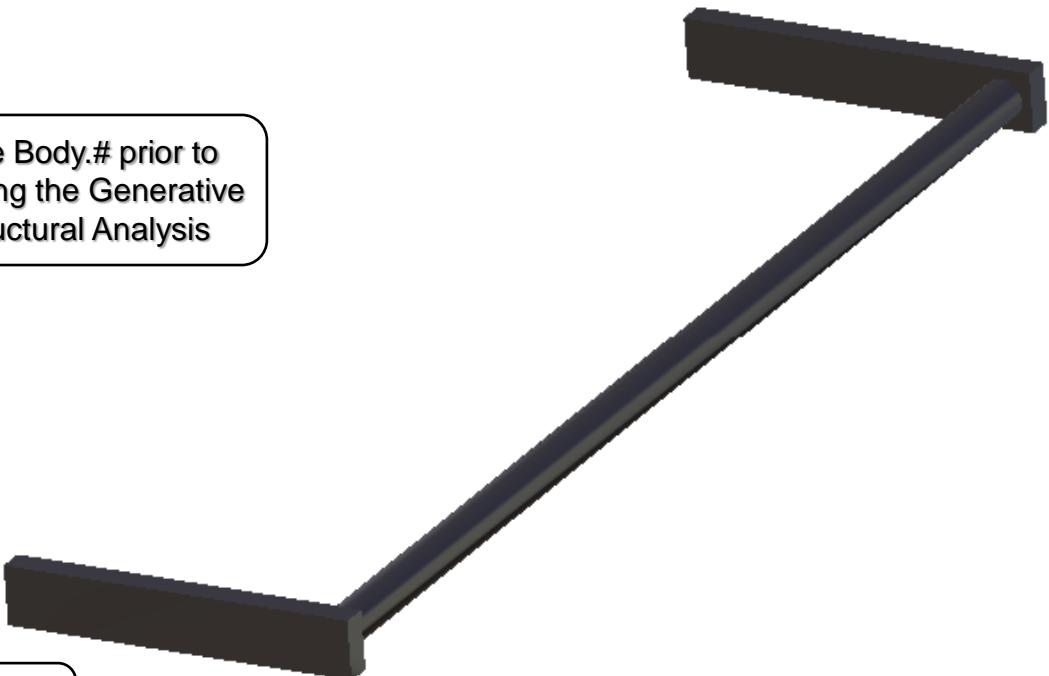
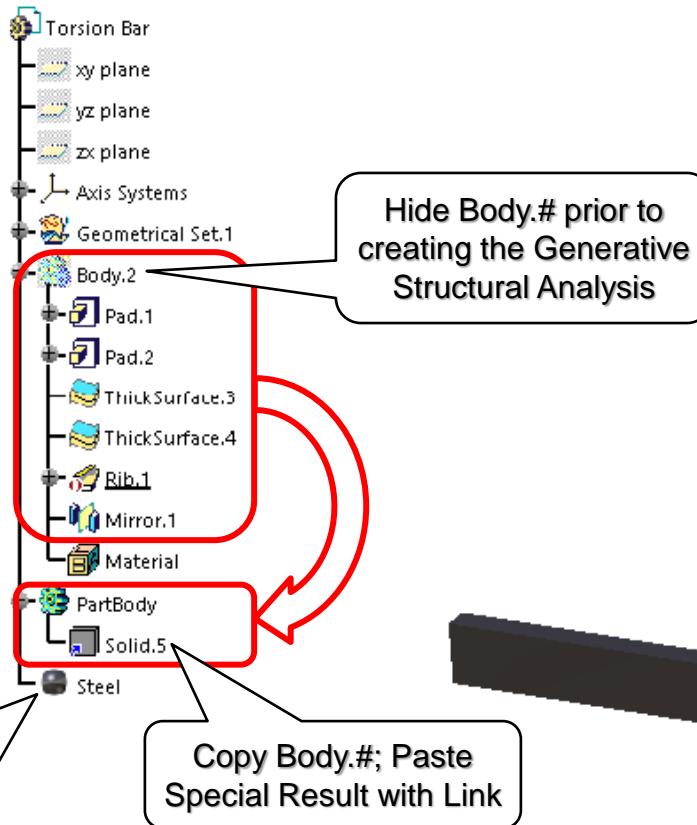


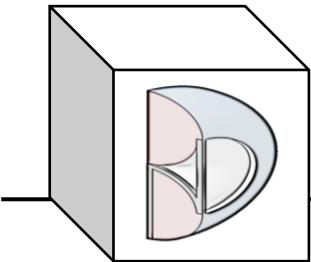


BND TechSource



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

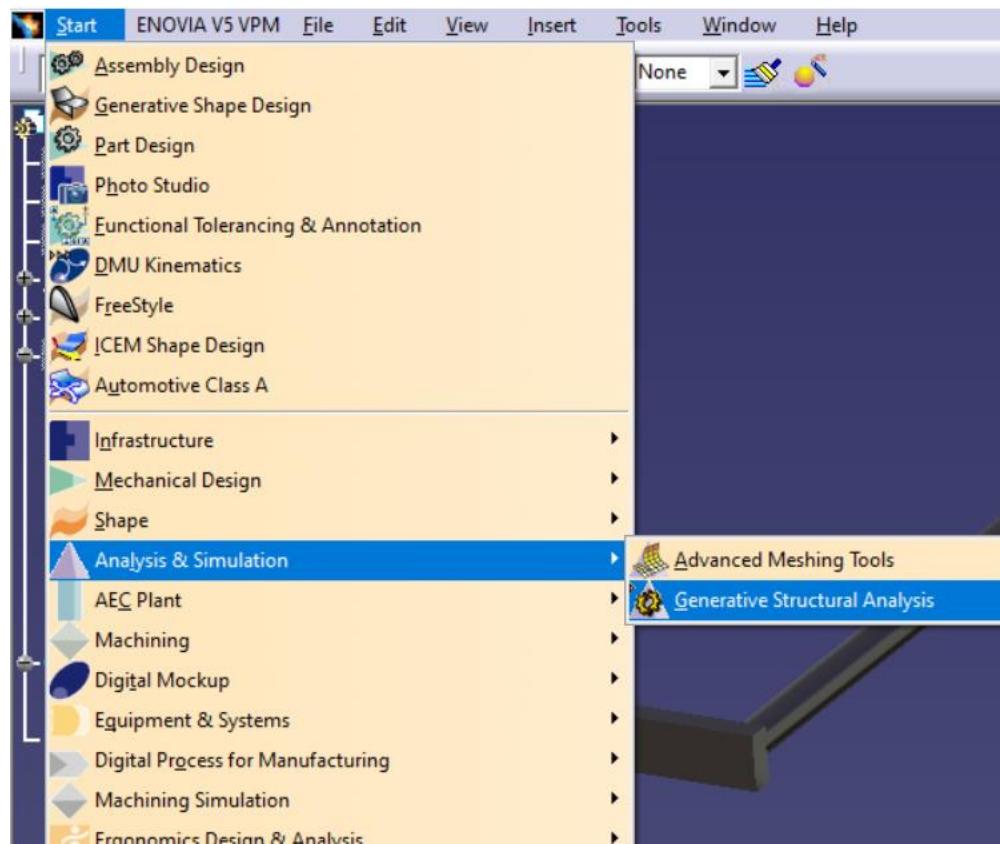


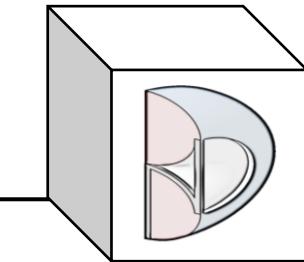


BND TechSource



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

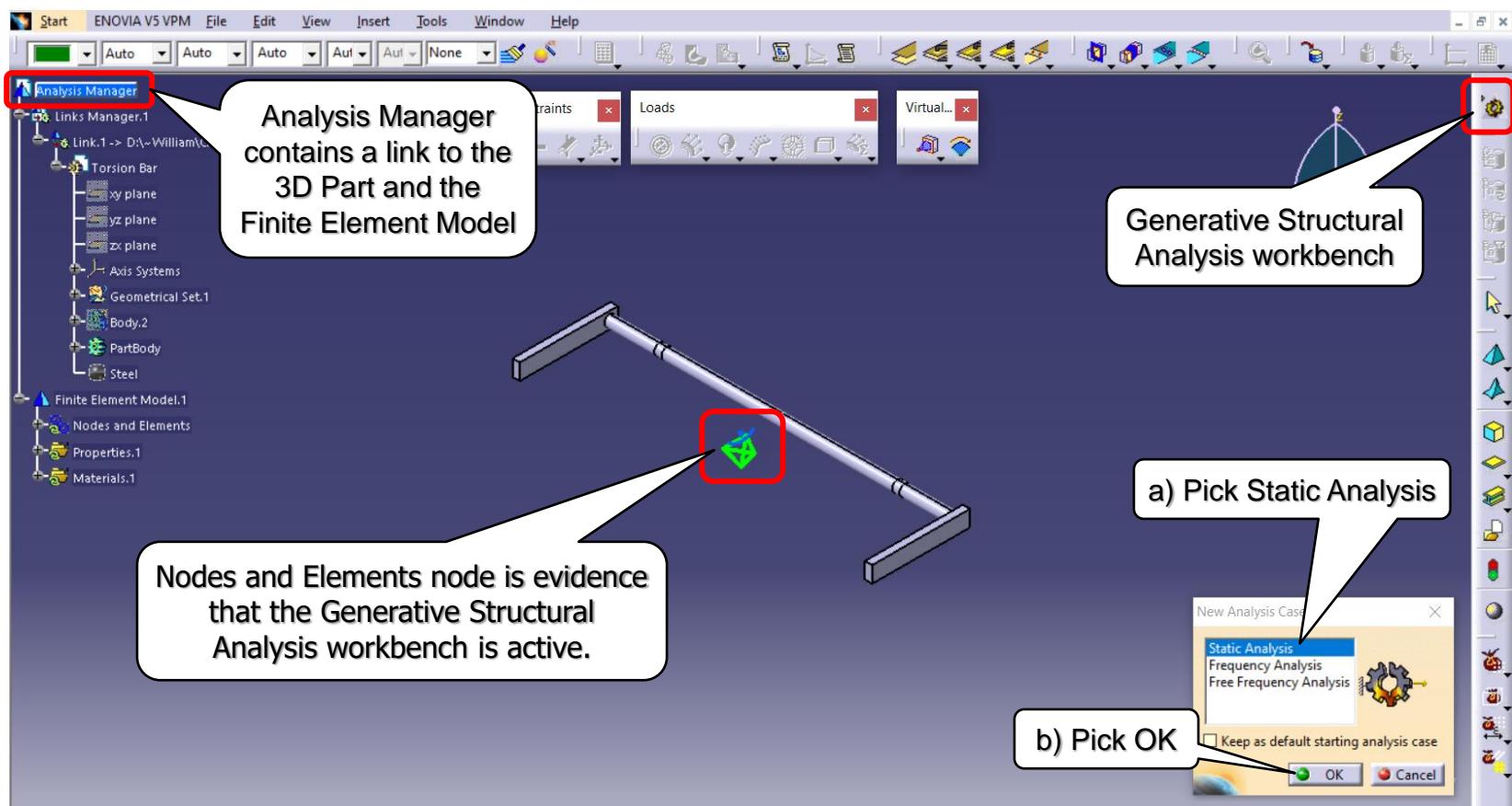


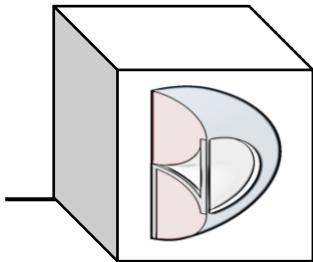


BND TechSource



- Generative Structural Analysis workbench creates the Analysis Manager.

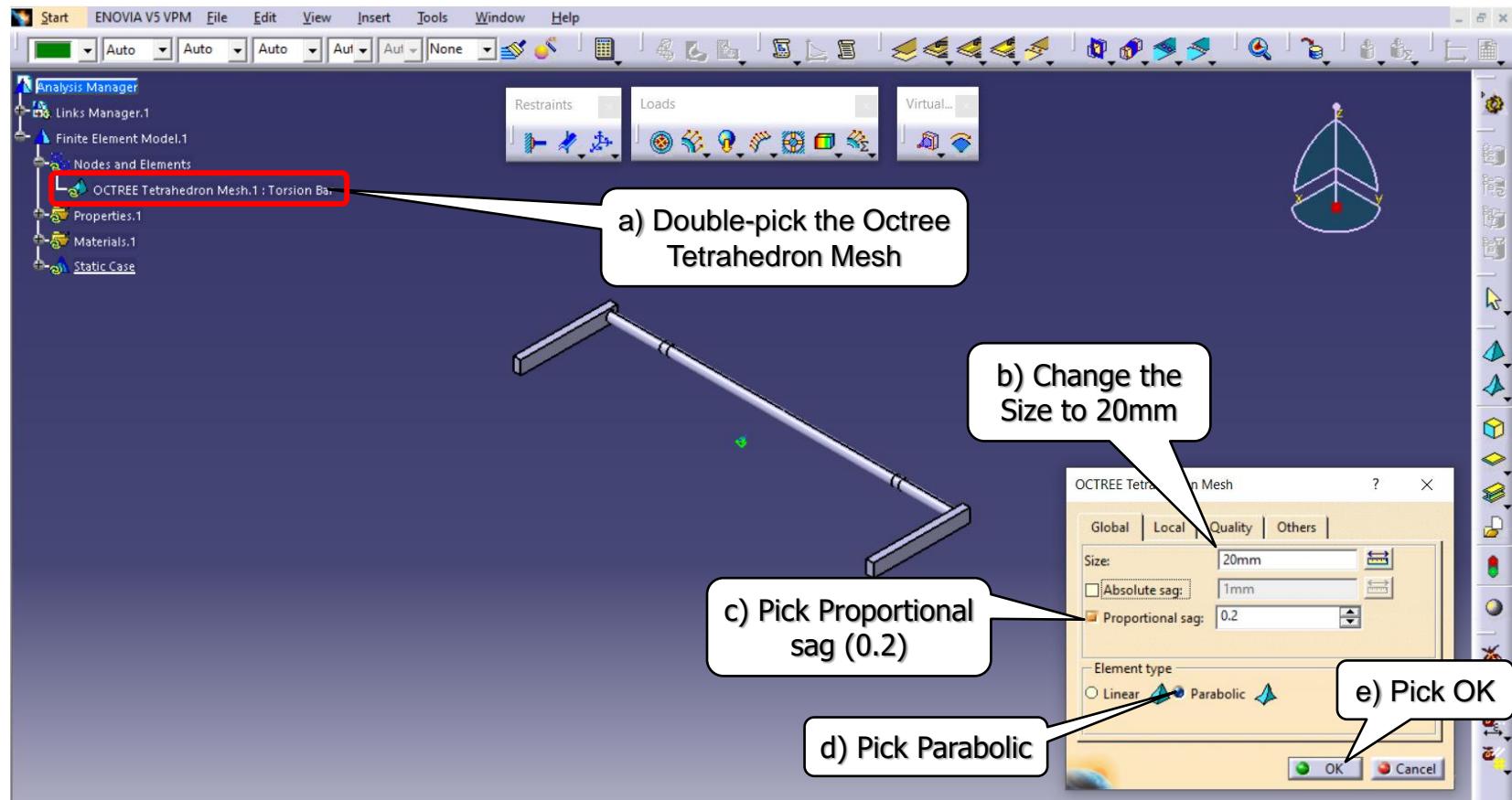


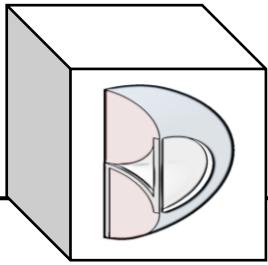


BND TechSource



- Generative Structural Analysis workbench; Optimize the Mesh.

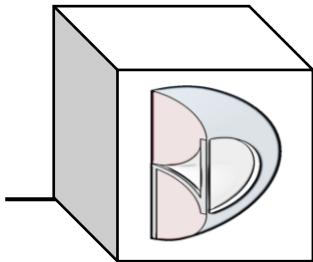




BND TechSource



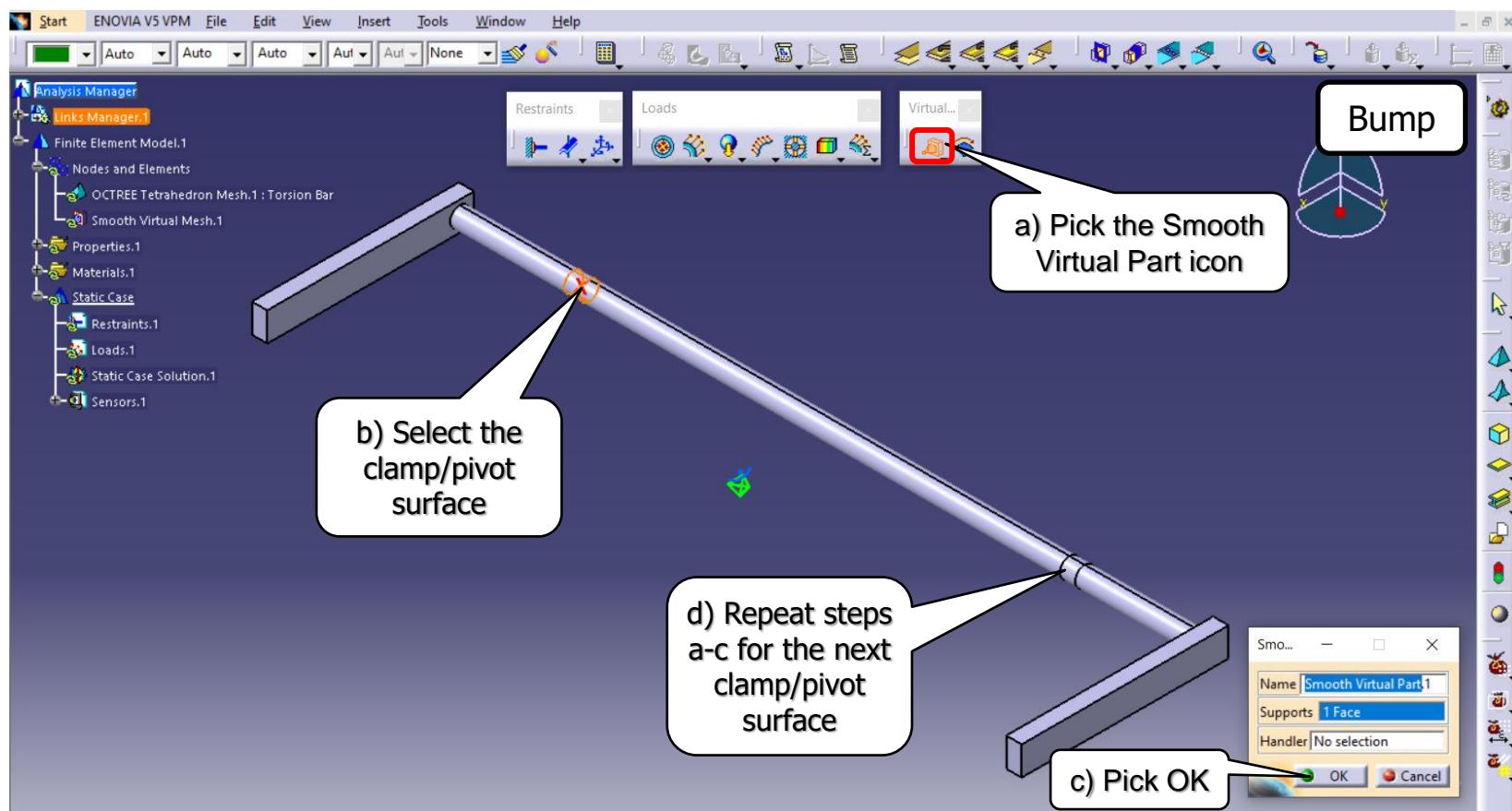
Torsion Bar Analysis in Bump condition

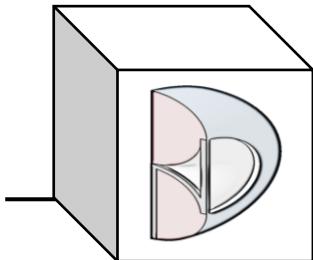


BND TechSource



- Generative Structural Analysis workbench; Create Smooth Virtual Parts for slider/pivot restraints.

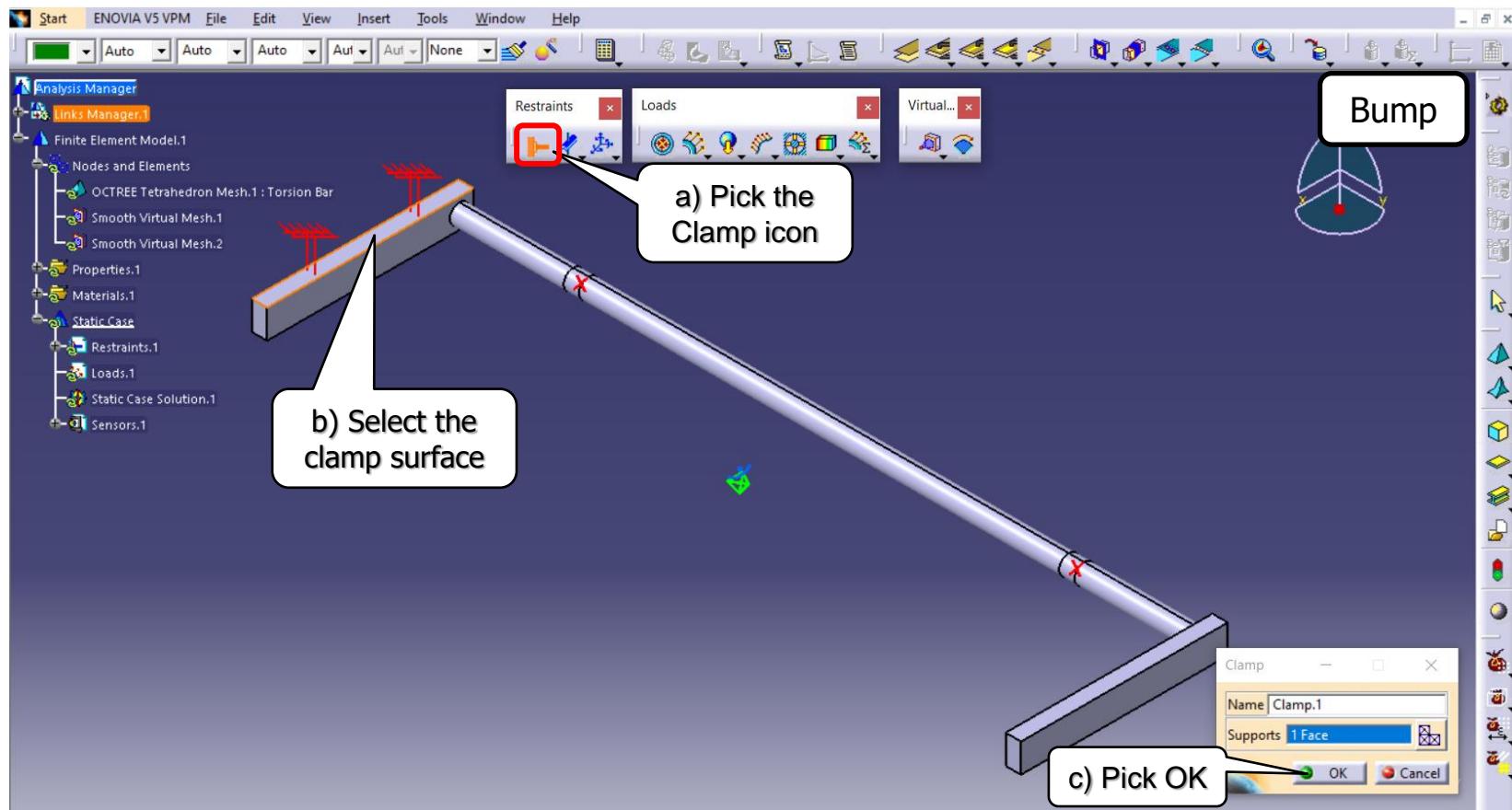


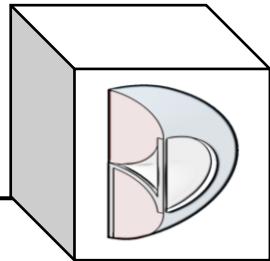


BND TechSource



- Generative Structural Analysis; Create the Clamp Restraint.

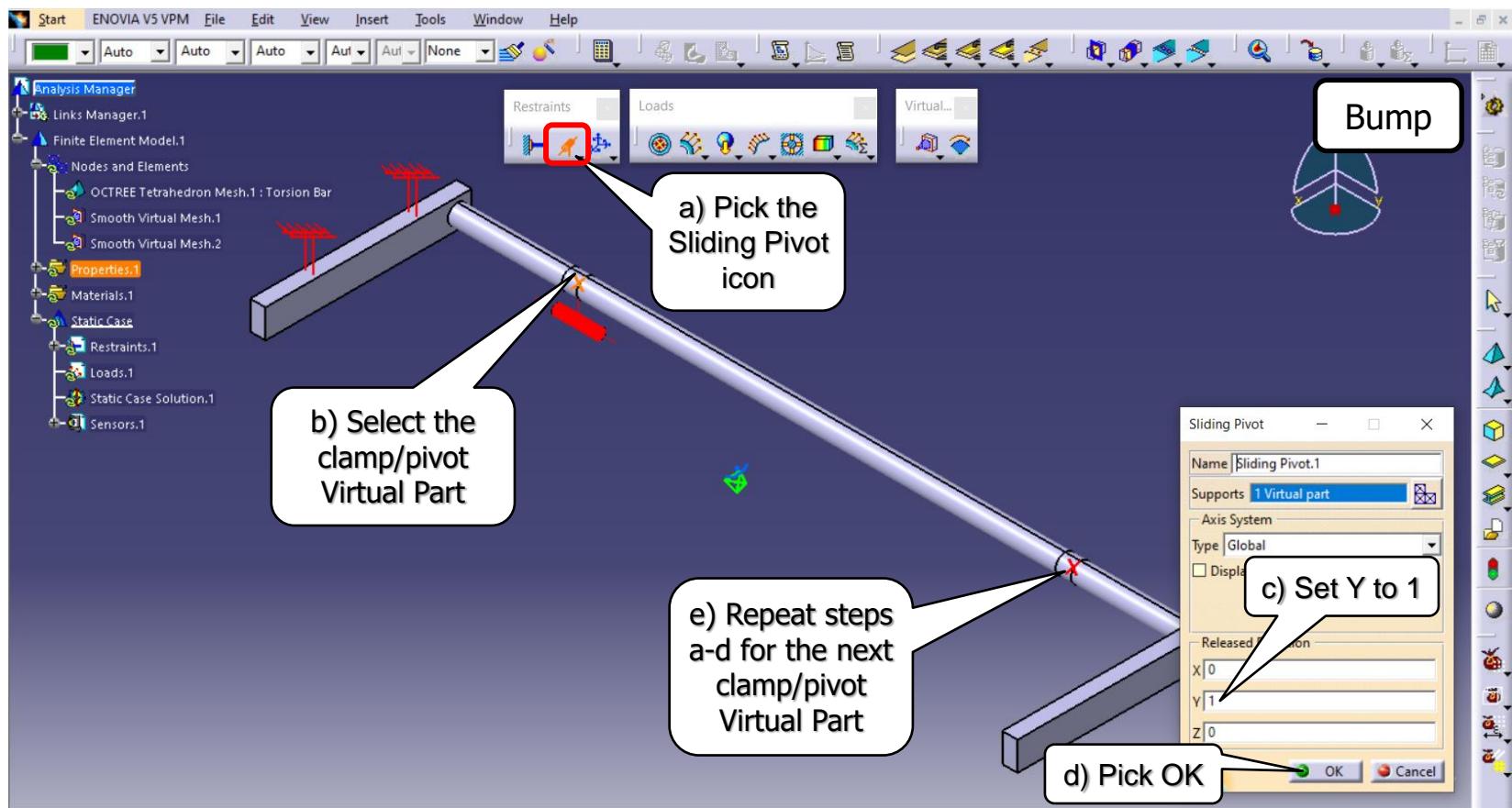


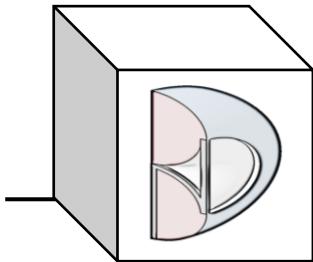


BND TechSource



- Generative Structural Analysis; Create the Sliding Pivot Restraints.

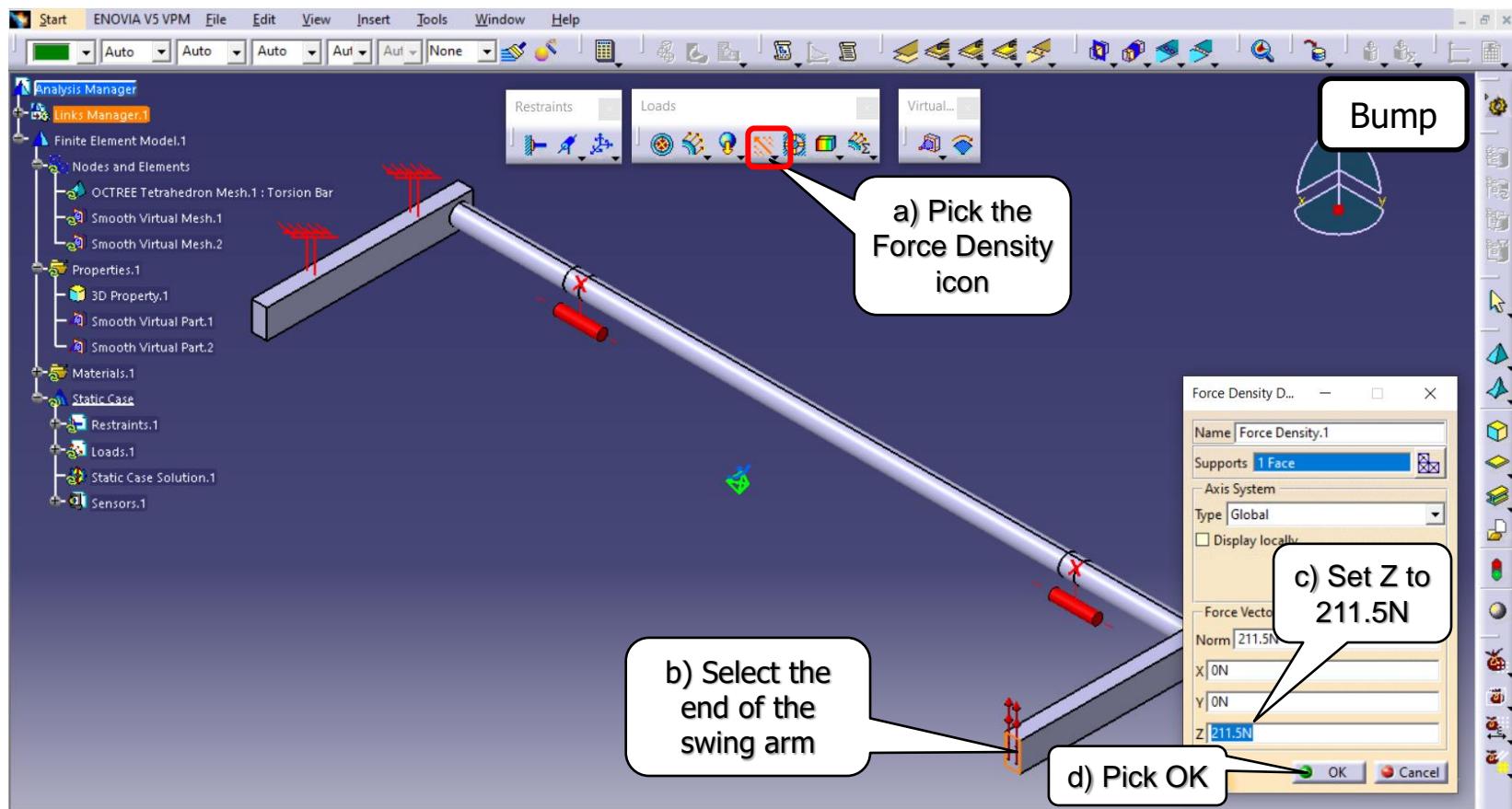


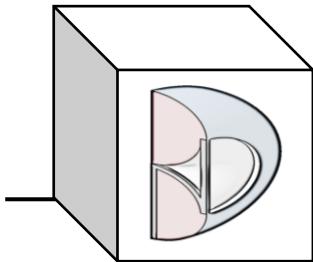


BND TechSource



- Generative Structural Analysis; Create the Load.

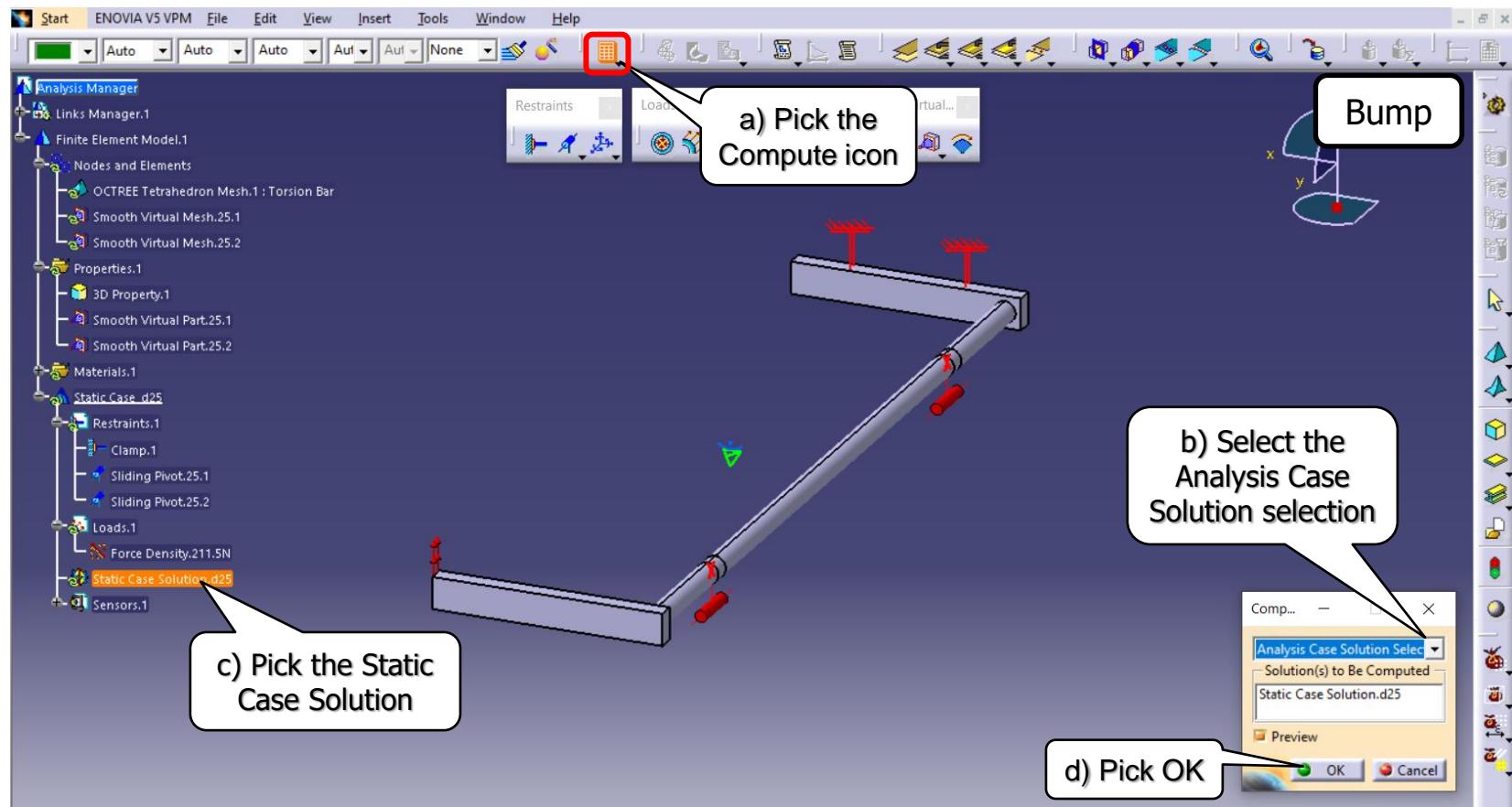


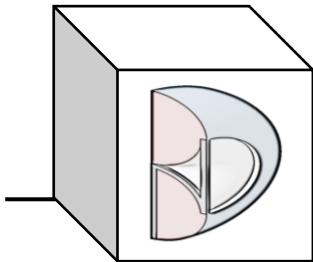


BND TechSource



- Generative Structural Analysis; Compute the analysis.

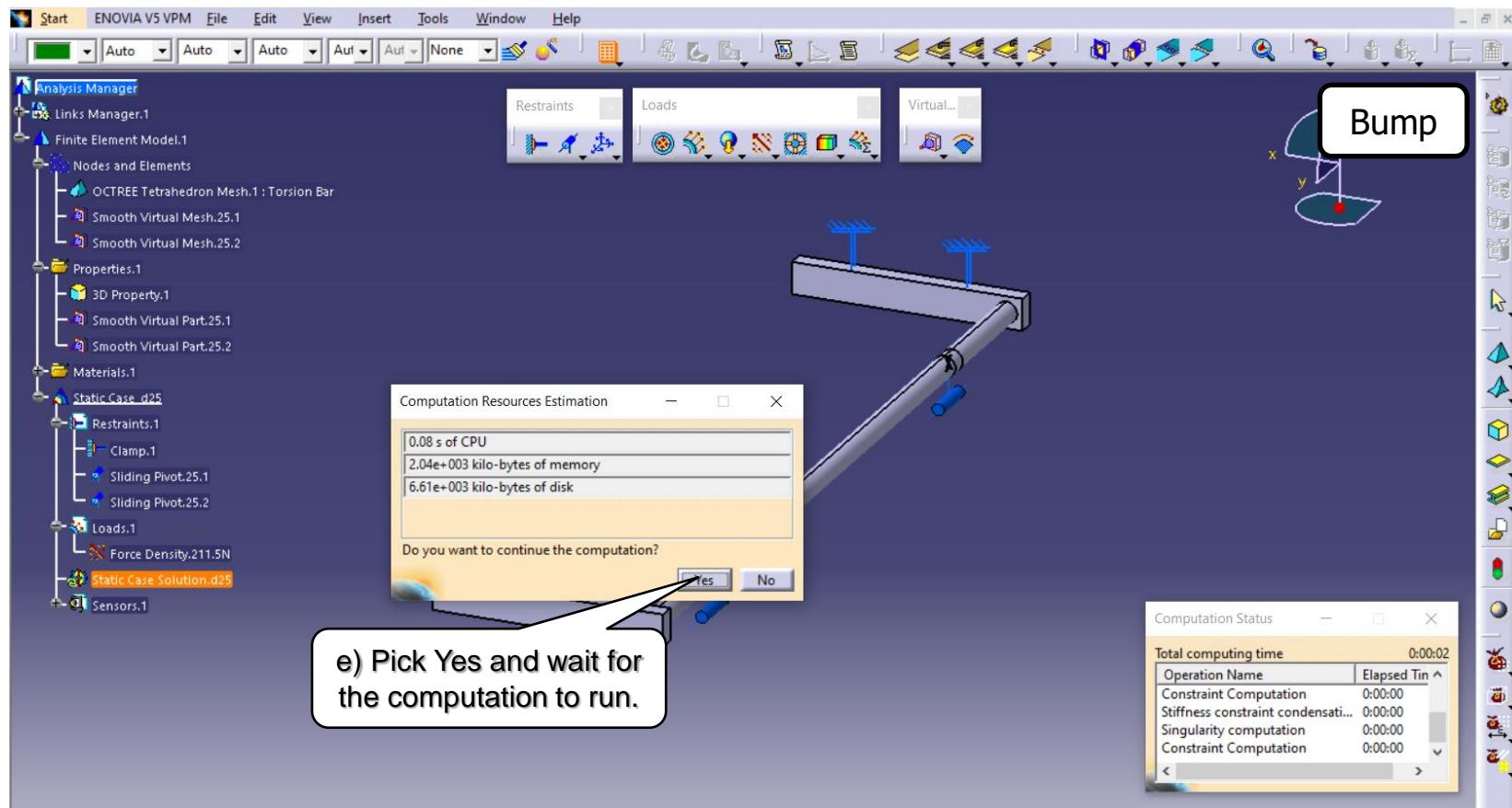


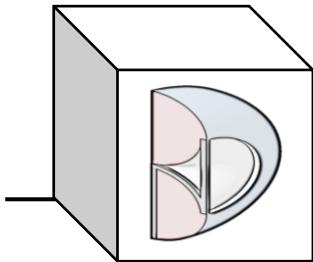


BND TechSource



- Generative Structural Analysis; Compute the analysis.

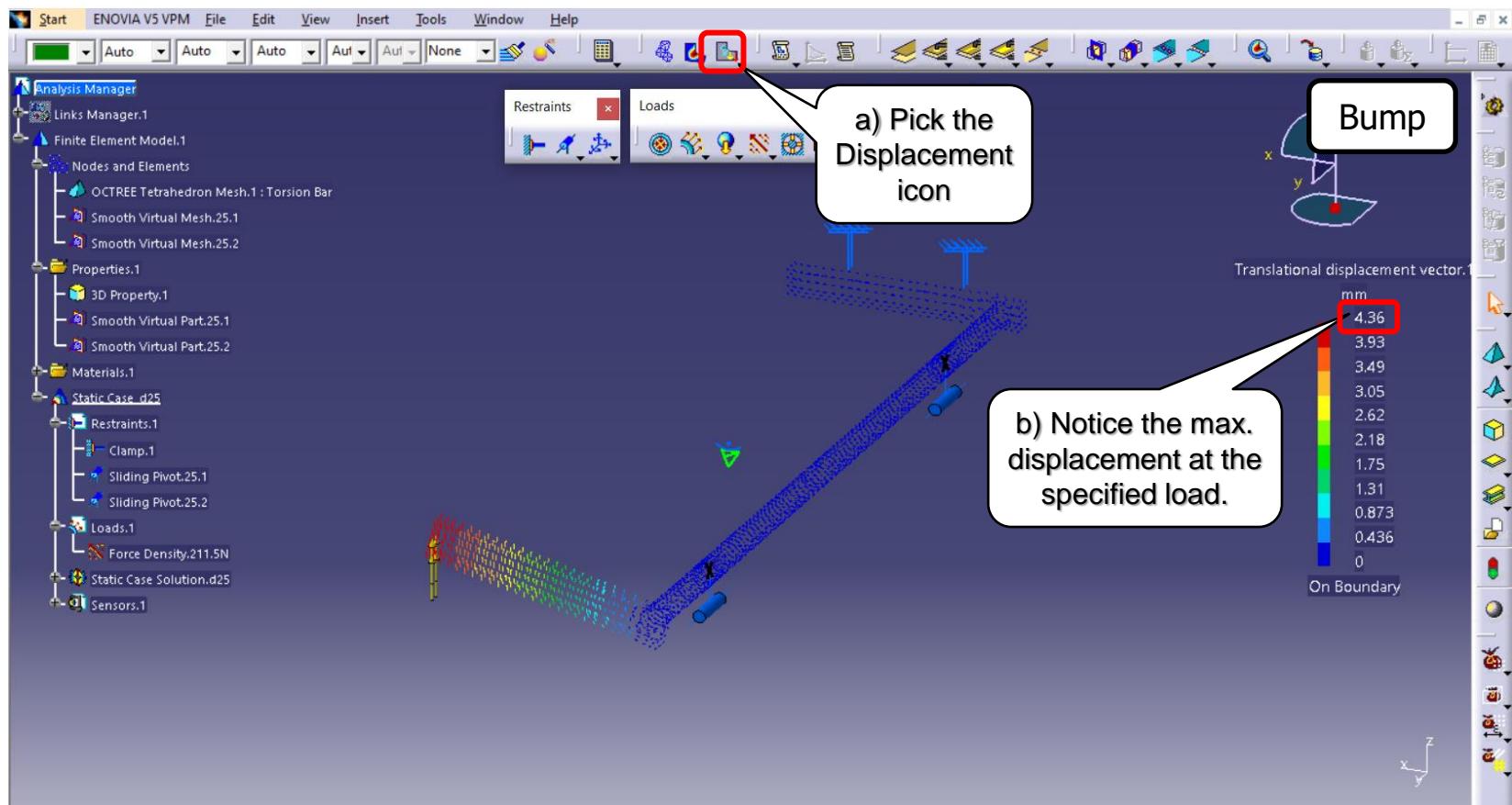


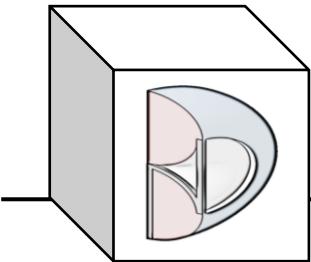


BND TechSource



- Generative Structural Analysis; Show results of the analysis.

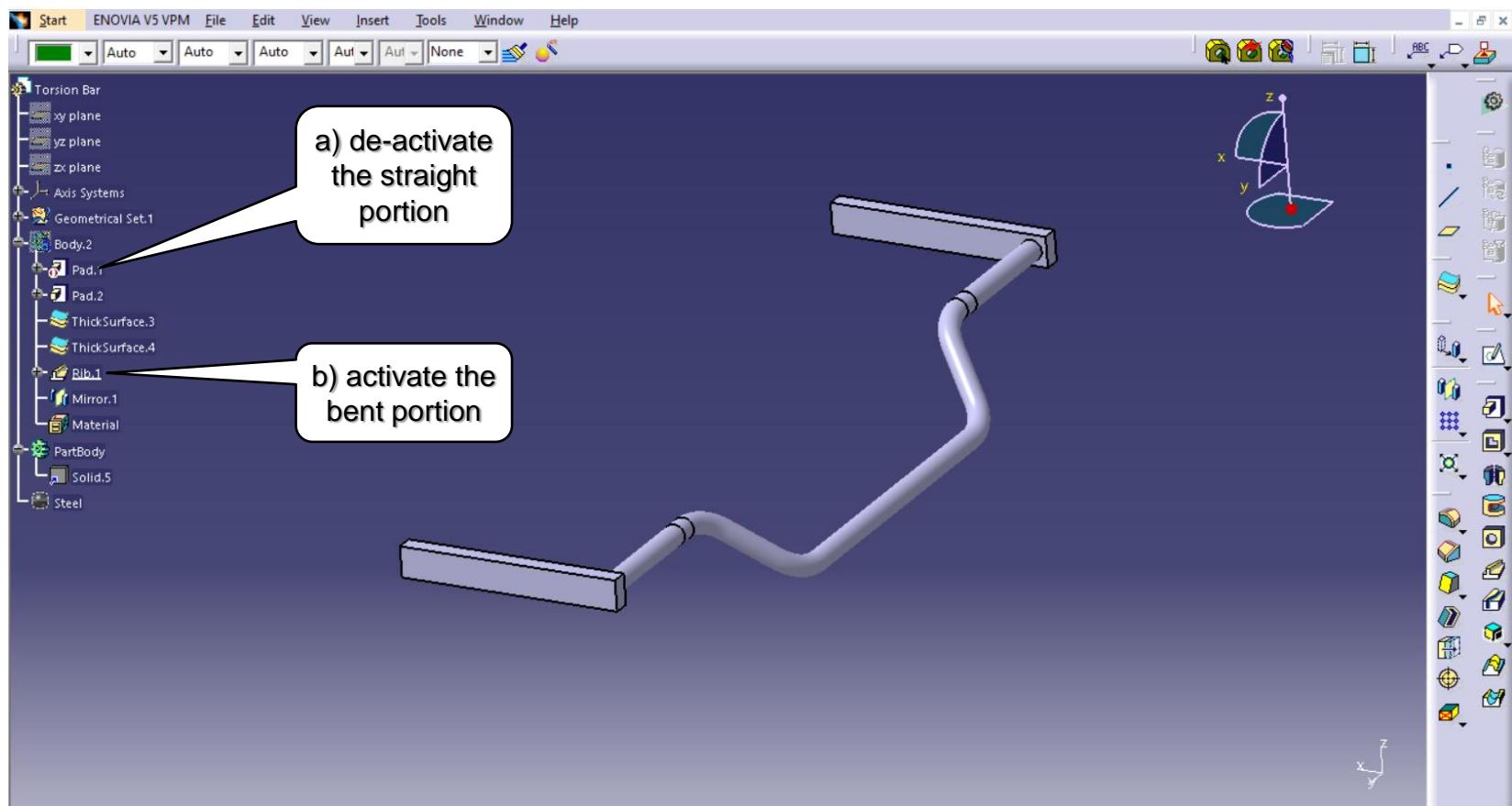


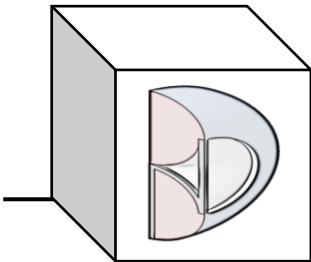


BND TechSource



- Back to the Torsion Bar CatPart to de-activate the straight portion and activate the bent portion.

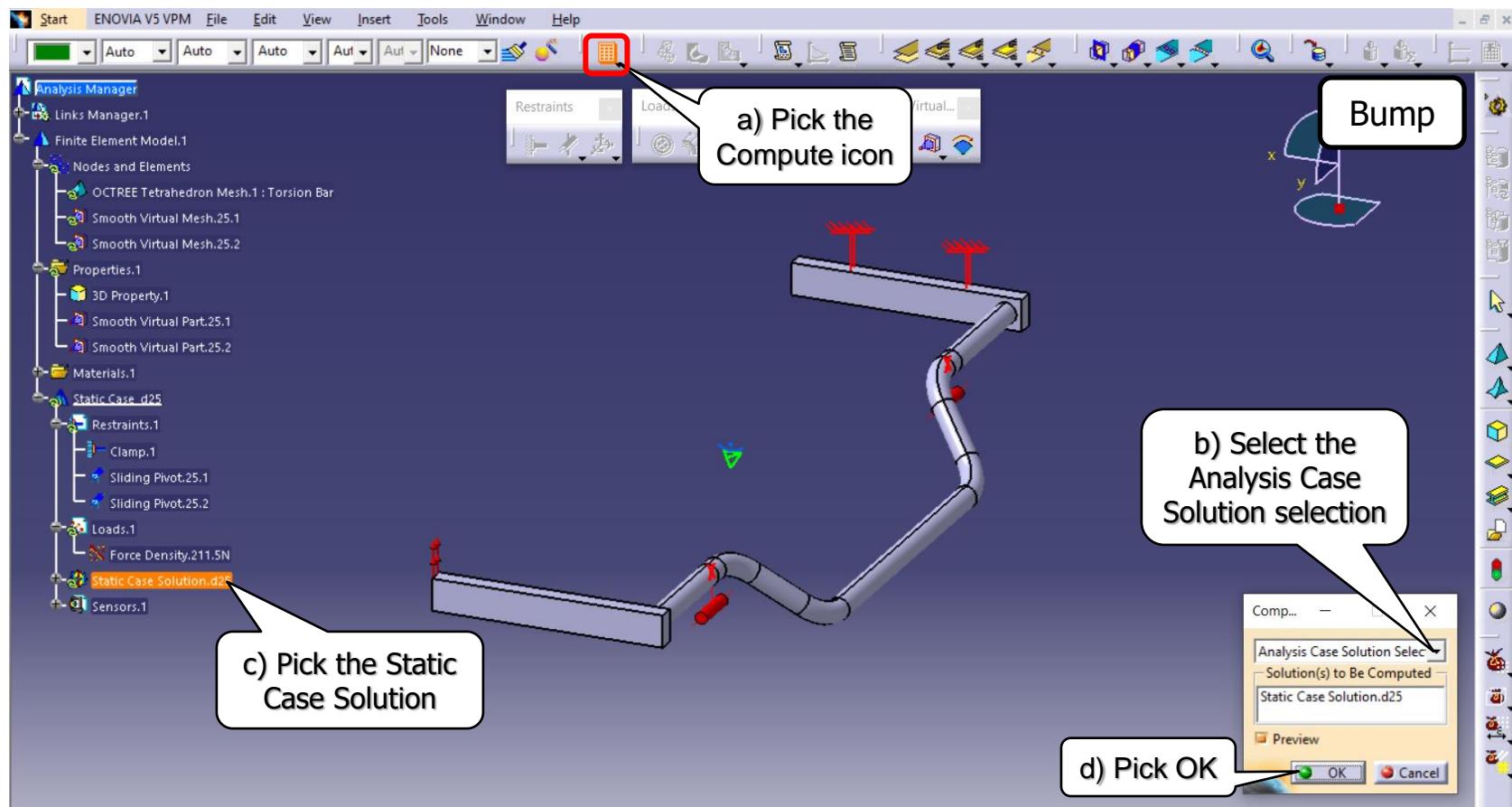


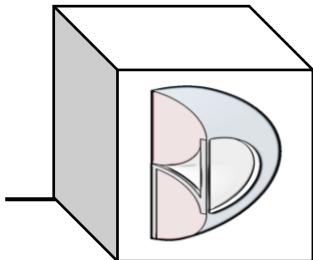


BND TechSource



- Back to Generative Structural Analysis; Compute the analysis.

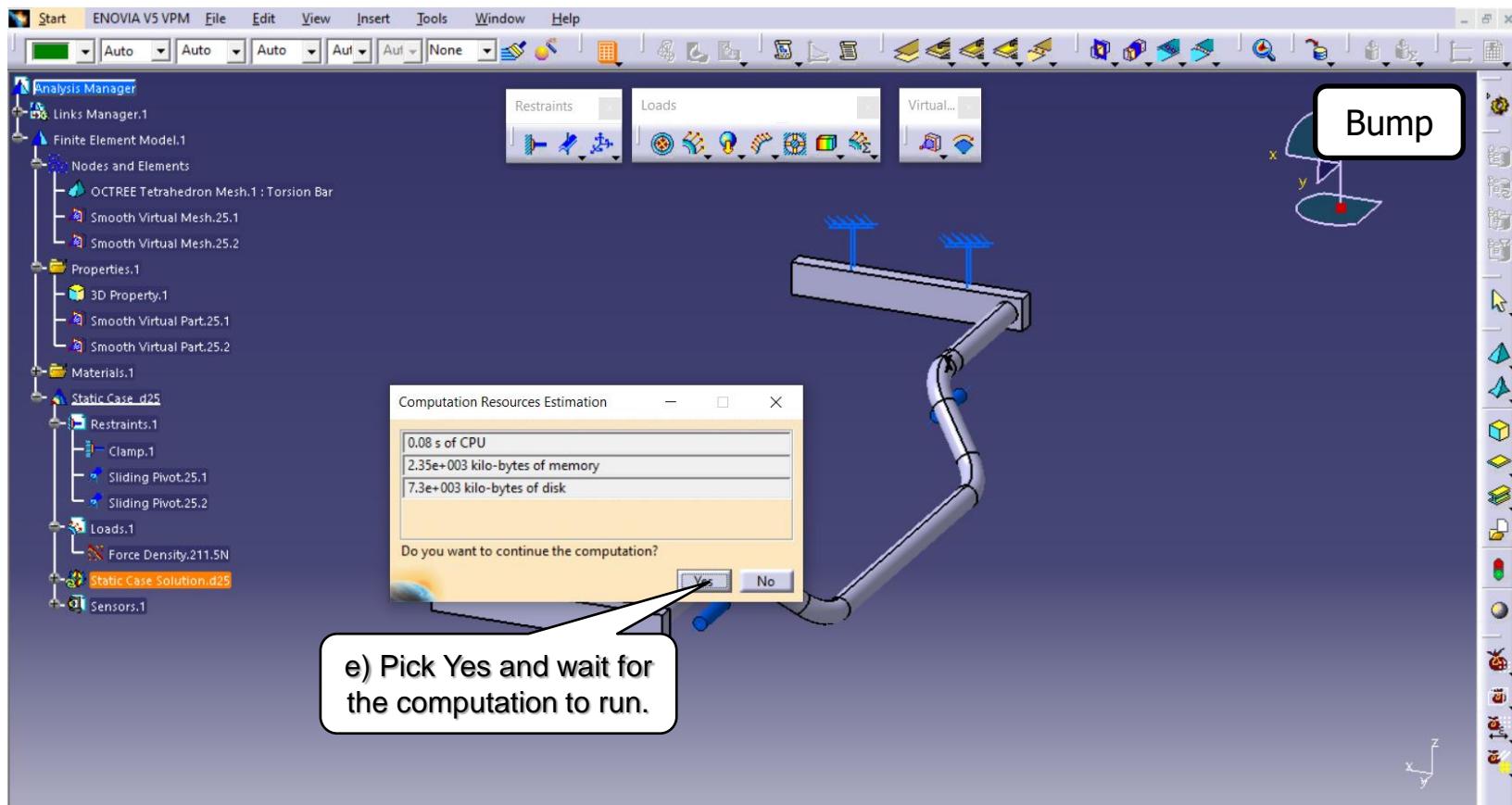


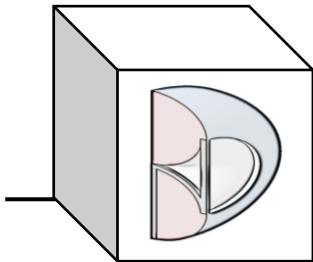


BND TechSource



- Generative Structural Analysis; Compute the analysis.

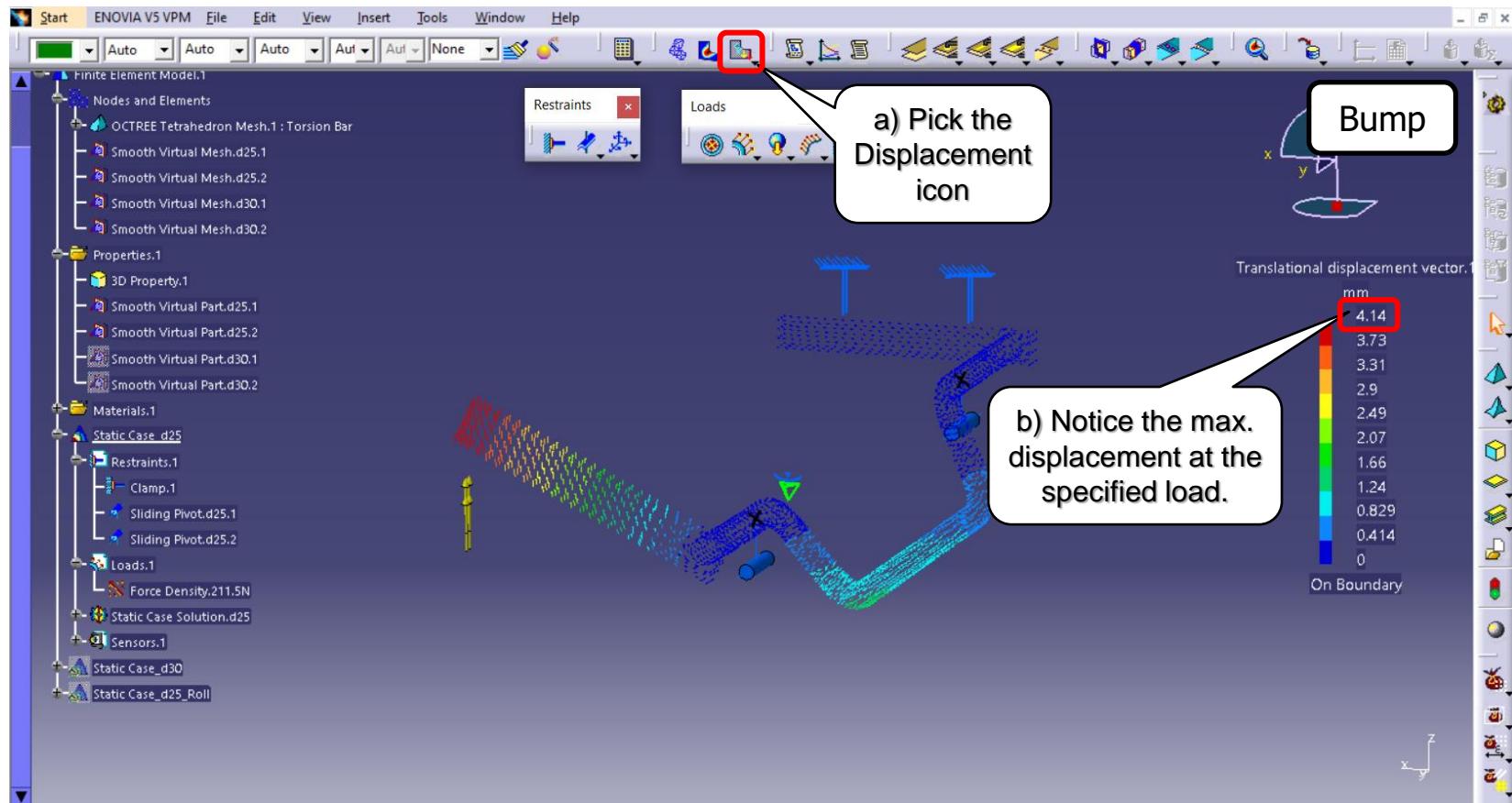


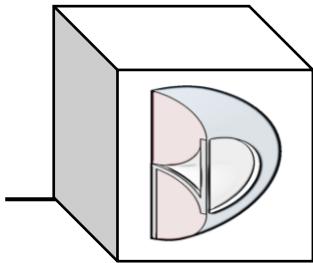


BND TechSource



- Generative Structural Analysis; Show results of the analysis.

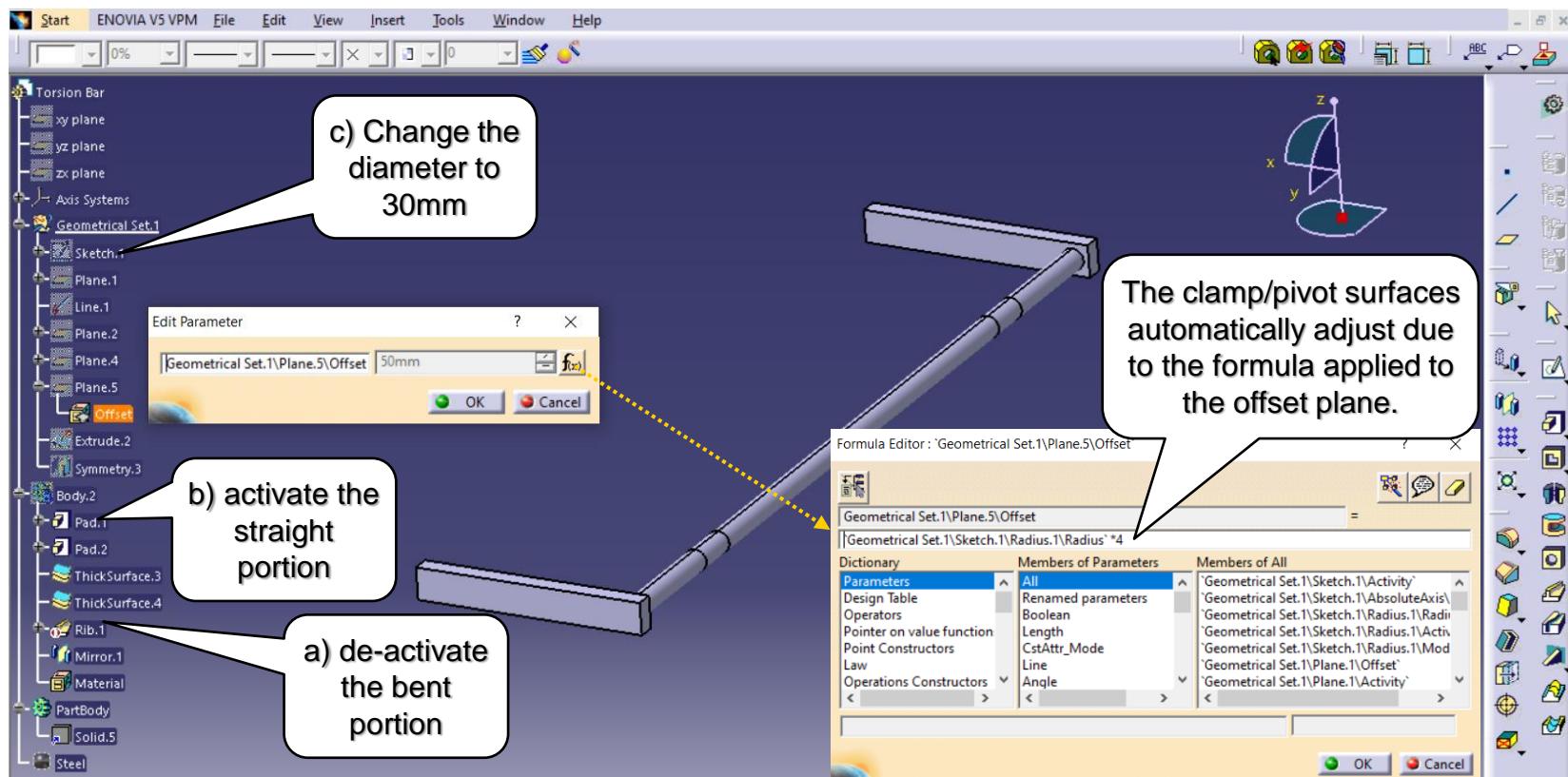


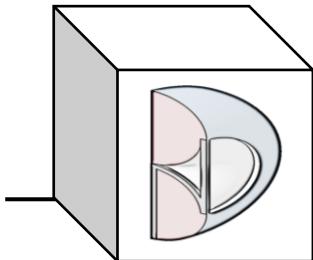


BND TechSource



- Back to the Torsion Bar CatPart to activate the straight portion and de-activate the bent portion and change the diameter to 30mm.

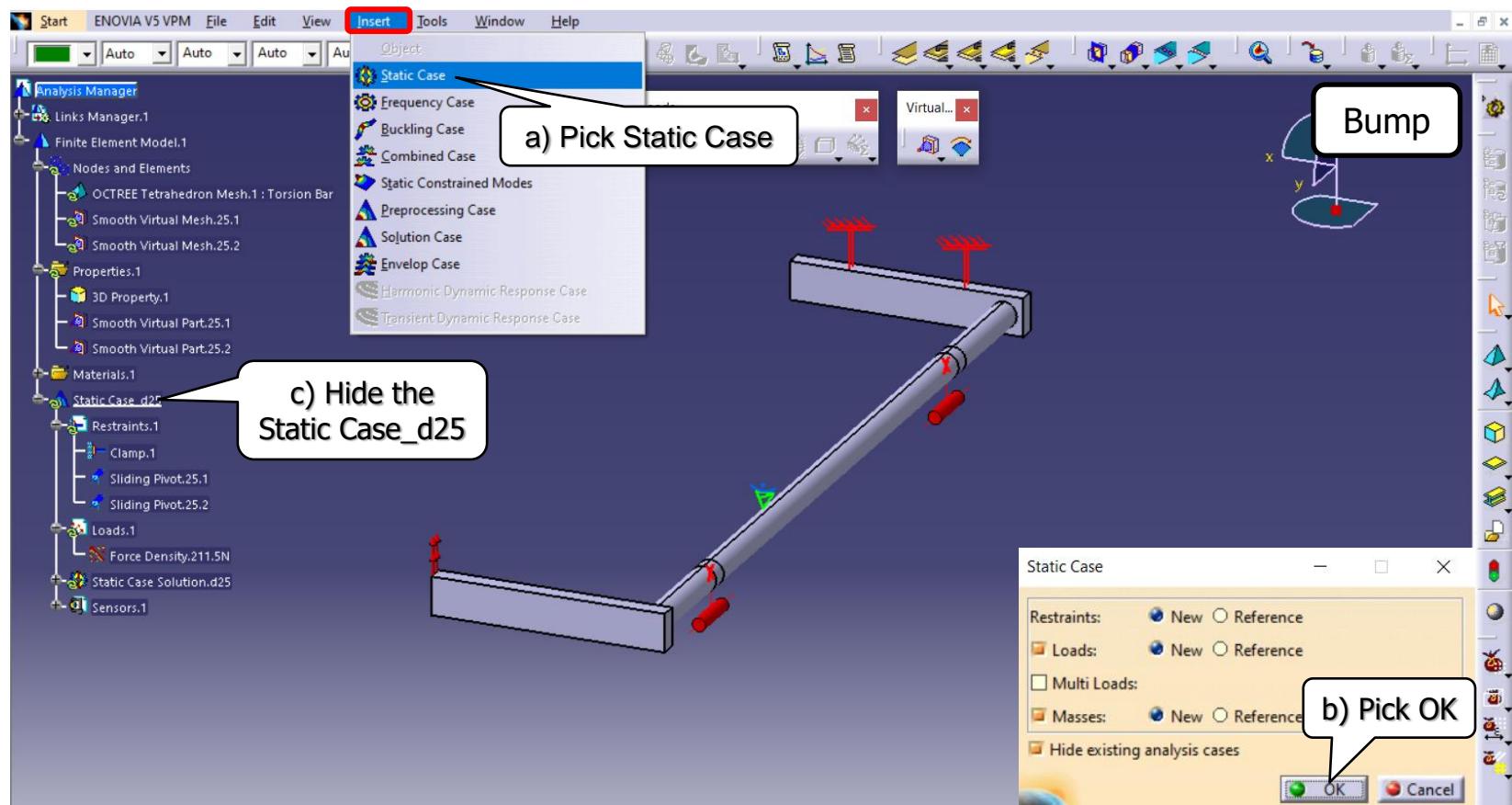


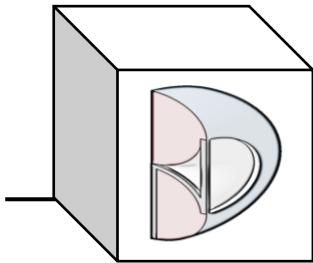


BND TechSource



- Generative Structural Analysis workbench; create a new Static Case_d30 for the diameter 30mm Torsion Bar.

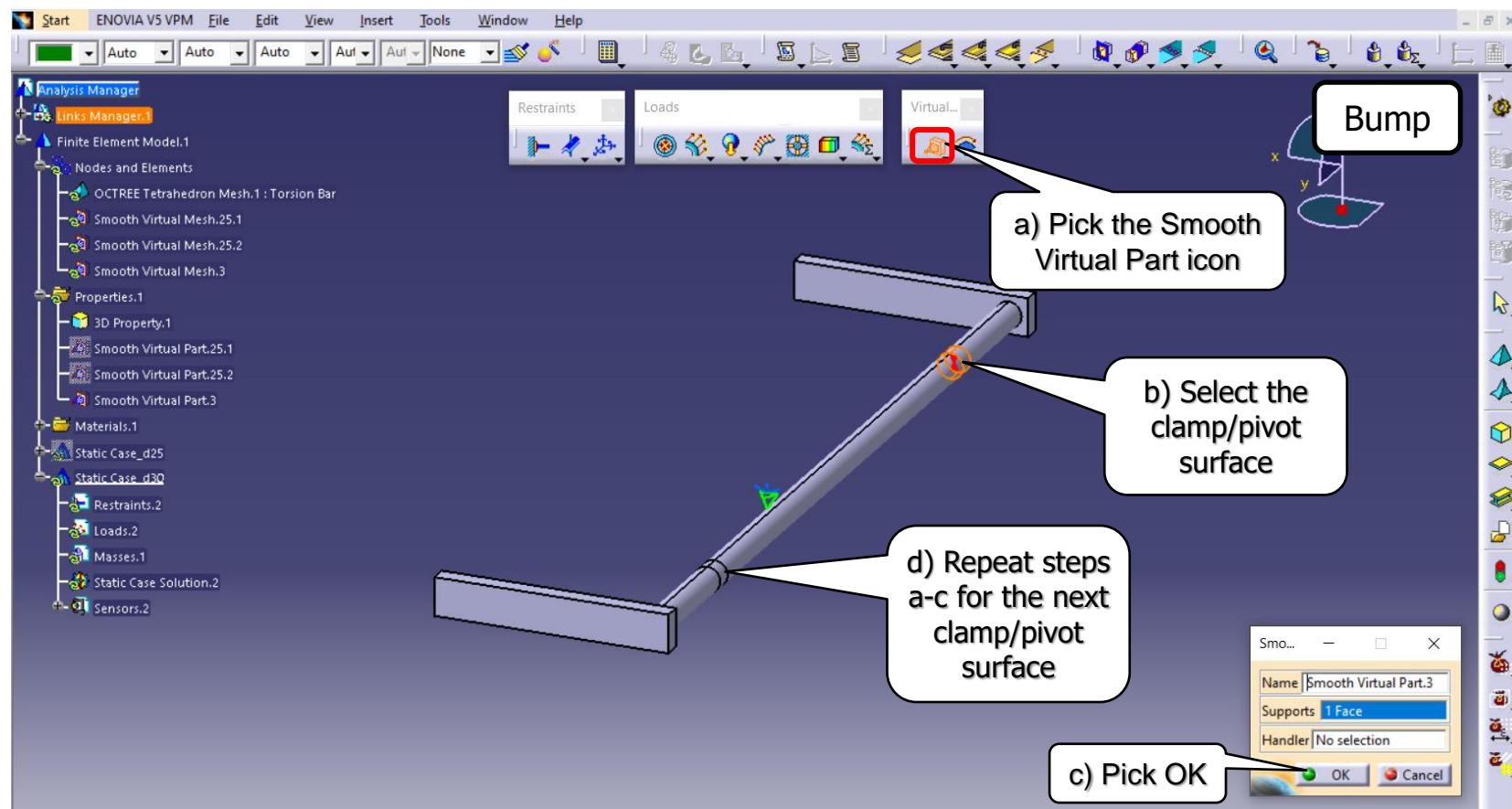


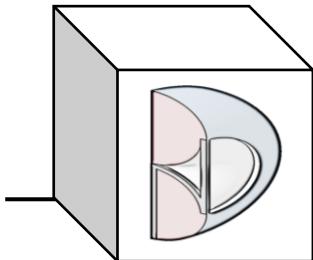


BND TechSource



- Generative Structural Analysis workbench; create Smooth Virtual Parts for slider/pivot restraints.

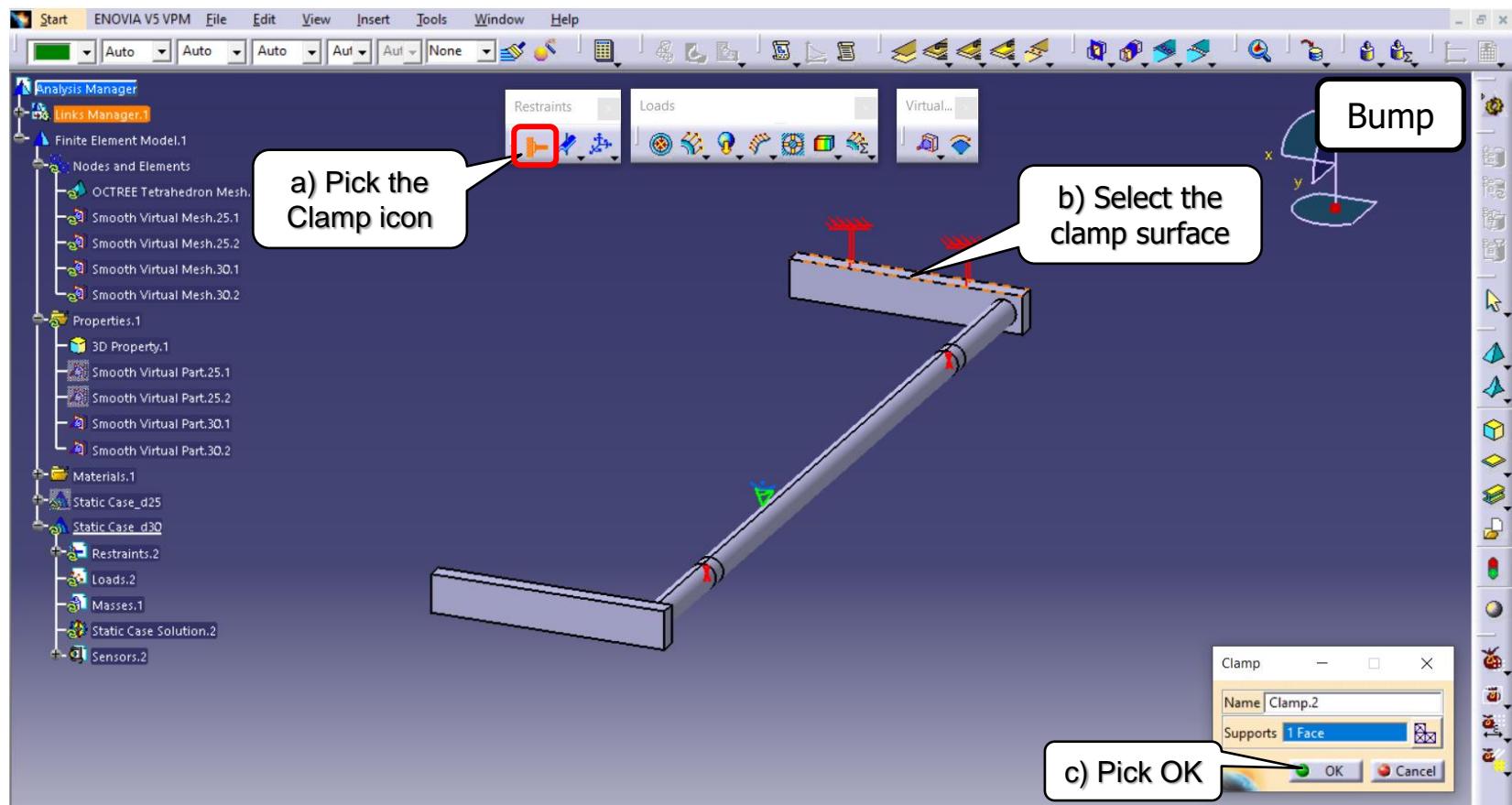


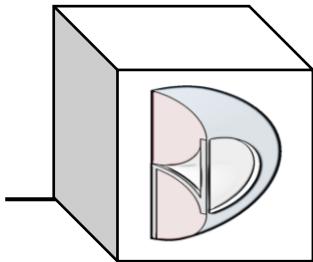


BND TechSource



- Generative Structural Analysis; create the Clamp restraints.

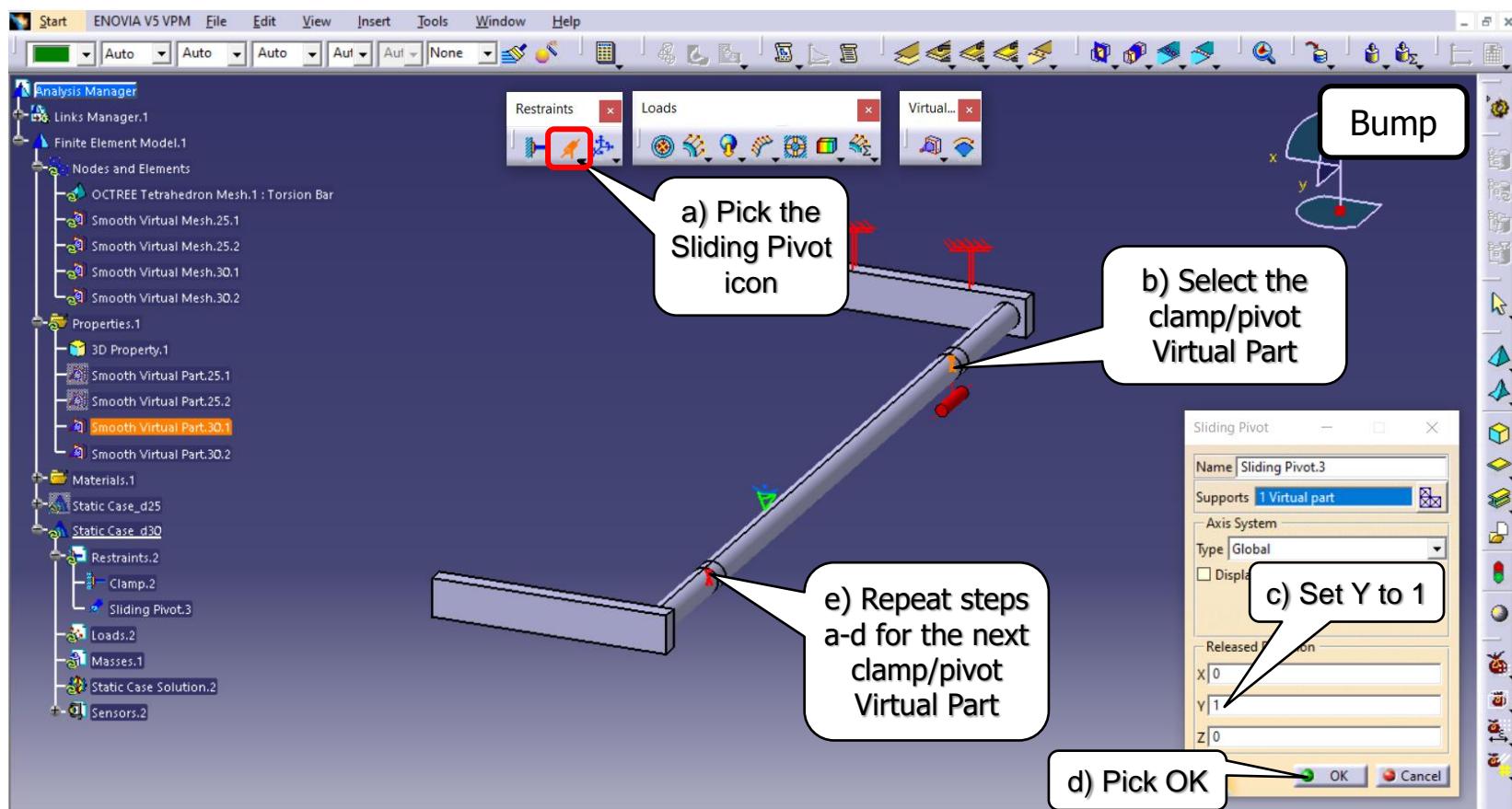


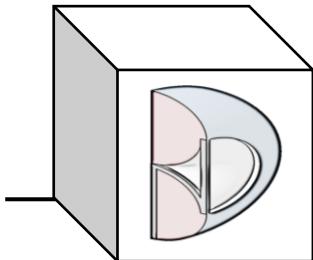


BND TechSource



- Generative Structural Analysis; create the Sliding Pivot restraints.

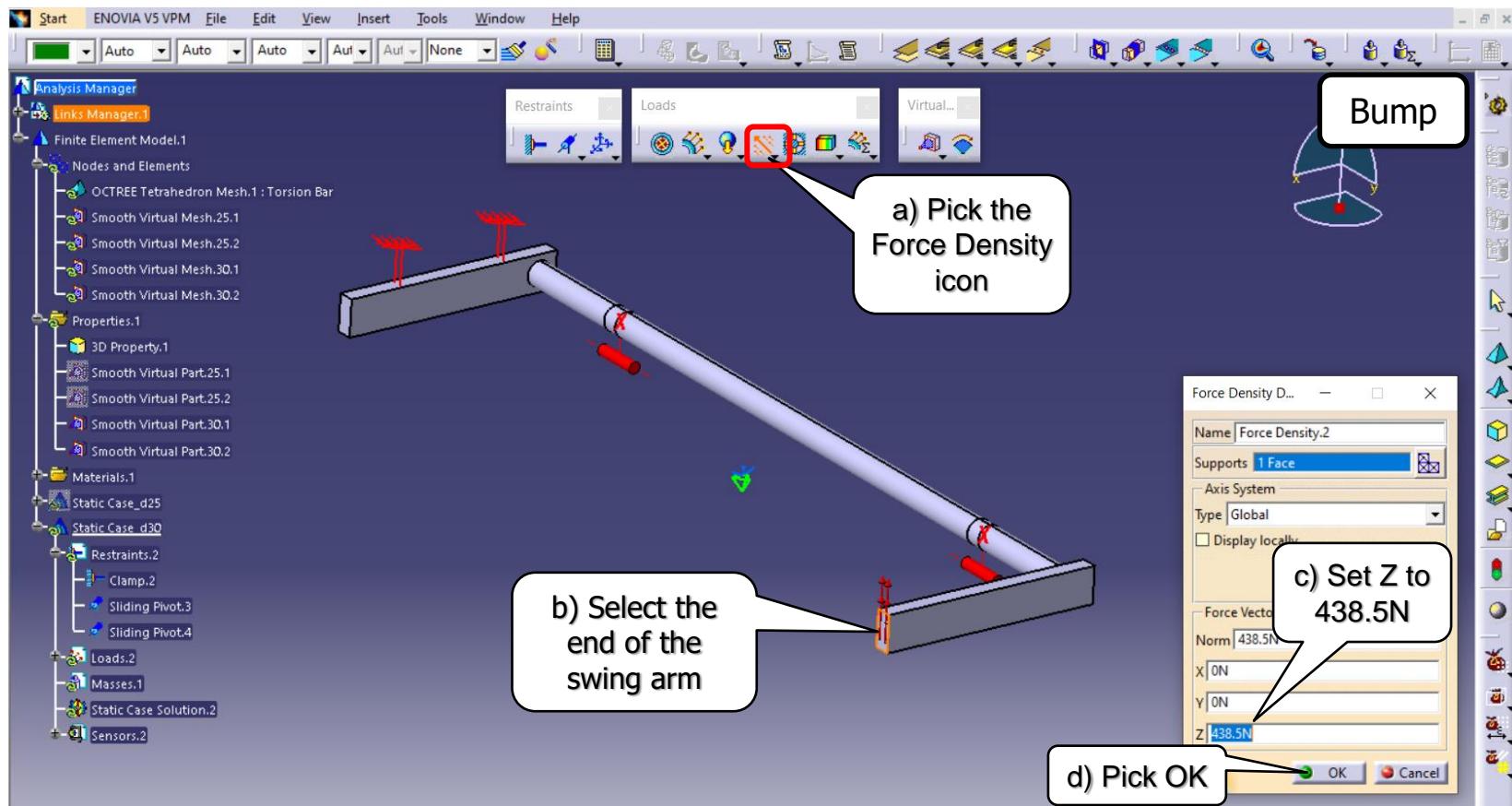


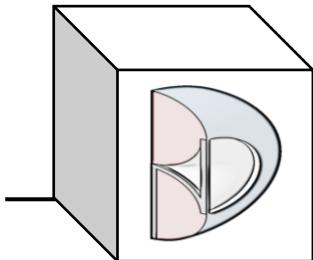


BND TechSource



- Generative Structural Analysis; create the Load.

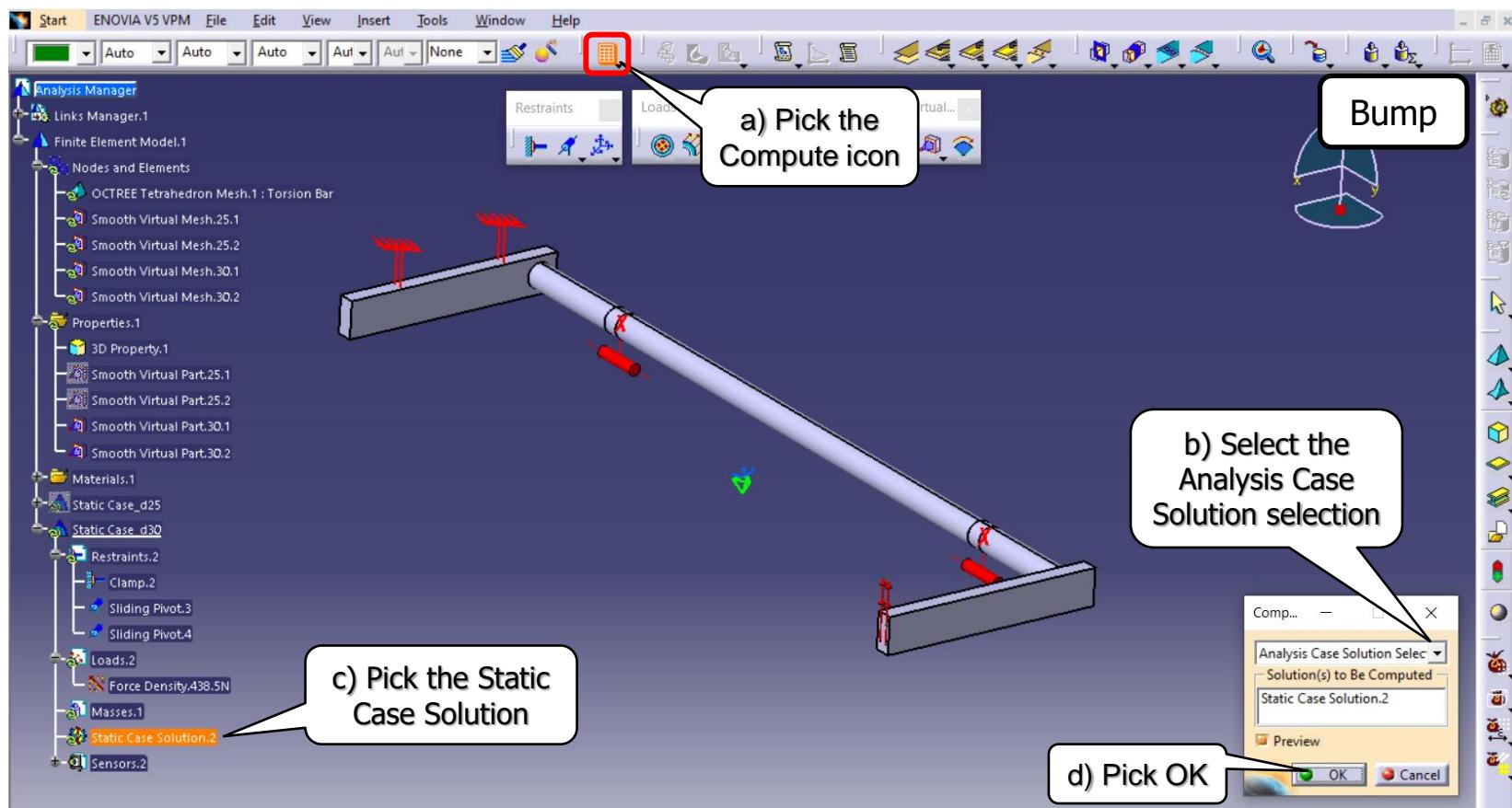


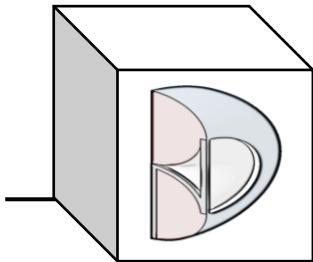


BND TechSource



- Generative Structural Analysis; Compute the analysis.

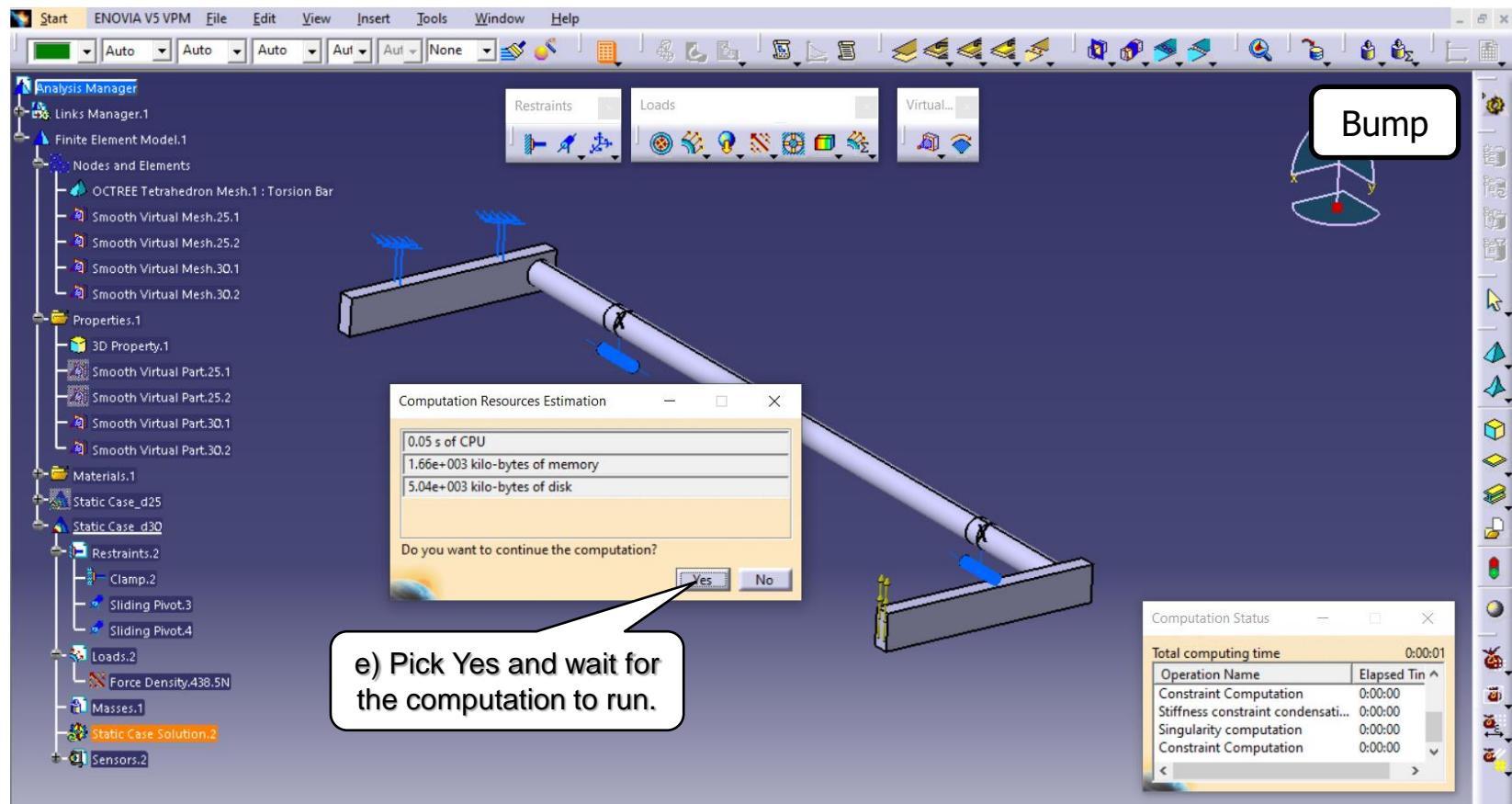


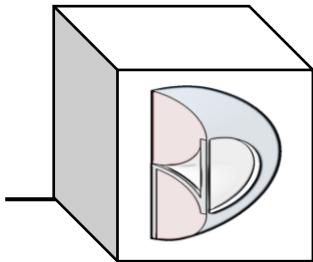


BND TechSource



- Generative Structural Analysis; Compute the analysis.

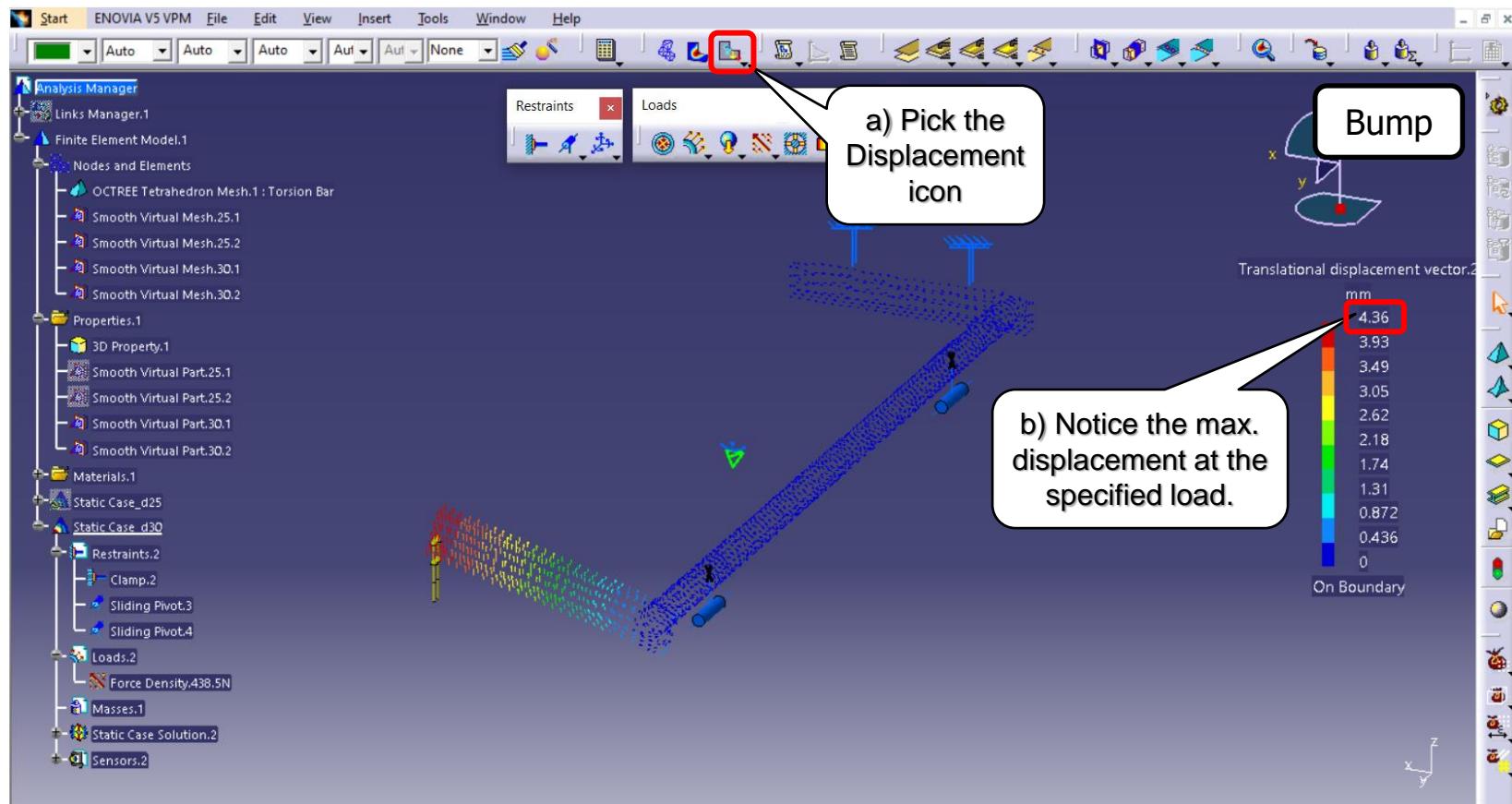


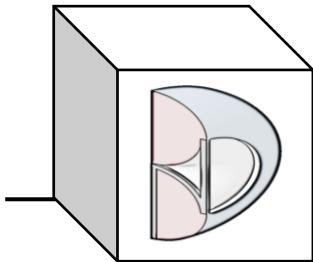


BND TechSource



- Generative Structural Analysis; Show results of the analysis.

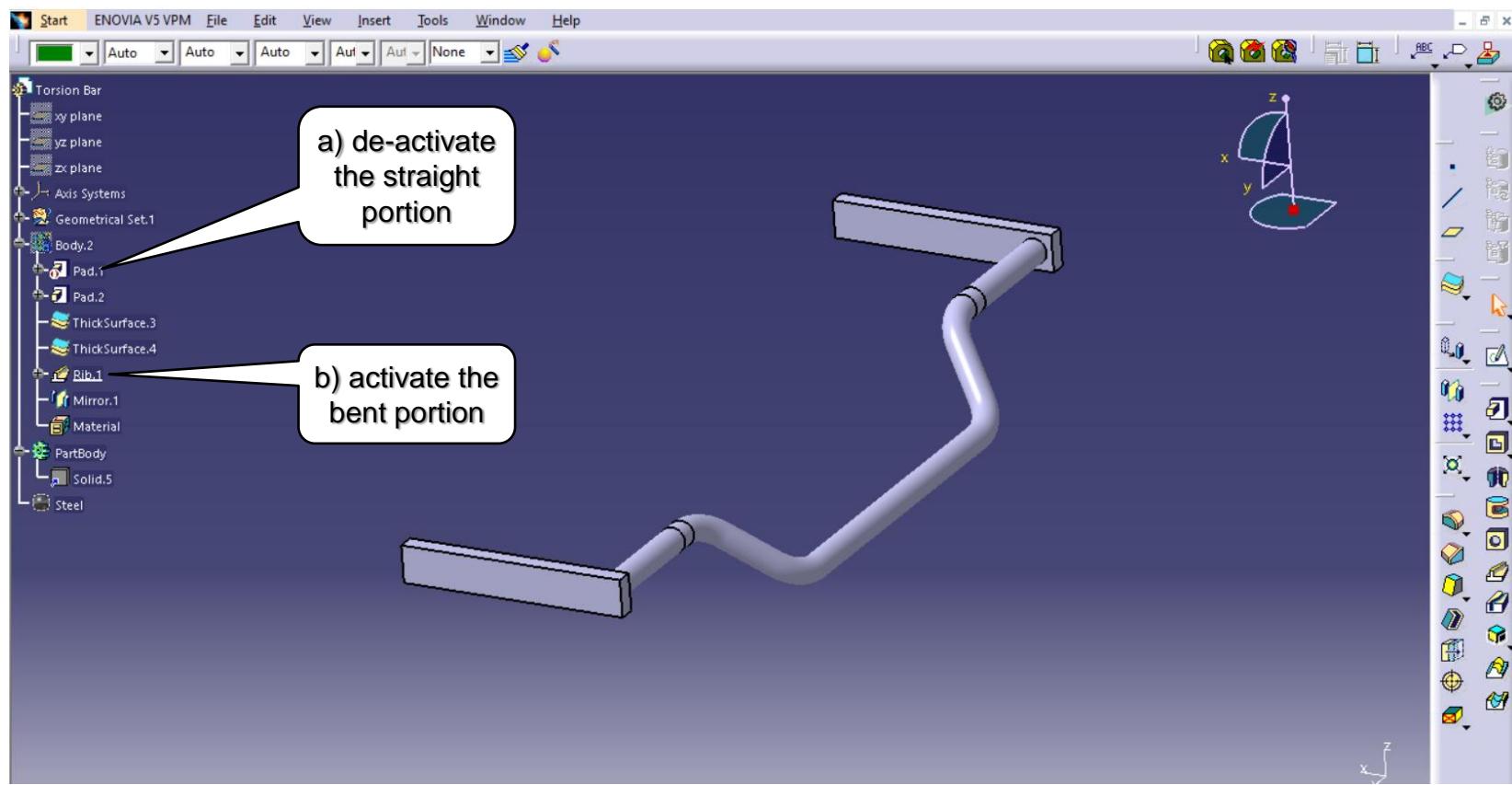


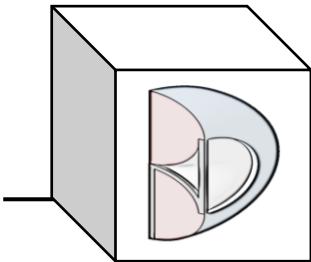


BND TechSource



- Back to the Torsion Bar CatPart to de-activate the straight portion and activate the bent portion.

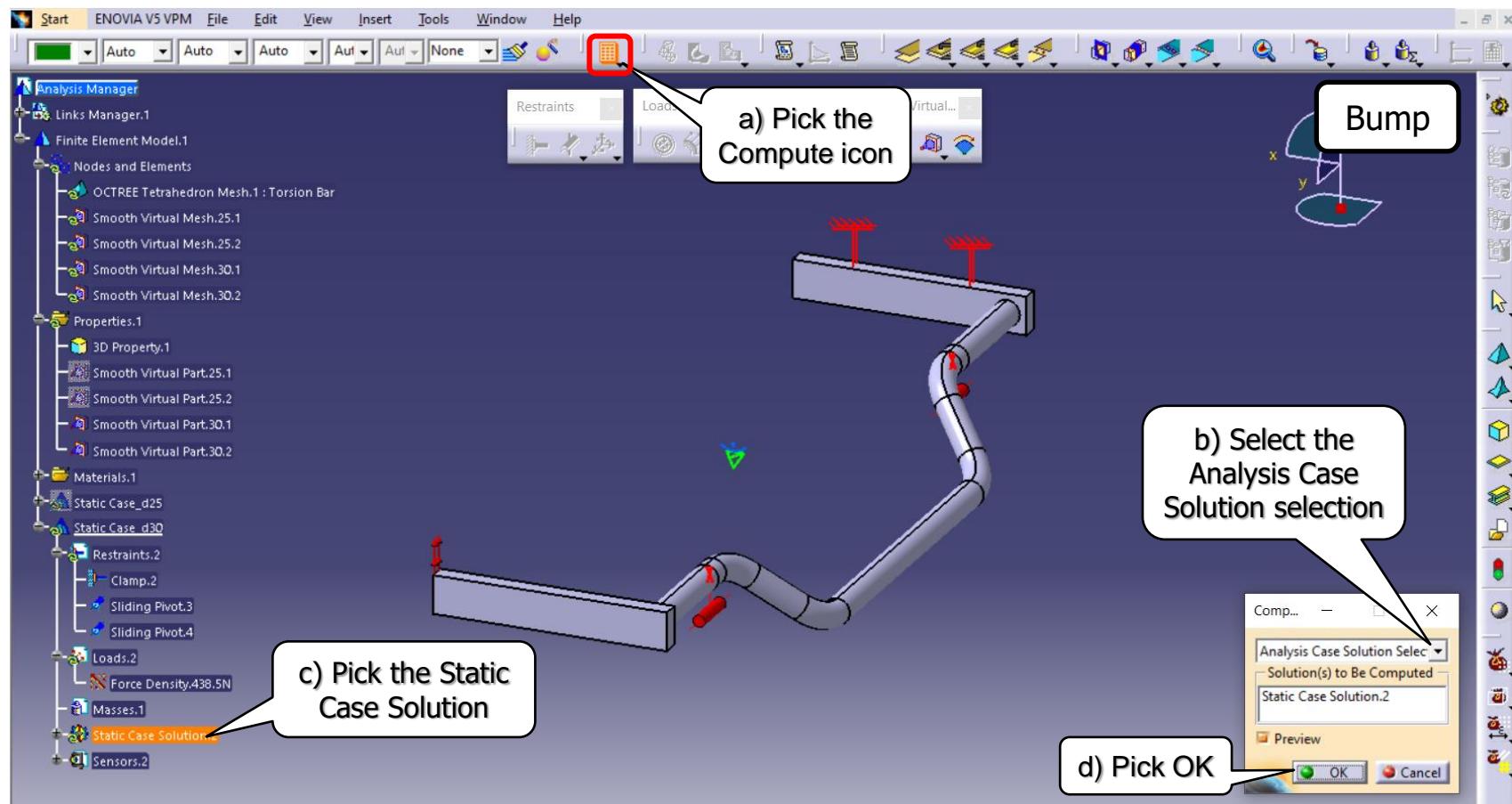


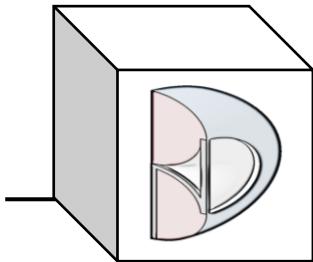


BND TechSource



- Back to Generative Structural Analysis; Compute the analysis.

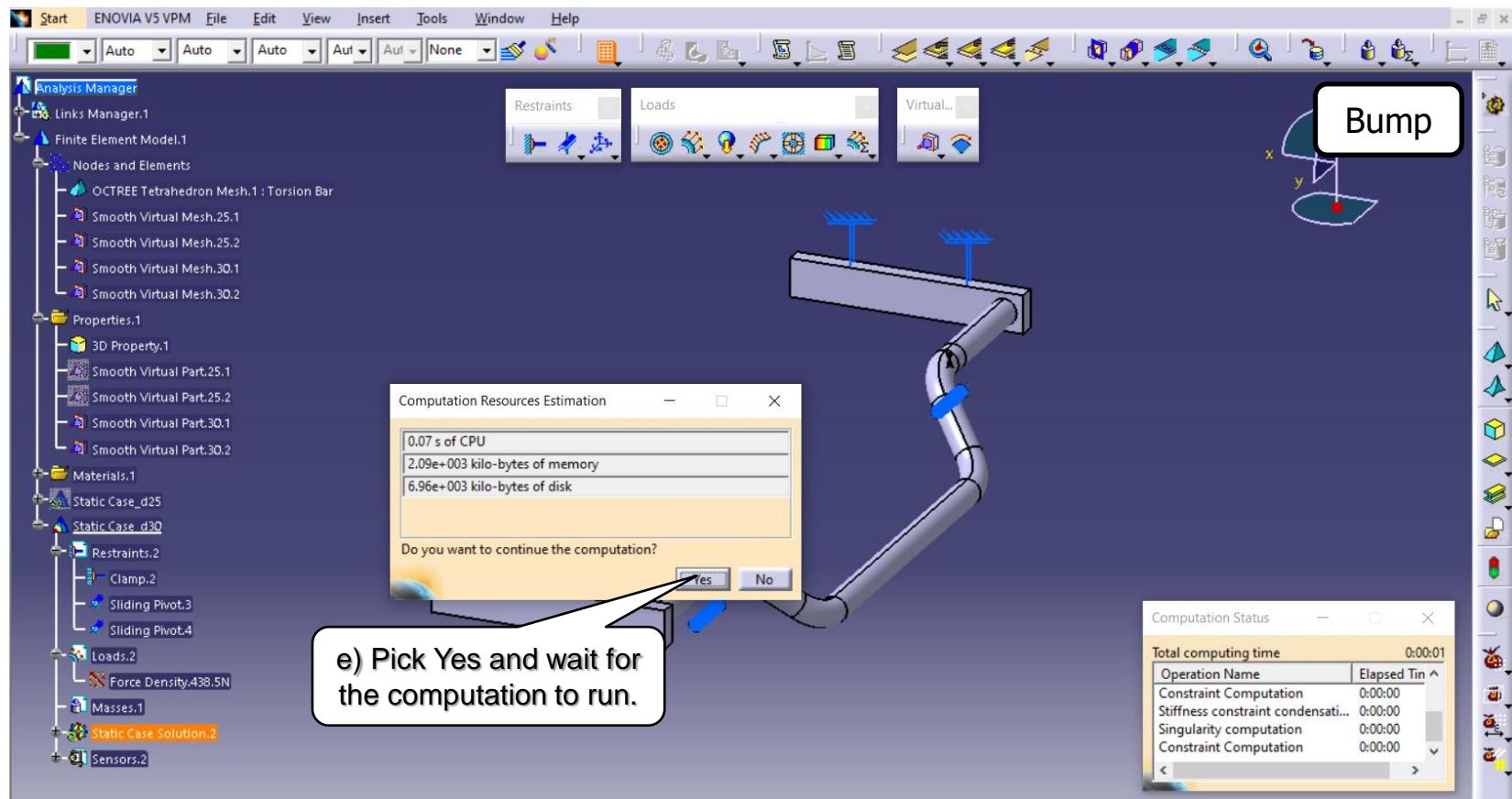


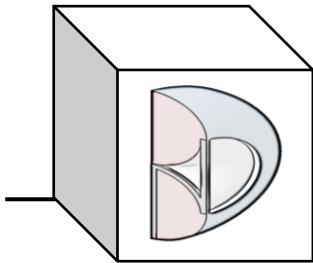


BND TechSource



- Generative Structural Analysis; Compute the analysis.

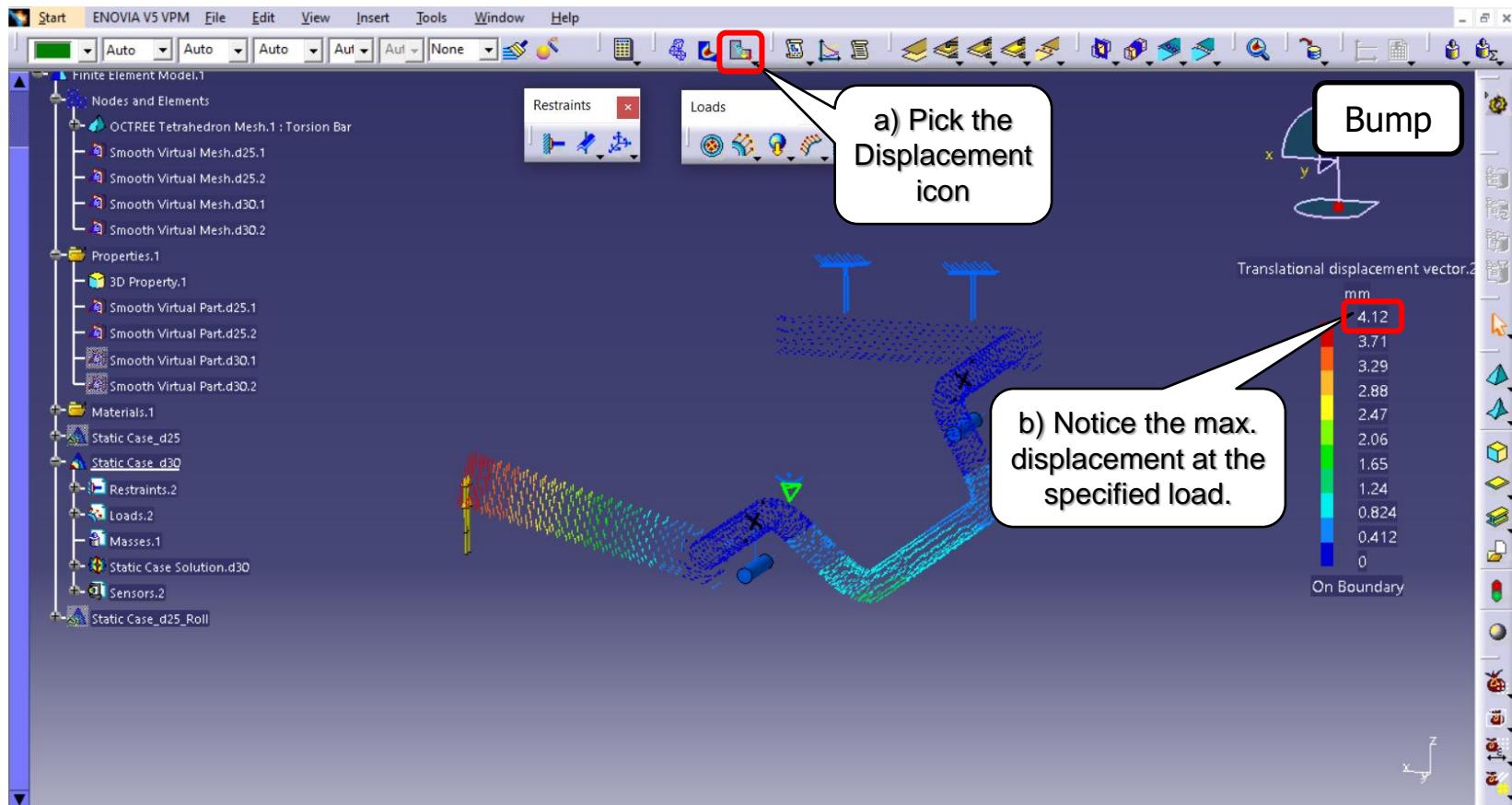


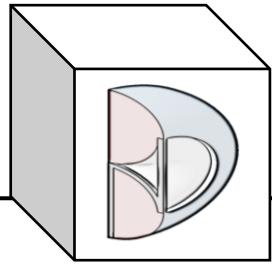


BND TechSource



- Generative Structural Analysis; Show results of the analysis.

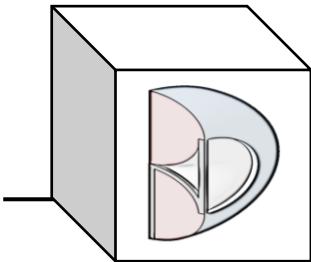




BND TechSource



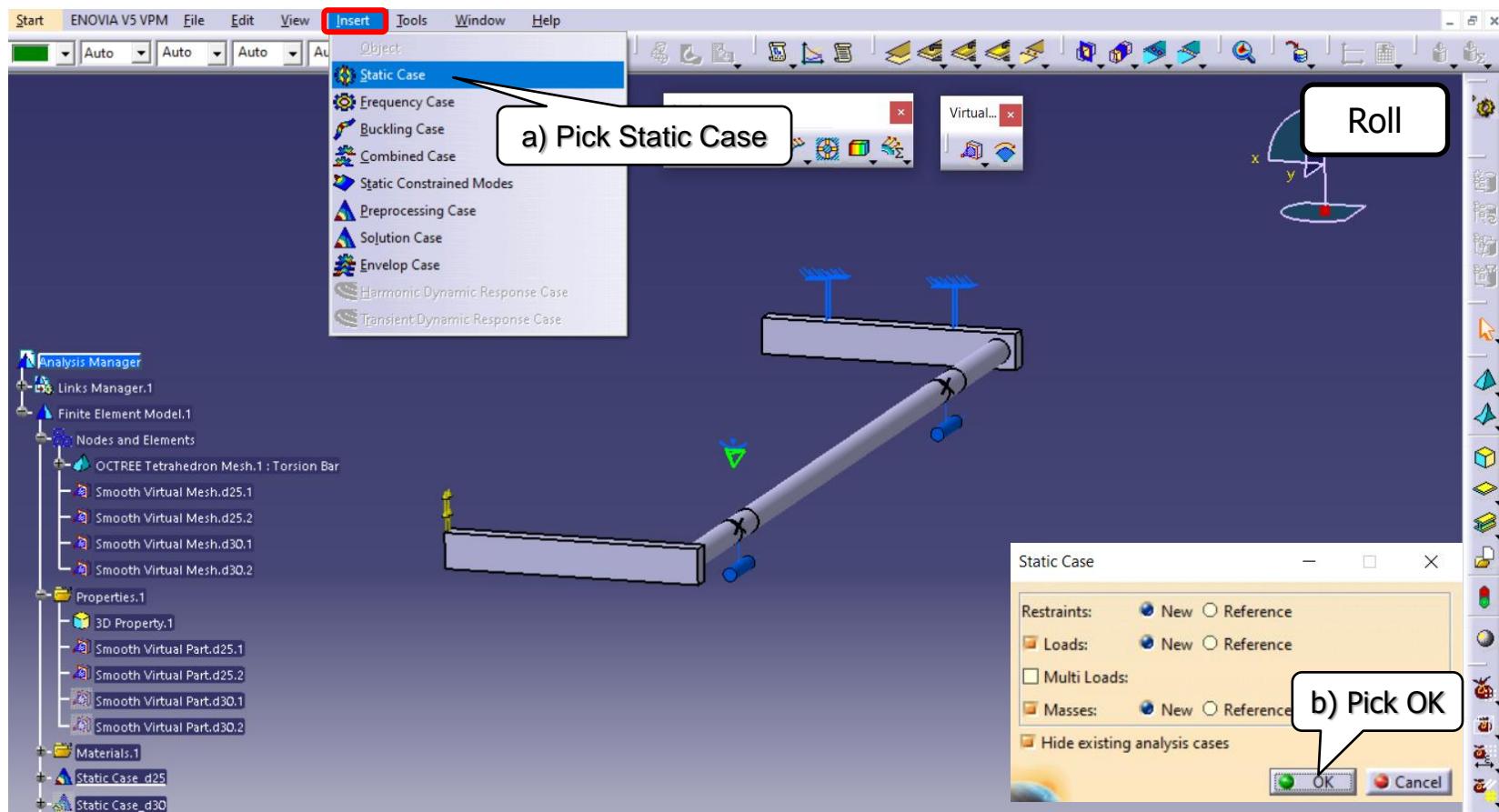
Torsion Bar Analysis in Roll condition

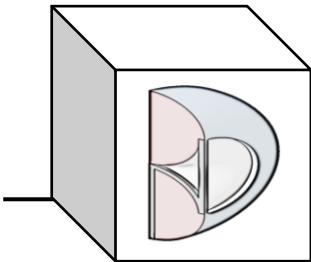


BND TechSource



- Generative Structural Analysis workbench; create a new Static Case_d25_Roll for the diameter 25mm Torsion Bar.

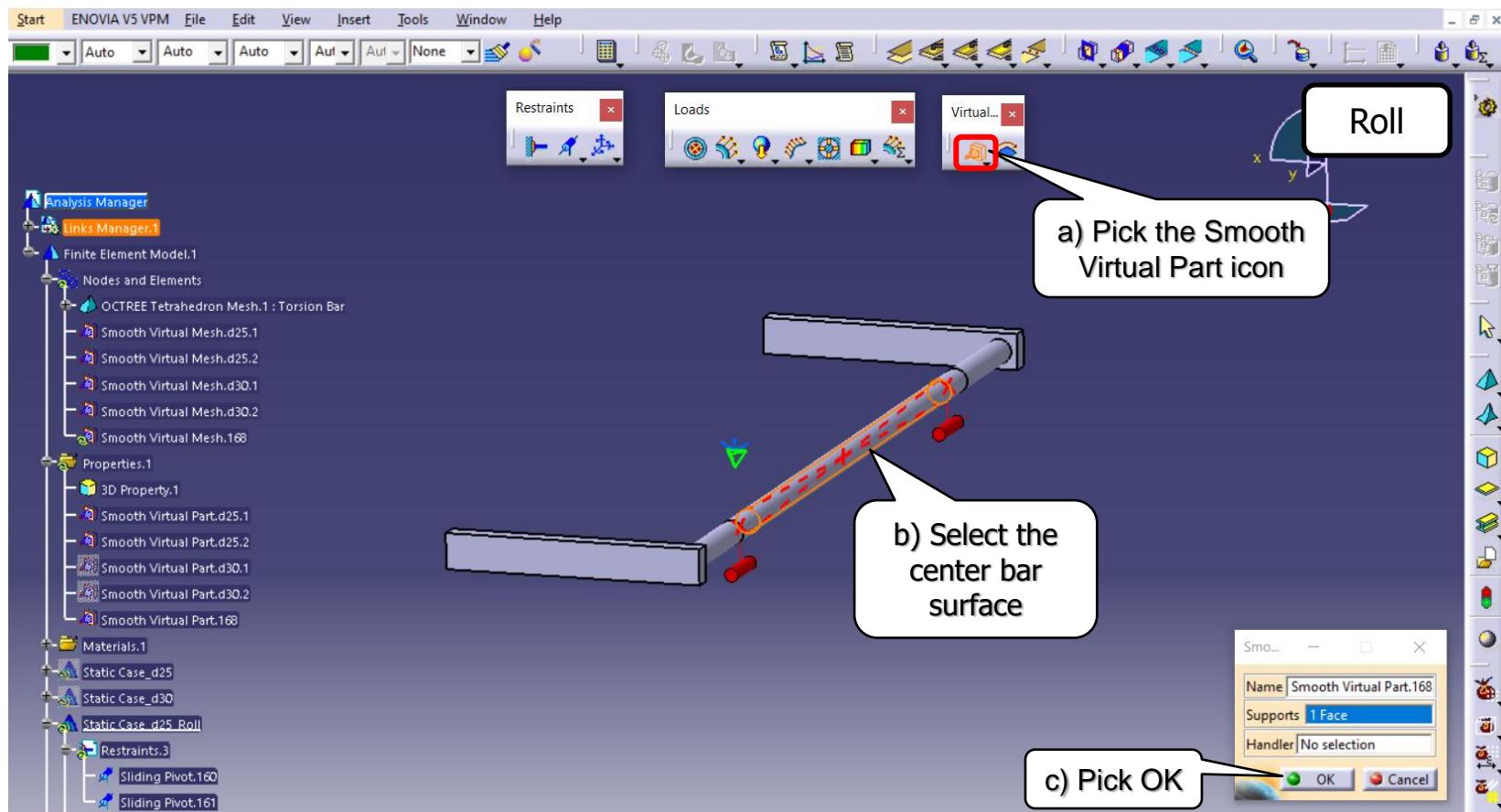


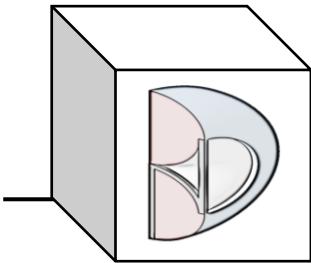


BND TechSource



- Generative Structural Analysis workbench; Create Smooth Virtual Part for center restraint.

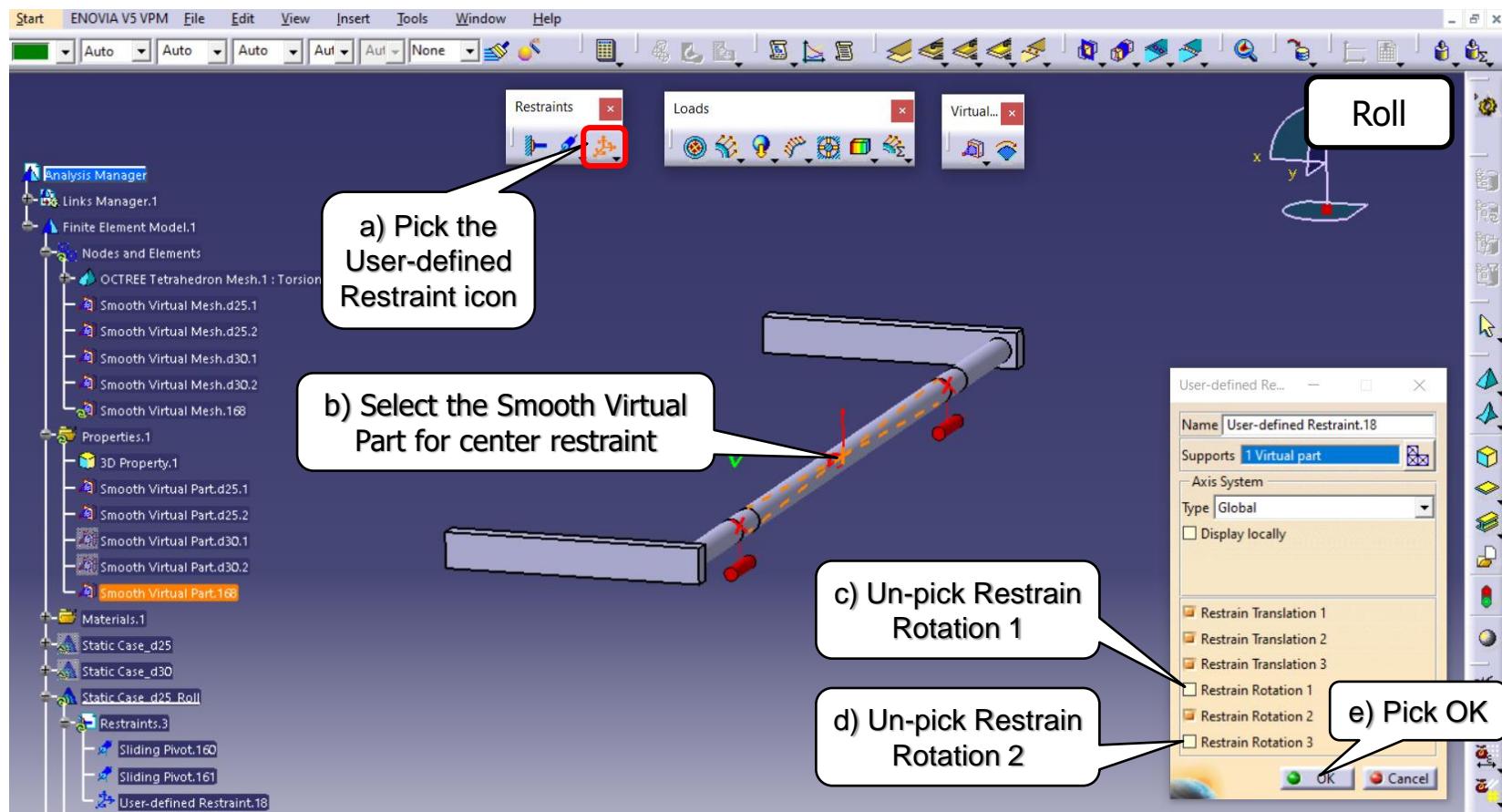


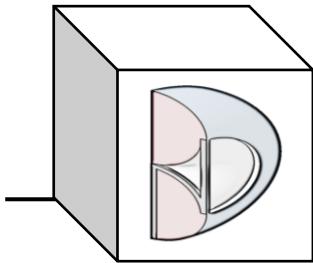


BND TechSource



- Generative Structural Analysis; Create the User-defined Center restraint.

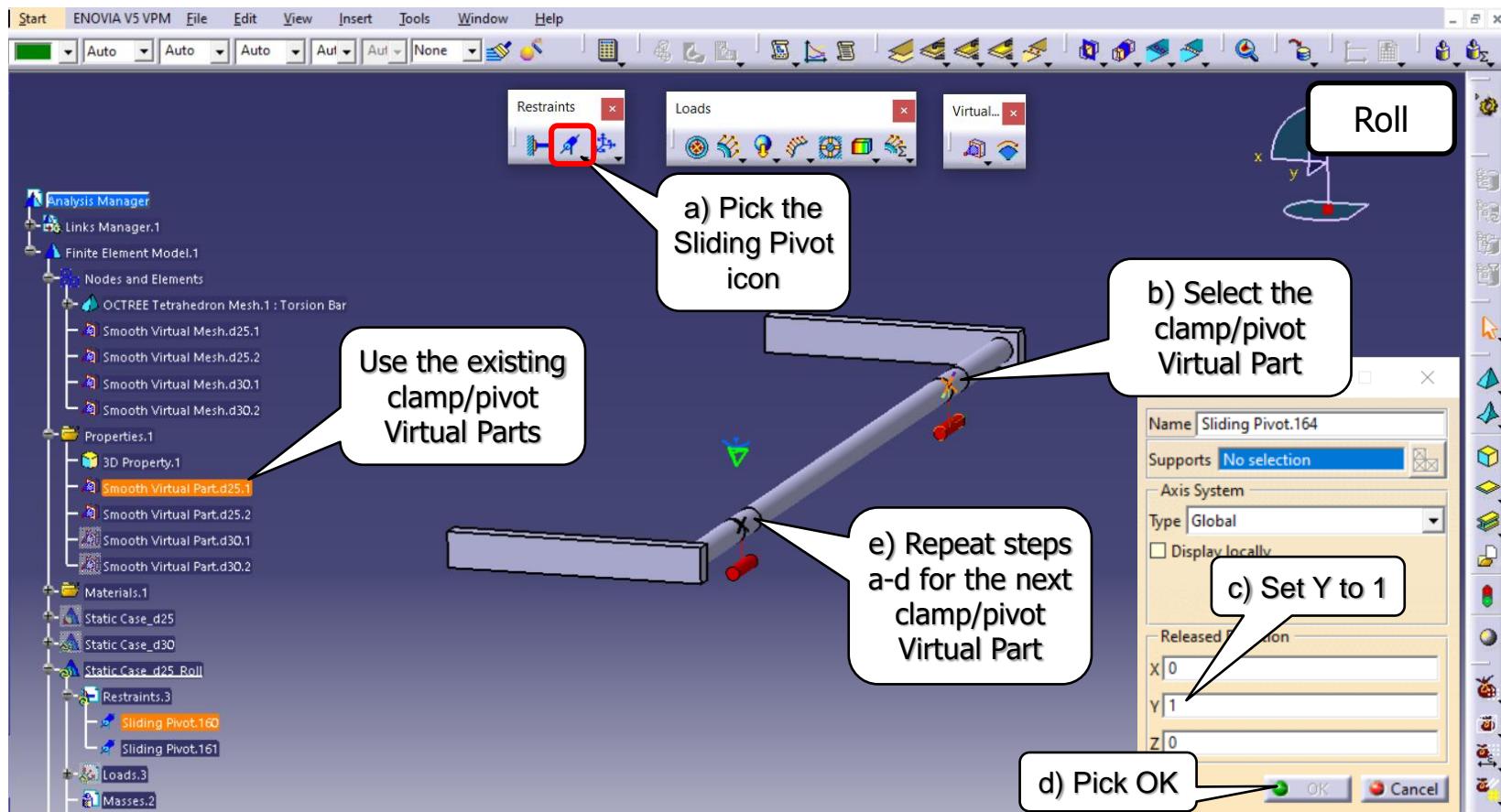


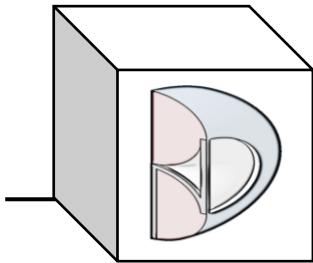


BND TechSource



- Generative Structural Analysis; Create the Sliding Pivot restraints.

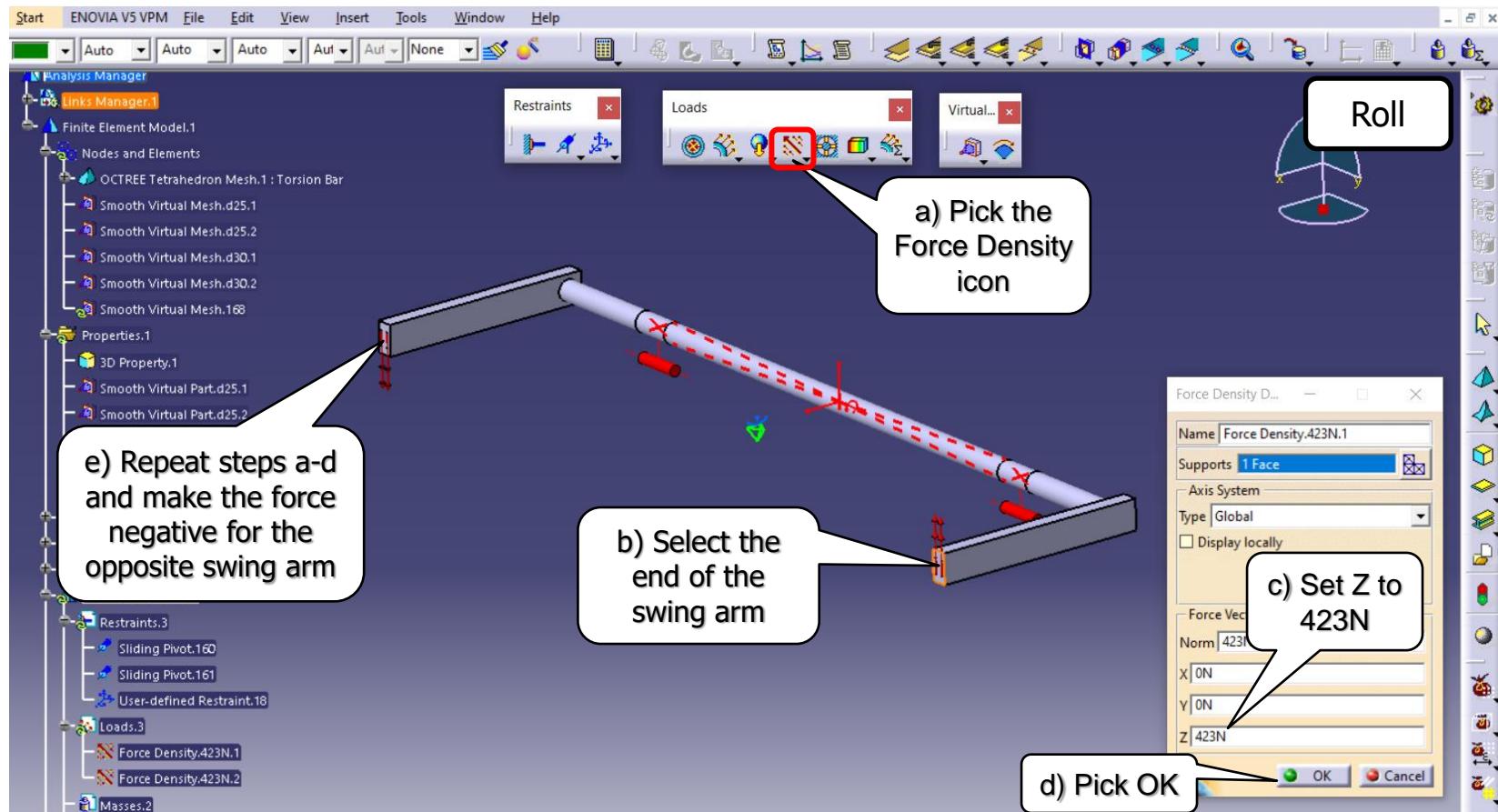


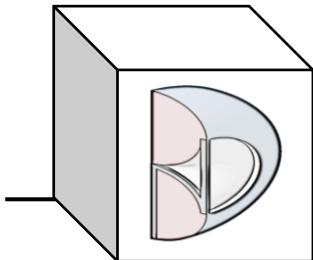


BND TechSource



- Generative Structural Analysis; Create the Loads.

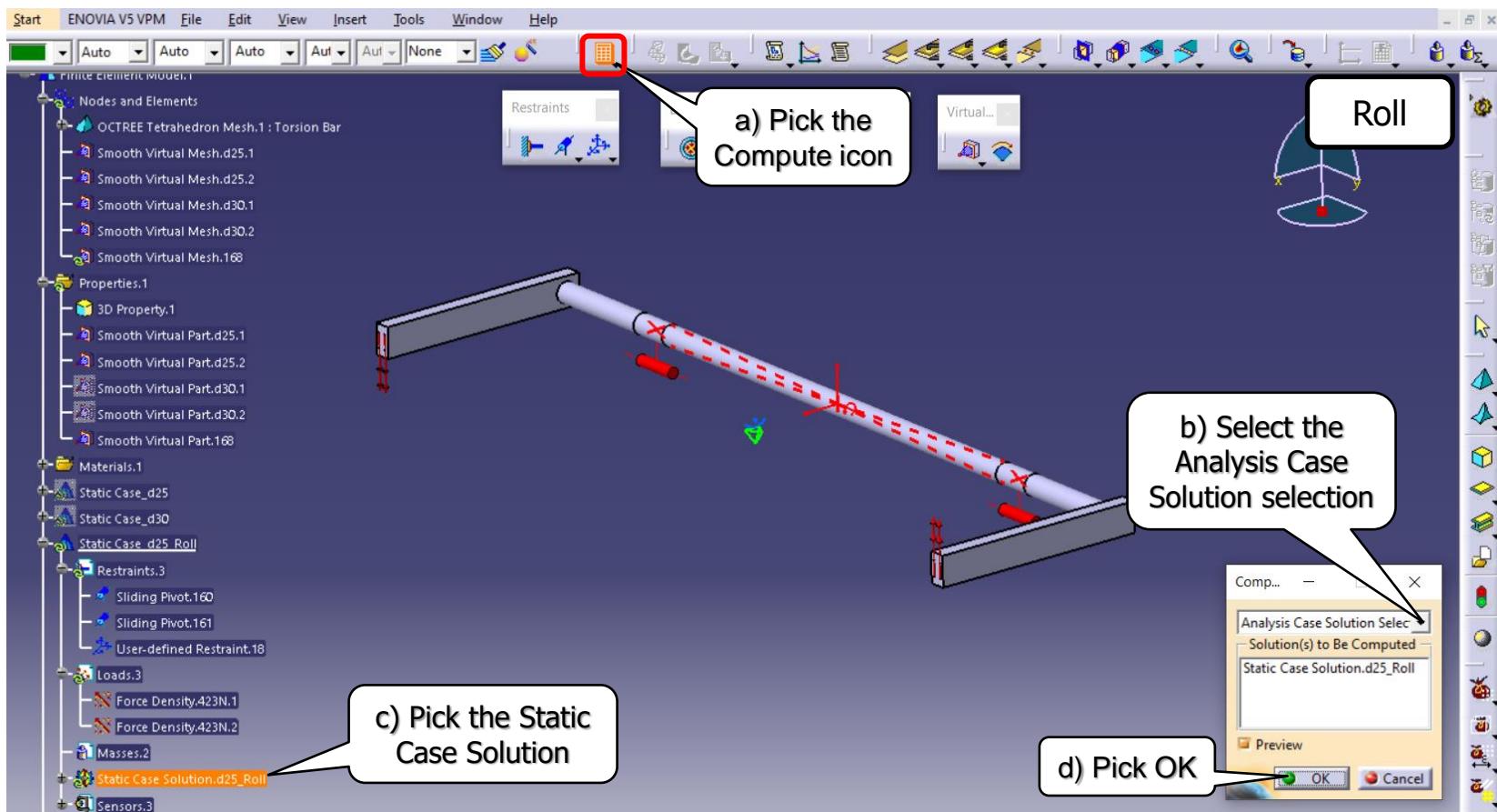


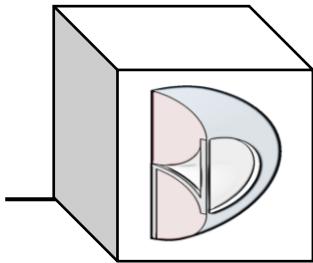


BND TechSource



- Generative Structural Analysis; Compute the analysis.

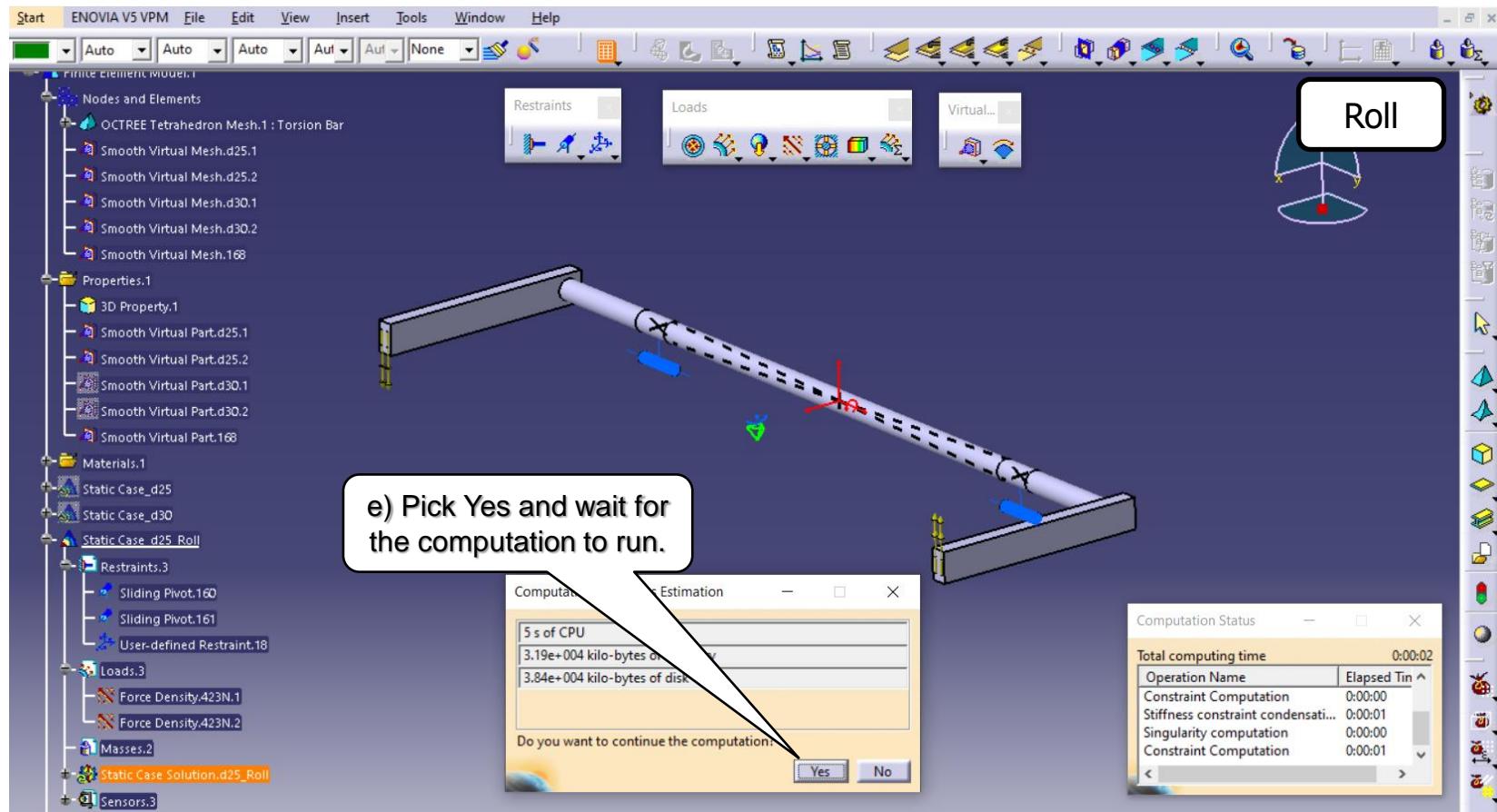


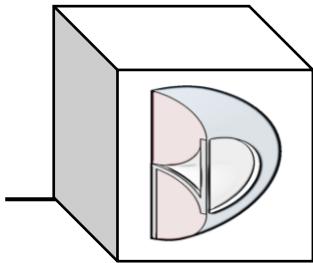


BND TechSource



- Generative Structural Analysis; Compute the analysis.

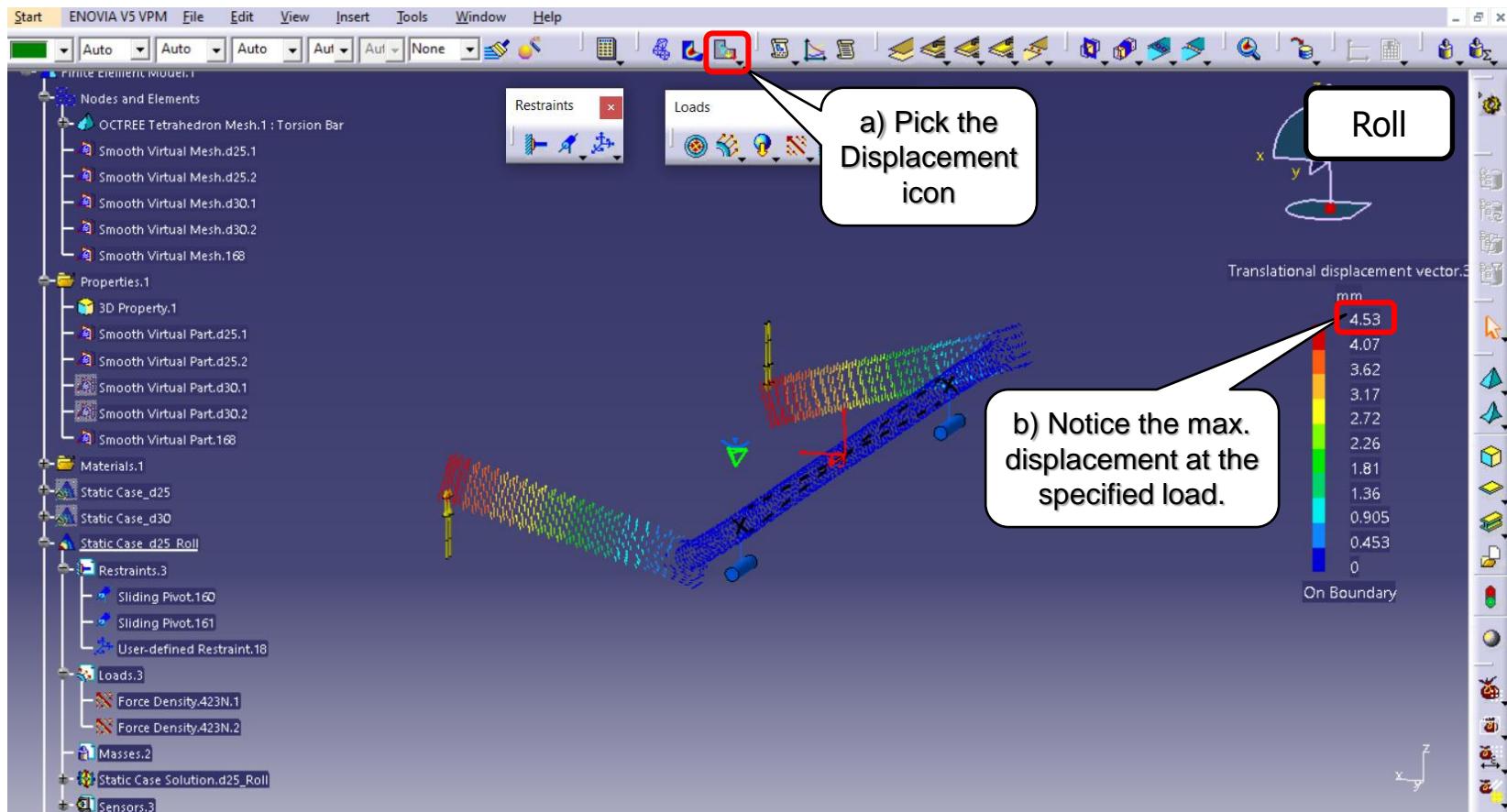


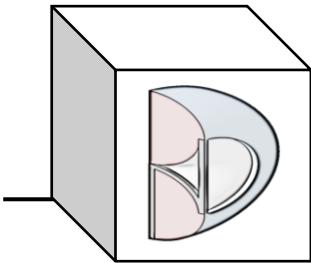


BND TechSource



- Generative Structural Analysis; Show results of the analysis.

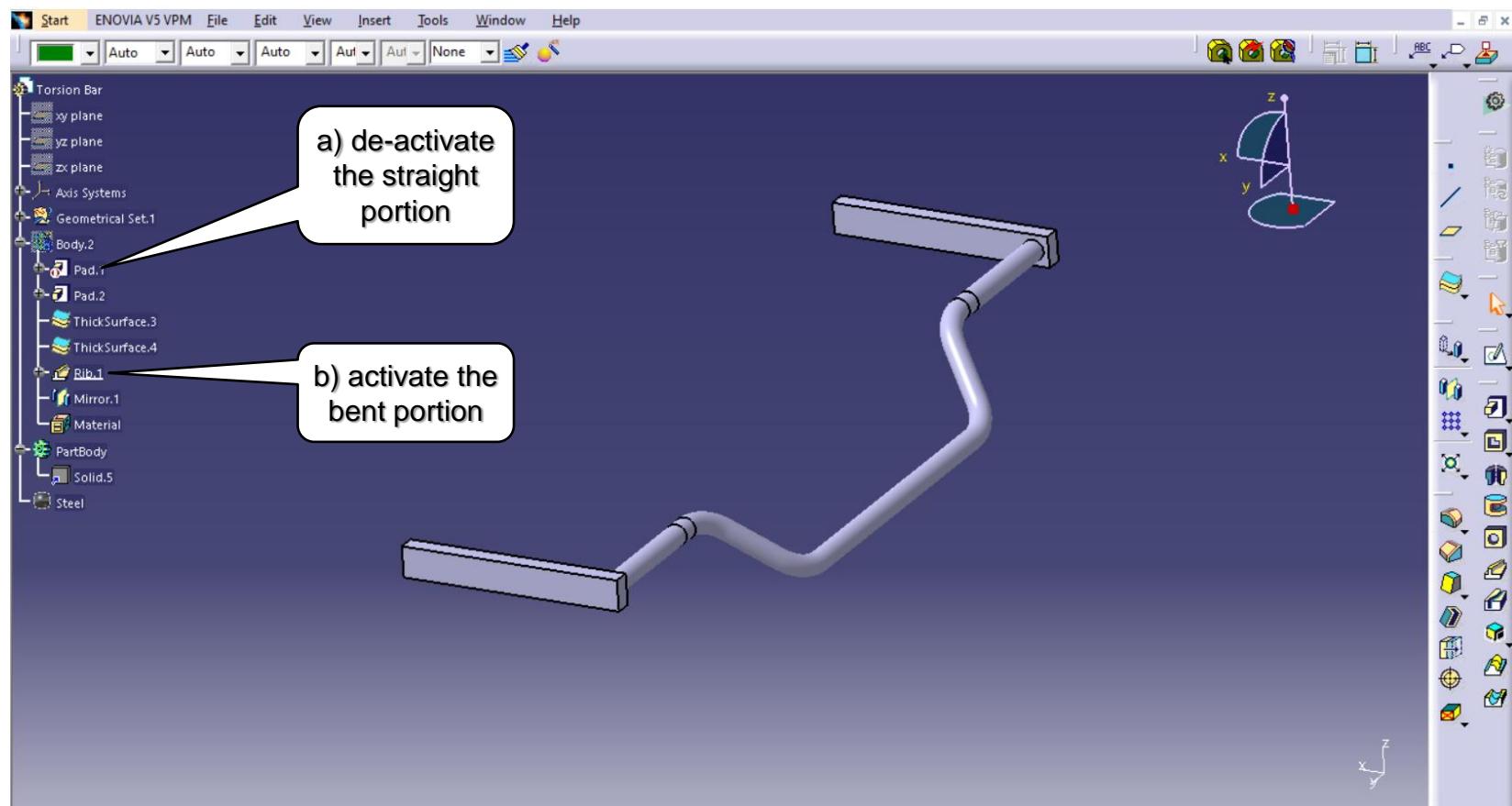


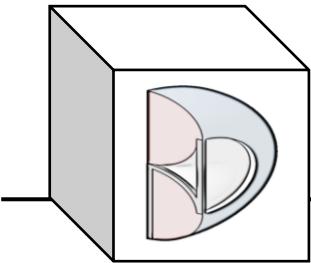


BND TechSource



- Back to the Torsion Bar CatPart to de-activate the straight portion and activate the bent portion.

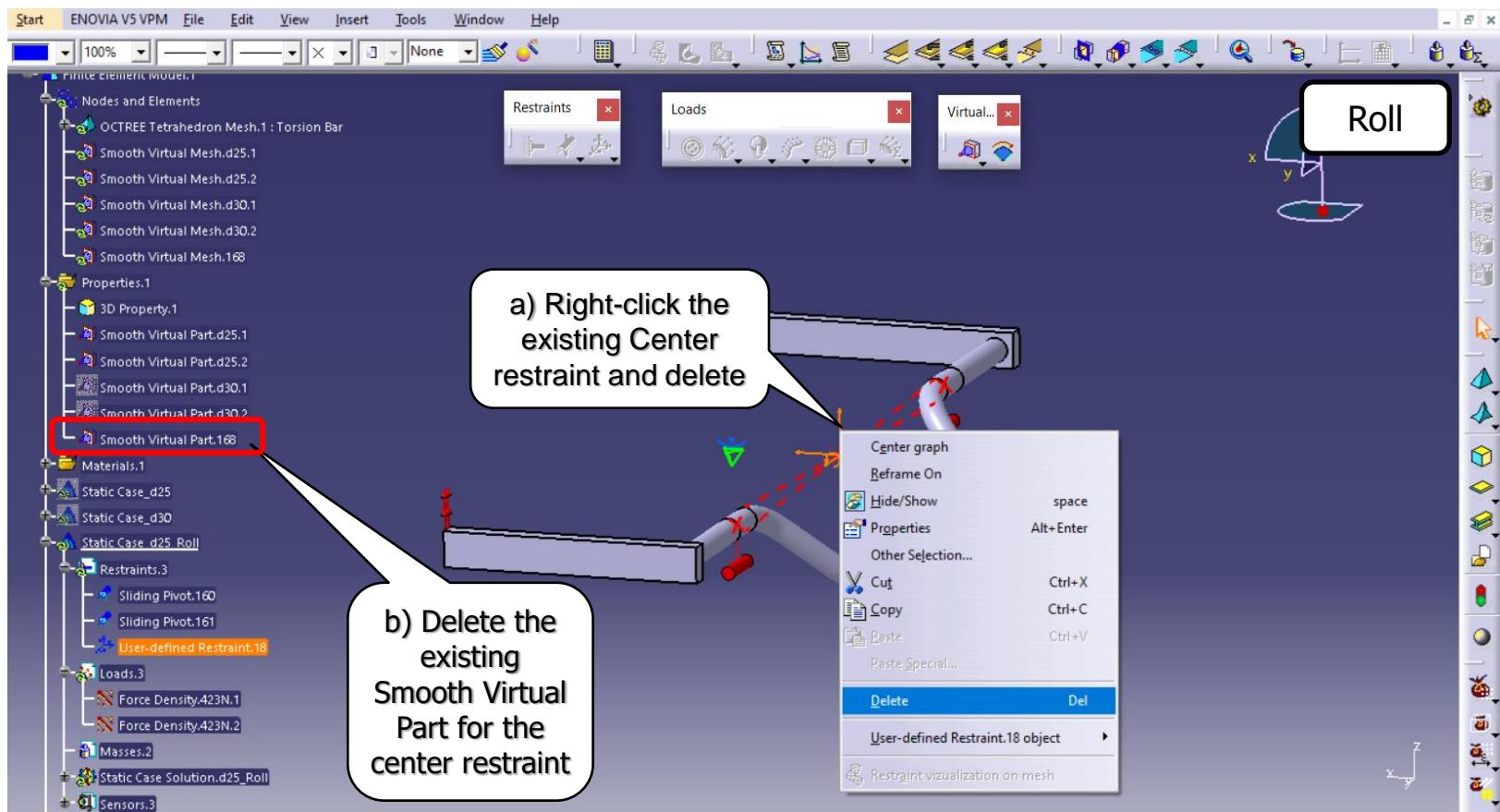


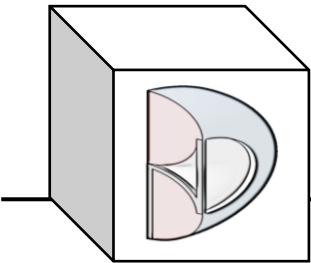


BND TechSource



- Back to Generative Structural Analysis workbench; delete existing Center restraint and Smooth Virtual Part.

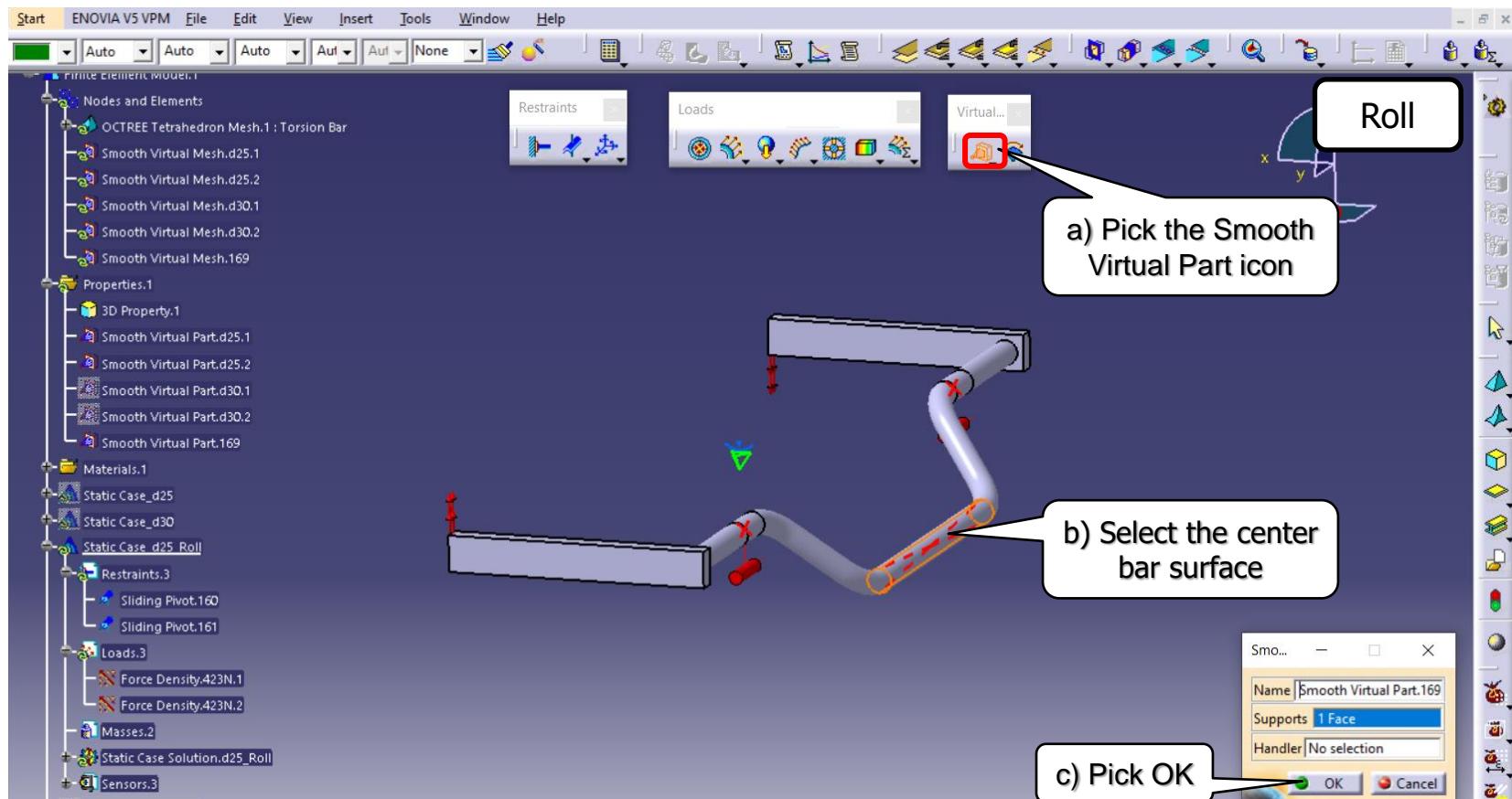


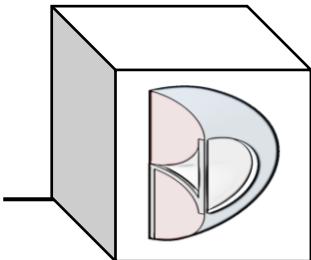


BND TechSource



- Generative Structural Analysis workbench; create Smooth Virtual Part for center restraint.

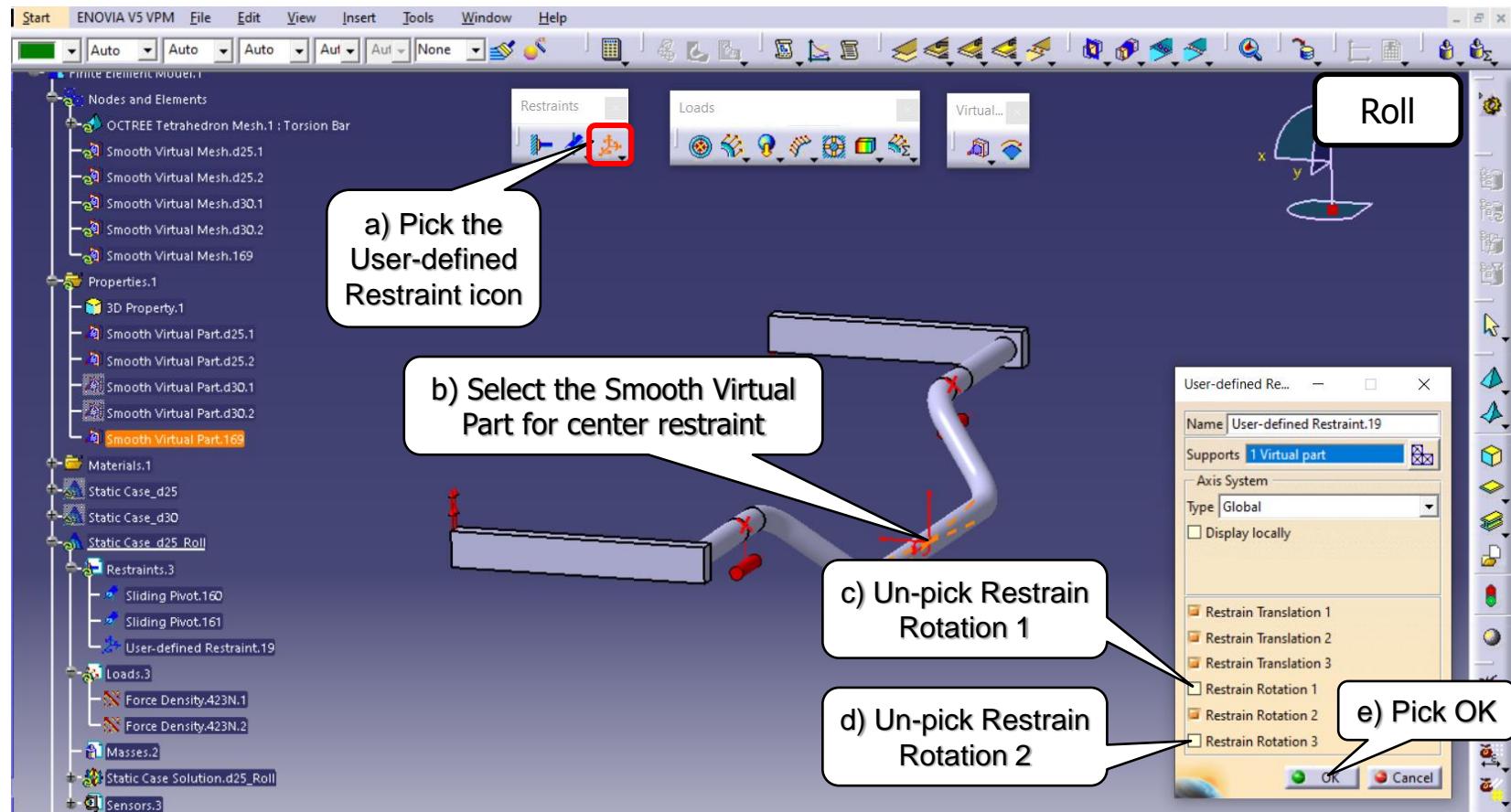


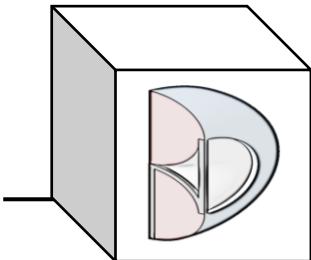


BND TechSource



- Generative Structural Analysis; create the Center restraint.

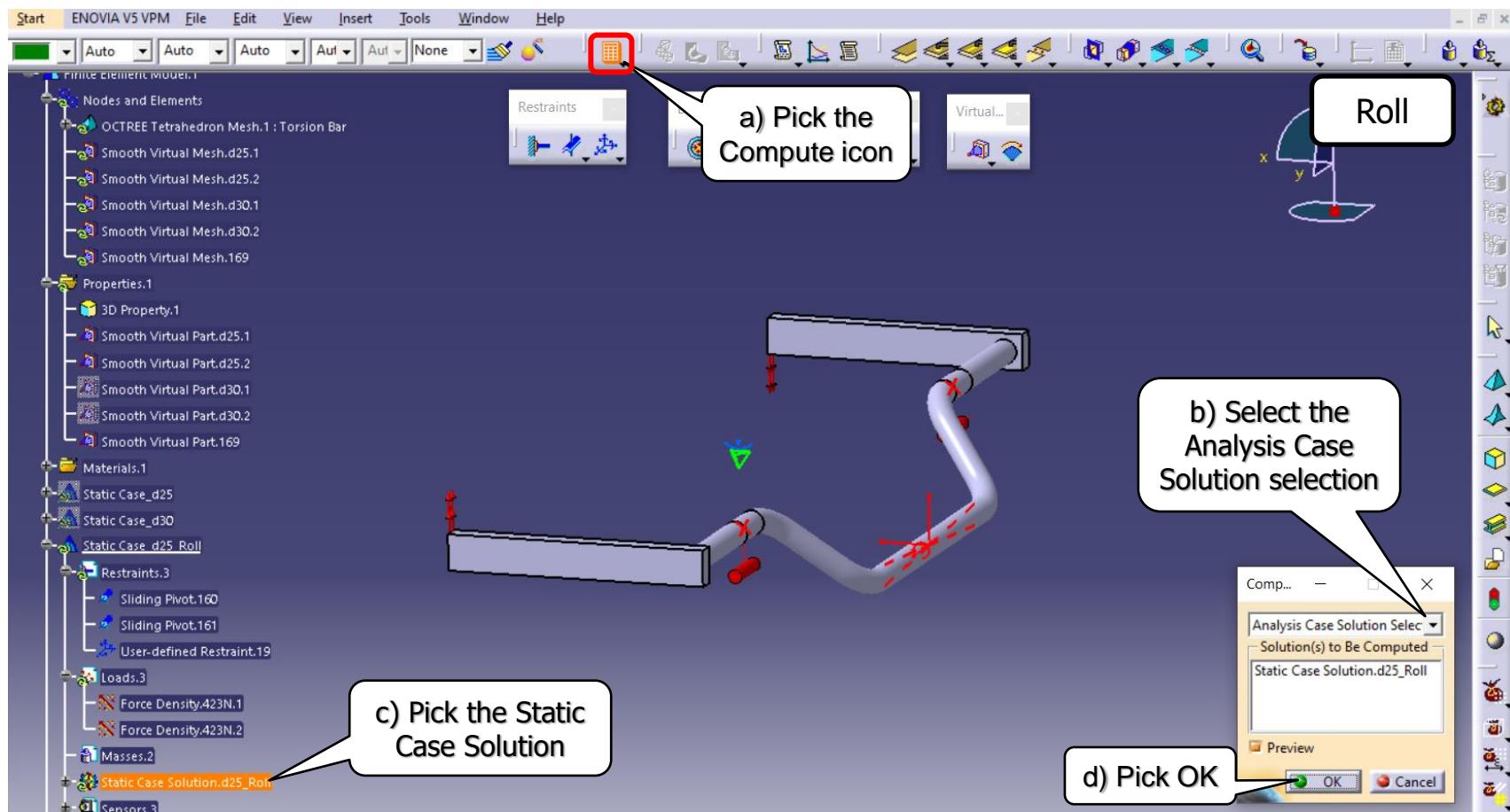


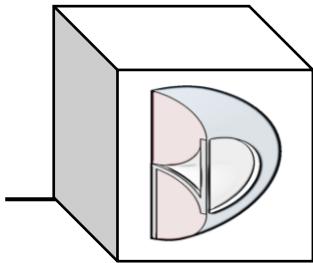


BND TechSource



- Back to Generative Structural Analysis; Compute the analysis.





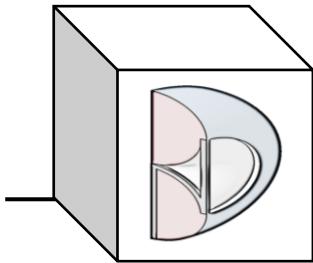
BND TechSource



- Generative Structural Analysis; Compute the analysis.

e) Pick Yes and wait for the computation to run.

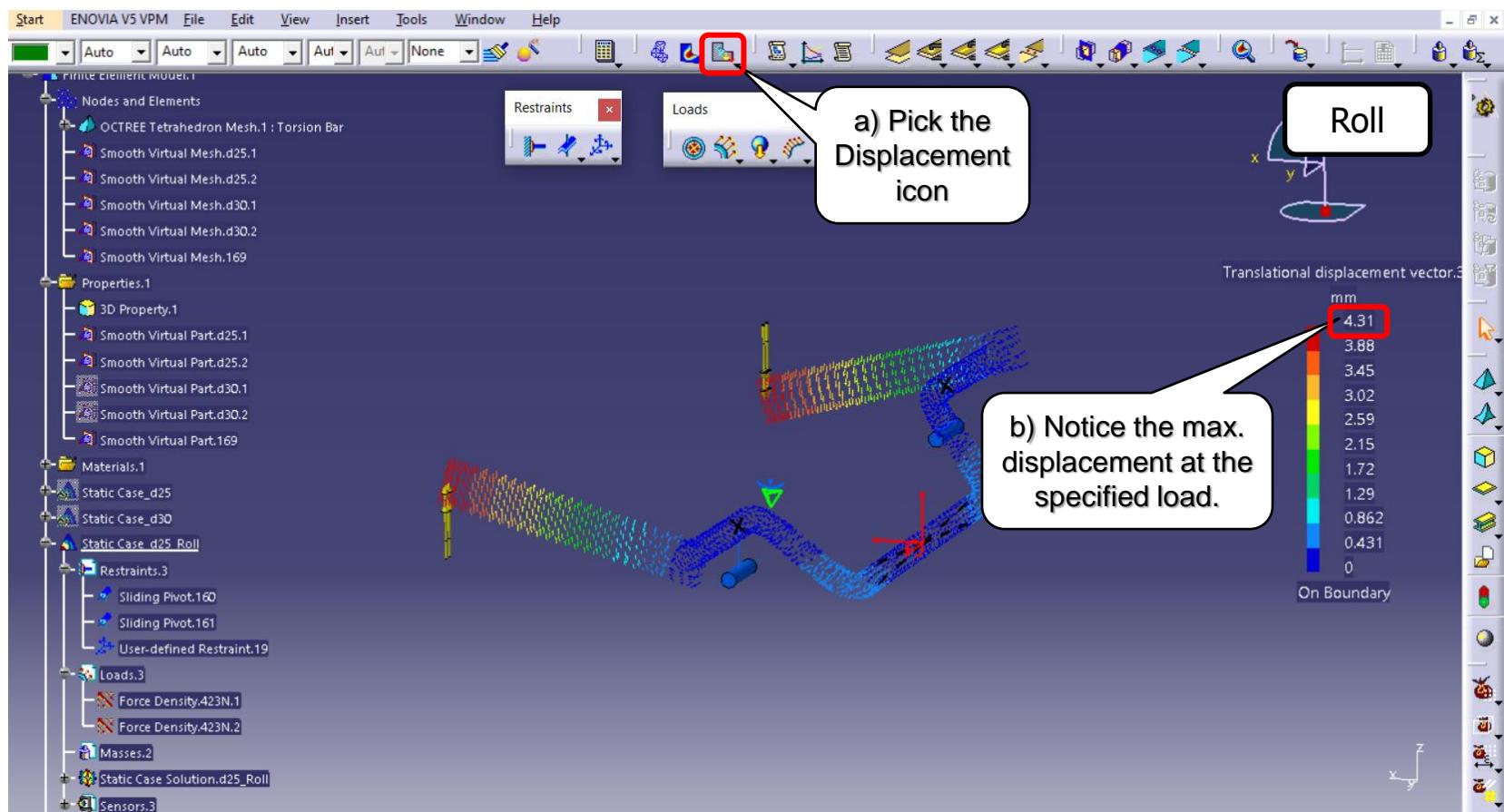
The screenshot shows the ENOVIA V5 VPM software interface. On the left is the Project Explorer tree view, which includes sections for Nodes and Elements, Properties, Materials, and Static Cases. The 'Static Case_d25_Roll' section is expanded, showing Restraints, Loads, and Sensors. In the center workspace, a 3D model of a mechanical assembly is displayed, specifically a 'Torsion Bar' component. A callout box points to a 'Computation Resources Estimation' dialog box at the bottom center. This dialog box contains fields for 'Memory' and 'Disk', and a message asking 'Do you want to continue the computation?'. Below the dialog are 'Yes' and 'No' buttons. To the right of the workspace, there is a 'Computation Status' window showing a table of operations and their elapsed time, all currently at 0:00:00. The status bar at the bottom of the software window displays the URL <https://bndtechsource.wixsite.com/home>.

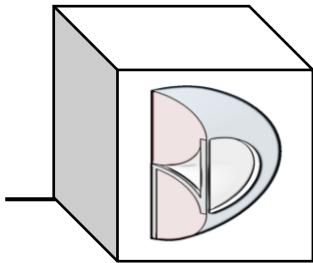


BND TechSource



- Generative Structural Analysis; Show results of the analysis.

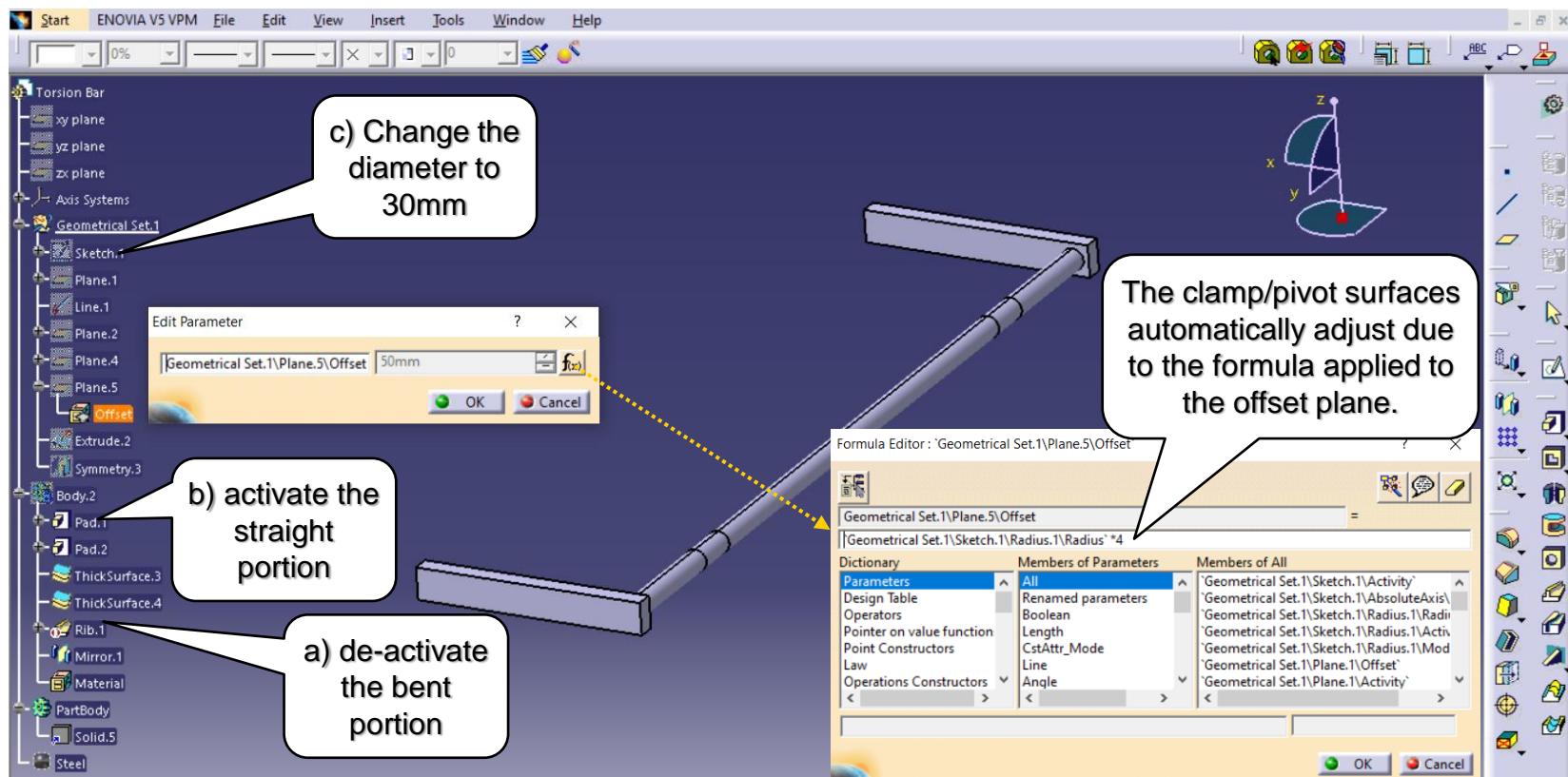


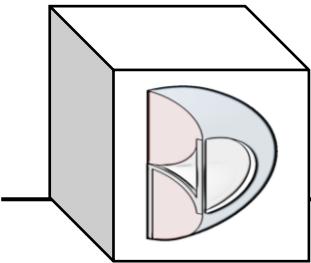


BND TechSource



- Back to the Torsion Bar CatPart to activate the straight portion and de-activate the bent portion and change the diameter to 30mm.

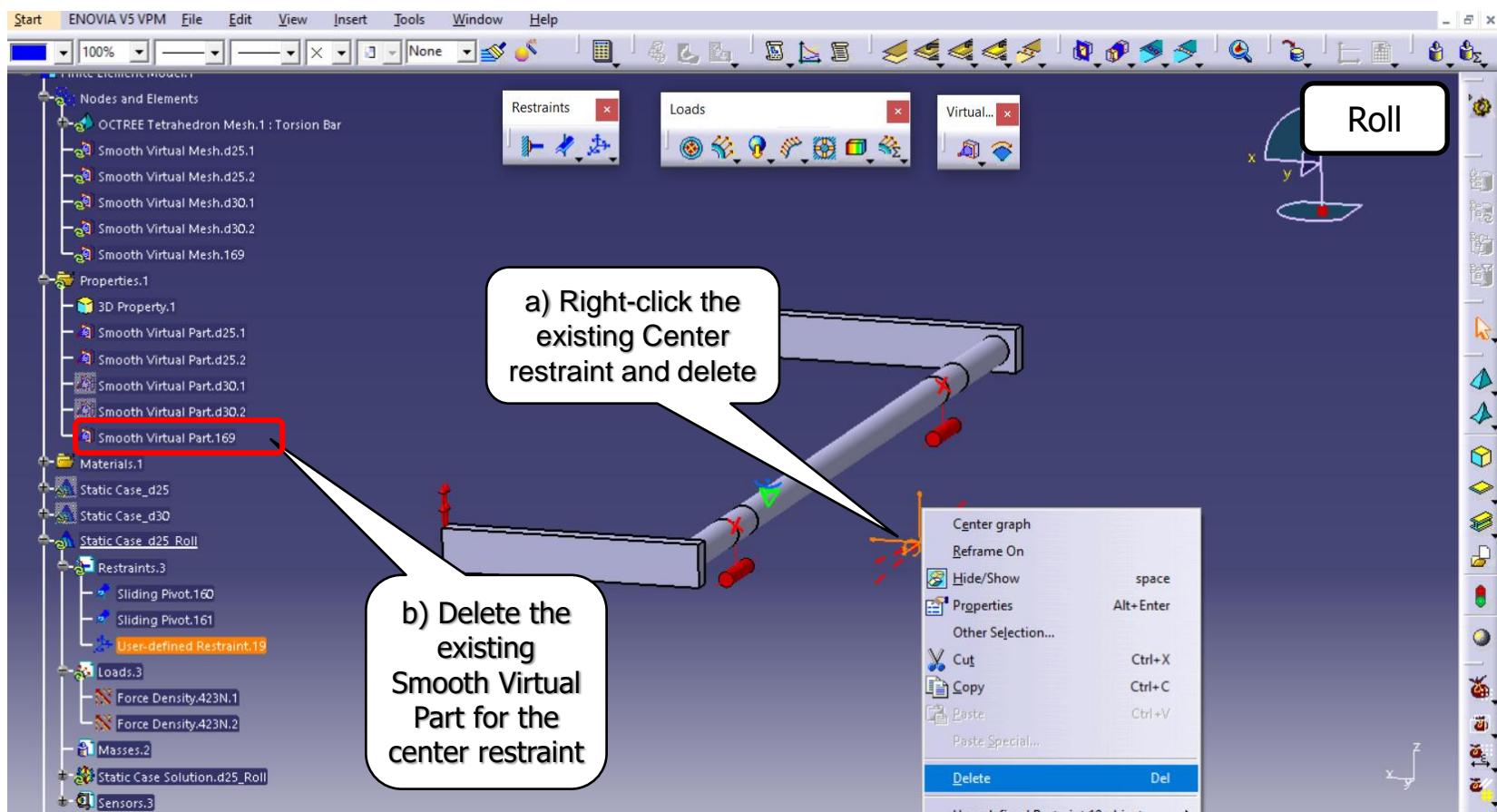


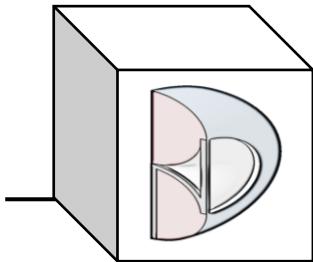


BND TechSource



- Back to Generative Structural Analysis workbench; delete existing Center restraint and Smooth Virtual Part.

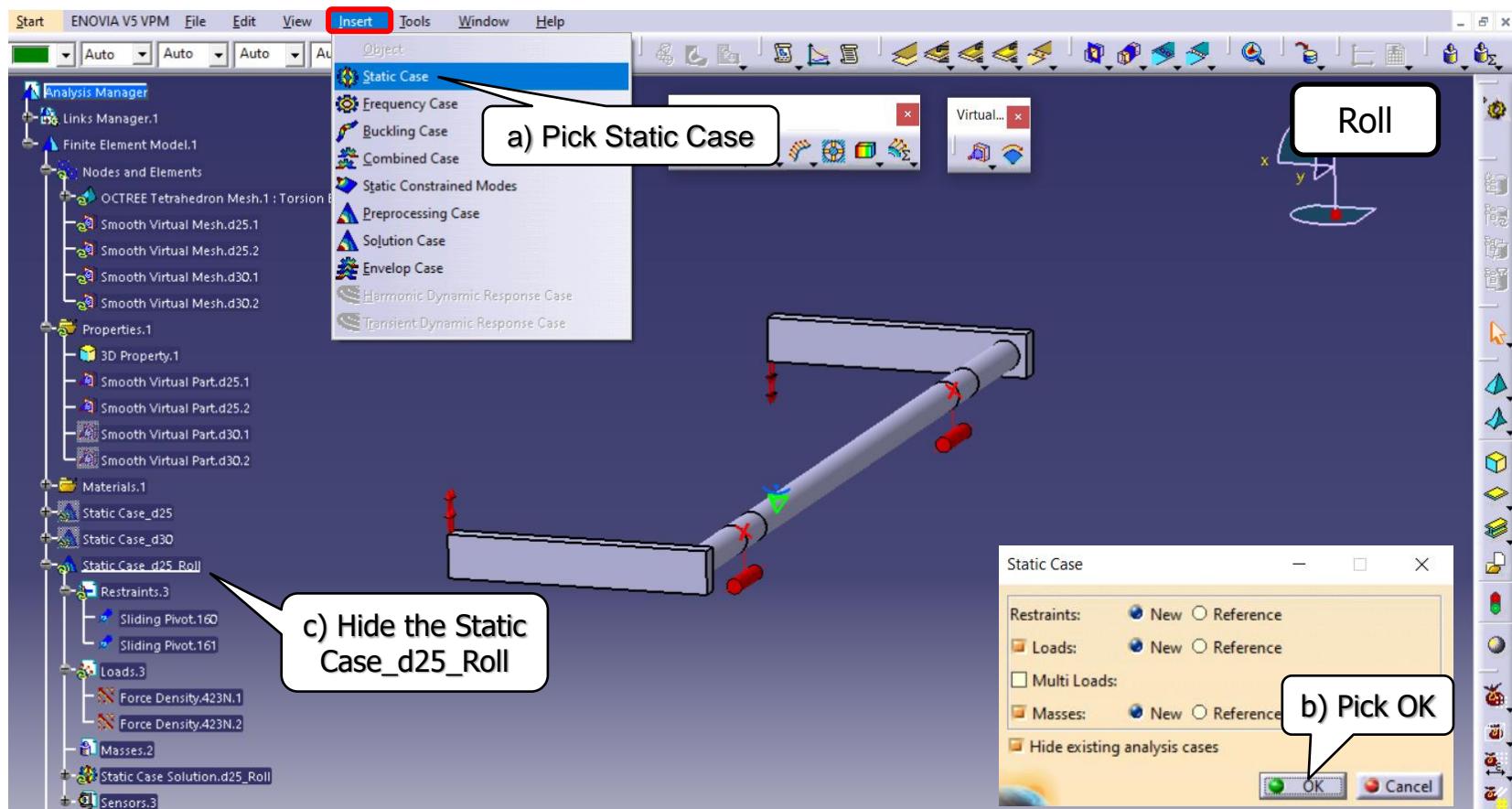


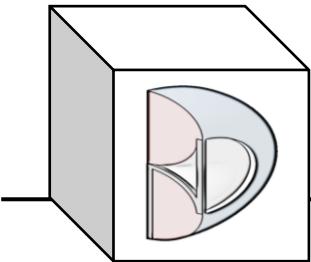


BND TechSource



- Generative Structural Analysis workbench; create a new Static Case_d30 for the diameter 30mm Torsion Bar.

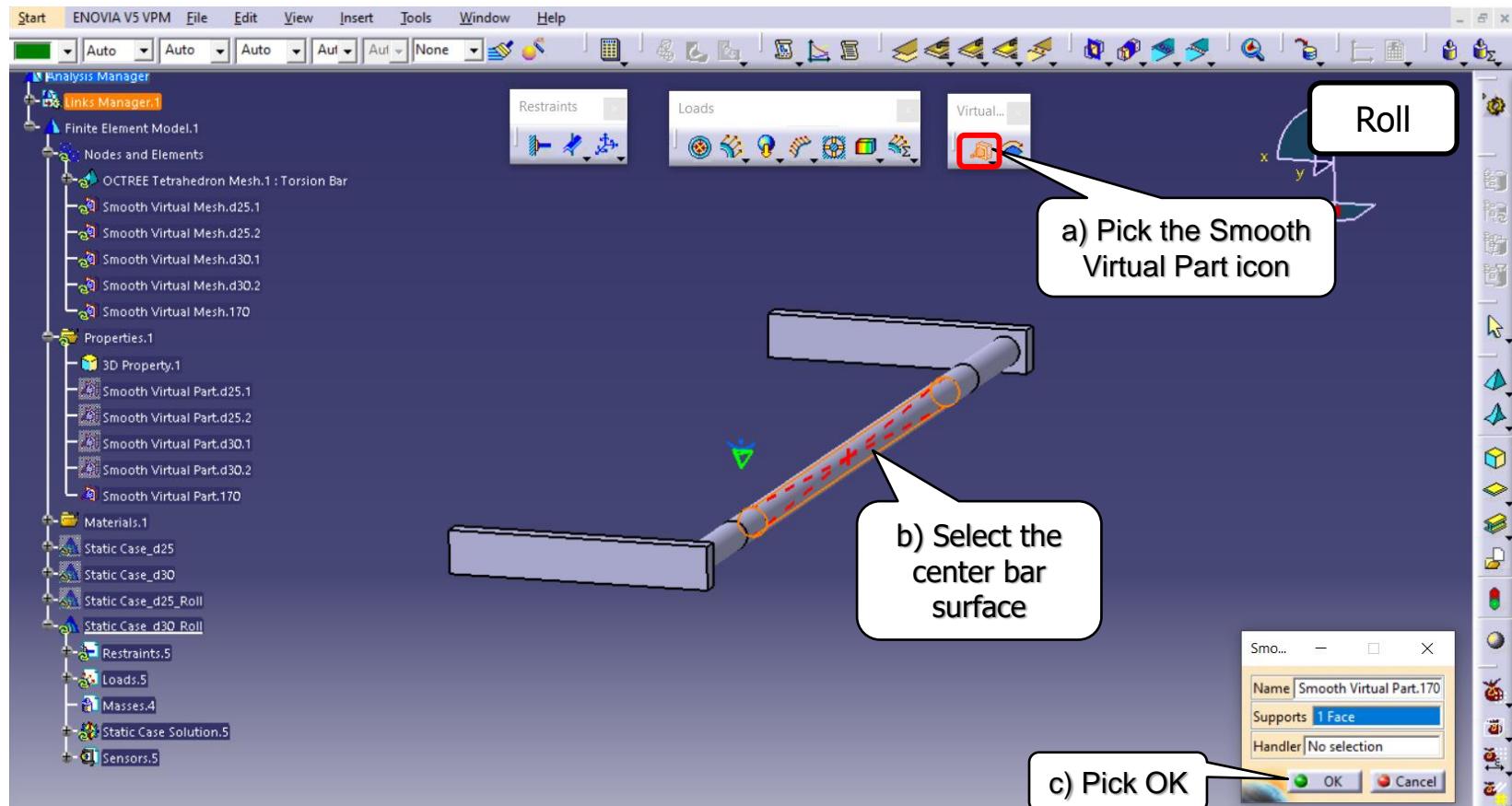


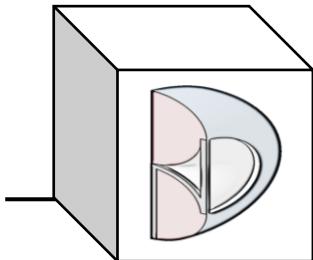


BND TechSource



- Generative Structural Analysis workbench; create Smooth Virtual Part for center restraint.

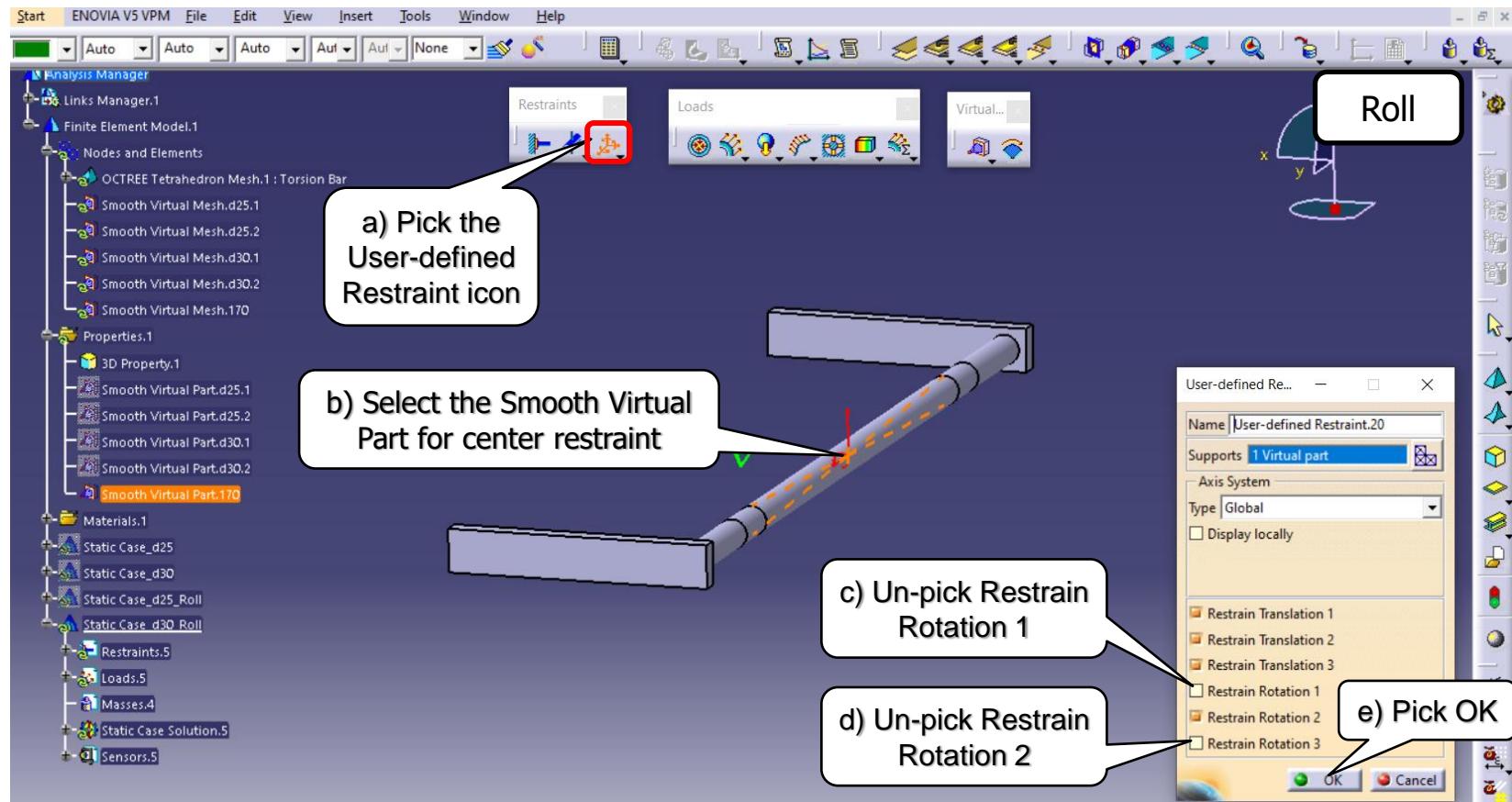


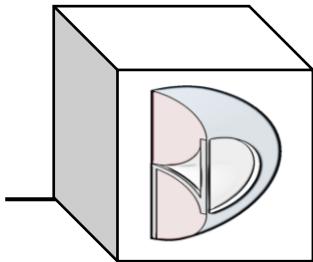


BND TechSource



- Generative Structural Analysis; create the Center restraint.

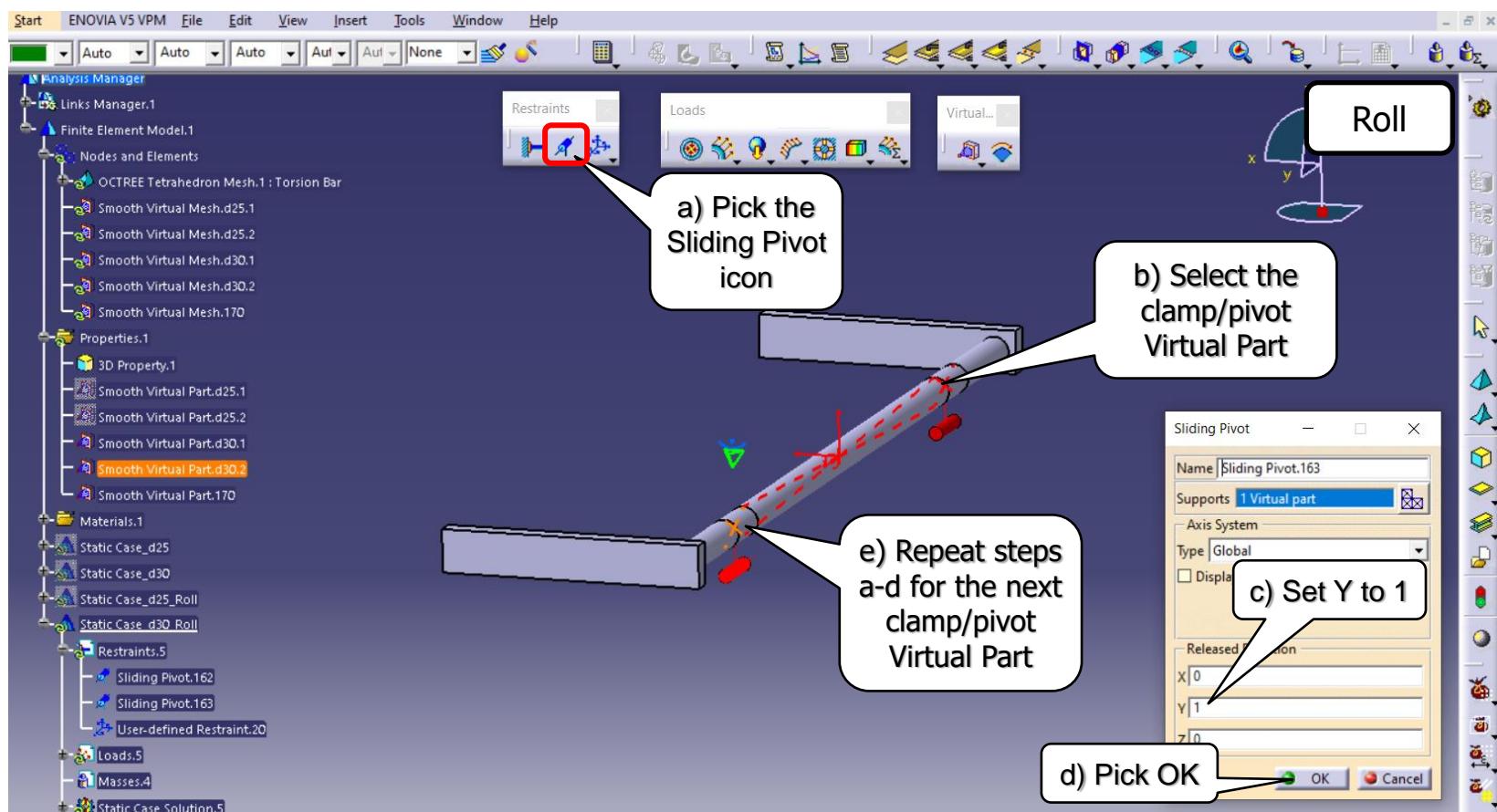


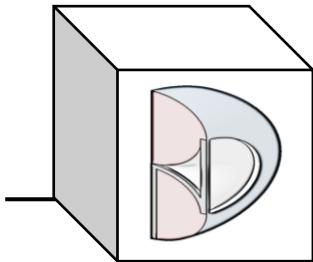


BND TechSource



- Generative Structural Analysis; create the Sliding Pivot restraints.

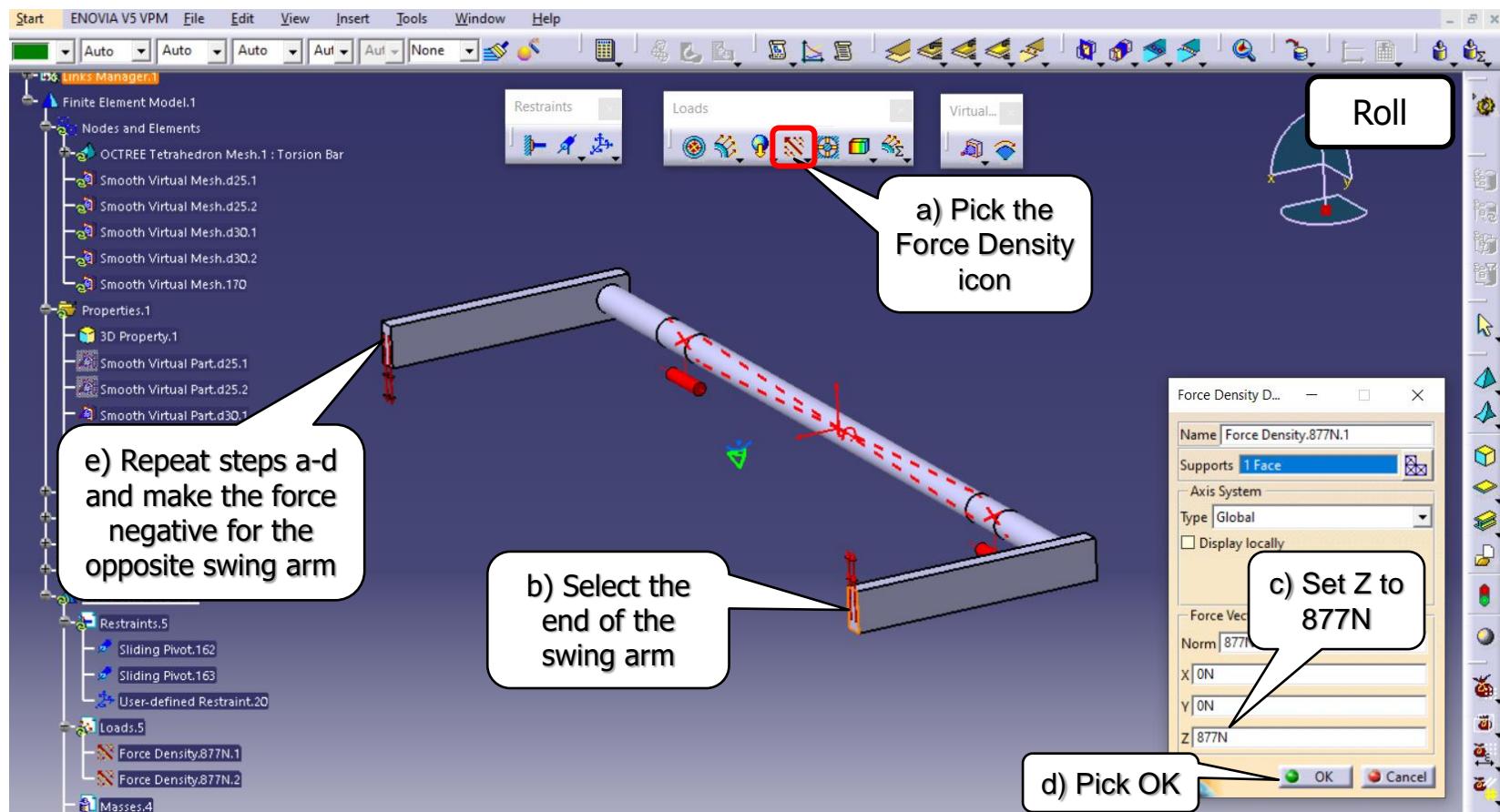


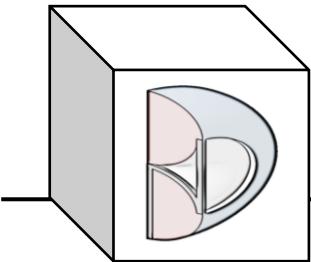


BND TechSource



- Generative Structural Analysis; create the Loads.

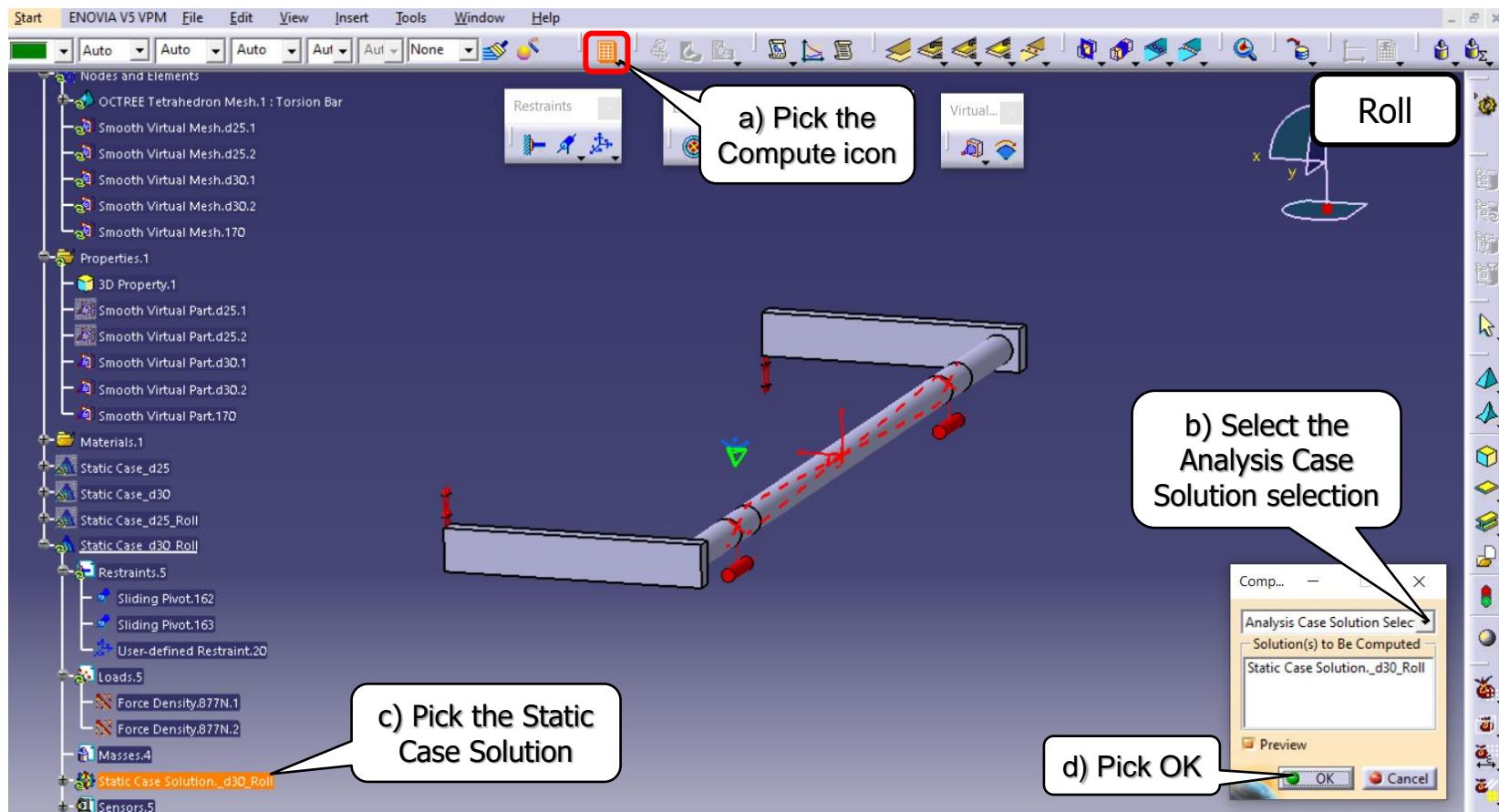


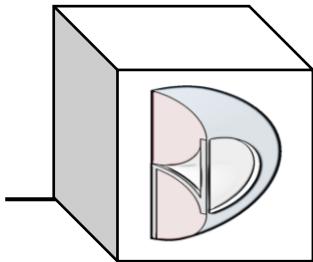


BND TechSource



- Generative Structural Analysis; Compute the analysis.





BND TechSource



- Generative Structural Analysis; Compute the analysis.

The screenshot shows the ENOVIA V5 VPM software interface. On the left is the Project Explorer pane displaying a hierarchical list of objects: Nodes and Elements, Properties, Materials, Restraints, Loads, Masses, Sensors, and Static Case Solution. The main workspace shows a 3D model of a torsion bar with a cylindrical end labeled "Roll". A callout box contains the text: "e) Pick Yes and wait for the computation to run." A small window titled "Computation Estimation" is open, showing CPU usage and disk space information. Another window titled "Computation Status" shows the total computing time and a list of operations with their elapsed times. The right side of the interface features various toolbars and a vertical toolbar on the far right.

e) Pick Yes and wait for the computation to run.

Computation Estimation

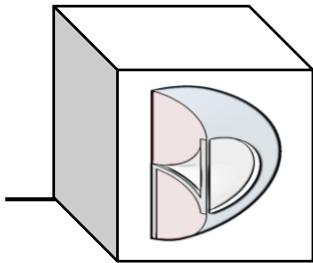
3 s of CPU
2.37e+004 kilo-bytes of memory
2.92e+004 kilo-bytes of disk

Do you want to continue the computation?

Yes No

Computation Status

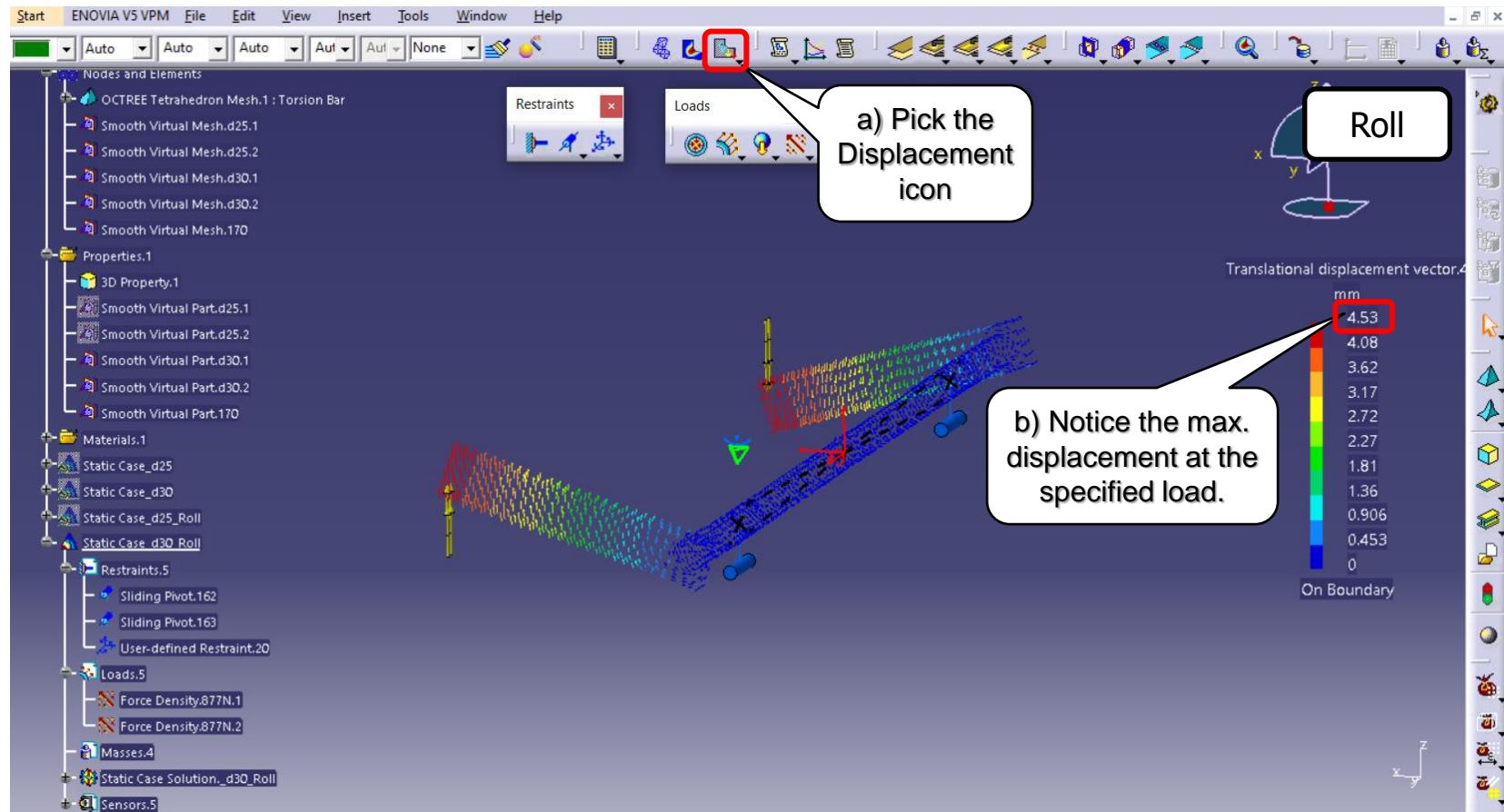
Total computing time	Elapsed Tin
Operation Name	Elapsed Tin
Constraint Computation	0:00:00
Stiffness constraint condensati...	0:00:00
Singularity computation	0:00:00
Constraint Computation	0:00:01

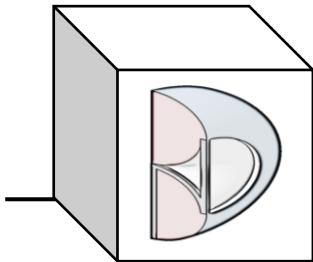


BND TechSource



- Generative Structural Analysis; Show results of the analysis.

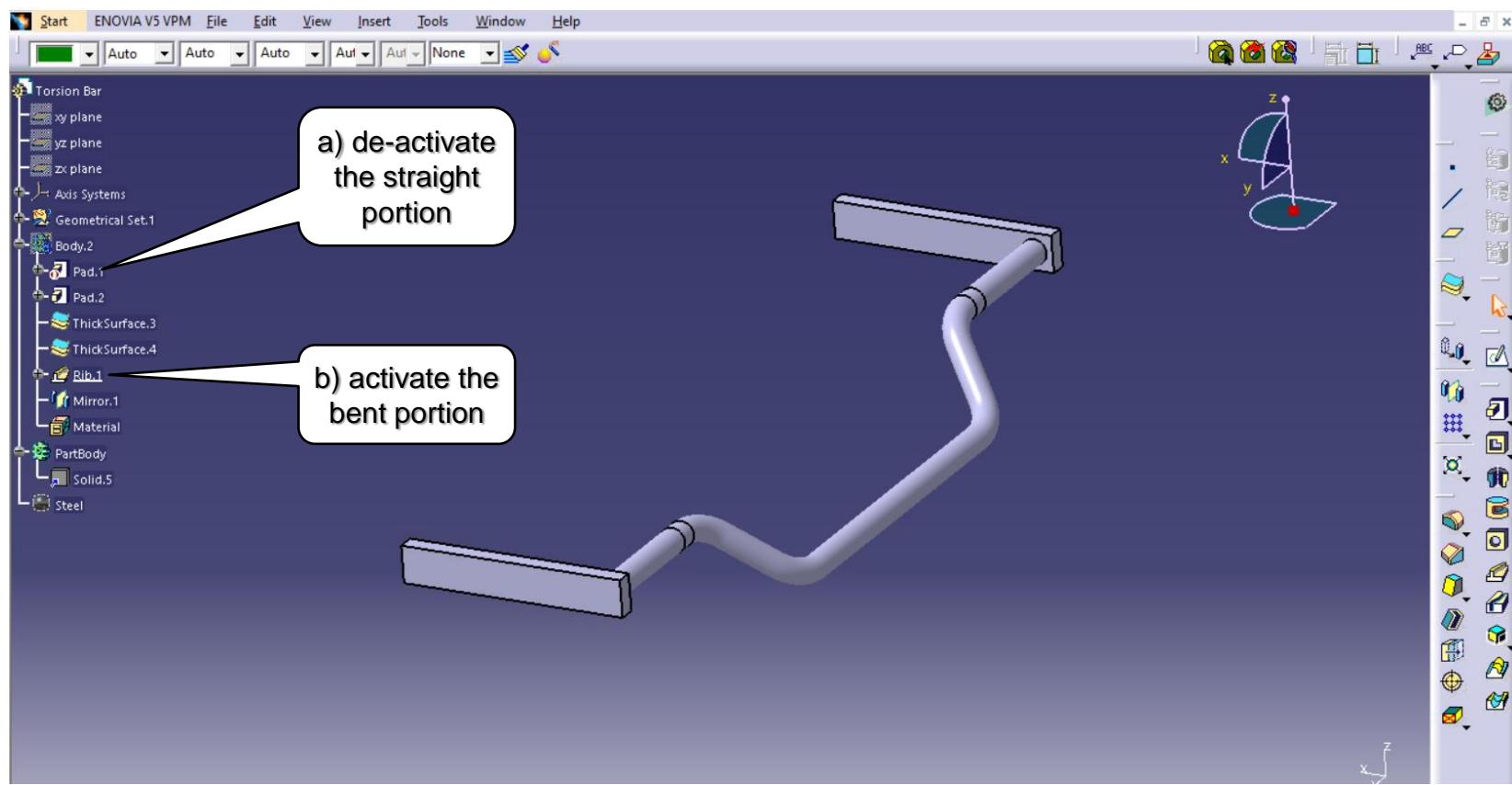


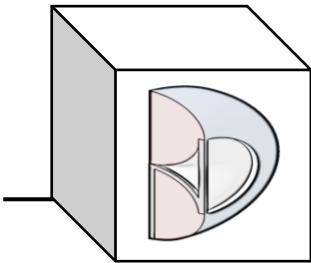


BND TechSource



- Back to the Torsion Bar CatPart to de-activate the straight portion and activate the bent portion.

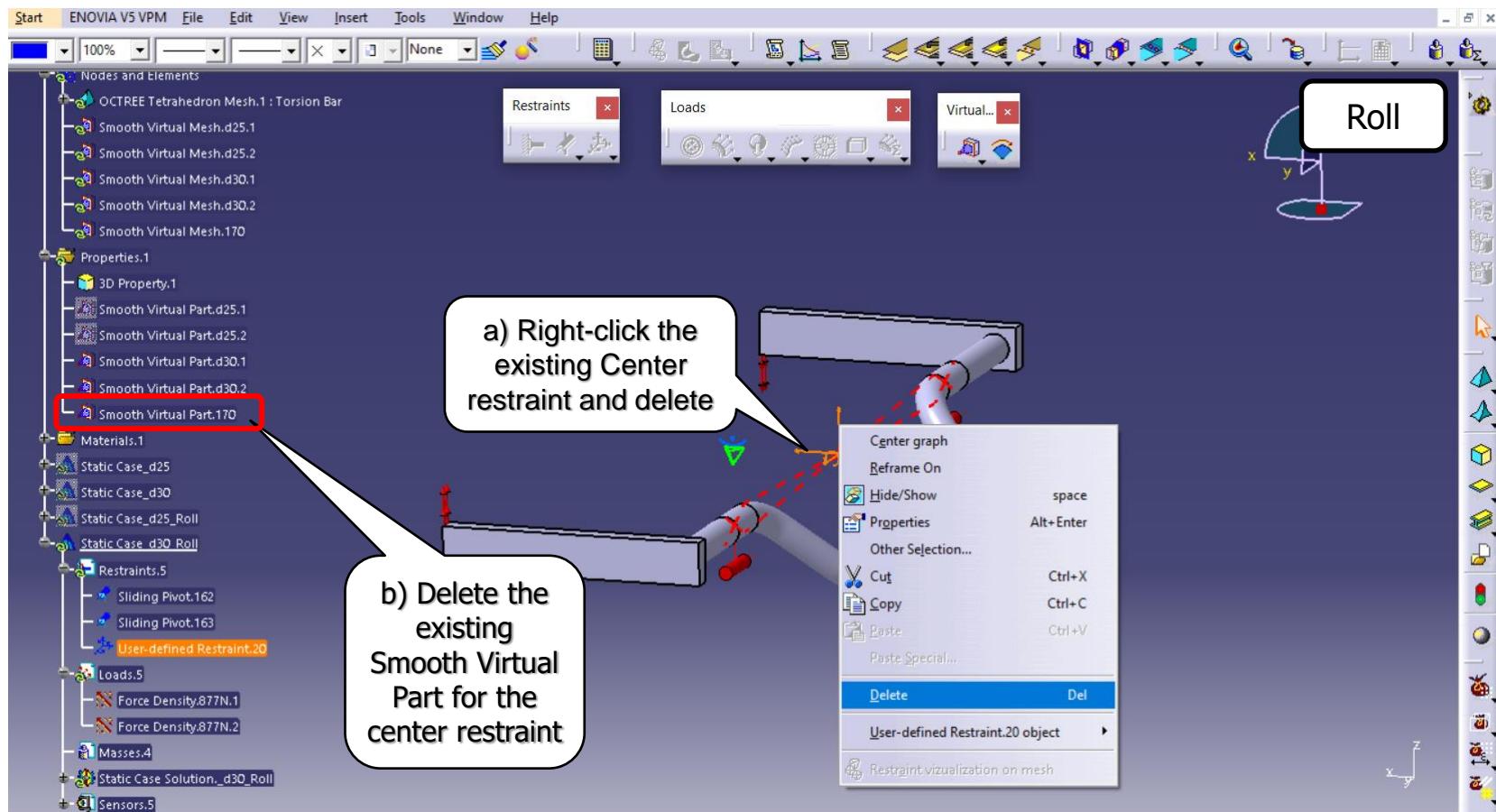


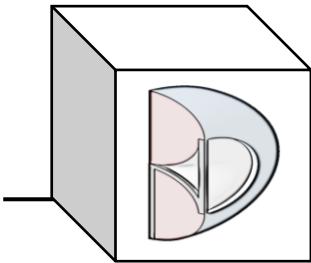


BND TechSource



- Back to Generative Structural Analysis workbench; delete existing Center restraint and Smooth Virtual Part.

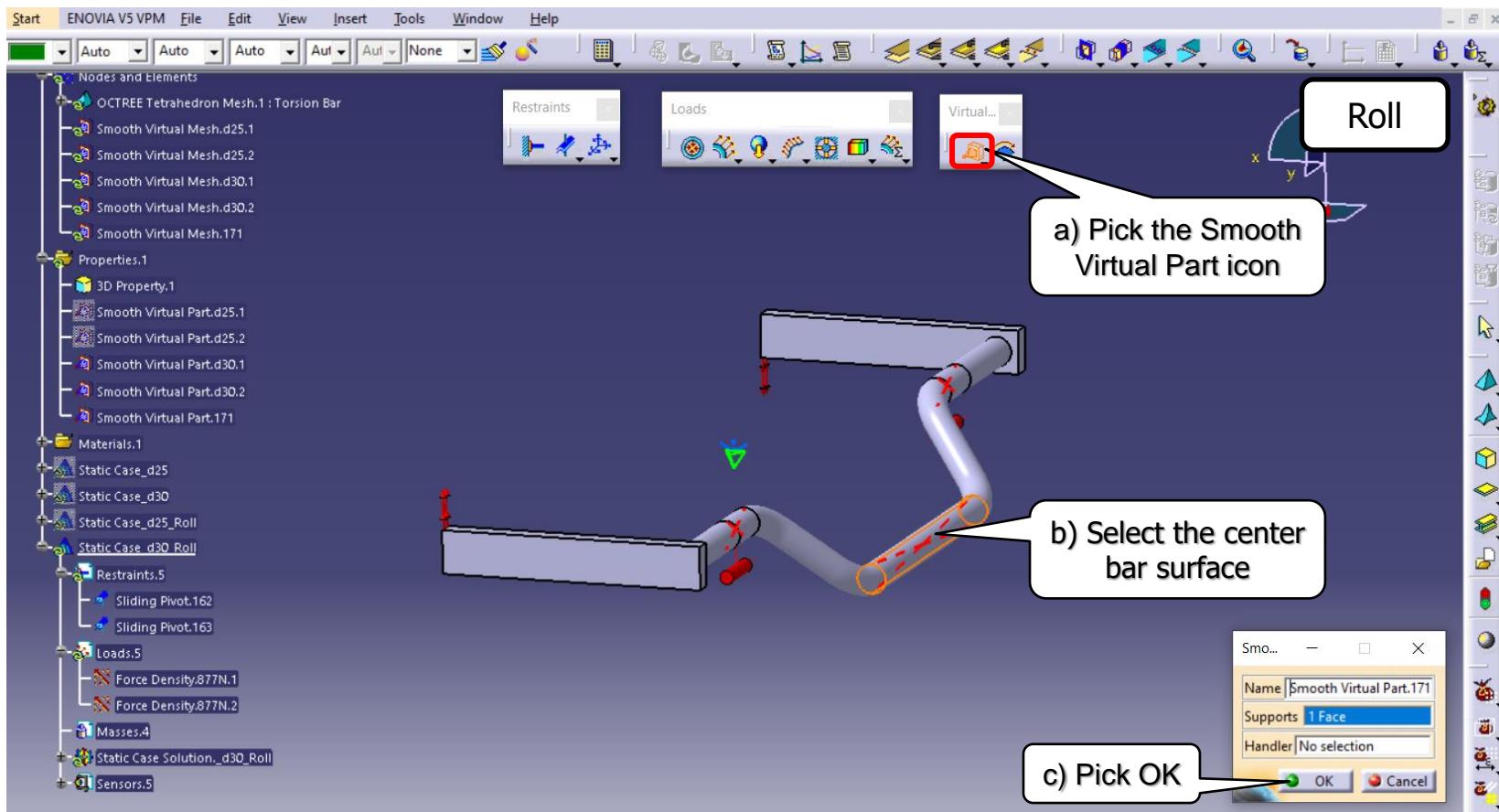


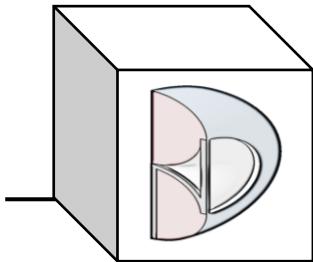


BND TechSource



- Generative Structural Analysis workbench; create Smooth Virtual Part for center restraint.

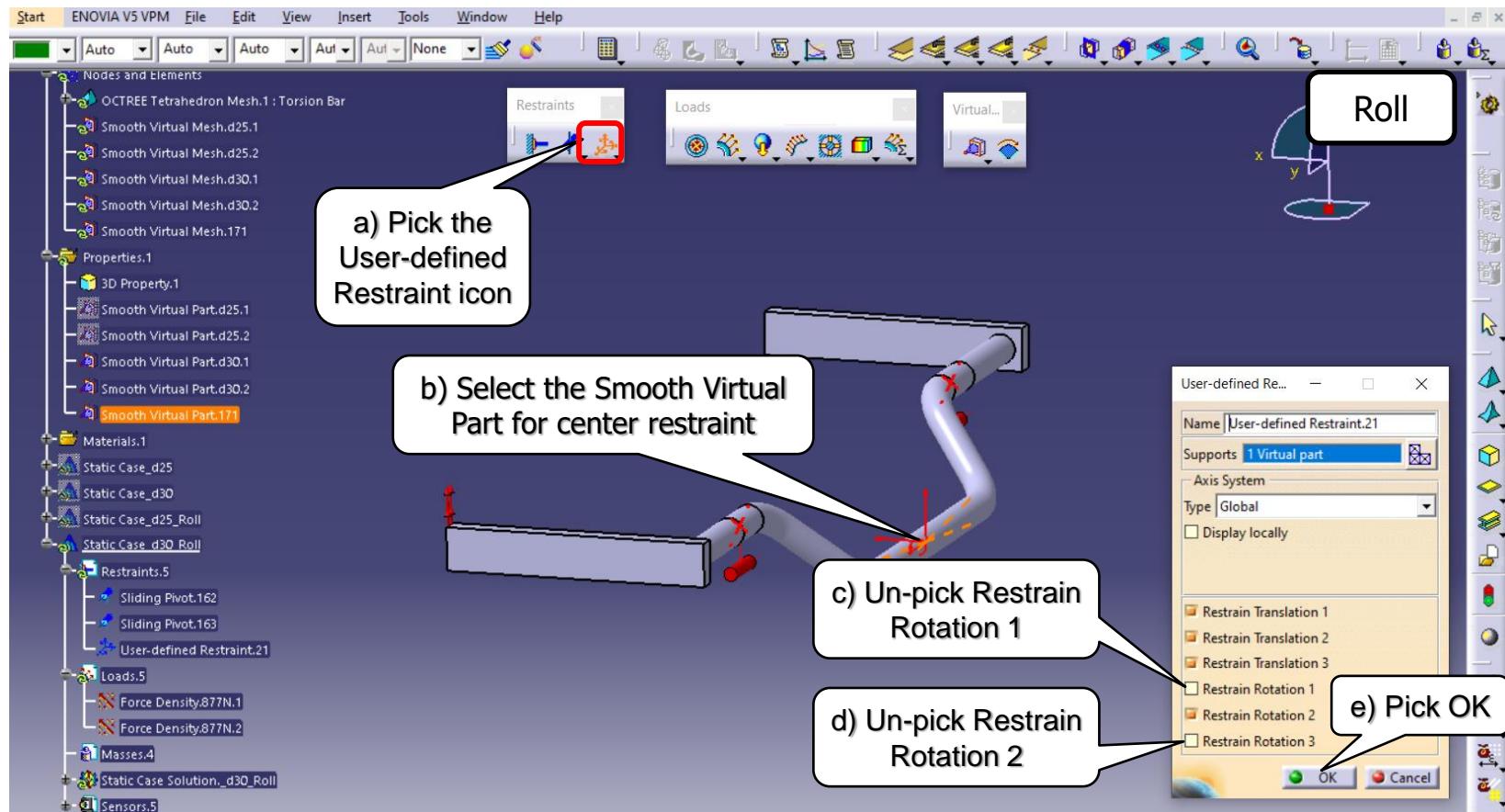


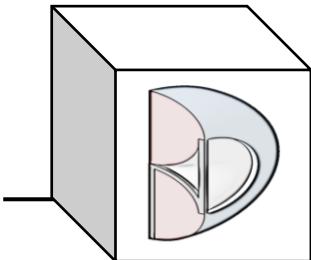


BND TechSource



- Generative Structural Analysis; create the Center restraint.

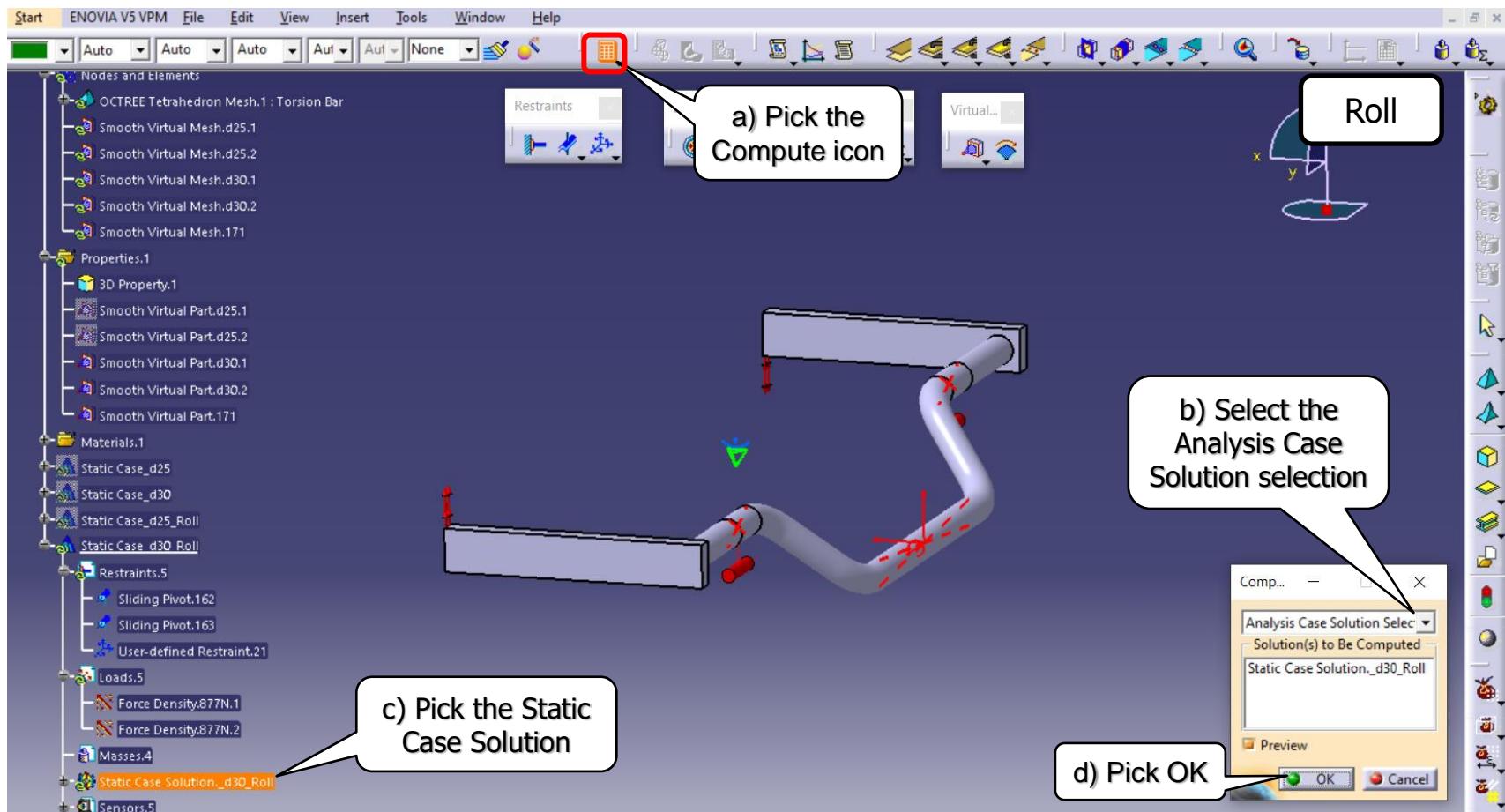


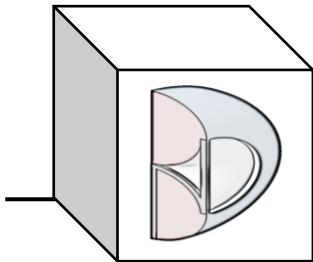


BND TechSource



- Back to Generative Structural Analysis; Compute the analysis.





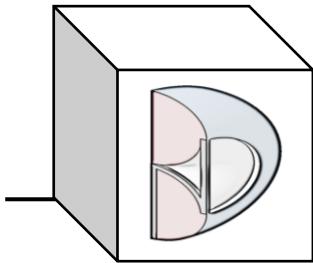
BND TechSource



- Generative Structural Analysis; Compute the analysis.

The screenshot shows the ENOVIA V5 VPM software interface. On the left is the Project Explorer tree view, which includes sections for Nodes and Elements, Properties, Materials, Restraints, Loads, Masses, and Sensors. The main workspace displays a 3D model of a torsion bar with various constraints and loads applied. A callout box contains the text: "e) Pick Yes and wait for the computation to run." A small window titled "Computation Resources Estimation" is visible in the foreground. In the bottom right corner, there is a "Computation Status" window showing the progress of the computation. The status table includes columns for Operation Name and Elapsed Time, with several entries listed.

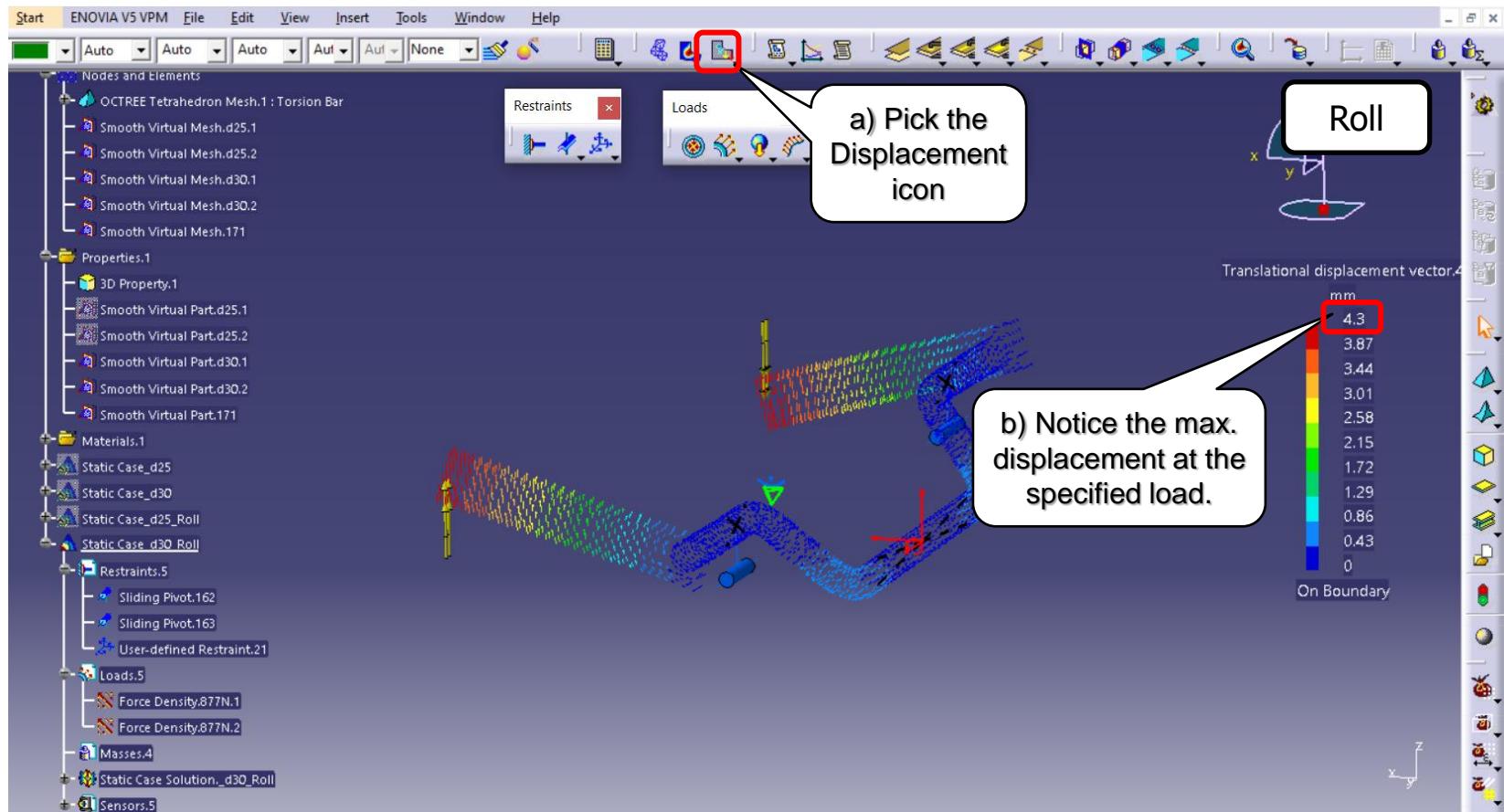
Operation Name	Elapsed Time
Constraint Computation	0:00:00
Stiffness constraint condensati...	0:00:00
Singularity computation	0:00:00
Constraint Computation	0:00:00

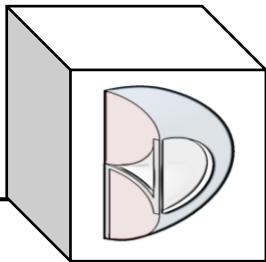


BND TechSource



- Generative Structural Analysis; Show results of the analysis.





BND TechSource



- We have proven through FEA that shape change does indeed affect the spring rate of a torsion bar in both Bump and Roll.

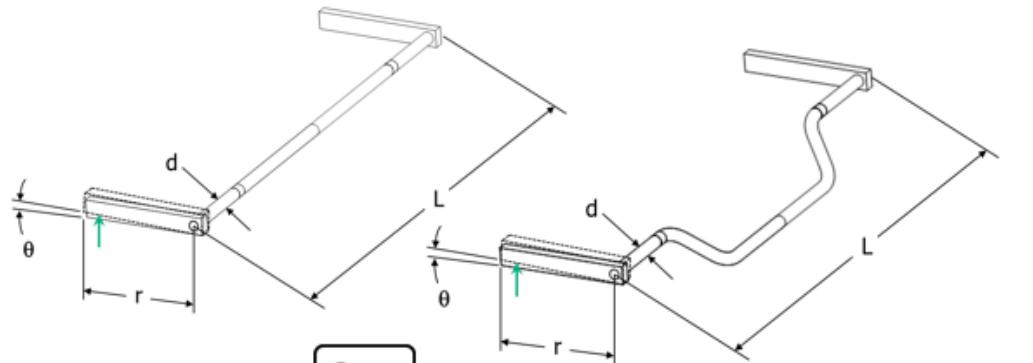
Prove: Shape change affects the spring rate of a torsion bar

$$\delta = \frac{F 32 L r^2}{\pi(d_1^4 - d_2^4)G}$$

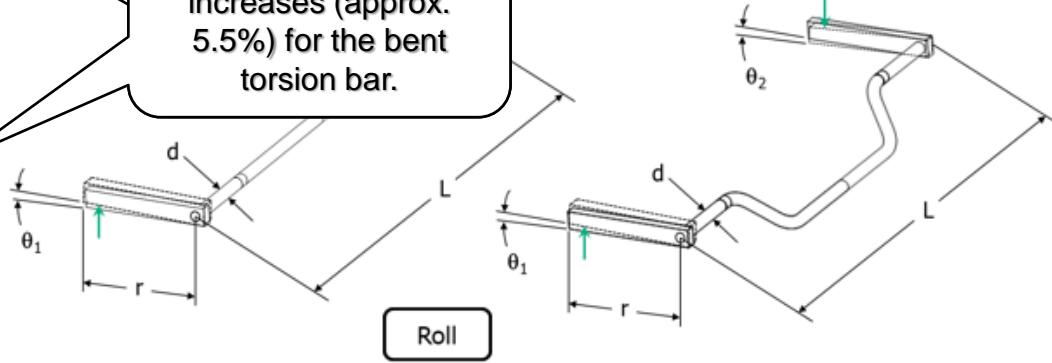
F =	211.5	N
	47.547	lb
inch	m	mm
0.172	0.0044	4.36

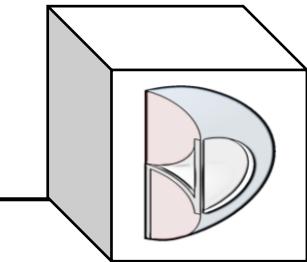
Bump	Dia.	Force	straight		bent	
			δ (mm)	N/mm	δ (mm)	N/mm
	mm	N	211.5	4.36	48.5	51.1
	25	211.5	4.36	48.5	4.14	51.1
	30	438.5	4.36	100.6	4.12	106.4
	in	lb	in	lb/in	in	lb/in
	0.984	47.55	0.980	1.9	0.163	291.7
	1.181	98.58	0.980	4.0	0.162	607.7

Roll	Dia.	Force	straight		bent	
			δ (mm)	N/mm	δ (mm)	N/mm
	mm	N	423	4.53	93.4	4.31
	25	423	4.53	93.4	4.31	98.1
	30	877	4.53	193.6	4.3	204.0
	in	lb	in	lb/in	in	lb/in
	0.984	95.09	1.018	3.7	0.170	560.4
	1.181	197.16	1.018	7.6	0.169	1164.6



Notice the spring rate increases (approx. 5.5%) for the bent torsion bar.





- Conclusion:

This is an example of how to use CATIA Generative Structural Analysis to prove shape change affect the spring rate of a torsion bar.

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!

