

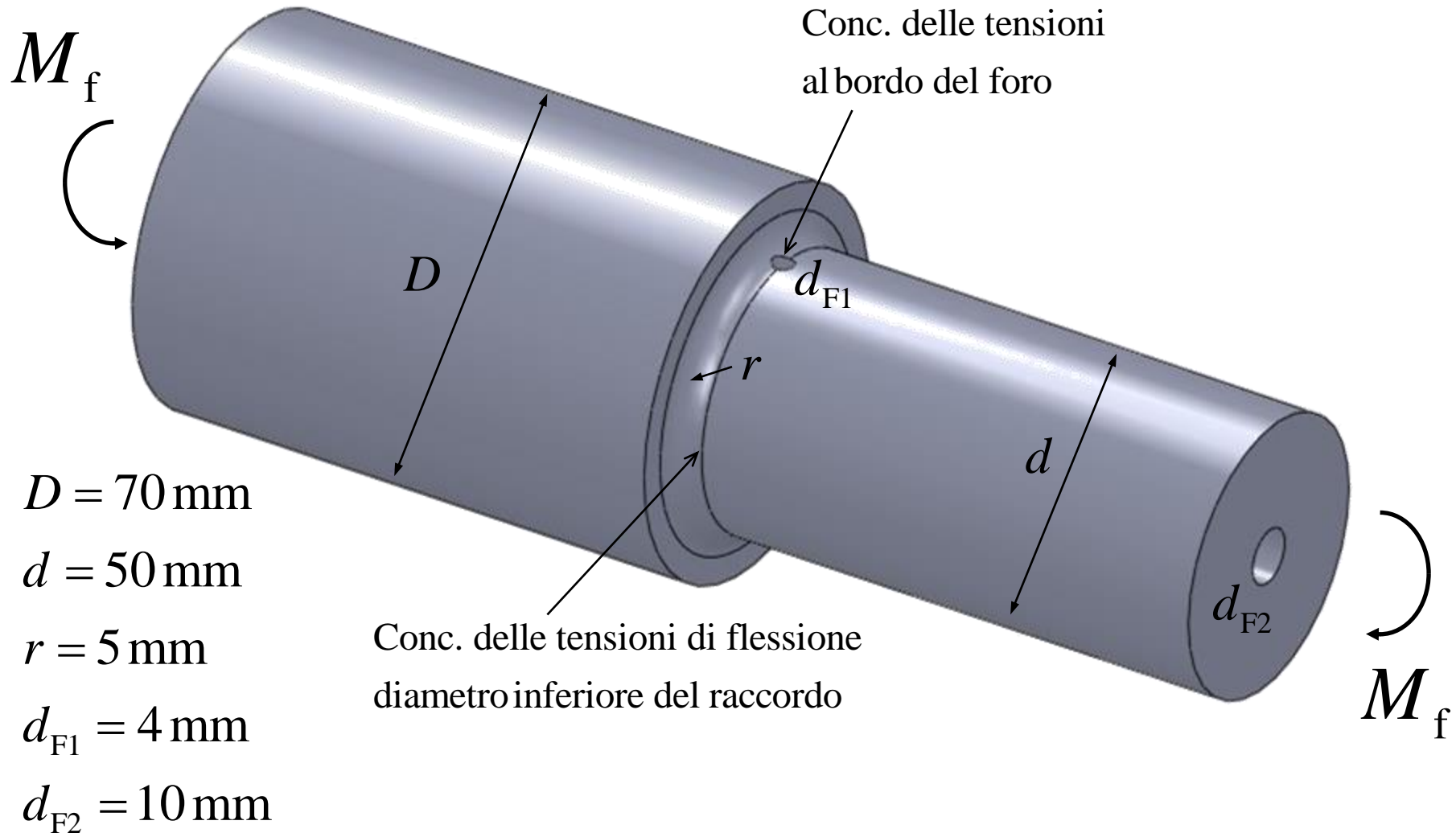
Corso di
Metodi Computazionali per l'Analisi Strutturale (MCAS)
CLM Ing. Veicoli/Meccanica

Esercitazioni guidate di
Ansys Workbench

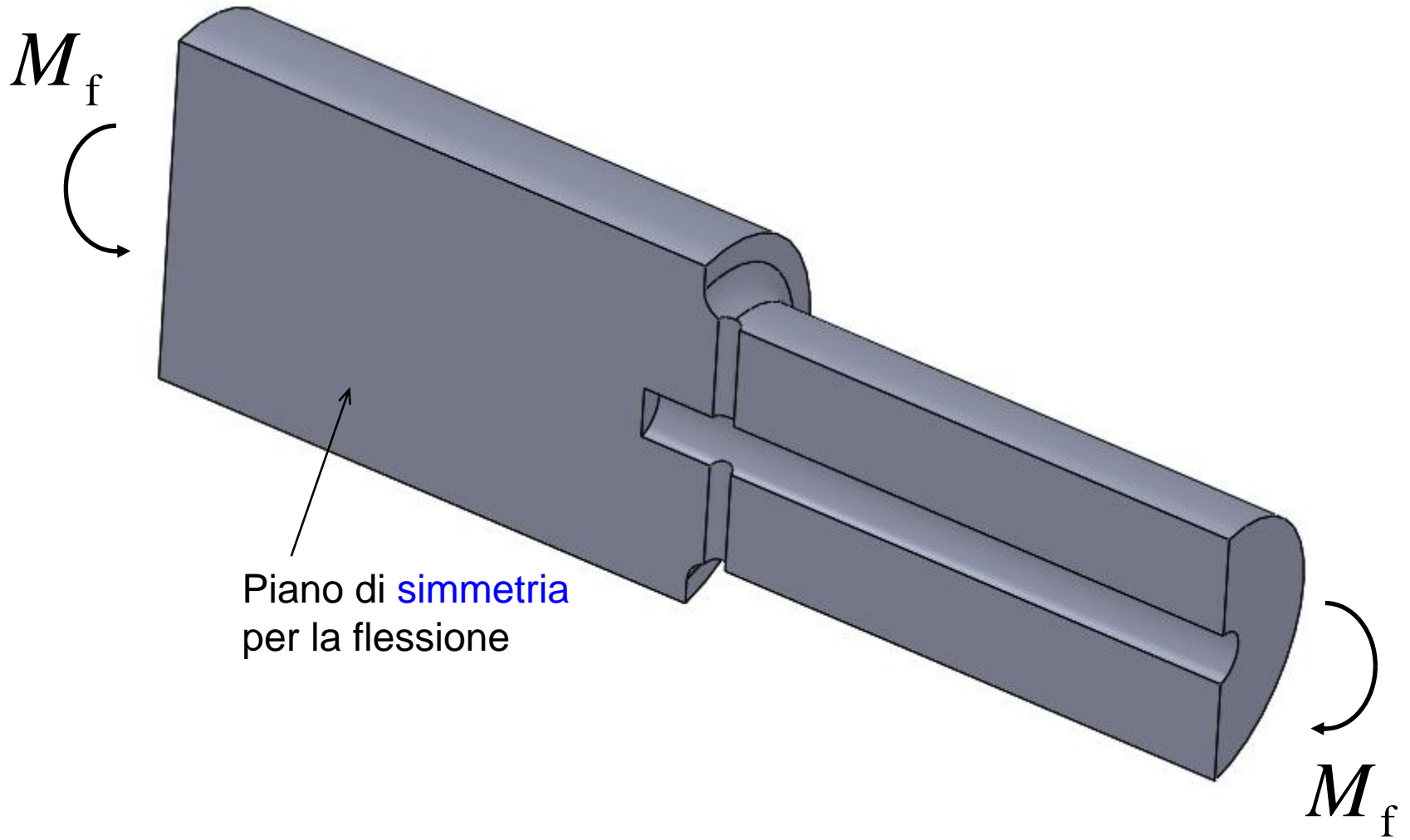
1. Modellazione di parti singole
2. Connessioni fra più parti (Connections, Contact&Target)
3. Semplificazioni dei contatti
4. Riduzione del modello sfruttando le simmetrie
5. Carico di forza remota
6. Vincolo di spostamento remoto
7. Utilizzo del sottomodello

Lez. 4. Utilizzo delle simmetrie

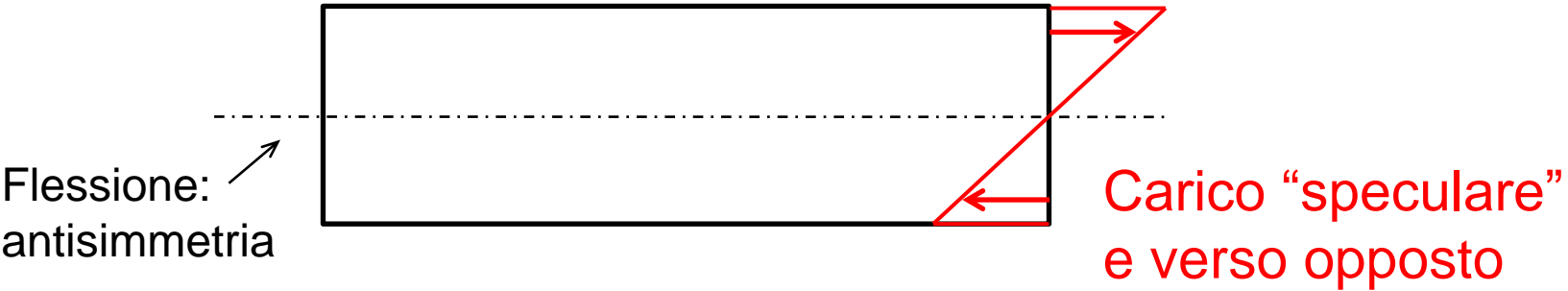
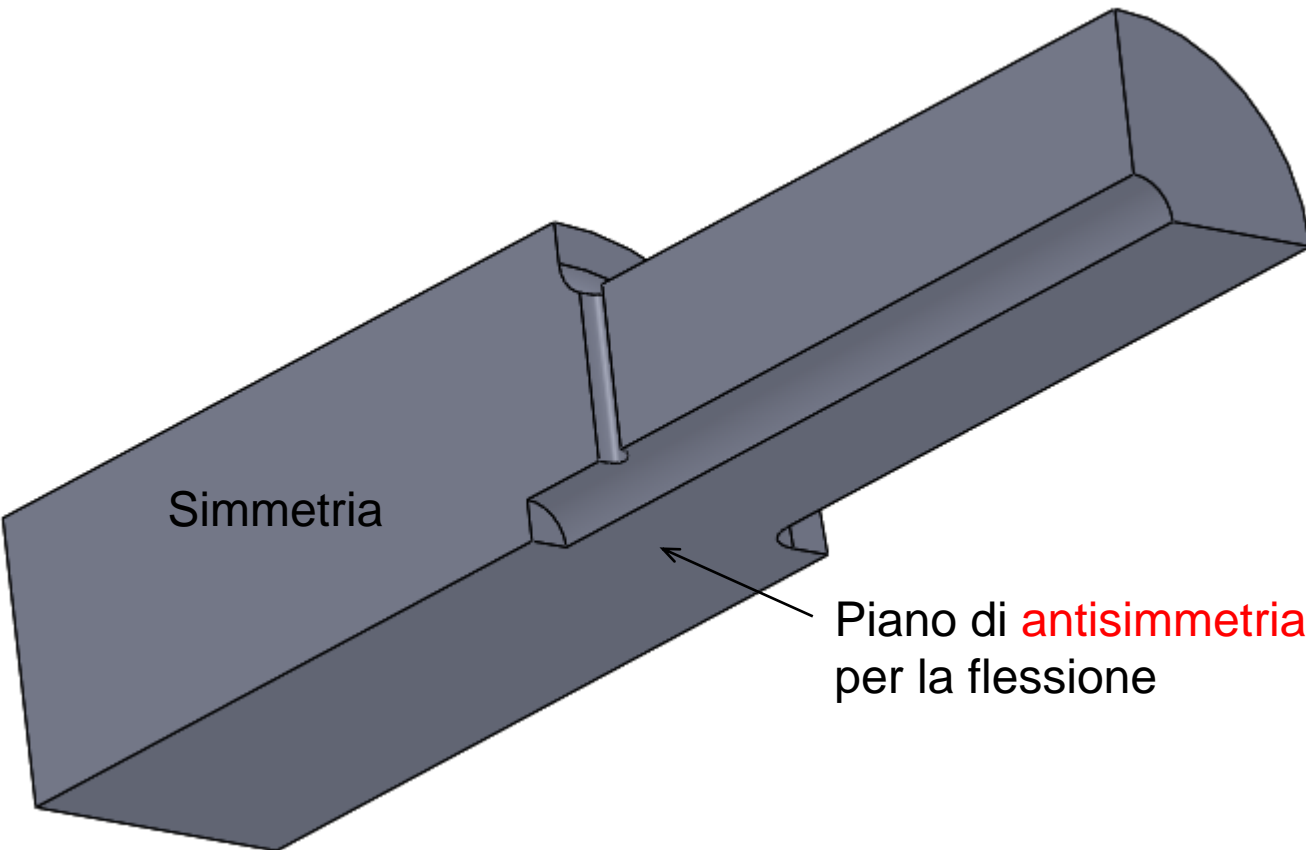
Albero con variazione di diametro e raggio di raccordo, determinazione del K_t



Utilizzo delle simmetrie – Simmetria rispetto ad un piano



Utilizzo delle simmetrie – Antisimmetria rispetto ad un altro piano




Simmetria

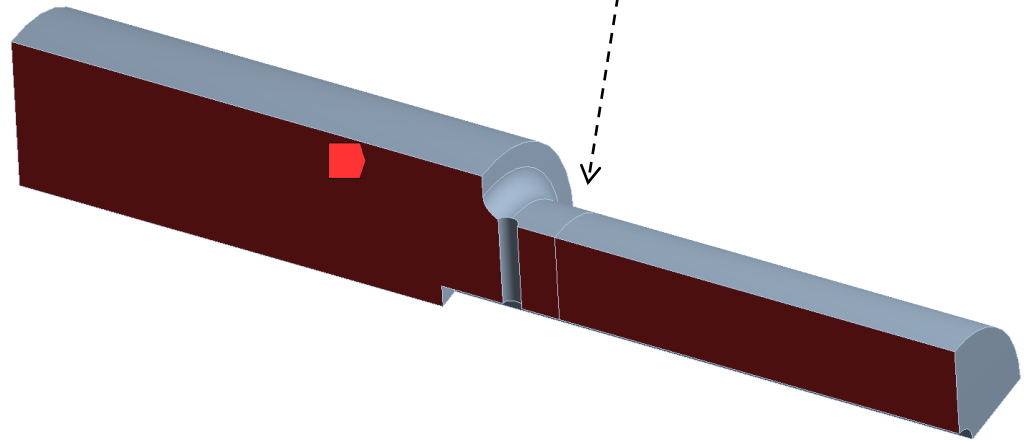
Outline

Name Search Outline

- Project
 - Model (A4)
 - Geometry
 - Materials
 - Construction Geometry
 - Coordinate Systems
 - Symmetry
 - Symmetry Region
 - Symmetry Region 2
 - Mesh
 - Static Structural (A5)
 - Analysis Settings
 - Displacement
 - Moment
 - Solution (A6)
 - Solution Information
 - Normal Stress
 - Normal Stress - Path
 - Total Deformation

Symmetry Region
 Symmetry Region

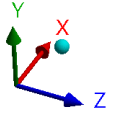
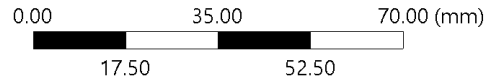
Suddivisione delle superfici per facilitare le impostazioni sulla mesh



Details of "Symmetry Region"

Scope	
Scoping Method	Geometry Selection
Geometry	3 Faces
Definition	
Scope Mode	Manual
Type	Symmetric
Coordinate System	Global Coordinate System
Symmetry Normal	X Axis
Suppressed	No

Simmetria
 ⊥ asse X



Antisimmetria

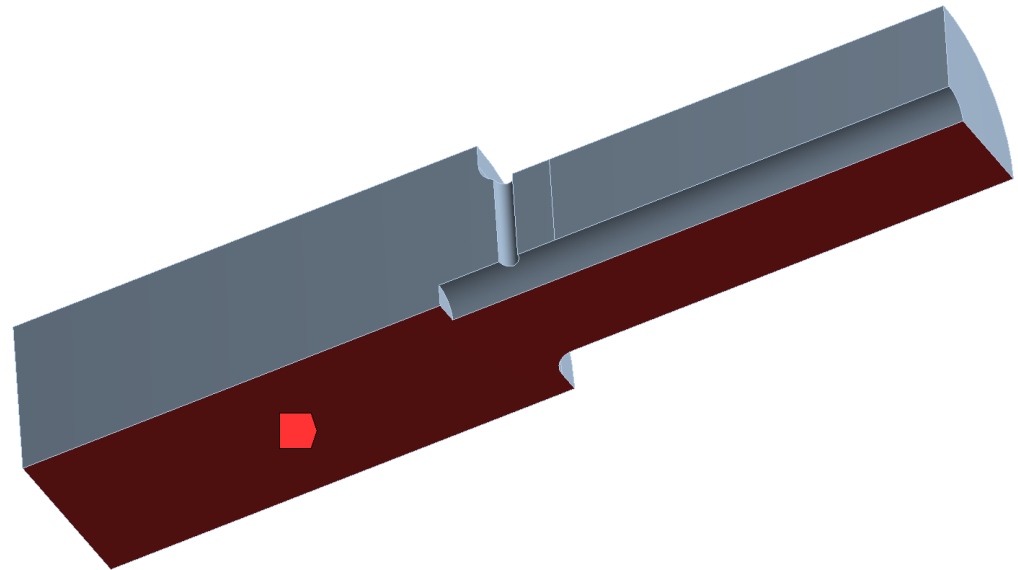
Outline

Name Search Outline

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 - Geometry
 - Materials
 - Construction Geometry
 - Coordinate Systems
 - Symmetry
 - Symmetry Region
 - Symmetry Region 2
 - Mesh
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 - Analysis Settings
 - Displacement
 - Moment
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 - Solution Information
 - Normal Stress
 - Normal Stress - Path
 - Total Deformation

Symmetry Region 2

■ Symmetry Region 2

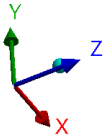
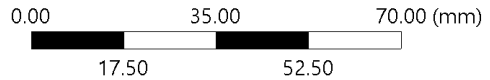


Details of "Symmetry Region 2"

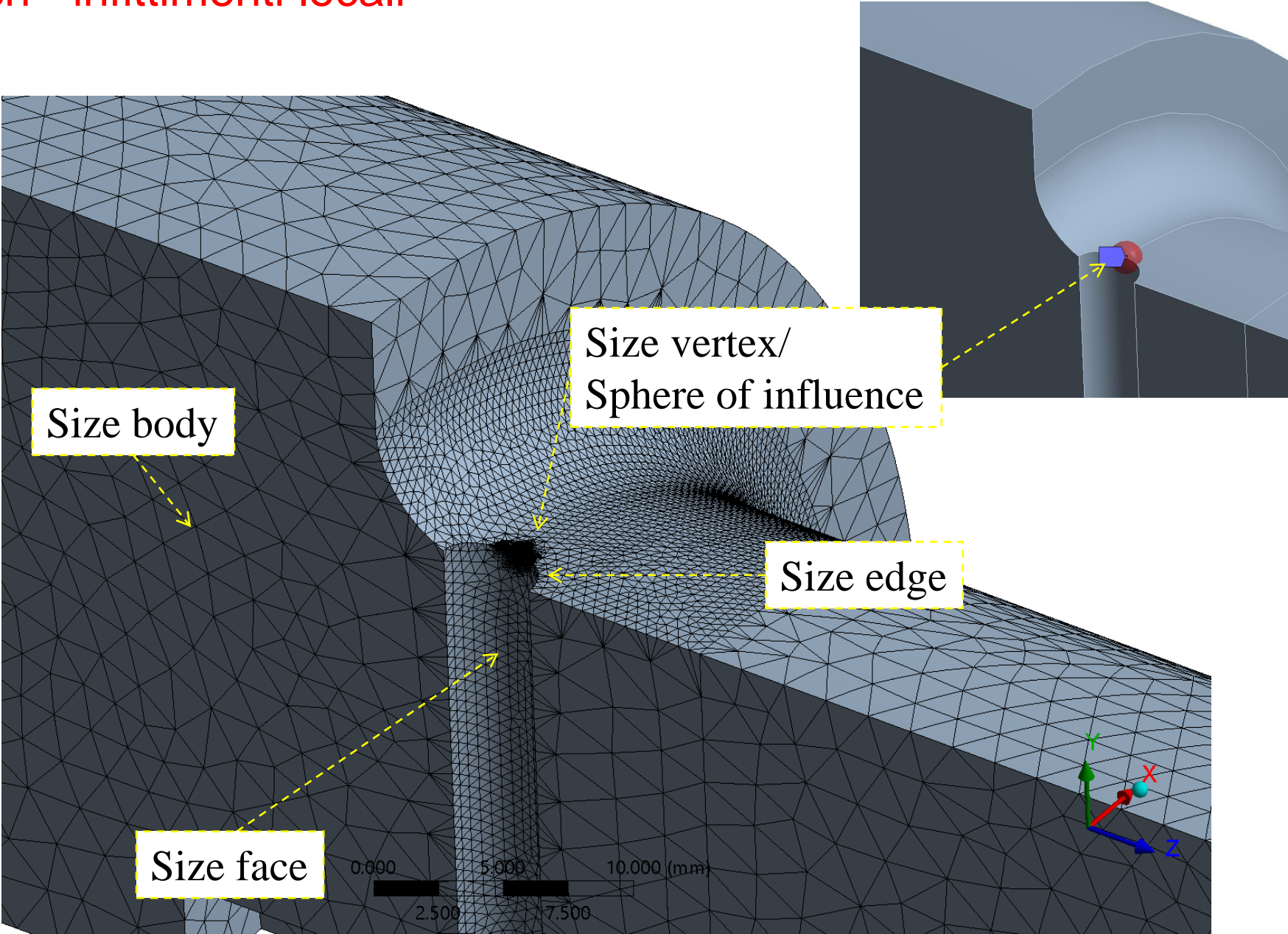
Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
Definition	
Scope Mode	Manual
Type	Anti-Symmetric
Coordinate System	Global Coordinate System
Symmetry Normal	Y Axis
Suppressed	No

Anti-simmetria

⊥ asse Y



Mesh - infittimenti locali




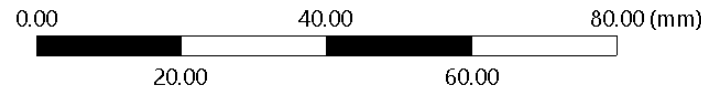
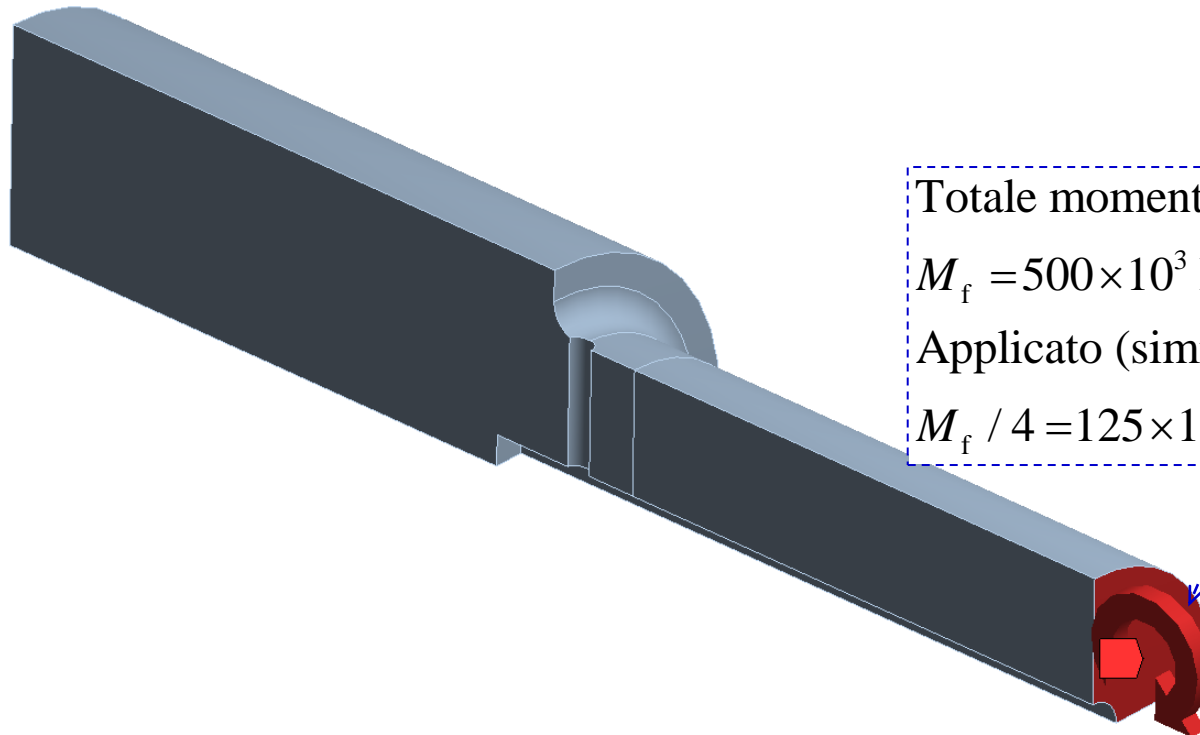
Momento flettente, applicato ad $\frac{1}{4}$ del modello

A: Static Structural

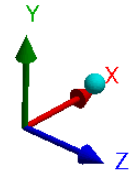
Moment

Time: 1. s

 Moment: 1.25e+005 N·mm
Components: 1.25e+005,0,0. N·mm



Totale momento equivalente:
 $M_f = 500 \times 10^3 \text{ N mm} = 500 \text{ N m}$
Applicato (simmetria - antisimm.):
 $M_f / 4 = 125 \times 10^3 \text{ N mm} = 125 \text{ N m}$

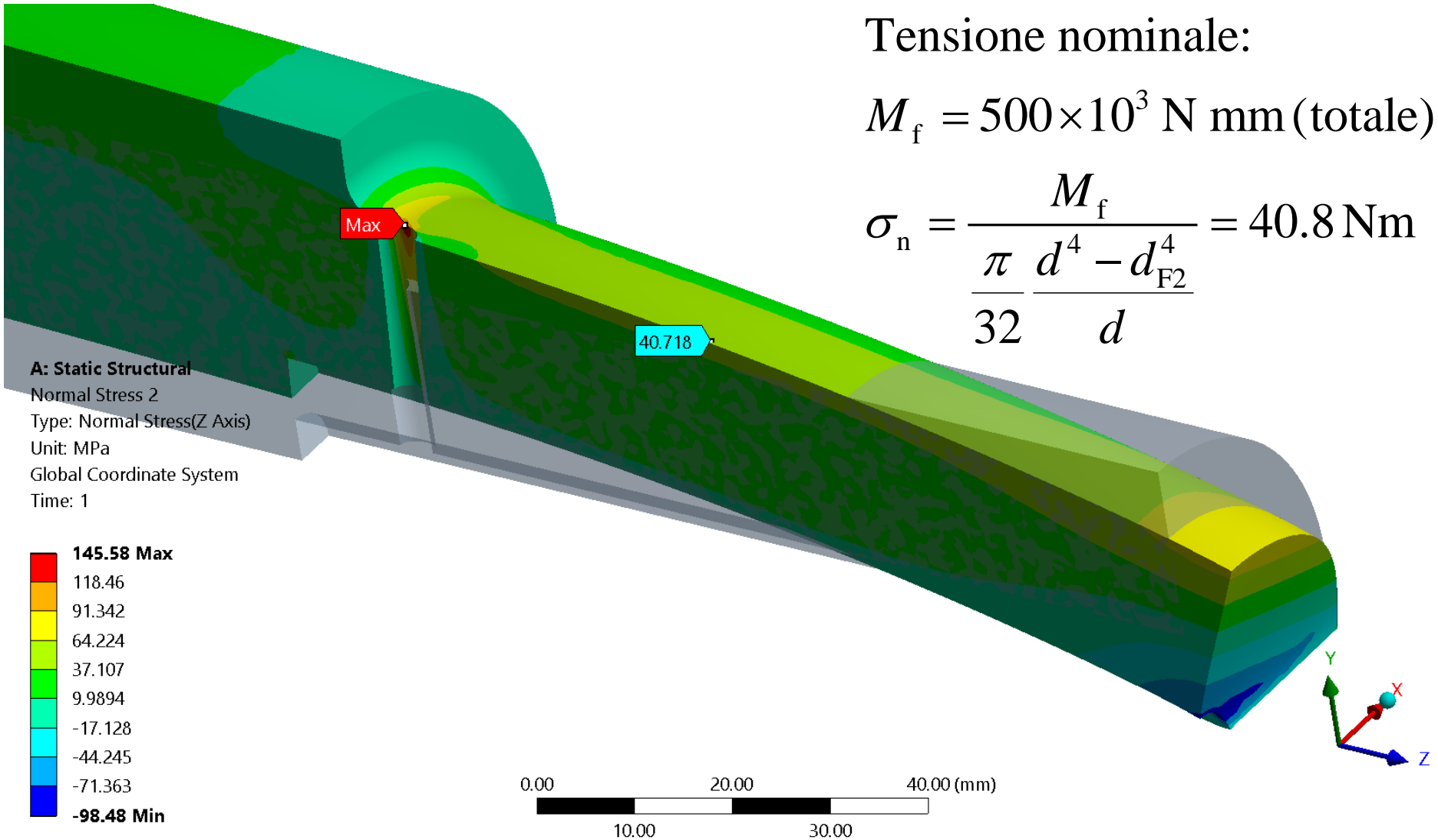


Soluzione – Tensione nominale

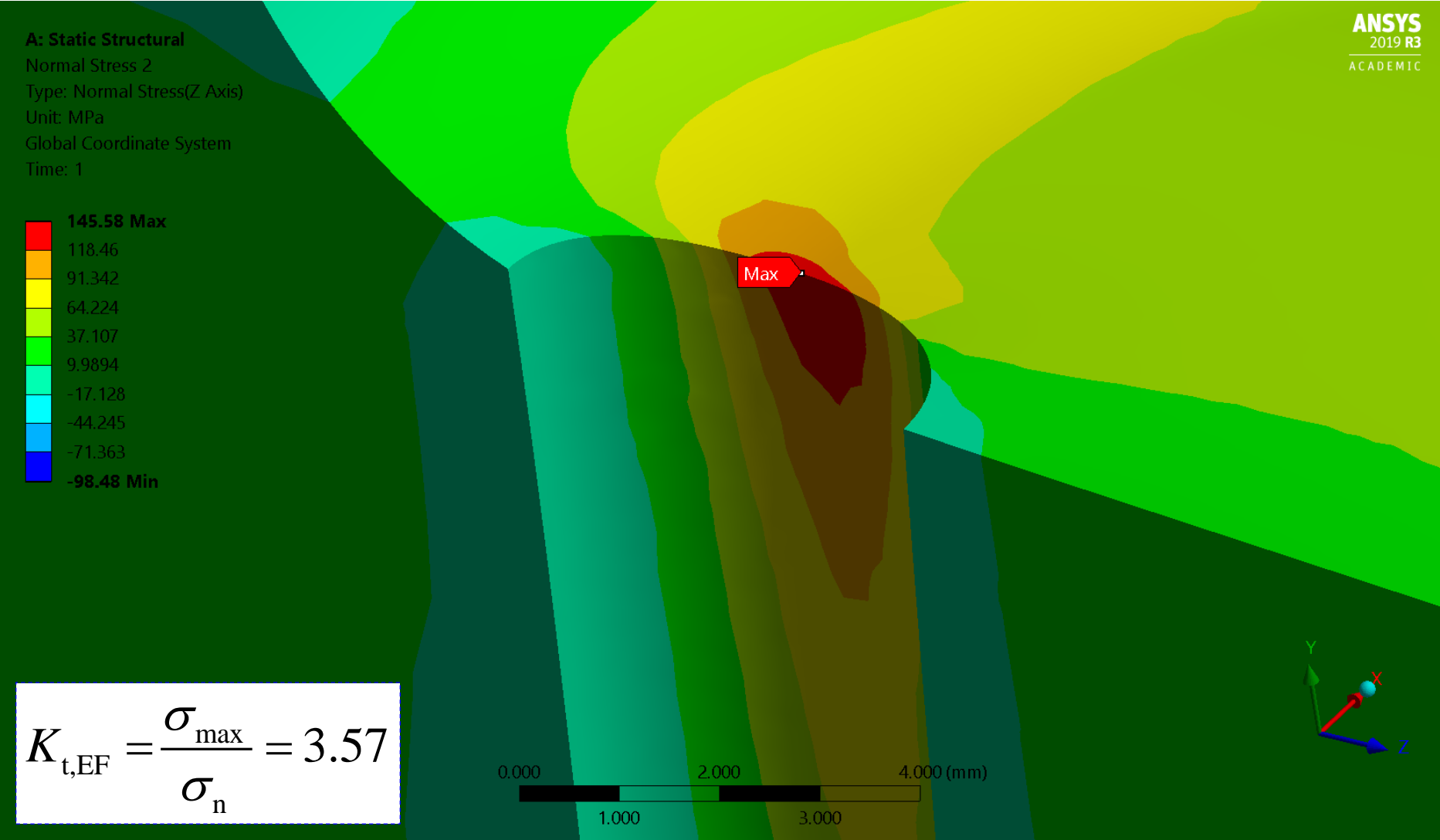
Tensione nominale:

$$M_f = 500 \times 10^3 \text{ N mm (totale)}$$

$$\sigma_n = \frac{M_f}{\frac{\pi}{32} \frac{d^4 - d_{F2}^4}{d}} = 40.8 \text{ Nm}$$

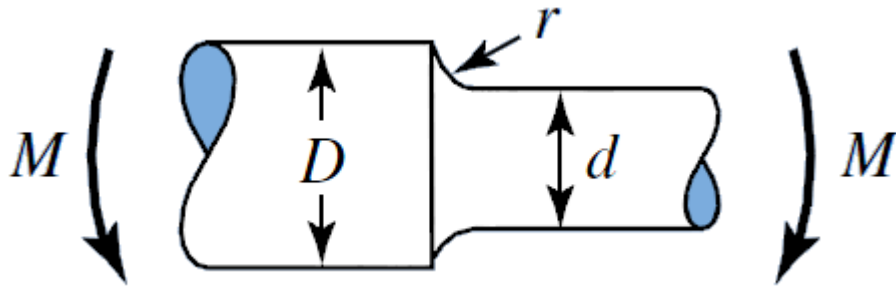


Soluzione – Concentrazione delle tensioni

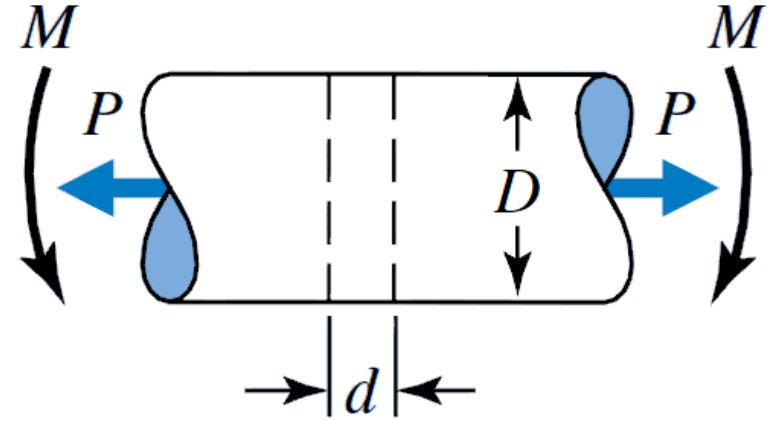


Soluzione di riferimento

Combinazione di concentrazione delle tensioni – prodotto di K_t



$$K_{t,1} = 1.57$$



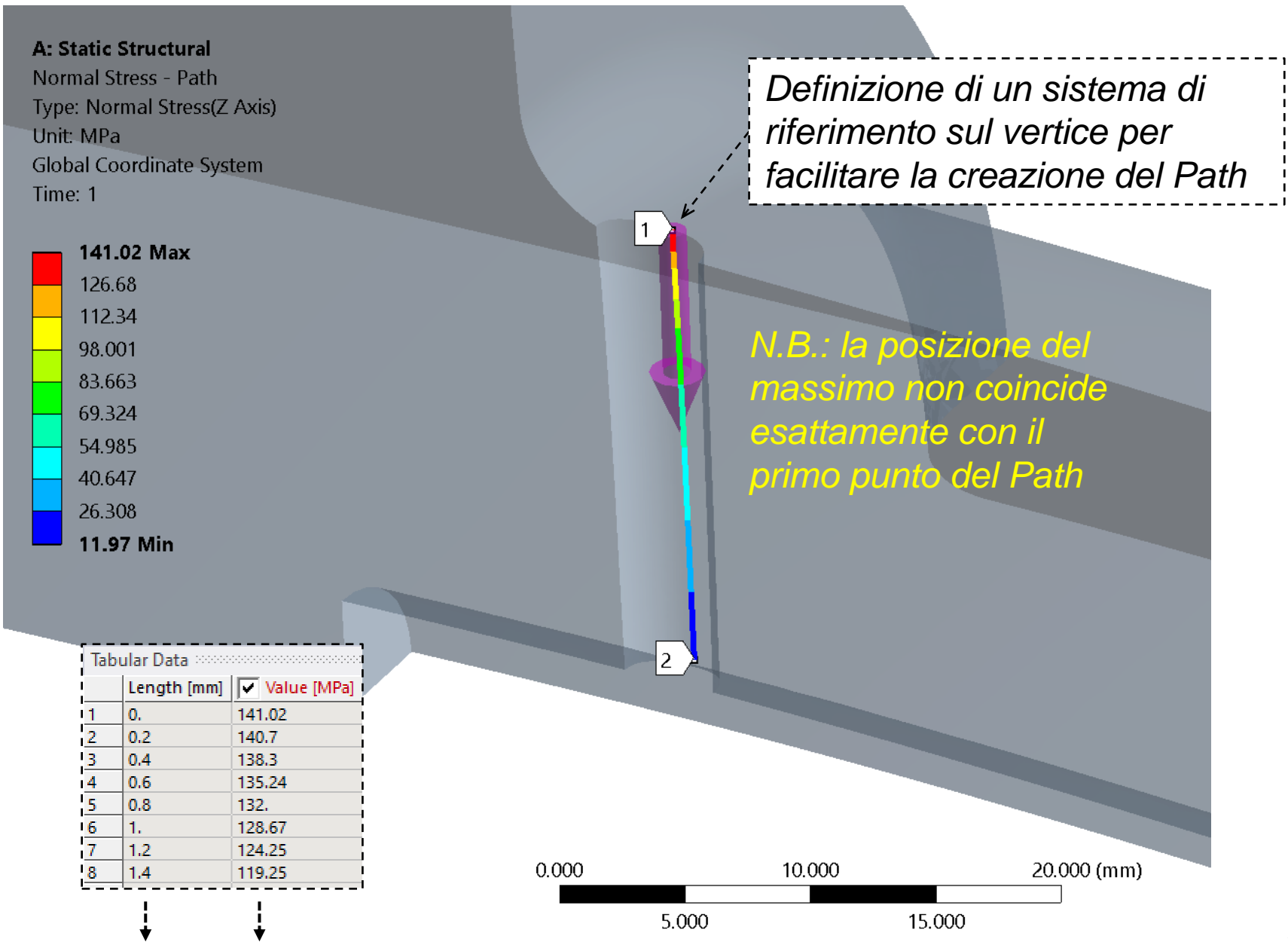
$$K_{t,2} = 2.69$$

$$K_t \approx K_{t,1} \times K_{t,2} = 4.22$$

$$(K_{t,EF} = 3.57)$$

Sviluppo della modellazione

Inserimento di un *Path* in corrispondenza del vertice

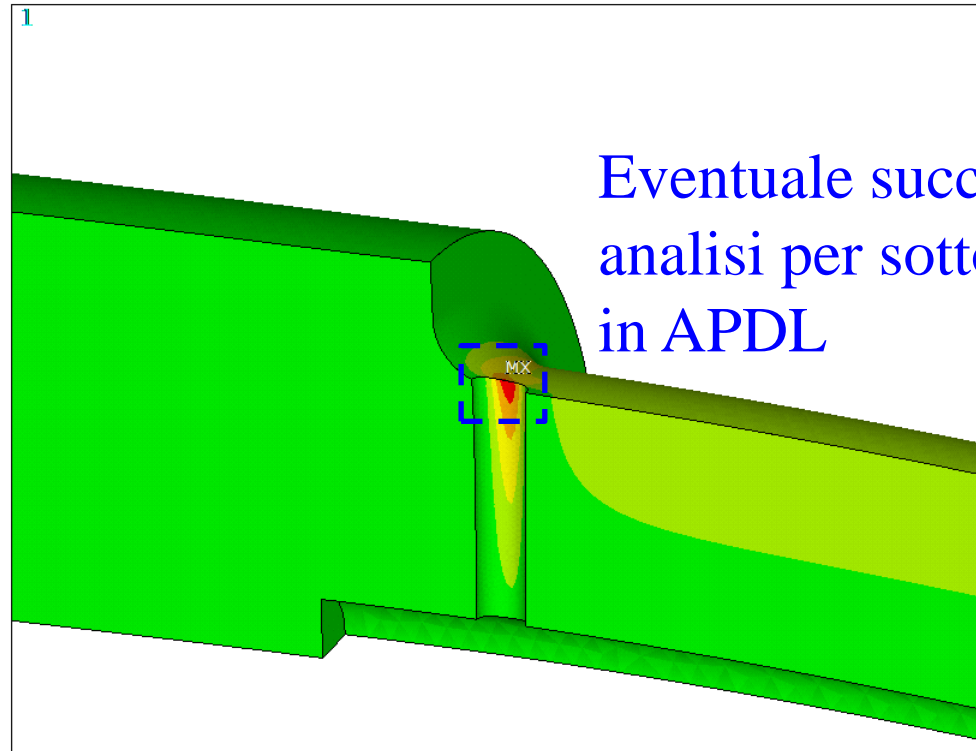


Sviluppo della modellazione

Salvataggio da Workbench ad ambiente APDL ed eventuale analisi per sottomodello

The image shows the ANSYS Workbench interface. The 'Outline' panel on the left lists the model hierarchy: Geometry, Materials, Construction Geometry, Coordinate Systems, Symmetry, Mesh, and Static Structural (A5). Under 'Static Structural (A5)', 'Analysis Settings' is expanded. The 'Details of "Analysis Settings"' panel at the bottom shows various control options. A red dashed arrow points from the 'Analysis Data Management' section to the text box on the right. A red arrow points to the 'Save MAPDL db' option, which is set to 'Yes'.

Details of "Analysis Settings"	
Step Controls	
Solver Controls	
Rotordynamics Controls	
Restart Controls	
Nonlinear Controls	
Advanced	
Output Controls	
Analysis Data Management	
Solver Files Directory	K:_Documenti\Didattica\ANSYS_...
Future Analysis	None
Scratch Solver Files ...	
Save MAPDL db	Yes
Contact Summary	Program Controlled
Delete Unneeded Fil...	Yes
Nonlinear Solution	No
Solver Units	Active System



Eventuale successiva
analisi per sottomodello
in APDL

Albero_F

- Eventuale creazione del sottomodello in ambiente CAD ed importazione in APDL (parasolid) con riconoscimento di Keypoints, Linee, Aree e Volume
- Successiva applicazione di vincoli e carichi, e gestione della mesh in ambiente APDL

Simmetria / Antisimmetria ottenute come condizioni di vincolo

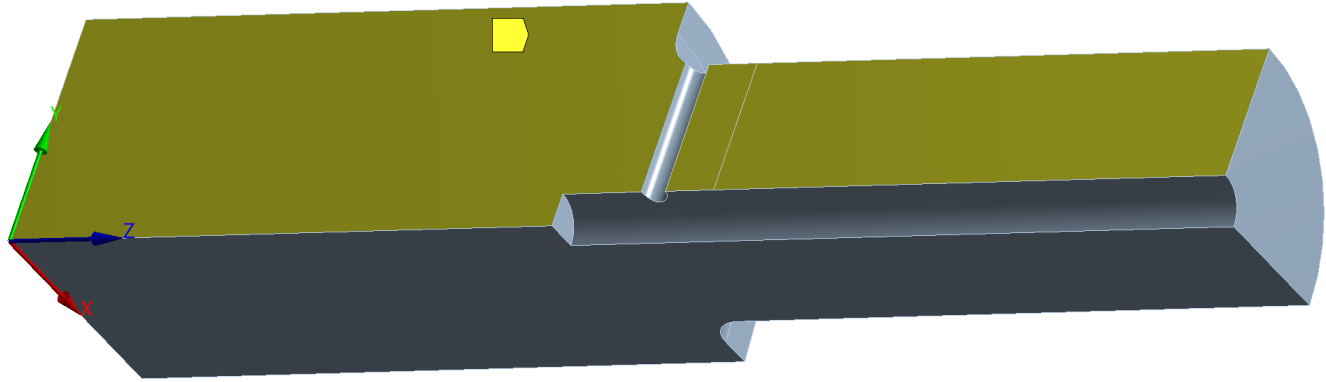
A: Static Structural

Displacement - Simm

Time: 1. s

Displacement - Simm
Components: 0.,Free,Free mm

Simmetria:
Spost. nullo in direzione X



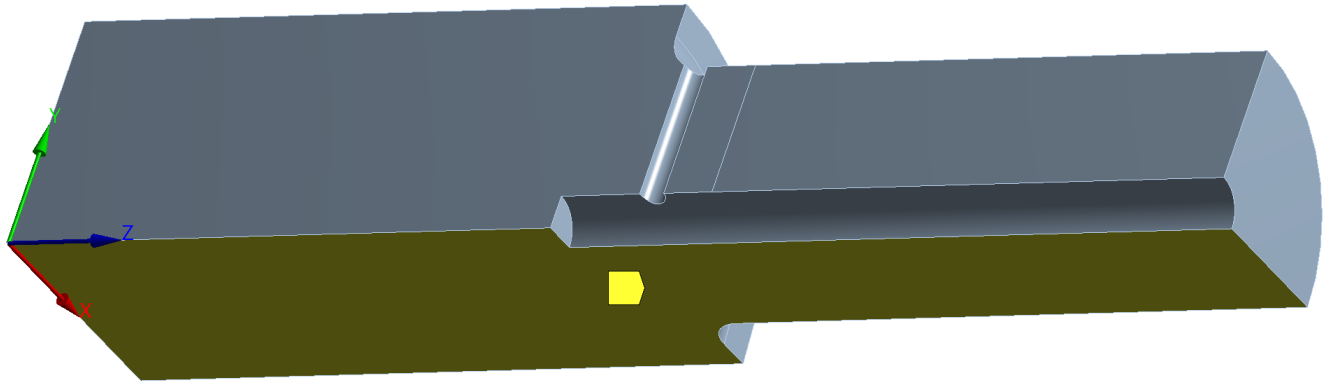
A: Static Structural

Displacement - Antisimm

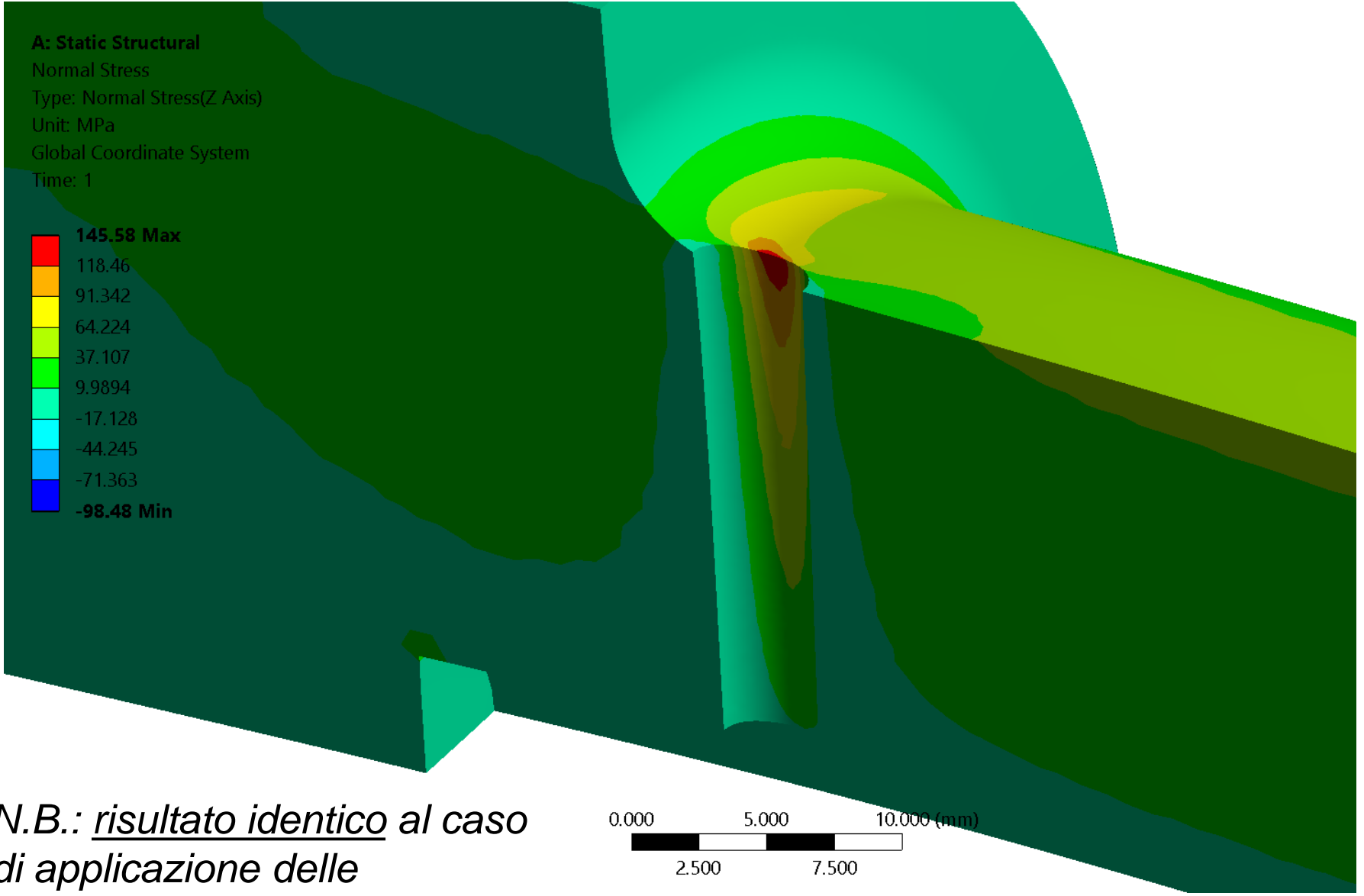
Time: 1. s

Displacement - Antisimm
Components: 0.,Free,0. mm

Antisimmetria:
Spost. nullo in direzione X, Z



Simmetria / Antisimmetria ottenute come condizioni di vincolo



N.B.: risultato identico al caso di applicazione delle simm./antisimm. al modello

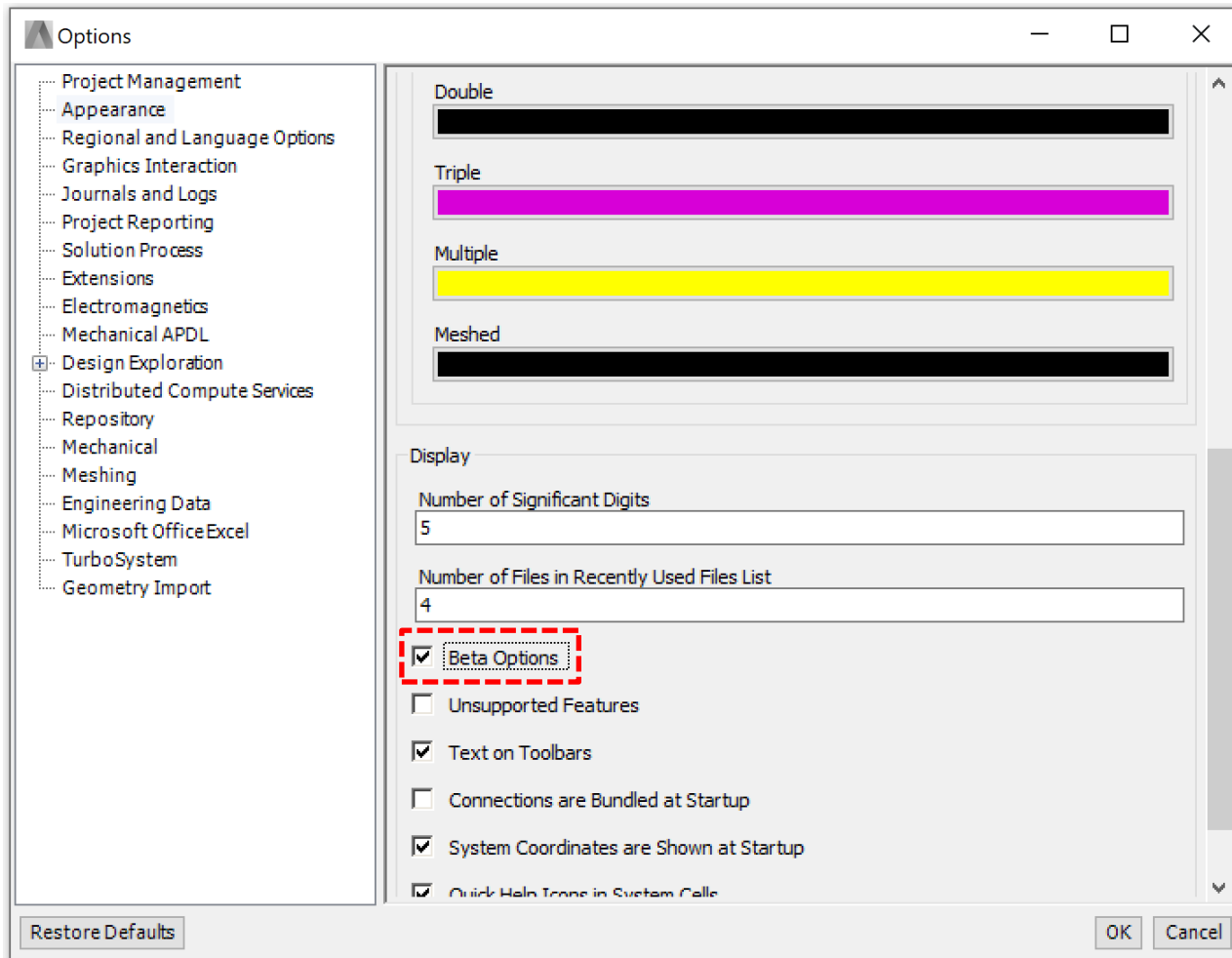
Espansione grafica di simmetria

Visualizzazione del modello completo duplicando (graficamente) il risultato ottenuto

Impostazione grafica:

Ansys Workbench → Tools → Options → Appearance → Beta Options

... varie altre impostazioni



Espansione grafica di simmetria

Visualizzazione del modello completo duplicando (graficamente) il risultato ottenuto

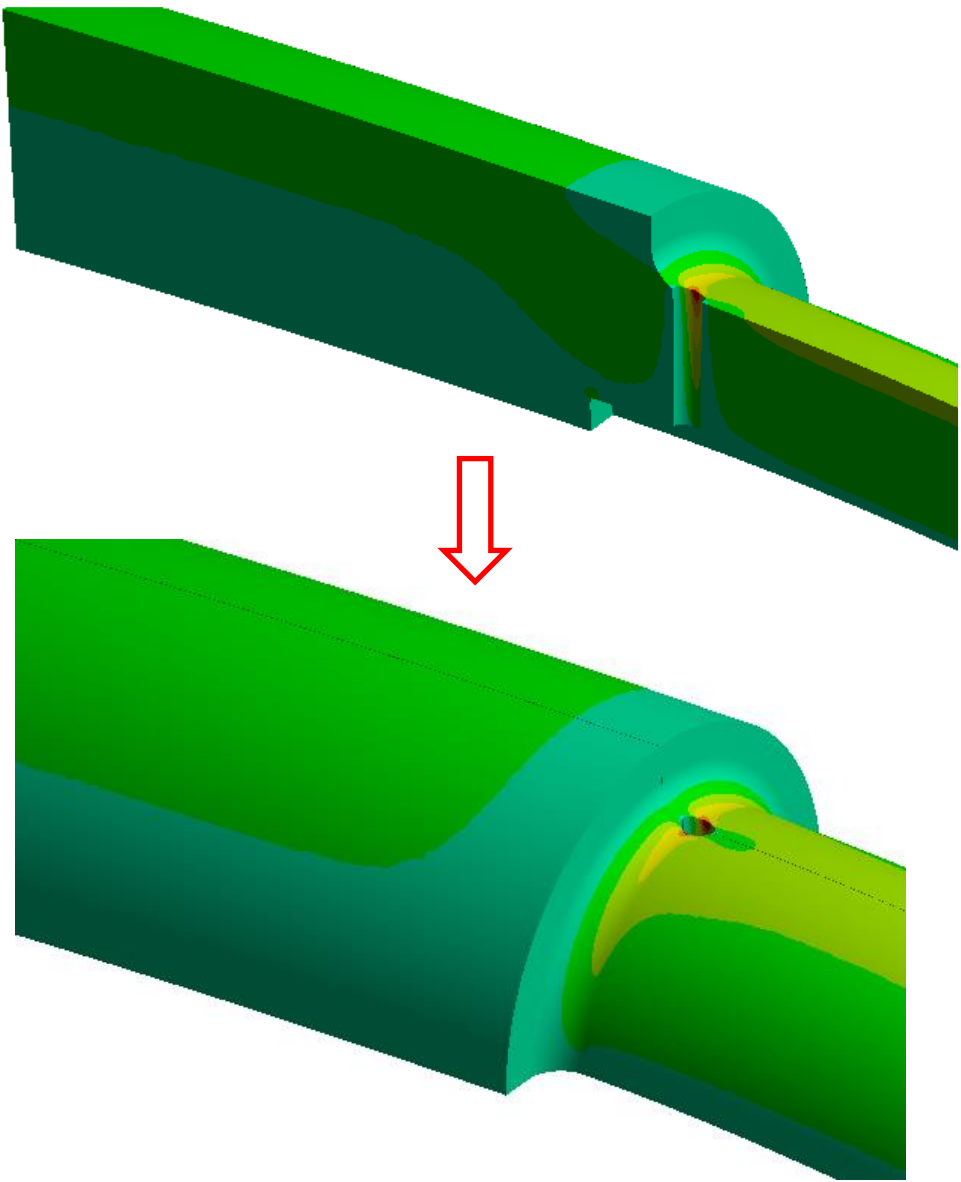
Mechanical → Symmetry

Outline

- Project*
- Model (A4)
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 - Materials
 - Construction Geometry
 - Coordinate Systems
 - Symmetry
 - Mesh
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 - Analysis Settings
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 - Solution Information
 - Normal Stress
 - Normal Stress - Path
 - Total Deformation

Details of "Symmetry"

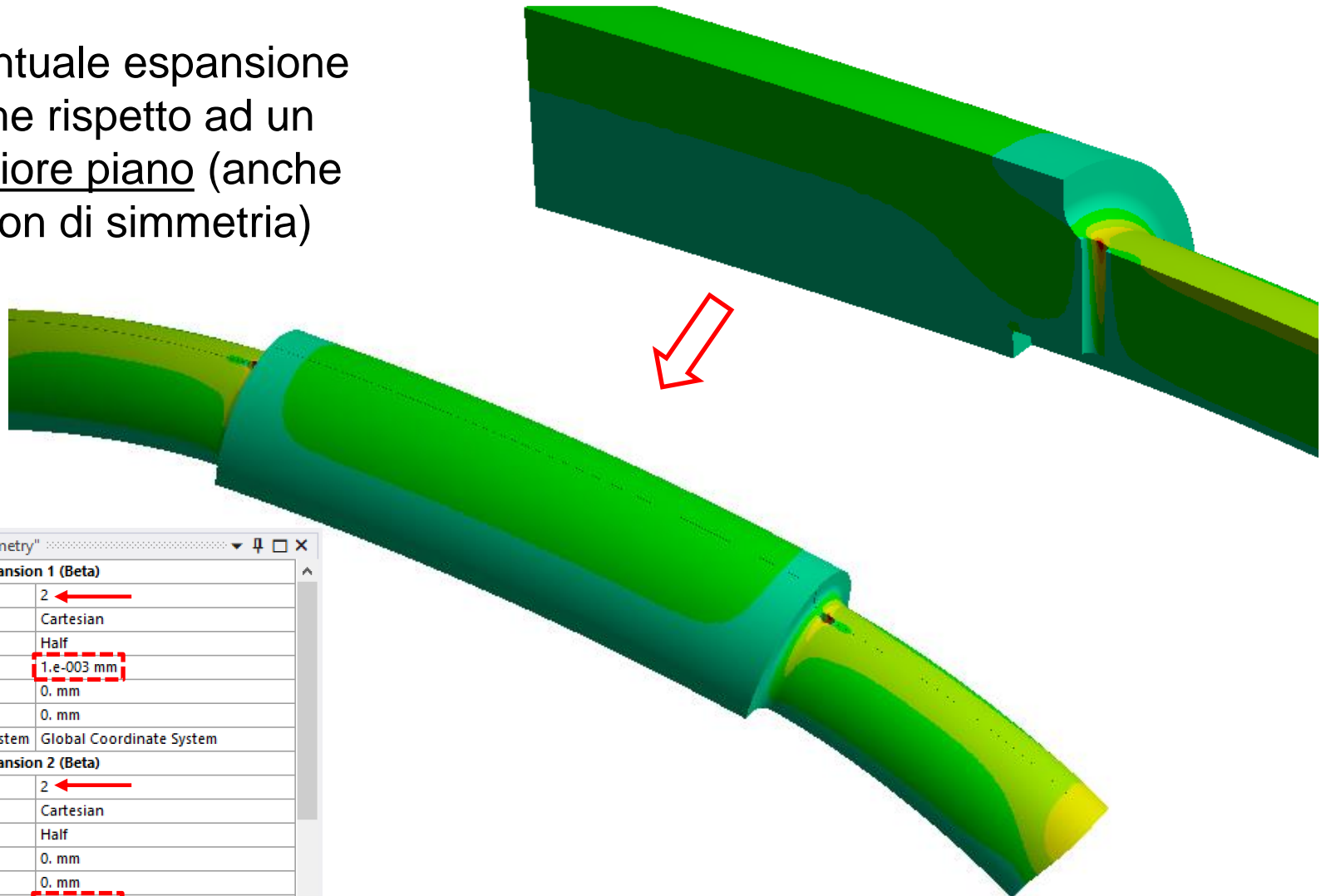
Graphical Expansion 1 (Beta)	
Num Repeat	2
Type	Cartesian
Method	Half
ΔX	1.e-003 mm
ΔY	0. mm
ΔZ	0. mm
Coordinate System	Global Coordinate System
Graphical Expansion 2 (Beta)	
Num Repeat	0
Type	Cartesian
Method	Full
ΔX	0. mm
ΔY	0. mm
ΔZ	0. mm
Coordinate System	Global Coordinate System



Espansione grafica di simmetria

Visualizzazione del modello completo duplicando (graficamente) il risultato ottenuto

Eventuale espansione anche rispetto ad un ulteriore piano (anche se non di simmetria)



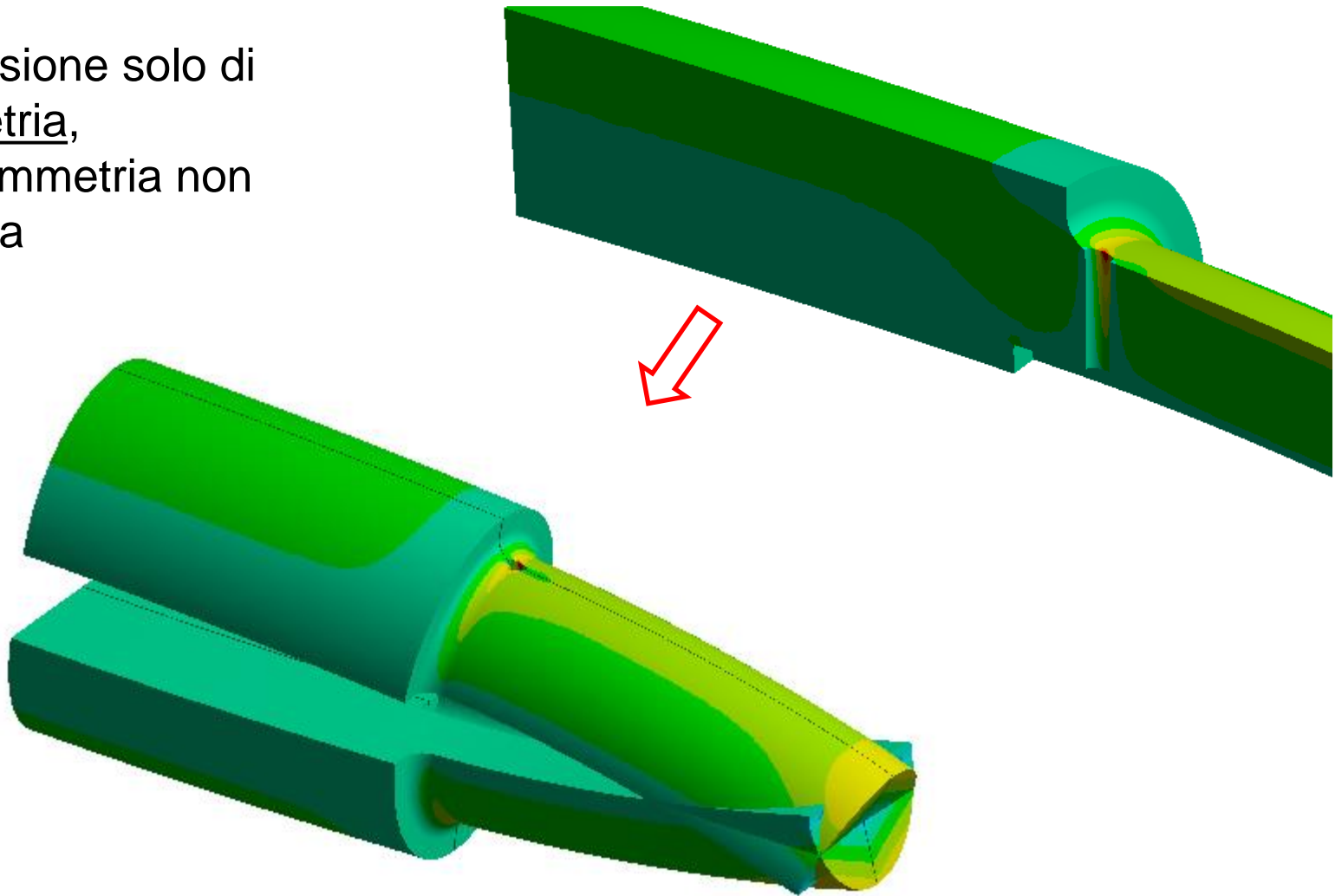
Details of "Symmetry"

Graphical Expansion 1 (Beta)	
Num Repeat	2
Type	Cartesian
Method	Half
ΔX	1.e-003 mm
ΔY	0. mm
ΔZ	0. mm
Coordinate System	Global Coordinate System
Graphical Expansion 2 (Beta)	
Num Repeat	2
Type	Cartesian
Method	Half
ΔX	0. mm
ΔY	0. mm
ΔZ	1.e-003 mm
Coordinate System	Global Coordinate System

Espansione grafica di simmetria

Visualizzazione del modello completo duplicando (graficamente) il risultato ottenuto

Espansione solo di
simmetria,
Anti-simmetria non
corretta

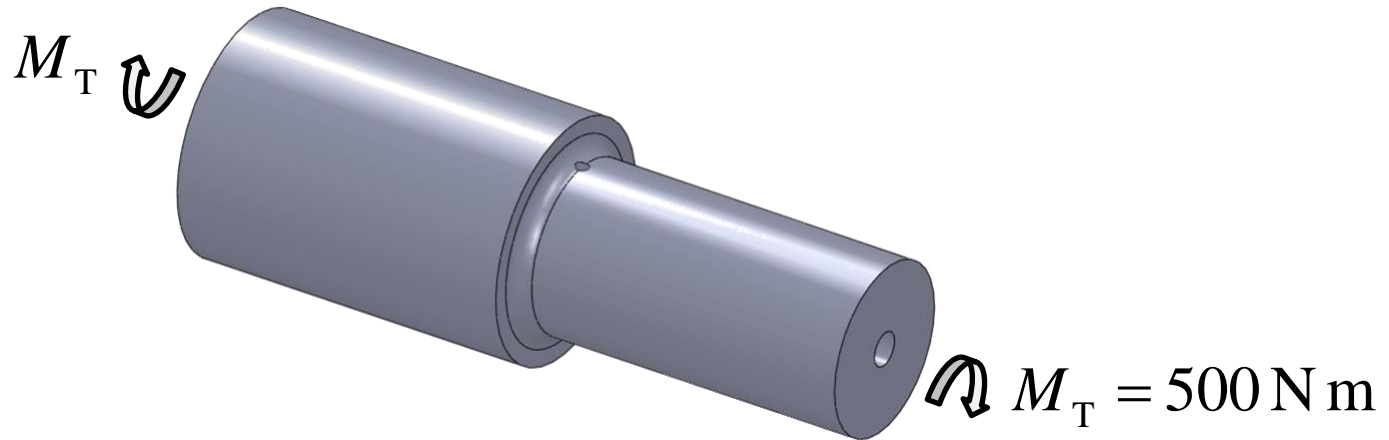


Sommario Lez. 4

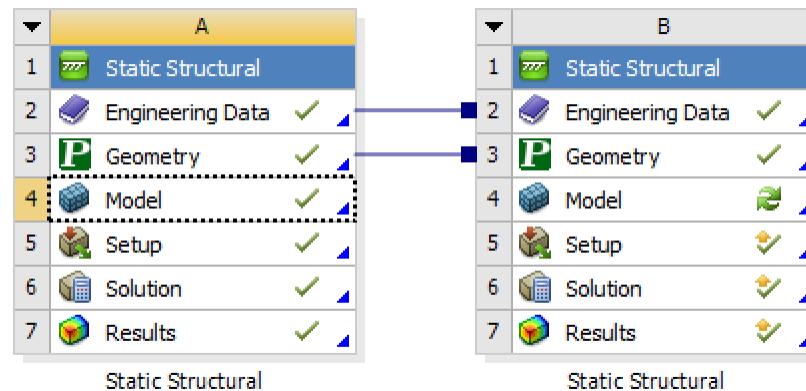
1. Possibilità di ridurre il volume modellato sfruttando le simmetrie del problema
2. **Simmetria** e **Antisimmetria** rispetto ad un piano
3. Simmetria: condizione di spostamento nullo *perpendicolarmente* al piano
4. Antisimmetria: condizione di spostamento nullo *nel piano*
5. Applicazione a casi di flessione e torsione
6. Combinazione di concentrazione di tensione

Esercitazione da svolgere:

Determinare il coeff. di conc. delle tensioni a *Torsione*, utilizzando il modello a 1/4 e le simmetrie



N.B.: È possibile riutilizzare la stessa geometria trasferendola da un progetto all'altro, oppure semplicemente importandolo di nuovo



Lez. 5. Utilizzo del carico di Forza remota

Tubolare flangiato caricato all'estremità ad elevata distanza

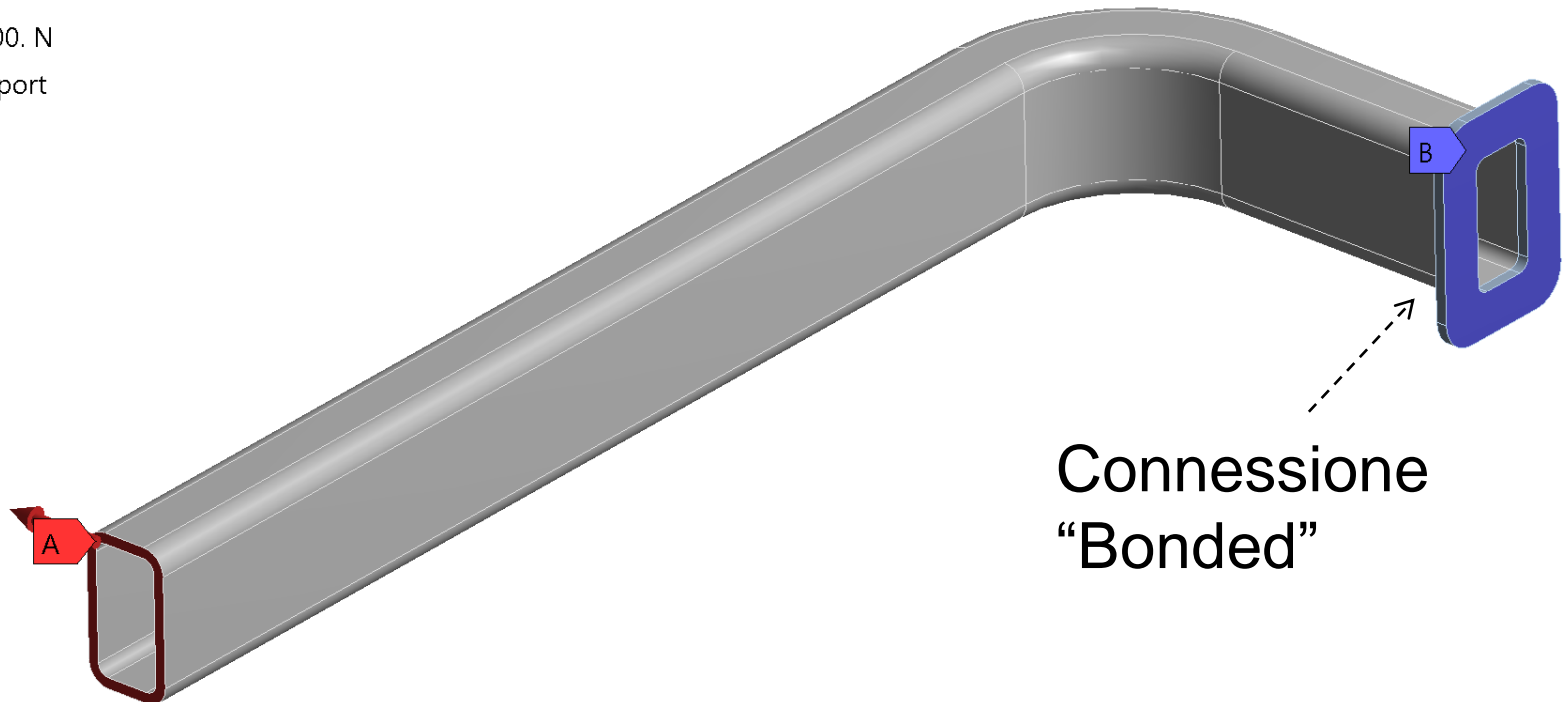
A: Static Structural

Static Structural

Time: 1. s

A Force: 2500. N

B Fixed Support



Connessione
"Bonded"

Soluzione – Modello completo

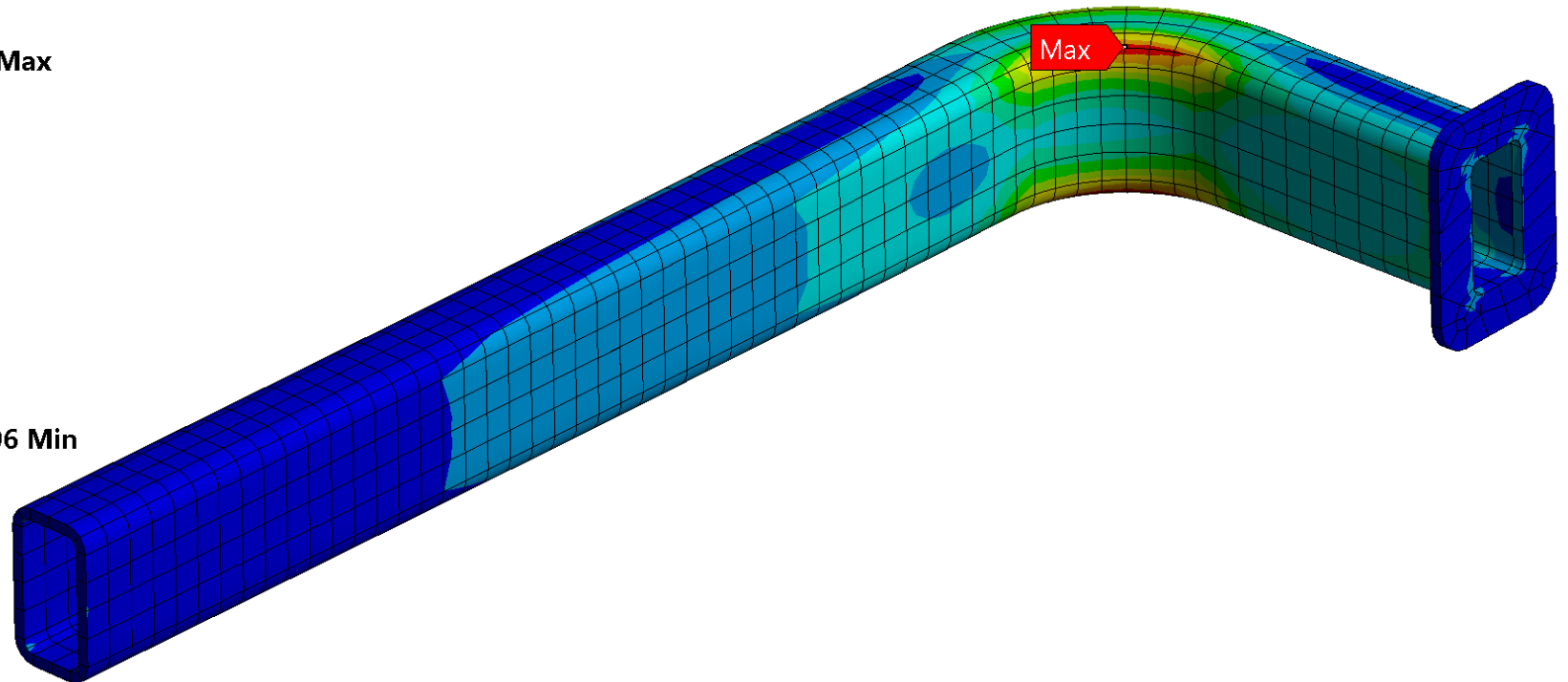
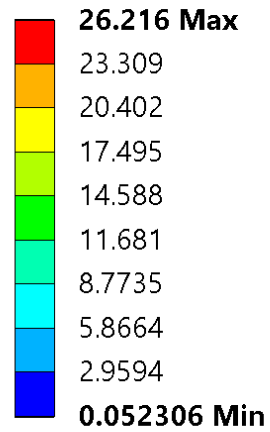
A: Static Structural

Equivalent Stress

Type: Equivalent (von-Mises) Stress

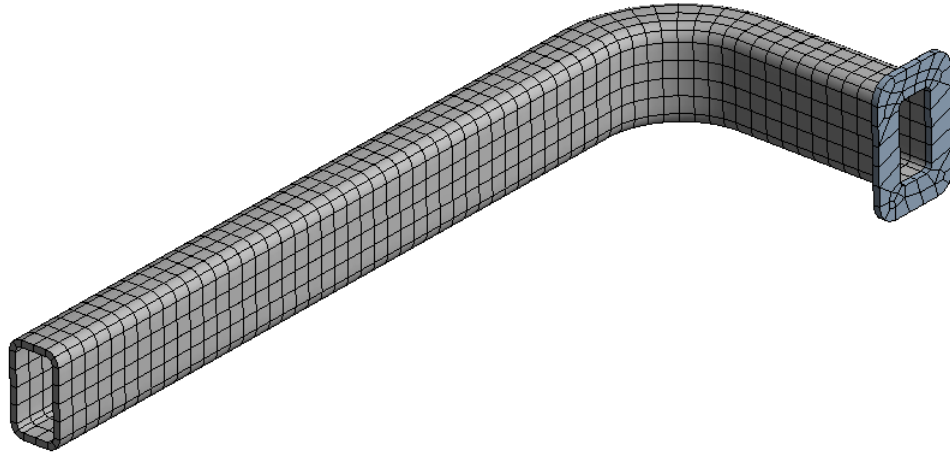
Unit: MPa

Time: 1

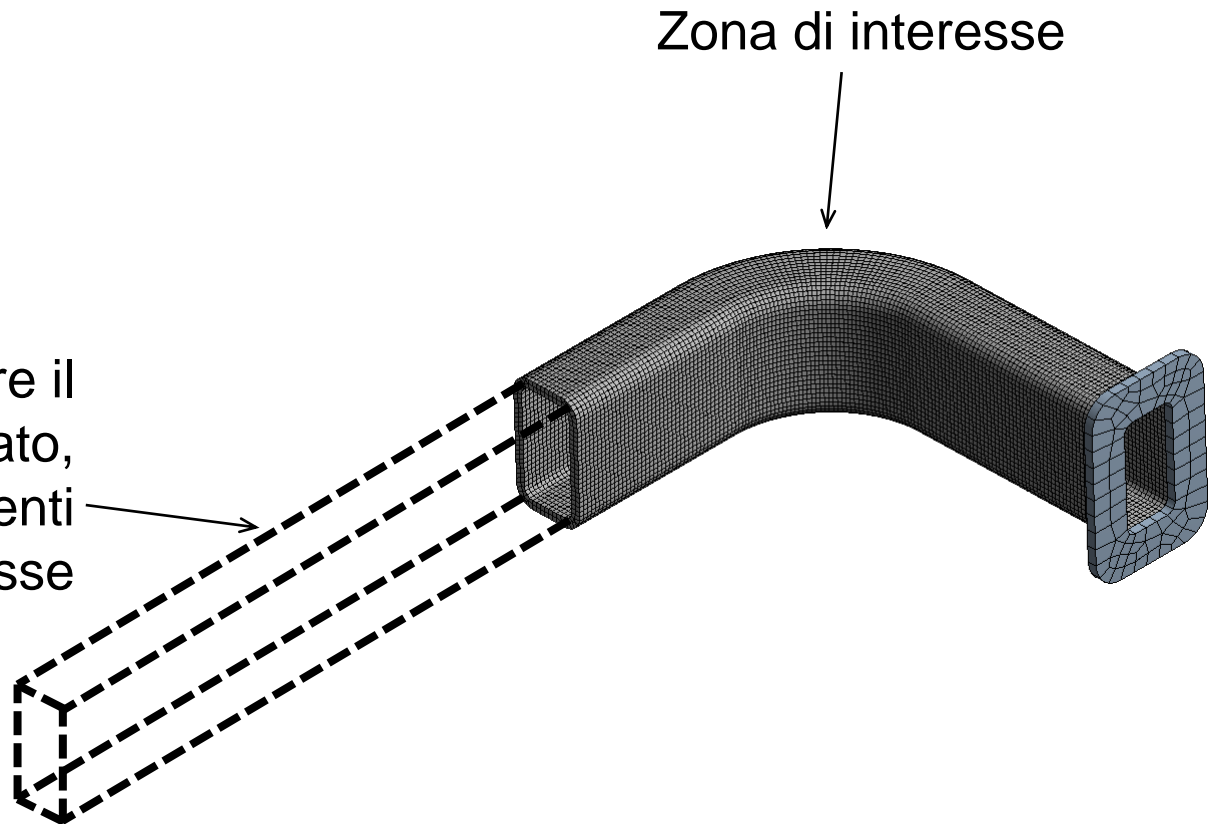


Utilità del carico di Forza remota

Modello completo



Possibilità di ridurre il volume modellato, concentrando più elementi nella zona di interesse

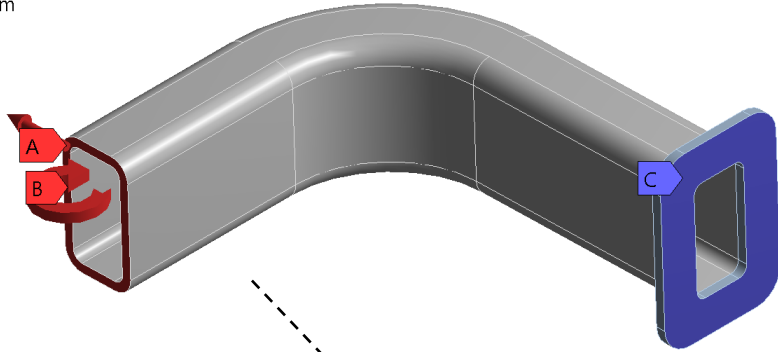


Applicazione di una Forza e del Momento di trasporto

B: Static Structural
Static Structural
Time: 1. s

- A** Force: 2500. N
- B** Moment: 4.25e+006 N-mm
- C** Fixed Support

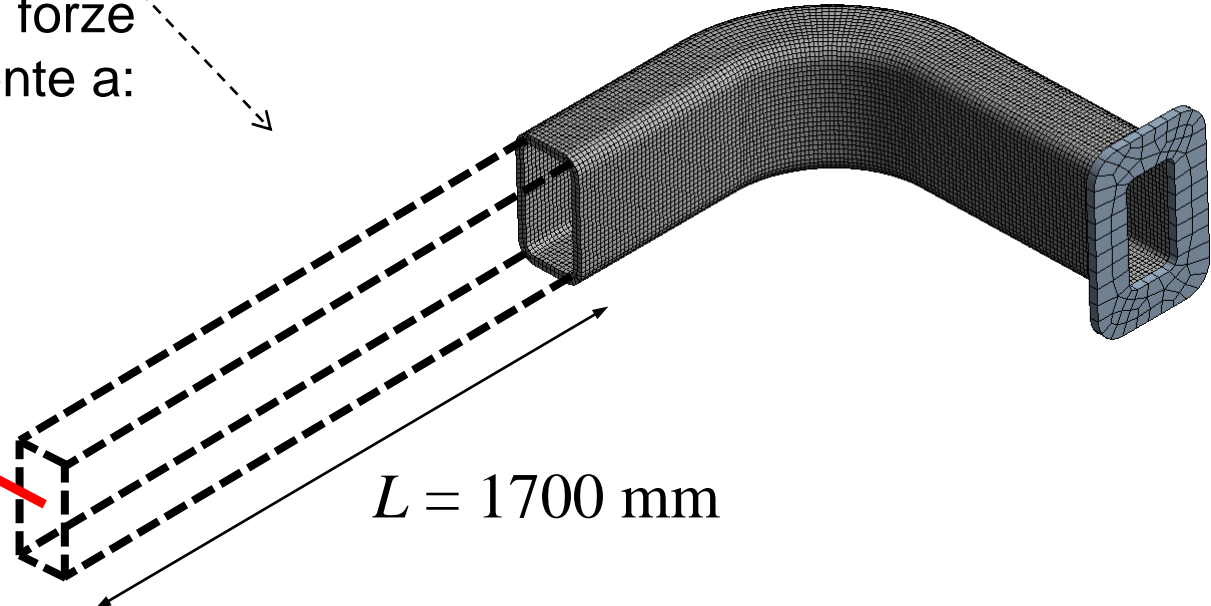
$M = 2500 \times 1700 \text{ N mm}$



Sistema di forze
equivalente a:

$F = 2500 \text{ N}$

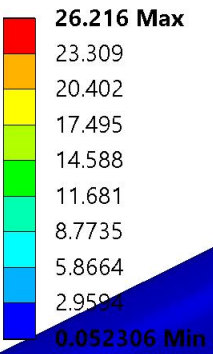
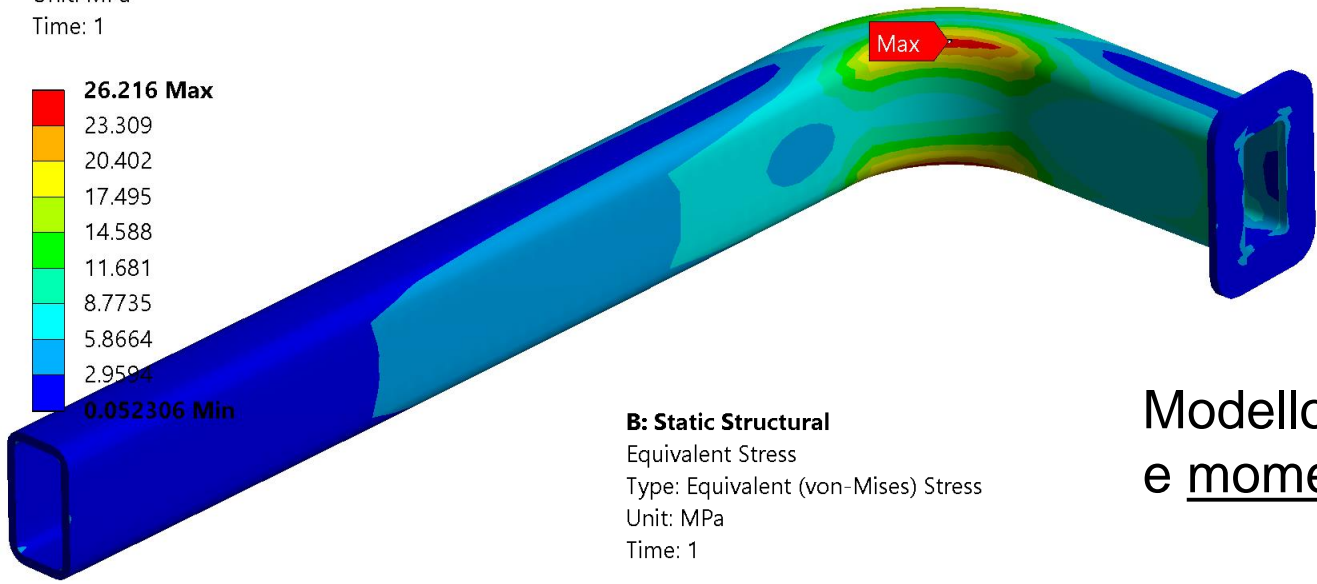
$L = 1700 \text{ mm}$



Confronto dei risultati

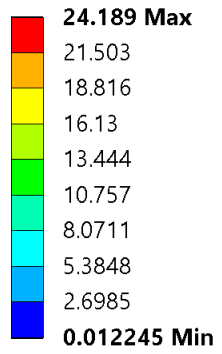
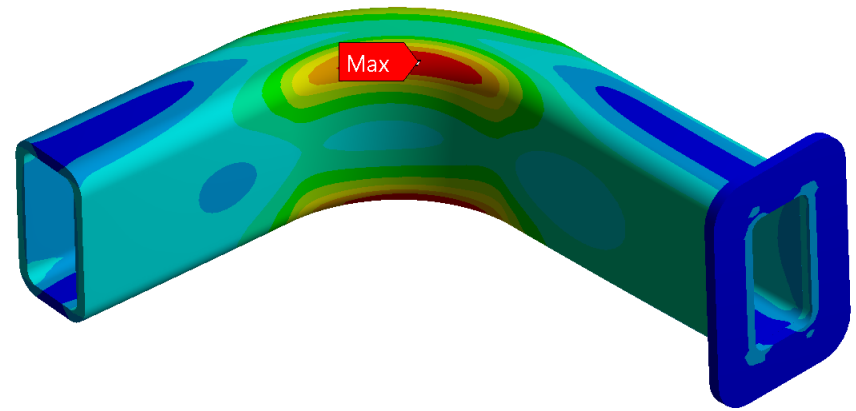
A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1

Modello completo



B: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1

Modello parziale con forza e momento di trasporto



Applicazione del carico di Forza remota

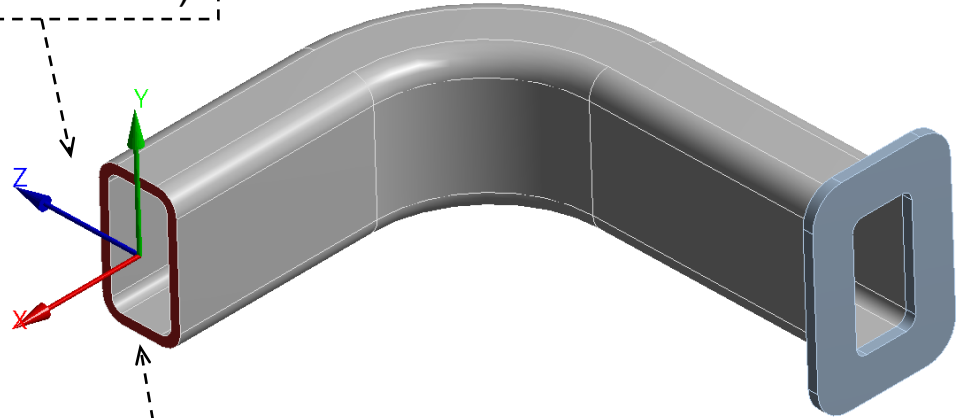
B: Static Structural

Remote Force

Time: 1. s

Remote Force: 2500. N
Components: 0.,0.,2500. N
Location: 1700., 0., 0. mm

È utile definire un sistema di coordinate (sist. di coord. locale)



Il punto di applicazione della forza può essere posizionato liberamente nello spazio



La forza remota è comunque applicata ad una superficie

Applicazione del carico di Forza remota – Confronto dei risultati

Modello completo

A: Static Structural

Equivalent Stress

Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 1

26.216 Max

23.309

20.402

17.495

14.588

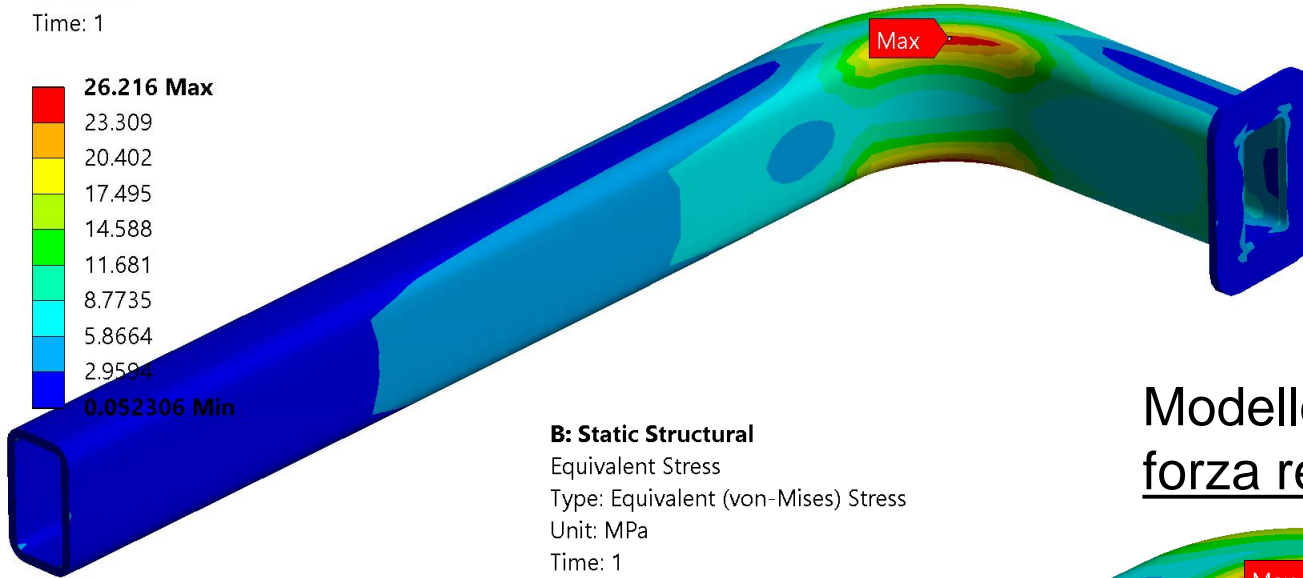
11.681

8.7735

5.8664

2.9594

0.052306 Min



B: Static Structural

Equivalent Stress

Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 1

24.189 Max

21.503

18.816

16.13

13.444

10.757

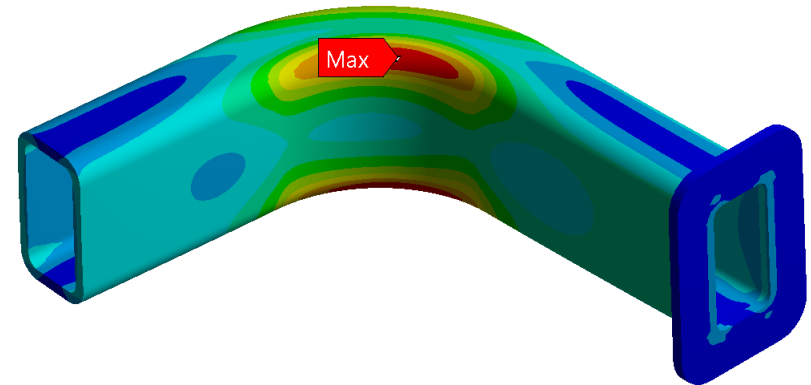
8.0711

5.3848

2.6985

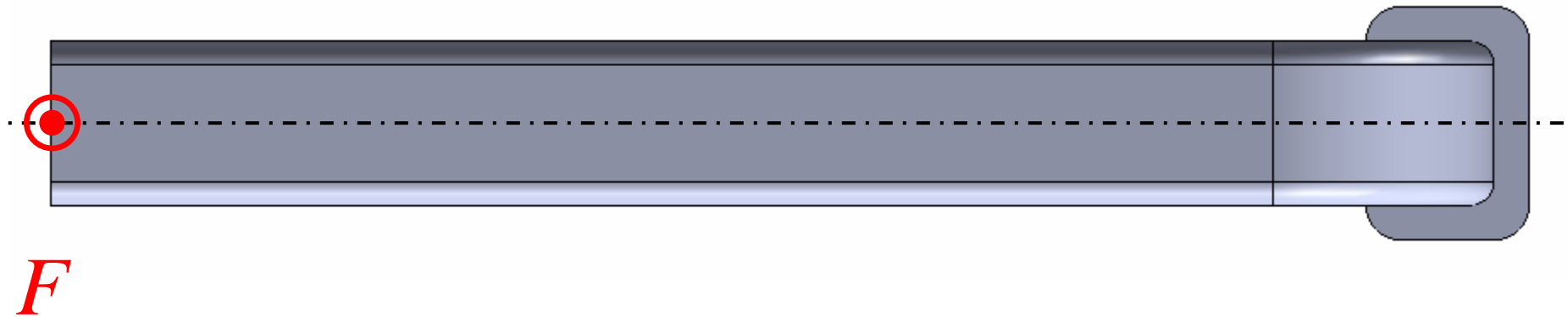
0.012245 Min

Modello parziale con forza remota



N.B.: risultato identico al caso di forza + momento di trasporto

Ulteriore riduzione del volume modellato: utilizzo della simmetria



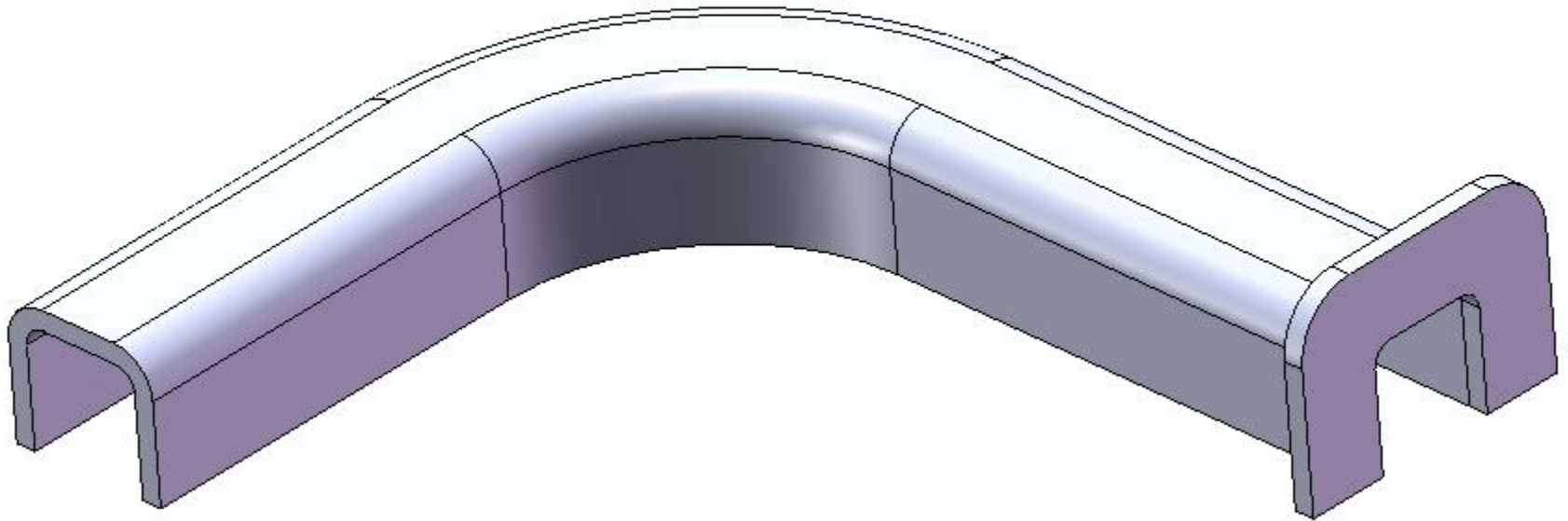
Il modello presenta un piano di simmetria geometrico e di carico

È possibile sfruttare la simmetria per ridurre ulteriormente (dimezzare) il volume da modellare

Utilizzo della simmetria

Si prepara un modello già sezionato, in ambiente CAD

Si prevede anche l'utilizzo della forza remota oltre alla simmetria

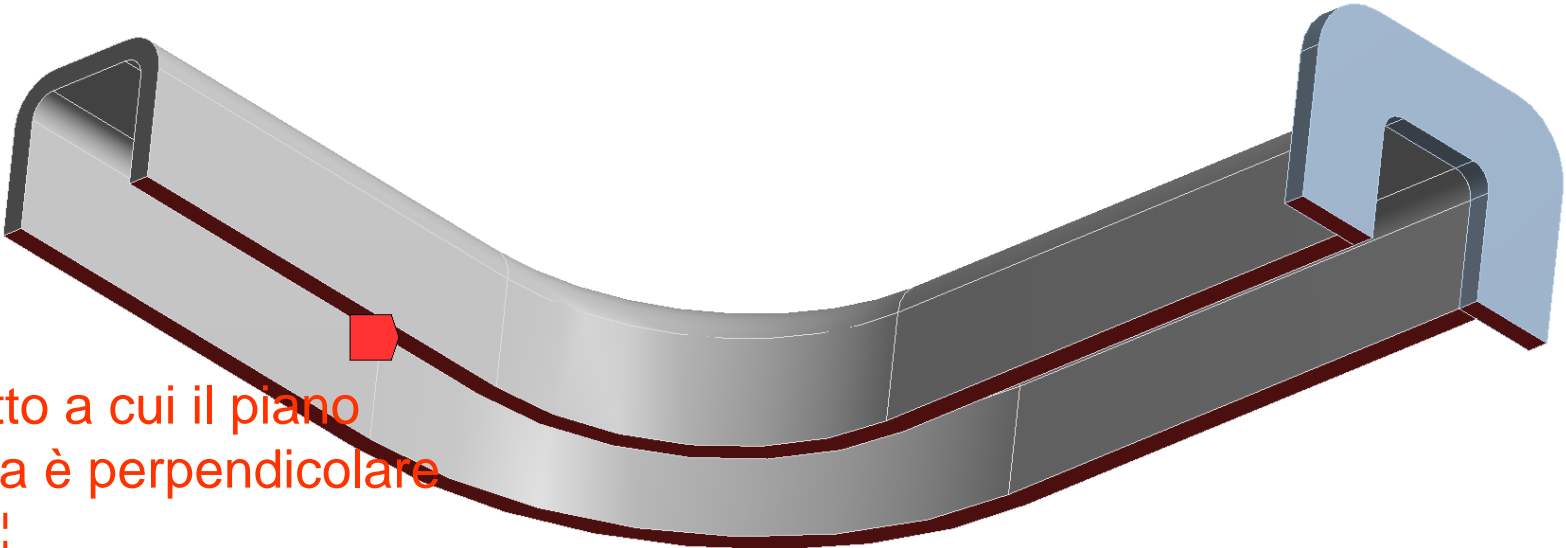


Utilizzo di simmetria e forza remota – vincoli e carichi

Condizione di simmetria applicata alle facce che sono sul piano di simmetria del problema

Symmetry Region

■ Symmetry Region



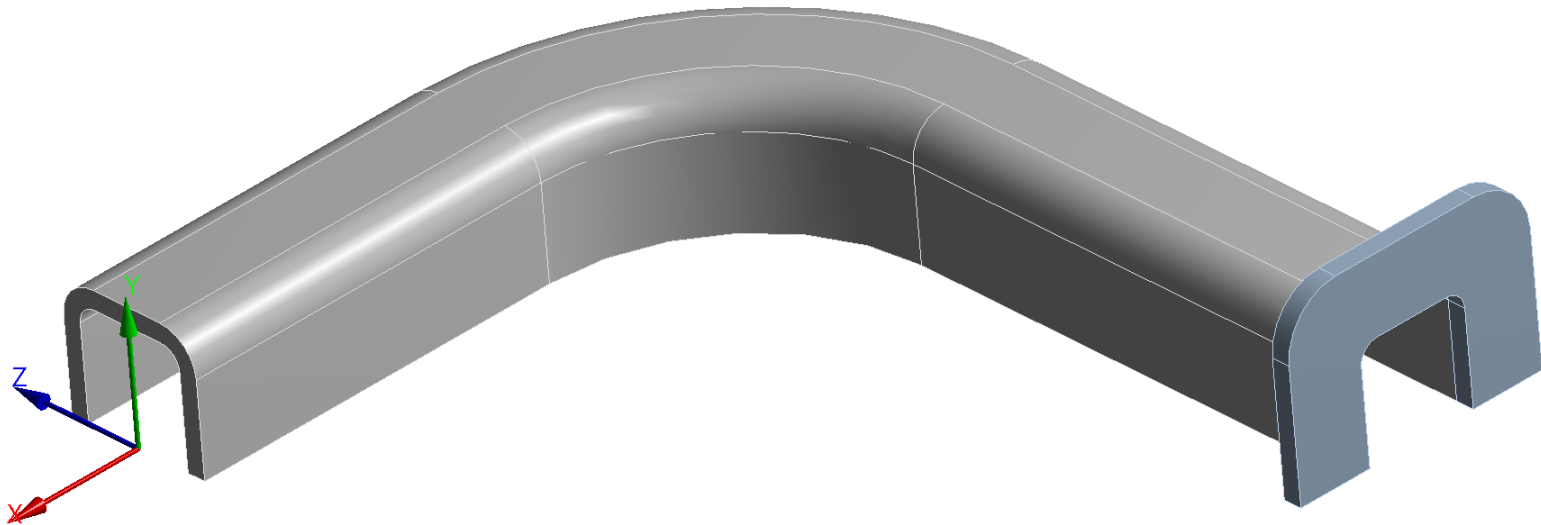
Asse rispetto a cui il piano di simmetria è perpendicolare

Scoping Method	Geometry Selection
Geometry	4 Faces
Definition	
Scope Mode	Manual
Type	Symmetric
Coordinate System	Global Coordinate System
Symmetry Normal	Y Axis
Suppressed	No

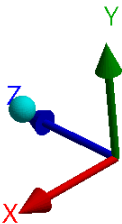
Utilizzo di simmetria e forza remota – vincoli e carichi

Creazione di un sistema di coordinate per la forza remota

N.B.: l'orig. del sist. di coord. non coincide con il baricentro della sezione, è quindi necessario ricorreggere le quote, rispetto al sist. di rif. Globale



Details of "Coordinate System"	
Definition	
Type	Cartesian
Coordinate System	Program Controlled
APDL Name	
Suppressed	No
Origin	
Define By	Global Coordinates
Origin X	700. mm
Origin Y	0. mm
Origin Z	820. mm
Location	Click to Change



Utilizzo di simmetria e forza remota – vincoli e carichi

Applicazione della forza remota

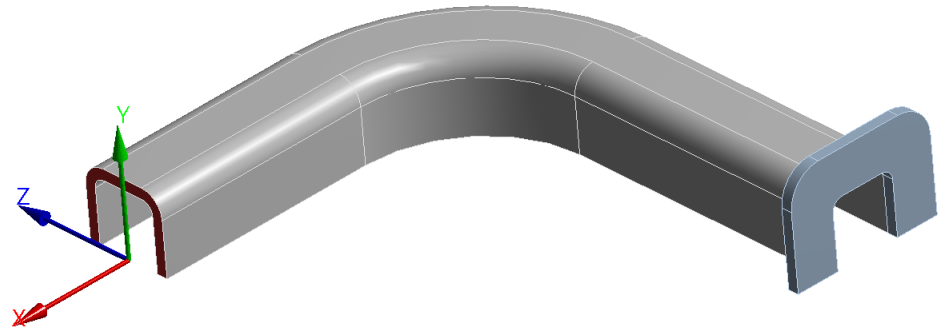
N.B.: l'entità della forza da applicare è pari a **metà della forza totale**

C: Static Structural

Remote Force

Time: 1. s

Remote Force: 1250. N
Components: 0.,0.,1250. N
Location: 1700., 0., 0. mm



Quesito:



In che modo cambia il risultato se il p.to di applicazione (remoto) viene fatto traslare secondo Z? oppure secondo Y?

Analisi dei risultati

Risultato in pieno **accordo** con le precedenti analisi

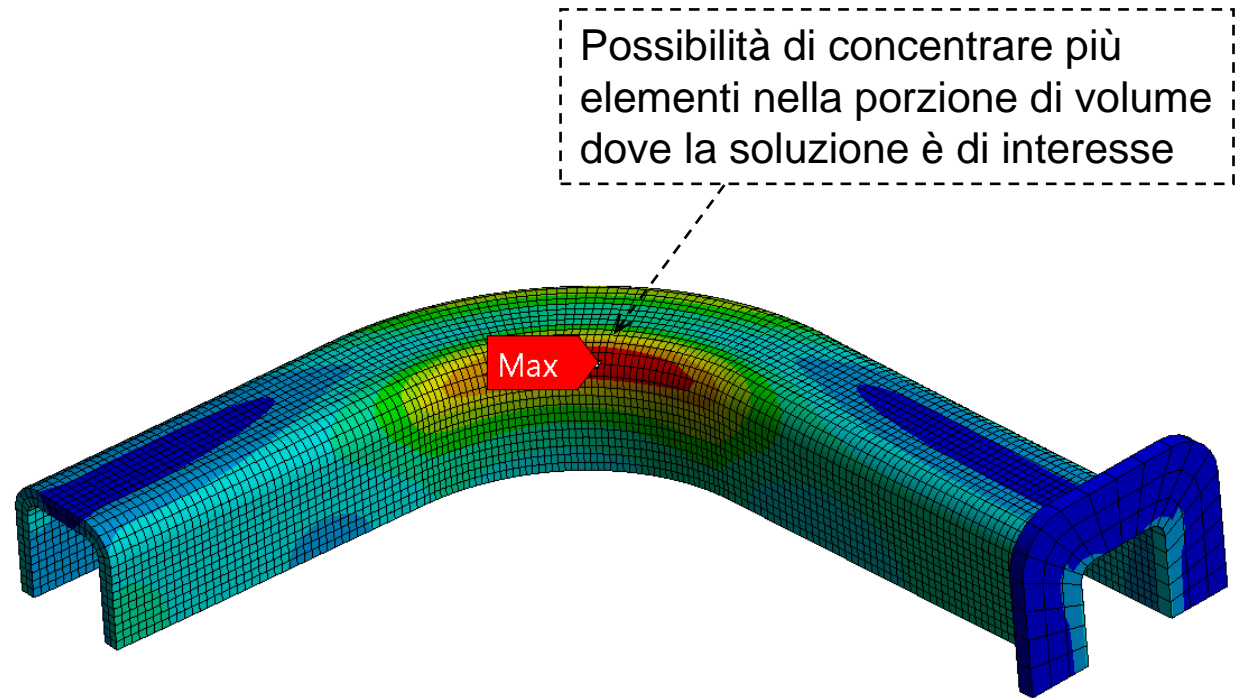
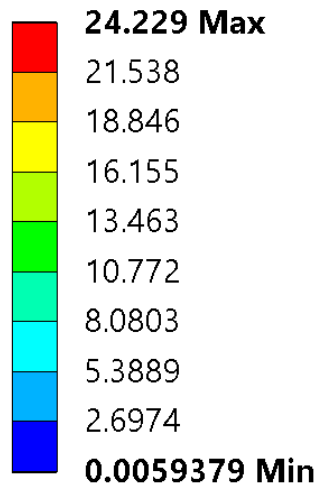
C: Static Structural

Equivalent Stress

Type: Equivalent (von-Mises) Stress

Unit: MPa

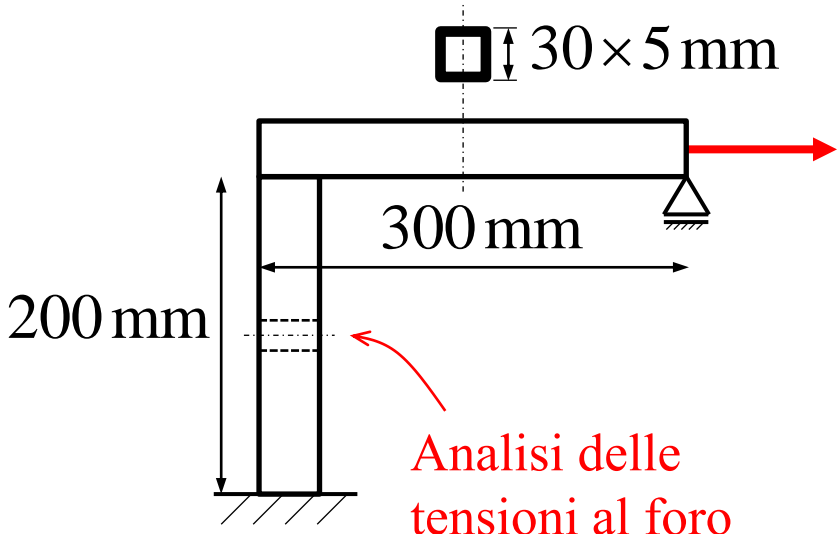
Time: 1



Sommario Lez. 5

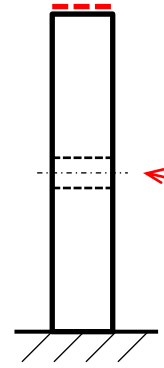
1. Possibilità di ridurre il volume modellato con il carico di **Forza remota**
2. Forza remota = **Forza** + **Momento** (coppia) di direzione e intensità opportune
3. Possibilità di ridurre il volume modellato sfruttando le Simmetrie del problema (già nota da precedente esercitazione)
4. Eventuale utilizzo combinato di Forza remota e Simmetrie

Esercitazione da svolgere: Utilizzo della forza remota, trave ad L



$F = 1000 \text{ N}$

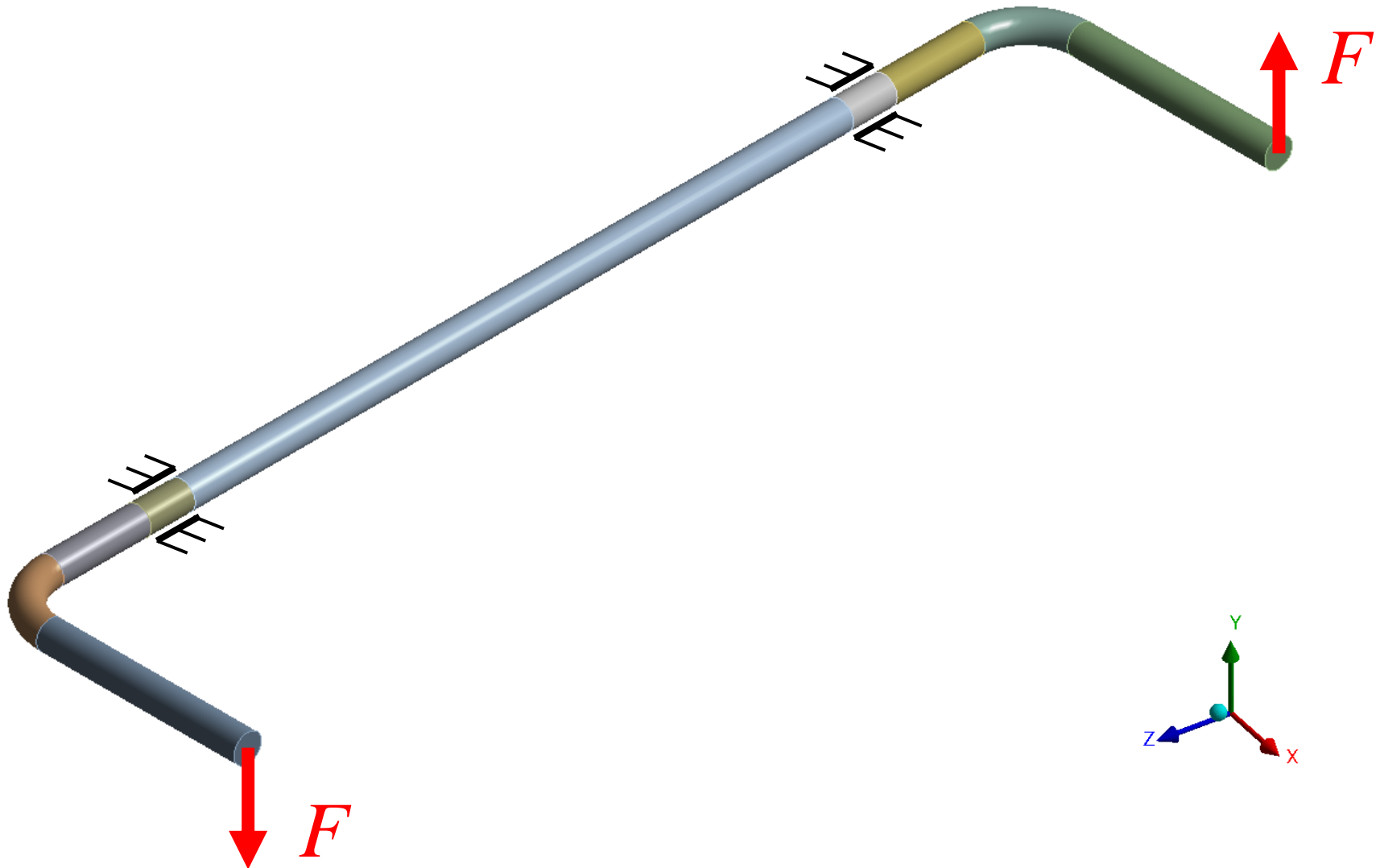
Ottenere la stessa sollecitazione sul primo tratto, con unico carico di *forza remota*, applicata all'interfaccia fra le due travi



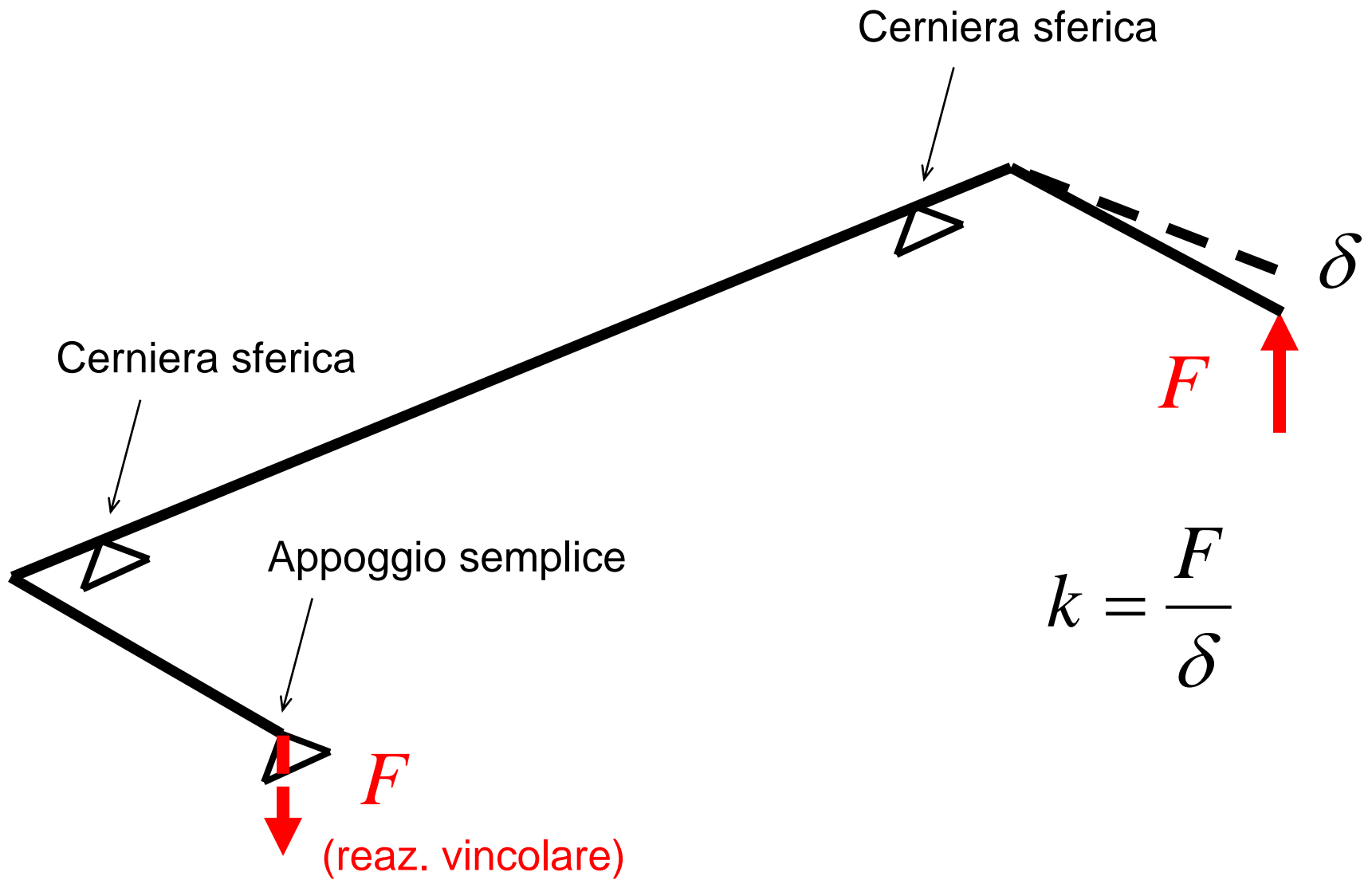
Analisi delle tensioni al foro

Lez. 6. Utilizzo del vincolo di Spostamento remoto

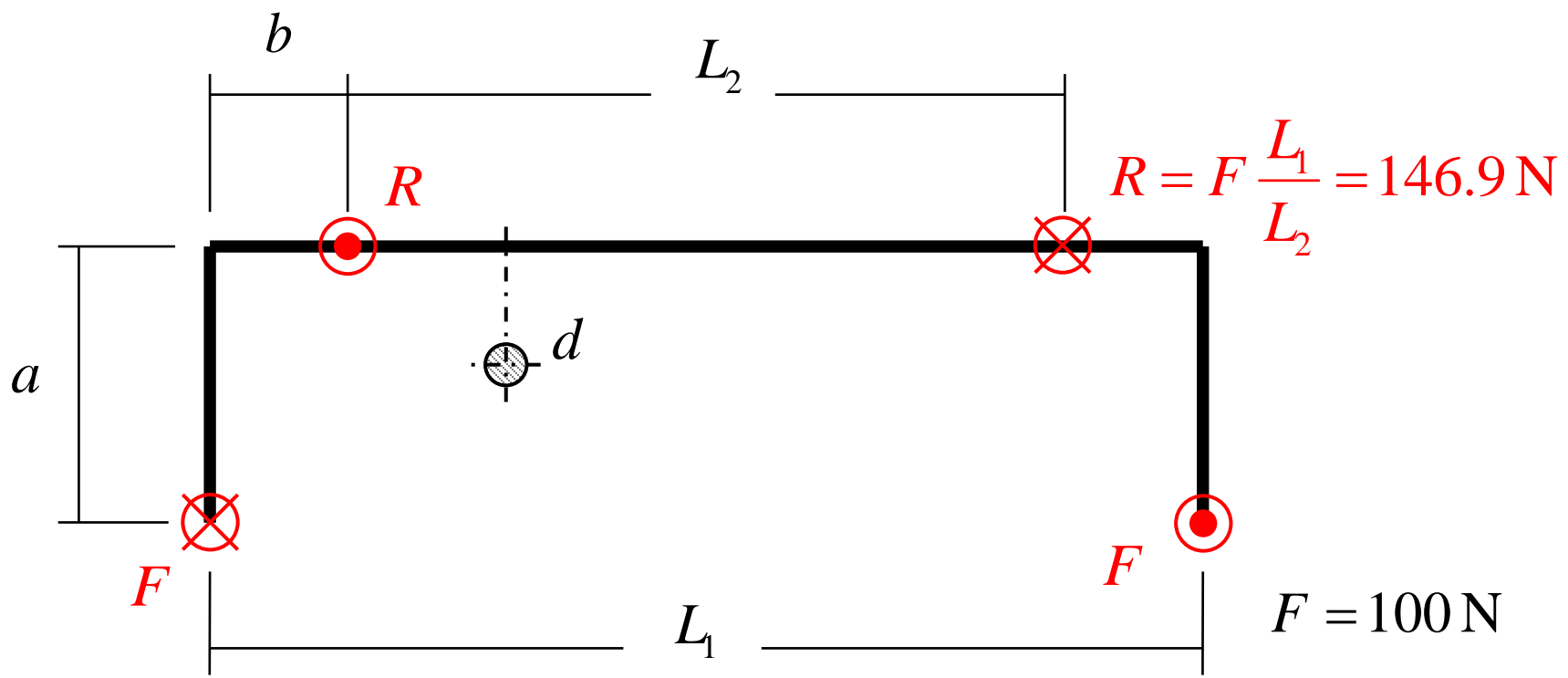
Barra di torsione caricata alle estremità con diverso comportamento delle cerniere



Modello a trave per il calcolo della rigidezza



Modello a trave per il calcolo della rigidezza



$d = 25 \text{ mm}$

$I = \pi / 64 d^4 = 19175 \text{ mm}^4$

$I_0 = 2I = 38350 \text{ mm}^4$

$E = 205000 \text{ MPa}$

$\nu = 0.3$

$G = \frac{E}{2(1+\nu)} = 78850 \text{ MPa}$

$F = 100 \text{ N}$

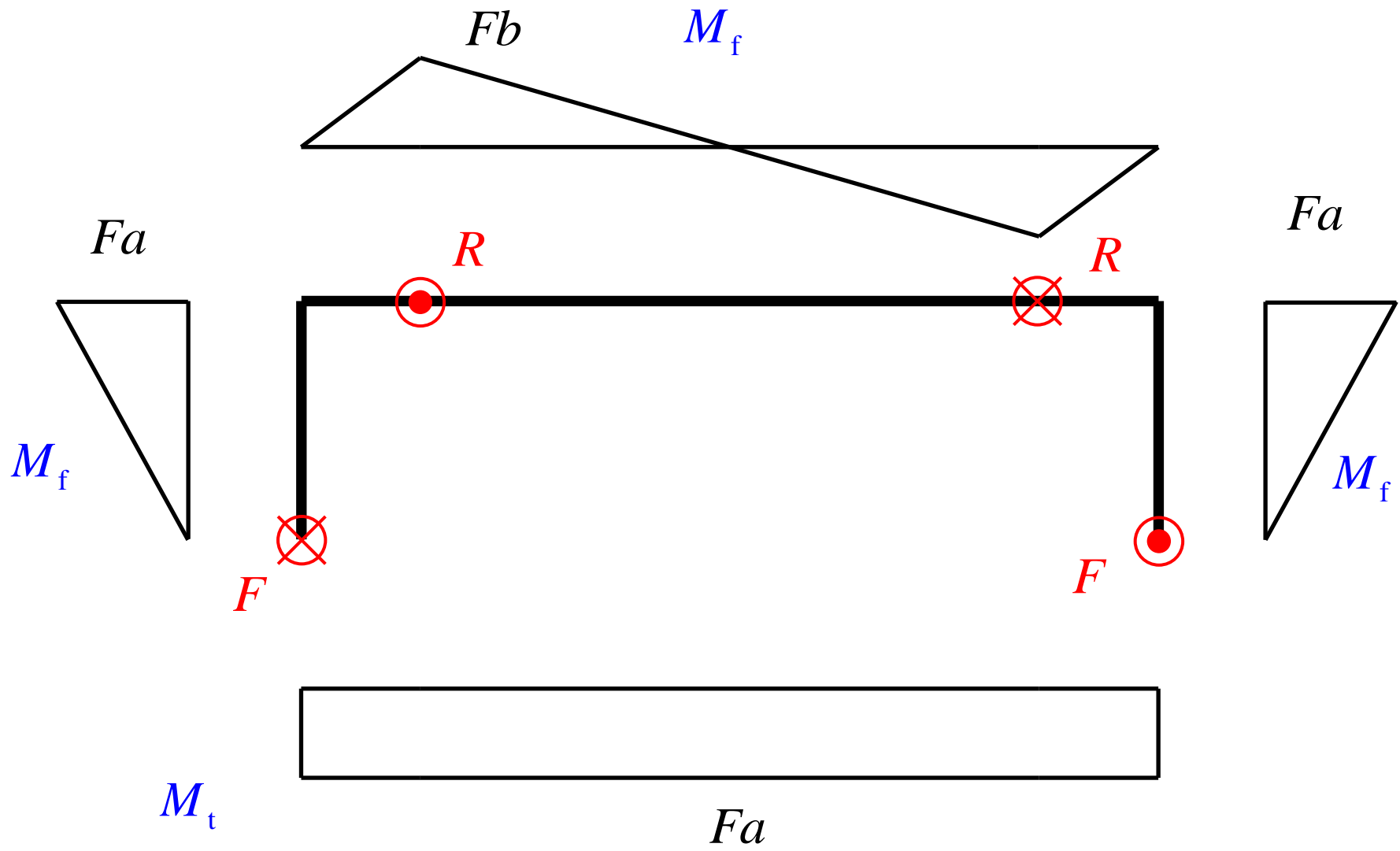
$a = 230 \text{ mm}$

$b = 150 \text{ mm}$

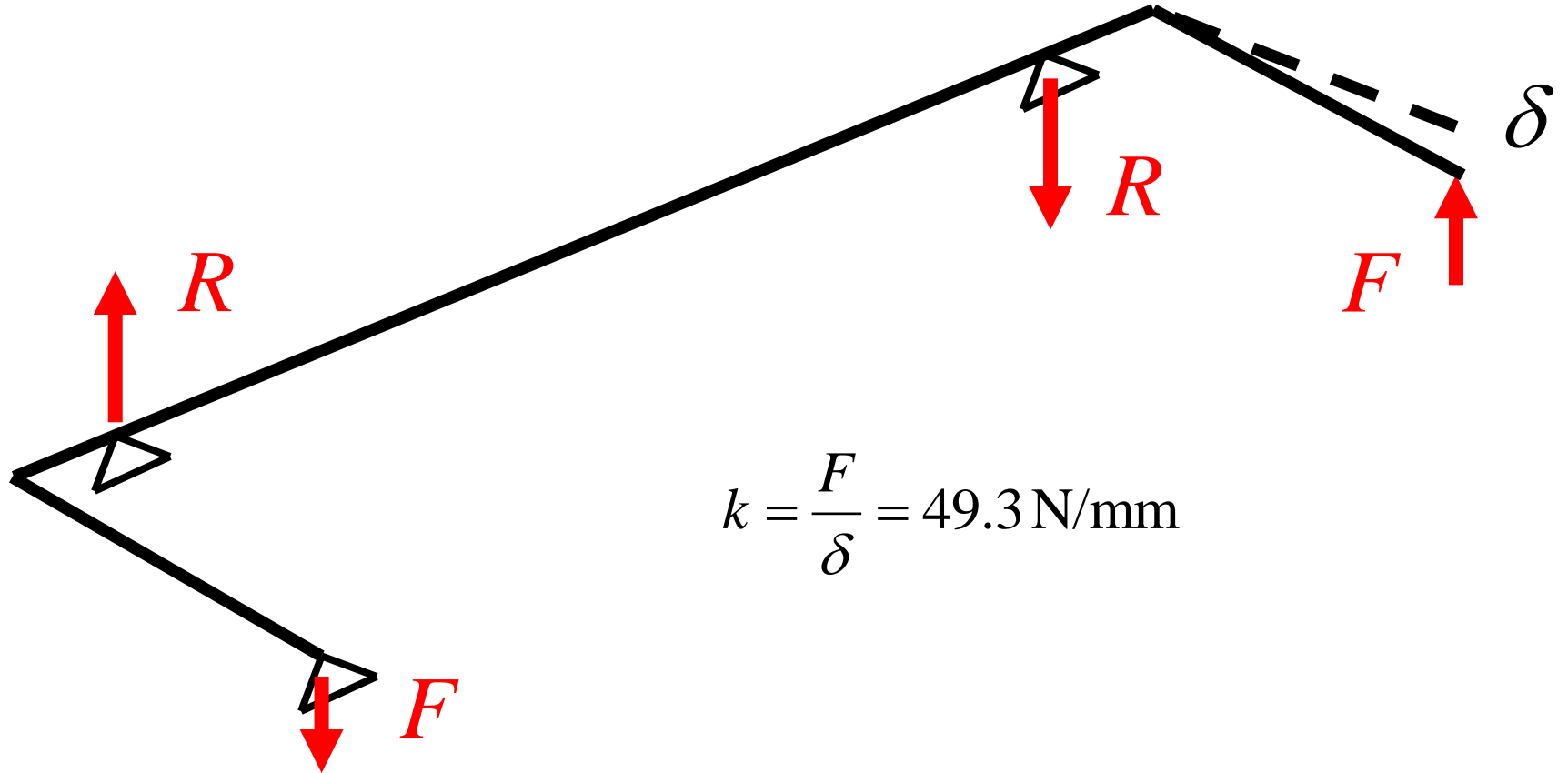
$L_1 = 940 \text{ mm}$

$L_2 = 640 \text{ mm}$

Modello a trave per il calcolo della rigidezza



Modello a trave per il calcolo della rigidità,
integrale di Mohr



$$k = \frac{F}{\delta} = 49.3 \text{ N/mm}$$

$$\begin{aligned} \delta &= 2 \int_0^a F \frac{x^2}{EI} dx + 2 \int_0^b F \frac{x^2}{EI} dx + 2 \int_0^{L_2/2} F \frac{x^2}{EI} \left(\frac{b}{L_2/2} \right)^2 dx + \int_0^{L_1} F \frac{a^2}{GI_0} dx = \\ &= 2 \frac{F}{EI} \frac{a^3}{3} + 2 \frac{F}{EI} \frac{b^3}{3} + 2(R-F) \frac{(L_2/2)^3}{3EI} + F \frac{a^3}{GI_0} L_1 = 2.030 \text{ mm} \end{aligned}$$

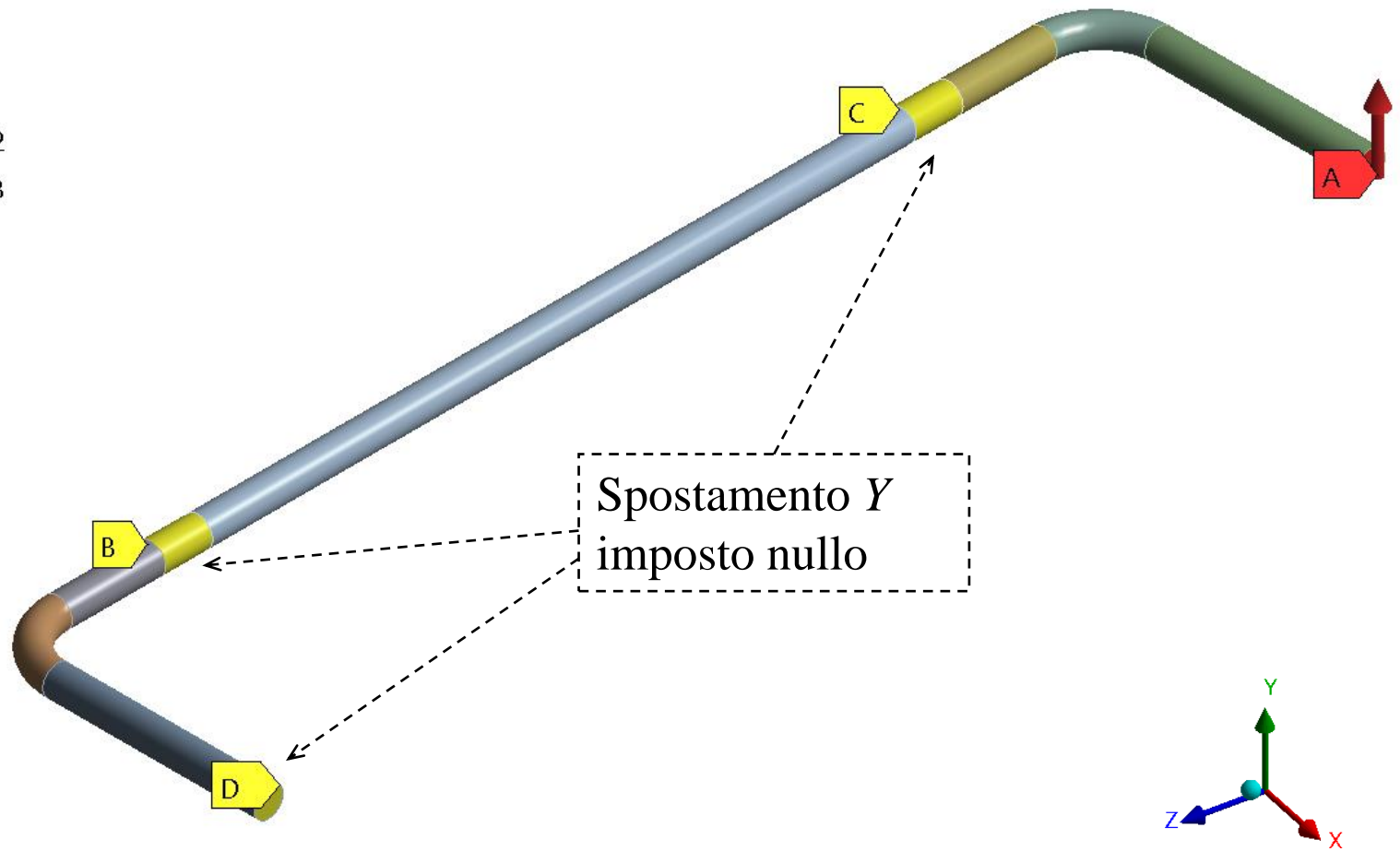
Carivo verticale e vincolo di spostamento nullo

A: Model, Static Structural

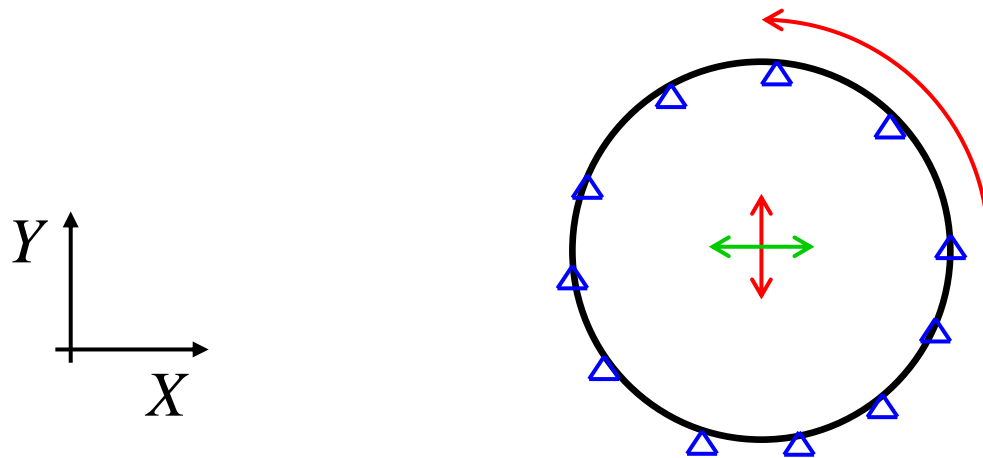
Static Structural

Time: 1. s

- A** Force: 100. N
- B** Displacement
- C** Displacement 2
- D** Displacement 3



Vincolo di spostamento nullo



Vincolo improprio:

lo spostamento Y imposto nullo su tutti i nodi della superficie cilindrica **impedisce anche la rotazione** della sezione

Vincolo di spostamento nullo

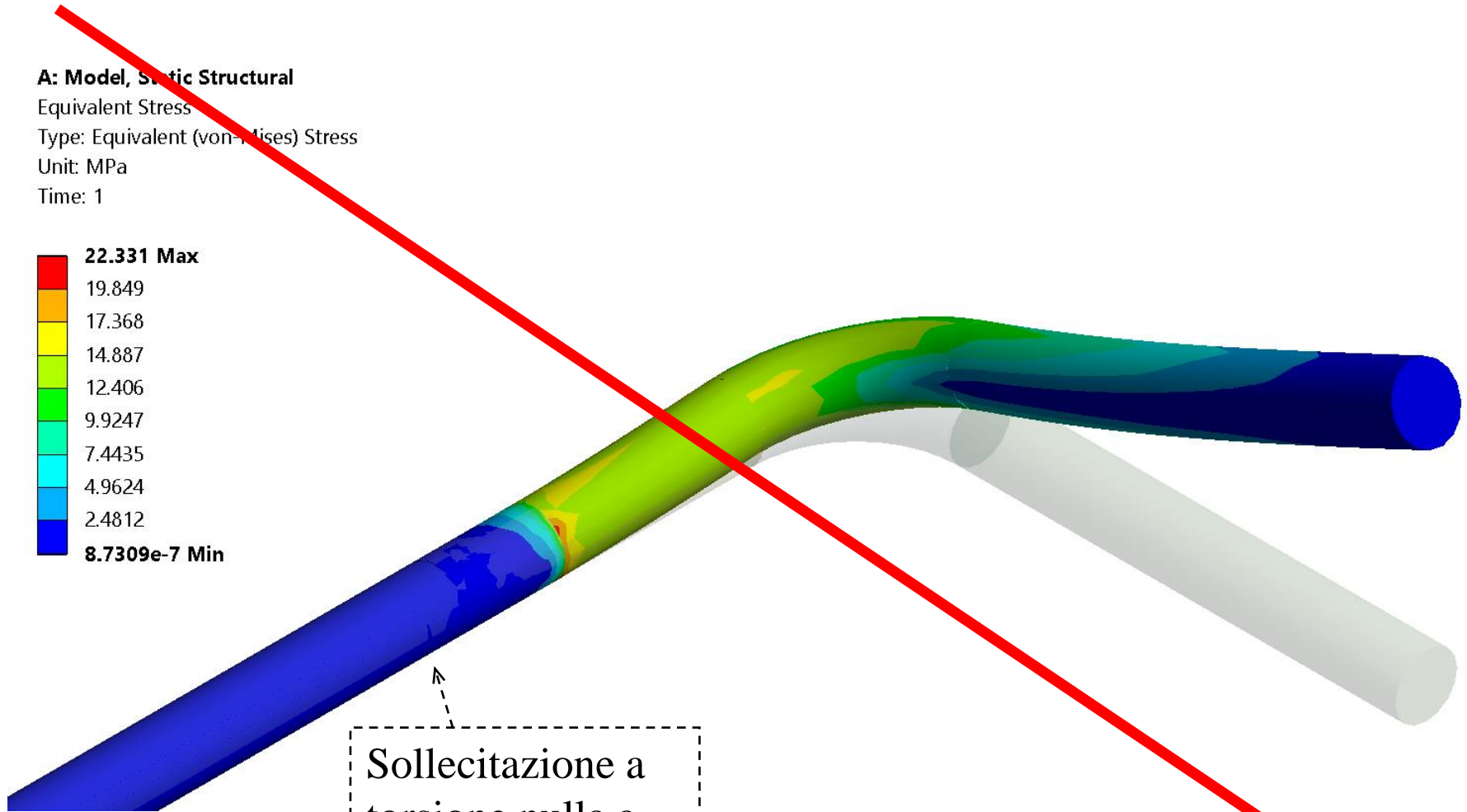
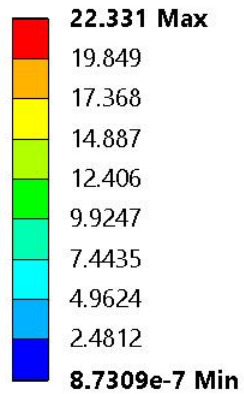
A: Model, Static Structural

Equivalent Stress

Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 1



Solllecitazione a torsione nulla a valle del vincolo


Analisi errata

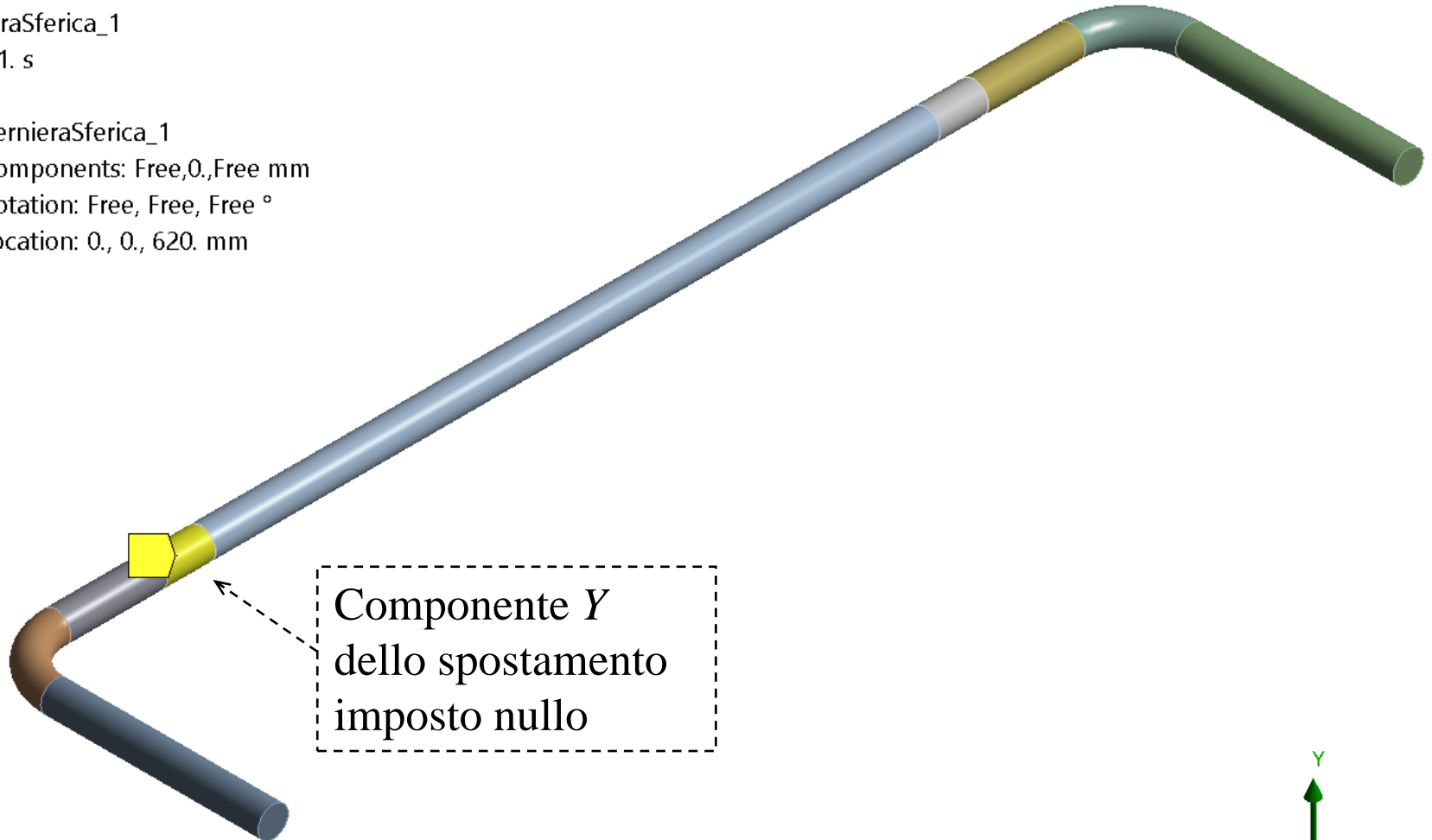
Vincolo di spostamento Remoto

A: Model, Static Structural

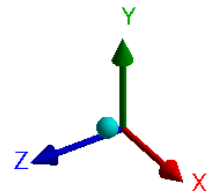
CernieraSferica_1

Time: 1. s

 CernieraSferica_1
Components: Free,0.,Free mm
Rotation: Free, Free, Free °
Location: 0., 0., 620. mm



Componente Y
dello spostamento
imposto nullo




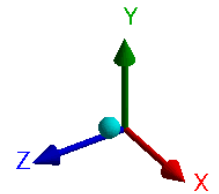
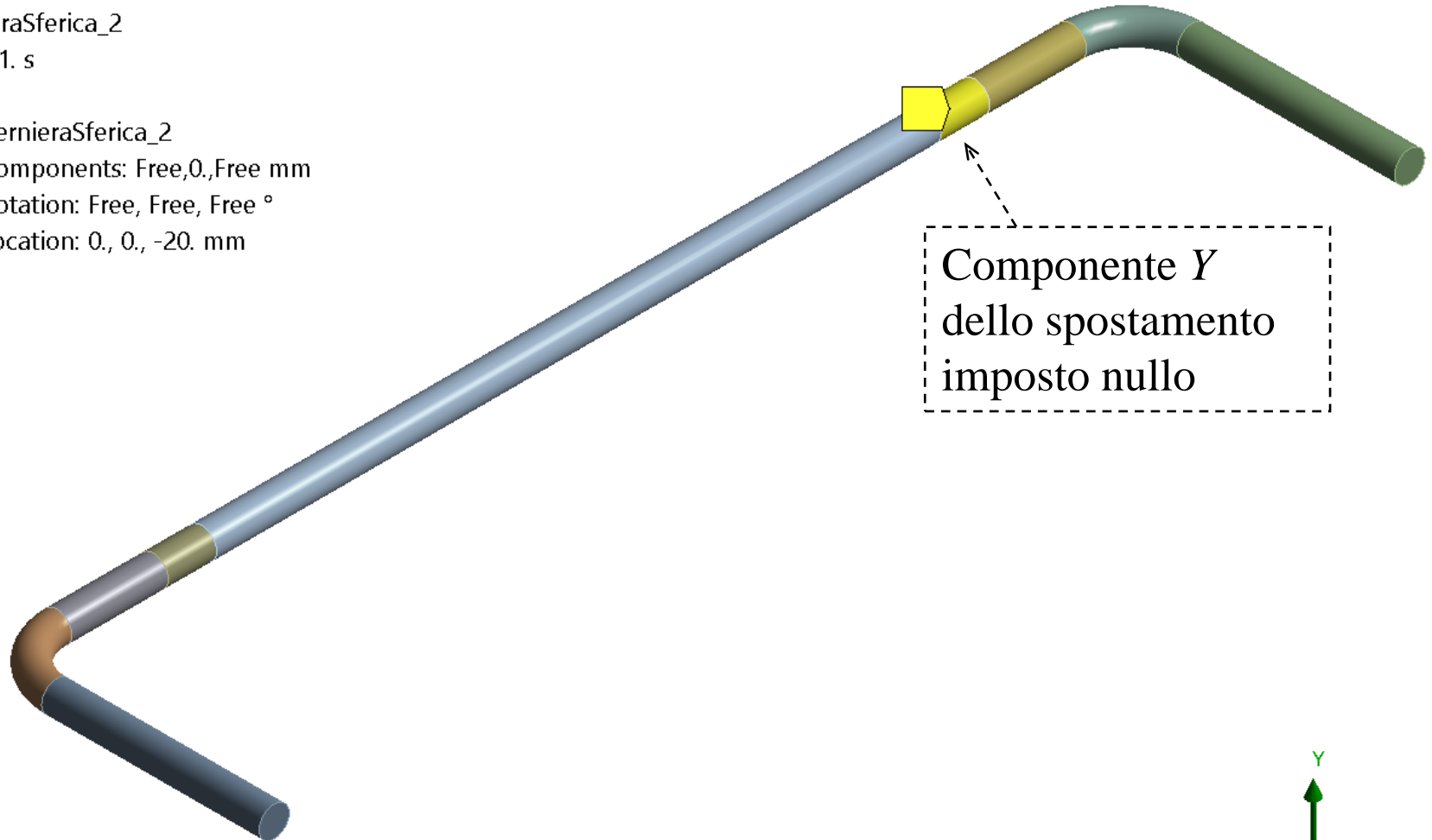
Vincolo di spostamento Remoto

A: Model, Static Structural

CernieraSferica_2

Time: 1. s

 CernieraSferica_2
Components: Free,0.,Free mm
Rotation: Free, Free, Free °
Location: 0., 0., -20. mm




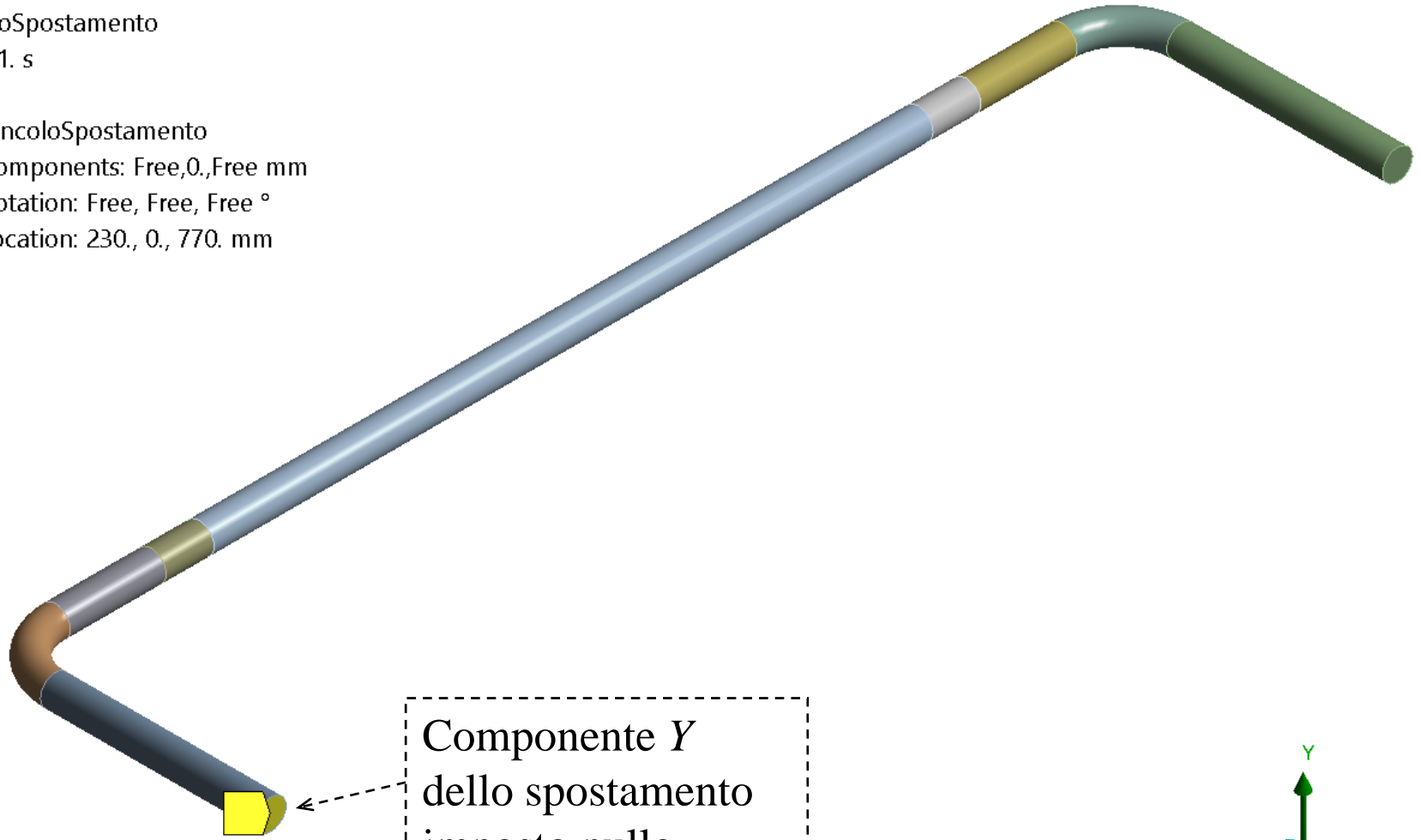
Vincolo di spostamento Remoto

A: Model, Static Structural

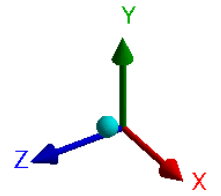
VincoloSpostamento

Time: 1. s

 VincoloSpostamento
Components: Free,0.,Free mm
Rotation: Free, Free, Free °
Location: 230., 0., 770. mm

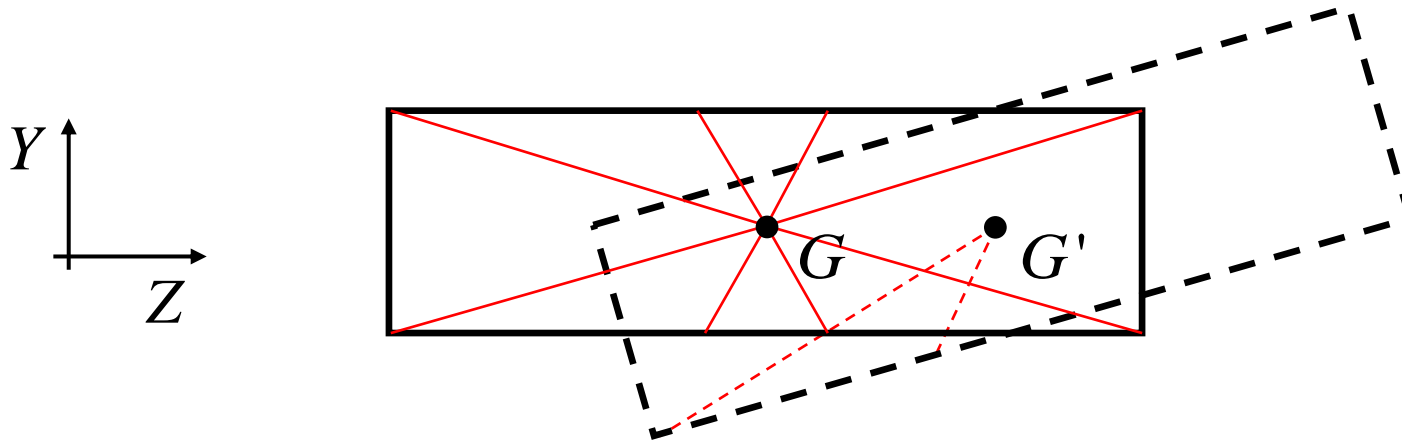


Componente Y
dello spostamento
imposto nullo



Vincolo di spostamento Remoto

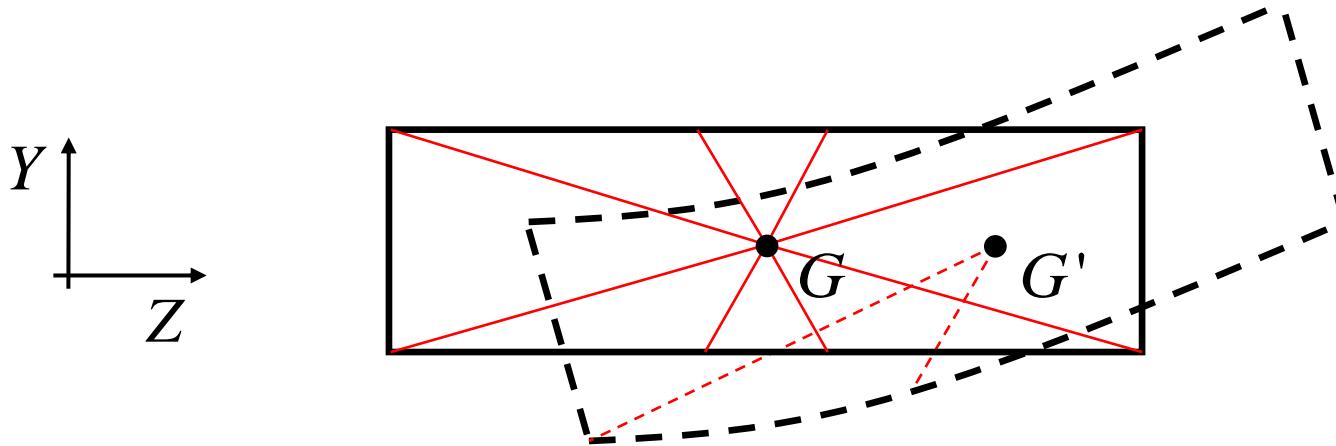
Spostamento remoto Y imposto nullo
(opzione: Comportamento **Rigido**)



Il baricentro della superficie può spostarsi nelle direzioni libere
(ad esempio Z), non può spostarsi lungo Y , ma **può ruotare**

Vincolo di spostamento Remoto

Spostamento **remoto** Y imposto nullo
(opzione: Comportamento **Deformabile**)



Il baricentro della superficie può spostarsi nelle direzioni libere (ad esempio Z), e può ruotare ma non può spostarsi lungo Y .

La superficie può deformarsi, introducendo la deformabilità delle **aste di collegamento** e minimizzando l'energia distorcente

Soluzione

A: Static Structural

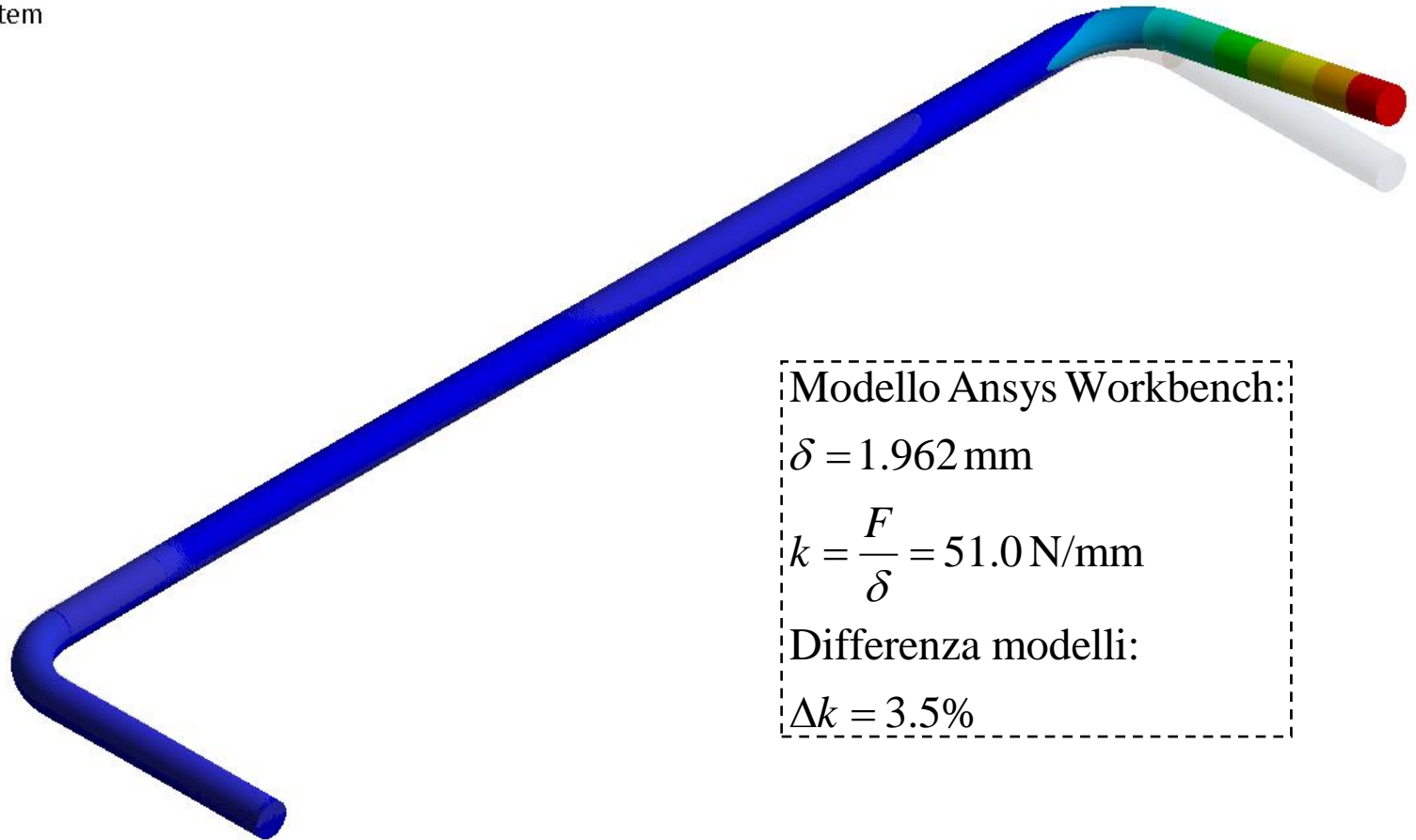
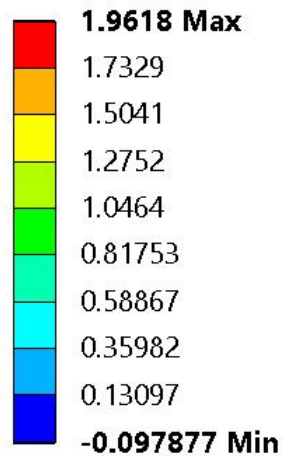
Directional Deformation

Type: Directional Deformation(Y Axis)

Unit: mm

Global Coordinate System

Time: 1



Modello trave:

$$\delta = 2.030 \text{ mm}$$

$$k = \frac{F}{\delta} = 49.3 \text{ N/mm}$$

Modello Ansys Workbench:

$$\delta = 1.962 \text{ mm}$$

$$k = \frac{F}{\delta} = 51.0 \text{ N/mm}$$

Differenza modelli:

$$\Delta k = 3.5\%$$

Necessità di imporre uno spost. rem. anche all'estremo vincolato

A: Static Structural

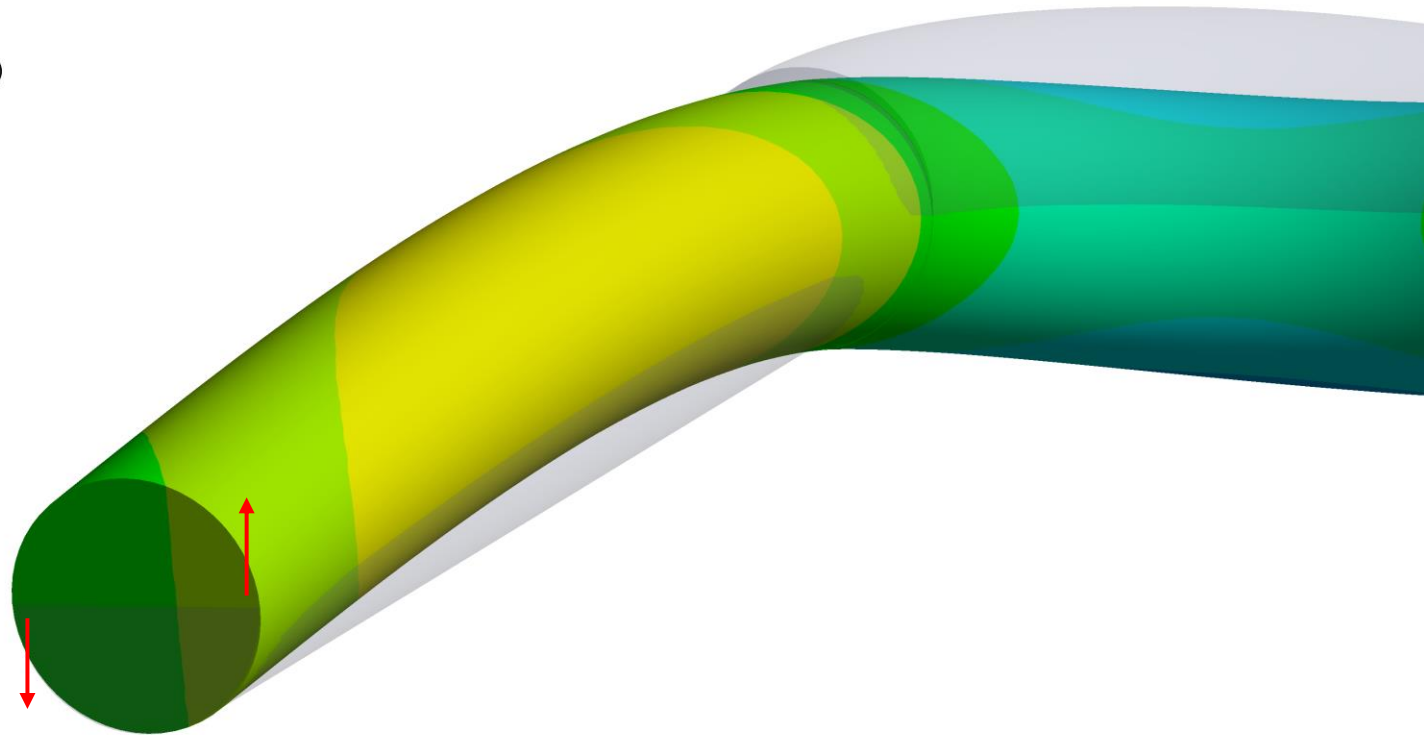
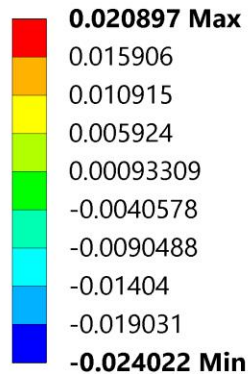
Directional Deformation

Type: Directional Deformation(Y Axis)

Unit: mm

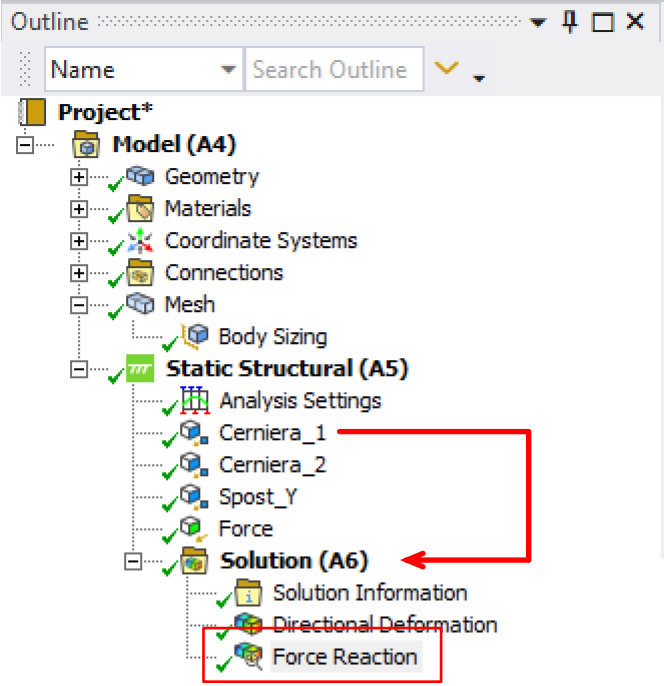
Global Coordinate System

Time: 1



In corrispondenza di questa sezione
si ha una rotazione molto piccola secondo l'asse,
che giustifica l'utilizzo, di nuovo, dello spostamento
remoto piuttosto che il semplice vincolo
su tutta la superficie in direzione verticale (direz. Y)

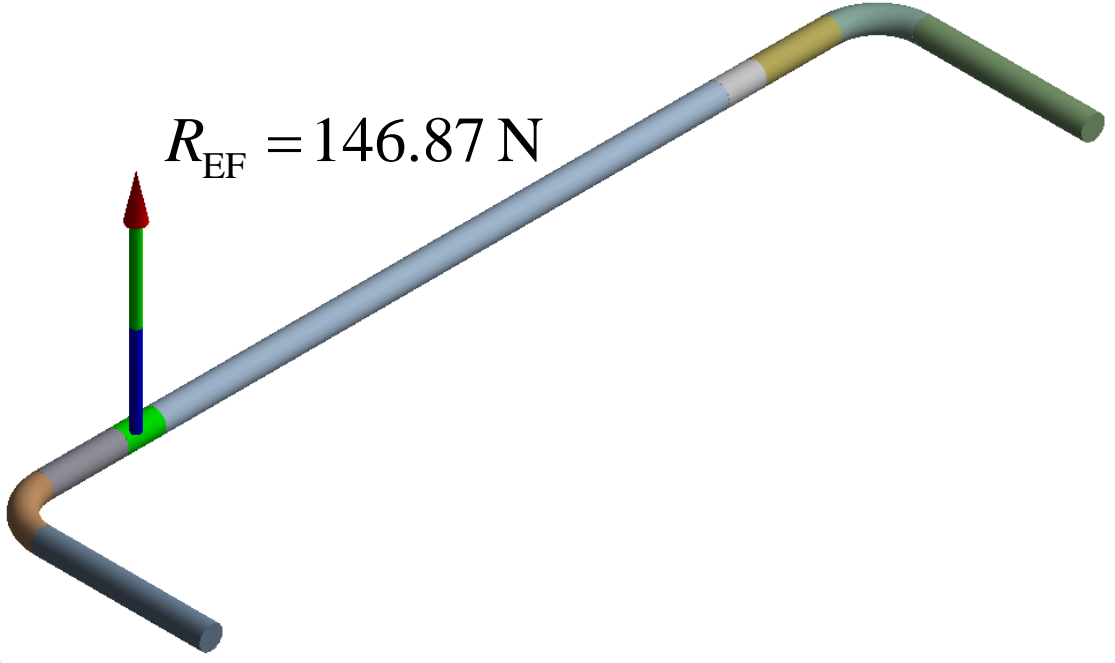
Reazioni vincolari



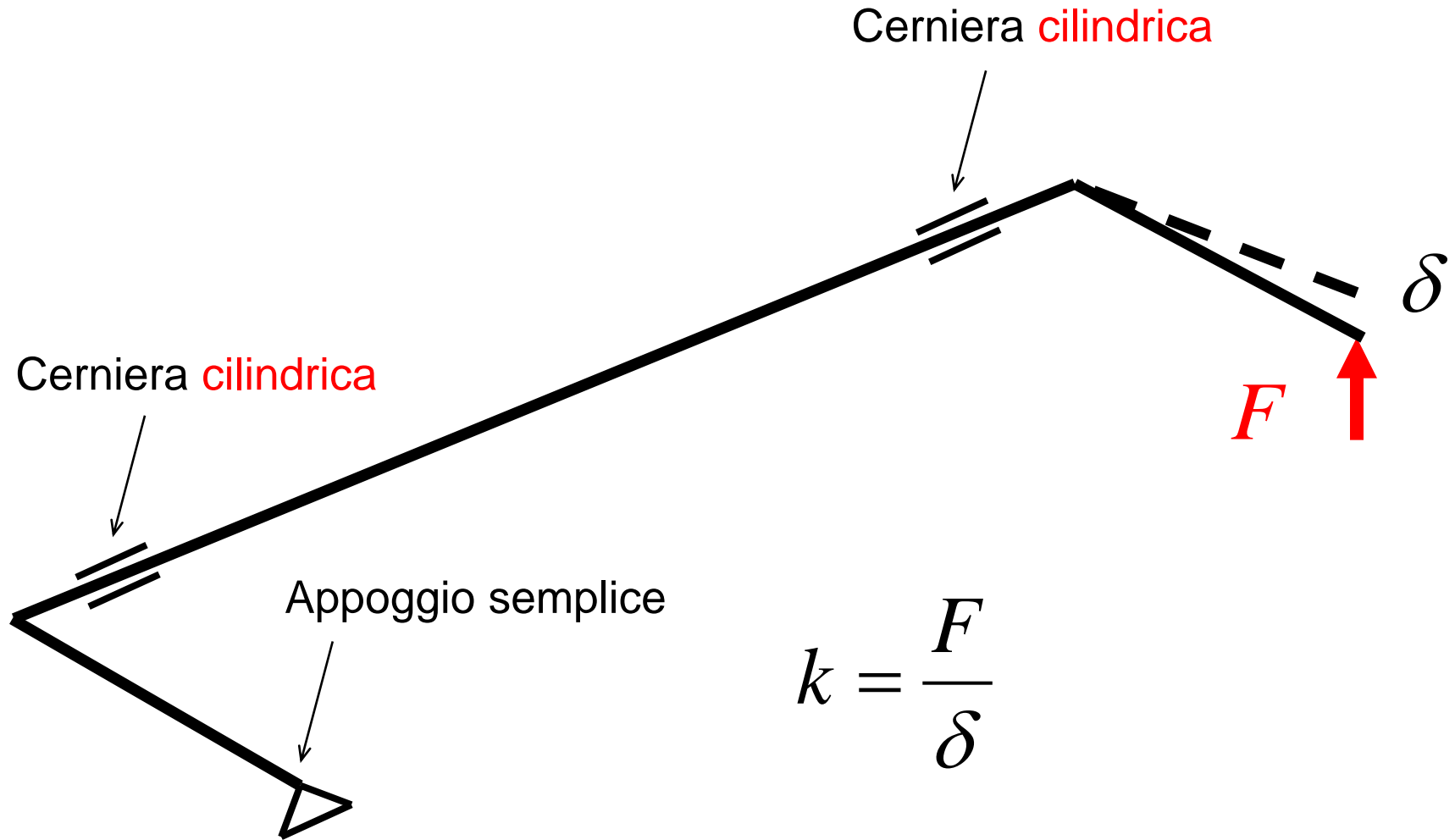
$$R = F \frac{L_1}{L_2} = 146.9 \text{ N}$$

Details of "Force Reaction"

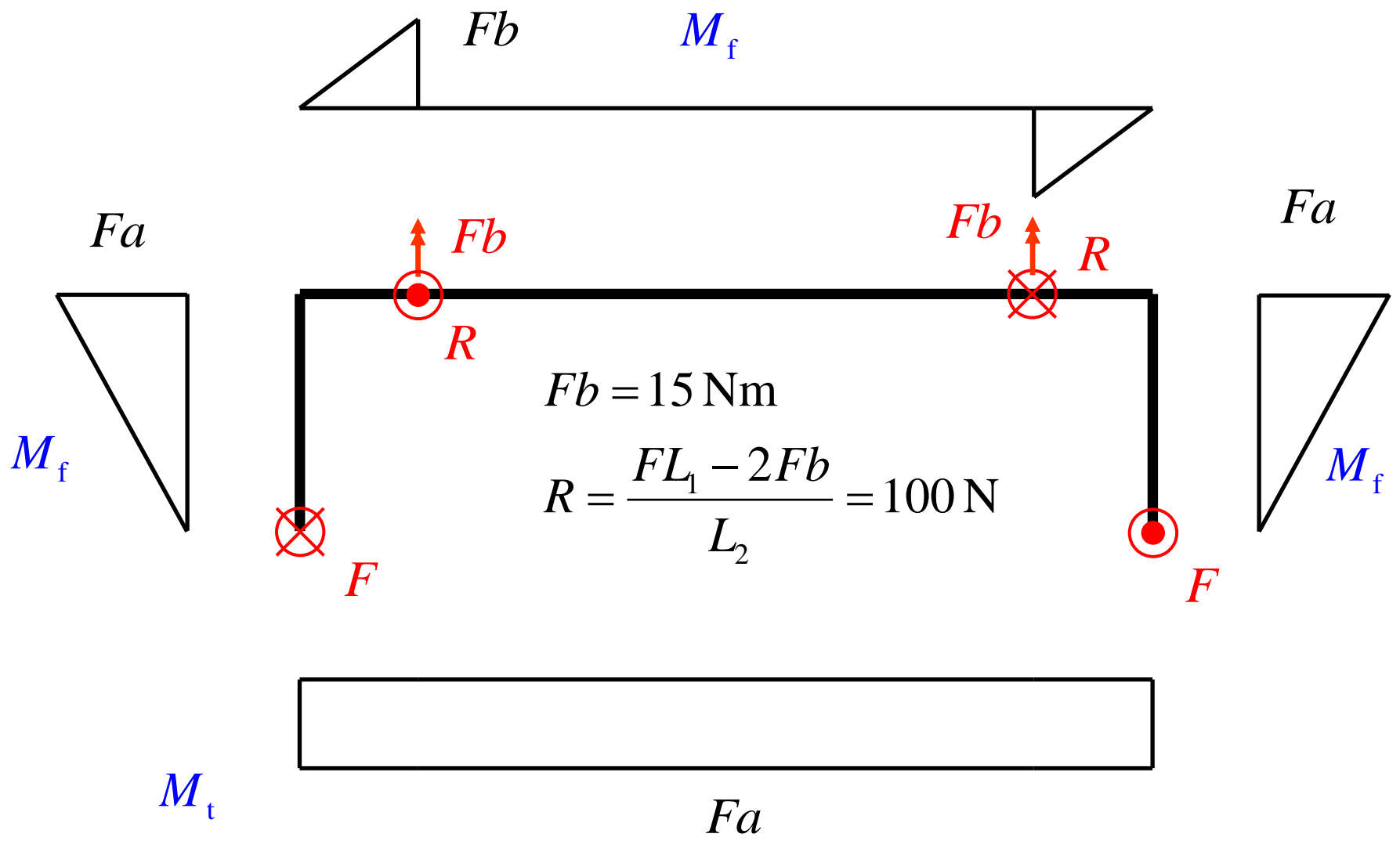
Definition	
Type	Force Reaction
Location Method	Boundary Condition
Boundary Condition	Cerniera_1
Orientation	Global Coordinate System
Suppressed	No
Options	
Result Selection	All
<input type="checkbox"/> Display Time	End Time
Results	
<input type="checkbox"/> X Axis	0. N
<input type="checkbox"/> Y Axis	146.87 N
<input type="checkbox"/> Z Axis	0. N
<input type="checkbox"/> Total	146.87 N



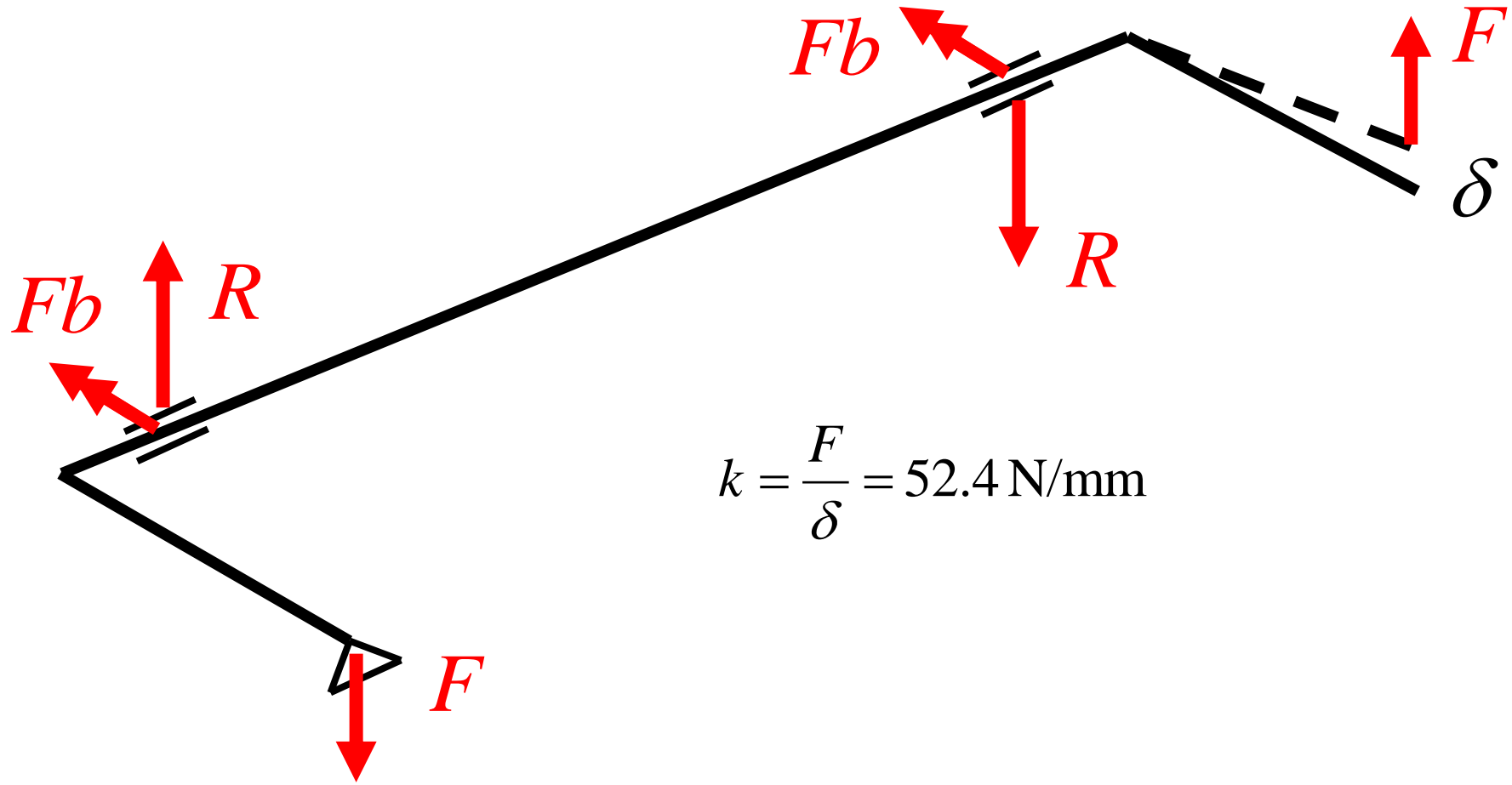
Modello a trave per il calcolo della rigidezza, cerniere cilindriche



Modello a trave per il calcolo della rigidezza



Modello a trave per il calcolo della rigidità,
integrale di Mohr



$$k = \frac{F}{\delta} = 52.4 \text{ N/mm}$$

$$\delta = 2 \int_0^a F \frac{x^2}{EI} dx + 2 \int_0^b F \frac{x^2}{EI} dx + 2 \int_0^{L_2/2} F \frac{x^2}{EI} \left(\frac{b}{L_2/2} \right)^2 dx + \int_0^{L_1} F \frac{a^2}{GI_0} dx =$$

$$= 2 \frac{F}{EI} \frac{a^3}{3} + 2 \frac{F}{EI} \frac{b^3}{3} + 2(R-F) \frac{(L_2/2)^3}{3EI} + F \frac{a^3}{GI_0} L_1 = 1.908 \text{ mm}$$

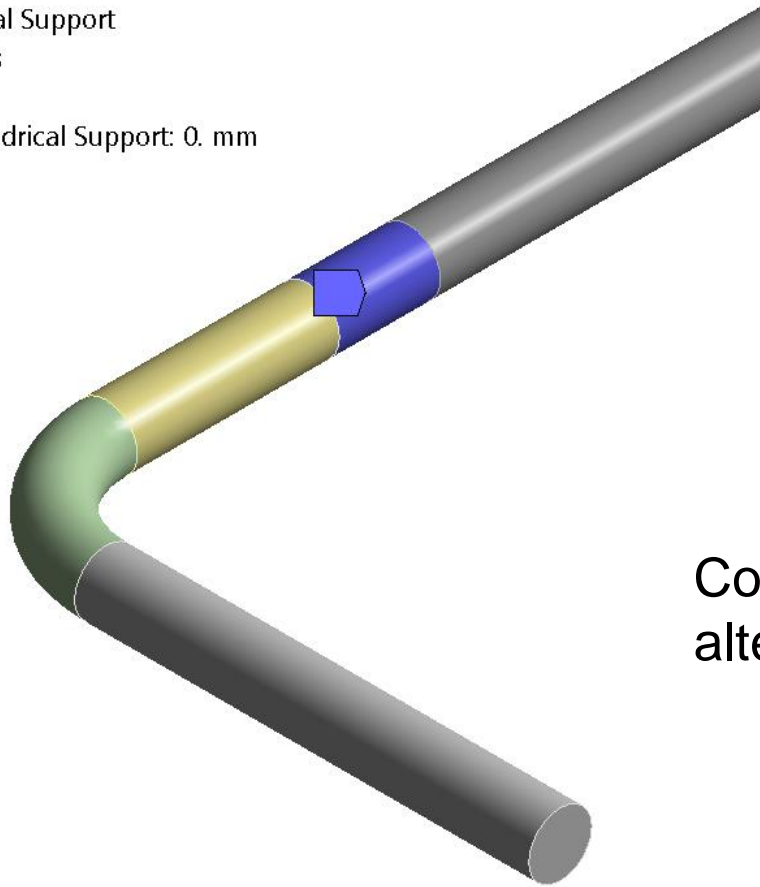
Vincolo cilindrico

A: Static Structural

Cylindrical Support

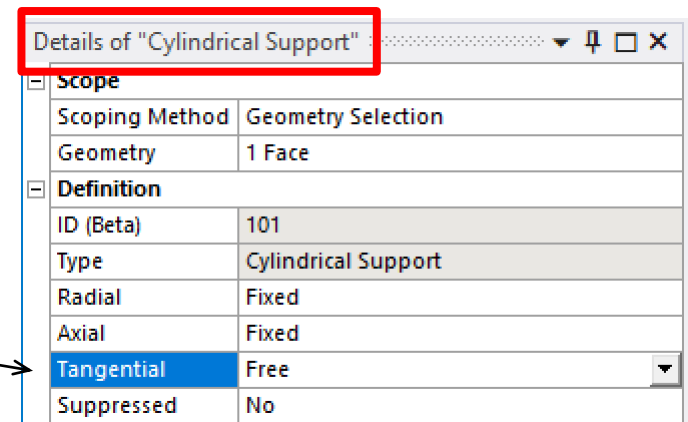
Time: 1. s

 Cylindrical Support: 0. mm



Condizione di vincolo alternativa a spost. remoto

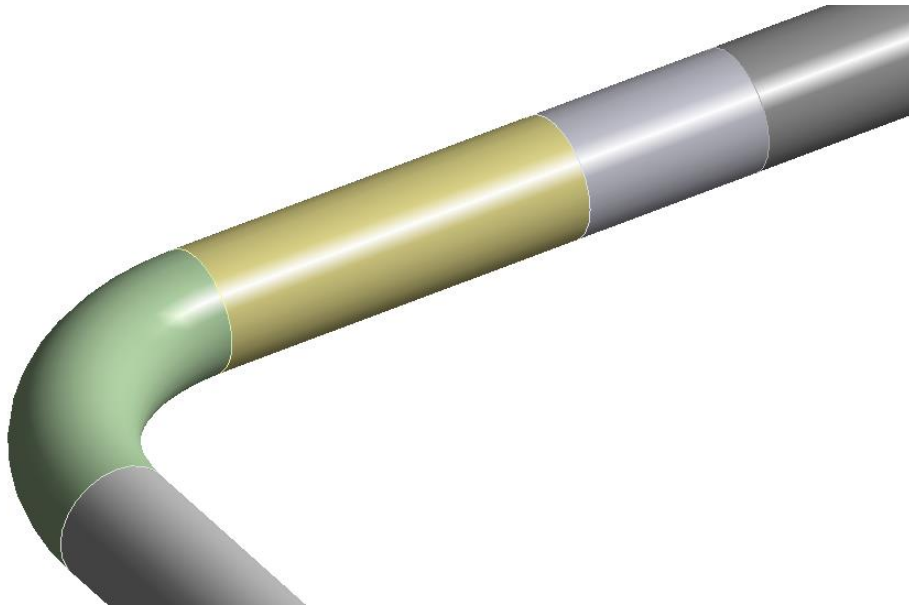
Rotazione libera



Details of "Cylindrical Support"	
[-] Scope	
Scoping Method	Geometry Selection
Geometry	1 Face
[-] Definition	
ID (Beta)	101
Type	Cylindrical Support
Radial	Fixed
Axial	Fixed
Tangential	Free
Suppressed	No

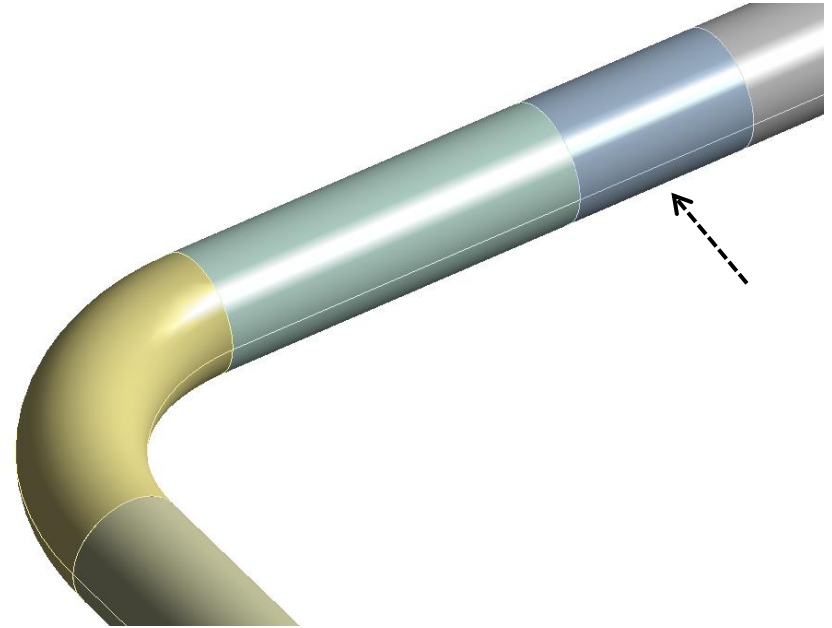
Vincolo cilindrico

Differente importazione:



Parasolid:

Effettiva superficie cilindrica,
utilizzo del vincolo cilindrico
possibile



Iges:

Superficie cilindrica 'spezzata',
utilizzo del vincolo cilindrico
non possibile, tuttavia possibile
spost. remoto

Vincolo di spostamento remoto

A: Static Structural

Cerniera_1

Time: 1. s

■ Cerniera_1

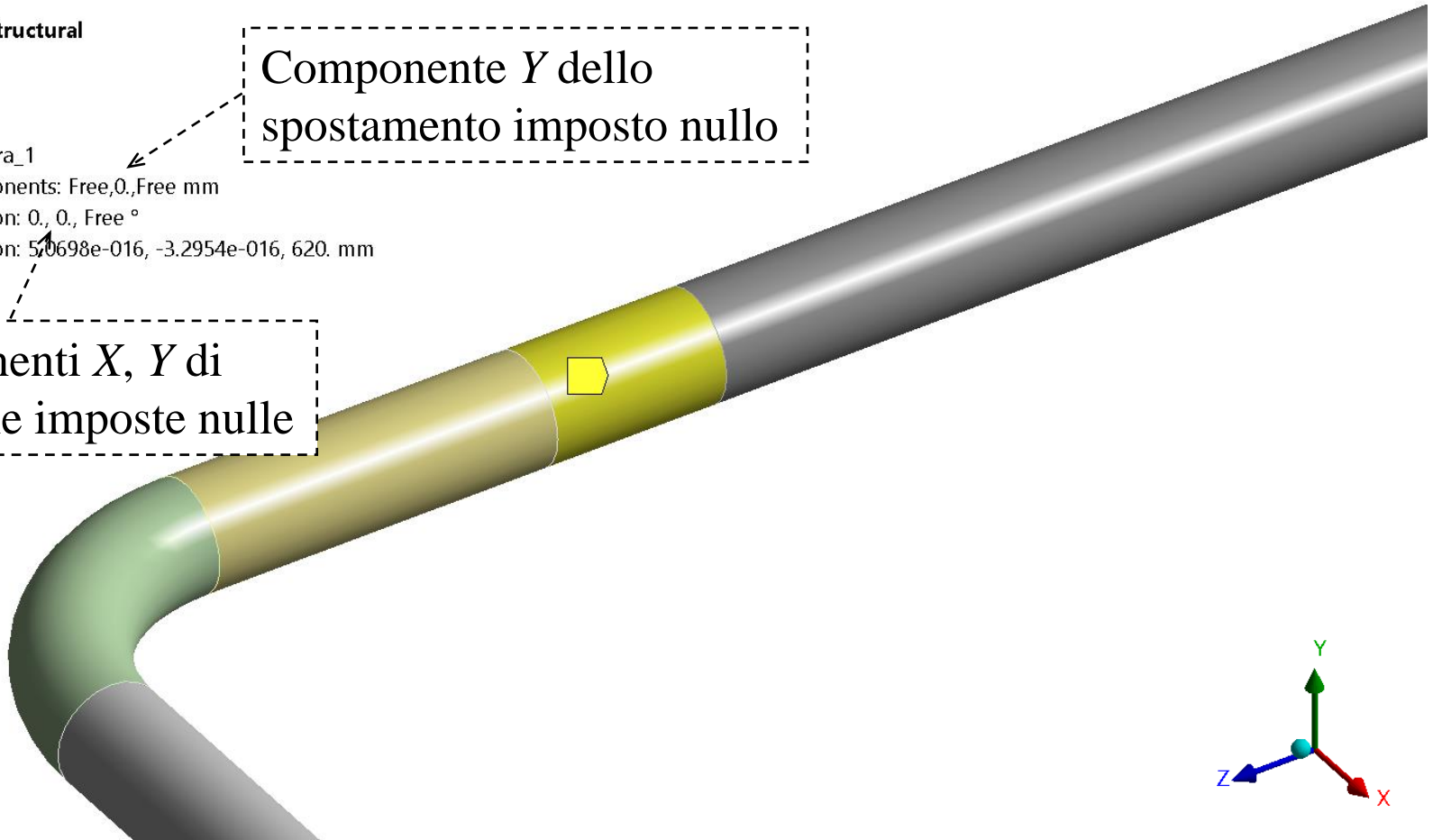
Components: Free,0.,Free mm

Rotation: 0., 0., Free °

Location: 5.0698e-016, -3.2954e-016, 620. mm

Componente Y dello
spostamento imposto nullo

Componenti X , Y di
rotazione imposte nulle



Vincolo di spostamento remoto

A: Static Structural

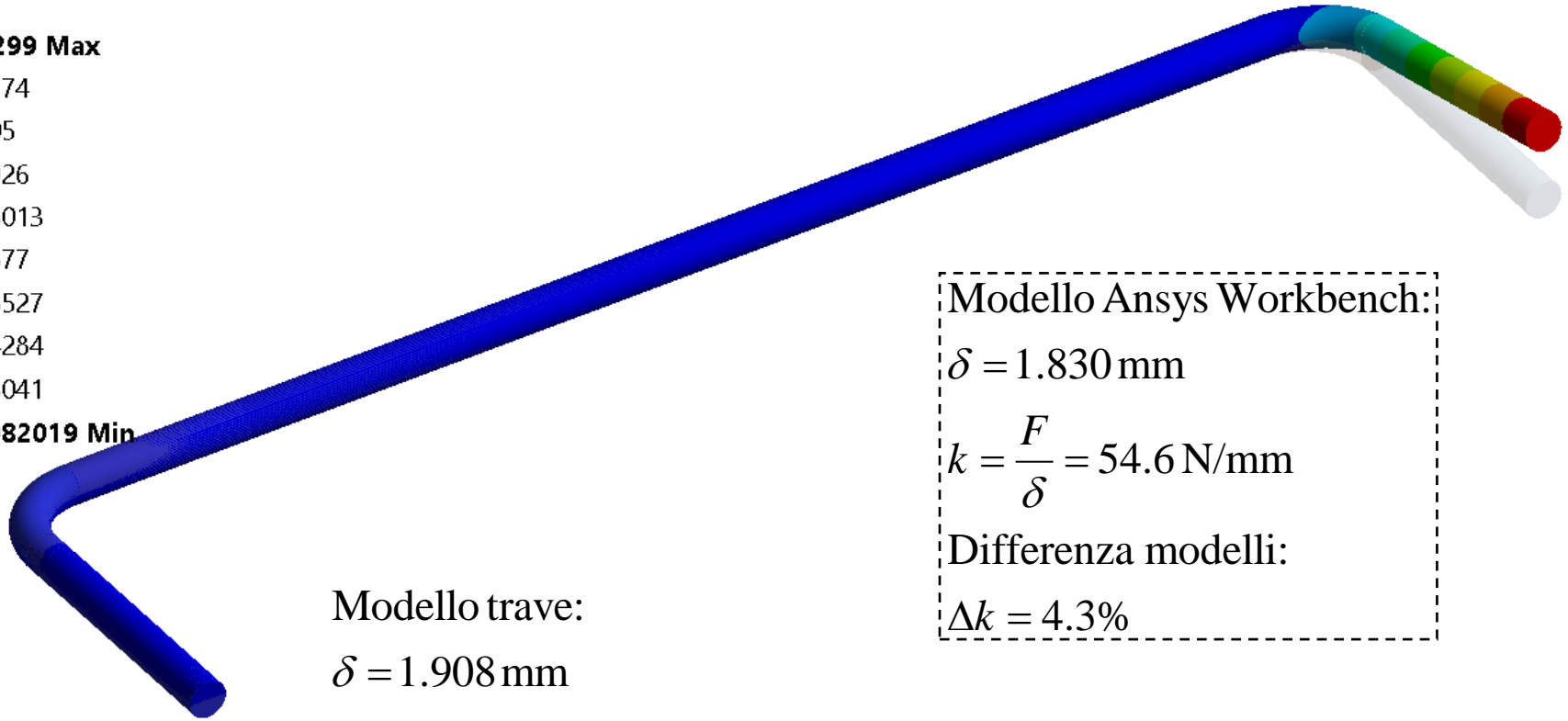
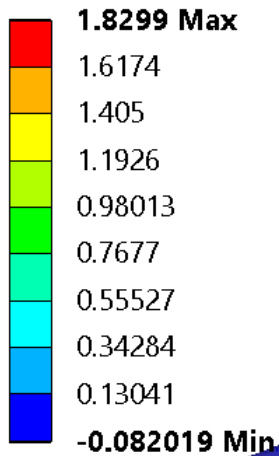
Directional Deformation

Type: Directional Deformation(Y Axis)

Unit: mm

Global Coordinate System

Time: 1



Modello trave:

$$\delta = 1.908 \text{ mm}$$

$$k = \frac{F}{\delta} = 52.4 \text{ N/mm}$$

Modello Ansys Workbench:

$$\delta = 1.830 \text{ mm}$$

$$k = \frac{F}{\delta} = 54.6 \text{ N/mm}$$

Differenza modelli:

$$\Delta k = 4.3\%$$

Reazioni vincolari, forza di reazione cerniera

Outline

Name Search Outline

- Project*
 - Model (A4)
 - Geometry
 - Materials
 - Coordinate Systems
 - Connections
 - Mesh
 - Static Structural (A5)
 - Analysis Settings
 - Cerniera_1
 - Cerniera_2
 - Spost_Y
 - Force
 - Cylindrical Support
 - Solution (A6)
 - Solution Information
 - Directional Deformation
 - Force Reaction

Details of "Force Reaction"

Definition

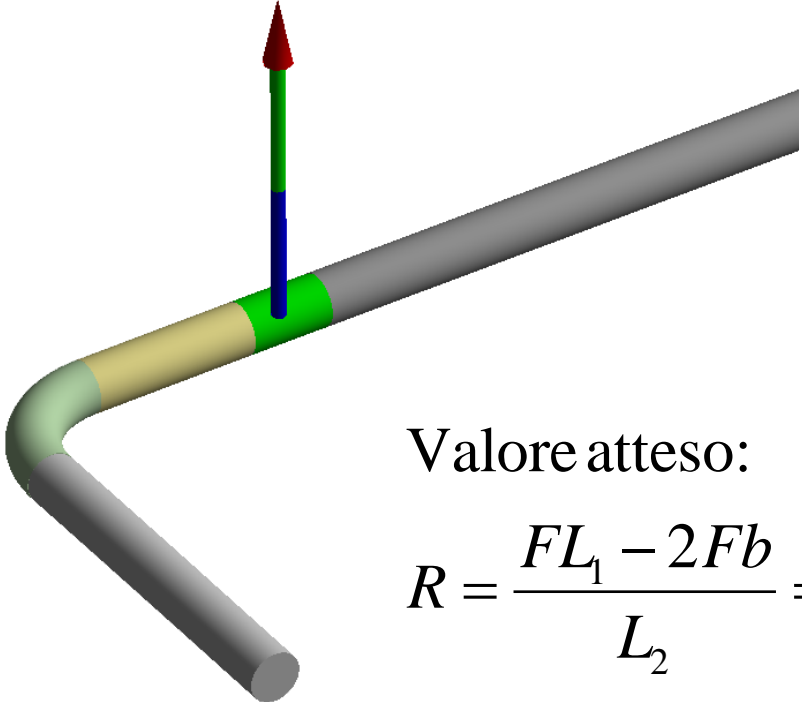
Type	Force Reaction
Location Method	Boundary Condition
Boundary Condition	Cerniera_1
Orientation	Global Coordinate System
Suppressed	No

Options

Result Selection	All
<input type="checkbox"/> Display Time	End Time

Results

<input type="checkbox"/> X Axis	0. N
<input type="checkbox"/> Y Axis	98.155 N
<input type="checkbox"/> Z Axis	0. N
<input type="checkbox"/> Total	98.155 N



Valore atteso:

$$R = \frac{FL_1 - 2Fb}{L_2} = 100 \text{ N}$$

Valore ottenuto:

$$R_{EF} = 98.155 \text{ N}$$

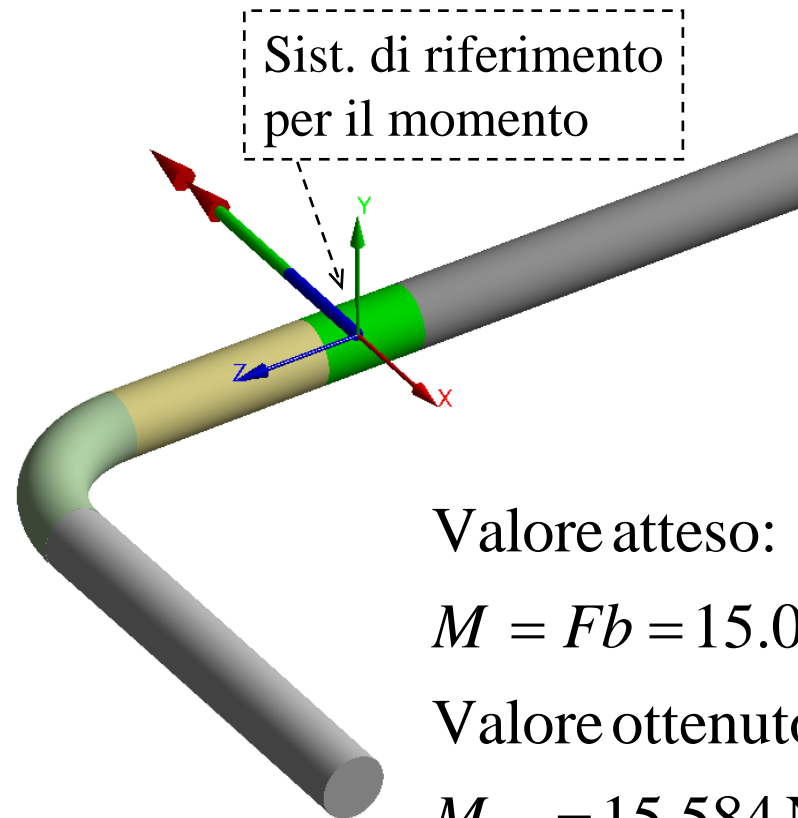
Reazioni vincolari, momento di reazione cerniera

Outline

- Global Coordinate System
- Coordinate System - c1
- Coordinate System - c2
- Connections
- Mesh
- Static Structural (A5)
 - Analysis Settings
 - Cerniera_1
 - Cerniera_2
 - Spost_Y
 - Force
 - Cylindrical Support
- Solution (A6)
 - Solution Information
 - Directional Deformation
 - Force Reaction
 - Force Reaction 2
 - Moment Reaction
 - Moment Reaction 2

Details of "Moment Reaction"

Definition	
Type	Moment Reaction
Location Method	Boundary Condition
Boundary Condition	Cerniera_1
Orientation	Coordinate System - c1
Suppressed	No
Options	
Result Selection	All
<input type="checkbox"/> Display Time	End Time
Results	
<input type="checkbox"/> X Axis	-15584 N·mm
<input type="checkbox"/> Y Axis	6.1415e-002 N·mm
<input type="checkbox"/> Z Axis	0. N·mm
<input type="checkbox"/> Total	15584 N·mm



Valore atteso:

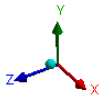
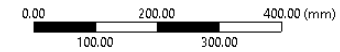
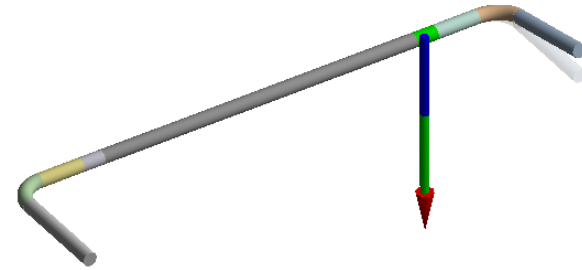
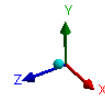
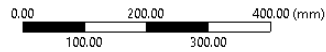
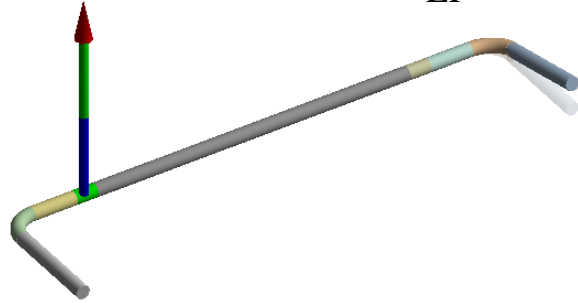
$$M = Fb = 15.0 \text{ Nm}$$

Valore ottenuto:

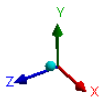
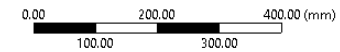
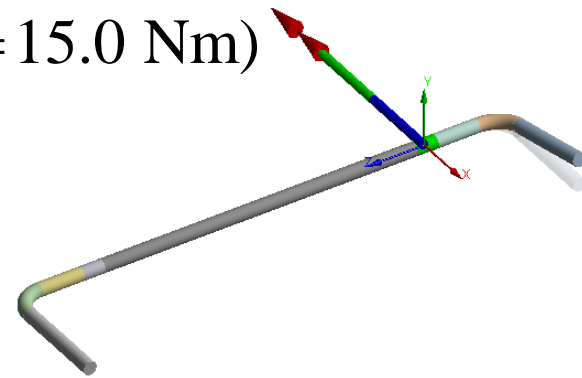
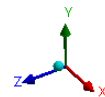
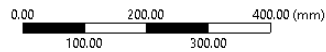
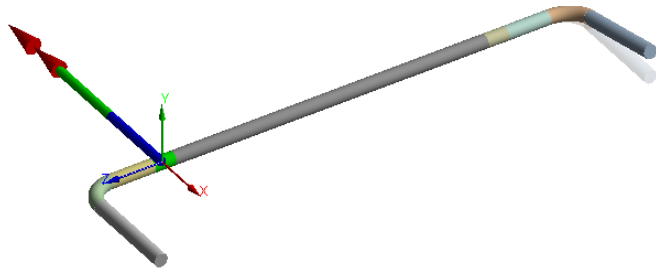
$$M_{EF} = 15.584 \text{ Nm}$$

Reazioni vincolari, forze e momenti delle cerniere

$$R_{EF} = 98.155 \text{ N} \quad (R = 100 \text{ N})$$



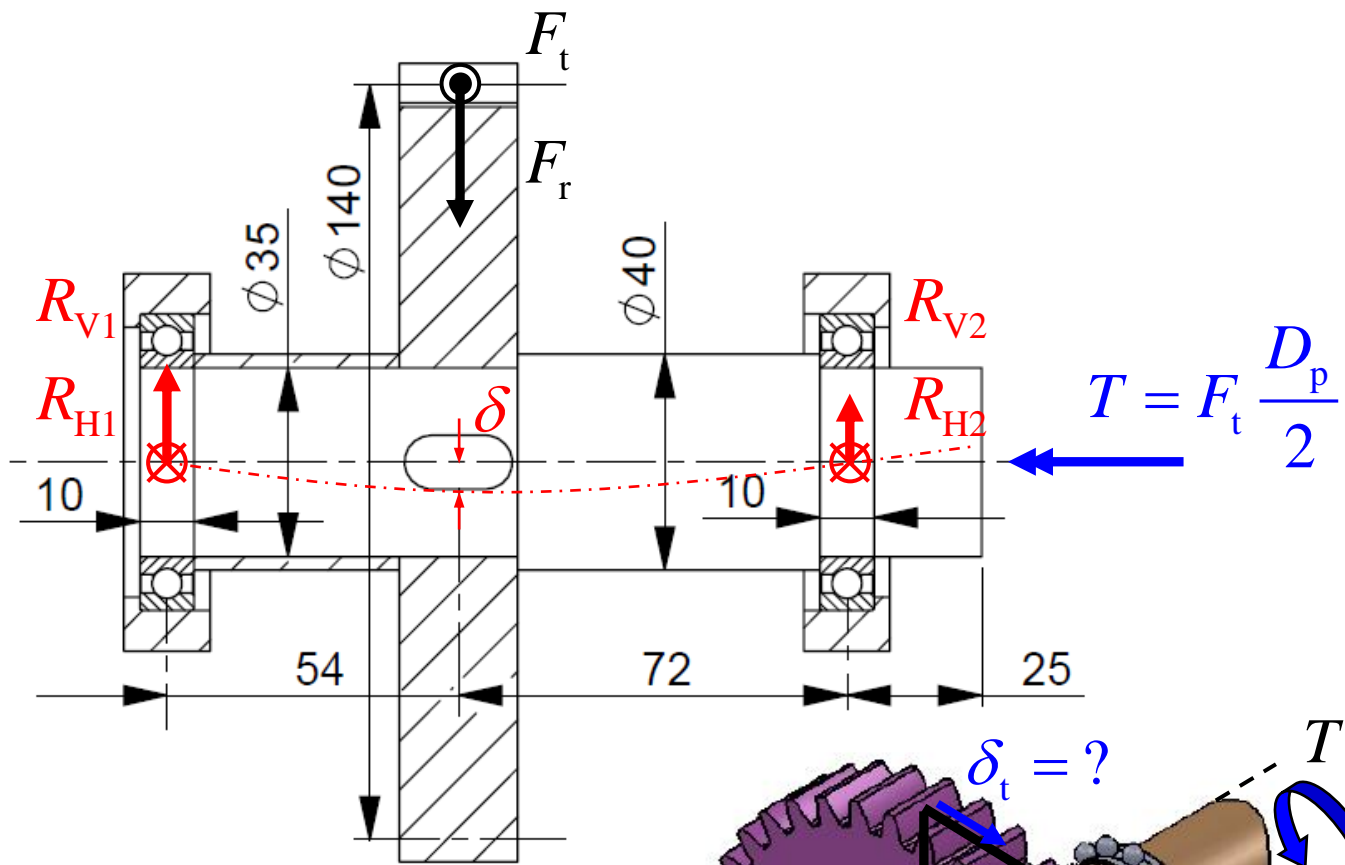
$$M_{EF} = 15.584 \text{ Nm} \quad (Fb = 15.0 \text{ Nm})$$



Sommario Lez. 6

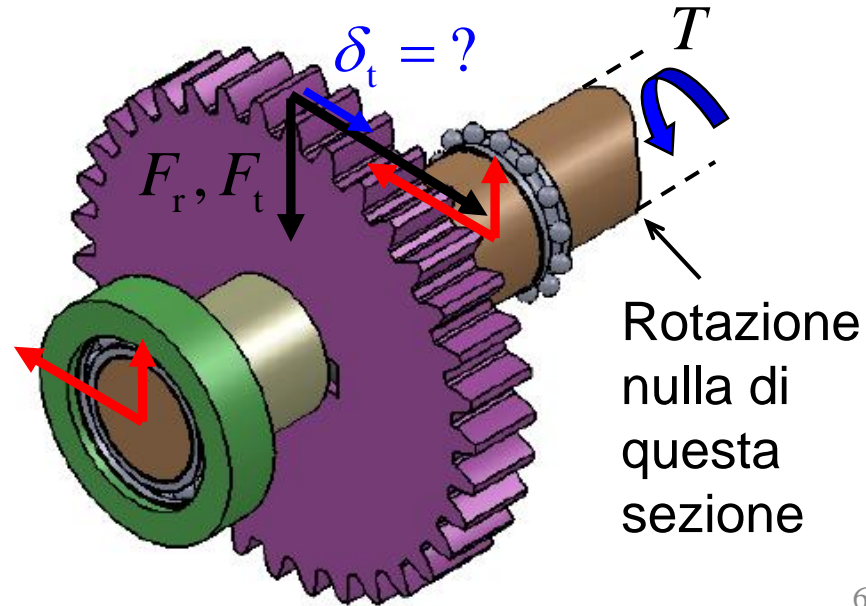
1. Utilizzo dei vincoli di **Spostamento Remoto**
2. Riferimento ad un punto rispetto al quale è possibile definire le componenti di **Spostamento** e **Rotazione**
3. Esempio di utilizzo: Alberi/Assi vincolati mediante supporti

Esercitazione da svolgere: Albero – Ruota dentata a denti dritti



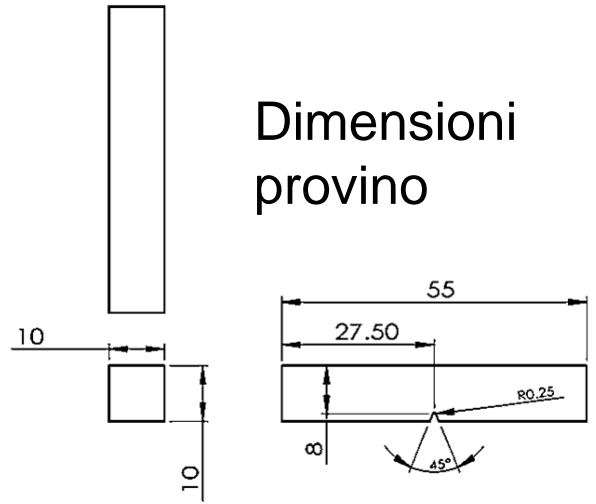
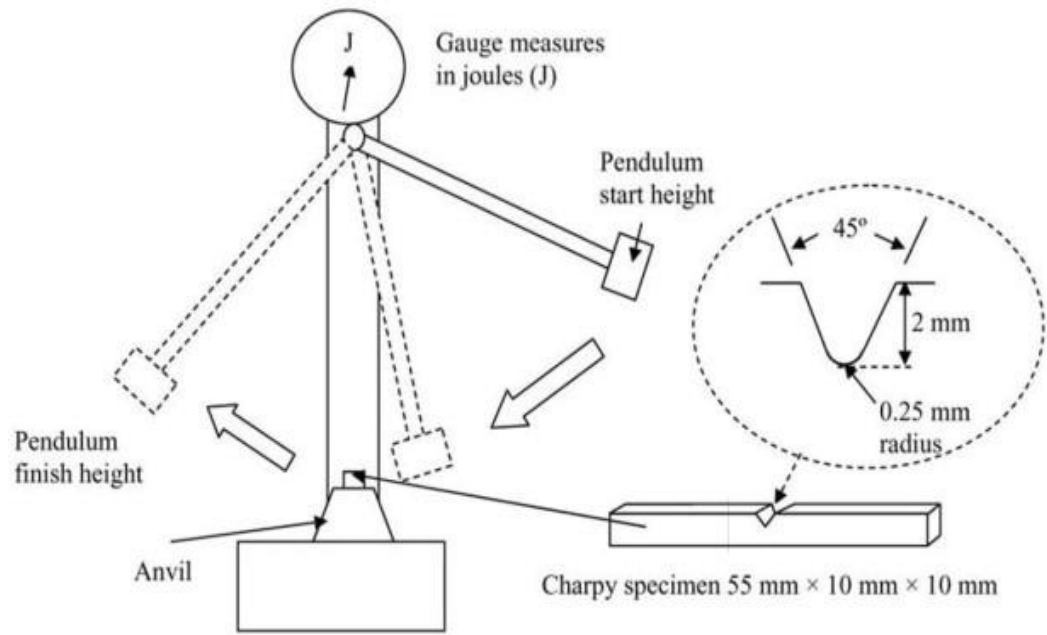
$T = 200 \text{ N m}$
 $F_t = 2857 \text{ N}$
 $F_r = 1040 \text{ N}$

Calcolo spostamento:
 $\delta_t = ?$

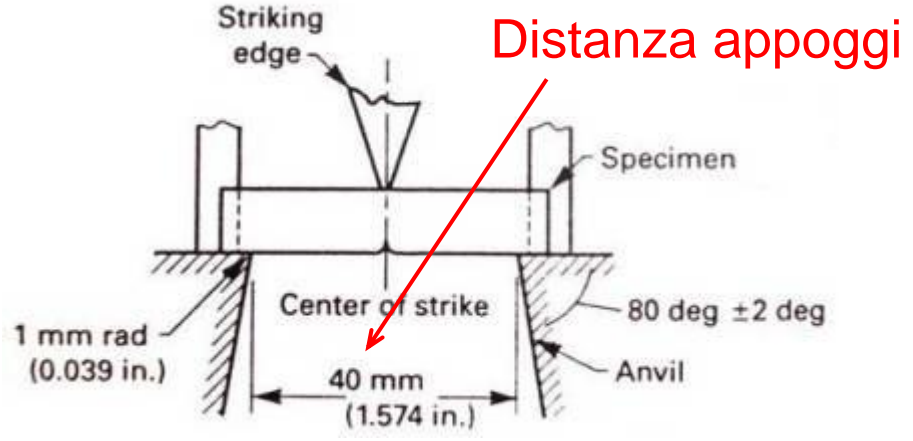
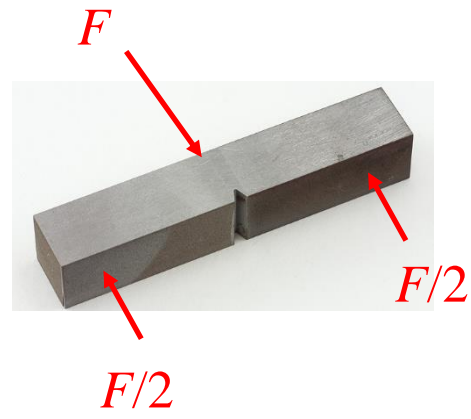


Lez. 7. Uso del sottomodello

Esempio di modellazione del provino di Charpy

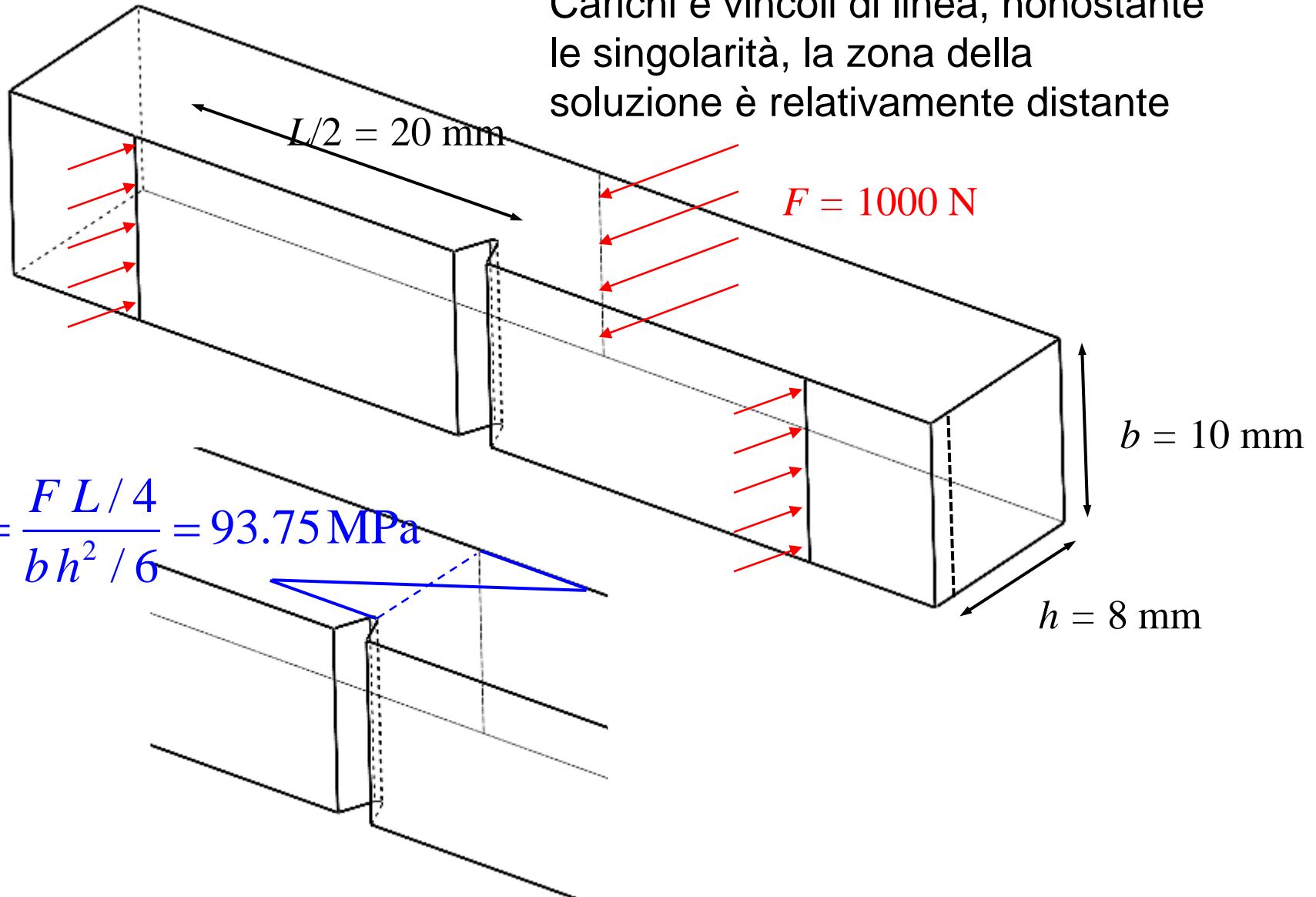


Dimensioni provino



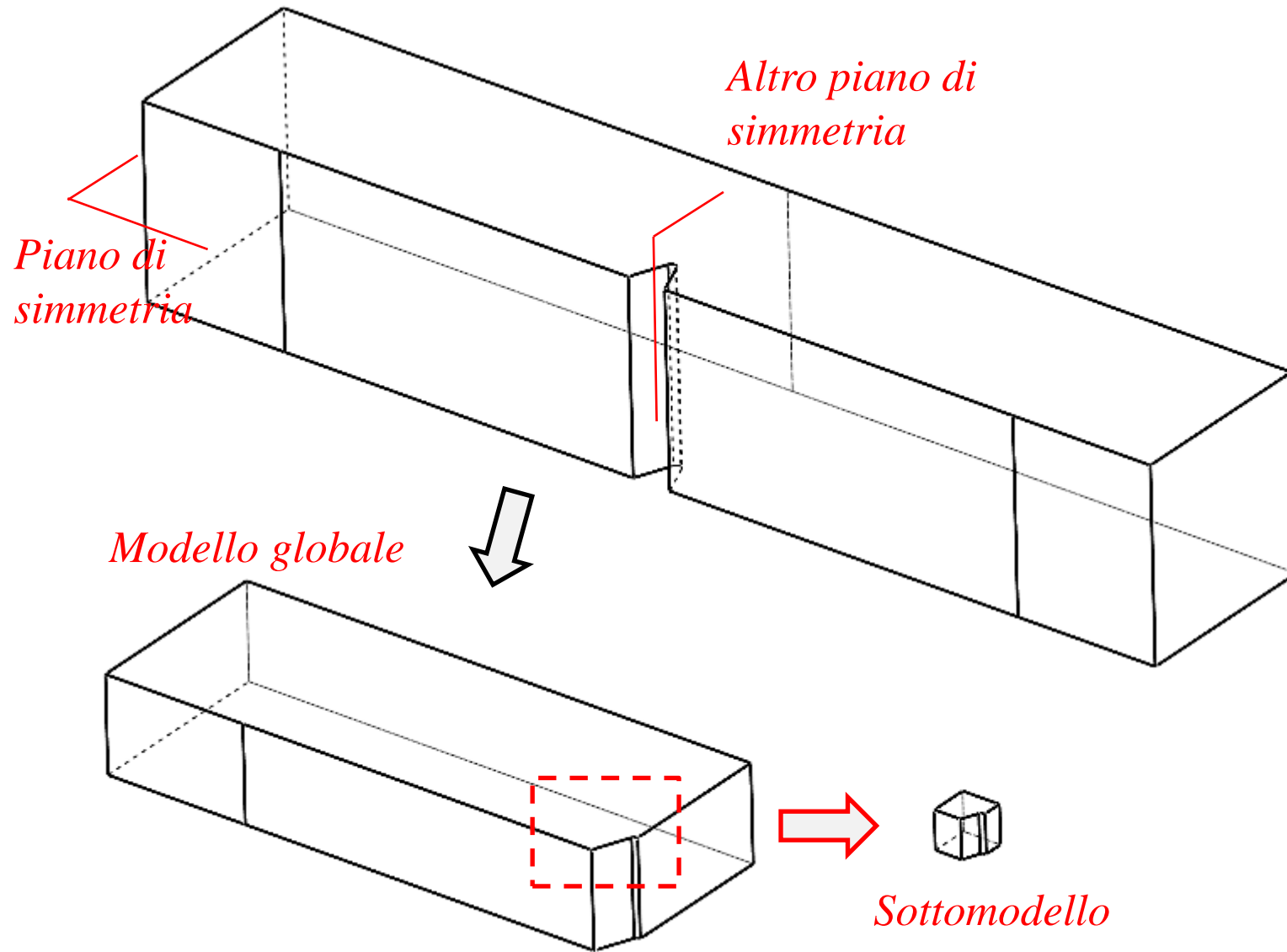
Tensione nominale

Carichi e vincoli di linea, nonostante le singolarità, la zona della soluzione è relativamente distante

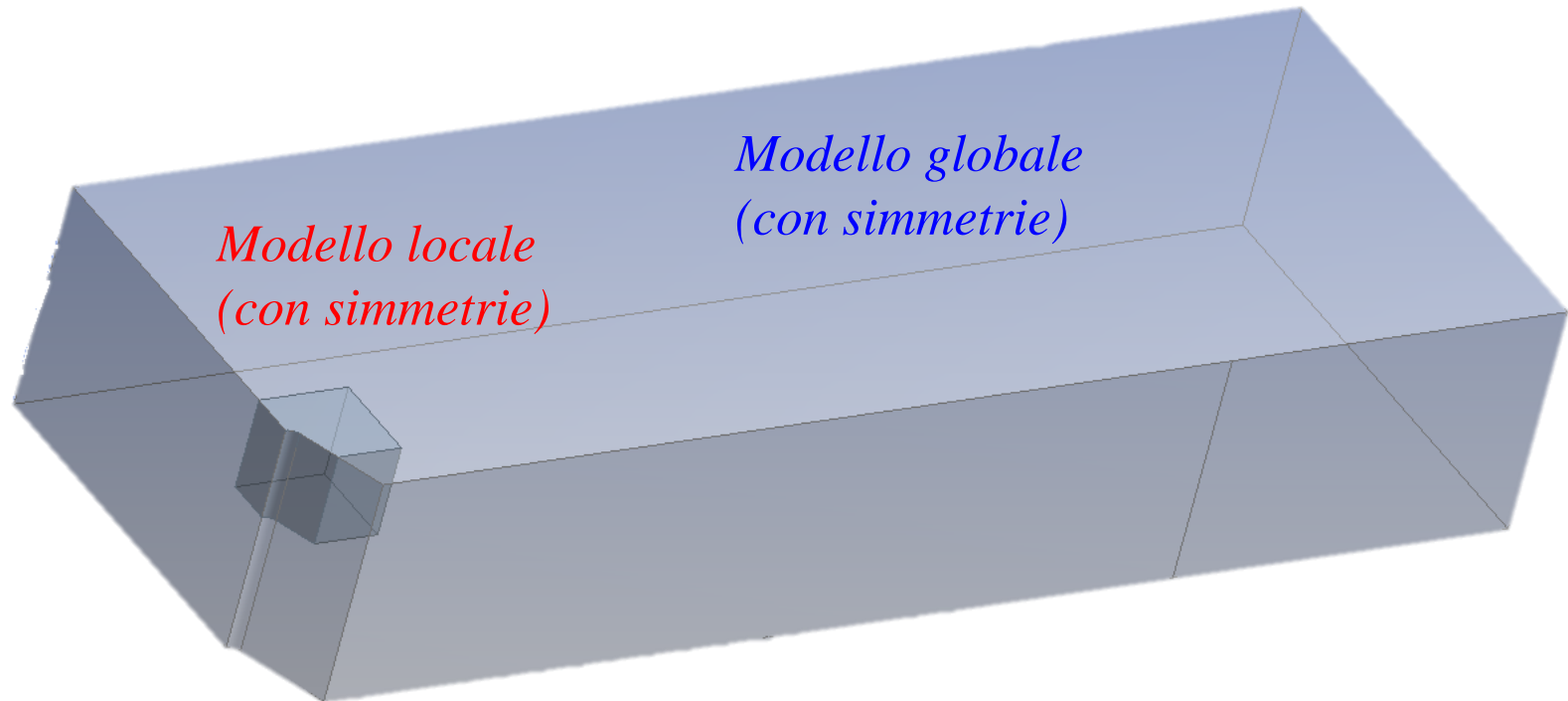


$$\sigma_{\text{nom}} = \frac{F L / 4}{b h^2 / 6} = 93.75 \text{ MPa}$$

Modello CAD, simmetrie e sottomodello



Modello CAD, simmetrie e sottomodello

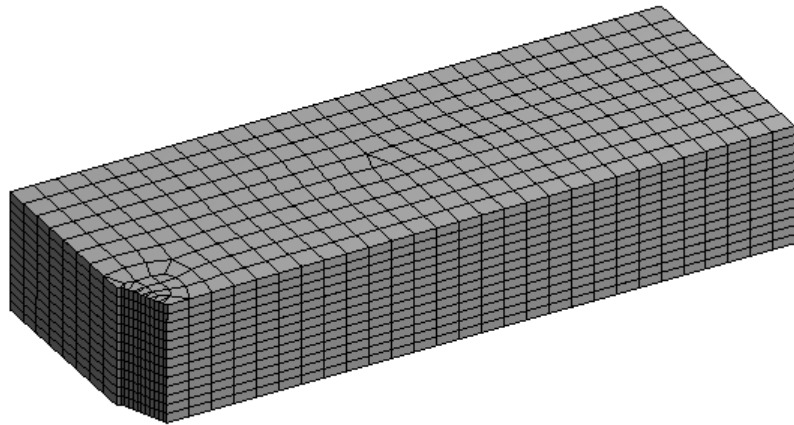
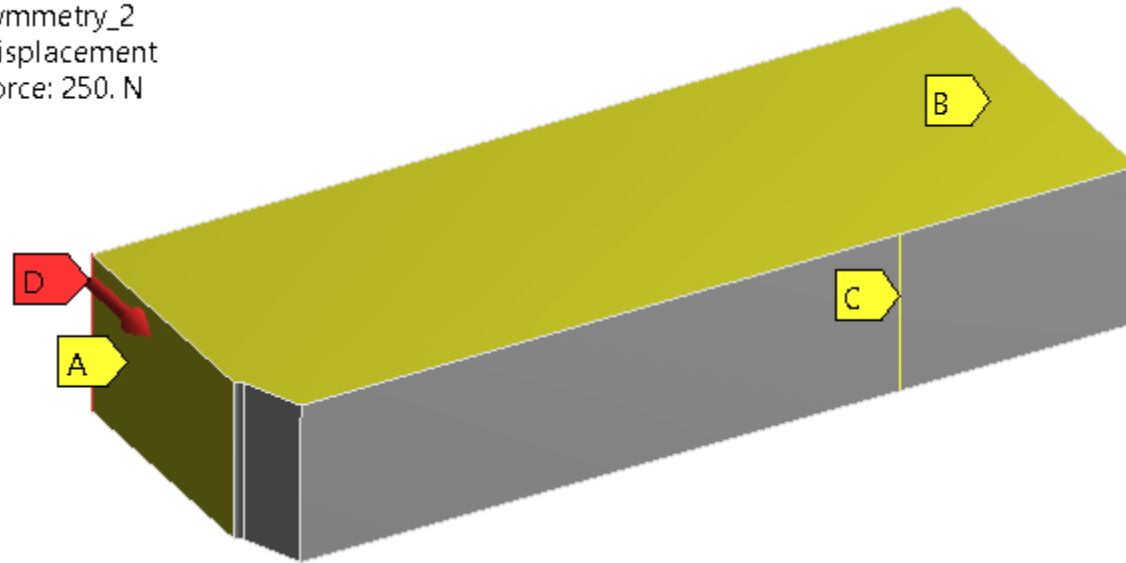


N.B.: I due modelli geometrici non compariranno insieme ma ciascuno in analisi separate

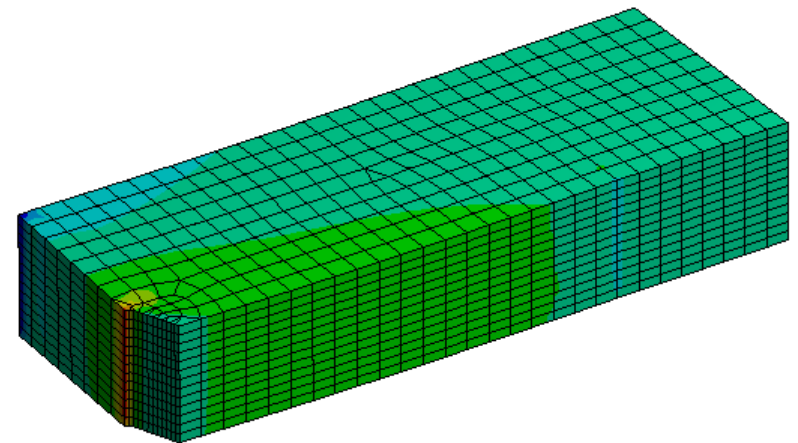
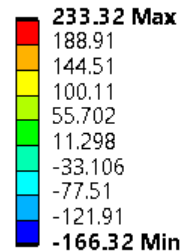
Analisi Workbench del modello globale

- A** Symmetry_1
- B** Symmetry_2
- C** Displacement
- D** Force: 250. N

Condizioni di vincoli e carico, considerando le simmetrie

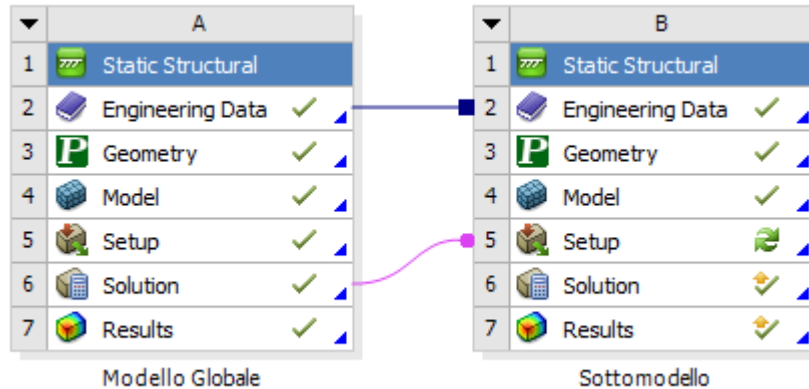


Mesh relativamente grossolana

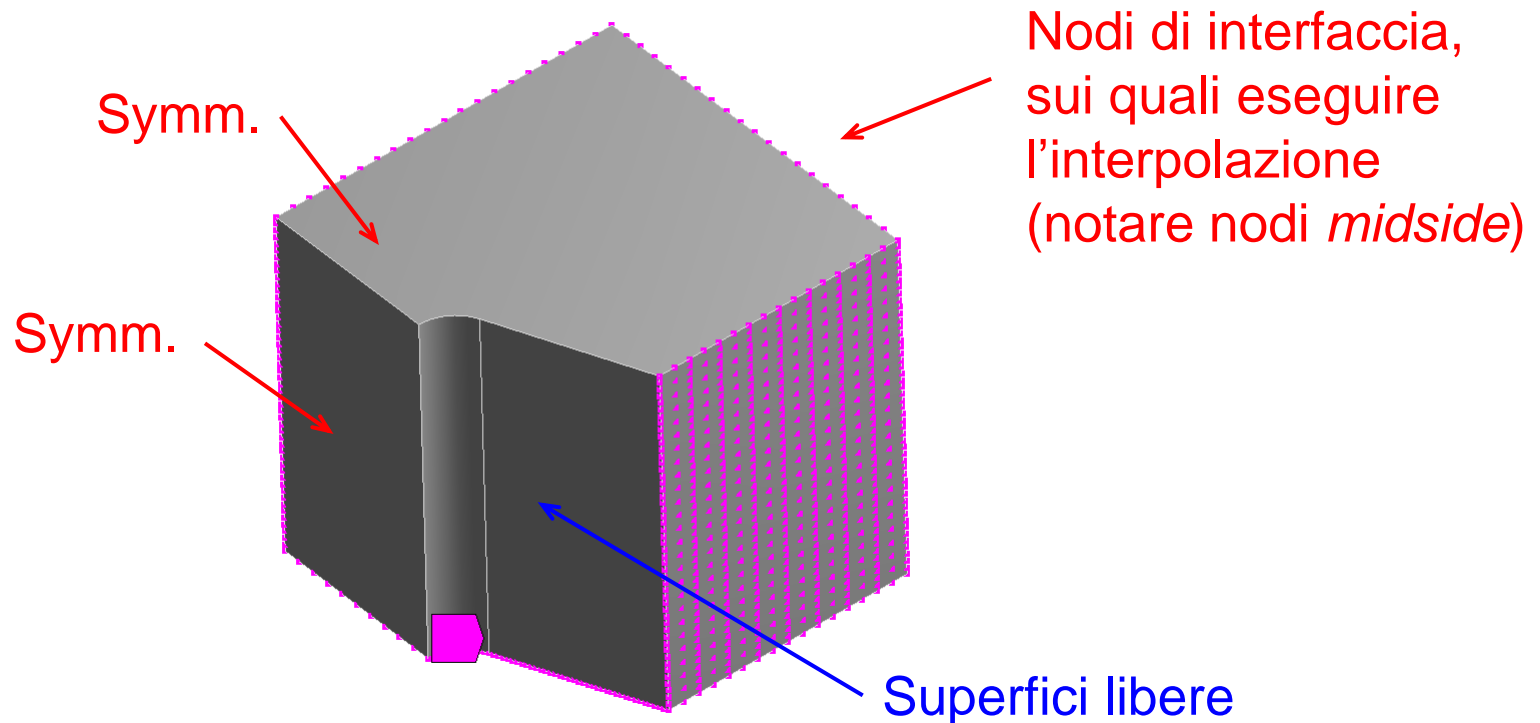


Risultato modello globale, effetti singolarità molto modesti

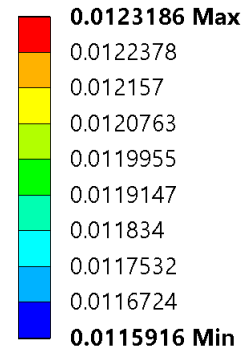
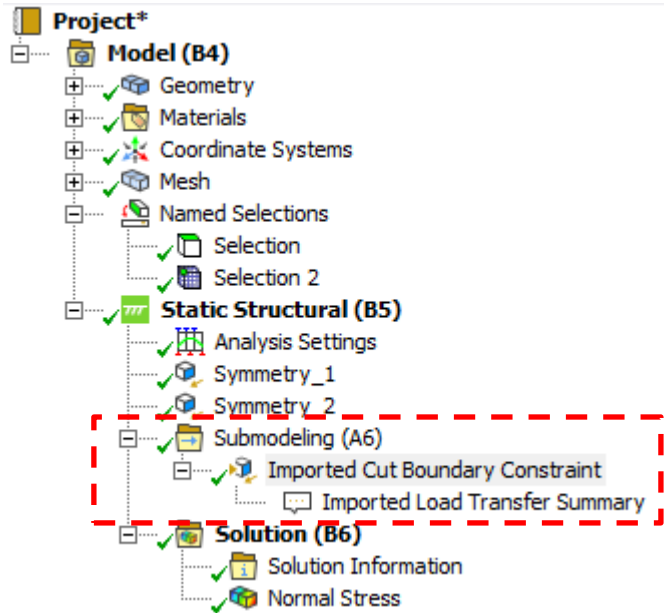
Trasferimento al modello locale



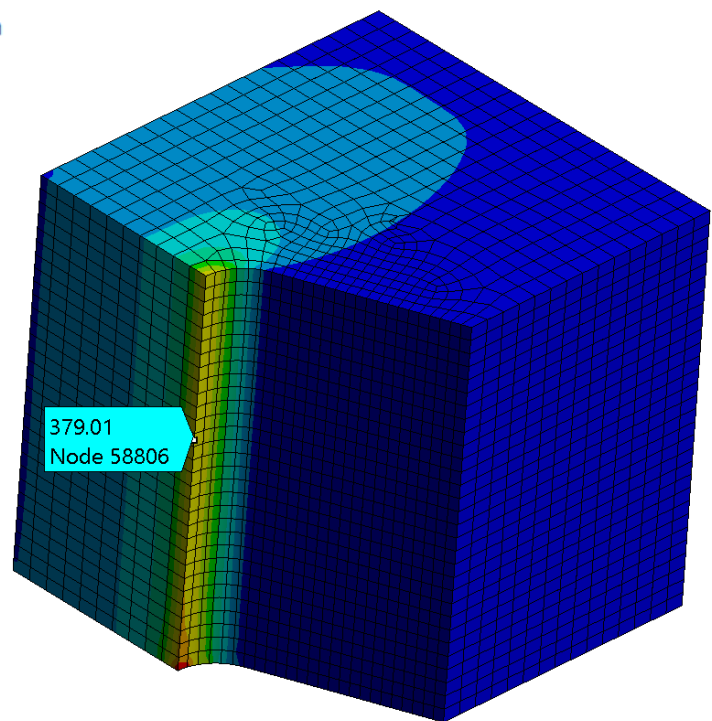
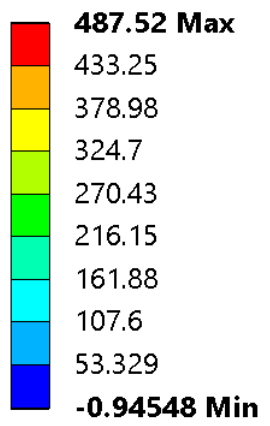
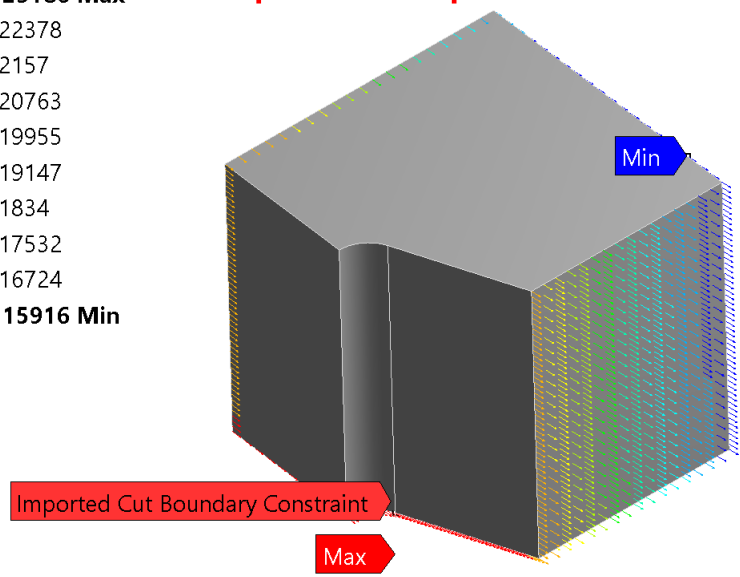
La soluzione del primo modello diventa il carico (o una componente di carico) del secondo modello



Trasferimento al modello locale



Campo di spostamenti per interpolazione



Risultato sottomodello

$$K_t = \frac{\sigma_{\max}}{\sigma_{\text{nom}}} = \frac{379.01}{93.75} = 4.04$$

Sommario Lez. 7

1. Utilizzo della tecnica del **Sottomodello**
2. Possibilità di eseguire analisi con **ridotto** numero di gradi di libertà, raggiungendo comunque un'ottima **precisione**.
3. Esempio di utilizzo: Calcolo di un K_t di un **componente 3D**.