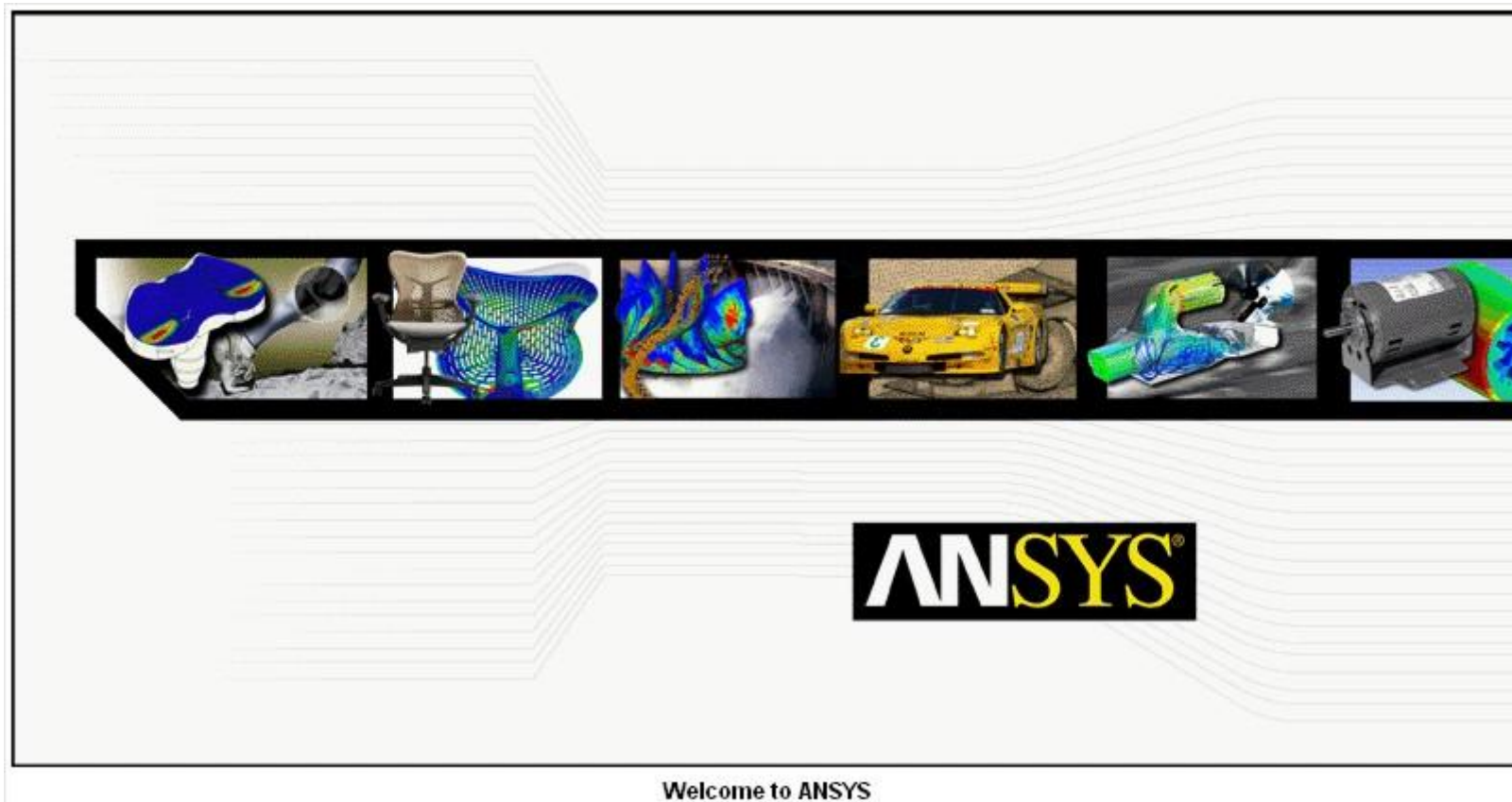


Rīgas Tehniskā universitāte Materiālu un Konstrukciju institūts

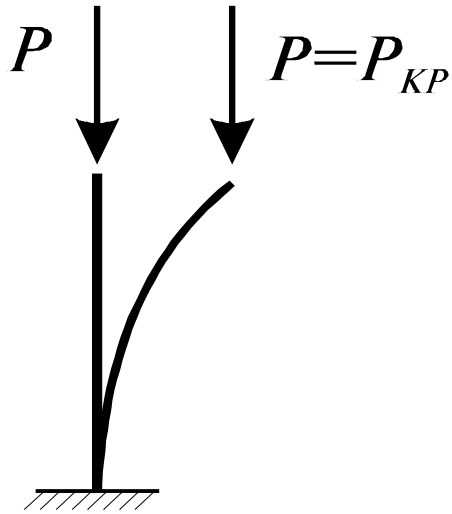
Uzdevums: Spiestu Stieņu Noturība

Programma: ANSYS 9

Autori: A. Kovaļovs



Spiedes spēka analītisks aprēķins



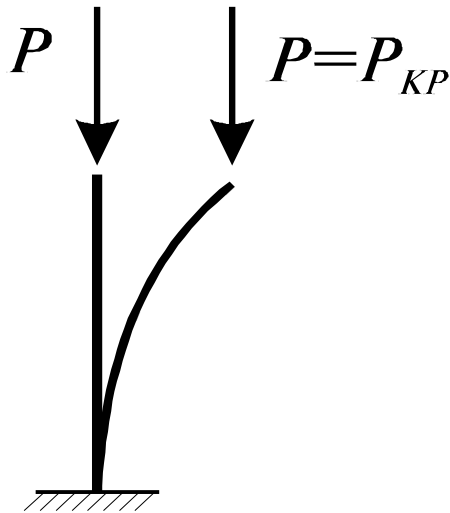
$$[P] = \frac{P_{kr}}{[n_{not}]}$$

$[P]$ - spiedes spēka pieļaujamā vērtība

P_{kr} - spiedes spēka kritiskā vērtība

$[n_{not}]$ - normatīvais noturības drošības koeficients

Eilera formula vispārīgam gadījumam:



$$P_{kr} = \frac{\pi^2 EJ}{(\mu l)^2}$$

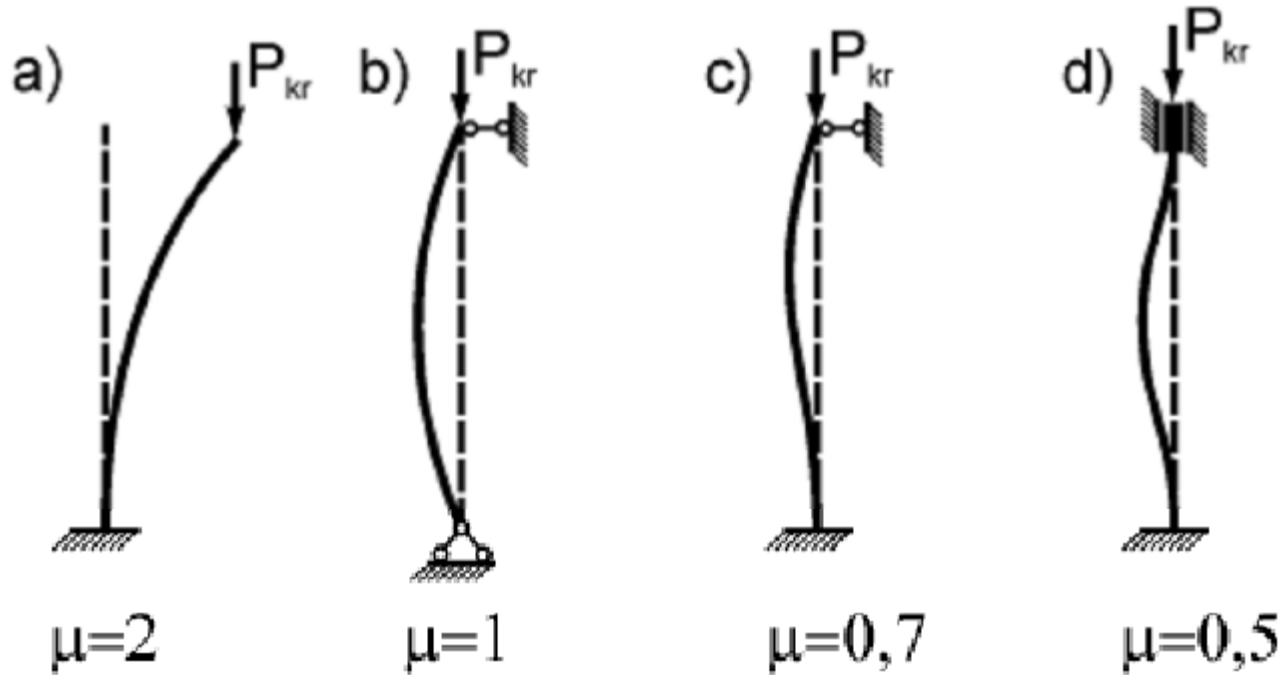
E - elastības modulis

J – aksiālais inerces moments

l - stieņa garums

μ - stieņa garuma redukcijas koeficientu

Eilera formula



$$P_{kr} = \frac{\pi^2 EI}{l^2}$$

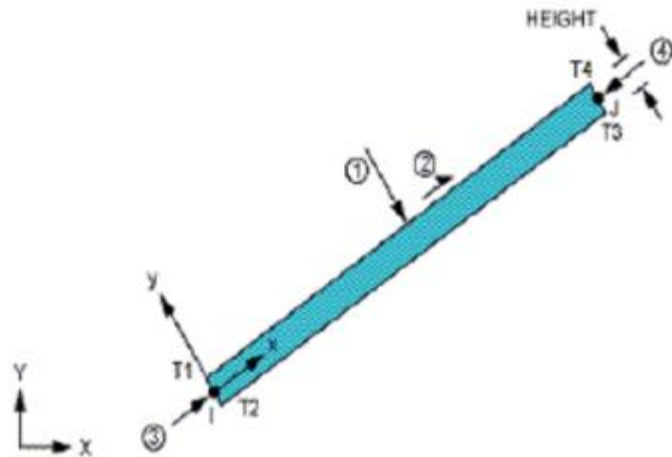
$$P_{kr} = \frac{\pi^2 EI}{4l^2}$$

$$P_{kr} = \frac{4\pi^2 EI}{l^2}$$

$$P_{kr} = \frac{2\pi^2 EI}{l^2}$$

Beam 3 2-D sijas elements

Sijas elementa Beam 3 ģeometrija



Mezgli

I, J

Brīvības pakāpes

UX, UY, ROTZ

Materiāla īpašības

AREA, IZZ, HEIGHT,

SHEARZ, ISTRN, ADDMAS

EX, ALPX, DENS, GXY, DAMP

Slodzes

Vienmērīgi izkliedētas slodzes

konstante **1** (I-J) (-y normāles virzienā),

konstante **2** (I-J) (+x perpendikulārā virzienā),

konstante **3** (I) (+x ass virzienā),

konstante **4** (J) (-x ass negatīvā virzienā).

Papildus iespējas

Materiāla šļūde

Lielas deformācijas elementā

3D sija modelēšana ar Beam3 palīdzību

$$L = 10 \text{ [m]}$$



Dubult-T profila šķērsriezums GOST 8239-89 Nr.20Б1

$$W1 = 0.1 \text{ [m]}$$

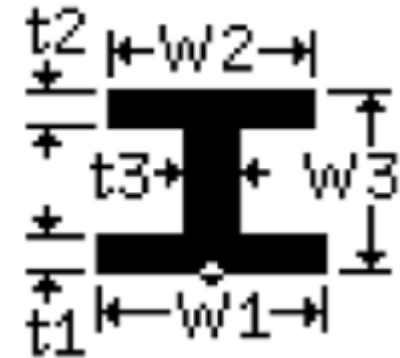
$$W2 = 0.1 \text{ [m]}$$

$$W3 = 0.2 \text{ [m]}$$

$$t1 = 0.008 \text{ [m]}$$

$$t2 = 0.008 \text{ [m]}$$

$$t3 = 0.0055 \text{ [m]}$$

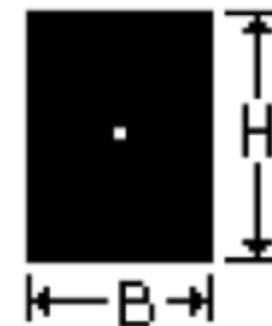


Ekvivāenta taisnstūra profila šķērsriezums

$$H = 0.2 \text{ [m]}$$

$$I = 0.0000194 \text{ [m]}$$

$$A = 0.0028 \text{ [m]}$$



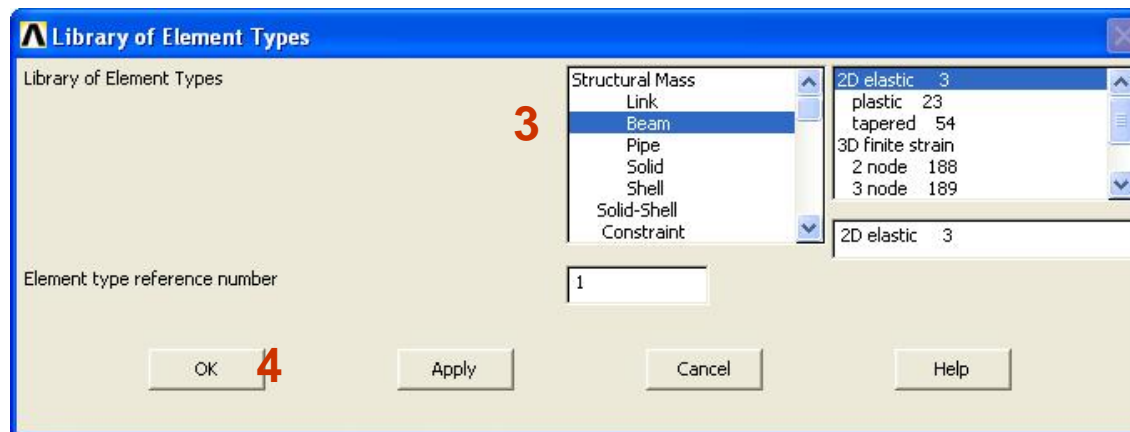
Elementa tipa definēšana – BEAM 3



(1) Preprocessor/
Element Type/
Add/Edit/Delete



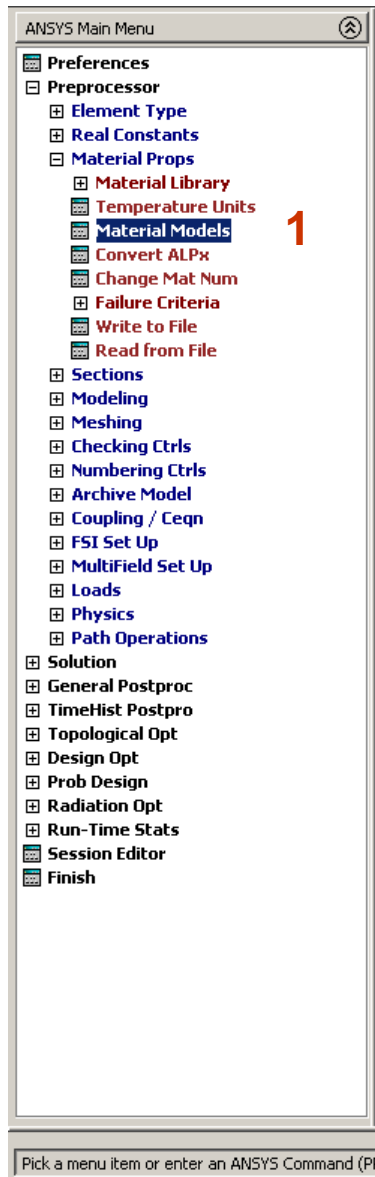
(2) Add...



(3) Beam
2D elastic 3

(4) OK

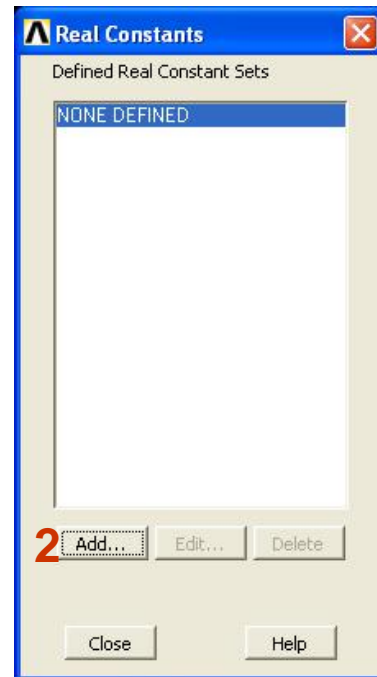
Materiāla īpašību definēšana



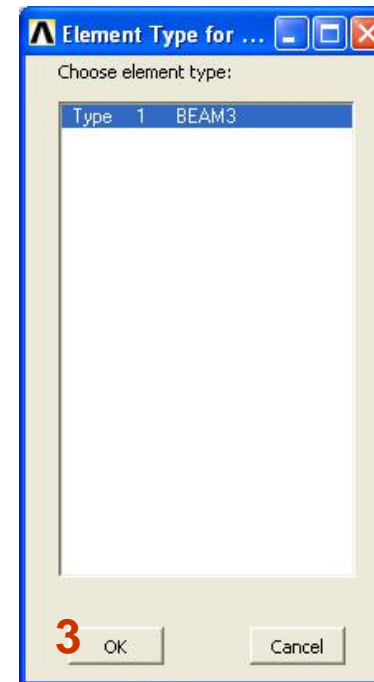
(1) Preprocessor/
Real Constants/
Add/Edit/Delete

1

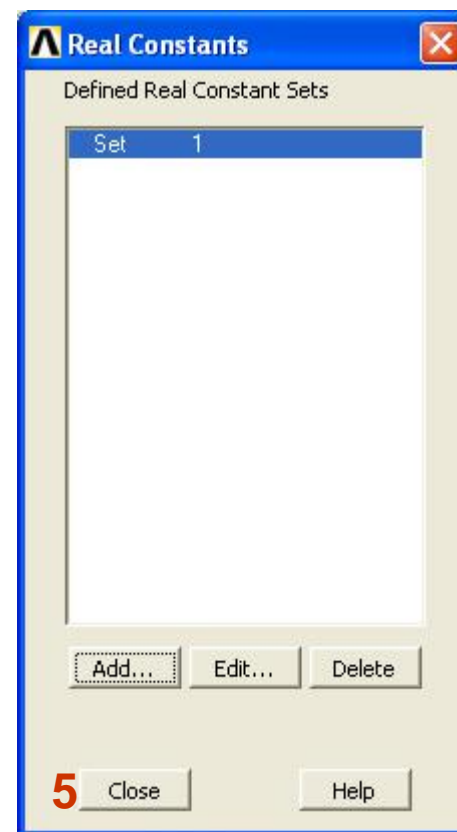
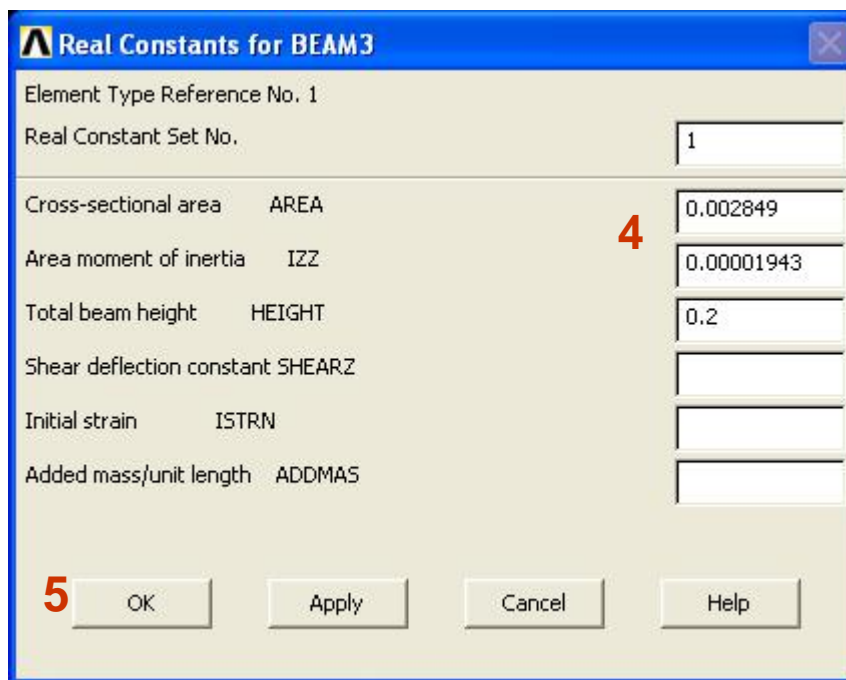
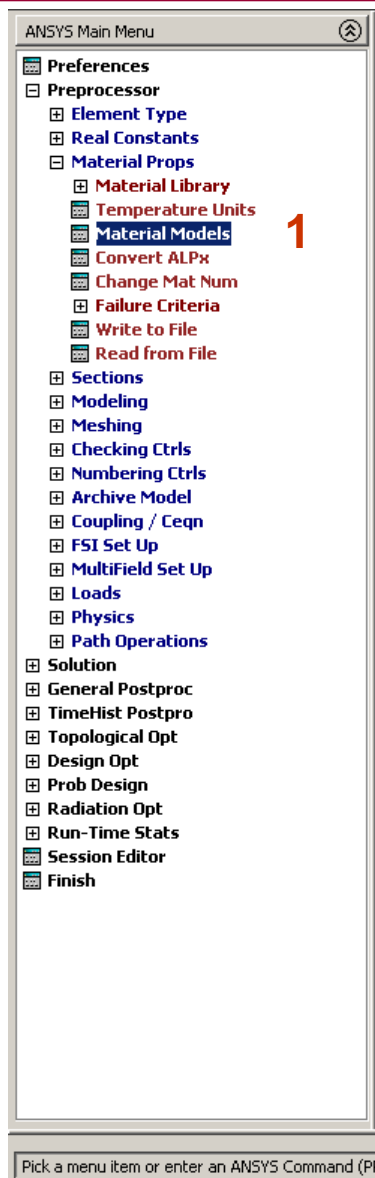
(2) Add...



(3) Ok...



Šķērsriezuma profila definēšana



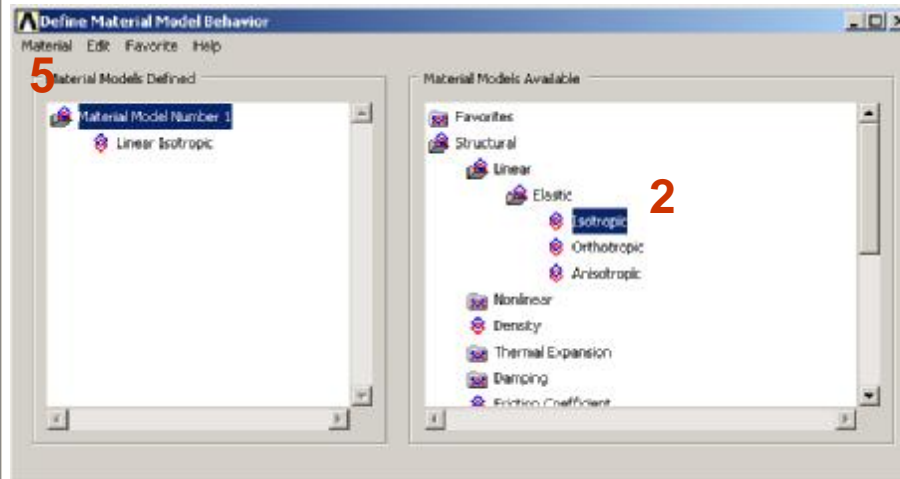
$$(4) \text{ AREA} = 0.002849 \quad \text{m}^2$$
$$\text{ IZZ} = 0.00001943 \quad \text{m}^4$$
$$\text{ HEIGHT} = 0.2 \quad \text{m}$$

- (5) OK
- (6) Close

Materiāla īpašību definēšana

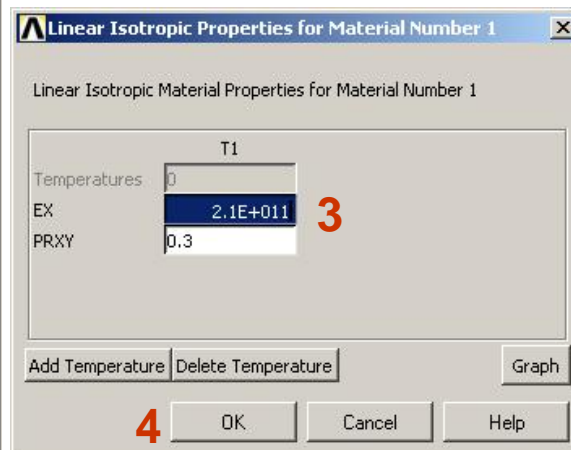


(1) Preprocessor/ Material Props/ Material Models



(2) Material Model Number

Structural
Linear
Elastic
Isotropic



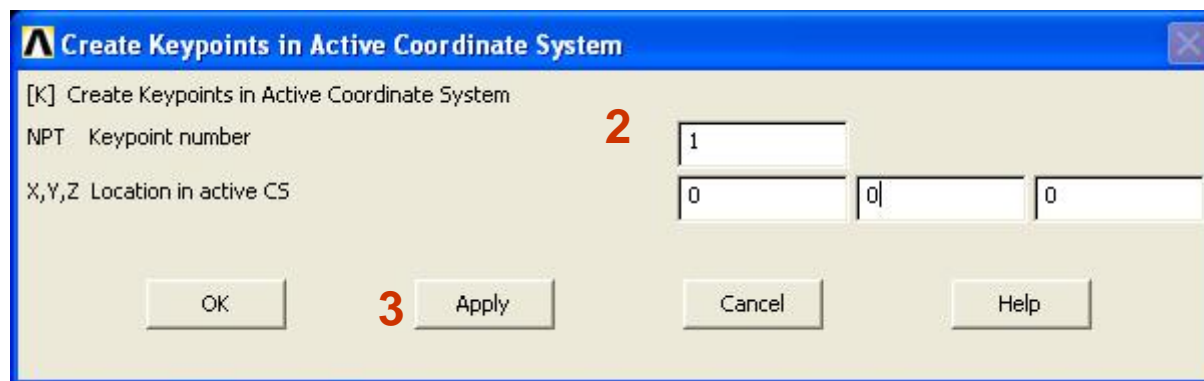
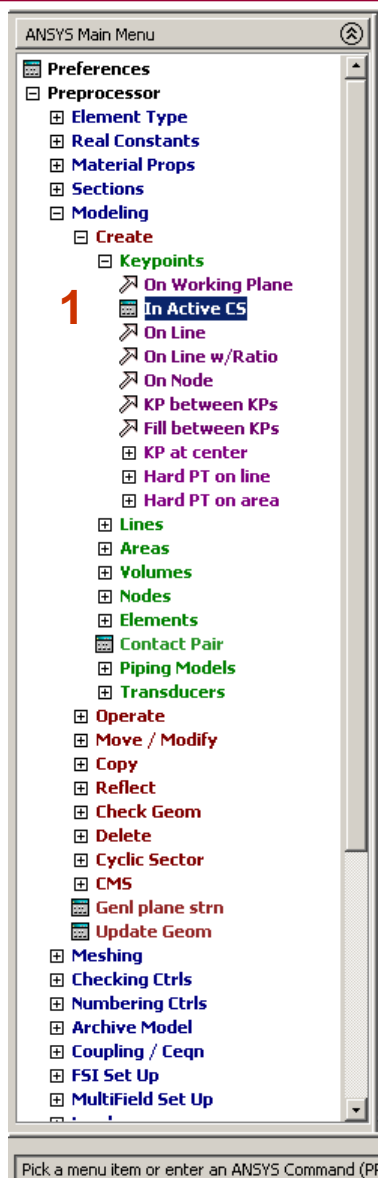
(3) $E_x = 2.1E+011$ [Pa] *Elastības modulis*
 $\nu = 0.3$ *Puasona koeficients*

(4) OK

(5) Material/Exit

Koordinātu mezglu definēšana

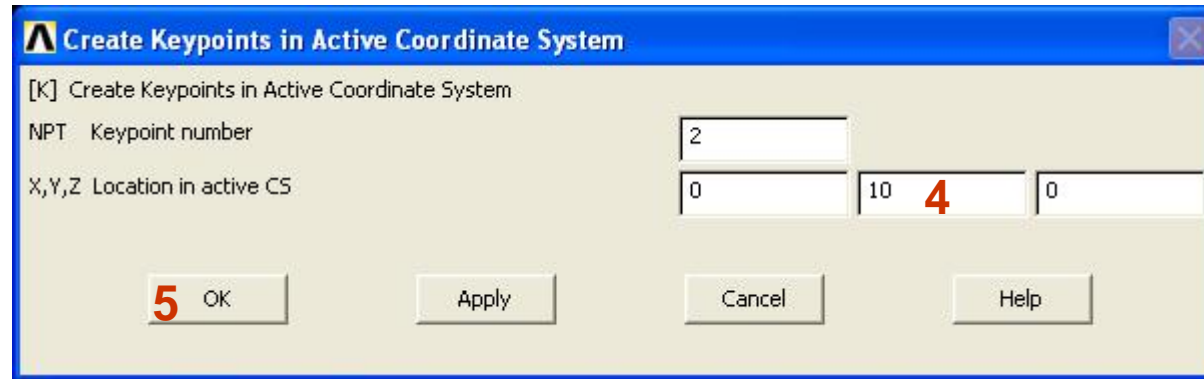
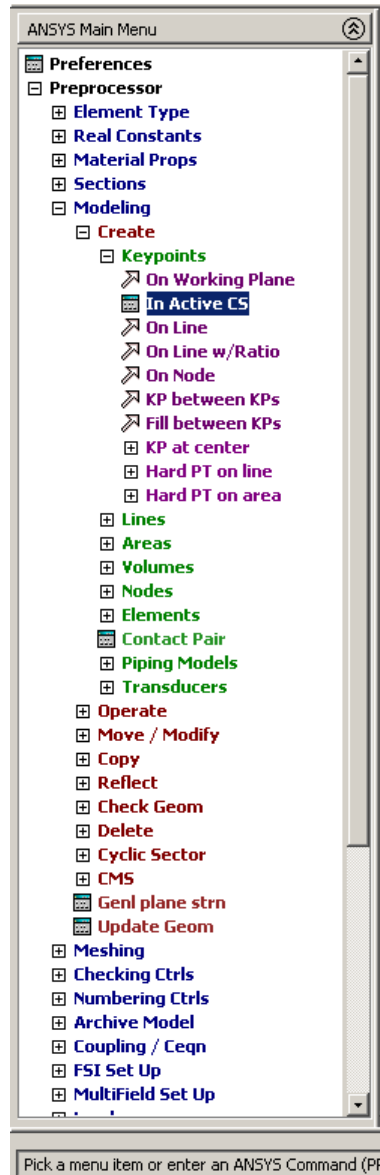
- (1) Preprocessor/
Modeling/
Create/
Keypoints/
In Active CS



(2) NPT X, Y, Z
 1 0 0 0

(3) Apply

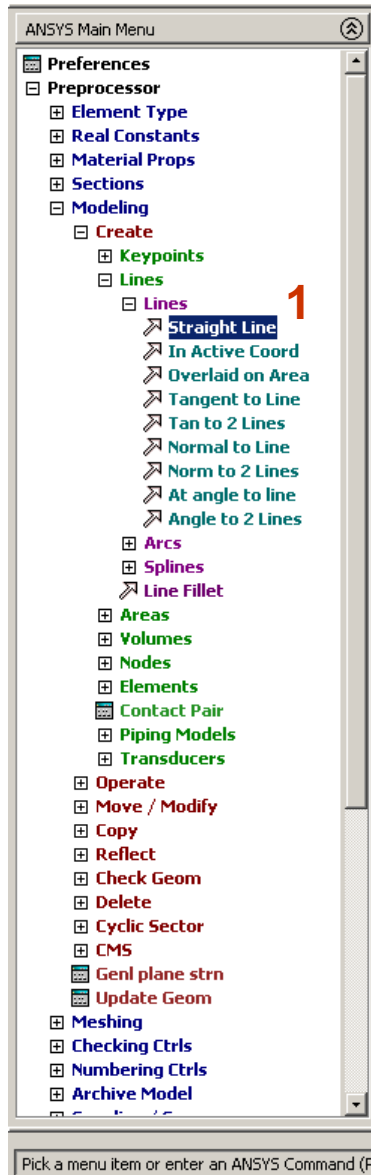
Koordinātu mezglu definēšana



(4) NPT X, Y, Z
 2 0 10 0

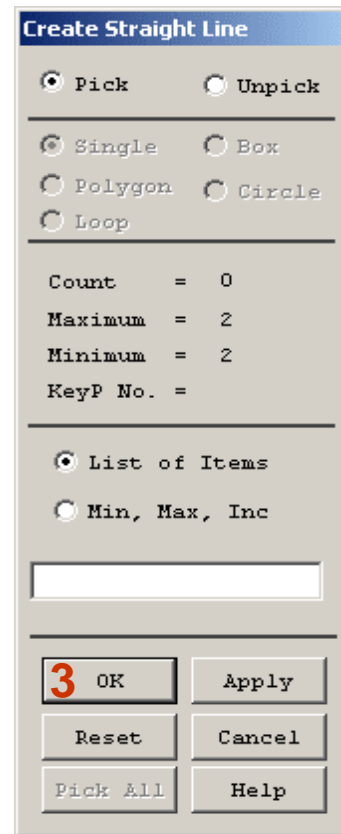
(5) OK

Līniju definēšana

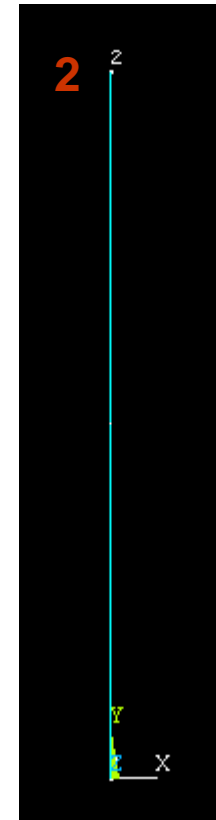


(1) Preprocessor/
Modeling/
Create/
Lines/
Lines/
Straight Line

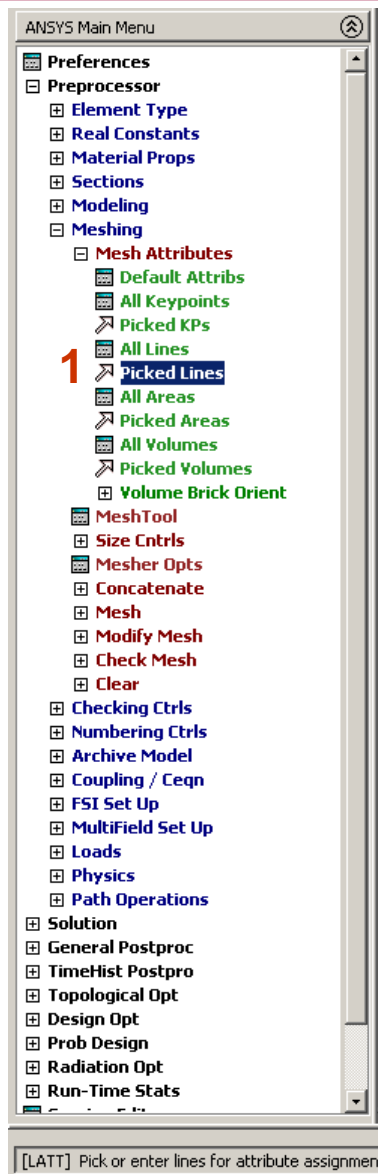
(2) Savienot punktu Nr.1 ar punktu Nr.2



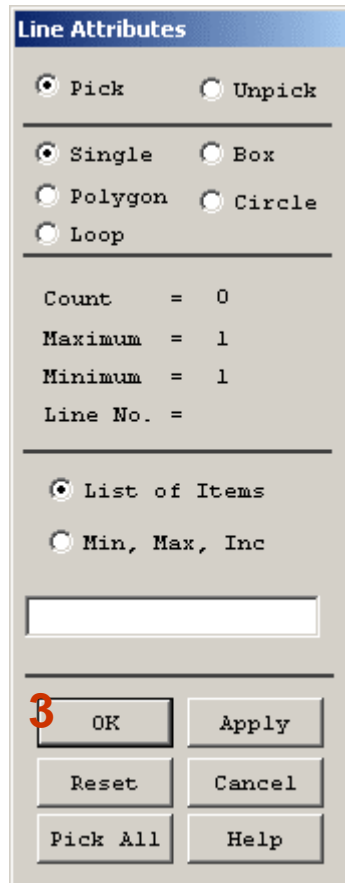
(3) OK



Elementa tipa piesaiste konkrētam ģeometriskam modelim

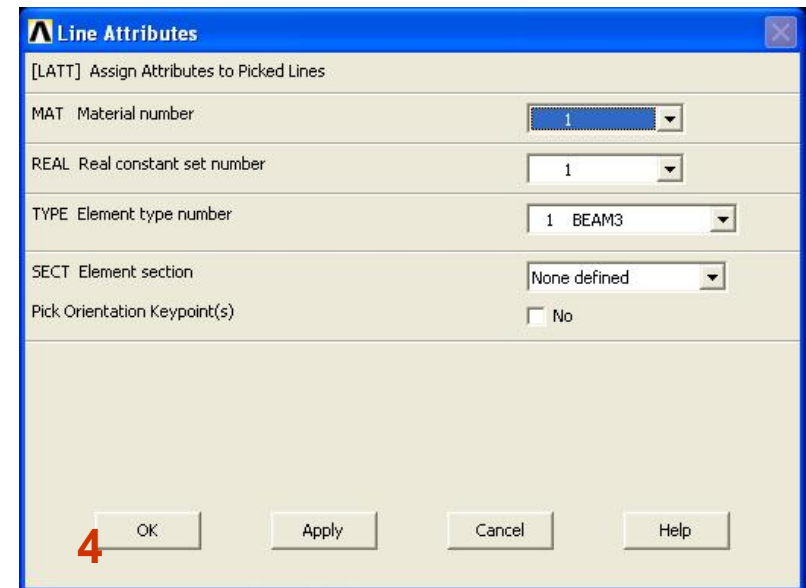


(1) Preprocessor/
Meshing/
Mesh Attributes/
Picked Lines/



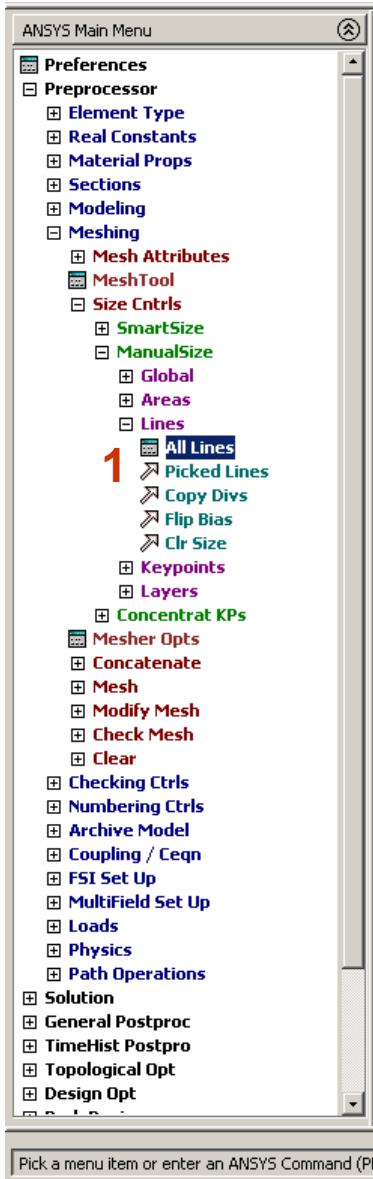
(3) OK

(2) Picked Lines – lezīmēt līnijas



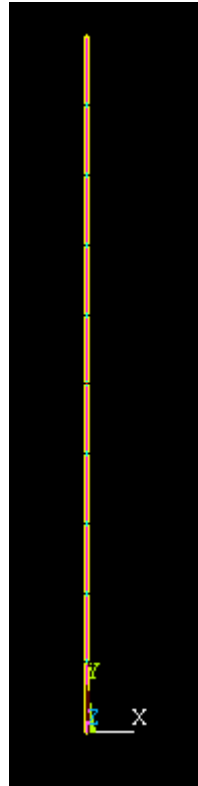
(4) OK

Galīgo elementu izmēru definēšana

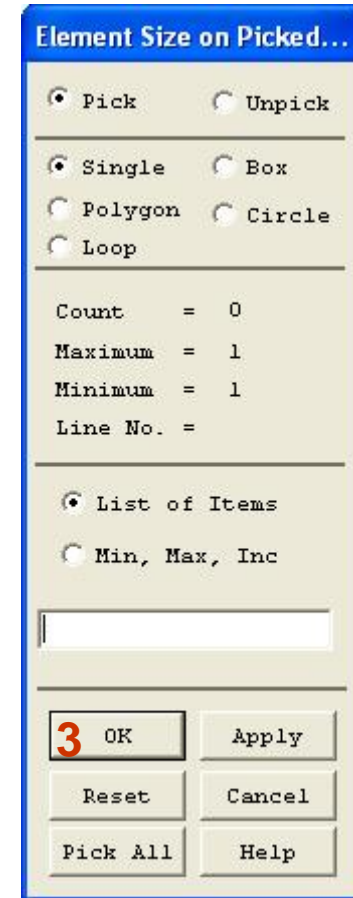


(1) Preprocessor/
Meshing/
Size Cntrls/
ManualSize/
Lines/
Picked Lines

(2) Picked Lines – lezīmēt līnijas



(3) OK



Galīgo elementu izmēru definēšana

Element Sizes on Picked Lines

[LESIZE] Element sizes on picked lines

SIZE Element edge length

NDIV No. of element divisions **4**

(NDIV is used only if SIZE is blank or zero)

KYNDIV SIZE,NDIV can be changed Yes

SPACE Spacing ratio

ANGSIZ Division arc (degrees)

(use ANGSIZ only if number of divisions (NDIV) and element edge length (SIZE) are blank or zero)

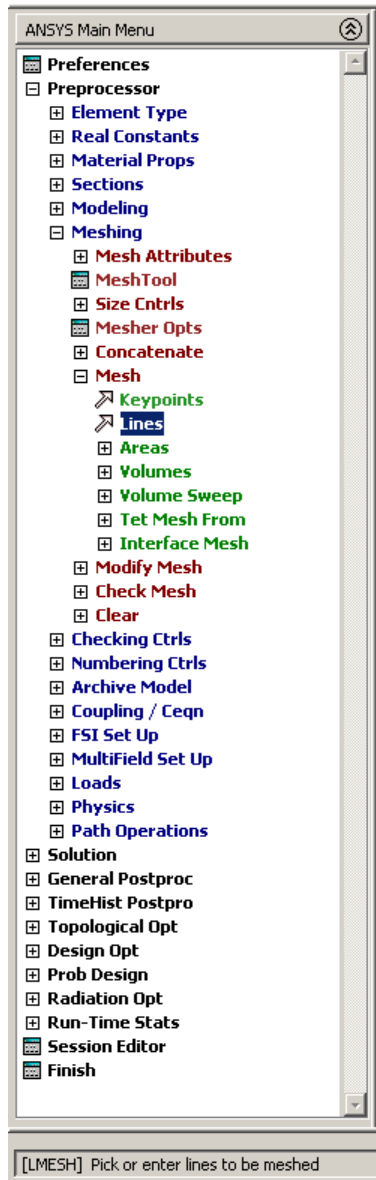
Clear attached areas and volumes No

5 OK Apply Cancel Help

(4) NDIV 10

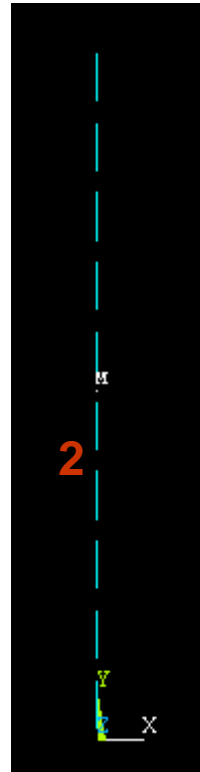
(5) OK

Sijas dalījums galīgos elementos

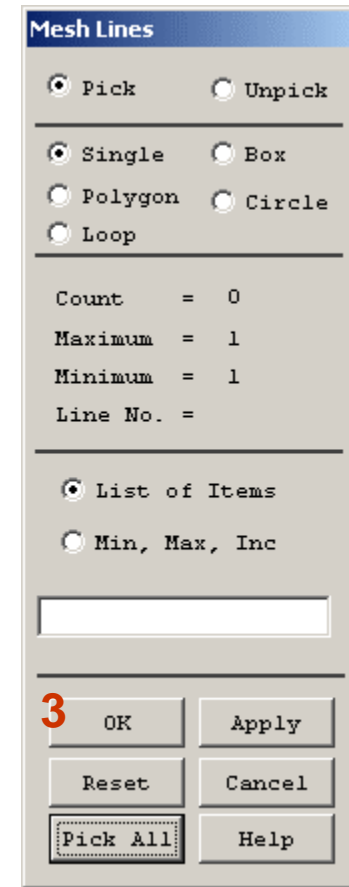


(1) Preprocessor/
Meshing/
Mesh/
Lines/

(2) Picked Lines – lezīmēt līnijas

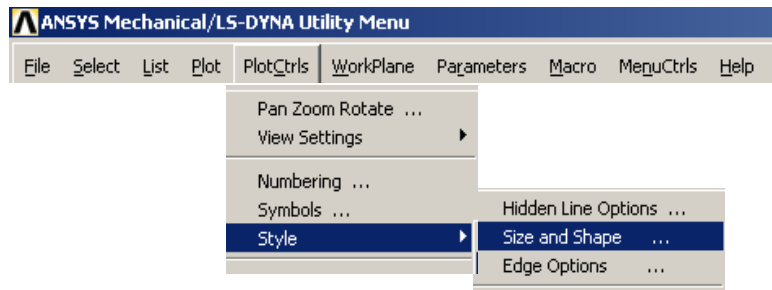


(3) OK

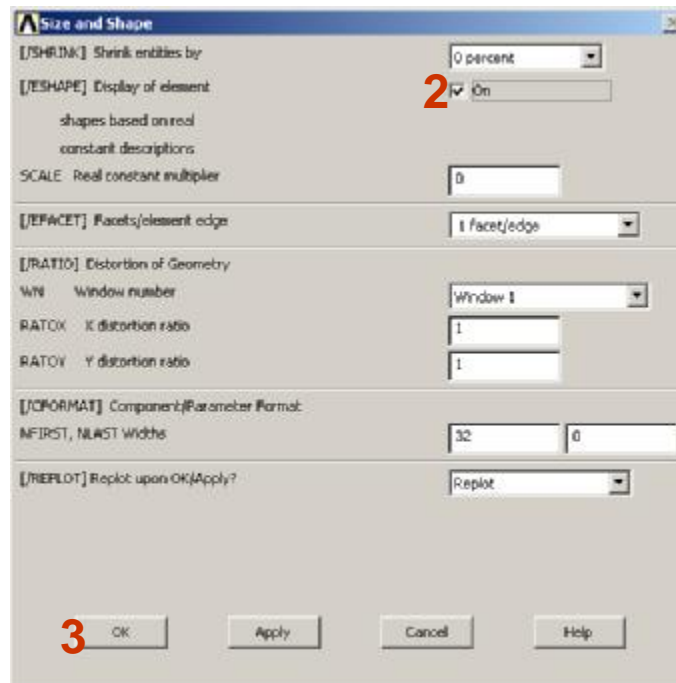


Šķērsriezuma sijas izometriska izskats

(1) PlotCtrls/ Style/ Size and Shape/



(2) Display of element On



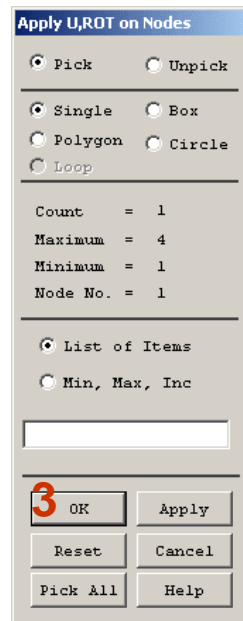
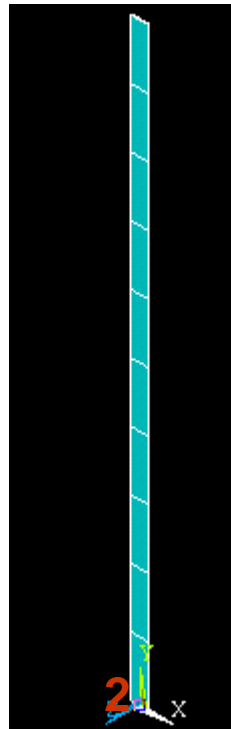
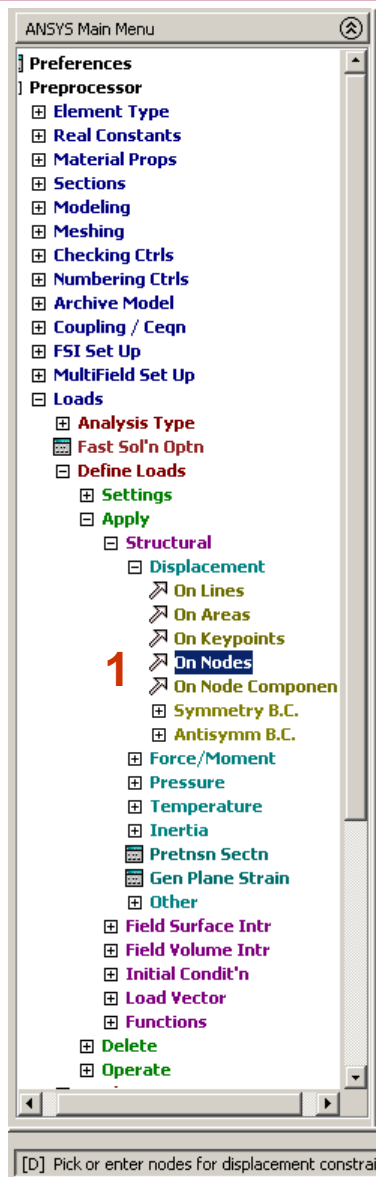
(3) OK



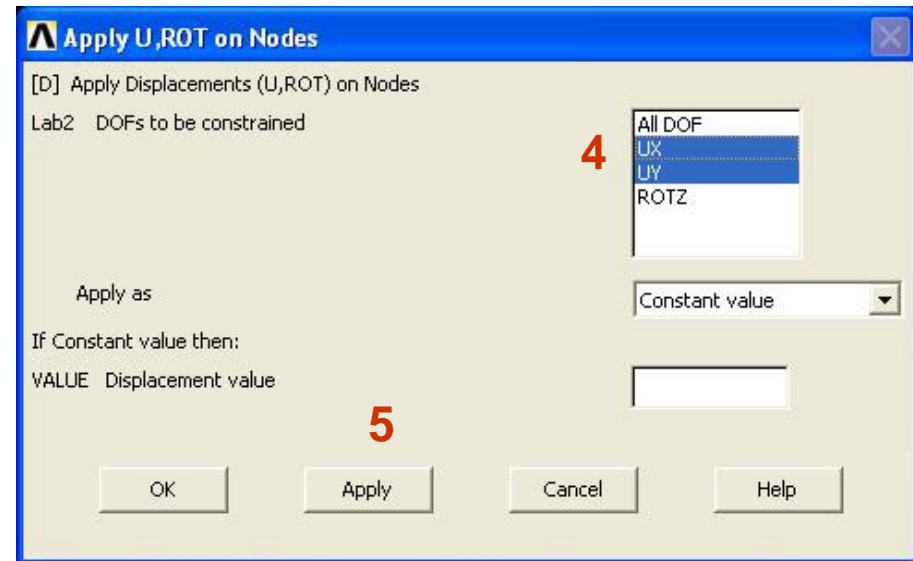
Elementa nostaprinājuma definēšana (Mezgli Nr.1)

(1) Preprocessor/Loads/Define Loads/Apply/
Structural/Displacement/On Nodes

(2) Iezīmēt punkt Nr.1



(3) OK

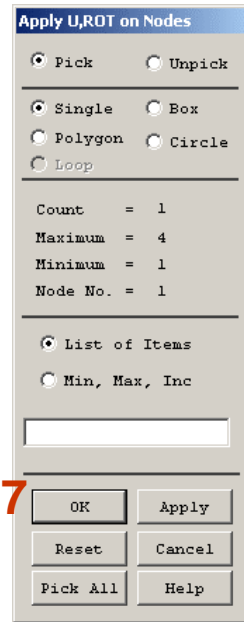
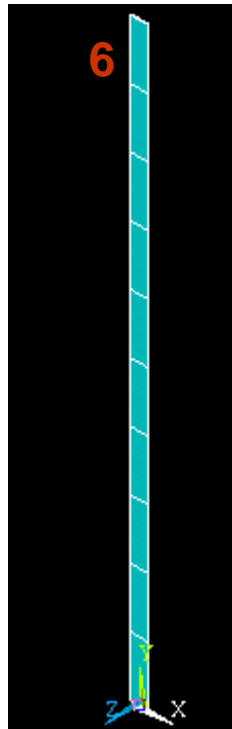


(4) UX, UY,

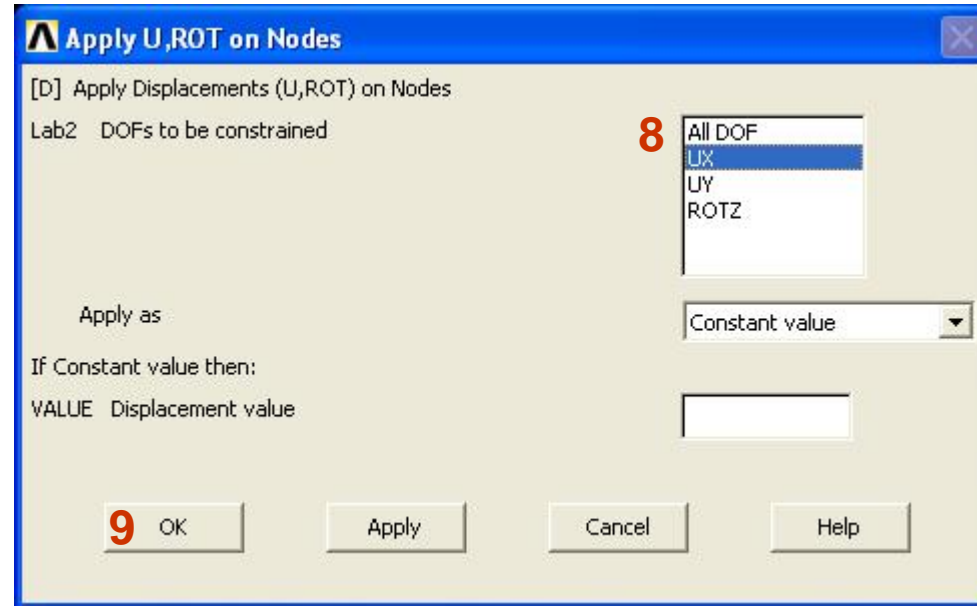
(5) Apply

Elementa nostaprinājuma definēšana (Mezgli Nr.2)

(6) Izzemet punkt Nr.2



(7) OK

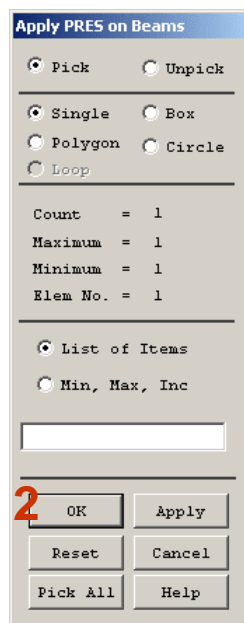
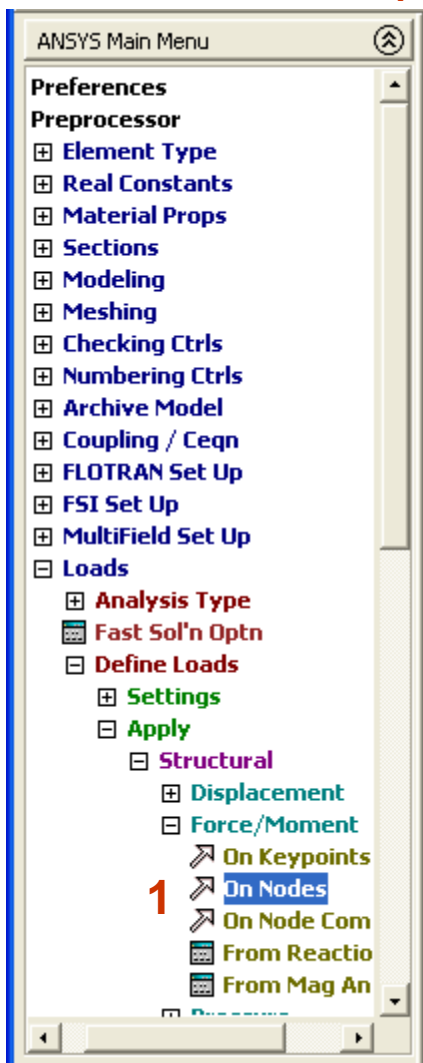


(8) UX,

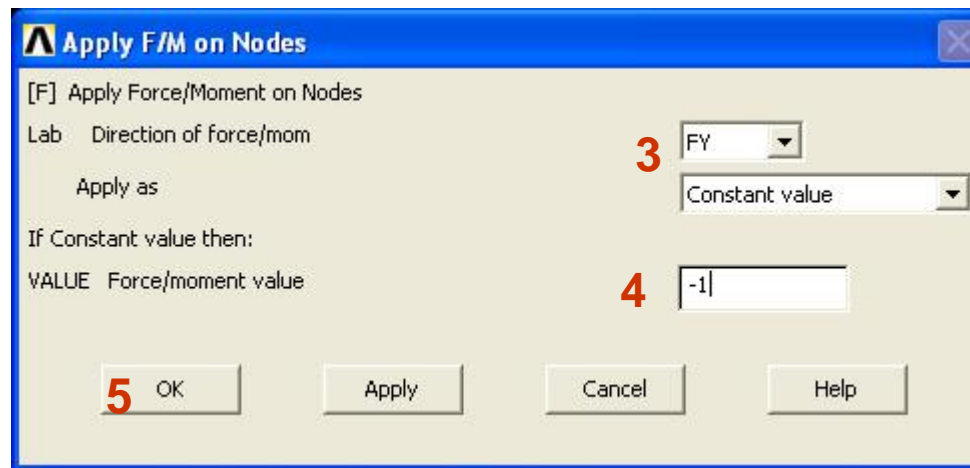
(9) OK

Sijas slodzes definēšana

(1) Preprocessor/
Loads/
Define Loads/
Apply/
Structural/
Force/Moment
On Nodes



(2) Ok

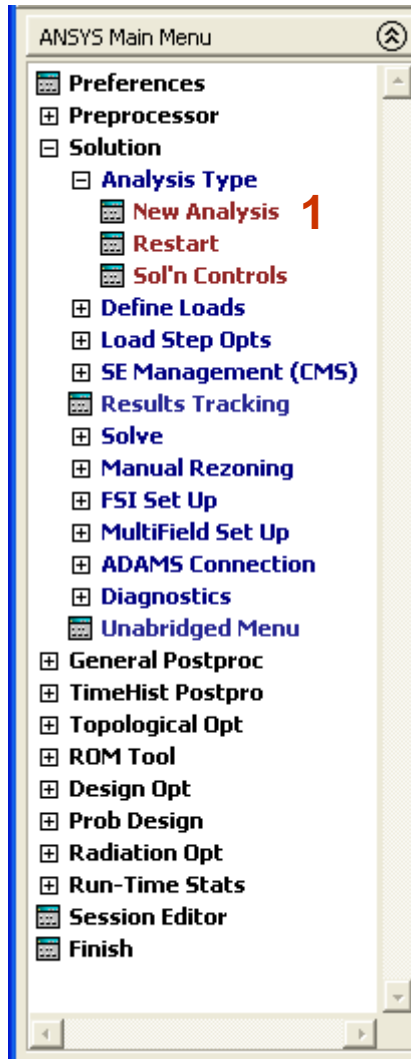


(3) Lab = FY

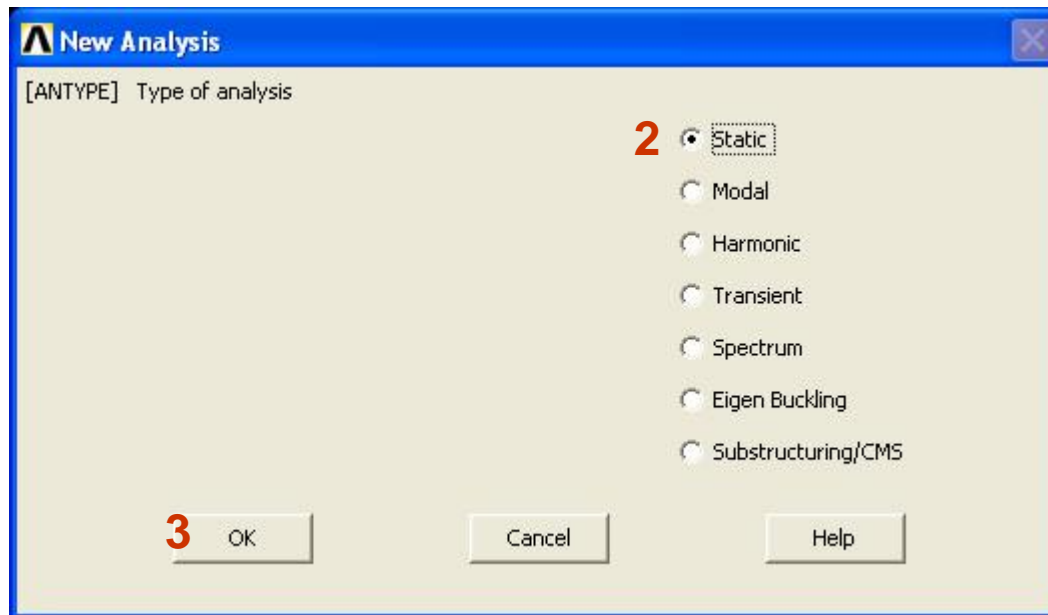
(4) VALUE = -1

(5) OK

Uzdevuma aprēķina shēmas izveide un aprēķins



(1) Solution/
Analysis Type/
New Analysis/

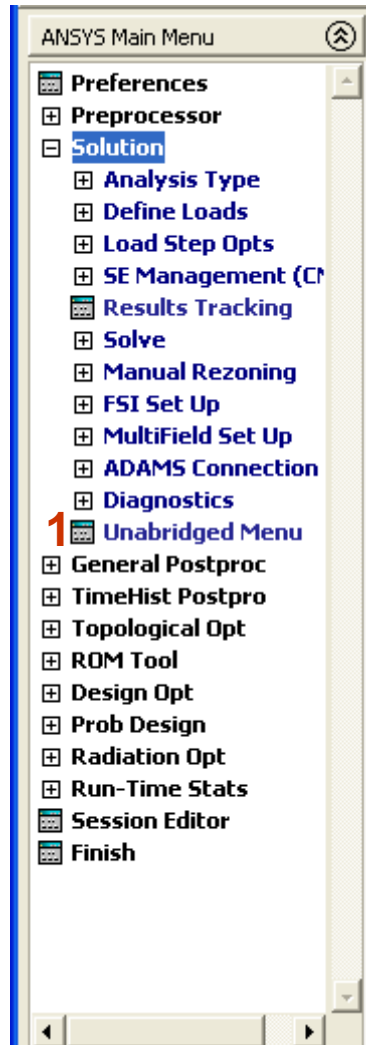


(2) Static

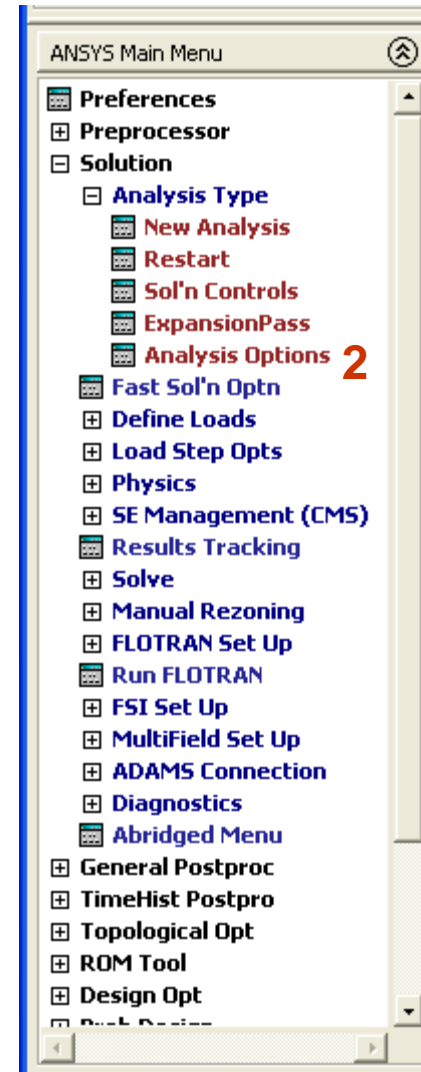
(3) OK

Uzdevuma aprēķina shēmas izveide un aprēķins

(1) Preprocessor/
Solution/
Unabridged Menu/



(2) Analysis Options



Uzdevuma aprēķina shēmas izveide un aprēķins

Static or Steady-State Analysis

Nonlinear Options

[NLGEOM] Large deform effects Off

[NROPT] Newton-Raphson option Program chosen

Adaptive descent ON if necessary

Linear Options

[LUMPM] Use lumped mass approx? No

[EQSLV] Equation solver Program Chosen

Tolerance/Level -

- valid for all except Frontal and Sparse Solvers

Multiplier -

- valid only for Precondition CG

[PRECISION] Single Precision - Off

- valid only for Precondition CG

[MSAVE] Memory Save - Off

- valid only for Precondition CG

[PIVCHECK] Pivots Check On

- valid only for Frontal, Sparse and PCG Solvers

[SSTIF][PSTRES]

Stress stiffness or prestress None

Note: If NLGEOM,ON then set SSTIF,ON.

[TOFFST] Temperature difference- 1

- between absolute zero and zero of active temp scale

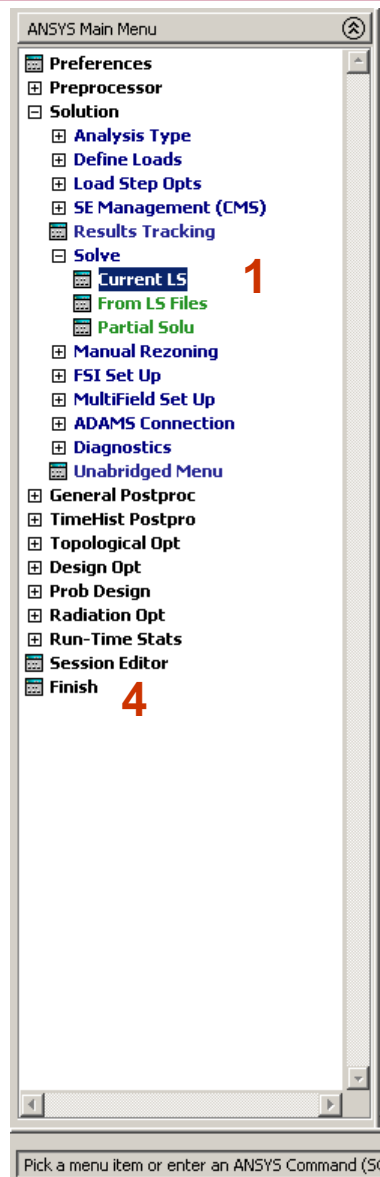
2

OK Cancel Help

(1) Static or Steady
State Analysis
Stress stiffness
or prestress/
Prestress ON

(2) OK

Uzdevuma aprēķina shēmas izveide un aprēķins

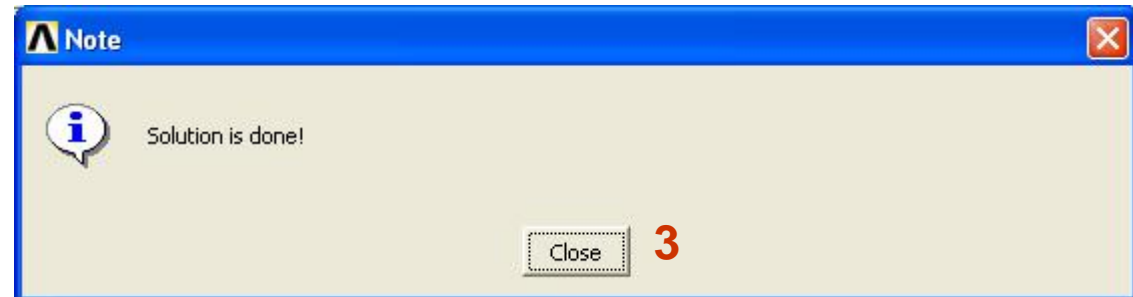


(1) Solution/
Solve/
Current LS/



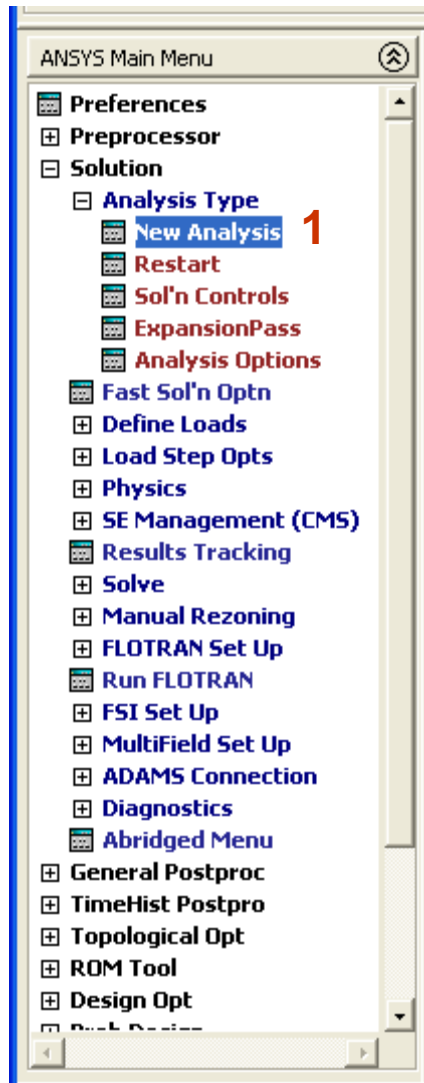
(2) OK

(3) Close



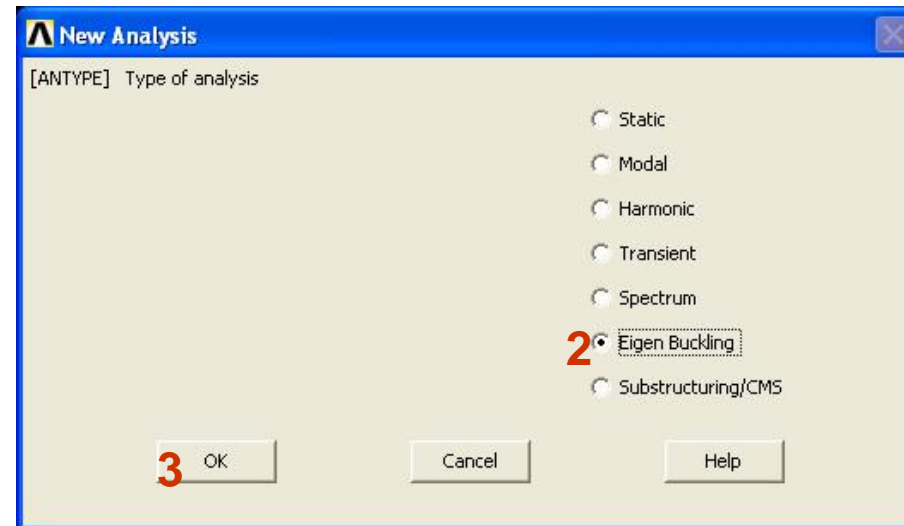
(4) Finish

Uzdevuma aprēķina shēmas izveide un aprēķins



(1) Preprocessor/
Loads/
Analysis Type/
New Analysis

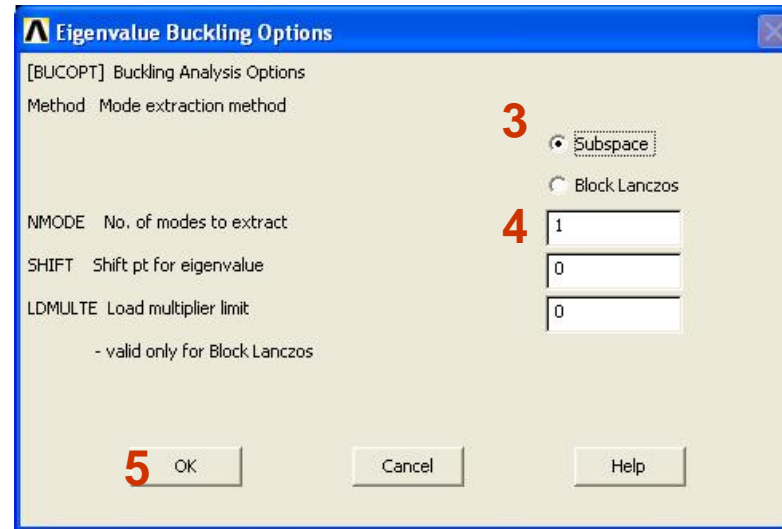
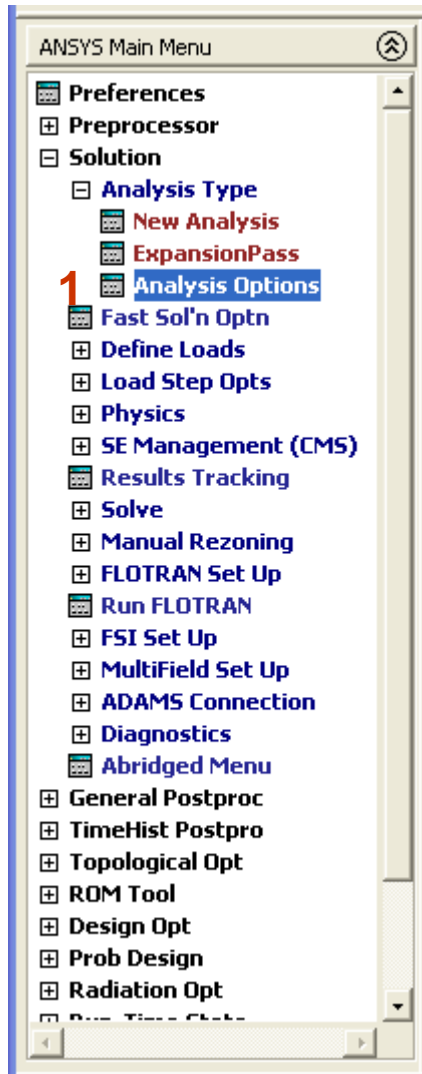
(2) Eigen Buckling



(3) OK

Uzdevuma aprēķina shēmas izveide un aprēķins

(1) Preprocessor/Loads/Analysis Type/Analysis Options

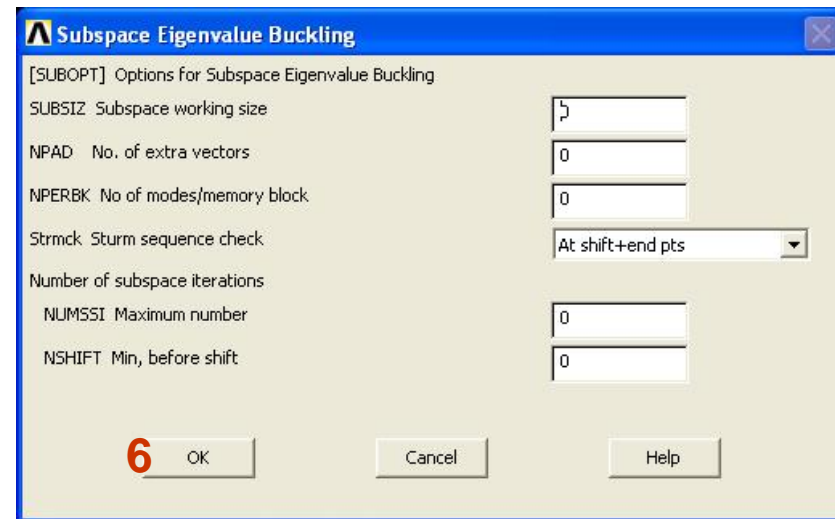


(3) Subspace

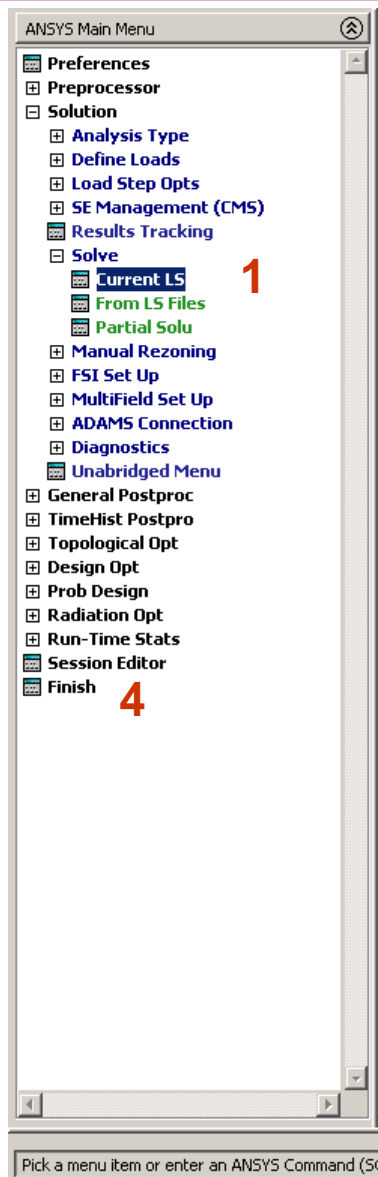
(4) NMODE 1

(5) OK

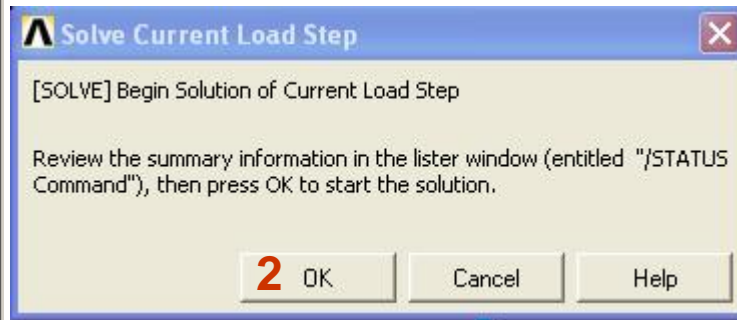
(6) OK



Uzdevuma aprēķina shēmas izveide un aprēķins



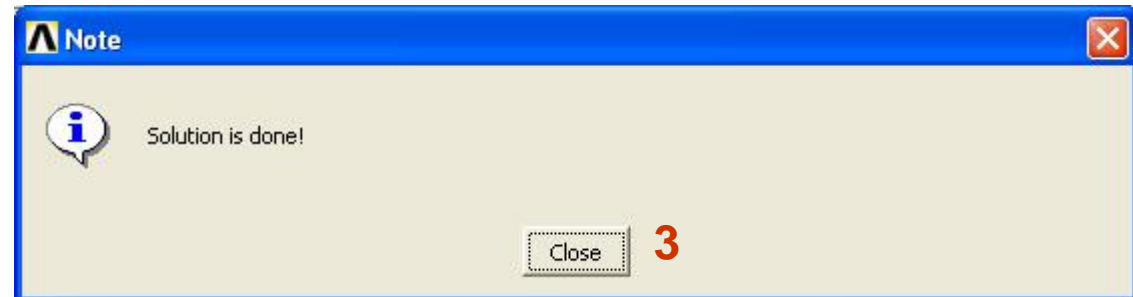
(1) Solution/
Solve/
Current LS/



(2) OK

(3) Close

(4) Finish



Stieņa noturības skaitliskās vērtības iegūšana

(1) General Postproc/
Results Summary

(2) Close

The screenshot displays the ANSYS Main Menu on the left and the SET,LIST Command window on the right. The Results Summary menu item is highlighted with a red '1', and the window's close button is highlighted with a red '2'.

ANSYS Main Menu

- Preferences
- Preprocessor
- Solution
- General Postproc
 - Data & File Opts
 - 1 Results Summary**
 - Read Results
 - Failure Criteria
 - Plot Results
 - List Results
 - Query Results
 - Options for Outp
 - Results Viewer
 - Write PGR File
 - Nodal Calcs
 - Element Table
 - Path Operations
 - Surface Operations
 - Load Case
 - Check Elem Shape
 - Write Results
 - ROM Operations
 - Submodeling
 - Fatigue
 - Safety Factor
 - Define/Modify
 - Nonlinear Diagnostics
 - Reset
 - Manual Rezoning

SET,LIST Command

File

```
**** INDEX OF DATA SETS ON RESULTS FILE ****
SET  TIME/FREQ  LOAD STEP  SUBSTEP  CUMULATIVE
 1  0.40271E+06      1          1          1
```

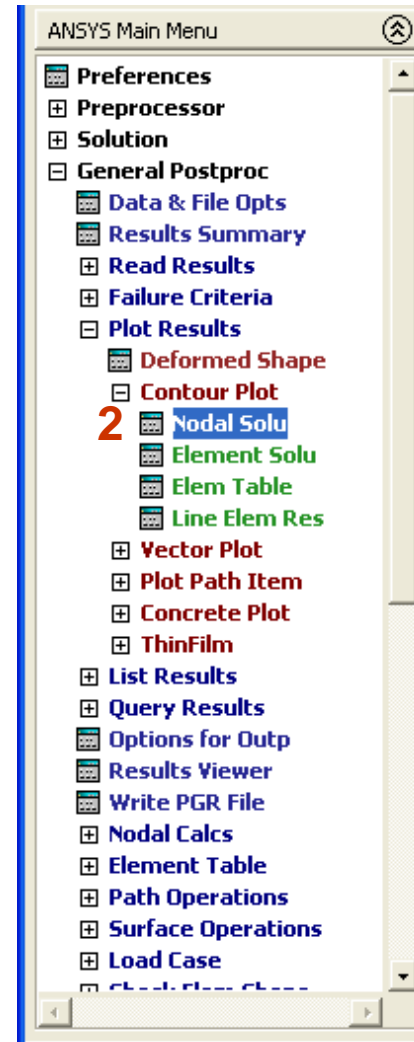
TIME/FREQ
0.40271E+06

Stieņa noturības zaudēšanas formas grafiska izveide

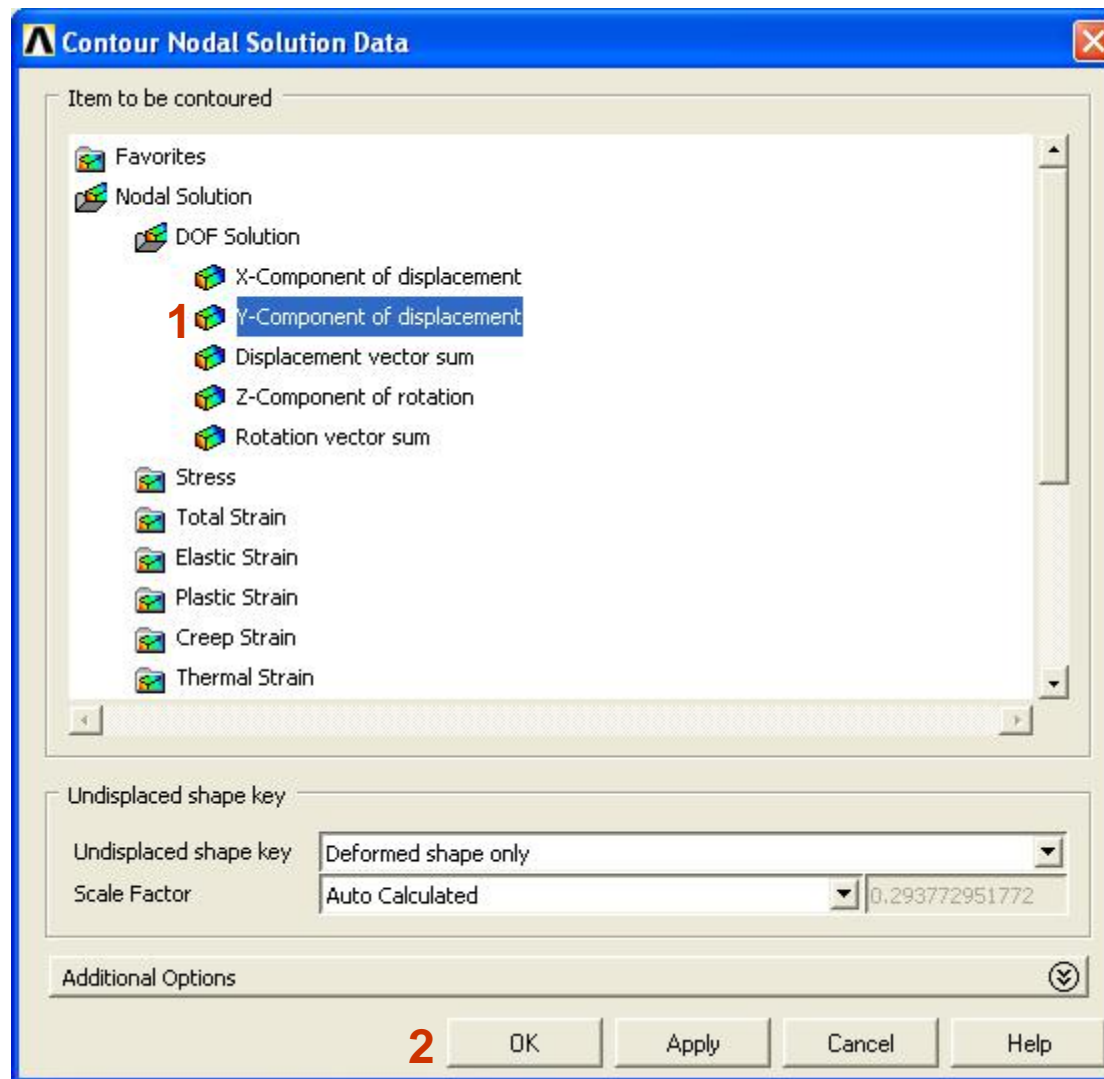


(1) General Postproc/
Results Summary/
First Set

(2) General Postproc/
Plot Results/
Contour Plot/
Nodal Solu



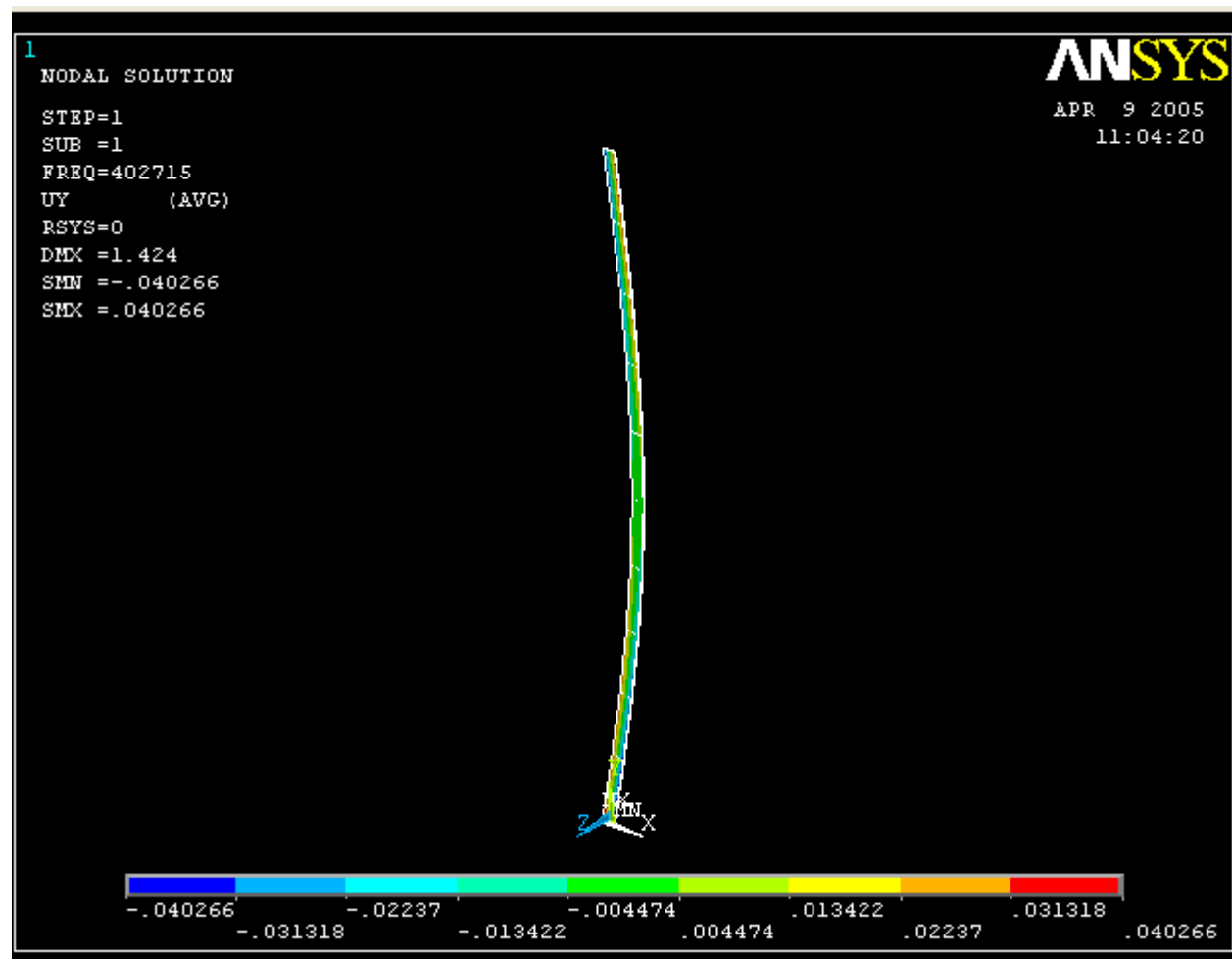
Stieņa noturības zaudēšanas formas grafiska izveide



(1) Y-Component of displacement

(2) OK

Stieņa noturības zaudēšanas formas grafiska izveide



$$F = 402715 \text{ N}$$

Stieņa ģeometrisko īpašību aprēķins



J - šķērsriezuma laukuma inerces rādiuss

$$J = 1943 \text{ cm}^4$$

A - stieņa šķērsriezuma laukums

$$A = 28.49 \text{ cm}^2$$

Šķērsriezuma laukuma inerces rādiuss

$$i = 8.26 \text{ cm}$$

$$i = \sqrt{\frac{J}{A}} = \sqrt{\frac{1943}{28.49}} = \sqrt{68.199} = 8.26$$

Stieņa reducētais garuma aprēķins, ja $m = 1$

$$l_o = m \cdot l = 1 \cdot 1000 = 1000$$

Stieņa kritiskā spēka analītisks aprēķins

Stieņa slaidums

$$l = \frac{l_0}{i} = \frac{1000}{8.26} = 121.07 > l_{rob} = 100$$

Kritiskais spēks

$$P_{kr} = \frac{p^2 \cdot E \cdot J}{l_0^2} = \frac{3.14^2 \cdot 2.1 \cdot 10^5 \cdot 10^{-1} \cdot 1943}{1000^2} = 402715N$$

Pieļaujamais spēks

$$[P] = \frac{P_{kr}}{[n_{not}]} = \frac{402715}{2} = 201.4kN$$

**P.S. <http://www.bf.rtu.lv/?page=nvsd/materials>
"Būvmehānika, ievadkurss" (.pdf) - Fēlikss Bulavs, Ivars Radiņš
90-102 lpp.**

Log fail

/PREP7

!*
Elementa tipa izvele

!*
ET,1,BEAM3

!*
Skersgriezuma parametru definesana (m)

!*
R,1,0.002849,0.00001943,0.2, , , ,

!*
Materiala ipasibu definesana (Pa)

!*
MPTEMP,,,,,,,,,
MPTEMP,1,0
MPDATA,EX,1,,2.1e11
MPDATA,PRXY,1,,0.3

!*
Koordinatu mezglu punktu definesana

!*
K,1,0,0,0,
K,2,0,10,0,
!*
Koordinatu mezglu punktu svienosana ar taisnu liniju

!*
Liniju definešana

!*
CM,_Y,LINE
LSEL, , , , 1
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
LSTR, 1, 2
!*
Liniju definešana

!*
CM,_Y,LINE

!*
LSTR, 1, 2
!*
Liniju definešana

!*
CM,_Y,LINE

!*
LSEL, , , , 1
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CM,_Y,LINE

!*
LSEL, , , , 1
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
LSEL, , , , 1
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CM,_Y1,LINE
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CMSEL,S,_Y
!*
CMSEL,S,_Y1
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CMSEL,S,_Y1
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
LATT,1,1,1, , , ,
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CMSEL,S,_Y
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CMDELE,_Y
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CMDELE,_Y1
!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
FLST,5,1,4,ORDE,1
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
FITEM,5,1
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CM,_Y,LINE
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
LSEL, , , ,P51X
CM,_Y1,LINE
CMSEL,,_Y

!*
CM,_Y1,LINE
CMSEL,,_Y

!*
CMSEL,,_Y

!*
CMSEL,,_Y

!*
CMSEL,,_Y

Log fail

Dalijums galigos elementos

!*
/GO

LESIZE,_Y1, , ,10, , , ,1

!*
/GO

LMESH, 1

!*
/GO

/SHRINK,0

/ESHAPE,1.0

/EFACET,1

/RATIO,1,1,1

/CFORMAT,32,0

/REPLOT

!*
/GO

3D skats

!*
/GO

/VIEW,1,1,1,1

/ANG,1

/REP,FAST

FLST,2,1,1,ORDE,1

FITEM,2,1

!*
/GO

Elementa nostiprinājuma definēšana (Mezgli Nr.1)

!*
/GO

/GO

D,P51X, , , , ,UX,UY, , , ,

FLST,2,1,1,ORDE,1

FITEM,2,2

!*
/GO

Elementa nostiprinājuma definēšana (Mezgli Nr.2)

/GO

D,P51X, , , , ,UX, , , , ,

FLST,2,1,1,ORDE,1

FITEM,2,2

!*
/GO

Sijas sloģošana

!*
/GO

/GO

F,P51X,FY,-1

FINISH

Log fail

```
!*  
/SOL  
!*  
ANTYPE,0  
!*  
NLGEOM,0  
NROPT,AUTO, ,  
LUMPM,0  
EQSLV, , ,0,  
PRECISION,0  
MSAVE,0  
PIVCHECK,1  
PSTRES,ON  
TOFFST,0,  
!*  
Sijas aprekins  
!*  
/STATUS,SOLU  
SOLVE  
!*  
FINISH  
!*
```

```
Modal aprekins  
!*  
/SOLU  
!*  
ANTYPE,1  
!*  
!*  
BUCOPT,SUBSP,1,0,0  
!*  
SUBOPT,0,0,0,0,0,ALL  
!*  
/STATUS,SOLU  
SOLVE  
!*  
FINISH  
!*  
/POST1  
SET,LIST  
SET,FIRST  
!*  
/EFACET,1  
PLNSOL, U,Y, 0,1.0
```