



Division of Strength of Materials and Structures

Faculty of Power and Aeronautical Engineering

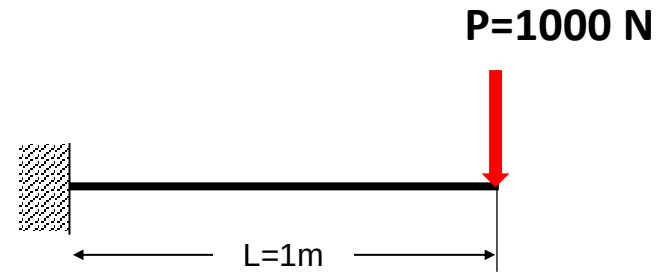
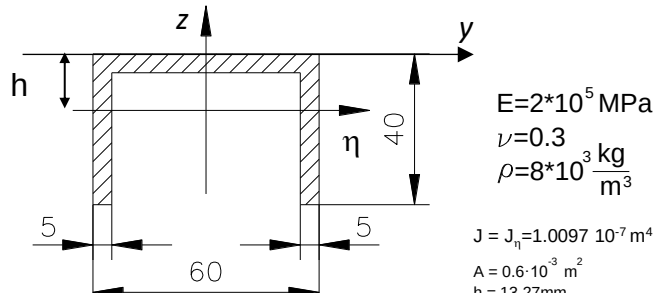


Finite element method (FEM1)

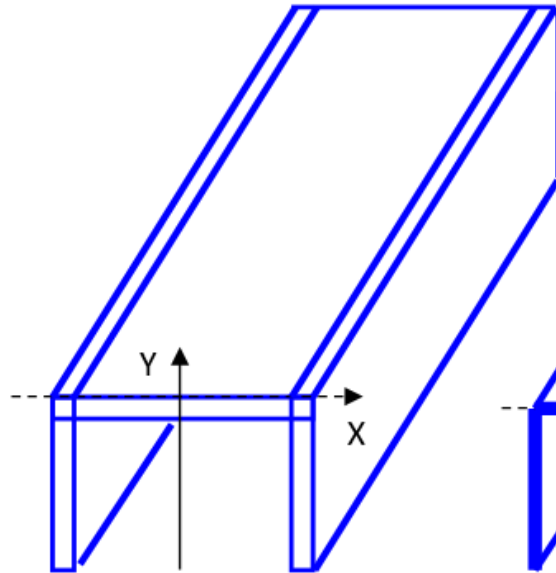
Lecture 13A. Examples of FE modeling

05.2025

Example 1. Cantilever beam

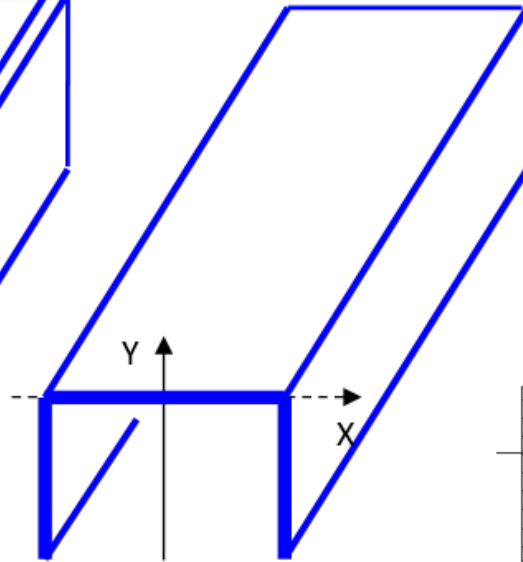


Solid 185



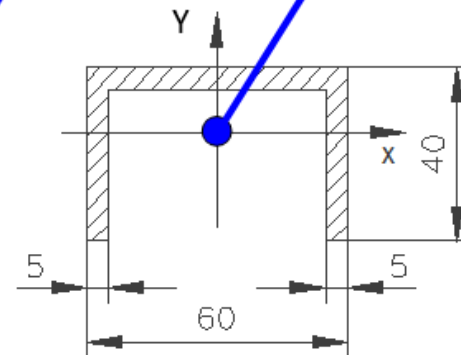
Extruding surfaces produces solids filled with solid elements (3D modeling)

Shell 181



Extruding lines gives areas that we will cover with shell elements of a given thickness

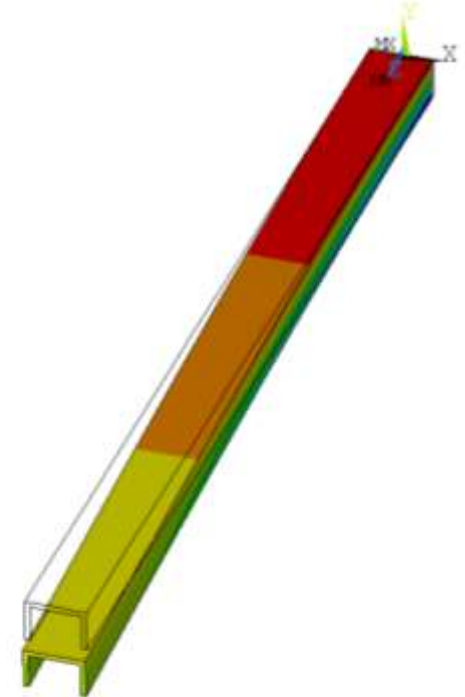
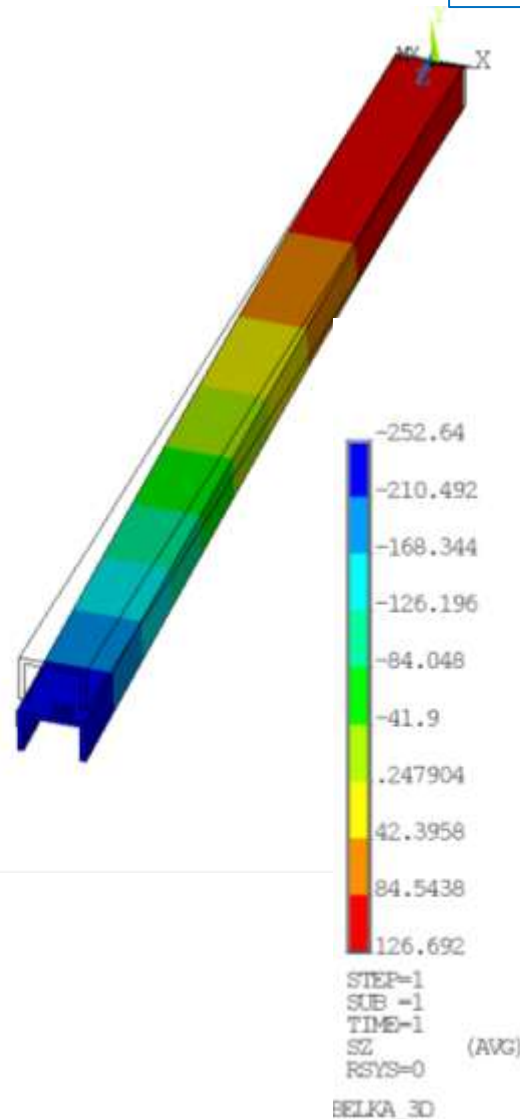
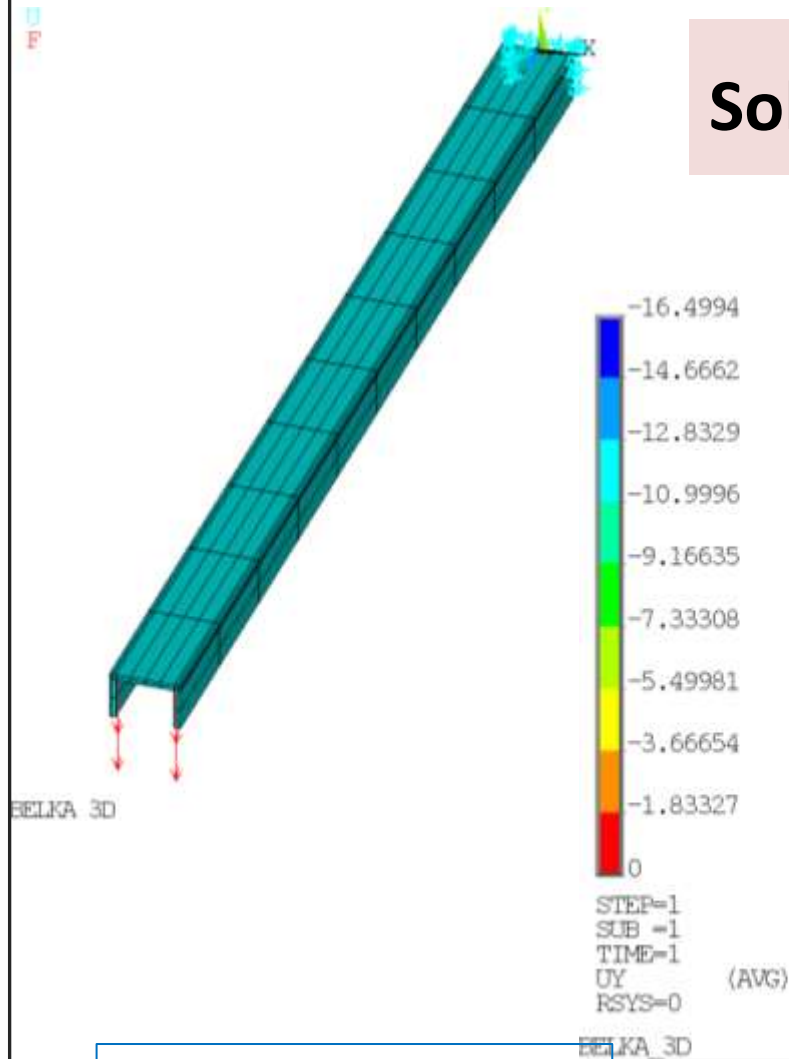
Beam 188



Extracting a point gives a line to which we assign a section defining the features of the cross section

Solid 185

Nodes . .	429
Elements.	240



Analytical results:

$$f = PL^3/(3EJ) = 16,5\text{mm}$$

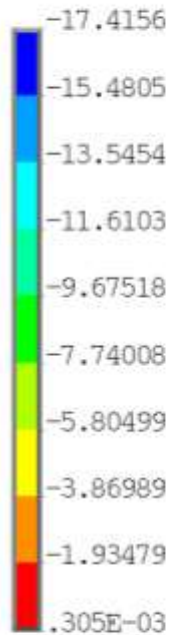
$$\sigma = +132 / -265 \text{ MPa}$$

Shell 181

Nodes . .	143
Elements.	120

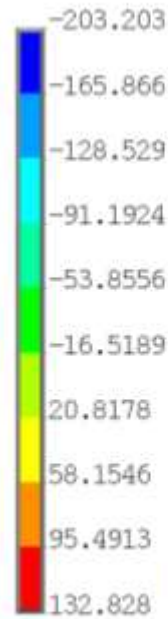
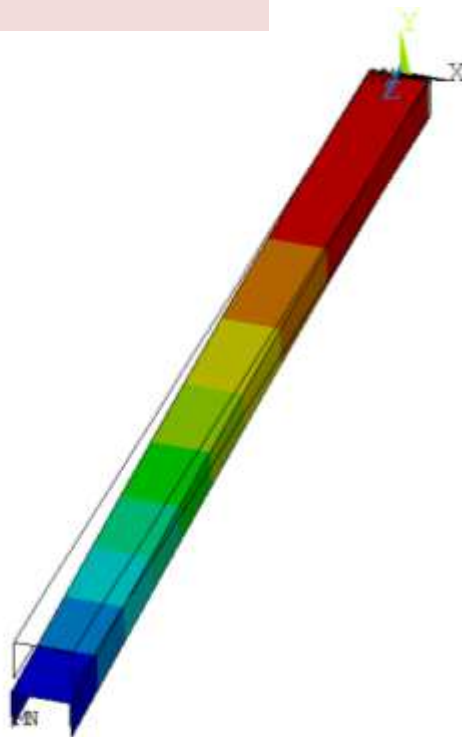


BELKA Shell181



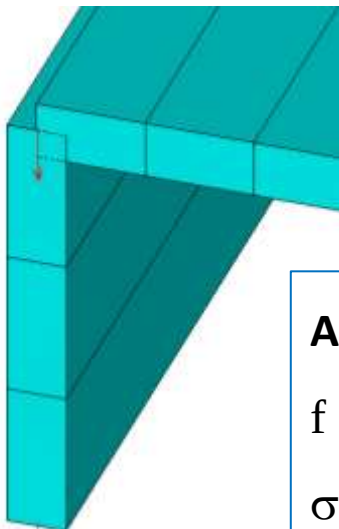
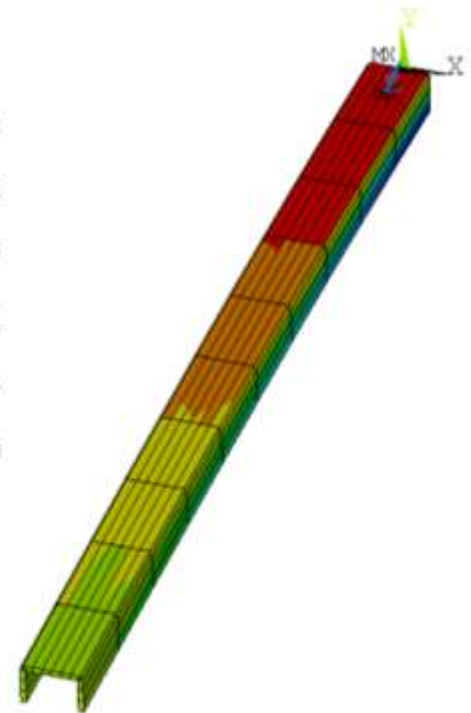
STEP=1
SUB =1
TIME=1
UY (AVG)
RSYS=0

BELKA_Shell181



STEP=1
SUB =1
TIME=1
SZ (AVG)
RSYS=0

BELKA_Shell181



Analytical results:

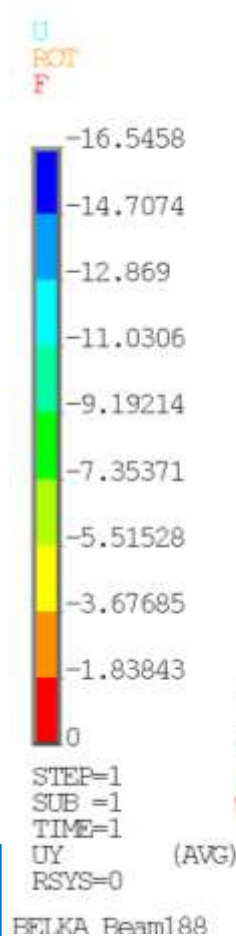
$$f = PL^3/(3EJ) = 16,5\text{mm}$$

$$\sigma = +132 / -265 \text{ MPa}$$

Beam 188

Nodes . .	31
Elements.	10

BELKA Beam188

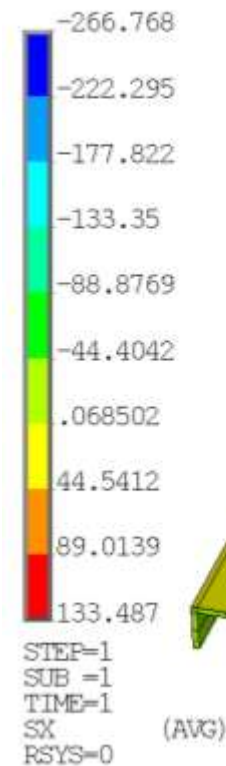


Analytical results:

$$f = PL^3/(3EJ) = 16,5\text{mm}$$

$$\sigma = +132 / -265 \text{ MPa}$$

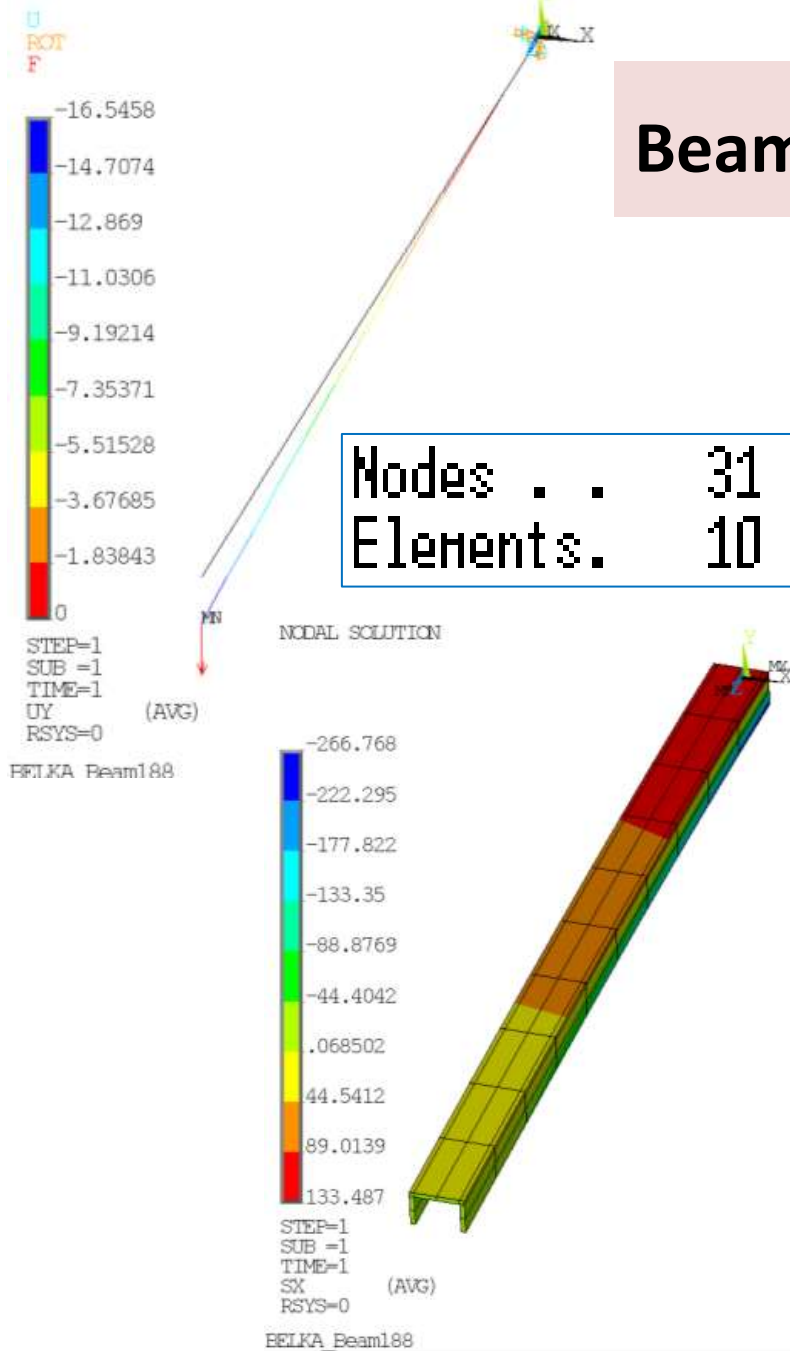
NODAL SOLUTION



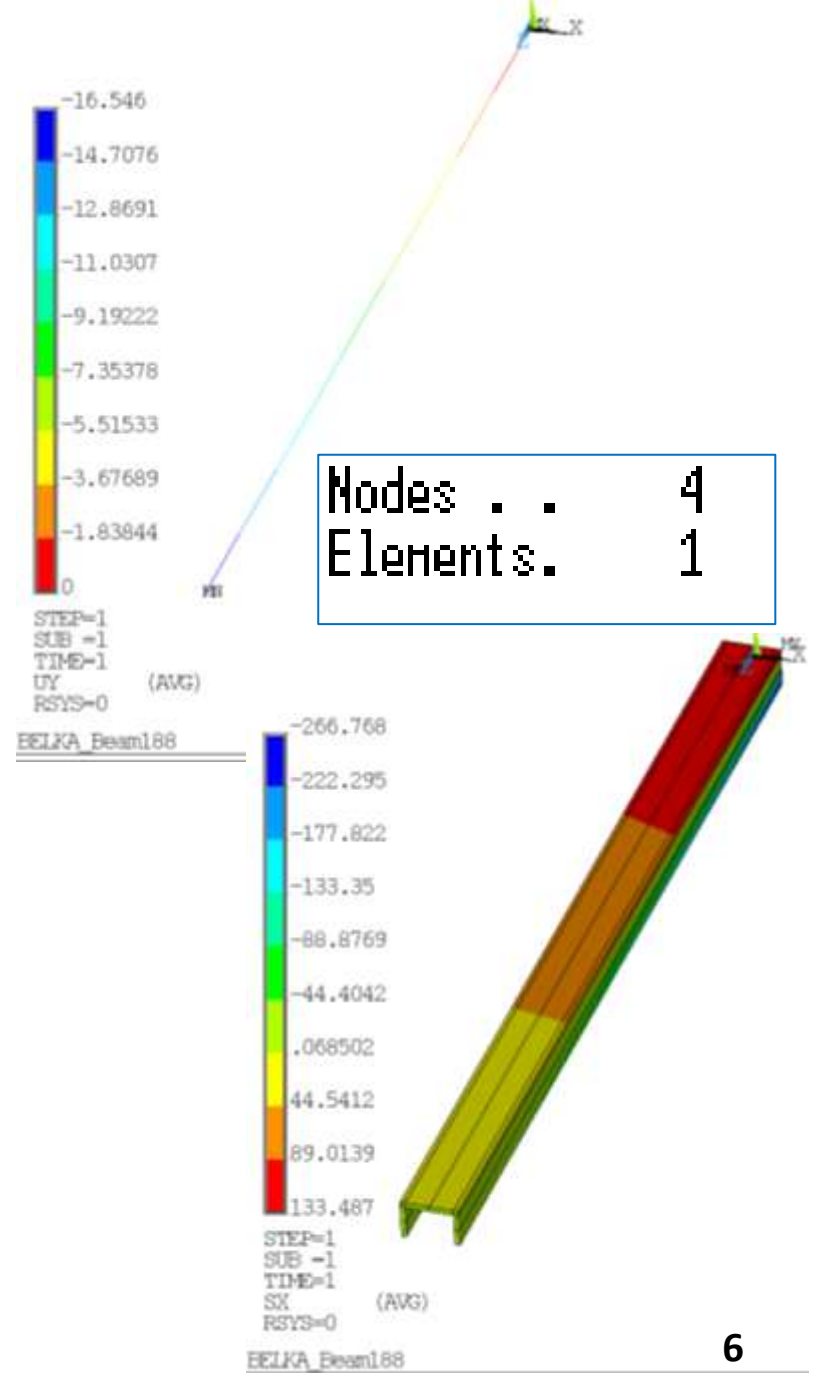
BELKA Beam188

Beam 188

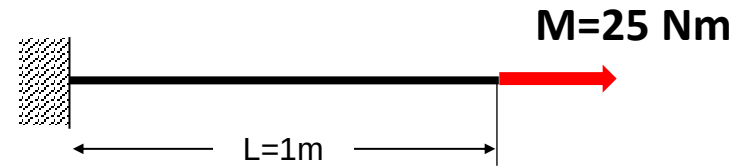
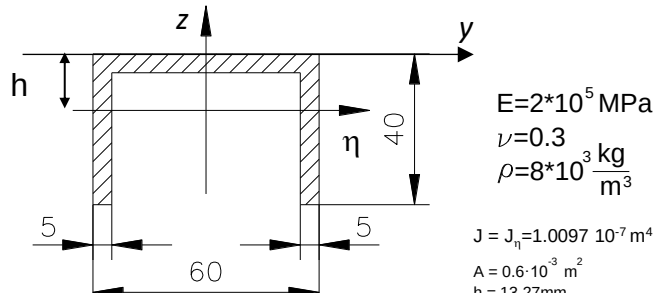
Nodes . . 31
Elements. 10



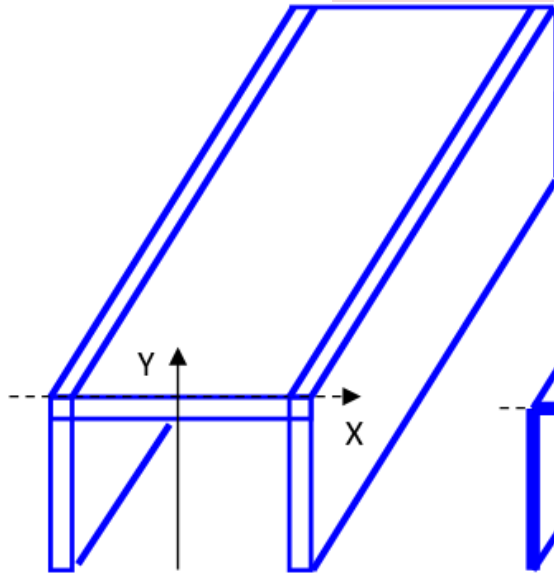
Nodes . . 4
Elements. 1



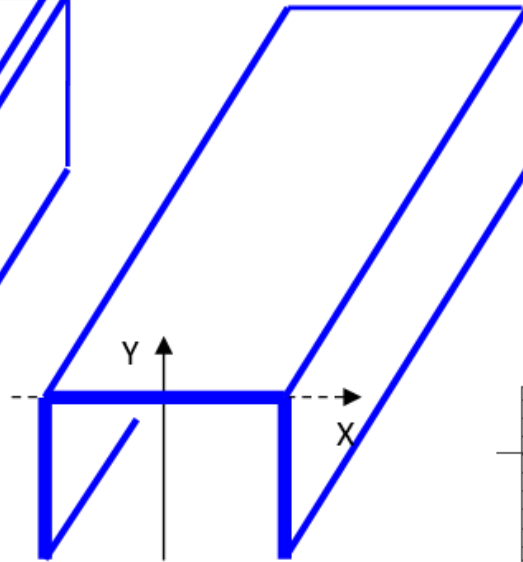
Example 2. Twisted rod



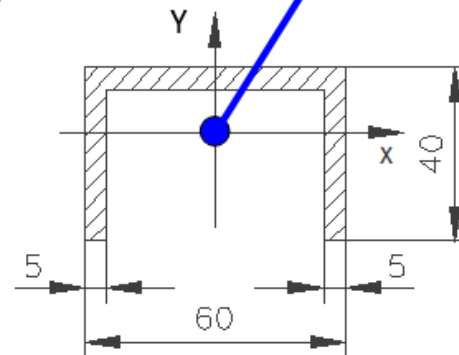
Solid 185

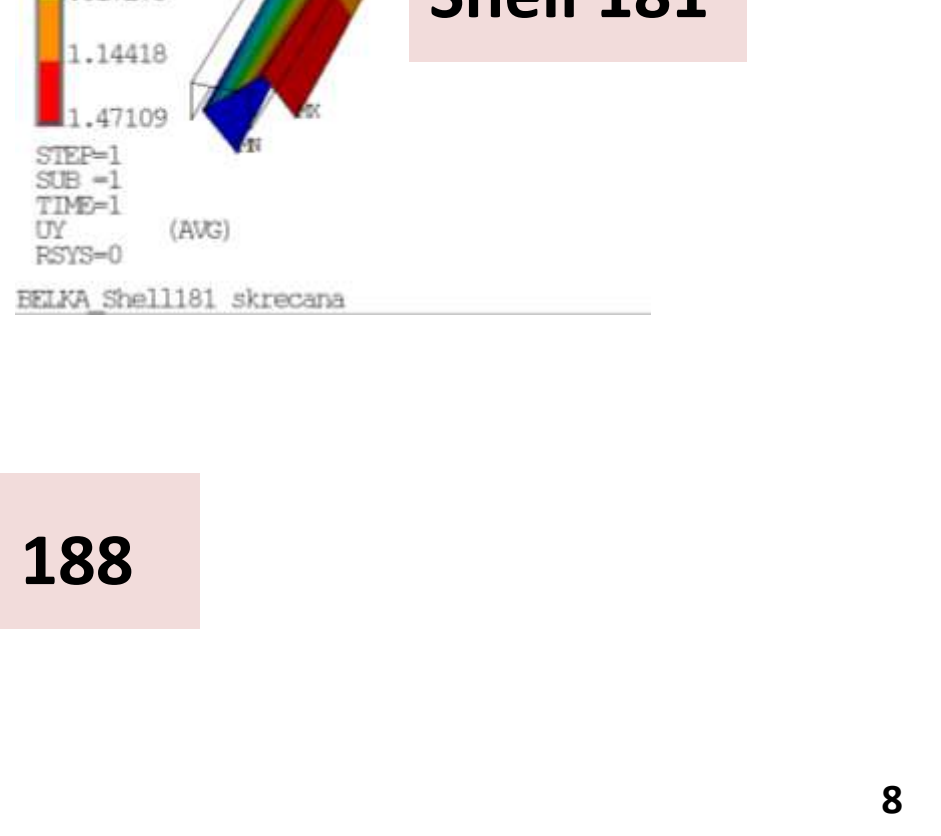
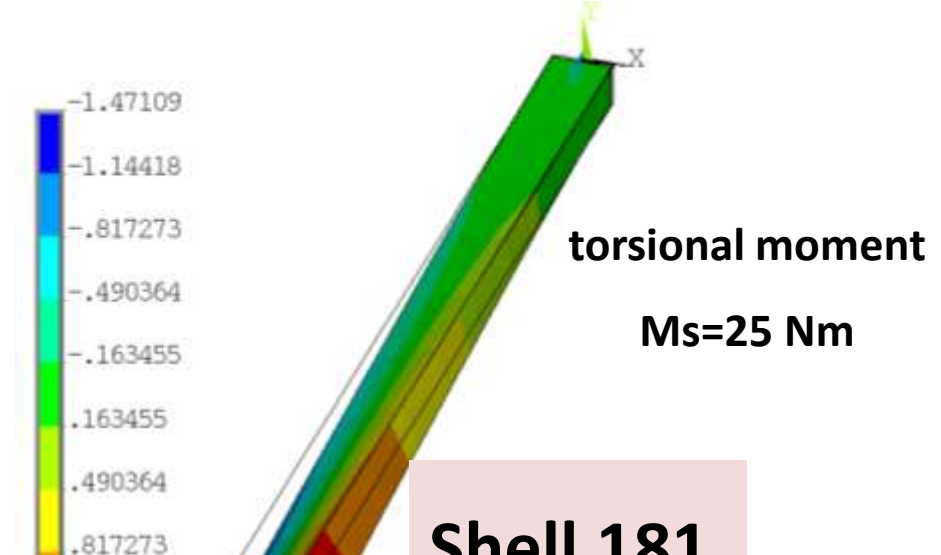
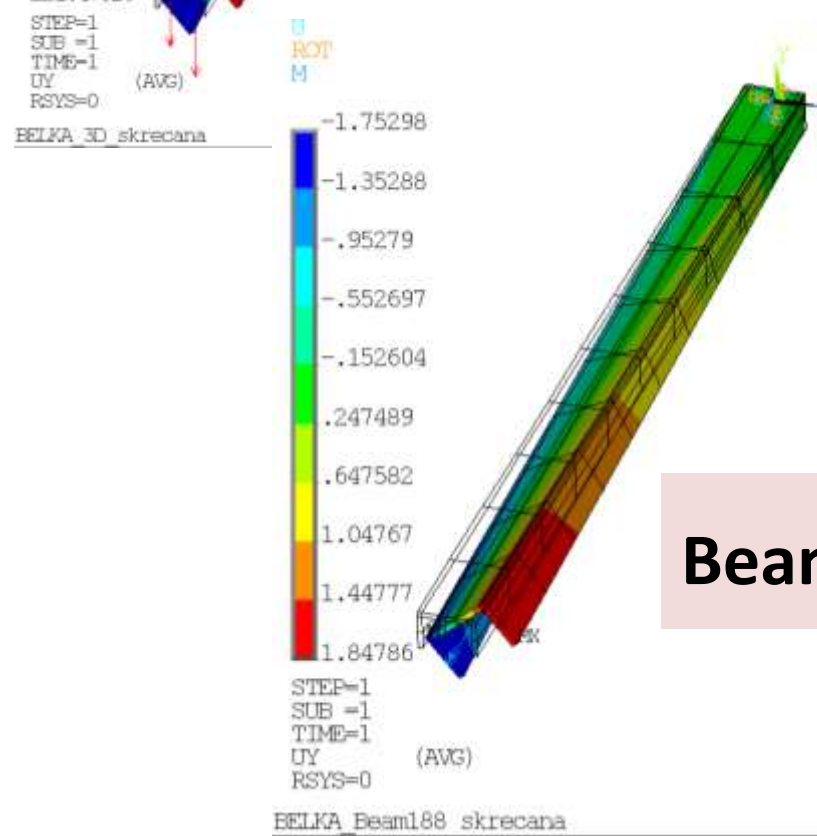
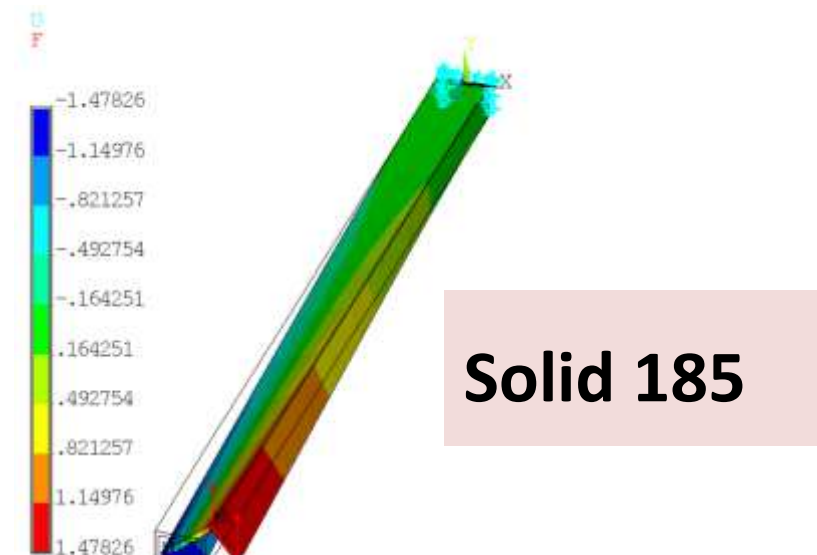


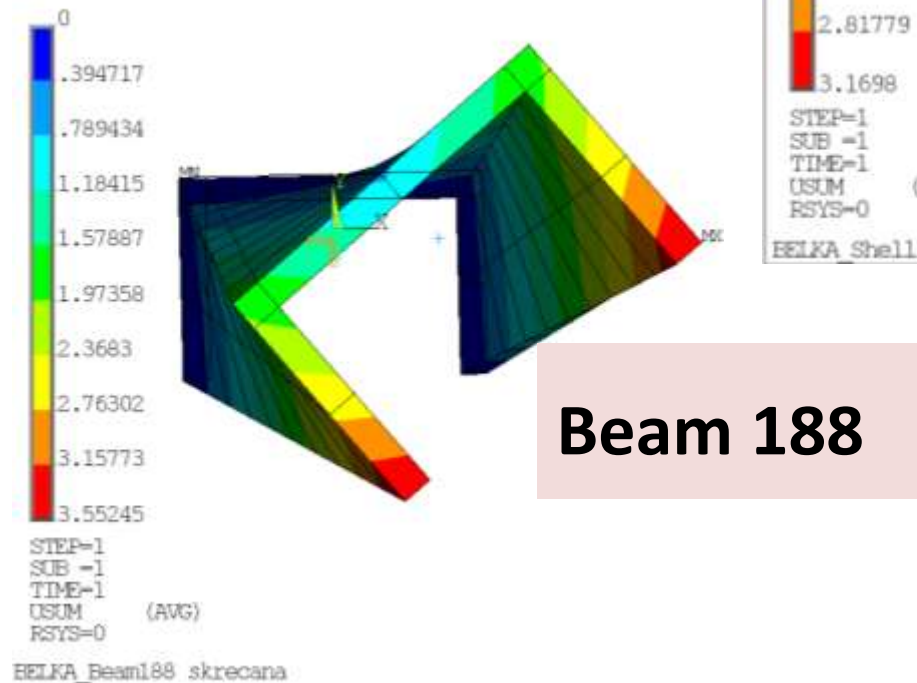
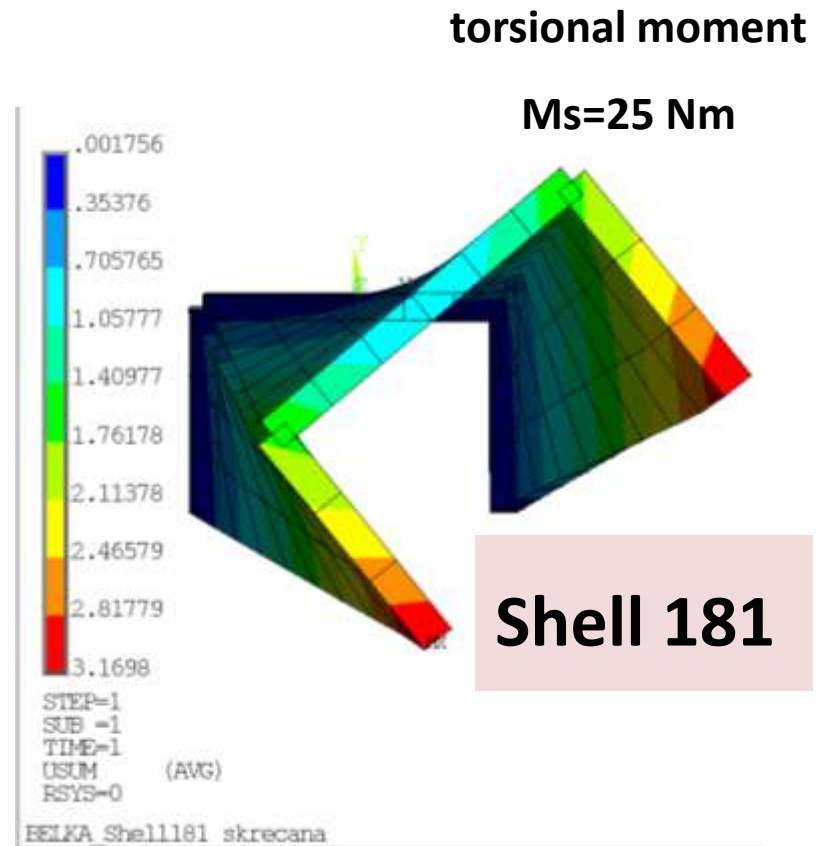
Shell 181



Beam 188

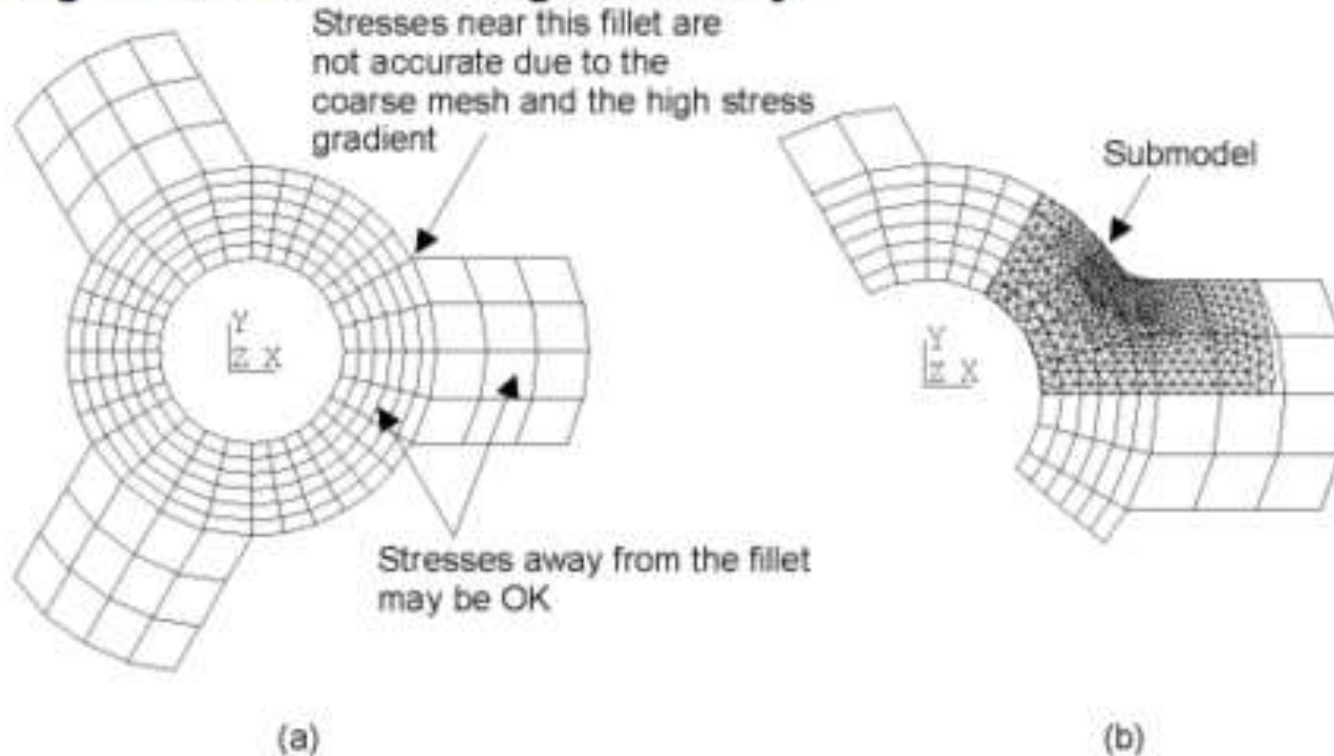






Submodeling

Figure 9.1: Submodeling of a Pulley



Submodeling of a pulley hub and spokes: (a) coarsely meshed model, and (b) finely meshed submodel (shown superimposed over coarse model)

Understanding Submodeling

Figure 9.2: Coarse Model

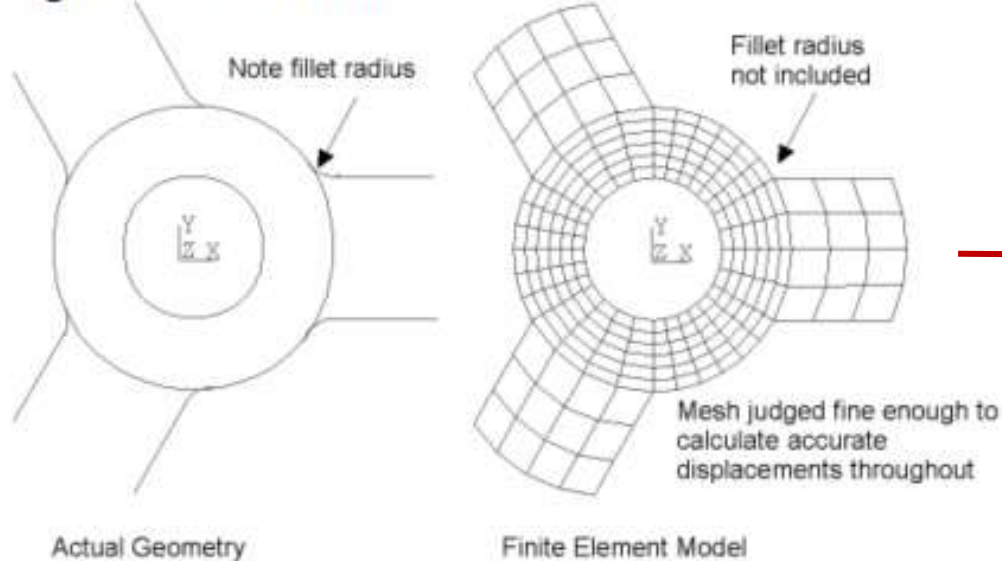
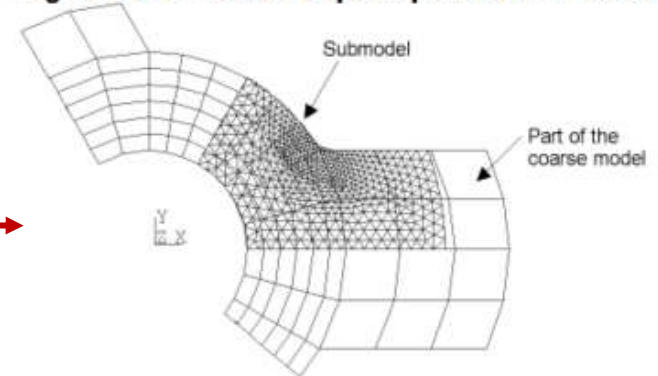


Figure 9.3: Submodel Superimposed Over Coarse Model



Initial, coarse model may not need to include many details

Figure 9.4: Cut Boundaries on the Submodel

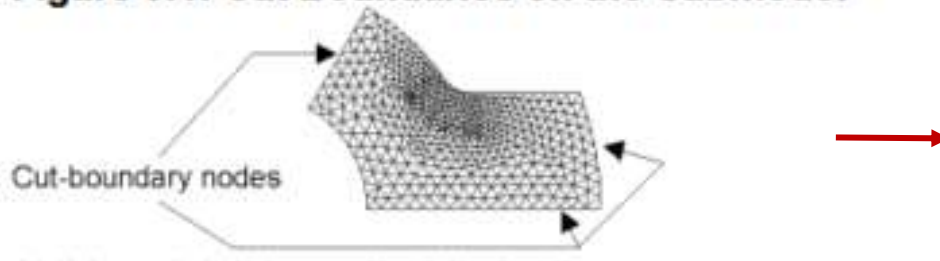
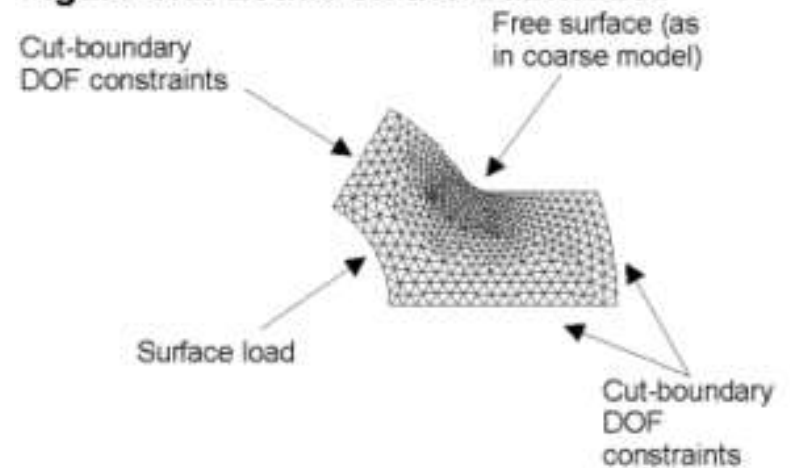
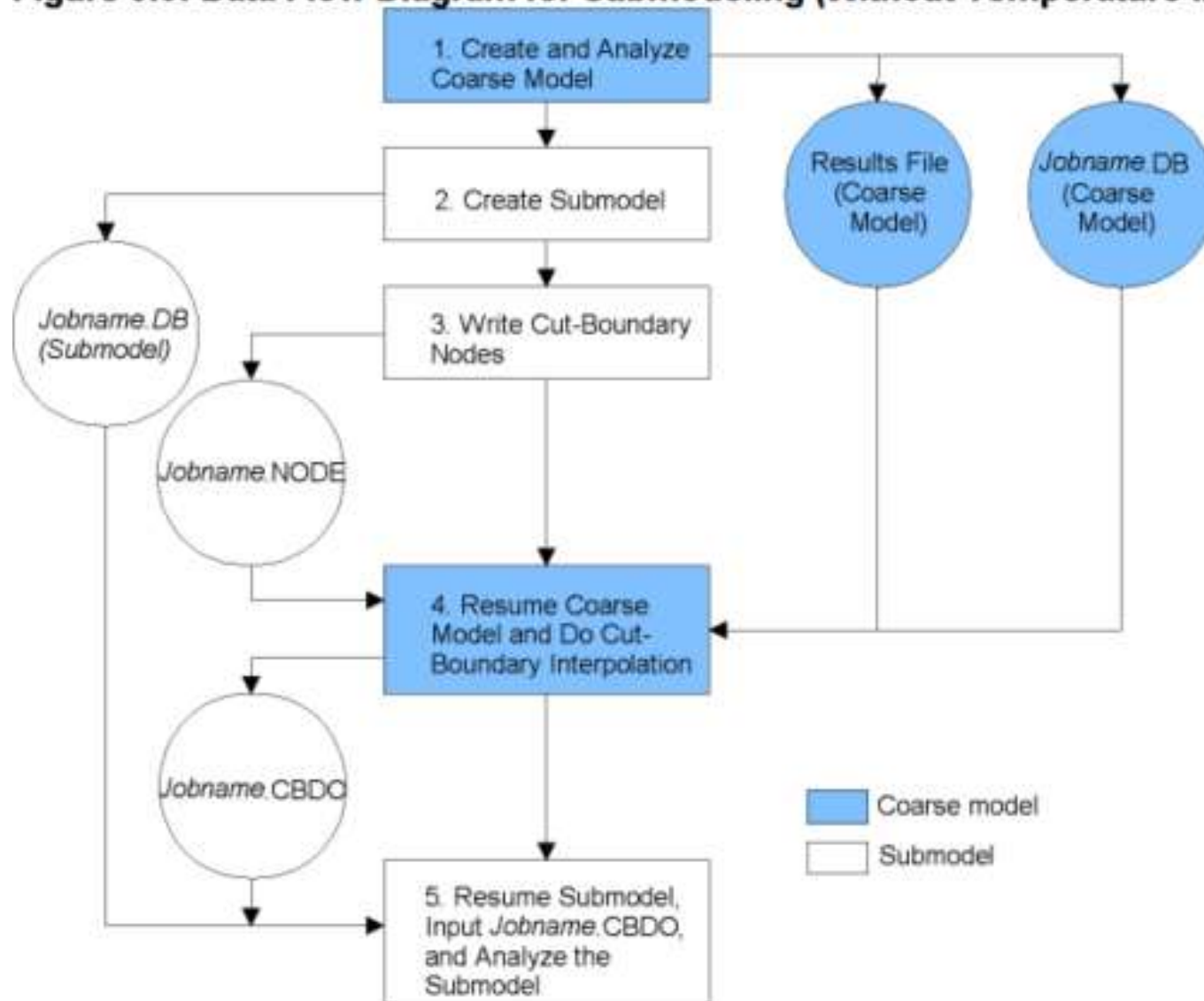


Figure 9.5: Loads on the Submodel



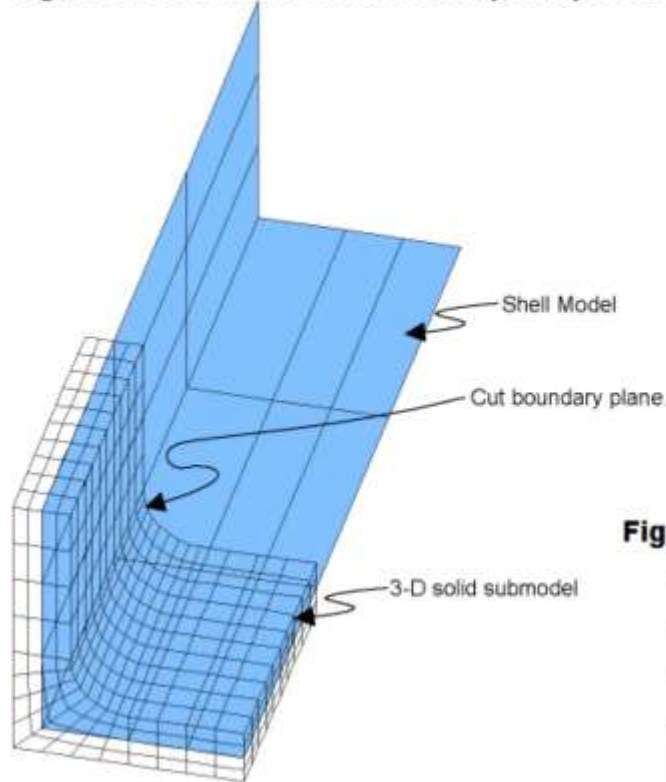
Understanding Submodeling

Figure 9.6: Data Flow Diagram for Submodeling (Without Temperature Interpolation)



Shell-to-Solid Submodels

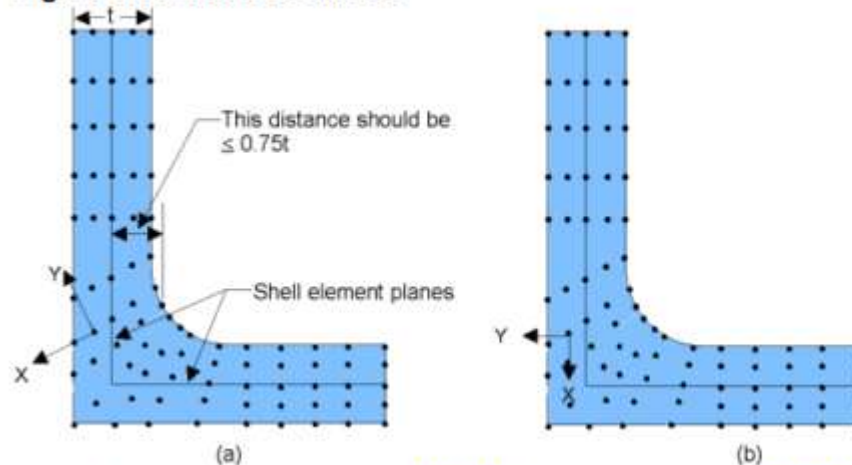
Figure 9.9: 3-D Solid Submodel Superimposed on Coarse Shell Model



In a structural analysis, only translational displacements are calculated for the cut boundary nodes, but their values are based on both the translations and rotations of the projected point.

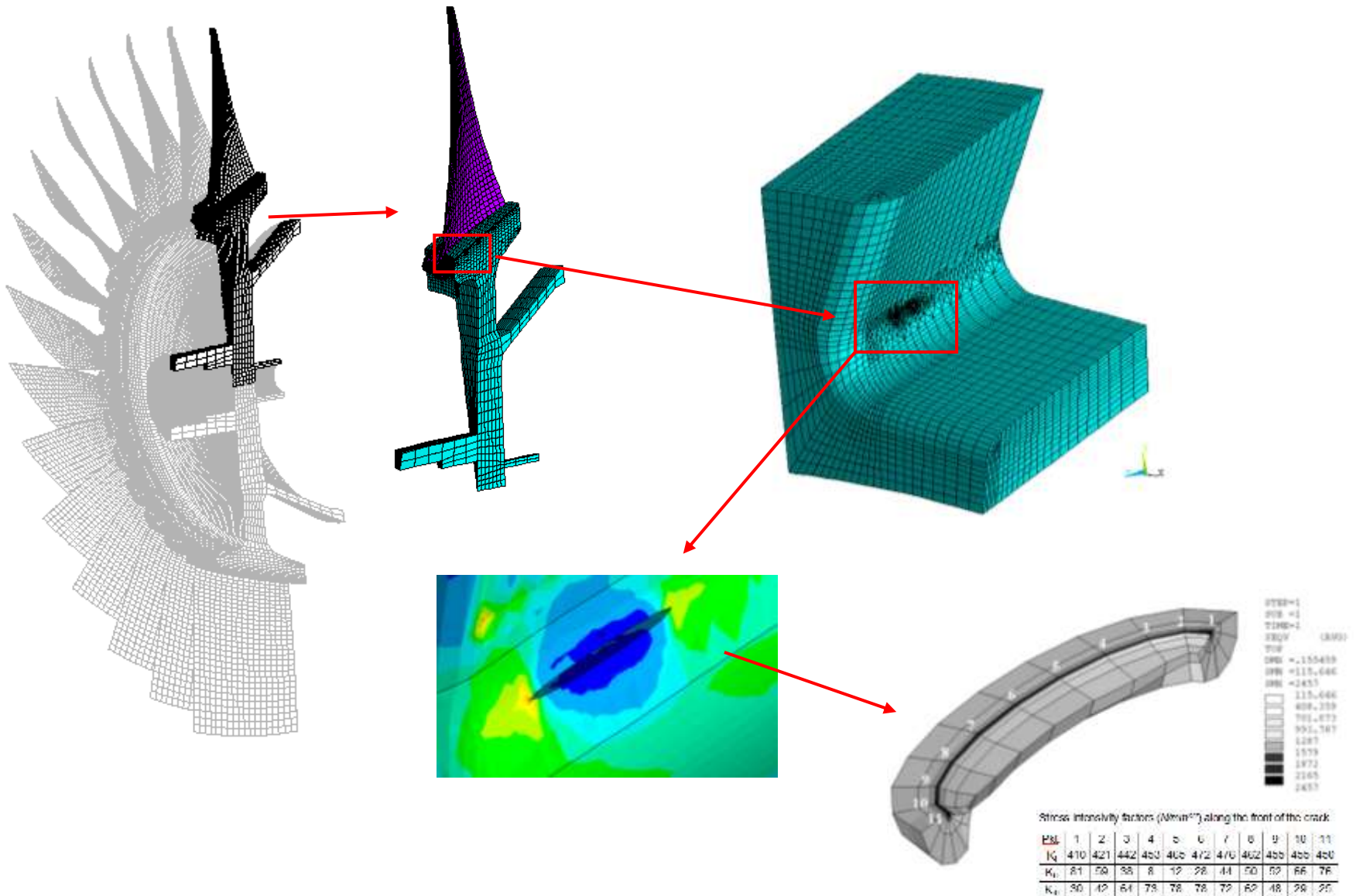
Also, the node is rotated such that the nodal UY direction is always perpendicular to the shell plane

Figure 9.10: Node Rotations

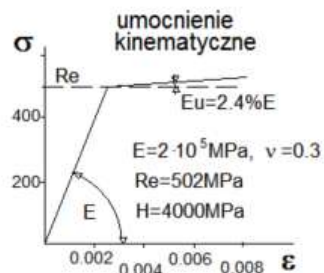
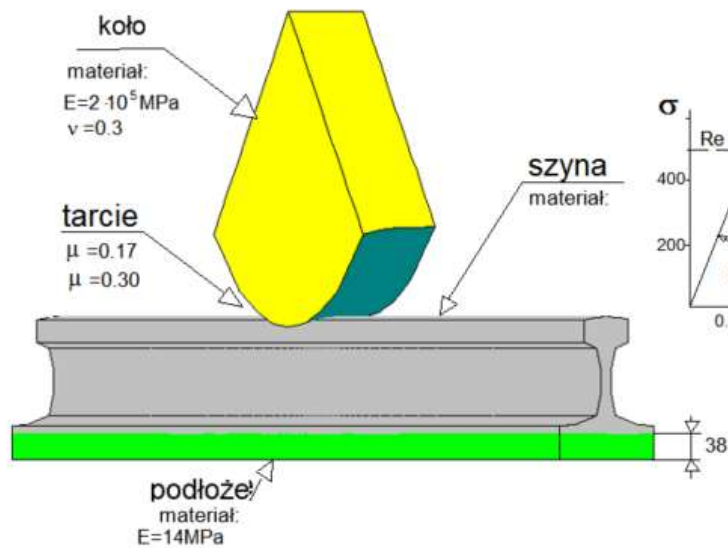
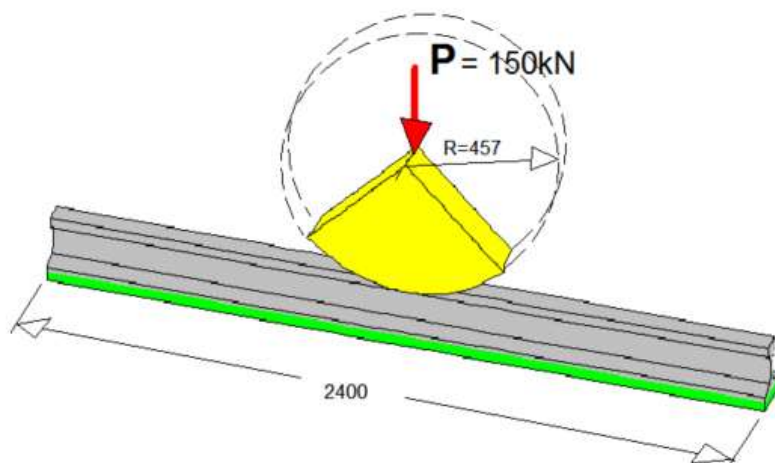


Node rotations: (a) before **CBDOF** command, (b) after **CBDOF** command

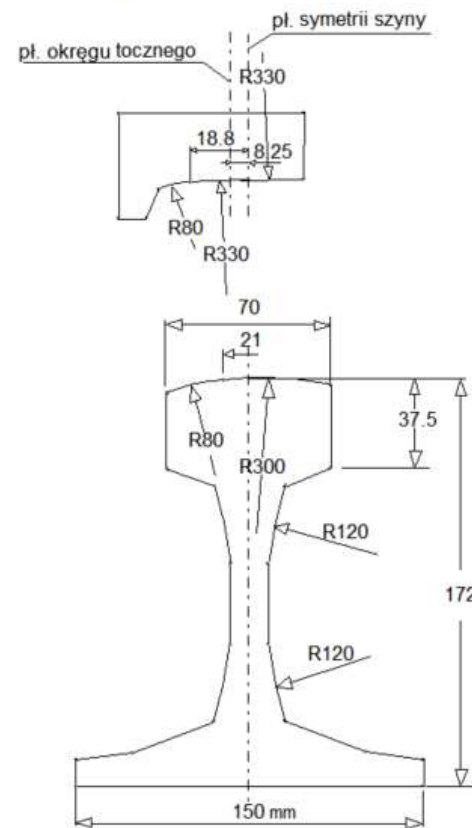
FE ANALYSIS OF THE TURBINE BLADE LOCKING PIECE DEFECTS



Rough model



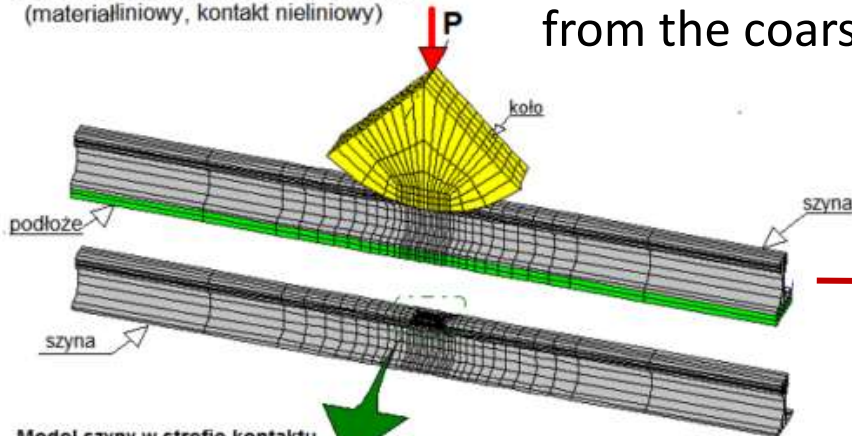
Geometria przekroju poprzecznego koła



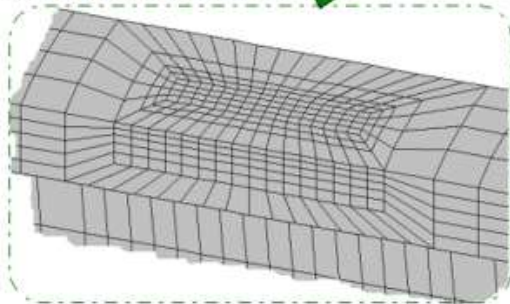
Geometria przekroju poprzecznego szyny

Rys.6.6. Geometria ciał i model materiału przyjęte w analizie kontaktu tocznego szyny z kołem.

Pełny model kontaktu szyny z kołem
(materialiniowy, kontakt nieliniowy)

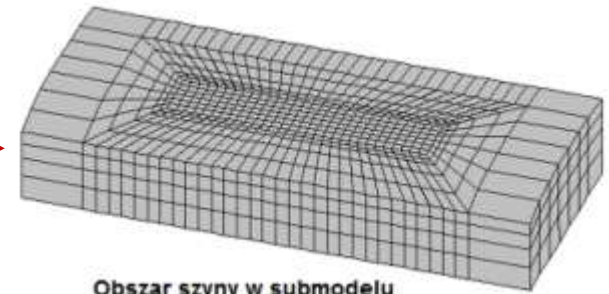


Model szyny w strefie kontaktu



Transferring displacement conditions
from the coarse model to the submodel

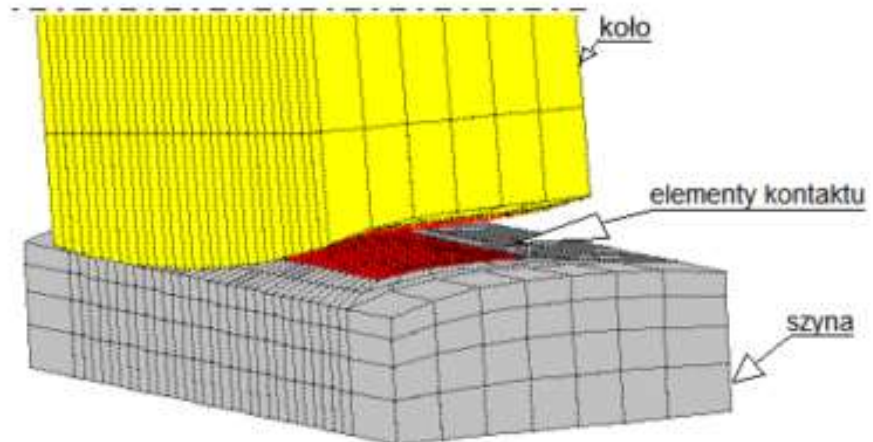
przeniesienie przemieszczeń
z rozwiązania zadania pełnego
(model o uproszczonej dyskretyzacji)
do nowego,
nieliniowego zadania kontaktu
w postaci warunków
na brzegach submodelu



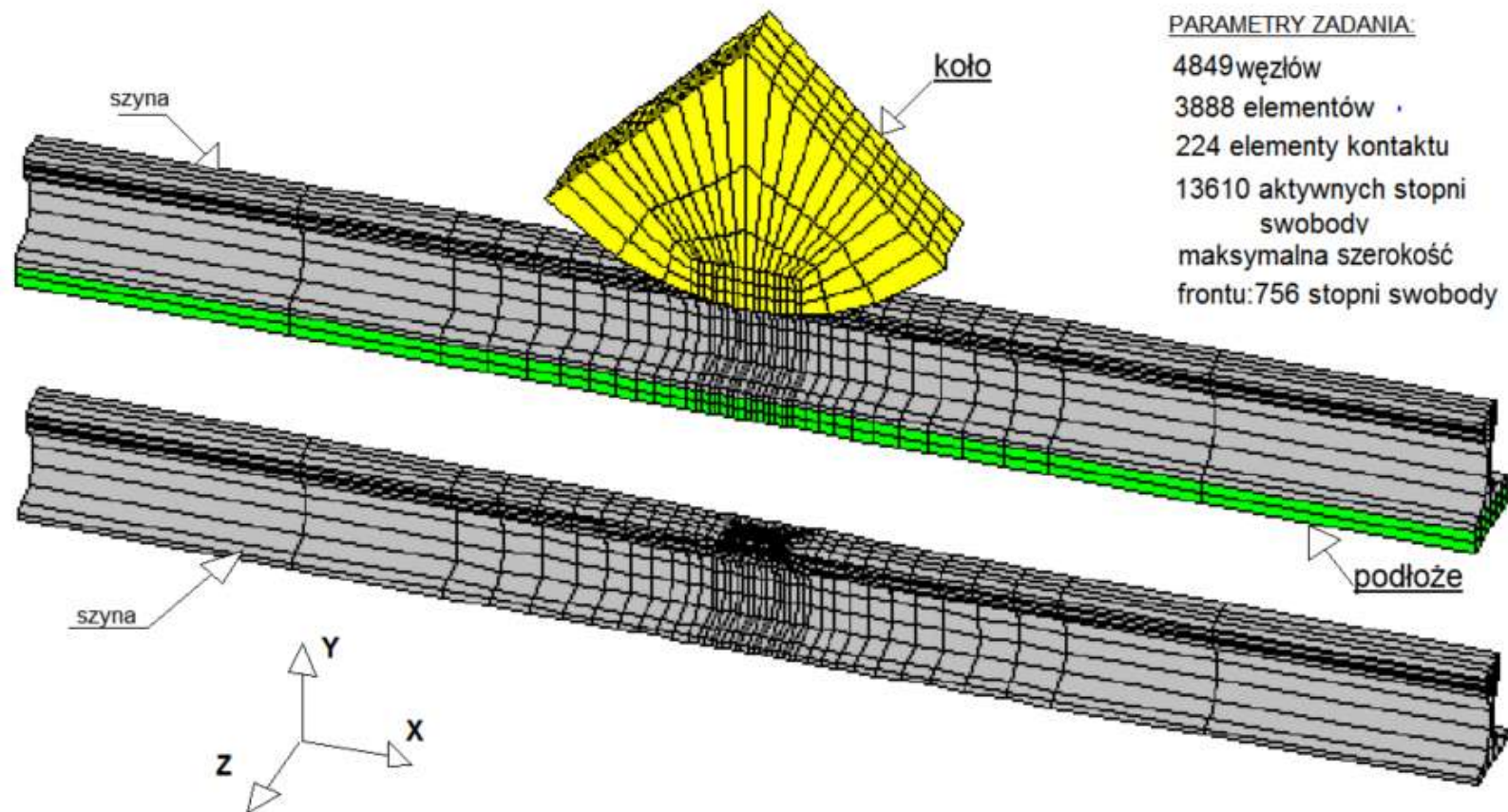
SUBMODEL

KONTAKTU SZYNY Z KOŁEM

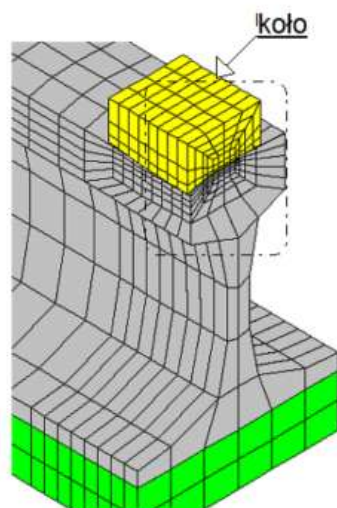
(material szyny nieliniowy, kontakt nieliniowy z tarciem,
obciążenie siłami i krokiem przemieszczenia)



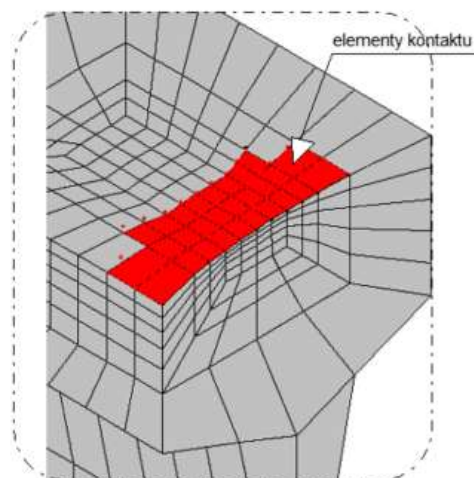
Rough model



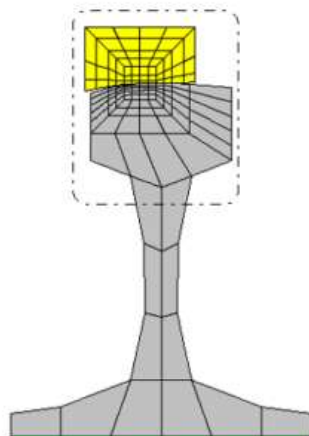
Budowa strefy kontaktu



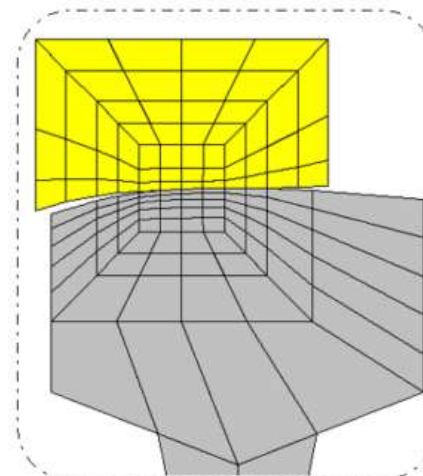
przekrój modelu płaszczyzną symetrii



elementy kontaktu na powierzchni szyny

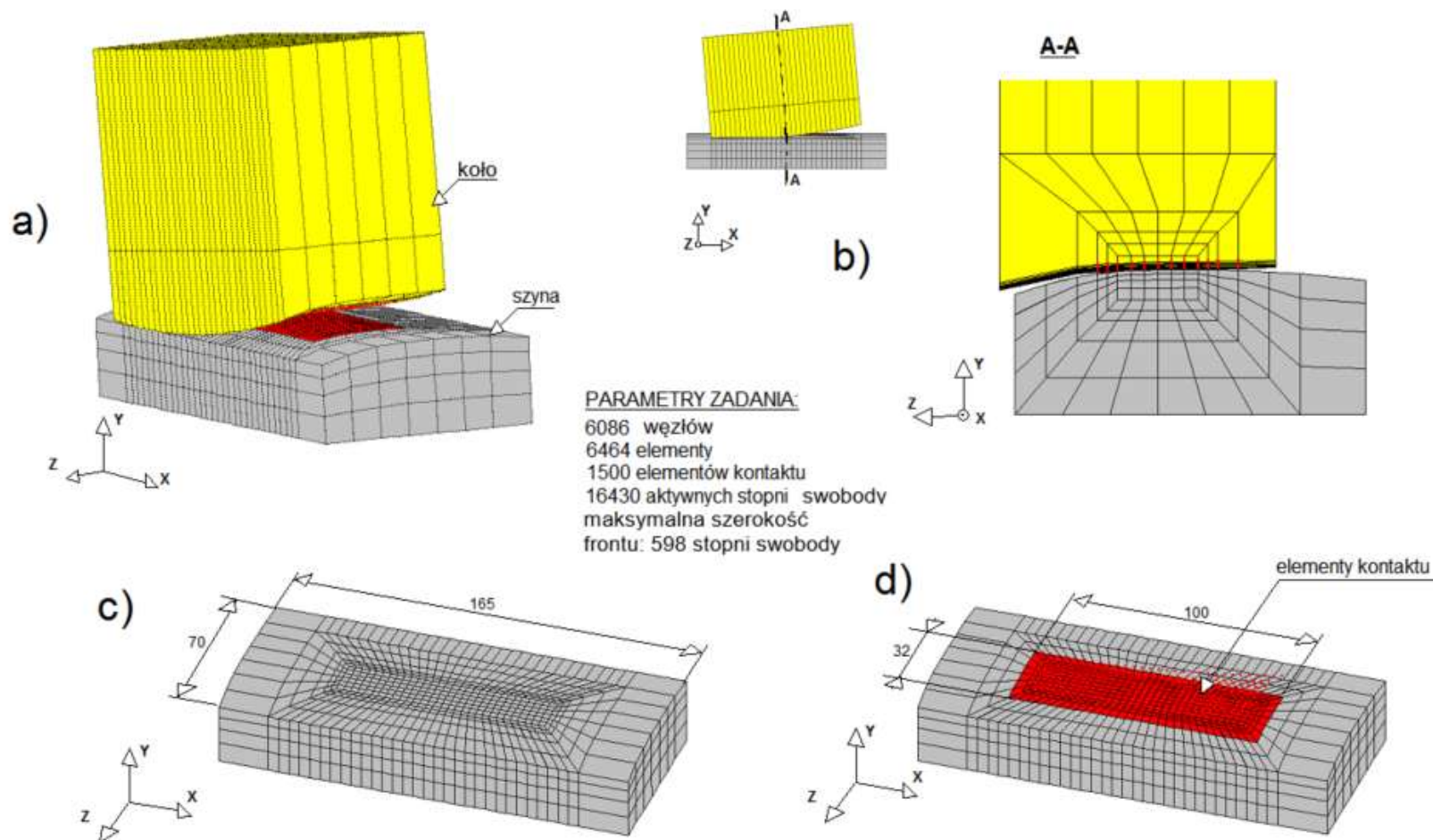


widok przekroju modelu płaszczyzną symetrii



powiększenie przekroju modelu w strefie kontaktu

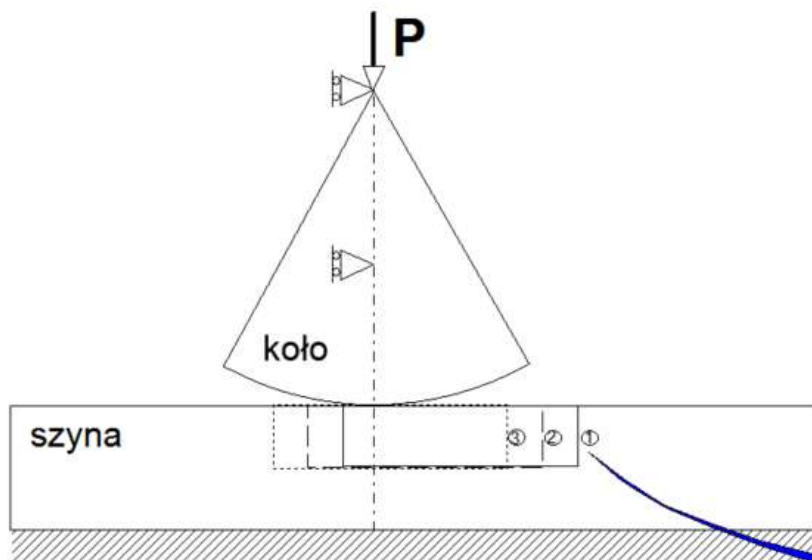
Rys.6.8. Siatka dyskretizacyjna dla zadania pełnego kontaktu szyny z kołem.



Rys.6.9. Dyskretyzacja submodelu w zadaniu kontaktu szyny z kołem;

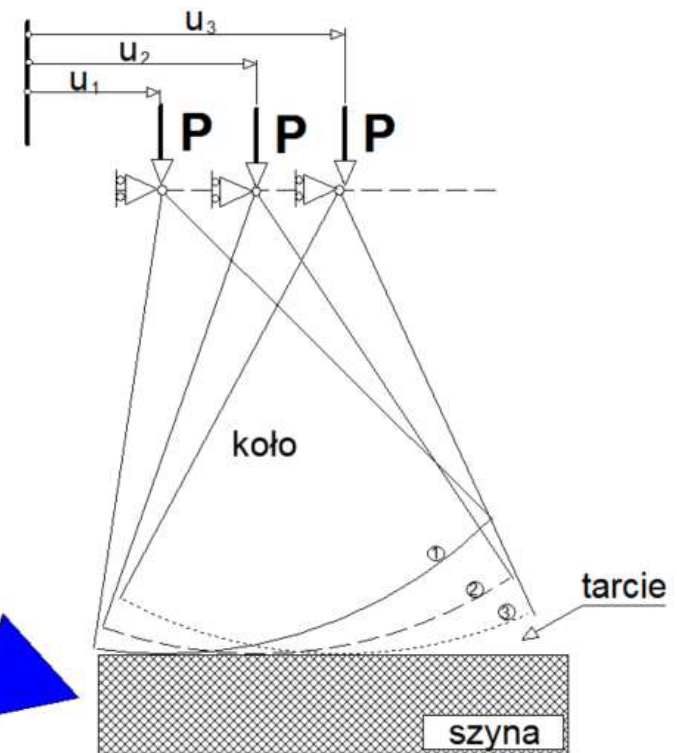
- a) wycinek szyny objęty submodelem,
- b) przekrój submodelu płaszczyzną A-A,
- c) dyskretyzacja submodelu,
- d) dyskretyzacja strefy kontaktu z zaznaczeniem elementów kontaktu.

MODEL

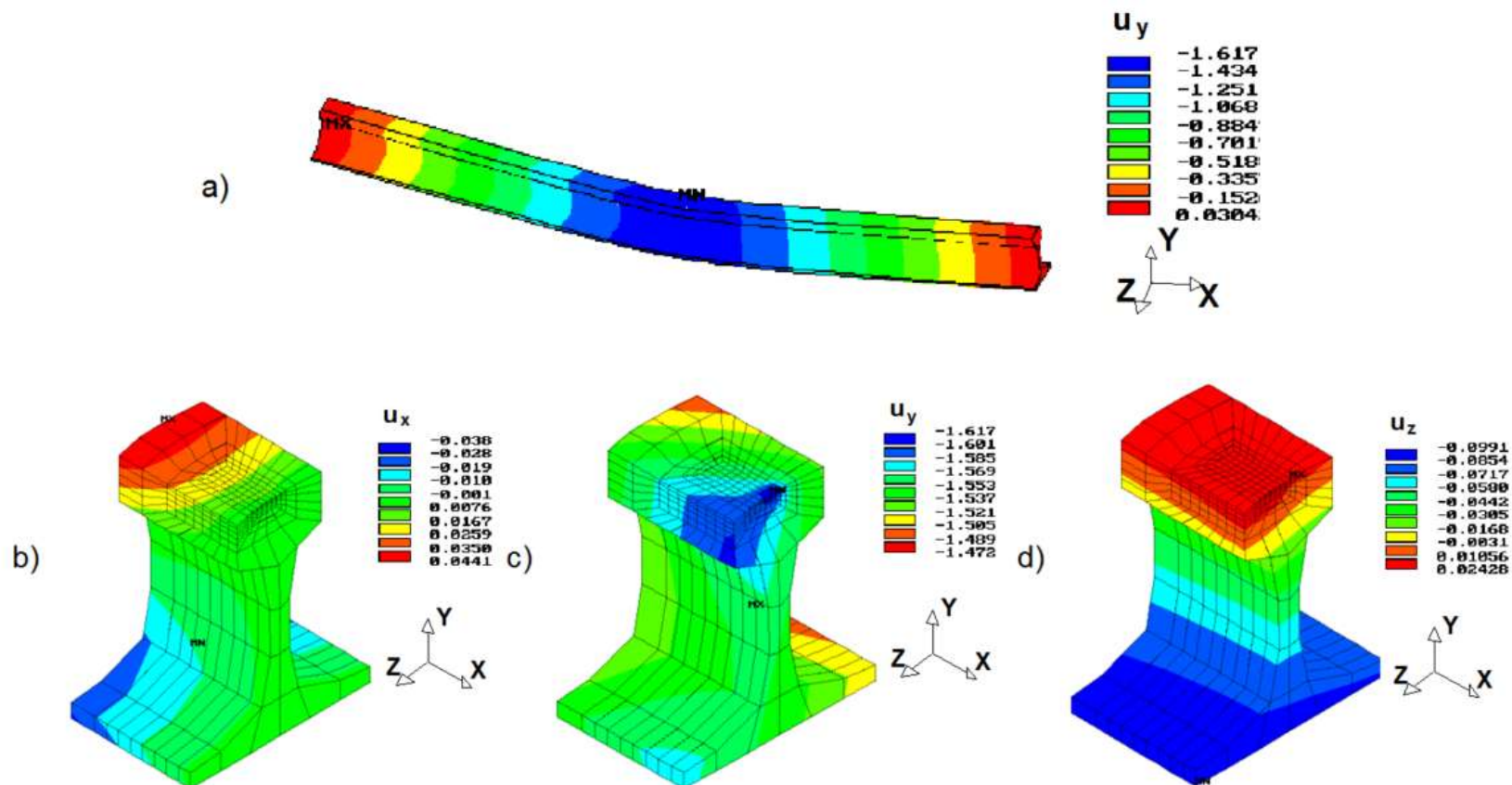


przeniesienie warunków
brzegowych w kolejnych
krokach obciążenia

SUBMODEL

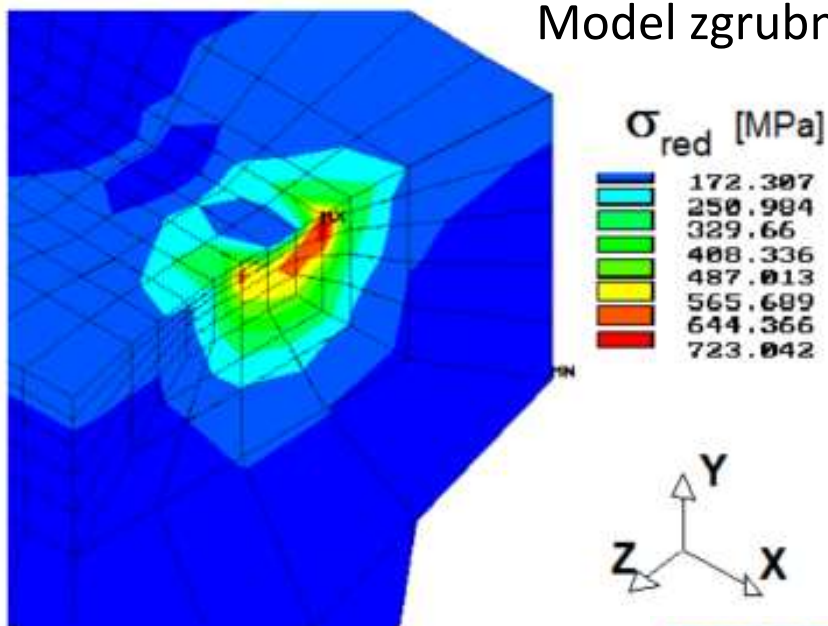


Rys.6.10. Koncepcja toczenia w zadaniu kontaktu szyny z kołem, przy wykorzystaniu modelu i submodelu.

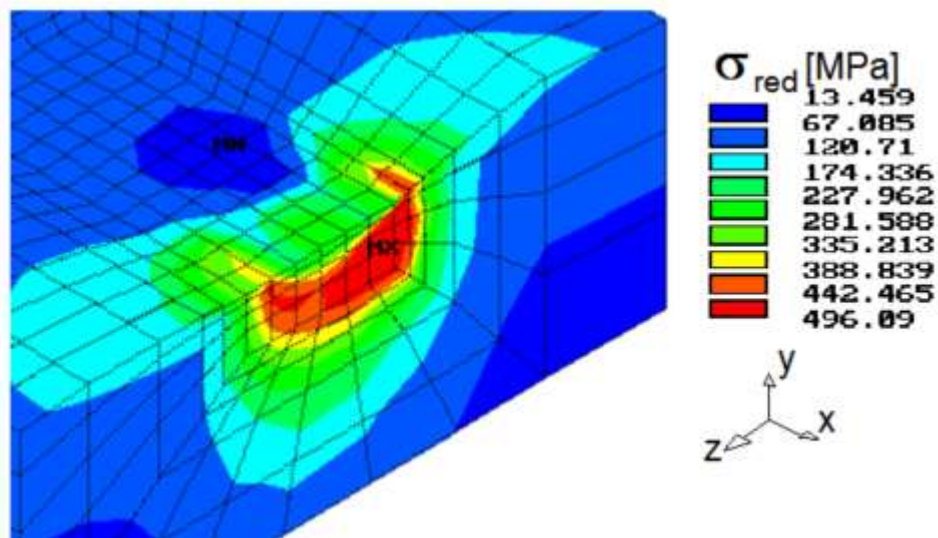


Rys.6.11. Wyniki obliczeń modelu pełnego: przebiegi składowych przemieszczenia [mm]: a) w kierunku pionowym dla całej szyny, oraz b) w kierunku wzdłużnym, c) pionowym i d) poprzecznym w strefie kontaktu.

Model zgrubny



Submodel

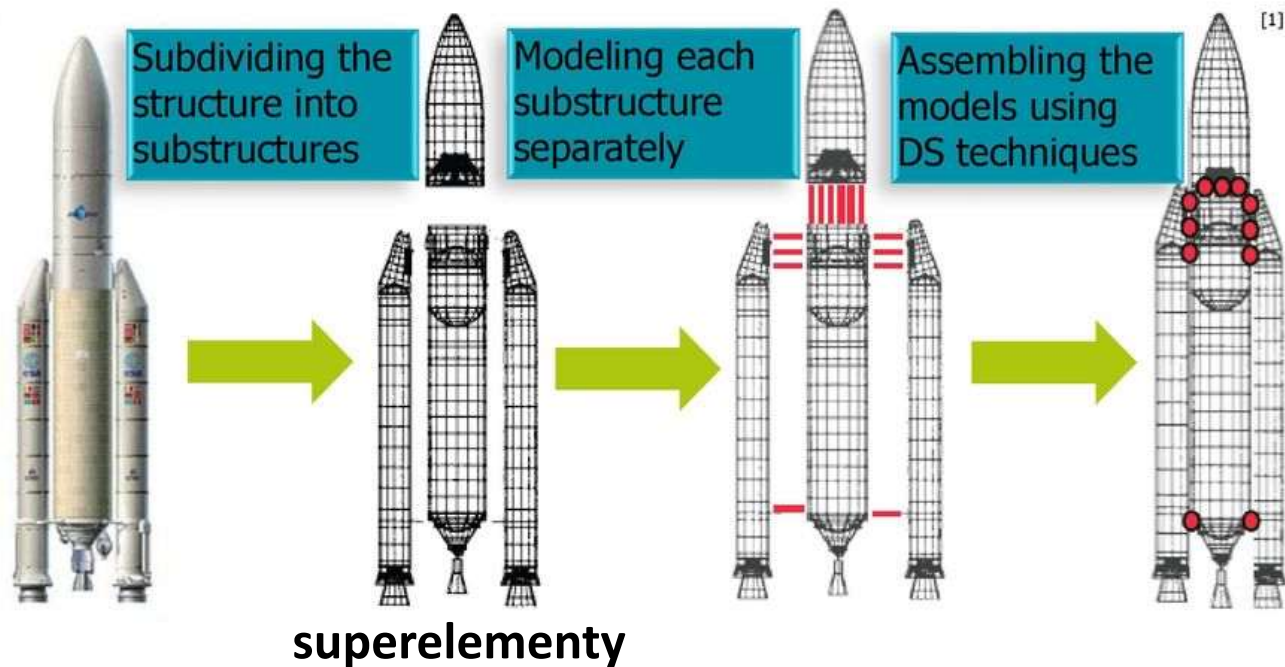


Substructuring

Dynamic Substructuring

Schematic overview

1. Introduction
2. Dynamic Substructuring (DS)
3. Experimental DS
4. Ampair 600 Wind Turbine
5. Experimental modeling
6. Assembly results
7. Conclusions
8. Recommendations



[1] Figures from Daniel J. Rixen, Dynamic Substructuring Concepts, Tutorial, IMAC 2010.

Elements Supporting Birth and Death

The following ANSYS elements support the birth and death feature:

LINK1	PLANE25	PIPE60	SOLID92	TARGE170	BEAM188
BEAM3	MATRIX27	SOLID62	SOLID95	CONTA171	BEAM189
BEAM4	LINK31	SHELL63	SOLID96	CONTA172	SOLSH190
SOLID5	LINK32	SOLID65	SOLID97	CONTA173	FOLLW201
LINK8	LINK33	PLANE67	SOLID98	CONTA174	SHELL208
LINK10	LINK34	LINK68	PLANE121	CONTA175	SHELL209
LINK11	PLANE35	SOLID69	SOLID122	CONTA176	PLANE230
PLANE13	SHELL41	SOLID70	SOLID123	CONTA177	SOLID231
COMBIN14	PLANE42	MASS71	SHELL131	LINK180	SOLID232
PIPE16	BEAM44	PLANE75	SHELL132	SHELL181	REINF264
PIPE17	SOLID45	PLANE77	SURF151	PLANE182	SOLID272
PIPE18	PLANE53	PLANE78	SURF152	PLANE183	SOLID273
PIPE20	BEAM54	PLANE82	SURF153	MPC184-Link/Beam	SOLID285
MASS21	PLANE55	PLANE83	SURF154	SOLID185	PIPE288
BEAM23	SHELL57	SOLID87	SHELL157	SOLID186	PIPE289
BEAM24	PIPE59	SOLID90	TARGE169	SOLID187	ELBOW290