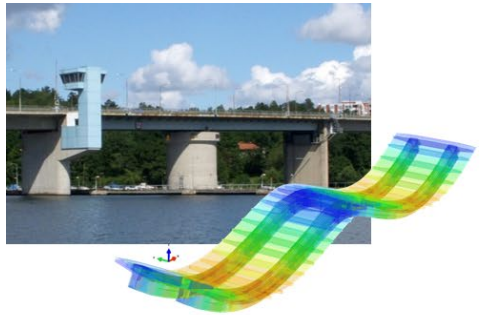
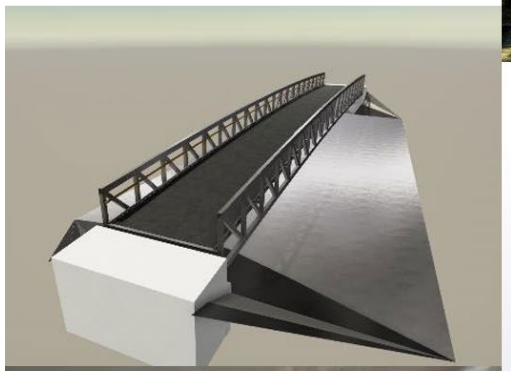
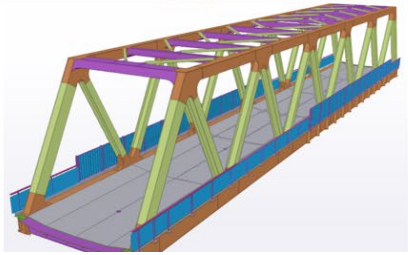
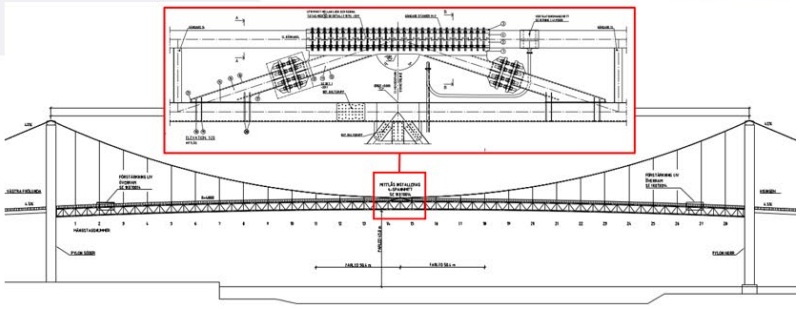
BERÄKNINGSEXEMPEL KAPACITETSANALYS

Peter Nilsson Strand, PhD



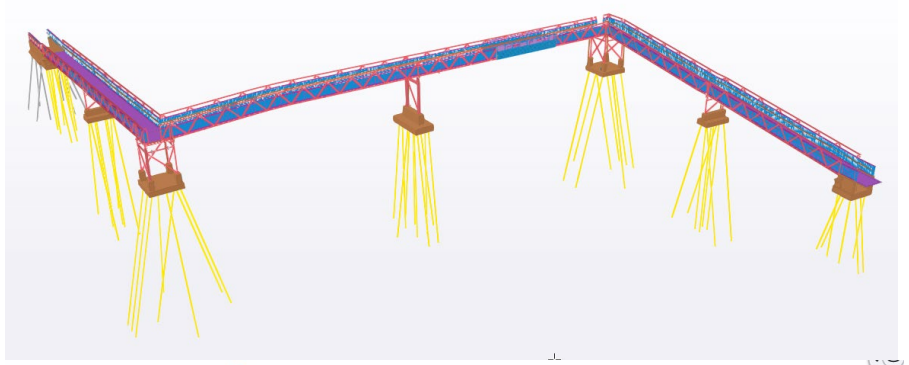



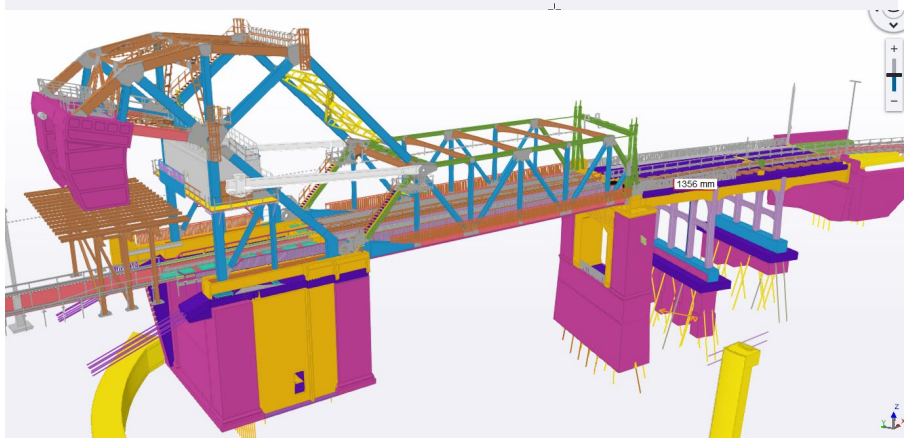


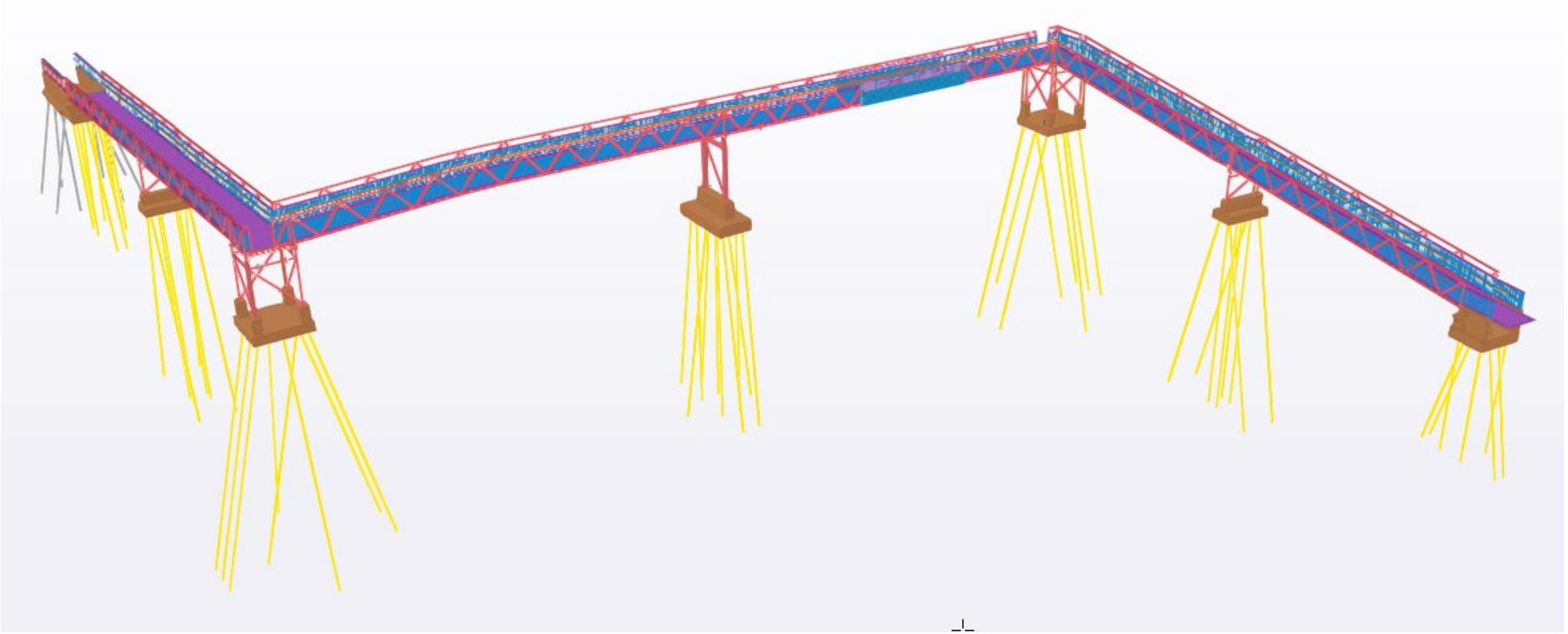
- **HAMNBANAN, GMNLA**
  DIGITALT BROTTLASTFÖRSÖK

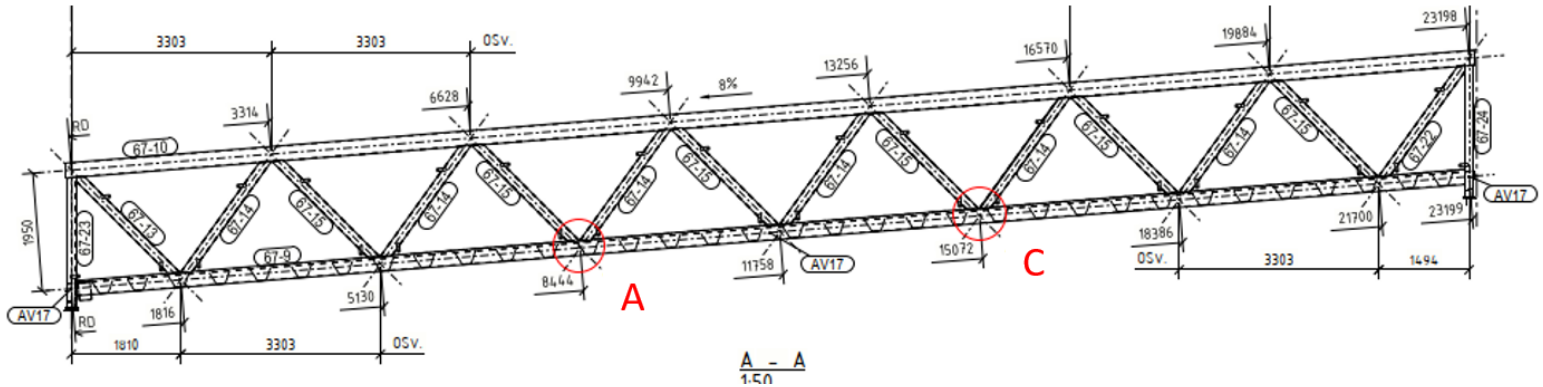
- **NORRA DANVIKSBRON, SUB-MODELLERING**
  KNUTPUNKTSDIMENSIONERING



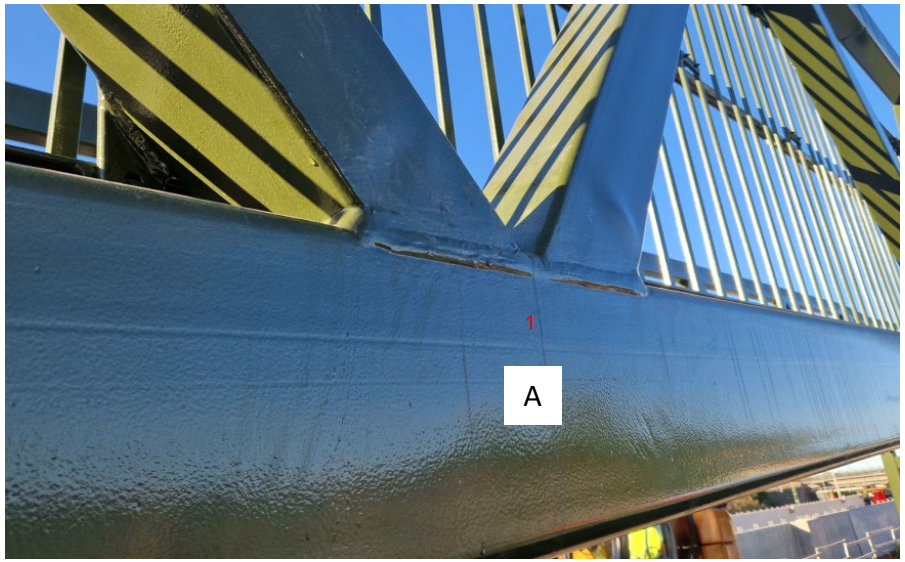


GMNLA
DIGITALT BROTTLASTFÖRSÖK




3303
3303
OSV.
6628
9942
8%
13256
16570
19884
23198
3314
RD
67-10
67-13
67-14
67-15
67-9
67-23
67-24
1950
AV17
RD
1816
1810
3303
OSV.
5130
8444
A
11758
AV17
15072
C
18386
OSV.
3303
1494
21700
23199
AV17

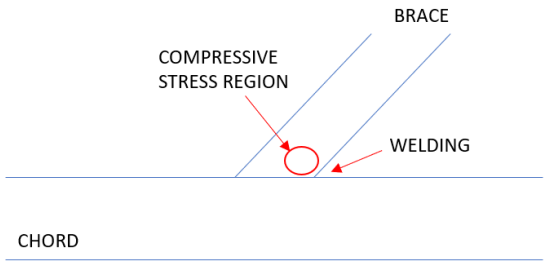
A – A
1:50


1
A

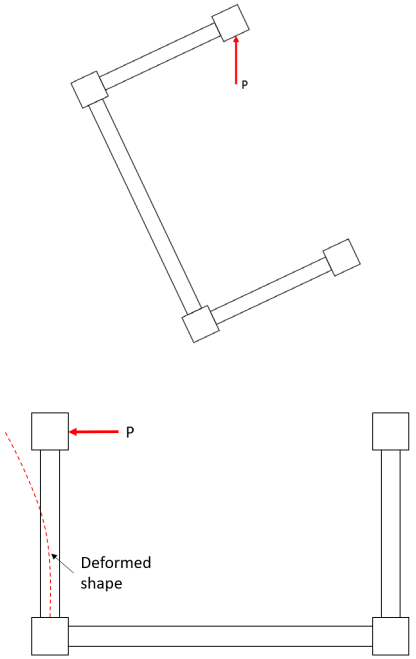

2
C

TRP/LYFT

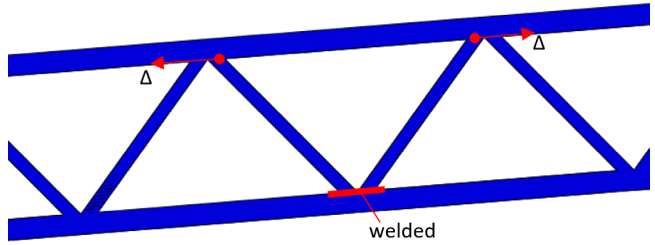
SVETSNING

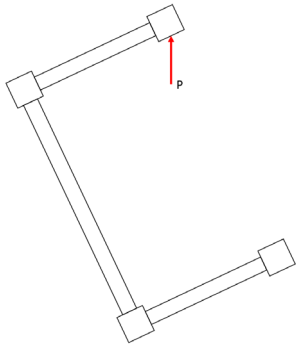


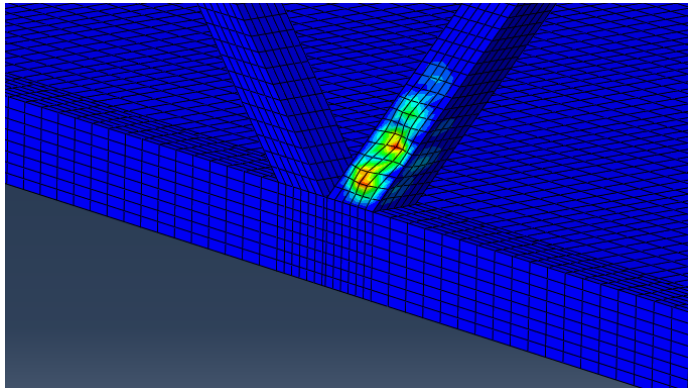
LYFT I VERKSTAD



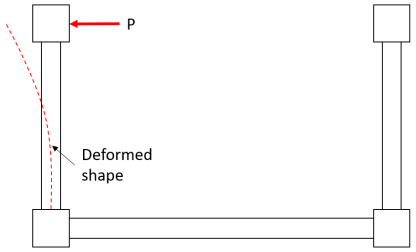
TVÅNG

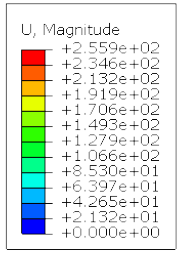


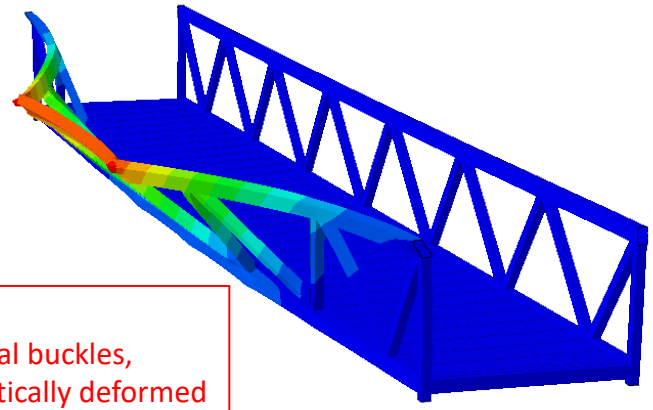




LINEAR BUCKLING

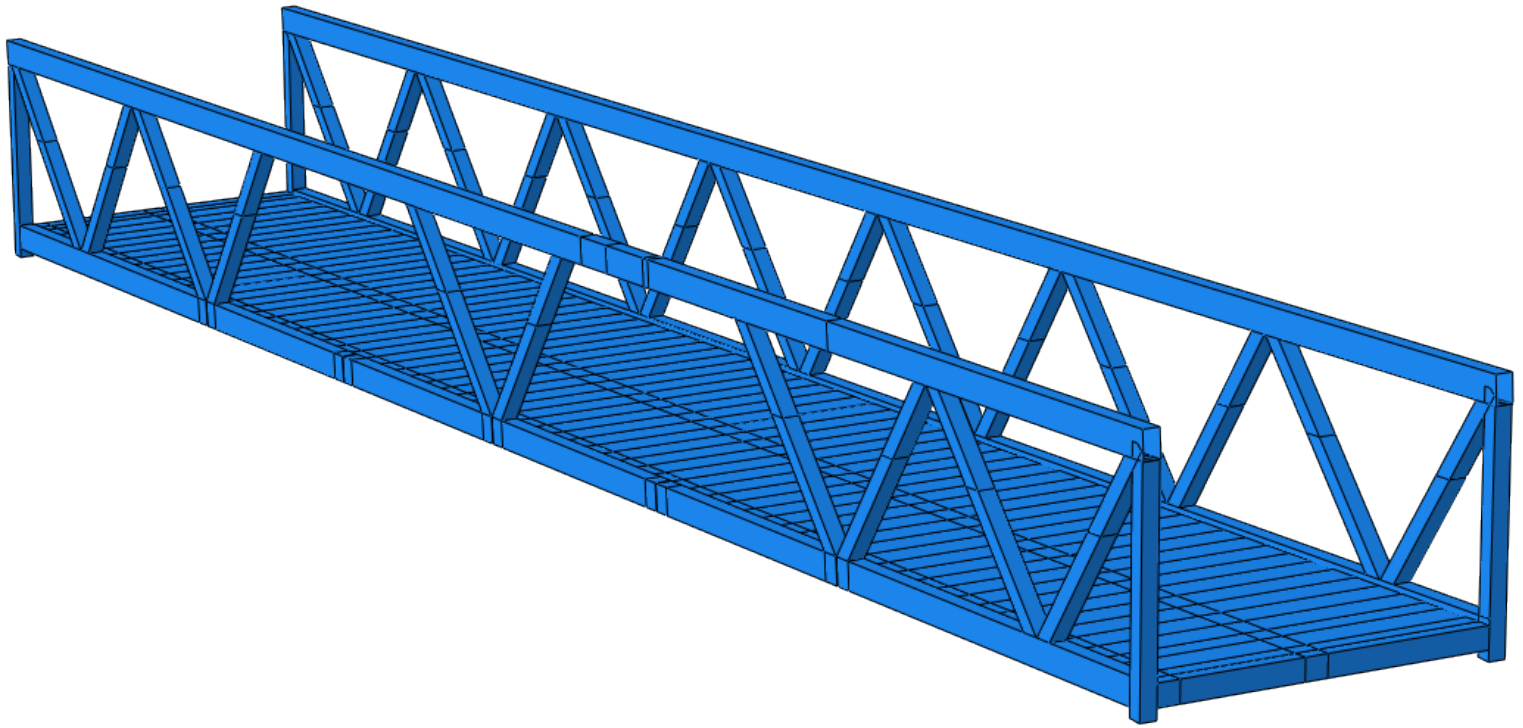




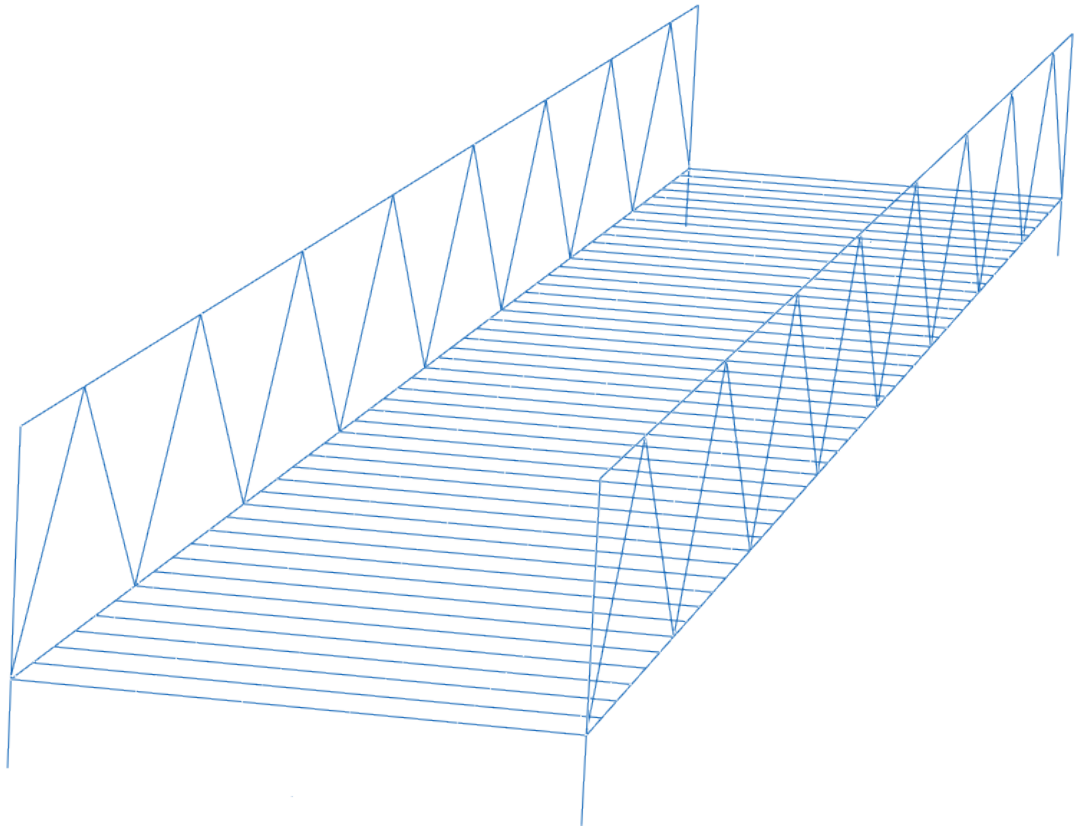


NL-FEA

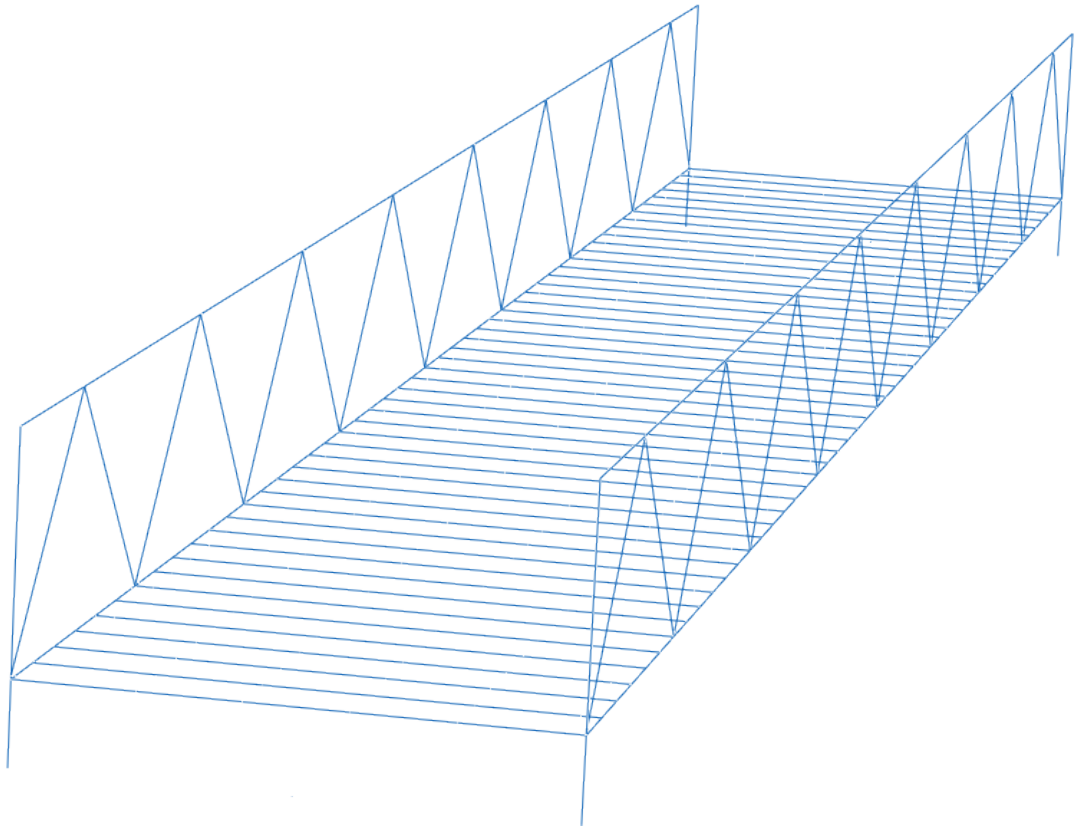
CONCLUSION:
In order to create the local buckles,
the whole truss would be plastically deformed



1. Ursprunglig beräkning utförs med skadade stänger
2. Relevanta delar kontrolleras med nya lasteffekter
    - Knutpunkter
    - Svängningar
    - Tvärsnittskapacitet
    - Elementkapacitet
    - Global kapacitet (knäckning av ÖRS)
3. Mer komplexa analysmetoder

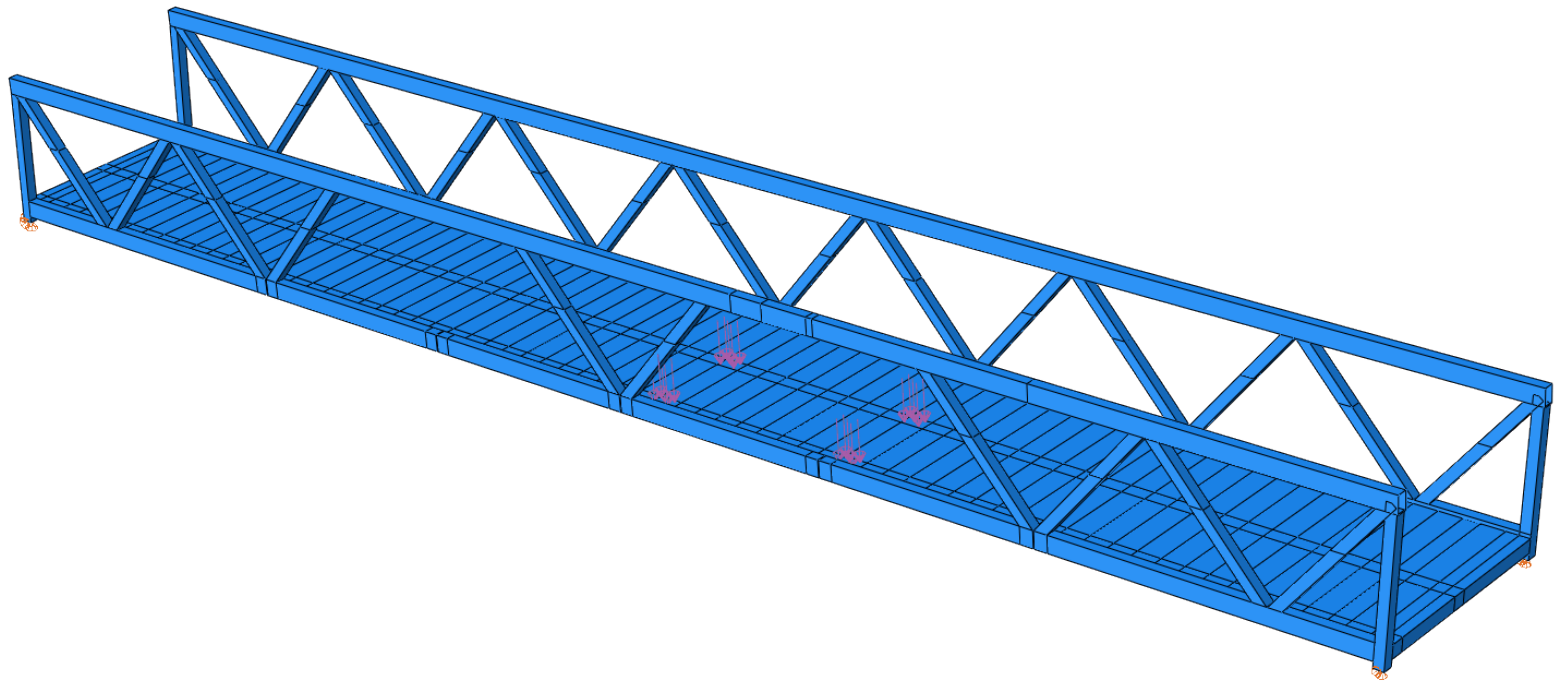


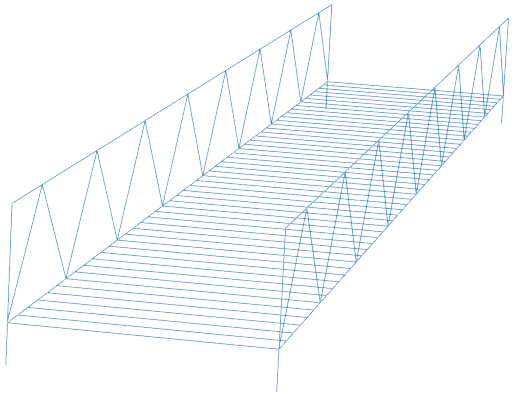
1. Ursprunglig beräkning utförs med skadade stänger
2. Relevanta delar kontrolleras med nya lasteffekter
   - Knutpunkter OK
   - Svängningar OK
   - Tvärsnittskapacitet OK
   - Elementkapacitet OK
   - Global kapacitet (knäckning av ÖRS) Ej OK, 108%
3. Mer komplexa analysmetoder



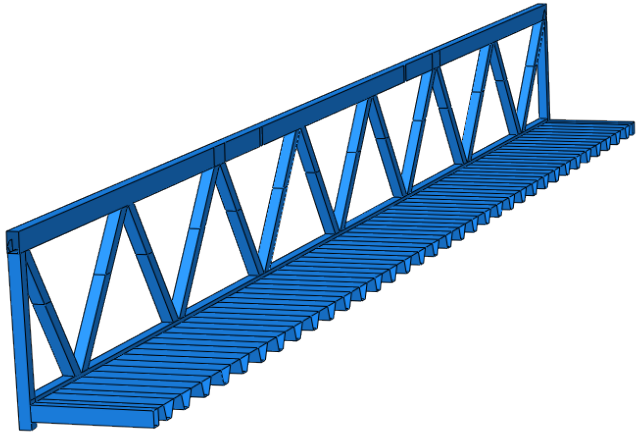
LOAD CASE:

- Servicefordon
- Vindlast
- Bromskraft
- Egentyngd

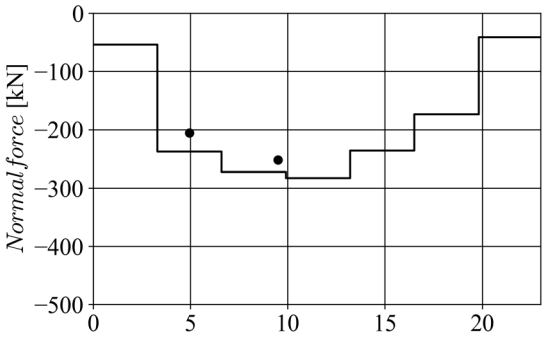




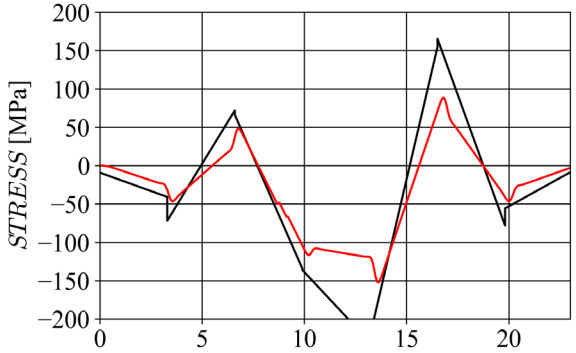
Design model



Detailed model



Normal force upper chord



Normal stress upper chord upper flange

Orsak till diskrepans:

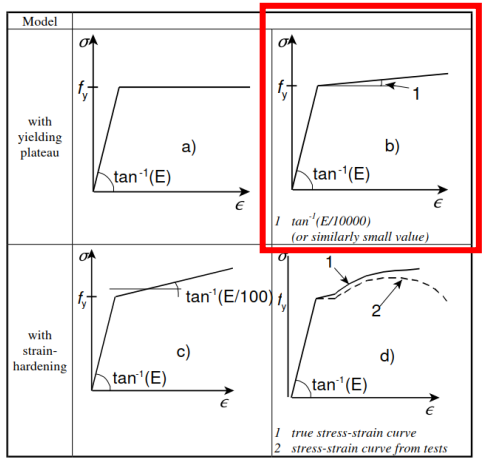
- *Tyngdpunkt*
- *Knutpunkternas styvhet*
- *Brobaneplattans inverkan*

MODELLTYP

Table C.1: Assumptions for FE-methods

No	Material behaviour	Geometric behaviour	Imperfections, see section C.5	Example of use
1	linear	linear	no	elastic shear lag effect, elastic resistance
2	non linear	linear	no	plastic resistance in ULS
3	linear	non linear	no	critical plate buckling load
4	linear	non linear	yes	elastic plate buckling resistance
5	non linear	non linear	yes	elastic-plastic resistance in ULS

MATERIALMODELL



BROTTKRITERIUM

- $F_{Ed} < F_u$
- Max töjning 5%

EKVIVALENTA GEOMETRISKA IMPERFEKTIONER

Table C.2: Equivalent geometric imperfections

Type of imperfection	Component	Shape	Magnitude
global	member with length ℓ	bow	see EN 1993-1-1, Table 5.1
global	longitudinal stiffener with length a	bow	min (a/400, b/400)
local	panel or subpanel with short span a or b	buckling shape	min (a/200, b/200)
local	stiffener or flange subject to twist	bow twist	1 / 50

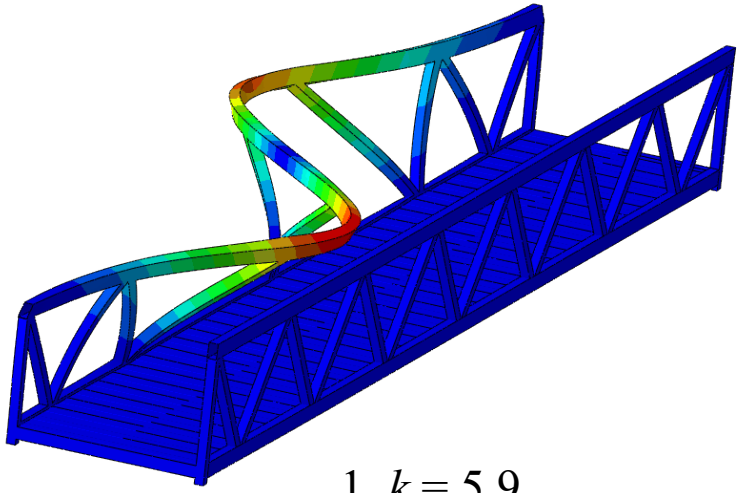
Tabell 5.1 – Dimensioneringsvärden för initialkrokighet e_0 / L

Knäckningskurva enligt tabell 6.1	elastisk analys	plastisk analys
	e_0 / L	e_0 / L
a_0	1 / 350	1 / 300
a	1 / 300	1 / 250
b	1 / 250	1 / 200
c	1 / 200	1 / 150
d	1 / 150	1 / 100

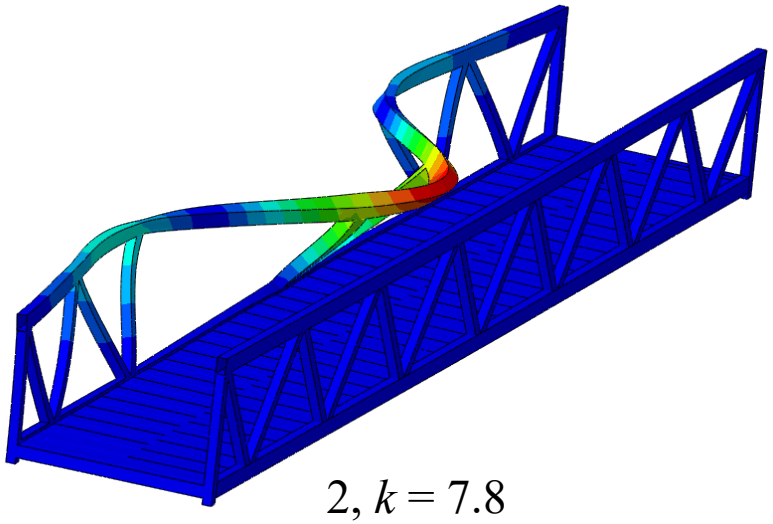
BUCKLINGSMODER

(5) In combining imperfections a leading imperfection should be chosen and the accompanying imperfections may have their values reduced to 70%.

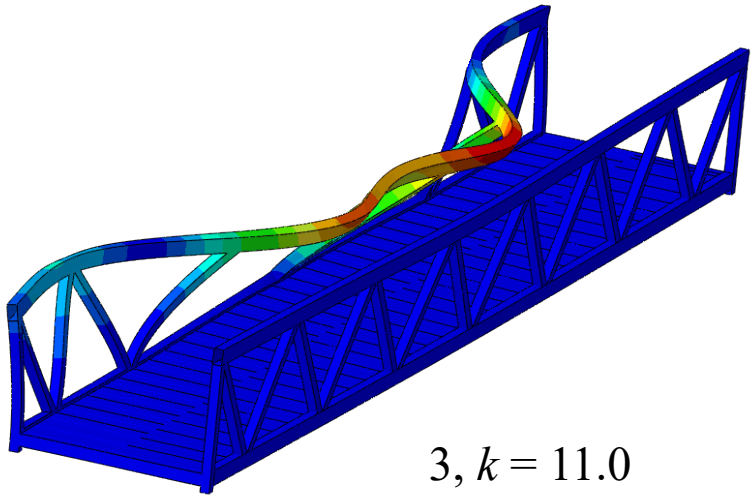
NOTE 1: Any type of imperfection should be taken as the leading imperfection and the others may be taken as the accompanying imperfections.



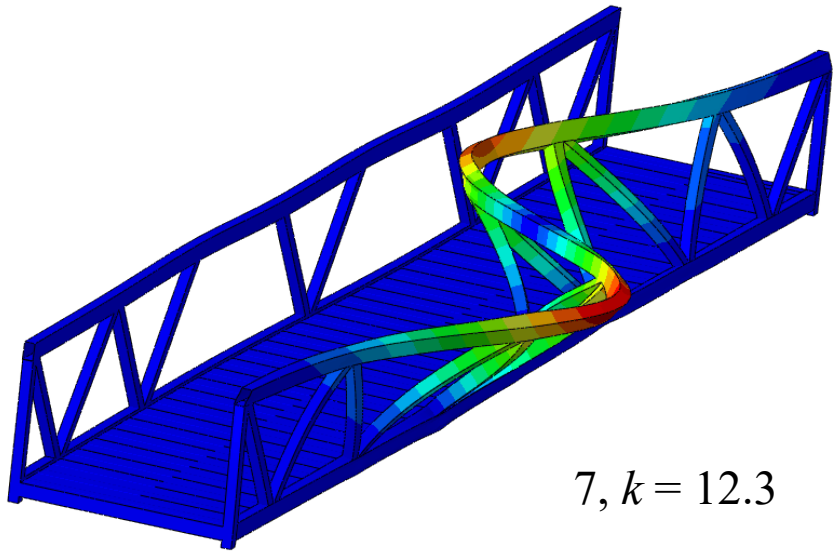
1, $k = 5.9$



2, $k = 7.8$



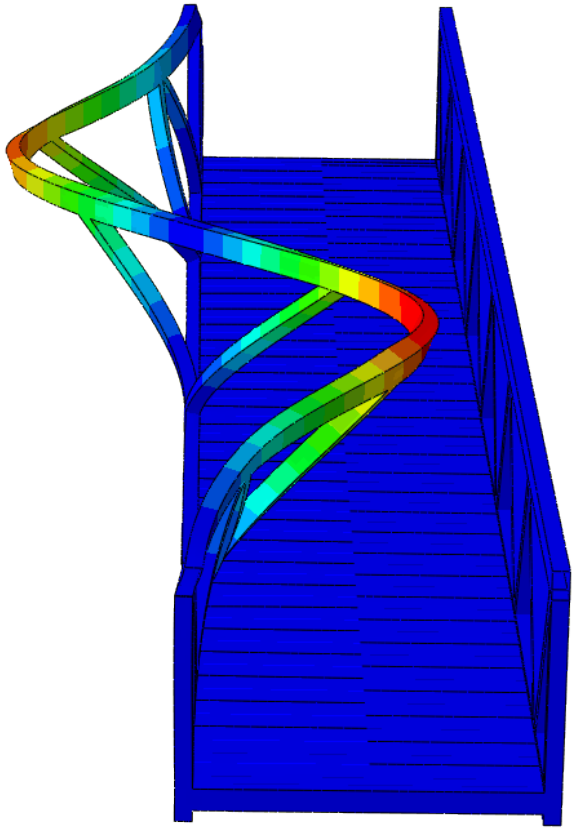
3, $k = 11.0$

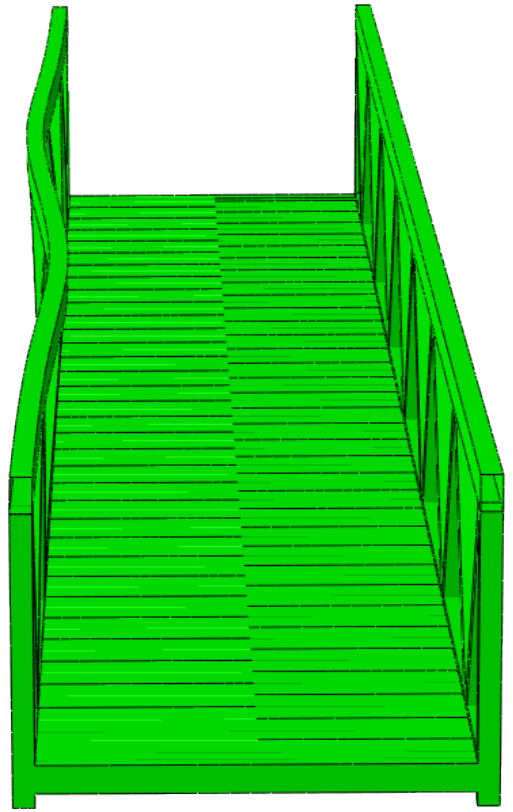


7, $k = 12.3$

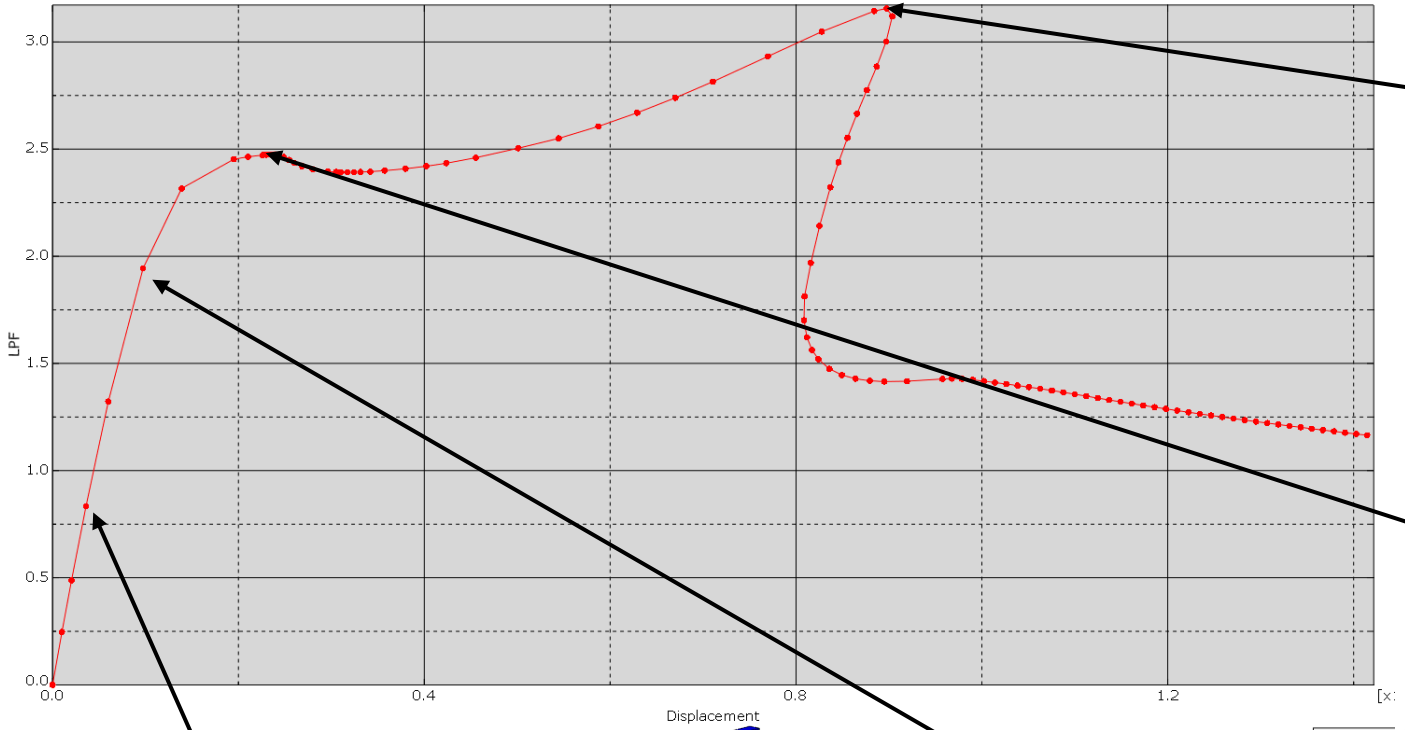
Fall	Moder
1	1
2	2
3	3
4	1, 2, 3, 7
5	1,2,7
6	1,3,7
7	2,3,7

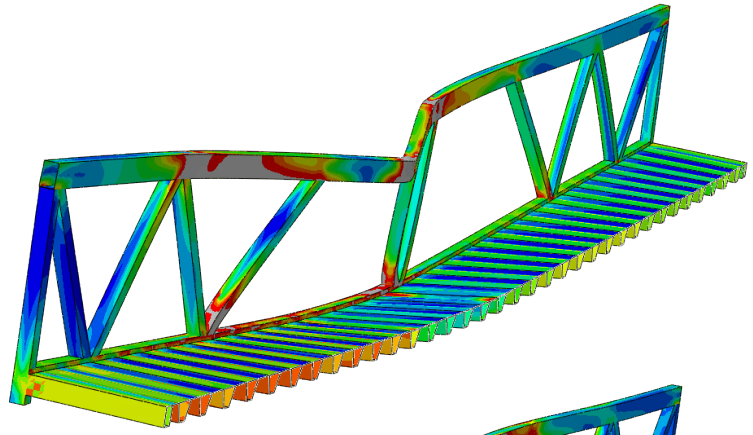
INITIELL EKVIVALENT IMPERFEKTION

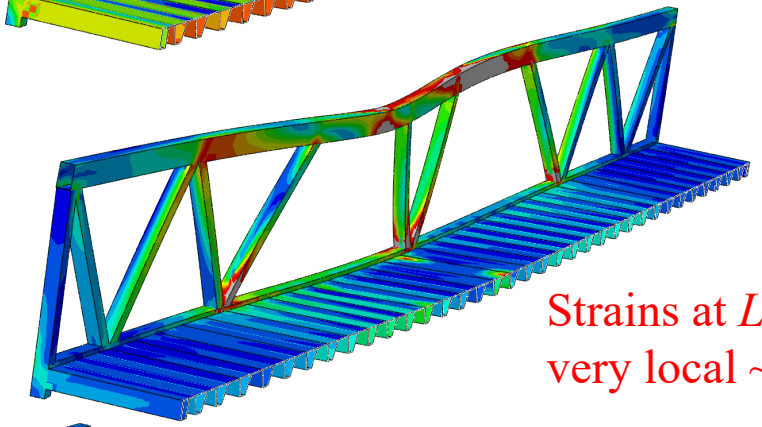




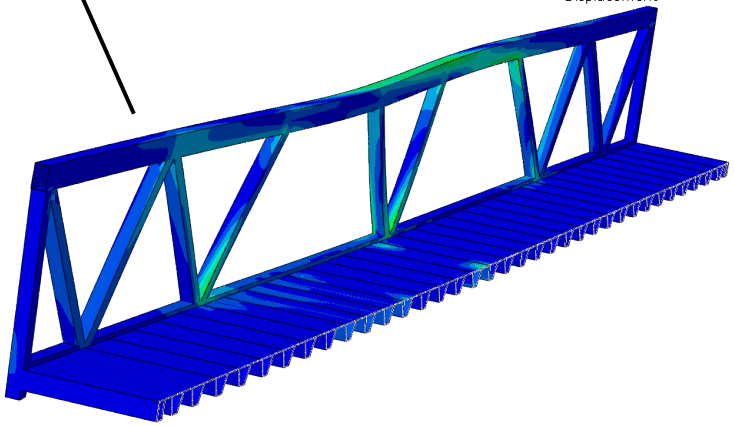
LAST - DEFORMATION

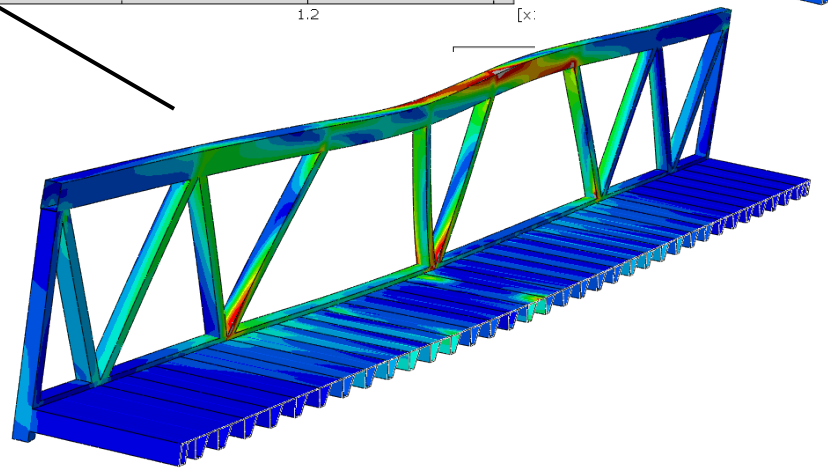




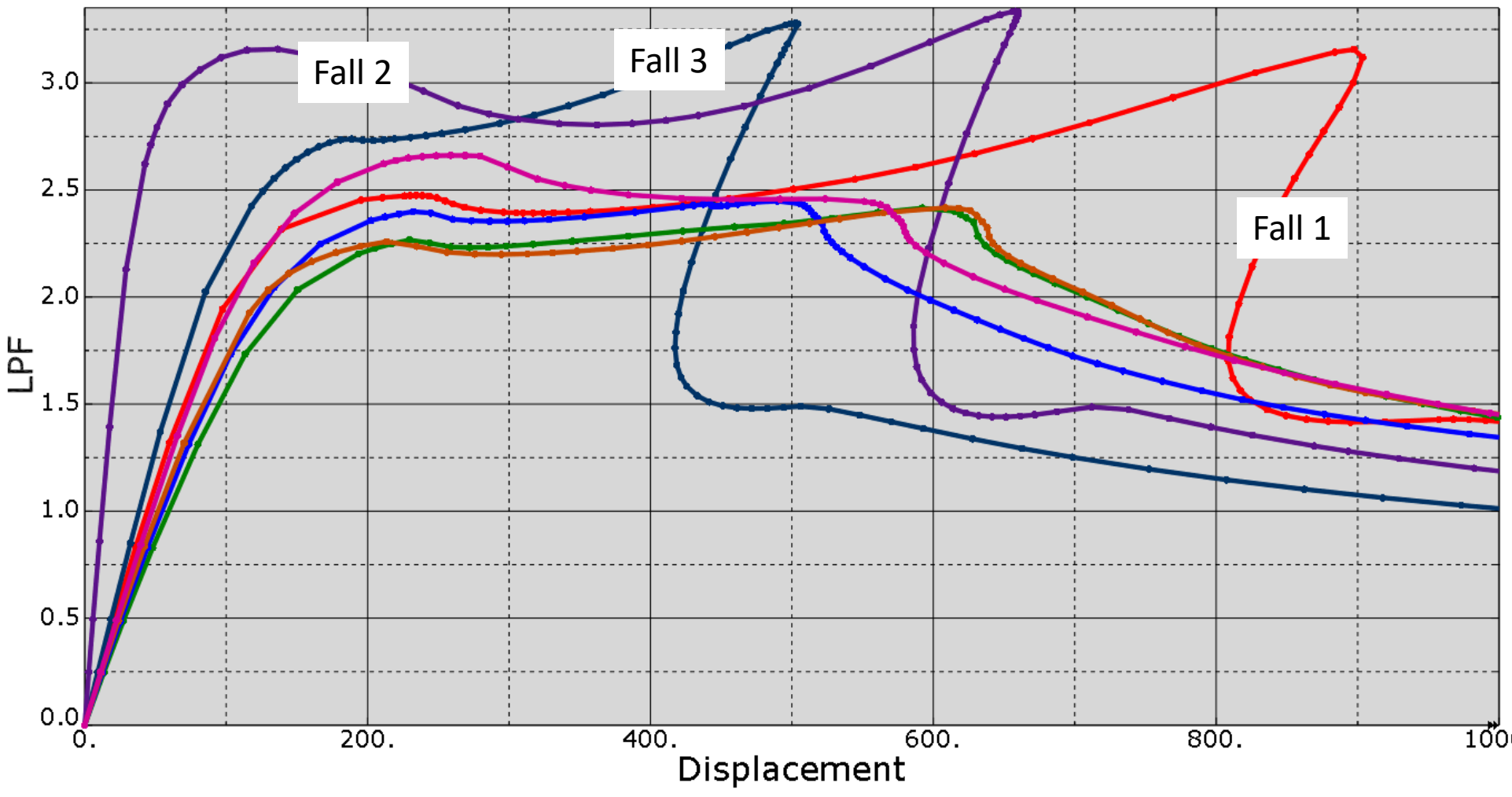


Strains at $LPF = 2.5$
very local ~ 3%





LAST – DEFORMATION - MODINTERAKTION

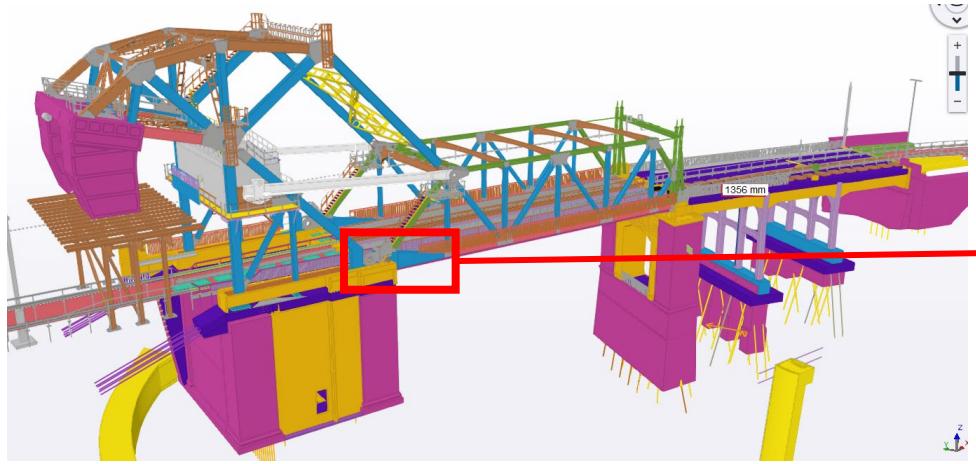


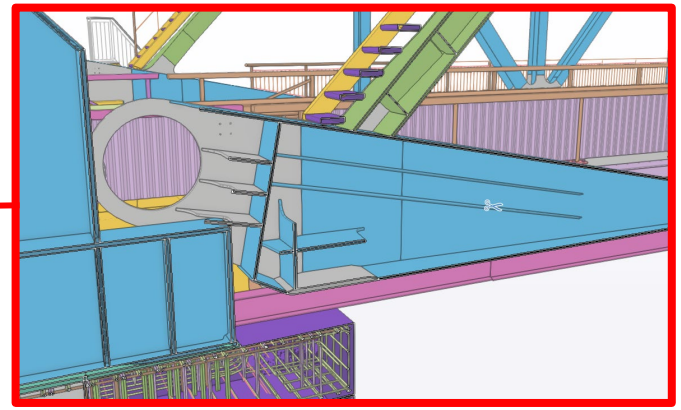
Fall	Moder
1	1
2	2
3	3
4	1, 2, 3, 7
5	1,2,7
6	1,3,7
7	2,3,7

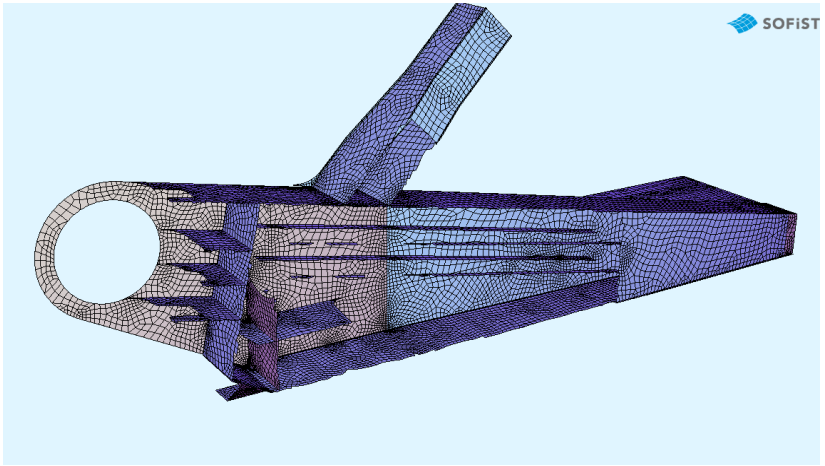
KEY LESSONS

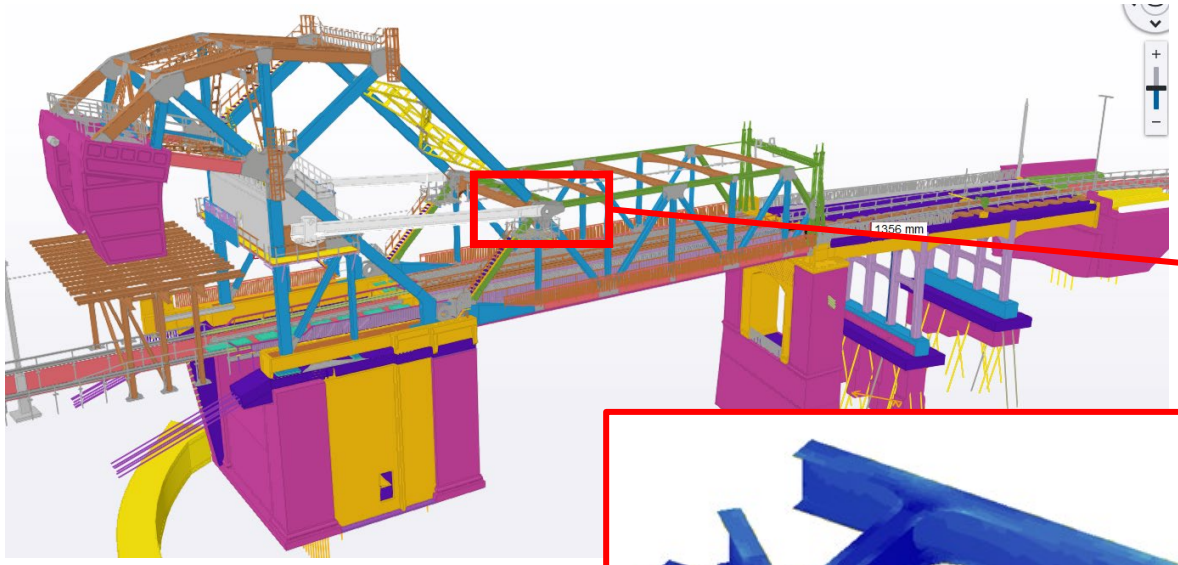
- DET KAN FINNAS EXTRA LASTKAPACITET ATT PÅVISA GENOM GMNLA
  - En modell med *ett lastfall* som *simulerar ett brott* istället för en modell med *många lastfall* för att *verifiera alla brott*
- I KOMPLEXA KONSTRUKTIONER KAN MODINTERAKTION HA EN SIGNIFIKANT PÅVERKAN

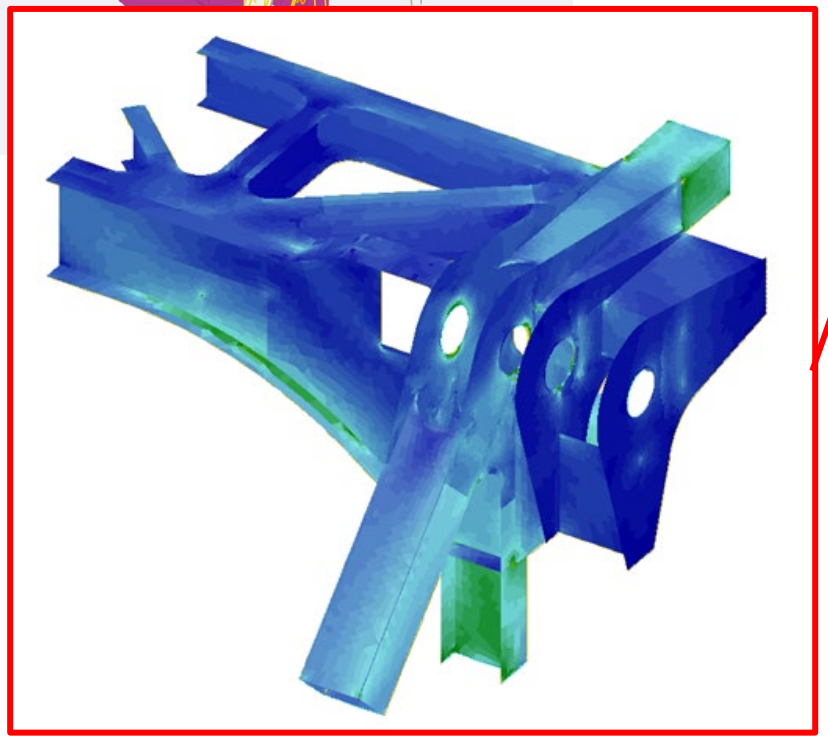
SUB-MODELLERING
KNUTPUNKTSDIMENSIONERING

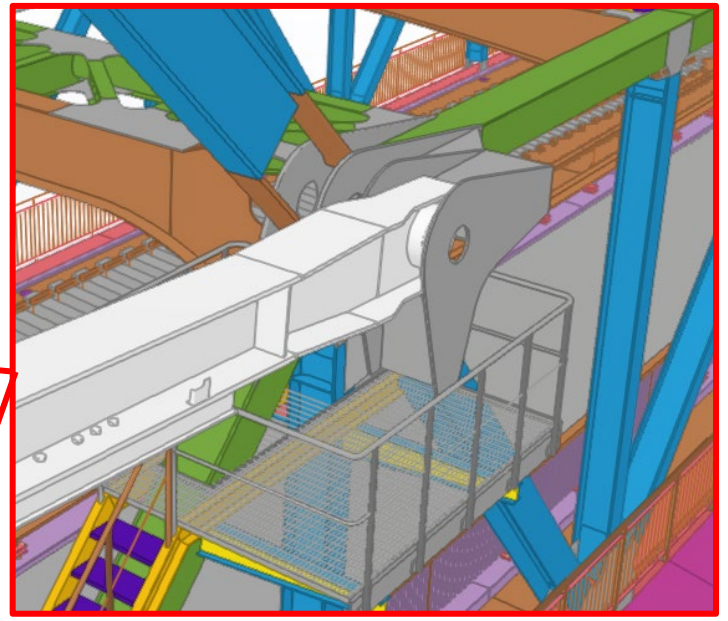


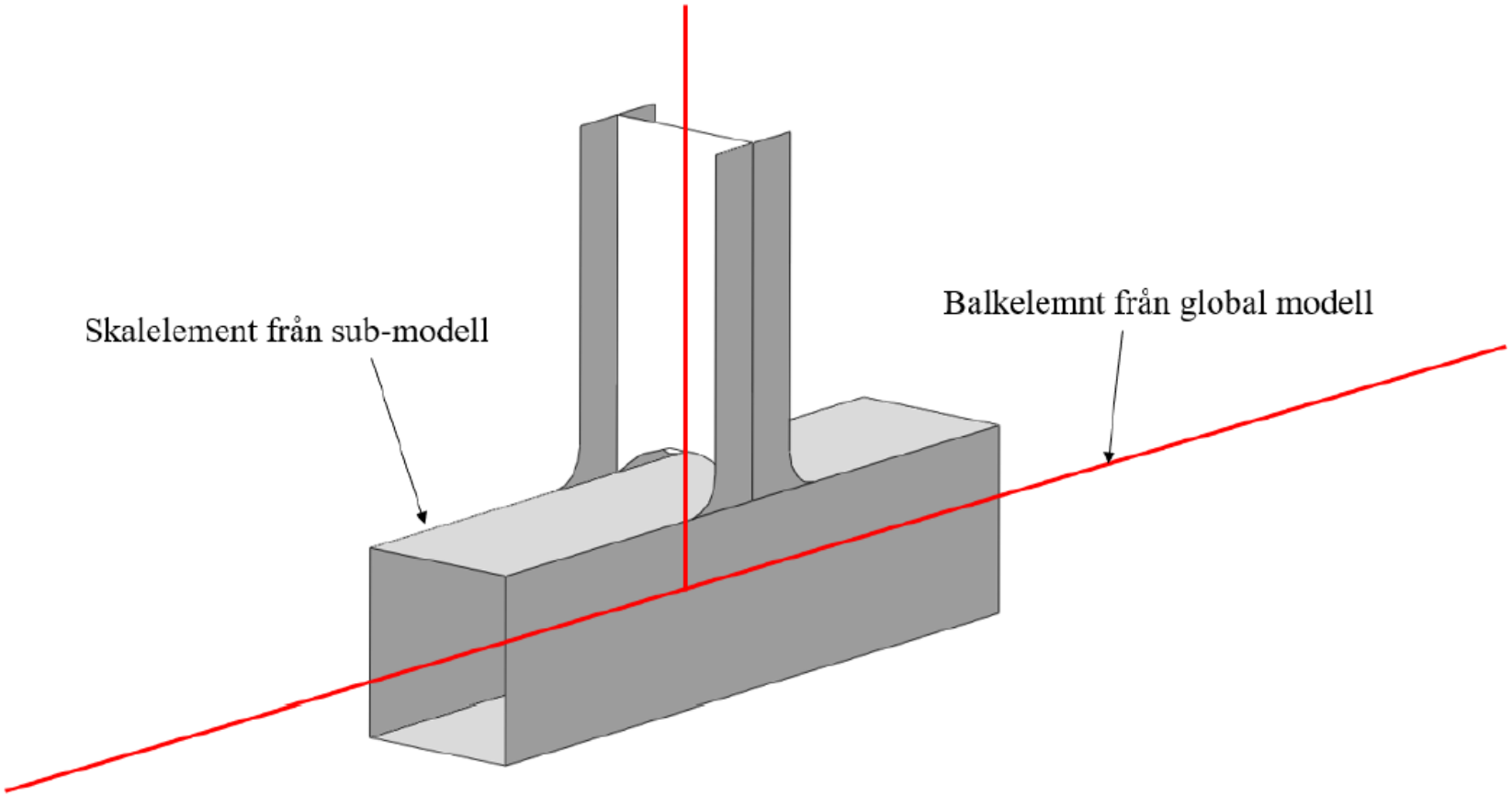




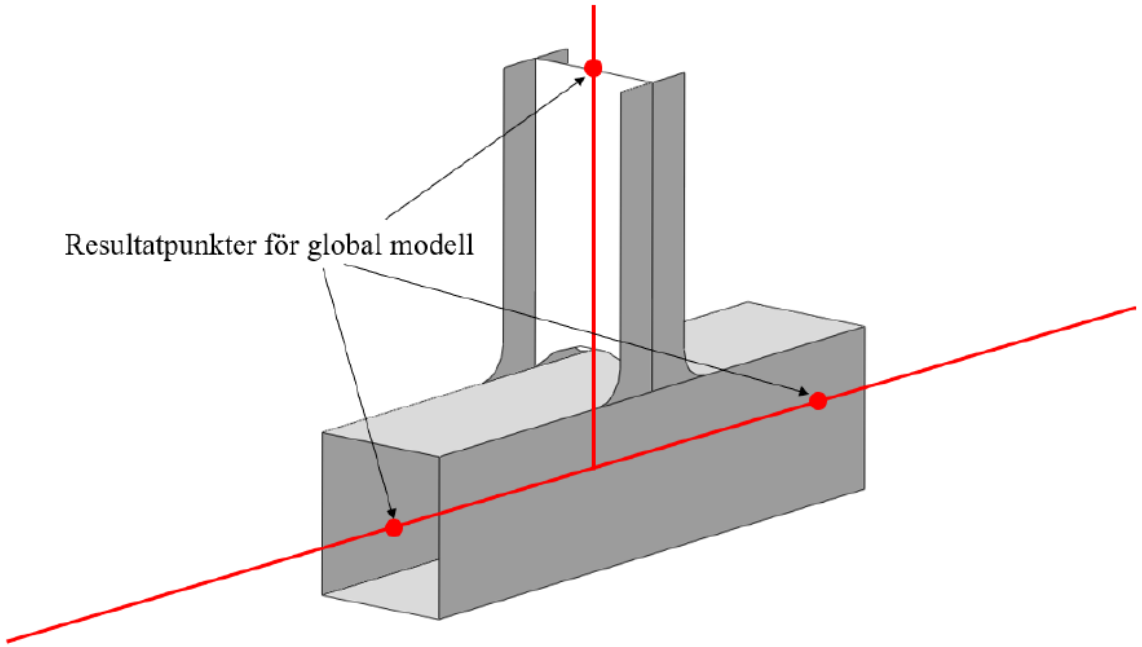

1356 mm



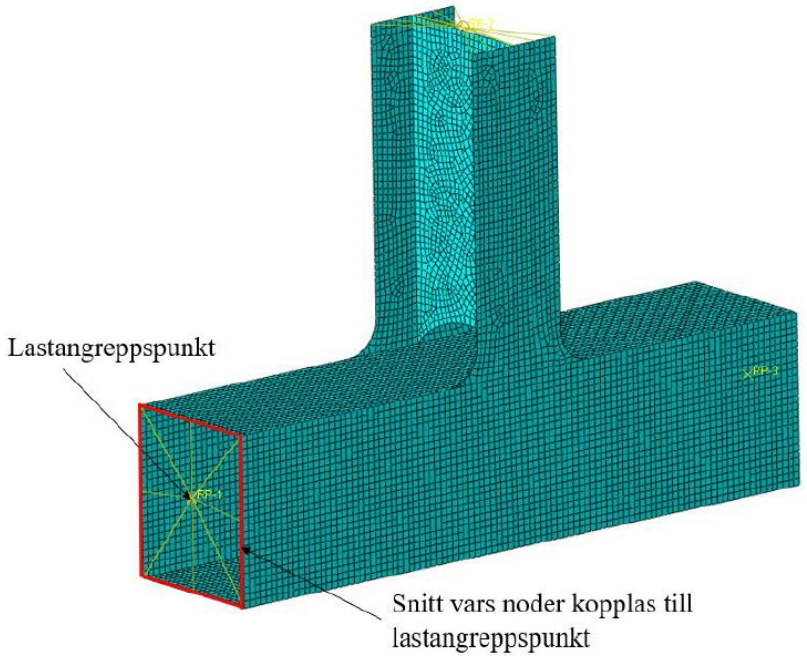




Figur. T-knutpunkt med global modell och submodell



Figur. Resultatnoder för global modell



Figur. Koppling mellan lastangreppspunkt och submodellens randsnitt.

Resultat nära lastangreppspunkt/stel rand felaktiga

Table C.1: Assumptions for FE-methods

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3	linear	non linear	no	critical plate buckling load
4	linear	non linear	yes	elastic plate buckling resistance
5	non linear	non linear	yes	elastic-plastic resistance in ULS

Elastisk verifiering ($\sigma < f_y$)

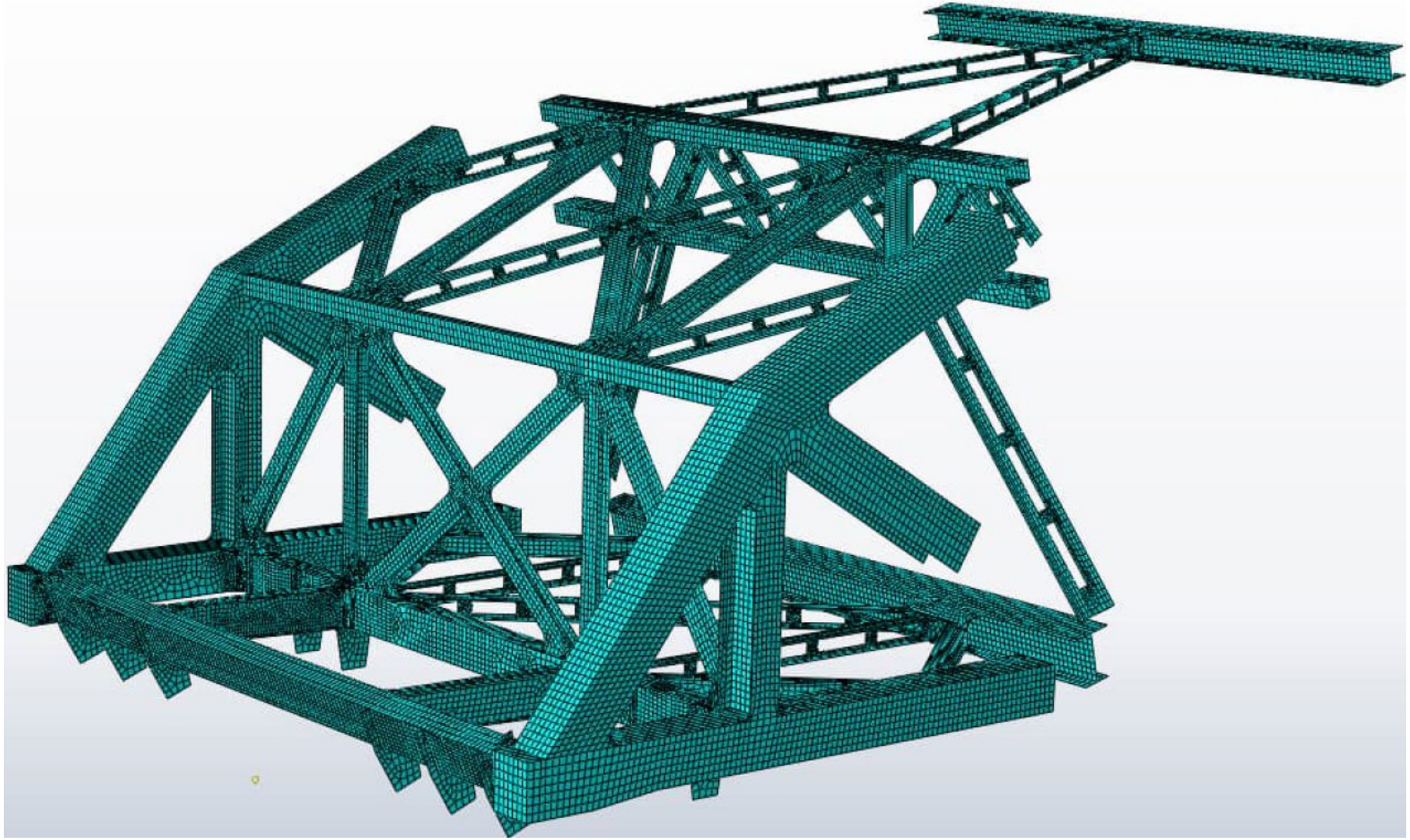
$\alpha > 10$ -> Geometriskt linjär modell

$\alpha < 10$ -> Geometriskt ickelinjär modell

Plastisk verifiering ($F < F_u$, $\varepsilon < 5\%$)

$\alpha > 15$ -> Geometriskt linjär modell

$\alpha < 15$ -> Geometriskt ickelinjär modell



KEY LESSONS

- SAMHÖRANDE LASTEFFEKTER FÖR GOTT RESULTAT
- LINJÄR VERIFIERING, ENKEL DIMENSIONERINGSMETOD
- PLASTISK VERIFIERING, FULL KAPACITET
- VERIFIERAR DET SPECIFIKA FALLET