

Predicting the Flexural Collapse Load of Concrete Slab Bridges

US Scanning Tour Visit, 11 June 2009

Andrew Jackson

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- Motivation
- Plastic methods
 - Upper bound analysis (COBRAS)
 - New lower bound analysis
- Examples

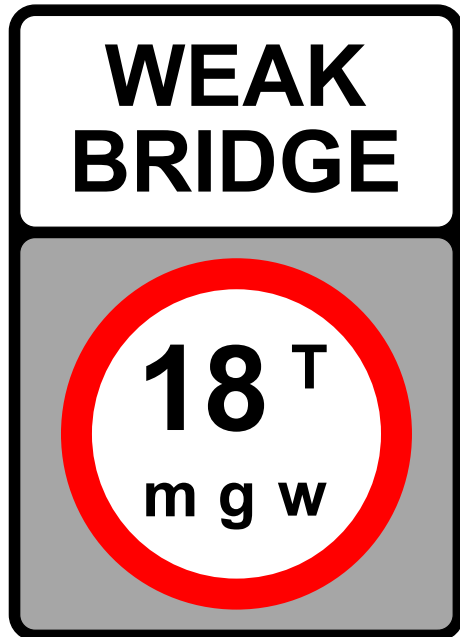
Motivation

Safe bridge assessments, like safe bridge designs, prevent disastrous collapses:



Motivation

But overly conservative assessments cause problems:

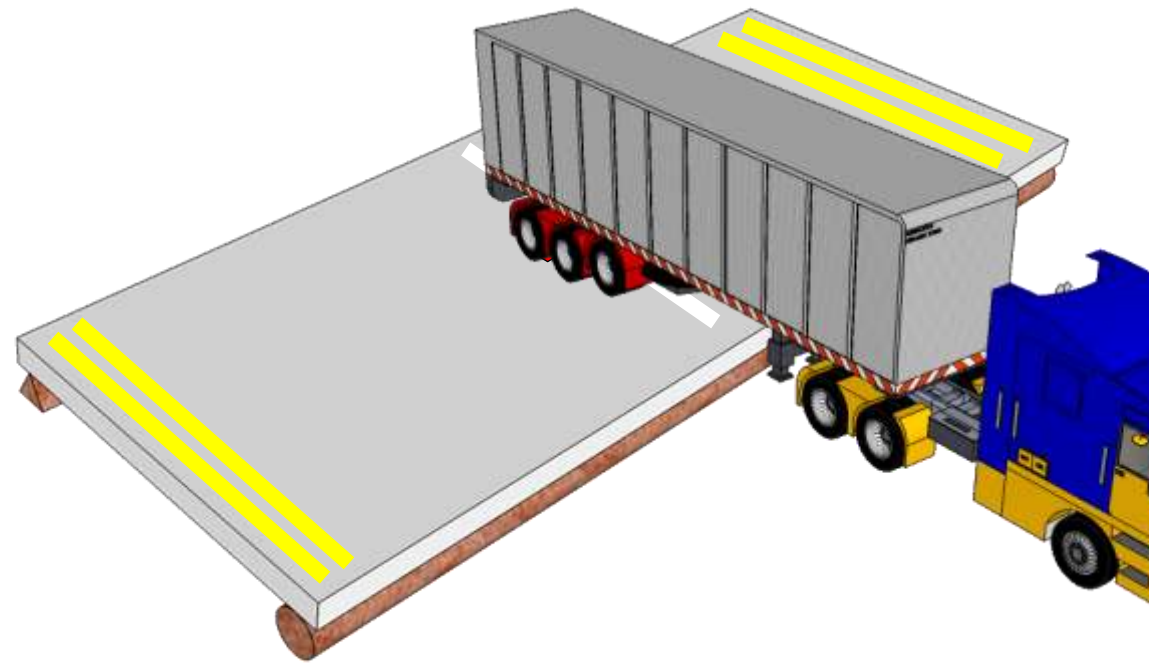




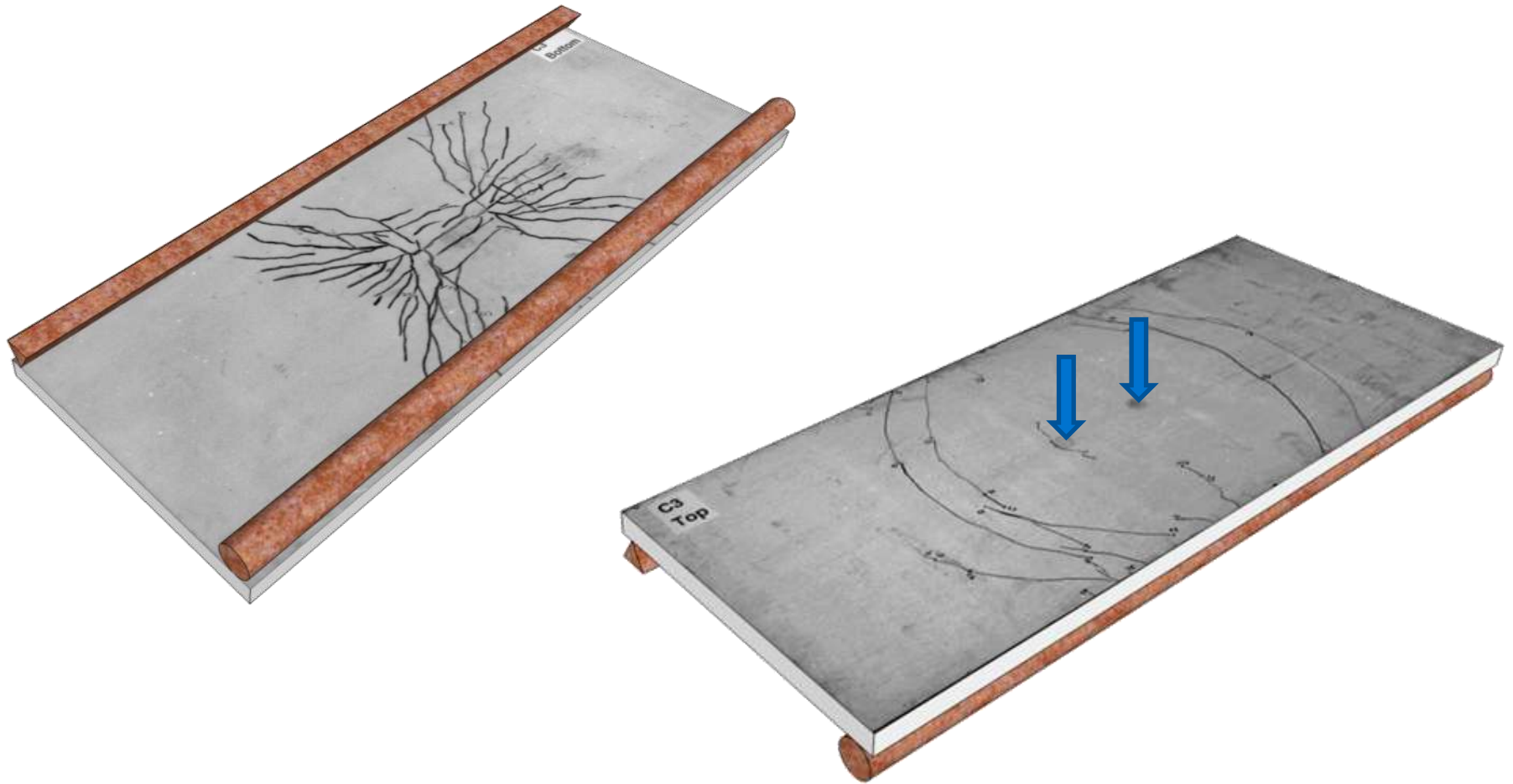
Assessment methods must be safe but not unduly conservative



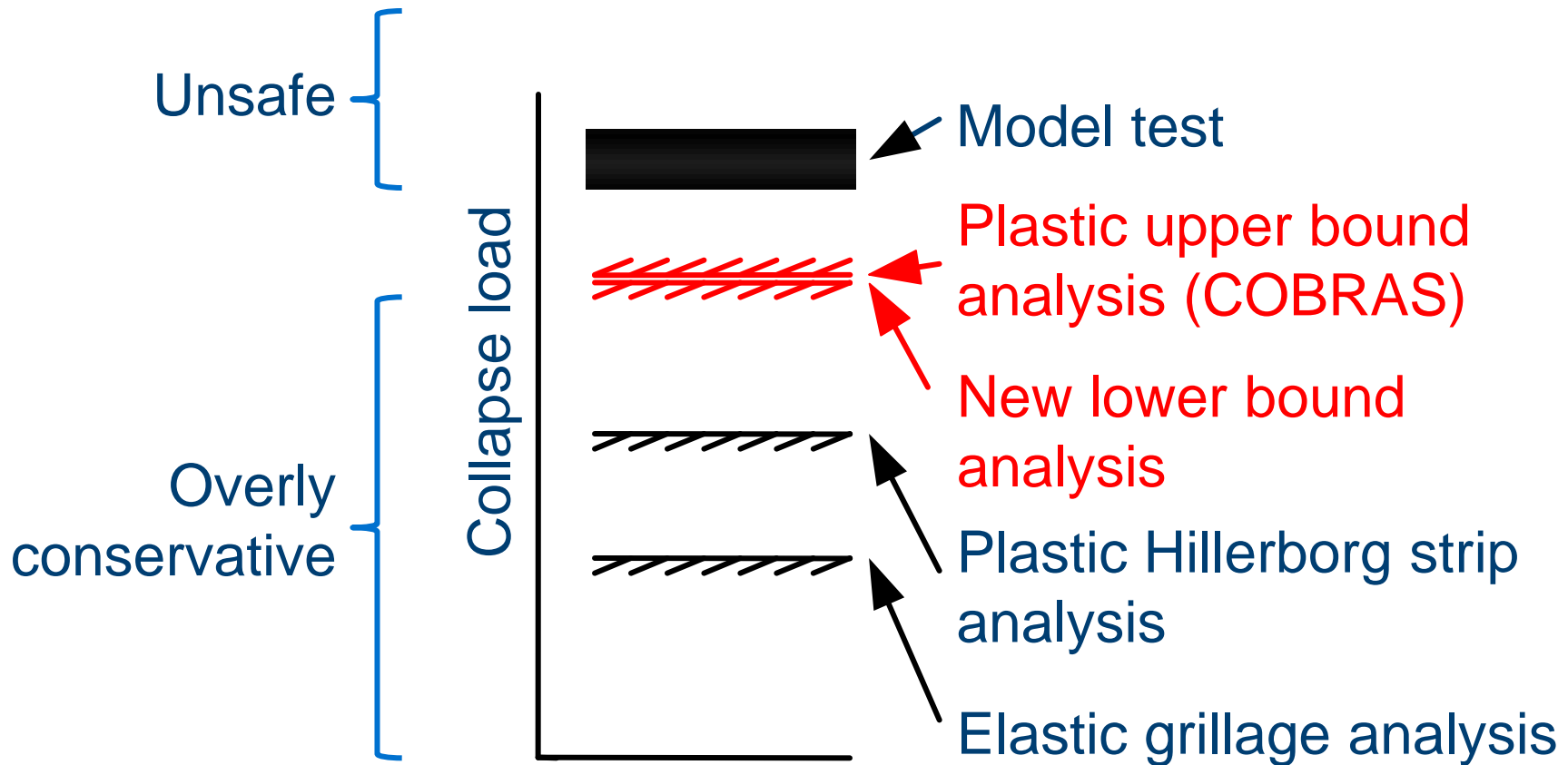
Motivation: an example



Motivation: an example



Motivation: an example



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Plastic methods

These methods consider flexural collapse of a ductile slab:

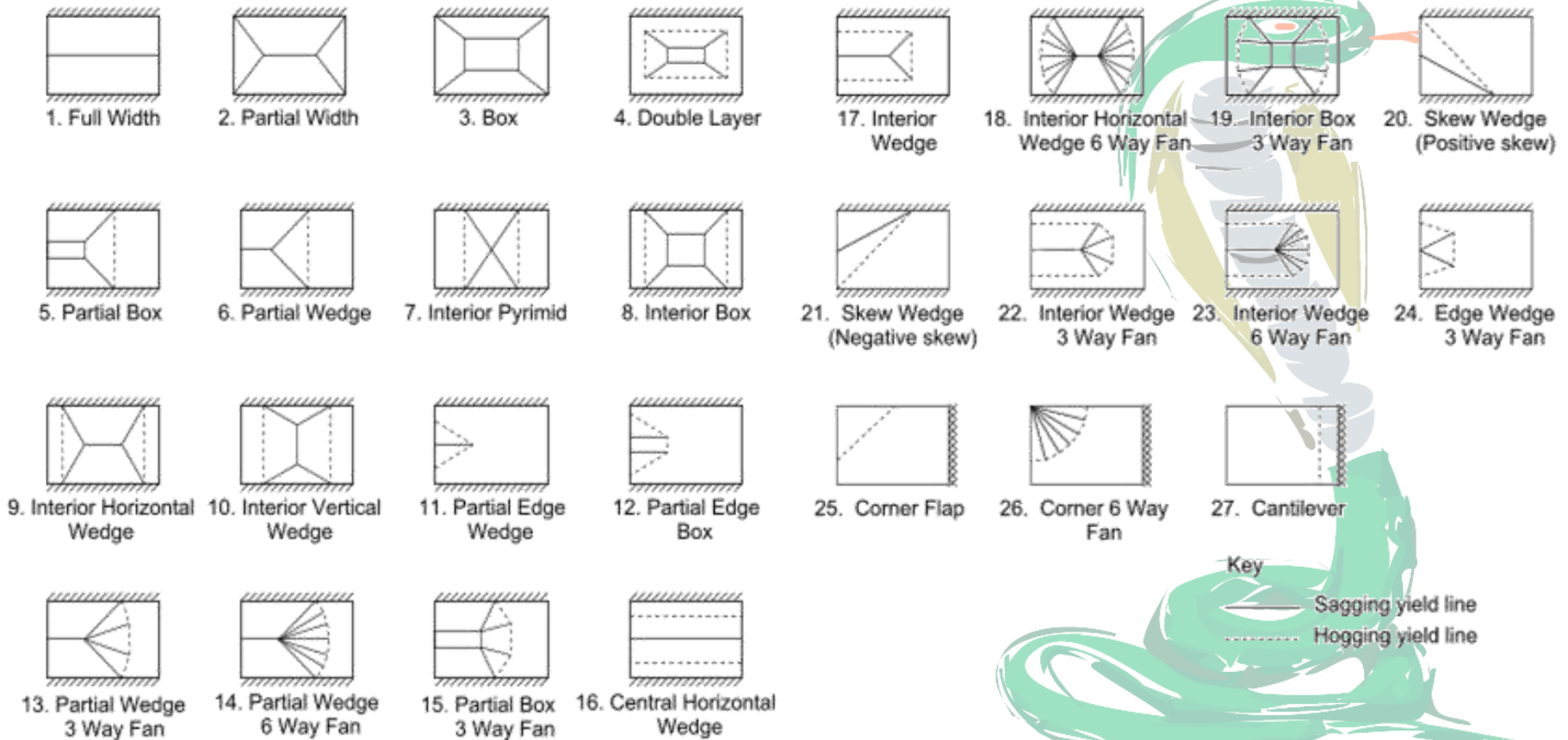
- Serviceability is not considered
- Shear is not considered
- Ductility is required

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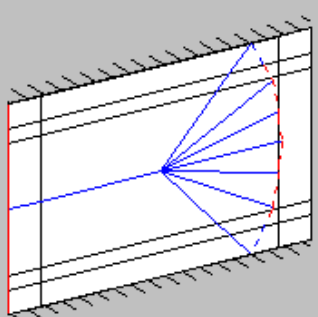


Upper bound analysis: COBRAS



Cobras Yield-line Analysis

Analysis Edit View Help



Collapse Analysis			Details	
w	l	h	Mechanism Type:	14
0.00	0.50	0.10	Live load Factor:	1.08
0.50	0.50	0.10		
0.80	1.00	0.00		
0.80	0.00	0.00		
0.87	0.80	0.00		
0.89	0.65	0.00		
0.90	0.50	0.00		
0.89	0.35	0.00		
0.87	0.20	0.00		

Check Work Done

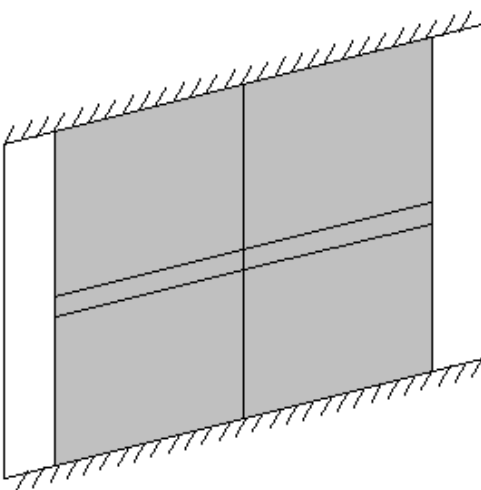
Face: Applied Load:

Self Weight:

Check Energy Dissipated

Edge:

COBRAS



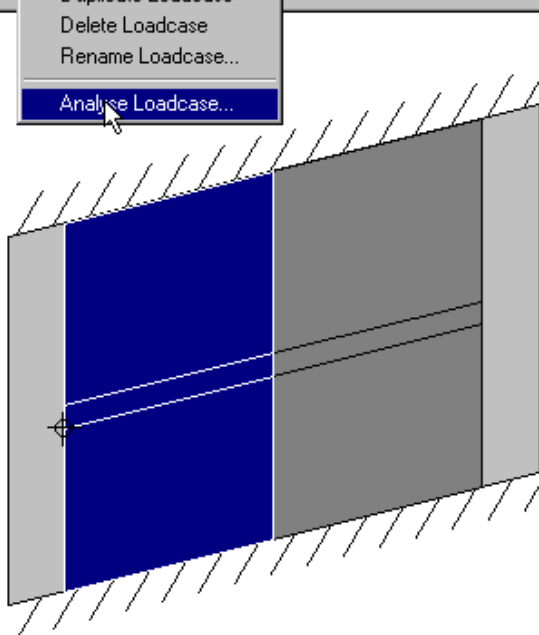
Loadcase feature polygons

Demo1.cobras - Cobras Bridge Editor

File Edit Loadcase View Help

General Reinforcement Factors Superimposed HA Loading HB Loading

- New Loadcase...
- Duplicate Loadcase
- Delete Loadcase
- Rename Loadcase...
- Analyse Loadcase...



Load Properties

Label:

Code:

Unfactored Intensity

UDL: kN/m²

KEL: kN/m

Wheels:

Load Factors γ_f : γ_{fL} :

Reduction Factor: Lane Factor:

Traffic Load

Geometry

Length: mm

Width: mm

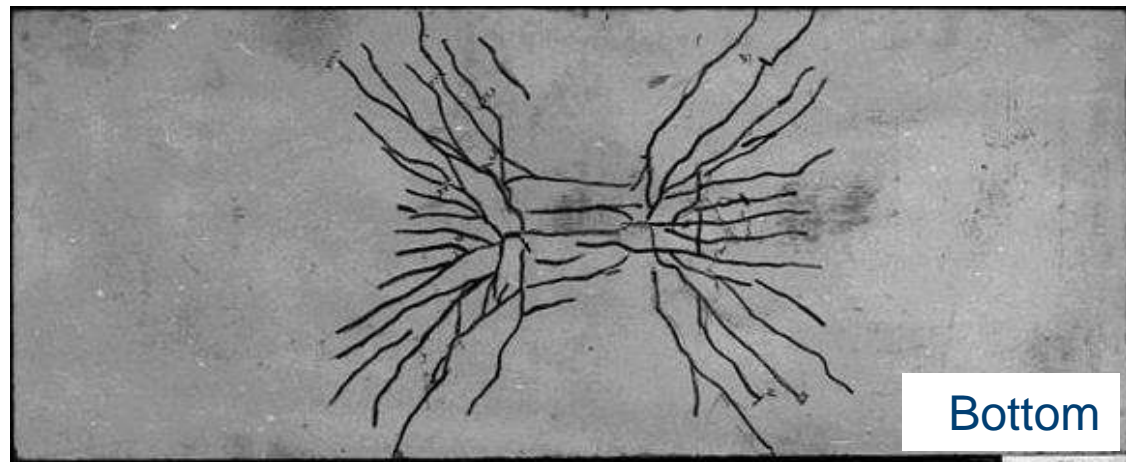
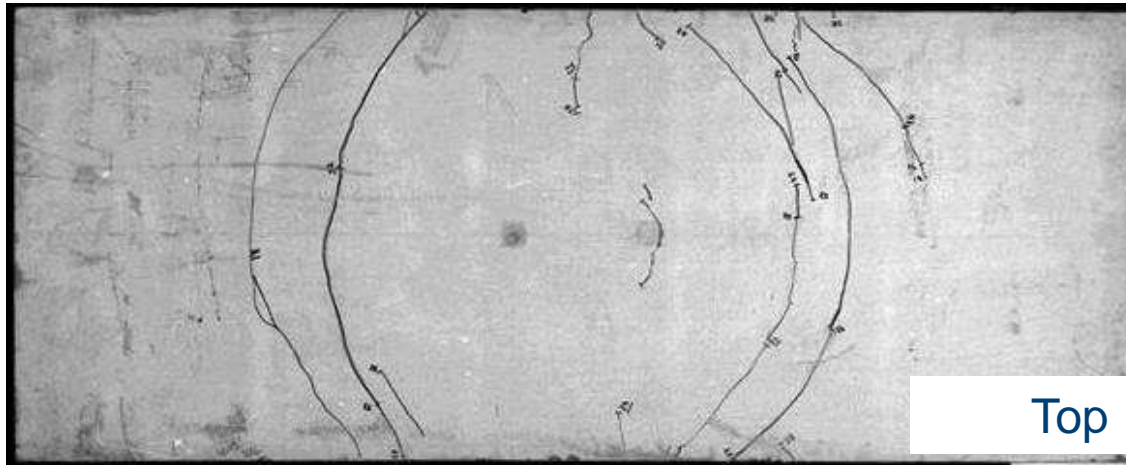
Skew: deg

X Coord: mm

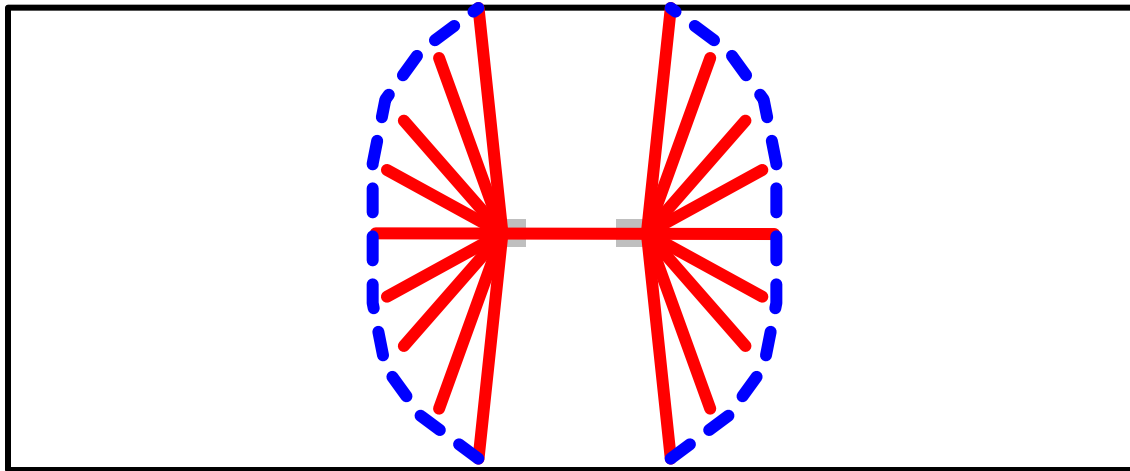
Y Coord: mm

Opens the analysis window with the current loadcase applied to the structure

Upper bound analysis: COBRAS



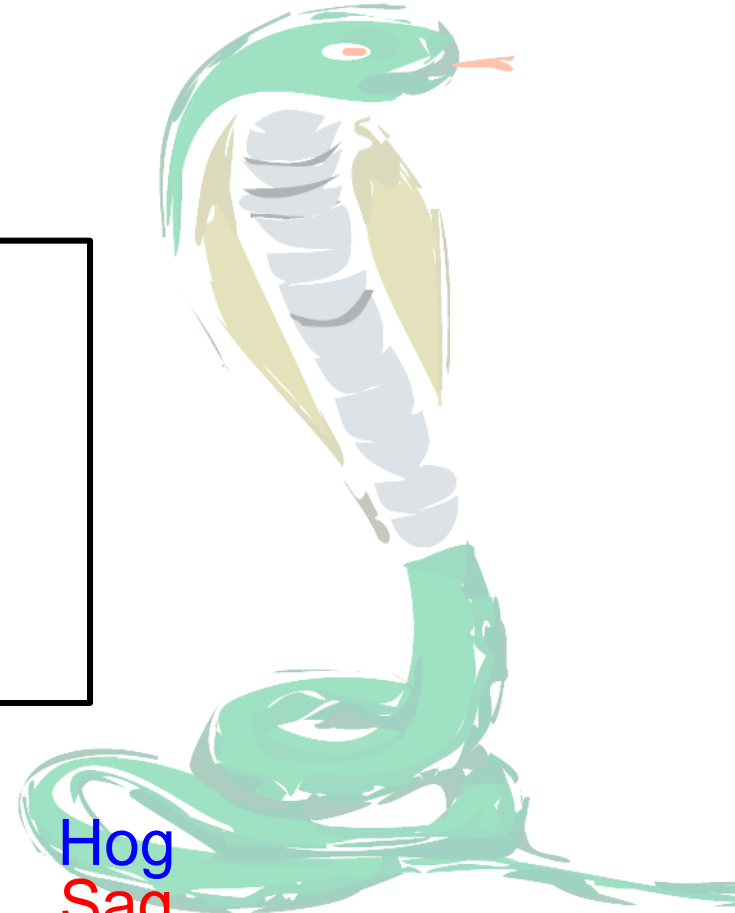
Upper bound analysis: COBRAS



Yield line indicators:



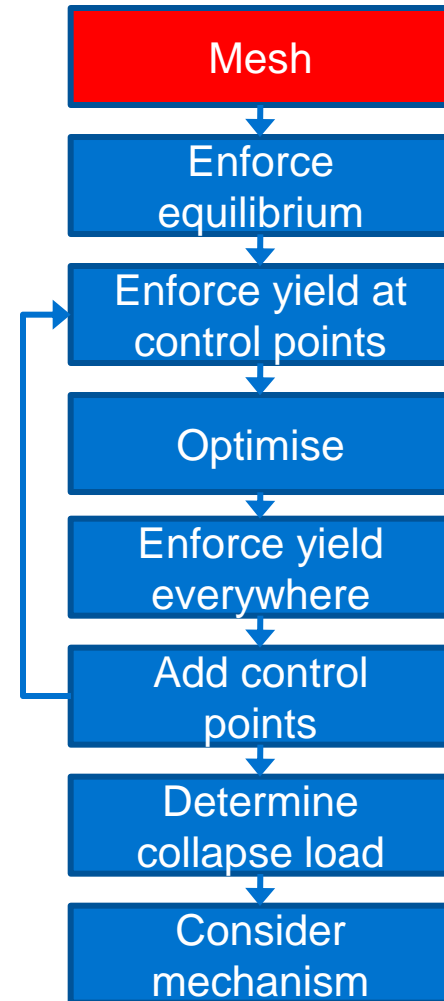
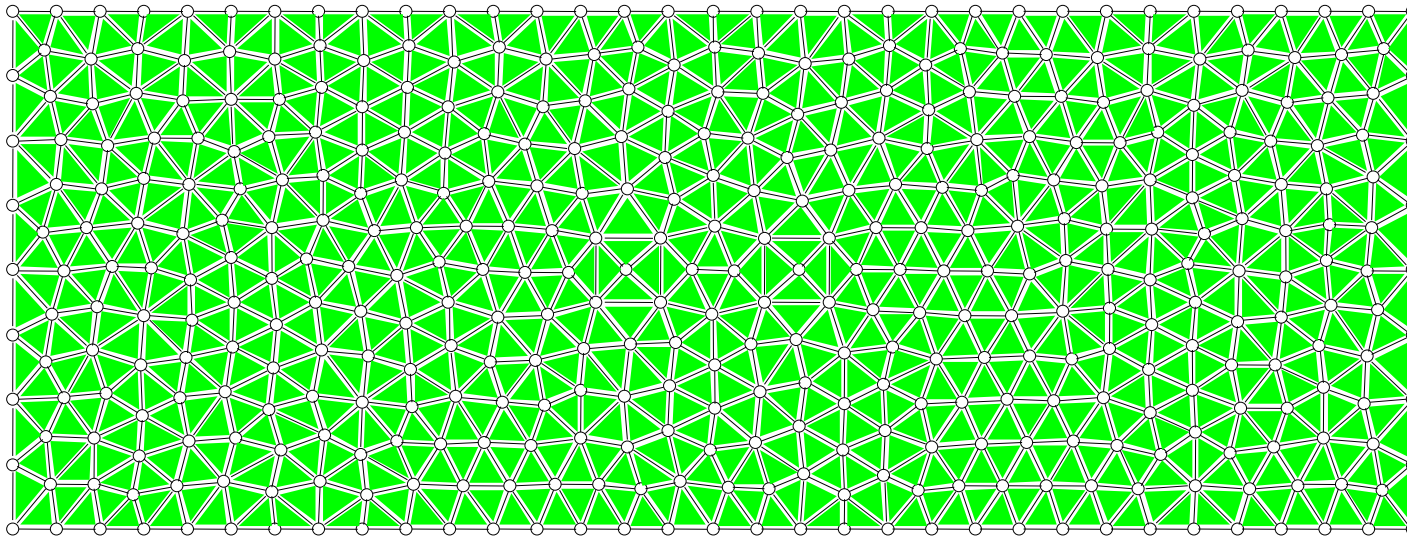
Hog
Sag



Contents

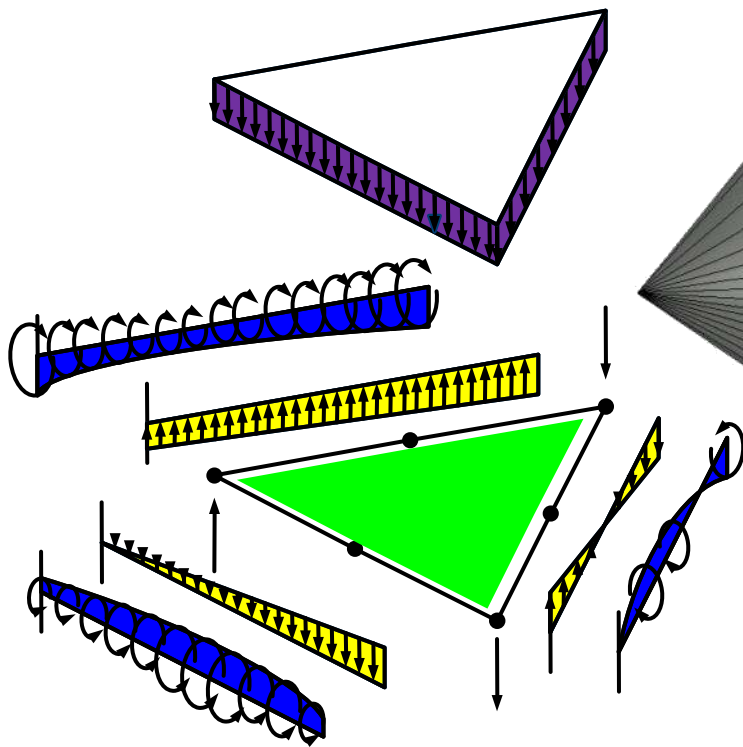
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New lower bound analysis

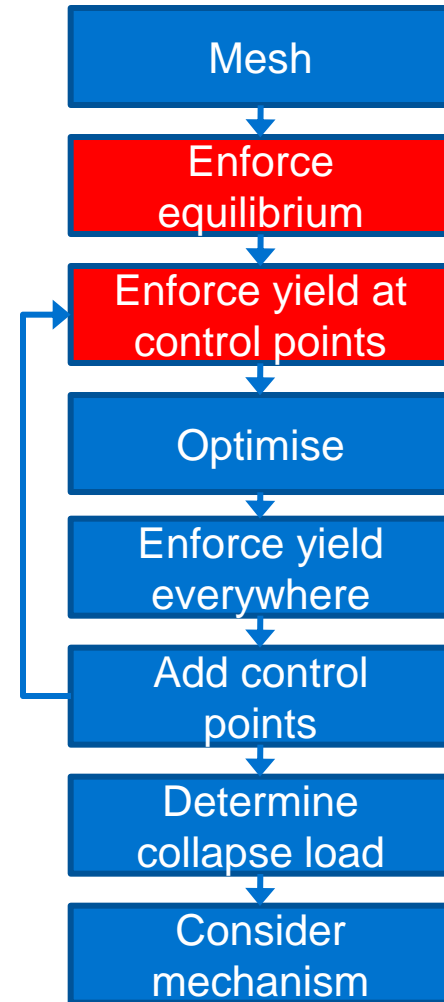
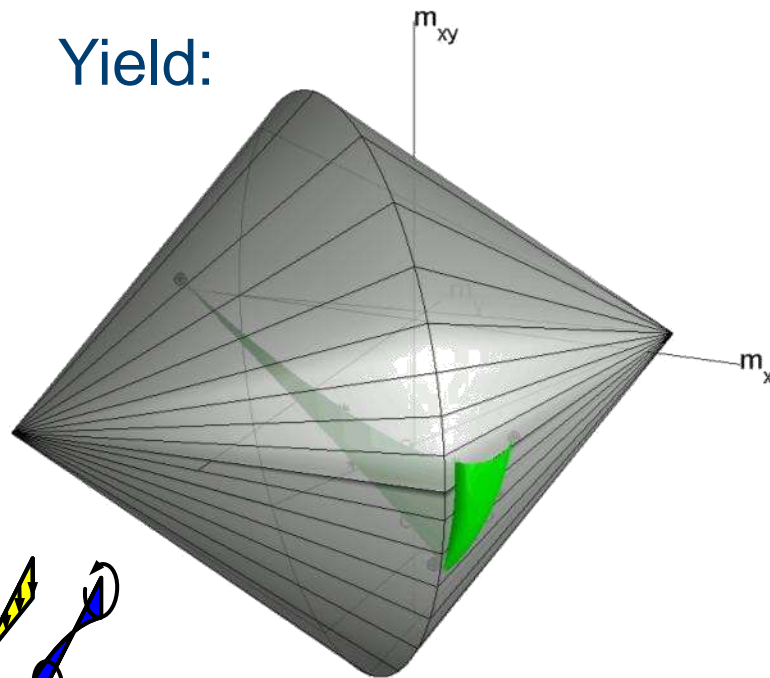


New lower bound analysis

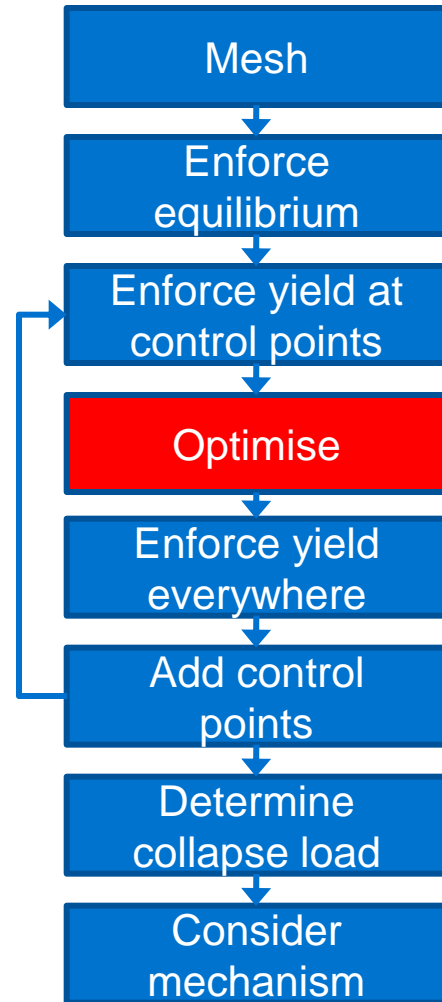
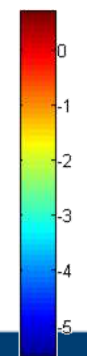
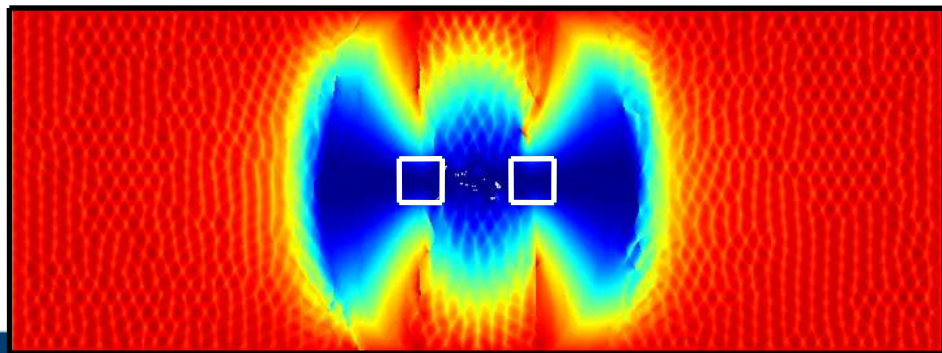
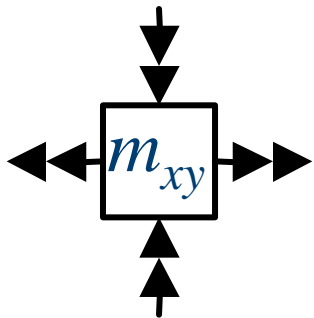
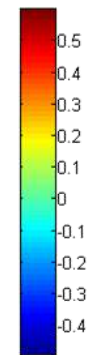
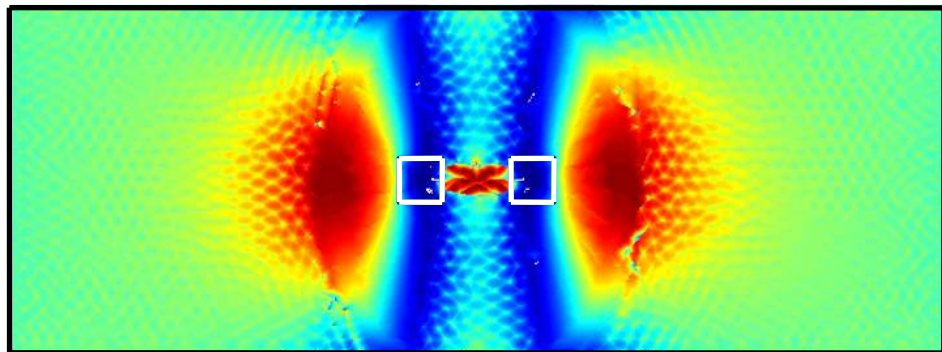
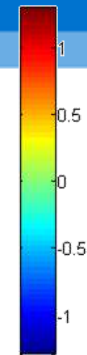
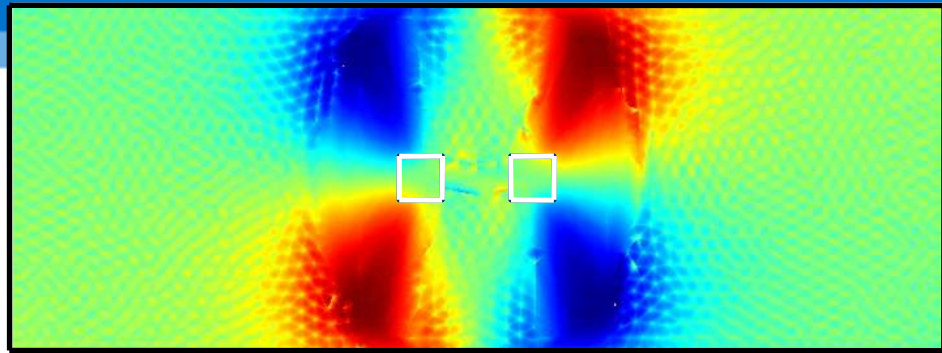
Equilibrium:



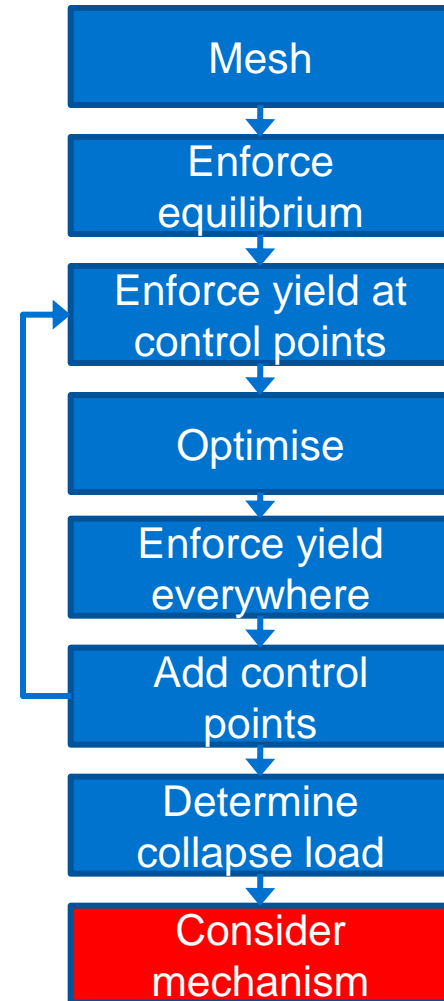
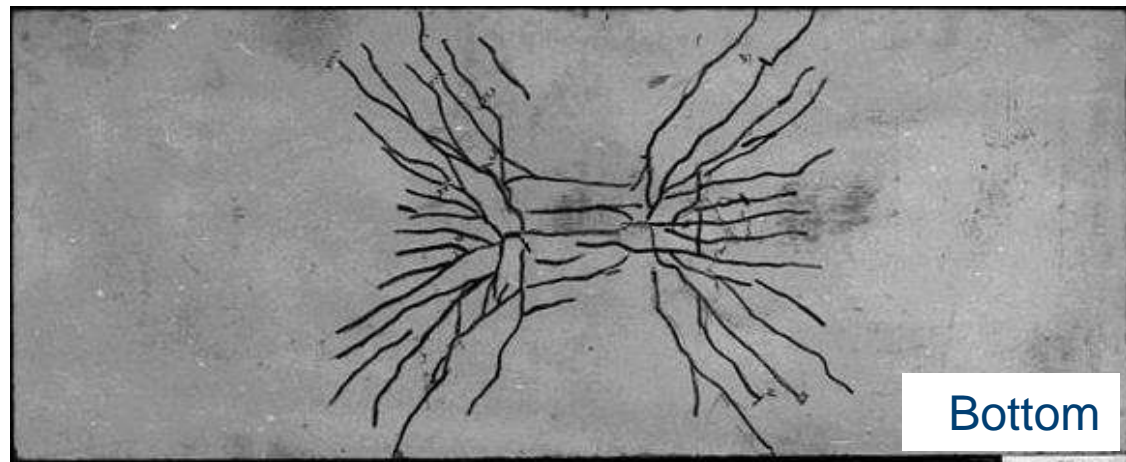
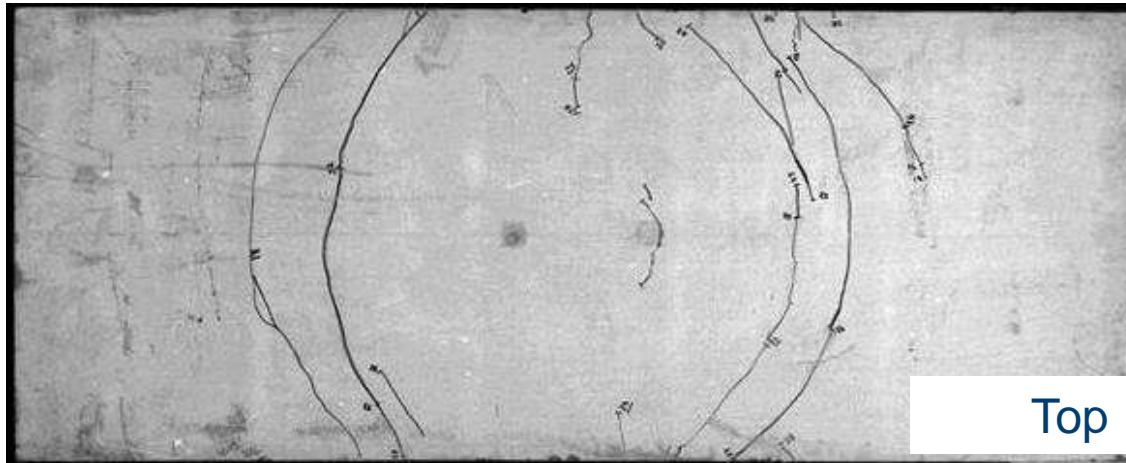
Yield:



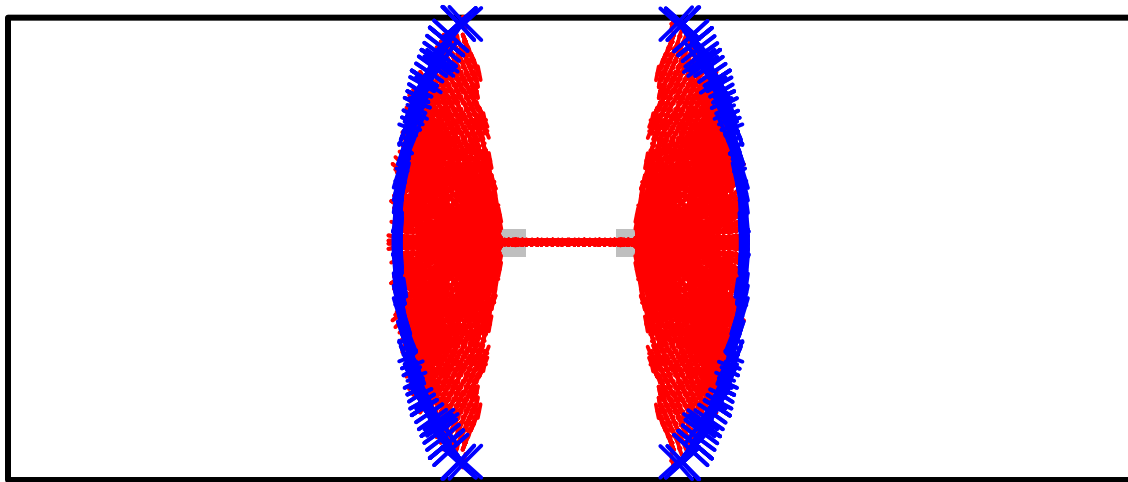
New lower bound analysis



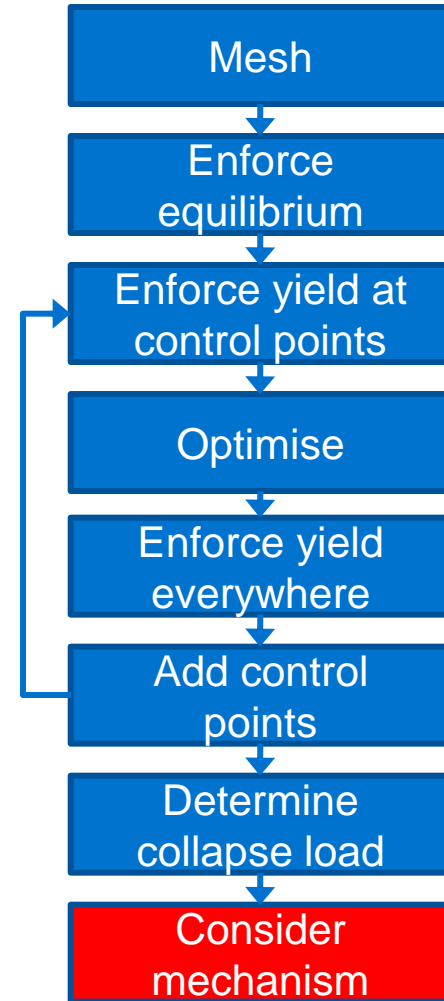
New lower bound analysis



New lower bound analysis



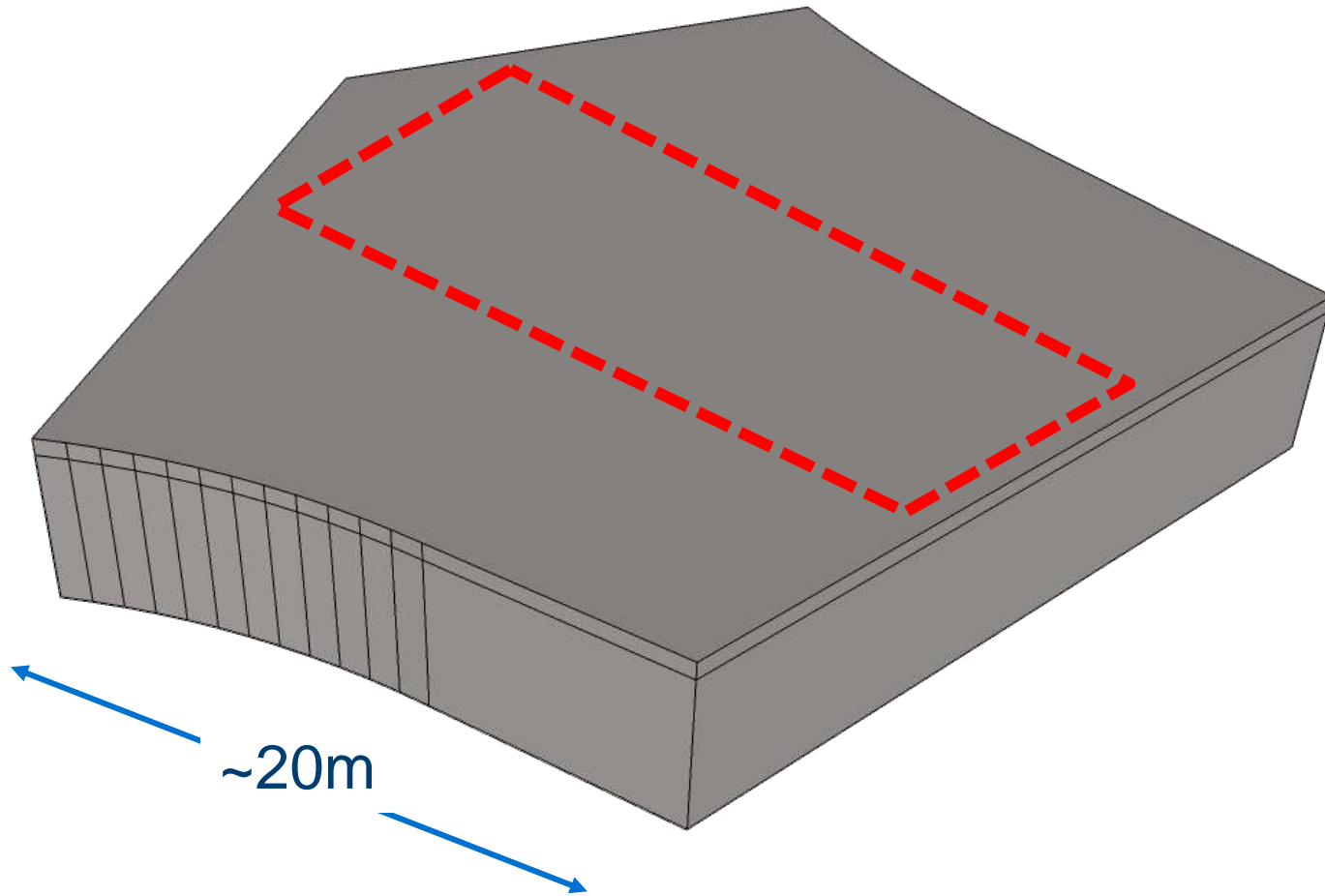
Yield line indicators:  Hog  Sag



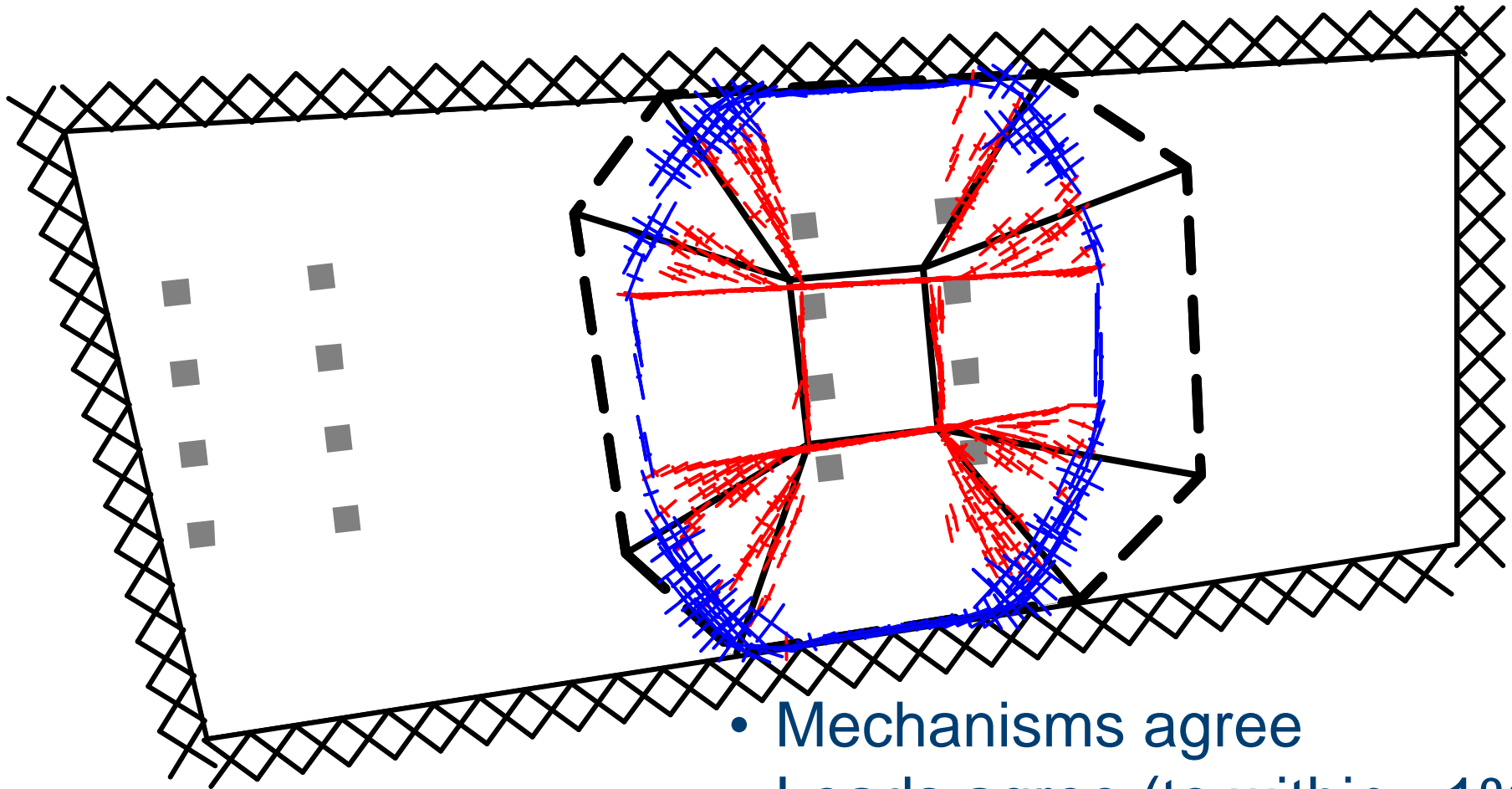
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Example 1

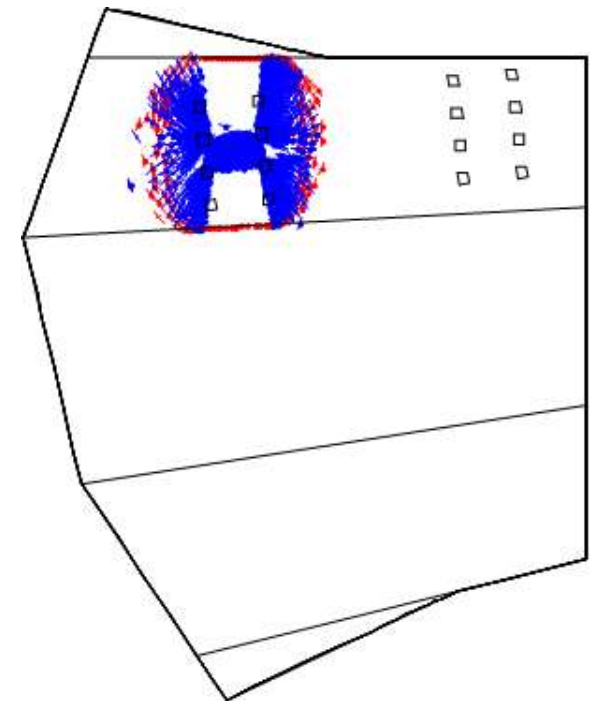
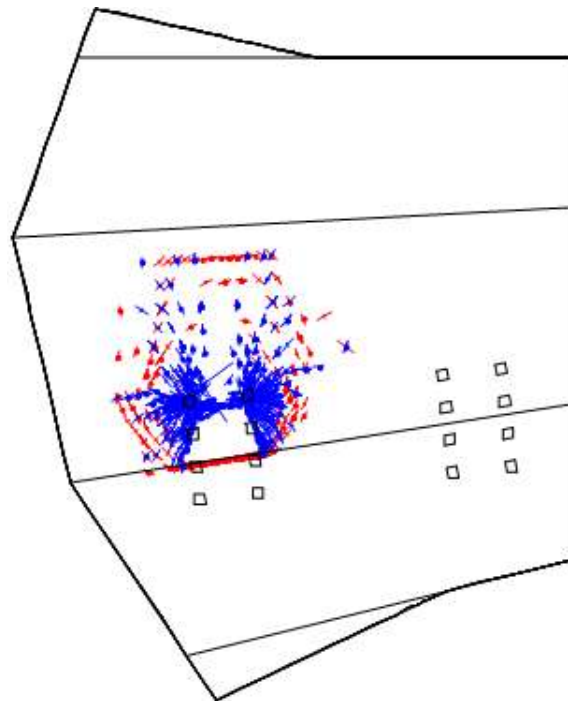
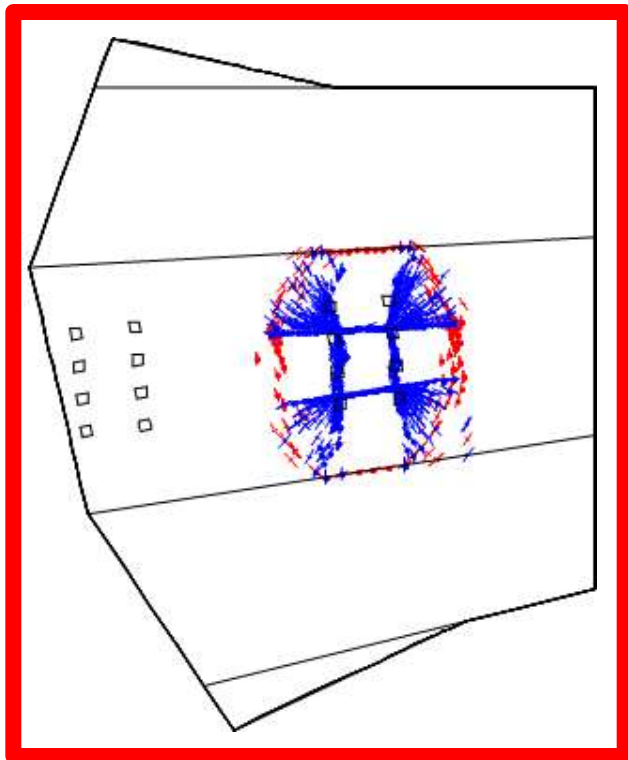


Example 1

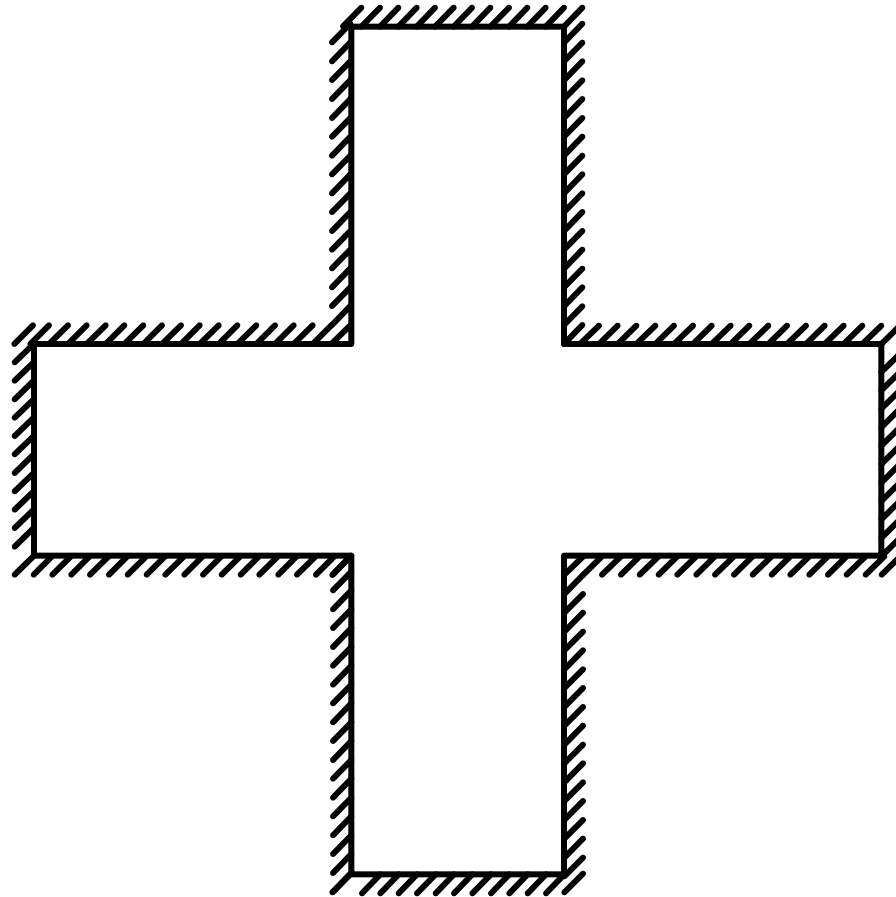


- Mechanisms agree
- Loads agree (to within $<1\%$)

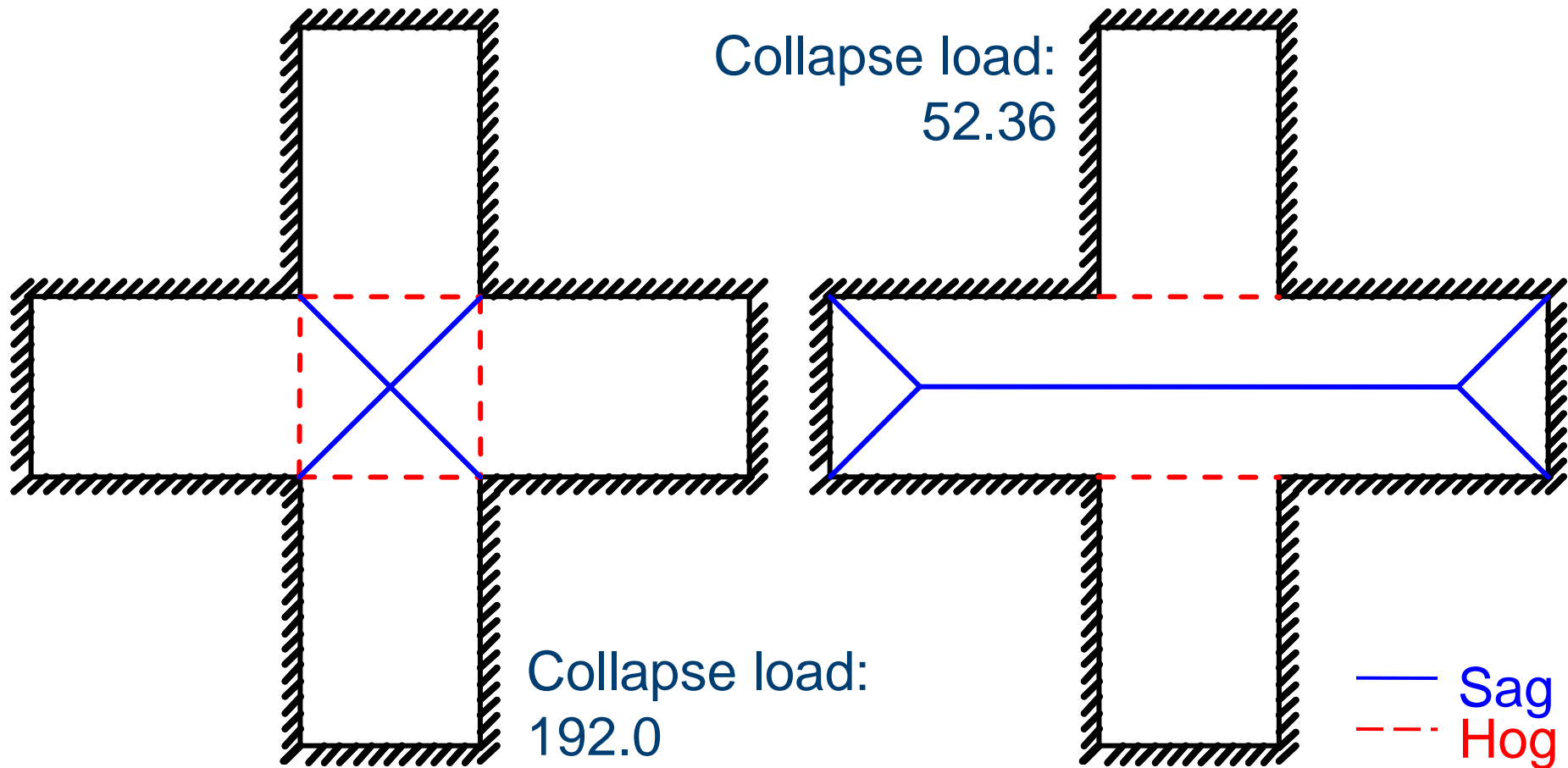
Example 1



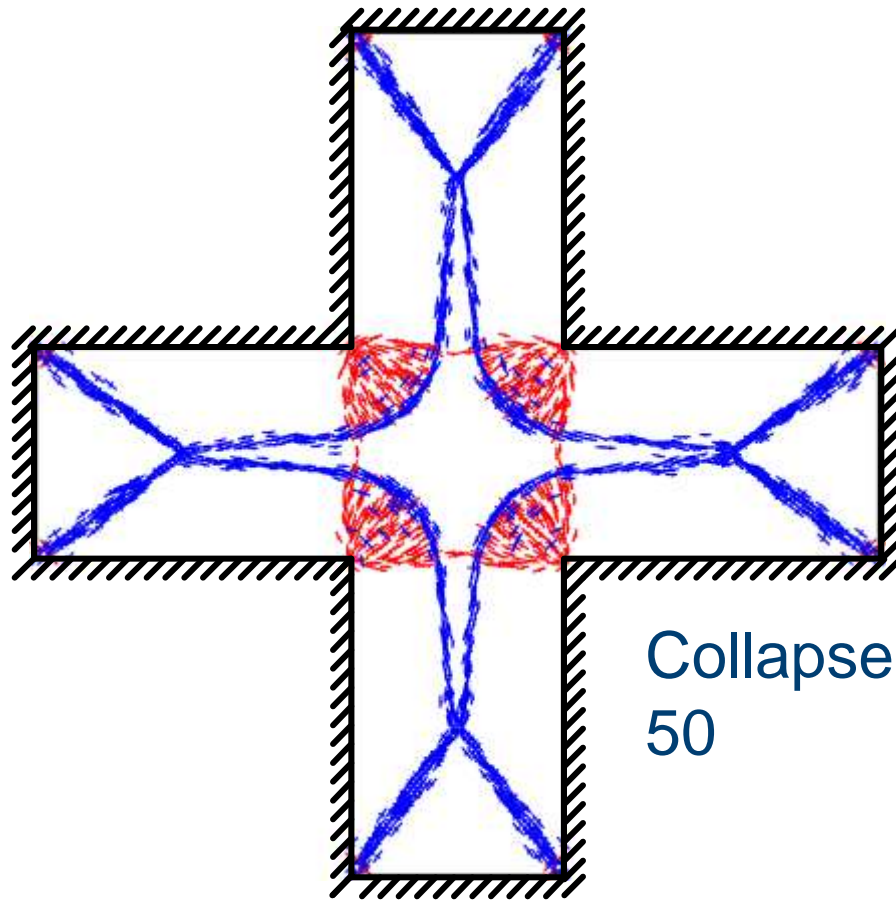
Example 2



Example 2



Example 2



Collapse load:
50

— Sag
— Hog

Conclusions

- Engineers need a safe but not unduly conservative general method for predicting the flexural collapse load of reinforced concrete slabs.
- Upper bound analysis is reasonably well accepted, but:
 - it is limited to slabs with relatively simple geometry
 - is an upper bound method
- New lower bound method may overcome these problems.

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