UNIVERSITY OF CAMBRIDGE

Predicting the Flexural Collapse Load of Concrete Slab Bridges

US Scanning Tour Visit, 11 June 2009

Andrew Jackson

Contents

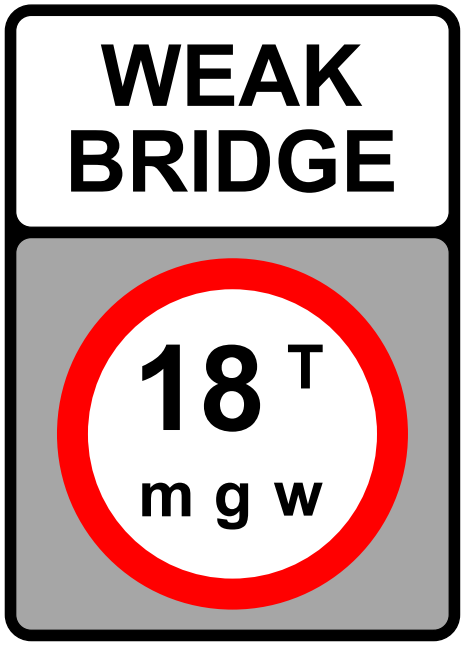
- Motivation
- Plastic methods
  - Upper bound analysis (COBRAS)
  - New lower bound analysis
- Examples

Motivation

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

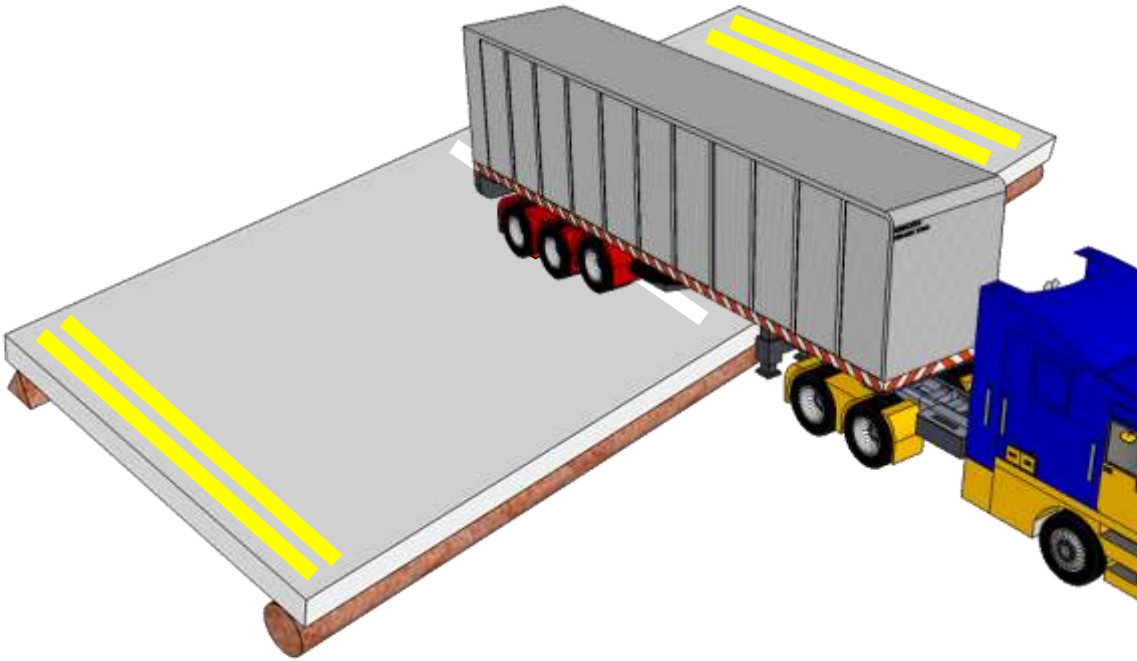
Motivation

But overly conservative assessments cause problems:

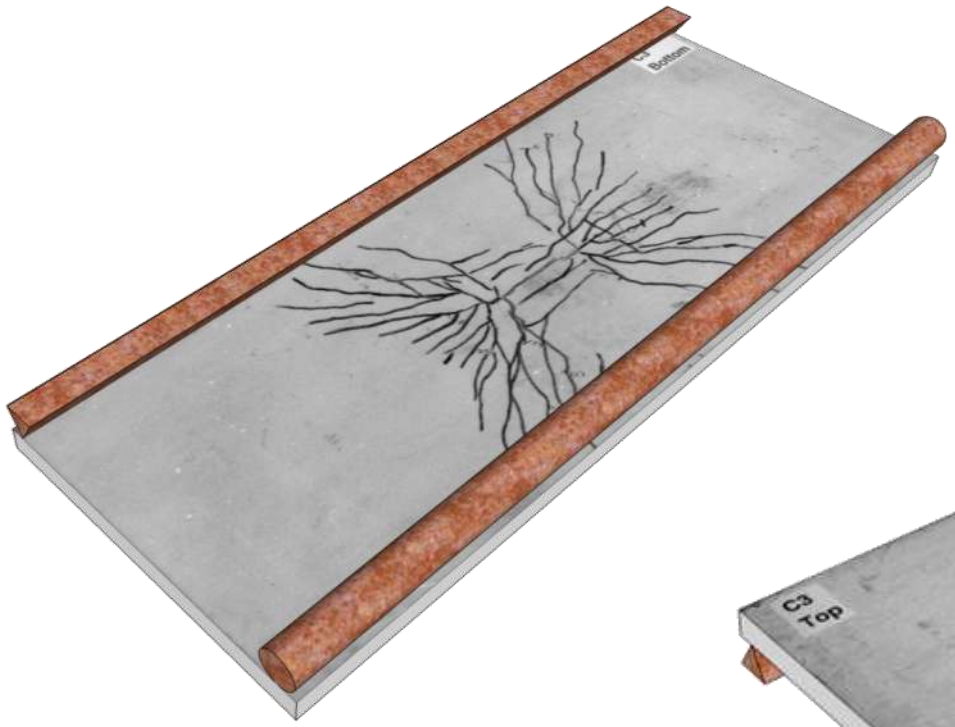


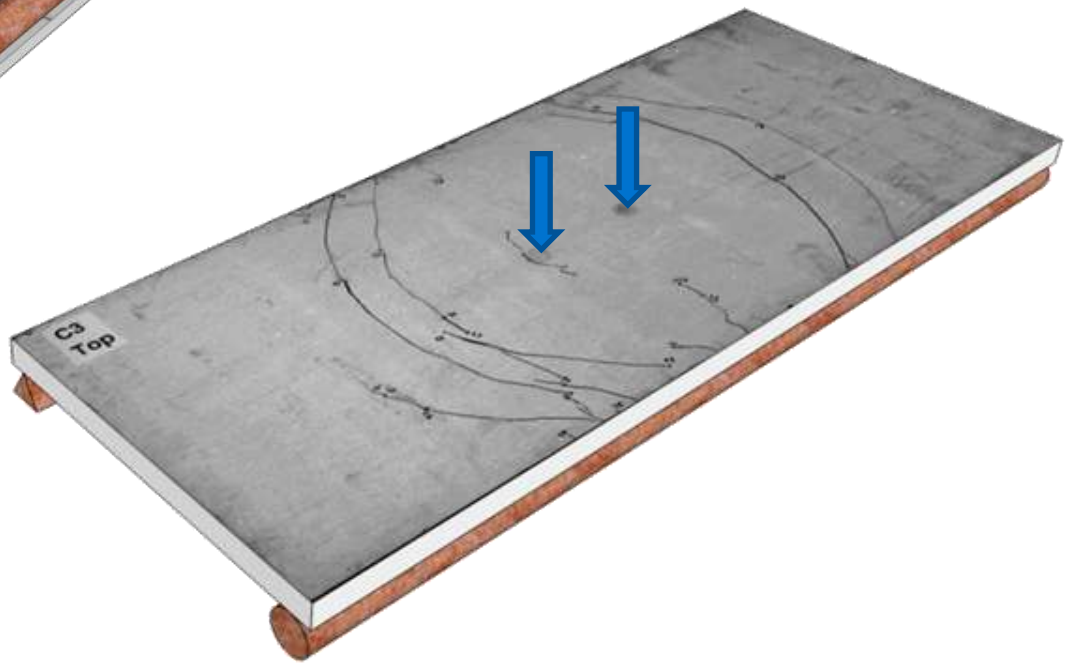
Assessment methods must be safe but not unduly conservative

Motivation: an example

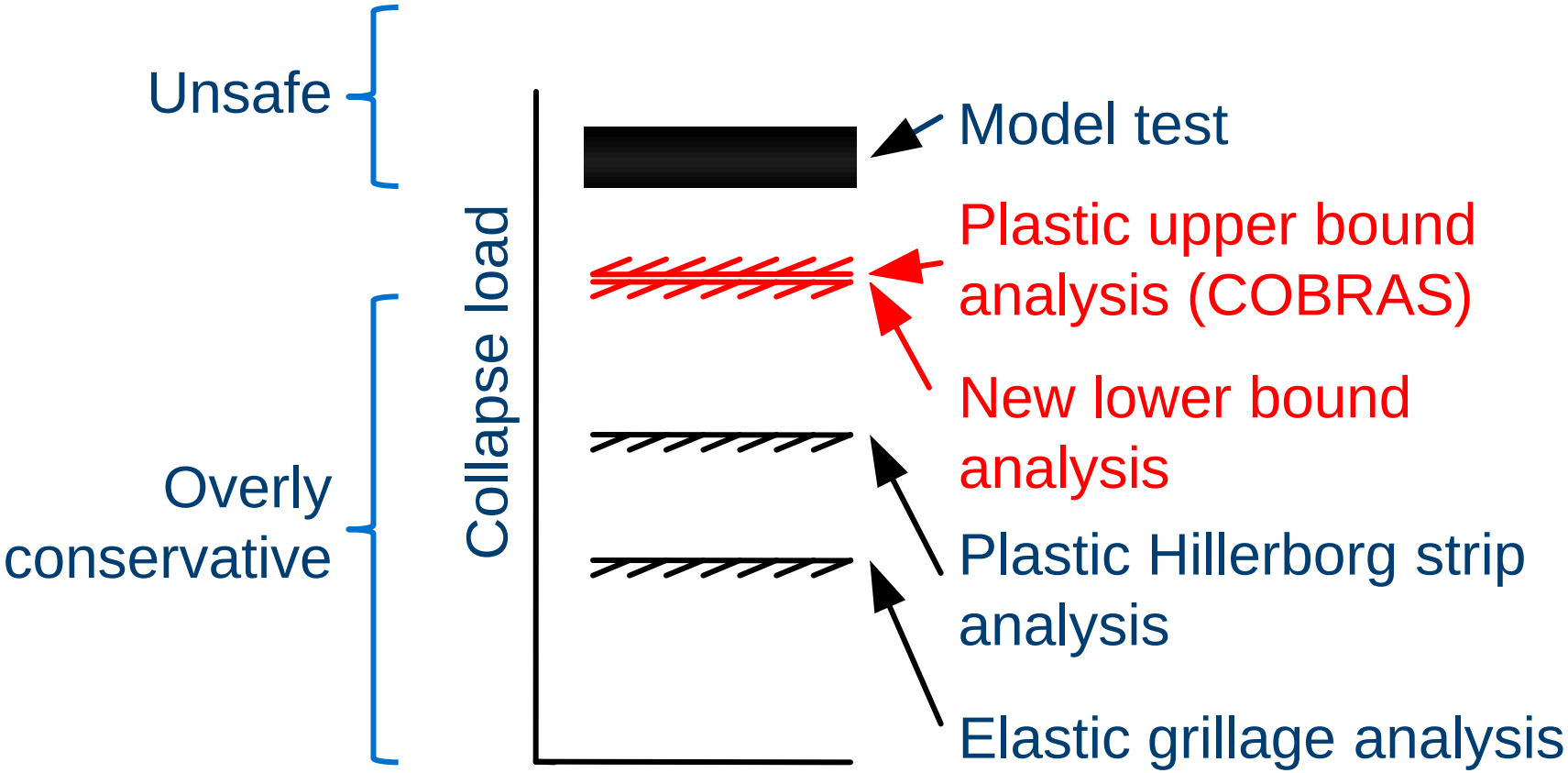


Motivation: an example

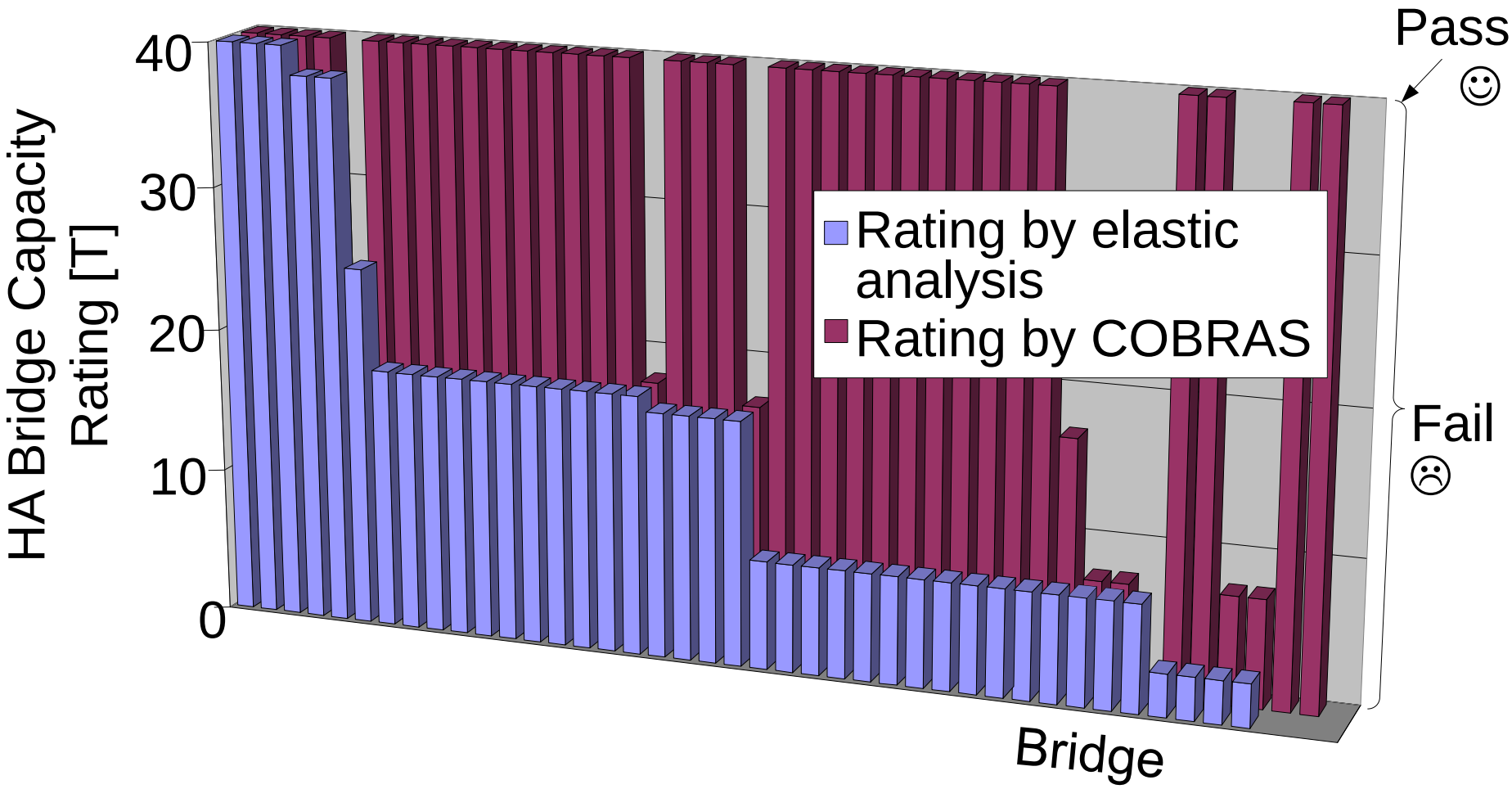




Motivation: an example



Motivation: real examples



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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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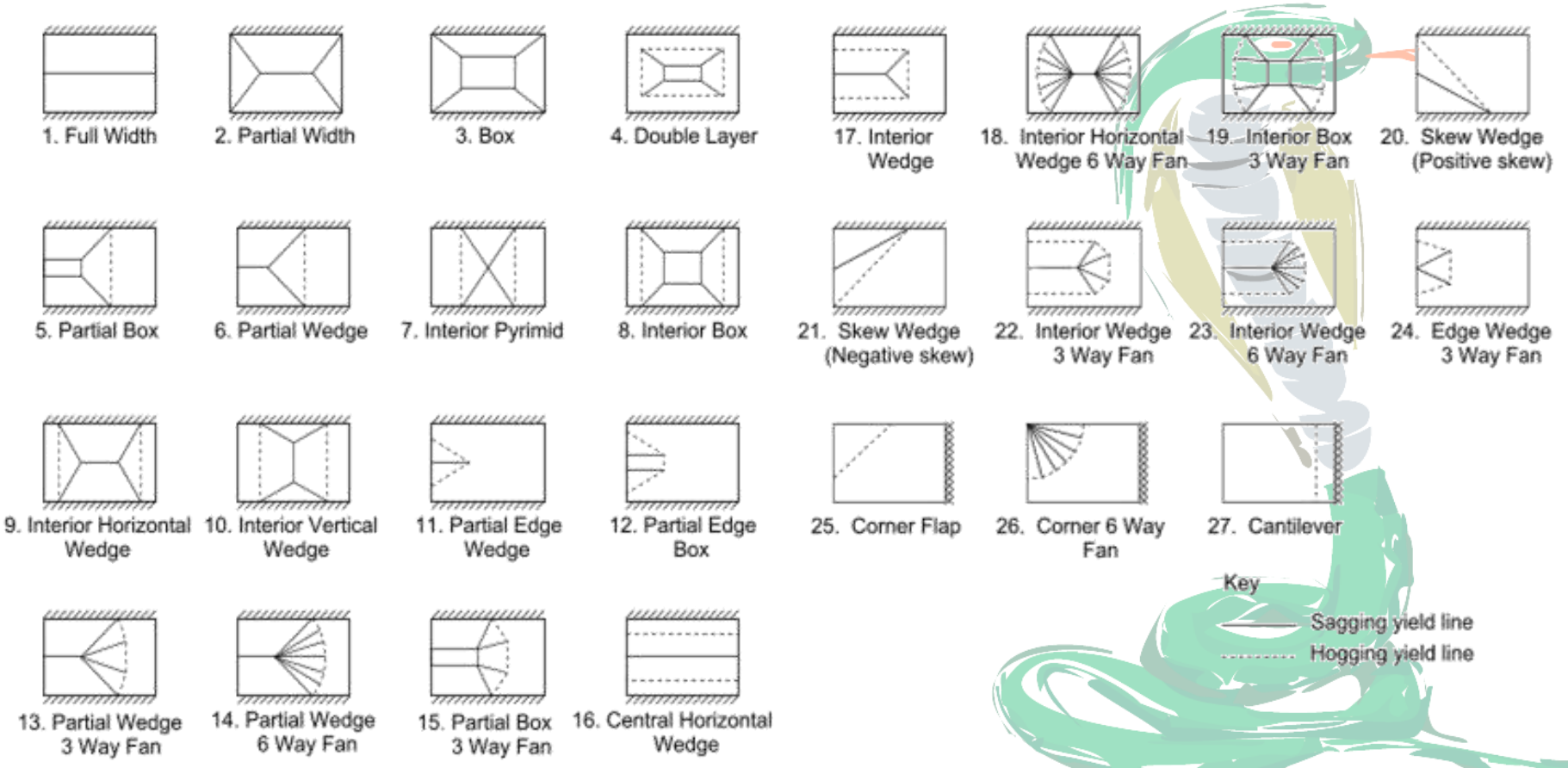
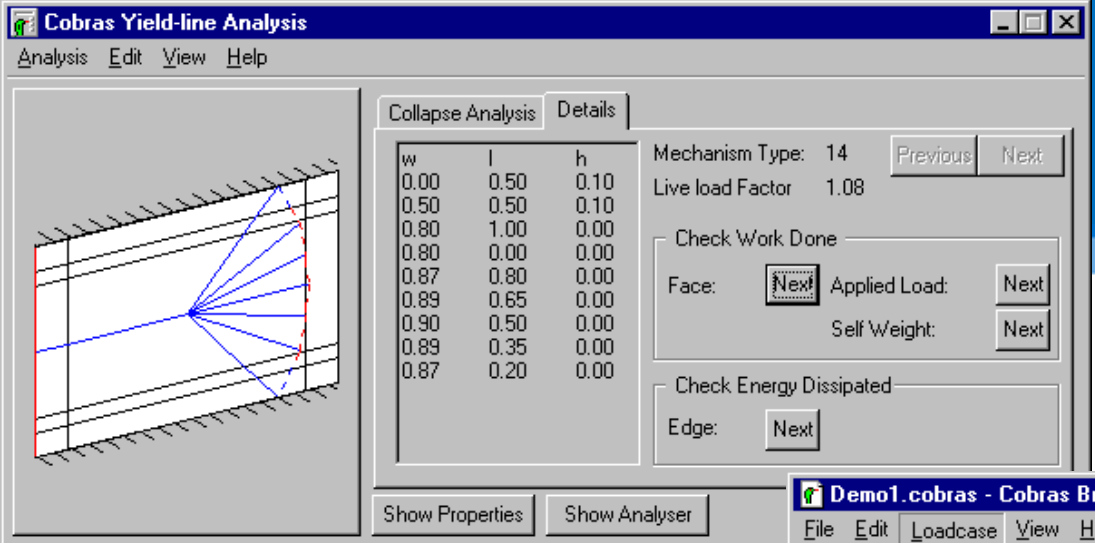
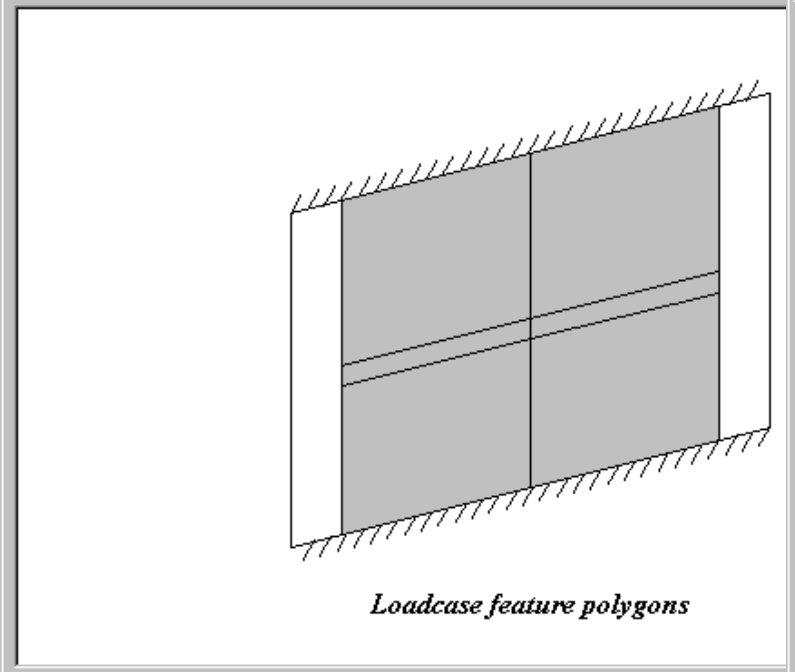
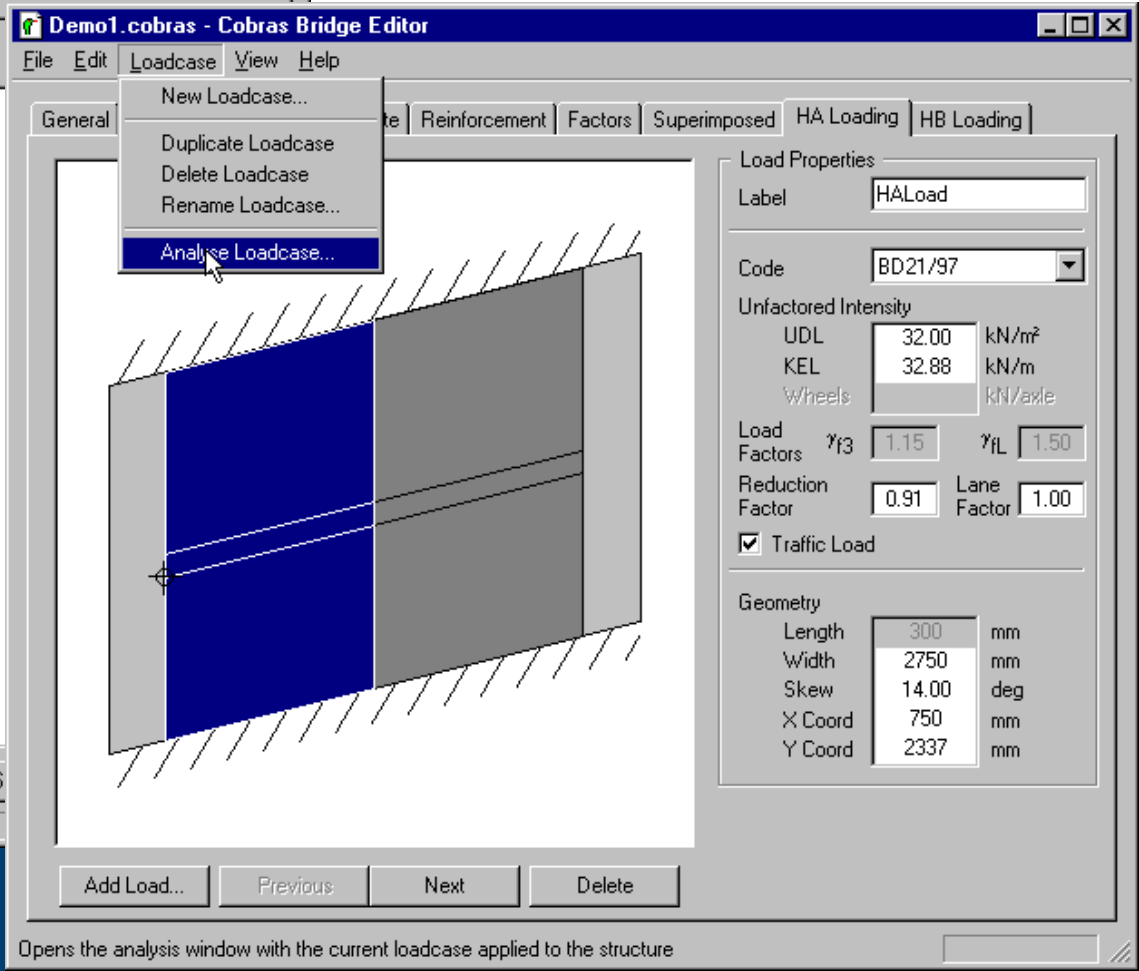
Upper bound analysis: COBRAS



COBRAS







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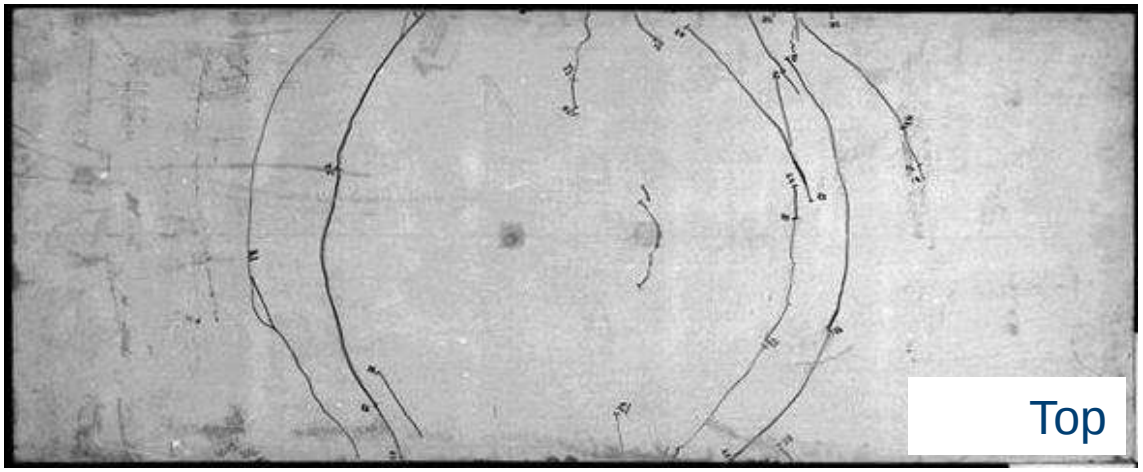
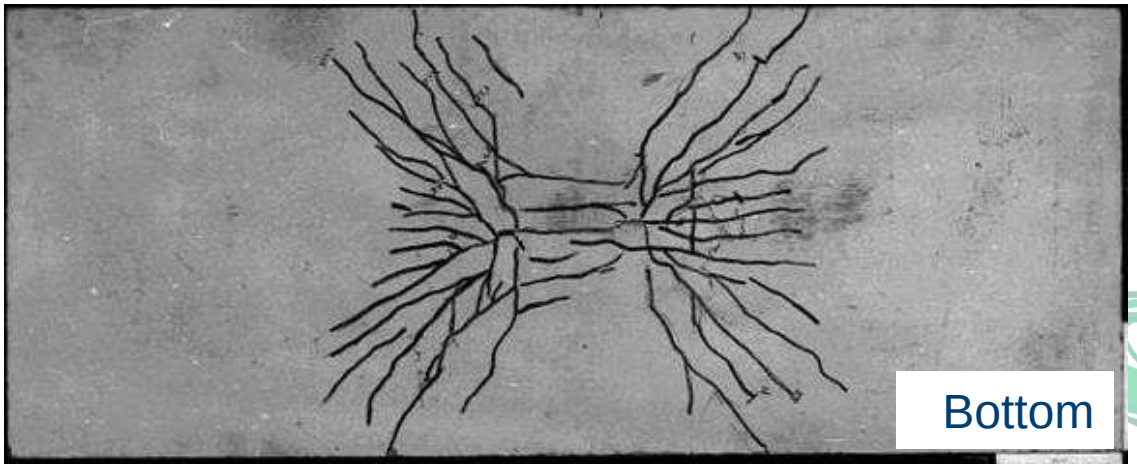
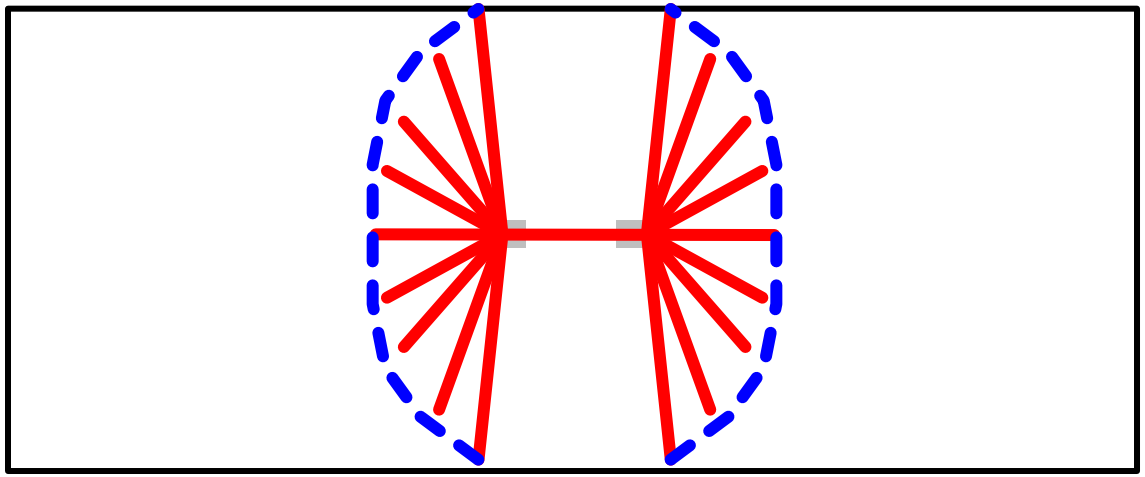
Upper bound analysis: COBRAS





Upper bound analysis: COBRAS



Yield line indicators: Hog Sag

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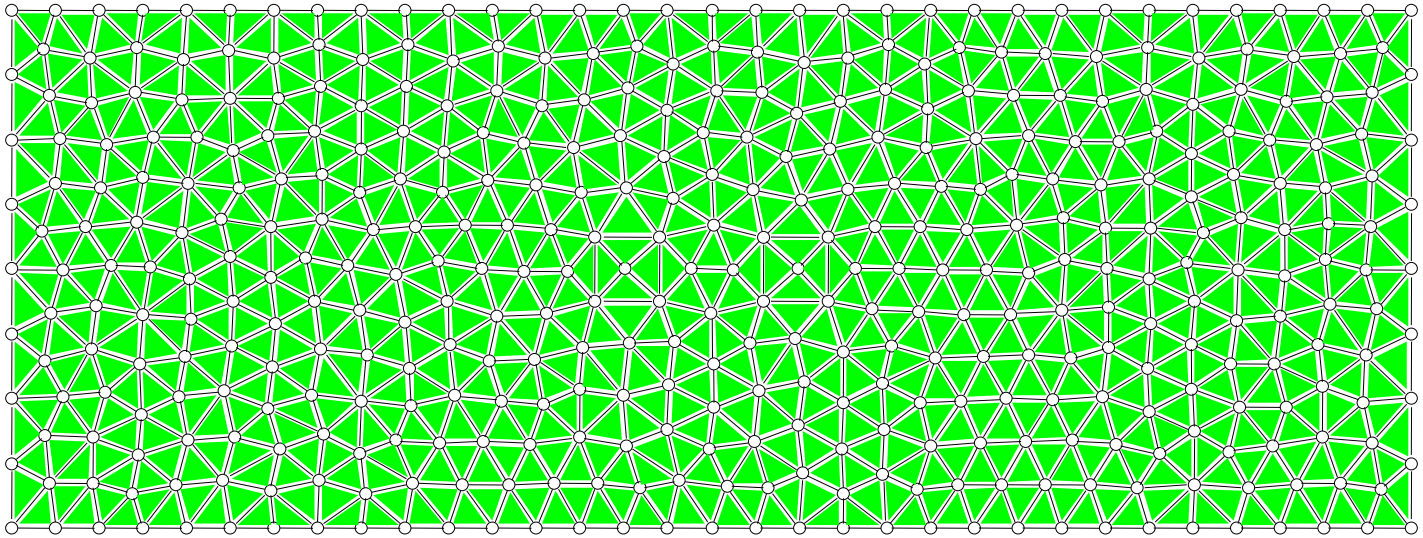
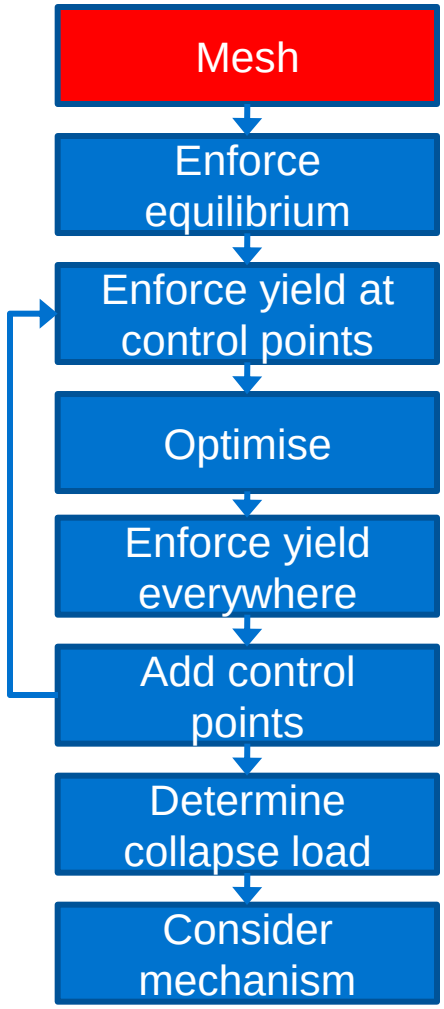
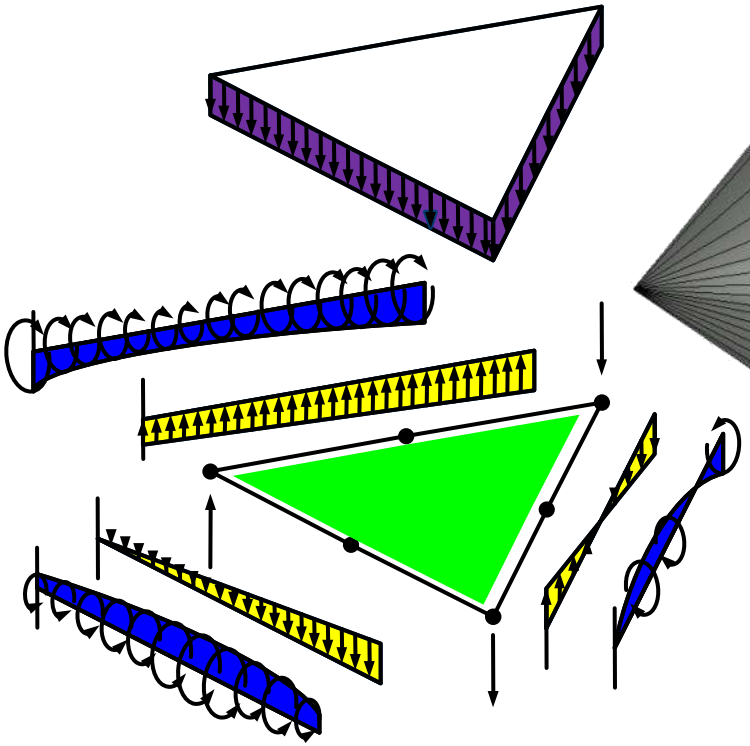
New lower bound analysis



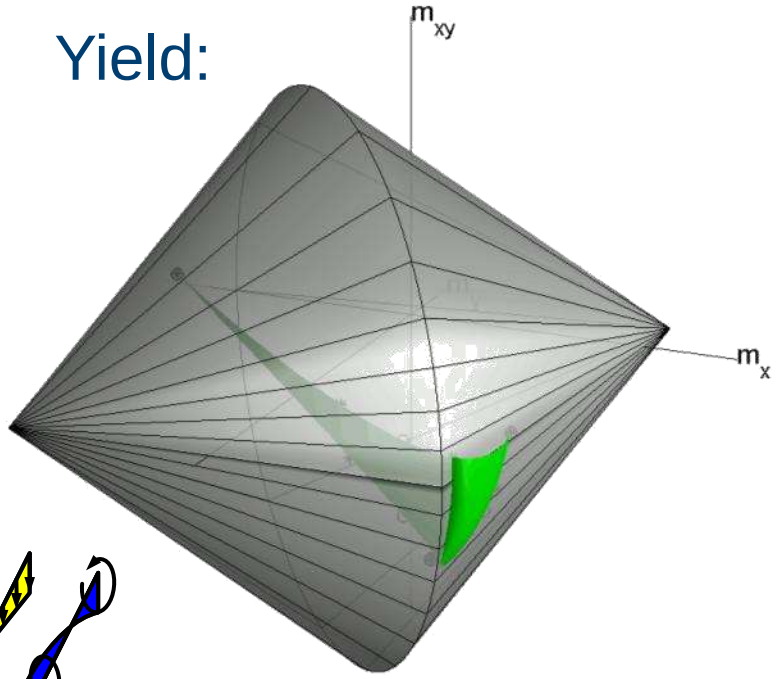


New lower bound analysis

Equilibrium:

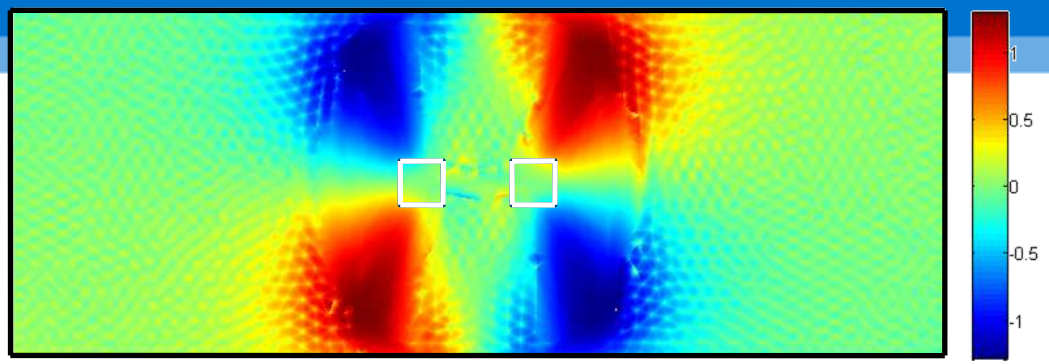


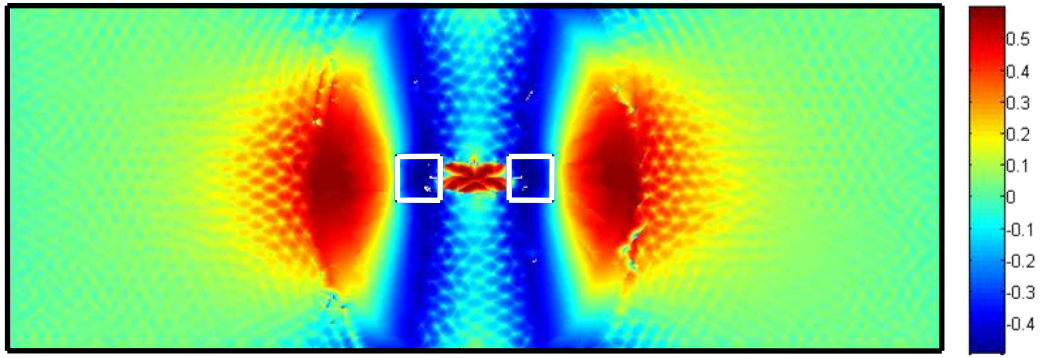
Yield:

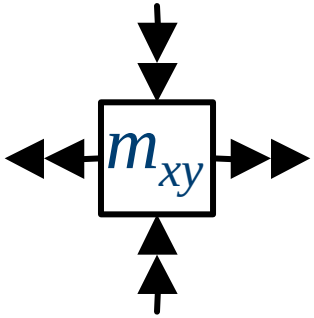


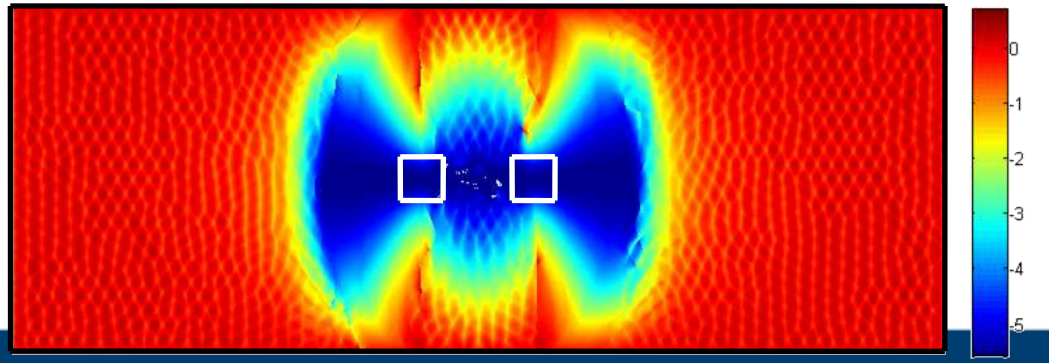
- Mesh
- Enforce equilibrium
- Enforce yield at control points
- Optimise
- Enforce yield everywhere
- Add control points
- Determine collapse load
- Consider mechanism

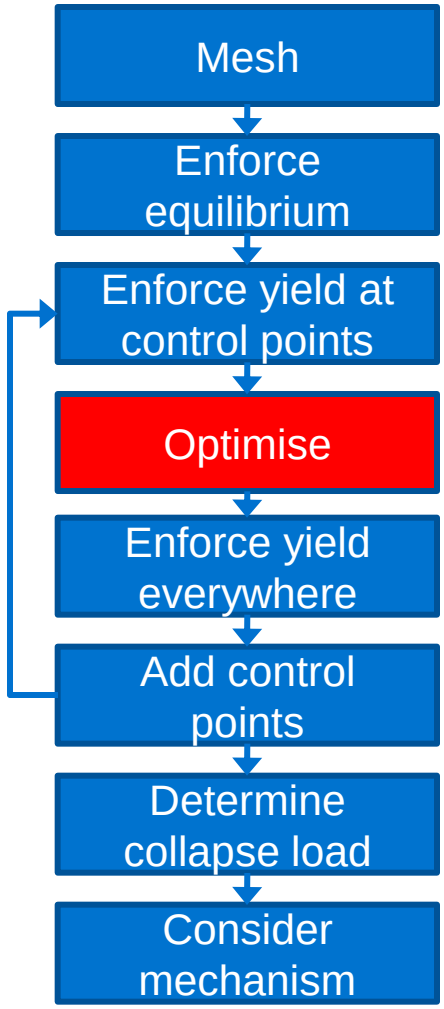
New lower bound analysis



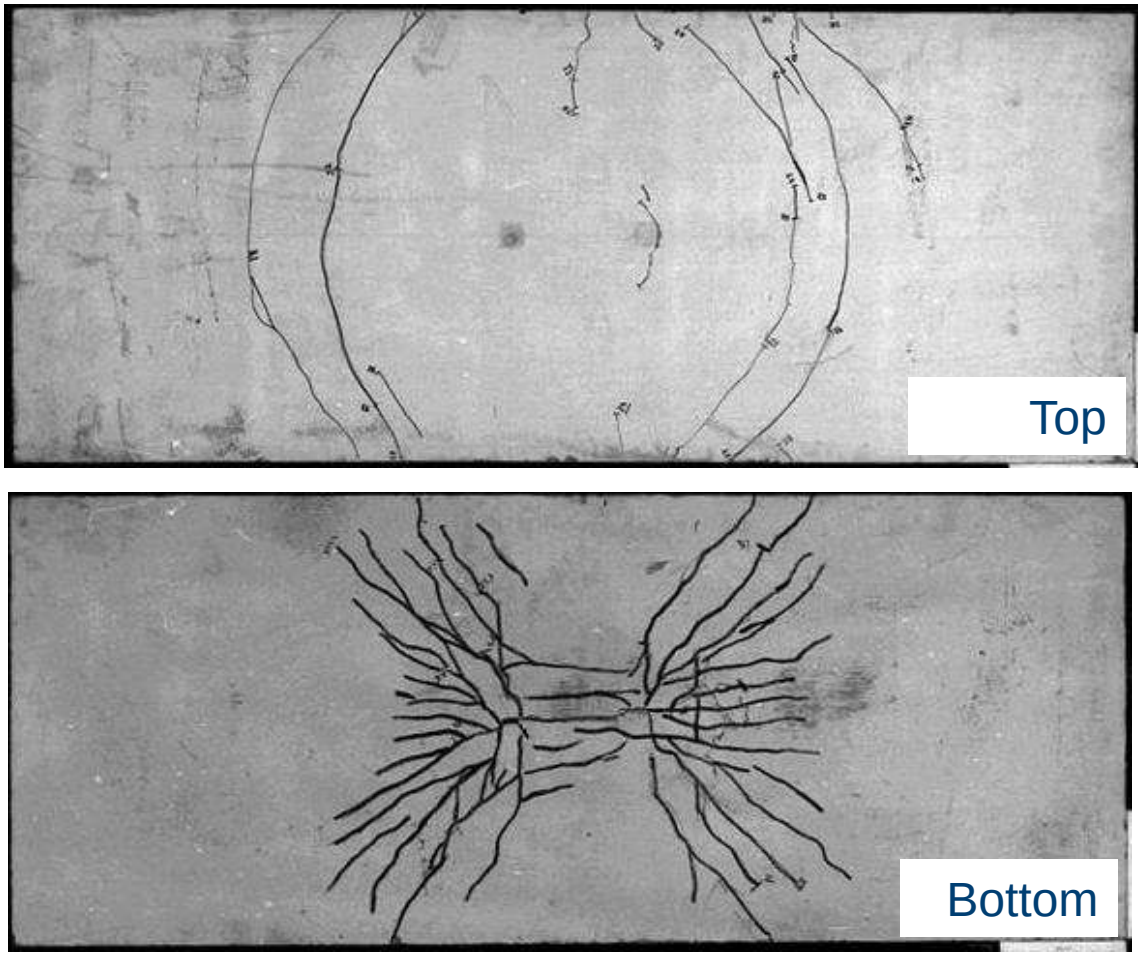


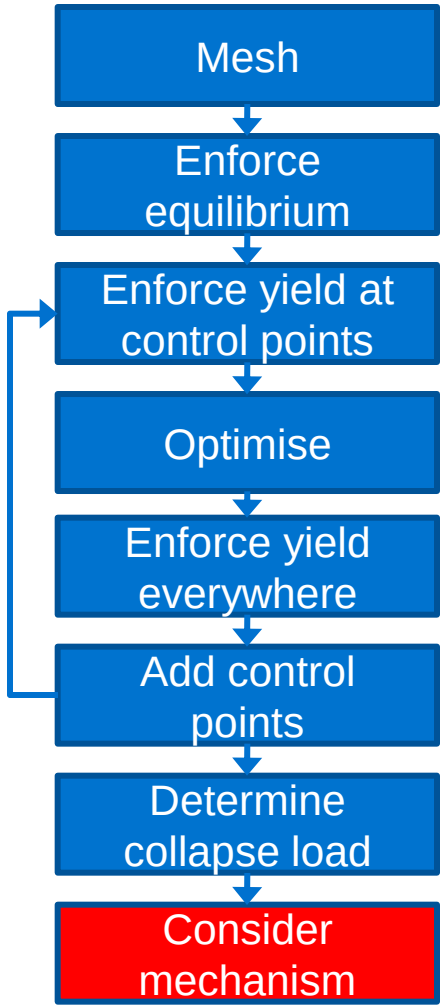




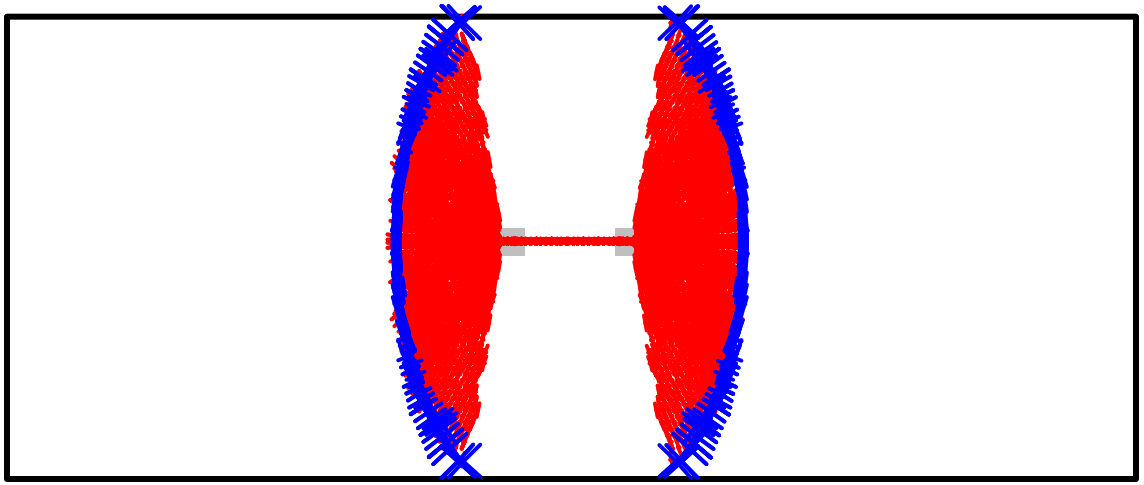


New lower bound analysis

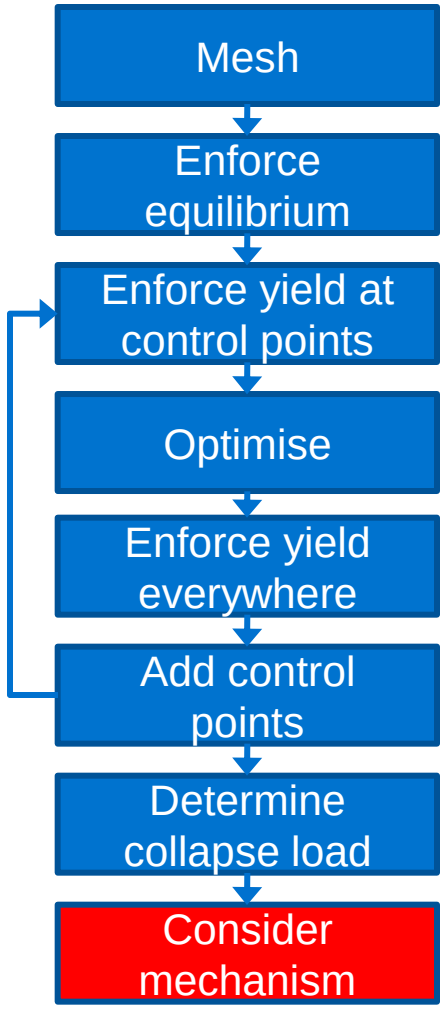




New lower bound analysis



Yield line indicators: Hog Sag



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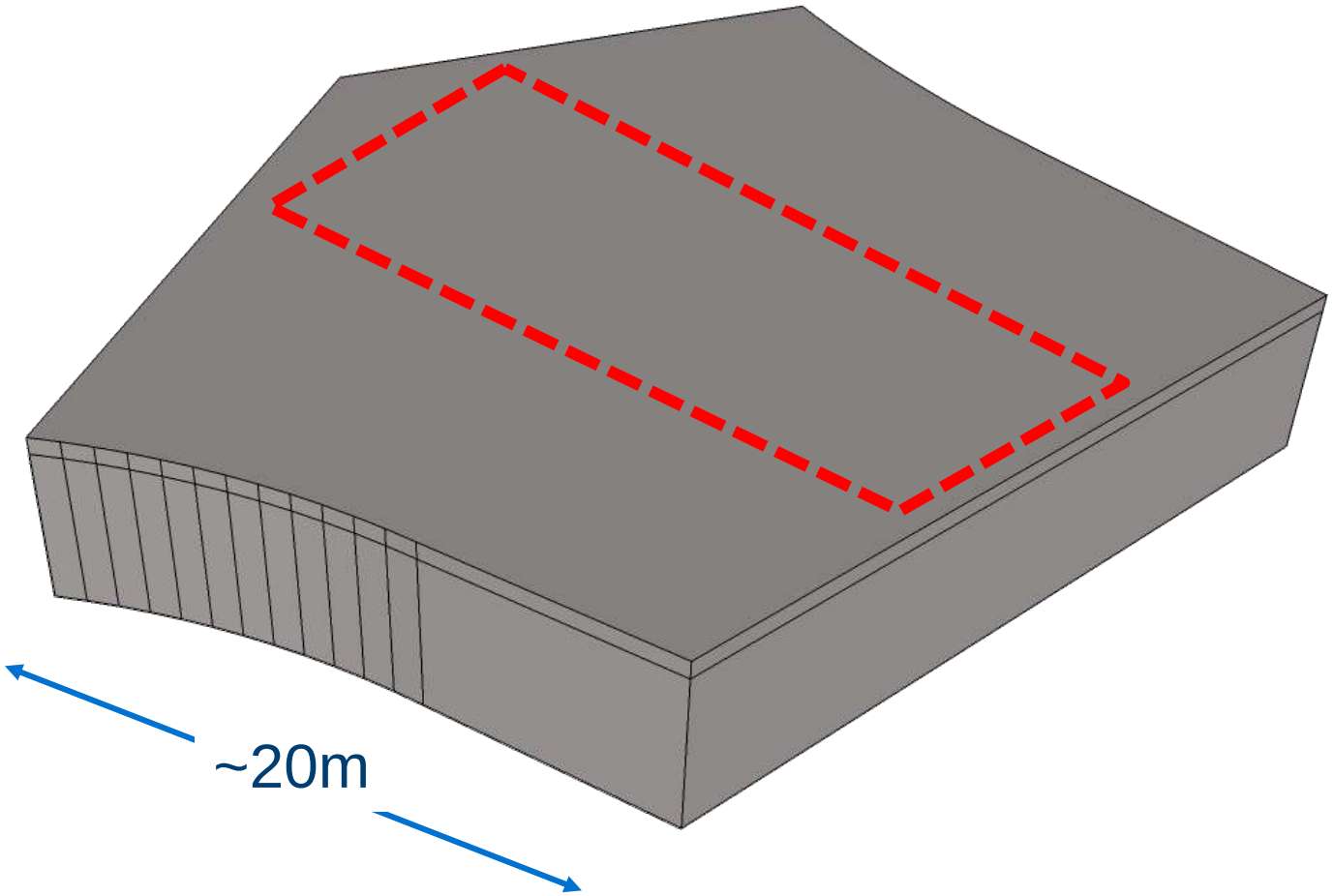
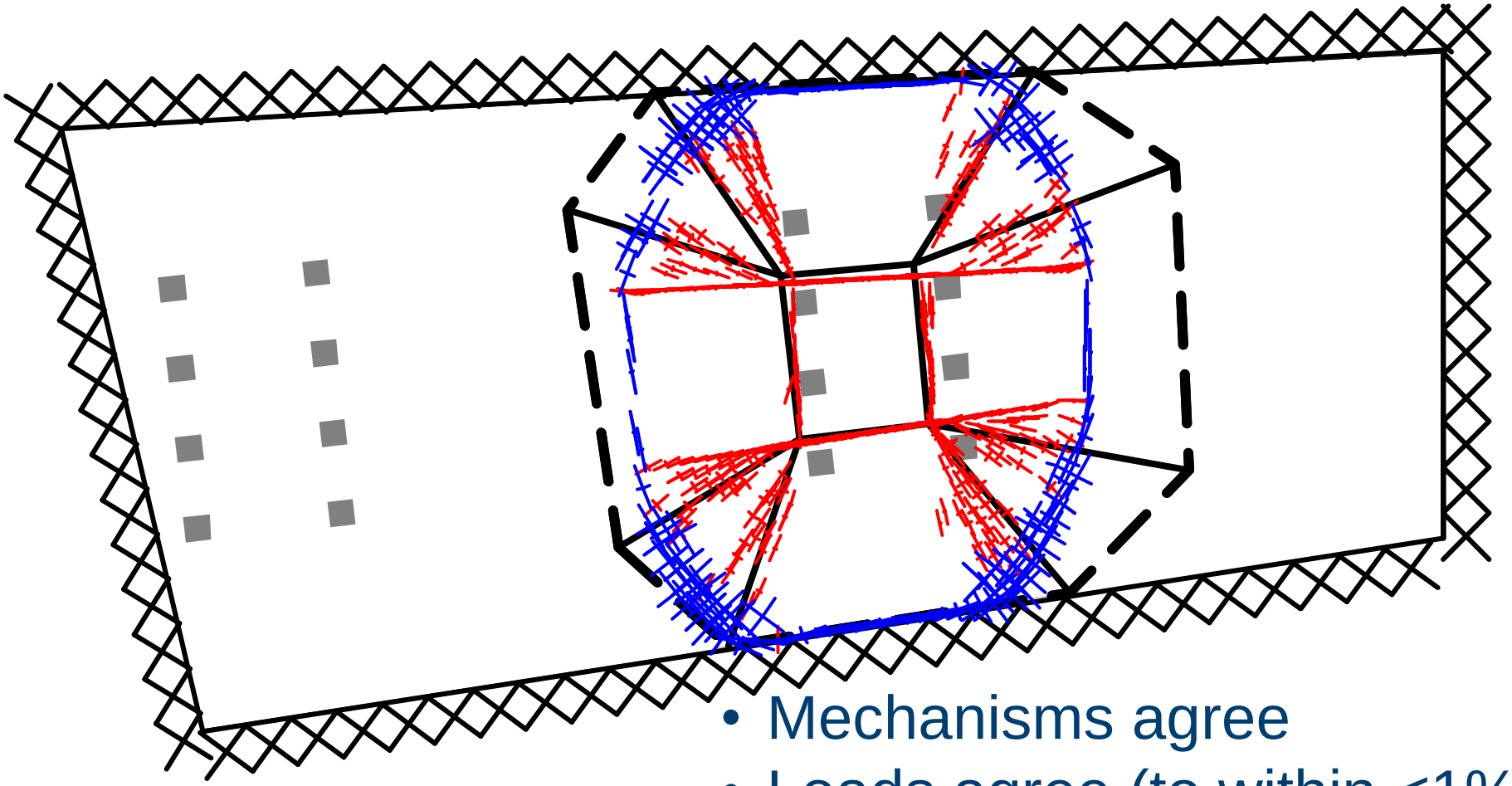
Example 1

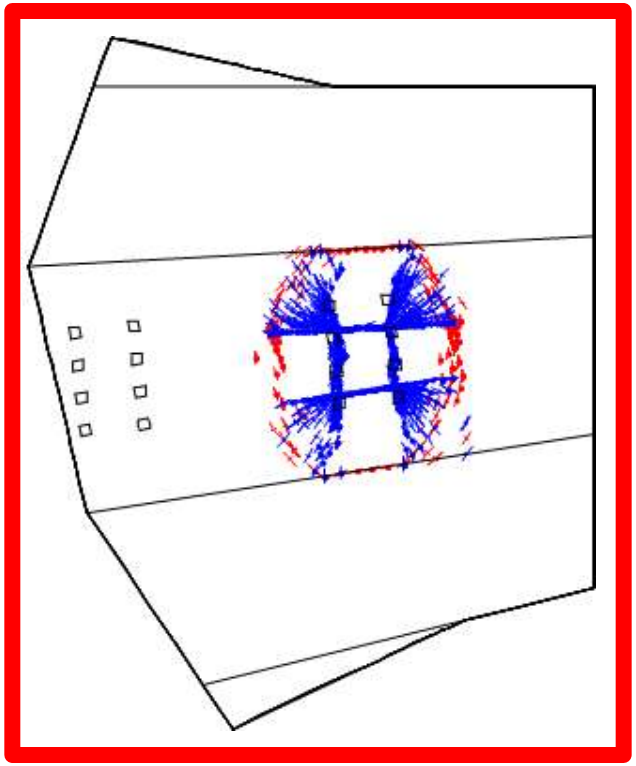


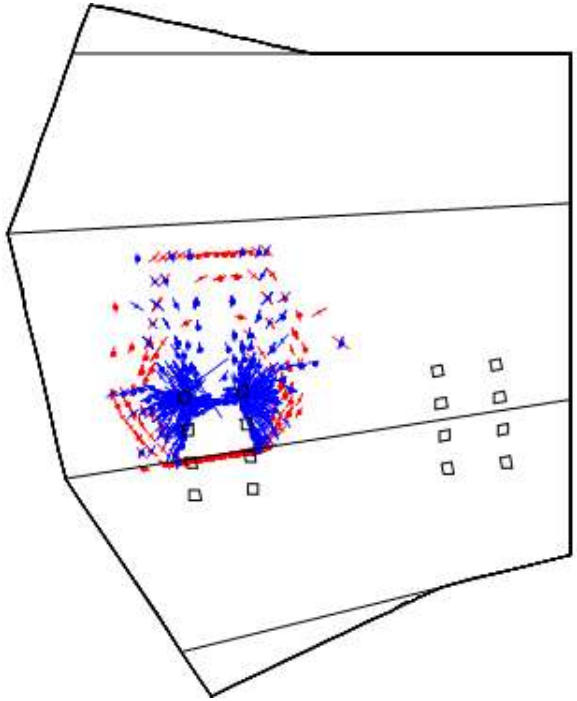
Example 1

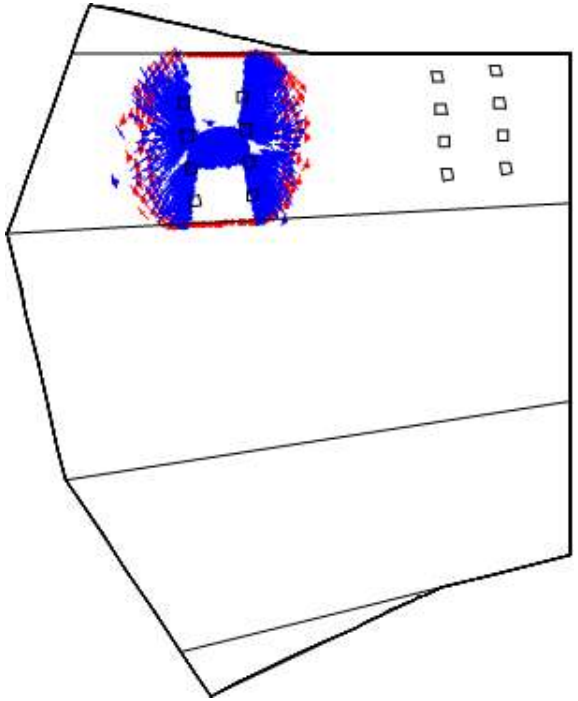


- Mechanisms agree
- Loads agree (to within <1%)

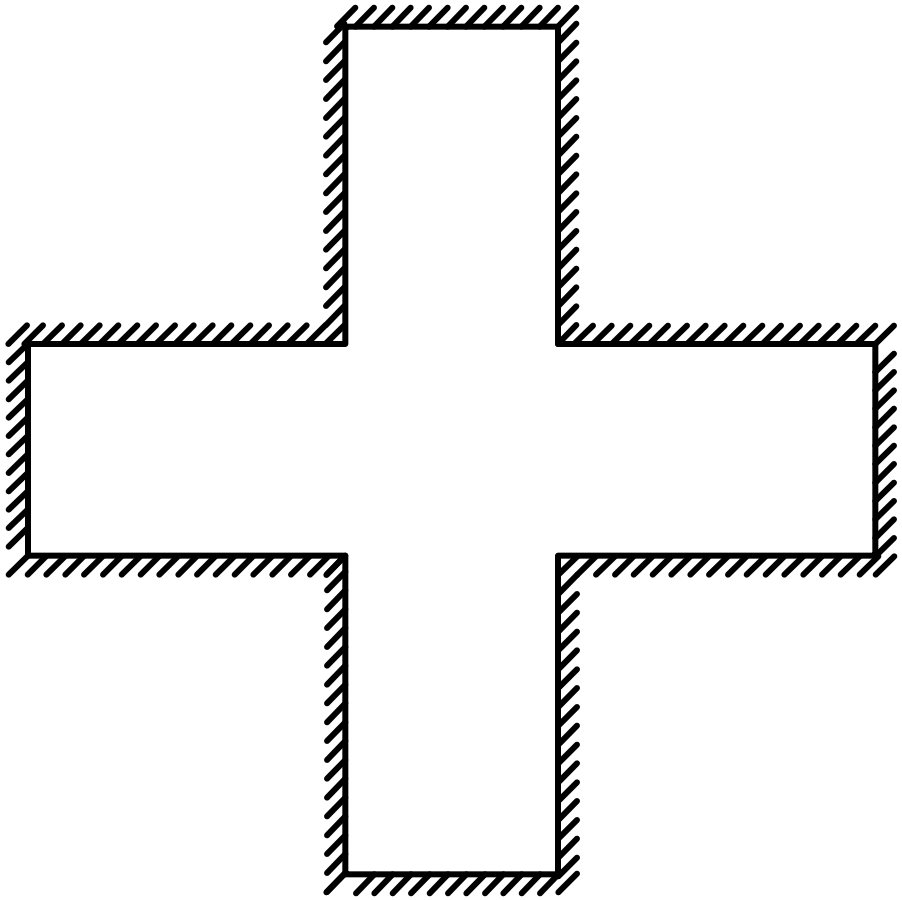
Example 1







Example 2



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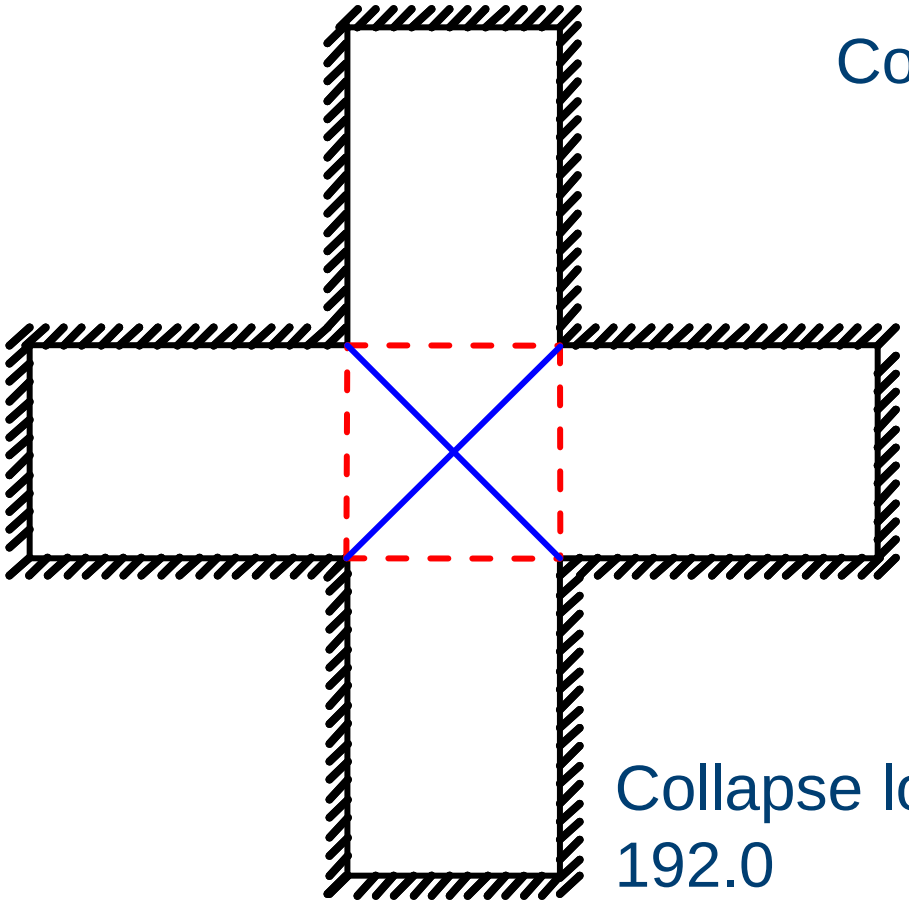
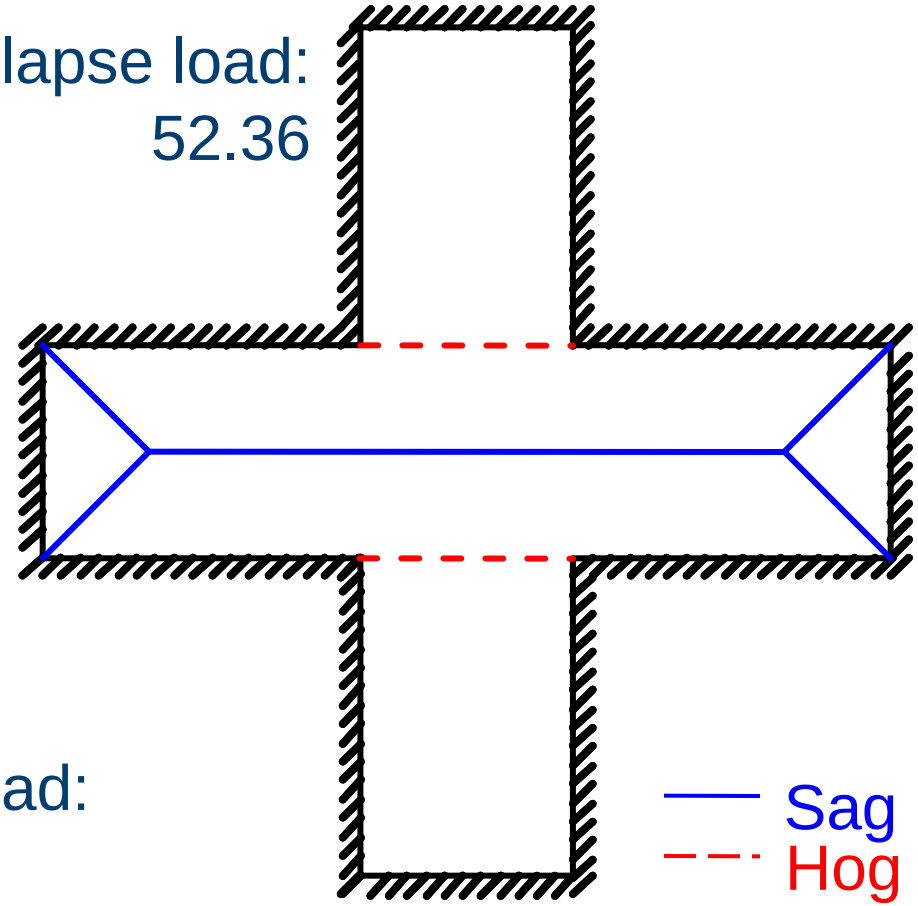


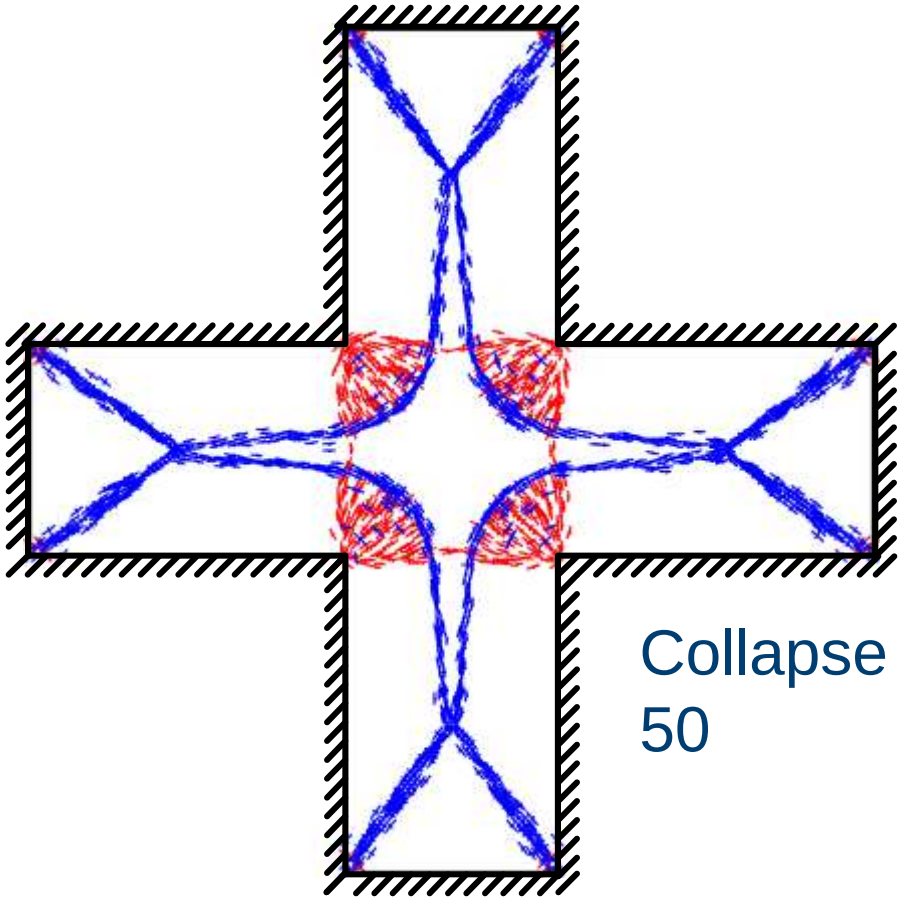
Collapse load:
192.0



Collapse load:
52.36

Sag
Hog

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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