Behaviour of Cellular beams and composite floors in ambient and elevated temperatures

Contents:

- Literature review
- Work done so far on:
  - ✓ Cellular beam
  - ✓ Cellular composite Floor
  - ✓ Ambient and elevated temps
- Future work

Cellular beams in comparison

1) solid-webbed beams

- ✓ Remarkable increase in vertical bending stiffness
- ✓ holes as a passage for services and ducts

2) castellated beams

Advantages:

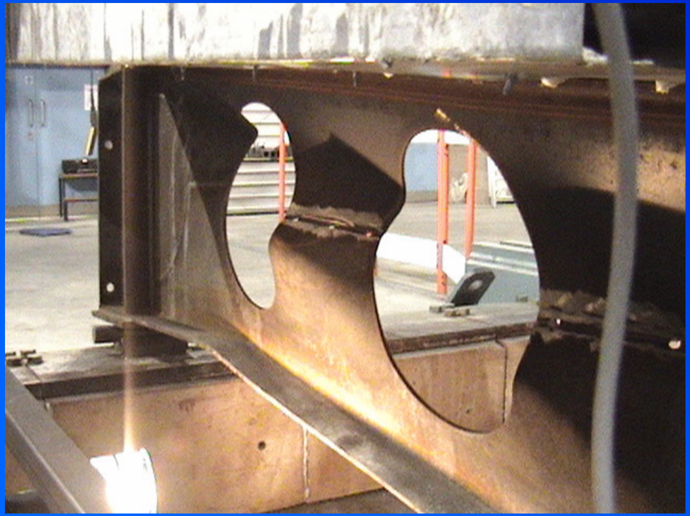
- ✓ aesthetically
- ✓ Generally lighter
- ✓ Having a far more flexible geometry
  1. Finished depth
  2. Opening diameter
  3. Opening spacing

Disadvantage:

- ✓ Wasting amount of material in Double cut fabrication process

Major modes of failure

- Vierendeel Mechanism
- Web-post Buckling
- Rupture of web-post weld
- Pure Bending
- Lateral-torsional buckling
- Local failures



FEA of cellular beam (CB)

1. Ambient Temp.s

   Single beams modelled

   - **Natal Beam No.4**
   - **Leeds Beam No.2**
   - Leeds Beam No.3
   - Leeds Beam No.5

   Cellular composite floor:

   - University of Kaiserslautern (2002)
   - Ulster Beam A1 (2005)
   - **Ulster Beam B1 (2005)**

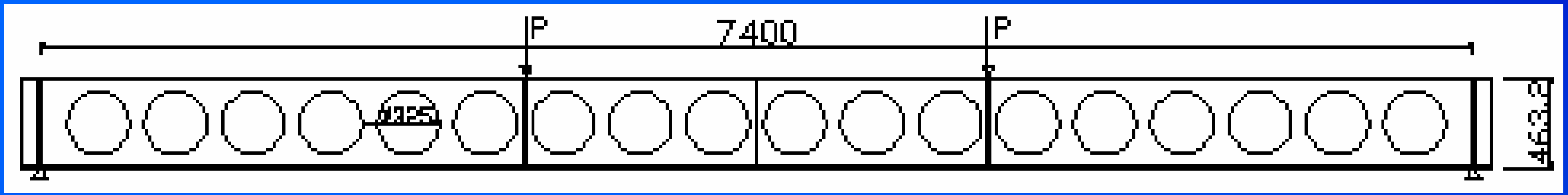
2. Elevated Temps

   Single Solid beams

   Cellular composite floor

   - **Ulster Beam A**
   - **Ulster Beam B**
   - Ulster Beam E
   - Ulster Beam F

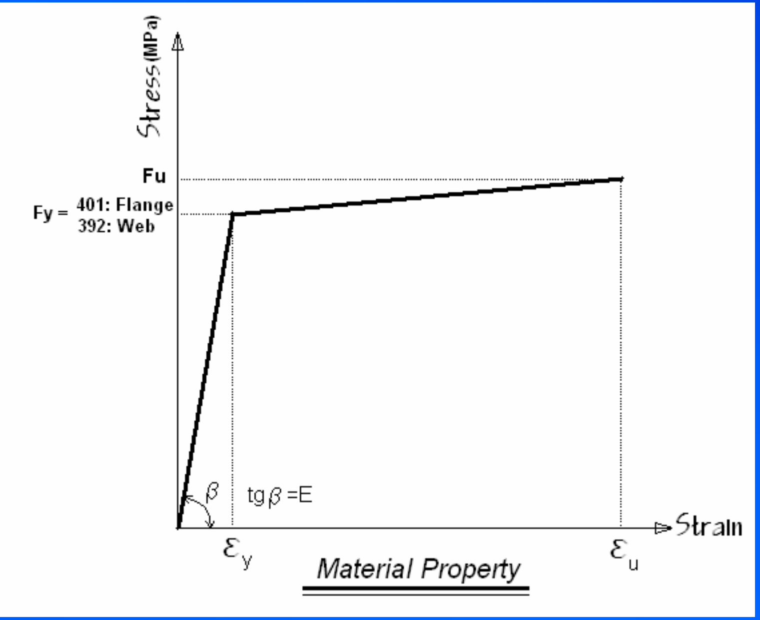
Modelling Natal Beam No.4



Software: ABAQUS , ANSYS

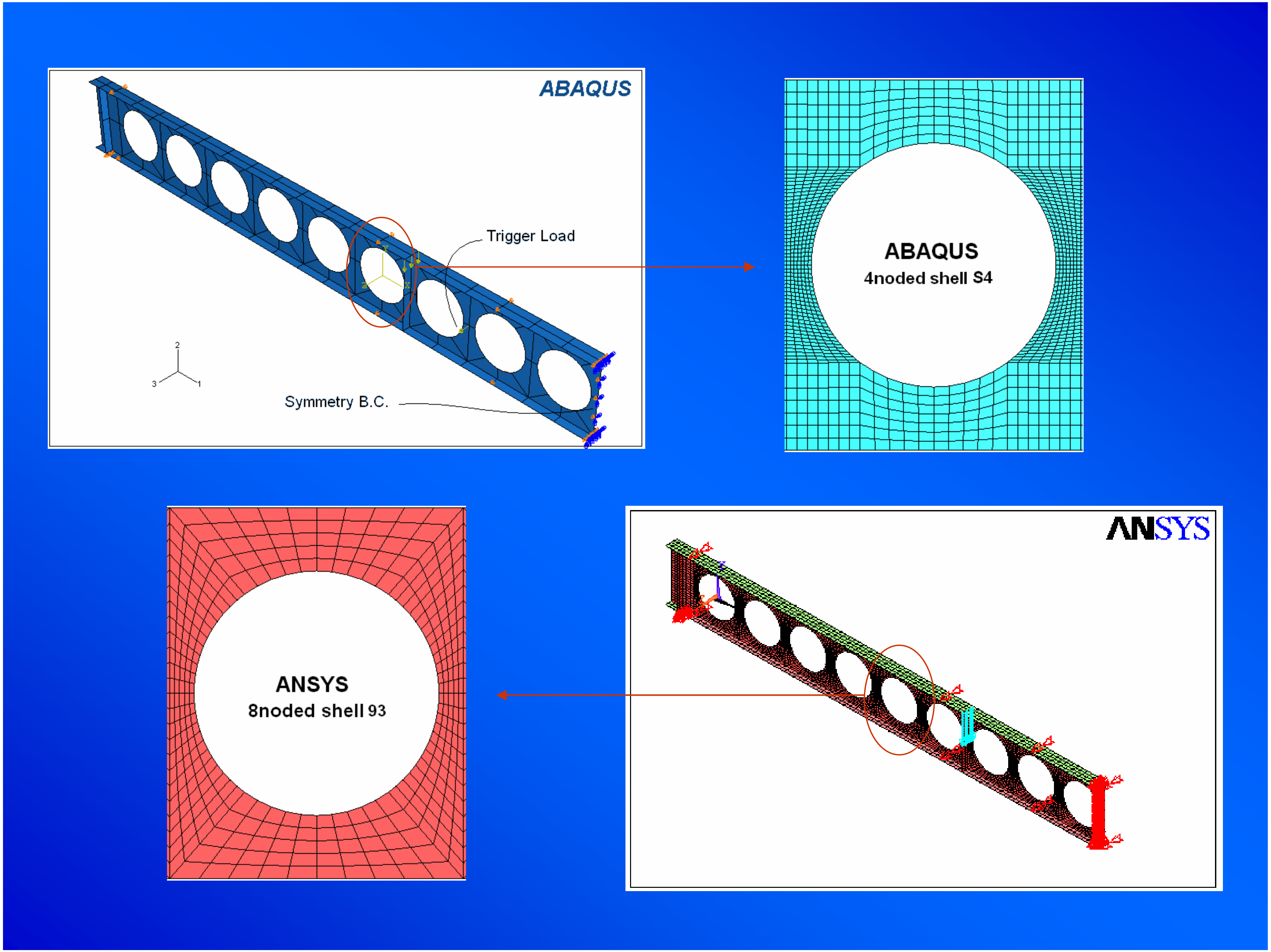
Material property:

- ✓ Bilinear kinematic

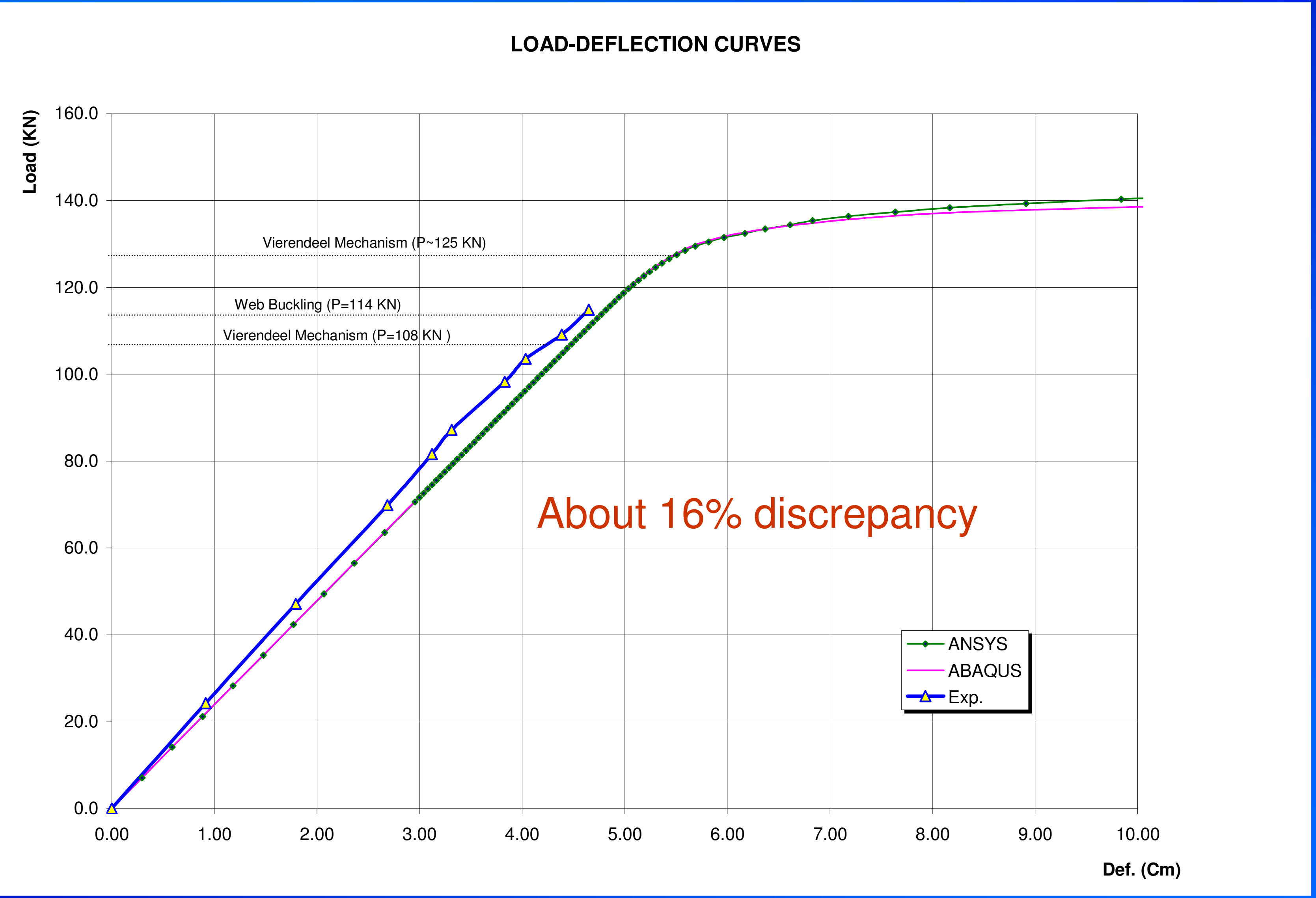


Shell elements:

- ✓ Large deformation
- ✓ Large strains
- ✓ Plasticity


ABAQUS
Trigger Load
Symmetry B.C.
ABAQUS
4noded shell S4
ANSYS
8noded shell 93
ANSYS

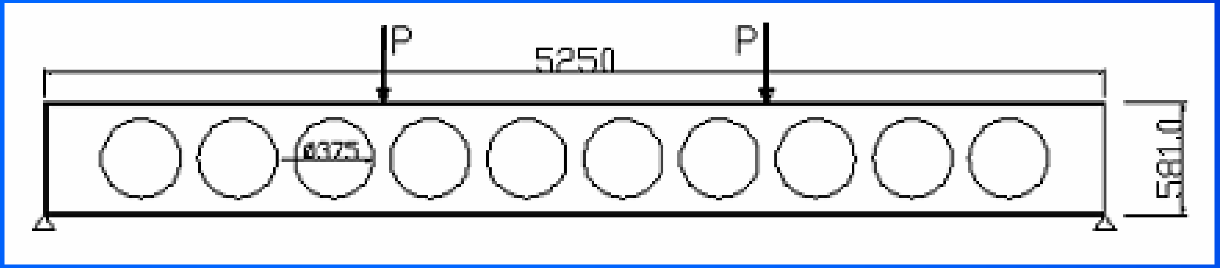
Load-Deflection comparison



Main reasons causing difference between FEA and experiment results

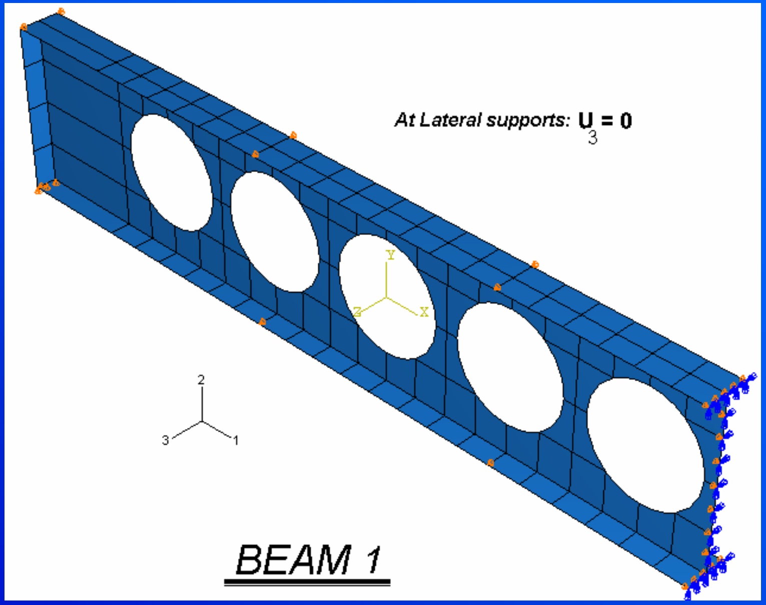
- Residual stresses
- Imperfections
- Nominal dimensions
- Boundary conditions
- FE and Instrumental errors

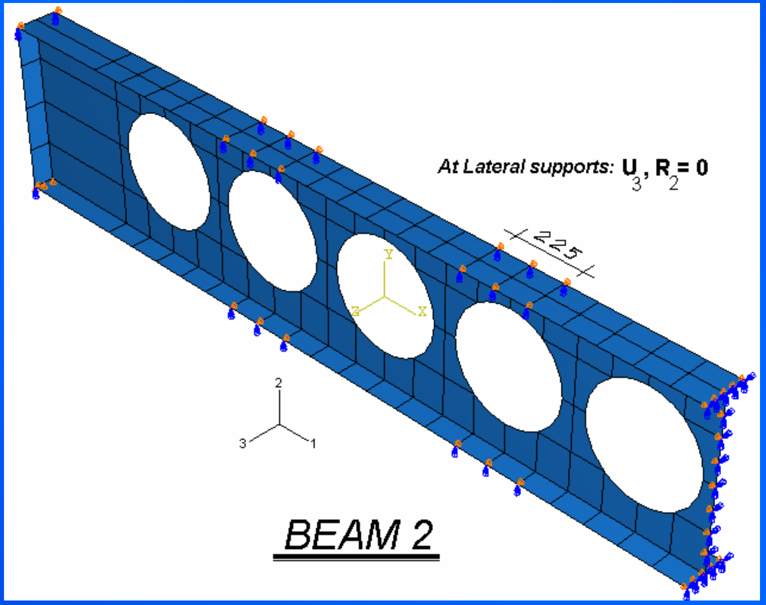
Modelling Leeds Beam No. 2



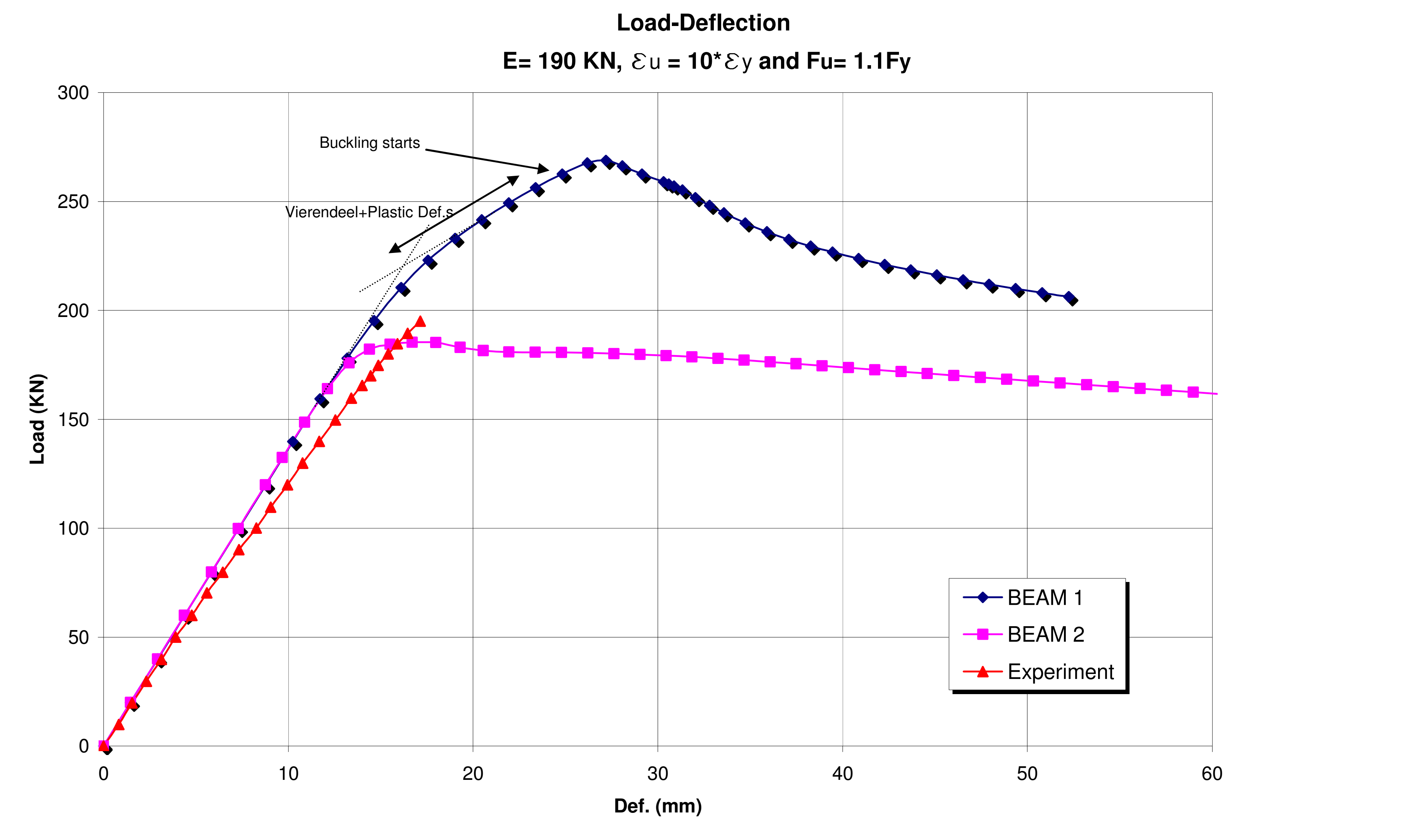
- Role of B.C.s

  Flange lateral support at 1m intervals



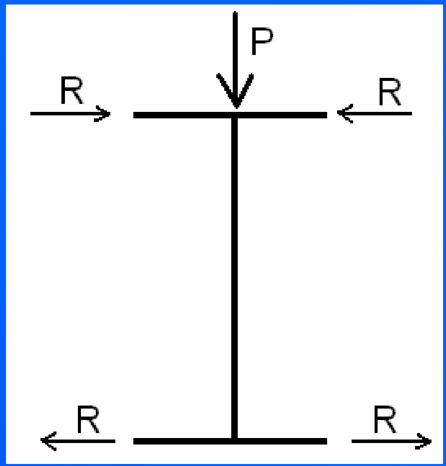


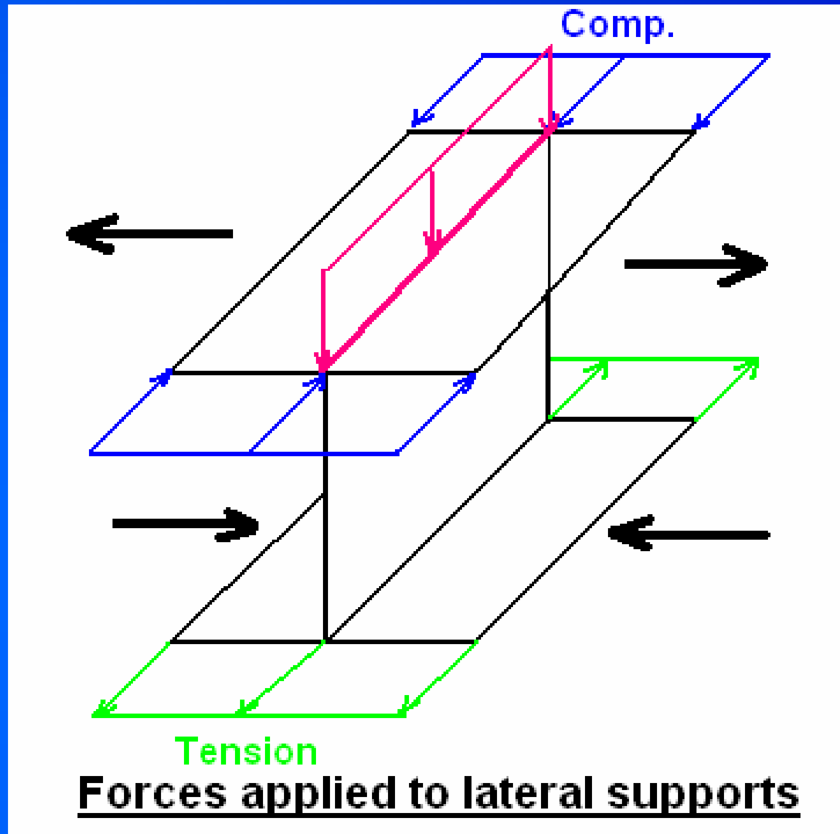
Role of B.C.

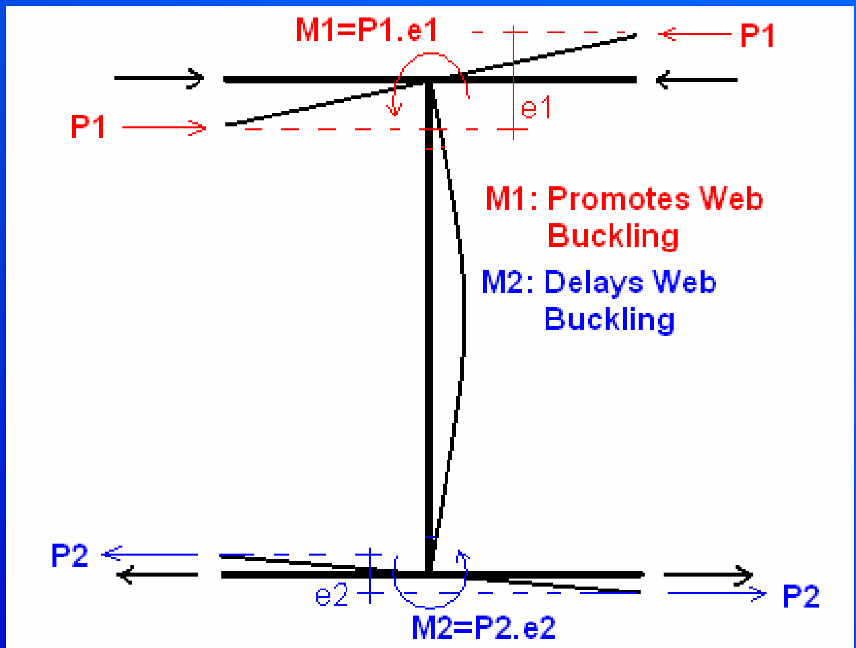


Load-Deflection
E= 190 KN, ℰu = 10*ℰy and Fu= 1.1Fy
Buckling starts
Vierendeel+Plastic Def.s
Load (KN)
Def. (mm)
0
50
100
150
200
250
300
0
10
20
30
40
50
60
BEAM 1
BEAM 2
Experiment

Role of Lateral Support on the Behaviour of CBs

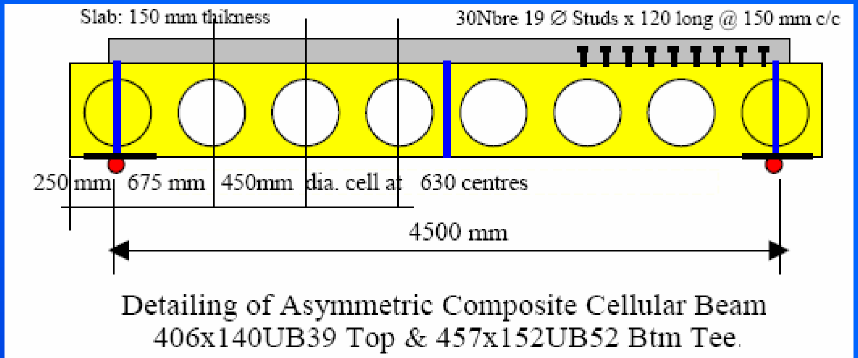


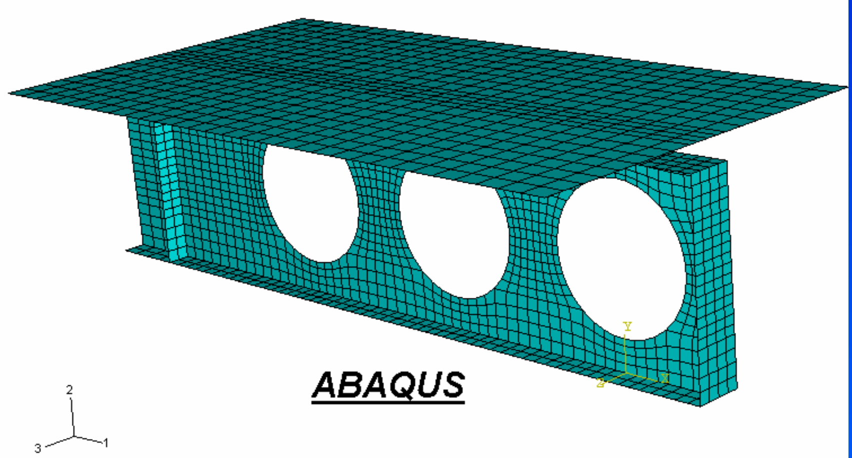




Cellular composite Floor:

Ulster Beam B1 (2005):

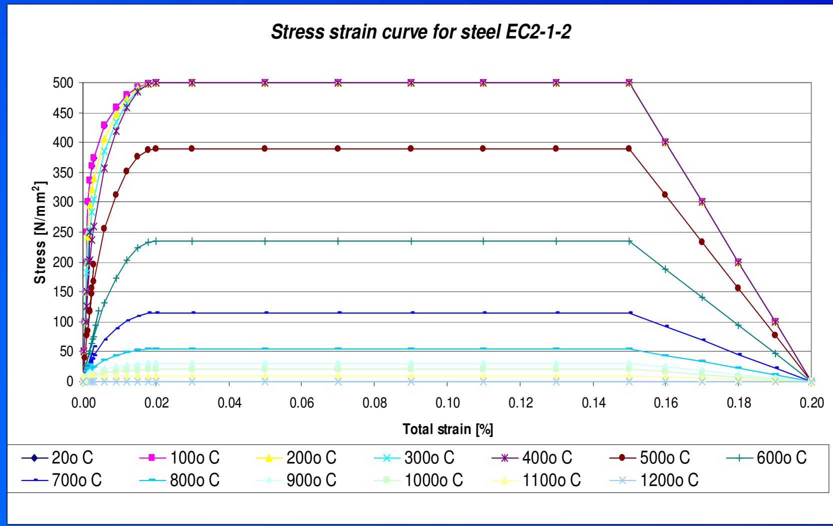




- ✓ High density of shear connector: Full interaction (Tied)
- ✓ Symmetry (Half of the structure is modelled)
- ✓ Composite shell with Smeared cracking approach for concrete

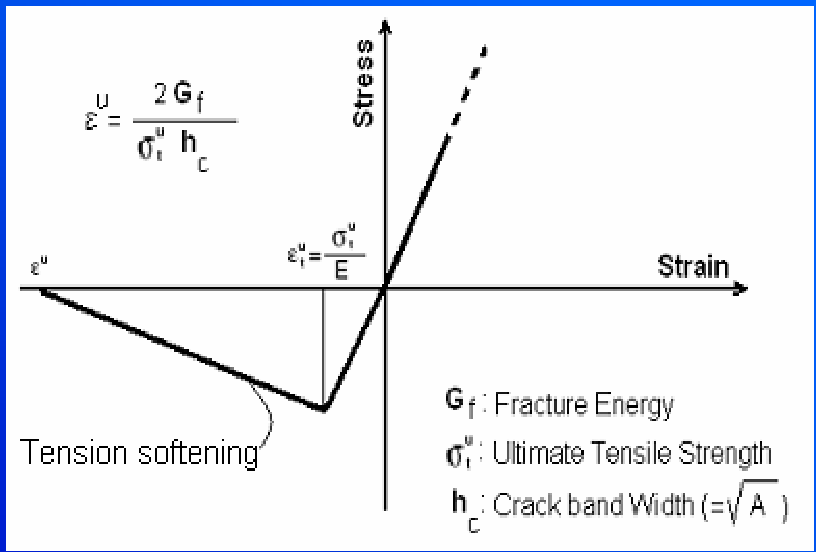
Material Property

- Steel

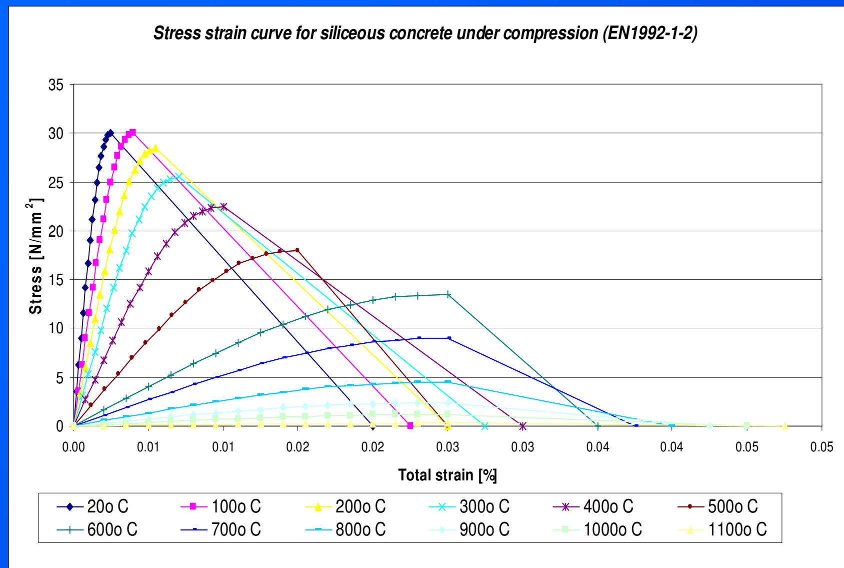


- Concrete

Tension

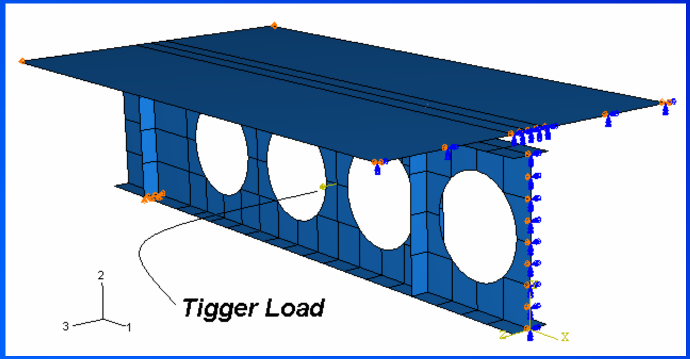


Compression

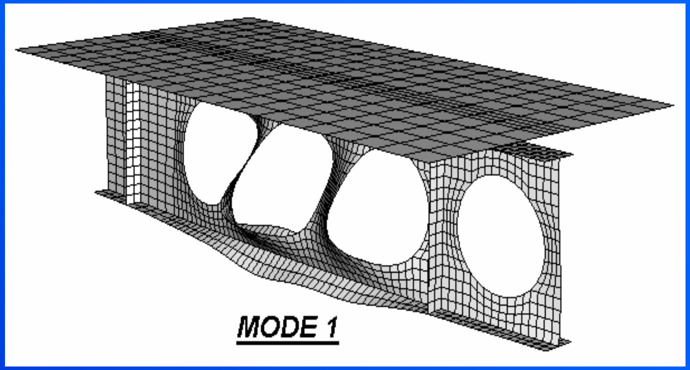


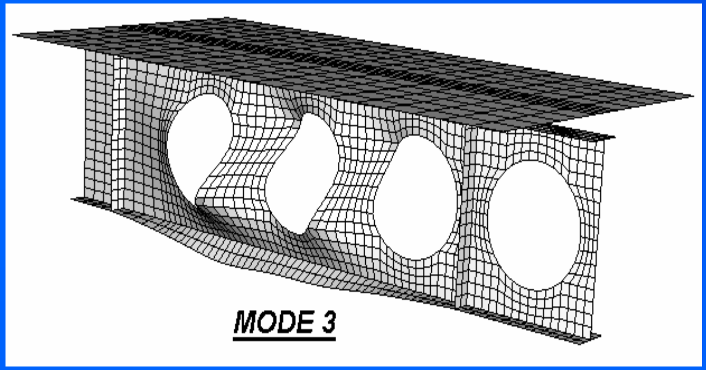
Imperfection

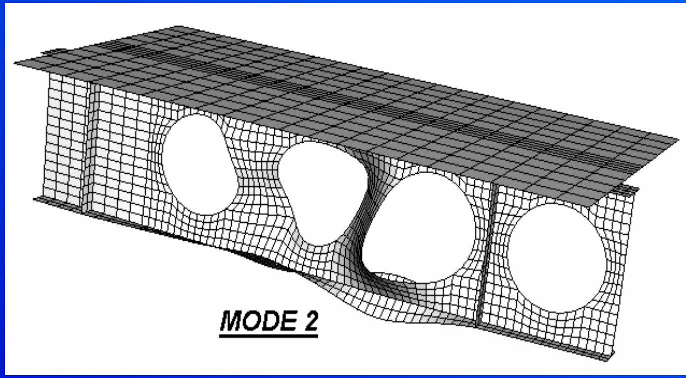
- Trigger Load



- Imperfection amplitude

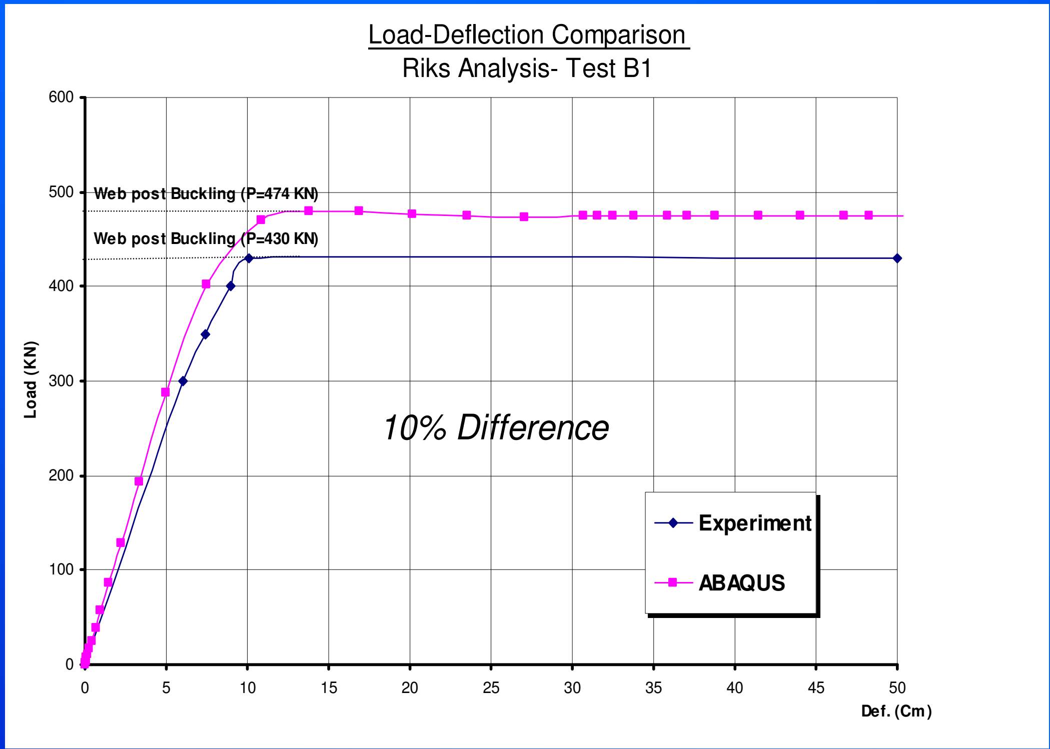


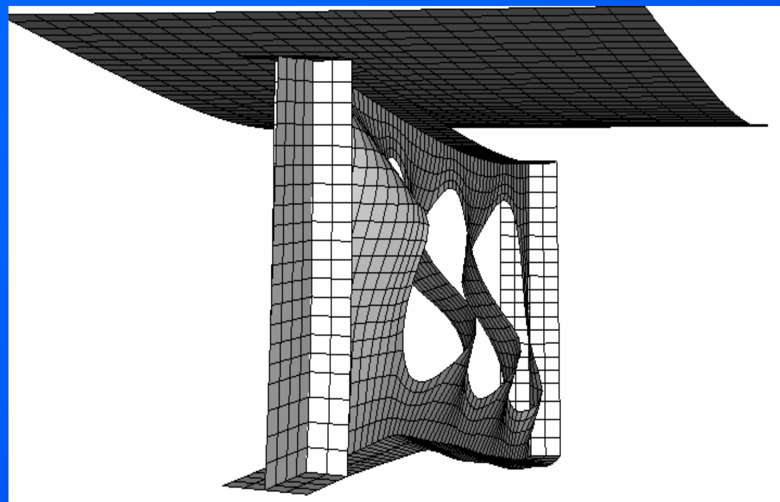




Imp = aM1+bM2+cM3+…

Results (Ulster Beam B1)

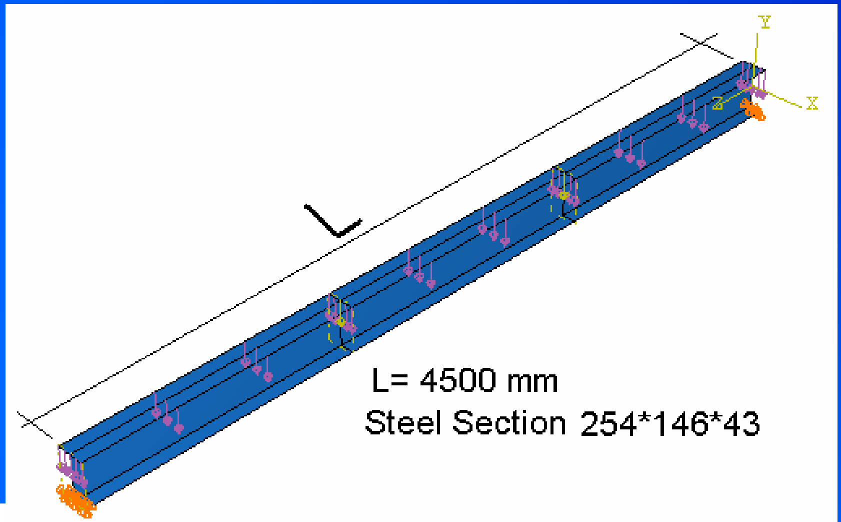


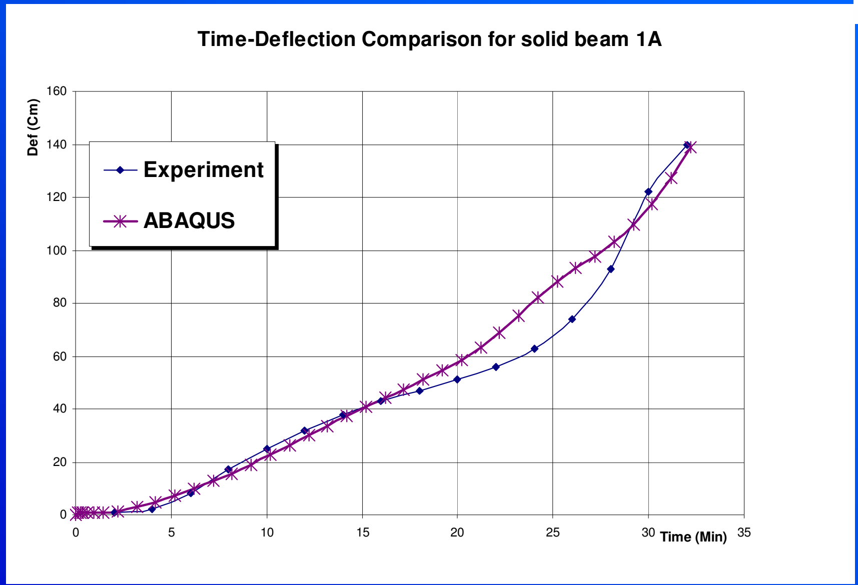


Solid Beams in Elevated temps

- Beams 1A, 9A, 14A, …

Beam 1A :

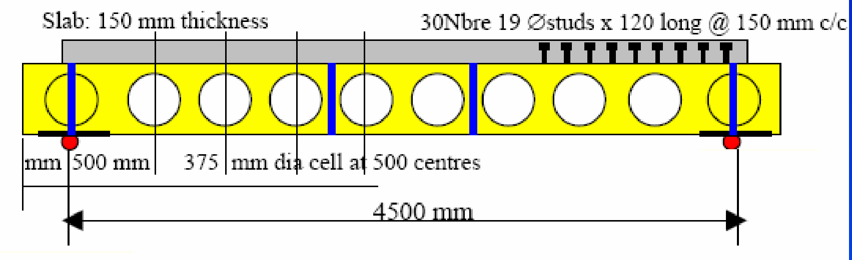




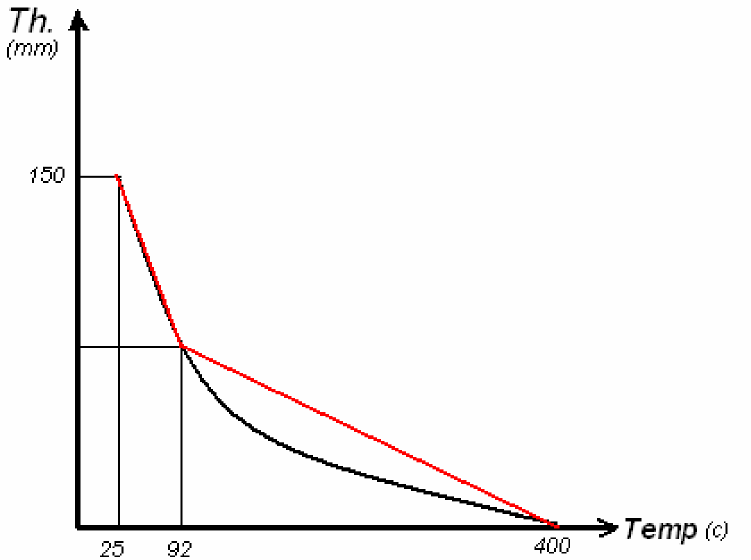
Elevated temperatures

Beam 1A:

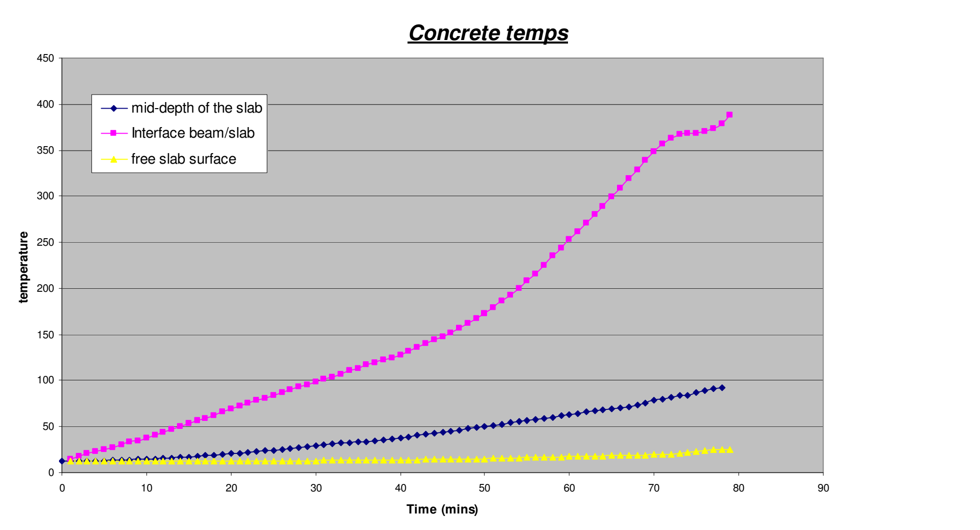
- Slow rate heating
- Load Factor 50%



Detailing of Symmetrical composite Cellular Beam
UB 406X140X39. UB Top & 406X140X39 Btm Tee

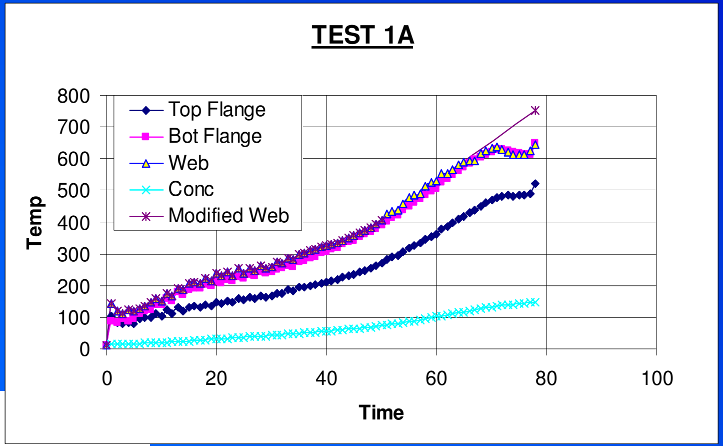


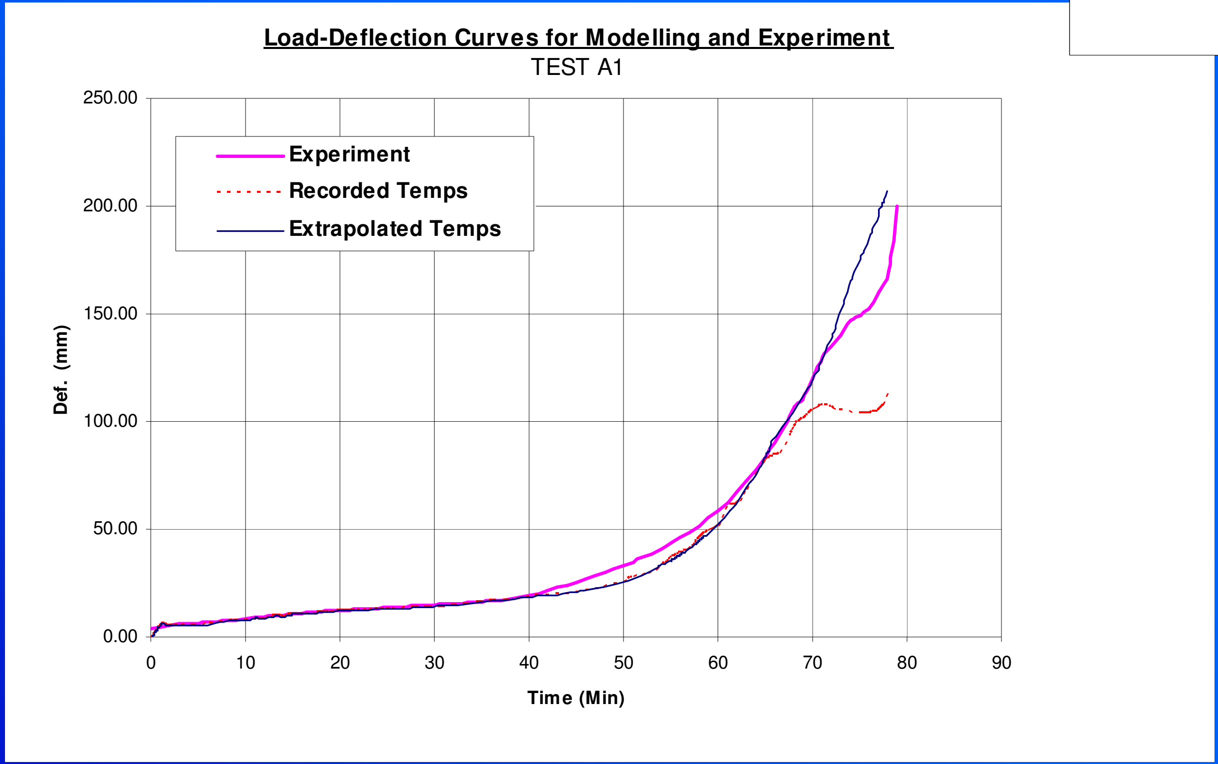
Temps distribution along the Concrete Thickness



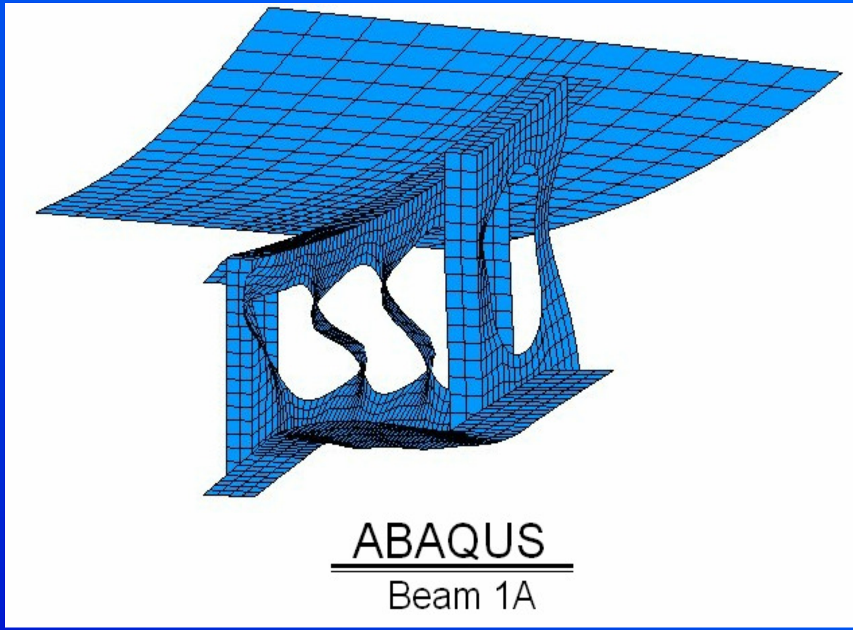
Results:

- Recorded Temps
- Modified temps



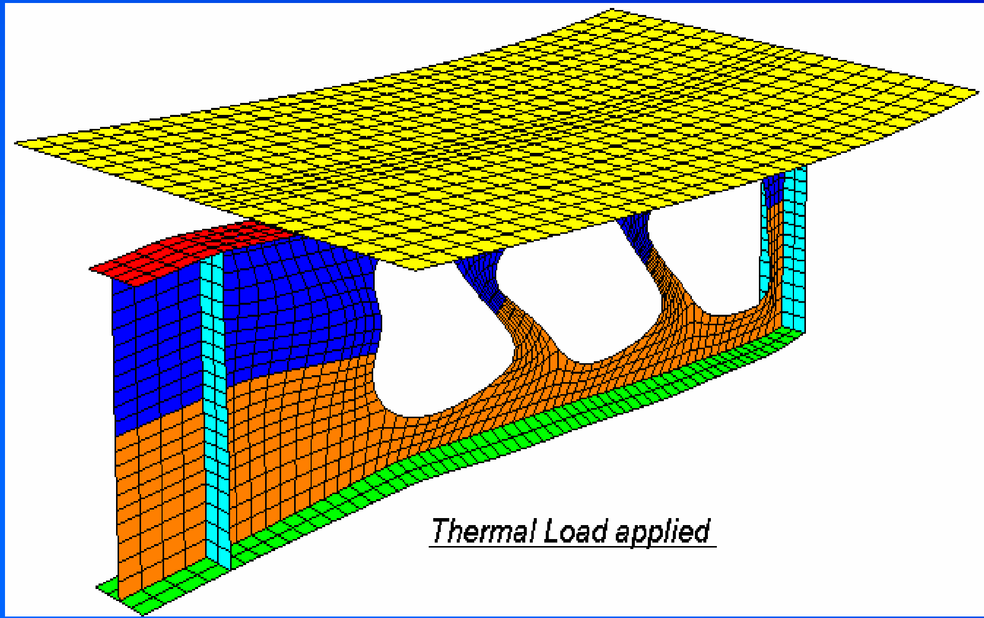


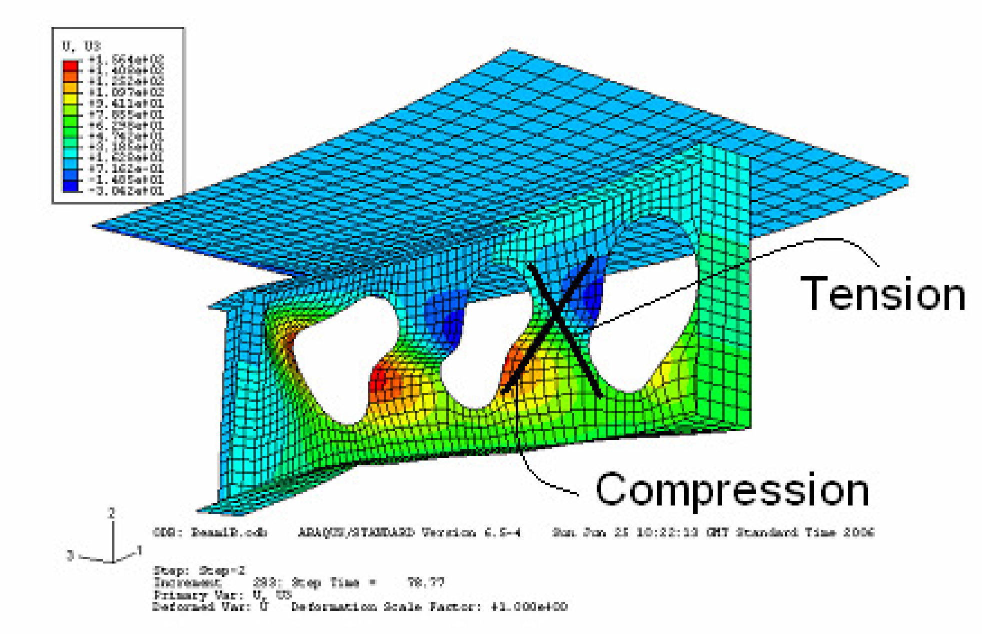
Failed Beam 1A



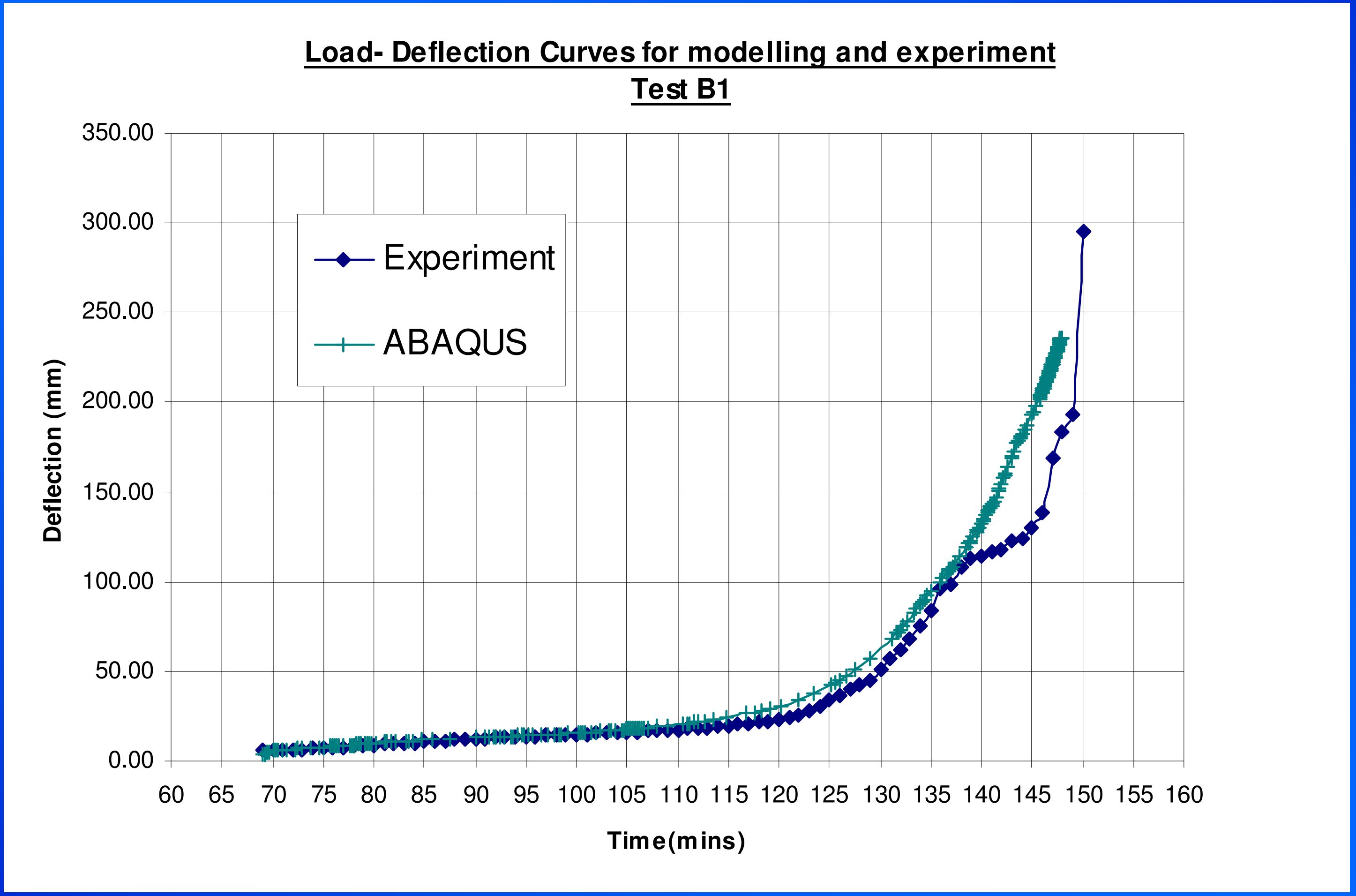
Beam 1B:

- Slow rate heating
- Load Factor 50%





Results:



Load- Deflection Curves for modelling and experiment
Test B1
Deflection (mm)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160
Time(mins)
Experiment
ABAQUS

Proposed Targets

- Understand stress distribution leading to proposal of a simple web post buckling model for ambient and elevated temperatures.
- Investigating the role of factors like BCs, Residual stresses and Imperfections in CBs in ambient and elevated temperatures.
- Parametric studies on the role of different load heating rates on different geometries of CBs and Composite slabs.

Thanks for your attention