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

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
Load-Deflection comparison

LOAD-DEFLECTION CURVES

- Vierendeel Mechanism (P=125 KN)
- Web Buckling (P=114 KN)
- Vierendeel Mechanism (P=108 KN)

About 16% discrepancy
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
Load-Deflection

E = 190 KN, \( \varepsilon_u = 10 \varepsilon_y \) and \( F_u = 1.1 F_y \)

Role of B.C.
Role of Lateral Support on the Behaviour of CBs

M1: Promotes Web Buckling
M2: Delays Web Buckling

P1 = P1.e1

P2 = P2.e2

Forces applied to lateral supports

Tension
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

\[ U = \frac{2G_f}{\sigma'_u h_c} \]

\[ \varepsilon' = \frac{\sigma'_u}{E} \]

Compression

\[ G_f : \text{Fracture Energy} \]

\[ \sigma'_u : \text{Ultimate Tensile Strength} \]

\[ h_c : \text{Crack band Width (=} \sqrt{A} \) } \]
Imperfection

- Trigger Load

- Imperfection amplitude

\[ \text{Imp} = a\text{M1} + b\text{M2} + c\text{M3} + \ldots \]
Results (Ulster Beam B1)

Load-Deflection Comparison
Riks Analysis - Test B1

10% Difference

Experiment
ABAQUS
Solid Beams in Elevated temps

- Beams 1A, 9A, 14A, …

Beam 1A:

L = 4500 mm
Steel Section 254*146*43

Time-Deflection Comparison for solid beam 1A
Elevated temperatures

Beam 1A:
- Slow rate heating
- Load Factor 50%

Concrete temps

Temps distribution along the Concrete Thickness

Detailing of Symmetrical composite Cellular Beam
UB 406X140X39, UB Top & 406X140X39 Btm Tee
Results:

- Recorded Temps
- Modified temps
Failed Beam 1A
Beam 1B:

- Slow rate heating
- Load Factor 50%

Thermal Load applied

Tension

Compression
Results:

Load-Deflection Curves for modelling and experiment

Test B1

- 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