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

- Overly conservative
- Unsafe

- Model test
- Plastic upper bound analysis (COBRAS)
- New lower bound analysis
- Plastic Hillerborg strip analysis
- Elastic grillage analysis
Motivation: real examples

- Rating by elastic analysis
- Rating by COBRAS

Pass 😊
Fail 😞
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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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• Examples
Upper bound analysis: COBRAS

Loadcase feature polygons

COBRAS

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
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New lower bound analysis

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

Equilibrium:

Yield:
New lower bound analysis

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

$m_{x}$

$m_{y}$

$m_{xy}$
New lower bound analysis

Top

Bottom

Mesh
- Enforce equilibrium
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New lower bound analysis

Yield line indicators: Hog Sag

Mesh
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Example 1

~20m
Example 1

- Mechanisms agree
- Loads agree (to within <1%)
Example 1
Example 2

Collapse load: 52.36

Collapse load: 192.0

---

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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