

INTRODUCING LIMITSTATE:RING 4

BETTER MASONRY ARCH BRIDGE ANALYSIS



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1. INTRODUCTION

ABOUT LIMITSTATE

Our mission:

- Provide engineers with powerful analysis & design software
- Leverage state-of-the-art algorithms & optimization technology
- Provide software that is robust and well validated
- Ensure applications are fully supported and are easy to use

Our clients include:

AECOM

Amey

 **ARCADIS**

ARUP

 **AtkinsRéalis**

aurecon

...plus many more!



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MASONRY ARCH BRIDGES

Vital infrastructure:

- Most >100 years old
- Many carrying heavy loads
- Many contain unique details



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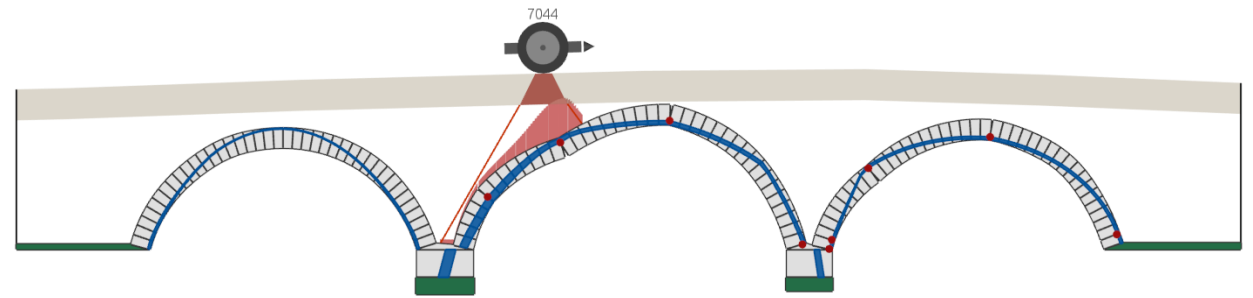
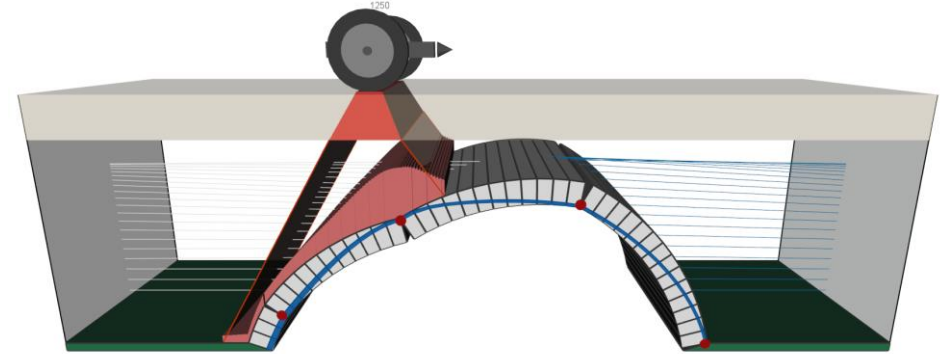
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WHAT IS LIMITSTATE:RING?

- Interactive software tool for the analysis of masonry arch bridges
- Capable of modelling:
 - both single and multi-span bridges
 - a wide range of potential failure modes
 - localised properties & defects
 - support movements



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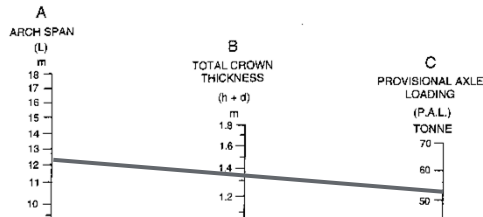
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WHERE LIMITSTATE:RING FITS

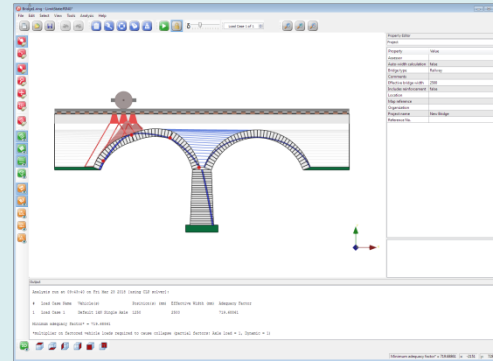
Traditional

Based on hand analysis solutions etc.



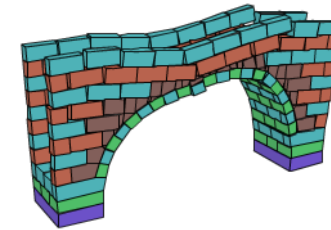
Best of both

Using numerical limit analysis



Advanced

Based on non-linear finite elements etc.



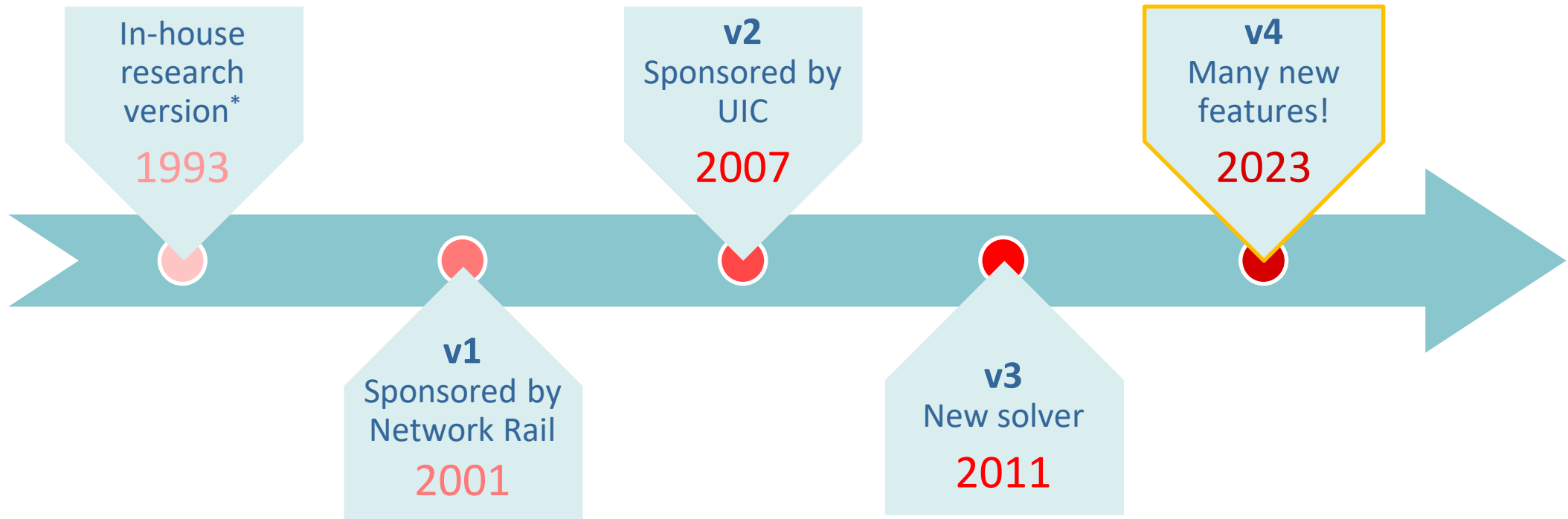
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A BRIEF HISTORY



*Used in papers published in *The Structural Engineer* in 1994, 1995 & 1997



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WHAT ABOUT V4?

Feature	Basic limit analysis software	LimitState:RING 3	LimitState:RING 4
Model arches of arbitrary shape	✓	✓	✓
Identify critical vehicle load position	✓	✓	✓ (Enhanced)
Compute margin of safety	*	✓	✓
Automatic analysis of multi-spans		✓	✓
Model sliding failures		✓	✓
Model multi-ring arches		✓	✓ (Enhanced)
Local modification of properties		✓	✓
Model arbitrary support movements		✓	✓
Visual display of mode of response		✓	✓
Permissible Limit State (PLS) mode			✓
CAD import functionality			✓
Bridge template functionality			✓
<i>...plus many more!</i>			✓

* some software only displays a line of thrust

2. FEATURE SPOTLIGHT

SPOTLIGHT: STREAMLINED VEHICLE LOAD MODELLING



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SPOTLIGHT: SERVICE LOAD BEHAVIOUR

- Bridge owners **rarely observe ULS** failures
- However, when a loading (traffic) regime changes, a bridge in good condition **may degrade rapidly**, then becoming unserviceable
- V4 allows analysis of the **Permissible Limit State (PLS)**
- The PLS is described in **CIRIA C800** and permitted by National Highways **CS 454** for UK road bridges



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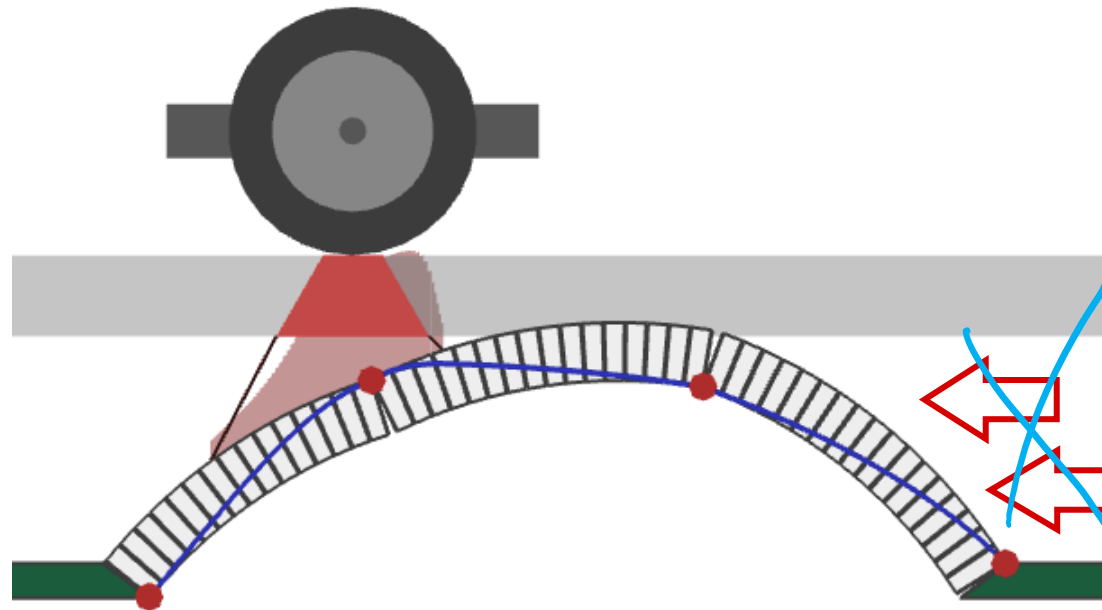
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SPOTLIGHT: SERVICE LOAD BEHAVIOUR

Simplified PLS calculation method (after CIRIA C800):

- Neglect passive restraint from soil (*as requires large structural deformations to generate*)
- Use reduced masonry strength (*as peak strength cannot be mobilised time & time again*)



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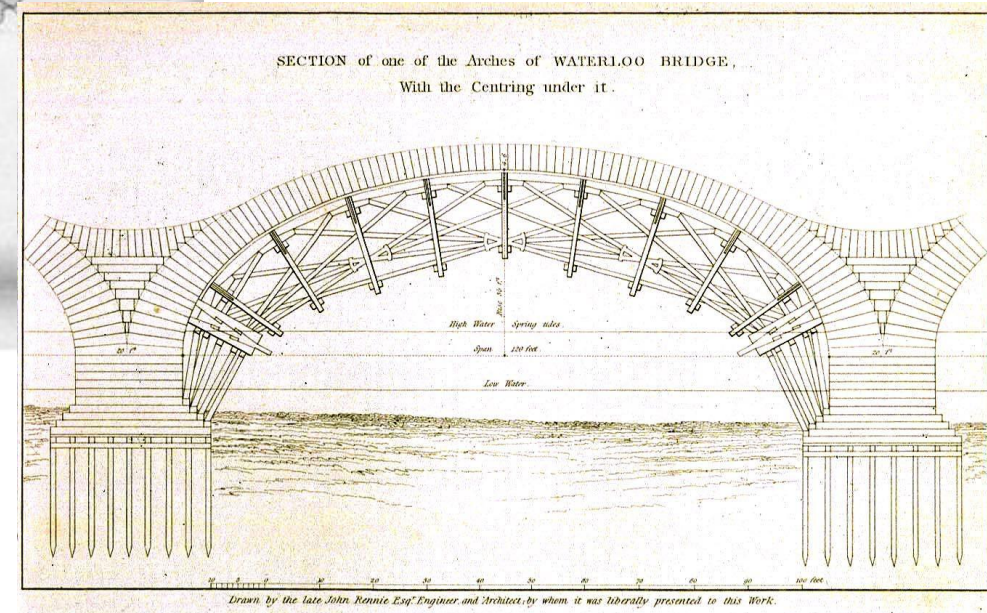
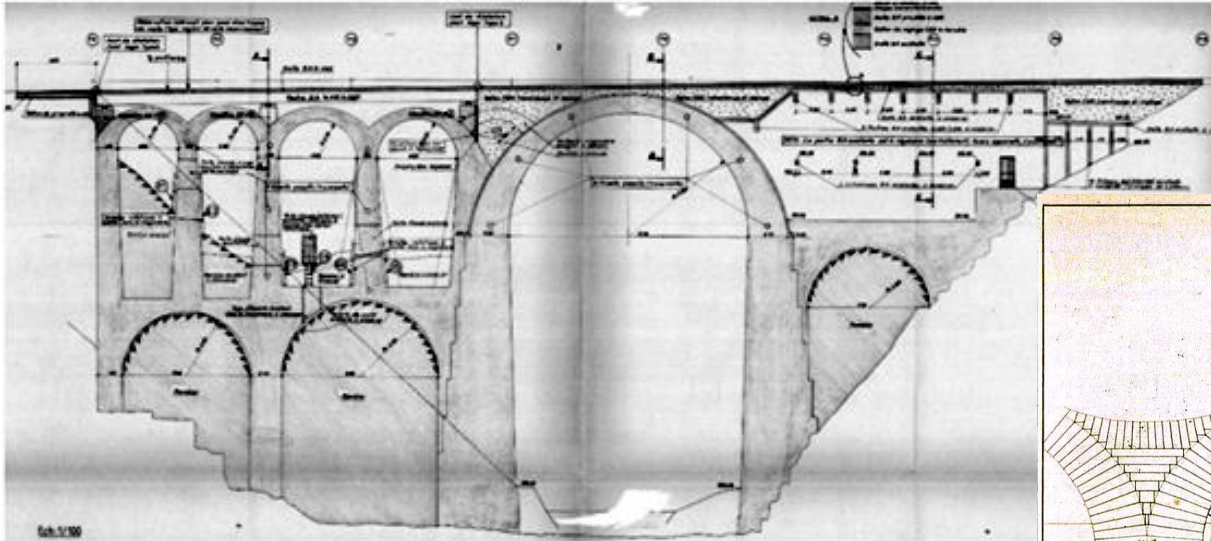
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SPOTLIGHT: COMPLEX GEOMETRIES

e.g. details of hidden internal features may be available, and it may be beneficial to model these:



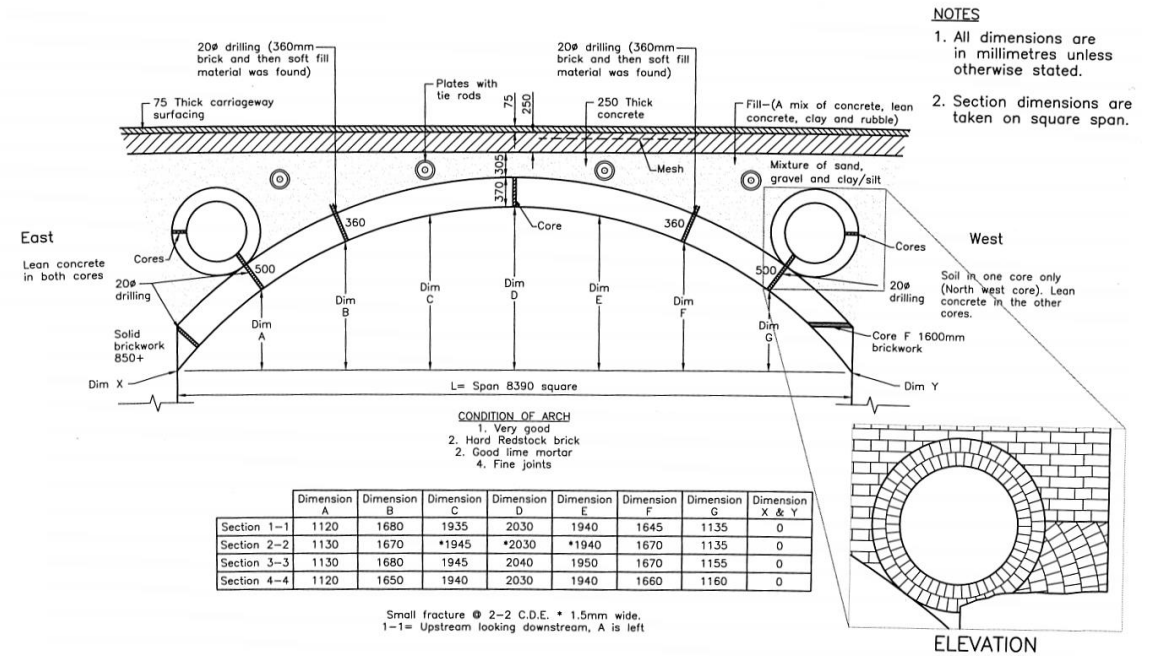
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OTHER NEW V4 FEATURES INCLUDE

- **Load models** – many new vehicles added to the vehicle database, including vehicles from National Highway's CS454
- **Command-line mode** – files can now be modified and solved via the command line, facilitating batch solving for increased productivity
- **Effective width** – bespoke transverse load distributions can now be specified
- **Multi-ring arches** – inter-ring shear bond strength can now be specified
- **Soil effects** – active / passive pressures can be specified more flexibly; also fill pressures are now by default applied behind end abutments
- **Arbitrary forces** – can now be applied to any masonry element

3. AVAILABILITY OF V4

AVAILABILITY OF V4

Current customers

Will receive v4 licenses and download details on day of release

Free mode

Access to majority of features (but no Adequacy Factor reported)

Evaluation

Request a free full license – email sales@limitstate.com

Public download

20th November from limitstate.com



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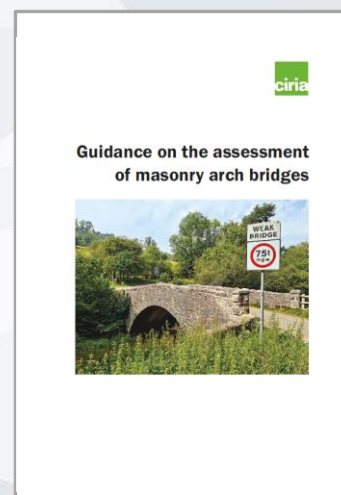
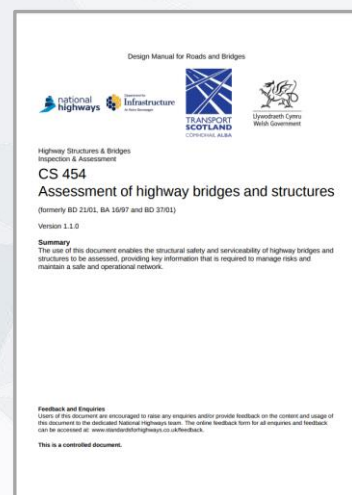


Q&A

FORTHCOMING WEBINAR 5TH DECEMBER

ASSESSMENT OF HIGHWAY MASONRY ARCH BRIDGES TO CS454 AND CIRIA C800 WITH LIMITSTATE:RING 4

events.limitstate.com/ring4-cs454



Thank you for
attending!