Building around existing tunnels

Seminar

Modelling considerations for the impact of loading on brittle brick lined oviforms

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Overview

- Introduction
- Literature Review
- Modelling Methodology
- Load Scenarios
- Results
- Conclusions

Introduction

- Urban construction works can potentially impact buried utilities
- Modelling of sensitive and brittle structures such as brick Oviforms (anisotropic, heterogeneous) are challenging.
- Modelling considerations, ability to withstand loads & behaviour at lower serviceability strains.
- A simplified approach to analysis with stiffness calibrated against discontinuum models.

(Source: Powerhouse museum)

Literature review

- Masonry structures are sensitive to tensile strains that can cause cracking.
- There are numerous publications on critical threshold strains on masonry building but are very limited for buried masonry structures
- Strains below 500με and crack widths less than 0.1 mm are considered insignificant (for masonry buildings)
- Should be used with caution for masonry sewers/drains (New 2017) as it may exceed serviceability limits.

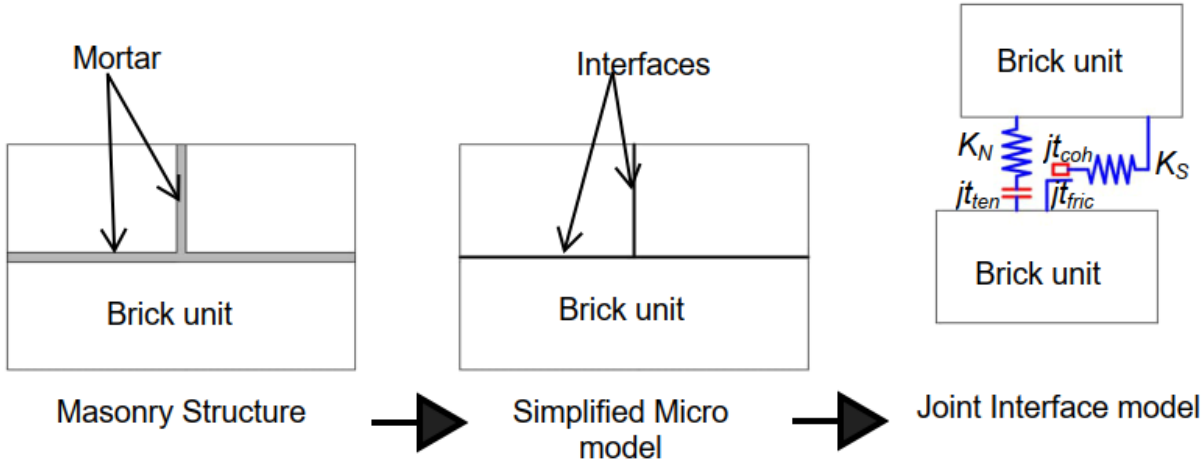
Literature review

- Thames Water
  - Tensile strain – 500με
  - Compression – 25% of the allowable stress

- Sydney Water
  - Tensile strain – 250με
  - Maximum crack width – 0.2mm
  - Maximum depth of crack – 1/5 of section thickness

Modelling strategies

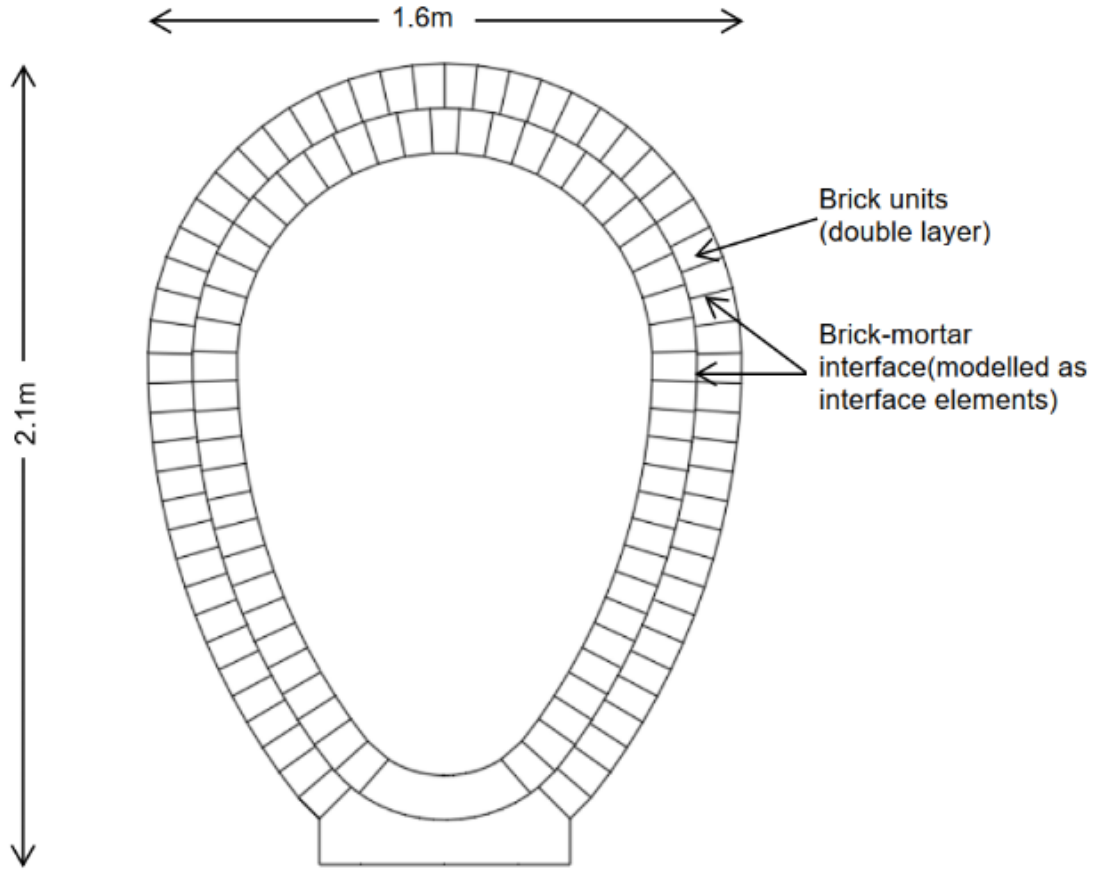
- Detailed micro-modelling
- Simplified micro-modelling
- Macro modelling



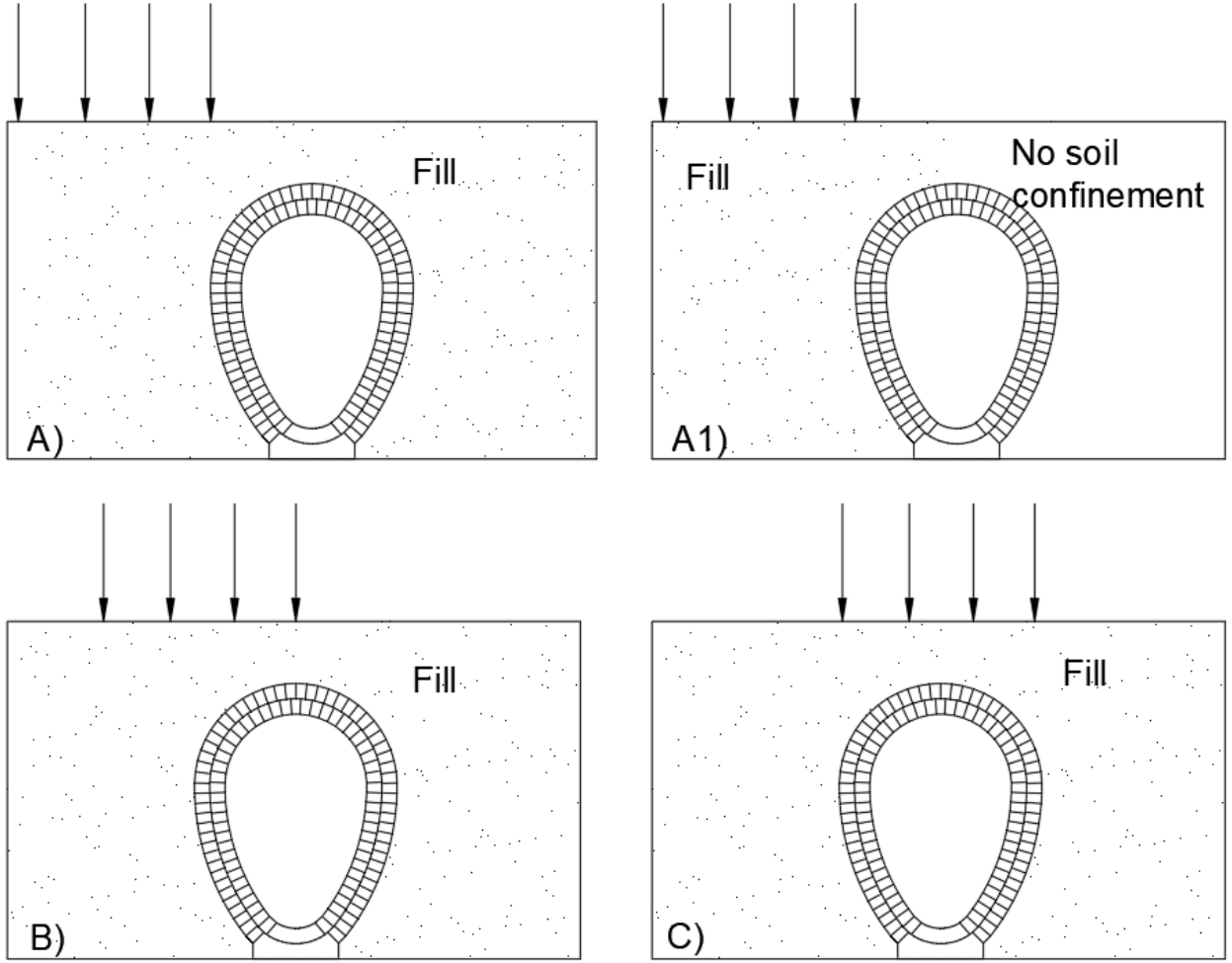
Simplified micro-modelling of masonry structures (Idris et al 2009, Lourenco 1996, Al-Heib 2012)

Oviform geometry

- Brick units allowed to translate, rotate or fail along the interface.



Transverse Load scenarios

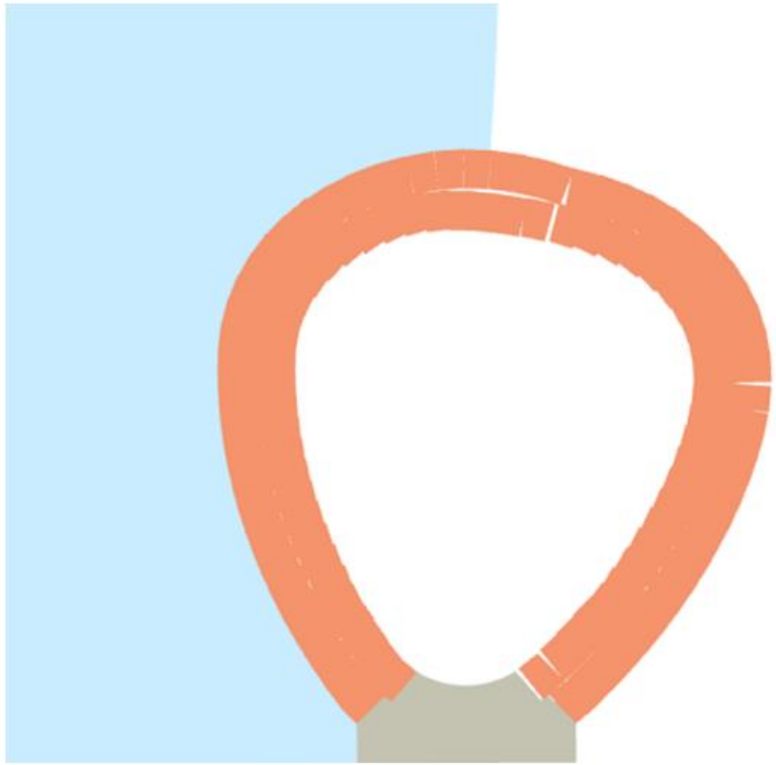


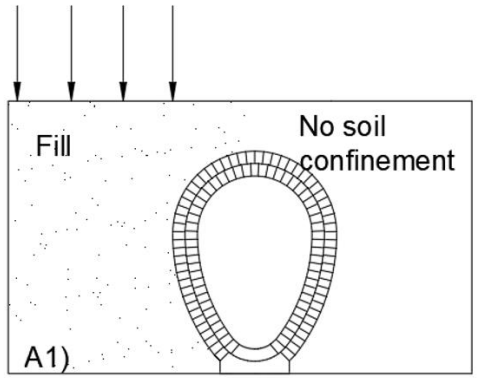
Masonry Properties

Parameter	Symbol	Unit	Mortar	Brick
Young's modulus	E'	MPa	-	10,000
Cohesion	J_{coh} / c'_{ref}	kPa	10-100 [50]	1000
Friction angle	J_{fric}	o	25-35 [30]	-
Joint tensile Strength	J_{ten}	kPa	0	-
Joint normal stiffness	K_N	GPa/m	1-50 [20]	-
Joint shear stiffness	K_s	GPa/m	1-20 [8.3]	-

Transverse Modelling Results

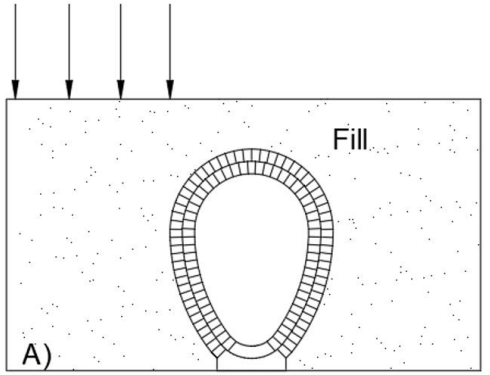
- Ultimate and serviceability performance
- Failure of structure without confinement
- Structure is stable only when confined

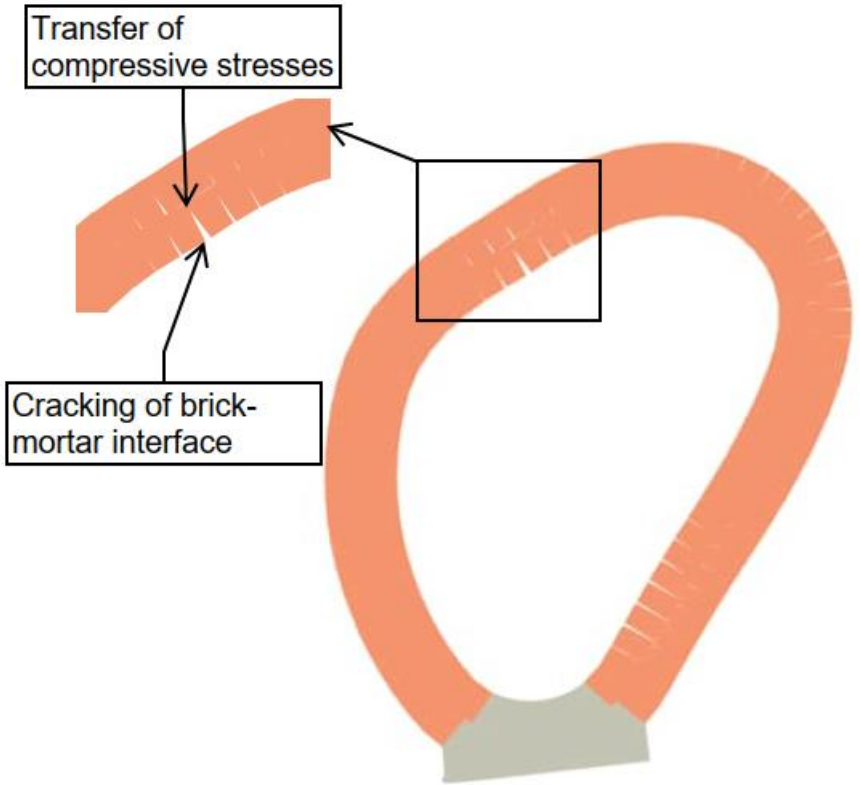




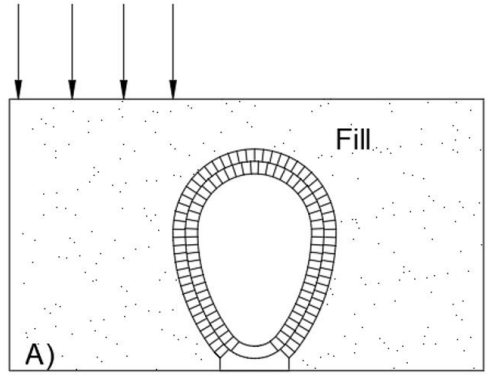
Transverse Modelling Results

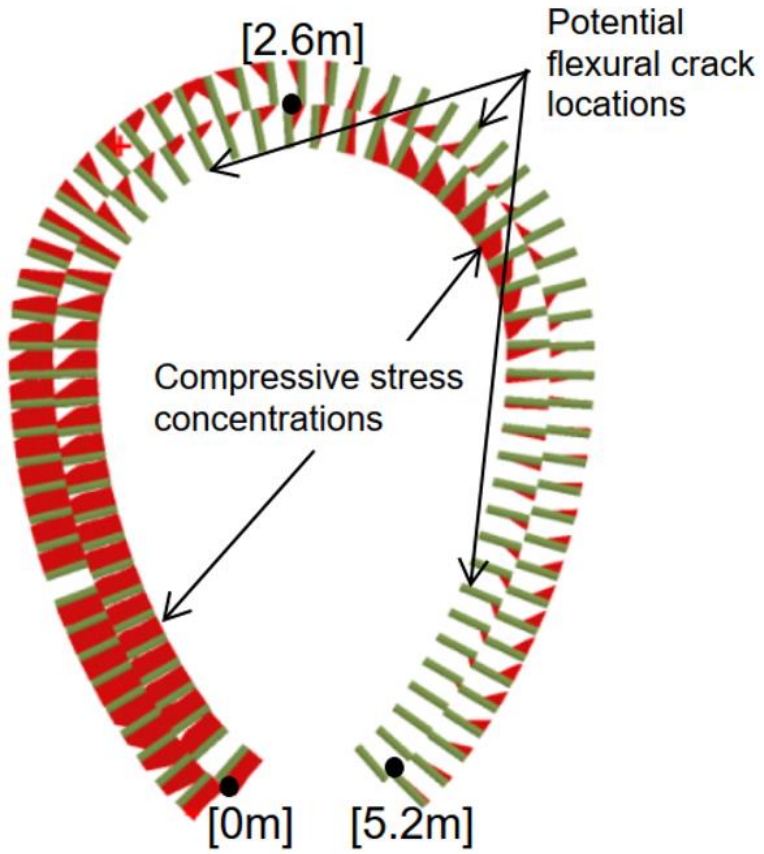
- Despite having no tensile capacity, Oviform can withstand substantial loads.
- Geometry of Oviform allows it to remain in a state of compression
- Surrounding soil fails, before the failure of oviform

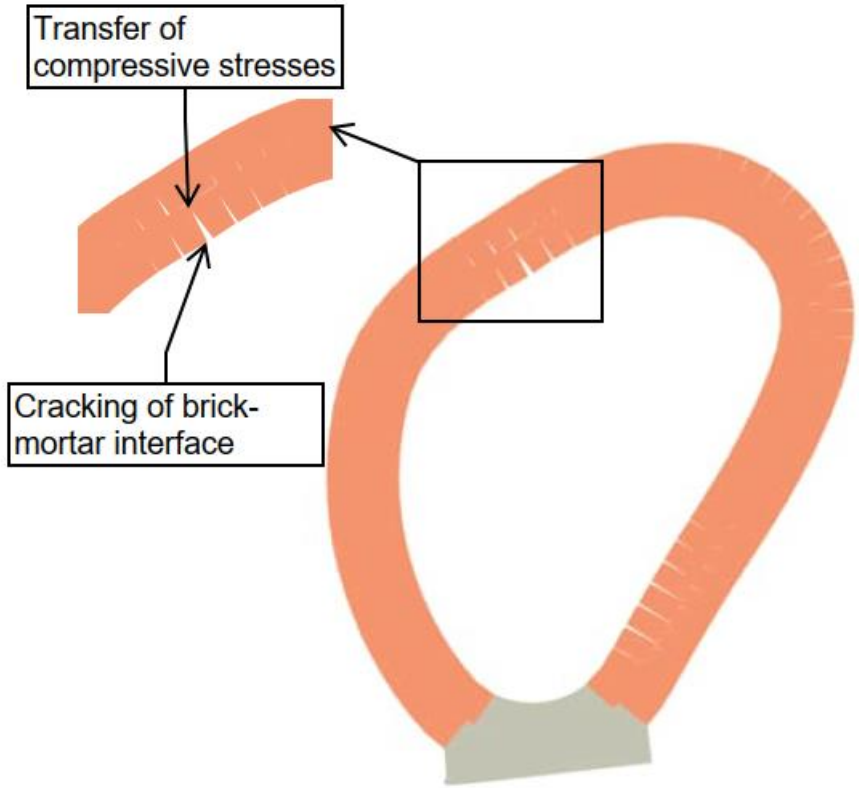




Transverse Modelling Results

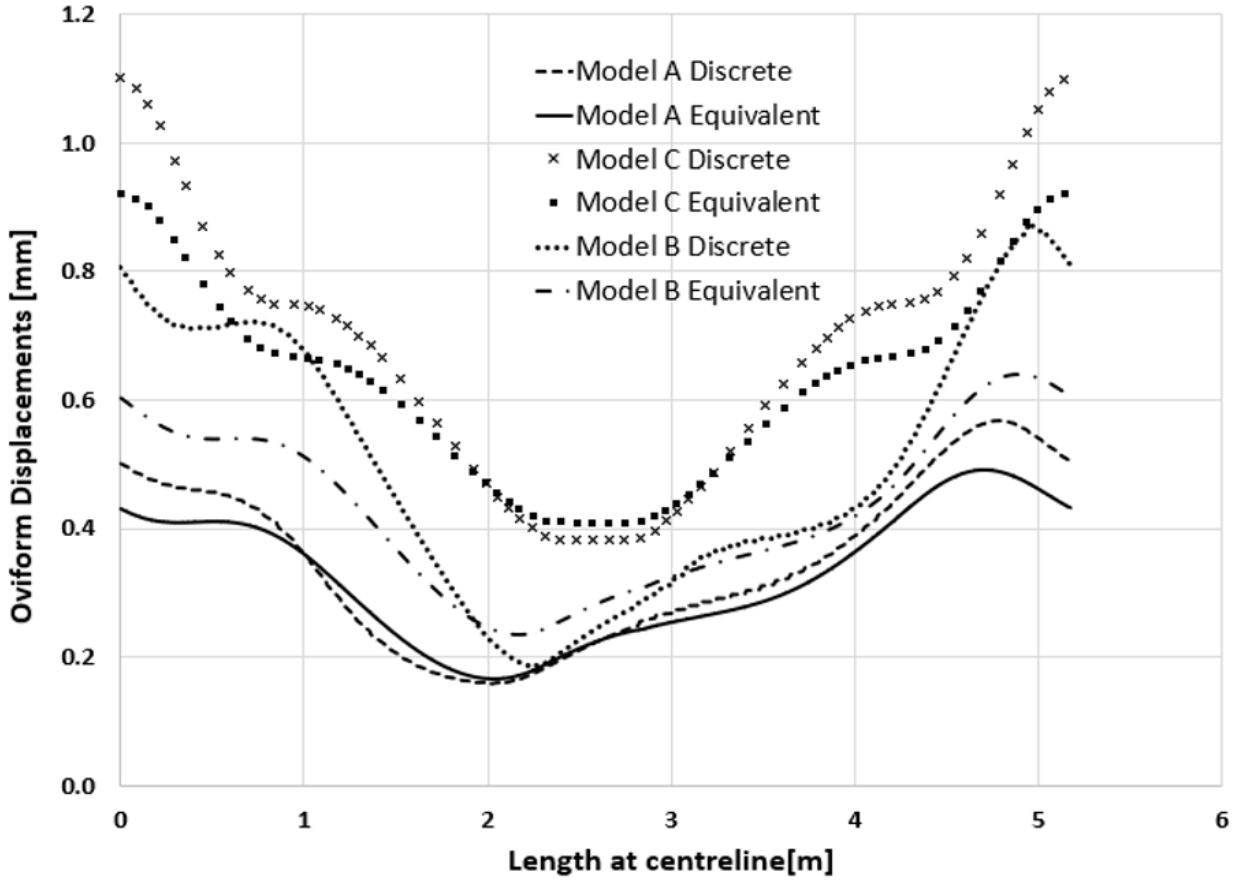






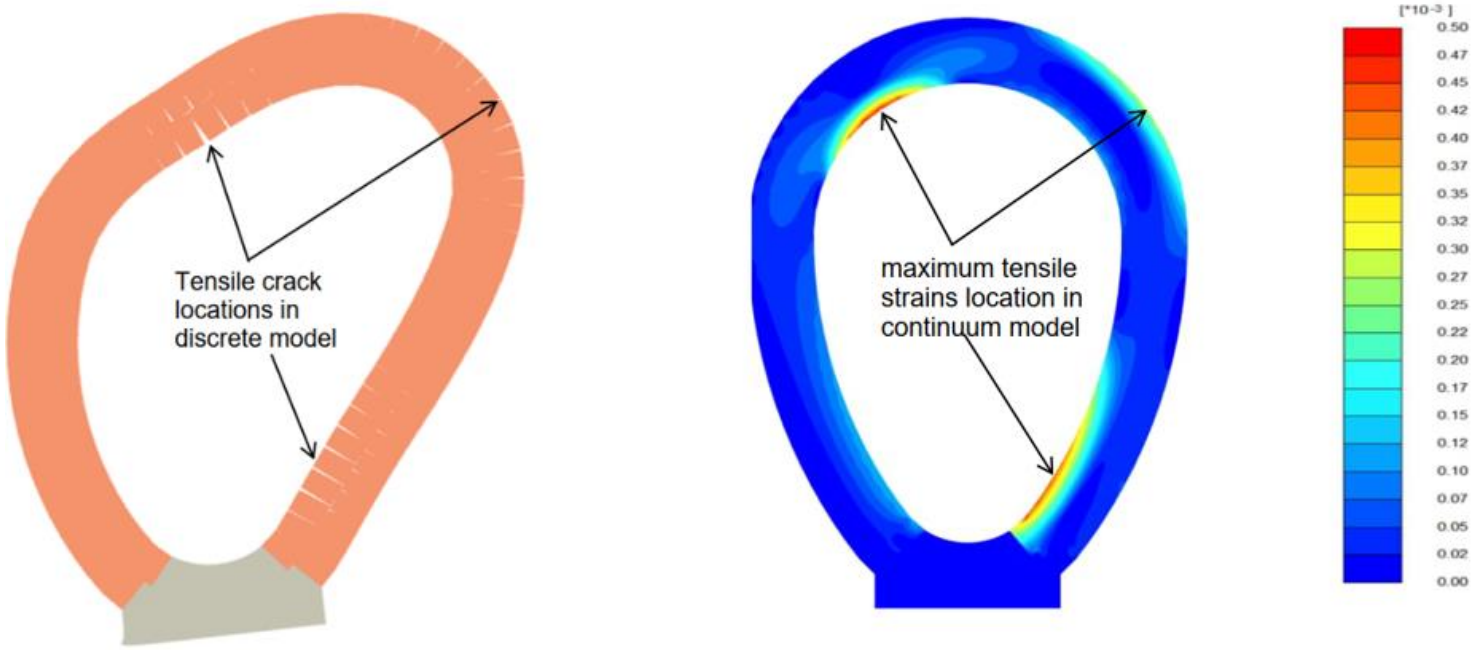
Continuum modelling with Equivalent stiffness

- Estimation of an equivalent liner elastic stiffness from discontinuum modelling
- **Estimated elastic equivalent stiffness is close to the stiffness of mortar.**



Macro modelling with Equivalent stiffness

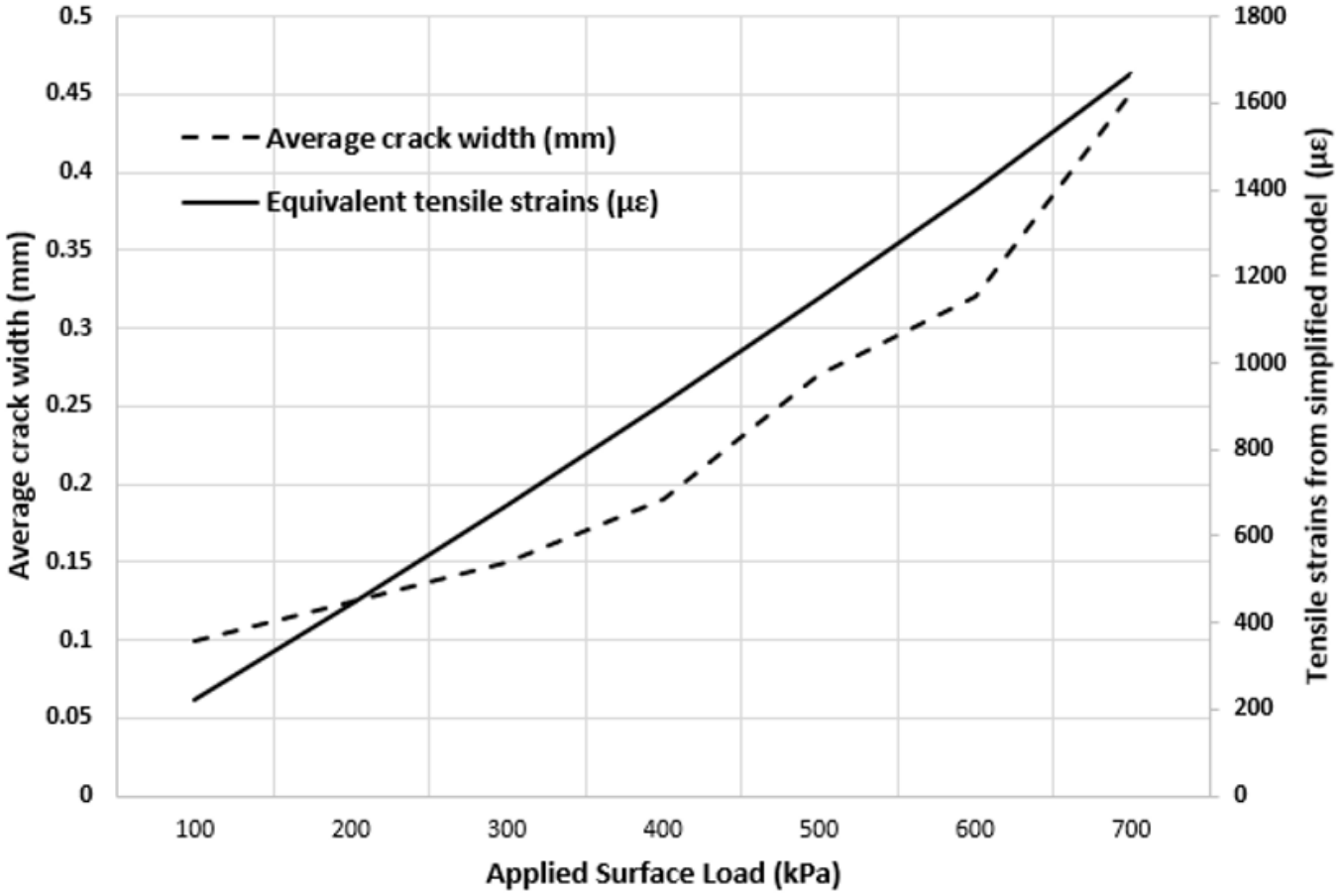
- Maximum predicted tensile strains coincide with maximum crack opening location



Comparison of tensile crack location of discrete model with tensile strains location of continuum model

Crack opening near oviform crown

- Cracking of mortar joints leads to increased permeability
- Figure shows the comparison of cracks widths to tensile strains.
- This can be used to make a prediction about crack widths without performing a discontinuum model calculation.



Comparison of crack widths to equivalent tensile strains

Longitudinal modelling

- Estimation of curvature
- Estimation of flexural strains (depth of neutral axis is assumed at extrados of structure)
- Estimation of axial tensile strains from horizontal ground strains
- Calculate total longitudinal strains by adding the above.

Conclusions

- Under confinement Oviform can withstand substantial loads without collapse
- Localised cracking is expected at small deformations, however, Oviform geometry allows it to remain in a state of compression
- Mortared joint brick Oviform can be modelled with linear elastic stiffness comparable to that of mortar.
- Results show maximum predicted tensile strains coincide with maximum crack opening location
- Maximum crack width can be estimated based on tensile strains on equivalent continuum model.

Thank You!

Questions