3rd ICTG 2016
04-07 September 2016, Guimarães, Portugal

Soil-Transition Slab Interaction in Jointless Bridges

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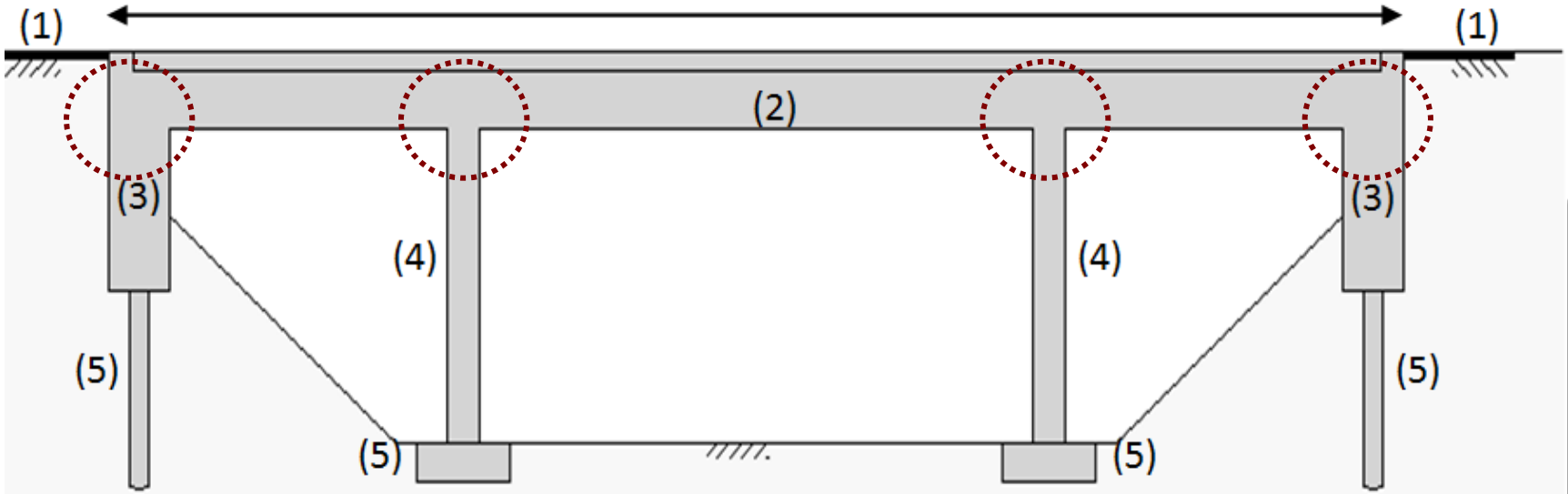
Time dependent movements principal direction

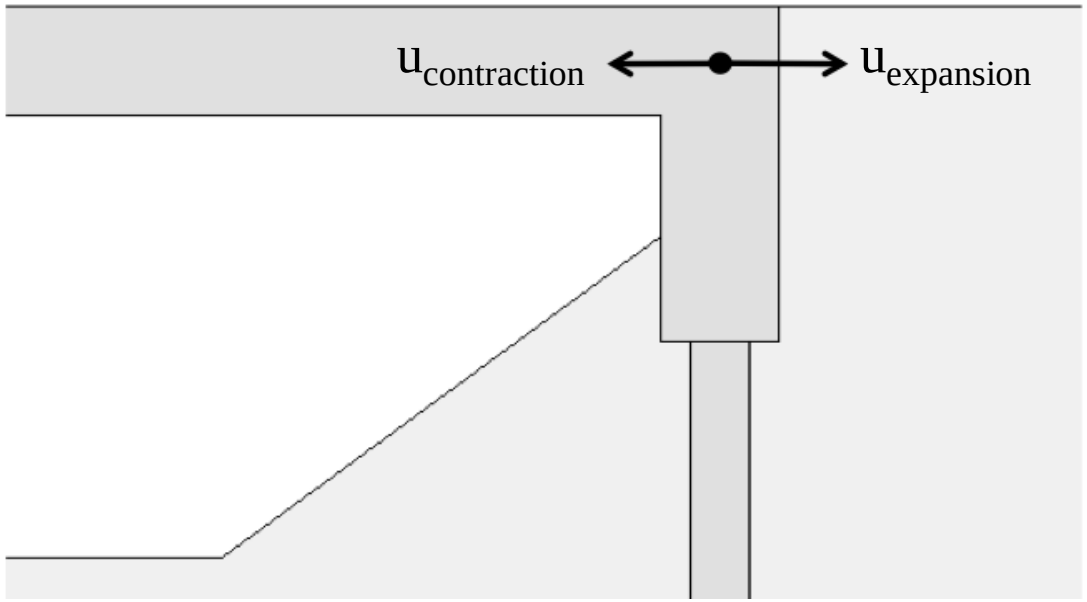


Monolithic connection

No need for Bearings or Expansion Joints

(1) Transition Slab
(2) Bridge Deck
(3) Abutment
(4) Piers
(5) Pile Foundation

INTRODUCTION



$$u_{contraction} = u_{\Delta T(-)} + u_{creep} + u_{shrinkage}$$

$$u_{expansion} = u_{\Delta T(+)} - u_{creep} - u_{shrinkage}$$

Bridge lenght =160m

$\varepsilon_{creep} \approx -0{,}25$ mm/m

$\varepsilon_{shrinkage} \approx -0{,}30$ mm/m

$\varepsilon_{\Delta T} \approx -0{,}20$ mm/m ($\Delta T = -20°C$)

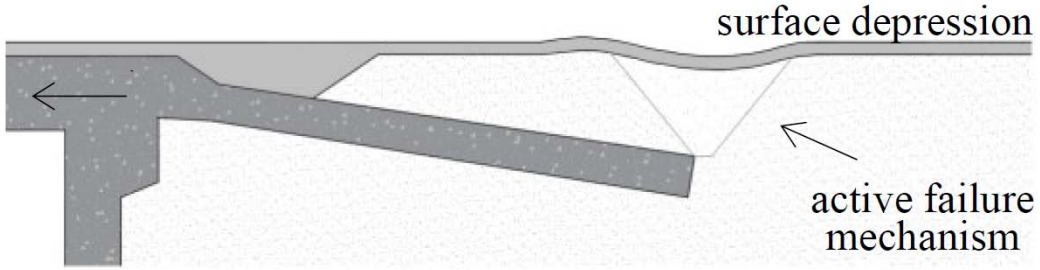
↓

Abutment imposed displacement

u = 60mm

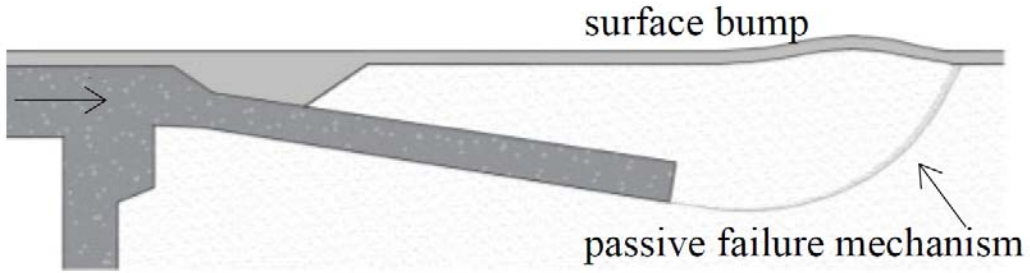
INTRODUCTION

Bridge Contraction



Active failure mechanism
|
Surface Settlement

Bridge Expansion



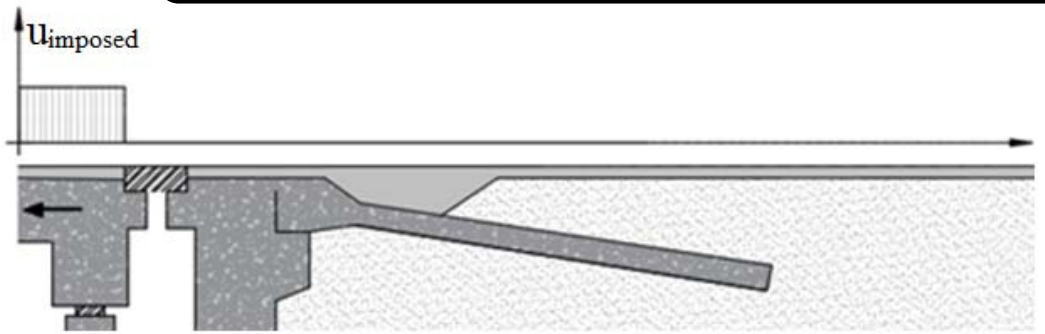
Passive failure mechanism
|
Surface Bump

INTRODUCTION

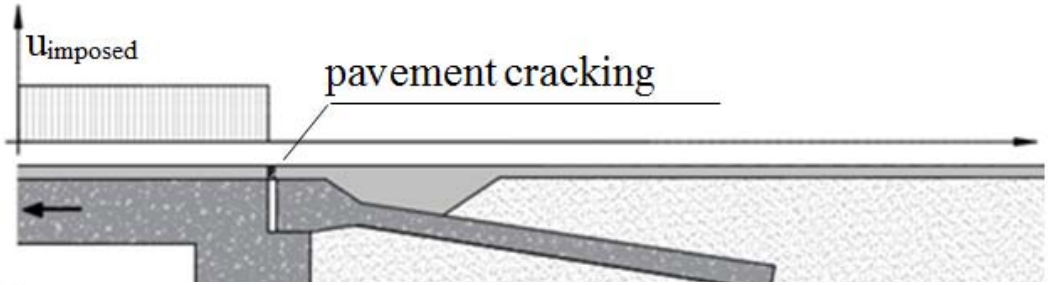
Bridge Contraction

Pavement longitudinal imposed displacements

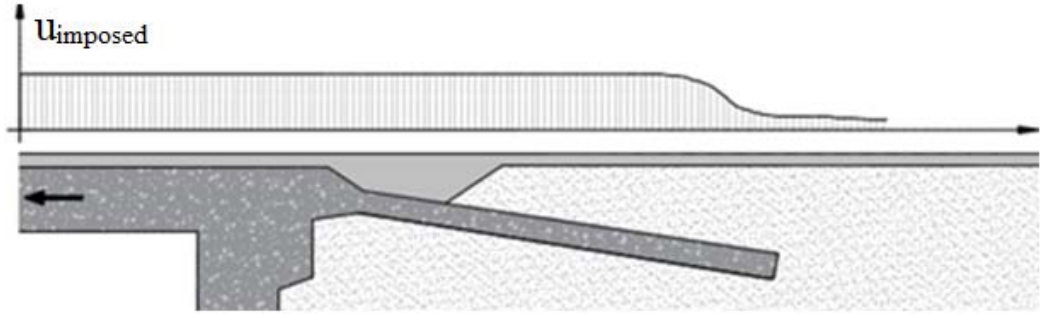
Expansion Joint



Non-Monolithic Slab

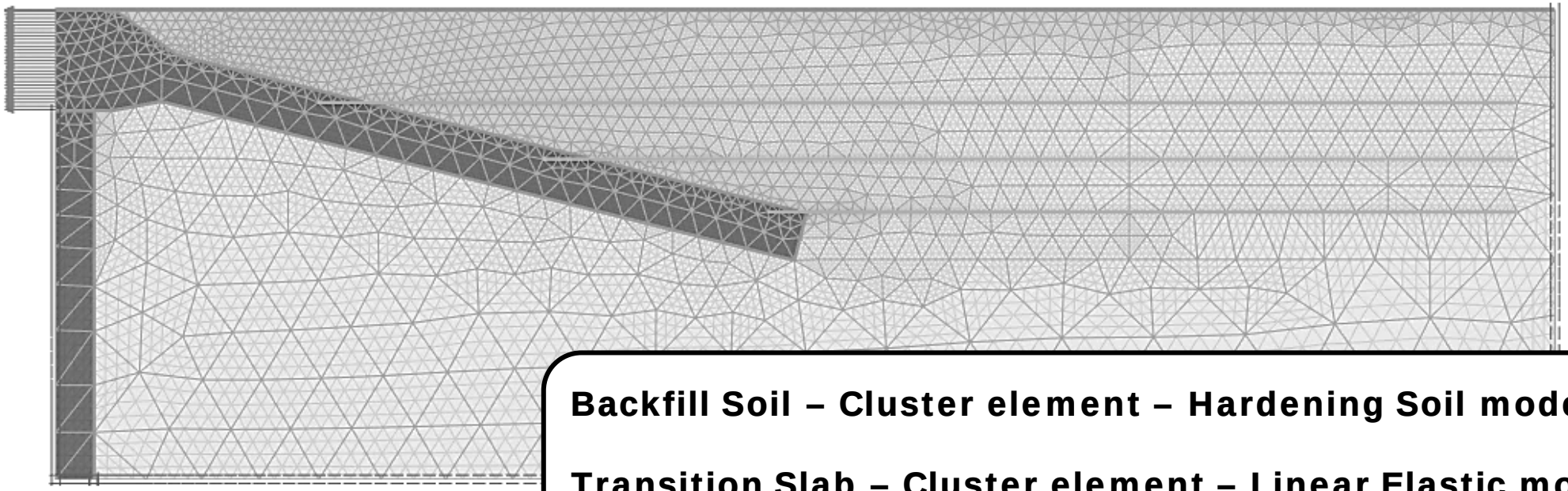


Monolithic Slab



INTRODUCTION

2D Model [PLAXIS]



Backfill Soil – Cluster element – Hardening Soil model

Transition Slab – Cluster element – Linear Elastic model (E=E')

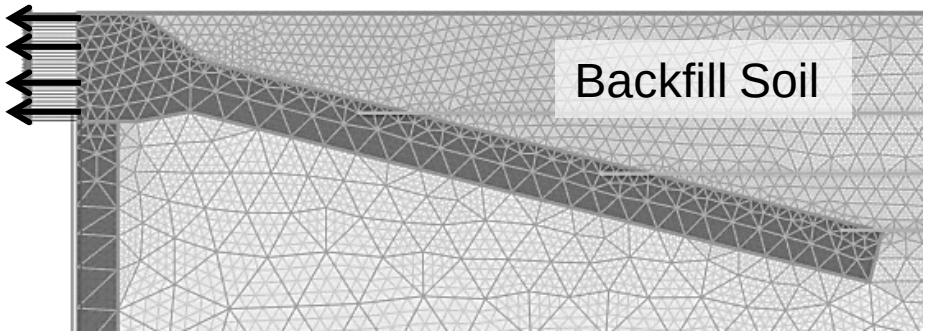
Concrete-Soil interface – Interface elements (Rinter=2/3)

Transition slab movement – Imposed translational displacement

NUMERICAL ANALYSIS

Imposed Displacements

Bridge Contraction ux < 0
Bridge Expansion ux > 0



Backfill Soil Properties – Hardening Soil Model

γ	Soil unit weight	18	(KN/m³)
E_{50}	Secant stiffness in standard drained test	80	(MPa)
E_{eod}	Tangent stiffness for primary oedometer loading	80	(MPa)
E_{ur}	Unloading / Reloading stiffness	240	(MPa)
ϕ	Internal friction angle	38	(º)
c'/ ϕ / ψ	Cohesion	1	(kPa)
c'/ ϕ / ψ	Dilatancy angle	7	(º)

NUMERICAL ANALYSIS

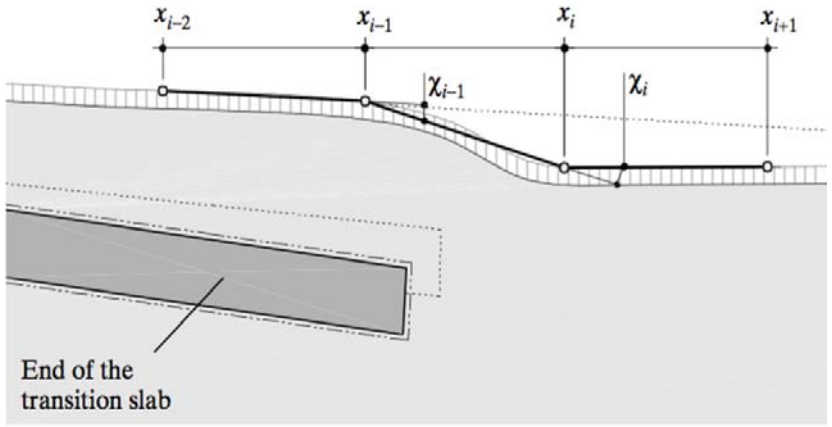
Measured Indicators

Absolute Surface Vertical Displacements [surface settlement / bump]

Absolute Surface Longitudinal Displacements [imposed pavement strains]

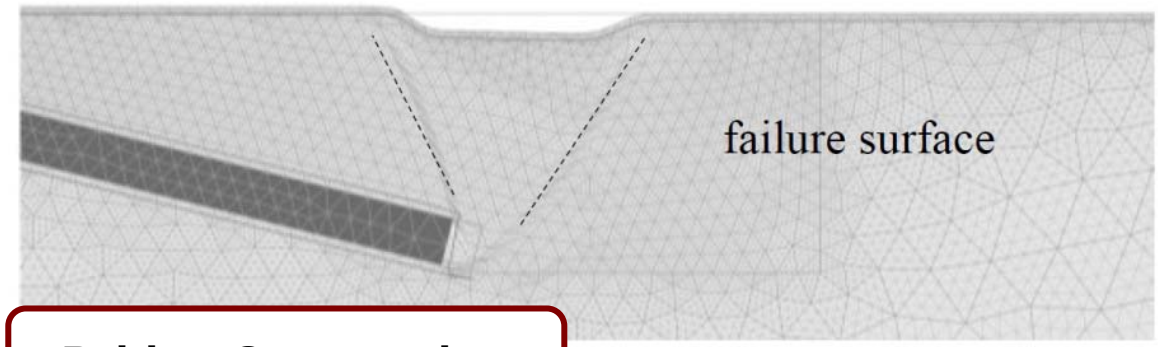
Slope Variation [surface planirity]

$$\chi(x) = \frac{w(x_j) - w(x_i)}{x_j - x_i} - \frac{w(x_k) - w(x_j)}{x_k - x_j} \leq \chi_{adm}$$

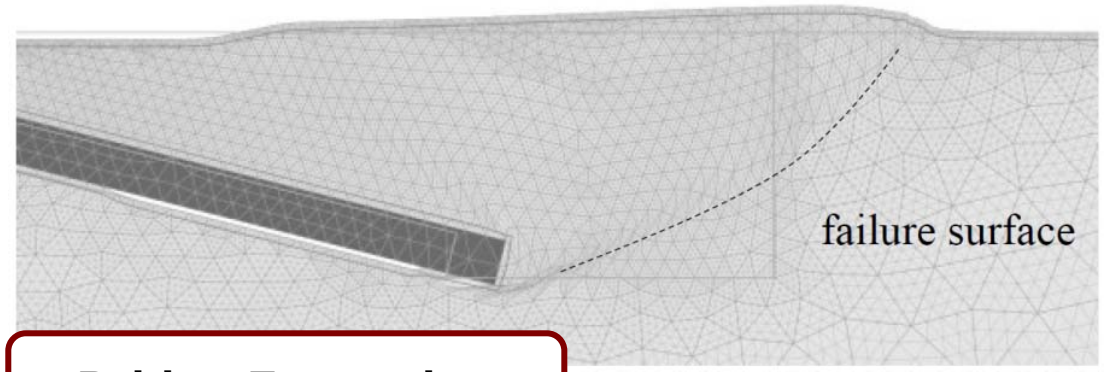


Suiss Code
SN 640 520a / 521c
χ_{adm} = 20‰ Highways

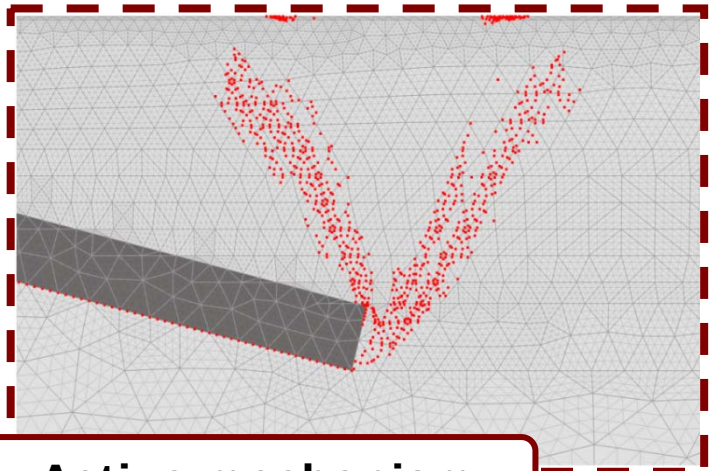
NUMERICAL ANALYSIS



Bridge Contraction

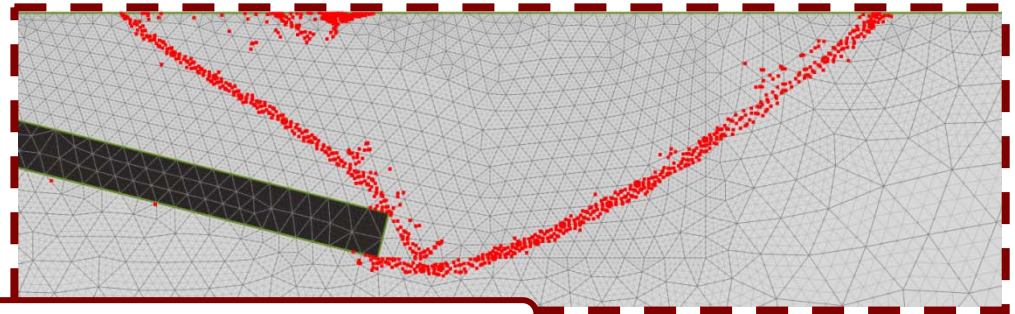


Bridge Expansion



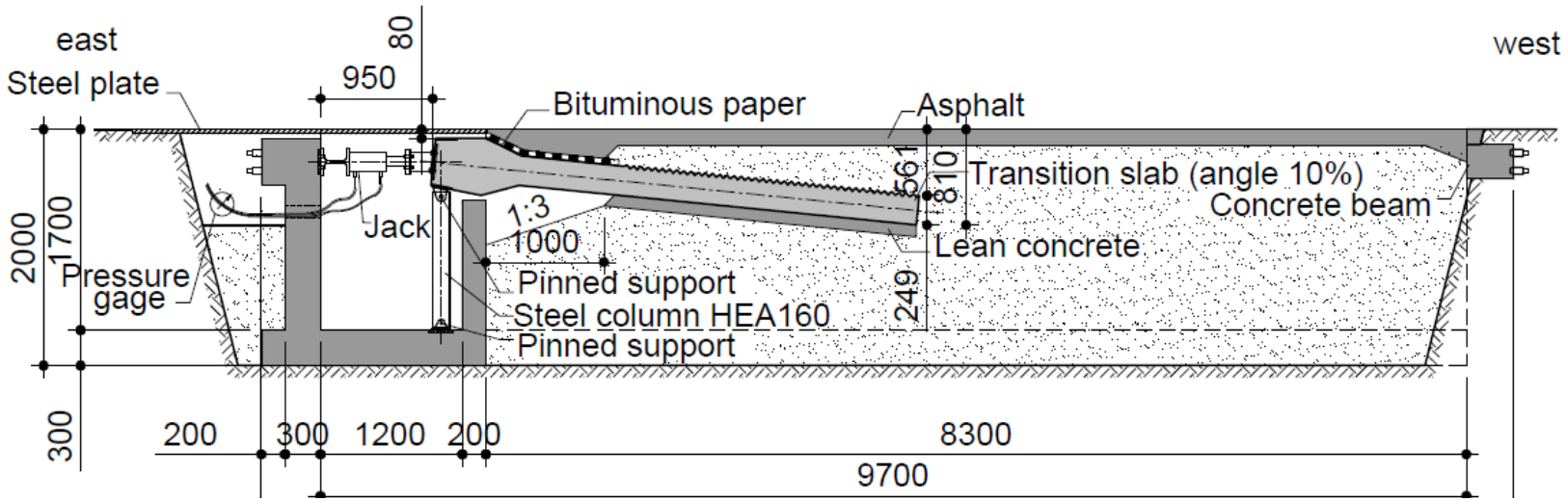
Active mechanism

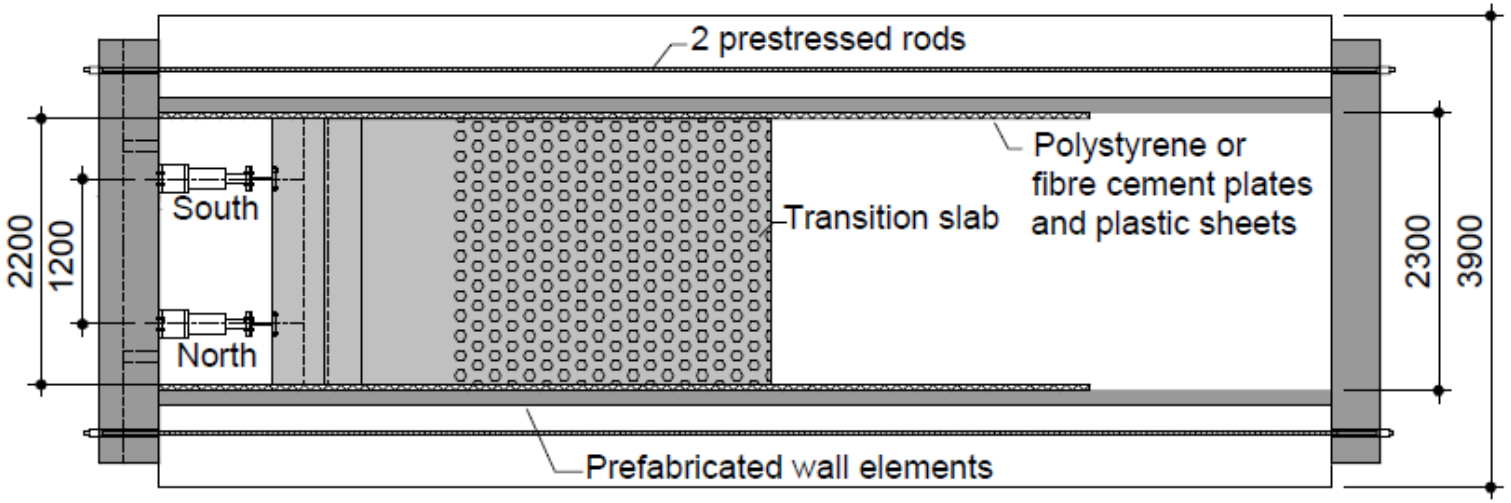
Mohr-Coulomb failure points



Passive mechanism

NUMERICAL ANALYSIS





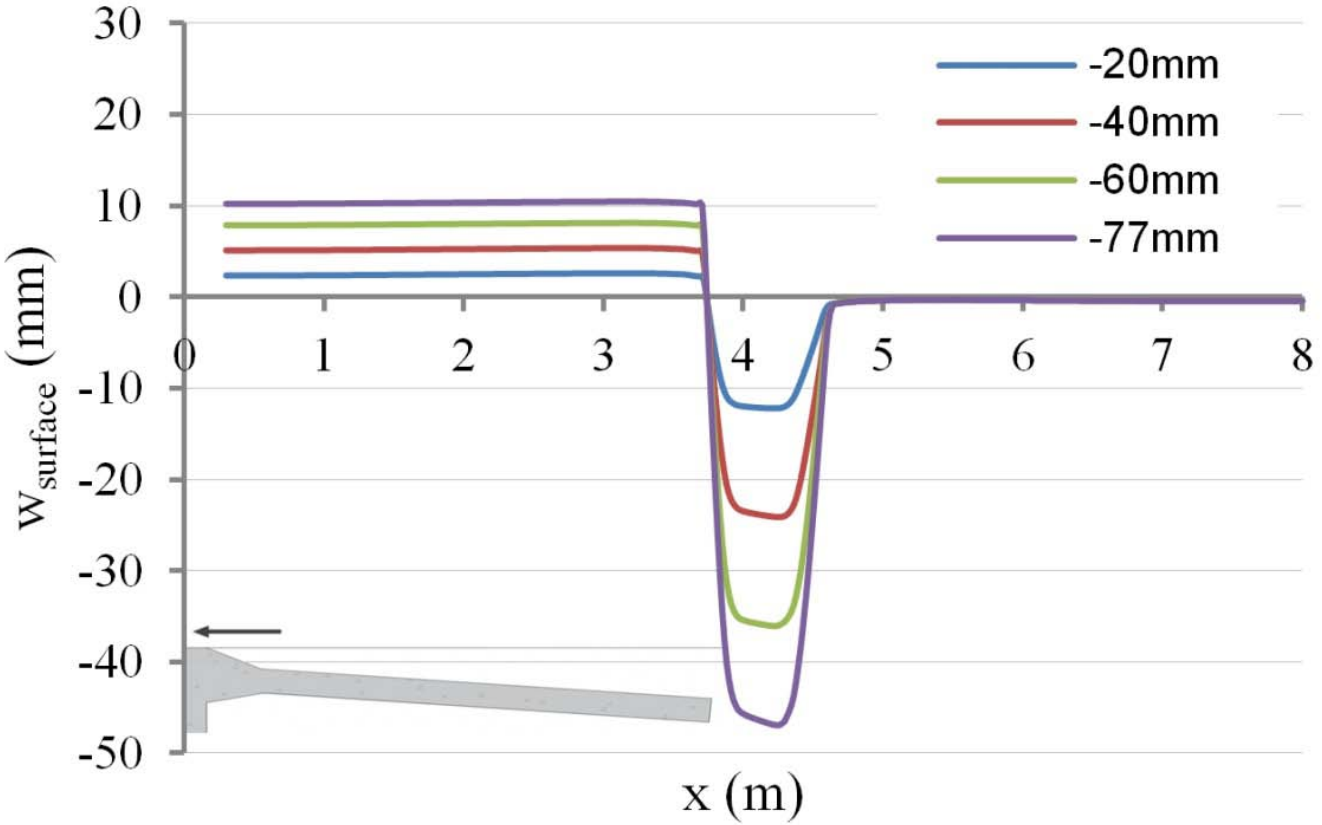
Experimental Campaign

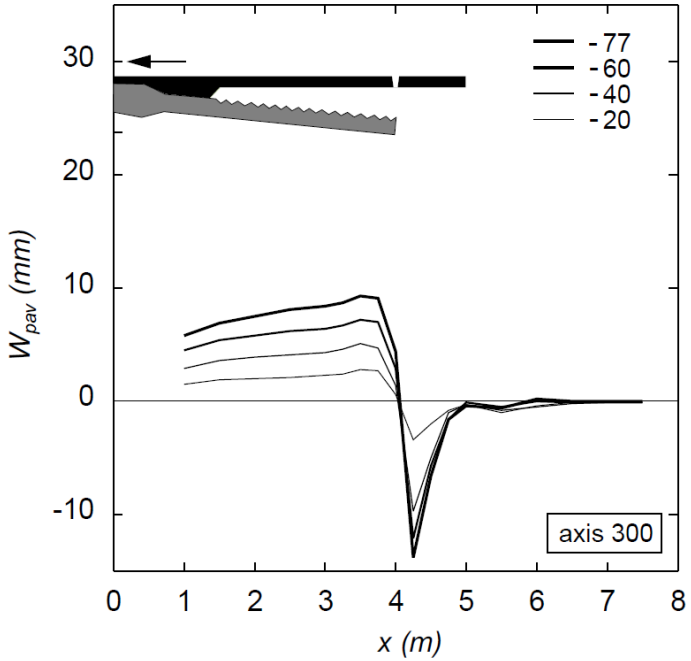
Muttoni *et al*. (2015)

EXPERIMENTAL FULL SCALE MODEL

Bridge Contraction

Vertical Surface Displacements



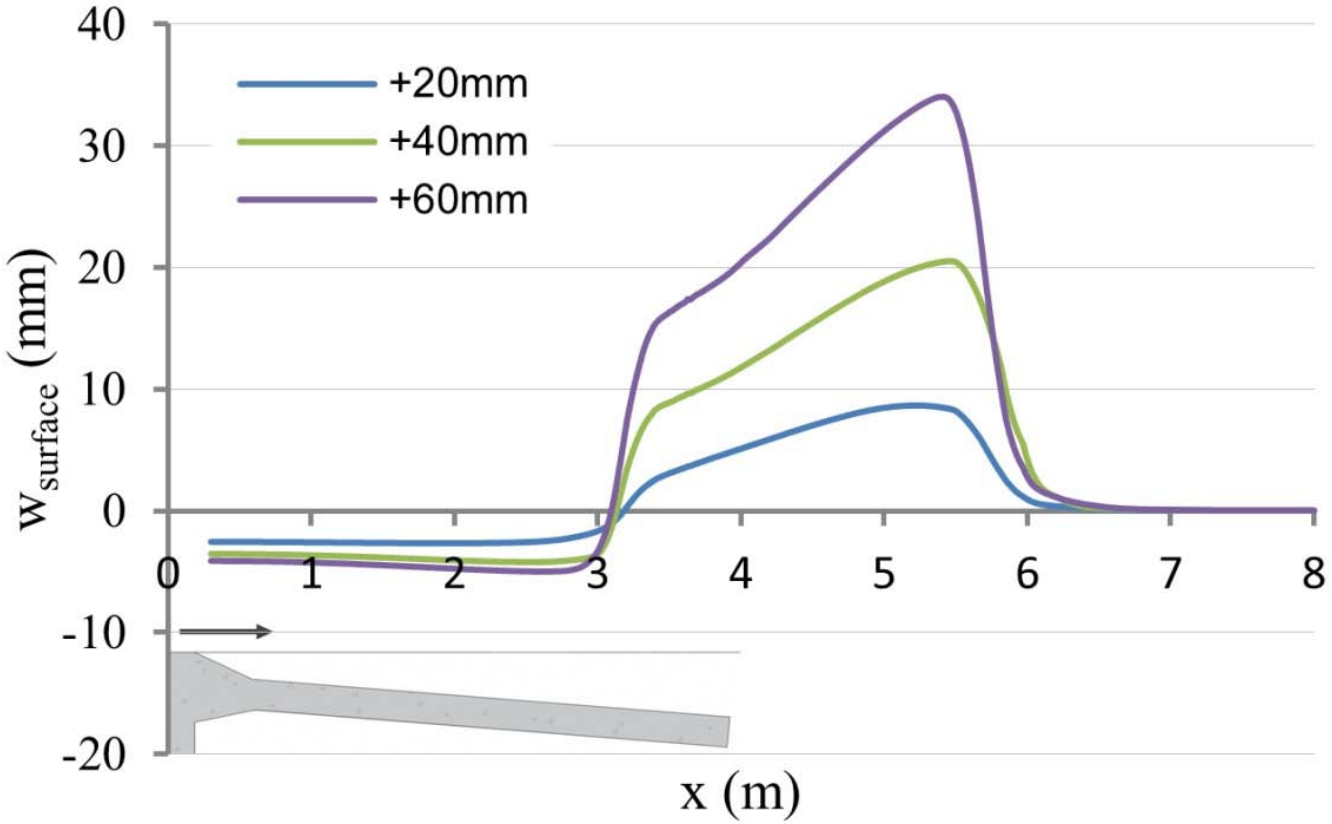


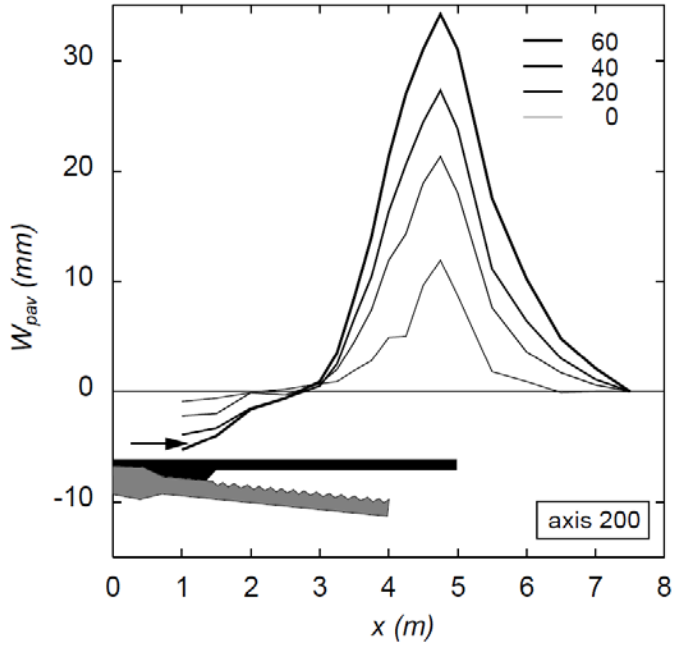
Muttoni *et al.* (2015)

NUMERICAL ANALYSIS

Bridge Expansion

Vertical Surface Displacements



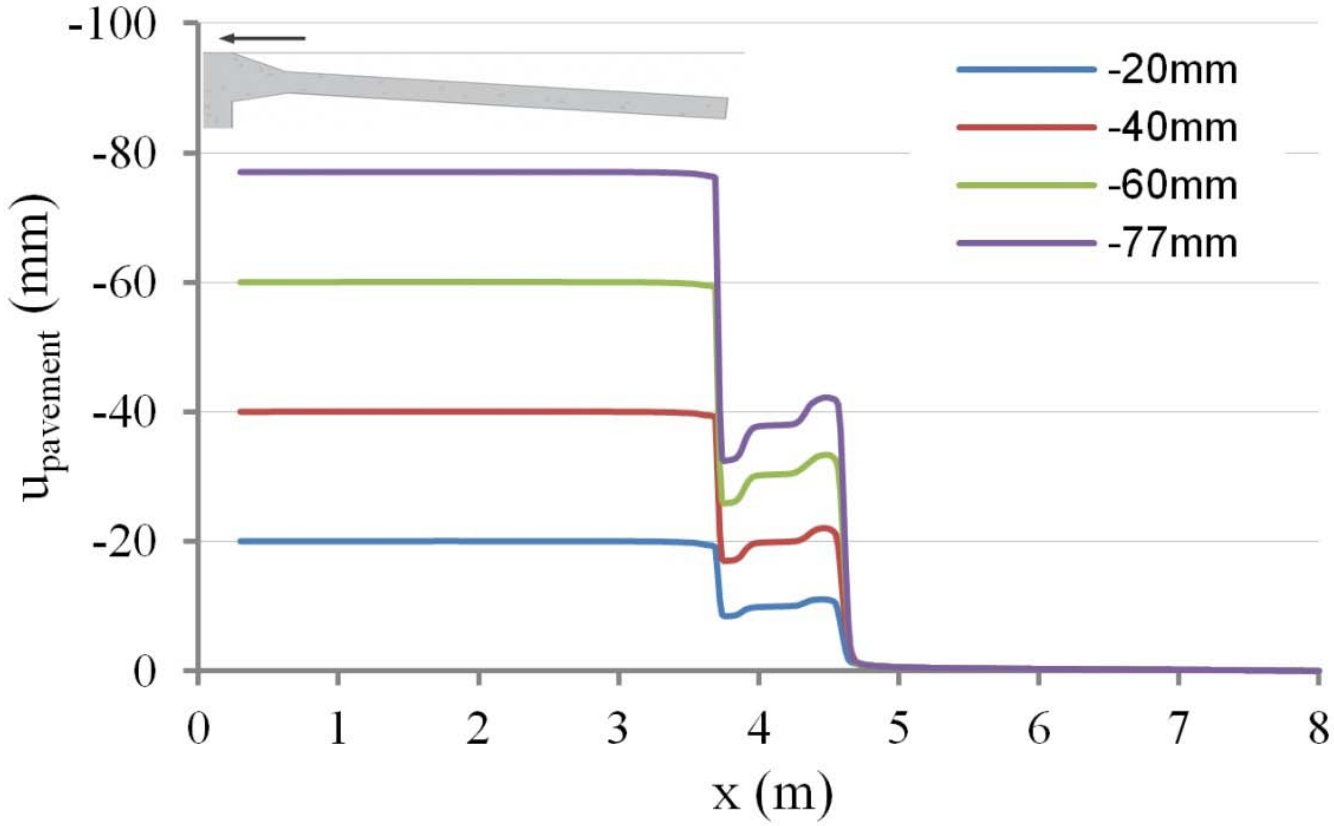


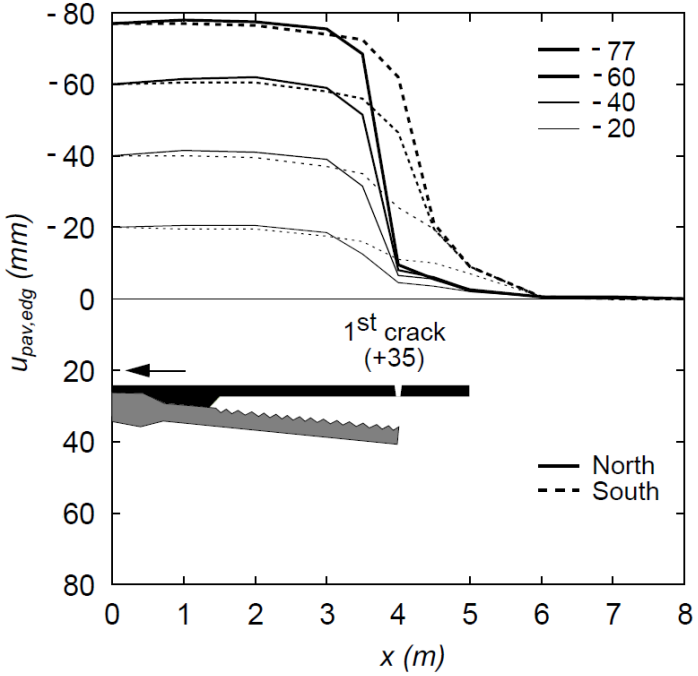
Muttoni *et al.* (2015)

NUMERICAL ANALYSIS

Bridge Contraction

Longitudinal Surface Displacements



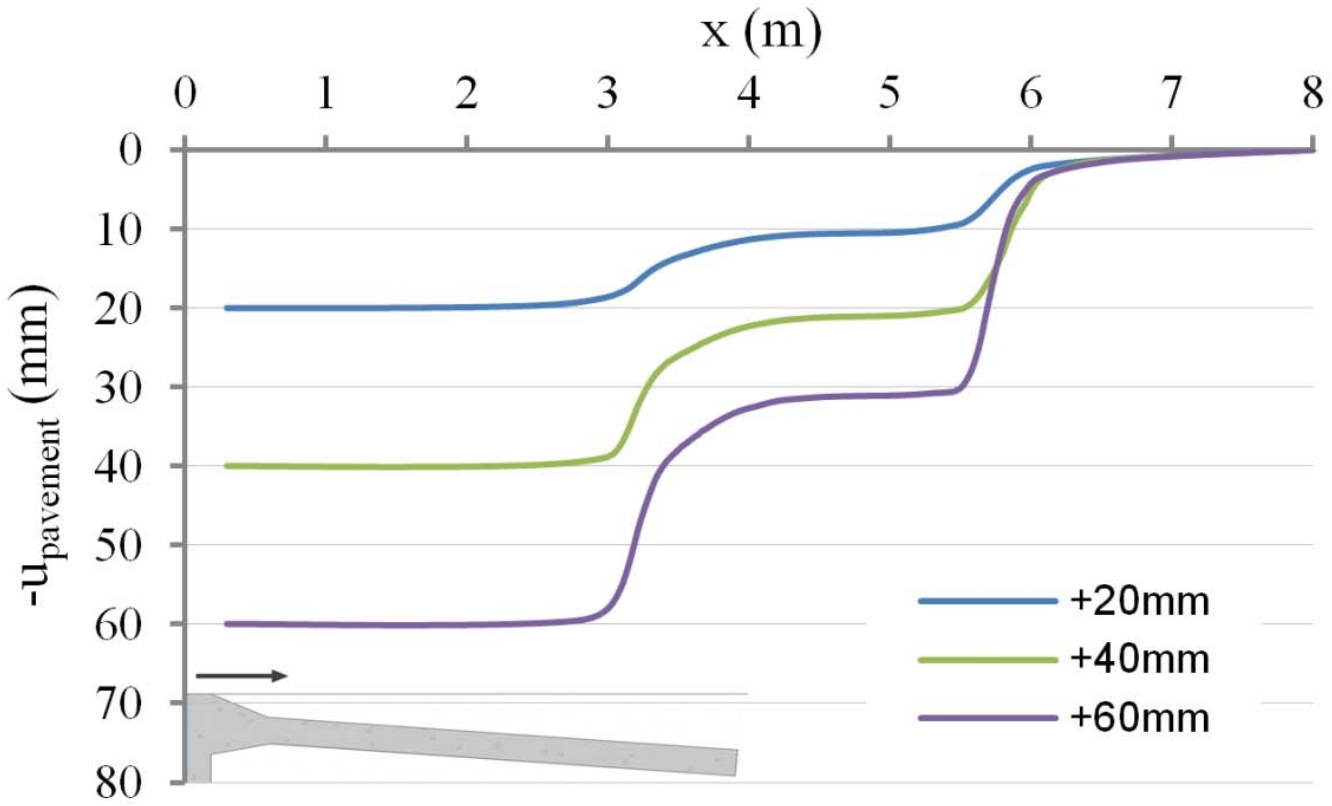


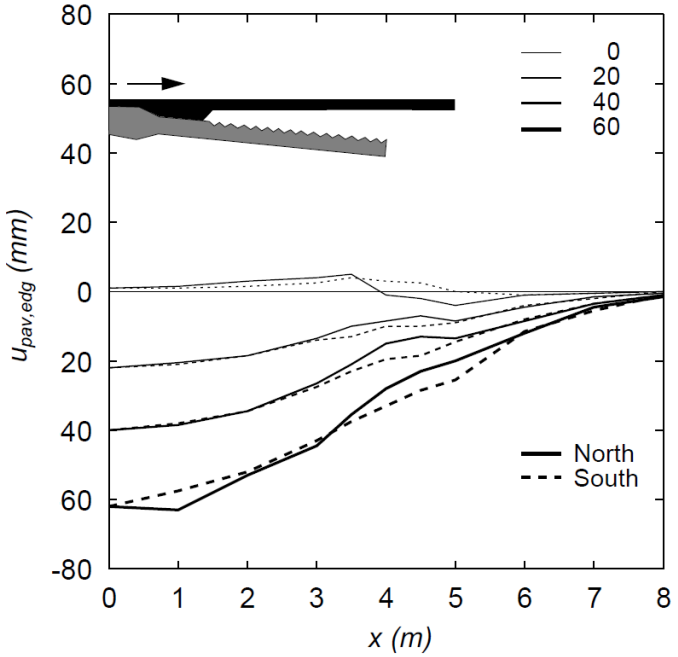
Muttoni *et al.* (2015)

NUMERICAL ANALYSIS

Bridge Expansion

Longitudinal Surface Displacements



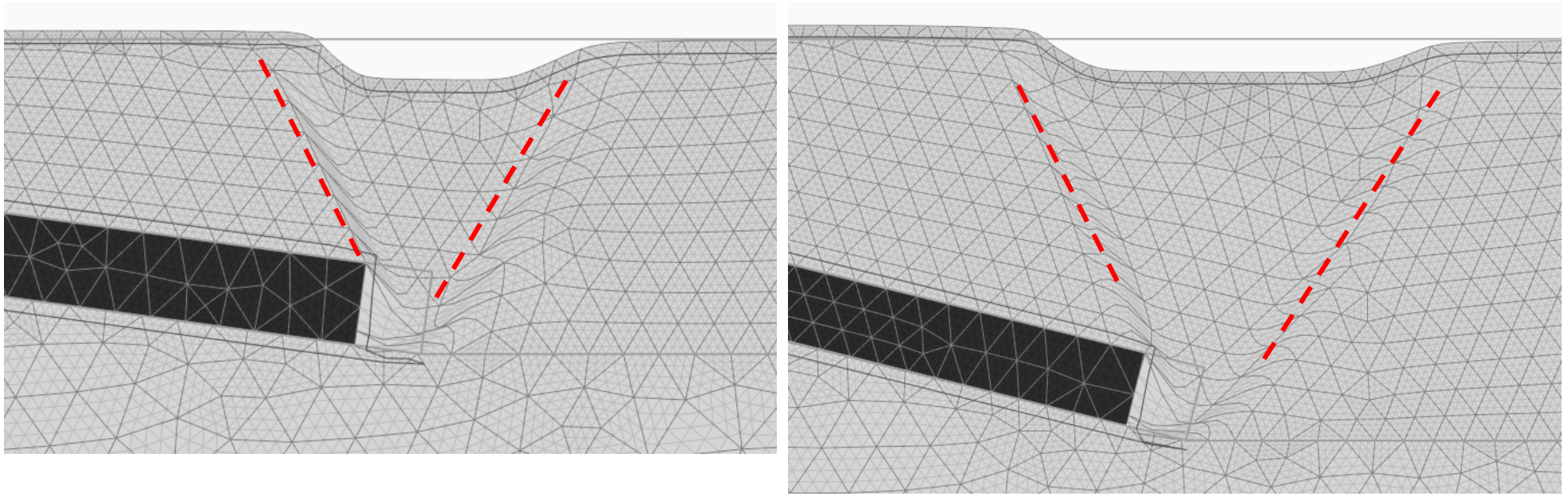


Muttoni *et al.* (2015)

NUMERICAL ANALYSIS

Bridge Contraction

Influence of transition slab buried depth



> Transition Slab End buried depth	Same Active Failure Surface	> Surface Active Zone	< Surface Settlement

MAIN CONCLUSIONS

- **The numerical model is representative of physical behavior observed in the experimental campaign**
- **For short bridges (minor imposed displacements) the transition slab length and its slope can be chosen in order to mitigate soil disturbance at the surface**
- **For longer bridges a technical solution that address both surface settlement and pavement cracking is required**
- **The understanding of phenomena here presented and its related kinematics mechanisms is essential to define a technical solution for jointless bridges approach embankments**

MAIN CONCLUSIONS