Soil-Transition Slab Interaction in Jointless Bridges

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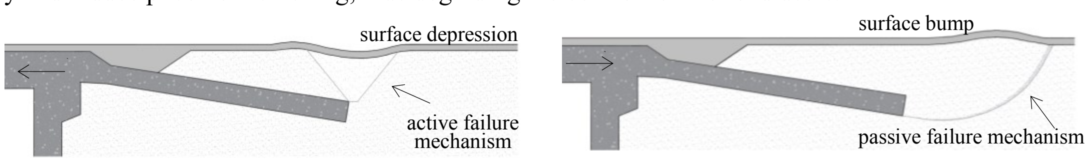
1 Introduction

In integral abutment bridges (IABs), in order to avoid the high maintenance costs during a bridge service life associated to the use of bearings and expansion joints, transition slabs are directly connected to the abutments. Hence, this element is subject to a cyclic bridge shortening and elongation movements due to creep, shrinkage and deck thermal variations leading to a complex soil-structure interaction phenomenon.

In bridge shortening, these displacements cause a local settlement of the pavement at the end of the transition slab, induced by an active soil failure mechanism in the embankment (Figure 1a)). Bridge expansion leads to a surface bump, induced by a passive soil failure mechanism (Figure 1b)). These cyclic effects reduce road pavement planarity and induce pavement cracking, thus degrading the comfort of the road users.



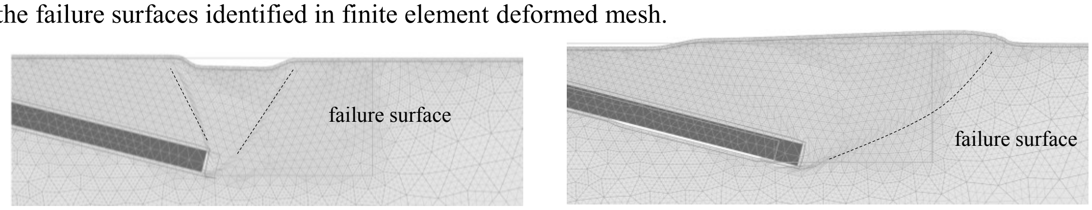
a) settlement due to bridge deck shortening   b) bump due to bridge deck expansion

Figure 1: Soil disturbance induced by transition slab movements

Muttoni *et al*. (2015) with an experimental campaign have 'measured' the transition slab – soil interaction. A comparison between those experimental results and numerical ones was made (Gama *et al*. 2016) and its main conclusions are here presented.

2 Numerical Analysis

The numerical analysis was performed using a plain strain two dimensional PLAXIS model. Geometry input and soil and interfaces properties were chosen to replicate the conditions of the experimental investigation conducted. Bridge deck contraction/expansion was simulated through imposed displacements to the transition slab. Figure 2 shows the failure surfaces identified in finite element deformed mesh.



a) bridge deck shortening   b) bridge deck expansion

Figure 2: Numerical model deformed mesh and failure surfaces at transition slab end

The numerical results for surface settlement induced by bridge contraction have qualitatively a good accordance with the experimental data: up to $x=3.5m$ the soil moves with the transition slab, leading to positive vertical displacements; $3.5m<x<5m$ corresponds to the active failure mechanism zone where soil settlement occurs and for $x>5m$ the soil is not disturbed by the transition slab movement. Quantitatively, however, there is a discrepancy: the surface settlements obtained in numerical tests are considerably higher, as shows in Figure 3a). This should happen because the bituminous pavement is not modelled in this study. In the experimental results a sharp jump for the

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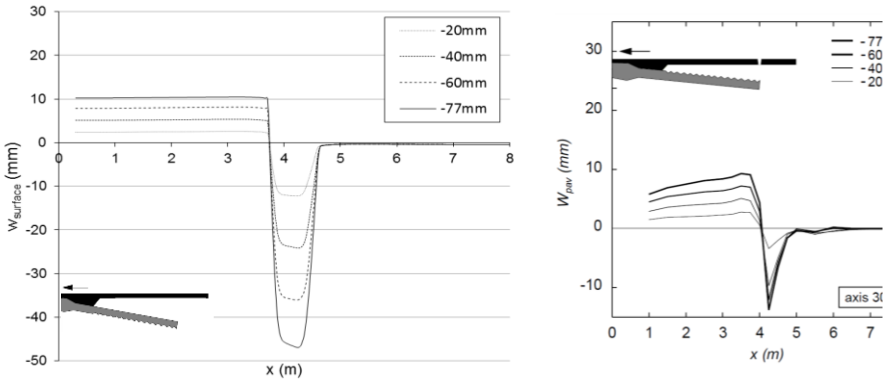
maximum settlement is registered after pavement cracking (which occurs for u_x=–60mm), indicating that the bituminous layer is not deforming with the soil movement and is bridging the gap created by soil settlement before the pavement cracks. This could have influenced significantly the measured surface settlement, and explain the difference for the numerical results.



a) Numerical analysis results (left) and Muttoni *et al.(*2015) experimental results (right)

Figure 3: Surface vertical displacements for bridge contraction

The analysis results also showed, in accordance with experimental results, that a larger buried depth of the end of the transition slab reduces the influence of the imposed displacements at the surface of the pavement. The deeper the transition slab end is placed the wider is the active failure zone and consequently the settlement is reduced since the soil disturbance is spread to a larger length at the surface. Regarding the passive failure mechanism, an analogous conclusion can be made: for a deeper transition slab a smother bump is observed at the surface.

For bridge expansion a greater quantitative conformity between numerical analysis and experimental results was observed. The bituminous (where the measuring devices are placed) buckles up with the soil as a result of the passive failure mechanism. Therefore, in this case, modelling the bituminous does not have a major impact on the vertical displacements prediction.

3 Conclusions

The numerical analysis performed was representative of the physical behavior observed in the experimental campaign. Although some quantitative uncertainty remains, the analysis conducted was essential to the understanding of the phenomena involved in the soil-structure interaction and its physical consequences. The transition slab length and its slope can be chosen in order to mitigate the soil disturbance at the surface. However, as this approach is not effective for large displacements a technical solution that addresses both surface settlement and pavement cracking is required.

References

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