INTEGRAL ABUTMENT BRIDGES APPROACH EMBANKMENT: DESIGN SOLUTION USING SOIL REINFORCEMENT ABOVE THE TRANSITION SLAB

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ABSTRACT

In integral abutment bridges (IABs), the transition slab is directly connected to the abutment to avoid bearings and expansion joints. Hence, this element is subject to bridge shortening and elongation movements due to creep, shrinkage and thermal variations in the deck. These movements cause a soil settlement at the end of the transition slab, which, beyond certain limits, can become problematic, as it reduces the planarity of the road surface, degrading the comfort of users. Additionally, the displacements imposed to the transition slab are transferred to the surface, potentially resulting in high strains in the road pavement and leading to cracking. In this paper, a technical solution, based on the use of geosynthetic soil reinforcement to improve the soil above the transition slab, is proposed and studied using numerical modelling. Results show that the solution is very effective in reducing both pavement settlements and the strains causing pavement cracking, thus allowing for greater imposed displacements on the bridge abutments, and, consequently, longer IABs.

Keywords: Integral Abutment Bridges, Approach Embankment, Transition Slab, Geogrid

Introduction

The geometry of the studied problem is illustrated on Fig 1. It was chosen to represent transition slabs commonly built for European bridges and replicate the conditions of the experimental investigation used to validate the numerical model adopted, where a semi-integral abutment geometry was used; for the studied phenomena differences for an integral abutment are minor. Various single-layer geogrid depths were tested to identify optimum position (w_{bottom}, w_{middle} or w_{top}), as well as multiple layers evenly distributed between w_{bottom} and w_{top}. Geogrid stiffness was varied (1000kN/m, 5000kN/m, 10000kN/m) and the length of 4.0m was tested for displacements up to 60mm.

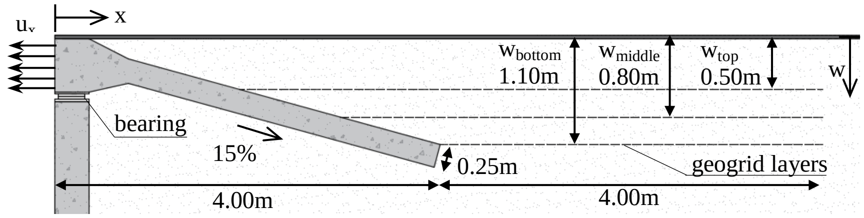
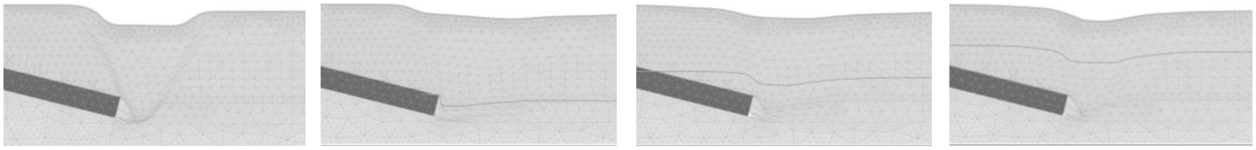


Fig. 1. Model geometry and geogrid positioning.

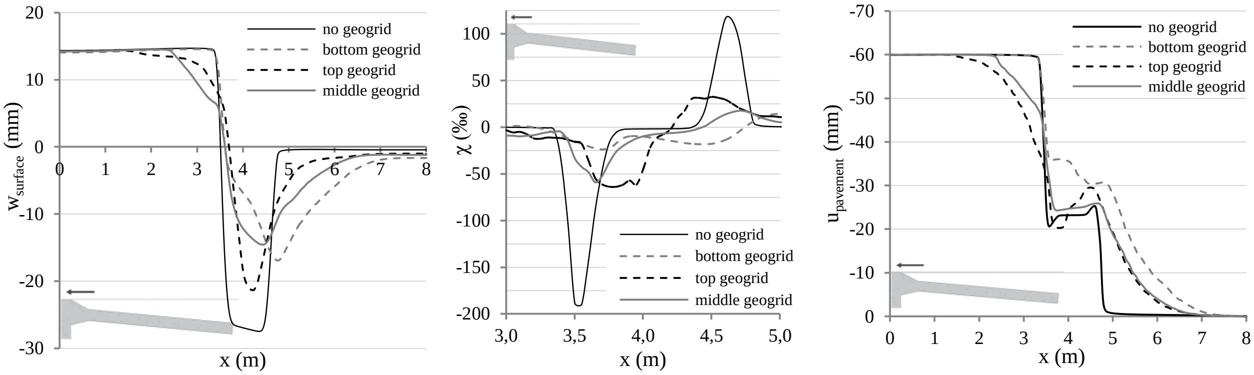
Relevant Results and Discussion

For the case of **bridge contraction**, Fig. 2 shows the deformed shape of the soil. Results in Fig. 3 show that: *a geogrid placed at the bottom* (w_{bottom}) is the best option for the mitigation of soil settlements and surface curvatures (the main serviceability parameter, regarding road planarity): there is a reduction of 50% in maximum settlement (**Error! Reference source not found.**(a)) and of 86% in surface curvatures (**Error! Reference source not found.**(b)). When *placing geogrids at the top* (w_{top})**,** Fig. 3 shows that there is a minor effectiveness in mitigating soil settlement. Nevertheless, the gradient of the longitudinal displacements ($u_{pavement}$) transferred from the slab to the surface is much smaller than when placing the geogrid at the bottom. A smaller $u_{pavement}$ gradient leads to smaller strains in the pavement, improving cracking control. Therefore, for this effect, placing the geogrid on top is a better solution.



(a) No geogrid (b) Bottom geogrid (c) Middle geogrid (d) Top geogrid

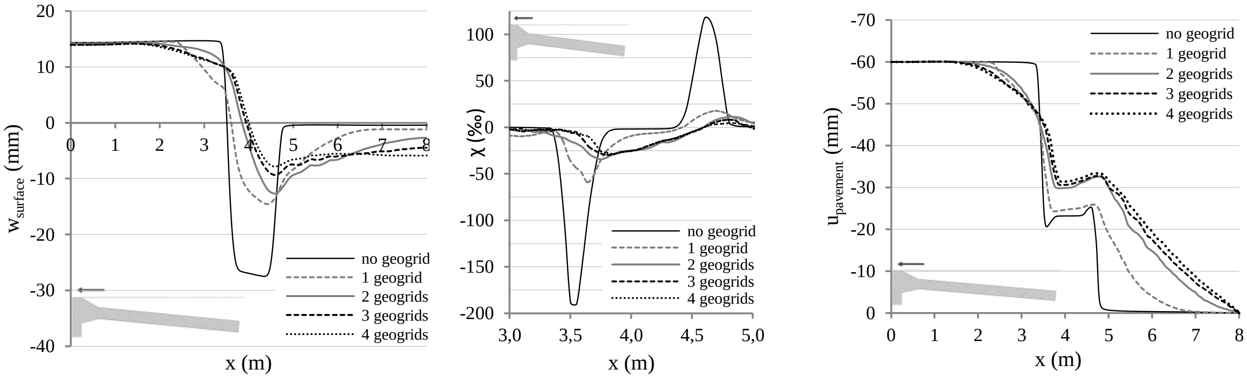
Fig. 2. Deformed mesh at the end of transition slab for u_x=–60mm (scaled up 5 times)



(a) Vertical displacements (b) Pavement curvatures (c) Longitudinal displacements

Fig. 3. Results for u_x=–60mm considering reinforcement with one geogrid differently positioned.

When *testing multiple geogrid layers*, Fig. 3 (a)) shows a reduction in the maximum settlement value of 55% with two geogrids (at w_{top} and w_{bottom} depths), and of 67% with three geogrids. However, a greater increase in geogrid numbers does not significantly impact the results; the same conclusion can be drawn for surface curvatures, as shows Fig. 3 (b). Regarding the transmission of longitudinal displacements to the surface pavement Fig. 3 (c) shows that one geogrid placed on the top has an effect on results, but the increase in quantity has insignificant effects.



(a) Vertical displacements (b) Pavement curvatures (c) Longitudinal displacements

Fig. 4. Results for u_x=–60mm considering reinforcement with more than one geogrid.

Based on the previous conclusions, 2 geogrids should be used in order to mitigate both pavement settlement and cracking: at the maximum and minimum depths; additional layers can be beneficial in case of large imposed displacements.

Results obtained in this research also showed that for imposed displacements up to 60mm the magnitude of the forces installed in the geogrids is perfectly acceptable considering: (i) geogrids tensile strength, deformation and creep behavior; (ii) anchor length needed to transfer forces to the soil, and (iii) forces transmitted to the transition slab. It was also found that the variation of the geogrid stiffness does not impact the studied problems and that geogrid effectiveness is independent from the order of magnitude of displacements imposed to the transition slab by bridge contraction.

Finally, for the case of **bridge expansion,** results have shown that using geogrids does not impact soil response (vertical or longitudinal displacements). However, the “bump” occurring is significantly less problematic than the soil settlement in bridge contraction.