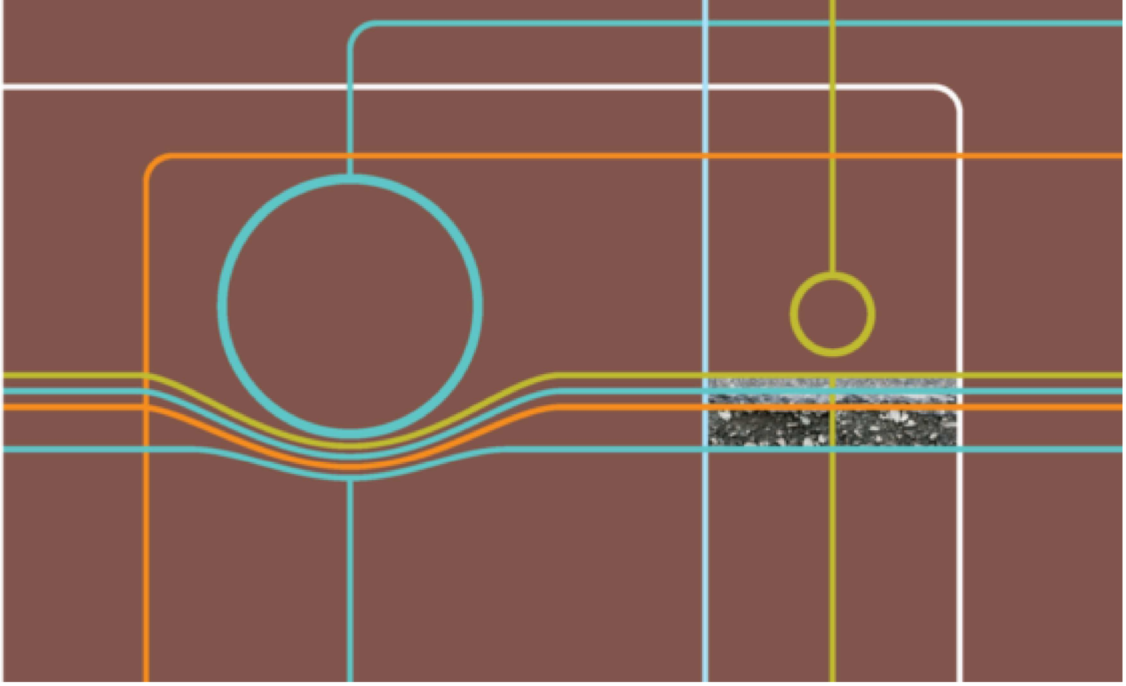
Volume 8, September 2016
ISSN 2214-3912

ELSEVIER

Transportation GEOTECHNICS

Special Issue: Use of Geosynthetics in Transportation Infrastructure
Guest Editors: Jorge Zornberg
Fumio Tatsuoka



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Transportation Geotechnics

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Transportation Geotechnics 8 (2016) 1–3

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Editorial

Special Issue on Geosynthetics in Transportation Geotechnics

Earth retaining structures and roadways are two good examples of systems where geosynthetics have made a significant impact in terms of improved performance and cost savings. Now it is the time to collect and summarize a State-of-the-Art (SOA) on the use of geosynthetics in roadways, railways, and airfields in order to share key perspectives of their use in transportation infrastructure.

This special issue of Transportation Geotechnics reports the SOA on the use of geosynthetics in transportation, including the theory and research behind the use of geosynthetics engineering for transportation engineering as well as key issues in practice and perspective. Five of the papers in this issue focus on geosynthetic-reinforced soil structures, while four of them focus on the use of geosynthetics in railway and roadway systems. Because of space constrains and timing, a number of papers on the use of geosynthetics in roadway systems will be published in subsequent issues of Transportation Geotechnics.

Tatsuoka et al. presents the research and practice of geosynthetic-reinforced soil (GRS) integral bridge, developed to overcome serious problems with conventional type simple-supported girder bridges: high construction and maintenance costs due to the use of girder bearings; massive abutment structures supported by piles; the infamous "bump-at-the-end-of-the-bridge;" and a relatively low stability margin of girders and backfill against seismic loads. The paper summarizes experiences that have involved the construction in the following sequence: (1) initial construction of a pair of GRS walls, (2) deformation of the supporing ground and backfill (3) construction of lightly steel-reinforced full-height-rigid (FHR) facings by casting-in-place concrete on the wall face wrapped-around with the geogrid reinforcement, and (4) construction of a continuous girder with both ends integrated to the top of the FHR facings.

Lenart et al. report the construction of the first GRS integral bridge with FHR facing in Europe, which was constructed across the stream Pavlovski potok in Ţerovinci by late 2014. Due to the lack of previous experience with staged construction of GRS RW with FHR facing in Europe, the designers decided to combine this technology (widely used in Japan) with the GRS integral bridge system construction approach typically adopted by FHWA in the US. Thus, the bridge system consists of a girder placed on the crest of GRS immediately behind a FHR facing (i.e., a single simple-supported girders directly placed on the two GRS abutments). Insight and experience gained from the design and construction of this pioneering bridge, as presented in this paper, show many significant advantages of GRS integral bridges in comparison to conventional steel-reinforced concrete cantilever structures.

Mirmoradi and Ehrlich report the effects of toe restraint on the behavior of geosynthetic-reinforced soil (GRS) walls, as observed in three model tests representing a similar large-scale wall but involving different toe restriction considerations. The walls were heavily instrumented in order to monitor the reinforcement forces, toe loads, horizontal facing displacements, horizontal stresses at the back of the block facing and vertical displacements on top of the wall. A higher toe restraint was found to lead to a greater toe loads and lower maximum reinforcement forces, as well as to lower horizontal facing and vertical displacements. Furthermore, the measured reinforcement forces were compared to those predicted by current design methods, revealing some limitations of these design methodologies.

Vahedifard et al. report that the soil suction can lead to significantly lower reinforcement requirements than those predicted by classic earth pressure methods. This is consistent with field measurements, which have usually revealed lower reinforcement forces than those predicted by conventional design methods. The authors point out that limit state methods have often been criticized for being conservative (or inaccurate). However, lower-than-expected reinforcement unit tension requirements can be justified by the several redundancy factors adopted in design, including toe resistance, soil volumetric dilation, underestimated soil shear strength, and the effect of soil suction, which are not accounted for in current design procedures. By properly quantifying the impact of soil suction, this study

http://dx.doi.org/10.1016/j.trgeo.2016.07.006

quantitatively explains much of this discrepancy. The authors provide a suction-based formulation to calculate the active earth pressures coefficient of unsaturated soil conditions. Two backfill soils, referred to as marginal and high quality backfills, along with three representative annual rain events are examined.

Felix Jacobs et al. report results from heavily-instrumented model tests on large geogrid-reinforced soil retaining wall models ($H \times W \times D = 1$ m $\times$ 1 m $\times$ 0.45 m) performed to improve current understanding on geogrid-reinforced soil behavior. The backfill soil was a dry uniformly-graded medium sand. Major findings from this investigation include: (1) the earth pressure mobilized on the back of rigid facing was found to decrease significantly due to the presence of geogrid reinforcements, even under comparatively small facing displacements, (2) Comparatively high reinforcement density was found to lead to decreasing lateral earth pressures, (3) The connection of the reinforcement layers to the facing was found not to affect the earth pressure distribution, (4) The locus of the shear zone was found to be closer to the wall facing with increasing reinforcement density, resulting in lower lateral earth pressures against the facing, (5) Soil arching between two reinforcement layers was found to develop even under comparatively small facing displacements, (6) Soil arching was found to develop between reinforcement layers, with the *unconfined soil* beneath the arch being the only soil mass causing lateral earth pressures against the facing, and (7) The distance from the vertex of the unconfined soil arch to the facing was found to equal the distance of the corresponding major failure plane to the facing.

Ngoc Trung Ngo et al. report on the behavior of geogrid-reinforced ballast subjected to monotonic and cyclic loading using a large-scale direct shear box and a novel Track Process Simulation Apparatus (TPSA). The shear stress–strain response of fresh and fouled ballast reinforced using geogrids was investigated through large-scale direct shear tests with varying levels of fouling. Cyclic tests involving fresh and fouled ballast were conducted using the TPSA to realistically simulate actual track conditions. The authors found that geogrid provided added confinement and interlocking of the aggregate particles, hence reducing ballast deformations. The Discrete Element Method (DEM) was subsequently used to simulate the experiments. Irregularly-shaped particles and geogrid were simulated by clumping spherical balls together, while coal fines were simulated by adding 1.5 mm-diameter spheres into the ballast pore spaces. The DEM analysis was found to predict well the experimental results, indicating that the peak shear stress of fouled ballast decreases and that the dilation of fouled ballast increases with increasing level of fouling.

Indraratna et al. report on the stress-strain and degradation response of ballast analyzed through discrete element (DE) and finite element (FE) methods, quantitatively assessing the influence of particle breakage, fouling, and the effect of artificial inclusions on the shear behavior of ballast. In the DEM simulations, irregularly shaped ballast aggregates were simulated by clumping together spheres in appropriate sizes and positions. In the FEM simulations, a composite multi-layer track system involving an elasto-plastic model with a non-associative flow rule was used to capture ballast degradation. The DEM and FEM predictions showed good agreement with large-scale laboratory tests. This paper outlines the advantages of the proposed DEM and FEM models in terms of capturing the correct stress-strain and degradation response of ballast with particular emphasis on of the use of geosynthetics and shockmats.

The paper by *Keller* highlights numerous cost-effective applications involving the use of geosynthetics in low-volume roads. The USDA Forest Service has been using geosynthetics in their low-volume roads for the past 40 years in applications including separation, reinforcement, drainage, and filtration. The many cost effective advantages of geosynthetic in these applications are highlighted in the paper. Low volume roads make up roughly two thirds of all the roads worldwide, or roughly 30 million kilometers of roads, yet they do not receive the attention and appropriate technologies deserving of such a major amount of infrastructure. The paper provides insight on the significant cost savings, design improvements, and ultimately roadway performance that can be realized with the increased use of geosynthetics in applications such as underdrains, subgrade reinforcement, geosynthetic-reinforced retaining structures, and erosion control.

Finally, *Kongkitkul et al.* report on the Behavior of geosynthetic-reinforced asphalt pavements, investigated using physical model tests. Specifically, a study was undertaken to evaluate the combined effect of improving an asphalt pavement by using polymer additives and, at the same time, geosynthetic reinforcement. Accordingly, a series of physical models were conducted, involving both new pavements and repaired pavement (i.e., asphalt overlays). Both conventional and polymer-modified asphalt cements were considered. In addition, two types of geosynthetic reinforcements (i.e., geogrid with apertures, geocomposite without apertures) were used to reinforce the asphalt pavement layer. The pavement models were vertically loaded, and photogrammetric analyses were performed to determine the mobilized strain fields in the sand layer. The experimental results indicated that: (i) the use of reinforcements led to smaller surface settlements and less localized maximum shear strains; (ii) asphalt permanent deformations were reduced due to improvement in asphalt cement; (iii) installation of geogrid in the asphalt layer is particularly beneficial to maximize interlocking, while installation at the base of the asphalt layer was found to be appropriate in the case of geocomposites.

Ultimately, the nine technical papers in this issue of *Transportation Geotechnics*, submitted by highly accomplished research groups and rigorously peer-reviewed to ensure the highest possible standards provide unique insight into the advances on the use of geosynthetics in transportation systems. The Editors are thankful by the efforts of the anonymous paper reviewers as well as by the support provided by Catherine Liu and Divya Kaliyaperumal of the Elsevier editorial team. The opportunity of serving as Guest Editors of this special issue, extended by Professors Antonio Gomes Correia, Erol Tutumluer and Yunmin Chen (Editors) is kindly acknowledged. Ultimately, we believe that this Special Issue provides a comprehensive set of key references encompassing the use of geosynthetics in Transportation Geotechnics, which will benefit both researchers and practicing engineers.

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Accepted 22 July 2016

Available online 25 July 2016