XVI ECSMGE 2015
13-17 September 2015 - Edinburgh

TC202 Workshop on Railroad Geotechnics

at XVI ECSMGE, Edinburgh, 2015

Sunday, September 13, 2015, 13:30-17:30

Venue: Tinto Room, Edinburgh International Conference Center (EICC)

All members and friends of ISSMGE Technical Committee **TC202 on Transportation Geotechnics** are invited to attend this specialty workshop on **Railroad Geotechnics**, which will provide a forum for exchange of technical knowledge on state of practice and state of the art research in railroad track substructure topics at the XVI European Conference on Soil Mechanics and Geotechnical Engineering scheduled on September 13, 2015.

Program

13:30 - 13:40	Opening Address	Prof. Erol Tutumluer, Chair of ISSMGE TC202
13:40 - 14:00	Some Unsaturated Soil-Related Aspects in Railway Substructures	Prof. Yu-Jun Cui, Ecole des Ponts Paris Tech (ENPC), France
14:00 - 14:20	Prediction of Earthworks Failure using Track Geometry Car Data	Dr. Phil Sharpe, AECOM, UK
14:20 - 14:40	Investigation of Ballast Flight under Aerodynamics Flow using Computational Fluid Dynamics	Dr. Lee Pardoe, University of Southampton, UK
14:40 - 15:00	Recent Solutions to Improve the Degraded Ballasted Tracks	Dr. Yoshitsugu Momoya, RTRI, Japan
15:00 - 15:20	Lateral Resistance Characteristics of Ballasted Tracks subjected to Angular Rotation at Boundaries between Structures	Prof. Kimitoshi Hayano, Yokohama National University, Japan
15:20 - 15:35	Questions and Answers / Discussion	

15:35 - 15:55 Coffee Break

15:55 - 16:15 Water Impact on Dynamic Performance and Accumulative Settlement of High-Speed Railway Infrastructure under Train Moving Loads

Prof. Xuecheng Bian, Zhejiang University, China

16:15 - 16:35 Soft Computing Applied to Earthworks Optimization: A Survey and Application

Prof. Antonio Gomes Correia, University of Minho, Portugal

16:35 - 16:55 Synergistic Effects of Moving Wheel Loads and Water Content Change on Mechanical Behavior of Substructures at Ballasted Track

Prof. Tatsuya Ishikawa, Hokkaido University, Japan

16:55 - 17:15 Effectiveness of Remedial Measures Applied to Mitigate Differential Movement at Railroad Track Transitions

Prof. Erol Tutumluer, University of Illinois at Urbana-Champaign, USA

17:15 - 17:30 Questions and Answers / Discussion

Sponsored by TC202 Transportation Geotechnics:

http://www.eng.hokudai.ac.jp/labo/geomech/ISSMGE%20TC202/

http://www.issmge.org/en/technical-committees/applications/147-transportation-geotechnics

Correspondence:

Dr. Tatsuya Ishikawa
Secretary, TC202, the Technical Committee on **Transportation Geotechnics** within ISSMGE
Laboratory of Analytical Geomechanics
Div. of Field Engineering for the Environment Faculty of Engineering Hokkaido University Kita13, Nishi8, Kita-ku Sapporo, Hokkaido, 060-8628, Japan TEL & FAX: +81-11-706-6202
E-mail: t-ishika@eng.hokudai.ac.jp

Presentation Abstracts

1. Some unsaturated soil-related aspects in railway sub-structures

Prof. Yu-Jun Cui, Ecole des Ponts Paris Tech (ENPC), France

The hydro-mechanical behavior of some unsaturated soils in the sub-structures of both new and conventional railway lines was investigated. For the new lines, an example of track instability related to the sensitivity of the loess subgrade behavior to water content changes was firstly presented, followed by a second example involving the track instability due to the swelling of marl in the sub-structure. For the conventional lines, emphasis was put on the effects of water content and fines content on the hydro-mechanical behavior of the unsaturated interlayer soil which was formed mainly by the interpenetration between ballast and subgrade soils under the effect of traffic.

2. Prediction of Earthworks Failure using Track Geometry Car Data

Dr. Phil Sharpe, AECOM, UK

Performance of ageing earthworks is one of the major concerns on UK railways. While there are known areas of the railway that are prone to failure by virtue of the local geology, there is as yet no reliable method of predicting exactly when and where failures are likely to occur. Earthwork movements clearly affect track geometry; Network Rail currently undertakes frequent runs with their track geometry car to monitor track quality, but the data is used predominantly to plan a track maintenance strategy. Observation of long term records of track geometry has shown that geometry deterioration due to earthwork movements is erratic, rather than the regular deterioration normally seen. There are various factors that govern the rate at which track geometry deteriorates, mainly related to track type and condition, traffic and trackbed condition. However, for the main part these occur at a predictable rate. Earthwork movements on the other hand are less predictable, particularly if unstable and when more extreme weather results in rapid changes in hydrogeological conditions. A study undertaken in 2014 is described, to analyse track geometry records for the previous four years for a 4 track section of railway located on the Midland Main Line between London and Leicester where earthwork failures had occurred during the heavy rainfall of Winter 2013/14. Analysis of the track geometry data showed clear evidence of earthworks instability at least three years prior to failure. The study concludes that track geometry data can identify failing earthworks sooner than methods currently used, thus allowing a pro-active approach to earthworks management.

3. Investigation of Ballast Flight under Aerodynamics Flow using Computational Fluid Dynamics

Dr. Lee Pardoe, University of Southampton, UK

This presentation discusses the aerodynamics of ballast flight, with a focus on numerical studies of wind flow around obstacles including idealised ballast grains and aerodynamic sleepers. Detached Eddy Simulation (DES) is used to simulate the flow at a Reynolds number of approximately 335,000 and the results are compared with experimental wind tunnel data and numerical computations from RANS and URANS modelling. Comparisons are made between models and the relative advantages and disadvantages of using RANS and URANS are highlighted, particularly for flows around complex geometries. Additional numerical studies include particles being rotated and /or elevated to observe changes in aerodynamic forces. Results demonstrate that DES is better able to obtain the complex flow field behind the particles than RANS and URANS. Experimental techniques to retrieve additional validation data are discussed. Conclusions are drawn regarding the flow behaviour around the solid boundaries and the relative contributions of mechanical vibrations and the aerodynamics of High Speed Trains to ballast displacement.

4. Recent solutions to improve the degraded ballasted tracks

Dr. Yoshitsugu Momoya, RTRI, Japan

One of the important benefits of the ballasted tracks is the easiness of maintenance work. Track irregularities of the ballasted tracks are easily corrected by tamping, however, this important benefit is disappeared when the ballast is fouled by fine particles. In the fouled ballasted tracks, mud pumping is likely to occur and the track irregularity becomes large immediately after the tamping. In most of the local railway lines, it is difficult to invest a sufficient budget to maintain the degraded ballasted tracks. To cope with the issue to maintain those degraded ballasted tracks, we developed two different new solutions. The first method is a roadbed improvement method recycling the fouled ballast. In this method, fouled ballast is recycled as the roadbed improvement material with cement grout. By recycling the fouled ballast, the execution cost for the roadbed improvement becomes much lower. The second method is the improvement of the fouled ballast by biodegradable polymer. The shear strength of the ballast is increased by improving the fouled ballast by the polymer. The full scale tests and the in-situ application proved that these techniques effectively reduce the track irregularity in the low cost.

5. Lateral Resistance Characteristics of Ballasted Tracks subjected to Angular Rotation at Boundaries between Structures

Prof. Kimitoshi Hayano, Yokohama National University, Japan

When earthquakes induce local displacements on ballasted tracks at boundaries between structures, the lateral resistance decreases and the lateral stability becomes lower. However it is difficult to examine the lateral resistance characteristics under various conditions occurring in the field, so that our knowledge related to this issue have not been accumulated. Therefore, angular rotation which is one of the phenomena causing local displacements is focused in this study. After an apparatus which could generate angular rotation was newly developed, a series of model tests were conducted. From the model tests, effects of rotation angles, the repetition numbers, and the opening or closing status on the lateral resistance were investigated. In addition, differences between lateral resistances from single-sleeper pullout tests and those from track-panel pullout tests were also studied.

6. Water Impact on Dynamic Performance and Accumulative Settlement of High-Speed Railway Infrastructure under Train Moving Loads

Prof. Xuecheng Bian, Zhejiang University, China

Railway infrastructures can be exposed to high water levels due to extreme weather events, such as floods and heavy rainfalls, leading to reduction in the performance of railway infrastructures and jeopardize the safety of train operations. The objective of this paper is to evaluate the performance of high-speed railway infrastructure under different water levels based on experimental testing. A full-scale physical model of a high-speed railway was constructed in a test box measuring 15 m wide, 5 m long and 6 m deep. Water levels in the physical model were raised and lowered using a water level control system. Stationary cyclic loading and train moving loading tests were carried out at four typical water levels, i.e., at 3m below ground surface, at the ground surface, at the subgrade surface, and falling back to the ground surface. The test results reveal that variations of water level in the ground had a minor influence on the dynamic performance of the railway infrastructure. When the water level rose in the subgrade, the track modulus degraded significantly. Both the displacement and tensile strain of the track structure increased rapidly with a submerged subgrade. The distribution of the contact pressure beneath the railway track changed significantly with variations in the water level. More details on the dynamic performance and accumulative settlement of the track structure are reported in the paper for different water levels.

7. Soft Computing Applied to Earthworks Optimization: A Survey and Application

Prof. Antonio Gomes Correia, University of Minho, Portugal

The earthworks represent in many cases around 30% (or more) of rail infrastructure construction activities, and also a significant cost in maintenance and rehabilitation works. It is then obvious important to optimize de costs associated with this task. In fact, earthworks are characterized by a chain of tasks ranging from excavation and transport to spreading and compaction, that can be treated as a production chain. However, this approach generally was applied in individual applications, whereas most focus on the optimization of partial aspects or specific tasks of the earthwork process, leaving some space for further development. This presentation reviews the existent optimization earthwork systems, based in Soft Computing techniques, such as data mining (i.e., neural networks) and metaheuristics (i.e., evolutionary computation) with focus on their structure, capabilities and limitations. Finally, an application using real-world data from a construction site illustrates the potential of the developed tool when compared with current manual earthwork optimization.

8. Synergistic effects of moving wheel loads and water content change on mechanical behavior of substructures at ballasted track

Prof. Tatsuya Ishikawa, Hokkaido University, Japan

This research presents an experimental study to evaluate the synergistic effects of principal stress axis rotation and change in water content on the mechanical behavior of granular geomaterials like gravel and sand in order to examine the mechanism of cyclic plastic deformation of railroad ballast and roadbed subjected to cyclic moving wheel loads at a ballasted track. Two types of small scale model tests and laboratory element tests, in which a single-point loading method and a moving-wheel loading method were adopted, were mainly performed with gravel and sand under air-dried condition and saturated condition. Based on the test results, the applicability of a multi-ring shear test, which is a torsional simple shear test, to an element test of granular geomaterials subjected to moving wheel loads, and the influence of water content and moving-wheel loads on the deformation-strength characteristics of geomaterials were examined. As the results, it was revealed that the multi-ring shear test has excellent applicability to the estimation of deformation behavior of geomaterials subjected to repeated moving-wheel loads. Besides, it was revealed that residual settlement of submerged geomaterials is more likely to increase with the repetition of moving-wheel loads than that of air-dried one and under single-point loading, showing that the difference in loading method and water content has a considerable influence on the cyclic plastic deformation of granular geomaterials. These lead to the conclusion that for the precise prediction of the long-term performance of substructures at ballasted track under cyclic moving-wheel loads, it is important to take into account the synergistic effects of principal stress axis rotation and water content change on the cyclic plastic deformation characteristics of granular geomaterials.

9. Effectiveness of Remedial Measures Applied to Mitigate Differential Movement at Railroad Track Transitions

Prof. Erol Tutumluer, University of Illinois at Urbana-Champaign, USA

Railway transitions such as bridge approaches experience differential movements related to differences in track system stiffness, track damping characteristics, foundation type, ballast settlement from fouling and/or degradation, as well as fill and subgrade settlement. An ongoing research study at the University of Illinois has used advanced geotechnical instrumentation to identify and quantify different factors contributing to recurrent differential movement problems at three different bridge approaches along Amtrak's Northeast Corridor (NEC) near Chester, Pennsylvania. Field instrumentation data have identified excessive ballast movement to be the primary factor contributing to the "bump development" at these bridge approaches. This presentation will discuss the effectiveness of polyurethane grouting, stone blowing, and under tie pad track panel as remedial measures to mitigate the differential movement problem at the NEC railroad bridge approaches. Details of the remedial measure implementation methods are discussed and field effectiveness is demonstrated using track geometry records and instrumentation data. Ballast transient and permanent deformation data collected from multi depth deflectometer installed ties under train loading have been reduced through both stone blowing and grouting. Degree of ballast fouling has been found to control the effectiveness of chemical grouting as a remedial measure. However, presence of excessive fouling material in the ballast layer adversely affects the ability of the grout to bond with individual ballast particles. A "clean" ballast layer, on the other hand, can facilitate adequate bonding between the grout and ballast particles leading to significantly improved long-term track performance.