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Report of Parallel Session 3.1: applied unsaturated soil mechanics

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ABSTRACT: This paper presents a summary on the development of Parallel Session 3.1 on Applied Unsaturated Soil Mechanics.

1 INTRODUCTION

Session 3.1 "Applied Unsaturated Soil Mechanics" was held on March 11, 2002, during the UNSAT 2002 Conference held in Recife, Brazil. The chairman of this session was Dr. A. Correia (Portugal). Dr. Zornberg (USA) was the general reporter of the session. The chairman opened the session and the general reporter subsequently provided a summary of the papers to be presented. The summary of the papers is presented in Section 2 of this report.

Figure 1 shows the composition of the papers prepared for this session. The papers in the session provided a good geographical representation. As observed in the figure, 17% of the papers for this session were prepared by Brazilian researchers, 25% were prepared by researchers from countries in the Americas (excluding Brazil), and the remaining 58% were prepared by researchers from the rest of the world. On the other hand, there was a certain lack of representation from industry in the composition of the papers. As observed in the figure, only 19% of the papers were

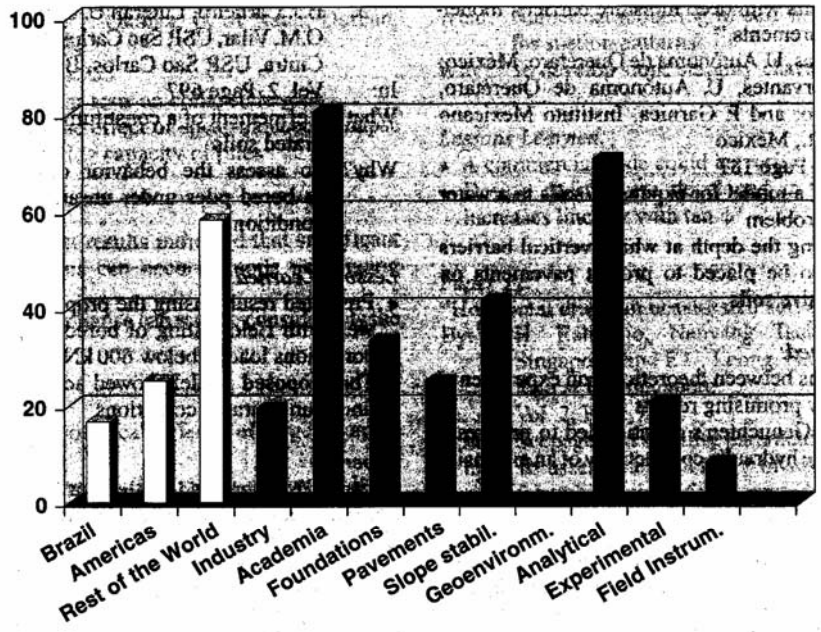

Figure 1. Composition of papers in the session "Applied unsaturated soil mechanics".

prepared by researchers in industry, while the remaining 81% were prepared by academicians. There was an even distribution of general topics in the papers prepared for the session. The notorious exception was the geoenvironmental area. As shown in the figure, 33% of the papers addressed foundation issues, 25% addressed pavements, and 42% addressed slope stability issues. No papers on geoenvironmental issues were prepared for this session. Finally, there was a heavy representation of papers that presented research studies involving analytical developments. Specifically, 71% of the papers involved analytical developments, while 21% involved experimental studies, and only 8% involved field instrumentation. Questions were taken subsequent to each of the presentations. Finally, the overall contents of the presentations by the different presenters were open to general debate.

2 SUMMARY OF PAPERS IN TECHNICAL SESSION

A brief overview of the papers presented during the technical session is provided below. They include the main objective of the paper, the main justification for conducting the research, and a summary of the lessons learned from each study. The reader is referred to the proceedings of the conference for the printed version of the document.

Paper 1:
"Expansive soils with deep moisture barriers: modeling and measurements."
By: E. Rojas, U. Autónoma de Querétaro, México; R. Cervantes, U. Autónoma de Querétaro, México; and P. Garnica, Instituto Mexicano del Tpt., México
In: Vol. 1, Page 187
What? Use of a model for expansive soils in a water flow problem
Why? Defining the depth at which vertical barriers need to be placed to protect pavements on expansive soils

Lessons Learned:
- Comparisons between theoretical and experimental results show promising results
- Use of van Genuchten's equation led to underestimation of the hydraulic conductivity of an expansive soil

Paper 2:
"Moisture transfer and deformation behaviour of pavements. Effect of climate, materials and drainage."
By: E. Alonso, UPC, Spain; Cañete, UPC, Spain; and S. Olivella, UPC, Spain
In: Vol. 2, Page 671
What? Numerical modeling of pavement structures under various climate conditions
Why? To assess the effect of longitudinal drains on the system

Lessons Learned:
- Longitudinal drains affect significantly the base and subbase degree of saturation
- The effect of longitudinal drains on the subgrade degree of saturation is more limited
- The effect of longitudinal drains is site-specific

Paper 3:
"Longitudinal cracking of a bicycle trail due to drying shrinkage."
By: J.B. Nevels Jr., Oklahoma Department of Transportation, USA
In: Vol. 2, Page 687
What? Analysis of changes in suction profiles under pavement
Why? To investigate the causes of pavement cracking

Lessons Learned:
- Longitudinal cracking was attributed to changes in suction
- Soil moisture deficit was identified as a useful concept for assessment of soil shrinkage

Paper 4:
"Soil plasticity aspects applied in the prediction of the behaviour of field structures."
By: S.L. Machado, Federal U. of Bahia, Brazil; B.J. Carneiro, Luteran U. of Brazil, SP, Brazil; O.M. Vilar, USP, Sao Carlos, Brazil; and J.C.A. Cintra, USP, Sao Carlos, Brazil
In: Vol. 2, Page 697
What? Refinement of a constitutive model for unsaturated soils
Why? To assess the behavior of structures such as bored piles under unsaturated and soaked conditions

Lessons Learned:
- Predicted results using the proposed model agreed well with field testing of bored pile under soaked conditions loaded below 600 kN
- The proposed model showed adequate results also under unsaturated conditions

Paper 5:
"Bearing pressure and settlement for a lean clay in saturated and unsaturated conditions."
By: J.C. Rojas, U. Mayor de San Simón, Bolivia; and L.M. Salinas, U. Mayor de San Simón, Bolivia
In: Vol. 2, Page 703
What? Evaluation of bearing capacity and settlement of shallow footings

Why? To compare the results between traditional and unsaturated soil mechanics formulations

Lessons Learned:
- Fitting procedures for SWCC may lead to significant differences in predicted results
- Use of unsaturated soil mechanics formulations led to accurate prediction of load plate test

Paper 6:
"Numerical modeling of a footing load on unsaturated collapsible soil."
By: M.S.S. Almeida, Federal U. Rio de Janeiro, Brazil; F.C. Silva Filho, U. of Fortaleza, Ceará, Brazil; and M.M. Futai, Federal U. of Rio de Janeiro, Brazil
In: Vol. 2, Page 715
What? Numerical modeling of shallow foundations
Why? To evaluate the effect of changes in water level and suction

Lessons Learned:
- Different patterns in collapse/expansion are obtained for reduction in suction due to either rise in water table or infiltration from surface
- Increase in unit weight with increasing moisture content should be accounted for in the analyses

Paper 7:
"The effect of shear induced collapse on pile capacity."
By: H.D. Schreiner, U. of Natal, Durban, South Africa; and F. Okonta, U. of Natal, Durban, South Africa
In: Vol. 2, Page 733
What? Simple shear tests on collapsible soils
Why? To assess the effect of shear-induced collapse on the bearing capacity of piles

Lessons Learned:
- Simple shear test results indicated that significant contractile strains can occur in soils undergoing shearing
- Shear-induced collapse can reduce considerably the pile capacity

Paper 8:
"Analysis of hydrological effects of vegetation on slope stability."
By: A. Tarantino, U. degli Studi di Trento, Italy; L. Mongiovi, U. degli Studi di Trento, Italy; and J.R. Dougall, Napier U., Edinburgh, UK
In: Vol. 2, Page 749
What? Numerical simulation of the influence of vegetation in suction profiles
Why? To assess the effect of vegetation on slope stability

Lessons Learned:
- Lowering the zone of water extraction from the ground surface to the root zone is relevant for less permeable soils
- The assumed depth of water table plays a significant role in the analyses

Paper 9:
"Numerical analysis of infiltration into unsaturated residual soil slopes."
By: I. Tsaparas, U. of Durham, UK; and D.G. Toll, U. of Durham, UK
In: Vol. 2, Page 755
What? Numerical modeling of a residual soil slope in Singapore
Why? To assess flow mechanisms and the effect of vegetation

Lessons Learned:
- Definition of a thin permeable soil layer at the ground surface was needed to get good comparison between field and numerical data
- Perched water may develop near the soil slope surface

Paper 10:
"Numerical modelling of infiltration into unsaturated residual soil slopes."
By: R. Subramaniam, Ranhill Bersckutu, Malaysia
In: Vol. 2, Page 763
What? Numerical modeling of soil slope accounting for suction patterns
Why? To develop slope stability charts

Lessons Learned:
- A commercial code could be verified
- Design charts were developed in which the FS increases linearly with tan ϕ^b

Paper 11:
"Horizontal drains in unsaturated soil slopes"
By: H. Rahardjo, Nanyang Technological U., Singapore; and E.C. Leong, Nanyang Technological U., Singapore
In: Vol. 2, Page 773
What? Seepage and stability parametric studies
Why? To assess the efficiency of horizontal drains for stabilization of unsaturated slopes

Lessons Learned:
- Horizontal drains are ineffective in minimizing infiltration even during prolonged rainfalls
- Horizontal drains will be activated only when the soils surrounding the drains become saturated

Paper 12:
"A new simple analytical solution for estimating groundwater rise in a soil slope due to sewer or drain leakage."
By: L.T. Zhan, Hong Kong U. of Science and Tech.; C.L. Liu, Hong Kong U. of Science and Tech.; and C.W.W. Ng, Hong Kong U. of Science and Tech.
In: Vol. 2, Page 779
What? Development of analytic solution for unsaturated/saturated flow from leaking pipe
Why? To assess the rise of groundwater table

Lessons Learned:
- Description of the problem as a four-stage process was useful in obtaining a solution
- The approach is useful for evaluating the effect of groundwater rise the stability of slopes

3 CONCLUDING REMARKS

In addition to discussions related to the specific topic of each paper, overall discussions were conducted regarding different aspects of applied unsaturated soil mechanics. The major overall issues during the debate were as follows:

Foundations: Is it conservative or unconservative to incorporate unsaturated soil mechanics in geotechnical design?
Pavements: Is the performance of structures still governed only by those events in which the system components become saturated?
Slope stability: What stabilization measures are effective in unsaturated slopes?

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Unsaturated Soils

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