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Chairman's report: Embankments

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In Session 1 - EMBANKMENTS, there are altogether 20 papers written by authors from 7 countries in 3 different continents. A thorough and constructive review of each individual paper was presented by Professor D. T. Bergado, the able Discussion Leader of this Session. It is therefore not the intention of this Reporter to give further detailed account of the papers. Rather, a few thoughts pertaining to a broader picture of the subject area will be outlined.

The titles and authors of the 20 papers are tabulated in Table 1; furthermore, an attempt has been made to group the papers into a number of subsets as shown in Table 2. Since many of the papers deal with more than on subset listed, as such, the grouping is indeed subjective, serving only as a reference.

The papers presented in this Session cover a broad range of approaches and considerations in studying reinforced embankments and other earth retaining structures, which include theoretrial formulation, numerical simulation, model testing, laboratory testing and design methodology. All of the above are essential elements forming the wealth of knowledge upon which safe and economic design of reinforced earth structures can be achieved. One of the most encouraging indications gleaned from the papers is the increasing application of reinforced earth technology to "problem soils"; e.g. very soft clay foundation and claying fill.

As the practice of ground improvement moves into areas of problem soils and hostile environments, it is conceivable that the complex soil behavior and the uncertain site conditions will not allow us to carry out a design or analysis with a high degree of confidence. Thus field performance monitoring with extensive instrumentation remains a viable means to provide valuable and meaningful information to identify the prototype behaviour and to guard the safety of a structure. When properly documented, field records are the best information for case studies from which lessons can be learned and experiences can be shared. We therefore must report cases of both success and failure. Fortunately or perhaps unfortunately, of the 20 papers, none was dedicated to address failure.

The advancement and practice of soil reinforcement technology is somewhat unique in the filed of geotechnical engineering, because its activities are largely market driven, e.g. by the various reinforcing elements available on the market and the promotion of the manufacturers of their respective products. This is quite different from the normal progression of research, development and application in geotechnical engineering practice. In the field of reinforced soil the availability and the types of

Table 1. List of Session 1 Papers

1. Chilean experiences with geosynthetics in embankments
   P.M. Acevedo and C.A. Martinez
2. Effects of reinforcement rigidity on the behavior of reinforced soil wall-embankment system on soft ground
   M.C. Alfaro, S. Hayashi and N. Miura
3. Limit design of earth reinforcement methods considering displacement field
   K. Arai and K. Kasahara
4. Dynamic response analysis of geogrid reinforced steep embankment subjected to an earthquake
   T. Fujii, N. Fukuda and N. Tajiri
5. Creep behavior of laboratory embankment reinforced with geogrid
   H. Furuya, M. Toriihara and K. Hirama
6. Geogrid reinforced railway embankment on piles - monitoring
   E. Gartung and J. Verspohl
7. In situ failure test of high water content soft clay embankments reinforced by GHDs
   M. Kamon, T Akai, M. Fukuda and Y. Nanbu
8. Direction and magnitude of reinforcement force in embankments on soft soils
   S. R. Kaniraji
9. Geosynthetic-reinforced soil retaining wall using clay on a very soft ground for Hokuriku bullet train yard in Nagano
   K. Kojima, N. Sakamoto, M. Tateyama and O. Maruyama
10. Some factors affecting the structural performance of reinforced fills spanning voids
    C. R. Lawson, C.J.F.P. Jones and G.T. Kempton
11. Importance of strong motion in the design of earth reinforcement
    S.P.G. Madabhushi
12. Effect of geogrid stiffness on the resistance behavior of reinforced embankment under loading
    Y. Miyata, H. Ochiai and K. Kogure
13. Evaluation of effects of soil reinforcement using a new prototype shear apparatus
    H. Ochiai, N. Yasufuku, G.L. Xu, T. Yamaji and T. Hirai
14. Numerical simulation of beam-shaped soil structure reinforced by geosynthetics
    H. Ohta, S. Goren, A. Iizuka, T. Yamakami, K. Yamagishi and N. Moroto
15. A case history of the construction of a reinforced high embankment on an extra soft ground
    H. Oikawa, S. Sasaki and N. Fujii
16. Centrifugal and finite element modelling of reinforced embankments on soft clay
    J.S. Sharma and M.D. Bolton
17. Behavior of reinforced earth embankments on liquefiable sandy ground
    R. Uzuoka, M. Mihara, F. Oka and A. Yashima
18. A partial factor approach for reinforced fill slope design in Hong Kong
    H.N. Wong
19. Application of the velocity field method to stability analysis of earth reinforcement
    J.J. Yang, N. Moroto, H Ochiai and A. Suzuki
20. Review of design temperature for reinforced fill slopes in Hong Kong
    K.C. Yeo and P.L. R. Pang

Table 2. Grouping of Papers

EMBANKMENT FOUNDED ON SOFT & VERY SOFT CLAY FOUNDATIONS	ANALYTICAL SOLUTION & PREDICTION	SPECIAL CONSIDERATIONS IN DESIGN	MODELS NOT FOUNDED ON SOFT CLAY FOUNDATION
* Field performance and case study #6, #9, #15	*Analytical formulation #3, #8, #19	* Reinforcement #2, #8, #9, #20	#12,#14
* Parametric study using numerical solutions #2, #10	* Numerical prediction #4, #5, #14, #17	* Interface #11, #13, #14	
* Centrifuge model study #16		* Loading #5	
* Design considerations #1, #6, #8, #9		* Foundation soil #1, #9	
		* General #18	

merchandise appear to dictate the state of prevalent practice and application, while academic pursuit and fundamental research seems to lag behind. For the profession as a whole, I think it is important that a balance be maintained for research, development and marketing to warrant a healthy environment to nurture the continuing growth of this technology.

The performance of reinforced earth structures under seismic loading has been widely discussed, particularly after the 1995 Kobe earthquake. The fact that reinforced earth walls performed better than other types of earth retaining structures is reassuring, but our knowledge on the interactive behavior of a soil-reinforcement system during earthquake is still lacking. More fundamental and experimental research are indeed needed. Dynamic centrifuge model testing is one of the more promising research areas to understand the prototype behavior.

In short, I believe the use of reinforcing elements for ground improvement is still a young and emerging field in geotechnical engineering. Close cooperation and collaboration among the manufacturers, the users, and the researchers will give the impetus to advance the state of knowledge in reinforced soil technology.