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TC5 – Environmental geotechnics: Workshop report

TC5 - Géotechnique de l'environnement: Rapport sur le workshop

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1 SUBJECT AND AIM OF THE WORKSHOP

The TC5 workshop held on September 15th 2005 was devoted to present a discussion of the preliminary version of the TC5 report devoted to Environmental Geotechnics. This report is a scientific and technical state of the art addressed to practitioners and researchers in the field of Environmental Geotechnics. The preparation of the report was one of the main and most demanding activities of the TC5 during the period 2001-2005.

The primary aim in generating this report is to provide an overview of the state-of-the-art and the state-of-practice pertaining to three main areas of Environmental Geotechnics, viz., waste disposal by landfills, remediation of contaminated soils and underwater geoenvironmental issues. All three of these topics are considered from both scientific and technical points of view, and are covered for the purpose of both practitioners and researchers working in the field of Environmental Geotechnics, as well as individuals in other professional areas (e.g., chemical engineering, environmental engineering) who desire a comprehensive, yet relatively concise, overview of the field of Environmental Geotechnics.

The report describes the roles and functions of the fundamental components required for safe disposal of polluting materials or remediation of polluted lands from the standpoint of design, control and management. Attention also is given to research currently in progress that is devoted to improving our knowledge of design parameters significantly influencing the performance of modern landfill containment systems.

The task of the invited speakers was to describe the contents of the six chapters of the preliminary version of the TC5 report and to promote free discussion and contributions from the audience. In this regard, the workshop promoted cultural exchange among the TC5 members and geotechnical professionals interested in the field of Environmental Geotechnics.

The workshop agenda was organised according to the six chapters of the report. After introductory comments by the TC5 Chairmen, the following contributions were delivered (the main authors of each chapter are listed together with the speakers, in brackets):

Chapter 1. Design basics and performance criteria
R. Clark (S. Jefferis)
Chapter 2. Managing contaminated sites
S. Jefferis (S. Jefferis)
Chapter 3. Traditional and innovative barriers technologies and materials
A. Bouazza, C. Benson, E. Fratalocchi, M. Manassero, C.D. Shackelford (E. Fratalocchi)
Chapter 4. Underwater geoenvironmental issues
M. Kamon (M. Kamon)
Chapter 5. Landfill design within seismic areas
M. Maugeri, P. Seco e Pinto (P. Seco e Pinto)
Chapter 6. Education in environmental geotechnics
M. Manassero (M. Manassero)

A fruitful discussion occurred after each contribution and at the end of presentations.

2 INTRODUCTION

M. Manassero and C. Shackelford described the primary purposes and philosophy of the report. In particular, they elucidated the need to understand the role and functions of all of the fundamental components required for safe disposal of polluting materials or remediation of polluted lands for the purpose of proper design, control and management. The importance of the current research that is being devoted to the improvement of the knowledge on design parameters was also emphasized. Indeed, the introduction (and in some cases the reintroduction) of the concept of performance design and its increasing acceptance by the geoenvironmental community has led to reconsideration of the proper approach for the design of containment systems. With increasing emphasis on the need for performance-based design, the engineer must consider several additional aspects with respect the design of waste containment systems. These aspects include a knowledge of the contaminant transport parameters for the mineral (clay) barriers, drainage layers, geosynthetics, as well as the primary characteristics and properties of the waste in order to allow an estimation of the leachate quality and production over the landfill activity and post-closure periods. Today, most of these parameters are rather readily assessable whereas others are presently being investigated through research programs and, therefore, cannot still be considered fully reliable.

After this introduction, M. Manassero acknowledged the contributors to the report, including the members of TC5 who served as the focal points for preparation of each of the chapters, as well as a number of individuals, both TC5 members and others, who contributed to various parts of the chapters. In addition to the contributors, each chapter of the report was peer reviewed externally by a number of recognized experts, whose efforts were acknowledged, including: David Daniel (USA) and Jorge Zornberg (USA) for Chapter 1; Akram Alshawabkeh (USA) and Ian Hosking (Australia) for Chapter 2; John Bowders (USA) and Russell Jones (UK) for Chapter 3; Andy Fourie (Australia) and Mark Van den Broek (Belgium) for Chapter 4; George Buckovalas (Greece) and Edward Kavazanjian (USA) for Chapter 5; Pietro Jarre (Italy) and Hywel Thomas (UK) for Chapter 6. Special thanks also were extended to Rolf Katzenbach (Germany), who provided much of the impetus for this report during his tenure as the former TC5 Chairman.

Finally, the main contents of the two additional chapters, namely "Nuclear waste storage" and "Regulations and technical guidelines", that are currently in progress, were briefly illustrated by M. Manassero. The former is focused on further de-

veloping geotechnical knowledge and involvement in the field of the nuclear waste storage, whereas the latter focused on collecting, analyzing and summarizing the state of the art of the official regulations, technical recommendations and guidelines available worldwide.

3 DESIGN BASICS AND PERFORMANCE CRITERIA

The design basics and performance criteria in the field of Environmental Geotechnics are illustrated in the first chapter of the TC5 report. In particular, after a detailed collection of definitions and proper terminology, the primary phases and problems associated with design, construction, quality control and risk assessment are treated, to give an introduction for the following chapters and to define each term consistently and clearly. The chapter is divided into six sections, viz.: (1) Flow diagram, (2) Terminology and definitions, (3) Classification and characterisation, (4) Risk assessment, (5) Lifetime of components, and (6) Quality assurance and control. The effort to define reference terminology was particularly appreciated by all the participants, as its usefulness was widely recognised.

4 MANAGING CONTAMINATED SITES

After a detailed introduction on risk assessment and site assessment, this chapter focuses on the many different systems for remediation of contaminated lands that are discussed and analyzed in terms of technology, methodology and strategy. Sections are devoted to: (1) Environmental risk for geotechnical engineering, (2) General structure of contaminated land legislations, (3) Assessment of the site, (4) Practical consideration in remedial design and implementation, (5) Risks and risk based methodologies.

The chapter describes the evolving concepts of risk that have influenced the development of procedures for the management of contaminated land. However, the chapter is not a manual on contaminated land investigation nor on remediation procedures, since these aspects have been well presented elsewhere.

S. Jefferis pointed out that, in many countries, the management of contaminated land is now a commodity product underpinned by well established rules and regulations. As a result, clients now expect low cost products such that the involvement of senior experts may be limited to the role of review or the management of large or complex sites where their involvement can be financially justified. That contaminated land has reached the stage of a commodity product demonstrates that it should now be a standard item in the geotechnical engineer's toolbox. Furthermore, the geotechnical engineer must be able to establish a dialogue with the many environmental disciplines that are also involved today in environmental and sustainability issues. The geotechnical engineer also will have to develop an awareness of the social sciences which are important to the wider sustainability issues required for the development of many of today's projects. In addition to developing her/his expertise and maintaining links with environmental science professionals, the geotechnical engineer must understand the intellectual basis of risk management as applied to contaminated land.

5 TRADITIONAL AND INNOVATIVE BARRIERS TECHNOLOGIES AND MATERIALS

This chapter summarizes and develops some of the main geotechnical topics related to modern waste containment barriers. Extensive references are made to the available literature to offer the possibility to gain more insight on all the illustrated aspects.

The chapter essentially consists of two parts: traditional and innovative barriers. The technologies discussed in both parts are classified into two broad categories: liners and covers.

The basic assumption for the traditional barriers is that general the design and construction procedures for barriers can be considered to be mature areas of development such that the current primary research efforts are focused on:

- evaluation and quantification of key factors affecting the field scale;
- performance of component materials, such as compacted clay liners (CCLs), geosynthetic clay liners (GCLs) and geomembranes;
- evaluation of the service life of these components;
- evaluation and control of the stability of slopes involving composite liners; and
- development of specific models and related parameters for pollution risk assessment.

In particular, after an overview of the main parameters affecting the hydraulic conductivity at the field scale, and problems related to the presence of leachate (compatibility, sorption, dispersion, diffusion) are discussed in this chapter. The performance of GCLs compared with that of CCLs is also evaluated, since this currently is a 'hot' topic for the engineers involved in landfill design, construction and management.

The portion of the chapter devoted to innovative barriers provides an overview of some current and promising technologies for waste containment applications that are considered to be innovative from the viewpoint that their use has not gained widespread acceptance at the present time. In particular, an excellent overview of the concept of 'alternative covers' is presented, including monolithic and capillary barriers, geochemical covers, exposed geomembrane covers, and covers from pulp and paper mill sludge. The presentation also includes a discussion of some 'innovative liners', including reactive barriers, biobarriers, geochemical barriers, asphaltic barriers, glass liners, clay membrane barriers, lateritic soil liners, chemically stabilised clay liners, and polymer gel barriers.

6 UNDERWATER GEOENVIRONMENTAL ISSUES

The management and utilization of waste sludge and dredging are the focus of this chapter. Recent developments in dredging operations and containment techniques are also described. Waste and dredged sludge contamination can still be a daunting problem from a technical and regulatory standpoint. Many utilization techniques are available under a carefully controlled operation system. In particular, beneficial use of dredged materials as reclamation is introduced with case studies for land use. The chapter provides a basic description of the following topics: (1) General overview of underwater problems; (2) Basic characteristics of underwater materials; (3) Dredging operations, (4) Dredging and clean-up of underwater materials; (5) Spill water treatment; (6) Odour control; (7) Containment and isolation; (8) Remediation of contaminated sludge; and (9) Beneficial uses of dredged materials.

Dredging operations and containment techniques are highlighted as being among the most important issues. Waste and dredged sludge contamination are widely distributed in urban areas and, thus, a careful treatment is required.

Agencies at various levels, including industries and the public, have made progress in developing regulatory and technical approaches to the cleanup of the most contaminated sites and to identify sites that require the most rapid action. However, no single regulatory or technical approach will work in all situations. According to a variety of authorities, additional resources and new approaches that are being applied on all fronts, the possibility of environmentally friendly reclamation is proposed in

the chapter in order to solve the problems concerning a contaminated environment and waste management.

7 LANDFILL DESIGN WITHIN SEISMIC AREAS

The performance of solid waste landfills and lining systems during earthquakes is addressed and the analysis of solid waste landfill stability during earthquakes is presented. Both experimental methods and mathematical methods are described. Selection of design earthquakes is presented, as well as determination of material properties for dynamic analysis. The seismic response analysis and the assessment of liquefaction potential of landfills and foundations are discussed.

The dynamic response of geomembranes liners is addressed. Some case histories are described to illustrate the performance of solid waste landfills during earthquakes. Monitoring and safety control of landfills are analysed.

The contributors point out that the tools described in the chapter are very important to assist the design engineer in incorporating adequate design measures to prevent deleterious effects of earthquake shaking. All the essential steps of good analyses, whatever type of material or type of analysis are involved, should be performed with a degree of accuracy that is sufficient to ensure that the overall results are useful in guiding the engineer in the final assessment of seismic stability. This final assessment should not be based on numerical results, but rather should be based on the expertise of engineers who have the necessary experience gained from studies of past landfill performance and are, therefore, familiar with the difficulties in defining the design earthquake and the material characteristics, as well as the strengths and limitations of analytical procedures.

8 EDUCATION IN ENVIRONMENTAL GEOTECHNICS

The chapter begins by considering some points of view expressed by recognized geotechnical engineers and professors on the teaching of traditional and advanced geotechnics. Thereafter, an attempt is made to adopt the primary aspects of these points of views to education in Environmental Geotechnics to provide a consistent approach for teaching Environmental Geotechnics after a solid background on basic geotechnical principles has been achieved. Burland's (1987) triangle is applied to the teaching of Environmental Geotechnics and the considerations reported in the following are submitted for discussion, comments and contributions. Based on the aforementioned observations, a summary of an investigation on the main features of the undergraduate and graduate educational programs of some universities, primarily in Europe (EU) and United States (USA), is given in an attempt to frame the main trends arising from the different basic schools.

As concluding remarks, Environmental Geotechnics can be considered a discipline that diverges away from traditional geotechnics. Classical concepts and principles of geotechnics do not fail when applied to soil-waste systems; however, they must be applied with the understanding that concurrent processes and interactions must be taken into account. Analyses are complicated primarily by the reactions and interactions among materials. These reactions and interactions also introduce the greatest uncertainty into results.

Education in Environmental Geotechnics must consider the aforementioned aspects, in order to provide to engineers the necessary knowledge to properly address and solve soil pollution problems.

9 CLOSURE

At the end of the presentation of the TC5 Report's Chapters, the discussion from the floor was focused on the relevance of prescriptive design trends versus issues in Environmental Geotechnics, with particular reference to developing countries. The main conclusions led to an appreciation of the flexibility of this kind of design approach which allows calibrating environmental protection and remediation measures with the actual conditions and sustainability aspects of each specific country.

Moreover, some observations raised about the definition of Environmental Engineering role and skills within the more general field of Environmental Engineering. This particular point as been further discussed under the light of the General Report *Environmental Issues of Geotechnical Engineering* delivered by C. Shackelford at the Plenary Session C of this conference.

At the end of the Workshop, the TC5 Chairmen have pointed out the next very important event in the field of Environmental Geotechnics that will take place in Cardiff (UK) on June 26-30, 2006. The 5th ICEG, International Congress on Environmental Geotechnics, will be devoted to the opportunities, challenges and responsibilities for Environmental Geotechnics looking at the sustainable development. During this congress, a new and more comprehensive version of the TC5 Report will be presented and the main aspects of this matter will be again under observation and discussion within the Geotechnical Community.

Free copies of the report on CD were distributed at the end of the workshop to all participants