Technical Session 2-A: Deep Foundations and Retaining Structures

Séance Technique 2- A:

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1 INTRODUCTION

For the Technical Session 2a, 94 papers were submitted. This great amount covers a wide variety of topics dealing with deep foundations and retaining walls in general. The papers can be divided into the following categories:

- Investigation of pile behavior
- Piles under special loading
- Combined Pile-Raft Foundations (CPRF)
- Pile load tests
- Regulations and design
- Pile case studies and special applications of piles
- Retaining walls
- Modeling

2 OVERVIEW OF THE PAPERS

2.1 *Investigation of Pile Behavior*

The following presented papers give an overview of the investigation of pile behavior.

Results of PDA test and the connection to the dynamic stiffness of soft soils are explained by Rodriguez et al.

Hussien et al. analyze the soil-structure interactions for vertical and lateral loaded pile foundations and conclude that it depends mainly on the pile spacing as well as the load direction.

The shaft friction of bored piles in sand is discussed by Akbar et al. who share experiences from five pile load tests. The analysis of the pile load tests is carried out by various techniques. Furthermore back calculations are presented.

Verifications of boreholes roughness measurements systems are presented for large diameter drilled piles by Park et al. Laboratory verifications allow the definition of conditions. Sadrekarimi et al. focus on the surface roughness effects on the bearing capacity of piles in dry sand. Their investigation shows in all tests that the pile settlement at ultimate capacity due to shaft resistance was 9 - 10 % of the pile diameter.

The design, testing and monitoring of large diameter casing piles are discussed by Brinkman et al. The analysis of piles that were equipped with a grouting device injected after hardening of the concrete piles is presented. CPT's were carried out for checking the influence of the piles installation on the surrounding soil. Furthermore statnamic load tests were carried out.

Holman describes the behavior and mechanics of micropiles in rock and presents advanced analyses of load test. De Nijs et al. present the performance evaluation of the MT-pile applied in the IBIS Amsterdam project. The analyses show neither time-dependent behavior in the load settlement curves nor ultimate bearing capacity. The piles failure does not appear to be imminent.

Vidyaranya et al. present an interaction analysis of displacements which were observed for granular pile anchors which of granular piles modified by placing an anchor at the base to allow pullout and uplift forces.

Hazzan deals with the comparison between the behavior of coated and uncoated lightly loaded piles in swelling soils by full-scale static pull test on thirteen piles. He states that the coating of piles with plastic sleeves can lead to a reduction of the heave forces on piles in expansive clays.

Longterm consolidation settlement of skirted foundations for subsea structures in soft clay is discussed by Hernandez-Martinez et al. with the help of numerical investigations. The conclusion can be drawn that the long term settlement is underestimated if the remoulded zone is not taken into account.

2.2 *Piles Under Special Loadings*

Liquefying soils cause critical uncertainties in the analysis of piles and damage pile foundations on seismic loss assessment of structures (Haskell et al.). Adak et al. focus on the failure mechanism of piles in liquefiable soils due to earthquakes.

Studies into deep foundations subject to loading from soil collapsing into a deep sinkhole are presented by Sartain et al. Similar to that theme Areshkovych et al. discuss about soil base deformation features of the pile foundations on loessial and landsliding territories at static and dynamic loadings.

The earth pressure acting on single driven piles in sand is described by Sabry et al. The application of the method of initial parameters to laterally-loaded piles may cause difficulties that may be avoidable (Salgado et al.).

Rakotonindriana et al. discuss the behavior of a pile subjected to a cyclic horizontal loading. Mayoral et al. explain seismic performance evaluation of deep foundation system built in the lake zone area in Mexico City. The behavior of micropiles under vertical tension and compression loads are clarified by Farouk.

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2.3 *Combined Pile-Raft Foundations (CPRF)*

Due to the very successful use of the Combined Pile-Raft Foundations (CPRF) this topic is of interest worldwide.

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Justo et al. give a presentation of the performance of CPRF´s. They conclude that a 3-D method should be used to obtain usable results. The best method was identified to be the usage of embedded piles. The failure of individual piles does not cause a failure of the pile raft, but the failure of the whole pile raft needs to be studied.

Special aspects related to the behavior of CPRF´s are explained by El-Mossallamy et al.

The analysis of deformation of a CPRF constructed using reverse construction method is presented by Sonoda et al. Post-analysis of the foundation deformation as well as a 3-D analysis were carried out and compared to the results of a pile load test which leads to an estimation of reduced shear moduli of the surrounding soil.

Yamashita et al. discuss the settlement and load-sharing of a CPRF combined with grid-form soil-cement walls on soft ground. On the basis of the monitoring of a case history the load sharing between piles and raft, especially the soil-structure interaction is analyzed.

2.4 *Pile Load Tests*

The results of full scale vibro-driving tests on sheet piles are explained by Whenham et al.

The lateral reaction of piles by using free-field response is described by Kubilay Kelesoglu et al. El-Geneidy describes the advantages of combined load tests. Dynamic and static pile tests are compared by Santos et al. The experiences Manna et al. made with nonlinear vertical dynamic response of pile groups are compareable. Practical aspects of dynamic methods are defined by Svinkin et al. Load-settlement data and how to analysis them are explained by Dewaikar. Rapid load field tests are interpreted with a new guideline by Hölscher et al.

Experiences of testing piles in different subsoils and rock types are presented in the following papers. Düzceer et al. compare measured shaft resistance of in-situ load tests in limestone to computed values. The interpretation of the end bearing condition of bored and cast in-situ concrete piles using static pile load test results is explained by Thilakasiri. In very different subsoil van Paassen et al. did high load tests on VM-piles and MV-piles in Rotterdam. Føyn et al. report about a steel pile tested 13 years after installation. Dynamic load tests of piles in Poland are presented by Brzozowski et al.

2.5 *Regulations and design*

The papers of this category deal with the application of regulations as well as the design of pile foundation and retaining walls.

Schuppener et al. worked on the question “Eurocode 7 for geotechnical design – a model code for non-European countries?” by spreading geotechnical design examples to geotechnical engineers and institutes throughout Europe. The results of the final evaluation are presented.

El-Bordany et al. deal with the reliability of mooring dolphin structures and the corresponding safety factors to ensure a safe and economic structure by investigating the uncertainties of the structure as well as by determining the partial safety factors required for the codified structure.

Arnold et al. analyze the influence of unloaded walls on the stress distribution under raft foundations to point out the importance of the rising structure for the stiffness.

Building new pile foundations near by existing buildings may cause damages on those. How to avoid the risk on that is explained by Tonks.

El-Nahhas et al. deal with SPT-based probabilistic assessment of the skin friction of large diameter bored piles in sand to develop a risk-based design technique for pile skin friction.

Furthermore Cuira et al. present two simple tools for evaluating the complex interactions in a pile-like reinforced soil since 2D models are too simple and 3D models too complex: a module dealing with an elementary cell and a module dealing with a plate of any required geometry laying on a layered elastic medium. Both require a short time of calculation due to reduced complexity of the model.

2.6 *Pile case studies and special applications of piles*

Kooistra et al. report about the driving fatigue during installation of monopole foundations of a wind farm. The use of screw piles for floatation resistance is explained by Hsi et al. Wong et al. report about case studies on installation and dynamic testing of large diameter steel tubular piles in sand. A case study about RCC Piles in soft clays is presented by Yasin et al.

The stability assessment of bridges impacted by scour is presented by Sayed et al.

The paper by Kikuchi et al. introduces the changes adopted for pile foundations used in Japan´s port facilities and presents the latest studies on the bearing capacity at the base of open-ended piles.

Popsuenko et al. present the peculiarities of foundation construction during expansion of a concentrating mill of integrated ore concentration plant. Another case study to settlement reducing piles in Finland is presented by Avellan. Some comparative analysis of different type of piles in Kazakhstan are offered by Zhusupbekov et al.

Piles are used for soil improvement and settlement reduction, for example for large storage capacity cement silos and clinker deposits of an off-shore sandy fill (Auxilia et al.) or for foundation of viaducts (Guilloux et al.). Experiences about the estimation of bearing capacities of single piles in Estonia are presented by Mets et al.

Paikowsky et al. present their paper “Uncertainty in shallow foundations settlement analysis and its utilization in SLS design specifications”.

Design considerations for offshore structures in the Dead Sea are presented by El-Mossallamy et al. dealing with the complex geological and geotechnical aspects due to the difficult and dynamic environment of the Dead Sea foreshore.

2.7 *Retaining walls*

Ingram et al. presents a design methodology for retaining walls for the deep excavation in London using pseudo finite element methods. This methodology considers the wall friction conditions appropriate for the excavation sequence and vertical loading conditions and is compatible with EC7.

Pun et al. discuss the Geoguide 7, the guide to soil nail design and construction, describing the experiences in Hong Kong that have been made since publication.

Recent and future developments in quay wall structures are discussed by Richwien by mentioning the advantages and risks of the new design concepts.

Lateral earth pressure experiments with a large-scale shake-table are presented by Wilson et al. A new approach on seismically induced lateral earth pressure is presented by Al-Atik et al. Earth pressure acting on a vertical shaft in multi-layered soils is investigated by Lee et al.

Berthelot et al. deal with the swelling phenomena for the design of retaining and civil work structures pointing out that the swelling pressure is not an intrinsic parameter but depending on the soil-structure interaction and on stress or strain loading.

The paper by Munwar Basha et al. pertains to the pseudo-static seismic stability analysis of reinforced soil structures. Visone et al. explain the performance-based approach for seismic design of embedded retaining structures. Narasimha Reddy et al. present their paper to the theme "Pseudo-dynamic analysis of reinforced soil wall-effect of kinematics of sliding mass considering linear backfill response". Belezza et al. analyzed the stability of waterfront retaining walls in seismic conditions.

Oung et al. present predicted and measured settlements due to the installation and removal of sheet piles by the application of Barkan-Hergarden-linear summation as well as the Barkan-Hergarden-vertical spreading which show the same trend of settlements.

Model tests on reinforcement effect of an anchorage work added to the existing anchored sheet pile wall are shown by Morikawa et al. to investigate the effect of the additional anchorage on the bending moment of the sheet pile and the tension of the existing tie rod.

The damage in geogrid reinforced soil walls based on wall displacement is evaluated by Izawa et al. based on centrifuge tilting and shaking table tests. Furthermore research is done by Nakajima et al. who examine the effects of shaking histories and material properties on seismic performances of geogrid retaining walls and gravity type retaining walls. The seismic load results in an earlier occurrence of local bearing capacity failure. The examined behavior is explained by the difference in the pullout rigidities which is not considered by the design procedures.

How to reduce the deep dynamic compaction induced deflections of sheet piles by rectangular open trenches is explained by Tan et al.

The dynamic behavior of suction caissons in deep water floating is the theme the paper presented by Ejezie et al. deals with. Matveev et al. focused in their paper the aspects of the reconstruction of buildings in urban areas.

The construction of reinforced retaining structures by using tire treads is presented by Yoon et al. to be very effective. The pull-out load of tire treads was determined to be higher than the load of geogrid and geocells under comparable conditions.

Hegazy et al. present their studies about metallically reinforced earth (MSE-) walls. Probabilistic methods in the stability analysis of earth retaining structures are presented by Ejezie et al.

Škrabl et al. present solutions of selected problems of plasticity in soil mechanics by a simple upper-bound theorem applicable for the determination of earth pressure on embedded retaining structures. The design of blockwork walls is described by Christensen et al. A new limit equilibrium tool that takes into account the volume of backfill acting together with the wall is invented.

2.8 *Modeling*

The numerical modeling of the pile installation is a very important issue that needs further scientific research. The papers of Said et al. as well as Kinzler et al. emphasize on this special topic by presenting different simplified procedures and comparing it to experimental results. They offer a good overview of new approaches and models to be used.

Engin et al. investigate pile behavior using embedded piles because of its efficiency. The model in PLAXIS is validated by case histories as well as single piles tests. It is stated that the embedded pile is valuable for modeling piles and pile-raft foundations – especially for foundations with a great number of piles and for inclined piles. D´Aguiar et al. explain numerical modeling of piles under cyclic loading using an elastoplastic state dependent constitutive law. Aspects of the numerical modeling of pile installation are explained by Henke et al.

Oh et al. give some information about numerical analysis of Combined Pile-Raft Foundations (CPRF´s) in sandy and clayey soils. A barretted raft design for high-rise buildings applying 3D numerical tools is described by Leszczynski.

Soe et al. explain the back analysis of a deep excavation-pile interaction using a 3D finite element method. Numerical modeling of offshore piles in Incheon Marine Clays land the characteristics of lateral rigidity are proposed by Kim et al.

The invented numerical methods also allow to model retaining systems. Tavakolian et al. present three design cases of reinforced earth walls modeled by a geotechnical finite difference program. Aspects of the numerical modeling of a failed MSE wall constructed with marginal soils are shown by Kim et al.

Szavits-Nossan et al. explain the design of anchored structures by numerical modeling to face challenges in design regarding soil stiffness, drained and undrained soil behavior etc. Di Fonzo et al. give some remarks on the effect of soil-nail interface stress state on the determination of pullout resistance of driven nails. Also Nájar et al. report on 3D modeling of soil nailed excavations.

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