Workshop & Lectures on Piled and Piled Raft Foundations

Organised by: Centre for Infrastructure Engineering and Management and School of Engineering, Griffith University Gold Coast campus

Date: September 25-26, 2006
Venue: Building G06- Lecture Theatre 1.04
Griffith University Gold Coast Campus

See "Registration form" for daily registration

For additional information please contact (preferably by e-mail)

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Introduction

During the September Break at Griffith University, a Practice oriented Lectures and Courses are arranged in Pile Groups and Pile Raft Foundations.

The workshop (September 25-26) on pile groups and piled raft foundations will be conducted by Prof. Tatsunori Matsumoto and Dr. Kitiyodom from Kanazawa University, Japan. The other lectures on foundations and ground support case studies will be presented by Mr. Max C. Erwin & Mr. Jim E. Finlayson from Golder Associates, Melbourne; Mr. Patrick Wong from Coffey Geotechnics, Sydney ; and Dr. Jeff Hsi from SMEC.

These Workshops and lectures as described above for the September Event are selected with a view to compliment those which have already been presented in the previous lecture series and also, they are of direct relevance to on-going projects in Southeast Queensland. Prof. Tatsunori Matsumoto and Dr. Kitiyodom will concentrate mainly on the Workshop on pile foundations and piled raft foundations, an area in which Prof. Tatsunori Matsumoto has worked extensively now for more than a decade and has developed his own computer software. He has considered both static and dynamic loadings on the behaviour of piled raft foundations. In addition has also performed experiments with a Shake Table where earthquake loading can be simulated. Prof. Tatsunori Matsumoto will also present many case histories from Japan.

The unique presentation by Mr. Max Erwin and Mr. Jim Finlayson will be on the 300m high and 92 storey Eureka building pile foundation in Melbourne. Bored piles and CFA piles were used bearing in very high strength basalt and siltstone formations. Mr. Patrick Wong of Coffey Geotechnics has extensive experience on the design of bridge foundations, and, currently the expansion of the gateway project and others will need similar expert knowledge and as such would be of great value. Dr. Jeff Hsi, Manager Geotechnical Services at SMEC was actively involved in the Southeast Transit Project Section 2 (SETP2) in Brisbane, where steep excavations were inevitable in a narrow project corridor. Excavations as deep as 20m with near vertical surfaces were encountered at some locations and cost-effective soil nails were used in slope protection. The cut and cover Hawthorn Street Tunnel was also part of the same project. The same project also involved the Buranda tunnel below an existing railway line. Dr. Jeff Hsi will speak on these Geotechnical Challenges.

Registration Form / Tax Invoice

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Workshops on Geotechnical and Pavement Engineering

Griffith University, Gold Coast, 25-29 September 2006

TO REGISTER: email, fax, mail

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DETAILS OF ATTENDEE

First Name: Last Name:

Organisation:

Email:

Phone: Mobile:

Fax:

Post Address:

State: Postcode:

WORKSHOP FEES (*25-29 September 2006*)

Please indicate day of participation and total amounts

☐ **AUD $ 390** (*GST included*) for Monday, 25 September.

☐ **AUD $ 390** (*GST included*) for Tuesday, 26 September

TOTAL AMOUNT: [AU $]

PAYMENT METHODS

☐ **CHEQUE ENCLOSED**

All Cheques crossed and payable to Griffith University (Griffith University is GST registered, ABN 78 106 094 461) Mail cheques to Prof. A. S. Balasubramaniam, Griffith School of Engineering, Gold Coast Campus, Griffith University, PMB 50, Gold Coast Mail Centre, QLD 9726, Australia. ***Please enclose your registration form.***

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Please send your REGISTRATION / TAX INVOICE FORM **by 18th September** that will help us to operate this workshop more efficiently.

***PLEASE NOTE*: THIS REGISTRATION FORM SERVES AS A TAX INVOICE WHEN COMPLETED. PLEASE RETAIN A COPY FOR YOUR RECORDS.**

DAILY PROGRAMME

25th September 2006 (Monday)

08:30 – 09:00 am Registration

09:00 – 10:15 am Part 1: What's piled raft foundation?

Part 2: Various methods of analysis for single piles and pile groups

Prof. Tatsunori Matsumoto

In Part 1, fundamental issues of the piled raft foundation such as the design aspects, the concept of pile as settlement reducer, the merits of piled rafts over spread foundations, the favourable soil conditions for piled rafts, the types of piled rafts, and other pertinent materials will be introduced.

In Part 2, the analytical methods for single piles and pile groups will be extended to piled rafts; thus first the analysis of single piles and then the pile groups will be presented.

Simple methods such as the equivalent raft method, the equivalent pier method and the method of using settlement ratio of single piles to pile groups will first be presented, followed by detailed methods such as the load transfer method, the BEM and the FEM.

10:15 – 10:45 am Coffee break

10:45 – 12:00 am Experiments of piled raft models subjected to static loads

Prof. Tatsunori Matsumoto

The results of static load tests of model piled rafts in the centrifuge and under 1-g conditions will be presented. In order to demonstrate the performance of the piled raft, vertical load tests on the raft alone, the single pile and the piled raft were carried out in the centrifuge.

Horizontal load tests of the piled rafts were performed after the vertical loading stage. It is shown that not only the pile raft is effective to reduce the settlement, but it is also effective in resisting the horizontal load with the mobilisation of the raft base resistance.

The influence of the type of connection condition between the pile head and the raft is studied from the results of the

1-g model tests. Various pile head connection conditions from perfectly rigid to hinged type were investigated by varying the diameter of the connection bar between the pile head and the raft. It is shown that the hinged pile head connection reduces the bending moment of the piles and the inclination of the foundation subjected to horizontal loading; however the horizontal stiffness of the foundation seems to be only reduced in a very small amount.

12:00 – 01:30pm Lunch

01:30 – 02:45 pm Various types of analysis on piled raft foundations
Prof. Tatsunori Matsumoto

The analytical methods on piled rafts are categorised as:
(1) Simplified calculation methods
(2) Approximate computer-based methods, and
(3) Rigorous computer-based methods.

Among them, the following methods are briefly explained.

1) Simplified calculation methods
- Poulos-Davis-Randolph (PDR) Method
- Burland's Approach

2) Approximate computer-based methods
- Strip on Springs Approach
- Plate on Springs Approach
- Hybrid Methods: Combination of FEM and the theory of elasticity

3) More rigorous computer-based methods.
- BEM
- Methods combining boundary element for the piles and finite element analysis for the raft.
- FEM (two-dimensional and three-dimensional)

02:45 – 03:15 pm Coffee break

03:15 – 04:30 pm **Simplified Analysis of Piled Raft Foundations subjected to Active Loading and Passive Loading**

Dr. Pastsakorn Kitiyodom & Prof. Tatsunori Matsumoto

Considering current trends toward the limit state design (or performance based design) in the area of foundation engineering, precise estimation of the deformation of a foundation and the stresses of its structural members is a vital issue in the framework of this new design criterion. In the preliminary design stage, a number of alternative calculations are required, varying the number of piles, the pile length, the pile spacing, the locations of the piles, the size of the raft, and so on. Hence a feasible but reliable deformation analysis method of piled raft foundation is often sought for in the design and analysis.

This lecture will present a simplified deformation analysis program PRAB (Piled Raft Analysis with Batter piles) for the estimation of the deformation and the load distribution of piled raft foundations subjected to active loading (vertical load, horizontal load and moment) and passive loading (due to ground movement). In this program, a hybrid model is employed in which the flexible raft is modelled as a thin plate, the piles as elastic beams, and the soil is treated as springs. Both the vertical and horizontal resistances of the piles as well as the raft base are incorporated in the formulation of the model. The interactions between structural members, pile-soil-pile, pile-soil-raft, and raft-soil-raft interactions, in both vertical and horizontal directions are taken into account. The piles may be straight and/or batter piles. The considered soil profile may be homogeneous semi-infinite, arbitrarily layered and/or underlain by a rigid base stratum. PRAB can also be used for the estimation of the non-linear deformation of the foundations, due to the bi-linear (elastic-perfectly plastic) response of soil springs. The validity of PRAB was verified through comparisons with three-dimensional finite element analysis and model test results. These comparisons suggest that PRAB is capable of predicting reasonably well the deformation and the load distribution of single piles, pile groups and piled rafts.

DAILY PROGRAMME

26th September 2006 (Tuesday)

09:00 – 10:15 am Case studies on piled raft design

Prof. Tatsunori Matsumoto

More than ten case studies of piled raft foundations for buildings mainly in Japan are presented. The case studies include low-rise to high rise buildings and a coal silo structure. The case studies also include various soil conditions, sand, clay, alluvial ground and diluvial ground. Long-term observations of the behaviour of the piled rafts, such as settlements, loads carried by the raft and the piles, pore water pressure beneath the raft base, are presented. The observations on foundation behaviour during top-down construction method are also included. These studies revealed that the loads carried by the raft and the piles are relatively stable for a long time after the final completion of the superstructure.

10:15 – 10:45 am Coffee break

10:45 – 12:00 am Piled Raft Foundations Subjected to Seismic Loading

Dr. Pastsakorn Kitiyodom

Establishment of a seismic design concept for piled raft foundations is necessary especially in highly seismic areas. Although piled raft foundations have been used for the foundations of actual buildings in Japan, most piled rafts were treated as rafts alone in the seismic design, and the behaviour of piled raft foundations during earthquake has not been well explained. The current trends toward limit state design in the field of foundation engineering, requires the performance needs to be well explained. With this aim, the behaviour of piled raft foundations subjected to seismic load was further studied with a series of model load tests.

In this lecture, first the results from a series of shaking table tests on piled raft models on dry sand at 1-g gravitational field, and the results from the tests using a geotechnical centrifuge will be presented. Much focus was placed on the load-displacement relationship and the load sharing between the piles and the raft. A traditional seismic design method of a foundation in which dynamic loads acting on the foundation are modelled by an equivalent static

horizontal load and moment in order to predict the maximum seismically induced bending moment and shear forces in the pile. The importance of taking into accounts both inertial and kinematic effects in the analysis will be discussed. Finally some results of dynamic analysis of piled raft foundations will be presented.

12:15 – 01:00 pm Lunch

01:00 – 02:30 pm Foundations for Bridges—Case histories
Mr Patrick Wong, Coffey Geotechnics, Sydney

02:30 – 03: 45pm Foundation for Eureka Tower in Melbourne
Mr. Max Erwin and Mr. Jim Finlayson

03:45 – 4:00pm Coffee Break

04:00 – 05:15pm Ground support techniques used for cut slopes and excavations on South East Transit Project Section 2, Brisbane
Dr. Jeff Hsi, SMEC

Bio-data of Lecturers

Prof. Tatsunori Matsumoto

Prof. Matsumoto is now with Kanazawa University in Japan for nearly 32 years. He was educated at the Kanazawa University and received his Doctoral Degree from Kyoto University for his work on steel pipe piles in 1989. He has extensive research and practical experience on piled foundations and piled raft foundations. Prof. Matsumoto has a Shake Table Facility for the study of dynamic and earthquake type of behaviour of piled foundations. He has also worked on the centrifuge with pile groups and piled raft foundations.

His research work on piled raft foundations range from the simplified calculation methods of Poulos-Davis and Randolph (PDR Method), Burland's method to approximate computer based methods such as the strip on spring and plate on spring approaches and hybrid methods. He has also worked on more rigorous method using boundary elements and finite elements.

From his vast practical experience, Prof. Matsumoto has selected more than ten case histories involving piled raft foundations. These foundations are under various soil conditions. These studies involve the long term performance as well.

Prof. Matsumoto also has wide experience in the seismic design of raft and piled raft foundations. Prof. Matsumoto is the author of the computer software PRAB—Piled Raft Analysis with Batter Piles. With this software piled raft foundation can be analyzed with vertical and horizontal loads as well as moment .Prof. Matsumoto has travelled very widely and have lecture red in Piled foundation and Piled Raft Foundations. He has also published his research work in numerous journals and conferences.

Dr. Pastsakorn Kitiyodom

Dr. Pastsakorn Kitiyodom did his doctoral research work with Prof. Tatsunori Matsumoto on piled raft foundations. He is currently teaching and researching at the Kanazawa University. Pastsakorn worked in the development of the PRAB computer program for Piled Raft Analysis with Batter Piles. There are many instances in practice where batter piles are used to resist horizontal loads. Also, the deformation analysis is currently of interest in the limit state design approach. In this program, Pastsakorn used a hybrid model in which the flexible raft is modelled as thin plates, the piles as elastic beams, and the soil is treated as springs. Both the vertical and horizontal resistances of the piles as well as the raft base are incorporated into the model. The interactions between structural members, pile-soil-pile, pile-soil-raft, and raft-soil-raft interactions, in both vertical and horizontal directions are taken into account. The piles may be straight and/or batter piles. The considered soil profile may be homogeneous semi-infinite, arbitrarily layered and/or underlain by a rigid base stratum. The validity of PRAB was verified through comparisons with three-dimensional finite element and model test results. These comparisons suggest that PRAB is capable of predicting reasonably well the deformation and the load distribution of single piles, pile groups and piled rafts.

Dr. Pastsakorn also worked on Seismic and dynamic aspects of piled raft foundation. He used the shake table and the centrifuge in these studies. He then further continued with these studies to develop a seismic design method for piled raft foundation.

Patrick Wong

Patrick has been a geotechnical consultant ever since joining Coffey in 1979, and is currently a Senior Principal responsible for providing technical leadership, mentoring and coaching of staff, and providing high level technical advice and innovative ideas on major infrastructure projects. He has extensive experience on the investigation and design of bridge foundations. Examples of major bridge projects that he has worked include: My Thuan Bridge in Vietnam; Anzac Bridge in Sydney; Australia Avenue/Home bush Bay Drive Interchange in NSW; Karuah Bypass Bridge in NSW; North Kiama Bypass Bridge in NSW; Bridge across the Murray River between Robinvale in Victoria and Euston in NSW; and Widening of the Spit Bridge in NSW

Dr. Jeff Hsi

Dr Jeff Hsi is a Chief Technical Principal in Geotechnics of the Snowy Mountains Engineering Corporation (SMEC) and is presently based in Sydney. He was awarded a PhD in Geotechnical Engineering by the University of Sydney in 1992, and previously received his BSc and MSc in Civil and Geotechnical Engineering from the National Cheng Kung University in Taiwan in 1981 and 1983 respectively. Prior to joining SMEC in 1995, he worked with Moh and Associates, a leading consulting firm in Taiwan, from 1985 to 1988 and with Coffey Partners International in Sydney between 1993 and 1995. He was also a Research Fellow at Sydney University and the National Cheng Kung University and is currently a Guest Lecturer at the Western Sydney University. He has had over 30 technical papers published in Australian and International journals and conferences. Most recently, he has been the Geotechnical Design Manager for Westlink M7 (AUD $1.6B) in Sydney and Kallang and Paya Lebar Expressway C421 (AUD $300M) in Singapore. Over his 20 years professional career, he has managed and led geotechnical designs and studies for many large-sized multi-disciplinary projects both within Australia and overseas.

Max Erwin

Max Erwin, named as the Australian Civil Engineer of the Year 2001 by Engineers Australia and Geotechnical Engineering Practitioner of 2006 by the Australian Geomechanics Society, had his Engineering Education at the University of Melbourne. Max has now practiced for nearly 35 years starting with the then Country Roads Board of Victoria, State Electricity Commission of Australia, Consolid (South Pacific) Pty. Ltd, Coffey Geotechnics and Golder Associates. Now with Golders for nearly two decade (and earlier with Coffeys for a decade), Max is currently the Regional Manager for Victoria, New south Wales and South Australia and Director of Golder Associates (New Zealand) Limited. He was involved with numerous projects in several Pacific Island countries, as well as Bangladesh, China, Hong Kong, India, Laos, Malaysia, New Zealand, Philippines, Thailand and Vietnam.

Over the years Max is responsible for geotechnical investigation and design for a wide range of projects, including high rise buildings, roads, bridges, major

excavations, tunnels, industrial pavements, wharf developments, earthworks and reclamation, and industrial developments. He was also responsible for several regional and site specific slope stability studies and reviews. Max is consulted extensively on soft ground engineering and on piled footings as well. He was also an expert witness in various litigation matters.

Max is also a Past-Vice President for Australia of the International Society for Soil Mechanics and Geotechnical Engineering and a Fellow of Engineers Australia.

Jim Finlayson

Educated in Melbourne University Jim Flayson started his career with Golder Associates in Melbourne in 1991. After working for dour years, Jim spent some time with Beresford Blake Thomas and AF Holland Associates. He then worked for nearly two years in the Ove Arups & Partners Office in London and then in Melbourne with the Arups for a year. Jim now works for Golders again in the Melbourne Office for more than five years.

His experience with Beresford Blake Thomas in UK was mainly with contractors across UK on many projects including tunnels and site contamination assessments and earth works; With AF Holland Associates in UK, Jim worked on a 6km flood relief and sewerage tunnel.

While working with Ove Arups in London, Jim worked in UK, Channel Islands and also in Africa and Europe. He was also engaged in road and bridge duplications through areas of low rise buildings while working in the Melbourne Office of Arups.

With Golder Associates at Melbourne Jim was involved with the Eureka Tower in Melbourne, Fresh water Place and the new Melbourne Convention Centre. He did work on a large number of Civil Engineering projects including bridges and tall buildings, and also excavation and earth works.