SRILANKAN GEOTECHNICAL SOCIETY SLGS 1986

SLGS NEWSLETTER

SRI LANKAN GEOTECHNICAL SOCIETY

Established in 1986 A Member Society of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE)

n the Editor

2006 October: No 4

Three months have passed since you received the last issue of the SLGS Newsletter. During the last three months SLGS had several very successful activities, such as; monthly Geotechnical forums, conference on Geotechnical Engineering under difficult ground conditions, SLGS general meeting and the Project Day competition 2006. Further details of these events are given in the Newsletter.

October issue of the Newsletter contains an article from Dr. Jayantha Ameratunga on Recent Ground Improvement Techniques based on his presentation during the Geotechnical Forum held in June 2006. SLGS members are requested again to contribute articles on their experiences in the field of geotechnical engineering to the Newsletter. SLGS assumes that members have already submitted abstracts on their research work for the conference organized for the 20th anniversary to be held from 6th to 10th August 2007. SLGS members are invited to apply soon (to avoid disappointment) for the Short courses; the details of which are sent in a bulletin.

Finally, I would like to thank the few members who contacted me at udeni@cee.ruh.ac.lk to share their comments and advice and I am still waiting for contributions from the majority of members to enhance the quality of the newsletter.

Dr. Udeni P. Nawagamuwa – Editor Newsletter.

New Office Bearers of SLGS for the Session Commencing from August 2006

General Meeting of SLGS was held at 3.30PM on Tuesday, 15th August 2006 at ICTAD Auditorium Sawsiripaya, Wijerama Mawatha, Colombo 7 and the following members were selected as the new office bearers for the above session.

President -	Mr. Kirthi Sri Senanayake
Vice President -	Prof. Nimal Senevirathna
Hony. Secretary -	Mr. K.L.S. Sahabandu
Treasurer -	Mr. W.A.A.W. Bandara
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Editor-Newsletter -	Dr. Udeni P. Nawagamuwa
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	Mr. N.M.L.B. Nawarathne

Project Day Competition 2006

The annual SLGS Project Day competition for the undergraduates of Sri Lankan Universities who have done projects in the area of Geotechnical Engineering was held on 15th August 2006 in the afternoon after the General Meeting of SLGS at the same venue. 3 universities sent papers for the project day, namely, University of Moratuwa, University of Peradeniya and University of Ruhuna on the following themes respectively.

Developing a Foundation Design Software "GEOSOFT" , Development of Low Cost Early Warning System for Natural Disasters in Sri Lanka and Stability Analysis on Watawala Landslide under Different Critical Conditions: An application of Slope/W Software.

A panel consisting of senior engineers and academics assessed the papers and oral presentations. There were lively discussions on the projects, with encouragement and guidance given on how to improve the quality of their work. Each member of the project teams was awarded a certificate in recognition of their participation in the Project Day. SLGS anticipates larger participation at the Next Project Day and requests the Engineering Faculties to encourage their students towards this goal.

Conference on Geotechnical Engineering under Difficult Ground Conditions

SLGS organized its annual conference on the topic of "Geotechnical Engineering under Difficult Ground Conditions" on 15th August 2006 at ICTAD auditorium. More than 160 participants attended this successful conference. The abstracts of the presentations are given in page 4 and 5. Official opening of the conference by the then president Mr. D.P. Mallawaratchie is shown in the photo below.

Contents

Recent Ground Improvement Techniques

By Dr. Jayantha Ameratunga, Principal ,Coffey Geosciences Pty Ltd, Australia

This article outlines four case histories where ground improvement methods were used successfully. The case histories relate to:

- Dynamic Replacement
- Geofoam embankments
- Lime columns
- High strength geotextiles

Dynamic Replacement

The Dynamic Replacement (DR) technique (see Figure 1) was introduced to the world by Menard and is a variation of the stone column technique. The difference lies mainly in the construction. Stone columns use a vibratory probe to introduce gravel into the weak ground whereas in the Dynamic Replacement, gravel columns are constructed by repeated dropping of a heavy weight. Columns of 2m to 2.5m diameter and up to about 7m are generally installed by this technique. This is different to Dynamic compaction with the latter not very effective in fine grained soils and also the effect is shallower than for Dynamic Replacement. As the installation is relatively quick there are significant advantages in comparison to stone columns. The disadvantage is its limiting depth of about 6m to 8m depending on the soil strength as the columns tend to bulge, soil heave occurs at shallow depth. Another advantage of the Dynamic Replacement is the possibility of using lower quality gravel for column installation.

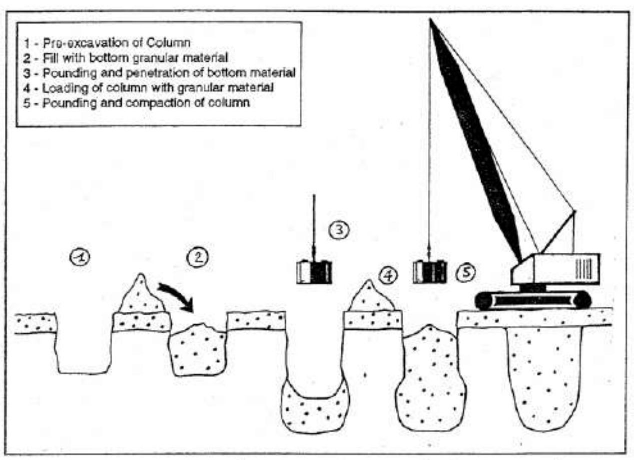

Figure 1

To assess the strength improvement to the soil mass, either numerical analysis such as Plaxis or Expressions developed for stone columns by Madav and Nagpure (1996) can be used. To assess the settlement, the stiffness increase due to Dynamic Replacement needs to be worked out. There are several methods in the literature and the method by Watts (2000) finds the equivalent stiffness based on the replacement ratio and the modulus ratio. For the current project the method of Poulos (2002) was adopted which is a modification of the equation of Watts.

Dynamic replacement was used successfully at the Alexandria City Centre project in Egypt. The site is underlain by up to 9m of very soft, organic clay and included the reclamation of part of a lake. The client needed shallow footings to cater for high design loads of 700kN with tight differential criteria of 1 in 1000. As the final layout was not finalised the ground improvement method adopted had to be innovative to ensure shallow foundations to be adopted.

Several options including rigid inclusions and vacuum consolidation were considered and finally dynamic replacement was adopted because of its speed of construction and cost effectiveness.

An important aspect of the design was that the thickness of the soft clay layer was too thick for the DR columns to penetrate fully. However wick drains and surcharging were used in combination with DR which allowed the full depth of the layer to be improved. DR diameter adopted was 2.5m and spacing of 5.5m was adopted for the main complex area.

Details of the design approach are published in Wong and Lacazedieu (2004). In summary, the following steps were taken:

i) one-dimensional settlement analysis without improvement.
ii) Preliminary assessment of settlement reduction due to DR columns using equations discussed earlier
iii) Three-dimensional finite element analysis using FLAC 3D

Geotechnical investigations (before and after) and extensive instrumentation and monitoring were used to assess the performance of the treatment. The results from Phase 1 were back-analysed and learnings used for subsequent stages. The design prediction and monitored results from Phase 1 are presented in the Figure 2:

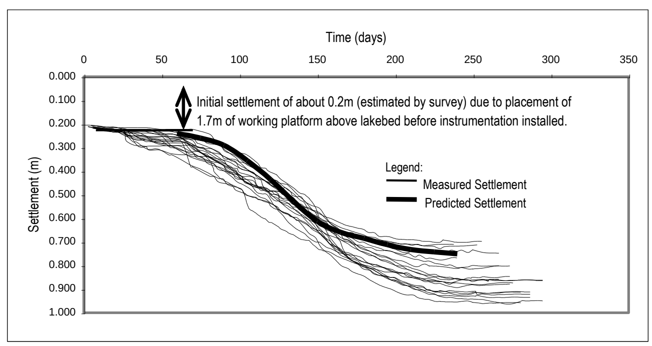

Figure 2

The following assessments were made based on settlement monitoring results and back analysis:

- On average, the settlement was under-estimated by 150mm to 200mm. This was assessed to be caused by a lower actual modulus of the DR columns based on the CPT results carried out through the columns after installation. The breakdown of particles of crushed limestone during pounding was assessed to be the reason.
- The estimated time-rate of settlement generally agreed closely with field performance.
- The gain in strength of the soft clay was higher than predicted. This perhaps is due to high lateral stresses induced in the soil due to the large displacement associated with the DR process.

Geofoam Embankments

A geofoam embankment is a structure comprising expanded polystyrene (EPS) blocks with a surficial pavement layer. The sides of the embankment could be vertical with a facing to protect the blocks, or it could be a conventional trapezoidal embankment with protection provided by soil cover. It is generally used in the following situations:

- Bridge abutments/embankments on soft ground – to reduce settlement (Figure 3)
- Stabilising embankments where the load from soil fill could lead to slope instability (Figure 4)

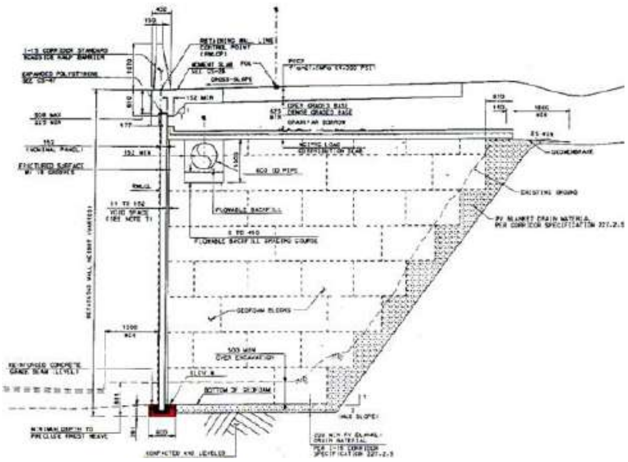

Figure 3 Typical Bridge Abutment

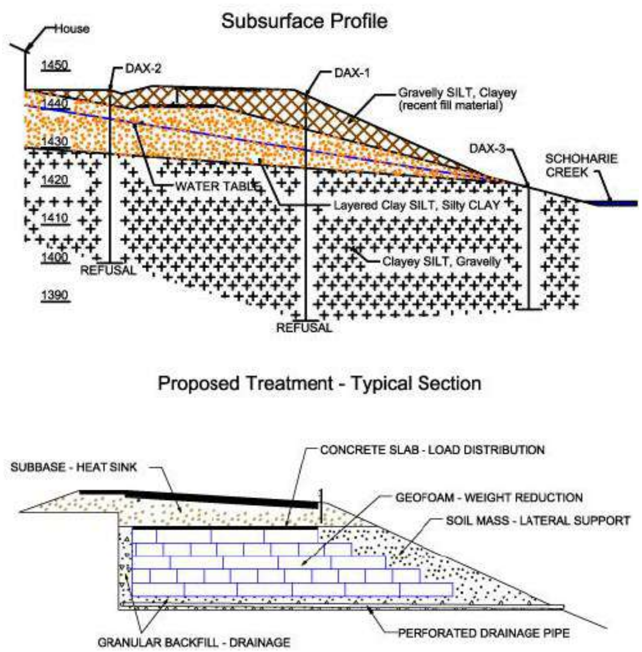

Figure 4

Design issues include:

- Internal/External stability
- Buoyancy of EPS
- Consolidation Settlements
- Bearing capacity of soils at base
- Pavement design
- EPS protection
- Vertical stress on EPS
- Geometrics
- Seismic issues

Analyses to address the above issues are based on conventional soil mechanics theory and therefore not discussed here.

Where the soils are normally consolidated and settlements have to be controlled, preloading/surcharging can be adopted prior to placement of EPS or consider excavation of soils and replacement with EPS.

There are many construction issues which need to be resolved for any site. They include stacking of blocks, connectors, shaping/cutting, wind (need for anchoring), protection of EPS from compaction stresses, handling HDPE, storage (UV & water), and allowance for light poles, signs & cross drainage.

Geofoam embankments were successfully used for the Port of Brisbane Motorway in Brisbane at the Lindum Road Bridge abutment (see Figure 5). The reason for this approach was the time available for full construction was insufficient for conventional treatment such as wick drains for the deep alluvial profile. As the soils were slightly overconsolidated the geofoam solution could be implemented without surcharging.

Figure 5. Geofoam embankments at the Port of Brisbane Motorway in Brisbane

Chemical Lime Piles

This method refers to introducing columns of quick lime into the soil without mixing. The procedure involves screwing a hollow casing to the desired depth, and the reversal of rotation and progressive withdrawal of the casing as the quick lime is injected, by compressed air, through the opening located at the bottom end of the casing. This method has been used in Japan for stabilisation of soft soils up to 45m deep.

Figure 6 illustrates the typical installation process of lime piles.

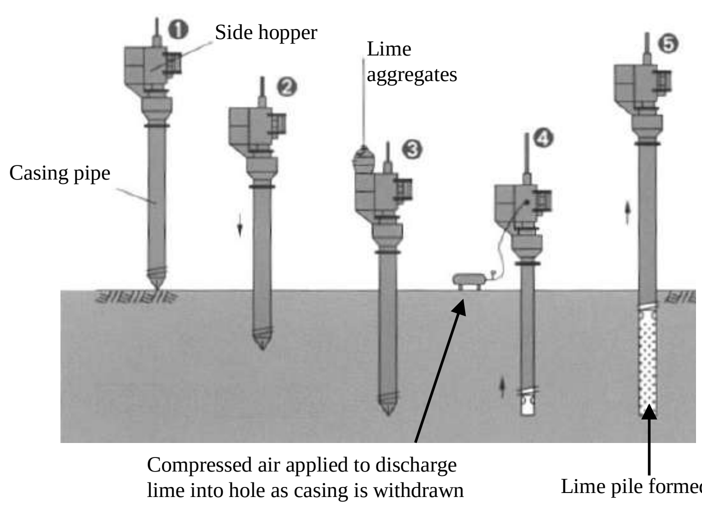

Figure 6. Chemical Lime Pile Installation Process

These lime columns have the following effects on the soil to be improved:

a. Consolidation / dewatering effect
b. Ion exchange effect
c. Pozzolanic effect

The dewatering/consolidation effect is the main process by which the strength of the soil mass is improved in the shorter term and the other effects are generally ignored in the design. The increased strength effects can be calculated by semi-empirical formulae developed by Onoda Chemicals Co. Ltd.

The method was successfully used for a Project in Penang (Malaysia), constructed during 2000 and 2001. In this project, 400 mm diameter lime piles were installed at 1.7m spacing to an 8m deep soft clay layer to achieve the following:

- To increase the passive resistance and reduce deformation for the shoring wall during basement construction.
- To improve trafficability at the base of the excavation during construction.
- To increase the stiffness of the soft clay layer for a piled raft foundation system that was proposed for the 23-storey tower structure.

High Strength Geotextiles

High strength geotextiles are often used to act as a basal reinforcement when embankments are constructed over soft soils. They were successfully used in a recent Project at the Port of Brisbane, Fisherman Islands. The project was a 4.6km long seawall to be constructed at the Moreton Bay, adjacent to a sensitive Moreton Bay Marine Park. The height of the seawall varied from 5m to 8m but the seabed was very soft, 3 to 5kPa undrained strength, and was not competent to act as a bearing stratum. As the weak subsoil profile was about 30m deep, the settlement during construction alone was more than 2m and the final height of the embankment was higher than the design value. The most economical solution was found to be the use of high strength geotextiles and a sand pancake to distribute the load to carry the weight of the rock wall and the armour protection (see Figure 7). The strength of geotextiles varied and ranged from 400 to 850kN/m (ultimate). In addition to the direct benefit the geotextile provided for stability and bearing, it also acted as a separator and reduced disturbance at the seabed. Figure 8 shows the completed seawall.

Madhav M.R. and Nagpure,D.D. (1996) "Design Of Granular Piles For Embankments On Soft Ground" Proc. 12th SE Asian Geot. Conf., Kuala Lumpur, 1: 285-290.

Oneda Chemical Co. Ltd. (undated) "Deep Soil Stabilisation Method – Chemico-pile Method" Technical Manual.

Poulos H. G. (2002) "Foundation Design For Very Soft Clays" Coffey Geosciences Pty Ltd Internal Research Development Report RD004/1-AB April 2002. (unpublished)

Watts, K. S., Johnson, D., Wood L.A. and Saadi A., (2000) "An Instrumented Trial of Vibro Ground Treatment Supporting Strip Foundations in a Variable Fill", Geotechnique 50, No. 6, 699-708.

Wong P. K. and Lacazedieu M. (2004) "Dynamic Replacement Ground Improvement – Field Performance Versus Design Predictions for the Alexandria City Centre Project in Egypt". The A. W. Skempton Memorial Conference, 29 to 31 March 2004, London.

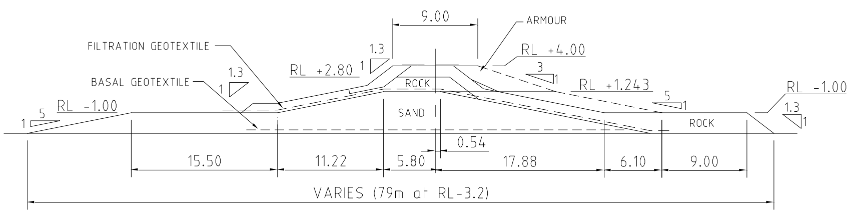

Figure 7

Figure 8

From the Conference on Geotechnical Engineering under Difficult Ground Conditions …………………

SLGS organized its annual conference on the topic of "Geotechnical Engineering Under Difficult Ground Conditions" on 15th August 2006 at ICTAD auditorium from 9.00AM to 3.00 PM. There were six presentations on Constructions on Problematic Soils, Improvement of Soft Clays with Prefabricated Vertical Drains, Improvement of Soft Peaty Clays by Electro Osmosis, Use of Geosynthetics, Use of Pile Foundations etc by the following researchers/ engineers, Dr. G.P.Karunarathna (Formerly at National University of Singapore),Prof. Manjrikar Gunarathna (University of South Florida), Mr. Kirthi Sri Senanayake (NBRO), Dr. Athula Kulathilaka (University of Moratuwa), Dr. Saman Tilakasiri (University of Moratuwa) and Dr. Udeni P. Nawagamuwa (University of Ruhuna)
All the participants received a hard copy of research papers presented. However, to give an equivalent opportunity to the SLGS members who could not attend the conference due to unavoidable reasons, six abstracts of the presentations are given in this section and if any member is interested to receive a copy of the proceedings, please contact Dr. Athula Kulathilaka (sas@civil.mrt.ac.lk)

Construction on Problematic Soils

Eng. Kirthi Sri Senanayake
Consultant, Geotechnical Engineering Divission, NBRO

With the growing population and rapid development, land hitherto considered as good quality ground for construction is becoming scare. With the scale of modern infrastructure becoming larger, builders and engineers are faced with the challenge of effectively utilizing the available poor quality land, yet ensuring the safety, stability and economy of the structure.
Difficult ground conditions are generally implied when general weakness or high degree of variability or complexity is encounter-red in the sub soil that are affected by the structural loads/ foundation pressure and/ or by the construction operations and could not be easily responded with conventional techniques.
In Sri Lanka, problematic soils with unique engineering characteristics do exist among the highly compressible peat and other organic soils found in the urban and coastal low lying areas, complex lateritic formations found in most parts of the wet zone, expansive soils occasionally observed in some dry zone areas, the residual soils found in the hill country and the unplanned man made earth/ waste fills now found almost everywhere, which often present difficult ground conditions that require specific geotechnical engineering solutions.

This paper gives an introduction to some problematic soils, their influence on construction, some ground/ structural improvement techniques available and some geotechnical factors to be addressed from planning to construction and maintenance.

Effects of intermediate permeable layers on the consolidation of soft clays with prefabricated vertical drains

Dr. Udeni P. Nawagamuwa
University of Ruhuna

For more than 60 years, vertical drains have been employed to promote more rapid consolidation of relatively thick deposits of fine-grained soils. Although the design of vertical drains is based on Barron's or Hansbo's theory considering the clay layer to be homogeneous, some field data from the improved grounds using the vertical drains have shown the advantages of modifying the commonly used equations to account for the presence of permeable laminations in the clay. As such there are clear advantages in doing a thorough study of the effects of intermediate permeable layers that could lead to an optimized design. In this paper, the effects of the presence of intermediate permeable layers and the effects of smear are discussed using the consolidation equations developed by considering the mass balance and variation of permeability and void ratio. Finite difference analysis has been done for the combined effect of vertical and radial consolidation and the results are given with two defined parameters, namely; $K=[k_s/k_c].[H_s/H_c]$ and $\alpha_{98}=t_{98(2D)}/t_{98(radial)}$. A new design methodology is proposed with a set of graphs and a design example.

Improvement of soft peaty clays by Electro Osmosis with Electro Kinetic Geosynthetics

Dr.Athula Kulathilaka
University of Moratuwa

Finding economical and speedy methods for the improvement of extremely soft peaty clays is a major challenge ahead of the Sri Lankan geotechnical engineers involved in new infrastructure development projects. Extremely soft consistency of soils encountered in some sites makes it impossible to place any fill without the use of reinforcements and separation layers. Even with that the construction will have to be done in several stages to prevent shear failures. In this context the possibility of consolidating the extremely soft peaty clays by electro-osmosis without application of a physical load was studied. Laboratory studies have indicated that the method would be feasible and the use of non corrosive electro kinetic geo synthetics has given many advantages. These studies should be supplemented by a well instrumented field investigation.

Construction with Geosynthetics in Difficult Ground Conditions

Dr. G.P.Karunaratne
Formerly at National University of Singapore

Geosynthetics have many advantages in construction on difficult ground conditions. Important aspects of using them include identifying their properties, behavior and proper application in the individual designs. Advantages of their use include cost saving, speed of construction and durability over other types of materials. It is also important for designers to keep the limitations in mind. Among the latter are damage during installation, effect of UV and sun light in weakening the original properties such as strength and permeability.

Stabilization of waste phosphatic clay settlement areas using phoscrete

Prof. M. Gunaratne
University of South Florida, USA

Florida (USA) is one of the largest phosphate producing areas in the world and hence phosphate mining is a principal industry in Central Florida. The phosphate extraction process has produced thousands of acres of phosphatic waste during the past few decades creating vast areas of highly compressible clays. Several stabilization methods have been used on phosphatic clays including vertical drains with surcharges, lime-columns, replacement and other methods. This paper describes an innovative method that uses a mixture of quicklime and other pozzolans called *Phoscrete* to stabilize phosphatic clay at a desired location. This is a relatively rapid and cost effective method compared to deep foundations, excavating and replacing, and surcharges. The study involved three investigative phases; 1) laboratory investigation of compressibility and shear strength properties of phosphatic clay, 2) numerical investigation of the optimal field implementation based on the finite element method, 3) field settlement monitoring of a phoscrete treated clay site and a control site. The results certainly indicate the effectiveness of the new stabilization method.

Development of negative skin friction on piles installed through soft compressible soils

Dr. H.S. Thilakasiri
University of Moratuwa

Utilization of grounds with soft compressible layers near the ground surface for development projects requires the use of pile foundations to support the structural loads. Therefore, in most cases the piles are installed through the compressible layers, which undergo consolidation settlement due to placing fills, lowering of the ground water table, pile driving etc. As a result of the consolidation of the surrounding soil, a frictional drag force commonly referred to as the 'negative skin friction' is developed on the pile shaft. The drag force is due to the skin frictional resistance between the pile and the soil layers above the consolidating layer. The concepts of the drag force, drag-down force and neutral plane are discussed in this paper with the help of some case histories of measured negative skin friction acting on steel piles. The mechanism of development of drag force is also discussed to investigate the effect of the drag down force on the estimation of the carrying capacity of end bearing bored piles and floating pile foundations consisting of precast concrete piles. Finally, the use of the new research findings in estimation of the negative skin friction in the design and testing of piles in Sri Lanka is presented.

Panel Discussion

A section of the conference participants

Forthcoming Conferences

(1). IIIrd Asian Conference on Unsaturated Soils (21 – 23 April 2007), Nanjing, China, www.geohohai.com/english/unsat.htm

(2). Geotechnical Engineering for Disaster Prevention & Reduction (25 – 27th July 2007), Yuzhno – Sakhalinsk – Russia. Contact: Prof. Askar Zhusupbekov, askarz@nets.kz

(3). Xth ANZ Conference on Geomechanics (21 – 24 October), Brisbane, Australia anzgeo2007@ccm.com.au

(4). XIIIth Asian Regional Conference on Soil Mechanics and Geotechnical Engineering (10 – 14 December), Calcutta, India. www.13arc2007.com

(5). **First Sri Lankan Geotechnical Society International Conference on Soil and Rock Engineering (6-11th Augusut, 2007), Colombo, www.slgssr2007.org**

The SLGS Newsletter comes to you in volumes of four fascicles issued in January, April, July and October in each year.

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Geotechnical Forums since the last issue

*August Geotechnical Forum was not held due to the conference on **Geotechnical Engineering under Difficult Ground Conditions in the same month.***
Measurement of Stress-Strain Relationships of Rock Ground by Field Tests by Prof. Kazuo Tani, Yokohama National University, Japan on 18th September

SLGS Journal

SLGS is planning to publish the next issue of the Journal within this year. Members are kindly invited to submit research papers and technical notes to the Journal. For further details please contact Dr. Athula Kulathilaka at sas@civil.mrt.ac.lk

Important Dates for *First Sri Lankan Geotechnical Society International Conference on Soil and Rock Engineering*

Abstract Submission Closes	October 2, 2006
Abstract Acceptance	November 3, 2006
Manuscript Submission Closes	January 5, 2007
Manuscript Acceptance	March 20, 2007

SLGS and ISSMGE Membership Fees

All the ISSMGE Members who still have not paid their membership fees for the years 2005 & 2006 are requested to pay any dues immediately to ensure their names are not deleted from the ISSMGE Membership List. **Members are informed that following membership fees are effective from next year.**

Membership Admission Fee	Rs. 200/=
Annual Membership Fee	Rs. 300/=
ISSMGE Fee	Rs. 1000/=

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