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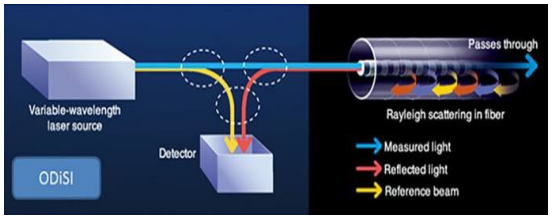
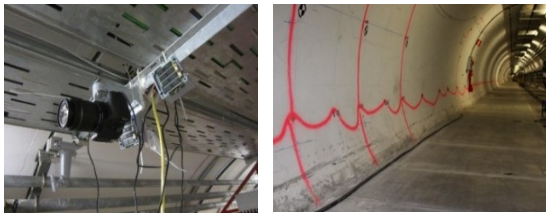
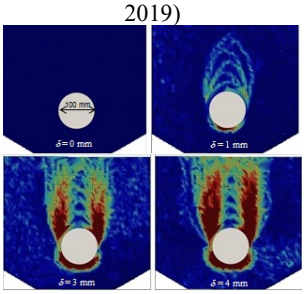


Benefits of standards for fiber-optic sensors in soil-structure interaction (After W. R. Habel and J. K. Jeyapalan, 2019)



Long-term Deformation Monitoring of CERN Concrete-lined Tunnels using Distributed Fibre-optic Sensing (After V. Di Murro, L. Pelecanos, K. Soga, C. Kechavarzi, R.F. Morton, L. Scibile, 2019)

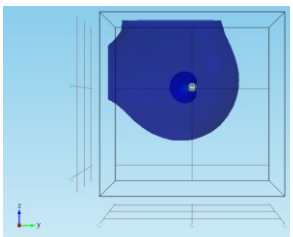
State-of-the Art of Geotechnical Monitoring with Geodetic Techniques (After W. Lienhart, 2019)



State-of-the Art Knowledge on Upheaval Buckling of Buried Pipelines (After N. I. Thusyanthan and D. Robert, 2019)

Distributed Optical Fiber Sensors for Strain and Deformation Monitoring of Pipelines and Penstocks (After D. Inaudi, 2019)

Smart Geosynthetics based on Distributed Fiber Optic Sensors in Geotechnical Engineering (After A. Wosniok and K. Krebber, 2019)



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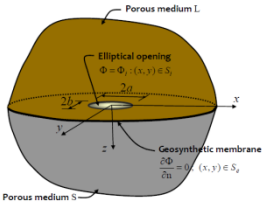

Loss of flexibility in geosynthetics subjected to chemical exposure: Experiments, constitutive models and computations and estimates for contaminant leakage (After A. P.S. Selvadurai, 2019)

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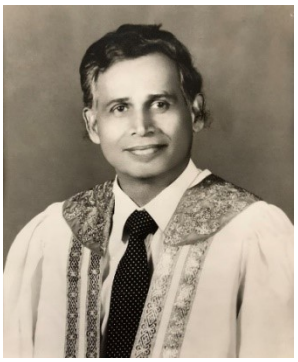
Recent Advances in Geomaterial-Structure Interaction and Fiber-optic sensors

Dedicated to late Professor Alagiah Thurairajah

Guest Editor: Dr. Jey K. Jeyapalan, P.E.



Alagiah Thurairajah

Alagiah Thurairajah fondly called as Thurai was a dedicated teacher and researcher. He taught Soil Mechanics to many students who are now spread all over the globe. A great mentor, Thurai is always remembered with much affection.

Thurairajah was born on 10 November 1934 in Imayanan, Udupiddy in northern Ceylon. He was the son of Velupillai Alagiah and Sellammah from Imaiyanan in Vadamarachchi He was educated at the Udupiddy American Mission College and Hartley College. Thurai graduated from, the University of Ceylon Colombo Campus with First Class Honours in 1957 by topping the list and maintaining a record performance. He earned the Ceylon Government University Scholarship to Cambridge University and worked with late Kenneth Harry Roscoe; he received his Ph D in June 1962: Soon his pioneering research became world famous as the Cam Clay Theory with Roscoe & Schofield with the original dissipation function he invented widely named as "Thurairajah's Theorem."

Thurairajah worked in London for Terreasearch Ltd in 1962 before returning to the University of Ceylon as a lecturer. He was the Dean of the Faculty of Engineering at the Peradeniya Campus of the University of Sri Lanka from May 1975 to September 1977, and February 1982 to February 1985 and the Dean of the Faculty of Engineering at the Open University of Sri Lanka from April 1987 to August 1988Thurai spent his sabbatical leaves in the University of Waterloo and the University of British Columbia. Thurai was appointed the Vice-chancellor of the University of Jaffna in 1988 and resigned in 1994 due to medical reasons. He died in 1994 in Colombo. He was posthumously awarded the Maamanithar (Great Man) honour.

Thurairajah was a fellow and a member of many Professional bodies: National Academy of Sciences (Sri Lanka); Institution of Engineers (Sri Lanka); and the Institution of Civil Engineers (UK). He was the president of the National Academy of Sciences (Sri Lanka) in 1986 and the president of the Institution of Engineers (Sri Lanka) from 1989 to 1990. He was an expert in geotechnical engineering and commanded all subject areas in Civil Engineering. He was an inspiration to all his students and he was always helpful in recommending them to excellent universities worldwide for higher education.

Thurairajah's contribution to engineering education in Sri Lanka is amply demonstrated by the following excerpts from Professor Thurairajah Memorial Lecture delivered by Professor Sarath Abayakoon-former Vice Chancellor of the University of Peradeniya in 2016.

"I have known Professor Thurairajah in several capacities, but in my mind his soul is mostly cemented as a great teacher and a great human being. When I could select a topic for today's presentation, I struggled initially but decided on the title "Ethics for University teachers " which, in spirit, captures Professor Alagaiah Thurairajah

exactly. I would like to select a few such as: respect for the autonomy of others (value free expression, conducive environment), doing no harm (physical or emotional, neither tolerating), being beneficial to others and accepting responsibility, fairness and equity (treating others the way we like to be treated), fidelity and honesty (integrity, follow through, respecting procedures), dignity (dignity of all, respecting diversity, do not exchange for popularity), caring (compassionate to all, exercising duties with care), and doing your best at all times (valuing the pursuit of excellence and taking pride in your work). Professor Thurairajah engaged fully in his job and was a great teacher and administater who inspired many generations of students. He went beyond his normal teaching duties to help his students.

I remember him asking me to call all young staff members to a lecture room at 5 pm. He would come in and start lecturing us on areas beyond the undergraduate programme. The lecture would go for two to three hours. The subjects include not only geotechnical engineering -the field of his specialty- but also mathematics, mechanics, finite elements and latest innovations in Civil Engineering. He encouraged us to read scientific papers. He would give me a paper and request me to explain it to him and my other colleagues the next day. This forced learning helped us to improve our presentation skills and critical thinking skills during our postgraduate studies abroad. Some of the advanced subjects were not new to us as they had been covered in Professor's informal lectures. Naturally all of us were at the top of the class at our respective universities."

"I noted his strong patriotism once again. The year was 1983 and the troubles broke out in Sri Lanka. Professor Thurairajah was in Peradeniya and he was requested to vacate his house by the Vice Chancellor, apparently to protect him from a possible mob attack. They had to live in one of the student residencies with other members of the academic staff who were also asked to move there. My supervisor in Canada, who was the Dean of the Faculty sent a fax to Professor Thurairajah requesting him to come to Canada. In fact, I was aware that the Dean has organized an academic position for Professor Thurairajah at the University of British Columbia. One day, my supervisor called me into his room and showed me Professor Thurairajah's reply. It contained two sentences. "Thank you very much for your kindness and help. But I will not leave MY country, whatever happens"

"Finally, let me add a very personal experience of mine that demonstrates how caring a person, Professor Thurairajah was. I was born and raised in Peradeniya and I was the only child for my parents. Professor Thurairajah sensed that my parents were worried about my trip to Canada for higher studies. He visited them one day and explained the importance of higher education for me and the benefits that the country can harvest upon my return. He also knew that my father was a heart patient[1] and took great efforts to lessen his agony. In fact, he visited my parents quite frequently at my home after I left the country, until he had to leave Peradeniya to assume a position at the Open University of Sri Lanka. Professor Thurairajah was a true patriot and refused many attrtactive offers for academic positions abroad to serve the mother land despite all the hardships that Sri Lankan Universities faced in 1980s. Professor Thurairajah's determination inspired many young academics to return to Sri Lanka and continue to follow the ethical values and academic traditions that Thurairajah established as a great University teacher."

Thurairajah married Rajeswari. They raised three daughters and two sons.

[1] Professor Abayakoon was not able to be with his father at the time of his passing away as he was in Canada doing his research work toward a doctoral degree at the University of British Columbia. He rushed home for the funeral.

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IEM Academy Sdn Bhd
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Email: <werner.lienhart@tugraz.at>

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Email: <ying.huang@ndsu.edu>

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PREFACE

June 2019: Issue on Buried Pipelines

There are 20 peer reviewed papers reporting on the recent advances in geomaterial-structure interaction and fiber-optic sensors forming this volume 50 Issue No. 2. The authors and the peer reviewers are to be commended for their devotion to their field of expertise and their initiatives to share their knowledge with others. The following synopses are intended for the readers pressed for time to spot the papers that are in line with their research interests.

The first paper is by V. Di Murro, L. Pelecanos, K. Soga, C. Kechavarzi, R.F. Morton, and L. Scibile on Long-term deformation monitoring of CERN concrete-lined tunnels using distributed fibre-optic sensing: The Centre for European Nuclear Research (CERN) uses large and complex scientific instruments to study the basic constituents of matter by operating a network of underground particle accelerators and appurtenant tunnels. Long-term safety and structural health of this critical infrastructure highlighted the need for a sensing plan that could provide remote monitoring and resistance to high radiation.

The second paper is by N. Noether and S. von der Mark on Distributed Brillouin Sensing for Geotechnical Infrastructure: Capabilities and Challenges.This paper addresses the implications of high spatial resolution to the accuracy of relative and absolute strain and temperature data from the perspective of the Brillouin optical frequency domain analysis (BOFDA) technology and outlines the need for a clear definition and a standardization scheme to make the terms dynamic range and optical budget comparable between different instruments and technologies.

The third paper by W. Lienhart is on State-of-the Art of geotechnical monitoring with geodetic techniques: This article reviews the state-of-the art and discusses the potential of current geodetic techniques. It is demonstrated that modern geodetic techniques are capable to perform long-term measurements with millimetre or even sub millimetre accuracy over long distances and completely remotely.

In the paper (fourth) by P. Rajeev and D. Robert on Performance Assessment and Failure Prediction of Corroded Cast Iron Pipes: Cast iron (CI) pipes are among the oldest buried assets in many water supply networks. This paper assesses the pipe performance using different theoretical pipe stress prediction models and 3-D finite element analysis.

The fifth paper is on Comparative study of distributed sensors for strain monitoring of pipelines by B. Glisic The aim of this paper is to compare performances of different distributed fibre optic strain sensors in terms of strain transfer quality, costs, and implementation approaches.

In the sixth paper on Instrumented Laterally Loaded Pile Test Using Distributed Fibre Optic Sensors by H. Mohamad, B.P. Tee, M.F. Chong, K.A. Ang, A.S.A. Rashid and R.A. Abdullah: The objective of this article is to present one of the earliest deployment of BOTDA optical fibre sensors in lateral pile load test in Malaysia under offshore environment and share invaluable lessons learned from the instrumentation process. Installation method, lateral load test setup and data interpretation are also discussed.

The seventh paper by C. Kechavarzi, L. Pelecanos, N. de Battista and K. Soga is on Distributed fibre optic sensing for monitoring reinforced concrete piles: This paper introduces the methodology and illustrates these advantages through an example obtained from an instrumented pile load test in

London. While it synthesises, several lessons learned in the application of DFOS for pile testing, it also supports the case for routine long-term monitoring of working piles.

The subsequent paper eight in the series is by Indrasenan Thusyanthan and Dilan Robert. This paper presents state-of-the-art knowledge on upheaval buckling, providing an overview on commonly used upheaval buckling soil models, latest uplift resistance results from experimental and numerical studies, investigations into the factors affecting the uplift resistance of soils and recommendations for design.

Indrasenan Thusyanthan is the author of the ninth paper on Cost Effective Free Span Rectification for Offshore Pipelines: Offshore pipelines often experience free spans due to uneven seabed, local scour or a storm event. When free span lengths are beyond acceptable limits, vortex induced vibrations (VIV) can cause pipelines to undergo fatigue damage and severely reduce the pipeline's design life. This paper presents a cost effective long-term free span rectification method known as "Pipeline Lowering."

The tenth paper is by D. Inaudi on Distributed Optical Fibre Sensors for Strain and Deformation Monitoring of Pipelines and Penstocks: The aim of this review paper is to present the main technologies used for distributed strain and deformation monitoring of pipelines or penstocks and illustrate their applications through several application examples.

Ravin N Deo, Chunshun Zhang, Jian Ji, Suranji Rathnayaka, Benjamin Shannon, Jayantha K Kodikara are the authors of the eleventh paper on A methodology for identification of pipe failure hotspots: This study provides a methodology that can be utilised for identifying pipe sections, which can be considered under high risk of failure. Application of the proposed methodology is demonstrated using a case study involving an in-service large (~1.7 km) critical water main in Sydney, Australia.

12th in the series is the paper, ADYTrack: Development of a Railroad Trackbed Model and Parametric Study of Track Modulus, by Asif Arshid, Ying Huang, and Denver Tolliver: In this paper, a finite element based three-dimensional (3D) model has been developed in MATLAB. This model has the capability to study the effects of track modulus, subgrade modulus, interactions between track and soil, the track geometry, and the wheel loads. The results of the ADYTrack are validated with other numerical models and full-scale field test results reported in the literature.

The 13th paper by Klar, A., Linker, R., and Herrmann, S., on Leakage-induced pipeline stressing and its potential detection by distributed fiber optic sensing: The paper aims to develop an approximated analytical solution to model the bending moment profile in a sewage pipe, buried within an unsaturated soil, which occurs because of a leak.

A. Wosniok and K. Krebber are the authors of the 14th paper on Smart Geosynthetics based on Distributed Fiber-optic Sensors in Geotechnical Engineering: This paper presents selected examples of smart geosynthetics based on Brillouin and Rayleigh scattering effects in incorporated fiber optic sensors for monitoring of large geotechnical structures like dikes, dams, railways, embankments or slopes. The focus of the presented work is on real field tests of measurement capability with respect to the chosen measurement principle and used fiber type.

The fifteenth paper is by A. P.S. Selvadurai on Loss of flexibility in geosynthetics subjected to chemical exposure: Experiments, constitutive models and computations and estimates for contaminant leakage : The paper presents results of recent research related to the development of advanced mathematical models for describing the behavior of strain rate sensitive materials such as geosynthetics that are used extensively as barriers to the migration of contaminants and other hazardous materials.

C. Prohasky, R. Vivekanantham, P. Rajeev, H. Bao, and S. Roy are the authors of the 16th paper on Monitoring of buried pipeline using distributed fibre optic technologies: This paper presents the development of distributed optical fiber sensing system, which combined acoustic-temperature-strain sensing to enhance the condition monitoring of buried pipeline.

The 17th paper on Benefits of Standards for Fiber-optic Sensors in Soil-structure Interaction is by H. R. Habel and J.K. Jeyapalan: This lack in standardization makes the acceptance of FOS technologies in SSIHM systems more difficult. Some success has been made in publishing first standards to fill this gap over the past decade. Much more effort is needed in this area and this paper gives an overview of what has been accomplished, what is in progress, and what obstacles were along the way. A case is made for a truly independent standard writing platform that can govern itself for the fiber-optic sensing industry composed of its sellers, buyers and subject matter experts.

The 18th paper is on Rational Methods of Steel Pipe Design Accounting for Poor Native Soils and Soil Migration by J. K. Jeyapalan, G. Leonhardt, P. Rajeev, and A. M. Britto: In poor native soils there is always a concern whether sufficient embedment support around the haunch and spring line level exists to prevent over-deflection of steel pipe. This paper reviews the fallacies surrounding methods on how to cope with poor trench wall conditions and provides a rational method. This paper covers soil migration, and the adverse consequences if not considered.

The 19th paper is one of the two contributed papers from the in house editors and is on Technical Challenges and Solutions for Super-Long Mountainous Tunnels at Great Depth by Yan Jinxiu. There are various technical challenges faced by the construction of super-long mountainous tunnels at great depth, and also a series of new requirements for tunnelling arising from such aspects as geological investigation, construction duration, special geological conditions (high ground stress, high geothermal temperature and high-pressure groundwater), disaster prevention & evacuation and social development. Based on analysis of the above-mentioned technical challenges, the paper presented technical views on solutions to those challenges and specified the objectives of related technical development in the future. To improve the validity and accuracy of the geophysical prospecting, it is necessary to not only increase the accuracy of ground geophysical exploration at great depth, but also carry out research on the application of such techniques to tunnel investigation as airborne geophysical prospecting and HDD combined with borehole geophysical exploration. To maximize the benefits of tunnel projects, it is of importance that more attention should be paid to those issues relating to the tunnel design concept, such as the multiple functions of tunnel projects, energy saving and emission reduction, and environmental protection. As for tunnel support theories, in addition to optimizing the current theories, some unconventionally new lining theories need to be put forth to make the tunnel structure more durable and economical. It is also suggested that, in terms of construction, sustained efforts should be put into the development of innovative tunneling techniques for a better, faster and more economical tunnelling, as well as the realization of intelligent mechanized tunnelling. When it comes to operation, it is obvious that there will be a trend towards intelligent maintenance in the future.

The 20th paper is on Risk Analysis and Countermeasure Study of Shield Tunnelling in Karst Stratum of China by Zhong Changping, Zhu Weibin, Huang Weiran, Zhu Siran and Xu Minghui. In China, many cities have the experience of shield construction practice in Karst stratum, such as Guangzhou, Nanning, Changsha, Wuxi and Dalian. In the Karst area, there are many construction risks such as groundwater inflow, sand inflow, surface subsidence, cutter head damage and expulsion-retarded of slurry shield. Based on the analysis of the development mechanism of the Karst and the practice of the shield tunneling in the Karst stratum of Guangzhou and Nanning Metro, the paper analyses the main

risks in the process of shield tunnelling, and according to concrete construction risks, it proposes concrete controlling measures from the aspects of planning of the line shallow buried, the pretreatment of the Karst cave and shield selection and construction control, which provides significant guidelines for the shield tunneling under the similar Karst stratum condition.

Dr. Jey K. Jeyapalan

GEOTECHNICAL ENGINEERING

June 2019: Issue on Buried Pipelines

Guest Editor: Dr Jey Jeyapalan

Dr. Jeyapalan graduated from the University of Sri Lanka with first class honors in Civil Engineering; from Monash University with a master's degree in Applied Mathematics; and from the University of California at Berkeley with masters and doctoral degrees in geotechnical engineering with minors in structural engineering and engineering mechanics. He also was an engineering professor in USA and Germany. He is a renowned global water, wastewater, desalination, oil and gas industry expert with over 40 years of experience in pipeline design, market positioning of new technologies, construction methods, trenchless technology, pipeline integrity assessment and rehabilitation, telecommunications, underground utilities and structures, hydropower penstocks and tunnels up to 14.6 m. in diameter, industry standards, codes and regulations, and sharing rights-of-way of existing pipelines to house optical fiber networks and other cables. Dr. Jeyapalan developed the techniques for evaluating the potential of flow failures and for preparing inundation maps for mine tailings impoundments in 1979 and these tools are still the state-of-the- art used by mining companies and regulatory agencies for selection of suitable sites for mine tailings disposal around the globe. Dr. Jeyapalan has worked as an expert witness on numerous lawsuits and claims for failures of pipelines made of clay, concrete, steel, ductile iron, plastics, and composites and underground cables. Dr. Jeyapalan has completed over 400 projects in Algeria, Australia, Austria, Canada, Chile, China, Egypt, Finland, Germany, Iceland, India, Italy, Japan, Korea, t h e Netherlands, Oman, Pakistan, the Philippines, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, the United Arab Emirates, the United Kingdom, and the United States. Dr. Jeyapalan's writings on pipelines, cables, sharing rights of way, and underground structures are used widely in engineering practice. He is the author of the 400+ page authoritative book "Advances in Underground Pipeline Design, Construction and Management," where he has shared his practical lessons with readers. He chaired the Executive Committee of the Pipeline Division of the American Society of Civil Engineers (ASCE) and the 1st and 2nd International Conferences on Advances in Underground Pipeline Engineering sponsored by the ASCE. Dr. Jeyapalan was the founding chair of the ASTM International Committee F-36, writing global standards on the last mile technologies, FTTX, underground utilities, cables, asset management, etc. He served on numerous other pipe and cable related standard writing bodies, technical committees and working groups within ASTM, AWWA, ASCE, Cigre', and IEEE. He is the author of over 200 papers and has taught over 100 seminars on underground pipelines and cables to engineers and contractors worldwide and is a registered professional engineer.

GEOTECHNICAL ENGINEERING

June 2019: Issue on Buried Pipelines

Edited by:
Dr Jey Jeyapalan

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ACKNOWLEDGEMENTS

Twenty papers are contained in this issue. The Guest Editor is Dr Jey Jeyapalan. No doubt the material contained herein would be most valuable to our profession. The editors have adequately described the contributions in the preface. They are to be congratulated for these contributions.

Dr. Teik Aun Ooi
Prof. San Shyan Lin
Prof. Kwet Yew Yong
Dr. Noppadol Phienwej
Prof. A. S. Balasubramaniam

GEOTECHNICAL ENGINEERING

Paper Contribution, Technical notes and Discussions

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Geotechnical Engineering Journal accepts submissions via electronic. The manuscript file (text, tables and figures) in both words and pdf format together with the submission letter should be submitted to the Secretariat and copied to the Editor-in-Chief, Geotechnical Engineering Journal, c/o School of Engineering and Technology, Asian Institute of Technology, Room no. 211, AIT Library, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand. Email: seags@ait.ac.th. Papers under review, accepted for publication or published elsewhere are not accepted. The guidelines for author are as follows:-

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7. The paper must have an introduction and end with a set of conclusions.
8. Practical applications should be included, if appropriate.
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12. Each author must use SI (International System) units and units acceptable in SI. Other units may be given in parentheses or in an appendix.
13. Maximum of five keywords should be given.

14. REFERENCES

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Website: http://www.seags.ait.ac.th

Ir. Kenny Yee

Hon. Secretary General
Association of Geotechnical Societies in Southeast Asia
E-mail: kenny.yeeks@gmail.com
Website: http://www.agssea.org

IEM Academy Sdn Bhd

Wisma IEM, First Floor,
21, Jalan Selangor,
46150 Petaling Jaya, Selangor Darul Ehsan
P.O. Box 224 (Jalan Sultan)
46720 Petaling Jaya, Selangor Darul Ehsan, MALAYSIA
Tel: (60) 03 7931 5296
Fax: (60) 03 7958 2851
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