Indian Society of Engineering Geology

The India National Group of the International Association for Engineering Geology and the Environment

(1965-2015)

Golden Jubilee Year

50 Years

International Conference on
"Engineering Geology in New Millennium"

EGNM

27-29 October 2015 | IIT Delhi, New Delhi

Keynote Abstract Volume

October 2015

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Coordination, Editing, Compilation:

Yogendra Deva

Co-chair & Convener Technical Committee, EGNM 2015
Head-Geology, ICCS Ltd, Bhilwara Group, A-12, Sector-1, NOIDA 201 301, India
IAEG Vice President for Asia
Email: yogendradeva@gmail.com; yogendra.deva@lnjbhilwara.com

Akhouri Bishwapriya

Superintending Geologist, Geological Survey of India
Lohia Nagar, Kankarbagh, Patna 800 020, India
Email: akhouri123@gmail.com

Published by:

M. Raju

Secretary
Indian Society of Engineering Geology
C/o Dy. Director General & HoD, Eastern Region, Geological Survey of India
Bhu Bijnan Bhawan, Block DK-6, Sector- II, Salt Lake City, Kolkata 700 091, West Bengal, India
Email: geolraju@gmail.com

Printed at Army Printing Press, 33, Nehru Road, Sadar Cantt., Lucknow 226 002;
Email: armyprintingpress@gmail.com, Phone: +91-522-2481164, 6565333

Foreword

It is a matter of great pride and privilege for me to introduce the "Extended Abstracts" Volume of the Indian Society of Engineering Geology that contains the essence of 29 keynote lectures, authored by a galaxy of erudite Earth Scientists and Technologists from across the globe. In fact, on the request of the Society, this devoted lot stole time from its crowded schedule and sent the contributions well in time, enabling us to print and release this Publication at the Golden Jubilee International Conference on "Engineering Geology in New Millennium" (EGNdM 2015) being held at IIT Delhi on 27-29 October 2015. The recordings of these keynote lectures would be web-streamed on the websites of the IAEG and the ISEG.

It has been the effort to encompass the whole gamut of topics that require attention of a practising Engineering Geologist. The objective has been to demonstrate the state-of-the-art knowledge on issues concerning safe and frugal designs of structures as well as an understanding of the natural forces impacting the environment and the society. The subjects incorporated in this Volume can broadly be grouped in to themes such as geotechnical engineering, exploration and tunnelling techniques, rock-soil mechanics, groundwater and natural hazards. It is heartening to note that all the Key Papers, 17 of which have been received from overseas, will be presented at the three-day deliberations of the EGNM International Conference.

The process of inviting, pursuing, receiving and compiling the keynote lectures has been a tough, but, pleasant job. On behalf of the Society and the Organising Committee of the EGNM 2015, I wish to place on record our appreciation to Shri Yogendra Deva, Head-Geology, ICCS Ltd., Bhilwara Group, and IAEG Vice President for Asia, for his role in gracefully carrying out this responsibility.

This Publication of the Society is an assortment of ideas and thought processes penned down by a group possessing vast experience, exposure and knowledge on various facets of earth sciences. I hope it would be greatly beneficial to the Engineering Geology fraternity, in general, and to the researchers, designers and planners, in particular.

Gopal Dhawan
President ISEG
Chair EGNM 2015
CMD, MECL

Schedule of Keynote Lectures Tuesday 27 October 2015				
S.No.	Time	Hall	Speaker	Title
1	11:00-11:30 hrs	'A' Main Auditorium (Seminar Hall)	Ramesh Narain Misra	Hydropower - Myths and Conjectures
2	11:30-12:00 hrs	'A' Main Auditorium (Seminar Hall)	S. P. Sen	TBM in Himalaya Case Study: Parbati II HRT Excavation by TBM
3	12:00-12:30 hrs	'A' Main Auditorium (Seminar Hall)	Robert Goldsmith	The Determinator: Engineering Geology and Hydropower Development in India
4	12.35-13:05 hrs	'A' Main Auditorium (Seminar Hall)	A. B. Pandya	New Frontiers in Geotechnical Engineering: Challenges and Opportunities
5	14:20-14:50 hrs	'A' Main Auditorium (Seminar Hall)	Shuichi Hasegawa	Engineering Geology in Active Mountain Belts-Application of Knowledge from Japan to the Himalaya
6	14:50-15:20 hrs	'A' Main Auditorium (Seminar Hall)	Bimalendu B. Bhattacharya	Understanding the Emerging Potential of Geophysics for Novel Application in Complex geotechnical problems
7	16:20-16:50 hrs	'A' Main Auditorium (Seminar Hall)	Martin Culshaw	How to Write a Paper
8	16:50-17:20 hrs	'A' Main Auditorium (Seminar Hall)	Joe Roby	Application of TBMs in Tunnels in the Himalaya
9	17:20-17:50 hrs	'A' Main Auditorium (Seminar Hall)	Paul G. Marinos	Tunneling in Difficult Ground

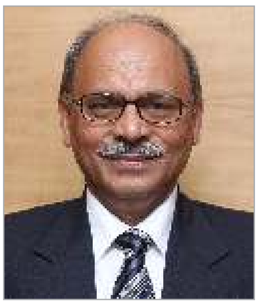
Wednesday 28 October 2015				
S.No.	Time	Hall	Speaker	Title
10	09:30-10:00 hrs	'A' Main Auditorium (Seminar Hall)	Helen Reeves	The Challenges of an Engineering Geologist in the Digital Era of Communication
11	09:30-10:00 hrs	'C' Block V (Lecture Theatre)	Rajinder Kumar & Bhasin Bhoop Singh	Cost effective method for early warning of rainfall induced landslides in Asian countries
12	10:00-10:30 hrs	'A' Main Auditorium (Seminar Hall)	Faquan Wu	Large Deformations in Tunnels
13	11:50-12:20 hrs	'A' Main Auditorium (Seminar Hall)	Rajbal Singh	Issues in Rock Mechanics Testing for Hydropower Projects
14	11:50-12:20 hrs	'C' Block V (Lecture Theatre)	Surya Prakash	Natural Disasters in the Himalaya-Lessons Learnt and Way Forward
15	12:20-12:50 hrs	'C' Block V (Lecture Theatre)	Arindam Basu	International Practices in Engineering Geology: Education in India
16	14:15-14:45 hrs	'A' Main Auditorium (Seminar Hall)	Carlos Delgado	Soils Prone to Volume Instability and Unstable Structure: Proposals for Improvement
17	14:45-15:15 hrs	'A' Main Auditorium (Seminar Hall)	Victor Osipov	Shear resistance as a Multifactor Parameter of Soil Strength
18	15:15-15:45 hrs	'A' Main Auditorium (Seminar Hall)	Ricardo Oliveira	Role of Environment in Project Optimisation

Wednesday 28 October 2015				
S.No.	**Time**	**Hall**	**Speaker**	**Title**
19	16:05-16:35 hrs	'A' Main Auditorium (Seminar Hall)	M. M. Madaan	Energy Development Scenario in India
20	16:35-17:05 hrs	'A' Main Auditorium (Seminar Hall)	Viswanathan Balachandran	Engineering Geology Development of Hydroelectric Projects in Peninsular India
21	17:05-17:35 hrs	'A' Main Auditorium (Seminar Hall)	Prabhas Pande	Seismotectonic Constraints in the Development of Hydropower in the Himalaya
22	17:35-18:05 hrs	'A' Main Auditorium (Seminar Hall)	Sujit Dasgupta	Foreland and Hinterland Structural Features Across Himalaya: Exposition and Seismic Propensity

Thursday 29 October 2015				
S.No.	**Time**	**Hall**	**Speaker**	**Title**
23	9:30-10:00 hrs	'A' Main Auditorium (Seminar Hall)	Louis N. Y. Wong	How Do Rocks Fail?
24	10:00-10:30 hrs	'B' Block IV Lecture Theatre	Runqiu Huang	Landslides and GLOFs in Eastern Tibet and their Response to Global Climate Change
25	10:30-11:00 hrs	'B' Block IV Lecture Theatre	Mohd. J. Ahmed	Rock-cut Slope Stabilization – A Systematic Approach in the Design and Construction
26	11:35-12:05 hrs	'A' Main Auditorium (Seminar Hall)	Scott F. Burns	Urban Landslides: Challenge to the Forensic Engineering Geologist and Geotechnical Engineer
27	12:05-12:35 hrs	'A' Main Auditorium (Seminar Hall)	Ann Williams & Sian France	Groundwater Drawdown and Consolidation Settlement Effects of Deep Excavations in Urban Areas – Predicted Versus Measured
28	12:35-13:05 hrs	'A' Main Auditorium (Seminar Hall)	Janusz Wasowski	Advanced Satellite Monitoring of Road and Railway Infrastructure in Landslide-prone Areas

Contents

Hydropower - Myths and Conjectures



Ramesh Narain Misra

About Speaker

Ramesh Narain Misra has a career spanning about 37 years in Power Sector. He is a Civil Engineering graduate from Allahabad University and a post-graduate in Water Resources Engineering from prestigious IIT, Delhi. He has earned Maters in Business Administration with specialization in Finance. He is Fellow of Institution of Engineers as well as Institution of Public Health Engineers, India.

He is Chairman and Managing Director of SJVN Limited, a schedule "A" Miniratna Central Public Sector Undertaking. Prior to being appointed as CMD, he was Director (Civil) and credited with timely completion of 412 MW Rampur Hydro Power Project. Ministry of Power, Government of India awarded two units of this project with Gold Shield and Silver Shield for early completion of project.

Prior to joining SJVN, he had served NHPC for 31 years in various capacities. He has vast experience in project implementation, investigations, planning, Environmental aspects, project appraisal, commercial aspects and contract management of large projects. He has also actively contributed in diversification of SJVN into thermal, wind and solar energy. He has to his credit more than 35 papers published in various journals and presented in National and International Conferences/ Seminars.

Extended Abstract

It is inherent for human beings to fear the unknown, the complex and the unexplainable; reason being, the projections we make onto the unknown based on the little knowledge we possess. In other words, FEAR is nothing but False Evidence Appearing Real. It is human nature to believe the negative over the positive. If you give the public two contradictory facts, chances are they will pay more attention to the scary and threatening one, even if it is false. Most do not fact-check before forming an opinion, and the result, we are surrounded by myths and conjectures – the untrue ideas or opinions formed without proof or evidence.

But once the truth is revealed, the unknown and unexplained becomes acknowledged and accepted. Though the process is time-consuming, the truth does always come on top at the end.

Human beings have been harnessing the power of flowing water to perform work for thousands of years. The Greeks used water wheels for grinding wheat into flour more than 2,000 years ago. In 1882 itself, the world's first hydroelectric power plant began operating in the United States in Appleton, Wisconsin, with an output of about 12.5 kilowatts. India's first Hydro-Electric Power Station - Sidrapong Hydel Power Station, with 2 x 65 kW capacity was commissioned at Darjeeling on 10 November 1897. But 118 years into the use of this technology, India has only utilized (tapped) 27.75 % of its hydro-power potential. It may seem odd that under the ever-growing threat of global warming and other environmental disasters, some still oppose the industry's attempt to shift toward clean, sustainable energy. Many people support hydropower and other renewables in theory but disapprove of it in reality. Why? It is likely that their knowledge about the industry is limited. As a result, we are often left with myths that are scary in nature but false in their essence. Granted that making electricity from falling water can seem like magic, it is filled with such myths that instigate public opposition.

Many a misconceptions/dogmas plague the development of hydro power and cause unnecessary tension and disapproval in the public eye. Here, we'll separate fact from fiction when it comes to Hydropower and its importance/usefulness.

• Myth no. 1: Hydropower projects cause enormous submergence and extensive displacement

Bust: Submergence and displacement due to the hydropower projects are often exaggerated. Based on a study conducted by Indian National Hydropower Association comprising 15 hydroelectric plants with capacity ranging from 60 to 2000 MW, on an average, the area of submergence is only 0.90 ha/MW and displacement of persons is only 0.22/MW. Thus the land requirements are not enormous and neither are the displacement figures.

• Myth no. 2: Hydropower project emit green house gases and hence is not a 'cleaner' source of energy - Some critics of hydropower claim that this source of energy is not, in fact, carbon-neutral. They claim that some hydropower dams create more greenhouse gases than a fossil fuel plant of the same size. If soil and vegetation are trapped in turbines, spillways and surfaces of a dam, they will decay and emit methane and carbon dioxide.

Bust: Green House Gases (GHG) in a balanced condition keeps the earth's surface warmer in the range that is suitable for living beings. Certain human activities however add to the concentration levels of most of naturally occurring green house gases and become responsible for climate change also known as global warming. Green house gases are emitted by virtually every economic sector, including residential and commercial energy use, industrial processes, electricity generation, agriculture and forestry.

To assess the impact of GHG, frequently applied yardstick in international discussions is the power density ratio (Watts/m2) i.e. ratio of power generation capacity per unit of reservoir area. The thumb rule is that if power density ratio is more than 0.5 Watts/m2, we may assume that such hydropower project has a lower green house effect than from an efficient fossil fuel power station.

For eligibility of hydroelectric power project for CDM benefits, UNFCCC also uses the criteria that in case power density ratio is more than 10, the emission from reservoir may be treated as nil and project shaving power density ratio between 5 to 10, an emission of 100 gm CO_2/kWh may be considered. Most of the hydropower plants in India have power density ratio more than 10 confirming that GHG emissions from them is almost nil.

• Myth no. 3: Hydropower is Costly.

Bust: Capital costs of hydro projects ranges between INR 6 cr to 10 cr / MW compared to INR 3 cr to 5 cr / MW for thermal plants. But even if hydropower appears costlier to thermal power on initial capital costs, the generation cost of hydropower being insulated from fuel inflation, will be cheaper in later years.

Further, the specific cost of generations of hydropower would depend on the structures involved and load factor. But it may be technically incorrect to compare the cost of generation of thermal and hydropower without bringing them on a common base taking into account the value to the system, increase in fuel cost and O&M expenses over the years and the effective life span.

Estimated levelised cost of electricity (LCOE) for plants to be commissioned in 2019 (USD/ MWh) comes out to be 95.6 for Conventional coal fired, 115.9 for Integrated coal-gasification combined cycle (IGCC), 96.1 for Nuclear, 80.3 for Wind, 204.1 for Wind – Offshore, 130 for Solar – PV, 243.1 for Solar thermal and 84.5 for Hydropower (Source : US Energy Information Administration).

• Myth no. 4: Hydropower Projects cause Eviction of Tribal and adversely affect their culture

Bust: It is often said that tribals living in pristine forest area and cultivating fertile land for livelihood are forced to abandon their places and drift in to uncertain future. This is not true. In case of Arunachal Pradesh, the tribals practice jhoom land cultivation (Slash and burn) – a type of cultivation in which tribals shift from one area to another for the purpose of cultivation. Once highway or good connecting road has been constructed by Border Roads Organization (BRO), it was observed that the tribals shift location of their houses near to the roads so that they can keep themselves linked to district centre and other places.

Ethnographic studies are undertaken before formulating R&R plan for acquainting with the special traditions, social customs and habits of tribals. These tribals are settled in a homogenous group and all efforts are made to create environment/ surroundings similar to that in which they were living prior to displacement. The goal of resettlement efforts is to provide an opportunity to improve the quality of life for the affected tribal community while preserving their cultural heritage.

• Myth no. 5: Dams are unsafe against earthquakes

Bust: Doubts have been raised about safety of Dams against earthquakes in specific cases. All dams are adequately designed with ample factor of safety under worst conditions for all forces including seismic forces during earthquakes. Technology and expertise are available in our country for designing any structure to withstand forces unleashed during the earthquake.

Indian Dams have proven safe against seismic forces even in zone-V like in the North-Western region of Himalayas viz., Bhakra, Pong, Pandoh, Ramganga and Salal dams when the area was visited by earthquakes of high intensity.

• Myth no. 6: It disturbs ecosystem especially affecting the aquatic life

Bust: It is a fact that hydropower projects have positive as well as some negative impacts on ecosystem. The aim and endeavor should be to address properly and mitigate the negative impact to the extent possible by planning and implementing appropriate Environment Management Plans. The Bio-diversity of the area is conserved as a part of the project through compensatory and voluntary afforestation, Catchment Area Treatment and conservation of flora & fauna.

Also, Environment Agencies nowadays require that stream levels must be maintained at a certain level in order to sustain the life within. A small amount of energy compromise may result, but this will ensure that the project does not have adverse effect on aquatic life. It has been observed that reservoirs cause increase in resident fish population and other fish predator populations besides attracting large number of aquatic and migratory birds. At the same time proper mitigatory measures are undertaken to conserve the migratory fish species also.

WHY HYDROPOWER

Hydropower is a clean source of energy. It does not pollute the air like power plants that burn fossil fuels. Hydropower plants can quickly go from zero power to maximum output, thus providing grid stability. They can be shut down when energy requirements are low and the storage will be able to provide essential back-up power during major electricity outages or disruptions. Hydropower stations are known to have a much longer life than thermal stations. Once the initial investment has been made in the necessary civil works, the plant life can be extended economically by relatively cheap maintenance i.e. a plant designed for 40-50 years can have its operating life doubled by proper maintenance. In addition to a sustainable fuel source, hydropower efforts produce a number of benefits, such as flood control, irrigation, and water supply.

Storage dams can provide much need storage from water security point of view. India has highly seasonal rainfall pattern. 50 % of precipitation falls in just 15 days and 90 % of the river flows in just four months. India's per capita water storage is about 200 cum, whereas, it is 2200 cum for China, 6000 cum for USA and global average is about 900 cum. Thus the per capita water storage of India is not only well below global average, it is startlingly much less than other developing/developed countries in its peer group. If the days of average flow which reservoirs can store in basins of some of the countries are compared, it is 900 days in Colorado basin as well as Murray Darling Basin, whereas, for India, it is only 50 days, which is abysmally low. Therefore, the issue of water security is of prime importance in the Indian context and for this reason also storage dams are required, making hydropower a necessity.

CHALLENGES IN HYDROPOWER:

Hydropower is plagued with many misconceptions, which lead to its opposition in the public eye.

The environmental and social concerns, clearances from statutory bodies etc. represent another hurdle in development of hydropower. This can be very well taken care of by proper Environmental Impact assessment studies and preparation & implementation of suitable Environment management plan.

Also, the hydropower projects encounter geological adversities especially in the Himalayan region. Contrary to general belief, all geological challenges should not be termed as 'Geological Surprises'. If these conditions have been encountered in other projects in similar region, such conditions should be foreseen and proper contingency plans should be developed. Only unprecedented situations should be termed as Geological Surprises. This change in attitude and approach to project construction will make a lot of difference.

Another challenge in development of hydropower is to minimize the time and cost overruns. It has been seen that project which have been well investigated with proper investment of time and money, they face lesser time & cost overrun. Therefore hydropower projects should be properly investigated and planned in all aspects at the time of preparation of DPR, including preparation of proper contingency plan for geological uncertainties.

CONCLUSION

Thus, even though hydropower is cleaner and environment friendly, provides peak power and system reliability to the grid, prevalent myths about hydropower have led to a situation that overall percentage of hydro in energy mix has deteriorated.

To overcome this, hydropower producers and government should work together to "bust" negative myths about the industry. The hydropower is a 'low hanging fruit' that shall be plucked first rather than other sources of energy.

In the words of John F. Kennedy – "The great enemy of truth is very often not the lie--deliberate, contrived and dishonest--but the myth--persistent, persuasive and unrealistic. We enjoy the comfort of opinion without the discomfort of thought."

So replace the fear of unknown with curiosity and bust the myths.

TBM in Himalaya Case Study:
Parbati II HRT Excavation by TBM

Siba Prasad Sen

About Speaker
Siba Prasad Sen did his B.E. in Civil Engineering for B. E. College, Sibpur and also did his M.E. in Advanced Hydraulics from the same Institution. He worked in Irrigation and Waterways in Government for 8 years on flood control and irrigation engineering, subsequently for 29 years or so he worked with NHPC in Hydropower till retired as Director Technical from NHPC, India's largest hydropower company.

Subsequently he headed a new Design and Engineering Company namely M/s Aquagreen Engg. Management (P) Ltd till 2009.

Since 2010 works as Independent Consultant in Hydro Power, Dam and Tunnel and also as Technical Advisor, The Robbins Company, USA (till mid 2014) for TBM in Himalaya. He was independent consultant to Aditya Birla Group on hydropower 2011 to 2013. Presently works as independent consultant to companies in the field of hydropower, water resources, dam and tunnels.

He is presently

1. Vice Chairman of the Technical Committee on Role of Dam in Development of River Basin, ICOLD and
2. Member of the Technical Committee on Hydraulics of Dam, ICOLD.

He is located at New Delhi.

Extended Abstract

The Headrace Tunnel of the Parbati Stage II forms a vital part of the Project and is the essential supply line to the Parbati II Hydro-Power Plant and subsequently to the Parbati Stage III Project.

The HRT has a 6 meter diameter finished Horse Shoe Shape in the sections RD 3,500 m to RD10,304 m and RD 19,354 m to RD 24,733 m and a 6 m finished diameter circular shape between RD 10,304 m to RD 19,354 m in the TBM section, which will be concrete lined throughout its entire length.

Package Lot-PB.2 comprises the civil Construction of Head Race Tunnel (HRT) of Parbati Hydroelectric Project, (Stage II) from RD 3,500 to RD 24,733 including 3 Adits, namely Adit1, Adit 2 and Adit 3. In September 2002 this package was awarded to Himachal JV.

In May 2004 TBM started excavation. By August 2004 specialised sub-contractor NCC deserted the site only after excavation of 200m. Subsequently Robbins USA agreed to assist HJV the main contractor in TBM operation. Later stage took over excavation job as sub-contractor of HJV. TBM was a refurbished but strong machine. Still it had limitation in the geological and hydrological setup of Parbati II. Appropriate tools for ground engineering and even space for execution of the same were not available. So as the machine entered in the difficult ground trouble started and rate of excavation slowed down due to lack of appropriate ground engineering.

During excavation Robbins introduced a modified support system which takes account of the incompatibility of the existing equipment to apply sufficient rock support in due time and at the right location.

During TBM excavation in the period May 2005 to November 2006 mainly three different rock categories have been identified, these are:

- Bandal Granites over a length of 3445 m
- Manikaran Quartzite over a length of 571 m

- Talc chlorite schists within the Bandal Granite section with totally 40 m length

Average excavation rate was 4.60m/day in place of contractual commitment of about 15m/day. Frequent stoppages and long interruptions due to insufficient measures for appropriate rock support application and proper ground engineering works slowed down the TBM.

On 18th November 2006 after excavation of around 4 Km after tunnel entered in Manikaran Quartzite an investigative drill hole brought huge water along with silt. After 8 hours situation went out of control. Discharge increased to 2500 l/min and later to 7000 l/min. Silt and sand buried the TBM partly and accumulated up to RD 2700.00m with volume about 7000m3.

In the balance 5000m length to be excavated, aerial photography and satellite imagery indicates that the Manikaran Quartzite is likely to be traversed by a number of lineaments which represents major joints and fractured zones which may act as pathways of water seepage during excavation.

After 5/6 years of indecision NHPC decided to terminate the old contract but awarded new contract with exactly same technical specification and ground engineering requirement. It is true that NHPC could not have asked for a new machine with required specification but could have suitably modified the ground engineering as may be suitable. In view of shortcoming of the TBM for difficult ground, it was required that a sound ground engineering planning, with planning for uncertainties will be available as the excavation proceed. New contract was awarded in later period of 2013

This presentation does a chronological analysis of what happened which is considered an effective way of understanding for future TBM excavation in long and deep tunnels in Himalaya. In long and deep tunnel in any region of Himalaya where geological information will not be available up to micro level due to many reason, a risk assessment for excavation by TBM is very much necessary. Appropriate tender document providing proper technical specification and suitable provision for ground engineering under uncertainty of geological and hydrological condition, requires to be made. Construction companies require understanding the risk properly and preferably documenting it in their submission. Till date few of the TBM excavation for long and deep tunnels in Himalaya where either TBM was abandoned or held up for long clearly indicate the importance of proper ground engineering at planning and implementation stage.

The Determinator: Engineering Geology and Hydropower Development in India

Robert Goldsmith

About Speaker

Robert Goldsmith is Chief Technical Principal Engineering Geologist with SMEC International, from Australia. He has more than 40 years' experience on both civil and mining projects, working in 24 different countries. In recent years Robert has worked more extensively in dam and hydropower projects, including three years in India where many hydropower schemes were studied along the breadth of the Himalayas. His main interests include applied geomorphology, landslides hazards, site investigation management and assessment of rock mass properties.

Robert has a Master of Geoscience from Australia, is a Fellow of the Geological Society and Chartered Geologist.

Extended Abstract

The successful developments of hydropower projects in India and in particular in the Himalayan Ranges generally hinge on the geological conditions. Such projects inherently have a diverse range of structures intimately arranged within or on the ground, including dams, sediment handling structures, tunnels, shafts, underground chambers; plus channels, pipelines and roads cut into the surface.

The geological conditions depend on the tectonic settings which can be quite varied. The positions within the tectonically active areas commence from the foreland hills and ranges, then move into the ever increasing relief of the middle Himalaya and across much of these areas are the ever present active and potentially active faults. In addition the geomorphological processes that shape the land present additional challenges for hydropower projects.

The established procedure for hydropower development in India follows various stages of investigations, including Detailed Project Reports and construction supervision. To contribute to the success of each stage the engineering geologist should understand all aspects of the geology and geomorphology and be able to identify the issues and communicate them effectively.

With increasing private sector involvement in developments the Indian Government's aim is to ensure a high standard through all these project stages. It is essential for the engineering geologist to participate from the start of all projects not only to provide the necessary technical input but to maintain the inter-disciplinary input to ensure awareness of key issues.

Several case studies are included to demonstrate the role engineering geology plays in the assessment of particular issues.

New Frontiers in Geo-technical Engineering: Challenges and Opportunities

A. B. Pandya

About Speaker

Shri A.B. Pandya, Chairman, Central Water Commission was born on 23rd April, 1955. He graduated in Civil Engineering from Saurashtra University and M. Tech. in Structural Engineering from IIT, Delhi. Shri Pandya joined the Central Water Engineering Service in CWC in October, 1977 as Assistant Director and has held various positions in the Department and other organizations under the Ministry of Water Resources like WAPCOS, NWDA and NPCC.

In his long distinguished service encompassing all aspects of water resources sector, Shri Pandya has gained all round experience in water resources sector involving resource assessment, project planning, design, execution, operation and safety assurance, funds management, commercial consultancy management etc.

Major areas of his works include

• Planning of water resources projects for hydropower and irrigation including regional planning for optimum water resources utilization.

• Managing funding programmes for accelerated development of water resources projects and problems analysis as well as policy formulation for smoother funds flow.

• Advanced experience in engineering software development and associated technologies like NET platform for desktop and web based software system development. Planning and implementing IT infrastructure projects.

• Advanced experience in numerical modeling of structures and geo-technical problems using elasto-plastic material models and finite elements.

• Real time flood and conservation operation of a chain of reservoirs and interstate water management for Damodar basin.

• Planning and implementation of satellite based real-time telemetry networks for stream gauging, meteorology and flood forecasting.

• Legal and constitutional aspects of international and interstate water disputes and international water data sharing and treaty management at international level.

• Dam safety assurance and management of dam safety programmes including distress analysis and recommendation of remedial measures for dams and appurtenant works, comprehensive safety review of dams and setting up guidelines and legal framework for dam safety. Managing World Bank funded Dam Rehabilitation and Improvement Project covering more than 210 dams in the country.

• Design of dams and appurtenant works. Analysis and planning for alternative layouts.

• Planning structural behavior, monitoring programmes for dams and analyzing the observed behavior of dams.

Extended Abstract

Geo-technical engineering has played a pivotal role in the development of civil infrastructure. This had been possible because of the way geotechnical engineering has developed over the last century in association with a number of empirical, analytical and observational approaches. This has led to construction of variety of structures involving deep foundations, underground works, tunnels and various other utility structures. However, geo-technical science may face enormous challenges in the foreseeable future due to global developments related to water & energy needs, infrastructure for rapid increase in population, and increasing proportion of lands which are

ill-suited for development and of foundation sites which are of poor or marginal suitability. Most research and professional activities will be constrained by the need of developments in congested urban areas, recycling buildings and foundations, and designing and constructing geo-structures in difficult site conditions (e.g. unstable soils, steeper slopes, erosion problems, previous constructions, etc.), and geo-environmental issues. This will require improvements in existing approaches and development of new geotechnical construction methods and surely of new research strategies as well as an integrated and multi-disciplinary approach in order to find novel and creative solutions.

Multi-disciplinary approaches, already very desirable for geotechnical engineers, will increasingly become more important and even essential in the future. The widespread adoption and further development of versatile spatial tools such as Geographical Information Systems (GIS) has to be encouraged and accelerated.

Increasing understanding of the importance of geology and, in particular, of geological structure is required. The performances of slopes, embankments, foundations and other structures can be significantly influenced by minor geological details which may not be revealed by conventional or routine site investigation. Specialized methods in the areas of remote sensing and geophysical surveys shall supplement conventional investigation methods.

Advanced deterministic methods of analysis such as the finite-element, boundary-element and distinct-element methods have been developed rapidly with the advent of computers. These sophisticated methods are versatile with applications in many fields. However, reliable data of key geotechnical parameters is needed for better predictions of deformations. However, obtaining good data is not an easy task considering heterogeneous and anisotropic nature of soil and rock masses. Thus a careful balance has to be struck between, on the one hand, adoption of simplified methods of analysis with limited aims as to outcomes but requiring limited number of parameters to be evaluated and, on the other hand, the use of sophisticated methods allowing far better predictions but requiring the evaluation of far more data which are generally difficult to obtain.

The development of an observational approach was a notable development in the history of geotechnical engineering. Looking to the future, broader perspectives on the 'observational approach' are needed to meet the challenges of the future, including risk management.

Lessons have been learnt, to some extent, from failures of geotechnical structures resulting from one or more of the following factors; incomplete understanding of the problem or of the geo-mechanics principles, inadequate investigation, flawed modeling, inaccurate analysis, poor design, faulty construction, lack of proper observation and monitoring. The profession needs to devote sufficient resources and time to improve from observed performances and from any future failures. Better strategies need to be developed in meeting the challenges of uncertainty, spatial and temporal, posed by catastrophic failures caused by extreme natural events such as earthquakes or rainstorms.

Geotechnical Engineers in the future have to be prepared to expand their roles to find solutions to civil infrastructure needs, for the mitigation and prevention of earth system problems related to global changes, increased energy demand, and emission and waste management and disposal. Practitioners and researchers should work together if we desire geotechnical engineering to have a leading role in defining strategies and designing solutions to the new challenges of this century.

Engineering Geology in Active Mountain Belts: Application of Knowledge from Japan to the Himalaya

Shuichi Hasegawa

About Speaker

Dr. Shuici Hasegawa is a Professor at the Department of Safety Systems Construction Engineering, Faculty of Engineering, Kagawa University. He attained his early education from the Faculty of Science during 1974-78 and from the graduate school during 1978-80 from University of Tokyo. He achieved his degree in Master of Science in 1980 and later his Ph.D in 1993 from University of Tokyo.

He is a registered professional engineer in Japan with expertise in Engineering Geology. Professionally, he has worked for the Shikoku Electric Power Co., Inc. from 1980-2000, been an associate professor at the Kagawa University from 2000-02 and was then promoted as Professor in 2002.

He received prizes for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology in 2014. His research topics include Mitigation of earthquake & landslide hazards, Geological engineering valuation of construction sites and development of sustainable society through geopark activity.

He has also served as the President, Japan Society of Engineering Geology, Japan(JSEG), has been a member of the IAEG and Founder Member of Himalayan Landslide Society (HLS).

Extended Abstract

The Himalaya is characterized by the highest mountain range of over 8000m in height which has been formed by the collision of India and Eurasia plates. Because the Himalaya is considered as one of the most active mountains on the earth having steep slopes and monsoon heavy rainfalls, this mountain range suffers various types of natural hazards including earthquake, landslide, debris flow, flood, glacier lake outburst flood (GLOF) and so on except for volcanic eruption and tsunami. The 2015 Gorkha Earthquake is the typical inter-plate earthquake near the main frontal thrust between the subducting India plate and the overriding Eurasia plate to the north. GLOF and landslide outburst dam (LDOF) triggered by massive earthquake is Himalayan tsunami. Thus, evacuation toward higher place from the bottom of ravine is necessary in case of Himalayan massive earthquakes. Fortunately, because the Gorkha Earthquake occurred at the end of dry season, GLOF and LDOF did not occurred during the earthquake.

Japan is located where the Pacific and Philippine Sea plates subduct under the Eurasian plate. The Japanese arc is characterized by the mountain range of chiefly under 3000m where seismic and volcanic activities occur constantly. Japan has suffered great damages from the massive inter-plate earthquakes produced by plate subduction plate subduction (such as the 2011 Tohoku Earthquake) and the inland crustal earthquakes caused by active faults (such as the1995 Kobe Earthquake). Japan lies in the northeast tip of the Asian Monsoon Zone. In 2004, ten typhoons landed on Japan, and caused flooding and landslides in Japan. About 70 % of the Japanese archipelago is mountainous. The mountains are steep and the rivers are short with steep gradients. Japan suffers various types of natural hazards including earthquake, tsunami, volcanic eruption, landslide, debris flow, flood and so on except for GLOF.

Southwest Japan is located where Philippine Sea plate subducts under the Eurasian plate. Mountains in the outer zone (fore-arc side) of Southwest Japan is only 2000m of the maximum height, but height difference between the Nankai Trough (Trench) and the mountains attains almost 7000m.

Although the Himalaya and the outer zone of Southwest Japan are located in non-volcanic belts, the Miocene granitic rocks have played important role in upheaval of mountain ranges and hydrothermal alterations to surrounding bedrocks.

The leucogranites distributed along in the Higher Himalayan Zone are closely related to the highest peaks in the Higher Himalaya such Mt. Everest (Sagarmatha), Mt. Manaslu etc. The radiometric age of the leucogranite is 9 to 24 Ma which indicates that the leucogranites intruded mainly in Miocene. The batholith of the Miocene granites have uplifted isostatically due to the buoyancy of relatively light granites.

The Miocene granitic rocks and gabbroic rocks are sporadically distributed in the Shikoku Range, Ashizuri, Muroto nad Kii Peninsula in outer zone of southwest Japan. The highest peaks, such as Mt. Ishizuchi (1982m) in Shikoku and Mt.Hachiken (1915m) in Kii, are closely related to the Miocene granitic rocks. The radiometric age of the granitic rocks is around 14 Ma.

Although no Quaternary volcano is distributed in the Higher Himalaya and Shikoku Range and Kii Peninsula, present hydrothermal activities are recognized in both areas. The thermal source of hydrothermal activities of both areas must be closely related to the hidden Miocene batholith. Most of hot springs are distributed along the MCT. The water temperature is 90 degrees in centigrade at Yunomine hot spring in Kii Peninsula where the Middle Miocene granitic rocks are distributed along the axis of peninsula in the direction of north to south.

Recognition of hydrothermal alteration is very important because it had spread along major faults and has prepared clayey sliding surfaces of deep-seated landslides. Engineering geological investigations on large-scale landslides along the major faults named Median Tectonic Line (MTL) in Shikoku have revealed that smectite-bearing clay-rich zones are the origin of sliding surfaces (Hasegawa et al., 2001). The smectite is inferred to be formed by hydrothermal alteration which is originated from Middle Miocene volcanism.

The rockmass types of tunnels along the MTL is divided into four types from view-points of landslide and hydrothermal alteration (Hasegawa et al, 2006). The large convergence tends to appear in H-type and HS-type tunnel ground which have affected hydrothermal alteration. X-ray diffraction analysis suggests that smectite-bearing clay veins originated from hydrothermal alteration and have caused large convergence during tunnelling. Therefore, it is very important to confirm the presence of the swelling clay mineral (smectite etc.) before and during tunnel construction.

Hasegawa et al. (2008) have revealed by X-ray diffraction analysis that large-scale landslides along the highways in central Nepal have significant clay mineralization in sliding zones. The substantial hydrothermal alteration in the Lesser Himalaya during and after the advancement of the MCT and thereby clay mineralization in sliding zones of large-scale landslide are the main causes of large-scale landslides.

Inter-plate mega-earthquakes and active fault earthquakes have caused innumerable large-scale landslides. Large-scale landslide masses which had formed before middle Pleistocene are completely dissected and are usually recognized as hills in front of the mountain ranges. Such large-scale landslides are concentrated along the MTL in Southwest Japan and the trace of active faults becomes obscure in landslide masses (Hasegawa, 1991:Hasegawa & Sawada, 2001).

Unexpected troubles in large-scale construction projects are related to hydrothermal alterations and dissected large-scale landslide. Most of fragile rock-masses in both mountain belts are caused by landslide deformation which is often misunderstood as tectonic origin. This indicates that large-scale landslides in the Himalaya might be triggered by strong earthquake caused by not only mega-thrust along the plate boundary but also hidden active faults beneath landslide masses and sediments.

Understanding the Emerging Potential of Geophysics for Novel Application in Complex Geotechnical Problems

Bimalendu B. Bhattacharya

About Speaker

Bimalendu B. Bhattacharya, FNAE, FWAST, FIETE, was born on January 1, 1942. He received M. Sc, (Geophysics) degree from the Banaras Hindu University and PhD from Leningrad State University, Russia (now St. Petersburg, Russia). He served in Geological Survey of India, National Geophysical Research Institute (NGRI) and Indian School of Mines (ISM). He superannuated from the Indian School of Mines as Director. He was the Leader of the Fourth Indian Scientific Antarctic Expedition and is also a recipient of the National Mineral Award.

Professor Bhattacharya is Chairman, Research Council, NGRI; President, Indian Centre for Space Physics; Adjunct Professor, ISM, and is associated with the S. N. Bose National Centre for Basic Sciences, Kolkata..**

He has written a book (coauthor Professor Shalivahan) titled "Geoelectrical Methods: Theory and Application" which was published in June, 2015 by Tata McGraw-Hill Education India.

Extended Abstract

The outermost part of the earth's crust is extremely dynamic. Geophysical investigations for the shallow subsurface features, also referred as "near surface geophysics" (Butler, 2005) include numerous and varied types of applications, e.g., engineering, geotechnical, environmental, groundwater, mining, archaeological, forensic etc. I shall confine myself mainly to engineering and geotechnical geophysics which mainly deals with characterization of the foundation beneath critical structures; mapping subsurface rock topography; non-destructive evaluation of engineering structures, e.g., bridges, buildings, dams, etc.; cavity and tunnel detection; geologic mapping etc. The role of geophysical investigation is that it can reduce the required drilling, sampling and lower the overall cost. Tomographies of seismic, electrical and electromagnetic data are widely used now-a-days for shallow subsurface imaging.

Butler (2005), with the help of an amusing cartoon, discusses a hypothetical scenario of a geophysicist presenting results of geophysical investigation to the users with differing background, approach, expectations and conceptual understanding having different perceptions of the result, e.g., by an engineer, a geologist, and a regulator.

It is observed that a project manager will spend about 90 percent of the exploration or site characterization budget for drilling and sampling before employing shallow geophysical investigations. The geophysicist quite often does not have or is not given the full background of the site or the up-to-date characterization work. This type of shortcoming fails to appreciate the full potential of geophysical investigation to contribute to a fundamental understanding not only of geologic structure and stratigraphy but also conditions, processes, and spatial heterogeneity (National Research Council, 2000). The scenario changed globally may be from three decades back when it was realised that the potential for site characterization by geophysics is versatile, cost-effective, non-invasive, and integrative. The program managers now are generally eager to include geophysics as part of the site characterization program (Butler, 2005). Dobecki and Romig (1985) stated that the "geophysical

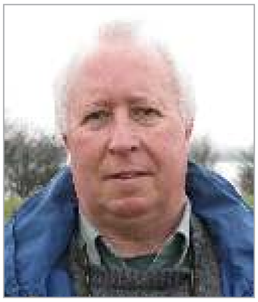
applications to geotechnical and groundwater problems . . . have leaped from a role of merely a sensible, cost-effective substitute for boreholes or a scapegoat in difficult subsurface geology to one in which they are often the only means by which an important problem can be addressed “. Subsequently, the National Research Council (2000) noted that there is great potential for the geophysical methods to define subsurface details not only with a desired degree of accuracy, economy and safety that can approach direct sampling but also with a much greater areal coverage. The challenge before the geophysicist is now to exploit this emerging understanding and potential of geophysics by understanding the requirements of the project and communicating clearly the capabilities and limitations of the methods. The geophysicists now must present their results avoiding jargons, as far as practicable, and try to be in same wavelength such that capabilities of geophysics are understandable to the administrators and technocrats.

A key role for the geophysicist is to articulate and advocate forcefully the objectives that can be addressed by employing geophysical methods and how they integrate with overall program objectives. In many cases the geophysical studies may help in guiding the feasibility assessment and remedial measures to avoid surprises and risks that may be encountered during progress of work using all the time the basic philosophy of “minimizing the cost while maximizing information.”

Due to the present day possibility of obtaining (1) soil and rock properties from measured parameters using physics-based models; and (2) the models for interpretation has enhanced the scope of utility of geophysics many folds in engineering and geotechnical problems. Both geological and geophysical conceptual models are utilized in planning and in interpreting near-surface investigations. While conceptual models are generally qualitative, geophysical interpretation uses quantitative model on the conceptual models. A quantitative geophysical model uses forward modelling procedures to predict a model with a given set of data. The forward models are also applied in inverse geophysical modelling. A systematic, model-based approach to planning, executing and interpreting geophysical investigations is essential for establishing and maintaining credibility and acceptance of results.

It will not be out of place to discuss briefly the way shallow geophysical methods were employed in the construction of united Berlin as decided by the Parliament assembly after the unification of Federal Republic of Germany (West Germany) and the German Democratic Republic (East Germany) in 1990. Two problems were mainly encountered during the planning of “new face of the town”: first, sparse knowledge about foundations and remains of edifices built before the Second World War, and the second was encountering unexploded bombs. The main objective of geophysical survey in this entire program was to find old and unknown foundations. Figure 2 shows that several obstacles were precisely located. In addition the geophysical survey provided detailed information about finished, unfinished and destroyed subsurface structures (Glebke et al., 2005).

How to Write a Paper



Martin Culshaw

About Speaker

Martin Culshaw is an independent engineering geological researcher and consultant. He was Director of Environment and Hazards at the British Geological Survey (BGS) and the Survey's Chief Engineering Geologist until 2008. He is Visiting Honorary Professor in Engineering Geology at the School of Civil Engineering, University of Birmingham and an Honorary Research Associate at the BGS.

He has been involved in research into the relationship between litho-stratigaphy and geotechnical properties, environmental and engineering geological mapping, geohazard assessment, site investigation, urban geosciences and the application of geology to land use planning for over forty years.

He is a former Vice President of the Geological Society. He has published over 160 papers, books and articles and over 120 technical reports. He received the Engineering Group of the Geological Society's Award for 1989, the Geological Society's Glossop Medal in 2004 and the E B Burwell Jr Award from the Geological Society of America in 2006.

In 2010, he was awarded the International Association for Engineering Geology and the Environment's Hans Cloos Medal. He is currently Editor-in-Chief of the Bulletin of Engineering Geology and the Environment.

Extended Abstract

For those who have already published in the international scientific literature, writing a scientific paper (as opposed to interpretation of the data) often seems straight-forward.

However, as with most skills, we are not born knowing how to do it; rather, we have to learn.

Most scientists begin their careers by writing technical reports. These can be a quite simple record of laboratory or field/site data or more sophisticated if interpretation of the data is required or solutions to specific ground problems are to be proposed.

Factual reports provide a permanent record of measurements and observations, while interpretative reports give an explanation of why the data are what they are.

For example, a factual report might be a series of borehole logs and in situ test results; an interpretative report might explain why the in situ results vary and how that variation relates to litho-stratigraphy etc. Also, it should be recognised that, often, these reports are contractually constrained.

This lecture has been prepared to help early career scientists and engineers who deal with ground-related problems, whether as researchers or practitioners, to publish their work and so help those that follow to understand and anticipate what the ground is like.

Published papers, particularly in engineering geology and geotechnical engineering, are usually of one of three types:

- a review paper (often based on a keynote lecture);
- a case history (for example, based on work at a specific engineering site);
- a hypothesis-based research paper (often, but not always, based on academic research.

A review paper brings together the knowledge and information gained over many years on a particular, usually quite narrow, aspect of research. There may be few, or no, new results but the paper gives the reader an overview of most of what is known about the particular subject covered.

A case study usually looks at a particular problem encountered on site and indicates how the problem was overcome and what lessons were learned. Sometimes, a case study will cover failures; these papers are particularly useful as they enable us to understand the mistakes made so that they are not repeated. Obviously, these types of studies are not very common as few of us are willing to publicize our failures!

A hypothesis-based research paper essentially provides the outcome of the testing of a specific scientific hypothesis. For example, the hypothesis might state that the 'abc' clay formation is more susceptible to mass movement than the 'xyz' clay formation. Factual data will be collected, summarized and interpreted to either prove or disprove the hypothesis.

So, let us begin the presentation but, first, I must acknowledge that the majority of it was developed and prepared by Niek Rengers, a former President of the IAEG. Though I have modified and added to the presentation, it remains essentially his.

Application of TBMs in Tunnels in the Himalaya

Joe Roby

About Speaker

Joe Roby is a B.Sc. (Hons.) in Mechanical Engineering from the University of Washington. He has worked in the tunneling industry for more than 27 years. He started at The Robbins Company as a stress analyst specializing in finite element analysis of complex structures. Subsequently, he was a member of the 19-inch cutter development team following which he served as a technical liaison for the service department. For five years, he was the managing director of Robbins refurbished and leased TBM division. For over 20 years, he has been the Vice President at Robbins with management responsibilities ranging from engineering, sales, marketing, cutters, service and international operations. He has authored more than 25 technical papers for conferences and industry publications on subjects ranging from cutters to TBM, rebuilding practices and proper design of EPB's for ground conditioning application. Presently, he is Vice President of Business Development at Robbins' at Kent, Washington.

Extended Abstract

The Himalayan Mountains are the youngest mountain range on Earth and are located on a very active plate margin zone. The Himalayan range is rising at a rate double that of the Andes and nearly six times that of the Alps. As a result, the in-situ stress in the Himalaya is in most cases far higher than might be found in any other mountain range. In addition, the geology is heavily folded creating widely varying geology on a single tunnel and potential for multiple fault zones. This creates extremely challenging, adverse and oft times dangerous tunneling conditions in the Himalaya including extremely hard and abrasive rock, rock bursting, difficult to negotiate and long fault zones, sudden inflows of mud/sand/water under great pressure as well as the requirement for the installation of extreme tunnel support measures.

In spite of these geologically challenging conditions, the use of tunnel boring machines in the Himalaya has increased quite recently. The first modern attempt to employ a tunnel boring machine (TBM) in the Himalaya was for the 390 MW Dul Hasti hydroelectric project (HEP), the construction of which took place from 1989 through 2007. Dul Hasti is located in the Kishtwar district of the state of Jamu and Kashmir. A 6.8 m diameter open hard rock TBM was employed on the project. The eighteen-year construction period gives some evidence of the difficulties faced in the construction of the project, though not all of the difficulties were geologically based.

In subsequently years, TBMs have been employed on several other Himalayan tunneling projects. A partial list would include:

• 2014: Vishnugad Pipalkoti, Uttarakhand, 444 MW, 12.3 km x 9.85 m bore diameter / 8.8 m tunnel I.D. headrace tunnel, double shield TBM

• 2010: Kishanganga, Jamu & Kashmir, 330 MW, 14.8 km x 6.18 m bore diameter / 5.2m tunnel I.D. headrace tunnel. Tunnel completed in 2014.

• 2006: Tapovan Vishnugad, Uttarakhand, 520 MW, 12.1 km x 6.57 m bore diameter / 5.64 m I.D. headrace tunnel. 8.6 km of the headrace tunnel is to be excavated by a double shield TBM.

• 2000: Parabati HEP, Himachal Pradesh, 2,051 MW (Stage I = 750 MW, Stage II = 800 MW, Stage III = 501 MW). Stage II of the project employed two TBMS:

- 2000: Stage II employed 2 TBMs; 1) a 6.8 m diameter open hard rock machine for the 9.05 km long pressure headrace tunnel which has yet to be completed and 2) a double shield for the two, 1,542 m long, 4.3 m I.D., 30 degree incline pressure shafts, completed in 2006.

The six tunnel boring machines employed on the projects referenced above have met with widely varying degrees of success due to an equally wide variety of causes. The geology in most cases has been very difficult on all of the projects. However, in addition to geology, it must be discussed the effect on TBM performance of a number of other factors including;

• Suitability of TBM design,

• Availability of accurate geological mapping in advance of excavation of the tunnel,

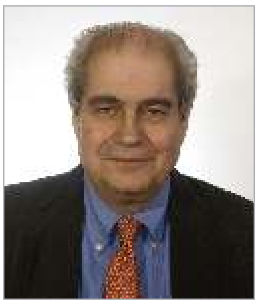
• Experience of the contractor / management and tunnel personnel,

• Existence of technically sophisticated probing / ground prediction monitoring equipment and maintaining a knowledge of conditions ahead of the TBM excavation,

• Existence of a contingency plan and supporting materials, tools and specialist manpower to quickly negotiate potential geological challenges (faults, inflows, rock bursting, bypass tunnels, etc.)

This keynote lecture will discuss the challenges of TBM tunneling in the Himalaya and discuss the specific challenges faced at each of the projects mentioned above. In addition, the speaker will attempt to provide some advice regarding fundamental minimum precautions which one would be prudent to observe when employing a TBM in the Himalaya.

Tunneling in Difficult Ground



Paul G. Marinos

About Speaker

Paul G. Marinos is an Emeritus Professor at the Nat. Tech. Univ. Athens and offers engineering consultancy as a free lancer. He has been the President of International Association of Engineering Geology and the Environment.

He pursued his Mining Engineering from NTUA in 1966 and subsequently acquired his postgraduate degree in Applied Geology and Doctorate, University of Grenoble, France in 1969. He has acquired Doctor honoris causa from Democritus University of Thrace and has been Knighted by the French Republic (Palmes Académiques).

He has been a visiting Professor at the University of Grenoble (1987) and Paris School of Mines (2003).

He is the proud recipient of the Hans Cloos medal of IAEG and Glossop medal of the GSL. He has carried out research on a variety of applications of geology to engineering. He is also the author of over 320 papers in journals or major conference proceedings. He is Editor in chief of the scientific journal "Geotechnical and Geological Engineering". He is also a Consultant and Expert on major civil engineering structures works, mainly dams and underground structures all around the world.

Extended Abstract

The growth of infrastructure needs has increased the demands for the excavation of tunnels in poor ground or varying geological conditions. The assessment of ground for design has to be based on a sound understanding of the regional geological rules and the establishment of a geological model, where data and conditions are translated into an engineering description. A series of geological models for a variety of rocks associated with different structural conditions in various tectonic environments, based on the geological history are presented. Site investigation is an important factor for the establishment of the geological model and it must be based on a sound geological understanding of regional geology, otherwise it is likely not to find much of value. Examples and cases from both mountain and urban tunnels under complex or difficult geological conditions are discussed.

Going from the geological model to the ground model, the design requires knowledge on the quality of the material in which the tunnel will be constructed. Engineering design requires numbers and the lecture explores and discusses methods that can be used to assess the geological factors that have an impact on this quality. These mainly are the quality of the intact rock, the fabric of the mass, the quality of discontinuities. Since the attempt of Terzaghi, in 1946, to correlate the characteristics of a rock masses for the tunnel design, a number of rock mass classifications have been developed and play an important role providing input data on strength and deformation properties of the ground for numerical models. A discussion on this issue is presented, with the field of application of this quantitative characterization of the rock masses and its limitations. Together with the rock mass properties, the in situ stresses field has to be estimated or measured and this is one of the most difficult tasks.

Although the role of engineering geology has been extended into the area of defining the design parameters, the

idealization process, in the form of numerical analysis, should be driven by sound geologic reasoning in order idealization does not misinterpret reality. In this context the understanding of the real behaviour is indeed absolutely necessary before any calculation is attempted. Thus, the engineering geological "I.D" of the geomaterial and the stress environment define this ground behaviour such us: brittle failure, gravitational falling or sliding or "chimney" type failure, or ravelling, or formation of a "plastic" zone by shear failure with deformation problems and squeezing, or swelling.

Mechanizing tunnelling is discussed in relation with the geological conditions in complex mountain ranges and particularly the use of the appropriate type of TBM to face either rock bursting phenomena or squeezing ground.

Along the lecture geological uncertainties and decisions, in the design and construction are discussed. These relate to:

-spatial changes of the geological formations with particularities in their borders, some time with chaotic structure.

-variability of properties of the ground and its behaviour

-in situ stresses, with some particular and extreme cases

-specific geological features, such as fault zones, thrusts, evaporitic intrusions

-hydrogeologic conditions with special emphasis to karst

Examples from a number of tunnels from around the world illustrate the design and construction procedures. Attention is specified to tunnels in the Himalayan range.

The Challenges of an Engineering Geologist in the Digital Era of Communication

Helen Reeves

About Speaker

Dr. Helen Reeves is an Engineering Geologist with 17 years' post graduate experience in engineering geology research, with over 30 papers in engineering geological mapping, rock mass characterisation, geohazard mapping and geomechanics. She acquired her undergraduate Geological Sciences degree from the University of Leeds and an M.Sc and Ph.D in Engineering Geology from the University of Durham.

Currently, Helen is the Science Director for Engineering Geology at the British Geological Survey (BGS) and leads the BGS Engineering Geology research programme investigating the processes and the spatial distribution of shallow geohazards in the UK (particularly landslides and subsidence); geotechnical & geophysical properties of the UK land mass and urban geoscience challenges in cities.

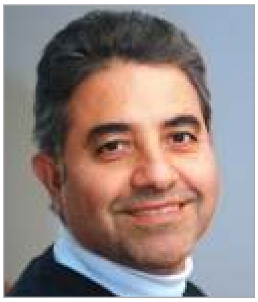
Helen is the co-chair of the UK Natural Hazards Partnership Hazard Impact Model (HIM) working group; has contributed to the UK Government's Scientific Advisor Group for Emergencies during 2013-2014 winter storms; is an EU Civil Protection Mechanism Technical Expert; IAEG UK National Group President, an active committee member of the TRB standing committee on Engineering Geology (AFP10) and has contributed to a (US) National Research Council of the National Academies Committee on the "Underground Engineering for Sustainable Underground Development.

Extended Abstract

How engineering geologists present data, information and expert knowledge, to an ever increasing variety of stakeholders, is a continual challenge. In the last twenty-five years, information technology and increased computing capacities have transformed the way in which engineering geologists and geoscientists work. In particular, the development and use of Geographical Information Systems (GIS) and modelling packages have meant that there is now a far greater opportunity to develop engineering geological products that show more effectively the third-dimension (3D) and now increasingly spatially monitor temporal data in four-dimensions (4D) . With the increasing speed of development of information technology and computing capacities for visualising ground investigation information and geological knowledge it is important for engineering geologists to keep knowledge and expertise up to date. Training and continual professional development is vital, as well as the development of standards and best practice to ensure consistency and interoperability of data.

These tools are for the first time enabling geologists and engineering geologists to create and communicate, interactively, 3D geological and engineering geological models that were previously developed as two-dimensional images (maps and cross-sections) by combining ground investigation information and geological knowledge. These tools have also opened up the question of how to deal with uncertainty and spatial variability. Various techniques are now being advanced looking at both deterministic and probabilistic approaches to answer these questions. This is now a key research challenge for engineering geology.

Cost Effective Method for Early Warning of Rainfall Induced Landslides in Asian Countries



Rajinder Bhasin

About Speaker

Rajinder Bhasin is currently holding the position of Regional Manager Asia, Norwegian Geotechnical Institute. He did his M.Sc in Geotechnical ngineering and later acquired his Ph.D degree in Rock Mechanics from University of Oslo, Norway. He followed it up with BE in Civil Engineering from India.

Professionally, he started as an Engineering Trainee, General Directorate of State Hydraulic Works, Ankara, Turkey in 1989. He later served as an Engineering Geologist at Hydroelectric Project Sites in the Himalayan Regions of India from 1990 onwards. He was also the Research Fellow at NGI during 1996-1991.He became the Project Engineer, Rock Engineering and Reservoir Mechanics in 1997.

Dr. Bhasin has wide experience from Norway and abroad on Rock slope stability analysis and evaluation of landslide hazards, numerical modelling of infrastructure projects such as dams and underground structures, advanced rock mechanics laboratory testing to obtain geotechnical input for numerical analysis for design of nuclear waste repositories etc. He has over 70 papers in international journals , scientific magazines and conference proceedings to his credit.

Bhoop Singh

About Co-Author

Bhoop Singh is currently working in Department of Science and Technology. He did his Phd in Landslide Hazard Mitigation and Advanced Training on Disaster Mitigation, from Japan.

Extended Abstract

The frequency and intensity of landslides in Asia have increased significantly over the past years causing extensive damages to life and property in the affected regions. A key triggering factor for many of the landslides has been the precipitation events that occur over a period of time. A review of available literature emphasizes the role of precipitation as an important control on the initiation of slope failures and provides evidence that landslides are often triggered by meteo-climatic events that are in excess of some thresholds. Therefore, it is necessary to investigate the possibility of interpreting landslide events in terms of the rainfall patterns immediately preceding the slide event. Rainfall threshold values vary from region to region due to differences in existing soil characteristics and climatological patterns in different areas. Therefore, a complete study of the rainfall patterns in landslide prone areas and their records of landslides are warranted. This will help predict reasonable threshold values of rainfall and use them as a tool for landslide forecasting. The Norwegian Geotechnical Institute (NGI) in cooperation with the Department of Science and Technology (DST) has performed a pilot study for setting-up a landslide early warning system for predicting rainfall-induced landslides in the Nilgris area of Tamil Nadu. In addition, NGI through a Regional Co-operation Program with the Asian Disaster Preparedness Centre (ADPC) in Bangkok is implementing a research project for documenting and sharing good practices for early warning of landslides with national institutions from Bangladesh, Bhutan, China, India, Indonesia, Nepal, Pakistan, Philippines Sri Lanka, Thailand, and Vietnam. This paper describes a cost effective method for early warning of rainfall-induced landslides in some Asian countries where instrumentation is being performed for monitoring of landslides.

Large Deformation in Tunnels

Faquan Wu

About Speaker

Professor Faquan Wu is a Professor at the Shaoxing University, Shaoxing, Zhejiang, China. He acquired his Ph.D degree in Engineering Geology from the Institute of Geology and Geophysics, Chinese Academy of Sciences in 1992.

He has been serving as a research Professor from 1995 onwards. From 1995-2011, he was the Deputy Director and subsequently Director of the Key Laboratory of Engineering Geo-mechanics, Institute of Geology and Geophysics, Chinese Academy of Sciences. From 2013 onwards, he served as Honorary Professor at the Shaoxing University.

He became the Secretary General of IAEG in 2011 and is continuing on the post till date. He has also been the Vice President of IAEG of Asia during 2007-2010. He has also been the director of IAEG China National Group. He served as the Vice President and Secretary General for Chinese Society of Rock Mechanics and Engineering.

His research interests include Rock Engineering Geology, Engineering geomechanics and statistical mechanics of rock mass.

Extended Abstract

Large deformation of soft rock tunnels under great depth is a frequently encountered problem in the railway construction in western China. A lots of tunnels have to degrade their original classification of rock quality and upgrade the designed supporting systems due to the excavation disturbance and the redistribution of stress field in surrounding rock-mass.

The rock-mass of tunnels led to large deformation are the widely distributed layered-strata or compressive metamorphic rock in the western China. In most cases, the integrality and continuity of rock-mass will be significantly destroyed while the unloading and structurally loosening of rock-mass near the excavated faces. This is the structural weakening to the mechanical property of rock-mass, which will remarkably reduce of the mechanical property of rock-mass with anisotropisation which could not be predicted through the modification in any classification method.

A method based on Statistical Mechanics of Rock Mass has been developed for the calculation of modulus and other mechanical parameters of rock-mass, which could reflect the mechanical effect of structural failure due to the excavation. And also we could obtain the quality grade through calculation of experienced formula.

A module of Flac3D, JointModel.dll, has been developed for the numerically estimation of the large deformation of surrounding rock mass. The calculation has shown that the deformation is well controlled by the mechanical effect of beddings of strata. And some asymmetrical supporting method is also proposed to control the reduction of rock quality and anisotropisation.

Issues in Rock Mechanics Testing for Hydropower Projects

Rajbal Singh

About Speaker

Dr. Rajbal Singh completed M.Tech. and Ph.D. in Rock Mechanics from I.I.T. Delhi and joined the Central Soil and Materials Research Station (CSMRS) in 1985. He has published 208 research papers with 15 best paper awards. He has been involved in investigation of about 200 hydroelectric projects and has also prepared over250 technical reports.

He visited Norway and USA on UNDP Fellowships and has been to Norwegian Geotechnical Institute on a prestigious Research Fellowship programme during 1999. He has also visited several times to Nepal, Bhutan and Myanmar as consultant of Rock Mechanics. He has served as the President of Indian Society for Rock Mechanics and Tunneling Technology (ISRMTT). He received ISRMTT Award on "Outstanding Contribution to Rock Mechanics" in 2006 and IGS Delhi Chapter "Leadership Award" in 2007. He worked as Head of Quality Control and Instrumentation for construction of 1020 MW Tala Hydroelectric Project, Bhutan. He also worked as Joint Director and Head of Rock Mechanics in CSMRS, New Delhi.

Extended Abstract

The modulus of deformation of rock mass is a very important parameter used in analysis and design of dam and underground excavations in the rock mass. The modulus of deformation of rock mass shows a large variation in test results. For design of engineering structures on or within rock, the main parameters of importance are the deformability of the rock mass, joint shear strength, strength of the rock material and the in-situ stresses.

It is generally known that in situ tests of the deformation modulus of rock masses are subjected to measurement errors, both from equipment, preparation and blasting damage in the test adit in addition to the measurement method and test procedure. But in order to arrive at the best possible results the persons involved in the tests must know the limits and problems involved in the tests.

There are variations in the modulus values determined by different methods. Sometimes these variations are due to the change in the rock mass properties also. The results of deformability measurements must be analysed by experience hands working in the field. The experience obtained at one project site cannot be utilized at another project site with the same type of rock mass. Therefore, the deformability of rock mass must be determined by any available method.

This paper deals with the scale effects on deformability of rock mass in Himalayas by conducting in-situ tests with different methods. The deformability tests conducted by using plate jacking test, plate loading test, Goodman jack test and laboratory test show the comparison among different measurements and scale effects on deformability of rock mass. Plate load test, flat jack test and Goodman jack test give values of modulus of deformation which are 2-3 times lower than large size plate jacking test. Hence, large size plate jacking test must be utilized to evaluate the modulus of deformation of rock mass, particularly due to jointing in Himalayan rock mass. The modulus of rock tested in the laboratory is 3 to 20 times higher than in-situ value of rock mass. The difference is mainly dependent on jointing in the rock mass

Natural Disasters in the Himalaya - Lessons Learnt and Way Forward

Surya Parkash

About Speaker

Surya Prakash did Ph.D. in earth sciences from IIT, Roorkee. He also did PG Trainings on Geohazards Risk Management from University of Geneva, on Aseismic Design and Construction from Institute of Earthquake Engineering & Engineering Seismology (IIZIS), Skopje, Macedonia and Risk Management and Insurance from Middle East Technical University, Turkey.

He is working as Head, Knowledge Management & Communication Division and Leader for "World Centre of Excellence on Landslide Disaster Reduction" at NIDM, Delhi. He is also the Coordinator for the ICL's International Thematic Network on Landslides Risk Management and is coordinating the Indo-Japanese Collaboration on Landslides and Disaster Management.

He has made over 50 publications to his credit.

Extended Abstract

Himalaya, being the youngest geodynamically active folded mountain chain, with very high altitudes overlain by glaciers and lakes that are perennial sources of water in its rivers which follow courses mostly defined by structural features, is susceptible to various types of natural hazards like earthquakes, landslides, landslide dams and river blockades, glacial lake outburst floods, flash floods, lightning, hailstorms and forest fires. Such natural hazards when interface with human habitations, resources and developmental activities, cause massive loss of lives and destruction / damage to economy and environment. The papers discusses some of the major significant catastrophic events that shaken or shattered the lives of the people and provides an insight into the causes of adverse consequences of these hazards on the humanity and points out the lessons learnt from some of the disasters, along with the way forward to efficiently meet the daunting challenges of such threats.

The author cites experiences gained from case studies in the Himalayan terrain on recent major and great earthquakes (Uttarkashi 1991, Chamoli 1999, Kashmir 2005, Sikkim 2011 and Nepal 2015), socio-economically significant and catastrophic landslides (Syari and Deorali 1990, Hilmen Aizawl 1992, Luggar Bhatti 1995, Malpa 1998, Phata and Ukhimath 2001, Budha Kedar and Khetgaon 2002, Varunawat 2003, Darjeeling 2003, Mokukchung 2005, Shimla 2008, Itanagar 2008, La Jhekla 2009, Kurseong 2009, Shumgarh 2010, Almora 2010, Upper Siang 2010, Aizawl 2013, Barhgam 2015). Landslide dammed lake outburst floods (Madhya Maheshwar 1998, Satluj 2000, Khanera 2001, Parechhu 2005, Phugtal 2015) and flash floods (Leh 2010, Uttarkashi 2012, Uttarakhand 2013). The aforesaid disasters have occurred at different times during the last 25 years in different parts of the Himalayan states and witnessed huge loss of lives, economy and environment. A study of these events indicates that despite the variations in space and time, the consequences were largely governed by certain conditions and factors that remained invariably the same in almost all of these disasters. The paper attempts to reveal some of these conditions and factors as lessons learnt from these events and focuses on the urgent need to alter them for efficient disaster risk reduction in the country. It also proposes some recommendations that may be considered in the strategies for way forward to make the region disaster free or foster a culture of prevention and preparedness in a disaster resilient society.

The major lessons learnt include gaps in science and practice, communication and coordination, lack of awareness and preparedness against natural disasters among the affected communities, absence of pro-active prevention and mitigation initiatives, inefficient monitoring and early warning system, non-implementation of relevant standards and codes in construction and development, inadequate training and capacity development of different stakeholders for integrating disaster risk reduction into developmental plans / programmes / projects, non-functioning of disaster management authorities at district and state levels, improper regulations and enforcement mechanisms for landuse and development controls, non-availability of reliable validated hazard and risk maps in laymen's language, unscientific damage and loss assessment after the disasters leading to either highly exaggerated or under-estimated values, indifferent attitude of responsible functionaries due to non-accountability and absence of liability or penalty. The difficulties in accessibility and adverse weather conditions during the disaster times have also lead to delayed response and aggravation of losses. However, there are some positive points also. These include a simple living coherent society that cares for each other well during disaster times and extends mutual help. The local inhabitants have very good traditional knowledge / wisdom that help them understand natural hazards and provides guidance for reducing the risks through the use of indigenous resources and skills. The people in the Himalayan terrain have been blessed with clean (unpolluted or less polluted) environment and rich natural resources in terms of bio-diversity, fresh drinkable water, forest cover, sub-tropical to temperate climate, fertile soil and mineral resources. But there is a need to conserve, preserve and protect these resources from the threats of natural disasters.

The way forward for disaster risk reduction would depend on how seriously these lessons learnt from the disasters are taken up for actions to improve the overall system in different sectors and disciplines at different levels. Although several initiatives have been taken by Government of India after disaster management act 2005 yet many more steps are still required to be taken to achieve the vision of the national policy on disaster management that envisages to build a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response. The paper proposes that the system should have a mechanism for introspection and improvement to enhance its capacity as well as efficiency. A complete SWOT analysis is a pre-requisite for planning and implementation of a practical strategy. It is recommended that gaps and weaknesses highlighted in the lessons learnt must be eliminated or reduced from the science, system and the society. It calls for greater involvement of the public in the process of planning, policy and decision making related to disaster risk reduction while emphasizing the need for sharing information and enhancing people's capacity through greater awareness and preparedness. Thus, there should be better communication and coordination among different stakeholders at all levels. Adequate provisions of funding must be ensured for promoting steps for prevention, mitigation and preparedness as well as for establishing reliable early warning system that can help issue timely alerts for protecting people, properties and environment against the risks from natural hazards in the Himalayan terrain.

International Practices in Engineering Geology: Education in India

Arindam Basu

About Speaker

Dr. Arindam Basu, with specialization in Engineering Geology and Rock Mechanics, is presently working as an Associate Professor at Department of Geology & Geophysics, IIT Kharagpur. He pursued M.Phil and Ph.D. studies at The University of Hong Kong (2000-2006) and carried out postdoctoral research at Universidade de São Paulo (2006-2007).

The major research contribution by Dr. Basu lies in the subjects like mechanical characterization of virtually isotropic and anisotropic rocks, improvement of rock index test methods, engineering significance of rock weathering, rock fracturing at laboratory scale, application of soft computing methods in rock mechanics and shear strength behavior of rock joints. Dr. Basu received the prestigious GSI Sesquicentennial Commemorative Award in the field of Engineering Geology for the year 2013. He was awarded Outstanding Reviewer Status in 2014in recognition of his contributions made to the quality of International Journal of Rock Mechanics and Mining Sciences, Elsevier, Amsterdam.

Extended Abstract

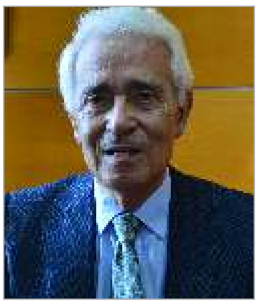
"Engineering Geology as a professional practice has been in existence for some 70 years, although others may argue that the practice has been around as long as man has been carrying out engineering works in and on the ground." (Norbury, 2004). Today, engineering geology happens to be the basis of all geotechnical practices and consequently, has become an indispensable discipline as far as rock and soil engineering is concerned. It is not only about the description of the in-situ surface and/or sub-surface soil and rock masses and the structures therein from geological perspectives, but also involves evaluation of in-situ stress conditions, comprehensive physico-mechanical characterization of all the concerned materials and above all, critical assessment of engineering behaviors of rock and/or soil masses proximate to a project. Moreover, identification and assessment of plausible natural hazards that might influence an engineering site or that are of societal importance fit well under the accountability of the concerned engineering geologists. Role of engineering geology in maintaining a diligent balance amongst various facets (e.g. socio-economic growth, exploitation of earth resources, environmental protection etc.) impacting sustainable development of a country is, therefore, well-acknowledged.

A large section of professional geologists provides service as engineering geologists to organizations or companies dealing with various civil, mining or geotechnical aspects, in general, all over the world. The various subjects, engineering geology is based on, include fundamentals of geology, soil and rock mechanics, hydrogeology and mining geomechanics. Meaningful and unambiguous exchange of scientific as well as technological knowledge primarily between trained geotechnical or other engineers and engineering geologists, and sensible amalgamation of the same can help formulate efficient strategies towards successful rock and soil engineering. It should be noted that there is also an increasing need in today's world for smooth communication of the technical aspects as well as usefulness and benefits of the undertaken strategies of an engineering project to the national and international stakeholders and engineering practitioners.

Keeping imperative role of engineering geologists in mind, a number of academic institutions particularly in North America and Europe host departments where engineering geology is of primary or of enormous importance as far as undergraduate degrees are concerned and the name of the department itself is indicative of the nature of such centers. There are also numerous earth science departments in academic institutions all over the world where degree programs in engineering geology or in equivalent fields are offered. In India, however, the scenario is very different. There is no engineering geology/geological engineering department as such in any of the regular academic institutes/universities of India. No degree program in the field of engineering geology is offered at undergraduate level (i.e. up to M.Sc. level) either. Engineering geology or an equivalent subject occasionally with or without its laboratory components, however, exists in the curricula of degree programs in Geology, Applied Geology etc. at some academic universities and institutes of India. It should be noted that there are students who join different organizations and companies after earning such a degree and have to work in the geotechnical division where they are supposed to provide inputs from engineering geological perspectives. It is well-acknowledged that many of these personnel do develop their skills through the training they receive at their work place and/or through self-learning processes and successfully perform their jobs as engineering geologists with great efficiency. Nevertheless, this does not discard the need for an appropriate course work in engineering geology and its laboratory components at undergraduate level that would not only enrich the students with the background knowledge in this subject area but also enable them work with enhanced efficiency along with their co-workers from different engineering disciplines in rock and soil engineering environments. This will also be beneficial for the organizations they would work for in order to develop well-integrated strategies for an engineering project.

This paper, with due need, first attempts to provide an overview of international practices in engineering geology. At this backdrop, the author makes an effort to cumulate the necessary topics as components of a virtually ideal engineering geology course at undergraduate level after looking at the engineering geology course contents of selected renowned universities from different parts of the world. Considering the present educational structure in India at undergraduate level and present scenario of engineering geology as a topic therein, attention has been given to the understanding of fundamental aspects of the subject as well as to the comprehensive coverage of various useful dimensions of the same within a limited time frame of a semester in an academic session. It is concluded that the proposed compact course structure of engineering geology along with its laboratory components at undergraduate level could be quite useful for future professional activities of the students, for the organizations/companies they would work for and above all, for improving the overall status of engineering geology in a country like India. It is also recommended that the students, who grow interests in the field of engineering geology based on such offered course works and wish to build their professional career as engineering geologists in future, should gather some on-site experience beforehand in a suitable professional organization through internships which should be a viable option during their undergraduate curricula. It is also hoped that in near future, engineering geology-specific degree programs and even departments, prompted by necessity, would evolve at least at some regular Indian academic universities/institutes.

Soils Prone to Volume Instability and Unstable Structure: Proposals for Improvement



Carlos Delgado

About Speaker

Dr. Carlos is in Civil Engineering Madrid Polytechnic University

MBA I.E.S.E. Barcelona

Professor of Geotechnics at the Madrid Polytechnic University.

Dean of the Civil Engineering School (Madrid Polytechnic University).

He developed himself in the field of engineering geology through his association in a number of study based projects in Spain, Switzerland, France, Holland, the Middle East, Africa, Central and South America. He initially worked in the RODIO Group as a Field Engineer and was later promoted as director of the foreign department of RODIO and and subsequently as CEO of RODIO, S.A. in charge of Spain, Portugal and Central and South America.

Later, he took to teaching at the University, in the Applied Geology and Geotechnics Department of the Madrid Polytechnic. He has directed many research studies in the field of treatment of rock and soils and hydraulic fracturing grouting. He has also directed over 80 Final Projects and Doctoral Theses, and has given Master courses on Geotechnics and Engineering Geology. He has published work at Congresses and in magazines specialized in these subjects.

He has been the Spanish representative of the European Foundation Association and President of AEGAIN (The Spanish Association of Geology applied to Engineering) and is a member of the Jury for Doctorate Theses of ANCI and a fellow of the Arbitration Chamber of the Spanish College of Civil Engineers. He is also a member of the Board of Directors of the Madrid Polytechnic University.

He served as President of IAEG from 2011-2014.

Extended Abstract

Soils prone to volume instability and of unstable structure. Proposals for improvement through treatment.

This communication studies terrains with problems for construction and civil work, describing the different typologies and characteristics. It subsequently proposes treatment to remedy these problems through grouting by the “sleeve pipe” method and describes some cases where these methods of treatment have been used.

Shear Resistance as a Multifactor Parameter of Soil Strength

Victor I. Osipov

About Speaker

Dr Ivanovich is an M.Sc, Ph.D, Dr.Sci. Prof. from Moscow State University. He is also the Full Member of the Russian Academy of Sciences, Honorary Professor of the Moscow State University and Honorary Professor of the Geological Institute, Academy of Science of China.

Dr. Prof. Victor Ivanovich OSIPOV is the full member of the Russian Academy of Sciences, director of the Sergeev Institute of Environmental Geoscience RAS, Dr. Sci. (Geol.-Min.). He is a leading Russian scientist in environmental geoscience, engineering geology, soil and rock engineering, and geodynamics. He has contributed to the world science with the considerable achievements in soil and rock engineering, the prediction, study of mechanisms and regularities of the development of geological hazards, natural risks assessment theory, and minimization of natural disasters consequences.

Prof. Osipov is the Chairman of the Russian national group IAEG, the head of the Scientific Council at the Russian Academy of Sciences on the problems of environmental geoscience, engineering geology, and hydrogeology; the member of the Russian National Committee of Geologists, editor-in-chief of the Russian academic periodical journal "Environmental Geoscience" ("Geoekologiya"). V.I. Osipov is the author of more than 560 scientific publications (including 13 monographs and 20 patents of inventions), awardee of the State Prize of the USSR (1988); laureate of the Moscow Major Prize in environment protection (2002), winner of the National Ecological Prize (2004); laureate of the Russia State medal of the first degree "For great services to the Motherland" (2008), and the State Award of the Russian Government (2008). He is the laureate of the IAEG Hans Cloos medal (2012).

Extended Abstract

Sliding of a massive body along another one is considered to form the basis of friction mechanism. However, this process is far more complex in fine-grained systems built of fragmentary grains. The term "internal friction" is often applied to such bodies. Internal friction in soils is controlled by a number of factors ignored in the Mohr-Coulomb theory, which describes the shear strength of soils. Therefore, the soil shear resistance calculated on the basis of this theory often do not agree with the experimental data. Hence, the shear behavior of various soils should be theoretically generalized to contribute to the further development of shear theory. The shear strength of soils is a complex parameter depending on four groups of factors. The first group includes the factors that control the origin and mechanism of friction on contacts. It includes mineral composition and particle-size distribution of soil, geometry and morphometry of structural units, the presence of solid coatings and adsorption water films on the grain surface. The second group includes structural cohesion closely related to surface forces and structural bonds in soils formed in the course of geological history, as well as density and moisture controlling the number and strength of contacts between structural units. The third group of factors is determined by the stress-strain state of soil depending on the external effective stress, disjoining effect of bound-water films and the actual effective stress. The fourth group unites factors dependent on the experimental technique and conditions. They are the history of soil loading, its shear drainage conditions, temperature, deformation velocity, and total deformation.

The present work analyzes the influence of enumerated factors and gives theoretical generalization of the shear behavior of different soils. This permits us to interpret adequately the obtained experimental data and to explain the regularities of changing soil shear resistance. Taking into account the multifactor dependence of the shear resistance of fine-grained soils, we should turn down any attempts of compiling versatile tables for shear strength indices of different soils. Genesis, composition, state, and lithification degree of soils should be taken into account for soil strength assessment in every particular case.

Role of Environment in Project Optimization

Ricardo Oliveira

About Speaker

Ricardo is the Co-Chairman of COBA Group, Engineering and Environmental Consultants. He obtained his Ph.D degree in Engineering Geology from LNEC, Portugal in 1965. He also holds the Senior Research Degree (Full Professor level) in Geotechnique (1983) from LNEC, Portugal. He also is the Emeritus Professor of Engineering Geology and Rock Mechanics at New University of Lisbon. He is the Visiting Professor at several Universities, namely in Brazil; Canada, Spain, and Switzerland and International Consultant for Dams and Underground Works.

He is the author of over 200 scientific papers, general and panel reports and chapters of national and international books. He also is the Member of scientific and professional Portuguese and International Associations and Member of the Portuguese Academy of Engineering. He is also the Member of the Brazilian National Academy of Engineering.

He has received several distinctions and honourable mentions from national and international scientific bodies namely the Hans Cloos Medal (IAEG, 1996), Manuel Rocha Research Prize (LNEC, 2002) and André Dumont Medal (Belgian Group of IAEG, 1993).

He was awarded the Insignia "Grande Oficial da Ordem de Mérito" by the President of the Republic of Portugal (2006). He was the Deputy Director of LNEC (1983/1991). He was Secretary General ISRM (1968/1974) and President IAEG (1990/1994).

Extended Abstract

The construction and operation of civil engineering projects have always resultant environmental impacts, some negative, others positive.

However, those projects are in most cases essential for the social and economic development of the regions where they are located and for many of them their main purpose is to protect people and goods from natural hazard such as landslides, floods, marine cliff erosion and earthquakes.

In general, the media and environmentalist organizations tend to enhance the negative impacts caused by the implementation of the projects and very seldom make clear reference to their positive impacts.

In this context, the need for high quality studies and adequate designs is assuming increasing relevance for engineering projects to assure that viable solutions with the least negative impacts are selected and subsequently constructed and operated by highly qualified staff.

The role of engineering geology and other geotechnical disciplines in the optimization of many civil engineering projects is therefore as important as is the efficient and early intervention of specialists and their decisions on the technical, economic, social operational and environmental aspects of the alternative solutions for the works. This is

especially relevant for engineering projects that have a significant interference with the ground. The purpose of this Lecture is to illustrate that it is often possible to optimize projects from an environmental point of view selecting the solutions that cause less impact on the environment and the landscape. Some examples are presented in relation to some topics, namely construction materials (soils and rocks), hydraulic developments, linear works such as roads, railways and waterways, maritime works and natural and excavated slopes.

In each case, emphasis is placed on the environmental concerns that require optimization of the design, in order to minimize the negative impacts without diminishing the benefits of the projects.

Energy Development Scenario in India

M. M. Madan

About Speaker

Mr. M. M. Madan, is a B. Tech in Civil Engineering & MBA. He has over 40 years of vast & rich experience in Hydropower industry, in public & private sectors. At present, he is the President & CEO (Hydro Business) at Jindal Power Limited, a company which is developing 5600 MW of hydropower through several big projects including India's largest Etalin HPP (3097 MW). Earlier, he worked at private sector companies like GVK and LNJ Bhilwara and Central Public Sector undertaking NHPC Ltd.

He has contributed towards sustainable development and implementation of hydropower projects aggregating 10,000 MW in the challenging Himalayan terrain. His success particularly in the state of Sikkim in North-East India has paved the way for more investment in hydropower sector by public & private sector companies in NE India.

As recognition of his outstanding contribution in water resources sector, Mr. Madan has been awarded with the prestigious I. N. Sinha Award for 2001-02 by the Central Board of Irrigation and Power, India's premier entity in water & power sector. He is also the proud recipient of Prof. V. K. Kulkarni Award for 1987. He has been recognized as one of the Top 100 Engineers in the world by International Biographical Centre, Cambridge, and England in 2009. Mr. Madan has published and presented 195 technical papers in national and international forums besides award winning book on Hydropower.

Extended Abstract

Energy supply is falling short substantially of demand of the fast growing economy and population in India. The peak power deficit during FY 2014-15 was about 5%. Capacity Addition during April 2012 to March 2015 – first three years of 12th Five Years Plan - is about 72,000 MW which comprise of 80% Thermal (53000 MW Coal & 5000 MW Gas), 16% Renewables (11000 MW), 3% Hydro (2300 MW) & 1% Nuclear (1000 MW). The hydropower capacity addition target for 12th Five Year Plan is 10897 MW but in first three years it has achieved only 21% of the total target. About 14,000 MW of hydropower projects are under construction in the country, but as the trend indicates hydropower capacity addition achievement shall be way behind vis-à-vis target during this plan period. Contribution of hydropower to total installed capacity which 'once upon a time' used to be about 45%, is now at its all time low – merely 15%. Out of total installed capacity of 271722 MW in the country, the hydropower installed capacity is 41267 MW only. Hydropower sector is in peril in India. The target for thermal power capacity addition for 12th Five Year Plan is 72340 MW & nuclear power is 5300 MW. These numbers evidently show that current trend in energy development in India, in spite of tempting promotion of renewable energy, is over dependent on fossil fuel. Even , the set back in thermal power sector due to cancellation of coal blocks by Hon'ble Supreme Court in August / September 2014 could not persuade the IPPs to opt for hydropower instead of thermal power though India is having about 100000 MW of untapped hydropower potential. This untapped hydropower potential is technically feasible, economically viable, socially equitable & environmentally sustainable. The target for renewable energy sector as promulgated by Govt of India at 'RE-INVEST', 1st Renewable Energy Global Investors Meet & Expo held on New Delhi during 15th - 17th February 2015 is 100000 MW of Solar, 60000 MW of Wind, 10000 MW of Bio-Energy & 5000 MW of Small Hydro by 2022. To cater its energy needs, India has imported crude oil worth USD 138 billion in 2014-15 which is approximately the total estimated cost of development of India's untapped hydropower potential of 100000 MW. Since operation & maintenance cost of hydropower plant is very less, India can save considerable amount of its foreign currency every year, if untapped hydropower potential in the country is developed by means of one time investment. Utilization of vast hydropower resources available in India's North-Eastern states particularly in Arunachal Pradesh in sustainable way is one of the most viable options for energy security in the country. Hydropower is renewable, entirely domestic, free of cost of fuel & inflation and clean energy.

Engineering Geology in Development of Hydroelectric Projects in Peninsular India

Viswanathan Balachandran

About Speaker

Viswanathan Balachandran, born on 8th June, 1950, obtained his Masters degree in Geology from Annamalai University in 1972. He served in the Geological Survey of India for a period of over 35 years and has worked in most parts of the country carrying out investigations in the field of Engineering Geology, Natural Hazards and Quaternary Geology.

He had the honour of serving various Expert Committees constituted by State Governments and the Government of India besides working in difficult geotechnical assignments both in Peninsular India as well as in Himalayas. Currently, he is working as an Executive Director of a Private Limited Company involved in carrying out geotechnical consultancy.

Extended Abstract

A host of factors such as availability of excellent sites, excellent rockmass media relatively free from seismicity, erstwhile princely states flush with funds, their vision, better accessibility, availability competent engineers/professionals and skilled labour from early twentieth century gave a head start to development of hydro electric power projects in the Peninsular region over the Extra Peninsular Region.

In total contrast to the Geology and structure of the Extra-Peninsular geomorphic province of the country, the peninsular region of India constitutes a Stable Cratonic Region (SCR).The country is predominantly occupied by rocks belonging to Archaean-Proterozoic period with bulk lithological assemblages of various para and ortho high grade schists and gneisses, Charnockite, quartzites, phyllites, limestones intruded and extruded by acid/basic rocks of various compositions of different time periods. Structurally the rocks have undergone polyphase of deformation and. metamorphism The principal east flowing drainages from North to South are, Mahanadhi, Godavari, Krishna, Pennar and Kaveri while the West flowing rivers are Tapi, Narmada Kali, Netravadhi, Bharthapuzha, Pamba and Periyar.

In the development of hydroelectric power in the southern part of India, the earliest contributions per se from engineering geologists was limited to attending specific requests arising out of adverse geological conditions as the projects were conceived and constructed with rigid design in ideally located site conditions with limited geological infirmities. Comprehensive engineering geological studies were either none or cursory during the period up to 1950. To cite but a few Projects thus executed are the Sivasamudram, Bhira, Pallivasal, Pykara, Moyar HEP, etc.

With the establishment of Engineering Geology Divisions in Geological Survey of India a pioneering Organization of the Government of India- in mid forties of the twentieth century- certain requests were made to study and evaluate Irrigation/Hydroelectric and Multi –purpose Projects geotechnically. It is worthwhile to remember here that systematic geological mapping was just initiated in the entire country, rock mechanics and instrumentation was unheard and the rock engineering design inputs expected were minimal and most of the projects were designed and executed by engineering judgment, adhering to rules of the thumb-conventional practices and skill. Planned exploration of the sites were minimal that too confined to the water storing/diversion

structures and not to speak off the exploration of water conductor system irrespective of the lengths. Engineering geology discipline personnel were a select few and equipped with the traditional practices .passed on in a disciplistic manner. Several investigations were initiated in such a technical milieu. Many such major projects were executed between 1950 and mid-sixties. Koyna, Kundah, Hirakud, Lingamakki,Parmbikulam-Aliyar Dam Projects are but a few to name.

The most unexpected Koyna Earthquake of 1967 galvanized civil engineers and geologists alike to rethink that the Peninsular region is no longer stable as it was considered to be and they grudgingly accepted the fact that the region is moderately seismic capable of generating major earthquakes. Hand in Hand progress of systematic geological mapping of the country led to better understanding of the geology and structure of the country, development of aerial photo interpretation and satellite image interpretation led to a thorough appreciation of regional tectonic fabrics and milieu and Bureau of Indian Standards brought out concept oriented revisions of Seismic Zonation Map of the country based on better update on geology, structure and seismicity. Parallel to that Design Engineers were exposed to modern rock mechanics application and understood the importance of rock mass media. As a sequel, harnessing of hydroelectric potential of major rivers commenced in right earnest and significant engineering geological design inputs provided more importantly engineering geologists were associated with construction of such projects on a regular and resident basis. The projects thus undertaken are Idukki Hydroelectric Project, Srisailam Multipurpose project, Kadamparai Pumped Storage Hydroelectric Project, Koyna later Stages, Kalinadhi Hydroelectric Project, Sabarigiri Hydroelectric Project, Nagarjunasagar Multipurpose Project in the early seventies.

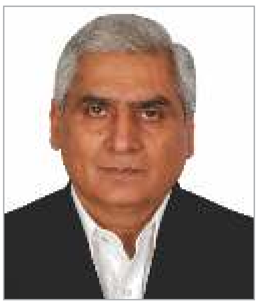
This development has further progressed in the past three/four decades and more and more power projects heralded a significant contributions from engineering geologists right from preliminary investigations to construction Stage extending beyond to post construction activities too wherein specific contributions are being made. In fact of the ten largest capacities of existing power stations in the country seven belong to the Peninsular India with a total Installed Capacity of 7096MW. These running projects are Koyna (1960 Mw), Srisailam(1670Mw), Sardarsarovar (1450Mw), Indirasagar (1000Mw), Nagarjunasagar (816Mw), Idukki (780Mw) and Kadamparai (400Mw).

As the water resources are relatively limited and purely rainfed in Peninsular India unlike the Himalayan Rivers, water availability and head for power generation is also limited. Hence most of the power stations constructed thus and contemplated in this region are underground power stations. This is greatly achieved due to the better rock mass conditions, structural set up and favourable stress conditions, seismicity of the terrain and by expert engineering geologists. Development of these stations surmounted peculiar geotechnical conditions such as pronounced and erratic weathering, within competent country rocks presence of sheared acid and basic intrusives having relatively poor shear characteristics, heterogeneity owing to competent and incompetent beds alternating adding to the tale of woe with unfavourable orientations of discontinuities warranting shear keys in dam foundations and special excavation pattern to have better arch actions in underground openings to avoid development of excessive tensile stresses, encountering uncontrolled enriched pockets of mica particularly in the crown portion of underground structures leading to poor stand up time more efforts required on impermeabilization measures with limited explorations etc.

As constructions of major hydroelectric projects are dwindling with the attrition of expert design experts from the government departments, liberalization policies of the Government of India, stringent environmental issues and attendant legal hurdles, the focus has shifted to development of Small hydroelectric plants with corporate participation. These projects are located in more and more geologically complicated sites such as landslide prone areas etc., although the engineering geologists both in government and private sectors are more equipped than ever before to face the challenges adopting to innovative, safe and economic designs.

The paper brings forth case histories of some of the major projects along side with some difficult small power projects for better appreciation of geotechnical issues peculiar to Peninsular India and the contribution of engineering geologists against all odds towards hydro power.

Seismotectonic Constraints in the Development of Hydropower in the Himalaya



Prabhas Pande

About Speaker

Dr. Prabhas Pande, born on 4th August 1951, did his M.Sc. in Geology in the year 1971 and was awarded the degree of Doctor of Philosophy in 2008 for his Ph.D. Thesis, "Seismotectonic evaluation of Kachchh rift, Gujarat, India and an assessment of the seismic hazard potential of the region", by the University of Lucknow. In his service career in the GSI, he carried out geotechnical investigations for several river valleys and communication projects in the States of Maharashtra, Madhya Pradesh, Punjab and Jammu & Kashmir and studied over 15 damaging earthquakes that occurred in the Indian subcontinent since 1980. He supervised seismic hazard assessment of Urban Agglomerations at micro level, active fault mapping in the Frontal Himalayan belt and palaeoseismic studies. He superannuated as Additional Director General, GSI on 31st August 2011.

He has served as a Member of the Scientific Board of IGCP, UNESCO from 2002 to 2005, and in this connection, visited France on four occasions. He was sent on deputation to France in 1995 and to Bhutan in 2001 to conduct seismotectonic evaluation studies. Dr. Pande was part of the Indian delegation to visit Chile, Peru and Canada in 2010 and 2011 and served as a geotechnical Consultant for Chindwin Valley projects in Myanmar. He was a Technical Consultant for Kalpasar Project, Government of Gujarat, and represented GSI in several National and International Committees including the Global Earthquake Model (GEM). He was a member of the Peer Group that was constituted by the BMTPC for the First Revision of the Vulnerability Atlas of India. Dr. Pande has written over 50 technical papers and authored/edited several major publications of GSI, including the Seismotectonic Atlas of India and 2001 Kutch Earthquake.

Since his superannuation in 2011, Dr. Pande is actively associated with various programmes associated with earthquake research, seismic hazard assessment, landslide studies and disaster management. Presently, he serves as the Chairman of the Expert Committee on Active Fault studies under the aegis of Ministry of Earth Sciences and is Member of various National Committees constituted by the DST, MoES, Nuclear Power Corporation of India, GSI, NGRI, etc. As a Consultant, he has carried out seismotectonic evaluation of a number of river valley projects in the North Eastern Region.

Extended Abstract

The mighty Himalaya, the abode to hundreds of snow clad mountain peaks, is bound in the north by the Tibetan Plateau and in the south by the sprawl of Indus-Ganga-Brahmaputra plains. This 2400 km long and 200-300 km wide system of mountain ranges constitutes parts of five countries namely India, Pakistan, Nepal, Bhutan and China. Its extremities are marked by the presence of the gorgeous Indus and Siang rivers that skirt around the majestic Nanga Parbat in the west and Namcha Barwa in the east. This youngest of the mobile belts came into being by the continued collision of the Indian plate with the soft underbelly of Eurasia since Miocene times, thereby uplifting the Himalaya and the Tibetan plateau and deforming the Asian interior as far as 3000 km. The ranges of North West Frontier Province, Afghanistan, and Baluchistan on the western side, and those of Myanmar, Malaysia and Indo-China belong to the same great series of earth movements as that which produced the Himalaya.

The southwest monsoon, in spite of its transit over the Indian peninsula, deposits its remaining load on the southern slopes of the Himalaya with very little of the moisture managing to sneak into the Tibetan side through the deep gorges and passes. This replenishes the snow pack and recharges the drainages year after year. The glacierised area in the Indian Himalaya is of the order of 18,528 sq km holding 1110 cu km of locked up ice. This cryosphere resource feeds as many as 9575 glaciers, which, in turn, augment and regulate the water supply of major Himalayan rivers falling under Indus, Ganga and Brahmaputra basins.

The Himalayan tectogen contains within its confines rock sequences with long history of sedimentation, magmatism and tectonism. Bulk of the rocks exposed here belongs to Proterozoic age with Phanerozoic cover of varying thicknesses in different parts. It is divisible into four principal tectonic belts of i) the Karakoram, ii) the ophiolitic melange and plutonic zone of the Indus-Shyok, iii) the Main Himalaya containing the complex fold-thrust stratigraphic stack and iv) the Frontal Fold zone comprising essentially the Tertiary rocks of the foreland basin. Each of these belts are demarcated by major dislocation zones, which from north to south are Shyok suture, Indus-Tsangpo-Tiding suture, Main Boundary thrust (MBT) and Main Frontal thrust (MFT) with Main Central thrust (MCT) being an important structural entity within the Main Himalayan belt. The terminal ends of the mountain chain are marked by the Western and Eastern syntaxes characterised by acute inflexion of rock trends. The length of the Himalaya is sliced into several discrete blocks by a host of transversely disposed basement faults. The dextral Karakoram fault in the Indo-Tibetan convergence zone has been regarded as an important structural element of NW Himalaya.

It is estimated that the Indian plate presently moves at the rate of 67 mm per year below the Eurasian plate. As a result, the Tibetan plateau continues to move upwards and the thrusting along the Himalayan southern front leads to rise of the Himalaya by about 5 mm per year. The convergence rate from east to west along the Himalayan arc has been deduced to vary from about 20 mm/yr to 10-14 mm/yr, respectively. The most convincing forms of evidence indicating continuation of convergence are earthquakes, which, in fact, are part of the normal and inevitable life history of the Himalaya. The mobile belt in the last 200 years has recorded over 650 earthquakes of $M \geq 5$ where the seismicity is mostly confined along the Main Himalaya, particularly between the MCT and MBT. In the Indian part comprising the states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, northern West Bengal, Sikkim and Arunachal Pradesh, $M \geq 5$ seismic events number 197, with one of M8, 13 of $M \geq 7 < 8$, 58 of $M \geq 6 < 7$ and 124 of $M \geq 5 < 6$. The four major earthquakes of 1833, 1934, 1988 and 2015 that inflicted considerable damage on the Indian side as well had their epicentres in Nepal. The great earthquakes of 1897 Shillong Plateau and 1950 Upper Assam, senso stricto, do not belong to the Himalaya but are definitely the outcome of the same stress regime.

The Himalaya can broadly be divided into three distinct seismotectonic domains of 'Frontal Arc' and 'Northeast Himalaya' mainly on the basis of the operative stress fields. The former includes the Kashmir, Himachal, Garhwal, Kumaon, Nepal, Sikkim, Bhutan and west Arunachal Himalaya. In this part, the larger magnitude earthquakes generally nucleate along a low dipping detachment surface in a thrust-type environment. Kinnaur and certain blocks in the Tibetan Plateau constitute an exception where the normal fault mechanism suggests prevalence of an extensional stress regime. The tectonics and stress distribution in the NE Region is much more complex because of N-S convergence of the Himalaya and E-W convergence of the Indo-Myanmar ranges. This segment coming under very high seismic hazard has three distinct units of Assam Syntaxis, Shillong Plateau and Arakan-Myanmar ranges. Probabilistic Seismic Hazard Analysis (PSHA) at the National level has been attempted so far by only a few groups. In one of such exercises, the peak ground acceleration (PGA) values vary from 0.1g along the frontal belt to 0.55g in the Eastern syntaxial bend for a return period of 2500 years.

The high gradient Himalayan rivers draining an area of roughly 486,600 sq km are estimated to hold power potential of 117,300 MW on the Indian land, which is almost 80% of India's total hydropower potential. Of the five Himalayan states, Arunachal Pradesh alone has an estimated power potential of 50,000 MW. Of the total hydro capacity, only 27% has been exploited so far and, therefore, the Himalaya offers tremendous scope for development of this clean source of energy. Besides various geotechnical, hydrological and environmental issues, the seismotectonics plays a vital role in safe designing of river valley structures, particularly in the Himalaya where the seismic hazard is of high to very high order.

The forces acting on dams and their appurtenant structures on account of earthquakes can be generated by strong ground particle oscillations as well as ground displacements along active faults or subsidence in case of liquefaction. The assessment of the second two causes can be made fairly convincingly by carrying out systematic field mapping and subsurface explorations. However, uncertainties regarding the recurrence period of large magnitude events, earthquake distribution in time and space, attenuation relationships and crustal structure make the task of evaluation of seismic design parameters highly intricate and assumptive. The National Committee on Seismic Design Parameters, Central Water Commission has issued elaborate guidelines for evaluation of site specific seismic parameters in terms of response spectra for MCE and DBE conditions, horizontal and vertical seismic coefficients, estimated duration of shaking and acceleration time histories. It certainly requires lot of professional skill, experience and a sense of judgement to make a proper and reasonable estimation of the seismic forces likely to act on a structure in its lifetime.

Foreland and Hinterland Structural Features Across Himalaya: Exposition and Seismic Propensity

Sujit Dasgupta

About Speaker

Sujit Dasgupta completed his M.Sc (Geology) from Calcutta University in 1971. He joined the Geological Survey of India in December 1973 and worked under different capacity till his superannuation from the position of Deputy Director General in April 2010.

He worked with NHPC during 2011 as Consultant for finalization of DPR on Hydroelectric Projects in Myanmar. He is an expert in Earthquake Geology and Seismotectonics, and has published more than 50 papers in national and international peer reviewed journals. One of his major contributions is the publication of 'Seismotectonic Atlas of India and its Environs' released by GSI in 2000.

He is a recipient of National Mineral Award (1987-88) and also 'H.C. Dasgupta Medal' for best publication of 1995 in Indian Journal of Geology. He attended and contributed for UNESCO-RELSAR workshops held in Bangladesh, Bhutan, China, Iran and Thailand.

Extended Abstract

Active deformation along the Himalayan fold-thrust belt albeit with varying convergence and shorting rates has produced large and major earthquakes in the past (1905, 1934, 1950 etc.) including the recent disastrous earthquakes in Kashmir (8 October 2005; Mw 7.6) and Nepal (25 April 2015; Mw 7.8 and 12 May 2015; Mw 7.3). It is generally accepted that under-thrusting of the Indian lithosphere beneath the lofty Himalaya presently occurs along a gently north dipping basal detachment known as the Main Himalayan Thrust (MHT) from which emergent ramps branch out sequentially and day lighted as MCT, MBT and the MFT from north to south. The southernmost Main Frontal Thrust, the youngest in the sequence, is geologically active during the Quaternary period and capable of generating large earthquake to the tune of Mw ~ 8.0+.

In Himalaya, modelled parameters for surface rupture and allied slip for great thrust earthquakes varies from west to east. The Kashmir earthquake (Mw 7.6) in western Himalaya produced a surface rupture of 75-80 km (subsurface ~100 km) with fault offset of 4 m on average and a peak of 7 m northwest of Muzaffarabad. The rupture lasted about 25 s and propagated up-dip and bi-laterally by ~2 km/s (Avouac et al 2006). The Nepal earthquake main-shock (Mw 7.8) in central Himalaya did not produce any surface rupture; subsurface rupture length is of the order of 100 km (width ~ 80 km; slip 3-4m) produced in about a minute (USGS poster). Compare this with the Assam earthquake (Mw 8.5-8.6; 15 August 1950) in northeast Himalaya whose rupture length is around 250 km (width 80 km) produced with rupture velocity of ~ 3 km/s and modelled average shear dislocation of ~ 35m (Ben- Menahem et al, 1974).

Furthermore, within the Himalayan collisional framework very large to great earthquakes (Mw~ 8.5) are predicted based on accumulated slip deficit [with critical strain attained] –and availability of un-ruptured continuous fault segment e.g. along the central seismic gap of 500- 800 km (see Rajendran and Rajendran, 2005 among others). The un-ruptured part of 80-100 km wide lesser Himalaya in this gap is thus friction locked to the under-thrusting Indian plate between great earthquakes, derived from the comparison between magnitude of geodetic vectors and

geological slip rates. The locking line more or less coincides with 3.5 km altitude contour of the Himalaya. Moreover, a recent publication (Morell, 2015) specifically announces 700 km long décollement (MHT) within the central seismic gap, constitutes a coherent fault segment capable of hosting a great earthquake. Note for comparison that the 1960 Chile earthquake (Mw 9.5) produced a rupture of ~ 800 km; the giant 2004 Sumatra earthquake (Mw 9.2) produced a segmented rupture of ~ 1300 km and in both the cases rupture lasted for about 10 minutes. Unlike subduction domain interplate fault zones, in the Himalayan collision scenario the MHT and the frontal thrusts are riddled with heterogeneities induced by varying geological milieu along strike and punctuated by physical barriers like transverse faults, lateral ramps, changes in fault geometry and a number of Indian shield basement ridges that continue northwards into the Himalayan domain and possibly beyond, resulting significant segmentation of the potential faults (MFT, MBT, MCT and MHT) that should hinder uninterrupted rupture propagation.

Key Speaker

In the present paper, we propose to discuss on the transverse structures namely the basement ridges and faults that are known from the Himalayan foreland, and many of them traverse across the mountain range to the Tibetan hinterland (see Valdiya, 1976; Dasgupta et al., 1987). The latter authors further suggested that some of these transverse faults are seismically active and could accommodate partial Indian plate convergence through strike-slip motion across the Himalaya. Since then, eastern Himalaya witnessed two deep crustal earthquakes that display clear strike-slip motion along faults transverse to the orogen; the Bihar-Nepal earthquake (20 August 1988; Mw 6.8, h 57km) ruptured the NE trending East Patna Fault in the foot-hill with left lateral shear (Dasgupta, 1993) and the Sikkim earthquake (18 September 2011; Mw 6.9; h 50 km) activated NW trending Tista lineament/ fault with right lateral movement (Dasgupta et al., 2013) in the lesser/higher Himalaya. The role of Monghyr- Saharsa ridge indenter vis-à-vis location of these earthquakes still remains a matter of speculation in the absence of geophysical constraints.

Central to our discussion are the four transverse ridges and their accompanying faults traversing from the Himalayan foreland to the hinterland and their seismotectonic behaviour, based on our previous work (Dasgupta et al., 1987; Dasgupta, 1993); the Seismotectonic Atlas of India (Dasgupta et al., 2000) and a more recent publication by Godin and Harris (2014). The western most basement structure, the Delhi- Hardwar ridge (DHR) [NNE extension of the Delhi fold belt; alternatively Kalka-Ambala uplift according to Agrawal, 1977] separating the Punjab from the Ganga foredeep, plunges towards the Dehradun re-entrant and possibly bounded by two prominent active faults; the Yamuna and the Ganga tear. The Mahendragarh- Dehradun fault to the west of the ridge and the Moradabad and Great Boundary fault (Etah- Budaun fault) to the east are pervasive basement structures. The Burang graben or the Kaurik Fault system in Himachal locates directly to the north in continuation of DHR (see also Godin and Harris, 2014). The next prominent subsurface Faizabad Ridge (FR) separates the Ganga foredeep into the western Sarda and eastern Gandak depression. Several faults and lineaments traverse across the Himalaya in continuation of FR to join the Takkhola graben in Nepal. These two positive barriers (DHR and FR) in all probability should impede smooth rupture propagation for several hundreds of kilometres along the central seismic gap; provided they do not behave like 'asperities' that remained un-ruptured during a previous historical earthquake. In eastern Nepal-Bihar sector the Monghyr-Saharsa Ridge (MSR) with its bounding faults divides the Ganga foredeep in the west from the Purnea Graben (GB) in the east. The subsurface basement ridge of the Garo-Rajmahal (GR) gap is bounded by the Malda-Kishanganj fault in the west and Dhubri fault towards east. The Goalpara basement wedge plunging towards the Bhutan Himalaya separates the Brahmaputra foredeep from the rest in the west. Many of the Quaternary grabens (Kung Qu; Pum Qu; Yadong Gulu etc) mapped from Tibet locate in continuation of the foredeep basement ridges. Seismic activity along transverse structures across Himalaya as detailed above are discussed.

How Do Rocks Fail?

Louis N.Y. Wong

About Speaker

Dr. Wong is an Associate Professor in the Department of Earth Sciences at the University of Hong Kong (HKU). He previously worked as an Assistant Professor and Assistant Chair (Academic) at the School of Civil and Environmental Engineering at NTU, and as a consulting tunnel engineer in the USA. He also served the Geotechnical Engineering Office (GEO) of the Hong Kong Government. He obtained his B.Sc degree in Earth Sciences from HKU, and PhD degree in Geotechnical Engineering from MIT. His teaching and research interests are in engineering geology, rock mechanics and underground engineering.

Dr. Wong has authored and co-authored more than 80 publications in technical journals and conference proceedings. He is serving the editorial boards of Bulletin of Engineering Geology and the Environment, Engineering Geology, Rock Mechanics and Rock Engineering, and Journal of Rock Mechanics and Geotechnical Engineering.

Dr. Wong won is the proud recipient of the IAEG Richard Wolter's Prize 2014. He also recieved the Geoshanghai Prize for Best Paper in 2014, and the Youth Scholar Outstanding Paper Presentation Award in the 7th International Conference on Mining Science and Technology in 2015.

Extended Abstract

This presentation is a repeat of the one presented in the Richard Wolter's Prize competition during the IAEG Congress 2014 in Torino, Italy. "In his Ph. D. Thesis of 1945, Richard Wolters related experimental phenomena to mapped tectonic structures in various parts of the Earth" (Krefeld, 1981). The underlying issue of Dr Wolters' research is related to cracking problems in rocks. Cracking processes of crack initiation, propagation, interaction, and eventual coalescence dictate the physical properties and failure behaviour of rocks. A thorough understanding of these processes is a key in the satisfactory characterization and assessment of rock mass behavior and performance. This in turn can benefit geotechnical engineering design and implementation such as rock slope stability assessment, tunnel support design, and fluid flow prediction in rock masses.

The first part of the presentation will illustrate the use of various state-of-the-art experimental techniques in studying the cracking processes in rocks. The use of the high speed video technology allows us to observe and establish the crack types and cracking sequences. The use of the scanning electron microscope (SEM) allows us to observe the microscopic cracking events associated with the macroscopic cracking phenomena. The dynamic loading tests performed by using the Split Hopkinson Pressure Bar (SHPB) system with the high-speed data acquisition subsystem reveals the similarities and differences of cracking processes under quasi-static and dynamic loading conditions.

In particular, the crack coalescence of multiple pre-fabricated en echelon flaws are observed and analyzed in detail. The key observations from such experiments include:

1) The property (tensile vs shear) of linking cracks is controlled by the property of the rock bridge. Usually only tensile cracks develop in extensional rock bridges, while different types of shear cracks develop in contractional rock bridges.

2) The initiation location of wing crack is controlled by both the flaw inclination angle and the flaw-array angle. It moves away from flaw tips with the decrease of the flaw inclination angle and the increase of the flaw-array angle.

3) The branching angle (angle between the newly initiated crack and the pre-existing flaw) is also controlled by both the flaw inclination angle and flaw configurations. It shows an approximate range between 0° and 100°, and increases with the decrease of the flaw inclination angle. Interacting fault segments of extensional or contractional rock bridges may produce a larger or smaller branching angle than that of an isolated fault respectively.

4) Almost all en-echelon flaw configurations have coalescence styles similar to those observed in loading tests consisting of only two parallel pre-existing flaws. Special linking patterns are observed for specimens of =-15oand =-30o. The pre-existing flaws are linked up by straight inclined shear cracks through the straight edges of the flaws rather than at the flaw tips. The trajectories of these coalescence cracks are different from the coplanar and oblique shear cracks reported in earlier studies.

5) Given a similar ligament length, the configurations of en-echelon flaws dictate the coalescence stress. The coalescence stress of contractional configuration is higher than that of extensional configurations. The flaw inclination angle has varying effects within different regimes of flaw configuration. In extensional configurations, the coalescence stress decreases with the increase of flaw inclination angle, but the variations of stress are small. In contractional configurations, the coalescence stress increases with the increase of flaw inclination angle, and the variations of stress are relatively large.

6) The stress of a coalescence involving only tensile cracks is lower than that involving coplanar or oblique shear cracks, which in turn is lower than that involving shear cracks connecting flaws on the periphery.

The linkage of fault segments in nature is a much slower and more complicated process than in laboratory experiment. However, comparisons between the experimental results and field conditions suggest that if the key features of a linkage, such as geometry, loading condition and rock type, are determined and simulated properly in laboratory, the experiment results could be an analogue of the field conditions. Therefore, well-designed experiments will contribute to a better understanding of the complicated linking behavior of fault segments in the field.

In parallel with the experimental study, the fracturing processes in rocks are also studied numerically by different approaches in my research group, namely non-linear dynamics hydrocode (AUTODYN), discrete element method (DEM), and numerical manifold method (NMM). The talk will focus on (1) The capability of these three numerical techniques in capturing the cracking processes in rocks. (2) The influence of various parameters such as pre-existing crack geometry and properties, and the loading (boundary) conditions on the types of cracks developed. (3) The potential of using these methods to model hydomechanical coupled loading conditions, which are difficult to achieve in the laboratory setting, such as high loading rate and fluid flow conditions.

Landslides and GLOFs in Eastern Tibet and Their Response to Global Climate Change

Runqiu Huang

About Speaker

Prof. Runqiu Huang is an engineering geologist and is presently working as Director with the State Key Laboratory of Geohazards Prevention and Geoenvironment Protection (SKLGP), Chengdu University of Technology, Chengdu, China. He received the Ph.D. degree in Engineering Geology from Chengdu University of Technology in 1988, China. Then he joined the university and was engaged in slope stability analysis and geohazards prevention related to large-scale infrastructure construction, geo-hazards assessment and disaster reduction for almost 30 years and is one of the most active geoscientists in engineering geology field in China.

He is also the Chairman of International Research Association for Large Landslides (iRALL), the immediate past-vice president of International Association for Engineering Geology and the Environment (IAEG), the president of Chinese Engineering Geology Society and the Vice President of Chengdu University of Technology.

His main research interests in above fields are as follows:

- Description of complicated rockmass structures and probablistic models;
- Epigenetic reformation of rock mass structures due to unloading in high geostress area;
- Time-dependent deformation and mechanism of rock slope instability;
- Deformation stability analysis and landslide control;
- Progressive failure and formation mechanism of large-scale landslides;
- Early identification of large-scale landslides;
- Monitoring and early-warning of geohazrds;
- Geohazards mapping, risk assessment and risk reduction;
- Mitigation measures of geohazards.

Prof. Runqiu Huang has also contributed through some 300 scientific publications, out of which about 170 in ISI journals and international conference proceedings. He has received invitations to give keynote and plenary lectures in about 50 international conferences and universities. He has been awarded "The First Prize for National Science and Technology Achievements in China" in 2006, 2014 and many other important personnel awards such as "International Collaboration Prize" in 2012 by Japan Landslide Society, Lishiguang Geoscience Prize in 2007 by CGS, "National Prize for Excellent Teacher" in 2007 by the Minister of Education.

Extended Abstract

According to the Intergovernmental Panel on Climate Change (IPCC), the average temperature of the Earth's surface has risen by 0.74°C in the past century (1906-2005). The response of a glacier to climatic change involves a complex chain of processes. Changes in atmospheric conditions, especially temperature influence the mass and energy balance at the glacier surface. Due to the global climate change, the Tibet plateau has been heating faster than previously anticipated, resulting in glacial retreat. It was reported that the dramatic retreat of all the glaciers on the Tibetan Plateau in recent 50 years is related to the continuous warming on the plateau since 1980s. The Glacial Lake Outburst Floods (GLOFs) is one of the problems caused by the glacier retreat (Hewitt, 1982; Clague and Evans, 2000). Another potential hazard is landsliding, which in combination with the increasing socio-economic development in mountain regions, has led to hazard conditions beyond historical precedence.

In order to better understand the response of glacier to climate change, we carried out detailed investigation of the glacier lakes in the Zangbu Catchment. Multi temporal satellite images (Landsat MSS, 1976; Landsat TM, 1988; Landsat ETM, 2001, Landsat-8 OLI, 2013) were used to detect the changes of glacier lakes over the past four decades.

In addition, 5-m resolution RapidEye imagery was used for in-depth investigation of representative glaciers and glacier lakes in the study area. In total 617 glaciers were interpreted as shown.

Based on the interpretation results together with the field investigation to the accessible areas, we did the statistics analysis of the glacier parameters. From Table 1, it can be seen that there were two sharp decreases of the ice/snow area in the study area, 1976 to 1988 and 2001 to 2013, which were corresponded to the two rises in the number and area of glacier lakes.

Table 1 Statistics of ICE/Snow area in the study area

Year	1976	1988	2001	2013
Ice/Snow area(km^2)	3337.35	2194.12	5684.79	2782.05
Increase（%）	/	-34.26	159.09	-51.06

It was documented that there was a fast temperature increase process in Tibet from late 1970s to 1980s, which was also the most dramatic one in the past over 50 years. This temperature rise is corresponding to the shrink of glacier, indicating that the temperature rising is the major reason that caused the glacier retreat and increase of glacier lakes. Due to the rise of temperature, the retreat of glacier caused the number of glacier lakes increased from 30 to 229 from 1976 to 2013, with the coverage area increasing from 3908.68 m2 to 6045.09 m2 (by 54.7%). The data from 2013 shows that 65% of glacier lakes has a volume smaller than 10×104 m3, while 10% are larger than 1 million m3.

- Most of the glacier lakes in China are distributed in Tibet. More efforts need to put in completing glacier and glacier lake inventory using multi-temporal imagery;

- Glacial lake volumes vary, but may hold millions to hundreds of millions of cubic meters of water. Catastrophic failure of glacier lakes can cause deadly Glacial Lake Outburst Floods (GLOFs);

- Further research will focus on quantifying the impact of global climate change on glacier retreat, glacier lake stability and hazard assessment of GLOFs.

Rock-cut Slope Stabilization - A Systematic Approach in the Design & Construction

Mohd J. Ahmed

About Speaker

Born in 1953 (India), Ahmed completed his Masters in the year 1975 from Utkal University, India and did his in-service PG Diploma in Engineering Geology from ITC, Netherlands in 1988.

With a brief period of lectureship, he served the Geological Survey of India (GSI) for over 23 years. He received the National Mineral Award from Govt. of India in 1998 for his distinguished work in Applied Geology. During his professional carrier of over 37 years he worked & supervised the engineering geology/ geotechnical investigations, for large infrastructure projects like Indira Sagar & Omkareswar HE project, M.P; Baglihar HE project, J&K; Kingdom tower (up coming world's tallest tower- 1000 m) of Saudi Arabia.

At present he is with ACES, Dubai, UAE for the last 10 years, working on site characterization for foundations, ground improvement, slope stability etc. He is a life member of many national (India) and international technical societies like ISEG, ISRMTT, IAEG, ISRM and ITA.

He has published over 50 technical papers; co-supervised M.Tech and a PhD thesis works in Eng. Geology and is a co-author of one book on engineering geology.

Extended Abstract

Rock slopes are typically composed of heterogeneous rock masses with structural anisotropic systems of relatively regular discontinuities in the form of joint sets, bedding, fissures, or foliation. The mass strength and stability of these types of rock masses are typically controlled by the discontinuities. Analytical techniques for rock slope stability assessment consider the kinematic stability of blocks or groups of blocks sliding upon the discontinuities, toppling, or in terms of wedge failure. Engineered slopes are mostly cut slopes in the rock mass which require stabilization to ensure their long-term viability and reduce localized failures (which includes erosion, rock falls and slides). In general, the most effective strategy is to prevent the failure at the source through stabilization, and to do minimum installation of measures (rock bolts, anchors, shotcrete, mesh etc.) to support and protect the cut slopes for the future. The stability and long term performance of a rock cut slope depends on the quality of analysis, excavation and stabilization techniques deployed. In many parts of the developing world engineers and geologists are still ignorant about the mechanics of slope failure, hence the stability of the cut-slopes are either underestimated or exaggerated to make cost prohibitive stabilization proposals.

Stability analysis of rock cut slopes involves a thorough understanding of the structural geology and rock mechanics. For most rock cuts, the stresses in the rock mass are much less than the rock strength so there is little concern with the fracturing of the intact rock. Therefore, stability is concerned with the stability of rock blocks formed by the discontinuities. Hence, the need of the hour is to understand the influence of rock parameters and design sustainable, viable and safe cut slopes. The keynote address discusses the systematics involved in the study for an effective design and construction of a rock-cut slope. The discussed methodology involves from Field data acquisition to interpretations, to construction reviews to monitoring to quality assurance tests, besides the use/ application of specialist soft wares in the study. A systematic study using latest applications of data collection/ acquisition, software based analysis, slope rating concept, risk and assessments etc. leads to proper and optimum design and construction of the rock cut slopes, and gives remarkably cost effective structures with long term safety.

Urban Landslides: Challenge to the Forensic Engineering Geologist and Geotechnical Engineer

Scott F. Burns

About Speaker

Scott is a Professor Emeritus of Geology and Past-Chair of the Dept. of Geology at Portland State University with over 25 years of teaching experience. He lives in Portland, Oregon USA. He acquired his BS and MS degrees from Stanford University and a doctorate from the University of Colorado. He has been teaching applied geology for 25 long years and has had positions in Switzerland, New Zealand, Washington, Colorado, Louisiana and Oregon. He is the President of the International Association of Engineering Geologists and the Environment, and has also been the President of the American National Group: Association of Engineering Geologists. Scott has a command on Environmental and Engineering geology, Geomorphology, Soils, and Quaternary geology and has a specialty in landslide studies.

He has won several national awards in geology which includes the distinguished "Practice Award from the Engineering Geology division of GSA in 2012", the "Richard Johns Award for Engineering Geology (top engineering geologist in the U.S.) from GSA and AEG in 2011", the "Shoemaker Award for Public Service to the US (GSA) in 2011", and on the state level, the "Outstanding Scientist for Oregon for 2014" from the Oregon Academy of Sciences. He has been married for 40 years to Glenda, and they have three children: Lisa (35), Doug (32) and Tracy (29).

Extended Abstract

Each year landslides cause 25-50 deaths and on the average $3.5 billion in damage in the United States. Many of these landslides occur in urban settings. Figuring out what caused these landslides and also how to prevent them can be a challenge to geologists. The talk will focus on lessons learned from case histories in urban settings, focusing on homes hit by landslides, homes that moved down the slope on landslides, reactivation of ancient landslides, triggers such as precipitation and earthquakes, and vacant lots. Development of susceptibility maps, especially using LiDAR imagery, will be included. Different mitigation methods including different types of dewatering devices, walls, and freezing of the soil will be mentioned. The importance of lack of insurance for landslides on normal homeowner policies has great significance. The Oso landslide in Washington in 2014 will also be mentioned in reference to its significance.

Groundwater Drawdown and Consolidation Settlement Effects of Deep Excavations in Urban Areas - Predicted Versus Measured

Ann Williams

About Speaker

Ann is a Professional Engineering Geologist and a Technical Fellow with the consulting firm Beca Ltd, based in Auckland New Zealand. She has an MSc (Hons) in Geology from the University of Auckland and has completed her post graduate studies in Hydrogeology and Resource and Environmental Management. Ann has some 26 years' experience in engineering geology, hydrogeology and the identification of geotechnical risks related to infrastructure projects. She has focused on investigation and analysis of the interaction of soils, structures and groundwater as part of engineering design. She has scoped, directed and reviewed these aspects of many projects from concept design through assessment of effects and consenting to construction and monitoring. Ann has an in-depth understanding of geotechnical hazard and risk issues in dynamic landscapes and has undertaken landslide risk identification, mapping and mitigation assignments for a number of State Highways in New Zealand, as well as for projects in other high seismicity areas including Samoa, Vanuatu, Indonesia, Timor, West Papua and Papua New Guinea.

Ann is a Past Chair of the New Zealand Geotechnical Society Inc., and has recently completed a 4-year term as Vice President (Australasia) of the International Association for Engineering Geology and the Environment (IAEG). She is a member of the editorial boards of a number of international journals and of the External Reference Group to the School of Environment, University of Auckland. She was instrumental in establishing a register of Professional Engineering Geologists (PEngGeol) in New Zealand and is a PEngGeol assessor and Companion of IPENZ (the Institution of Professional Engineers New Zealand).

Sian France

About Co-Author

Sian has 12 years of experience in hydrogeology and engineering geology within NZ, working on a wide range of projects such as groundwater for municipal and industrial supply, land based disposal of stormwater and wastewater, and over the last 6 years with a particular focus on understanding soil-structure-groundwater interactions for assessing the impacts of groundwater abstraction from wells, tunnelling and deep excavation projects. This has included a range of activities from direction, management and analysis of site investigations, to the development of conceptual and numerical 2D and 3D groundwater models for engineering design and assessing environmental effects (as well as subsequent determination of ground and building settlement, contaminant migration, impacts on surface water bodies) to support the consenting process, right through to construction monitoring and reporting.

Extended Abstract

Drawdown of groundwater level to facilitate construction work in the dry can result in damaging settlement of existing structures nearby. For this reason an assessment of the expected amount and extent of groundwater drawdown and associated ground settlement is made as part of the design of infrastructure and building projects. Mitigation of potentially damaging settlements is addressed in the design or, where only temporary drawdown is anticipated, monitoring of groundwater levels and ground settlements might instead be used to assess whether mitigation needs to be implemented to avoid damage. In some countries and settings the potential for damaging settlements to result from drawdown is considered to be so great that subsurface works must always be watertight (tanked).

Groundwater level and ground settlement monitoring carried out to check the effects of a series of tunnelling projects in the urban area of Auckland, New Zealand, has demonstrated a need to better understand the relationship between drawdown of groundwater level and the occurrence of consolidation settlement so that the predicted effects of subsurface construction works are a more realistic indicator of actual effects on existing structures. This is important for establishing an appropriate scope of monitoring and reporting and to avoid implementation of unnecessary monitoring and mitigation measures.

The Auckland urban area is underlain by Tertiary age sandstone and siltstone locally interbedded with and cross-cut by coarse volcaniclastic sandstone, covered by Quaternary age alluvium that has filled paleo-valleys incised in the Tertiary rock. The alluvium is in places overlain by basalt lava and landfill of differing origins and thickness. In each project the assessed magnitude of drawdown actually occurred or was exceeded, and the extent of drawdown was similar to, but locally greater than indicated by groundwater modelling. However groundwater inflows were generally less than anticipated and the predicted consolidation settlement (beyond seasonal variations where this data was available) did not eventuate, suggesting that the assessments carried out are not realistic.

In all cases the projects involved installation of secant, D-wall and/or soldier piled perimeter walls prior to excavation below groundwater level. The floors of the excavations were open for periods of 1 month to more than 2 years. A combination of 2D seepage (SEEP/W) and 3D flow (Visual Modflow-Pro) was used to assess the extent and magnitude of groundwater drawdown, and pore water pressure profile outputs from the modelling were used together with coefficient of volume compressibility values (mv) derived from laboratory consolidation testing, to estimate consolidation settlement.

Building and ground settlement pins installed 12 months prior to commencement of construction on two of the three projects indicated a seasonal ground level variation of 2 mm to 6 mm and up to 40 mm locally. These values demonstrate the importance of a pre-construction record of natural variations in ground surface response to seasonal variation of groundwater levels if monitoring that controls project construction progress is to be meaningful.

In each case the assessments assumed that full consolidation settlement occurs immediately on groundwater drawdown, giving an upper bound envelope of effects. The effects on buildings were assessed using the method developed for tunnel construction by Burland [1] which determines the curvature and horizontal strain in a building and plots these values against a series of criteria to assess the likely effect on the structure.

On closer scrutiny of the assessment method we find that a series of conservatisms have been applied stemming from the practitioner's tendency to make cautious choices in the derivation of each parameter, ultimately providing an unrealistic assessment.

The magnitude and extent of drawdown varied as a result of the existence of local lenses of more or less permeable materials and the distribution and inter-connection of fractures in the rock mass. Calculated groundwater inflows to excavations were typically higher than occurred because a fully saturated soil profile is assumed even though investigations indicated perched groundwater conditions were likely to exist.

When there has been the opportunity to calibrate 3D groundwater flow models to the actual order of inflow a more realistic estimate of inflow and drawdown at subsequent sections results (half to a third of that estimated by selection of conservative saturation conditions).

Predictions indicated up to 50 mm of consolidation settlement could occur but no more than 3 - 10 mm of settlement attributable to groundwater lowering occurred in the vicinity of any of the projects. Over-estimates of consolidation settlement are likely to be due to a number of decisions:

• Calculations assume 100 % of consolidation settlement happens instantaneously

• A comparison of values of mv derived from oedometer tests, CPT and in-situ seismic dilatometer testing (SDMT) suggests that the oedometer tests over-estimate the average compressibility by a factor of 2 to 3. Although the laboratory test results accurately reflect weaker horizons in the profile, there is a sampling bias because practitioners tend to select samples from weaker horizons for testing which may not be representative of the soil mass as a whole

• A trace that approximates the lowest strengths of the 25th percentile SDMT for constrained modulus (M) was used to assess the volume of compressibility (M = 1/mv) that was in turn used for calculation of consolidation settlement. Selection of the 25th percentile helps to provide an upper bound assessment of effects to test a pessimistic case for building damage, but a less pessimistic fit would better reflect the recorded magnitude of settlement.

While it has become commonplace to provide an upper bound estimate of effects to test tolerances for building damage and to envelope the magnitude and extent of environmental monitoring undertaken during construction, this practice gives overly conservative estimates. We suggest that it is more helpful to test a realistic assessment and set trigger levels for monitoring that will advise if these expected limits are approached long before serviceability tolerances are reached.

3D imagery can now be used to determine the exact position elevation and distortion of structures in space. Calibration to these actual effects might allow a more realistic assessment of settlement cause and effect in the future.

Advanced Satellite Monitoring of Road and Railway Infrastructure in Landslide-prone Areas

Janusz Wasowski

About Speaker

Dr. Wasowski, holds a Ph.D in Geology from State University of New York at Buffalo. He has been a Research Geologist at CNR-IRPI (National Research Council-Institute for Geo-hydrological Protection), Bari, Italy from 1989 till date. He has also been a visiting Professor at the Lanzhou University, Gansu, China from 2011 onwards. He has also been the Science Officer of the Natural Hazards Programme, European Geosciences Union (EGU) from 2011 till present.

He has expertise in Engineering geology, natural hazards, remote sensing Landslide monitoring and hazard assessment Air/space-borne remote sensing e.g., Interferometry, for slope/ground and engineering infrastructure stability investigations.

He is the Associate Editor of the Quarterly Journal of Engineering Geology and Hydrogeology (The Geological Society, London) from 2007 onwards. He also is the Member of the Editorial Board of the Engineering Geology (Elsevier) from 2007.

Extended Abstract

Roads and railways are often exposed to instability and damage in landslide-prone areas. Ideally, in such settings, the hazard assessment should include periodical controls of known landslides, as well as of potentially unstable slopes and transportation infrastructure stability itself. In practice, due to the costs involved, ground-based controls and monitoring are not affordable in most situations, and especially on large-area scale. In situ controls and monitoring are also typically limited in terms of temporal frequency and coverage. Hence, they are often insufficient to prevent the occurrence of damage. It follows that the development of complementary, cost-effective approaches to timely detection and assessment of infrastructure instability hazard is desirable.

The assessment of road and railway instability hazards in landslide-prone areas can now benefit from recently developed sophisticated remote sensing techniques capable to provide precise information on land surface and engineering structure displacements linked to slope movements or ground deformations in general. Among these techniques, satellite Synthetic Aperture Radar Interferometry (InSAR) seems to offer the most advantages for regular, wide-area and local scale investigations (e.g., Colesanti and Wasowski, 2006; Bally, 2013).

In this presentation we solicit a widespread application of advanced satellite multi-temporal inteferometry (MTI), with emphasis on early detection of i) surface displacements on slopes and landslides present above and below roads and railways, and ii) small deformations affecting directly the transportation infrastructure. Thanks to long-term (years) monitoring capability, MTI is particularly suitable for the above tasks. MTI is also considered cost-effective as it provides wide-area coverage and can deliver large quantities of useful information for the mitigation of highway and railway infrastructure instability hazards.

Specifically, satellite MTI offers great surveying capability of terrain and engineering structure instabilities (e.g., Wasowski and Bovenga 2014a,b). MTI users can rely on the following strengths of the technique:

• Large area coverage (thousands of km2) together with high spatial resolution (1-3 m) of the new generation radar sensors e.g., Italian COSMOSky-Med, German TerraSAR-X, Canadian RADARSAT-2 and multi-scale investigation option (from regional to site-specific);

• Very high precision (typically mm) of surface displacement measurements only marginally influenced by bad weather;

• Regular, high frequency (days to weeks) of measurements over long periods (years);

• Retrospective studies using long-period (>20 years) archived radar imagery.

The lecture will first offer background information on radar interferometry and MTI, and an overview of the currently available radar satellite data. Then we will illustrate the great potential of high resolution MTI for the wide-area detection and monitoring of transportation infrastructure instability hazards in landslide-prone areas by presenting application examples from regions characterized by different topographic, climatic and vegetation conditions.

In particular, we will show examples from the moderate elevation Apennine Mts. of the Apulia Region (Italy), where roads are often damaged by shallow, slow landslides, and two cases from the Calabria Region (Italy), one showing the stability of the main railway along the Tyrrhenian Sea being locally threatened by coastal slope deformations, and the other concerning the instability of an A3 Highway viaduct crossing a landslide. The example from Haiti will illustrate the case of a deep landslide and local instabilities detected through MTI along the National Route No3.

Our main conclusions are the following: i) MTI is effective for monitoring roads and railways in landslide-prone areas, and ii) with regular globe-scale coverage and freely available imagery, the most recent radar satellite missions, such as the European Space Agency's Sentinel-1, are expected to foster an even wider and more efficient use of MTI in terrain and infrastructure instability hazard investigations.

Deep Foundation – An Approach to Economical Design of Drilled Shafts in Duabi

Emad Y. Sharif

About Speaker

Born in the year 1958 in Palestine, he obtained a B.SC degree in Civil Engineering from Alexandria University in Egypt in 1982 and thereafter obtained a Master's Degree in Geotechnical Engineering from Stanford University, California, U.S.A in 1984.

Emad remained as a lecturer in Birzeit University, Ramallah - West Bank (Birzeit is the leading Palestinian University adopting modern education systems) in the Civil Engineering Department for 10 years from 1984 to 1994.

He joined the Arab Centre for Engineering Studies (ACES) in 1994 as General Manager of ACES Palestine Branch, and in 2004 he moved to Dubai as Branch Manager, at ACES Dubai branch.

He was elected as one of the two representatives of the accredited laboratories in Dubai for the (Dubai Municipality Accreditation Centre) DAC Advisory and Technical Committee, in 2008.

Emad Sharif has been involved in geotechnical investigations of diverse nature for many unique and prestigious projects. His experience includes a variety of related fields such as planning of site investigation studies, geotechnical investigation and interpretation, design and testing of piles, liquefaction studies, soil and rock slope stability studies, design of dewatering and shoring systems, geotechnical instrumentation and monitoring, control of ground improvement works, investigation and design of roads and embankments, material testing and technology, quality control systems of construction material, etc.

Emad has also attended several professional trainings and short courses, offered by leading institutes and organizations on geotechnical and foundation related topics.

Emad is quite well known as a professional and a specialist in his work. He is also a Member of Board and steering committee of DFI - Mena, Emirates Ground Engineering Forum (EGEF) and member of the Society of Engineers in the U.A.E and American Society of Testing Materials (ASTM).

Extended Abstract

Drilled shafts are widely used in Dubai as the main foundation option for high towers and main structures as bridges. Hundreds of meters of shafts are installed in Dubai every day. Piling companies has witnessed noticeable growth over the past ten years such that large diameter piles and barrettes up to large depths have been installed. The rock formations noticed in Dubai area are mostly the mid to upper Tertiary sediments of Berzman Formation, consisting of an interbedded sequence of carbonate rich arenaceous, argillaceous and rudite/ conglomeratic rocks. The weathered calcareous sandstones/ Calcarenites with thin interbeds of siltstone are noticed to a depth of 18 – 25 m, underlain by the dominantly argillaceous/ calci silttites with interbeds of polymictic conglomerates- with pebble to gravel size clasts of gabbros, chert, sandstones and carbonate rocks, Some deep-seated thick evaporate- gypsum beds associated with clays and mudstones are noticed beyond a depth of 80 – 100 m. The local geology in Dubai is characterised by very weak to weak sedimentary rock of sandstone / siltstone / conglomerates / mudstone of compressive strength of 0.5-5.0 Mpa in general that is classified as an intermediate geo-materials (IGM) (1).

The use of drilled shafts in Dubai is attractive due to relative ease of drilling and advancing stable boreholes through the weak to very weak sedimentary rocks with time and cost effective drilling methods using augers / buckets. Bentonite muds and chemical polymers are typically used to support the drilled holes for piles of different diameters (as large as >2m) and as deep as >75m. Temporary steel casing is advanced through the upper un-consolidated sandy soil overburden of up to 10-20m depth.

Drilled shafts in IGM resist the applied loads by skin friction as opposed to end bearing. Side frictions ranging between 250 – 600 kpa are typical, depending on the local rock strength, mass parameters, and pile installation details.

Understanding the actual performance of drilled shafts in compression is essential for the pile design Engineer. Below is briefing on pile performance (FWHA – Drilled Shaft Manual (2)):

As axial load on the shaft increases from zero, the shaft displaces downward and side resistance in shear is mobilized (Point A in Figure b). This transfer of load to the surrounding soil or rock results in decreasing load with depth as shown by the dashed curve in Figure c. At this point, load is transferred predominantly in side resistance and load transmitted to the base may be small. With increasing load, the full side resistance is mobilized (Point B), typically at a displacement of approximately 1/2 inch. Further increases in load beyond Point B must be resisted by the base, until the maximum base and combined resistances are reached (Point C). The displacement required to mobilize the maximum base resistance varies, but research suggests that maximum resistance is reached at a displacement equivalent to about 4 to 5 percent of the shaft diameter for bearing in cohesive soil or rock and about 10 percent of the shaft diameter for bearing in cohesionless soils.

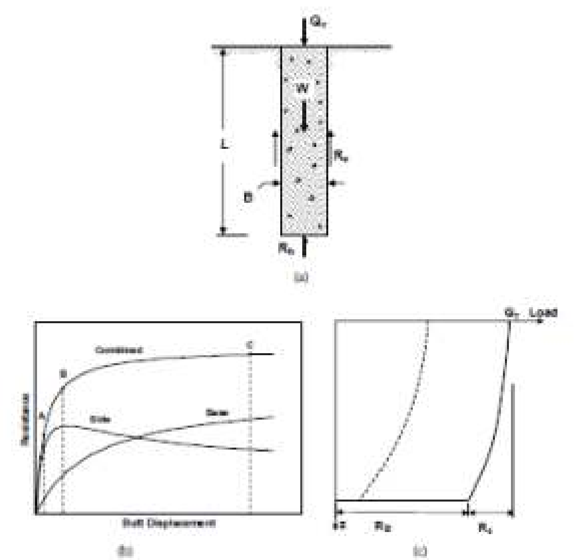


Figure 13-1 Generalized Load Transfer Behavior of Drilled Shaft in Compression

Figure 1: Generalized Load Transfer Behaviour of Drilled Shaft in Compression

Several important behavioural aspects of drilled shafts are illustrated in the above Figure; the first is that side and base resistances develop as a function of shaft displacement, and the peak values of each occur at different displacements. Maximum side resistance occurs at relatively small displacement and is independent of shaft diameter. Maximum base resistance occurs at relatively large displacement and is a function of shaft diameter and geomaterial type.

Additional Design Considerations for Rock Sockets: A design decision to be addressed when using rock sockets is whether to neglect one or the other component of resistance (side or base) for the purpose of evaluating strength limit states.

With regard to base resistance, AASHTO Article C.10.8.3.5.4a states "Design based on side-wall shear alone should be considered for cases in which the base of the drilled hole cannot be cleaned and inspected or where it is determined that large movements of the shaft would be required to mobilize resistance in end bearing" (AASHTO, 2007). The philosophy embraced in the above comment gives a designer the option of neglecting base resistance. Under most conditions, the cost of quality control and assurance is offset by the economies achieved in socket design by including base resistance.

Reasons cited for neglecting side resistance of rock sockets include (1) the possibility of strain-softening behavior of the sidewall interface, (2) the possibility of degradation of material at the borehole wall in argillaceous rocks, and (3) uncertainty regarding the roughness of the sidewall.

Design for service limit states must, therefore, account for differences in side and base resistance mobilization as a function of axial displacement.

Pile Design Optimization: The performance of drilled shafts in Dubai has been confirmed by many static loading tests and actual performance of existing heavily loaded structures as super tall tower buildings.

Design practice is to consider side friction resistance and ignore end bearing (or consider limited contribution, particularly for short socketed piles of large diameters). The procedures given by Horvath & Kenny (5) and Williams and Pells (4) are typically used to establish the theoretical side friction resistance. However, several Engineers still use the conventional pile design approach by summing the allowable skin friction and end bearing to obtain a working pile load!

Optimization of the design practice: With optimization, it is meant to utilize the advantages of understanding the factors controlling the mobilization of pile capacity to reduce the cost, while improving the level of confidence / safety of the design. Optimization may be achieved through several considerations as:

PLT based design approach: with PTP based design, an improvement of the theoretical skin friction could be confirmed. The use of O-Cell or Bi-Directional loading test procedures allow for mobilizing the full skin friction capacity at any location within the rock socket zone. Savings up to 25% has been obtained when comparing actual load test results against theoretical estimates. The use of t-z / q-w pile simulation analysis with suitable software allows for accurate interpretation of both top loaded or bi-directional load tests.

Enhancement of Base resistance - The End Bearing Dilemma as mobilization of end bearing requires much higher pile settlements than end bearing forces designers to ignore or consider a very limited contribution of base resistance. The use of base grouting (tip grouting) to enhance the axial capacity of drilled shaft foundations can achieve improvements in economy and reliability for many types of projects and soil profiles. The quality assurance provided by measurements obtained during post grouting the pile toe is another important aspect favouring its use; the base grouting is shown to identify weaker piles and provide a means of remediating some deficiencies so that increased foundation reliability is achieved. Although, proven in many projects; base grouting was never experienced in Dubai; where the ground conditions are very favourable for getting the best advantages!

The post grouting process entails installation of a grout delivery system during the reinforcing cage preparation (or drilled hole through the pile for pre-existing piles). The shaft is constructed as normal, and grout is injected under high pressure once the concrete has gained sufficient strength. Reaction for the grout pressure acting at the base is supplied by negative side shear, and thus the shaft is pre-compressed. The in situ soil at the toe is densified and any debris left by the drilling process compressed. As a result, the ultimate end bearing resistance can typically be developed within service displacement limits. According to the conditions prevailing in Dubai, base grouting may provide 15-30% of the pile working capacity resulting in great reduction of the socket length. Obviously, the cost of arranging for base grouting is very limited if compared to the expected savings.

LRFD Design Approach (2, 3): At present, WSD (working stress design) methods are adopted in Dubai by the local authorities and the majority of consultants and piling companies. However, recent applications of LRFD design methods have provided a new venue for improvement of the drilled shafts and pile designs in general. According to FHWA (2, 3) & AASHTO (9), the LRFD design method is based on strength reduction factors (φi factors) and load factors (γi) applied to selected load combinations. The φ factors are based on reliability or degree of confidence or probability of failure and therefore higher factors in the case of PLT-Based pile capacity design are allowed. The load factors are selected based on probabilistic estimates. With LRFD, different factors are applied to skin friction and base resistance, and higher factors are allowed for load test – based design resulting in a reduced overall safety factor as compared to the used global safety factor method. At least 10-20% reduction in the safety factor applied to the skin friction component may be achieved.

Post Construction Monitoring: Instrumentation to measure the post construction actual behaviour of the foundation including pile load transfer and settlement behaviour is a major and important consideration to not only confirm the predicted design performance of the piles, but also to provide reliable data on the actual performance of the specific piles in the local geology of Dubai that can be used for further refinement of the pile design procedures and safety factors. The cost of instrumentation and monitoring is very low, compared to the value of the foundations of the super tall towers and other major structures. Monitoring may include skin friction and end bearing resistance, with strain gauges, load cells, and other parameters.

In conclusion, by summing up the average socket length reduction that may result from the above optimization procedures, then significant reduction can be achieved resulting in major savings of millions of dollars, in addition to minimizing or eliminating much of the geo-risks associated with drilled shafts performance.

Speaker Index