



Department of Civil Engineering  
The University of Hong Kong



Geotechnical Division  
The Hong Kong Institution of Engineers

# The Tenth Lumb Lecture

## THE STORY OF STATISTICS IN GEOTECHNICAL ENGINEERING

PRESENTED BY

**PROFESSOR KOK-KWANG PHOON**

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6:30 p.m. December 6, 2018 (Thursday) | Rayson Huang Theatre, The University of Hong Kong

### About the Speaker

**Professor Kok-Kwang Phoon** is Distinguished Professor and Vice Provost (Academic Personnel), National University of Singapore. He obtained his BEng and MEng from the National University of Singapore and his PhD from Cornell University. He is a Professional Engineer in Singapore and past President of the Geotechnical Society of Singapore. His main research interests include statistical characterization of geotechnical parameters and reliability-based design in geotechnical engineering. He is the lead editor of 3 books: *Reliability of Geotechnical Structures in ISO2394* (CRC Press/Balkema, 2016), *Risk and Reliability in Geotechnical Engineering* (CRC Press, 2015), and *Reliability-based Design in Geotechnical Engineering* (Spon Press, 2008). He was bestowed with numerous research awards, including the ASCE Norman Medal in 2005, the ASTM Hogentogler Award in 2007, the John Booker Medal in 2014, and the Humboldt Research Award in 2017. He is the Founding Editor of *Georisk*, Board Member of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), Vice-President of the International Association for Computer Methods and Advances in Geomechanics (IACMAG), and Vice-President of the International Association for Structural Safety and Reliability (IASSAR). He was elected as a Fellow of the Academy of Engineering Singapore in 2012.



### Synopsis

Every story has a beginning. The idea that statistics can be used to quantify uncertainties in the properties of natural soils (an intrinsic characteristic of geotechnical data) and this statistical approach can provide a rational basis for the selection of a suitably cautious design value may arguably be traced to Lumb's classical Canadian Geotechnical Journal paper on "The Variability of Natural Soils" published in 1966. One may view this paper as being ahead of its time. The First International Conference on Applications of Statistics and Probability to Soil and Structural Engineering was organised in Hong Kong in 1971. It was not surprising that Professor Peter Lumb played a key role in launching this important conference series (the 13th ICASP will be held in Seoul, May 2019). It was only in 1995 that a National Research Council report "Probabilistic Methods in Geotechnical Engineering" recommended that "probabilistic methods, while not a substitute for traditional deterministic design methods, do offer a systematic and quantitative way of accounting for uncertainties encountered by geotechnical engineers, and they are most effective when used to organize and quantify these uncertainties for engineering designs and decisions". The latest 4th edition of the international standard "General Principles on Reliability for Structures" (ISO2394:2015) includes a new Annex D dedicated to the reliability of geotechnical structures. Annex D recognizes that geotechnical reliability-based design should place site investigation and the interpretation of site conditions/profile/data as the cornerstone of the methodology.

This lecture covers the estimation of useful statistics from the original classical univariate setting to a realistic multivariate setting covering the full suite of field and laboratory tests encountered in a typical site investigation programme. The focus is not on mathematical gymnastics, but to demonstrate that statistical analysis and other data-

driven methods are able to produce valuable insights to support decision making. If field and laboratory data collected at various depths were to be stored in a table, it is common to have empty cells in the table, because it is rare to conduct every test at every depth. In addition to this "incompleteness" characteristic, soil data are relatively sparse and unique to some degree at each site. The characteristics of geotechnical data, which can vary in space and time, can thus be succinctly described as MUSIC – Multivariate, Uncertain and unique, Sparse, and InComplete. In particular, although it is commonly accepted that each site is unique to some degree, there is no method of characterizing this "uniqueness" that can lead to an automatic selection of "similar" sites. It is evident that generic correlation models that are widely used in the absence of sufficient site-specific data can be refined when the supporting database is drawn from similar sites only. Recent research shows that this "site challenge" is tractable even under the constraint of MUSIC.

The moral of the story is that the value of geotechnical data is significantly under-appreciated and not fully exploited for decision making. The world is being revolutionised by new and powerful ways of collecting, analysing, and monetizing data. Clearly, there is a pressing need for the geotechnical engineering community to engage in this digital transformation. There is no doubt that engineering judgment is enhanced when it is guided by relevant data and analytical tools that make the most sensible use of data, be it mechanical or statistical. One suspects (with good reasons) that the story of statistics will unfold in exciting and unexpected ways in the near future.

**FREE ADMISSION - ALL ARE WELCOME**

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Attendance certificates will be available.

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