**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI**
**SHORT ABSTRACT OF THESIS**

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Thesis Title: Multivariate Probabilistic Characterization of Hydraulic and Physicochemical Soil Properties

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| Thesis Submitted to the Department/ Center | : | 16th December 2020 |
| Date of completion of Thesis Viva-Voce Exam | : | 16th December 2020 |
| Key words for description of Thesis Work | : | Probabilistic characterization; Multivariate distribution; Copula theory; Vine copula; Soil-water characteristic curve; Specific surface area; Cation exchange capacity; CLAY/C-S/5/278; Stochastic seepage; Slope stability; Spatial dependence structure ; Cross dependence structure |

## SHORT ABSTRACT

Probabilistic characterization of soil parameters is an essential pre-requisite for reliability based design (RBD) in geotechnical engineering projects. A lot of work in probabilistic characterization is focused on conventional mechanical, or, strength parameters for saturated soils. Studies accounting for hydraulic parameters e.g. soil water characteristic curve (SWCC), chemical properties such as cation exchange capacity (CEC) are relatively sparse. However these are equally important aspects for extension of RBD philosophy to unsaturated soils.

SWCC is an essential constitutive relationship for modelling unsaturated soil behaviour. Among the minimal studies for probabilistic characterization of SWCC, almost all of them are limited to soils with low clay fraction. However with increasing use of clay in various geo-environmental projects, characterization of SWCC for clays is also necessary. For this purpose, a database for SWCC of bentonite is compiled from the literature. The proposed approach entails the parametrization of SWCCs and constructing a multivariate probability distribution SWCC parameters. In the absence of measured data, the joint distribution of SWCC provides a first-hand estimate of SWCC. In case of few available site specific data, it provides useful prior information for updating sitespecific limited data. For this purpose, the study also formulates a Bayesian approach integrated with copula theory. Efficacy of the proposed approach is also demonstrated for three distinct soil textures.

Apart from SWCC, CEC and specific surface area (SSA) greatly influence the engineering behaviour of clayey soils. However, the measurement of CEC and SSA is not trivial but rather a challenging and time-consuming task. Therefore, this study proposes a multivariate probabilistic approach for the estimation of CEC and SSA. A global multivariate database (labelled as CLAY/CS/5/278) of five physico-chemical properties: liquid limit (LL), plasticity index (PI), clay fraction (CF), CEC and SSA is compiled. The joint distribution is constructed using vine copula theory. It is shown that the joint distribution can be viewed as "global" prior/unconditional PDF which can be updated to posterior/conditional PDF using Baye's rule when new data is available. Practical geotechnical examples are also shown.

Finally, as a practical RBD application for hydraulic properties, a stochastic seepage and slope stability analysis is

conducted. Both the spatial and cross dependence are modelled using vine copula based multivariate random field framework. For investigating the practical engineering importance of dependence structure, stochastic seepage and slope stability analysis under steady and transient seepage conditions is conducted. It is shown that the assumption of arbitrary dependence structure e.g. Gaussian, can significantly affect the RBD results.

Overall this study contributes towards the development of probabilistic models of specific hydraulic and physico-chemical clay properties which in turn are useful inputs for application of RBD approaches in unsaturated porous media.