Major Geotechnical Engineering Research Projects

- Research vistas
  - Geophysical investigation for subsoil stratigraphy through Active, Passive Roadside and Passive Remote MASW Survey
    - Junul Talpoddia, Dipjyoti Baglari (PhDs) and Shibayan Biswas (MTech)
  - Dynamic characteristics of soils through Cyclic Triaxial tests
    - Dr. Shi Shankar Kumar (PhD)
  - Slope stability, Foundations on slopes, Landslide Hazard Assessment and Mitigation
    - Rubi Chakraborty, Rana Acharya, Chiranjib Prasad Saras (PhDs), and Abhijeet Anand (MTech)
  - Analysis of Dams and Embankments
    - Priyanka Talukdar (PhD) and Madhurita Savant (MTech)
  - Ground response analysis
    - Madhulatha Boga (PhD) and Devesh Rawat (MTech)

- Soil-structure interaction for Bridges and Building foundations
  - Nishant Sharma, Debasmita Pal and Emte Ajom (PhDs), Ananta Sinha (MTech)

- Optimal design and analysis in geotechnical engineering
  - Sukheshwar Boro (PhD)

- Pavement Geotechnics
  - Ishan Boro (PhD) and Lokesh Choudhary (MTech)

- Rock slope stability and Rock engineering
  - Amolesh Jana and Aswathi C K (MTech)

- Preloading and PVDs for soft soil improvement
  - Dr. Giridhar Rajesh Bande and Sai Kiran Chukka (MTechs)

- Foundation and Retention systems
  - Michael Koch, Navneet Kumar, Milind Patil and Parasaav Roy (MTechs)

GEOPHYSICAL INVESTIGATION

- MASW apparatus comprising 24 channel seismograph
  - 4.5 Hz geophones and their connector cables
  - 10 kg sledgehammer and 40 kg Propelled Energy Generator (PEG)
  - Striker plates (Cast Steel and Rubber) and Trigger sensors

- Seismic borehole equipments (Cross-hole, Up-hole and Down-hole)
  - Ballard shear wave generator and 5-D Receptor Sensor

- 100 m Submersible Hydrophone Array
Multichannel Analysis of Surface Waves (MASW)

- Non-destructive seismic exploration
  - Subsoil stratigraphy
  - Shear wave velocity profile / Ground stiffness profile
  - 1D, 2D or 3D formats

Overall Procedure in MASW in a nutshell

Data Acquisition
- Using active or passive sources, geophones and a seismograph

Dispersion Analysis
- Phase velocity v/s Frequency (or Wavelength) image/curve

Inversion Analysis
- Shear Velocity v/s Depth profile

Time domain data \( F \) Frequency domain \( f \) dispersion curve \( v_s(f) \) inversion analysis

Vs profile \( v_s \) Depth

Types of MASW Surveys

- Procedure of generation of waves
  - Active MASW method
    - Controlled impact by the user (Various types of weight drops)
  - Passive MASW methods
    - Passively generated from natural and anthropogenic activities
    - Passive readings method – Traffic sources
    - Passive remote method – Microtremors, Tidal activities, Machine vibrations
  - Combined Active and Passive Technique
    - Numerical combinations of wavefields or dispersion images

Typical Records from MASW

- Quality / Reliability of Vs profile
  - Resolution of dispersion band

Filtering and Muting
Factors affecting Resolution of Dispersion Band

- Data acquisition, preprocessing and processing parameters
  - Taipodia et al., Disaster Advances, 2017
- Experimental investigation
  - Sampling frequency
  - Acquisition time
  - Offset distance
  - Inter-receiver spacing
  - Number of geophone receivers
  - Type of source
  - Number of stacks
  - Striker plate materials
- Series of recommendations
  - Taipodia et al., Journal of Geophysics and Engineering, 2018

Extraction from 2-D Dispersion Image

- Image processing techniques and Matlab coding
  - Dependency on the choice of the threshold amplitude of dispersion band
  - Enhanced error for thickened width of the dispersion bands

Extraction from 3-D Dispersion Image

- Image processing techniques and Matlab coding
  - Taipodia et al., Computer and Geotechnics (Under review)
**MASW Survey at a Bridge Site**

- A new 4-lane (1.2 km) carriageway bridge over Jiya-Bharali River bed
  - National Highway and Infrastructure Development Corporation Limited (NHIDCL)
  - Located in Tinzpur District, Assam state
  - Connects NH-52A and NH-37
  - Project completed with Simplex Infrastructures Ltd

**Roll Along method of Active MASW**

- Superstructure span 1.2 km - 24 Piers
  - 2 Abutments
- MASW test - Active mode
  - 10 kg sledge hammer impact as seismic source
  - 4.5 Hz Geophones
- Mass of land from piers 1-4
  - Submerged under river water
- Roll Along method of Active MASW test
  - Shifting equipment from pier to pier with a 12 m overlap

**Dispersion image from single record**

**Dispersion image after stacking 4-records**
MASW Survey at a Bridge Site

- Automated extraction of dispersion curve and Inversion

![Extracted multimodal dispersion curve]

1D Shear wave velocity profile

- Profiles obtained as a roll-along method

MASW Survey at a Bridge Site

Hill-Slope Stability Analysis in Local and Regional Scale

Major Area of Research

- Hill-Slope Stability Analysis in Local and Regional Scale

![Landslide Analysis Approaches]

Local scale:
- Single landslide
- Stability analysis

Regional scale:
- Cluster analysis
- Geomorphology
- Numerical modeling

Descriptive:
- Descriptive statistics
- Statistical analysis
Landslide Analysis on a Local Scale

- Slope Stability Analysis

**Limit Equilibrium Methods:**
- Buffalo Slope Stability Model
- Rankine Block Method
- Modified Methods
  - Modified (M.S) Method
  - Rankine (R.3)
  - Interovertor and Price (IPR)
  - Spencer (SPR)

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Hill-Slope Stability

**Static Stability**

- Effect of hydraulic and pseudo-static conditions on the stability of hill slope

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Hill-Slope Stability

- Statistical Regression Analysis

**Project for PWD Arunachal Pradesh**

**X1**
- $v = 0.3855 - 0.9914c + 0.0287\beta - 0.0077\phi - 1.0186\delta - 1.0084c \cdot 3.0934 \cdot 10^{-5} c$

**X2**
- $\phi = 8.5077 \times 10^{-6} \delta + 4.1349 \times 10^{-6} \beta^2 - 1.2939 \times 10^{-5} \phi^2 + 7.5860 \times 10^{-6} \delta^2$

**X3**
- $\beta = 1.8093 \times 10^{-5} \phi + 3.4335 \times 10^{-6} \delta - 3.0947 \times 10^{-5} \beta^2 - 0.9994 \delta$

**X4**
- $\delta = 0.0333 \phi - 0.1526 \phi \delta - 0.0029 \phi \beta - 1.1049 \times 10^{-7} \delta c - 0.1010 \phi \delta$

**X5**
- $\phi = 0.1526 \phi \delta - 0.0029 \phi \beta + 0.0678 \phi \delta$
Probabilistic Analysis of Landslides

- Deterministic framework of analysis
  - Natural tendency to define soil property by a single value
  - Defines a specific safety factor
  - Obtaining the analytical safety factor based on soil parameters is NOT GUARANTEED.

- No parameters affecting landslides are deterministic
  - All are uncertain in their determination
  - All are uncertain in their effect and functioning
  - Heterogeneity and uncertainty are the inherent properties of soil parameters

Probabilistic Analysis of Landslides

- Probabilistic framework of analysis
  - Defines a margin of safety and a probability of failure instead of a specific safety factor
  - Soil parameters are defined as random variables with a probability distribution of occurrence (single or joint probability)

Probabilistic Analysis of Toe Cutting on Hill Slopes

- A case study
  - 40 m high slope with inclination 40° subjected to vertical toe cutting
  - $\phi_{mean} = 40$ kPa, $\phi_{mean} = 27.5°$
  - LEM Morgenstern-Price method with MCS

Probabilistic Analysis of Landslides

- Random Finite Element Method (RFEM)
  - FE based on Random Field Generation for parameters
  - Accounts for spatial variability
  - Parameters are allotted to each grid based on specified correlation length
  - No prior assumption of slip surface required for failure
**Probabilistic Analysis of Landslides**
- Influence of correlation length in random field
  - Simulation of spatial variability of soil shear strength parameters
  - Isotropic correlation – Formation of parameter pockets
  - Anisotropic correlation – Formation of stratified layers

**Spatial Variability**
- Local scale stability analysis
- Influence of correlation length
  - Log-normal pdf with a CoV of 0.2

**Spatial Variability in Regional Scale**
- Salient variable parameters
  - Shear strength parameters
  - Permeability characteristics
  - Geological and geomorphological variability
  - Rainfall distribution

**Landslide in a Regional Scale**
- Regional Scale Analysis
  - Landslide Hazard Zonation and Landslide Susceptibility Studies
    - SHALSTAB, TRIGRS, SIRMAP, Physically Based Models
    - GIS platforms for Digital Elevation Models (DEM)
    - Shuttle Radar Topography Mission (SRTM) of 3 arc-sec resolution
Regional Scale Analysis

- Landslide Hazard Zonation and Landslide Susceptibility Studies
  - SHALSTAB, TRIGRS, SINMAP, Physically Based Models
  - Derived elevation and slope maps

Landslide Susceptibility of Guwahati City

Sarma et al., Landslides (Communicated)

Landslide in a Regional Scale

- Landslide Hazard Zonation and Landslide Susceptibility Studies
  - SHALSTAB, TRIGRS, SINMAP, Physically Based Models
  - Map of catchment areas
    - To identify the volume of water flowing into or flowing out of the particular grid

Catchment Area Map

Landslide in a Regional Scale

- Landslide Hazard Zonation and Landslide Susceptibility Studies
  - SHALSTAB, TRIGRS, SINMAP, Physically Based Models
  - Stability map for a single rainfall event

Stability Index Map

Landslide in a Regional Scale

- Landslide Hazard Zonation and Landslide Susceptibility Studies
  - SHALSTAB, TRIGRS, SINMAP, Physically Based Models
  - Derivation of steady state recharge for a single rainfall event
    - Based on infiltration characteristics of the soil

Steady State Recharge Map
Landslide in a Regional Scale

- Regional Scale Analysis
  - Landslide Susceptibility of Guwahati City
    - Incorporation of rainfall variability
      - Monthly mean rainfall based on 100 years data (1901-2002) at Kamrup metropolitan
    - Landslide Hazard Zonation and Landslide Susceptibility Studies
      - SHALSTAB, TRIGRS, SINMAP, Physically Based Models
      - Soil thickness map
  - Incorporation of soil depth variability
    - Change of landslide zones with rainfall duration at Guwahati city
    - Ongoing project for next 2 years with DST: Rainfall induced landslide hazard assessment study at Guwahati city and consequent Risk Assessment

IDF curves for Guwahati region

Common stratigraphic features at Guwahati region

Variation of weathered soil thickness and slope angle

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http://www.iitg.ac.in/arindam.dey/homepage/index.html#
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