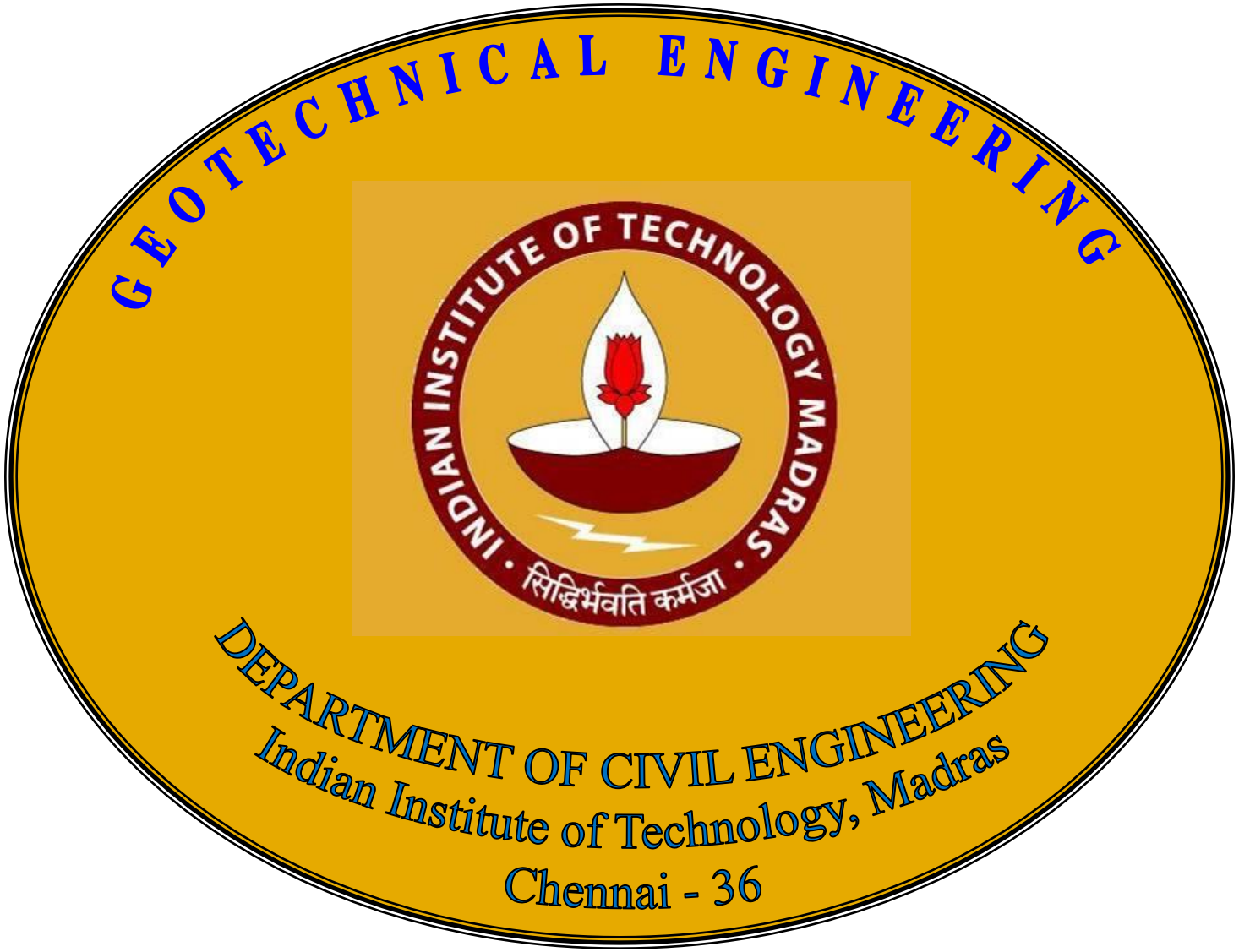
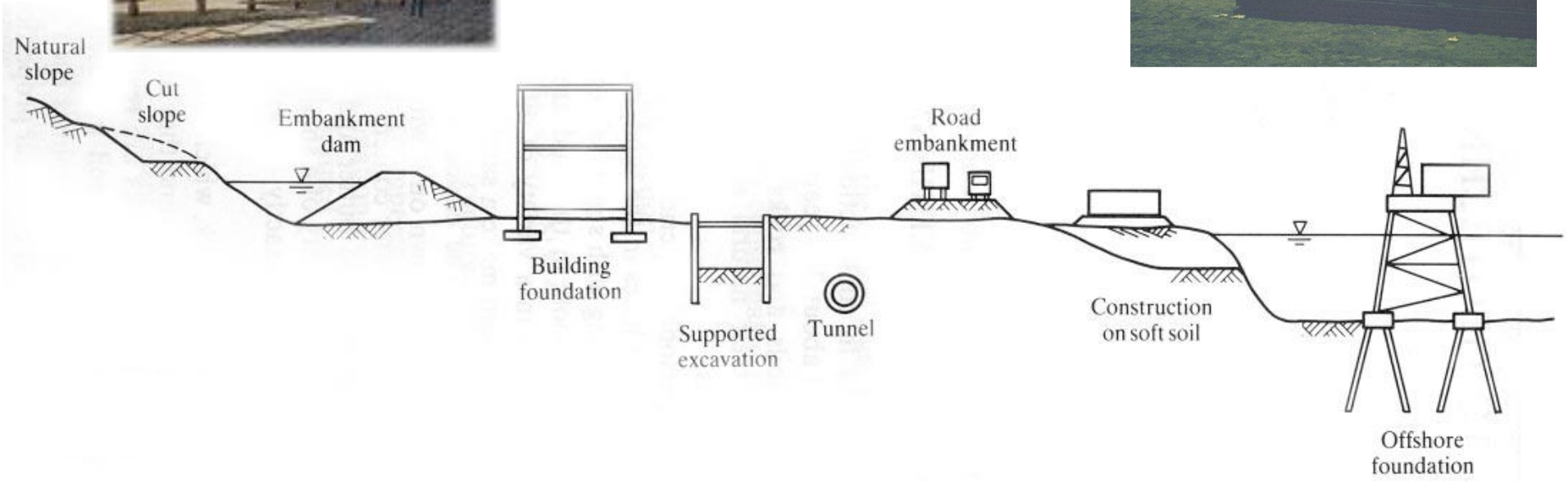

GEOTECHNICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY MADRAS
सिद्धिर्भवति कर्मजा
DEPARTMENT OF CIVIL ENGINEERING
Indian Institute of Technology, Madras
Chennai - 36

Geotechnical Engineering???

"…concerned with the engineering behavior of earth materials.



"Virtually every structure is supported by soil or rock.
Those that aren't - either fly, float, or fall over." Richard Handy, 1995


Computational GeoMechanics
Earthquake Geotechnical Engg.
Rock Mechanics
Ground Improvement
Major research areas@IITM
Unsaturated Soils
Geosynthetics
Geoenvironmental Engineering
Foundation Engineering

Geotechnical Engineering Division, IIT Madras

Dr. K. Rajagopal, Professor, Institute Chair Professor

Areas: Reinforced soil structures
Finite Element Analysis

Dr. A. Boominathan, Professor

Areas: Soil dynamics,
Geotechnical earthquake engineering
Ground improvement

Dr. G. R. Dodagoudar, Professor

Areas: Reliability analysis
Soil dynamics and earthquake engineering
Seismic hazard and risk assessment

Dr. R. G. Robinson, Professor

Areas: Expansive soils
Soft ground Engineering
Ground improvement

Dr. T. Thyagaraj, Professor

Areas: Unsaturated soils
Geoenvironmental Engg
Ground improvement

Dr. V. B. Maji, Associate Professor and Head of Lab

Areas: Rock Mechanics,
Numerical modelling

Dr. A. Dali Naidu, Associate Professor

Areas: Centrifuge modelling
Geoenvironmental Enggineering
Geosynthetics

Dr. Subhadeep Banerjee, Associate Professor

Areas: Soil Dynamics,
soil-structure interaction

Dr. Chandrasekhar Annavarapu, Assistant Professor

Areas: Computational Mechanics, Scientific Computing, Geomechanics, Fracture Mechanics, Finite Element Method

Dr. Tarun Naskar, Assistant Professor

Areas: Wave Propagation in Elastic Media SASW/MASW, Bender Element Test, Site Response Analysis, Geotechnical Earthquake Engineering, Artificial Intelligence

Dr. Ramesh Kannan, Assistant Professor

Areas: Constitutive behaviour of geomaterials, Energy geotechnics, Particulate mechanics Bioinspired geotechnics

MAJOR LABOROTARIES

- **Soil Engineering Lab**
- **Cyclic Triaxial Lab**
- **Soil Dynamics and Earthquake Engg. Lab**
- **Geosynthetics Lab**
- **Geotech computer Lab**
- **Geoenvironmental Engg. Lab**
- **Rock Mechanics Lab**
- **Unsaturated Soil Mechanics Lab**
- **Centrifuge Lab**

Various Programs

- M.Tech in Geotechnical Engineering
- MS in Geotechnical Engineering
- Ph.D in Geotechnical Engineering
- Direct Ph.D after BE/B.Tech

A number of theory and laboratory courses are offered by the faculty covering the diverse areas of Geotechnical Engineering.

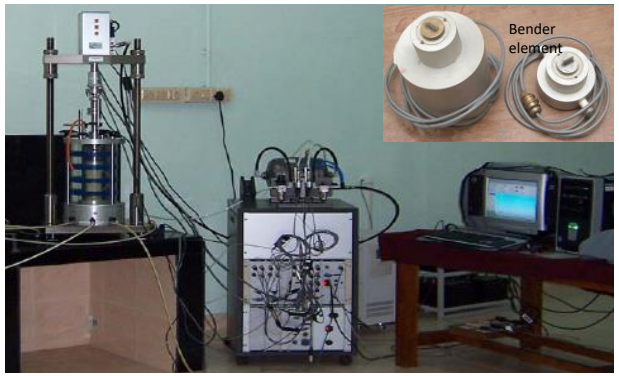
Courses include- Advanced Soil Mechanics , Soil Dynamics , Reinforced Soil Structures , Advanced Foundation Engineering, Applied Soil Mechanics , Ground Improvement Techniques , Rock Engineering , Earthquake Geotechnical Engineering etc.

MAJOR FACILITIES……..

Advanced Soil Testing Laboratory

Department of Civil Engineering

Cyclic Triaxial Apparatus with Bender Element



- Measure the shear modulus and damping ratio in the small to large strain range (10^{-6} - 10^{-1})
- Determine liquefaction potential
- Measure resilient modulus of pavement materials
- Frequency range - 0.01 Hz to 60Hz
- Cell pressure - up to 1000 kPa
- Load cell - ± 5 kN

Bishop-Wesley Stress Path Apparatus

- Control stress paths in either p, q or t, s.
- Perform K_0 consolidated triaxial testing
- Compression or Extension Tests
- Slow cyclic loading
- Stress controlled or Strain Controlled
- Can attach bender elements and on-sample transducers

Resonant Column Apparatus

- To measure the shear modulus and damping ratio of soils in the small to medium strain range (10^{-6} - 10^{-1})
- To determine liquefaction potential
- Frequency range - 0.01 Hz to 60Hz
- Cell pressure - up to 1000 kPa
- Load cell - ± 5 kN

Researchers

- **Prof. R.G. Robinson (robinson@iitm.ac.in)**
- **Prof. A. Boominathan**
- **Dr. Subhadeep Banerjee**
- **Dr. T. Thyagaraj**
- **Dr. V.B. Maji**
- **Several MS and Ph.D. scholars**

Geosynthetics for Sustainable Infrastructure Development

Introduction

Geosynthetics are modern polymeric materials that are used world over for development of highways and railroads, stabilisation of hill slopes, construction of very high retaining walls, ground improvement works and shore protection works. These product help in economic development of infrastructure facilities by reducing both construction time and material requirements.

Research work at IIT Madras on geosynthetics focuses both on practical and theoretical areas to develop innovative applications of these materials.

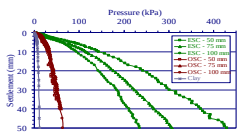
Applications in Ground Improvement

The following topics of ground improvement are being investigated at IIT Madras:

- Geosynthetic encasement for stronger and stiffer stone columns for constructions in soft clay soils
- Vacuum consolidation of soft clay soils for increasing their performance
- Use of geosynthetics for coastal zone stabilisation.

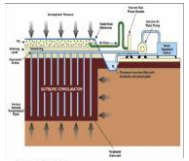
The above aspects are investigated through laboratory tests, full-scale field tests and finite element based numerical modelling studies.

Geotextile encased sand column

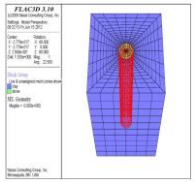


Improved performance with geosynthetic encasement

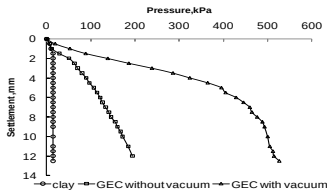
Sand filled bags and gabions for coastal protection



a.



b.



c.

a. Schematic of vacuum consolidation
b. Numerical modelling of stone columns
c. Improved performance with vacuum treatment

Roads and Railway Applications

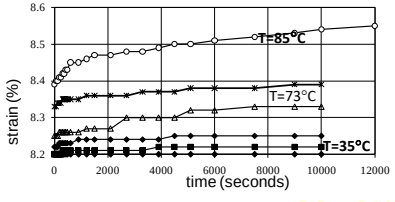
The road and railway projects require construction of steep sided embankments, retaining walls as part of RoBs and stabilisation of roads and railway tracks. The geosynthetics are used in these constructions as reinforcement, separator, filtration layer, drainage layer or as a paver fabric. Reduction in pavement thicknesses result in large savings in construction costs and also reduce the environmental impact of these projects. The particular research works connected to this area are:

- Connection strength between reinforcements and facing panels
- Pullout interaction between various types of reinforcements and soils
- Use of geogrids and geocells for reduction of granular subbase materials
- Use of geocells for construction of container yards
- Creep behaviour of polymeric reinforcement materials at high temperatures
- Application of geosynthetics for military roads in deserts

Geotextile placed below railway track for separation & filtration

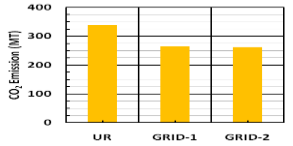
Model railway track with failure detection system

High temperature creep test chamber



Response of polyester grid at different temperatures at 68% peak load

Laboratory and field test photos



22m and 44 m high geosynthetic reinforced soil walls for ghat road at Vijayawada

Extra parking space on hill top

Sponsoring Agencies

1. Ministry of Human Resources Development, GoI, New Delhi
2. Department of Science and Technology, New Delhi
3. M/s IVRCL Limited, Hyderabad
4. M/s Netlon India Limited, Vadodara
5. M/s Garware Wall Ropes Ltd., Pune
6. M/s Gabion Technologies Ltd., New Delhi
7. M/s VSL India Pvt. Ltd., Chennai

Patent Applications

One provisional patent application has been submitted for the improved connection between geogrids and gabion boxes based on the development work at IIT Madras.

Researchers

- Prof K. Rajagopal (gopalkr@iitm.ac.in)
- Prof. A. Veeraragavan
- Dr. R.G. Robinson
- Dr. Sivakumar Palaniappan
- Dr. T. Thyagaraj
- Dr. V.B. Maji
- Several MS and Ph.D. scholars

Geoenvironmental Engineering Laboratory

Analytical Instruments


Atomic Absorption spectrophotometer


Gas Chromatography


UV-Vis Spectrophotometer


Water Quality Analyzer

Infrared Gas Sensors


Gas Diffusion Apparatus

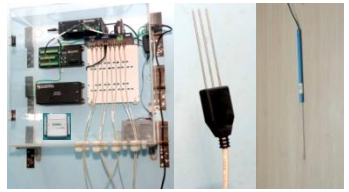
Material Characterization


Sieve Shaker *Pycnometer*


Impedance Spectroscopy


Flexible Wall Permeameter & Toxic Interface

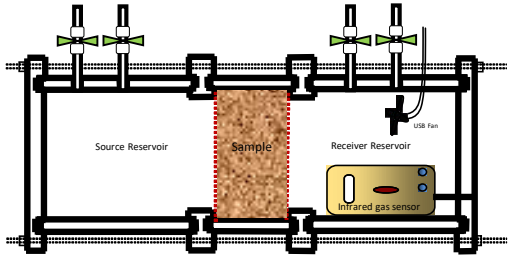

Column Flow Through Setup


DA System & TDR Probe, Potentiometer


1D-Swell Test & 1g Column setups

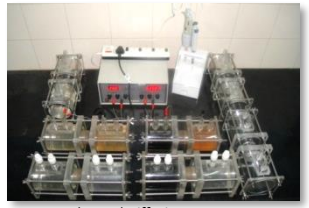
Indigenously Developed Setups


Pressure Control Panel for Gas Diffusion and Permeability Determination



Schematic View of Gas Diffusion (or) Permeability Apparatus


VOCs Diffusion Apparatus


Accelerated Diffusion Apparatus

Physical Modeling Tools


Research Centrifuge

Geotechnical Centrifuge

Geosynthetics Longevity Testing


UV Weather Chamber and Calibrator *Sample Cutter* *Melt Indexer*

Researcher

- **Dr. Dali Naidu Arnepalli (arnepalli@iitm.ac.in)**

Unsaturated Soil Mechanics Laboratory
Geotechnical Engineering Division

Major Facilities Available

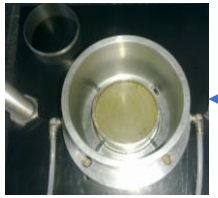
- Fredlund SWCC Device
- Dewpoint PotentiaMeter (WP4-T)
- Soil Vision Software (Version 4.23)

Fredlund SWCC Device

The Fredlund SWCC uses the axis-translation technique for applying matric suctions while following various stress paths.

GCTS SWC-150 Cell with pressure panel and pneumatic loading frame

Hanging column for low suctions (1-5 kPa)



SWC cell with sample

Specifications

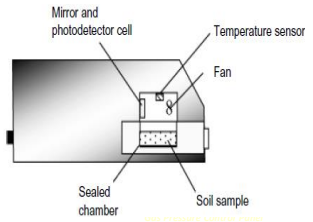
Accuracy :1 kPa
Suction range : 0 to 1500 kPa
Specimen diameter: 25 - 71 mm; Height: up to 50 mm

Applications

- Determination of soil-water characteristic curves of geomaterials, and geosynthetic clay liners during drying and wetting
- Null-type initial matric suction measurements can be made using axis-translation technique

Dewpoint PotentiaMeter

The Dewpoint PotentiaMeter (WP4) uses the chilled mirror dewpoint technique and is essentially a chilled-mirror hygrometer.



Schematic view

Dewpoint PotentiaMeter (WP4-T)

Specifications

Accuracy :
± 0.1 MPa from 0 to -10 MPa; 1% from -10 to -300 MPa
Suction range : 0 to 300 MPa
Measurement Time : Approx. 5 minutes
Sensor Type :Chilled-mirror dewpoint sensor

ii) Infrared temperature sensor

Applications

- Accurate measurement of total suction of soils up to 300 MPa
- Determination of soil-water characteristic curves of geomaterials, and geosynthetic clay liners
- To study effects of temperature on water potential

Ongoing Research

- Physico-Chemical Effects on Shrinkage Behavior and Soil-Water Characteristic Curves of Compacted Clays
- Effect of Physico-Chemical Factors on Behavior of Compacted and Geosynthetic Clay Barriers
- Compatibility Issues of Compacted and Geosynthetic Clay Liners
- Effect of Physico-Chemical Factors on Collapse Behaviour of Soils

Researcher

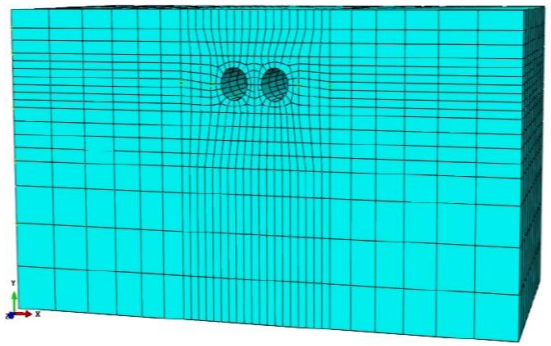
➢ Dr. T. Thyagaraj (ttraj@iitm.ac.in)

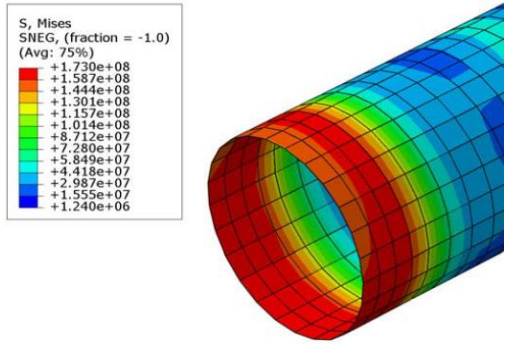
Soil Dynamics Laboratory

Geotechnical Engineering Division

RESPONSE OF SUBWAY TUNNELS UNDER BLAST LOADING

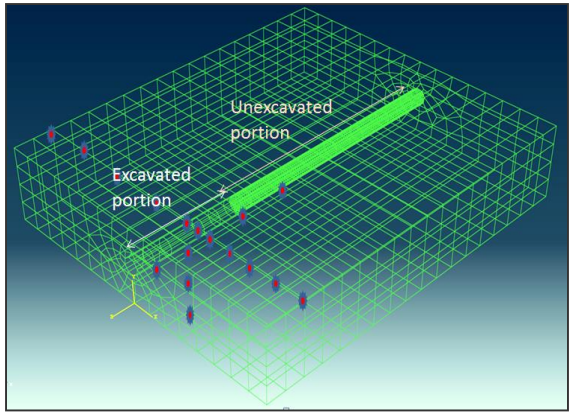
- To develop a 3D numerical model to study the behaviour of tunnels embedded in different ground media under various intensity of blast loads.
- To study the effective mitigation measures to increase blast resistance of subway tunnels.

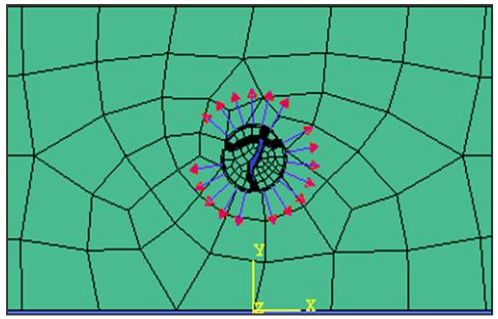




TBM AND UNDERGROUND TRAIN INDUCED VIBRATIONS ON ADJACENT STRUCTURES

- To develop a 3 D numerical model to study tunnelling and underground train induced ground borne vibrations
- To study the effect of these vibrations on adjacent structures for typical sites in Chennai.
- To study the effectiveness of various vibration isolation techniques to minimize the vibration levels.





SHAKE TABLE TESTING

- Soil-structure interaction studies
- Piles under lateral and dynamic loads.
- Studies on batter piles.

Researcher

- Prof. A. Boominathan (boomi@iitm.ac.in)
- Dr. G. R. Dodagaudar (goudar@iitm.ac.in)
- Dr. Subhadeep Banerjee (subhadeep@iitm.ac.in)

Rock Mechanics Laboratory

Geotechnical Engineering Division

Rock Triaxial Facility

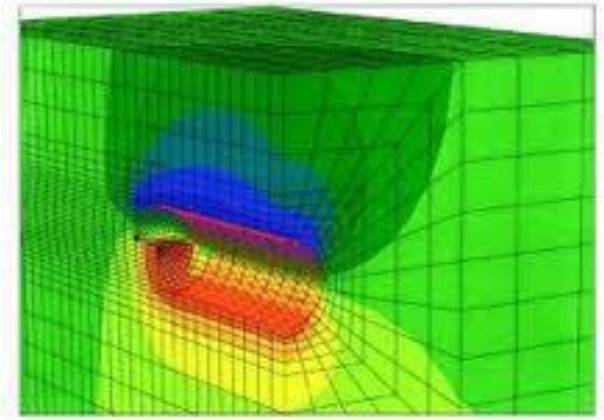
Researcher

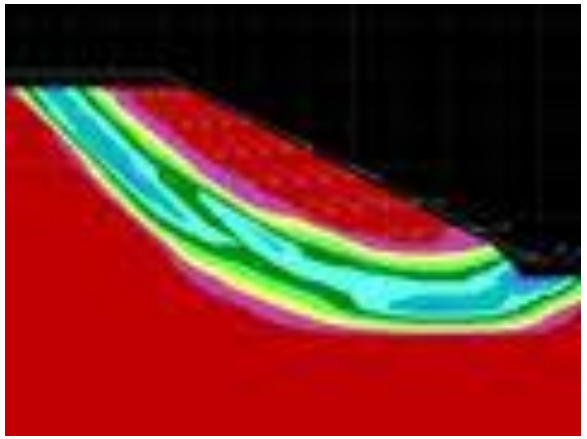
➢Dr. V. B. Maji (vbmaji@iitm.ac.in)

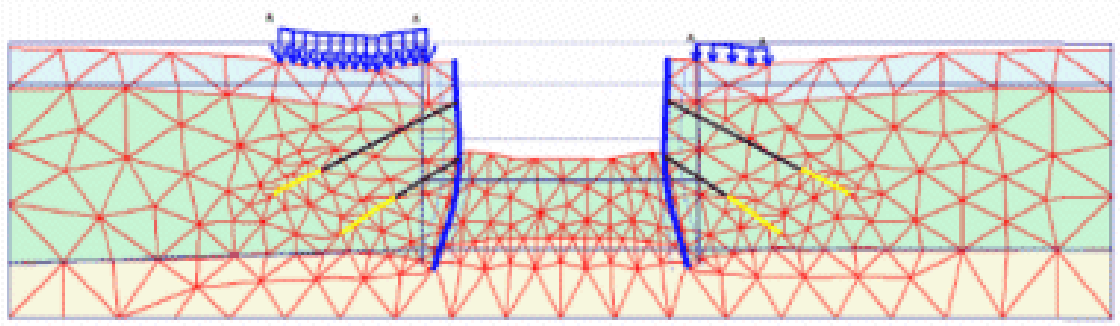
Geotechnial Computer Lab

Geotechnical Engineering Division

GEOFEM	GEO4
PLAXIS	SLOPEW
SASSI 2000	FLAC & FLAC3D
SHAKE91	SAGE CRISP 2D
CRISIS2003	QUAD4M
CARIS	FLUSH
REAME	







Researcher

- Prof. K. Rajagopal (gopalkr@iitm.ac.in)
- Dr. G. R. Dodagaudar (goudar@iitm.ac.in)
- Dr. V. B. Maji
- Dr. Subhadeep Banerjee


Thank you
S, Mises
SNEG, (fraction = -1.0)
(Avg: 75%)
GCTS
Fredlund
WP4