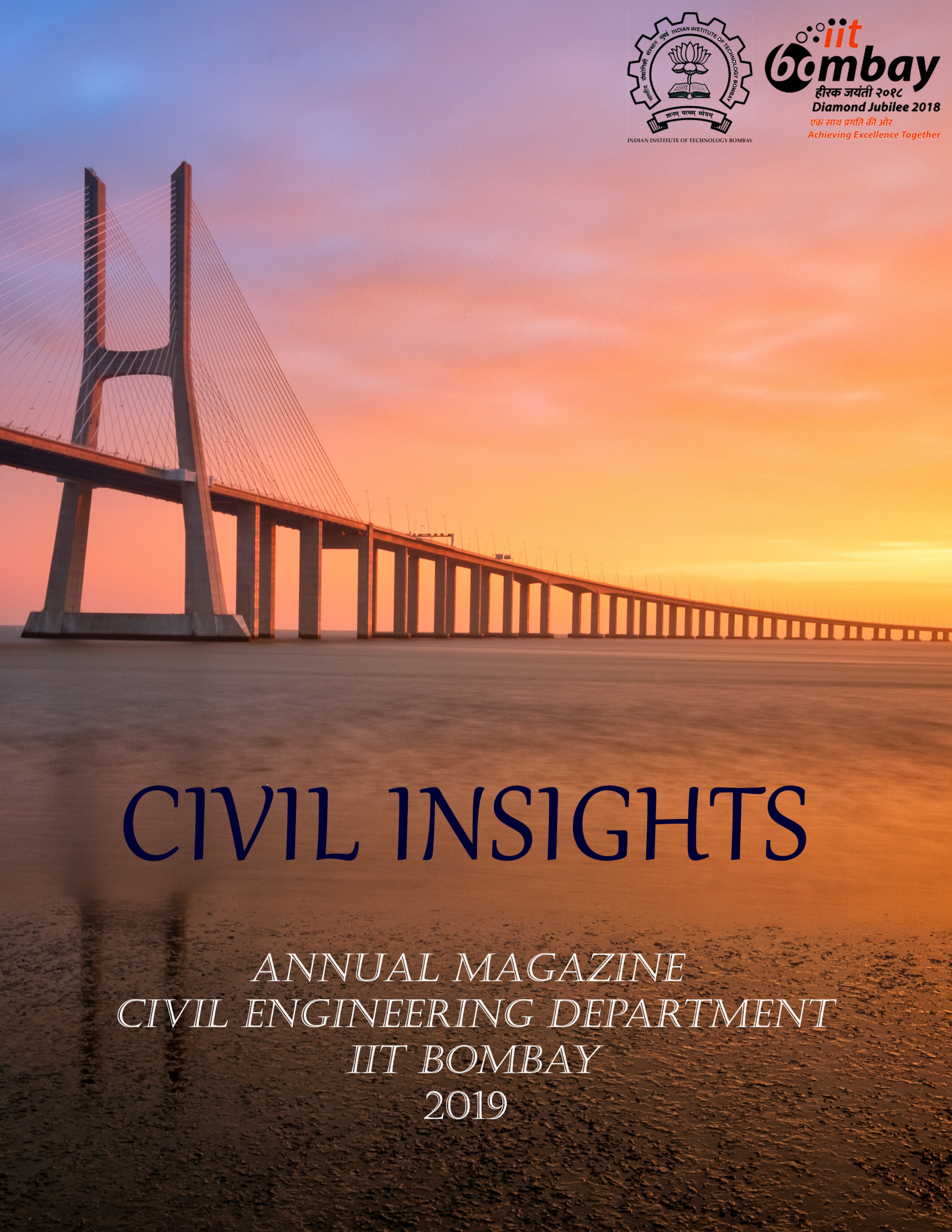

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

iit bombay
हीरक जयंती २०१८
Diamond Jubilee 2018
एक साथ प्रगति की ओर
Achieving Excellence Together

CIVIL INSIGHTS

ANNUAL MAGAZINE
CIVIL ENGINEERING DEPARTMENT
IIT BOMBAY
2019

Message from the Magazine Team

It gives us immense pleasure to lead the work in presenting before you the very first edition of our department magazine, 'Civil Insights'. The civil engineering department at IITB is an integral part of the institute with international recognition. In the following pages, we have tried to provide a glimpse of the inside picture of the department so that this magazine serves as a useful entity to all those who would want to have a first look of what the department is all about. The present edition highlights all the major activities that took place in the department in the year 2018-19. The team is extremely thankful to all the faculty, staff, and students who took the trouble of submitting articles for it and made it so diverse in its contents. We would also like to express our heartfelt gratitude to the HoD, Prof. T.I. Eldho, as well as to the CEA faculty advisors, Prof. Venkata Delhi, Prof. Meera Raghunandan and Prof. Albert Thomas, who have helped us with their invaluable suggestions. Without them, this magazine could not have taken shape. We hope the magazine will cater to a broad array of readers' interests. While the team has tried its utmost in making the contents error-proof, there might still be a chance of readers encountering mistakes or typos; please acknowledge our sincere apology. We hope that this magazine delivers the purpose it has been envisaged for and that it will serve as a lasting memory for the graduating batch to take along as the department bids them goodbye on the occasion of the Institute's 57th Convocation. We wish the batch of 2019 good luck for all their future endeavours.

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Message from the HoD

Indian Institute of Technology (IIT) Bombay was established in 1958 and the Civil Engineering department is part of the Institute since its inception. The department has grown tremendously over the years and is now recognized as one of the major engineering departments in the country. Besides high-quality teaching and instruction at both UG and PG levels, the department is actively involved in basic and applied research and consultancy and provides high-quality technical advisory support through various R&D projects and consultancy to various organizations. The civil engineering department with its multifaceted faculty continues to maintain and cultivate strong links with the infrastructural industry, academic and research institutions both within and outside the country. As the problems the society faces are multi-dimensional, so must be our efforts at combatting them. The value of inter-disciplinary work cannot be over-stressed in today's times when problems are deeply connected and solutions to one must account for possible implications on another and we give emphasis for the same. With this view in mind, the Civil Engineering department provides higher education in the various sub-disciplines of Civil Engineering. These include Construction Technology and Management, Geotechnical Engineering, Ocean Engineering, Structural Engineering, Remote Sensing, Transportation Systems Engineering, and Water Resources Engineering.

I congratulate all the passing out students of Civil Engineering Department. I hope you have achieved your goal/ ambition in your life with the education in IIT Bombay. I also welcome the newly joined students. I congratulate you on achieving your goal of pursuing your higher studies in one of the top civil engineering departments of the world. I am sure that your dream of doing higher studies in the best civil engineering department will be fulfilled here in IIT Bombay. On the occasion of the celebration of the Diamond Jubilee of IIT Bombay, we are very happy to publish this Civil Engineering Magazine. The magazine focuses on various activities of the department for the past year. The magazine is meant to give various information on the department life, academic matters, student activities and information on many aspects of research and development. I appreciate the work of the magazine's Editorial Committee for their contributions in the preparation of this magazine.

With best wishes.

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Freight Transportation

PhD student: Sowjanya Dhulipala

Freight transportation planning plays an important role in the economic growth of a country as the efficient movement of freight has a positive effect on it. It is necessary to know the demand for freight movement to deal with the planning issues and to frame policies for improving the system. In general, freight transportation is less concentrated compared to passenger transport; usually modelled at an aggregate level without any separate models for freight trips. Freight transportation has been a concern in developed countries since a few decades but in developing countries, this was recognized recently. Many developed countries (E.g. U.S. and European nations) have built statewide and nation-wide freight demand models and established systematic frameworks to collect the data on commodity movements within and across the concerned regions; which is lacking in the developing countries. These models are useful in planning facilities, planning strategies for improving logistics, and in decision-making for economic evelopment.

India is one of the fastest-growing economies in the world with a gross domestic product (GDP) growth rate of 7% in the year 2018-19. The country has been witnessing rapid growth in the freight activities from the past two decades; freight carried over road and rail increased from 257 billion tonne kilometres (BTKM) in 1980-81 to 2053 BTKM in 2011-12 (National Transport Development Policy Committee 2014). This significant growth of freight movements raised various challenges in the country's transportation sector. The Indian freight industry is suffering from a lot of inefficiencies despite policy reforms and investments over the sector by the government. Sub-optimal mode mix, higher logistics costs, congestion in the transportation system, inefficient infrastructure capacity are some of the major problems being faced by the sector. In a study by World Bank Group in 2005, the annual economic costs due to truck delays in India were estimated to be between Rs. 9 billion - Rs. 23 billion (~USD 400 billion - USD 1020 billion). Another study in 2016 reported that the logistics costs are nearly 14% of the country's gross domestic product which is quite high compared to other developing countries marking the inefficiencies of the system. This indicates the need to focus on freight demand modelling and estimation of future freight flows in the country. Although there are few studies, the research on freight transportation in India is still at its inception. There is no proper modelling framework or

database for commodity movements in the country. Therefore in our study, an attempt has been made to use publicly available data on various industry sectors and socio-economic data to develop industry-specific freight generation models to estimate freight demand at the regional level.

The region comprising eight states with 210 districts, covering South India, parts of Central and Western India is considered for the study. Usually, the movement of freight transportation is associated with economic activities in the country/region as it is related to the production and distribution of physical goods. Econometric methods such as regression and economic input-output models, those relate the socio-economic data with the freight activities are generally used for modelling at the aggregate level. In our study, various industry sectors that generate freight movements are identified from the industry sectors classified as per the standard National Industrial Classification (NIC-2008). Some examples of the industry sectors those generate freight movements are agricultural, manufacture of textiles, manufacture of coke and refined petroleum. Regression models are developed for these industry sectors to formulate the relationship between the value of output/tonnes generated of/from the industry sector and various explanatory factors considering district as a freight analysis zone. Population, employment, number of factories, gross district domestic product, and commodity-specific variables (E.g. gross cropped area and gross irrigated area for agricultural commodities) are used as explanatory variables. The developed models are statistically validated and have shown good prediction accuracy. The developed models can be used for estimating future freight demand provided the information on future population, employment, and other applicable explanatory variables. The tonnes generated can be converted to vehicle trips at a later stage based on the modal share. Further, this can be used in evaluating the traffic movements and transportation demand in the region considered, which in turn will help in decision-making for the provision of freight transportation facilities and policymaking. Thus the developed models can help planners and decision-makers in the estimation of freight demand. Since there are very few studies in India on freight generation modelling, this can be an outset for further research and improvement.

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Design of Water Distribution Networks Under Uncertainty: Trade-Offs Between Cost And Reliability

PhD student: Swati Sirsant

Water Distribution Networks (WDNs) are one of the most crucial infrastructures related to our daily life since they supply the treated water from the source to the consumers. Traditionally, the problem of WDN design is formulated as a single objective optimization problem, which requires minimization of the total cost of pipes in WDNs. Some studies also performed multi-objective optimization formulations considering minimization of cost and maximization of reliability as two conflicting objectives of the problem. Reliability is a measure of the level of demand satisfaction in case of working and failure conditions, which can be of two types, hydraulic and mechanical. Hydraulic failure occurs due to the uncertainty in nodal demands and pipe roughness coefficients, while mechanical failure is the failure of components such as pipe, pumps, valves etc. In addition, the WDNs are subjected to many future uncertainties such as changing water demand and availability scenarios. Therefore, in order to design a robust WDN, such scenarios need to be accounted for. While there are various techniques available for the estimation of hydraulic and mechanical reliability, these techniques are computationally expensive and time-consuming. Thus, in order to reduce the computational requirements for solving WDN design problems, various reliability surrogate measures (RSMs) such as entropy, resiliency, network resilience etc. are employed as substitutes for reliability, for performing multi-objective design of WDNs. To solve the multi-objective models, the study developed Multi-Objective Self Adaptive Differential Evolution (MOSADE) methodology. The methodology is tested on various benchmark WDN problems as well as a real WDN for various cases of RSM, viz. entropy, resiliency, network resilience and two combined indices, one consisting of combined index of entropy and resiliency and other combining entropy and network resilience.

Further, in order to design a WDN considering future changes in water demand and availability, three design strategies viz., precautionary, staged deterministic and flexible designs are engaged and evaluated for their utility. Precautionary design considers that all the design interventions are to be made at the initial stage itself, while staged deterministic design considers interventions to be made at various stages across the planning

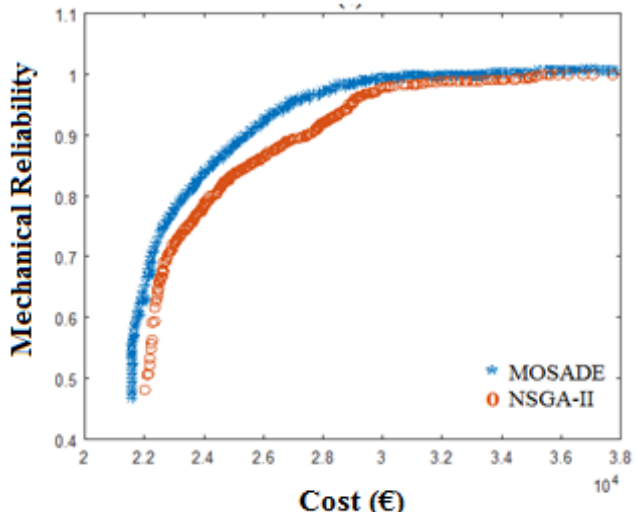
horizon. Both precautionary and staged deterministic design considers the design parameters such as nodal demands and pipe roughness coefficients to be deterministic. Flexible design methodology considers interventions to be made in stages considering the uncertainty in parameters such as nodal demands and pipe roughness coefficients. For generating the future water demand scenarios, the future population is projected using past census data. For projecting the future water availability, the effect of climate change is considered and General Circulation Model (GCM) data is used for future rainfall projections. The framework is tested on a benchmark WDN by considering hypothetical scenarios and is being applied on a real WDN of an urban area in Mumbai by using ward wise census data and GCM datasets.

The MOSADE algorithm is found to be converging faster than other optimization algorithms such as NSGA-II, leading to smooth Pareto-optimal fronts, having uniformly spaced solutions. A typical Pareto-optimal front obtained for multi-objective design of Fossolo WDN using MOSADE and NSGA-II algorithms is shown in the Figure below. On using the various RSMs as substitutes for reliability for multi-objective design of WDNs, it is found that a considerable amount of computational burden is reduced. Also, it is found that the combined index of entropy and resiliency performs well as a surrogate for both hydraulic and mechanical reliabilities.

Among the different WDN design strategies (Precautionary, staged deterministic and flexible) tested on benchmark WDNs, the study noticed that the flexible WDN design leads to a robust design having high reliability values at minimum cost.
The main findings of the study:

- MOSADE is an efficient tool for solving the problem of multi-objective design of WDNs.
- Using RSMs as substitutes for hydraulic and mechanical reliability proves to be an effective way of reducing the computational burden for solving the WDN design problem.

Flexible WDN design methodology should be adopted in order to handle the future risks associated with changing water demand and availability scenarios.



Trade-offs between the cost and reliability obtained using MOSADE and NSGA-II for Fossolo WDN.

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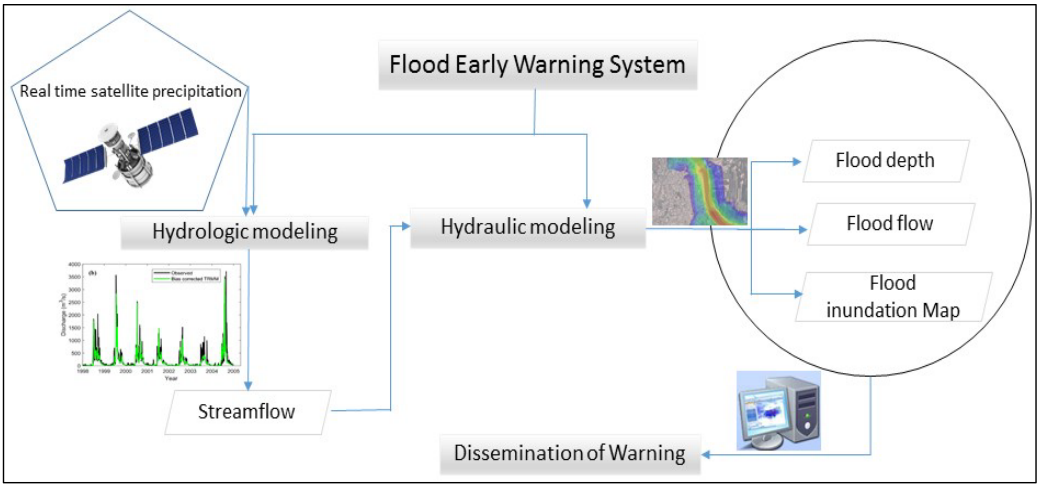
Remote Sensing Based Hydrological Modelling for Flood Early Warning System in the Krishna River Basin

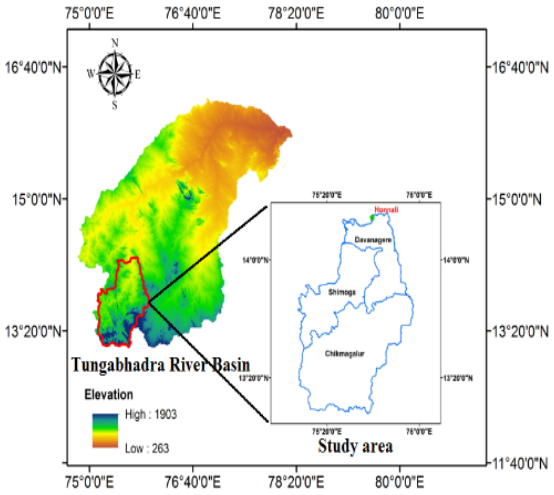
PhD student: Saswata Nandit

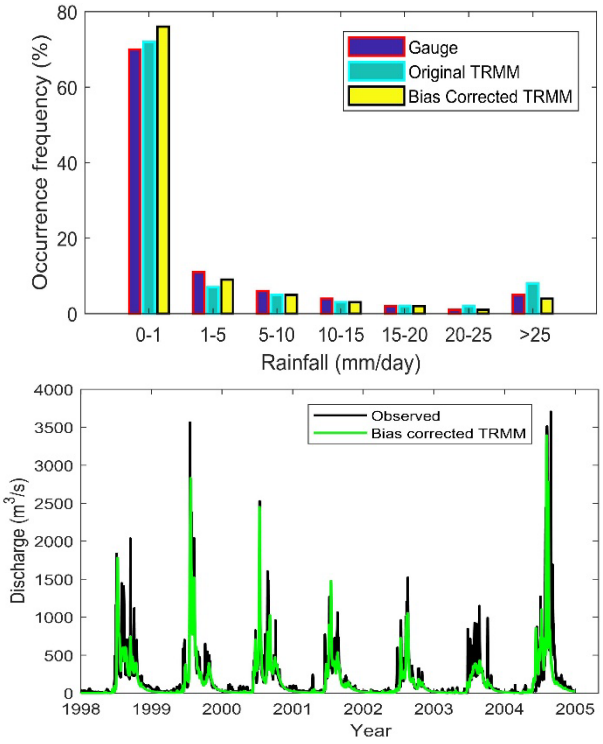
Flood being a natural disaster often has a huge impact on the environment and society. Regardless of the progress in technology, the economic loss and deaths due to floods are increasing day-by-day. World Meteorological Organization (WMO) reported an estimated worldwide economic loss of $788.9 billion and 272,251 deaths during 1970-2012. Climate change and global warming might exacerbate the situation further in future. India faced several catastrophic floods in the recent past, like Mumbai floods (in 2005, 2017), Uttarakhand flood (in 2013), Chennai flood (in 2015), Gujrat Flood (in 2017), etc. Therefore, in order to prevent or reduce the impacts of flooding, there is a need for an early flood warning system. Hydrological models are generally employed to translate rainfall to river flow over a catchment area. This eventually provides support for real-time flood forecasting and developing early warning system which further helps in improved decision making during flood incidents.

Precipitation is the main driving force for any hydrological model application, and it can be obtained from field measurements (gauges) or satellites. The difficulty with meteorological data from gauges is that it has limited temporal and spatial coverage, and also such data are not easily accessible. Moreover, it only embodies point measurements and does not offer complete coverage of the processes that happen in a catchment. Hence, using (near real-time) satellite-derived products as an input to a hydrological model for developing flood early warning system has an advantage, because it provides good temporal and spatial coverage and they are also readily accessible from various scientific organizations (e.g., NASA). The study developed a physically-based distributed hydrological model, which considers all the relevant hydrological processes in a catchment along with their space-time variation. Satellite-based precipitation estimates were obtained from NASA's Tropical Rainfall Measuring Mission (TRMM), which were bias corrected and subsequently fed into the hydrological model for generating the runoff. Furthermore, in this context the study aims to integrate hydraulic model for the preparation of flood risk mapping and also, to disseminate the outcome of the study using Web-GIS framework.



The framework was applied for a case study of the upper Tungabhadra River basin and evaluated the suitability of the methodology by comparing the simulation results with observations of river discharge in the study area. In this regard, grid-based rainfall from TRMM 3B42 v7 was collected for the period of 1998- 2004, and a time-space variable (TSV) bias correction approach was applied for bias correction of the raw satellite precipitation data. After successful evaluation of the TRMM rainfall, a physics-based semi-distributed hydrological model, namely variable infiltration capacity (VIC) model, was applied to simulate the streamflow using inputs of TRMM rainfall. Calibration and validation of the hydrological model indicated that there is a good match between the simulated and observed stream flows during the concerned period. An interesting finding from the study is that the timing and magnitude of flooding were well captured when remote sensing products were engaged as inputs and thus this study recommends for more such studies on exploring the potential of remote sensing based hydrological modelling for flood early warning system especially for data-scarce regions in India.





The main findings of the study:

- The raw satellite precipitation estimates may contain a large amount of bias associated with them, which needs a systemic assessment followed by their appropriate correction.
- The hydrological model well captured the timing and magnitude of peak flow events in the Tungabhadra River basin when bias corrected TRMM remote sensing precipitation data was utilized.
- Future works will explore the prospect of integrating hydraulic model (i.e., HEC-RAS, LISFLOOD), web-GIS and other remote sensing products to reduce the impacts of flooding in the Krishna river basin.

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Study Of Rheological Behavior of Alkali-Activated Binders

PhD student: Aparna Sai Sree Nenduri

Alkali activated materials (alternative cementitious materials to OPC) use a precursor and alkaline activator that produces a binder having cementitious properties. In order to utilize these materials as a replacement to OPC based binders, they need to be engineered to overcome a few drawbacks which limit their applications on a large scale like quick setting time, high drying shrinkage, low strength at ambient temperatures, etc. The focus of the study is to address one such drawback (workability) by understanding the evolution of rheological parameters with time in alkali-activated slag and fly ash mixtures. An attempt has been made to study the influence of parameters like the oxide composition, solid content, molar modulus and % of Na2O on the evolution of yield stress, spread diameter and apparent viscosity. It was observed that calcium oxide content plays a significant role in the evolution of rheological parameters. Results showed that the yield stress, spread diameter and apparent viscosity were also influenced by molar modulus, activator dosage and solid content. Another dimension of this study deals with the effect of various organic or inorganic additions on the reaction kinetics (and thereby the workability) of alkali-activated slag (AAS) binders. It was observed that the amount of sulphate ions in the system exhibits a significant influence on the yield stress, apparent viscosity and setting time of AAS binders. Future study is directed towards finding the suitable organic or inorganic addition that can decrease the rate of slump loss and improve the workable time of AAS binders.

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Development of Sustainable Construction Material Using Bagasse Ash

PhD student: Mohammad Junaid Siddiqui

Tremendous pressure is being exerted on the natural resources to meet the construction demand all over the world. Therefore, they are quickly depleting causing a severe ecological imbalance in addition to extreme financial constraints. Partially replacing natural sand with manufactured sand (M-sand) can lessen the exploitation of natural resources. India is the second largest sugarcane (SC) producing country. The SC industry produces a high amount of waste material, commonly referred to as sugarcane bagasse ash (BA), which is categorized as non-biodegradable solid waste. The final disposal of this solid waste is a great challenge for the industry. Its utilization for the production of M-sand will prove to be a win-win situation for both SC and construction industries. Natural lightweight aggregate (LWA) are not easily available in India and hence there is tremendous research scope for discovering economic means of producing LWA for its use in the construction. The research proposes the use of natural waste material, viz., bagasse ash, which is a by-product of the sugarcane industry, to produce LWA or M-sand through indigenous pan pelletizer process.

Currently the work being done is on the following:

1.Chemical analysis/ composition of bagasse ash by IS: 4032-1985.

2.Mineral Composition of SCBA at 400°C, 600°C, 800°C and 1000°C by X-ray diffraction technique.

3.Manufacturing of pan pelletizer machine as shown in the figure below.

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Microbial Concrete For Construction Applications

PhD student: Junaid Maste

The formations of initial cracks in concrete are common due to shrinkage, temperature effect & ability to take lower tensile strength by concrete. Further, these initial cracks result in the increase of porosity thereby allowing the external weathering agency elements to cause deterioration of concrete. One of the novel techniques to overcome the formation of cracks is the addition of microbes in concrete. Before the addition of microbes, it is important to study their survival rate under high alkaline conditions. Hence the current study deals with the investigation of the survival of various bacteria under different ranges of pH viz. 8 to 12. The study also focuses on the urease activity rate of various bacteria as the presence of enzyme as urease produced by bacteria plays a vital role in the formation of final product calcium carbonate.

Preparation of bacterial solution of pH-12

Formation of bacterial colonies

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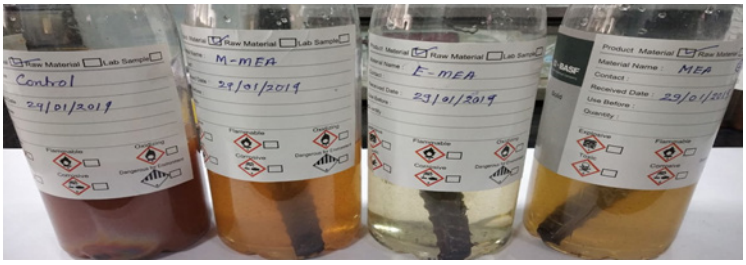
Evaluation of Organic Corrosion Inhibitor In Vapour Phase Action To Protect Reinforced Concrete

PhD student: Amol Anand Patil

We live in a metal-based society. Various types of steel are used in residential and commercial structures. Corrosion processes are responsible for numerous losses in the infrastructure sector. The best way to combat is prevention. The focus of this research has been on the different organic inhibitors in vapour phase action mode applications in water and concrete for the protection of metals. Historically, inhibitors had great acceptance in the industries due to excellent anti-corrosive proprieties. However, many showed up a secondary effect like damage to the environment. Thus, the scientific community began searching for environmentally friendly inhibitors, like organic inhibitors. In this research work, the focus is to use various organic corrosion inhibitors and evaluate their inhibitor efficiency (IE) by using various test procedures (ASTM & JIS). Volatile corrosion inhibitor (VCI) shows good IE, which may be attributed to the formation of a physical barrier between the metal and the corrosive environment by the interaction of the metal and the inhibitor molecules.



Weight loss measurement (ASTM G1) with 3.6 % of NaCl added in deionized water for accelerated corrosion.

Measuring VCI efficiency by JIS 1535

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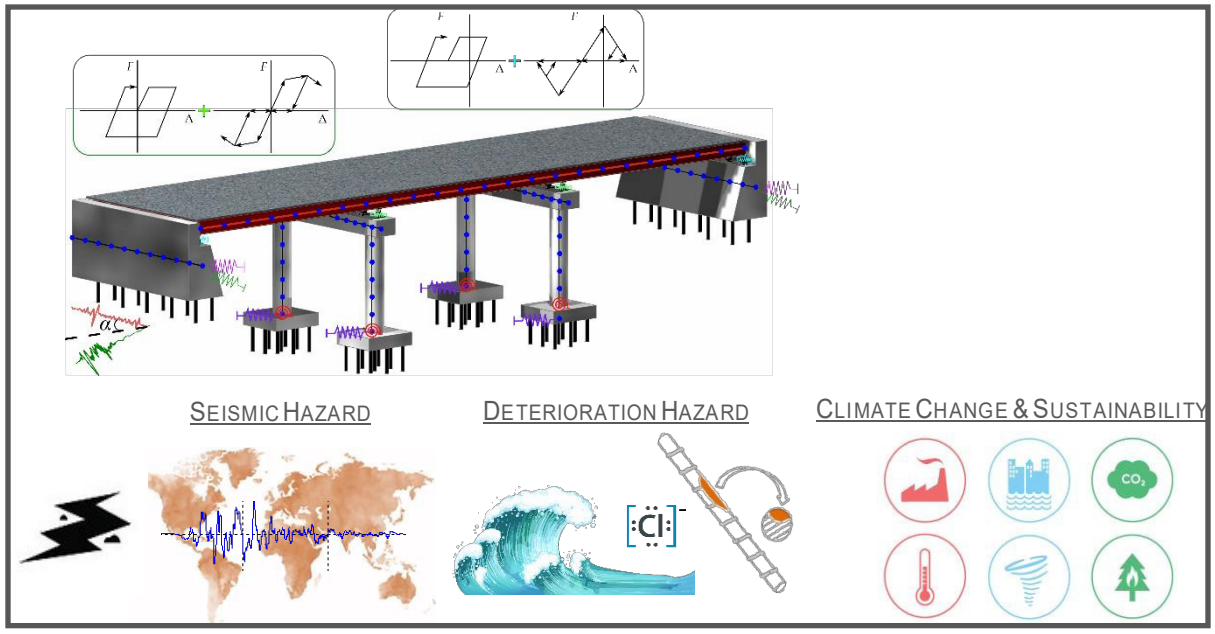
A Lifetime of Hazards

Are our structures safe?

PhD students: S.Shekhar, B. Panchireddi, M. Mortagi, S. P. Rayjada.

Civil structure and infrastructure systems play an essential role in the sustained economic growth and social development of a nation. During their service life, these systems may be exposed to multiple intermittent as well as continuous sources of hazards. When not effectively monitored and managed, these hazard instances can cause significant reduction in structural functionality and safety especially during extreme event occurrences. Therefore, it is critical to to assess the lifetime vulnerability of existing structures to inform decision making andretrofit prioritization in both pre and

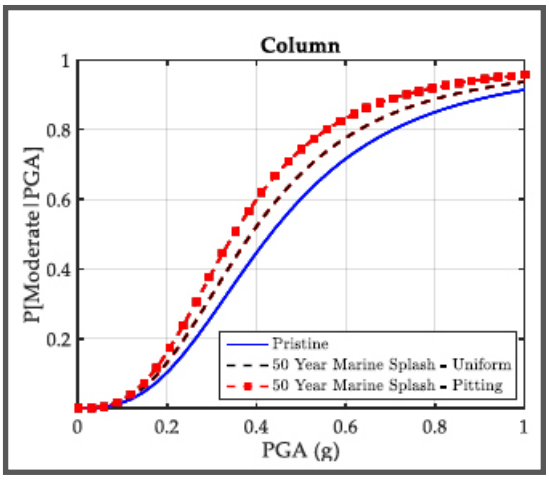


post-hazard disaster management. Some of the ongoing research work in our group highlight the potential lifetime vulnerability of structures to provide avenues for risk mitigation.

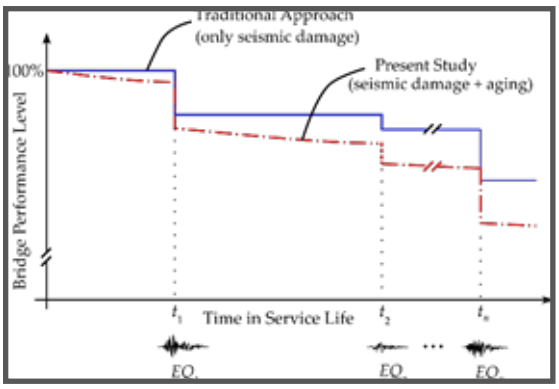
†Co-supervisor: Prof. Siddhartha Ghosh; *Co-supervisor: Prof. Meera Raghunandan

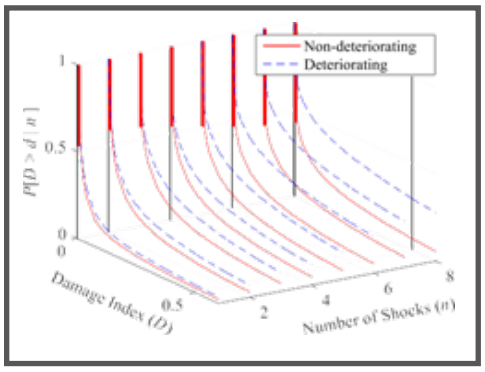
Improved Deterioration Modeling and Vulnerability Assessment of Aging Highway Bridges

This research provide an enhanced understanding of the impact of realistic and commonly occurring critical deterioration mechanisms typically ignored in the past. Such mechanisms include pitting corrosion of embedded rebars in bridge columns and deterioration of anchor bolts due to necking at interface in bridge bearings. Seismic fragility curves that represents conditional probabilistic statement of damage state exceedance given the intensity of the ground motion are then developed for commonly occurring exposure conditions while incorporating the improved deterioration models. The results highlights the need to consider realistic deterioration within the seismic vulnerability and seismic life-cycle cost assessment framework.



Cumulative Vulnerability Assessment of Deteriorated Bridges under Multiple Earthquakes

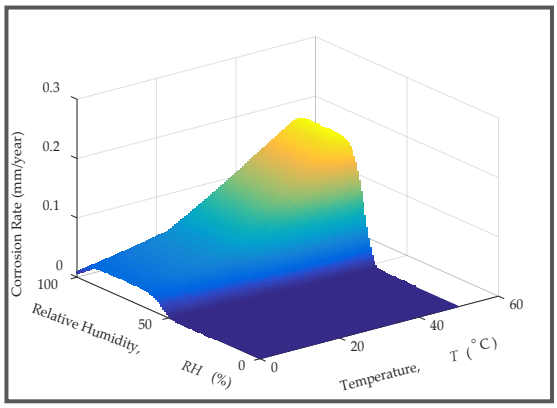




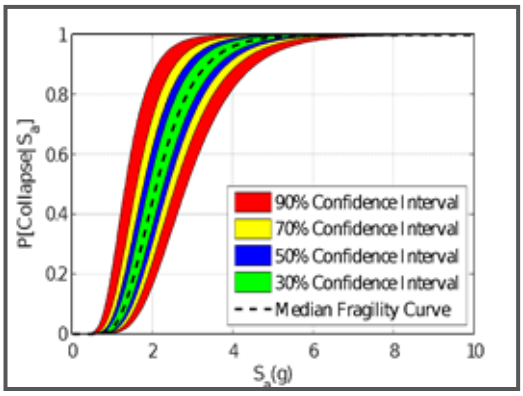
Structures located in high seismic zones may experience multiple earthquake events during its service life. This study presents a novel methodology that considers intermittently occurring repeated main shock events and ongoing continuous corrosion deterioration in estimating cumulative damage in highway bridge structures. The results reveal a significant impact of corrosion deterioration on the seismic damage accumulation under multiple earthquakes and underlines the necessity to incorporate aging effects within bridge asset management in high seismic zones.

Impact of Climate Change on Lifetime Seismic Vulnerability of Highway Bridges

Deterioration along the service life is often affected by the ongoing climate change. This study provides a novel framework to evaluate the seismic vulnerability of highway bridges considering aging due to chloride-induced corrosion deterioration, and potential climate change in future years. The results reveals that climate change further exacerbate the corrosion process and vulnerability of aging structures.



Uncertainty Quantification in Seismic Collapse Assessment of Buildings



Uncertainty is inherent in seismic fragility assessment due to complexity of earthquake phenomena and underlined assumptions of modeling techniques. For reliable estimation of collapse fragility, there is a need to quantify and propagate sources of uncertainty. To know the extent of uncertainty around the mean fragility estimate, a study is carried out to generate confidence bounds due to modeling uncertainty. On-going study aims to reduce this variation that will further aid in accurate estimation of risk and will further help in prompt decision making for repair and rehabilitation.

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Effect of the Wind Drag Estimation Methods on Numerical Storm Surge Modelling

PhD student: C. Gowri Shankar

1. Introduction

Cyclonic storms have evinced catastrophe among all the natural disasters because of their frequent occurrences, heavy loss of life and properties along the coastal regions. Similar to the North Atlantic, South and Northeast Pacific oceans, the Bay of Bengal (BoB)) basin of the Northern Indian Ocean rim is well known for its historic cyclonic surge events and their corresponding effects. Despite the fact that only seven percent of the global cyclones occur in the NIO, they are considered to be relatively fatal. Studies reporting the magnitude of damages caused by Cyclone Bhola (1970) (Madsen et al., 2004) and Odisha Super Cyclone (1999) (Dube et al., 2000) eventuated from the BoB, exemplify the evident cataclysmic consequences of such extreme storm surge events. Hence, precise quantification (prediction) of such enormous surges through numerical modeling would greatly facilitate in extenuating the disaster management aspects during such calamities. A numerical storm surge modeling is attributed by major governing factors such as the wind stress, tidal variation, pressure along the eye (center) of the cyclone, coastal profile and water depth (bathymetry). Among the above-mentioned parameters, wind stress (~wind drag coefficient, Cd) significantly contributes in terms of accuracy of the surge estimation.

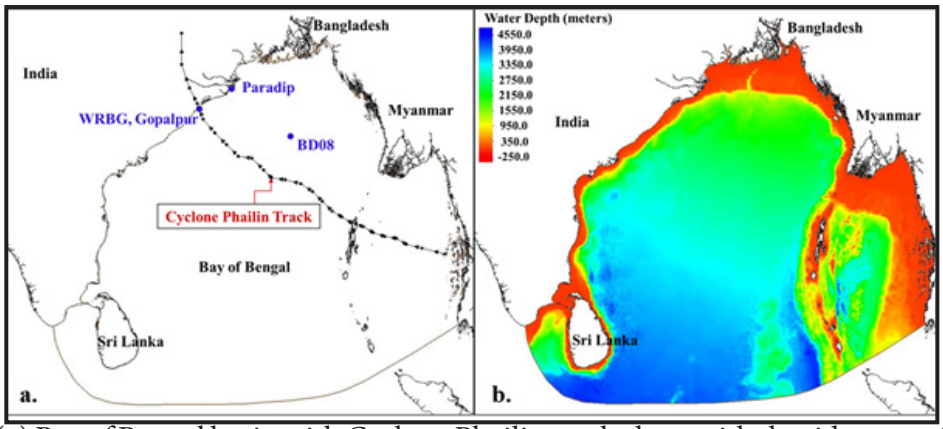

Figure (a) Bay of Bengal basin with Cyclone Phailin track along with the tide gauge (Paradip) station and buoy locations (WRBG, BD08). (b) Bathymetric water depth (in meters) of the entire computational domain.

The present study builds on identifying the best-adaptable method for the estimation of wind drag coefficient along the BoB basin, by comparing - the enhanced Wave Boundary Layer Model (e_WBLM, which considers the effect of sea-spray into the air-sea interaction process) (Chen and Yu, 2016), and three other bulk-formulae methods (Garratt (1977, Wu (1982) and Zijlema et al., (2012)). The wind stress computed based on all four methods are then incorporated into the coupled hydrodynamic circulation and wave model (ADCIRC and SWAN) to further compute the surge and wave parameters. The numerical simulation was carried out for Cyclone Phailin (2013) as the Indian Meteorological Department (IMD) categorized it as an Extremely Severe Cyclonic Storm (ESCS) with wind speeds exceeding 50 m/s.

2. Methodology

The model domain considered for the study is illustrated in Figure 1 (along with Cyclone Phailin track and the observation stations), which was discretized into smaller unstructured triangular mesh of 494,110 elements and 255,142 nodes. Bathymetric water depth (as shown in figure 3) with respect to the mean sea level assigned to the model is a combination of the 30 arc second bathymetry chart from GEBCO (General Bathymetric Chart of the Oceans) and a high-resolution hydrographic chart approved by the National Hydrographic Office, Government of India. The coastal resolution was set to 200 meters along the Odisha coast and 1000 meters for all the other locations, whereas the ocean boundary was set to a coarse resolution of 15 km.

3. Results and Discussions

The comparison of the residual surge (over and above the astronomical tide) from Paradip location distinctly depicts the over-estimation of storm surge through the bulk-formulae methods and a close correlation with the values obtained through e_WBLM method (as shown in Fig. 2 a). The model simulated significant wave heights (Hs) were analysed with a shallow-water buoy (WRBG) and deep-water buoy (BD08) data obtained from the Indian National Centre for Ocean Information Services (INCOIS) and portrayed in Fig. 2 (c and d). The e_WBLM method also computed promising results for the wave parameters compared to the other wind stress methods.

4. Conclusions

The current study employed the enhanced Wave Boundary Layer Model (e_WBLM) to incorporate the air-sea interaction process pragmatically, and estimated the wind stress for cyclonic wind speeds that exceed 40 m/s. Three other wind drag estimation methods (bulk-formulae methods) were also adopted to calculate the storm surge and storm wave features. The model-generated values were then compared with the available observed field data from the tide gauge station and buoy locations respectively. The residual surges obtained through e_WBLM method corresponds well with the in-situ values than the other three bulk-formulae methods. The significant wave heights (Hs) computed by the model with respect to e_WBLM method was also well in accordance with the buoy data (both in deep and shallow water) than the other empirical relationships. This study does not necessarily state that the e_WBLM method is superior to all the other three methods (considering the fact that these methods are simpler to solve in terms of computational efficiency than that of e_WBLM).

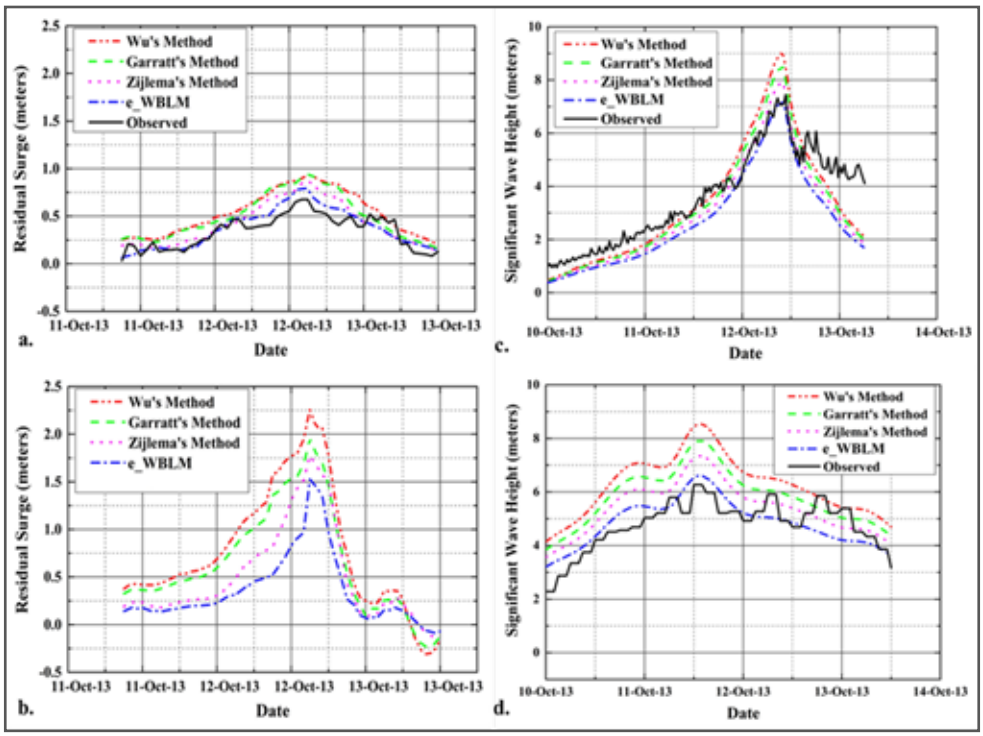

Figure 2. Residual surge (a & b) and Significant wave height (c & d) obtained from the model through all four wind stress methods. (a) Paradip; (b) Gopalpur; (c) Wave Rider Buoy Gopalpur (WRBG); (d) Deep-water moored buoy (BD08)

However, through this research it could be plausibly concluded that the computational cost (of performing such studies) is worth incurring, given the model's efficacy in real-time prediction of such extreme weather events.

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Impact Force on Decks of Fixed Ocean Structures Under Extreme Waves

PhD student: Rameeza Moideen

1. Introduction

Wave impact on deck is a complex non-linear phenomenon which affects the structural integrity and reliability of marine structures. A wave that reaches and strikes the deck may generate forces exceeding the elastic, static capacity of the structure and the decks which are not designed for any wave loading, cannot sustain such impact. Damage of coastal bridges (figure 1 (ii and iii)) during extreme events affect the transport of people and essential goods from one location to other. Coastal bridges are subjected to wave impacts due to extreme events like tsunami and storm surges. Indian Ocean tsunami (2004), East Japan tsunami (2011), hurricane Katrina (2005) are some recent examples those caused large destruction to coastal bridges. These extreme events are becoming more frequent and the expenses spend on coastal bridge repairs are high.

Offshore installations are often subjected to extreme loading from continuous wave action and severe storms which endanger the safety of these structures. Data's from environmental conditions indicate that certain extreme events such as rogue waves (figure 1(i)) are not as rare as previously predicted. Hence accurate prediction of wave in deck loading is relevant, mainly for the safety of existing structures.

Figure 1: Wave impact on Ocean structures (i) Rogue waves hitting Draupner Platform (ii) Bridge damage during Hurricane Katrina(iii) Displacement of bridge deck

2. Objectives

To investigate the loading due to extreme wave conditions on decks and to get maximum wave forces acting on marine structures.

To study the effect of air entrapment and green water loading on elevated coastal bridge deck above SWL.

3. Methodology

A numerical investigation is carried out using the open source CFD model REEF3D (Bihs et al., 2016) to study the wave load on the bridge deck. The incompressible unsteady Reynolds-Averaged Navier-Stokes (URANS) equations along with continuity equation are used to solve the flow dynamics including the free surface. The investigations are carried out in a 2D frame work considering the x (direction of wave propagation) and z-directions (along the depth) as shown in Figure 2. The first step to solve the fluid flow problems represented by differential equations is to discretise the convective terms. Conservative finite differences are used in REEF3D for the discretisation of the velocities. The Hamilton-Jacobi formulation of the WENO scheme is employed in the present study for the discretisation of turbulence and level set equations. The Total Variance Diminishing (TVD) third-order Runge-Kutta scheme is used for the discretisation of time-dependent terms. To maintain an adequate time step size using explicit methods, the CFL (Courant-Friedrich-Lewy) criterion is used. The signed distance level set function is employed in REEF3D to capture the free surface air water interface.

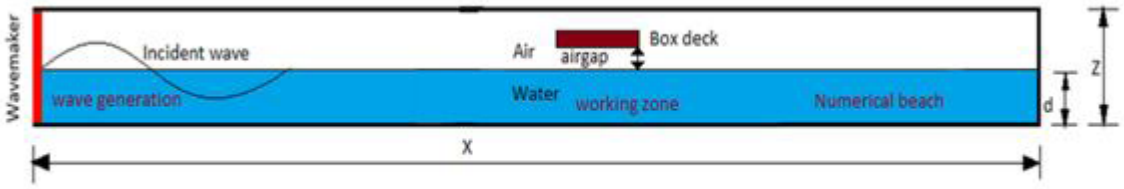

Figure 2: Numerical wave tank with the flat deck structure

4. Results and Discussion

Deck with girders as shown in figure 3(i) is considered to study the realistic deck and for checking the effect of girders. The comparison of impact force in case of deck with girder and flat deck (figure 3(ii)) shows an increase of 73 % in vertical impact force above sill water level. The sudden increase in vertical force above the SWL (figure 3(ii)) is the result of air entrapment in the chambers between the girders. Further increase in the airgap reduces the impact force as the wave height is not high enough to fill the chambers, reducing the entrapped air. Thus, it is evident that the vertical impact force for deck with girders is maximum for the elevated cases and depends on the wave height and airgap. The vertical impact force time history (figure 3(iii)) shows a sudden slamming force, a slowly varying positive and negative force during the impact.

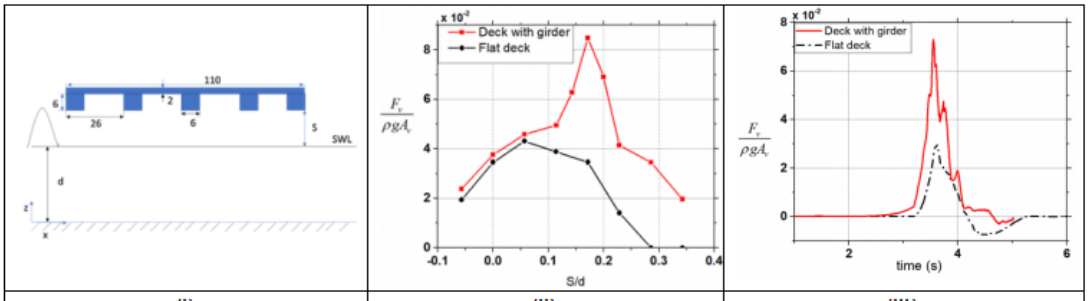

Figure 3: (i) Deck with girders above SWL (ii) Comparison of peak vertical impact force for flat deck and deck with girders (iii) Vertical impact force time history for the peak impact condition

5. Conclusion

- The study reveals that the maximum vertical uplift force on coastal bridge deck occurs above still water level.
- The vertical uplift force for elevated deck is found to increases with number of girders, unlike the submerged cases studied earlier.
- More studies are recommended on bridge structures during flood and storm events to analyse the failure and for taking correction measures.

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Modeling techniques and their application in surface and groundwater hydrology

PhD students: Anshuman, A., Rakesh Kumar Sinha, S. Sreedevi

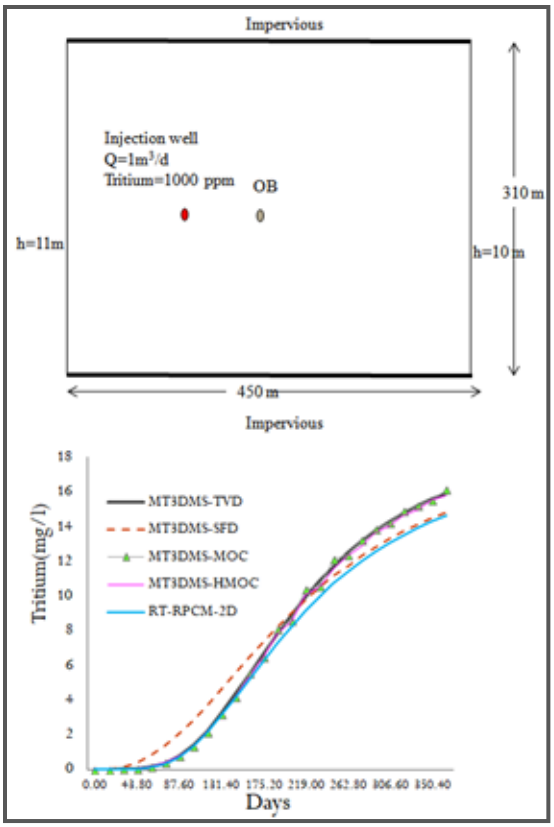
The changes in watershed hydrology are influenced mainly by two factors i.e landuse/landcover and climate variability. Hence, quantitative assessment of the effects of landuse/landcover and climate change is imperative for water resources management at river basin-scale. Modelling of groundwater flow and transport involves solving partial differential equations (PDEs) in the problem domain with appropriate boundary conditions. Solutions of simplistic problems are available as in analytical form. Solving real/field problems becomes infeasible using analytical methods and numerical models are used in such cases.

Reactive transport simulation in porous media using meshfree radial point collocation method (RPCM)

In RPCM, the problem domain is represented using nodes with local support domain. The state variable (head or concentration) is approximated using shape functions and their directional derivatives using Multiquarics radial basis functions (MQ-RBFs). An example of a hypothetical homogenous and isotropic confined aquifer is presented in the Figure here. Radioactive contaminant Tritium (Half-life 12.8 yrs) is injected through injection well and the observation well is located at OB. The model results after 1 year of simulation period are plotted against different modules of Finite Difference based code MT3DMS.

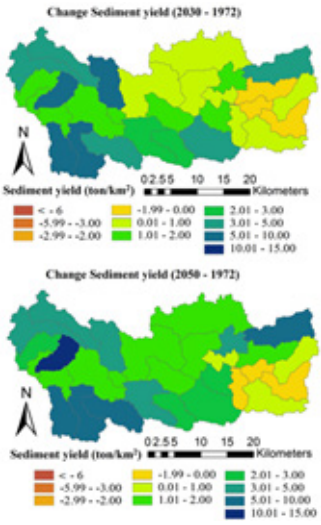
It is observed that RPCM model gives similar results compared to MT3DMS. The advantage of the proposed method is that unlike grid/mesh-based method, RPCM does not use operator splitting and predefined grid/mesh. Apart from that, the method minimises artificial oscillation and numerical dispersion errors.

Reference: Anshuman, A. and Eldho, T. I, Reactive transport simulation in porous media using meshfree radial point collocation method, NFiCE 2018, IIT Bombay.



Modeling the sediment flux due to future land use/ land cover change in a River basin scale

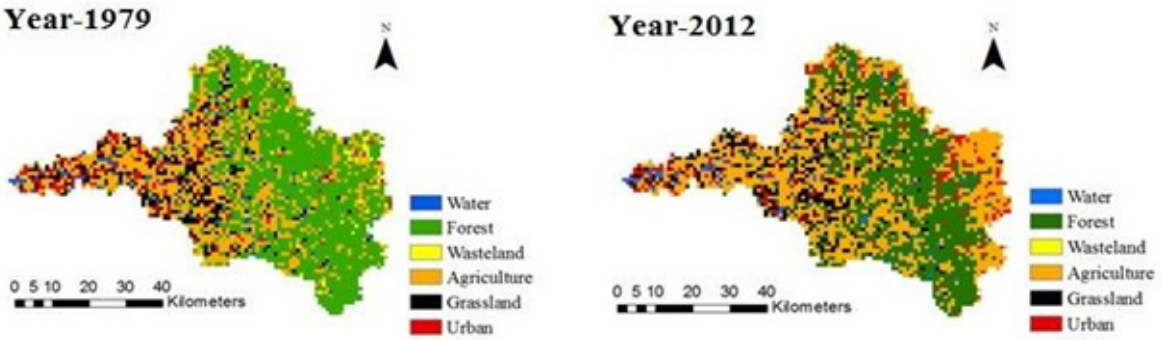
In this study, we investigated the sediment flux using Soil and Water Assessment Tool hydrologic model for the future LULC change of Kadalundi river basin, India. The 2030 and 2050 LULC were projected using land change modeler. The results revealed that under the same condition of soil texture and terrain slope, the sediment yield increased by urbanization, agriculture and decreased by forests and grassland and it would aggravate in the future. This is due to gradually changing landscape characteristics of the basin. Planner and policymaker can be used urbanization, and agriculture expansion to mitigate the negative effects of changing LULC in the basin.



Reference: Rakesh Kumar Sinha, Eldho T.I, Ghosh Subimal (2018) "Modeling the sediment flux due to future land use/ land cover change in a River basin scale". *Proc. International Congress on Urban and Civil Engineering*, October 22 – 23, 2018, Prague, Czech Republic, P-25, (Invited speaker).

Assessing the Impact of Landuse/Landcover Change on Streamflow and Sediment Yield Using a Distributed Hydrologic Model

A fully distributed physically-based hydrologic model, SHETRAN was used to assess the hydrologic response as well as the effect on sediment yield due to landuse/landcover change within the Netravathi basin located in Southern part of India. Landsat imageries displayed that the forest area decreased (21%) and the agricultural land, as well as urban land, increased by 30% and 25% respectively between 1979 and 2012. Landuse change resulted in an increase in streamflow (38.4 mm yr-1) and a decrease in actual evapotranspiration (AET) (38.2mm yr-1). Climate change effect caused a decrease in streamflow (275.8 mm yr-1) and an increase in AET (24.2 mm yr-1). The combined effect of both landuse and climate change showed both streamflow and AET decrease. Overall, the effect of climate change is more pronounced than landuse change. Sediment yield also showed a significant increase owing to the deforestation and urbanization within the region.



Reference: Sreedevi. S, T. I Eldho 2017 Assessing the Impact of Landuse/Landcover Change on Streamflow and Sediment Yield Using A Distributed Hydrologic Model 9th International Conference on Geomorphology, New Delhi.

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Scour And Flow Hydrodynamics Around Bridge Piers

PhD students: B.A Vijayasree, Priyanka Gautam and Gaurav Misuriya

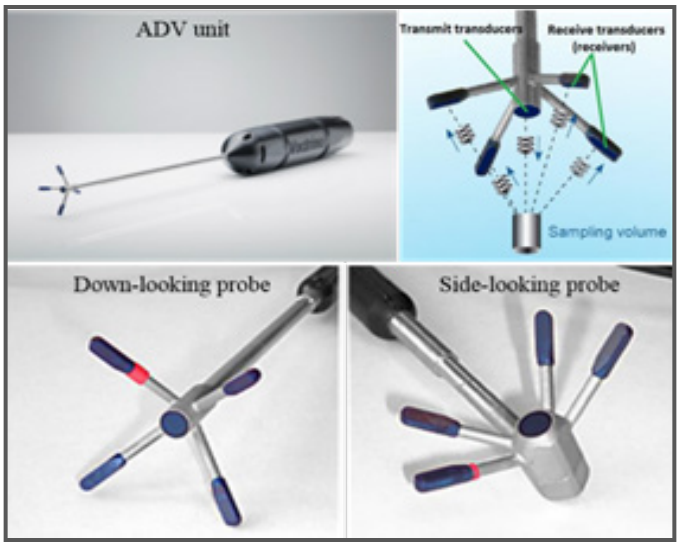
What is local scour and why is it important to study? The localized lowering of stream bed elevation occurring in the vicinity of a bridge pier constructed in rivers or streams may lead to the failure of the bridge in extreme flow conditions. According to the Federal Highway Administration (USA) report, about 70 % of bridge failures happen because of scouring. When the flow impinges upon a rigid structure, turbulence is generated in the form of horseshoe vortex, wake vortex, and surface roller. Horseshoe vortex causes an increase in shear stress around the base of the structure resulting in sediment entrainment and the wake vortex contributes to the lifting of the entrained sediment and displacing it outside the scour hole.

What we do? At Hydraulics laboratory of Department of Civil Engineering, IIT Bombay, students are conducting several experimental studies to estimate the maximum scour-depth that occurs around bridge piers of different shapes and configurations in channels of different widths and lengths. The channels have a re-circulating facility to simulate river flow.

Along with scour measurements, instantaneous velocity measurements are also taken to investigate the physics of the turbulent flow responsible for scouring around the bridge piers. The velocity measurements are primarily done using two instruments available in Hydraulics laboratory which are described below.

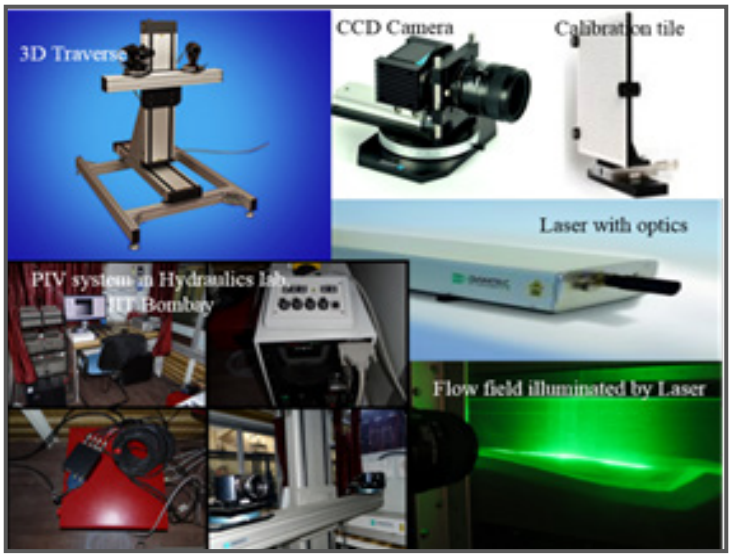
Acoustic Doppler Velocimeter (ADV)

ADV is designed to record instantaneous velocity components at a single point with a relatively high frequency. ADV utilize a pair of acoustic pulses with a known time lag to determine a Doppler induced phase shift. The measured phase shift is converted to velocity by scaling with the speed of sound in water. Data acquisitions are performed by measuring the velocity of particles in a remote sampling volume. It is ideal for near-boundary flow measurements.



Particle Image Velocimetry (PIV)

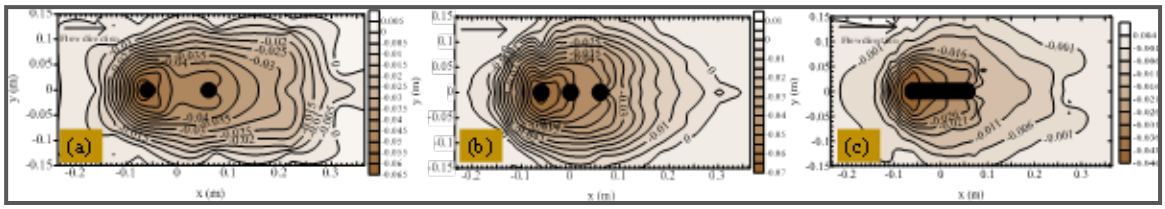
PIV is a whole-flow-field technique providing instantaneous velocity field measurements in a cross-section of a flow. Use of a stereoscopic approach permits all three velocity components to be recorded, resulting in instantaneous 3D velocity vectors for the whole area. Stereo-PIV measurements are based on the same fundamental principles as human eyesight; i.e., stereovision. Our left and right eyes see two similar but not identical images. The brain compares the two images and re-build the 3-dimensional information of the object observed.



Case Studies:

a) Experimental study of scour around bridge piers of different shapes with the same aspect ratio

In this study, three different arrangements of bridge piers were considered: a) A combination of two circular piers, namely twin in-line circular piers with a diameter 0.03 m and an upstream end to downstream end distance of 0.15 m; b) A combination of three in-line circular piers of diameter 0.03 m and an upstream to downstream end distance of 0.15 m and c) an oblong pier with width 0.03 m and length 0.15 m. All three cases have a length/width ratio (aspect ratio) of 5. The flow field becomes complex around a group of piers due to the interference of horseshoe vortex formations of individual piers. The horseshoe vortex loses its strength around the solid pier and reduces the scour geometry parameters. In the two in-line circular pier arrangement, the scour at the downstream pier is due to a combined effect of wake vortices and horseshoe vortices generated at the respective regions of the cylinders. When the arrangements of the piers were changed from twin circular pier to three circular piers and oblong pier, the scour volume was reduced by 21.5 % and 55.63 %, respectively. A single solid pier produces less scour compared to a group of piers of equivalent aspect ratio at the upstream end, mid-section and downstream end of pier compared to the other two arrangements of the same aspect ratio.

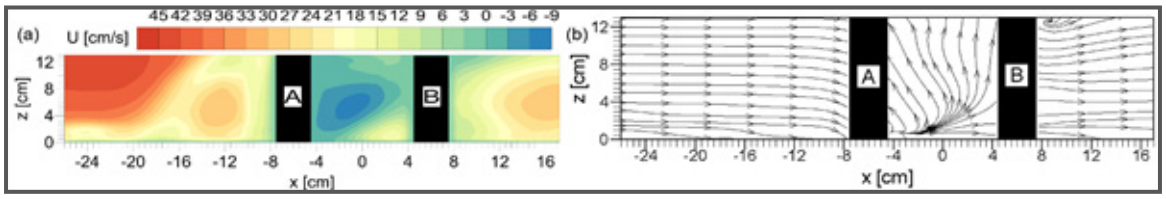


Reference: Vijayasree, B. A., & Eldho, T. I. (2016). Experimental Study of Scour around Bridge Piers of Different Arrangements with Same Aspect Ratio. Proceedings of the 8th International Conference on Scour and Erosion, ICSE, Oxford, UK, 889–895.

b). Experimental study of flow hydrodynamics around two in-line circular piers using PIV

The objective of the study is to analyse the flow field around two in-line circular piers placed along the flow direction using PIV. The diameter of the piers is 0.03 m and the end to end distance is 0.15 m. Instantaneous velocity at the test section was measured using Stereo-Particle Image Velocimetry (PIV) with camera resolution of 2048 × 2048 pixels and double-pulsed Nd: YAG laser (1200 mJ/pulse) to illuminate the test section. Streamwise velocity contours and streamline plots for flow with an approach velocity of 0.42 m/s and average water depth of 0.13 m are shown in the figure below. Parallel flow was observed on the upstream of the piers, representing the virgin condition. However, flow circulations were observed near the piers and in between the piers. Strength of circulation was found to be maximum in the space between the piers. Based on these flow observations, it is recommended to provide special countermeasures like bed concreting or bed armoring in the region in front of the upstream pier and between the two piers, to avoid excessive

scouring and ensure the safety of the bridge.



Reference: Gaurav Misuriya, Priyanka Gautam & Eldho T. I. (2018). Experimental study of flow around two in-line circular piers using PIV. National Frontiers in Civil Engineering, IIT Bombay.

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Dr. J. Indu
Assistant Professor, Remote Sensing
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Hydrometeorology & Remote Sensing

Students ki Zubani

The hydrometeorology and remote sensing group from Prof. J. Indu's lab, consisting of undergraduate and postgraduate students, give a bird's eye view of their research in this snippet.

Akhilesh S Nair: "Our study focuses on improving model predictions to quantify and understand the changeability in the land surface due to climate change and anthropogenic activities. We implement methods to reduce the uncertainty in the models by constraining it with remote sensing observations. The method through which we integrate observations to models is known as Data Assimilation. The main aim of our study is to check the feasibility of data assimilation on different satellite observations to improve the estimation of hydrological variables. We intend to further implement this methodology for improved estimation of groundwater resources."

Rohit Mangla: "My research work revolves around the evaluation of spaceborne microwave sensors to study the deep convection events. We simulate the cloud properties of CloudSat and GPM satellites for the tropical cyclones over the Indian region. This work contributes towards the improvement in forecast skills through assimilating new instruments in operational weather forecast models. Presently I am working in Meteo France through the funded Raman Charpak fellowship to pursue the same."

Thiruvengadam P: "When we go to a doctor, he measures our temperature and blood pressure to diagnose the condition of our body. Similarly, we meteorologists are doctors of the atmosphere. We assess the temperature and pressure of the atmosphere using different instruments and predict its behavior in the future. Our research uses Doppler weather RADARs to study the condition of the atmosphere and predict how the weather will be in the near future."

Ankita Pradhan: "Our study focusses on quantifying the effects of precipitation uncertainty in hydrological studies. Understanding how the precipitation sampling error manifests itself in other components of the hydrological cycle is an important step in determining the accuracy of satellite-based precipitation products. My PhD work has been recently accepted into NASA PMM science team."

Sooraj K: "Have you ever thought of the significance of surface soil moisture? Of course, the answer will be 'NO' because we are concerned only about the depletion of water content in our near-by wells, ponds and rivers. But between the vast atmosphere where all the precipitation and radiation happens and the big mass of the earth where all the rivers, ponds and ocean exist, lies the infinitely small content of water above the surface of earth: Soil Moisture. You will be surprised to hear that this small portion of water can control the whole water budget in the earth and can affect the weather and climatic conditions around the world. So the study of the effect of soil moisture on the dynamics of water budget is only possible when the accurate measurement of soil moisture is available. But the in-situ measurement of soil moisture for a vast area is time-consuming and difficult. So we focus on the indirect measurement of surface soil moisture by measuring the microwave thermal emission from the ground surface. "

Vinayak H: "Have you ever imagined what happens to moisture in soil and the significance of soil evaporation? Well, our research involves studying the impact of soil moisture on subsequent rainfall over a region. We do this using satellite and field datasets. Our major objective is to observe subtleties in the propagation of moisture through evaporation till that water forms clouds and it rains."

Kaushlendra V: "71% of the Earth's surface is covered with water out of which only 0.4% is directly accessible for human civilization. The reservoir, lakes and rivers are the major contributors to freshwater but the rapid growth of population and subsequent water demand is a major threat to it. So, our objective is to monitor and manage the inland freshwater bodies of India by using remotely sensed satellite data. "

Training session with Microwave Radiometer on Gymkhana Grounds, IIT Bombay, May 2019.

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Dr. Ashish Juneja
Professor, Geotechnical Engineering
Department of Civil Engineering, IIT Bombay

Performance of Piled Raft with Unequal Pile Lengths

PhD student: Rajendra Bisht

The use of a group of piles beneath the raft can control the settlement and also improve the load carrying capacity. All this leads to effective and economical foundation design. It is a common practice to install piles of similar lengths and arrange them symmetrically under the raft. It was observed that the position of the piles and their lengths significantly affect the performance of piled raft. Since the increase in pile length results in decrease in settlement and increase in bearing capacity, non-uniform distribution of piles can be more advantageous, than placing all the piles uniformly beneath the raft. The use of longer piles below heavily loaded columns or beneath centrally loaded raft can be more effective than if all the piles were of similar lengths. Optimal design of piled raft can be achieved by suitably placing the piles at critical locations beneath the raft and by using piles of unequal lengths.

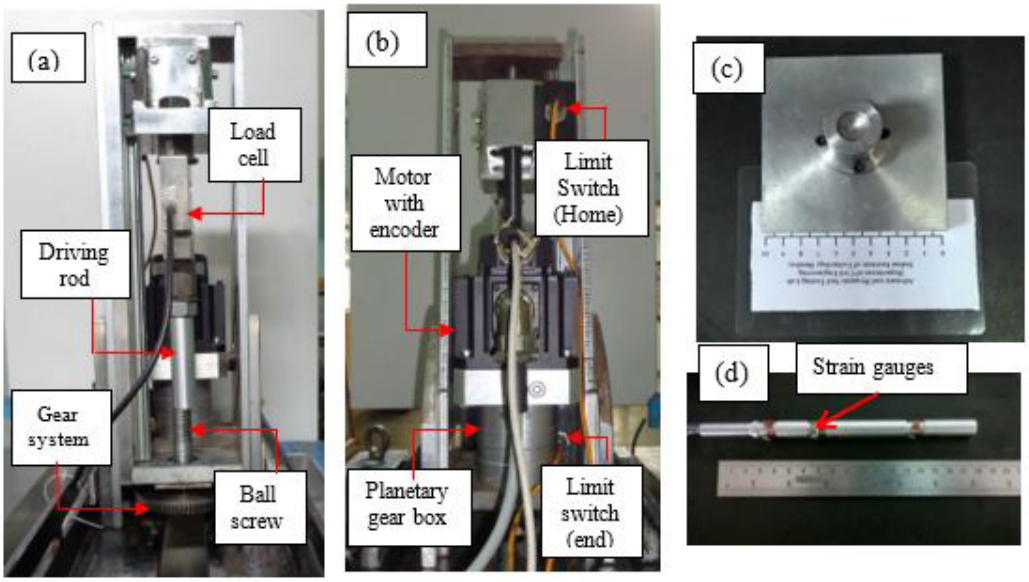
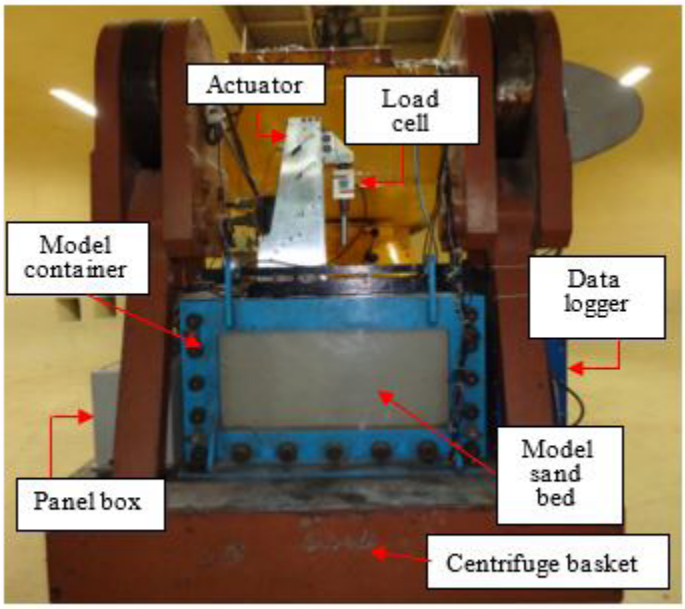


Figure 1 Test apparatus: (a) and (b) Front and rear view of electro-mechanical actuator developed at IITB; (c) Model raft; and (d) Model instrumented pile

The performance of piled raft with unequal pile lengths was investigated by using a series of centrifuge tests on small piled raft at 30g. The inclusion of one-additional central pile and the effect of the uneven length of the piles were investigated. The model piled raft was centrally loaded using an in-flight electro-mechanical actuator. Figure 1 (a) and (b) shows the actuator and its component. 100 x 100 mm size and 20 mm thick aluminum plate was used to model the raft as shown in Fig 1(c). Piles were modeled using hollow aluminum tubes of 150 to 250 mm length. Some of these piles were instrumented using strain gauges along the pile length as shown in Fig. 1(d). Figure 2 shows the assembly on the centrifuge basket. Figure 3(a) shows the effect of the number of piles on the behavior of piled raft. In the figure, the load capacity of the piled raft, QPR was normalized by the load capacity of the raft alone, QR. Similarly, the total settlement of the raft, St was normalized by the width of the raft, Br. As can be seen, settlement decreased with the introduction of piles. The performance of the foundation was further improved with the addition of a pile at the center. QPR/QR rapidly increased with the number of piles increased to four. This was especially true when St/Br was small. This was due to the higher contribution of the piles at small settlements.



Centrifuge Tests

CUR: Unpiled raft
CPR1: Piled raft with a single pile
CPR4: Piled raft with a group of four piles
CPR5: Piled raft with a group of five piles
CPR5CL: Piled raft with a long pile in the center
CPR5AL: Piled raft with all long piles

Figure 2 Model container mounted on centrifuge basket

Figure 3(b) shows the effect of variation in the length of the central pile on the performance of piled raft. In the figure, the sum of the lengths of all the piles, nLp were normalized by the pile diameter, dp. In CPR5AL, the relative stiffness of the piled raft was significantly high compared to all other tests. When St/Br was equal to 0.5%, QPR/QR in CPR5CL was about 16% higher than CPR5 although there was only 13.5% increase in the total pile length. While the, QPR/QR in CPR5AL was about 39% higher than CPR5, when the total pile length was increased to 67% in the latter. This variation shows a greater pile-soil-pile interaction amongst dissimilar length piles. The piled raft performance increased significantly with the use of unequal piles under the raft.

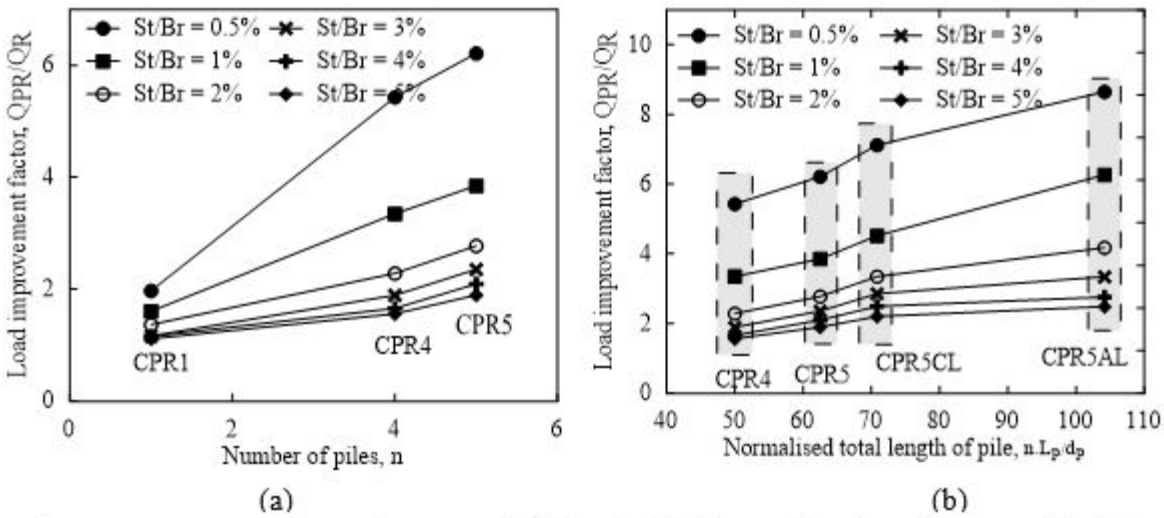


Figure 3 Improvement in performance of piled raft with (a) Introduction of center pile (b) Variation in length of center pile

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Numerical Analysis of Tunnelling in Jointed Rock Mass

PhD student: Kota Vijay Kiran

Tunnelling in jointed rock is always a challenge for the engineer on site, as the wedge failure and rock spalling is very common due to the existence of unfavourable lineages. Theoretical /analytical approaches to analyse the stresses and displacements becomes very complex and cannot be applied in such cases due to various factors. Hence the studies related to this area of research are essential to be performed using numerical tools. In the present state-of-art methods and technologies available, it is suggested to consider for the use of efficient numerical tools like Discrete element methods (DEM) and Discrete Fracture Networks (DFN) to simulate and predict the actual response of the tunnels in jointed rock. Hence, to assess the stability of a tunnel excavation in jointed rock mass, two cases have been studied using Discrete element numerical code i.e. 3DEC. The first case was tunnel excavation under a terrain, for which a model without the joints was created treating it as continuum. This was considered to validate the model and test for discrepancies, since the presence of joints cutting across an excavation could make the analysis of the stress fields around the excavation a confusing or complicated task. Once the validity of this model was established, in the second case, the joints were incorporated into the model using DFN technique.

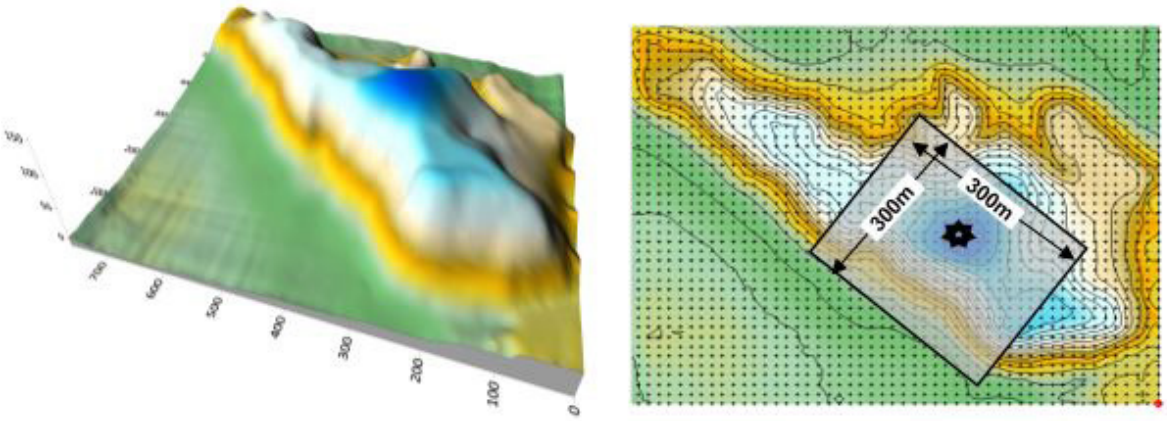

Fig. 1 **a** Topography around the site and **b** the Contour showing the section adopted for current study

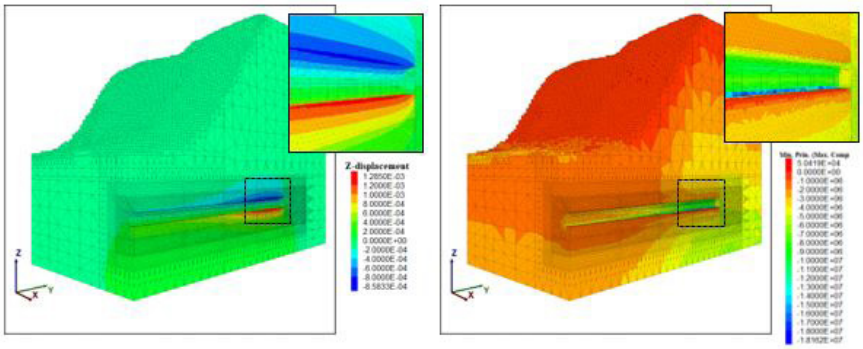

Fig.2 **a** Vertical displcement contours **b** Minimum Principal stress contours – Continuum Model

For modelling the terrain as shown in figure 1, stereolithographic file modified in Rhino v.9 was imported to 3DEC. The dimensions of the model were 300 m x 300 m x 200 m. The access tunnel runs at a depth of about 200m from the terrain top surface. The access tunnel of D-shaped, with dimensions 10m x 10m was considered and 3DEC routine was used to create the tunnel geometry. The tunnel length of 200m was considered, to reach deepest location with a short distance. The material properties obtained from infield and laboratory investigations were incorporated into the model. Roller boundary conditions are applied on all the four sides of the model to restrain its movement laterally and also at the bottom to restrain its vertical movements. The gravity was applied using 'In-situ Topo' command in the 3DEC routine, which aids in calculating the in-situ stresses based on the topography. The model was run to initial equilibrium and then the excavation sequence was simulated in both continuum and discontinuum models. Further, to understand the effect of joints on tunnel behaviour in jointed rock, joints were incorporated into the model. For this purpose, the joints orientations attained in field using surface mapping was utilised. The Discrete fracture networks technique (figure 3) was used to incorporate the joints with the joint intensity and size as uniformly distributed and incorporating the joint set orientations attained in the field.

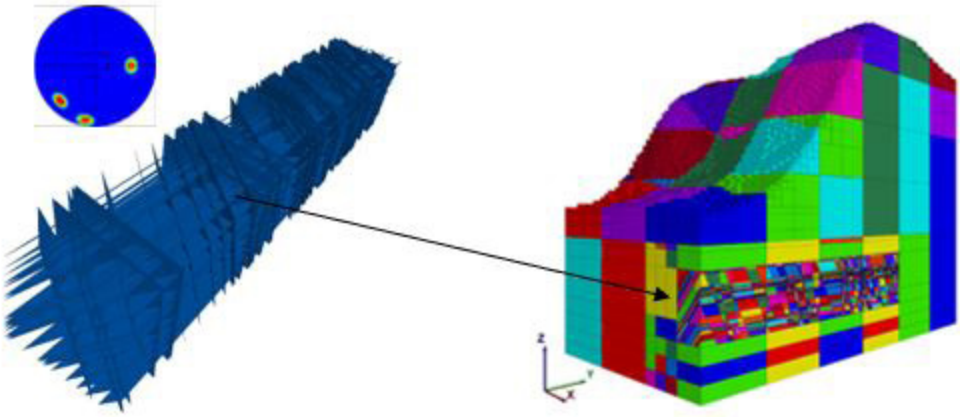

Fig.3 Discrete Fracture Network (DFN) Realization and the generated discontinuum model

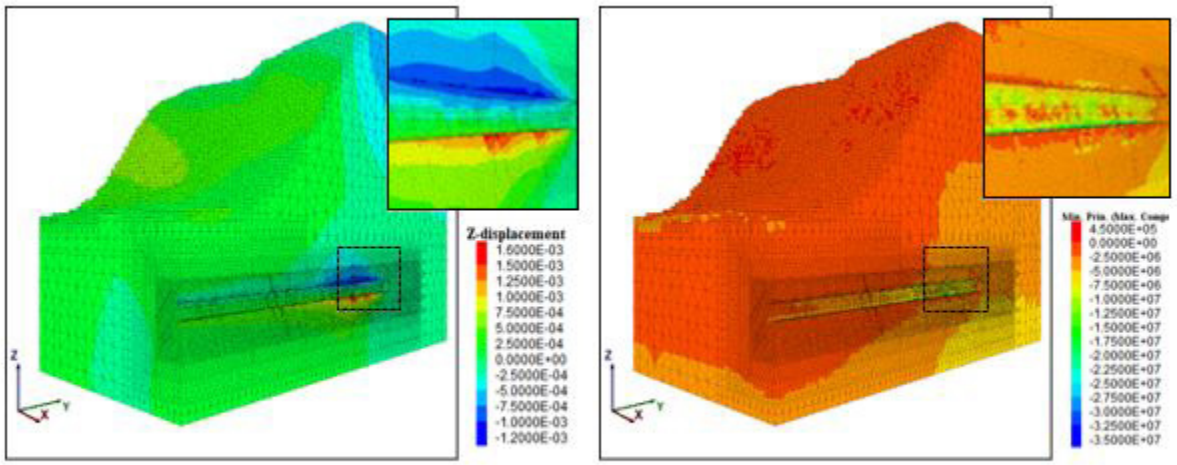

Fig. 4 a Vertical displcement contours and **b** Minimum Principal stress contours – discontinuum Model

The analysis allowed the computation of the complete stresses and deformation patterns around the tunnel excavated in jointed rock conditions, comparing with the Intact rock/ continuum model. The maximum horizontal displacement computed for the second case i.e. for jointed rock was 0.6 mm (figure 4) and it was 0.16 mm in case of intact rock continuum model (figure 2). The floor heaving and crown displacements were distinctive in the case of jointed rock conditions. The maximum floor heaving was observed as 1.6 mm and crown displacement as 1.2mm for tunnel excavated in jointed rock. Comparatively, the jointed rock displacements observed were slightly higher compared to continuum But it was noted that, the vertical and horizontal displacements occur within safe limits i.e. 2% of the size of the opening. The minimum principal stresses (Maximum compressive) were observed to be in the range of 14 to 35 MPa and were much concentrated at the tunnel side wall and floor intersection. This was due to the sharp transition of the tunnel geometry creating at a sharp corner leading to concentration of stresses. However, it was noticed that the rock mass strength when compared to maximum compressive stresses, yields a factor of safety more than 1, which falls within the safe limits. Also, the analysis revealed that, in jointed rock model in the vicinity of the openings, the surfaces were very much affected due to occurrence of tensile stresses. Hence measures to strengthen surface of the underground opening and even weaker inner portions were identified.

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The Behaviour of Desaturated Sands Under Static and Cyclic Loading

PhD student: Sayantan Chakraborty

Soil liquefaction is a concern for structures constructed on saturated sandy soils. When soil liquefies, it loses its strength and stiffness. Although the strength loss is of short duration, it is still sufficiently long to cause failure, deaths and significant financial loss. Different soil improvement techniques to mitigate liquefaction have been used, such as the vibro-flotation, dynamic compaction, deep mixing, dewatering by lowering the ground water level and grouting. If already there is an existing structure over the ground, it would be difficult to utilize much of the above methods, as they can cause ground subsidence or make the structure unusable or uneconomical. In this case, desaturation by air intrusion method would be a useful and cost-effective technique to reduce the soil's cyclic potential. To study the behaviour of desaturated sandy soils under static and cyclic loading, triaxial tests were performed in the Advanced and dynamic soil testing laboratory (ADsoil).

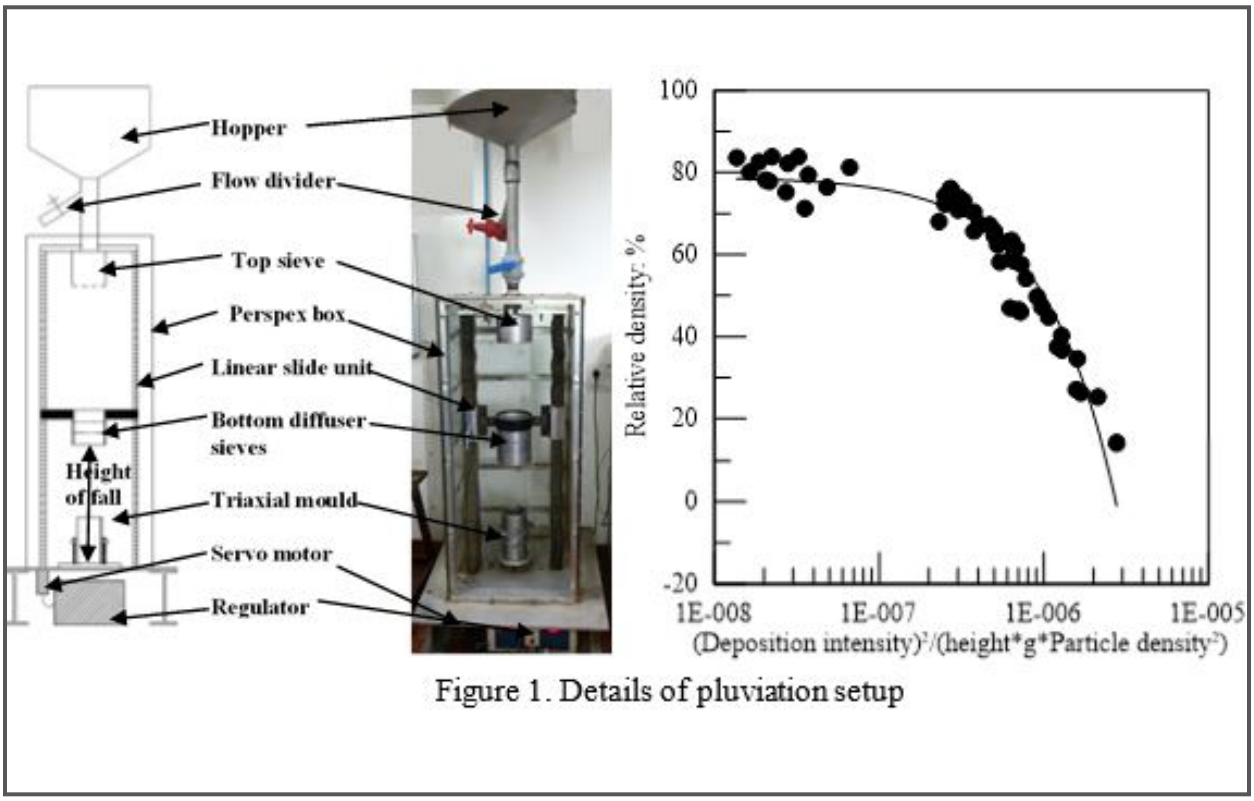

Figure 1. Details of pluviation setup

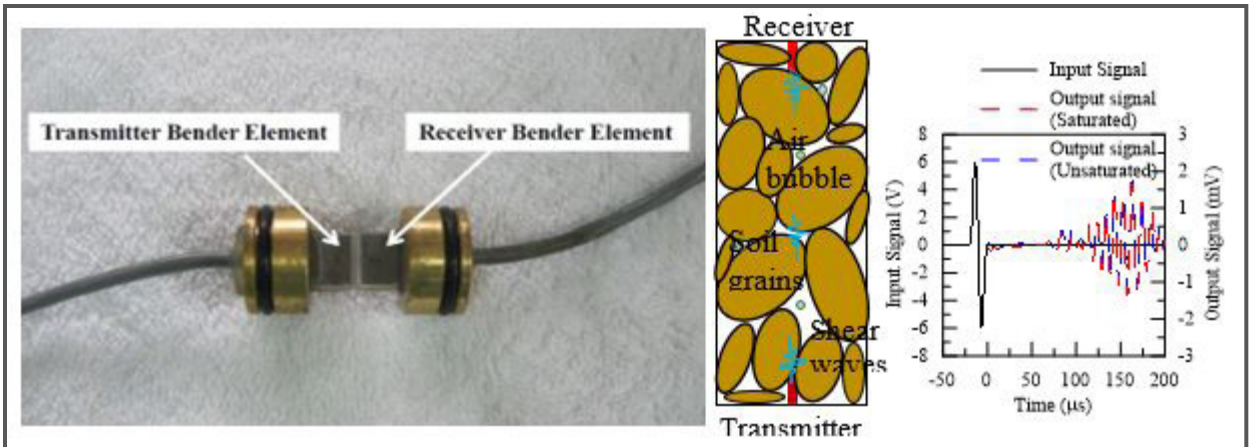

Figure 2. Effect of desaturation on the initial fabric of the soil

Different sample preparation methods are available to prepare sandy soil sample for triaxial test. Among them, air pluviation method is better as it simulates the natural deposition process. A new travelling pluviator was developed as shown in Fig. 1 through which sample of different densities were prepared by changing deposition intensity and height.

The desaturation was done by injecting the compressed air into the saturated sample which was saturated using CO2 flushing and back pressure. Bender element tests were performed on the desaturated samples to check any disturbance of the initial fabric of the soil due to desaturation. Figure 2 shows that both output signal of saturated and desaturated samples overlapped which indicated no disturbance during desaturation.

In Figure 3, static undrained tests on saturated and desaturated samples show that the compressibility of the air bubbles reduced the generation of excess positive pore water pressure, whereas it also reduced the amount of dilation. Therefore, the desaturation method is mostly useful for loose soil, which is prone to generate positive pore pressure during shearing.

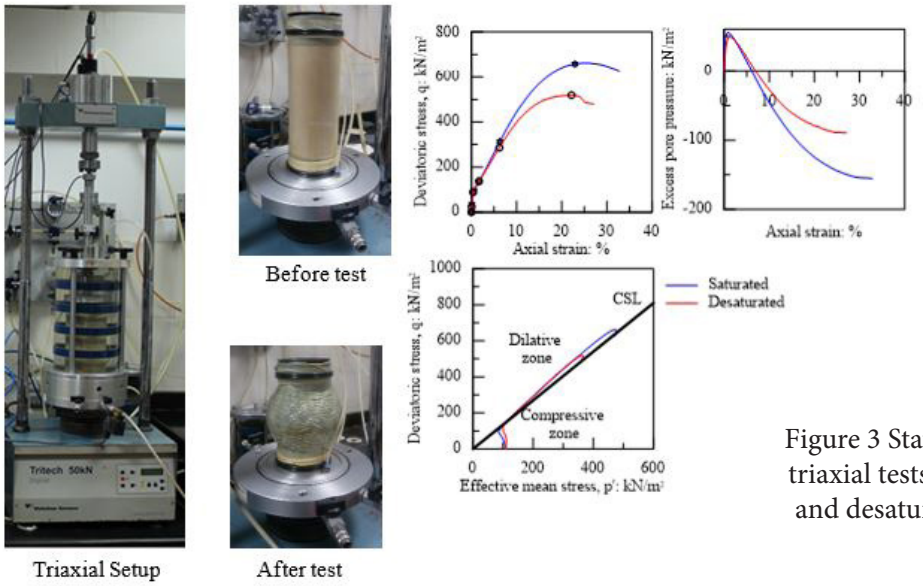

Figure 3 Static undrained triaxial tests on saturated and desaturated samples

Figure 3. Static undrained triaxial tests on saturated and desaturated samples

Figure (4) shows the improvement of the desaturated sample over saturated one during cyclic loading. As the air bubbles compressed in cyclic loading, generation of excess pore pressure reduced and the corresponding degradation of strength and stiffness became more gradual in nature.

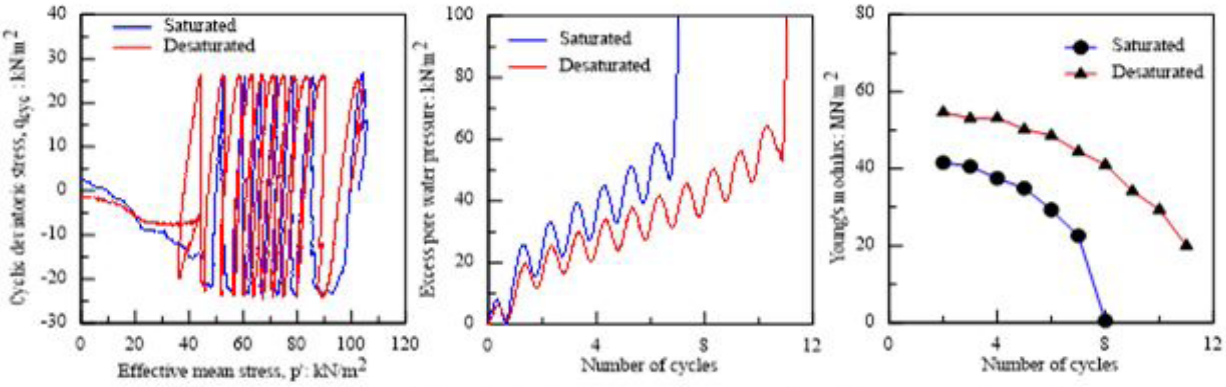

Figure 4. Cyclic undrained triaxial tests on saturated and desaturated samples

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Application of Bio-mineralization to Geotechnical Problems

PhD student: T. Aishwarya

Precipitation of calcium carbonate in soil matrix through microbes or enzymes is widely studied in recent times. As it is eco-friendly, economical and a simple solution to various engineering problems. It is proposed to be used for Structural repair, Erosion control, and Co-precipitation/immobilization of contaminants, Dust mitigation, Ground improvement for rural roads and urban road sub grading, Shallow carbon sequestration, Leak management, Rehabilitation of ancient monuments, Soil liquefaction mitigation and several other applications. The basic principle underlying this phenomenon is the hydrolysis of urea by the bacteria or the urease enzyme in the presence of calcium ions resulting in the precipitation of calcite. This calcite acts as binder in soil particles and prevents it from getting eroded; increase the fines content, reduce the void ratio and bind the particles making it suitable for liquefaction mitigation; repairs the leak by filling the cracks etc. . Microbial induced calcite precipitation (MICP) and Enzyme induced calcite precipitation (EICP) are bio-mineralization process, where bacteria and enzyme An attempt has been made to study the performance of MICP and EICP on improving the cyclic property of cohesion less soil using cyclic simple shear testing. Figure 1, shows the schematic and SEM image of the calcite bond in sand.

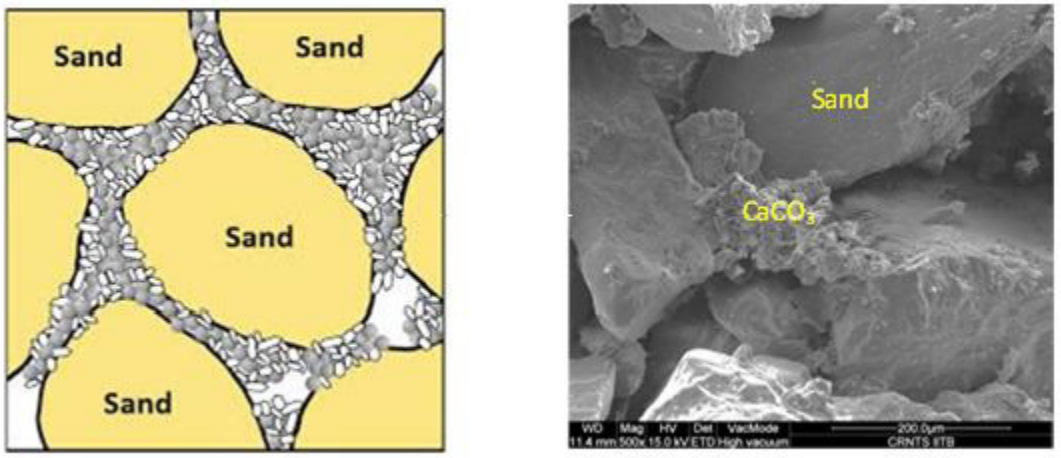

Figure 1 Schematic and SEM image of the calcite bond in sand

The bacterial suspension was prepared by inoculating the bacterial strain of Sporosarcina pasteurii in a nutrient media and culturing it to required optical density. Urease enzyme extracted from jack bean seed, commercially available in powder form was mixed with distilled water to obtain urease solution of desired concentration. Equimolar solution of Urea and Calcium chloride of 0.5 M was used as cementation solution for both the methods. Dry sand was packed into the cylindrical column of 71 mm diameter and 22 mm height made up of stainless steel. The column consisted of opening on the top and bottom plates. The bacterial culture, urease solution and cementation solutions were injected into the soil column from the bottom that eventually helped in the expulsion of air pockets from the soil matrix. In case of MICP the bacteria solution was first injected followed by the cementation solution after 4 hours. During this period the bacteria attaches itself to the sand particle. Urease solution and cementation solution were mixed prior to injection in case of EICP.The column was so fabricated that its size was identical to the CSS (Cyclic simple shear) sample, thus enabling the sample treated in column to be extracted and subjected to cyclic loading.

Cyclic simple shear tests were done on virgin soil, MICP treated and EICP treated soil. Stress controlled cyclic tests of CSR 0.1 under 100kPa vertical stress was conducted after treatment and curing period of 1 day. Constant volume tests were conducted where, change in vertical stress is related to change in pore pressure. Hence the ratio of change in vertical stress to the initial vertical stress was considered as the pore pressure ratio. Soil was deemed to fail when the pore pressure ratio becomes 1 or at 3.75 % single amplitude shear strain, whichever occurred first.Figure 2 shows the input shear stress plot with time for CSR of 0.1 at vertical stress of 100 kPa and the corresponding the variation of pore pressure ratio with number of horizontal cycles for MICP, EICP and untreated sand.

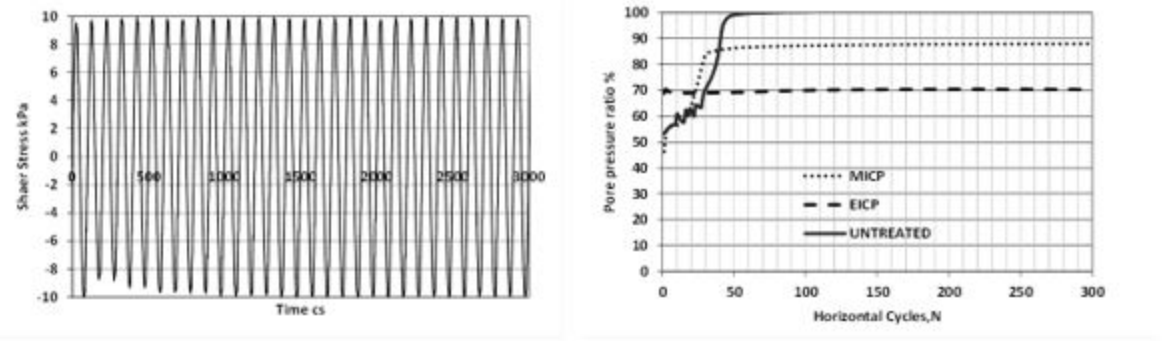

Figure 2 Input shear stress plot and variation of pore pressure ratio with number of horizontal cycles

Maximum cyclic resistance was observed in EICP treated soil followed by MICP. It could have so happened that the bacteria couldn't attach to the soil matrix and was instead flushed resulting in lesser precipitate. Additionally the survival of the bacteria inside the soil sample was doubtful considering its delicacy to adverse surrounding. EICP is therefore suggested to be potential solutions to mitigate liquefaction. However, extensive experimental studies of these methods are required for effective application in the field.

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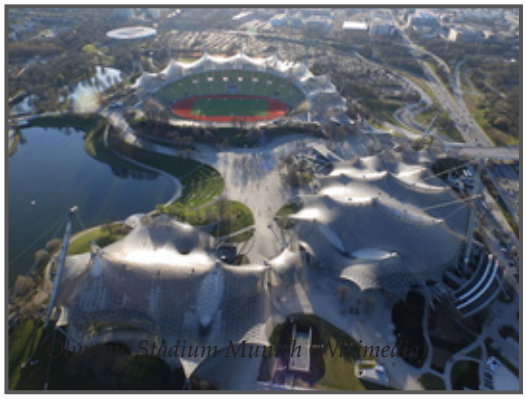
Dr. Siddhartha Ghosh
Professor, Structural Engineering
Department of Civil Engineering, IIT Bombay

Tensile Member Structures

At the Structural Safety Risk and Reliability Lab headed by Prof. Siddhartha Ghosh, we are looking into the analysis and design of tensile membrane structures (TMS). A TMS is composed of a stretched membrane and a supporting (steel) frame, sometimes with the aid of cables, much like an umbrella. Typically, these are attractive roofing solutions covering very large areas, as in stadium galleries, airport terminals, railway stations, etc. Structures like tents and canopies, at first glance, do not seem complex. This is however far from reality, as membranes are "large-deformation structures" and are difficult to analyse and design by conventional means.

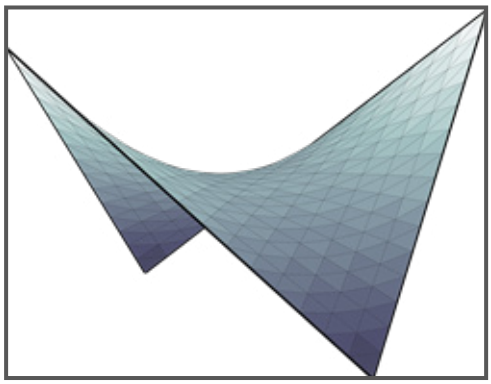


Stadium Munich - Wikimedia

While we marvel at their aesthetic beauty and structural efficiency, there remain quite a few challenges with these structures. For example, have you seen an umbrella getting inverted under heavy winds? You would not like that to happen to a railway station roof.

Computational Methods for Form Finding

The form of the membrane is not known beforehand, unlike an RC beam for example. Obtaining a stable and equilibrated form is computationally challenging and we are looking for new methods to do that.



Form-found shape of a hypar-like structure

Conic-type TMS (Wikimedia)

Design optimization

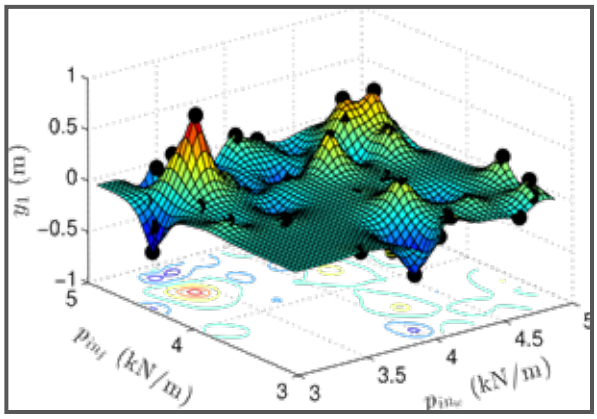
Maintaining its integrity and functionality during the normal "service loads" and also during extreme environmental conditions, such as high winds, is necessary for the TMS. The membrane needs to be stretched by the right amount so that it neither slacks nor tears. The prestress applied to the membrane for giving it the required strength and stability, thus, needs to be optimized for different (uncertain) loading conditions.

Behaviour under wind loading

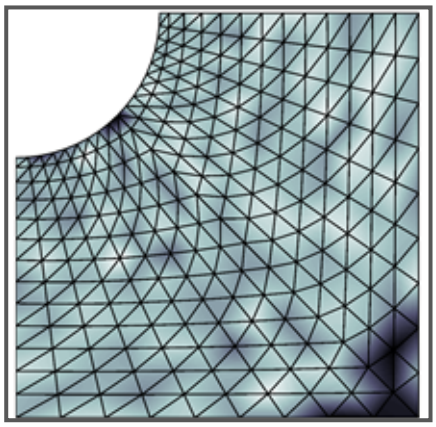
Our current understanding of how wind affects a flexible membrane (as opposed to a rigid structure) is approximate. It must also be noted that wind loads on structures are uncertain in nature, which makes the problem more complicated.

Lack of Indian code provisions

There is no Indian standard that specifies the design provisions for TMS. There is an American standard on TMS and a new European standard is currently being prepared. A design standard ensures both the safety of users and the functionality of the structure, and it is typical of regulators (say, a municipality) to make the use of such standards mandatory in the design of structures under its jurisdiction.



Stress optimization using kriging metamodel



Stress distribution for optimized TMS

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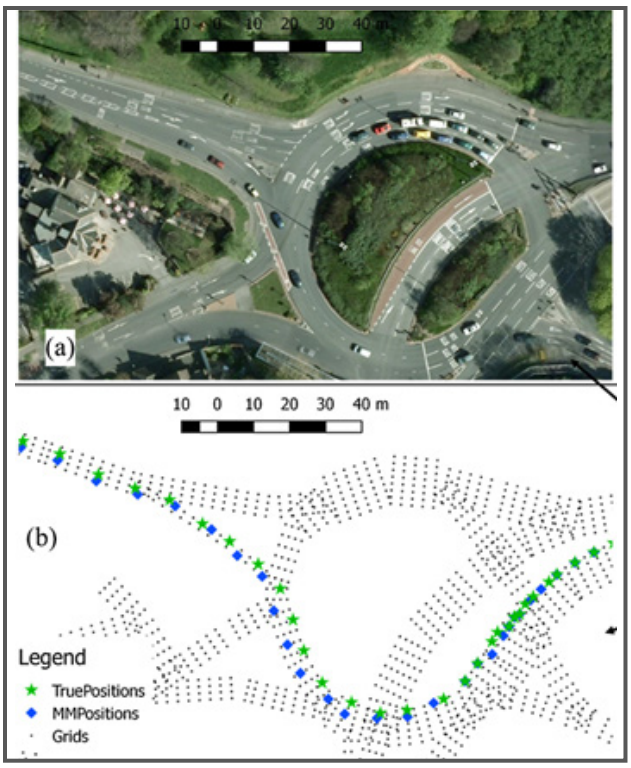
Dr. Nagendra Rao Velaga
Associate Professor, Transportation Systems Engineering
Department of Civil Engineering, IIT Bombay

Development of weight-based map-matching algorithm for lane level localization using GPS

PhD student: Sharath M. N.

Map matching is a process of obtaining the accurate state (position, speed, and heading) of the vehicle and locating the vehicle on the road map. It is one of the essential components of autonomous vehicles and several ITS applications. uses information coupled with errors from the global navigation satellite system (e.g., GPS) and digital road maps. Hence locating a vehicle at the lane-level is not trivial. We have developed a weight-based map-matching algorithm that is capable of locating the vehicle at the lane-level on a digital road map. Grids are used to represent roads, instead of line segments. Only the information available from ubiquitous GPS is used, and fusion of other expensive sensors (like cameras, radars, lidars, DGPS) is avoided to make the implementation of the developed map-matching algorithm feasible even in developing economies like India.



Top view (a) and corresponding representation by grids (b) of an intersection

Modeling the Influence of Time Pressure on Driving Performance of Driver

PhD student: Nishant Pawar

Driving under time pressure is a condition where drivers have a limited amount of time to reach their desired destination. Driving under the influence of time pressure is considered as one of the most prominent rationales of risky driving faced by most of the road users. The common driving behavioral changes observed in time pressure are over-speeding, tailgating, illegal overtaking, traffic rules violation, etc. These behavioral changes of one particular driver may affect the overall driving behavior of the traffic stream and in adverse conditions may result in serious consequences such as rear-end or side-swipe collision. Further, the driver's response to the dangerous event like pedestrian crossing defines the overall safety of the subject driver as well as pedestrians. The response of the drivers to these events is assessed using performance parameters like reaction time, transfer time, etc. Therefore, it is important to analyze all the driving performance parameters to quantify the change in driving behavior of the drivers and assess the overall safety of the road users. It is difficult as well as dangerous to collect data in real-world conditions. Therefore, driving simulator study is performed to assess the safety of the drivers under time pressure condition.

Driving Simulator

Dr. Vedagiri Perumal
Associate Professor, Transportation Systems Engineering
Department of Civil Engineering, IIT Bombay

Analyzing dilemma driver behavior at signalized intersections

PhD student: Bharat Kumar Pathivada

Signalized Intersections are important node points in the road network, ensuring a safe and efficient way of manoeuvring the traffic. Even though traffic signals are considered to be the most effective way of controlling the traffic, over 15,100 (8.6 percent) accidents took place in India at the signalized intersections. One of the main contributing factors in traffic signal related crashes is the presence of dilemma zone, where often drivers are skeptical, whether to cross the intersection or stop without entering the intersection at the onset of a yellow signal. An erroneous decision might lead to right angle collision or rear end collision. The existence of the dilemma zone increases the frequency and severity of the crashes, affecting the efficiency and safety of intersections. The overarching objective of the study is to understand the dilemma zone at signalized intersections and its existence under mixed traffic conditions. Specific objectives of the study are directed towards finding various factors influencing the driver decision behaviour at the onset of yellow, quantifying the boundaries of dilemma zone for different vehicle types, assessing the associated risk and accident potential of a vehicle when facing a yellow signal at the intersections and evaluating various engineering countermeasures to counter the issue of dilemma zone using driver simulator. The insights from the study results can be used to enhance the safety and performance of signalized intersections in developing countries like India.

Reference:

Pathivada, B. K. and Vedagiri P. Analyzing dilemma driver behavior at signalized intersection under mixed traffic conditions. Transp Res Part F Traffic Psychol Behav. 2019;60:111–120. doi: 10.1016/J.TRF.2018.10.010.

Modeling Driver Behaviour and Safety Evaluation at Roundabouts

PhD student: Vinayaraj V.S.

The broad area of the study is to understand the driver behaviour characteristics and safety evaluation of roundabouts in heterogeneous traffic conditions. The popularity of roundabouts is mainly due to the safety benefits of their configurations. Nevertheless, during the design or operation phase of roundabouts, if the safety measures are not considered properly, it adversely affects their overall performance. Therefore, additional information on the safety of roundabouts is extremely helpful for planners and designers in identifying existing deficiencies and refining the design criteria. Most of the studies related to roundabouts at the global level are grounded on the estimation of the capacity of the roundabouts using various approaches. Most of those works are pointed either towards gap acceptance or geometric conditions for the estimation of roundabout capacity (conventional studies). A lot of research has been carried out on roundabout traffic flow and driver behaviour using traffic data from fixed video camera systems and using a simulation-based approach. We use aerial monitoring techniques (Unmanned Aerial Vehicles) to overcome the limitations of traditional methods of traffic data collection due to its mobility, viewing angle, and ability to cover large areas. Limited studies are available related to the safety evaluation of roundabout using surrogate safety measures especially in mixed traffic condition, which is characterized by the presence of different vehicles with varying static and dynamic characteristics allowed to mix and move on the same stream. Hence, it is worth studying the appropriateness of evaluation of safety methods while explaining accident severity and complex driving behaviour at roundabout sections. For this study, six different roundabout locations have been chosen across the country. Locations for data collection were selected on the basis of the type of land use, number of legs (three, four, five or six), and diameter of the central Island. Subsequently, historical accident data was also collected. The Unmanned Aerial Vehicle (UAV)-based video-graphic survey will be conducted during different time slots.

UAV-based pictorial representation of study location

The recorded data will be extracted with the help of a video editing software, and the driver behaviour and safety-related parameters will be extracted based on the trajectory of each vehicle. This research introduces a methodology that analyses the complex driver behaviour such as speed (entry speed, approach speed, circulatory and exit), gap, acceleration, lateral, longitudinal movements and safety assessment while driving through the urban roundabouts. This methodology will be implemented as a tool for assessing the safety of urban roundabouts and developing warning strategy in collision avoidance systems for vehicle and autonomous vehicles (AVs) in mixed traffic conditions. Moreover, the results will be useful in realising the need of having a relook at guidelines for design parameters for better movement through the roundabout, thereby, improving the existing facilities to enhance the safety of road users and diminishing accident exposure to vehicular traffic at roundabouts in developing countries.

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CIVIL ENGINEERING ASSOCIATION (CEA)

EVENTS AND UPDATES

CEA Council 2018-19

Prof.T.I.Eldho
Head Of the Department

Prof.Venkata S. Delhi
Faculty-In-Charge

Prof.Meera Raghunandan
Faculty-In-Charge

Prof. Albert Thomas
Faculty-In-Charge

Jai Toshniwal
Dept. General Secretary

Ujjwal Kumar Maharana
CEA General Secretary

Bhanu Chandu Makineni
CEA Secretary

Siddhant Kurmi
CEA Secretary

Aarnav Saxena
Alumni Secretary

Gardas Ram Prasad
Web Secretary

Shantanu Samarth
Design Secretary

Ashish Thakur
PG Sports Representative

Sujoy Anirudha Das
PG Cultural Representative

Shubhankar Tiwari
M.Tech Representative

Sahana V
PhD Representative

Ankit Kumar
Class Representative
3rd year(S1)

Akhil Goyal
Class Representative
3rd year(S2)

Yash Agarwal
Class Representative
2rd year(S1)

Lovekush Tak
Class Representative
2rd year(S2)

Civil Engineering Association

The Civil Engineering Association (CEA) at IIT Bombay, was established with a prime objective to proliferate knowledge & address industrial issues by bringing corporates, professors and students on a common platform. CEA, having students as well as faculty as its members, is one of the most active organizations of civil engineers students in the country. The association aims to promote civil engineering by providing the much-needed practical exposure to the community members through its regular activities like technical seminars, research symposium, talks on ongoing research practices throughout the globe and many other related topics from distinguished practitioners of the trade. Collaboration between the school and industry is important for the advancement of engineering teaching and research. With this aim, to give the students some practical insight into civil engineering, CEA organizes several visits throughout the year to ongoing construction sites thus giving them a chance to interact with key personnel of the industry. Apart from the technical aspects, it also undertakes the responsibility of proper nurturing of students by organizing some social events as a part of extracurricular. Here is a brief description of the events organized by CEA throughout the year.

Traditional Day

Each year, Traditional Day is organised with enthusiasm by the association twice a year, one in each semester, where all the students, from UG fresher year to PhD students, gather together to have a fun-filled and healthy interaction with each other. Importantly, it is for freshers to get a chance to meet and interact with the seniors. As the name suggests, all the students wear traditional attire on this day. Different students from different cultural backgrounds come dressed in their native outfits, giving a diverse touch to the occasion and the civil department of IIT Bombay. During this get together, the students share their experiences, academic as well as non-academic, have delightful snacks, create memories through photoshoots, participate in some fun activities and take back a few prizes and a handful of memorable experience.

Students Trip

CEA organizes two students trips every year, first in the autumn semester and the other in the spring semester. Since the last two years, CEA has organised trekking and night camps. There is a lot of excitement among the students for the trips for hundreds of them go on these treks and nigh camps, have a chance to connect with their fellow batchmates outside the institute walls and explore wonderful places around Mumbai. The night camps include overnight stay in tents, bonfire, fun games and food. These trips provide a blissful time in nature's lap, away from the hustle and bustle of the city and a break from college routine. The first trip is focused on sophomores and freshies bonding while the second trip is focused on fourth-year students and the graduating students.

Know Your Department

Know Your Department is a one day event where the students, especially sophomores and freshmen, get an opportunity to explore the specialization fields of Civil Engineering. The department professors talk about their research work and projects under their respective specializations. The speakers are not only professors but also successful industrialists. This event holds a crucial role in shaping the career foundation of the students.

Core Talks

This event is a one-to-one interaction between the alumni and the students where the alumni share their experiences of industries with students. Also, the students get to know about the core job opportunities and insight into the professional lives of the alumni.

Sports Weekend

This is a two-day event, organised at the beginning of the spring semester. The sports weekend includes tournaments in various sports like cricket, badminton, table tennis, volleyball, chess and football. This weekend is eagerly waited by the sports enthusiasts. Not only this, the department staff also participates in the tournaments, playing alongside the students. The teams are divided on the basis of S1 and S2 batches, leading to a healthy competitive vibe among the participants. At the end of the sports weekend, the winners are honored with certificates and medals.

T-Shirt and Hoodie Design Competition

The department merchandise consists of t-shirts and hoodies or jackets. Each year, a different and innovative design is made for t-shirts and hoodies. To explore students creativity , a t-shirt and hoodie competition is organised by the CEA. This competition gives a platform to the design enthusiasts to get their vision printed on the merchandise. Once the best design is finalised, it gets printed and official merchandise is released by the association. Wearing the department t-shirts and hoodies gives the students a feeling of oneness and belonging to the big family of civil engineering department.

Seminars and Workshops

CEA has been offering many in-depth, high quality seminars and talks each year covering a wide range of technical, management and career oriented topics. These seminars include both formal and informal sessions being delivered by alumni, industry professionals, international faculties and research scholars. Along with this CEA also organizes software workshops covering all important aspects of software that are used in civil engineering.

AKAAR

AAKAAR

Aakaar is the annual technical festival of department of civil engineering, IIT Bombay. It is held in the month of March. Aakaar has been a great platform for students all across the country to showcase and enhance their skills at the highest level. Established in 2009, Aakaar is now Asia's largest civil engineering festival. There are numerous competitions held in Aakaar such as Civil Engineering Symposium, Civil Engineering National Exhibition, Bridge-It, Conquer-It, Smart Pitch which help the students strengthen their practical knowledge as well as allow them to partake in contests and competitions. As a part of knowledge sharing endeavour, many software workshops are conducted viz, Etabs, Autodesk Civil 3D, StaadPro, BIM, Revit etc. A national level civil engineering quiz named CiviQ is also conducted every year. Several fun events make Aakaar an enjoyable learning experience.

Symposium (ICES)

International Civil Engineering Symposium

It is a forum for young and promising students enthusiastic in research to present their work in front of the most experienced professors of the country, civil engineering leaders, industrialists and the best civil engineering students. Aakaar's Symposium is one of the largest of its kind in the entire country in terms of participation and it showcases excellent student research papers and presentations. It involves professionals in civil engineering domain as its audience. Symposium targets to take research and civil engineering to a whole new level.

CENEx

Civil Engineering National Exhibition

CeNEx provides an opportunity for civil engineering students all across India to showcase their research projects incorporating new technology via different models, prototypes, simulation models or samples in front of eminent professors and professionals. It aims to shower light on technological advancements by the youth of this country. Students in groups are supposed to display their models and give a brief description about the same. Best models are given prize money.

Bridge-It

Bridge-It is a popsicle bridge making competition. It is held every year with unique and challenging problem statements. This year it brought the challenge acquired from the bridges having the nonlinear decks supported by cables. These kinds of bridges are often used to construct large and complex highway interchanges into densely populated areas to avoid traffic congestion and to increase the aesthetics of the structure.Due to the curvature effect, the dynamic behaviour of such a bridge is more complicated than a straight bridge, thus inherently creating challenges for engineers to deal with the increased bending moment and the arrival of the torsional moment due to horizontal curvature. The task provided for the competitors from all over INDIA is to design a cable-stayed bridge with popsicle sticks, fevicol as adhesive and cotton strings that can sustain maximum possible load with minimum deflection. The competitors come up with their bridges with the mentioned specifications in the problem statement of the bridge and also with their own creativity.

Conquer-It

Conquer-it is another challenging competition where participants have to make concrete and its mix design based on a unique problem statement. This year Aakaar decided to investigate the maximum stiffness of lightweight concrete. The challenge was to come up with a mix design and the best possible model which adhered to the given set of regulations which demanded an optimization between the stiffness and the weight of the structure. The model was used to measure Young's modulus.

Smart Pitch

Smart Pitch is a competition which provides great opportunity for start-ups in the field of Civil Engineering. To register for the competition, a team has to send a presentation based on their idea. The idea should be based on the given theme. Shortlisting is done from the presentations the teams have sent. A mentor is allocated to each team, 10-15 days before the fest, to help them develop their business model. The team has to pitch their ideas in front of the judges. If interested, judges or investors can invest in their model. Winning team gets a certificate and a cash prize.

CIVIQ

National Civil Engineering Quiz

CIVIQ is the most exciting and brain-twisting competition of Aakaar. It comprises of quizzes and games related to the field of Civil engineering. It's a national level open civil quiz competition. The competition comprises of three rounds with 4 teams who are selected from a general quiz round with 2 participants each. Round 1 is a sliding tackle in which each team gets a question that can rotate between teams bounding some rules. Round 2 is the picture round in which a team gets a picture that contains the details to tackle it. Round 3 is Dumb Charades arranged for fun.

CIVIQ Zonals: This follows the same pattern as CIVIQ but is specially organized in the colleges to encourage the frontiers of civil engineering. For organizing this, the Aakaar team spreads out to colleges and gives incentives for the winners.

MSE Wall

MSE Wall is one of Aakaar's many competitions. It's objective is to design and build a mechanically stabilized earth retaining wall model which serves as a temporary wall, using paper reinforcement, taped to a paper wall facing. This competition tests promptness of ideating the design, teamwork, productivity in a constrained time period, etc.

Civil Expo

A great platform where the civil engineering students from various engineering colleges of India get to interact with professional and technical people of various civil engineering companies who display their new products and ongoing challenging projects during the fest. Aakaar 2019 had some of the well-known companies like L&T Construction, JSW Cement GGBS, Ultratech Cement etc. as exhibitors. This gives visitors an insight to industrial world of civil engineers and the up-coming technologies in this field.

Workshop

Workshop is the right platform to connect theoretical knowledge to practical knowledge. Through workshops, leading professional softwares being used in the field of construction are introduced. Gaining knowledge about these softwares from some of the best experts in the field will definitely help in delving deeper into the subject. It also provides a chance to interact with people sharing the same interests and to clarify doubts from the professionals. In the year 2019, we conducted BIM-AECOsim, STAAD Pro, Dynamo and Bridge Design workshops.

Lecture Series

Lecture Series contain some very interesting lectures selected from various fields of Civil Engineering, based on the impact they are producing around the globe and their use for future civil engineers. These lectures are delivered by experts in the field and provide deep insights to the audience. Students get to see the world from an expert's point of view. In Aakaar 2019, the topics for lecture series were:

1. 'The role of Drones in Civil Engineering; Taking Surveying to new heights' delivered by Dr. B. Babu Madhavan, President and CEO, Sakura Geoinformation Software Research Pvt. Ltd.
2. 'New era of High-Speed railway in India: Mumbai - Ahmedabad Bullet trains' delivered by Mr. U. P. Singh, Chief Project Manager, National High-Speed Rail Corporation Ltd.

Panel Discussion

A panel of fabled dignitaries is set to discuss and debate on a particular topic and they share with us all the details from their perspective. Words from these renowned and experienced personalities gives the audience a good view of the topic selected. Last year the topic for the panel discussion was 'Career Conclave' which guided several young civil engineers of India to choose the right career for their future.

Lab Visits

Lab visits have been introduced to Aakaar for the very first time. It was an initiative taken up by the events managers this year. More than 300 students from various colleges came to visit various labs in our Institute like Hydraulics labs, Heavy Structures lab, Transportation lab, Construction Management and Technology lab, Heavy Structures Lab, etc. Students were given booklets which contained information about the experiments. Lab assistants gave an overview on experiments.

MORE FROM THE DEPARTMENT

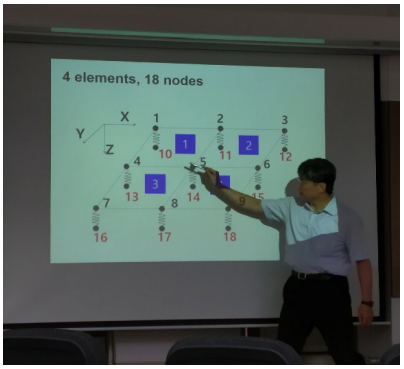
Global Initiative on Academic Networks (GIAN) Course On Deep Foundations Of Mega Structures

The above course was organised in the department to bring together fundamental concepts, recent developments as well as some of the Korean experience in the use of large and deep foundations amidst increasing demand of infrastructures in India and other Asian countries. Lecture notes were delivered by Prof Samsung Jeong of Yonsei University and Prof Ashish Juneja of IIT Bombay. New tools used in the design and construction of the mega foundations were presented.

The course was attended by about 70 participants which included graduate students, civil engineering professionals and research scientists. The course dealt with a class of problems with several special soil-structure interaction problems. Some of the topics included: equivalent raft, equivalent pier and PDR methods of piled raft with design and application; plasticity and elasto-plastic analysis using FEM, FDM and DEM, use of advanced soil models such as work-hardening plasticity and cap models and their advantages over Mohr-Coulomb; stiffness issue: non-linear stiffness and what modulus to use; comparison of design and analysis of pile foundation with commercial codes; and current approaches to modelling large and deep foundations.

View of the audience

Informal discussions during tea break



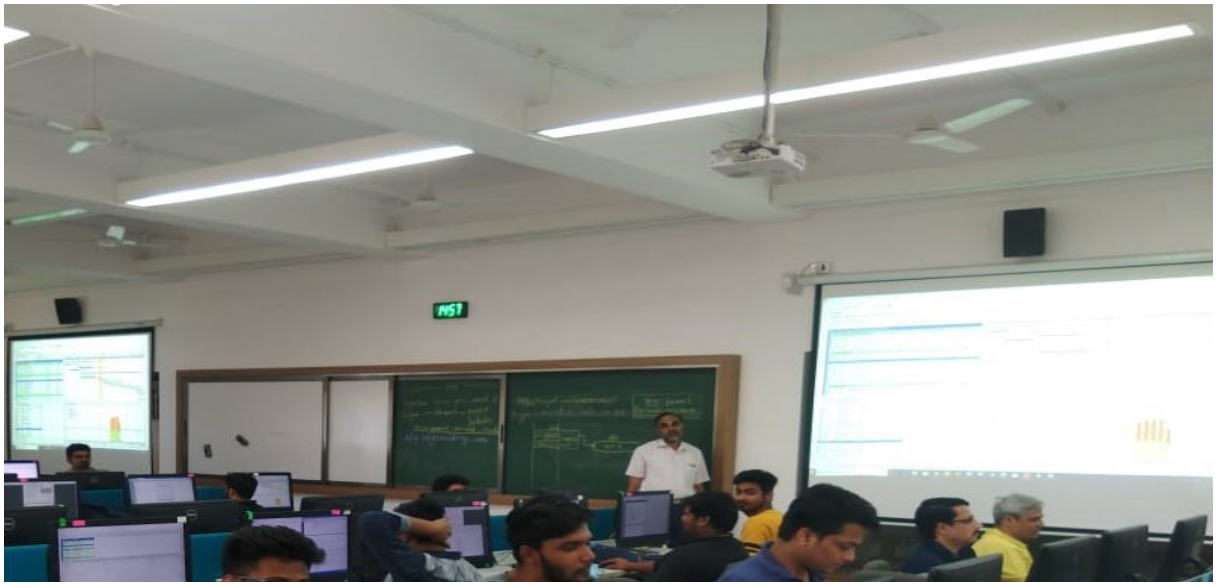
Lecture in progress

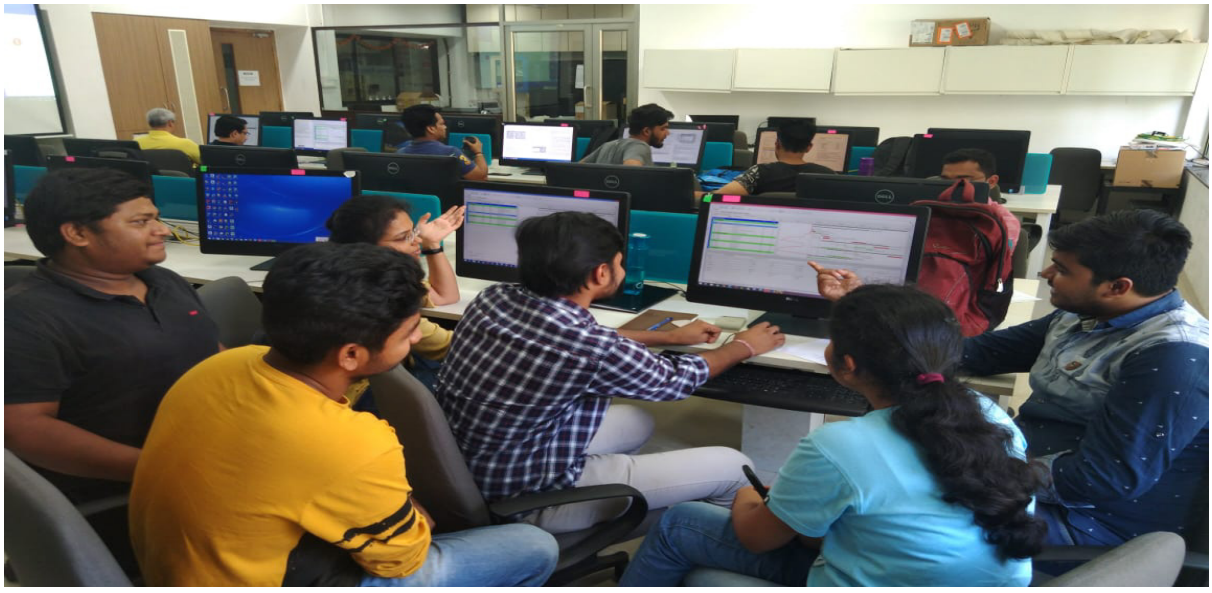
Hands-on session in progress

Hands-on session in progress

Training program on Oracle Primavera P6 organised for graduate, post graduate and PhD students in the department

Primavera P6 is a handy scheduling tool that helps construction, architecture, and engineering firms to plan, manage, control, and deliver projects on time and within budget. In March 2019, a three day training on Primavera (P6) was organized for the graduate, post graduate and the PhD students of the department, in association with Infinity PMC Private limited. The training introduced various aspects of scheduling using P6, covering aspects of resource management, time management, cost management, risk management, and portfolio management.The department computational facility and the construction management laboratory are now added with Oracle Primavera P6 capability. Primavera-P6 is now also part of the curriculum for the course, CE 722- Construction Management Studio.





CIVIL ENGINEERING DEPARTMENT
IIT BOMBAY

OPEN DAY CELEBRATIONS

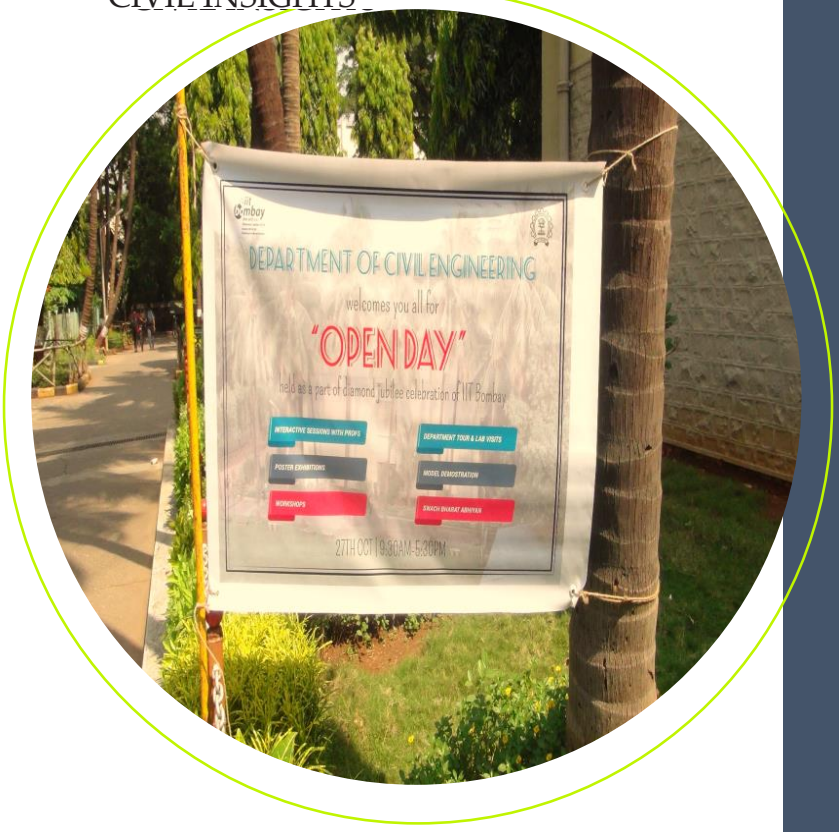
OPEN LABS

VISIT BY SCHOOL STUDENTS

POSTER EXHIBITION

LIVE MODEL DEMONSTRATIONS

SWATCH BHARAT SEMINAR



OPEN LABS

All the research and teaching labs of the Civil Engineering Department remained open to public from 9:30 am till 5:30 pm on the open day. Specific demonstrations of the working of some equipment were conducted by different labs. Lab visits were also part of the school children tour to the department.

School students visiting one of the research labs in the department

OPEN DAY CELEBRATIONS

As part of the Diamond Jubilee celebrations of Indian Institute of Technology Bombay, the Department of Civil Engineering, IIT Bombay has organized an open day on 27 October 2018 to showcase the facilities and labs of the department. As part of the Open Day the department labs were kept open through-out the day. A poster exhibition by the students belonging to the different research specializations of the department was organized to showcase the research being done in the department. Live model demonstrations of the various concepts/equipment related to the department were put on display for the entire day. The students of Kendriya Vidyalaya and Campus School of IIT Bombay were invited by the department to introduce them to the possibilities and the exciting opportunities available in diverse fields of Civil Engineering. The open day celebrations also included a special seminar by Prof. Anil Dutt Vyas of Manipal University, Jaipur on Swatch Bharat theme.

VISIT BY SCHOOL STUDENTS

The school students of Kendriya Vidyalaya and Campus schools of IIT Bombay visited the department to understand the work done in the department. About 240 students from the school predominantly from 10th, 11th and 12th classes visited the department. These students were accompanied by about seven teachers belonging to these schools. As part of this visit, the department organized a tour of four of the department labs, live demonstrations and session was arranged where faculty representing the seven research specializations in the department interacted with the students. The students spent about two and half hours in the department.

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Students visiting one of the department labs

FACULTY INTERACTION

The faculty interacted with the school students for about an hour introducing various aspects of Civil Engineering to students.

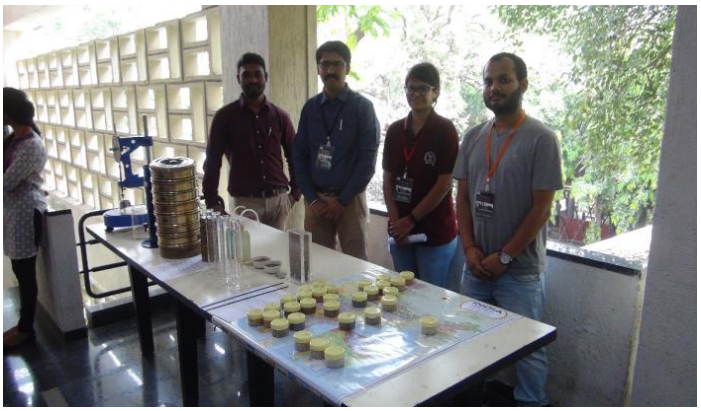
HoD interacting with the students

POSTER EXHIBITION

The students of the department presented posters related to various research areas of the department.

LIVE MODEL DEMONSTRATIONS

Various models and equipment were demonstrated during this event.



OPEN DAY GALLERY

Department of Civil Engineering, IIT Bombay

Report on National Conference 'Next Frontiers in Civil Engineering: Sustainable and Resilient Infrastructure' held at IIT Bombay during 30th November - 1st December 2018

As part of the Diamond Jubilee celebrations of Indian Institute of Technology Bombay, the Department of Civil Engineering, IIT Bombay organized a National Conference titled 'Next Frontiers in Civil Engineering: Sustainable and Resilient Infrastructure' from 30th November – 1st December 2018. The conference aimed to highlight the role of Civil Engineering towards the creation of a sustainable and resilient society. The conference covered all specializations of Civil Engineering, viz. Construction Technology and Management, Geotechnical Engineering, Ocean Engineering, Structural Engineering, Remote Sensing, Transportation Systems Engineering, and Water Resources Engineering, bringing together a wide range of keynote lectures and presentations dealing with various practical problems related to infrastructure, housing, transport and water and environment that the society faces today.

Images: (left) Conference registration desk. (right) participants registering for the conference on 30th November 2018.

As part of the conference, the following programmes were organized:

- Inaugural Function and Conference Keynote Lecture
- Oral and poster presentations on various disciplines of Civil Engineering
- Keynote lectures by eminent Engineers/ Scientists and Academicians
- Felicitation of Retired Civil Engineering Faculty

A brief overview of the activities during the two days is given below.

1.Inaugural Function and Conference Plenary Lecture

The inaugural function was held on the morning of 30th November. The inaugural function was presided over by Prof. A. K. Suresh (Deputy Director, IIT Bombay). Padmavibhushan Dr. Anil Kakodkar inaugurated the conference in the presence of the delegates of the conference and the Civil Engineering fraternity of IIT Bombay. He provided his views on how to move towards to a sustainable society and the role Civil Engineers. He stressed on the value of local solutions, such as using bamboo in construction of low-cost housing solutions for populations displaced due to large Civil Engineering projects. He also highlighted the value of field experience in Civil Engineering projects.


Images: (top left): Prof. Eldho welcomes the Chief guest; Prof. Eldho welcome the gatherings; Prof. Suresh address the gathering; Prof. Tarun Kant introducing Dr. Anil Kakodkar, Chief Guest; Conference delegates and Civil Faculty; Dr. Anil Kakodkar's address


Shri. Achal Khare delivering conference plenary lecture; Gathering during plenary lecture

Following this, as a part of the inaugural function, Shri. Achal Khare presented the conference plenary lecture on 'Ushering into New Era of High Speed Railway – Challenges & Opportunities'. Shri. Achal Khare provided numerous challenges faced by ongoing transport related projects that Civil engineers can address by developing adequate technologies. He presented the details of the Mumbai – Ahmedabad high speed rail corridor "Bullet train" project details with all the challenges in front of Civil Engineers. He guided the audience what will be the next frontiers in civil engineering, the main theme of the conference. Further he highlighted on the value of using state-of-the-art technology to enable fast project completion such as use of tunnel boring machine, LiDAR imagery for surveying etc.

2. Oral and Poster Presentations

The conference covered all major disciplines of Civil Engineering: Construction Technology and Management, Geotechnical Engineering, Ocean Engineering, Remote Sensing, Structural Engineering, Transportation Systems Engineering, and Water Resources Engineering. Extended abstracts were invited across all disciplines. There was good response to the call for abstracts and over 200 abstracts were received, out of which 150 abstracts were shortlisted for participation in the conference in terms of oral and poster presentations. The conference was attended by 111 delegates from various institutions across India other than IIT Bombay Faculty and students. A total of 91 papers were presented out of which 71 were oral

presentations and 20 were poster presentations. Oral presentations were carried out across multiple parallel sessions spread over the two days of the conference.




Images: Delegates presenting their research work in various technical sessions.

3. Keynote lectures

The keynote lectures were a highlight of the conference. Experts and eminent Scientists/ Engineers were invited from all major disciplines and presented problems faced in practical real world problems, highlighting possible avenues for future research and next frontiers of Civil Engineering. Overall 6 keynote lectures were delivered. They discussed the inherent inter-disciplinary nature of the real-world problems they deal with. The keynote speakers who delivered their expert lectures include: Mr. M.K. Gupta (Director, Mumbai Metro Rail co. Ltd.); Dr. M.A. Atmanand (Director, National Institute of Ocean Technology, Chennai); Mr. A.P. Mull (Former CEO, Tata Consulting Engineers); Mr. Satanu Chowdhury (Director, National Remote Sensing Center, Hyderabad, ISRO); Dr. Veeena Srinivasan (Fellow and Convener, Center for Environment and Development, Bangalore), and Dr. Chetan Hazaree (Head R&D, L&T Mumbai).

Images: Keynote speakers delivering their lectures: 1) Mr. M.K. Gupta; 2) Dr. M.A. Atmanand 3) Mr. A.P. Mull; 4) Mr. Satanu Chowdhury; 5) Dr. Veeena Srinivasan; 6) Dr. Chetan Hazaree

4. Felicitation of Retired Civil Engineering Faculty

Another highlight of the conference was felicitation of retired faculty from the Civil Engineering Department. The felicitation ceremony was aimed to acknowledge the hard work that these faculties had done to bring the Department to its present standing. All the available retired Faculty were invited to this function and nine could attend the function. In the function, Head of the Department Prof. Eldho welcomed all and thanked all the retired Faculty for their sincere services and hard work. Prof. Y.M. Desai introduced all the former colleagues who were present with their valuable contributions. Prof. A.K. Suresh, Deputy Director felicitated all the retired faculty present. The felicitation ceremony recognized their contributions and they shared their valuable experiences with the Civil Engineering fraternity

at IIT Bombay. The ceremony was greatly appreciated by the retired faculty who expressed their happiness over emails:

"It was a rare opportunity to me and for all of us to come together meet each other on such a grand occasion after many years". Prof. Gopalrao Kulkarni.

"…your touching gesture, the felicitation of retired faculty, recognizing their contributions of varying hues and honoring them was the crowning glory (of the conference)." Prof. Gopalkrishnan Venkatachalam.

"…..the Diamond Jubilee Conference was a great success. It was planned and executed meticulously. In particular, the Inaugural session and the felicitation function were well conducted. The latter brought back pleasant memories and I felt rejuvenated. I wish to thank you and your team members for the excellent hospitality shown to us during our visit which made us feel at home". Prof. V.S. Chandrasekaran.

Image: (left) Seated on the front row are retired faculty from Department of Civil Engineering, IIT Bombay with DD and Head; (right) Retired faculty with current faculty and staff from the department along with Deputy Director.

5. Valedictory Function

The Diamond Jubilee National Conference organized by Department of Civil Engineering, IIT Bombay 'Next Frontiers in Civil Engineering: Sustainable and Resilient Infrastructure' was concluded on second day evening (1st December 2018). In the valedictory function, the best poster and oral papers presented were awarded with a certificate and memento. Prof. Eldho, HoD, thanked the Institute authorities, delegates, the staff and students who made the conference a huge success.

Images: The best paper/ poster winners with Head, Prof. Eldho; Organizing team of Conference, Faculty and staff

RENDEZVOUS
with Professors

A Random Walk Through Life

With Prof. Raghu Murtugudde

By: Pallavi Goswami

Prof. Raghu Murtugudde has worked as a visiting faculty here in the Civil Engineering department at IITB, engaging in taking an undergrad elective and a PG course. He did his bachelors from the Aerospace Engineering department (then Aeronautical Engineering) here at IIT Bombay. He then went on to do his masters and later PhD from the U.S. Prof. Murtugudde is presently a Professor at the Department of Atmospheric and Oceanic Science in the University of Maryland, USA, and Executive Director of the Chesapeake Bay Forecast Project. His expertise lies in Earth System Science. He has a number of books, peer-reviewed publications, and awards to his credit. He has also worked as a research scientist at the NASA Goddard Space Flight Centre. Apart from a very successful research career, he has had some fantastic experiences, the essence of which he shares in this interview talk below.

What motivated you to choose this field and what kept you going on?

Well actually I'm an engineer. I did my Bachelors (from here IITB itself) and Masters in Aerospace engineering and later PhD in mechanical. During my PhD, I did some numerical work for a climate ocean group and that kind of got me curious even though I didn't take any ocean or climate courses. Although I had already worked before, after completing PhD I wasn't sure I wanted to go back to the corporations as there is not much independence and I believe that work should be fun. So I got a postdoc at NASA and started working on climate-related modeling. They were paying engineering salary which was higher than the regular postdoc salary so I thought to give it a shot. And then I got really interested in the research.

To stay interested I have basically expanded from modeling just the fluid dynamics that I did during my PhD to modeling biology, carbon and modeling climate impacts like how does it affect fish, carbon cycle or water. I used to work a lot with farmers in my area, Dharwad. That's basically what kept me going.

Would you like to share any of the hardships that you faced at any point of time. How did you overcome those and what lessons did you learn along?

When I was in Texas I was working on a very interesting project for a company and doing PhD at the same time. But the project got cut by the government and with that the airforce funding for it was stopped. So I lost my scholarship. And then I had to choose to either go back to work or continue PhD on my own. I got a programming job at Columbia University but I wasn't sure whether I wanted to take it or not. Then somebody else at Columbia from the climate science side looked at my background and said I could be a

PhD student and work in the area of climate science. I told them I wasn't interested. There was no aerospace at Columbia University. A professor from mechanical engineering there heard from a friend of mine about me and extended the offer of fellowship for PhD. That's how I joined at Columbia. The other professors from the climate science side again contacted me back asking that I help him with numerical methods which I finally agreed. So that's how I got introduced to the numerical work in climate. It was more like a complete fluke for me. I still don't know why the climate professor chose me. Again after PhD I had to choose. I could have gone back to the industry to be an engineer. But I took almost a 50% pay cut to go to research, which was the bigger choice for me. I had already started feeling curious about climate. So that's a hardship that didn't go waste. If I look back now I made the right choice. Had I gone back to the industry I would have probably made more money but would not have been working according to my mind.

Whom have you been inspired by?

Actually, it's my teacher from my seventh grade. He used to say do what you enjoy and then you'll be good at it and you can make money. That advice stayed with me. He also inspired a bunch of us students back at Dharwad to get into IITs even when in those times we hardly had any clear picture of as to what IIT was. He did a lot for us including a night class that he used to run so that we could study and prepare. Three of us finally made it. I have always been in touch with him. I used to visit him whenever I'd be back at Dharwad. Even after my PhD when I had made up my mind to pursue further in climate science I told him that I had finally made the right choice.

What difference can you feel from the time back when you were here as a student compared to what it is now?

One of the worst ones is that we used to have single rooms and students these days don't have single rooms anymore. IIT helped me build lasting friendships. The guys from our hostels meet every year several times even now. We plan hiking in the Himalayas or meet at someone's place. All this came out from the friendships that grew at IIT which apparently doesn't seem to happen so much now. But other than that it's quite a built-up place now. A lot more exciting things are happening. When I was here as a student my department was called Aeronautical engineering. Now it is the Aerospace department and they are doing pretty big projects.

How has been your experience of working with other fellow researchers or scientists and how has that helped bring more skills to the work that you do.?

I was lucky enough to work with some very smart people. The one thing you learn is to pick problems even if they are difficult. You find that the difficult ones actually happen to be very useful problems too like say the monsoon problem or the water problem. One then needs to work on them and build a team to address all aspects of the problems. Sometimes it is interdisciplinary work. When you are here as a student , say, as a civil

engineer or an aerospace engineer, you don't think much about other things. But now each field has begun to work in interdisciplinary fashions. You find engineers from computer science, electrical, mechanical, civil, etc., working on interdisciplinary problems. I learnt this much later. It was when I got involved with climate sciences. I've had chances to work with researchers from all over the world and have had amazing experiences to be part of great teams working on interesting interdisciplinary problems. A major challenge in the US is funding for research. When you get funded it's a lot of fun. You put together a team through a lot of effort but if you don't get funding then the team disappears and you have to rebuild a team again the next time. So there are a lot of challenges in doing interdisciplinary work. Oftentimes, when you work across disciplines like in my case when I work with fisheries people, their languages are very different from yours. That is when you have to learn to pick new interpersonal skills up.

What are some of the tips you would like to give to students who are interested in pursuing higher studies like a Masters (MS/M.Tech) or PhD degree.

One of the things is to be sure what you want to do and then it is important to pace yourself. Even though sometimes you may feel like there is not enough time, you have to remember that life is like a marathon, not a sprint. So you should not rush. Proper pacing is important. And you also need to remember that in life a lot of time it is luck. And they say luck favours the brave and brave are those who try. So you shouldn't be afraid to fail. You should try. Don't give up before trying and then luck will hopefully come your way. In no case should you feel discouraged. Sometimes having multiple research problems together going on can allow you to switch from one to another. So if you get bored of working on one you read something else. You must constantly improve your background knowledge. The more you know the easier you feel while figuring out problems. When you face a question you can draw from your broad knowledge.

How important is networking in the field of your profession?

It's important in the sense that it makes people know what you are doing so in case they want to collaborate it's easier for them to reach out. If they know you through talks, papers, portfolios, etc, the process gets easier and better. Networking does not strictly mean you are trying to choose collaborators or raise funds. You might want to write proposals with somebody. Let's say if I want to work on monsoons and if I want to reach out to somebody in India then I need to have a network to know who is working in that field, who might be a reliable collaborator, who is at a relevant place that I need to visit. So, that kind of networking is important.

How does one manage time in a profession like yours?

It is mostly about prioritising in terms of what you are really passionate about. If you're a postdoc then you are likely to have a PhD paper that you have to wrap up alongside your postdoc work and you also have to look for a future job. Managing all these is a matter of juggling multiple things without getting overwhelmed or missing the priorities. That's something you have to learn along. Interestingly at some point it becomes fun too. Research by nature is a 24/7 job; you cannot turn it off. Sometimes it may be appropriate to have enough things at hand to do so that you don't get bored. If you are focused on something and say you somehow are stuck then things may begin to look tedious. But if you have multiple problems then you can switch. So it is a good idea to have multiple things to work at provided you don't begin to feel overwhelmed.

What do you think presently are the limitations that stand in the way of effectively communicating science to people or to stakeholders?

A lot of that will depend on which field of science it is. If we take climate science for instance, there are a lot of controversies about, say, the climate change. So then it's the idea of letting people recognise what they're experiencing and try to see if that can fit into their known science. It's much more important to know the details of the problems that the people are facing. If you ask them what are the changes they're observing then you can explain those in terms of climate change instead of simply telling them that climate change is happening. If you ask a group of farmers how much carbon they are making they may not be able to tell that. But if you ask them what are the changes they are experiencing then they will be able to tell how the rain or heatwaves have changed. Then you can tell them what the Industrial Revolution has done or what the emissions are doing. So we need to contextualise our research in terms of people's experience. And then we have to offer solutions too. If you keep on saying the world is coming to an end and don't tell what can be done about it then they might say that it doesn't matter anyway.

How do you think India at the moment or the world as a whole stands prepared for the climate change and extreme events that are being predicted?

The good thing in India is that there is not a lot of scepticism about things. There have been some good initiatives like the Monsoon Mission that was rolled out, IMD spending millions of dollars for improving forecasts which have improved climate sciences in turn, switching to renewables like solar and wind, planning for electric vehicles, public transportation, metros, etc. At the same time, there is some bad news also. The population density is very high and often times the infrastructure is not built to handle extreme rainfalls. There's an increase in domestic flights which will shoot up urbanisation. Agriculture is not so well prepared for the extremes. We need some large scale solutions like agroforestry which is better for the Indian region for handling extreme rains, droughts, soil moisture problems, and so on. Health is a big issue. Air pollution is a horrible thing.

We are not really well prepared to handle air pollution or to reduce it. It's a slow process. Energy is a big problem. Renewables are increasing but not fast enough. We are still heavily dependent on importing energy which can be ugly if something goes wrong outside. We are too reliant on external energy sources. So food, water, energy, and health are four big things but it's a mixed bag. India is thinking about these things but we might have less time to implement these things. Places like IITs, for example, should be doing much more on climate solutions. One of the reasons why I want to teach climate as an undergrad elective is that all engineers should be aware of climate as a problem so that if there are solutions to be made or green technologies to be implemented with regards to climate solutions, engineers can potentially do that. Awareness about climate itself is really important. The online course that I recorded with a couple of other people is training teachers in this field. It got some 900 plus registrations in the very first start. So these kind of things have to happen more. I don't India think needs a lot of climate scientists per se. We need some though for improving extreme events predictions. But more importantly we need much more of climate awareness for engineers, doctors, lawyers, journalists, and environmentalists. They all have to understand that everything we do affects climate. We need to move towards global solutions.

Would you like to share any of your 'Aha' or 'Eureka' moments.

There aren't much <smiles>. The first time I had a good result was when one of my papers showed that phytoplankton can affect large scale circulations like El Nino. It has become a part of a working model. It was one of the first things I had worked on at NASA just after my postdoc. After that, it has been the fisheries work that has made me feel amazing that we can model fish. The work on monsoons has also been very exciting.

What is your philosophy of life?

Life is a marathon so keep pacing yourself and have fun. What will be the point of it all if you don't have fun. Considering if you spend eight hours a day on your work and if you don't enjoy it then it is probably miserable. You should find something you enjoy.

What are your plans ahead?

To get old and die peacefully <laughs>. Basically to teach, to do more climate things in India. Teaching across India is one thing but more important to that is building such teams which will work on big interdisciplinary problems, which in India is not that easy. All IITs are competing with each other and even within an IIT it's not so easy to get people from different departments to work on a problem unless it's a well-defined one. We should become better at working together for such problems especially for problems that are global missions and contribute solutions to these.

A Man Of Simplicity
Prof. M.C. Deo

By: Matru Prasad Nanda

Prof. Dr.M.C.Deo has been working as a Professor here in the Civil Engineering Department in IIT Bombay. He has also served as Head of Civil Engineering department, IIT Bombay. He has received various honours and awards for his service with distinction. He has received Prof. H H Mathur Award for excellence in Applied Research (2009), IIT Bombay best research paper award (2006), Jalavigyan Puraskar (1998) given by the Indian Society for Hydraulics, Excellence in Teaching award (2016,2018) IIT Bombay and many more. He has guided 17 PhDs and more than 60 M.Tech dissertations. His research interests include climate change impacts; ocean data analysis, artificial intelligence and advanced statistical models.

What made you decide to become a teacher?
Actually I did not have any plans of choosing this profession <laughs>, but what motivated me was the education of M Tech and PhD.

What are some of the common concepts which you feel students should have knowledge of to excel in their diverse engineering fields?
I can say that the M.Tech and the PhD students should have a clear understanding of important mathematical concepts like solutions of differential equations and their applicability, numerical methods such as FEM, FDM and importantly, coding of algorithms.

What do you do when you are not teaching? What are your hobbies?
I am a part of the executive committee of 'The Indian society for Hydraulics' wherein there are new technical articles to edit every day. Being in sync with the latest innovations and research does take a lot of your energy, and I thoroughly enjoy it. In spare time I engage in social work a lot, enjoy cooking, like taking a walk and shopping in malls.

What major changes have you seen during your time here and what do you think about them them?

The status of IIT has significantly changed from the past. The emphasis on the state of the art research by its faculty and students has increased. In a world increasingly propelled by technology, University research is the foundation of any nation's economic growth and this institute is committed to basic long term research in frontier areas. The institute has on-going academic and research collaborations with many national and international universities, and is constantly in touch with national needs and has projects by students in thrust areas of science and engineering. Across the student and faculty community a significant population comes from the local and the southern states leading to a cultural diversity. This institute is well placed to lead the way in supporting and celebrating the cross-cultural exchange, dialogue and nurturing an inter-cultural community of leaders who are ready to take on issues they are passionate about, learning more about problems affecting the society and making a lasting impact.

What advice do you have that would enable us to be a better institution?

Winds of change are blowing toward a more student-centric and flexible future for higher education globally. Universities have traditionally based the delivery of their teaching and learning mission on a teacher-centric, curriculum-based model. Some forward thinking universities are now pivoting to student-centric experience which goes well beyond simply having a strong student focus; it fundamentally redefines the "contract" with the student, moving from promise to delivery. The focus on linking the learning experience with professional outcomes will shape curriculum design at universities and to achieve this, it will require a concerted action on a broad front. Moving to a student-centric focus requires a reconfiguration of both the culture and the technology of a university and can be a challenge. But with the right vision the transformation can be readily achieved and innovation enabled.

You have been so successful in your life, but what would be that one failure which you believe taught you more than success?

I doubt if that is the case. As for the failure, I could not envision certain opportunities of growth; for example, I decided to discontinue collaborations with leading universities of the world. I mostly confined to myself and my students.

What would your advice be for a young teacher?

In research, go deep in a focussed area but spread laterally to broaden your vision. A new researcher in any discipline is often at sea without a compass but the breadth of the research will provide greater range of ideas. The best research often comes from real problems. If you are a young academician, form close ties with a local company or with a government facility. You may find that your best ideas, even general theoretical ideas, arise from their needs. Develop intuition. We avoid mistakes by having good intuition and develop intuition by making mistakes. As with teaching, lay more emphasis on quality over quantity. With nearly a quarter of India's population being in the age of attending school and college, whether our demographic situation is an asset for our country or not depends on the quality of their learning. Knowledge, skills and expertise are the key enablers for maintaining our economic growth momentum in a scenario of technology led disruptions, where skill requirements are ever changing.

What are the current trends in your subject area?

Ocean development is a common focus of global attention which urges the improvement of traditional research and exploration methods. Artificial Intelligence is one of the core technologies that have become support system for many fields. Artificial neural network (ANN)s have been applied to solve a variety of problems related to the coastal and ocean areas. Most of these studies have involved estimation or forecasting of environmental parameters, structural loads and responses. ANN models have been generally found to outperform the traditional empirical, statistical or numerical models to a large extent. Working out the best ways to tackle climate change is one of the key challenges facing policymakers and engineers both today and in the decades ahead. Therefore more comprehensive and integrated models have been created which have further improved the predictions. Though it has some uncertainties and limitations, it provides valuable insights on how the world's energy systems would need to change to respond to climate change.

Awards and Achievements

Prof. T.I. Eldho
Eminent Water Resources Scientist by Indian Water Resources Society.

Prof. R. Balaji and his students
Marine Engineering Division Prize

Prof. RAAJ Ramsankaran and his PhD student
Popular Science Story with 22nd rank in the DST ASWAR 2018 Science communication Competition.

Prof. RAAJ Ramsankaran and his students
AGU Travel Grants.

Prof. Dharamveer Singh and his students
Bihar PWD medal for best paper on road research by Indian Road Congress.

Prof. Dharamveer Singh
CTRG student paper award

Prof. B. V. S. Viswanadham
ISIGS- Smt. Indra Joshi Biennial Award

Prof. V. Jothiprakash
`Achivement Award for Academician' by Construction Industry Development Council (CIDC).

Prof. Ashish Juneja
Best paper award in IGC-2018, IISc Bengaluru

Prof. Subimal Ghosh
IITB Research Publication award & IRCC research award

Prof. Manasa Ranjan Behera
Prof. R J Garde Research Award 2018

Prof. Prakash Nanthagopalan
Excellence in Teaching Award 2018

Prof. J Indu
Venus Young Faculty Award,

Prof. Manish Kumar
STSI Indo-Japan Award

Prof. Albert Thomas
Young Faculty Award, IIT Bombay

Prof. E.P. Rao
Excellence in Teaching Award, IIT Bombay

Prof. Riddhi Singh
Editorial Board of Climate Risk Management.

Students' Achievements

Sayantan Chakraborty

Awarded the Best Paper Presenter Award

Conference
Indian Geotechnical Conference 2018 (IGC-2018), Indian Institute of Science, Bengaluru
(13 - 15 December 2018)

Name of the paper
Effect of variation of in-situ moisture content on pullout capacity of grouted soil nail

Authors:
Avishek Ghosh (M.Tech student),
Sayantan Chakraborty, (Research scholar),
Ashish Juneja, (Professor, Civil Engineering Department)

Gowri Shankar
Rameeza Moideen
Maneesha Sebastian
Vivek Francis

Received the OMAE fellowship by the American Society of Mechanical Engineers (ASME)

Rajashree B. R.

Received the Berkner Fellowship by the American Geophysical Union (AGU)
&
Early Career Fellowship from the European Geosciences Union (EGU)


INTERN EXPERIENCES

Aditya Biniwale (UG 4th Year)
Summer Internship at
University of Alberta, Canada

Background

Owing to my interest in exploring the field of research and to experience the fun of working in a multicultural environment I did my 2nd-year summer intern at the University of Florence in Italy. At that time, I was unsure whether I would pursue the field of research further and go for higher studies or to take up the non-core sector (though I must admit that I was more inclined towards the non-core sector). The work I did there even confused me further as I found the work really interesting and my inclination was then towards the field of research (though still unsure).

Selection & Process

Unsure of whether I would like to go for research or a non-core(finance based) internship, I did apply for both and got selected for the UARE program of the University of Alberta through the PT cell. The selection was done purely based only on resumes and no interviews were conducted. We were awarded a scholarship of 6000$ for the entire project. Application for the Visa was pretty simple as we just had to follow the given procedure and the paperwork was considerably less.

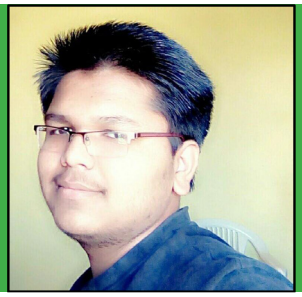
The Project

The topic of my Project was Design of Prototype Pipeline System. Unlike its name suggests it was not a completely civil design project. It involved a few concepts of fluid for the designing of the prototype but also involved a lot of concepts from PID controller design. What we typically had to do was to model the flow of an industrial pipeline system, say for example crude oil transportation pipeline system from Edmonton to Vancouver and control the output at the distribution terminal using a microcontroller flow meter sensors and pumps.

Life at Edmonton in General

Canada totally lives up to its expectation of being a very cold place with very warm and polite people. It was summer and the temperatures were soaring as high as 10 degrees (yup an irony). Combined with its ever so strong and chilly winds it took me a bit of time to get comfortable with the weather. But once you are accustomed to it, ohh it is such a wonderful feeling. You have really long days from 5 am to almost 11 pm not too sunny not too chilly and you can hang out with your fellow interns all evening. University to Alberta did host us really well with arranging few personality and research development sessions and not to mention, the trips to the national parks. To conclude, the experience was a really wonderful and fulfilling one where I could explore the field of research and also was able to work with people from different cultural backgrounds having research interest.

Shubham Barkale (UG 4th Year)
Summer Internship at
Hong Kong University of Science and Technology



Introduction

Owing to my keen interest in research and desire to explore the world, I had the ambition to work in a foreign university. Thanks to my recent projects and decent academic record, I received a summer internship offer from Prof. C K Y Leung at the Hong Kong University of Science and Technology. All I knew about HKUST before joining was Its academic reputation as well as the multicultural environment.

After Arrival

After a few months of waiting and loads of shopping, the day of departure arrived. Travelling first time abroad, I was very excited but with a tinge of nervousness. I reached Hong Kong on 9th May, Friday. Looking at the beautiful campus situated on the hillside with a calm seashore, I forgot myself for a moment. After completing all the registration formalities on the same day, I had the weekend off before starting my project. There was enough time for getting familiar with the local culture. I visited local markets as well as the places of local attraction where I was amazed by the culture of discipline which is seldom observed in India.

The Project

My project was entitled as "Self-healing strain-hardening cementitious composites for a leak-proof basement application." First time I was introduced to ECC, an optimum concrete composition having a very high tensile capacity as well as ductility. Using very sophisticated machines available in the lab, I analyzed the properties of various ECC mixes, their performance in direct tension and flexure to check the requirements suggested by NAMI (a company of construction materials) which was funding the project.I also developed an algorithm (analytical model) using MATLAB to predict the behaviour of ECC beams under various loading scenarios and suggested the best possible design using experimental strain-strain behaviour of ECC. The same analysis was published in the conference paper and journal awarding me co-authorship of both. Over time, I also attended official meetings with NAMI where I explored how things work on the industrial level and how industries adopt research work done in the lab. I was fortunate to meet Prof. Victor Li (University of Michigan), who is the inventor of ECC during his visit to HKUST.

Travelling Experience

My weekends were usually off and that gave me ample chances to visit many places in Hong Kong. There are many beautiful islands, each one showing its heritage and are easily accessible by ferry. Victoria peak, from where you can see whole Hong Kong bathing in colours of the night. Cable cars from the tip of one hill to another with clouds all around was a thrilling experience. Breathtaking rides of ocean park and unique experience in

Disneyland are worth remembering. Being vegetarian I couldn't relish much of Chinese cuisine but whatever I tasted was delicious.

Last Note

I believe that I had the best time in Hong Kong. I would like to encourage all for university internship which will provide a golden chance to get more insight into one's interest and a chance to fly around the globe.

Apoorv Srivastava (UG 4th Year)
Summer Internship at
École Polytechnique Fédérale de Lausanne(EPFL)

Introduction

Having done projects in the department and owing to my budding interest in the field of non-conventional structures with moving members or so as to say 'Active Structures' I started looking for possible research opportunities in this field. I started scouting through google scholar profiles of the professors who were working in the field of active structures. I found four professors, mailed them by the end of September and received a positive response from two. Having considered the pros and cons of the two, I choose one of them and was looking forward to it. Things were going well until I received a mail from lab secretary saying I won't be receiving a stipend and things started to go downhill. This was in mid-February, I did not apply for other universities that come through PT cell and had already rejected the MITACS selection (owing to my specific interest) and this left me devastated (#Tip1: Always Keep Options). However, after me explaining everything to the professor, he agreed to pay me the required stipend. And everything was green again.

After Arrival

I arrived at Geneva airport and headed straight to my place. Next day I reached the lab and was awestruck by the humongous lab (the lab was equal in size to three times that of our department and with huge models, tools, and what not).

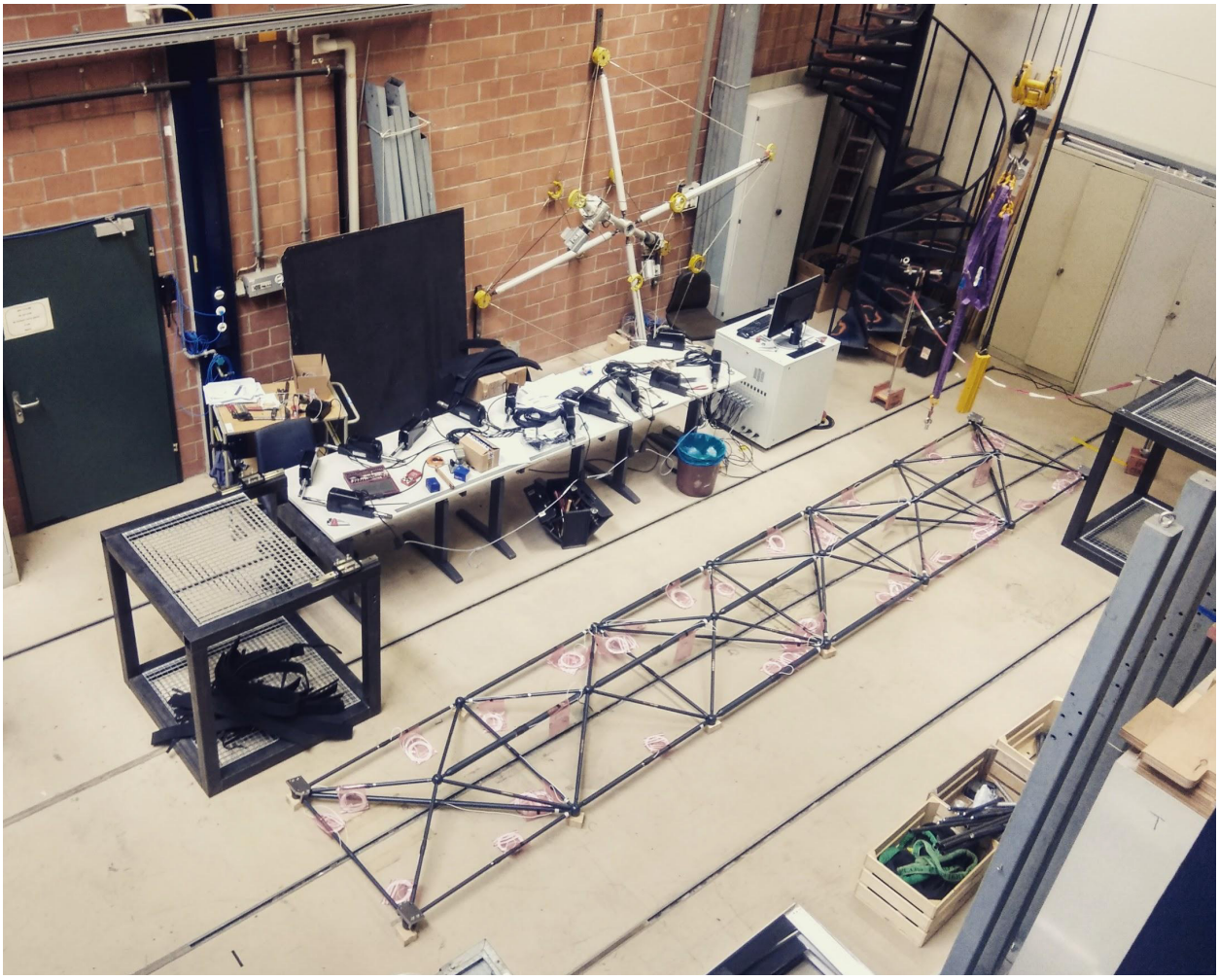
Work Experience

The days passed by, I worked during the week, travelled on the weekends. I was working on a control problem which involved structural control and optimization, making it quicker and ready to use in real-time and at the same time, I was helping in assembling the prototype (It is beautiful). The work environment was very nice, everyone was cheerful and friendly (Though not knowing french proved to be a bit of inhibitor in socializing). I went on some amazing treks in Switzerland (#Tip2: If you visit Switzerland, I suggest you do some treks rather than visiting many cities), few cities in France and Switzerland. I was travelling alone and this has its own pros and cons (the biggest one being there's no one to take your picture). In the end, In a meeting, I explained my progress and results obtained and was thrilled when I got to know that I will be a co-author on one of the research papers.

Conclusion

To conclude, It was a wonderful and fulfilling experience. Staying away from friends and family, I missed them sometimes but then you can always find something to do. I brought some Ready-to-cook food packets with me but didn't like them much, so I did some cooking as well. However, I tried local food and liked it too (Still missed the spices

though), so the food was not a problem for me. Everything is expensive here, so before going back I feel richer already. I'll suggest that if you want to do a research internship, be sure that it will be an awesome experience. Send your emails (If apping) wisely (#Tip3: Don't Spam) and best of luck.



The structure I was working on (If this is not cool, I don't know what is!)

Tanay Wagh (UG 4th Year)
Summer Internship at
Mumbai Railway Vikas Corporation

Introduction

Hey all!
My name is Tanay and I have recently completed my third year of Civil Engineering. As everyone knows, while pursuing civil engineering, one can make his/her career both in the core or non-core field. After completion of my second year, I made my mind to continue in civil core as I felt our core courses to be very interesting. I developed a huge interest in the courses like DOS I, DOS II, structural Mechanics and hence I decided to make my career in structural engineering. I have recently converted into a dual degree(B. Tech+M.Tech in five years) as well.

Procedure

The procedure for pursuing a credit-based internship is quite simple. You should be doing an internship in the core industry and it should be of minimum two months long. You just need to talk to the professor(He/She should be of the same field in which you are doing your internship) before the start of an internship and have to submit a report/Ppt (or both) at the end as per the professor's requirement. I had applied for this intern through PT cell and selection was totally based on resume and statement of purpose.

Intern Experience

Coming to my intern at Mumbai Railway Vikas Corporation(MRVC), it was altogether a pretty awesome two-month experience. I along with four other interns got selected as a Trainee for 8 weeks long internship program. The most important thing about this internship was that one can tag it as a credit-based internship. So, along with learning of the core field, one gets the advantage of completing one of the department electives. During my internship, I worked on three different projects. Construction of 5th and 6th line between Kalwa and Mumbra station, Construction of railway flyover near Mumbra station Design and construction of FOB's (Foot over bridges) First two projects were work on-site while the third project was designing a foot over bridge using STAAD software and its construction at the site. Out of the eight weeks, I utilized the first two weeks for designing a FOB using STAAD software where I had to go to the Design Cell of Mumbai Railway situated at CST station. The next six weeks were the execution of the work on different sites. One of the best parts of the internship at MRVC was that mentors that had been assigned to us were very helpful which helped me to clear all my doubts. For the first two weeks, I along with my co-interns had to reach CST by 11 am so we used to leave the campus by 9.30 am. We usually return by 6 pm in the evening. From the 3rd week onwards, work was not much hectic as it used to be. On average, we worked daily for 5 to 6 hours. Our mentor used to keep track of our work weekly by conducting a meet where we had to present our work. At the end of the internship, we gave a detailed presentation and submit a report of the work that we had done.

End Note

I think this internship was a huge learning experience for me. It not only helped me in learning civil engineering related stuff but also in improving my skills. Making a proper report, presenting the work, interacting with different people eventually helped me in building my enthusiasm for learning new and interesting things. And yes!, traveling in a local train was indeed hectic but joyful. I really hope that next year guys feel and enjoy the work the same way as I did during this internship.

Yashwanth Gunuputi (UG 4th Year)
URA Awardee for Research Project in
Building Materials & Construction

Introduction

Hi, I am Yaswanth gunuputi, 4th year undergraduate student of civil engineering department.

Interest

The interest in Construction Technology and Management trails back to when I took courses of Building Materials and Concrete Technology during my past semesters and it amazed me a lot. My theoretical knowledge got reinforced with practical experiences when I carried out experiments in Estimation and Materials Testing Lab during my summer in 2018.

Project

I was involved in a project on pervious concrete under the guidance of Prof Prakash Nanthagopalan in which we studied the feasibility of the use of performance enhancers like fly ash, slag, silica fume in improving the properties of pervious concrete.I conducted tests for 7 and 28 day's compressive strength, flexural test on cubes, tile and examined the dependence of the amount of fly ash and silica fume on the properties and also Investigated mechanical properties of pervious concrete tiles for withstanding light to moderate traffic conditions by riding a car over the 4 tiles of dimension 28cm X 28cm X 5cm. Initially I thought of doing this project for 2 months only but as time passed on, I continued for 6 months. Impressed by work, Prof. Prakash Nanthagopalan recommended me for URA 01. My interest and ability to manage time with research activities can be ascertained from the fact that I had received the Undergraduate Research Award for my research work in the field of Construction Materials.

POEMS

अगर दुनिया एक मंच है और हम सब इसके कलाकार,
तो इसका कोई दर्शक भी होगा,
उस दर्शक की कलम से इस मंच का वर्णन :

मैंने दोस्ती को टूटते देखा
दुश्मनी को पनपते देखा,

मोहब्बत को बिख़रते देखा
नफरत को फैलते देखा,

सम्मान का दम घुटते देखा
अपमान को सर चढ़ते देखा,

चालाकी की गहराई को देखा
मूर्खता के शिखर को देखा,

विचारो के घमासान को देखा
अर्थ का अनर्थ होते देखा,

बात का बतंगड़ होते देखा
राई का पहाड़ होते देखा,

अंगारों को आग होते देखा
पिघलते को पत्थर होते देखा,

अपनों को पराया होते देखा
चेहरों पर से नकाब उतरते देखा,

गड़े मुर्दों को उखड़ते देखा
असलियत को बाहर आते देखा,

मैंने इंसान को हैवान होते देखा,

सच्चाई को जंग लड़ते देखा
डर को निडर होते देखा,

दर्द को शब्द बनते देखा
शब्दों को तीर बनते देखा,

मौन को आवाज़ बनते देखा
आवाज़ को शोर बनते देखा,

उँगलियों को मुट्ठी बनते देखा
मुट्ठी को ताकत बनते देखा,

और आख़िरकार मैंने गलत को गलत होते देखा |

~Lavish Pankaj
(B.tech 4nd year)

लफ्ज़

अपनी सोच को तहजीब सिखा रहा हूँ,
दो लफ्ज़ लिखनेकी कोशिश कर रहा हूँ..

युं तो अल्फाजों की बहोत कमी है मेरे पास,
जज्बातों से ही सही
काम चला रहा हूँ..

माना की वो नमक मेरे लिखावट मे नहीं,
पर लफ्जों की मिलावट मेरे फितरत मे भी नहीं..
काश दर्द के भी दुकाने लगतीं इन बाजारों मे,
तो मेरे जैसा सौदागर
इन्हें कहीं मिलता ही नही...

मुसाफिर

उम्मीद ना छोड ए मुसाफिर
ये इज्हार का रवय्या सख्त लगता है

दिल की आवाज जुबां तक पहुंचने मे
थोडा ही सही पर वक्त लगता है...

दिल की आवाज

दिल की आवाज को दिल मे ही थाम रखो
ये दिल ही कम्बख्त सख्त लगता है

जज्बातों का कब्रिस्तान कोई हमे भी दिखा दो
कुछ उम्मीदों को दफनाना अब
हमे अपना फर्ज लगता है...

~Asim Mulani
(M.Tech 2nd year)

POEMS

मेरे गांव का बचपन याद आता है

वो छोटी सी चारपाई , और खुले आसमान में सोना
वो टिमटिमाते हुए जुगनू , और 'चंदा मां दूर के गुनगुनाना '।
वो बचपन की दोस्ती , दादी माँ का कहानियाँ सुनाना
वो आराम की नींद और सुबह खेतों पर जाना ।
वो गुल्ली डंडे का खेल और टुबवेल से नहाना
वो नीम का टूथब्रश और चिडियो को दाना खिलाना ।।

"मेरे गांव का बचपन याद आता है "

वो सावन की बारिश , बारिश में नहाना
वो महिंद्रा का ट्रैक्टर , और बैलो का हल चलाना ।
पेड़ पर पड़ा वो झूला , और चिडियो का चहचहाना
वो राजा रानी की कहानी और मम्मी से रूठ जाना ।।

"मेरे गांव का बचपन याद आता है"

वो रंग बिरंगी तितलियाँ , और सुबह मंदिर में जाना
वो B &W टीवी, और अन्टेने का घुमाना ।
वो छोटा सा खिलौना , मेले से लाना
वो सर्दी वाला जुकाम , और डॉक्टर अंकल का आना ।।

"मेरे गांव का बचपन याद आता है "

वो होली का त्यौहार , वो शादी बारातें
वो चहकता हुआ दिन , और शांत सी रातें ।
वो हरा भरा खेत , और किचन का धुआँ
वो मीठा सा पानी , वो शिव मंदिर का कुआँ ।।

"मेरे गांव का बचपन याद आता है "

ये नौकरी शहर में खींच लायी
पर दिल हमेशा गांव का गाना गाता है
"मेरे गांव का बचपन याद आता है "

~Shekhar Singh
(Tech. Supdt. Hydraulics lab)

मै खुद मे खुद को ढूँढ नही पाता
वो मुझमे पूरा जहान ढूँढती है
एक लड़की है, जो मुझमे भी इंसान
ढूँढती है

कहती है, दोस्त है हम
पर मेरे प्यार मे भी वो थोड़ा
इमान ढूँढती है
पर जब रातें सर्द होती है
वो जलाने को मेरे अरमान ढूँढती है

अपनी हीं अलमारी मे
वो अपने हिस्से का सामान ढूँढती है
यहाँ दिल मे पूरा शहर उसका है
और वो पागल रहने को मकान ढूँढती है

कद मे छोटी है वो
पर कारनामो मे बड़ी नजर आती है
मैने इक अरसे से खुद को देखा नही
मुझे तो आइने मे भी वो परी नजर आती है

कभी-कभी मुझे जलन सी होती है
उसके उस कंघे से,
जो उसकी झुल्फें सँवारता है
या फिर उसका वो आइना,
जो सिर्फ उसे हीं निहारता है

उसका वो काँफी का मग
जिससे वो अपने लबों को मिलाती है
या फिर उसका वो टेडी
जिसे वो अपनी बाँहो मे पकड़ बैठ जाती है

इन छोटी-छोटी बातों मे भी वो
अक्सर अपना गुमान ढूँढती है
एक लड़की है, जो मुझमे भी इंसान
ढूँढती है

~Rajiv kumar
(M.Tech 2nd year)

POEMS

Sound Of The Rain

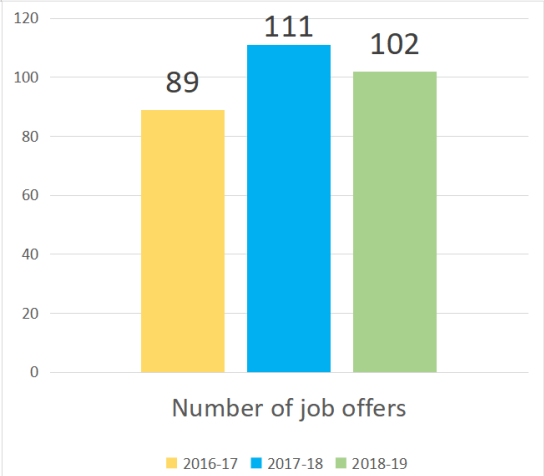
The sound of the rain,
That whispers through my ear,
The joy & pleasure of 'nature',
On having the heavenly meet,
With their love and the beloved..the rain..

The storytelling continues & I listen dumb,
While the rain & nature's senses go numb,
They hold each other's hand,
Going wild, surrounded by sand,
On seeing two couples' together once again,
"Love is Eternal" cries the rain.

Their love is what woke up the poet again,
His pen goes on in a way which is insane,
He thanks the rain for spreading love and joy,
Up goes the rain saying
"Keep Calm & Enjoy"..

~Rishabh Sharaff
(UG 2nd year)

Placements Statistics



Program	Participated	Placed	Percentage Placed (%)
B.Tech	82	67	81.71
M.Tech	39	32	82.05
PhD	4	2	50
Dual Degree (B.Tech + M.Tech)	2	1	50
Total	**127**	**102**	**80.31**

The placement statistics of students include all domains of jobs offered during the placement season of the years shown.

Batch of 2019 Ph.D.

1 Sreekumar M.
2 Patil Amol Ashok
3 Rajasree B. R.
4 Bollapragada Gopi Krishna
5 Agnes Anto C
6 Patil Kalpesh Ravindra
7 Partha Pinaki
8 Yebeltal Zerie Beju
9 Mohammed Aslam A. K.
10 Deba Datta Mandal
11 Sahana A. S.
12 Karan Gupta
13 Mane Abhinav Sonaji
14 Ajugia Mayank
15 Narendra Hengade
16 Sathish Kumar S
17 Dillip Rout
18 Sharad Patel
19 Abebe Worku Mekonnen
20 Shinde Shrikant Tanaji
21 M.B. Sushma
22 Shreya Shripad Kaduskar
23 Gourab Sil
24 Pushpa Choudhary
25 Uma Chaduvula
26 Alice Thomas

Batch of 2019 Dual Degree

1 Kshitij Vijayvargia
2 Siddharth Keshan
3 Subhrangsu Saha

Batch of 2019 M.Tech

1	Jaikishan Damani
2	Oormila .R
3	Yewale Akash Dilip
4	Paithankar Priyanka Vilas
5	Shubhankar Tiwari
6	Chintawar Soham Satish
7	Rashmeet Kaur Khanuja
8	Bharat Kumar Bhadrecha
9	Vishal Anil Wanode
10	Kondalwade Ashish Vijay
11	Amandeep Kalra
12	Bibin Benny
13	Deepak Kumar Sharma
14	Archita Gogoi
15	Soumyajyoti Ghosh
16	Ankit Kumar
17	Juhi Sharma
18	Bharti Banshiwal
19	Arvind Kumar
20	Vikram Singh Chandel
21	Shivakant Singh
22	Ashish Singh Thakur
23	Shefali Sankhla
24	Ramesh Kumar Pandey
25	Aswathi Sebha John
26	Chava Sankeerthana
27	Aiswarya P S
28	Gupta Ravindra Kumar Omprakash
29	Ruikar Suyog Sureshrao
30	Mujeeb Ul Haq
31	Pratiksha Prabhakar
32	Pradip Kumar Maity
33	Abhishek Kumar Dixit
34	Suggala Sai Chaithanya
35	Babu Lal Daga
36	Sajal Jain
37	Akash Deep Singh
38	Priyanshi Singh
39	Deepa Tomar
40	Mrinal Jyoti Mahanta
41	Poojari Dheeraj Rama
42	Manish Kumar Jangid
43	Sunil Suthar
44	Anju B Sunil
45	Uday Singh
46	Nishant Kumar
47	Rudra Vamshi Krishna
48	Sangharsh Vasantrao Meshram
49	Dhavale Mayuresh Vijay
50	Parvesh Deepan
51	Shruti Dhruw
52	Mathew Isac Puthenangady
53	Prasun Kumar Vatsh
54	Varne Kapil Chandrakant
55	Chhigan Lal Sharma
56	Anuj Angad Awad Shrivastava
57	Vartika Tomar
58	Raghavendra G Patil
59	Priyankshu Protim Deori
60	Savla Parth Rajendra
61	Sagar Rajkumar Madnani
62	Vaishnav N Peethambaran
63	Sankarlal R
64	Kumar Sujay
65	Amarnath P
66	Indresh Kumar
67	Shah Harsh Girishkumar
68	Prajapati Dhaval Rameshbhai
69	Yaduvansh Krishnakant Sharma
70	Sujoy Anirudha Das
71	Shivkumar Havagirao Malbhage
72	Sadanand Govilkar
73	Pravin Dattatraya Kotkar
74	Himanshu Rai
75	Mohammed Asfand Yar

Batch of 2019 B.Tech

1 Rana Sanjeevkumar
2 Manthan Shingala
3 Utkarsh Yadav
4 Kevin
5 Jetley Vishal Ashok
6 Neeraj Santosh Ahire
7 Soham Khadatare
8 Meena Rahulkumar Sureshchand
9 Pranay Bharat Raut
10 Manasi Sanjay Khade
11 Mrinal Dharmik
12 Rambhia Manit Ketan
13 Kunal Jain
14 Nihal Kumar Singh
15 Kulkarni Shounak Devendra
16 Akshay Chordiya
17 Shubham Nayak
18 Sant Varun Uday
19 Nikam Karan Mangesh
20 Borse Dnyanesh Vijay
21 Hardik Patil
22 Ketan Jadhav
23 Patil Sairaj Panditrao
24 Nagargoje Akshay Atmaram
25 Ritesh Burde
26 Shivani Digambar Sontakke
27 Ujwal Bagrodia
28 Mohit Udenia
29 Mohit Barupal
30 Sahas Aggarwal
31 Jai Toshniwal
32 Aman Mehta
33 Chetan Sharma
34 Ashwini Kumar Singh
35 Anant Jain
36 Himanshu Jotaniya
37 Ankur Wahane
38 Ashish Kumar Meena
39 Devesh Kumar Meena
40 Jai Prakash Meena
41 Pradeep Kumar
42 Abhishek Nagar
43 Dhiraj Soni
44 Sandeep Sirodia
45 Ajay Suwalka
46 Himanshi Garg
47 Saloni Shah
48 Vaishali Agrawal
49 Shalu Panwar
50 Kajal Kumari
51 Saloni Choudhary
52 Neeraj Kumar Meena
53 Vikas Meena
54 Anil Kumar
55 Chandrabhan Singh
56 Shreyansh Mehta
57 Aadityaveer Singh Rathore
58 Aayush Dhoot
59 Tapesh Rawal
60 Sawan Kumar Soni
61 Shyam Sundar
62 Tushar Chauhan
63 Neeraj Meena
64 Aadhar Khajanchi
65 Aditya Nahata
66 Yugansh Keshwani
67 Anushk Shukla
68 Piyush Kumar Soni
69 Rohit Patidar
70 Devesh Patidar
71 Deepika
72 Utsav Khinchi
73 Sudip Kumar
74 Badal Priyadarshi
75 Shivam Choudhary
76 Saurabh Pandey

Batch of 2019 B.Tech

77 Deepesh Nathani
78 Ayush Pandey
79 Himanshu Roy
80 Priyharsh
81 Mayank Pratap Singh
82 Sabbavarapu Tulasiram
83 Siddhant Jain
84 Sumegh Raj Prashasnik
85 Rupal Sahu
86 Videsh Suman
87 Kumar Priyanshu
88 Achyut Keshav
89 Raushan Sharma
90 Akash Bhairav Gupta
91 Saugata Haldar
92 Velchuri V V V Vani Dhanunjai Guptha
93 Amogha H A
94 Kala Subbarao Medha
95 P Sai Greeshman Reddy
96 Amit Ashok Bhujang
97 Kadarla Hari Kishore
98 Lakhinana Ravi Teja
99 Sudia Sriramsaimanideep
100 Dakka Sricharan
101 Vineet Srivastava
102 Venkatesh .D
103 V M Kaushick
104 Keshav Arora
105 Gurlovleen Singh
106 Shoham Teberiwal
107 Aditya Pandey
108 Janak Agrawal
109 Malviya Jay Hemendra
110 Asha Dhaka
111 Megha Venkateshan
112 Mhaske Sumedh Sukhdeo
113 Harsh Sharma
114 Arihant Parsoya

WORD BY ALUMNI

JAI TOSHNIWAL

EMAIL ID
jai.toshniwal98@gmail.com

ASPIRATION
Want to be a CEO

"Insti memories will be the best memories that anyone will have"

BHARTI BANSHIWAL

EMAIL ID
bhartibanshiwal96@gmail.com

ASPIRATION
Too many

MEMORABLE MOMENTS
TA duties, Site visits, Late night studies and many more.

"Enthu dikhao junta !! Make use of every facility and opportunity you get, which are innumerable in this department."

HIMANSHU RAI

"The exposure to latest technology, conferences and new learnings of the industry is immense. In a nutshell people, experience and learning over two years give a formidable strength. Be your knight in shining armour all your life."

SUJOY ANIRUDHA DAS

"I always attended the cultural events and performed on the stage. Performing in convocation hall was an experience which I will be nurturing my whole life. There is so much to tell... There are so many things I am taking from here. The trips, food, movies, dance rehearsals, ramp walk, photoshoots, all are part of my IIT Bombay life. I want to come back here again and again."

WORD BY ALUMNI

DHANUNJAI VELCHURI

EMAIL ID
velchuri365@gmail.com

ASPIRATION
To play an integral part in the development of Indian Railways

MEMORABLE MOMENTS
Midnight horror movies, Late night meets with friends and night outs before exams.

"It's not what you achieve, it's what you overcome. That's what defines your life."

AMIT ASHOK BHUJANG

EMAIL ID
litamit15@gmail.com

ASPIRATION
To be one of the finest dancers of India

MEMORABLE MOMENTS
Transportation class project and the Freshie year civil trip

"Study hard but always follow your heart !"

AAYUSH DHOOT

EMAIL ID
dhootaayu@gmail.com

ASPIRATION
To be a successful person with lot of experience & knowledge :-)

MEMORABLE MOMENTS
Aakaar, Department Goa Trip with seniors, kurta days, fun during labs etc.

"Civil chill nahi hota guys, and civil main bhi scope hota hai. :-p"

RITESH BURDE

EMAIL ID
riteshburde@gmail.com

ASPIRATION
Being in a C-suite position of a firm

MEMORABLE MOMENTS
Hostel room talks, long walk from H6 to lecture hall, playing cricket on lush green ground

"Thank you IIT Bombay for the wonderful experience"

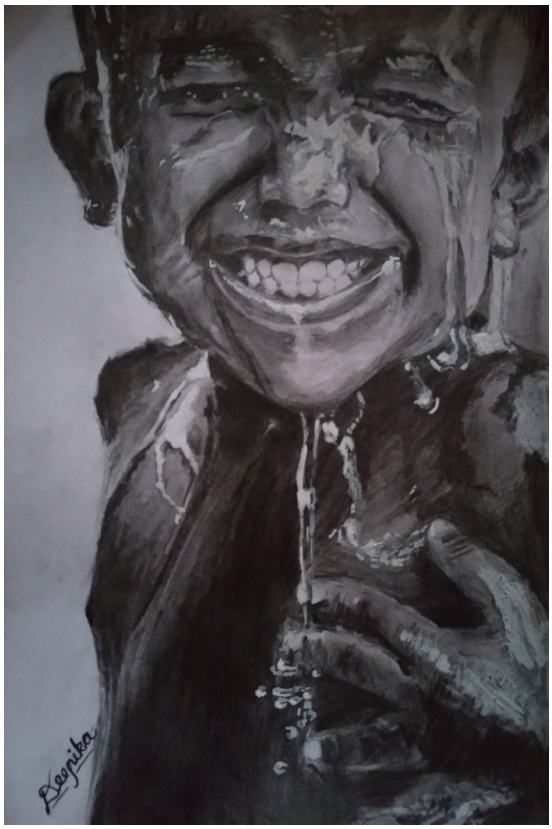
SKETCHES

Dipika Ratohd (UG 2nd Year)

Amar Kanth Jaiswal (M.Tech 2nd Year)

Pratik Naravane (Tech Assistant)

SKETCHES



Dipika Ratohd (UG 2nd Year)

B Priyanka (UG 2nd Year)

GALLERY

STUDENTS TRIP

GALLERY

TRADITIONAL DAY

GALLERY

SPORTS WEEKEND

VALEDICTORY FUNCTION

BATCH OF 2019