Civil Engineering Forum
IIT Bhubaneswar

INFRA-READ

Civil Enginerring Newsletter

The Dawn of
Rising Technology

CONTENTS

Dr. P.Dinakar

HOS, School of Infrastructure, IIT Bhubaneswar

The Civil Engineering Forum (CEF) of IIT Bhubaneswar was established very recently with the primary motive of exposing potential civil engineers to the challenges of the profession they are in. With both students and the faculty as its members, the association very soon will become one of the most active Civil Engineering Forums in India. The maiden event CIVISTA-22 of the School of Infrastructure will organize activities like lectures by distinguished practitioners of the profession, video shows, competitions, and socially relevant projects for the students. The CEF engages itself in the lively interaction between the students and faculty as well as with the industry. The CEF activities of a year culminate in the CEF Fest. The CIVISTA-22 will attract people from all over India and acts as a launching platform for budding civil engineers to showcase their talents in various competitions and they will be awarded too. I wish the students and the faculty the very best for the maiden event CIVISTA-22.

Dr. Devesh Punera

President, CEF

I'm extremely happy to see the first newsletter of the Civil Engineering Forum (CEF) take shape. The newly established CEF aims to create a strong and enriching ecosystem of civil engineering education at IIT Bhubaneswar. The idea of a newsletter becomes very important to realize this endeavour. I am happy to learn that students, faculty members, industry partners as well as our alumni could contribute to the first edition of this newsletter. We hope the activities of the civil engineering education at IIT Bhubaneswar, changing technological aspects from the field and research will find a wonderful space in the form of this newsletter. Our first civil engineering festival, Civista'22 is just around the corner and it feels great to launch this first edition of the newsletter during the Civista'22.

Dr. Anush Konayakanahalli Chandrappa

Vice President, CEF

Civil Engineering Forum (CEF) is a recent initiative from School of Infrastructure to accelerate industry-academia interaction. The civil engineering domain needs a constant exchange of technical know-how and practical experiences among its stake holders and that's where CEF plays a major role. It provides an arena for the students, faculties and industry experts to collaborate and share their experiences. In this regard, CEF has come up with its first edition of CIVISTA'22, the civil engineering fest. CIVISTA'22 is mainly organized by student body of CEF as directed by the faculties. A plethora of events have been organised in CIVISTA'22, including guest lectures, design competitions, start-up think tank, etc. It is anticipated that CIVISTA'22 provides a stage for the young budding civil engineers to innovate and build. In addition to the fest, CIVISTA'22 will also be publishing it's first Magazine "Infra-read", which has interesting articles, alumni interviews, etc. I wish all the stake holders a grand success for the first edition of CIVISTA'22.

BRIDGE ENGINEERING : CONNECTING THE WORLD

Anurag Barman, Akash Sahay
First year UG student of School Of Infrastructure
IIT Bhubaneswar

Figure 1.

Bridge Engineering is an interior discipline of Civil Engineering, the study of which involves planning, designing, construction and maintenance of bridges. For the modern world which is continuously being globalised, it is especially important to ensure safe and secure transportation for public for general as well as business purposes. Construction of bridges in the areas containing geographical obstacles (most commonly rivers) provide adequate transportation without causing any harm to the river and the life existing there.

The idea of construction of bridges is not new to the human civilization. Fallen trees or stepping stones are the most common examples of basic bridges that had been under usage by people for centuries. Like most other human inventions, the bridge construction ideas have also evolved and has reached new heights as per the demands of the modern world. From Engineering perspective, the main motive behind the construction of bridges is to be 'efficient', 'economic' and 'elegant'.

Many different bridge designs are currently under usage on various projects all over the world. The basic forms of bridges are mainly;

(I) Beam Bridges, (II) Truss Bridges, (III) Arc Bridges, (IV) Suspension Bridges, (V) Cantilever Bridges, (VI) Cable-Stayed Bridges and (VII) Tied-Arc Bridges.

The working principle of every form involves the operation of Tensile forces and Horizontal and Vertical compressive forces on distinct parts of the structure.

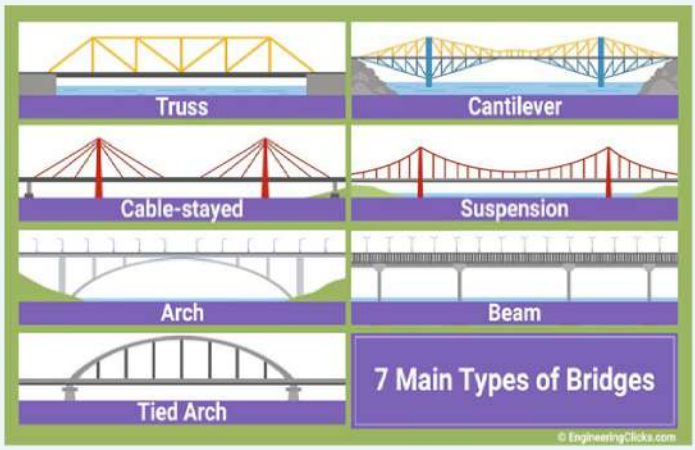


Figure 2.

The Lucky Knot Bridge spans the Dragon King Harbor River in Meixi Lake District Changsha, China. The bridge is 185m long and 24m high. The bridge design is a pedestrian truss bridge. The magnificent Lucky Knot Bridge was designed by Beijing and Amsterdam studio NEXT Architects. It is painted red, a colour which symbolises good luck and happiness in Chinese culture. The Lucky Knot Bridge interacts with its surrounding mountain range and offers a spectacular view of the river.

Figure 3.

An Example of Innovative Bridge Construction

According to John van de Water, partner at NEXT Architects in Beijing, *"The shape of the Lucky Knot was inspired by the principle of the Mobius ring, as well as bythe Chinese knotting art. In the ancient decorative Chinese folk art, the knot symbolises luck and prosperity."*

The lucky knot bridge has one of the most innovative designs in the world and its construction required some very solid infrastructural knowledge and skills. The bridge is made of steel. The bridge become an attraction with its remarkable LED lights show which are set in to the light route that traces the way of the river and brings the bridge to life at night. The bridge was designed with recreational, ecological and tourist activities in mind.

Figure 4.

The bridge connects multiple levels at different heights (the river banks, the road, the higher-placed park as well as the interconnections between them). The final shape of the bridge is the result of literally and metaphorically knotting all these routes together. The construction work started in 2013 and within 3 years, the bridge got completed in 2016. Completing such a design in such a short period of time is a result of remarkable engineering.

Construction Management

Shrikant Lahase

First year Student of School Of Infrastructure

IIT Bhubaneswar

The Art and Science of Managing Design & Construction

Professional construction project management is a super fine-tuned system designed to facilitate planning, coordination and control of a project from the early stages all the way to project closeout and completion. Qualified construction managers use specialized project management techniques to orchestrate a project's schedule, costs and quality. And orchestrate it is.

Imagine that you're underwriting a concert. You have an orchestra and a conductor in mind, a dream program, you know who you want to invite, and you expect flawless execution. But have you thought about all the details? Choice of venue, dates, flying your favorite cellist in from Hungary, personnel, permits, paperwork, rehearsals, unions, sound engineers, media, concert program printing, lighting, the piano tuner, ushers, caterers, etc.? Maybe not. In terms of putting on a dream concert, someone has to manage all that.

And in the world of building a complex construction project, of overseeing the big picture and fine-tuning the details, orchestrating everything is precisely what your construction management team does.

Figure 1.

Construction management is a highly professional system designed to facilitate planning, coordination and control of a project from inception to completion

The members of your team provide managerial expertise. Once a clear vision of your project has been elaborated, they control budgets, initiate cost-saving ideas , mitigate risk and ensure the flow of communication. Their role is to represent the owner's best interests, and they do that by making sure that the project progresses as smoothly as possible according to objectives in terms of time and resources. And they're able to accomplish that because they know how to manage a construction project step by step-it's what they do.

A construction manager's bigger view of the project as a whole is essential in order to manage and coordinate the many project team members, each of whom is focused on their own particular contractual role.

When trying to get a bead on the benefits of commercial or residential constuction management, know that professional construction managers provide services that differ from general contractors'. For starters, they typically do not perform any aspect of the construction themselves, but they do oversee every detail of the entire project—from the initial idea of making that sublime music happen all the way up to vacuuming the aisles, turning off the lights and locking the doors afterwards. Similarly, the construction project manager will support your project from preconstruction all the way to construction waste management and beyond.

For large or complex projects, construction managers are considered fundamental for project success.

What an effective constuction manager does is apply their strong leadership skills and depth of experience to a wide spectrum of projects andconstruction method . They make it their job to monitor the latest technologies and construction management software so you don't have to.

They coordinate all of the many project team members , up to and including the percussion player who tings the triangle.

Qualified construction managers use specialized project management techniques to manage a project's schedule, costs and quality.

There are many requirements for successful construction management, and these can be regrouped under three main categories: cost, scope and schedule. Cost includes the obvious, but it also covers elements that you, the layperson, may not see coming, as well as risk assessment and wiggle room for the unpredictable. Scope is a major element in construction project management. What it means in this context is: what exactly is the owner's program and architect's design intent, and how will it be accomplished? To make this all happen, the services that each team member provides need to be clear everything covered, but no duplications. Who is booking the cellist's hotel room? Who's making sure that all the permits are in order? Who's serving the champagne? If exact roles aren't designated from the get-go, you can expect delays and extra costs while they're determined on the fly. A good construction program team will work with the best construction management software to make certain that every detail of your project is accounted for before actual construction begins. Finally, schedule is a straightforward concept that also requires risk calculations and Plan Bs. Life is unpredictable juggling your/the owner's evolving ideas, new regulations, the contractor's kid's wedding in Tuscany, natural disasters and all the rest is best left to the experts. Trust your construction manager to get things done as well, as quickly and as cost-effectively as possible, so you can relax and enjoy your evening at the concert.

MACHINE LEARNING IN CIVIL ENGINEERING

Anurag Barman, Akash Sahay, Lokesh Sharma, Nikita Mina
First year student of School Of Infrastructure
IIT Bhubaneswar

WHAT IS MACHINE LEARNING?

Machine learning (ML) is seen as a part of artificial intelligence (AI). It Is the study of computer algorithms that can automatically improvise through experience and user data. Machine learning algorithms yield a model based on sample data known as training data to make predictions or decisions without being explicitly programmed to do so. These algorithms find their use in various platforms like medicine, speech recognition, computer vision, etc.

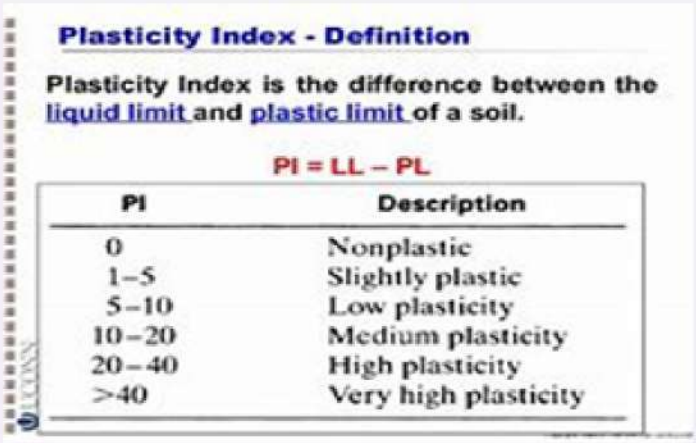
Figure 1.

REQUIREMENTS OF ML IN CIVIL ENGINEERING

Data analysis and prediction have a vital role to play in the field of civil engineering. To keep pace with the world and other engineering domains, the construction industry is using machine learning and other interdisciplinary technologies for data management purposes. The main benefit of using ML in civil engineering is that it reduces the errors in data management and prediction of certain events significantly whereas human agencies involve comparatively more error.

APPLICATIONS OF ML IN CIVIL ENGINEERING

Practical applications of ML are very different from theoretical or empirical studies involving organizational and human aspects and some other constraints too. ML concepts can be used at the beginning of small size projects such as:- knowing about the coefficient of thermal expansion (gamma), getting the idea about compressive strengths of materials, classification of soil type with the use plasticity index and liquid limits, using data of a building for energy variables estimation.



Plasticity Index - Definition

Plasticity Index is the difference between the liquid limit and plastic limit of a soil.

$$PI = LL - PL$$

PI	Description
0	Nonplastic
1–5	Slightly plastic
5–10	Low plasticity
10–20	Medium plasticity
20–40	High plasticity
>40	Very high plasticity

Figure 2.

Source :- https://image.slidesharecdn.com/soilphysics-

Machine learning finds its use in complex civil engineering problems such as drought forecasting, river flow forecasting, modelling evaporation, groundwater level forecasting etc. Parametric and non-parametric ML applications are used in vibration-based structural damage detection. Different techniques of ML is used to solve the major problems in the state-of-the-art expert systems like brittleness, lack of metaknowledge, knowledge acquisition and validation.

Digital images and video clips collected at construction job sites are commonly used for extracting useful information. Exploring new applications for image processing techniques within the area of construction engineering and management is a steadily growing field of research. One of the initial steps for various image processing applications is automatically detecting various types of construction materials on construction images. In one of the research papers, the authors conducted a comparative study to evaluate the performance of different machine learning techniques for the detection of three common categorists of building materials: Concrete, red brick, and OSB boards. The employed classifiers in this research are: Multilayer Perceptron (MLP), Radial Basis Function (RBF), and Support Vector Machine (SVM).

To achieve this goal, the feature vectors extracted from image blocks are classified to perform a comparison between the efficiency of these methods for building material detection. The results indicate that for all three types of materials, SVM outperformed the other two techniques in terms of accurately detecting the material textures in images. The results also reveal that the common material detection algorithms perform very well in cases of detecting materials with distinct colour and appearance (e.g., red brick); while their performance for detecting materials with colour and texture variance (e.g., concrete), as well as materials containing similar colour and appearance properties with other elements of the scene (e.g., ORB boards), might be less accurate.

- **ADVANTAGES OF ML APPLICATIONS**

The adoption of Machine Learning on construction sites has taken the level of safety to new heights.ML can be used to identify, assess, and instantly report any anomaly detected. The application of Machine Learning has made risk assessment faster and way more accurate. Machine Learning programs can look through it to come up with precise and detailed risk assessments. An Autodesk product called Construction IQ helps projects manage and mitigate risk daily and improve performance in real-time. When Autodesk software is used in a construction project, it increases the level of productivity. There are end-to-end systems that use machine learning and sensors to detect and alert companies of fluctuations in equipment vibration or temperature, with no machine learning or cloud experience required.

Machine Learning provides high accuracy, low-cost anomaly detection solutions that can process thousands of images an hour to identify defects and aberrations, and then report the images that differ from the standard to take appropriate action.

- **Conclusion**

In this report, we discussed the requirements, major applications and advantages of Machine Learning techniques in various sub-domains of Civil Engineering. In addition to that, we also cited an example of image processing techniques within the area of civil engineering and management. A civil engineer with an idea of multidisciplinary domains can be more successful in his/her profession. It not only helps the construction industry to develop more efficiently but also leads to more employment of different resources for an efficient and economical solution.

Sources-
https://en.m.wikipedia.org/wiki/Machine_learning
https://cutm.ac.in/study-guide/why-is-machine-learning-important-in-civil-engineering/
https://theconstructor.org/artificial-intelligence/machine-learning-applications-construction/553770/?amp=1#Applications_of_Machine_Learning_in_Construction
https://onlinelibrary.wiley.com/doi/abs/10.1111/0885-9507.00065

Nanomechanics Taking Over!

Nanomechanics is a branch of nanoscience. It studies the elastic, thermal, and kinetic properties of physical systems at the nanoscale. We are poised to unravel the traditional gap between the atomic and the macroscopic world in mechanics and materials. Nanoscale materials, in conjunction with other significant components with different response times. Hence, such systems involve calculations with varied time and length scales.

Nanomechanics allows designing systems with high functional density, high sensitivity, special surface effects, large surface area, high strain resistance, and catalytic effects. Nanomechanics would help civil engineers build lighter structures, stronger structural composites, for bridges and others. Low maintenance coating, Improved pipe joining materials and techniques, Better properties of cementitious materials, Reduced thermal transfer rate of fire retardant and insulation, Increased sound absorption of acoustic absorber, Increased reflectivity of glass, water repellents, nano-clay filled polymers,self-disinfecting surfaces, UV light protector, air cleaners, nano-sized sensors, and solar cells.

This gives us a better understanding to analyze the materials used in civil at a very nano-level. Nanotechnology will soon overtake all fields including civil engineering, and will help us get a sensitive understanding of fundamental properties, roots of the project.

Post-Tensioned Shear Walls

Shubham Tiwari
First year PG student of School Of Infrastructure
IIT Bhubaneswar

Earthquakes and winds are lateral loads that act on the system for a brief period, but they can be devastating if the building is not prepared to handle them. Moment-resisting frames, dampers, shear walls, and other lateral load resisting systems are commonly utilised in buildings. Shear walls have been frequently employed in buildings to resist lateral loads. Conventional shear walls inflict damage to dissipate the energy created by lateral loads. As a result, they will need to be replaced following the earthquake. The downtime of the structures is increased as a result of this. Because society is currently moving at a breakneck speed, structure downtime must be kept to a minimum.

As a result, structures with conventional shear walls have a reusability and sustainability problem. Conventional shear walls are fitted with high-strength post-tensioned (PT) tendons to tackle the problem of reusability. The PT tendons in the shear wall remain elastic, allowing the wall to return to its original position after the lateral load is released. When loads are applied to the wall, it rocks over the base and returns to its original position when the force is removed, providing it with self-centering characteristics (Figure 1). The benefit of PT shear walls is that they are self-centering, making them reusable even after a seismic event. This reduces the structure's downtime and increases its long-term viability.

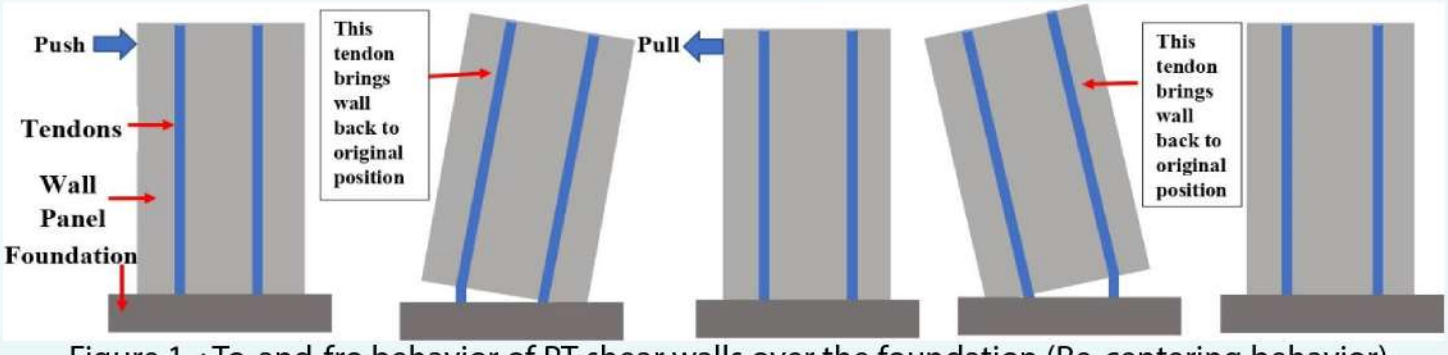


Figure 1. : To-and-fro behavior of PT shear walls over the foundation (Re-centering behavior)

Post-Tensioned Shear Walls

Several configurations of the PT shear walls exist, namely, Single panel (Figure 2a), multi-panel (Figure 2b), jointed (Figure 2c), coupled (Figure 2d), hybrid (Figure 2e), and PreWEC (Figure 2f). Though the problem of reusability is solved by single panel walls yet few issues remain and that is the problem of low energy dissipation capacity, inferior seismic performance in larger magnitude seismic loading, and small height (as we cannot cast a single panel of greater height). The problem of casting as a single panel to achieve greater height is solved by casting multiple panels and joining them one over the other.

To counter this problem the PT shear walls are fitted with energy dissipation devices. These walls are known as hybrid PT shear walls. Due to the use of energy dissipating devices, these walls have excellent energy dissipation capacity. These devices undergo plastic deformation and dissipate the energy coming on the wall due to lateral load thus, protecting the wall from getting damaged.There are a couple of ways in which these dissipaters can be fitted in the wall, either internally or externally.It is preferable to fit them externally because they can be easily replaced once they get damaged.

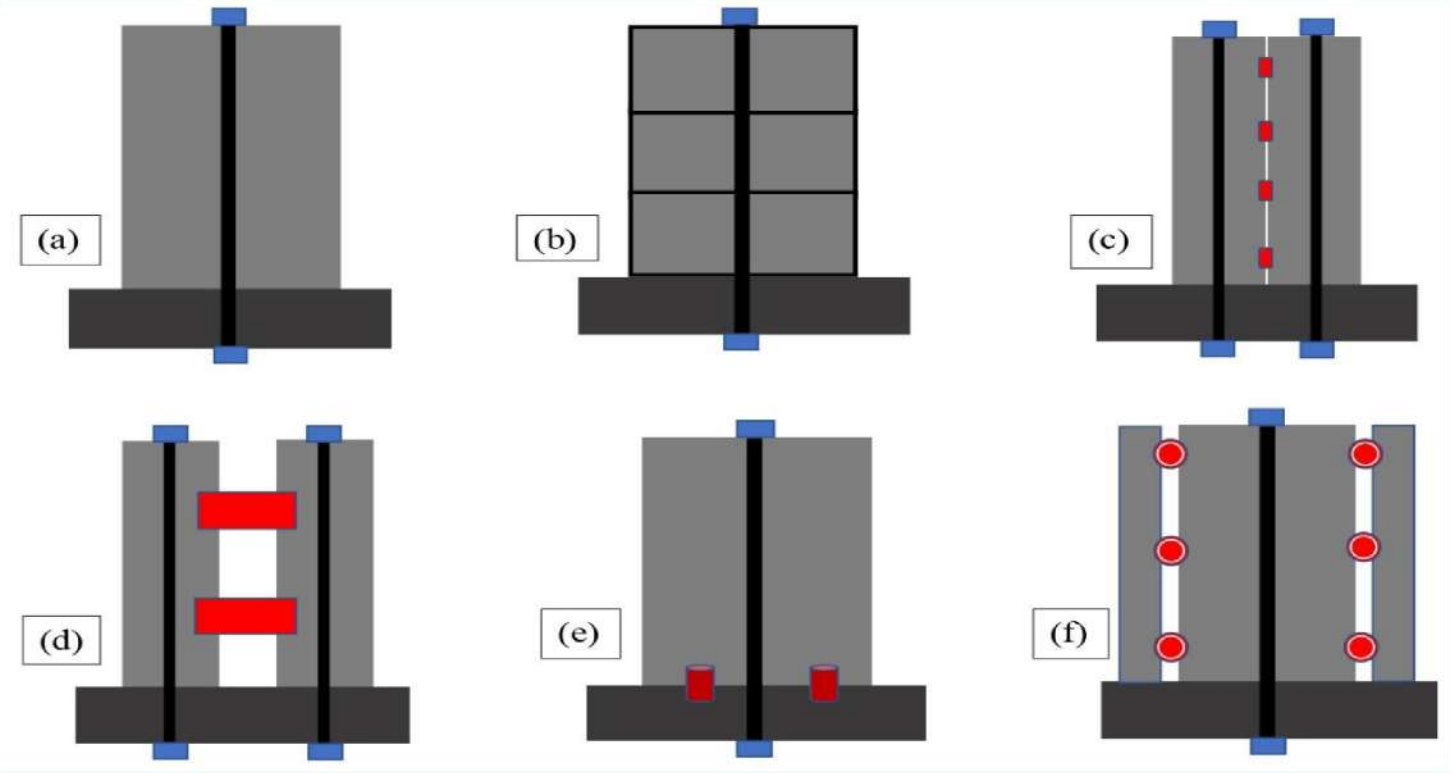


Figure 2. : PT shear wall configuration: (a) single panel, (b) multi-panel, (c) jointed, (d) coupled, (e) hybrid, (f) PreWEC walls

These are known as multi-panel walls. The problem of low seismic performance in larger magnitude lateral loads is solved by joining a single panel vertically to create jointed PT shear walls. In a jointed wall, single panels are jointed by connectors distributed evenly along the height of the wall. These connectors also act as energy dissipators. In the single panel or multi-panel walls, as tendons are in the elastic state, they cannot dissipate energy.

Recently, research has been carried out on a new configuration of PT shear walls known as PreWEC (Precast walls with end columns) systems. PreWEC systems consist of wall panels, PT tendons, O-connectors (energy dissipators), and end-columns. The system shows self-centering characteristics with excellent energy dissipation capacity. In the studies, the PreWEC system has been shown more effective than other PT wall configurations.

Post-Tensioned Shear Walls

Figure 3. :
PT wall integrated into the building frame
(Schoettler et al., 2009)

Figure 4. :
PT shear wall test-setup here at
IIT Bhubaneswar
(Left: PT shear wall, Right: Reaction wall)

All research endeavors are undertaken to solve a problem existing around us and then implement the solution practically. Similarly, PT shear walls have several advantages but they have to be put to use in practical scenarios to extract their benefits. For this PT walls are needed to be integrated into the building frames. Though the reliability of the isolated PT shear walls is well established yet their practical use is still limited. Some research has been carried out to check the performance of the building integrating the PT shear walls (Figure 3) and the results are promising. More study is needed to be carried out to increase the technology readiness levels (TRLs). The research has been extensively carried out in the U.S.A., Japan, and New Zealand. The U.S.A. (ACI ITG-5.1; ACI ITG-5.2) and New Zealand (NZS, 2006) have formulated their codes for the design of PT shear walls. As India is also an earthquake-prone country, research on the PT shear walls becomes of utmost importance. Despite various advantages of PT shear walls, very limited research has been carried out in India. IIT Bhubaneswar is pioneering and taking lead in carrying out extensive research on these walls. Here at IIT Bhubaneswar, a detailed literature review, an experimental (Figure 4), and a numerical study has been carried out on the PT shear walls. Research is underway in evaluating the seismic performance of PT shear walls when they are integrated into the building. To increase the TRL of the technology more extensive and collaborative research is needed to be carried out so that the benefits posted by these walls can be put into practical use. This will extensively benefit society and help us achieve the goal of sustainable development.

References:

ACI ITG-5.1, 2007. Acceptance Criteria for Special Unbonded Post-Tensioned Precast Structural Walls Based on Validation Testing and Commentary. ACI Innovation Task Group 5.

ACI ITG-5.2, 2009. Requirements for design of a special unbonded post_tensioned precast shear wall satisfying ACI ITG-5.1. 2009. ACI Innovation Task Group 5.

NZS, N. Z. S., 2006. Appendix B: Special provisions for the seismic design of ductile jointed precast concrete structural systems, NZS 3101:2006. Concrete standards New Zealand, Wellington, NZ.

Schoettler, M. J., Belleri, A., Zhang, D., Restrepo, J. I., and Fleischman, R. B., 2009. Preliminary results of the shake-table testing for the development of a diaphragm seismic design methodology. PCI Journal, (Winter), 100–124.

Virtual Reality in structural health monitoring

Ageing civil infrastructure systems require attention before any failure mechanism becomes critical. Structural Health Monitoring (SHM) tracks inputs of structural systems to decide if the system is at fault.Inspections and structural health monitoring require field visits, expert assessment of critical elements at site, which may be both time-consuming and costly. Also, fieldwork including visits and inspections may pose danger, require personal protective equipment and structure closures during the fieldwork. To address these issues, a Virtual Reality (VR) collaborative application is developed to bring the structure and SHM data from the field to the office such that many experts from different places can simultaneously virtually visit the structure for final assessment.

In this work, we present an SHM system in a VR environment that includes the technical and visual information necessary for the engineers to make decisions. The field of robotics, vision and inspection provide better means of surface documentation and act as an aid to structural health monitoring. In this VR application, for the visualization stage, UAV(Unmanned Air Vehicle) photogrammetry and LiDAR (Light Detection and Ranging) methods,etc. are used.

The multi-user feature in VR allows teams to collaborate simultaneously which results to be very essential for decision-making activities. In conclusion, the proposed VR environment offers the potential to provide beneficial features with further automated and real-time improvements along with the SHM models.

Emerging Trends in Offshore Geotechnics

Sumanta Haldar
Associate professor at School of Infrastructure
IIT Bhubaneswar

• Abstract

An overview of recent developments in offshore geotechnical engineering and design associated with shallow and deep-water foundations is deliberated. The behaviour of the foundations for offshore structures is challenging due to the complex nature of dynamic loads. The various foundations for offshore structures and design issues are discussed. The importance of research pertaining to offshore geotechnical engineering is evident due to the energy demand globally. An overview of future research directions is also highlighted.

• Introduction

India is venturing into deep and ultra-deep-sea waters for petroleum exploration and production and alternative offshore energy. In offshore geotechnical engineering, a site investigation is expensive, soil condition is unusual, and applied loads are large and complex. These pose special challenges to geotechnical engineers as far as site investigation and foundation designs are concerned. In addition, there are many issues related to shallow water areas which also need attention, update, and further research. There are 26 sedimentary basins in India, covering a total area of 3.4 million square kilometers. The site is spread across on land, shallow water up to 400 m and deep-water farther up to Exclusive Economic Zone(EEZ). Of the total sedimentary area, 49% of the total area is located on land, 12% in shallow water, and 39% in the deep-water (cf. Fig. 1).

Oil exploration in the deep seas is an unpredictable business. More than 100 offshore oil platforms have been installed, and many are in the pipeline. Network of submarine pipelines running into more than 1800 km connecting these platforms. More pipelines are to be laid in the future. ONGC also deliberates

Kerala-Konkan, Krishna-Godavari, and Cauveri basins, could be a vast yet undiscovered entrapment for hydrocarbons. Therefore, the role of civil engineering is going to be increased with time on the continental shelf and deep waters.

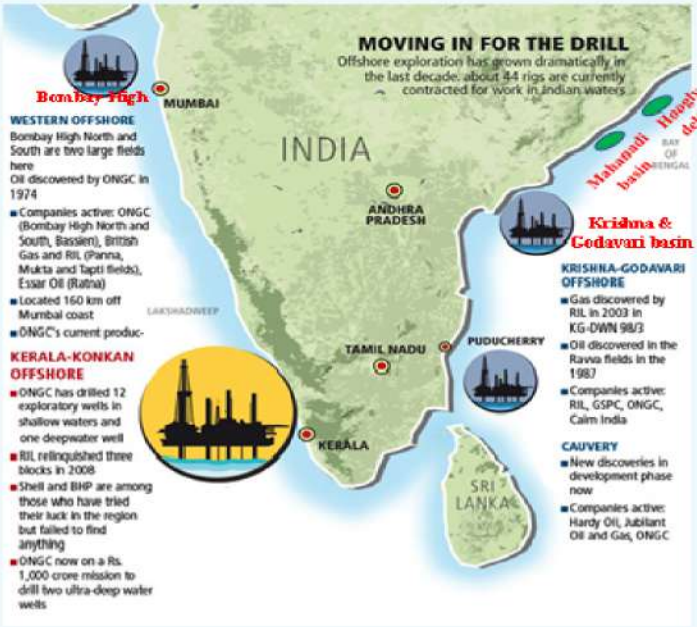


Figure 1. Indian offshore basins (https://www.forbesindia.com/article/big-bet/rigging-the-wild-west/4112/1).

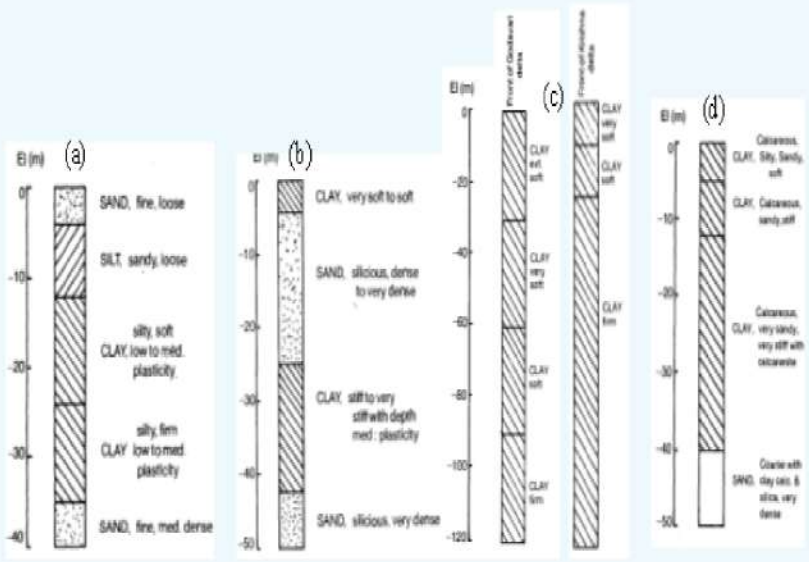


Figure 2. Typical soil profile at Indian offshore: (a) Hoogly delta, (b) Mahanadi basin, (c) Godavari and Krishna deltas, and (d) Bombay-High (Gulhati 1989).

• Soils in Indian Offshore

Soils at seabed are either terrigenic or pelagic (Gulhati 1989). The terrigenic soils originate on land and are transported to sea thereafter. The pelagic soils originate in the sea itself. In Indian offshore, soils are primarily terrigenic in nature and sometimes modified by the ocean environment. Fig. 2 shows the average soil profile based on a few boreholes at various offshore locations of India. Low to medium silty clay is found in the Hoogly delta. The deposits are underconsolidated, and strength varies from soft to firm. Soils near Godavari and Krishna basins are mostly clays and altering layers of sand and clay. The soils encountered at Bombay-High are calcareous sands, clays, and calcareous clays. The strength of this soil varies drastically. The carbonate contents are more in west coast than east coast soils. Soils at the southern tip of India are calcareous, hard, overconsolidated, and cemented (Gulhati 1989).

• Offshore Structures in Shallow and Deep-water

Offshore structures constructed at water depth up to 100 m may be considered as shallow water. The structures in shallow water require a specialized and dedicated approach for the design. The structures in shallow water are less prone to unstable collapse; however, they are subjected to increased flow velocity due to tide and waves. Offshore structures like oil and gas platforms, drilling rigs, semi-submersibles, and jack-up barges (Fig. 3), offshore wind turbines (Fig. 4) withstand complex, combined loading during their entire design life

(Randolph et al. 2005). The anticipated loads on offshore structures include the dead weight of the structure, hydrostatic force, and imposed loads. In addition, the structures are also exposed to complex environmental loading, including wind and wave action combined with strong tidal flows. The primary design considerations are structural stability, foundation design, corrosion resistance, and fatigue life, especially welded joints.

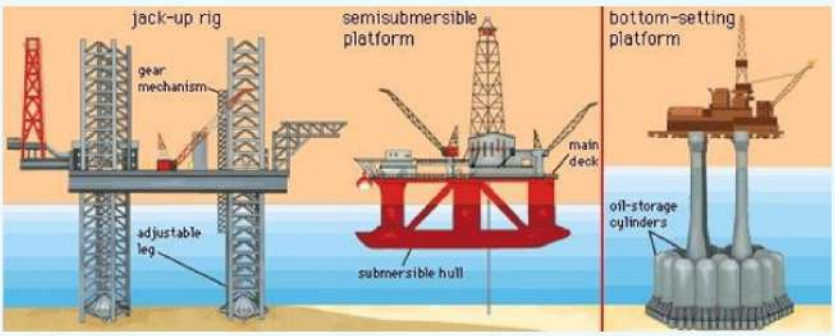


Figure 3. Various offshore structures
(https://www.indelac.com/blog/introduction-to-oil-gas-offshore-drilling).

• Soils in Indian Offshore

The rise in energy demand worldwide has led to petroleum exploration installation of wind energy converters in new regions of the world. The new regions require new design approaches for the new soil conditions. Another inevitable development from shallow to deep water. The installations in 2000 m water in the Gulf of Mexico have been done (Newlin 2003) and deeper fields are being planned at various parts of the world and India. The primary challenges in offshore geotechnical engineering include (i) soil characterization, (ii) changing soil properties, (iii) irregular environmental loading, (iv) long-term behaviour of foundations.

Figure 4(a)

Many offshore sites consist of soft fine-grained sediments, such as very soft clay, or carbonate sediments and silts in some regions. The deposits are formed relatively slowly and characterized by increasing strength with depth. Exploration of those soil samples is extremely difficult. Hence, in-situ testing is preferable, primarily with Cone Penetrometer and full-flow penetrometers. Full-flow penetrometers, ball and T-bar (Fig. 4), are widely used in

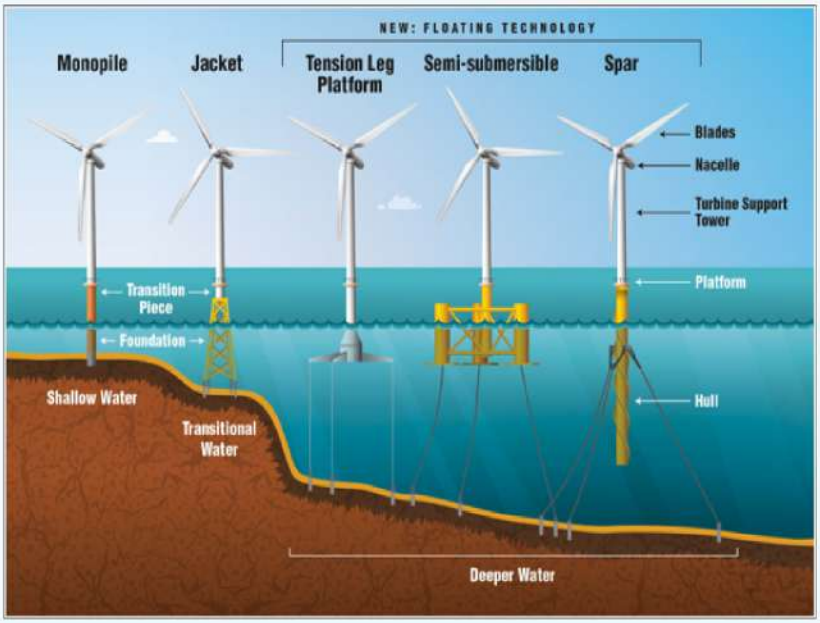


Figure 4. Offshore wind turbine structures

offshore engineering for measuring the shear strength of clayey sediments (Lune 2001, Stewart and Randolph 1994). The penetrometer is pushed into the seabed from the mudline (i.e., seabed), and the shear strength of the soil is derived from the net penetration resistance. Various seabed soil sampling techniques and sample collection methodologies are illustrated in Fig. 5.

Characterization of the seabed sediments is challenging, particularly for the design of pipelines, steel catenary risers, and foundations for offshore structures. The irregular nature of cyclic loading due to wind and wave actions, remoulding, reconsolidation, and water entrainment can cause significant changes in soil strength and stiffness of soil. On the other hand, cumulative fatigue damage due to long-term low-frequency cyclic loading could be dominant design considerations in several deep-water applications, such as offshore foundations, tension leg platforms, risers, and pipelines.

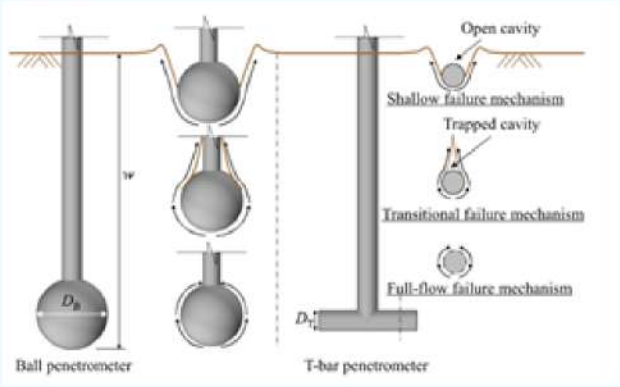


Figure 4(b). Full-flow penetrometers and its operational mechanisms (Chen et al. 2021).

Characterization of the seabed sediments is challenging, particularly for the design of pipelines, steel catenary risers, and foundations for offshore structures. The irregular nature of cyclic loading due to wind and wave actions, remoulding, reconsolidation, and water entrainment can cause significant changes in soil strength and stiffness of soil. On the other hand, cumulative fatigue damage due to long-term low-frequency cyclic loading could be dominant design considerations in several deep-water applications, such as offshore foundations, tension leg platforms, risers, and pipelines.

- **Foundations for Offshore Structures**

Foundation is the structural component of the offshore structure that extends downward from the seabed. The purpose of the foundation is to transfer the load from the support structure to the soil. Offshore structures are generally subjected to high horizontal dynamic environmental loads. Therefore, the foundation needs to be designed with great attention to withstand extreme loading conditions and operate efficiently (Cox and Jones 2010). Foundation is the most vital component of offshore structure as it plays a significant role in the stability of the structure. Details of various foundations are described in the following sections.

Shallow foundations in offshore are much larger in size than those used in onshore. It is also required to withstand much larger horizontal loads and overturning moments than onshore, and cyclic loading effects on capacity are more predominant. Concrete or steel bucket foundations are used as anchors for floating platforms or as permanent supports for jacket structures instead of piles (Fig. 6(a)). Skirts are provided to confine the soft

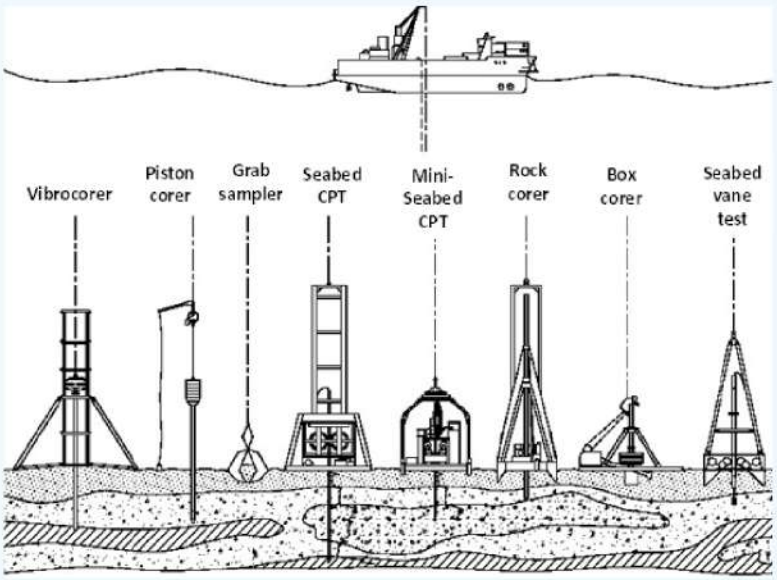


Figure 5. Seabed soil sampling techniques.

surface soil and transmit foundation loads to deeper, stronger soil (Andeanes et al. 1996). Offshore foundations are required to resist severe environmental forces from wind, waves, and currents, and in some cases, ice, which imparts large horizontal and moment loads that are not experienced in onshore. A schematic of loading conditions of a gravity base platform is shown in Fig. 6(b). The steel suction caisson

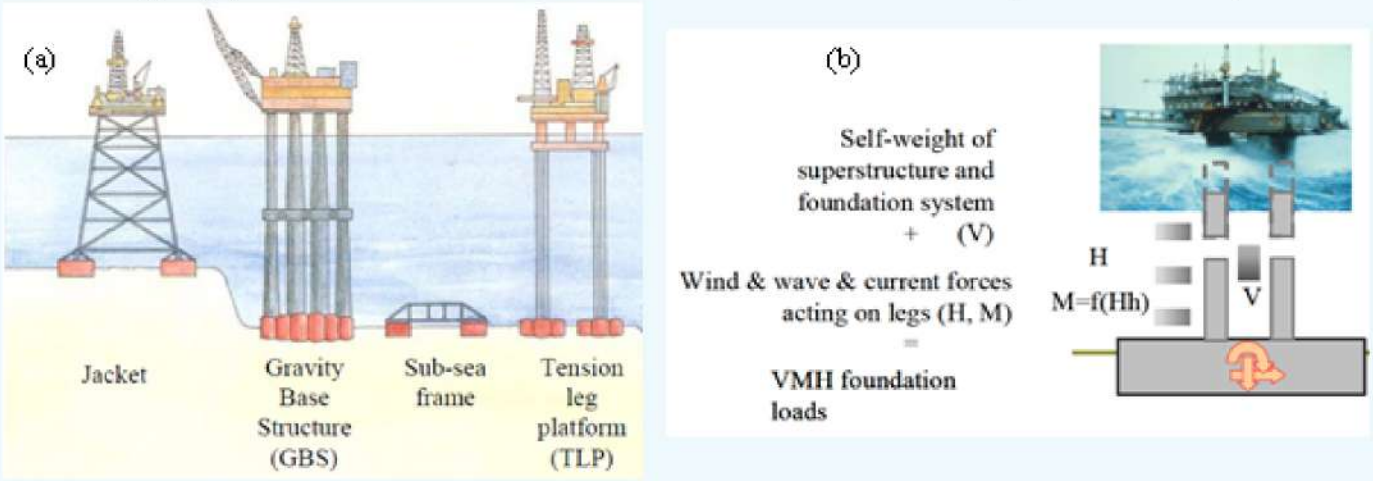


Figure 6. (a) Shallow foundations for various offshore structures, (b) loading conditions of a gravity base platform (Randolph et al. 2005).

foundations or steel 'buckets' are used as an alternative to pile foundations for jackets (Fig. 7). In shallow to moderate water depths, most offshore drilling is performed from self-elevating mobile (jack-up) units. The foundations of independent-leg jack-up platforms approximate large inverted cones and are commonly known as spudcans (Hossain and Randolph 2010). Spudcan foundations, circular in plan, typically have a shallow conical underside (in the order of 15 to 30° to the horizontal) with a sharp protruding spigot (Fig. 8). Anchoring systems are used to moor buoyant facilities such as tension leg platforms (TLPs), semi-submersible production systems (FPSs), floating production storage and offloading vessels (FPSOs), and spar platforms. Typical buoyant facilities are shown in Fig. 9(a). Anchors may also be employed to provide extra stability to fixed or flexible structures, such as a jacket or compliant tower platform. Typical anchors are shown in Figs. 9(b)-(c).

Deep foundations are often used for various offshore structures. The offshore piles are primarily made of steel pipes, which are driven open-ended into the seafloor. Pile sizes range from 0.76 m diameter up to over 2.5 m. In exceptional cases, such as offshore wind turbines, piles of 5.1 m diameter or more have been driven successfully (Randolph et al. 2005). The wall thickness of the pile varies along the length, with thicker walls used near the pile head where bending moments are maximum. Typical use of pile foundation for offshore platforms and offshore wind turbines are illustrated in Fig. 10.

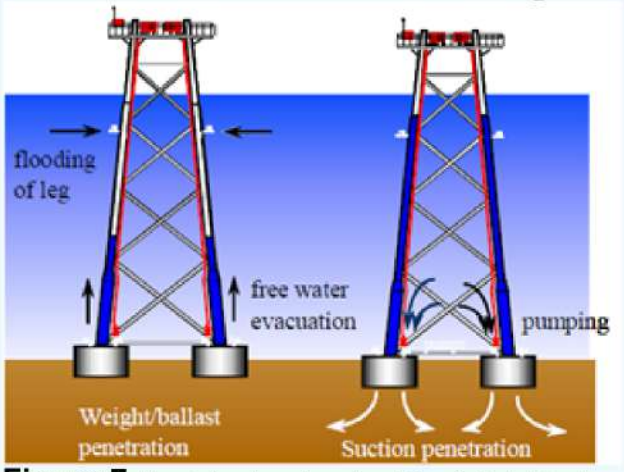


Figure 7. The steel suction caisson foundations for jacket structure (Erbrich and Tjelta 1999).

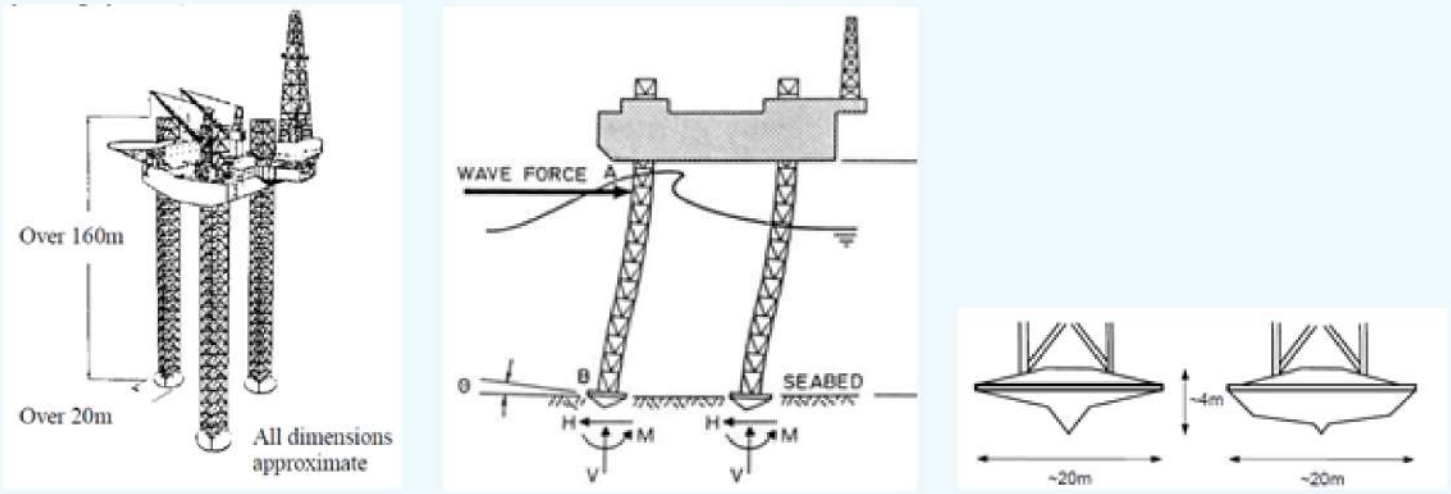


Figure 8.
Jack-up platforms supporting on spudcan (Reardon 1986, Santa Maria 1998).

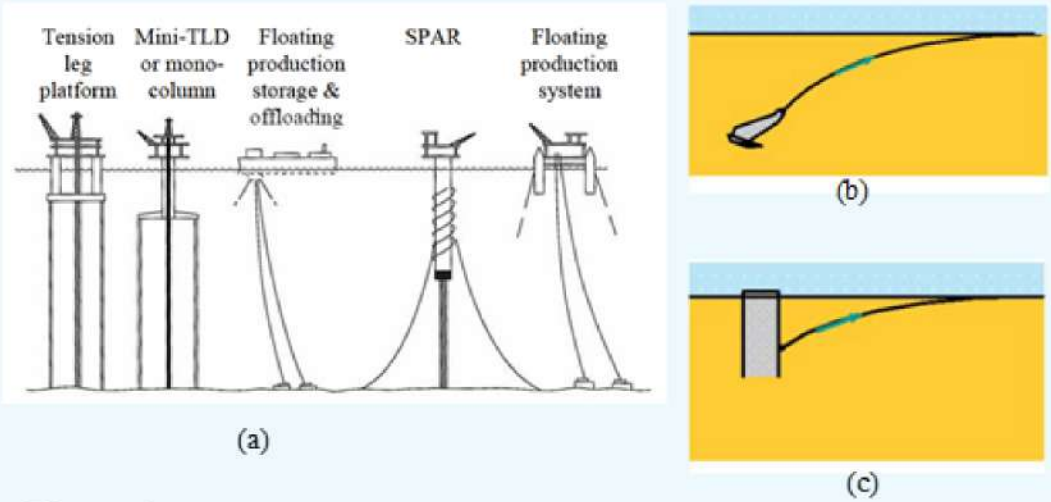


Figure 6. (a) Typical buoyant facilities (Leffler et al. 2003), (b) drag anchor, and (c) suction caisson anchor (Neubecker and Randolph 1995).

● Summary and Future Challenges

A brief review of geotechnical design issues associated with offshore foundations in shallow and deep water is discussed. The use of various shallow and deep foundations for various offshore structures and multi-dimensional loading are outlined. The offshore industries continue to expand and move towards deep water and extreme environment. This will require new geotechnical challenges, new foundation technologies, and rational design parameters. The anticipated research issues are summarized backside :

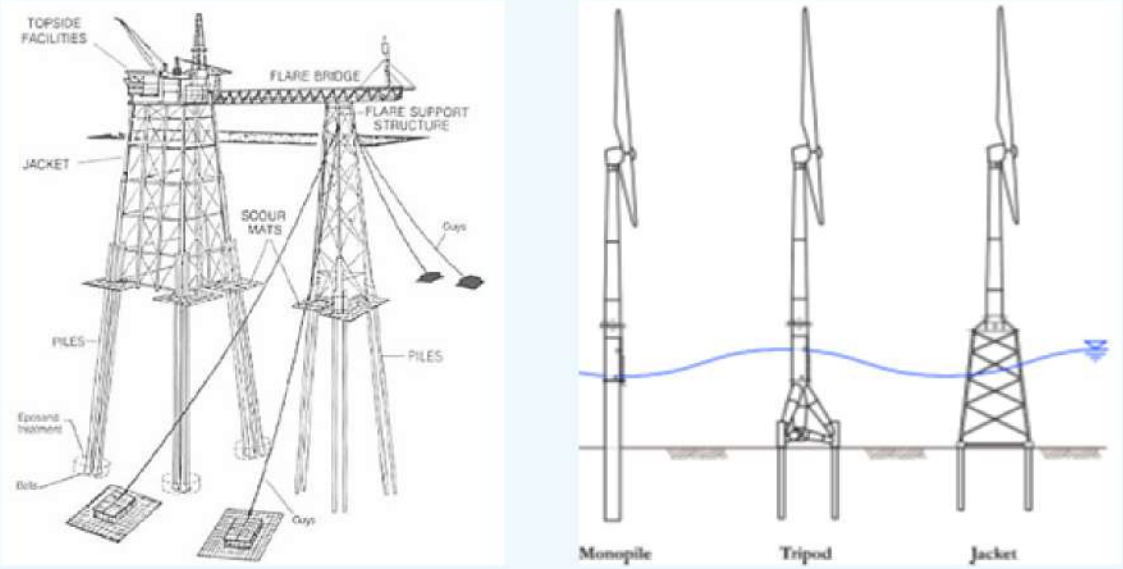


Figure 10. Typical use of pile foundation for offshore structures (Randolph et al, 2011, Cuéllar 2011).

(i) New, improved design methodologies are needed to account for large deformations, strain rate softening, or hardening, considering potential soil–fluid-structure interaction.
(ii) Incorporation of critical state soil mechanics, focusing on material behaviour at the micro-level is needed to address the effects of softening under long-term cyclic loading followed by reconsolidation.
(iii) Assessment of geotechnical risks is also needed as per the current regulations. Harmonization in the design considering the in-situ variability of soil properties and environmental loading require stochastic analysis and risk-based prediction methods to replace traditional deterministic design methods.
(iv) Hybrid modeling techniques need to be adopted where physical model tests can be controlled in real-time by output from numerical modeling and vice-versa. This will allow more realistic simulations, incorporating the interaction of soil–fluid–structure and complex coupling of mechanical, hydraulic, and thermal effects for pragmatic solutions.

Are Impervous Pavements in Urban Areas the Cause for Increased Flood Frequency in India?

Dr. Anush K. Chandrappa
Assistant professor of School of Infrastructure
IIT Bhubaneswar

India is one of the fastest-growing economies globally, which current stands in the fifth position with a gross domestic product (GDP) of 3250 billion USD as reported by International monetary funds (IMF). Since the year 1995, the GDP of India has increased by more than 700%, and it is predicted that India will stand third in the world economy within a decade. The rise in the economy of India has simultaneously driven the increase in the urban population, which has increased to 33% of the total population. The share of the urban population in India is predicted to be doubled in the next thirty years, as per United Nations (UN). The increase in the urban population has resulted in the haphazard growth of old cities such as Bangalore, Delhi, Hyderabad, Kolkata, Chennai, Mumbai, etc. To satisfy the infrastructure requirements, the cities have extended their boundaries and also encroached low-lying regions such as natural lakes, agricultural fields, etc., which have contours such that stormwater runoff would collect in these region.

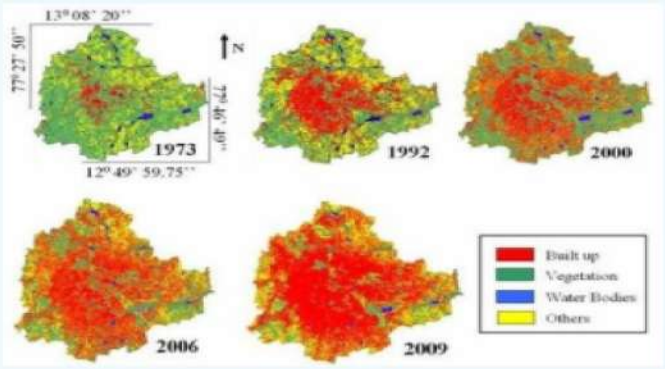


Figure 1.

Change in the Land-Use Pattern in Bangalore City from the year 1973

Figure 1 shows the increase in the built-up area in Bangalore city, which was once called the "Garden City" and also "The city of lakes". Unfortunately, to yield to the urbanization demand, several lakes have been encroached to develop housing societies, gated communities, industrial zones, etc., not only in Bangalore and several other such cities.

In addition to this, impervious pavements in the form of bituminous/ concret pavements have been extensively constructed to improve the connectivity in the city. Such impervious pavements are provided for all the classes of roads such as arterial roads, sub-arterial roads, collector streets, local streets, residential/ educational/ info-tech campus, parking lots, etc. The impervious pavements have converted the ground, which had permeable natural soil, into an impervious fabric.This change in the urban land use pattern has resulted in several anthropogenic changes, indicating lower stormwater runoff quantity and higher time of concentration. However, in the post urbanization period, the impervious pavements completely reduce the percolation of stormwater in the ground and act as a channel for the flow of runoff, thus decreasing the time of concentration, causing scenarios similar to "Pluvial floods". The frequency of such pluvial floods has increased in the recent past owing to the provision of impervious surfaces. The effect of pluvial floods in various metro cities is shown in Figure 3.

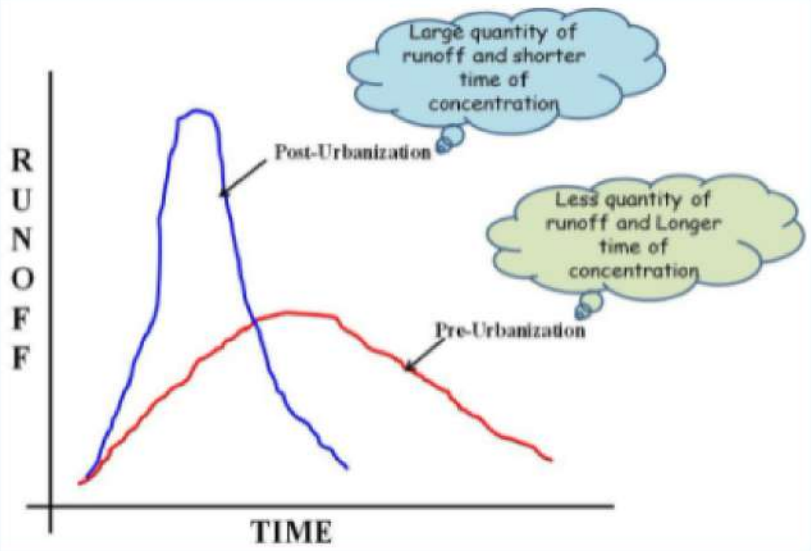


Figure 2.

Schematic of Hydrograph for Pre- and Post-Urbanization Period

one of them being changes in the hydrological characteristics of the urban stormwater runoff. Figure 2 shows typical hydrographs for the pre- and post-urbanization periods.In the pre-urbanization period, natural soil and vegetation slow down the runoff, and a large quantity of water is percolated into the soil.Therefore, the hydrograph in the pre-urbanization period has a shorter peak

The impervious surfaces such as pavements prevent water percolation, and since most stormwater drains are not designed for pluvial floods, a large quantity of runoff inundates the surface. Such pluvial floods have caused a number of lives and property losses and affected day-to-day activities. This kind of situation was hardly seen when we look back in the past, let's say a decade.

BANGLORE

HYDERABAD

CHENNAI

DELHI

Figure 3.
(Pluvial Flood Situations in Some Metro Cities of India)

This certainly raises several questions but not limited to:

- What are the possibilities/ methodologies to reduce such ill-effects of urban stormwater runoff?
- How other Asian countries are coping with increased urbanization as large portion of urbanization is currently taking place in this region?
- What are the possibilities/ methodologies to reduce such ill-effects of urban stormwater runoff?
- Is providing the stormwater drains the only solution to manage stormwater?
- Do we need the same type of impervious pavements for all the classes of urban roads?

Unfortunately, pluvial flood situations are also seen in many developed and developing countries. Hence, they have come up with several strategies to reduce the damaging effects of pluvial floods / urban floods. Some of the notable design strategies / policies are as follows:

- China: Design and Development of Sponge Cities
- New Zealand: Low Impact Urban Design and Development
- Japan: Sound Water Cycle on National Planning
- USA: Low Impact Development / Green Infrastructure
- UK: Sustainable Urban Drainage Systems
- Australia: Water Sensitive Urban Design
- South Korea : Smart Water City

Figure 4.
Schematic Depiction of Sponge City Project of China

(China Government has allotted 600 crore INR every year for the development of sponge cities and making the cities more resilient) (Source: China-Britain Business Council)

In all these strategies,permeable pavements, which mainly constitute pervious concrete and porous asphalt, are given due importance. These pavements have enhanced porosity in the range of 15-35%, which increases the interconnectivity of the pores. The interconnected pores allow the percolation of stormwater, thus reducing runoff generation and hence the pluvial flooding frequency. In addition, these pavements can also help in recharging groundwater, which is depleting in many urban localities due to imperviousness. The 3D image reconstruction of pervious concrete using X-ray tomography is shown in Figure 5.

The pervious concrete pavements are extensively used in many countries such as the USA, Japan, China, etc., mainly for parking lots, as shown in Figure 6. These pavements are ideal for parking lots as they have a very large surface area, which can generate a significant amount of runoff, if impervious. In addition, it can also be used in low-volume roads, roads inside the residential/ educational campus, etc.

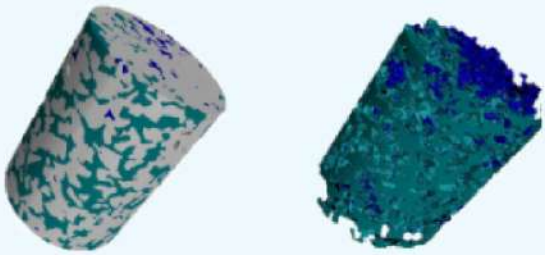


Figure 5.
3D Image Reconstruction of Pervious Concrete
(Left image: Grey portion is concrete,
right image: Shows pore network after removal of concrete)

In China In USA

Figure 5. Typical Pervious Concrete Parking Lot

In India, a few sections of pervious concrete have been constructed as part of the research projects and are known to perform well, as shown in Figure 7. .

At Tirupati Municipal Corporation

At IIT Kharagpur Campus

Figure 7.
Pilot Pervious Concrete Test Section in India

The pervious concrete pavements provide a very high degree of flexibility in stormwater management design. The collected stormwater can be used for groundwater recharge or stored temporarily for future usage. The pervious concrete pavements are still new in India and hence not studied and implemented extensively like bituminous or concrete pavements. Certainly, these pavements result in low impact development, where they not only provide a good, skid-resistant riding surface and mitigate the problems associated with impervious pavements. A properly constructed and well-maintained pervious concrete pavements in selected urban localities can play a significant role in stormwater management. Last, but not the least, impervious pavements contribute in stormwater runoff leading to pluvial floods and hence there is a need to look into alternatives such as porous pavements.

Interview Column

Interview of Dr. Satya Sapath Roy (MTech Structural Engineering 2013-15) By Vedanta Mohapatra

1. Why did you choose to opt for the discipline of Civil Engineering ?

   I Joined in the year 2002. At that time, the presence of social media was significantly less. We didn't get the info about the markets, salary, and all other aspects, nowadays you might be looking at. I think the choice of discipline was more based on the candidate's interest, friends and family's suggestions, and the concept of a core branch. I had made up my mind that I will pursue core branch. Civil engineering always attracted me rather than electrical or mechanical because my uncle was a civil engineer by that time. It always builds something tangible. Moreover, I am always fascinated by the bridges. I would say bridges are the only reason I choose civil engineering. And through out my life I have mostly worked in the area of bridge engineering.

2. After finishing your BTech what made you decide to do an MTech?

   I have always aimed for higher study. However, I thought of getting some experience in Industry so that it could help me understand the need better. Secondly, our undergrad courses are also extensive, 5-6 subjects, then lab works, projects, a lot.. With job, there will be a small break as well from the academics to prepare your mind to again go on the ride. Those experiences with the industry were fabulous because I got to know what works in the real field and what not. After a few years, I felt the work a bit monotonous and realized that I should pursue what I wanted to do from the beginning. Therefore, went ahead with GATE and MTech admissions at IIT BBS, respectively.

3. Why did you choose Structural Engineering as your field of specialization?

   I am truly fascinated by bridges. Even before my BTech class started, I learned a few chapters of structural analysis. Unfortunately, most of the structure books primarily focus on building structures. The bridge is the only reason I choose Structural Engineering.

4. What according to you are the pros and cons of pursuing a Master's program in IITs?

   Pros:

   - Firstly, studying in a prestigious college like IIT is a matter of pride.
   - Well-equipped labs
   - Research focused
   - Get a chance to do the collaboration with the finest minds
   - When you say/write in your resume/anywhere that you are from an IIT, at first you create a great impression on the mind of the person in front of you, irrespective of continent/country/state. Therefore, I can say you cleared the first round of interview/selection process by creating the first impression. Then ball is in your court to prove what they are thinking is right, which we always do.

   Cons:

   Apart from the technical stuffs, IIT should also give some lessons on life management. We are too much into academics.

Interview Column

5. How was your experience in IIT- BBS?

   It was one of the best experiences of my life. I joined the master's program after having 5 years of professional experience. Coming back to the classroom after 5 years of the gap was tough. But the faculty members and Colleagues are so cooperative and caring, they made the process very easy.
   Though it's been 7 years since I graduated, at any moment If I reach out to our faculty members, they are always in a willingness to respond and available for the discussion. Apart from the technical discussion, we also cherish our personal life

6. What do you think about the Civil Engineering students of IIT- BBS and the Civil department?

   I would say all the civil engineering students are extraordinarily helpful. The civil department has some of the brightest faculties and shown tremendous growth in research and placements

7. How do you react to the idea of a Civil Engineering Forum (CEF) in IIT- BBS?

   It's a great Idea. Good things have always come from great teamwork. There will be numerous advantages, but the most important is staying connected gives the opportunity to celebrate both success and failure together.

8. Nowadays, many people have started to assume that there is a lack of jobs in the Civil sector. What's your opinion on this?

   I do not think so. When I was in BTech, we also assumed there were no core sector jobs in the market. But when I graduated, I had two job offers on my hand. However, I would certainly agree that the starting pay band civil engineers get is low as compared to others. But with a few years of experience, it also starts paying the dividends in term of less stress and family life balance. I would say civil engineering is not like a crypto or short-term investment, rather it's like a stock, that gives a great return with long term investment.

   And we people must keep in mind, "we build the most wonders in the world".

9. What are the scopes available for future Structural Engineers in India?

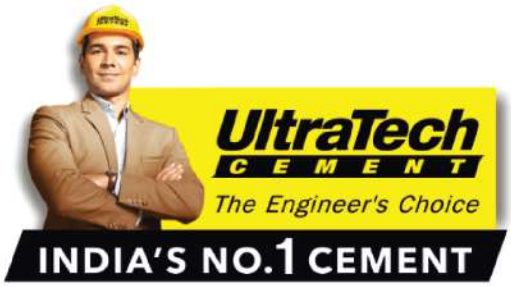
   I believe it's huge. India has now tremendous possibilities for structural engineers. It's also a global emerging market, now the top international companies are opening their office in India. Union road minister Mr Nitin Gadkari has also told recently in the parliament that India's road infrastructure will be like USA in upcoming few years only. This will definitely bring lot of job opportunities as well in next few years.

10. Tell us about your current organization and the work you do.

I currently work a structural engineer at AI Engineers. As a Structural Engineer, I am involved in several projects broadly related to detail site assessment, load rating and design of various complex bridges (ranged from reinforced concrete open-spandrel, bow-string arches, curved steel bridges, multi-cell box girders, steel/reinforced concrete/prestressed girder systems, integral pier caps, steel, and reinforced concrete substructures/piles) using several FE packages. I am also associated in detailed instrumentation and physical load testing of full-scale bridges and review of the technical reports. My involvement in these projects has extended the breadth of my research experience while giving me opportunities to supervise and mentor several graduate engineers and to be trained with other highly qualified personnel.

11. What message would you like to convey to the students pursuing Civil Engineering?

My message will be for all student fraternities. Don't thrive for overnight success. It needs time and tremendous effort to get overall success. Don't rush into anything. Things happen in their own time. You must be patient. Keep learning.



Dalmia DSP CEMENT

DHALAI EXPERT

ALTAIR

Aimil Ltd.
Instrumentation & Technologies

JP Scientific Equipments

BitChem
Asphalt Technologies Limited

Medini

HINCOL

Bentley
Developer Network

KNOWAFEST.COM
CAMPUS FESTIVALS IN INDIA

Contact Us At:

cef.sif@iitbbs.ac.in
Instagram : cef.iibbs
Facebook: Civil Engineering Forum IIT Bhubaneswar
LinkedIn: Civil Engineering Forum IIT Bhubaneswar