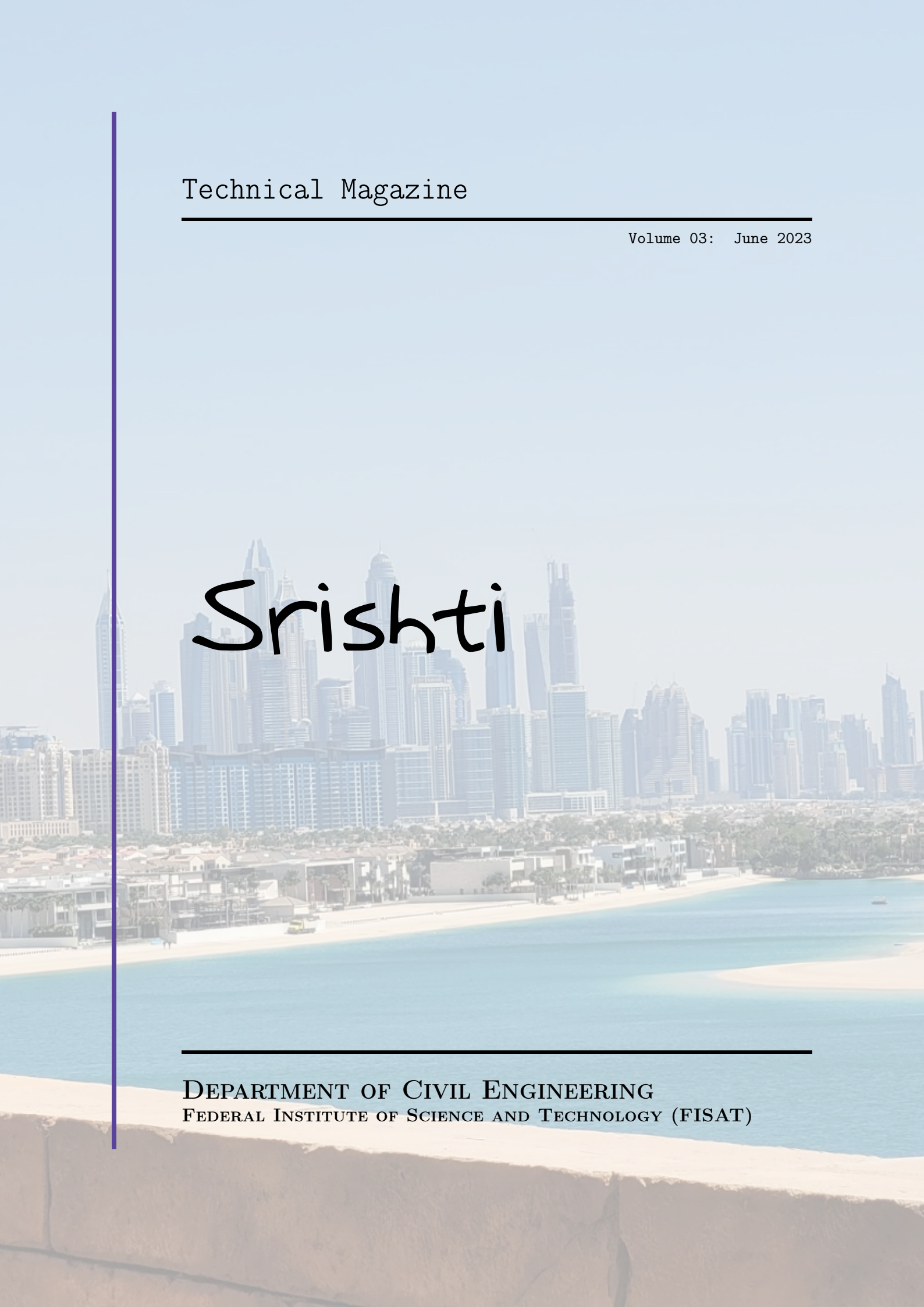
Technical Magazine

Volume 03: June 2023

Srishti



Department of Civil Engineering
Federal Institute of Science and Technology (FISAT)

Institute

Vision

To become a world class professional institute with focus on excellence, moulding committed global professionals and technocrats who can meet the demands of business, industry and research.

Mission

- To transform into an advanced centre of technical education, which will, in turn, bring out professionals with superior skills and social commitment.
- To provide state of the art facilities to mould brilliant young talents, enabling them to take up challenging assignments in the highly competitive global scenario.

Department

Vision

Emerge as a Center of Excellence in Civil Engineering, fostering globally competent and socially committed Civil Engineers.

Mission

- To provide a comprehensive education and training at the levels of materials, tools, planning, analysis, design and maintenance of structures.
- To encourage research and development in the field of civil engineering that are useful for the society.
- To equip the graduate with strong ethical and moral values and make them socially committed.

Program Educational Objectives

- The graduates of Civil Engineering will have a successful career in industry and government sector with their strong understanding of civil engineering solutions in a global, economic, environmental and social context.
- The graduates of Civil Engineering will pursue higher studies in the broad domain of Civil Engineering and engage in life-long learning through certifications and activities of professional bodies.
- The graduates of Civil Engineering will be successful as entrepreneurs and become a part of the nation building process serving the society in a responsible and ethical manner.

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Note from
HEAD OF THE DEPARTMENT:

It brings me immense pride to witness the passion and ingenuity that fill the pages of this publication. Our civil engineering students continue to push boundaries, turning innovative ideas into real-world solutions. Through articles, research, and projects showcased here, you'll witness the relentless spirit of exploration that defines our department. I encourage you to delve into these pages, be inspired, and recognize the limitless potential within the field of civil engineering. Together, we are shaping a brighter, more sustainable future.

JUNE 2023, No 3

Srishti

Department of Civil Engineering
Federal Institute of Science and Technology (FISAT)

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A note from the Editors:

Welcome to SRISHTI, edition 2023. In this exciting era of technological advancements and sustainable initiatives, we are thrilled to bring you the latest insights and trends in the field through our technical magazine. Our publication serves as a platform to foster knowledge exchange within the civil engineering community. As Winston Churchill once said "We shape our buildings, thereafter they shape us". Join us on this exciting journey as we unravel the mysteries of civil engineering and witness the transformative power it holds. Through captivating articles, and interactive features, our magazine provides an engaging space for inspiration, learning, and the exchange of ideas. We would also like to acknowledge the support from our respected faculty members and great team who has put on the effort for the accomplishment of our magazine. Happy reading!

by JAWAHAR SAUD S,
ASSISTANT PROFESSOR

Role of Epidemiology in Effective Air Pollution Health Risk Assessment in Industrial Areas

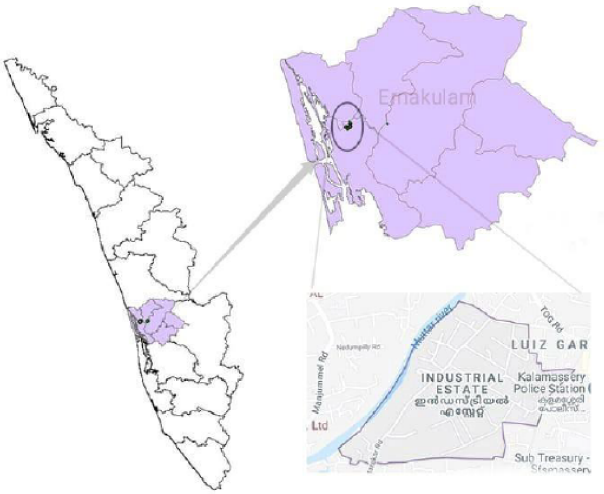
Air pollution is a pressing global health concern, linked to a wide array of diseases, particularly in developing regions. This article focuses on study centers in the Kalamassery Major Industrial Estate in Kerala, where industrial activities have thrived for decades. The findings reveal a prevalence of respiratory and cardiac ailments, especially among children and the elderly. Urgent risk management and improved healthcare infrastructure are advocated, highlighting the profound impact of industrial air pollution on public health in such areas.

Ailments and Air pollution

Introduction

AIR pollution is one of the biggest public health challenges, with well documented research. It is attributed to be responsible for a wide range of health issues ranging from pulmonary and cardiac disorders to gastrointestinal disorders. Air pollution has overtaken poor sanitation and poor-quality drinking water as the major contributor towards premature deaths among populations worldwide. In 2014, the World Health Organization (WHO) estimated that 92% of the world population lived in places with poor outdoor air quality. At least 80% of the human population in the developing world is exposed to pollution greater than air quality guideline values issued by WHO[1][2]. Furthermore, air pollution is responsible for about 6.5 million deaths globally (11.6% of all global deaths), of which about three million is attributed to outdoor pollution[3][4][5]. Epidemiological studies reveal that about 4.2 million people die each year from cardiopulmonary disease linked to inhaling the fine particles in air[6][7]. The problem is the most severe in developing countries because of overpopulation, rapid urbanization and unplanned growth along with rapid industrialization[8]. The accountability to public health seems to be amiss in such countries where pollution monitoring, exposure data and epidemiological study are limited or completely missing.

> Air pollution has overtaken poor sanitation and poor-quality drinking water as the major contributor towards premature deaths among populations worldwide.



1. Study area surrounding the Kalamassery Major Industrial Estate, Kerala

Risk perception is important for environmental and health risk communication because, it help determine the hazards people care about and how the community deal with the same. Perception of risk emphasizes importance of epidemiology for evaluating health of residents where main perceptible pollution sources are identifiable, even in the case where evidence obtained maintains uncertainty[9]. This is important as epidemiological data would be useful in understanding the short term as well as long term health risks the residents of an area have been subjected due to pollution. The study provides a starting point to develop a model for creating a risk communication system, to sensitise the public towards the health and ecological impacts of air pollution.

Methodology

Study area

The study area selected is the residential zone surrounding the Kalamassery Major Industrial estate within the Kalamassery Municipality of Ernakulam district, Kerala, India (Fig.1). The total population of Kalamassery Municipality was 71,038 as per the census of 2011. The literacy rate of the Municipality is 95.87% which is higher than the state average of 94.00%. The study area selected were the wards adjacent to the Major Industrial estate of Kalamassery, with 1478 households and a population of 6,012 within the ward boundaries[10].

Survey among medical practitioners

To evaluate the perception of residents on their health *vis-à-vis* their actual health conditions, the medical practitioners working in the area were interviewed. This was important because the epidemiological information would be useful in understanding the short term as well as long term health risks the residents have been subjected to over the past five decades. Epidemiology is a powerful tool in correlating health impacts with the exposure of populace to the air quality they are subjected to on a day-to-day basis[11].

Face-to-face interviews were conducted among the doctors and specialists working in the hospitals and clinics in the vicinity of the study area. Doctors were asked questions that would help in getting information on the prevalence of air pollution induced health impacts in the study area. The opinion of the doctors with regards to possible long term and short-term health risks were discussed during the interviews. The interviews were self-administered. The participation was voluntary and all the doctors involved in the study were assured of confidentiality. Only aggregated information was recorded and no information helpful in identifying the patients were recorded. The purpose of study was explained to doctors either in person and/or via phone and appointment for the same was sought beforehand. Of the total 30 doctors interviewed, 20 were specialists, five were general practitioners and the remaining five were practitioners of Alternate medical systems. Eight of respondents were from government hospitals, seven from private hospitals and 15 were from private clinics. The medical practitioners had at least a year of service at the hospitals or clinics and they were accessing fairly. 11 out of the 30 respondents have been working in the same hospital for at least 4 years, 9 out of 30 medical practitioners have been working in the vicinity of the study area for a period greater than nine years. Hence, their responses and assessments are backed with proper background knowledge of the health conditions of their patients as well as potential causes. The questionnaire consisted of both open and closed questions. The questionnaire was validated prior to administering using feedback from medical practitioners who volunteered to help. The opinion of doctors on the health of patients of different age group was taken. Also, the common ailments to which patients from the study area took medical help, frequency of visits, and the number of new patients they handled on a daily basis were also noted. The questionnaire adopted is given in supplementary material.

Results and Discussions

Results of survey among medical practitioners

Of the 30 medical practitioners interviewed, 20 were specialists, most being Paediatricians. Remaining 10 included general practitioners and doctors practicing alternative medicine (Fig. 2). These medical practitioners were from Central Government medical facility for employees working in industrial area and their family, a private hospital, small medical facilities and clinics in and around the vicinity of the study area. 29 of the medical practitioners interviewed were in agreement that the major source of air pollution in the study area are the day-to-day activities in the industrial area.

During the interview with the medical professionals at the government medical facility near the study area for the employees of the industrial area, it was found that 133 out of total 600 patients who visited all the departments per day had respiratory, dermatological and/or cardiac ailments which the doctors attributed to air pollution. Some of the practitioners pointed out that, out of the total cardiac and respiratory cases, at least one fifth have been chronically ill seeking medical help for the past 5 years. This could be correlated with the perception of local residents regarding the air pollution on day-to-day basis and an increase in the number of respiratory and cardiac illness among children and adults over the past decade. Among the cardiac and respiratory patients, less than one fourth only were reported to be smokers. This, according to the doctors, confirm air pollution as the major reason for these illnesses.

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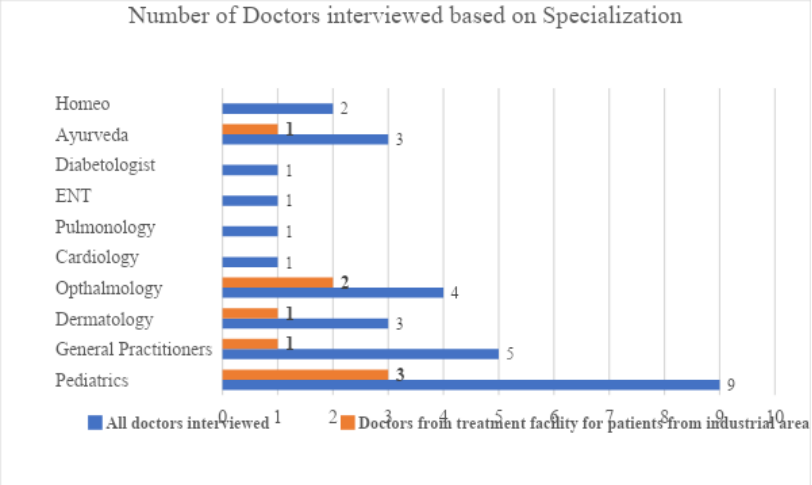
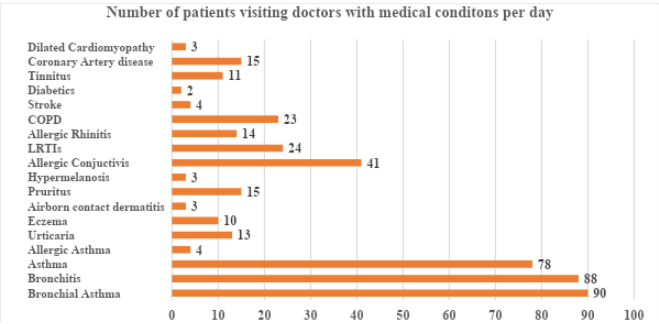
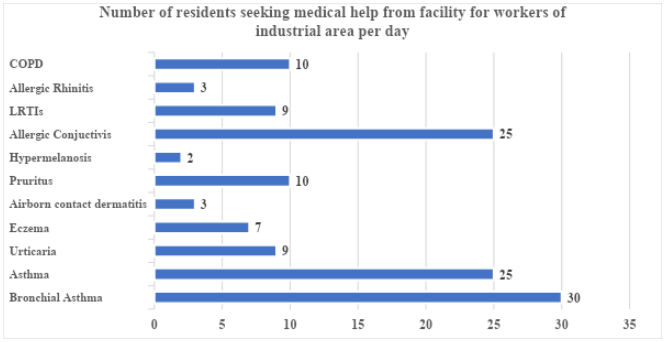


2. Details of doctors interviewed for the study



Details of patients visiting medical facilities in and around the study area



Details of residents or family members visiting the medical facility near the study area

22 of the doctors interviewed opined that there was an increase in number of respiratory and cardiac ailments among children and old aged people alike. The combined number of new child and geriatric patients on an average across the hospitals was about 77 for every 200 patients. It was also important to note that the doctors attributed most of the respiratory and cardiac illnesses to the presence of $PM_{2.5}$ and PM_{10} in the air. The annual mean of PM_{10} from the Central Pollution Control Board (CPCB) monitoring station within the study area were 24.82 $\mu g/m^3$ and 51.74 $\mu g/m^3$ during the period of June 2018 to June 2019 and June 2019 to June 2020, respectively[12] which were higher than the limit of annual mean of PM_{10} set by WHO at 20 $\mu g/m^3$[13]. The common ailments among the residents reported by the doctors at the medical facilities are attributed to exposure to Particulate Matter, VOCs, NO_2 and SO_2. This suggests that that there is a correlation between actual pollution, its source and perception of the residents, even though there is no clear understanding of long term health risks. The medical professionals rated 7 or above on a scale of 1 to 10 to the question about their perception on the long-term environmental risk due to air pollution among residents of the area was given by medical practitioners.

Review comments

This article represents a study conducted to address the resident's perception of air pollution, its source and health effects and comparing it with epidemiological evidence from the hospitals in the study area of Kalamassery Municipality in Ernakulam district of Kerala, India. The interview with medical professionals showed that the perception of residents was unbiased and true. They were facing short term and long-term environmental health risk due to air pollution from industrial activities primarily. The local residents primarily faced respiratory illness like Bronchial Asthma, Asthma, COPD etc. along with cardiac, dermatological and ophthalmological ailments. The respiratory ailments can be directly correlated with possible presence of PM_{10} due to industrial and allied activities happening within the industrial area. Increase in PM_{10} concentration in air can result in pulmonary illness like COPD and Asthma manifesting in adults and children [14][15][16][17] as reported from the doctors treating the local population. A possible presence of O_3, SO_2 and NO_2 from industrial activities can also result in the ophthalmological and dermatological ailments reported among the resi-

dents of the study area. Ailments like COPD, Bronchial Asthma and Asthma, Allergic Conjunctivitis, and Airborne contact dermatitis could be attributed to the presence of $PM_{2.5}$, PM_{10}, VOCs and NO_2 [18];[19];[20]. Since, the industrial units have been working for a period of over five decades, the effects among old aged people and children would be profound. Availability and comparison of real time data over two year period of June 2018 to June 2020 has shown that how such data could be correlated with perception and epidemiology studies [21][22]. The study however had its limitations, the data was collected during the winter period of the year, resulting in the effect of season on the amount of air pollution in the area. Also, possible bias in the responses arising out of the local issues with industrial units, health issues at personal or familial levels, job losses from the industrial area etc might have affected the final results.

Conclusions

Environmental pollution in areas with high levels of industrial activities is an external stimulus to the residents. Environmental pollution perceptions are usually driven by demographical factors. This study may offer an insight into the information that can be incorporated into decision-making and conflict resolutions in large scale industrial areas. The main conclusions are as follows:

- The doctors opined that number of patients with cardiac, respiratory illnesses are high in the area. They attributed this to drop in air quality due to the industrial activities in the area.
- There was concern among the doctors regarding to the rise in number of new patients with respiratory and cardiac ailments from the study area.

A strong risk management due to the exposure of the local residents to air pollution from the industrial area is important and urgent. With better air pollution monitoring and air pollution management techniques within the industrial area of Kalamassery, the environmental short term health risks due to air pollution may be controlled to a greater extent. The long-term health risks among resident population due to prolonged exposure of over five decades needs to be better managed clinically, the health facilities and access to medical facilities needs to be improved at the policy making levels ■

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DID YOU KNOW?

DUBAI was a small fishing village, that grew into a regional trading hub and a representation of luxury. The city is home to some of most luxurious and prestigious infrastructure projects in the world. In order to promote tourism they have created a truly global urban environment. It has a beautiful urban landscape and skyline. A glimpse offered in the magazine **COVER**.
Image Courtesy, Cover: Dr. Unni Kartha G

COMCAST CENTRE, Philadelphia contains the largest Tuned Liquid Column Damper (TLCD) in the world. The size of the damper tank was approximately 68 feet wide by 56 feet long and 20 feet high with a total self weight around 900 tonnes. The U-shaped column damper was sized to allow the liquid inside to oscillate freely at a frequency to match the building's natural frequency. It is now the tallest building in the world with a Tuned Liquid Column Damper. Check out more in the article on Pg 7.

CIVIL ENGINEERS are an integral part of space programs and mission. From testing out the spacecraft to handling command centres, there are multiple career opportunities. Command centre, space elevators, space stations, launch platforms, terraforming etc are some sectors that seek civil engineers. Check out the rectuitments of ISRO & DRDO, if this interest you. An article on Pg 22.

FRENCH RESEARCHERS from the Femto-ST Institute have used micro-robots to assemble the world's smallest house, which stands just 0.015 millimetres high. The tiny house, which has a footprint of 0.02 millimetres by 0.01 millimetres, is around half a million times smaller than a regular two-storey house. Read more on it in Pg 34.

Simulation of Tuned Liquid Damper (TLD) using Particle Finite Element Method (PFEM) using OpenSeesPy

by H AISWARYA, S4 SECM

TLDs are passive devices employing water sloshing to dampen structural vibrations. Modeling TLDs is complex due to the fluid-structure interaction and energy losses from sloshing. Particle Finite Element Method(PFEM) proves effective for this task. OpenSeesPy facilitates PFEM implementation, offering built-in functions and scriptability. Visualization is aided by ParaView. The study demonstrates PFEM's utility for simulating TLDs and Tuned Liquid Column Dampers, with results matching literature and potential for further computational time reduction.

Simulation by coding?

TUNED liquid damper is a passive device which can be used in building structures to dampen structural vibrations. A tuned liquid damper is a container of water, typically placed on top of a building, that uses the sloshing energy of the water to reduce the dynamic response of the system when subjected to excitation. Simulating tuned liquid dampers is challenging since modelling liquid and loss of energy due to sloshing will require special modelling techniques. This article briefs the project work that I undertook as part of the M.Tech thesis work.

To analyse problems involving fluid-structure interaction, one numerical technique that can be used is the particle finite element method (PFEM). PFEM uses particles to represent the fluid, and it uses finite elements to represent the structure. The technique can simulate the complicated fluid-structure interactions that take place in TLDs, making it an excellent choice for simulations of these devices.

"A tuned liquid damper is a container of water, typically placed on top of a building, that uses the sloshing energy of the water to reduce the dynamic response of the system when subjected to excitation."

For the purpose of implementing the PFEM, OpenSeesPy (Open System for Earthquake Engineering Simulation in Python) comes with built-in classes and functions. These consist of classes for meshing the domain, defining particles, and performing analysis. OpenSeesPy supports PFEM to simulate the behaviour of structures under various types of loading conditions, such as seismic loads or wave loads, and to model complex fluid-structure interactions. OpenSeesPy offers a versatile and effective tool for structural and geotechnical engineering with its scripting interface and built-in functions for analysis and visualisation.

ParaView is used to visualise the simulation-generated data. Using a graphical user interface (GUI), users can visualise and analyse large datasets using this open-source data visualisation and analysis software. A software company in the United States named Kitware created it.

The main objective was to conduct a study based on the simulation of Tuned Liquid Dampers(TLDs) and Tuned Liquid Column Dampers(TLCDs) using Particle Finite Element Method (PFEM) using OpenSessPy.

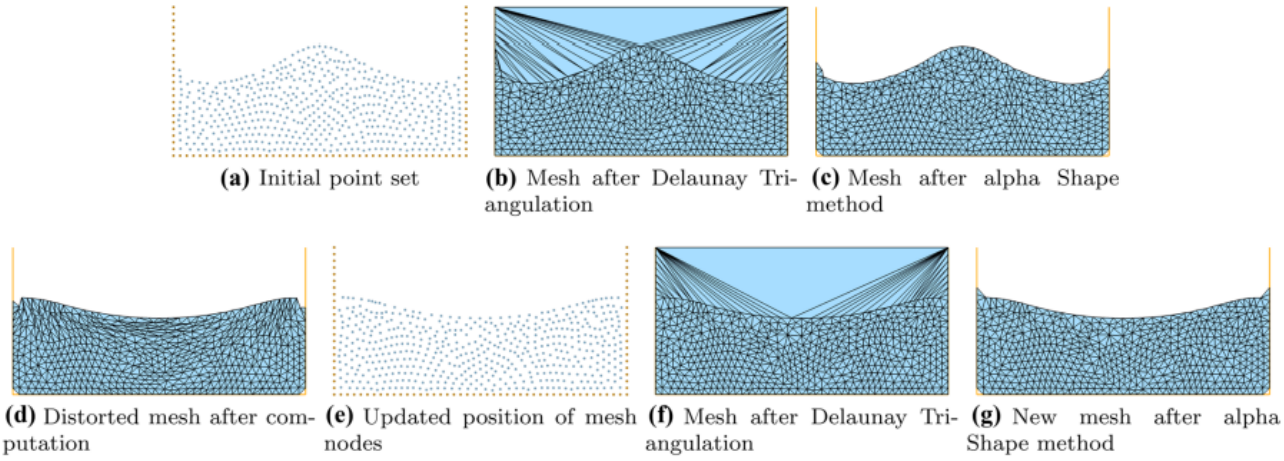
Particle Finite Element Method (PFEM)

Particle Finite Element Method (PFEM) is a numerical method developed to solve multiphysics problems with large-scale domain deformations. The core idea of PFEM is a combination of the Lagrangian finite element method (FEM) and an efficient and fast remeshing method. In PFEM, a domain is defined by a set of particles (matching mesh nodes) that move in a Lagrangian manner according to computed nodal variables (such as velocity and displacement) and their physical properties (such as density and viscosity). In contrast to meshless approaches, interaction forces between particles are evaluated using a finite element mesh. In this sense, PFEM can be considered both FEM-based and particle methods. It combines the accuracy and robustness of mesh-based techniques with the advantages of particle-based techniques. PFEM discretizes the physical domain using a mesh whose underlying differential equations are solved using a standard finite element approach.

OpenSeesPy

OpenSeesPy (Open System for Earthquake Engineering Simulation in Python) provides built-in classes and functions for implementing the PFEM. These include classes for defining particles, meshing the domain, and running the analysis. OpenSeesPy supports PFEM to model complex fluid-structure interactions and simulate the behaviour of structures under various types of loading conditions, such as seismic loads or wave loads. With its scripting interface and built-in functions for analysis and visualisation, OpenSeesPy provides a flexible and powerful tool in the field of structural and geotechnical engineering.

With OpenSeesPy, users can write scripts using Python, a high-level, easy-to-learn programming language that is widely used in scientific computing and data analysis. One of the main advantages of using OpenSeesPy is the ability to automate and customise simulations. It includes built-in tools for post-processing simulation output, such as visualisation and data analysis functions. Users can easily create plots and graphs of simulation results, perform statistical analyses, and export data to other software tools or formats. It also benefits from the large and active Python community, with a wide range of Python packages and libraries available for use in simulations. This includes numerical and scientific computing packages such as NumPy and SciPy, as well as visualisation packages such as Matplotlib and Mayavi. OpenSeesPy is also compatible with popular Python development environments such as Spyder and Jupyter Notebook, making it easy to integrate with existing Python workflows.



(a) Initial point set **(b)** Mesh after Delaunay Triangulation **(c)** Mesh after alpha Shape method

(d) Distorted mesh after computation **(e)** Updated position of mesh nodes **(f)** Mesh after Delaunay Triangulation **(g)** New mesh after alpha Shape method

ParaView

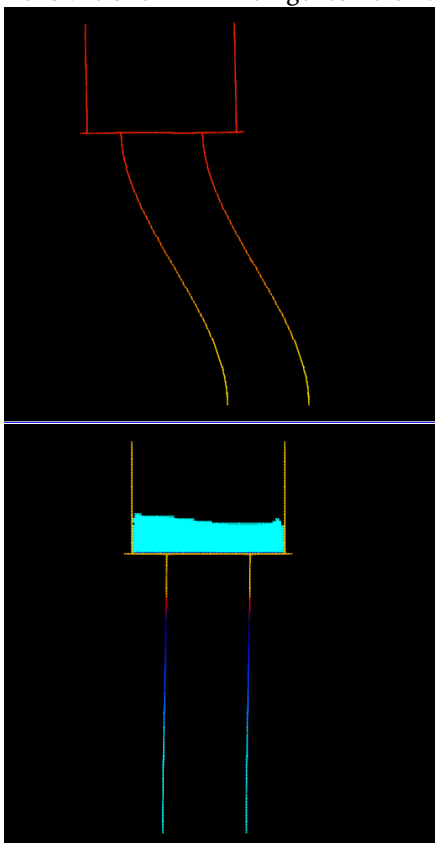
ParaView is used for visualising the data obtained from the simulation. It is an open-source data visualisation and analysis software that allows users to visualise and analyse large datasets using a graphical user interface (GUI). One of the key features of ParaView is its ability to handle large datasets. Many scientific and engineering applications generate large amounts of data, often in the form of three-dimensional models or simulations. ParaView is designed to handle these large datasets efficiently, with support for distributed computing and parallel processing. It supports a wide range of data formats, including popular scientific data formats such as VTK, HDF5, and NetCDF. This allows users to easily import data from a variety of sources, including simulations, experimental data, and numerical models.

> One of the main advantages of using OpenSeesPy is the ability to automate and customise simulations.

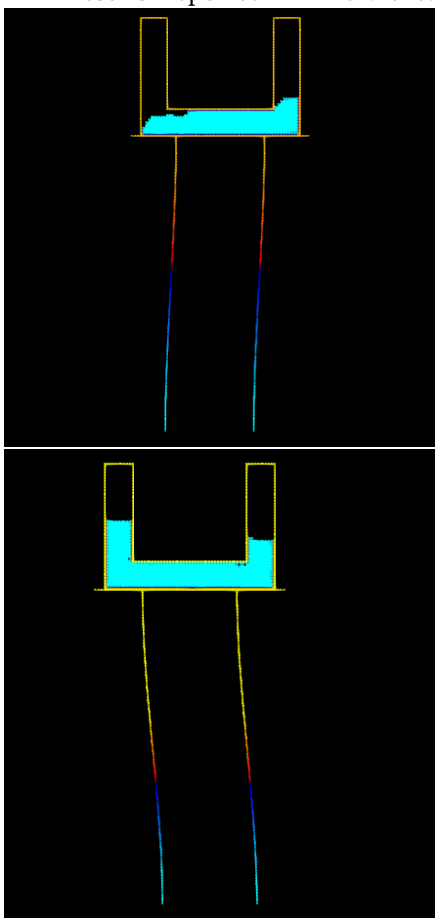
ParaView is built on an open-source platform, which means that users can customise and extend the software to meet their specific needs. This includes adding new data formats, visualisation techniques, and analysis tools. ParaView also provides a Python scripting interface, allowing users to automate and customise their analysis workflows. It has been used in a wide range of scientific and engineering applications which is used to visualise and analyse large-scale simulations of fluid dynamics, climate modelling, and geophysical phenomena. It has also been used in materials science, aerospace engineering, and biomedical research etc.

The study

A study on each Tuned liquid damper and Tuned liquid Column Damper was carried out to observe the simulation performance using PFEM. Jupyter Notebook is chosen as the interface for inputting the commands. Models were simulated for different case studies. In one case, a Tuned Liquid Damper along with a structure was modelled and then compared with the results from study conducted by some researchers. In the second case, a Tuned Liquid Column Damper along with a structure was modelled and the results were compared with the values obtained from the study provided in a report. A few visualisations are shown in the figures below:



The comparison of natural frequency of the Tuned Liquid Damper was carried out with the values obtained by FEM and experiment from a journal and the values obtained by analytical calculation and by PFEM simulation. From the comparison, it was clear that the values obtained by PFEM simulation and analytical calculation were comparable with results reported in literature.



Conclusions

In conclusion, the Particle Finite Element Method can be used to simulate a Tuned liquid damper or a Tuned liquid column damper along with a structure in it. PFEM can also be applied to the multi storied buildings with TLD. The simulation can help to determine the behaviour of the structure under various conditions of loading, boundaries etc. Also, these studies can be carried out on two dimensional or three dimensional models. One of the drawbacks that can come across during the analysis is that the computational time for the simulation using PFEM could be very high. Therefore, the studies regarding the reduction in computational time for PFEM can be further modified by the developers and researchers ■ □□□□□

3D Printing in Construction Field

by Remya Krishnan V, S2 SECM

The revolutionary technology of 3D printing has made substantial strides in diverse industries, and construction is no exception. This article explores the history, methods, and future prospects of 3D printing in construction. With its potential advantages, 3D printing is poised to revolutionize the construction industry. However, challenges such as the high cost of machinery, the need for skilled professionals, and material limitations must be overcome for broader adoption. Despite these challenges, the benefits in terms of cost savings, sustainability, and safety make 3D printing a compelling solution for the future of construction.

Future of construction

Introduction

3D printing refers to the fabrication of objects through the deposition of a material using a print head, nozzle, or another printer technology. It has been identified by Gartner, one of the leading information technology research companies, as "a rare example of a single technology that has become truly disruptive by itself". In 2013, McKinsey, a global management consulting firm, selected 3D printing technology as one of the 12 technologies that are expected to bring ground-breaking innovations. During the past decade, this technology has experienced major developments and revolutionized the manufacturing process. The technological developments in 3D printing have benefited the aerospace, automotive, medical, and food industries. Recently, 3D printing has also been employed in the construction industry with little progress over the last century. This combination of 3D printing with the construction industry is usually denoted as 'construction 3D printing'.

> "3D printing is one of the greatest technological advances and innovations of the 21st century. Its value in the global market reached $190 million (USD) in 2021, and is expected to increase to $ 680 million (USD) by 2030."

History

Construction 3D printing is defined as the process of joining materials to create constructions from 3D model data. The construction 3D printing era started in 1997 with one research and one patent. The 3D printing technology was first applied to construction by Pegna from Rensselaer Polytechnic Institute in 1997. In the same year, Khoshnevis from the University of Southern California published a patent titled 'Additive fabrication method'. The technology was later coined as 'Contour Crafting' in 2001. Following these endeavours, more automated construction systems were developed. 'Concrete Printing' was developed at Loughborough University in 2003, D-shape by Dini in 2007, and selective deposition for ultra-high-performance concrete by Gosselin in 2016. All of them can fabricate large-scale construction components, even whole buildings.

The Future

3D printing is one of the greatest technological advances and innovations of the 21st century. Its value in the global market reached $ 190 million (USD) in 2021, and is expected to increase to $ 680 million (USD) by 2030. The factors that most influence this growth are the increase in environmental concerns regarding the waste generated by the sector, the possibility of customization and architectural flexibility using this technology, and the rapid creation of models and prototypes.

As the technology continues to develop, the possibilities for adoption and growth increase, and by 2028 its compound annual growth rate (CAGR) is expected to be of 91.5%

compared to 2021.

What is 3D Printing in Construction?

3D construction printing (3DCP or 3DP) refers to the automated process of manufacturing construction elements or entire structures by means of a 3D printer. However, instead of using ink like the traditional printers we're used to, construction materials are printed layer-upon-layer, which is also why 3DCP goes by the name additive manufacturing or additive construction. It can be carried out both onsite and offsite.

How does 3D printing work in construction?

The technology around 3D printing has been questioned many times since the 1980s. However, it has gained greater relevance thanks to the improvement of the technique itself that allows for the creation of a three-dimensional object by superimposing successive layers of material. This method of construction is very versatile and can help create specific components of a project and even various types of complex structures in its entirety such as houses or living spaces, offices, bridges, walls, modular structures, reinforcement moulds, columns, urban furniture and even decorative elements. How is this possible?

In construction, much of the information needed to make this technology work comes from the design process. As the industry already has experience in the computer-aided manufacturing process and BIM (Building Information Modelling) continues to bloom in the construction sector, the integration of 3D printing technologies is less complicated. Using a CAD or BIM program, a 3D printer receives the information of what it needs to print, and machines begin to overlay material levels according to the indications. This can be done with various materials, the most common being a mixture of concrete, geo polymers, fiber, and sand. The evolution of 3D printing has been so favourable in the last decade, that its value in the construction market is expected to reach up to USD $ 1,034,096.7 thousand by 2028, according to a study by Research and Markets. This represents a 91.5% increase in its compound annual growth rate between 2021 and 2028.

Benefits of 3D printing in construction industry

3D printing brings great benefits to the construction industry, being a solution that touches almost all areas of the value chain of the sector. From contributions to sustainability, increased productivity and support in challenges on the supply chain, this technology came to revolutionize the way we build.

Time reduction

With traditional construction methods, a project can take many months to complete, with the norm being that large projects take 20% longer than expected and adding up to 80% in cost overruns over the initial budget. However, 3D printing allows to reduce up to 70% of the time and a project can be completed in just hours or days, depending on its magnitude. Therefore, contractors can

work on more projects and, consequently, increase their source of income.

More cost-effective and sustainable

3D printing allows the precise amount of material to be used to lift a structure, allowing up to 60% less waste to be generated at the job-site. Likewise, there will be no surplus in the purchase of materials, assuming a reduction in costs both in its purchase and subsequent storage. By reducing time and costs, companies will see an exponential increase in the benefits of this technology, which is also of great help in locations where there is a need for projects and a shortage of labour. By automating the creation of a structure through 3D printers, companies can see a reduction in labour costs of up to 80%.

Safer

The U.S. Occupational Safety and Health Administration (OSHA) reports that 1 in 10 workers on construction sites is injured each year, with falls and wrongful contact with equipment being the main causes. One of the most important benefits that 3D printing has brought to construction is in the health and safety of the employees onsite. By knowing how to work effectively with printers, workers can do their jobs more easily and reduce injuries in the field.

Design flexibility

Last-minute changes to the design will no longer be a problem nor delay the construction process. 3D printing allows you to customize the work until just before starting the printing of the structure, eliminating all the headaches that these changes entail.

Materials used

Once the 3D printed construction method has been selected, it's time to choose the material that will be used. Recent advances in construction 3D printing have increased the number of different materials available. The material selected should depend on the type of project in question, however, the most common materials used are:

- Standard concrete,
- Proprietary concrete mixes,
- Mortar,
- Plastic,
- Metal, and
- Local natural materials (stone, sand, mud, rice waste, etc. Any delay in the process can cause the concrete to harden and hinder the work.

> "3D printing allows the precise amount of material to be used to lift a structure, allowing up to 60% less waste to be generated at the job-site."

Methods

There is no one-size-fits-all 3D printing construction technology. Depending on the specifics of the project, different printing methods can be employed. These are the most common:

Extrusion:

Extrusion is the most common 3D printing technique as it can be used in almost all environments. Commonly used for modelling, prototyping and production applications, this method creates an object by layering material back and forth through one or more nozzles mounted on a robotic arm, gantry system or crane.

Powder Bonding:

Contrary to other 3D printer construction methods, powder bonding uses powdered raw material as its main component. There are two methods: powder bed jetting and binder jetting. The first is characterized by melting dust particles with a laser on the desired object layer by layer, while a coating sheet adds more material for each new layer. On the other hand, the binder jetting uses a print head that deposits a liquid adhesive agent on the powder printing bed. The liquid binds the powder particles together to form each layer of the desired object. Then a new layer is added, and the process is repeated layer by layer. This one allows printing with a higher level of accuracy and can handle more complex prints.

Spray:

The autonomous robot sprays the construction material under pressure in the desired shape and repeats the process layer by layer. This method allows to fill the spaces of the structure with concrete, and its use is currently being studied for vertical and outstanding applications such as facades or ceiling decorations.

Opportunities and challenges for 3D printing in construction

Although the benefits of 3D printing in construction will continue to develop as more companies bet on this technology, achieving greater adoption of this method in the market is still a challenge. Highlighting the following points that intervene when making this technology even more trendier among industry professionals and why large companies are still dubious about it: Although 3D printing itself is more cost-effective when building, the necessary machinery continues to be very expensive both to acquire and to operate it, and large companies still do not bet on them in a significant way.

The industry needs to develop more trained professionals to be able to handle the technology behind 3D printing, trained to design

computer models, operate the equipment and provide proper maintenance. More regulations and legislation are needed for 3D printing in construction that allows for clear guidelines on its use and benefits of its implementation in new construction sites. Likewise, the sizes and development of printers are a challenge because many of the models that emerge in the market limit their use to the size of the structure to be printed.

In addition, the material or formula of the mixture in which it is printed is one of the main limitations for 3D printing to stand out as a construction method. The material on which it is printed must have the desired printing capacity to be able to be extruded from the nozzle, and the buildability to be able to maintain its shape and sustain itself quickly. In addition, the open time, (which is the period where printing and buildability are consistent within the acceptable tolerances since there is a limited time to print the material), become a main challenge for 3D printing technology in construction.

> More regulations and legislation are needed for 3D printing in construction that allows for clear guidelines on its use and benefits of its implementation in new construction sites.

Conclusion

Overall, the potential of 3D printing is too great to ignore. While the industry may never reach a point where it is used exclusively, it is only a matter of time that the technology will be improved and advance significantly. Overall, 3D printing is poised to be a viable solution that offers key benefits in cost savings and environmental friendliness for our buildings and its future ■

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Are you GATE ready?

1. Which type of loading produces a combination of axial and bending stresses in a structural member?
2. Which type of structural analysis accounts for the second-order effects that arise due to large deformations?
3. Which construction technique involves building components being manufactured off-site and then transported to the construction site for assembly?
4. Which construction material is a composite made of thin sheets of wood veneer, which are bonded together with adhesive to create a strong and versatile panel?
5. What term refers to the total volume of vehicles passing a given point on a road during a specified period, typically measured in vehicles per hour?
6. Which type of pavement distress is characterized by a localized depression in the pavement caused by traffic loads and settlement?
7. Which type of pavement design method considers the structural capacity of the pavement and the traffic loads it will experience?
8. Which water treatment process involves the removal of suspended particles from water by allowing them to settle under the influence of gravity?
9. The process of treating water to make it safe for consumption by removing harmful contaminants is called:
10. Which type of surveying is used to determine the positions of points on the Earth's surface using a local coordinate system?
11. Which type of surveying is used to establish the legal boundaries and dimensions of land parcels for property ownership purposes?
12. The phenomenon in fluid dynamics where an increase in the velocity of a fluid occurs as the flow passes through a narrow section is known as:
13. The principle that states that the force exerted by a fluid on a solid body immersed in the fluid is equal to the weight of the fluid displaced by the body is known as:
14. What is the term for the loss of energy in a fluid flow due to the conversion of kinetic energy to internal energy, typically caused by friction?
15. The point in a fluid flow where the velocity is at its maximum and the pressure is at its minimum is known as:
16. A retaining wall of height 10 m is subjected to a water pressure of 20 kN/m^2 at its base. The wall is 1 m wide and is made of concrete of unit weight 25 kN/m^3. Find the total force acting on the wall.
17. A beam of span 10 m is subjected to a uniformly distributed load of 10 kN/m. The beam is made of steel of Young's modulus 200 GPa and cross-sectional area 0.2 m^2. Find the maximum bending moment in the beam.
18. A circular footing of diameter 2 m is subjected to a uniformly distributed load of 150 kN/m^2. Find the stress in the soil at the edge of the footing.
19. A reinforced concrete column of 200 mm $\times$ 200 mm cross-section is subjected to a compressive load of 2000 kN. Find the area of steel required for the column.
20. A culvert is to be constructed to carry a discharge of 100 m3/s. The culvert is made of concrete of roughness coefficient 0.015. Find the minimum diameter of the culvert.

Ancient Indian Architecture

by ABHISHEK RAJESH NAIR, S8 CEA

Ancient Indian architecture is a captivating journey through time, reflecting India's rich history and diverse influences. From the Indus Valley Civilization to the Gupta Empire, India's architecture evolved, leaving a legacy of remarkable temples, stupas, and viharas. The different periods beginning from Harappan followed by Mauryan, Gupta and South Indian architecture have left an indelible mark in the architectural styles and structure. It boasts of urban planning, water management, intricately carved caves as well as stupas and viharas. Here, we take a journey through time to look at the marvels inscribed in India's structural history.

Journey through time

THE architectural history of India is as old as its civilization. From the early evidence in the Indus Valley Civilization to the colonial era Victorian architecture, an empire's growth and fall, the invasion of foreign rulers, the blending of various cultures and architectural styles, and other events are all reflected in Indian architecture. It has a beautiful legacy of architecture, sculpture and temple construction. Ancient Indian architecture distinctly stands for its magnificent temples ranging from north to south and east to west, Chaityas, Stupas and Viharas. Ancient Indian Architecture is mainly divided into 5 main categories. They are

- Harappan Art and Architecture
- Mauryan Art and Architecture
- Post Mauryan Architecture
- Gupta Architecture
- South Indian Architecture

> The cities were known for their well planned cities, water supply systems, clusters of large non-residential buildings, and new techniques in handicraft and metallurgy.

Harappan Architecture

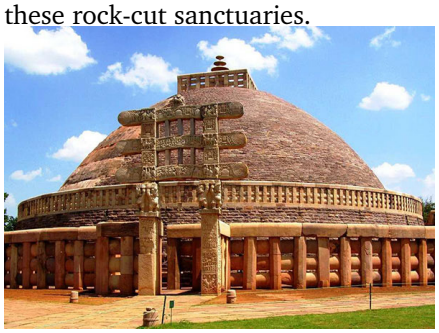
Harappan architecture represents the Bronze age Indus Valley civilization. The cities were known for their well planned cities, water supply systems, clusters of large non-residential buildings, and new techniques in handicraft and metallurgy. The art was indigenous and had no sculpture. In fact, more concentration was put on the utility factor rather than aesthetic factors. Evidence shows that the Indus culture lacked magnificent buildings such as palaces, monuments and tombs, on the contrary, most buildings were large-scale public buildings, commodious houses, or practical residences, which proved to be the first complex ancient society based on egalitarianism. The Harappan civilization is a significant milestone in the Indian subcontinent's past. In many aspects, civilization serves as a wonderful model for the modern world. Their knowledge of urban design, water management and harvesting systems, and drainage systems are unrivalled. The famous Indian Architecture sites related to the Harappan civilization include that of Harappa, Mohenjodaro, Lothal, Rakhilgarhi, Ropar, Dholavira, etc. Other Indus Valley Civilisation sites are Balathal and Kalibangan in Rajasthan, Surkotda in Gujarat, Banawali in Haryana, and Alamgirpur in UP.

The Great Bath, Mohenjodaro

Harappa's Granary and Great Hall

Mauryan Architecture

The earliest surviving architectural legacy in India, aside from the Harappan discoveries, dates to the Mauryan Empire's rule. The Mauryan emperors were great patrons of art and architecture and the buildings and pillars of this period can be considered as some of the finest specimens of Indian art. The great Greek ethnographer and historian Megasthenes was considerably impressed by the Mauryan art. In his work 'Indika', he gave a topographical account of Pataliputra, the capital of Maurya empire describing it as "the greatest city in India" having the shape of a parallelogram girdled with a wooden wall. He described that most of the houses were made of wood and the royal palace itself was made of timber. Several rock-cut caves, pillars, and stupas were constructed under the reign of Ashoka, laying the groundwork for the Buddhist School of architecture in India. In the 'Barabar' and 'Nagarjuni Hills' and Sitamarhi in Bihar, numerous cave-shrines from this time period have been excavated. These rock-cut shrines have a straightforward layout and no inside ornamental carvings. Numerous inscriptions found in the caves show that the 'Ajivika' sect's monks used to live in these rock-cut sanctuaries.



Stupa At Sanchi, Madhya Pradesh

Barabar Caves, Bihar

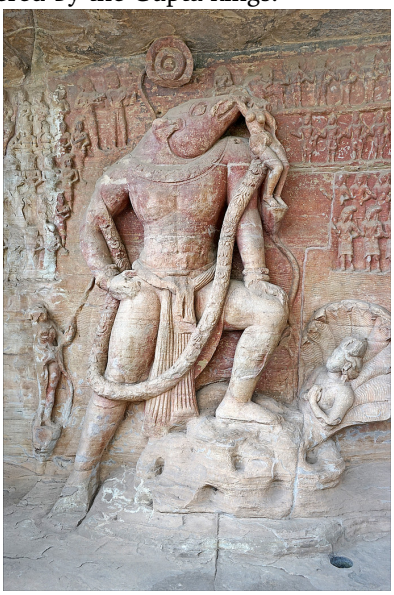
Ashoka's Pillar at Vaishali, Bihar

Gupta Architecture

The Gupta era is known as the golden era of Indian architecture. Emerged in the 4th century AD, it was classic in every sense of degree of perfection. Gupta architecture has a perfect balance and harmony of all elements in style and iconography. It included caves, stupas and temples. A wide variety of towers and elaborate carvings adorned the temples which were often dedicated to all hindu gods. One of the most magnificent cave structures that is regarded as the masterpiece of Buddhist religious art, the Ajanta caves have reflected the artis-

tic influence of Gupta architecture.

The oldest instances of religious architecture were cave-temples, which typically had a single carved doorway and an exterior adorned with relief sculpture. A Shiva linga and other ritual sculptures were set up inside the shrine, and the walls were lavishly adorned with further carvings depicting Hindu legend. A notable example is found in Udayagiri, Madhya Pradesh where one cave bears a date mark of 401 CE. One of the best pieces of Gupta art may be seen in this shrine, a famous relief depicting Vishnu as the boar-headed Varaha. The panel is 7 by 4 metres in size, and the focal point is a nearly circular figure emerging from the cosmos after slaying a snake-like monster and saving the goddess Bhudevi (Earth). The scene, a famous Hindu Purana, may also be an allegorical reference to the peace and protection offered by the Gupta kings.



Visnu, Udaigiri Caves

Ajantha Caves

Temple Architecture During Gupta Period

The long tradition of permanent free standing Hindu temples was started by the Guptas. Here, it's crucial to remember that Hindu temples were created as the dwelling place (devalaya) of a god rather than gathering places. Priests could make offerings to the gods in this decorated palace (prasada), and worshippers could also make offerings of prayers, flowers, and food (puja), usually to a holy object or statue that represented a particular god and was kept in a small, windowless building structure called the garbhagriha. Additionally, as part of a ritual act of worship, believers would walk around the temple. The Kusana, Mathura, and Gandhara styles were all influences on the Gupta style, and they all shared elements like T-shaped doors, ornamented door jambs, sculpted panels with high-relief figures, and laurel-wreath and acanthus patterns.

> In Gupta architecture, the square was considered the most perfect form and temples were designed to be appreciated from all sides so that each carries decorative architectural features.

Gupta-era temples were built with sandstone, granite, and brick, and they added horseshoe gavakshas arches and characteristic curved shikhara towers, which are frequently topped with a ribbed disc adornment known as an amalaka, to this architectural heritage. These pompous buildings are further embellished with a mass of ornate mouldings and sculptures set in niches. In Gupta architecture, the square was considered the most perfect form and temples were designed to be appreciated from all sides so that each carries decorative architectural features. The variety of Gupta structures shows that Hindu temple construction was still developing and hadn't yet reached the uniform state of subsequent centuries. However, there is no denying that Gupta-era structures had an impact on later Indian temple design, which persisted all the way up to the middle ages. Unfortunately, only a small portion of the numerous Gupta temples that were built have remained.

Bhitargaon Temple

Dashavatara Temple, Deogarh

Mahabodhi Temple, dating back to Gupta period

South Indian Architecture

South Indian Architecture or Dravidian architecture is a very distinctive form of temple architecture found in southern states of Tamil Nadu, Karnataka, Andhra Pradesh, Kerala, Telangana and some parts of Maharashtra, Odisha and Sri Lanka. A manual on Dravidian style Vastu Shastra architecture, construction, sculpture, and joinery technique can be found in the Mayamata and Manasara shilpa books, which are thought to have been in circulation during the fifth and seventh centuries CE. It is convenient to resolve the types of architecture into four periods corresponding to the principal kingdoms which ruled in southern India down the centuries.

Pallava (AD 600-900)

The temples at Mahabalipuram that were carved out of rock represent the pinnacle of Pallava architecture. A completely constructed temple complex with a towered sanctuary and mandapa (columned hall preceding the sanctuary) has been found in the Kailasanatha temple in Kanchipuram.

Shore Temple, Mahabalipuram

Kailasanathar Temple, Kanchipuram

Chola (900-1150)

Chola architecture achieved its peak at Thanjavur, the capital established by the Chola ruler Rajaraja I. The sanctuaries have rising pyramid towers crowned with dome-like roofs. Sculptures and paintings adorn the walls. Bronze sculptures of this era are the finest in southern India. These are delicately modelled, especially those depicting the Lord Shiva in his many aspects.

Brihadeshwara Temple, Thanjavur

> The temples at Mahabalipuram that were carved out of rock represent the pinnacle of Pallava architecture.

Hoysala (1100-1350)

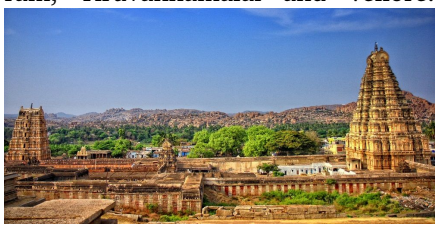
The Hoysala monarchs built temples with intricate designs and multiple angled projections. Usually done in chlorite, carved surfaces are accomplished with astounding precision. The columns are multi-faceted or lathe-turned. At Belur, Halebid, and Sringeri, you can still visit temples that date back to the Hoysala era. Raids by Alauddin Khilji and Delhi Sultanate towards the end of the 13th century disrupted architectural traditions of the Hoysala dynasty. The Vijayanagara empire later resumed construction on grand temples.

Chennakesava Swamy Temple, Somanathapura

Chennakesava Temple, Belur

Vijayanagara (1350-1565)

By the 16th century almost all of southern India was part of the Vijayanagara empire. The characteristic feature of this period is the development of the temple complex: concentric series of rectangular enclosure walls with the gopuras (towered gateways) in the middle of each side. Of the numerous Vijayanagara complexes in southern India, the most magnificent are those at Kanchipuram, Tiruvannamalai and Vellore.



Virupaksha Temple, Hampi

Vidyashankara Temple, Sringeri

Kerala on the western coast evolved a distinctive architectural

style at this time. The temples in this area were covered with sloping levels of metal or Terra cotta tiles because of the intense rainfall. The 12th century is when the Vadakkunnathan temple in Trichur was built. At Chengannur, Kaviyum, and Vaikom are later temples. The architecture of Kerala has been derived mostly from Indian Vedic architectural tradition and forms a part of the Dravidian architecture, one of the three styles of temples mentioned in the ancient books on Vastu Shastra ■

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Quote:

"Civil engineering is the art of directing the great sources of power in nature for the use and convenience of man."

- Thomas Telford

A Scottish civil engineer, prolific designer of highways and related bridges dubbed 'Colossus of Roads', elected first president of the Institution of Civil Engineers.

Bioconcrete: The Green Revolution in Construction

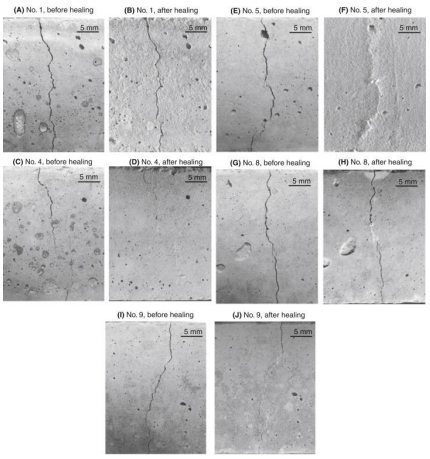
In a world prioritizing environmental sustainability, bioconcrete emerges as a revolutionary, eco-friendly alternative to traditional construction materials. Bioconcrete, also known as self-healing concrete, incorporates microorganisms, like Bacillus bacteria, into its matrix, allowing it to autonomously repair cracks, extending structural lifespan and diminishing maintenance needs. Though challenges exist, such as ensuring bacterial longevity and enhancing durability, bioconcrete represents a sustainable future in construction.

by MOHAMMED DHIYOOF P N, S6 CE

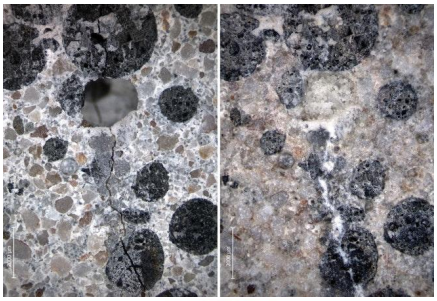
Microorganism in Concrete?

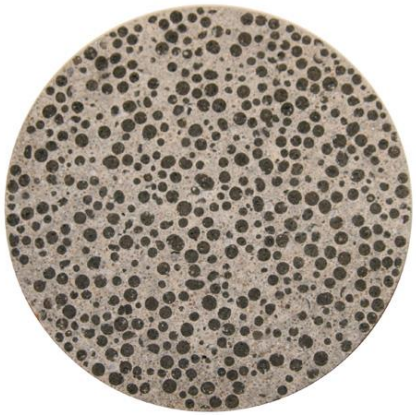
IN a world where environmental sustainability is a top priority, the construction industry is not exempt from the need to reduce its ecological footprint. Bioconcrete, a groundbreaking innovation, offers a sustainable alternative to traditional concrete, addressing both environmental concerns and structural performance. In this article, we will explore the concept of bioconcrete, its composition, benefits, applications, and the potential it holds for a greener future in construction.

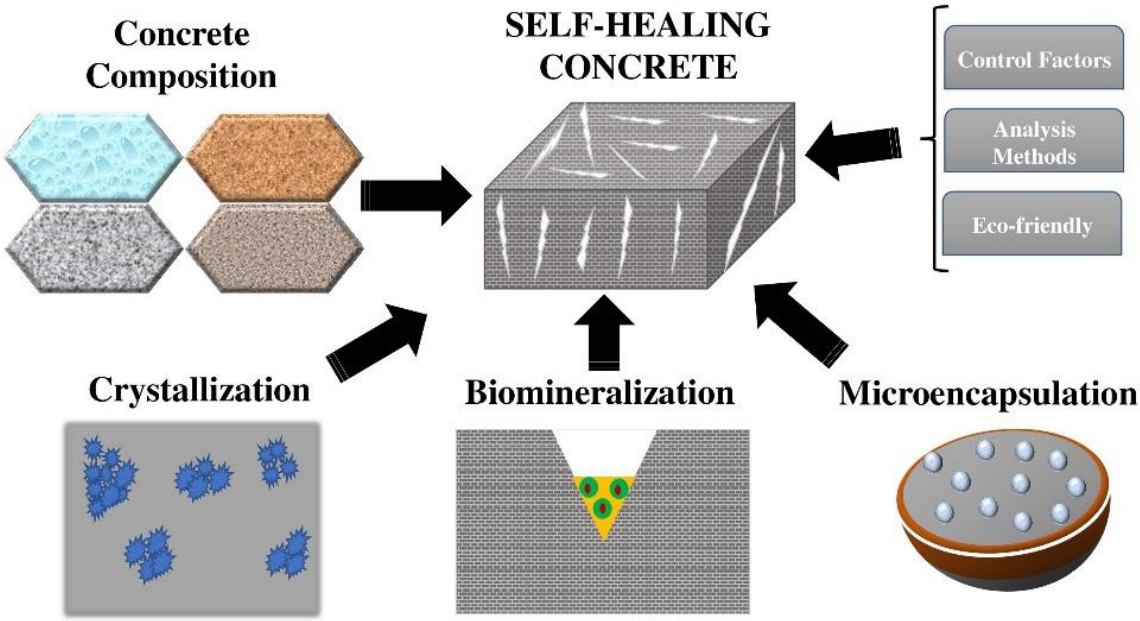
Bioconcrete, also known as self-healing concrete, is a revolutionary material that integrates microorganisms into the concrete matrix. These microorganisms, typically bacteria such as Bacillus species, are specially selected for their ability to repair cracks that naturally occur in concrete over time. This innovation aims to extend the lifespan of structures and reduce the need for frequent repairs and replacements. Bioconcrete's base is similar to conventional concrete, consisting of cement, sand, gravel, and water. A key differentiator, bioconcrete includes dormant bacterial spores that remain inactive within the concrete until cracks form. To activate the microorganisms, bioconcrete contains a source of nutrients, typically calcium lactate, which the bacteria feed on when exposed to moisture. When cracks appear in traditional concrete, they can lead to structural degradation. Bioconcrete's self-healing mechanism activates when these cracks allow water to penetrate. The dormant bacteria come into contact with moisture and begin consuming the nutrients, producing limestone as a byproduct. This limestone fills the cracks, effectively repairing and sealing them, preventing further damage.



The history of bioconcrete is a relatively recent development, with notable milestones in its development over the past few decades, The concept of using bacteria to repair concrete dates back to the 1990s. Dutch researcher Hendrik Jonkers is often credited with pioneering the idea. He began experimenting with self-healing concrete in the early 2000s, using a type of bacteria called "Bacillus" to mend cracks in concrete.







In 2010, Jonkers' research led to the first commercial application of bioconcrete in the Netherlands. A Dutch construction company used bioconcrete to repair a damaged concrete structure. This marked a significant milestone in the practical application of the technology. Throughout the 2010s, interest in bioconcrete grew, leading to more research and development efforts worldwide. Researchers experimented with different types of bacteria, improving their viability in concrete and optimizing the self-healing process. Bioconcrete gained international recognition as a sustainable and innovative construction material. Research institutions, universities, and companies around the world started investing in further studies and improvements in bioconcrete technology. In recent years, bioconcrete has found applications in various construction projects, including bridges, tunnels, and buildings. Its potential for reducing maintenance costs and increasing the lifespan of structures has made it an attractive choice for infrastructure development.

Bioconcrete reduces the environmental impact of construction by extending the lifespan of structures, reducing the need for frequent demolitions and reconstructions. Structures made with bioconcrete have enhanced durability, as the self-healing mechanism continuously repairs minor cracks, reducing maintenance costs.

> "Structures made with bioconcrete have enhanced durability, as the self-healing mechanism continuously repairs minor cracks, reducing maintenance costs."

Long-term savings are achieved by minimizing repair and maintenance expenses. The production of bioconcrete can potentially lower carbon emissions associated with the construction industry. Bioconcrete can be employed in various construction applications, including bridges, tunnels, and roads which benefits from bioconcrete's durability and reduced maintenance needs. Bioconcrere can also be used in the construction of homes and office buildings, providing long-lasting structures. Due to its resistance to saltwater corrosion, bioconcrete is ideal for coastal structures and it can be used to restore and preserve historic structures.

While bioconcrete shows great promise, it is not without challenges. One major hurdle is ensuring the long-term viability of the bacteria within the concrete, especially in harsh environmental conditions. Researchers are continually working to improve the durability and effectiveness of bioconcrete. In the future, bioconcrete could be further enhanced by incorporating other sustainable materials, such as recycled aggregates and alternative cementitious binders. Additionally, the development of bioconcrete for larger-scale construction projects and widespread adoption in the industry will be vital for its success.

Bioconcrete represents a promising and sustainable solution for the construction industry, offering enhanced durability, reduced maintenance costs, and a reduced carbon footprint. As research and development in this field continue, bioconcrete has the potential to revolutionize the way we build and maintain our infrastructure while contributing to a greener and more sustainable future ■ □□□□□

Civil Engineering In Space

by AJITHKUMAR A B, S4 CEA

Civil Engineering is expanding its horizons into the cosmos, tackling the challenges of space infrastructure. This article delves into the possibilities, challenges, and future of civil engineering in space. Engineers are tasked with designing habitats, power sources, launchpads, and transportation systems to support space colonization. Key considerations include resource utilization, harsh environments, and the development of innovative materials. The future holds promise for permanent habitats, space-based infrastructure, and sustainable practices in space engineering, albeit with significant financial and international cooperation challenges.

Buildings in Space?

CIVIL engineering has long been associated with the design, construction, and maintenance of the built environment on Earth. However, with the advancement of space technology and exploration, civil engineers are now exploring new frontiers in space engineering. We will discuss the possibilities, challenges, and future of civil engineering in space, with a focus on the Moon and Mars.

The field of space civil engineering offers exciting possibilities for the development of space infrastructure and colonization. With the growing interest in human exploration and settlement beyond Earth, civil engineers are tasked with designing and building the necessary infrastructure to support human life on the Moon and Mars. Some of the potential projects include the construction of habitats, power plants, launchpads, and transportation systems.

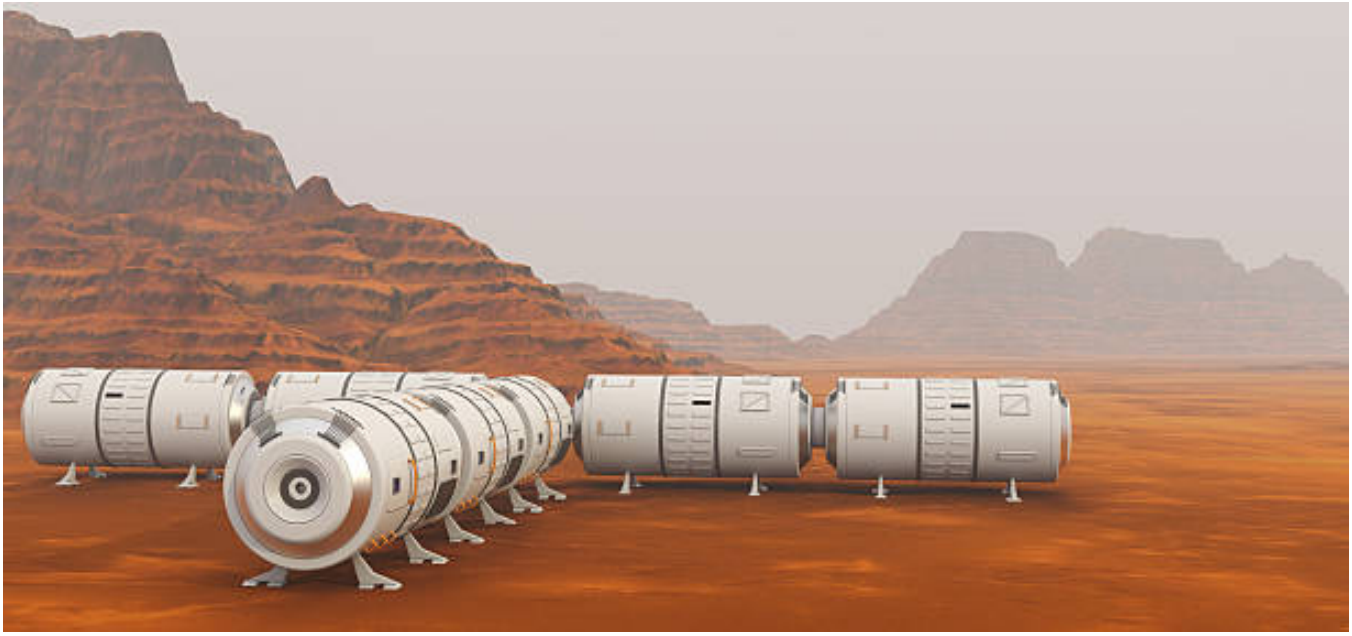
One of the primary benefits of developing space infrastructure is the potential for resource utilization. The Moon and Mars are rich in resources, such as water, iron, and other minerals that can be used to sustain human life and support space-based industries. Civil engineers can develop technologies and systems that can extract, process, and utilize these resources for various purposes, including the production of fuel and building materials.

> With the growing interest in human exploration and settlement beyond Earth, civil engineers are tasked with designing and building the necessary infrastructure to support human life on the Moon and Mars.

The Moon is considered one of the most promising destinations for space colonization and infrastructure development. The Moon's proximity to Earth, low gravity, and abundant resources make it an ideal location for the establishment of a permanent human presence. Civil engineers are already working on various projects aimed at developing lunar infrastructure, such as the Lunar Gateway, a small space station that will orbit the Moon and serve as a staging point for human missions to the lunar surface.

One of the most significant challenges of developing lunar infrastructure is the harsh lunar environment. The Moon's surface is covered in regolith, a layer of loose soil and rocks that can damage equipment and structures. Civil engineers must design structures and equipment that can withstand the harsh lunar environment, including extreme temperature fluctuations and exposure to radiation.

Mars is another promising destination for space colonization and infrastructure development. The Red Planet's similarities to Earth, including a day/night cycle and a carbon dioxide atmosphere, make it a potential site for terraforming and the establishment of a permanent human presence. Civil engineers are already



working on various projects aimed at developing Martian infrastructure, such as the Mars Habitat, a proposed modular living space that can be transported to Mars and assembled on-site.

One of the most significant challenges of developing Martian infrastructure is the planet's distance from Earth. Mars is located approximately 140 million miles from Earth, which makes communication and resupply missions more challenging. Civil engineers must design infrastructure that can operate autonomously and withstand the harsh Martian environment, including dust storms and extreme temperature fluctuations.

One potential material for space infrastructure is advanced composites. Advanced composites are materials made from two or more constituent materials with significantly different physical or chemical properties. These materials offer a high strength-to-weight ratio, making them ideal for space infrastructure. They are also highly resistant to radiation and temperature fluctuations, which makes them a suitable material for long-term space missions. Another material that is gaining attention in the field of space civil engineering is 3D printed materials. 3D printing allows for the creation of complex structures and shapes that are not possible with traditional manufacturing techniques. This technology allows for the production of lightweight, durable, and customizable materials that can withstand the harsh space environment. Additionally, 3D printing can be done using raw materials found on the Moon or Mars, making it a potentially cost-effective and sustainable option for space infrastructure development.

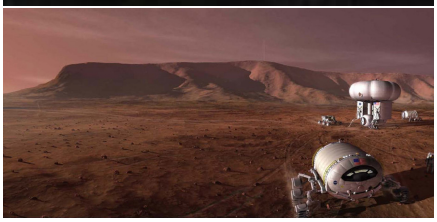
> "Advanced composites, 3D printed materials, carbon nanotubes, graphene, and aerogels are just some of the potential materials that could be used in space civil engineering projects."

Other potential materials for space infrastructure include carbon nanotubes, graphene, and aerogels. Carbon nanotubes and graphene are lightweight, strong, and highly conductive materials that have potential applications in space-based electronics and energy storage systems. Aerogels, on the other hand, are highly insulating materials that can be used to protect spacecraft and habitats from extreme temperature fluctuations. In conclusion, selecting the right materials for space infrastructure is critical to its success. Civil engineers must consider a range of factors, including strength, durability, weight, and resistance to radiation and temperature fluctuations. Advanced composites, 3D printed materials, carbon nanotubes, graphene, and aerogels are just some of the potential materials that could be used in space civil engineering projects. The use of these innovative materials has the potential to revolutionize space infrastructure development and support human exploration and settlement beyond Earth.

In the future, civil engineering in space is expected to play an increasingly important role in supporting human exploration and settlement beyond Earth. As space agencies, private companies, and governments continue to invest in space exploration, civil engineers will be called upon to design, build, and maintain the infrastructure needed to support these endeavors.

One of the most exciting possibilities for space civil engineering in the future is the establishment of permanent habitats on the Moon and Mars.

These habitats would provide a base for scientific research, exploration, and potentially even tourism. Civil engineers would be responsible for designing and building these habitats, ensuring they are durable, safe, and comfortable for human habitation.



Another important area of future development in space civil engineering is the construction of space-based infrastructure to support activities such as manufacturing, resource extraction, and power generation. The use of 3D printing and advanced composite materials will be critical in enabling the construction of these structures, which will need to be lightweight and durable to withstand the harsh space environment.

Furthermore, space civil engineering will also play a critical role in mitigating the environmental impacts of human activities in space. This will include the development of sustainable infrastructure and waste management systems that minimize the impact of human activities on the space environment.

> As humanity continues to explore and expand into space, civil engineers will be at the forefront of designing and building the infrastructure needed to support these activities.

Overall, the future of civil engineering in space is very promising. As humanity continues to explore and expand into space, civil engineers will be at the forefront of designing and building the infrastructure needed to support these activities. From permanent habitats on the Moon and Mars to space-based infrastructure for manufacturing and power generation, the possibilities for space civil engineering are virtually limitless, and the future is very exciting.

Developing space infrastructure and colonization is not without its challenges. One of the most significant obstacles is the high cost of space exploration and development. The development of space infrastructure requires significant financial resources, and funding for such projects can be difficult to obtain. Additionally, the harsh space environment can present significant engineering challenges, including exposure to radiation, micro-meteoroids, and extreme temperature fluctuations.

Another significant challenge is the need for international cooperation and collaboration. Space exploration and development are global endeavors that require cooperation between nations and organizations. Civil engineers must work closely with other stakeholders, including scientists, policymakers, and industry leaders, to develop and implement effective space infrastructure projects ■

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GIS Applications in Civil Engineering

by CARMEL LEEZA SHAJI, S2 CEA

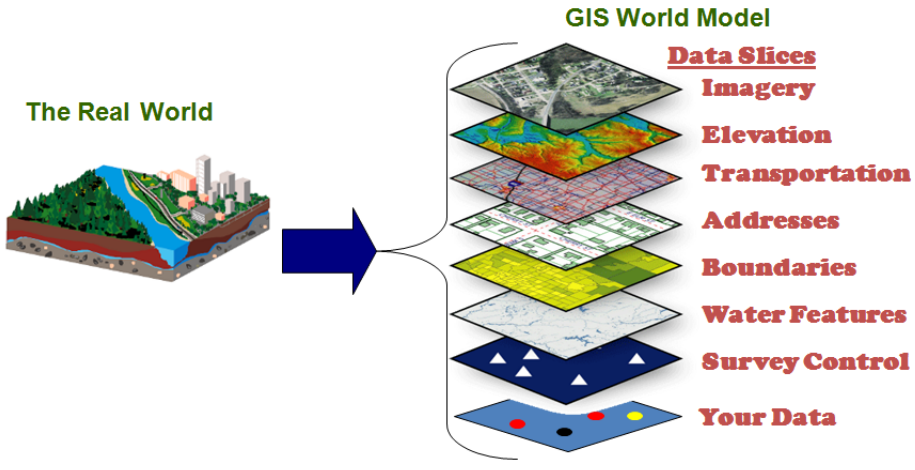
GIS (Geographic Information Systems) applications have revolutionized civil engineering by offering a powerful tool for data gathering, analysis, and decision-making. Several successful applications in urban planning, transportation, renewable energy site selection, and environmental impact assessment showcase its versatility. Future trends include AI and machine learning integration, real-time data utilization, augmented and virtual reality, cloud-based platforms, big data analytics, and mobile GIS, all poised to further transform the field of civil engineering.

Next revolution in Civil Engineering?

THE field of civil engineering has advanced substantially. Modern civil engineers can benefit from a variety of technologies, including geographic information systems (GIS). GIS can be used by engineers to gather and assess geographic data. The information can then be displayed in layered images using digital geographic maps. GIS software is used to analyze, store, and modify geographic data so that it may be compared to other items. It can be applied in a variety of businesses to gather data of various types, including environmental information and logistics. When used in projects involving civil engineering, GIS has various advantages. Here are a few significant benefits:

Improved Collaboration:

GIS makes it possible for civil engineers, architects, planners, and contractors to collaborate more effectively. GIS enables in-the-moment communication and collaboration by offering a centralized platform for data sharing. The same geographic database is accessible to all team members, assuring accurate and consistent data. This promotes project efficiency overall, enhances cooperation, and decreases errors brought on by misunderstanding.



> The ability to visualize data makes it easier to spot trends, connections, and potential problems that might not be obvious from tabular data alone.

Improved Project Visualization and Analysis:

With the use of GIS, civil engineers may visualize project data on maps, giving analyses a spatial context. The ability to visualize data makes it easier to spot trends, connections, and potential problems that might not be obvious from tabular data alone. To acquire insights and make wise judgments, engineers might overlay many layers of information, including terrain models, land use data, infrastructure networks, and environmental considerations. In order to examine project designs and potential environmental effects, GIS now provides 3D visualization.

Better Data Management:

Survey data, geotechnical data, utility networks, and project papers are just a few of the many types of data that civil engineering projects produce. A reliable framework for managing and organizing this data is provided by GIS. Engineers can efficiently store and retrieve data, assuring data accessibility and integrity. With GIS, it is simpler to keep track of changes, update project data, and preserve an extensive project history that is useful for future reference and upkeep.

Accurate geospatial analysis

It is possible because of GIS's robust analysis capabilities, which lets civil engineers model, simulate, and perform spatial computations. They may, among other things, analyze the transportation network and terrain, as well as evaluate the stability of slopes. These assessments aid in determining potential hazards, assessing the viability of design alternatives, and improving project schedules. Engineering decisions are more accurate and reliable when using GIS since it takes into account actual geographic factors.

Cost and Time Savings:

GIS may help civil engineering projects save a lot of money and time. Site selection, infrastructure routing, and resource allocation can all be optimized with the use of GIS. Multiple scenarios can be assessed, the effects of various design decisions can be evaluated, and cost-effective solutions can be found. By automating routine processes, minimizing manual labor, and eliminating human mistake, GIS also speeds up workflows. GIS aids in decision-making and efficiency improvements that keep projects on schedule and within budget.

Effective asset management

It is made possible by GIS, which aids in the ongoing management of civil infrastructure assets like utilities, facilities, roads, and bridges. GIS is a tool that engineers can use to keep track of asset locations, assess their condition, plan for improvements and replacements, and schedule maintenance tasks. This proactive method of asset management extends the useful life of the infrastructure, minimizes downtime, and optimizes resource use.

There are several instances of GIS implementation in civil engineering projects that has been successful. Here are a few noteworthy instances:

Infrastructure planning for cities

has made substantial use of geographic information systems (GIS). A GIS system, for instance, was put into place by the city of Barcelona in Spain to monitor and design its urban infrastructure. The system included information on utilities, land use, transportation networks, and environmental variables. This made it possible for city planners to better allocate resources, analyze and visualize the effects of proposed infrastructure investments, and enhance overall urban development strategies.

Assessment and management of flood risks

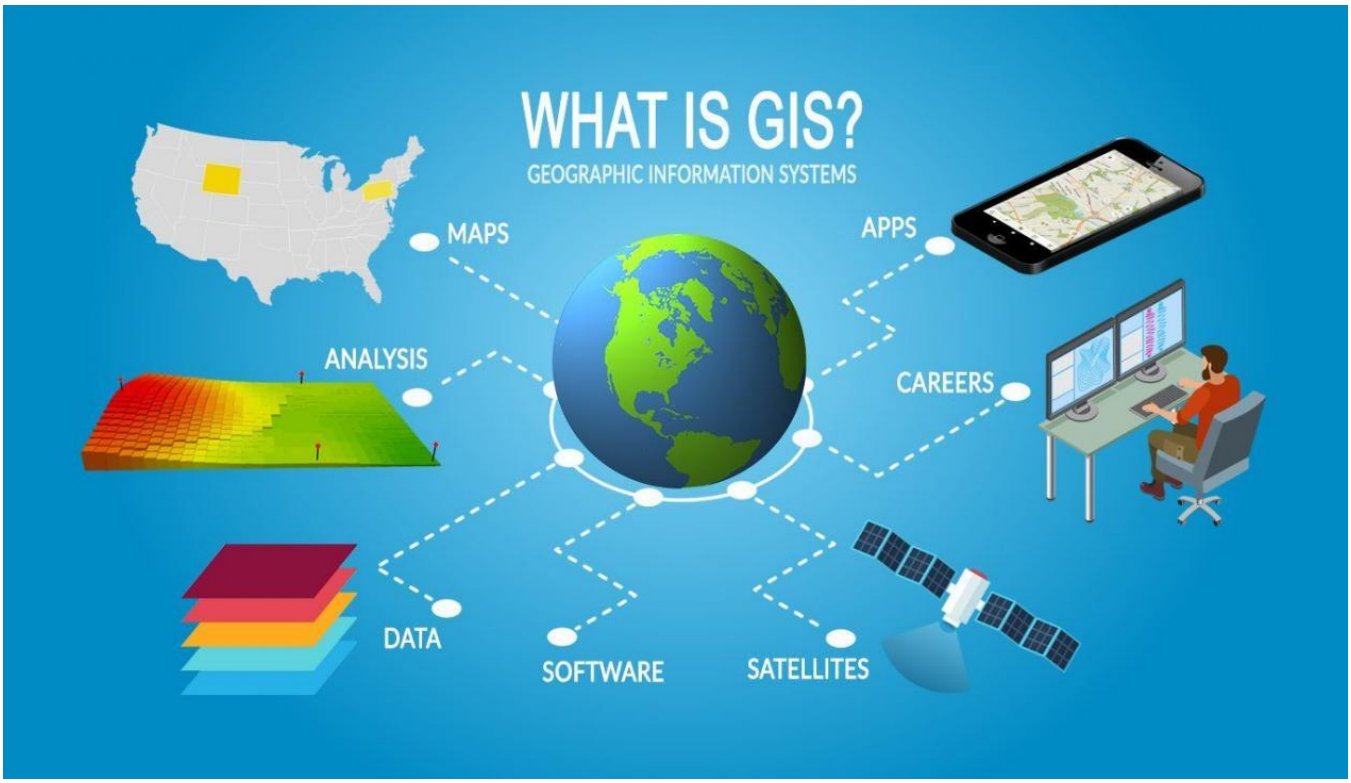
have both benefited greatly from the use of GIS. The Netherlands, a nation renowned for its intricate water management systems, has widely used GIS in this area. To analyze flood-prone areas, predict water flows, and develop flood defense plans, the Dutch government employs GIS. With the use of GIS's data integration and analysis tools, it is possible to detect flood-prone locations, build suitable drainage systems, and make well-informed choices regarding land use and development next to water bodies.

Planning and management for transportation

have been completely transformed by GIS. The Transport for London (TfL) organization in London has put in place a thorough GIS system named "London Streets." Data on road networks, traffic patterns, public transportation, and pedestrian infrastructure are all integrated by this system. GIS is a tool that TfL employs to analyze traffic patterns, plan for network expansion and enhancements, and optimize travel routes. Reducing travel times, strengthening public transit services, and increasing overall mobility in the city have all been made possible by GIS-based technologies like real-time traffic monitoring and congestion analysis.

Site Selection for Renewable Energy Projects:

GIS is essential for choosing appropriate locations for these projects. For instance, the Renewable Energy Potential (RE-POTENTIAL) tool was created in the United States by the National Renewable Energy Laboratory (NREL). To determine the best locations for solar and wind energy projects, this GIS-based program evaluates a variety of variables, including solar radiation, wind speeds, land availability, and environmental



restrictions. The tool helps developers to decide on a project's long-term viability, prospective energy generation, and feasibility with knowledge.

Environmental Impact Assessment:

During the planning and execution of civil engineering projects, GIS makes it easier to analyze the environmental implications. To evaluate the potential effects of coastal development on the Great Barrier Reef, the Great Barrier Reef Marine Park Authority (GBRMPA) in Australia employs GIS. The GIS system combines information on prospective development projects, water quality, marine habitats, and reef health. To safeguard and conserve the delicate marine ecology, the GBRMPA can analyze the combined effects of many elements, consider alternative outcomes, and take well-informed decisions.

A number of fascinating trends and advancements, such as the incorporation of machine learning (ML) and artificial intelligence (AI) methods, will shape GIS technology in the future. Here are some crucial areas where GIS development is anticipated:

AI and ML in Spatial Analysis:

To improve the capabilities of spatial analysis, AI and ML algorithms are rapidly being implemented into GIS software. These methods can automatically discover patterns or anomalies in geographic information, classify different types of land cover, extract characteristics from remote sensing data, and detect changes over time. Predictive modeling, which uses previous data to predict future patterns and make data-driven decisions, is another capability provided by AI and ML.

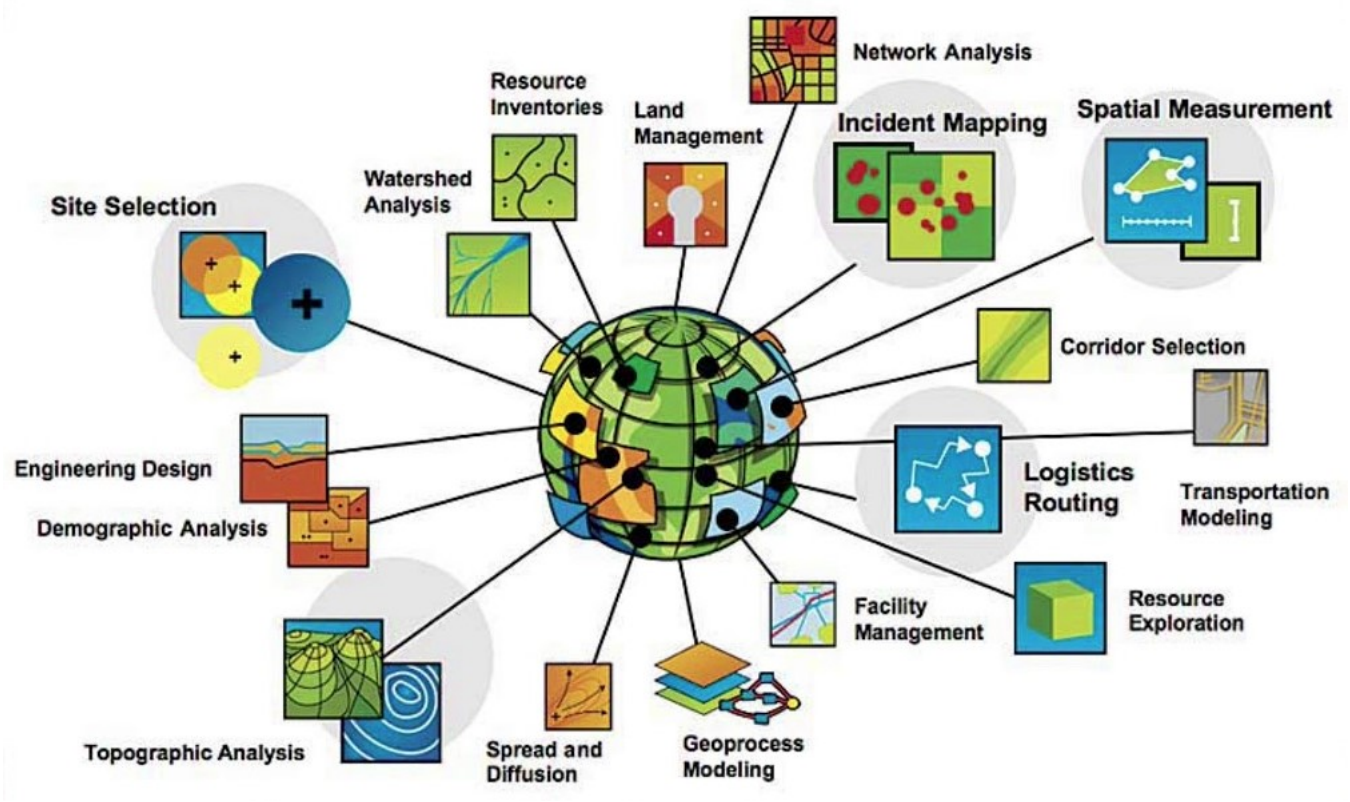
Integration of real-time data

from sensors, linked devices, and social media feeds is anticipated to occur as the Internet of Things (IoT) develops further. This integration makes it possible to dynamically visualize and analyze data streams, improving situational awareness and decision-making. To optimize traffic flow in real-time or to track the spread of illness during an outbreak, for instance, traffic sensors and social media data can be merged.

> GIS is developing to handle big data analytics as a result of the explosion of spatial data from numerous sources, such as satellites, drones, and social media.

Augmented reality (AR) and virtual reality (VR)

GIS is integrating augmented reality (AR) and virtual reality (VR) technology to provide immersive experiences for data visualization and analysis. Geospatial data can be superimposed on the actual environment with augmented reality, improving navigation and fieldwork. For scenario-based re-



Applications of GIS

search and planning, VR may construct virtual worlds. Stakeholders may now explore and engage with spatial data in more intuitive and engaging ways thanks to this integration.

Web GIS and cloud computing:

Due to its scalability, accessibility, and collaborative features, cloud-based GIS platforms are gaining popularity. Large geographic datasets may be efficiently stored, processed, and shared thanks to cloud computing. By allowing users to access GIS resources through web browsers, web GIS technologies increase the audience for GIS. Additionally, cloud-based GIS enables seamless data exchange and interoperability by facilitating the integration of various datasets and services.

Big Data Analytics:

GIS is developing to handle big data analytics as a result of the explosion of spatial data from numerous sources, such as satellites, drones, and social media. Massive datasets are being processed and analyzed using cutting-edge algorithms and distributed computing approaches. Better decision-making in a variety of areas, including urban planning, transportation, and environmental management, is made possible by these advancements, which enable the extraction of meaningful insights from huge and complicated geospatial data.

Location-based services and mobile GIS:

The prevalence of mobile devices with GPS capabilities has fueled the expansion of mobile GIS applications. Field staff can gather and update data locally using GIS on mobile platforms, which enhances data accuracy and real-time decision-making. Location-based services (LBS) are advancing as well, giving users contextually relevant and personalized information based on their location.

Conclusion

Data may be organized and distributed by civil engineers using GIS, and they can also use it to create reports and visualizations that are easy for others to comprehend and study. As a result, GIS is playing a bigger role in civil engineering businesses, helping with every stage of the life cycle of infrastructure. As we navigate the ever-evolving landscape of infrastructure development, GIS stands as a beacon of innovation, cost-efficiency, and sustainability, driving the industry forward into a new era of possibilities ■ □□□□□

by PAUL BOSE,
2017-2021 BATCH

Exploring the Expansive Horizons of Civil Engineering for Graduate Engineers in India

Civil engineering in India is undergoing a dynamic transformation, offering a diverse range of prospects for graduate engineers. This article explores the multifaceted world of civil engineering, including specialized branches, higher education ecosystem in India and job opportunities. The article further delves into international opportunities, emphasizing the importance of professional networks for career growth and innovation in this evolving industry.

What after BTech?

THE field of civil engineering has been a cornerstone of modern society, shaping the built environment and infrastructure that surrounds us. In India, this discipline has witnessed remarkable growth, offering an array of opportunities for graduate engineers to embark on a journey of further studies and career advancement. With a focus on diverse branches, job prospects, higher education avenues, and international opportunities, this article aims to shed light on the vast scopes that await these aspiring professionals.

Unveiling the Diversity within Civil Engineering:

Civil engineering, traditionally associated with designing and constructing physical structures, has evolved into a multi-faceted discipline encompassing various branches. Graduates can specialize in areas such as structural engineering, transportation engineering, geotechnical engineering, environmental engineering, and more. Additionally, emerging branches like mining engineering, ocean engineering, and forensic engineering have opened new avenues, enabling engineers to contribute to a broad spectrum of industries.

> Graduate engineers in civil engineering are in high demand across various industries.

Thriving Higher Studies Ecosystem:

India boasts a plethora of esteemed institutions offering higher education in civil engineering. Institutes like the Indian Institutes of Technology (IITs), National Institutes of Technology (NITs), and Indian Institutes of Information Technology (IIITs) provide comprehensive postgraduate programs. Specialized universities like the Indian Institute of Science (IISc) and Jawaharlal Nehru University (JNU) also offer advanced degrees in civil engineering, empowering students to delve deeper into their chosen branches.

Job Opportunities: Where Dreams Take Shape:

Graduate engineers in civil engineering are in high demand across various industries. In the infrastructure sector, names like Larsen & Toubro, Tata Projects, and Shapoorji Pallonji are synonymous with groundbreaking projects. Companies like Afcons, Gammon India, and Hindustan Construction Company (HCC) offer opportunities in diverse segments like construction, transportation, and urban development. Moreover, public sector undertakings like NHAI, DMRC, and Railways provide stability and impactful projects.

Rising Sun of Specialized Fields:

New horizons in civil engineering have emerged, beckoning young engineers to explore uncharted territories. Mining engineering combines engineering principles with geology to ensure sustainable extraction of mineral resources. Ocean engineering addresses challenges in coastal zone management, renewable energy, and offshore structures. Forensic engineering, on the other hand, applies engineering expertise to in-

vestigate failures and accidents, contributing to the legal system.

In addition to these exciting prospects, the digital revolution is reshaping the landscape of civil engineering in India. The integration of cutting-edge technologies like Building Information Modeling (BIM), Artificial Intelligence (AI), and data analytics is enhancing project efficiency and sustainability. Civil engineers now have the opportunity to leverage data-driven insights, predictive modeling, and virtual simulations to optimize designs and operations. This technological wave not only fosters innovation but also equips graduate engineers with invaluable skills to thrive in the industry's evolving demands, reinforcing India's position as a hub for dynamic civil engineering advancements.

Global Perspectives: Beyond Boundaries:

For those looking to broaden their horizons, pursuing higher studies abroad is an enticing option. Universities like Massachusetts Institute of Technology (MIT), Stanford University, and University of California, Berkeley offer cutting-edge programs in civil engineering. In Europe, ETH Zurich, Imperial College London, and Delft University of Technology provide research-intensive environments. International exposure not only enhances technical skills but also fosters a global perspective.

> "Being part of professional bodies is pivotal for holistic growth. Memberships enable engineers to stay updated with industry trends, connect with experts, and access resources that enhance career prospects."

Networking for Professional Growth:

Being part of professional bodies is pivotal for holistic growth. Organizations like the Institution of Civil Engineers (ICE), American Society of Civil Engineers (ASCE), Indian Concrete Institute (ICI) etc provide platforms for networking, knowledge sharing, and skill enhancement. Memberships enable engineers to stay updated with industry trends, connect with experts, and access resources that enhance career prospects.

Conclusion- Embrace the Opportunity:

In the expansive realm of civil engineering, opportunities abound for graduate engineers in India. With a myriad of branches, higher education avenues, and job prospects, this field offers a canvas for aspiring engineers to make their mark. From iconic infrastructure projects to innovative research, the journey promises challenges and rewards. By harnessing the power of professional networks and international exposure, these engineers can chart a course towards a successful and fulfilling career.

In the end, the potential for growth lies not only in the bricks and mortar but in the creative minds and visionary spirits of civil engineers. As India propels forward into a new era of development, these graduate engineers stand at the helm, ready to shape the future with innovation, expertise, and a commitment to sustainable progress ■ □□□□□

Visit to Bhurj Khalifa

This is an interesting and distinct article for you, the reader. You get the opportunity to visit the tallest building in the world. Would you choose to be a tourist and marvel at the structure, or would your engineering instincts kick in, sending you down a rabbit hole of contemplation about the intricate science behind it? Let's take a look at what happened with this beloved faculty on a trip to Dubai. Looks like he conducted a few experiments of his own. Sounds fun, isn't it? Also, brought us some unique questions to ponder over. Read to find out!

by UNNI KARTHA G,
PROFESSOR

What do you do when you visit the tallest building in the world?

IT was just a pleasure trip, my family decided to visit Dubai, the paradise of buildings during the vacations. There was a lot of excitement in me, when the visa was stamped and the tickets were booked.

Dubai is a city and emirate in the United Arab Emirates known for luxury shopping, ultramodern architecture and a lively nightlife scene. Burj Khalifa, an 830m-tall tower, dominates the skyscraper-filled skyline. At its foot lies Dubai Fountain, with jets and lights choreographed to music. On artificial islands just offshore is Atlantis, The Palm, a resort with water and marine-animal parks. Dubai is a relatively young city, founded in the early 1800s. However, it has grown rapidly in recent decades, thanks to its strategic location on the Arabian Gulf and its oil wealth. Today, Dubai is a major financial and trading hub, and a popular tourist destination. Being a civil engineer, the most exciting part of the trip was the tour through the city. The skyline is stunning. Dubai is known for its ultramodern architecture, and many of its buildings have been copied from other parts of the world. There are a few reasons for this. First, Dubai has the money to build these ambitious projects. The city is a major financial hub, and its rulers are not afraid to spend money on eye-catching landmarks. Second, Dubai has the expertise to build these buildings. The city has a large pool of skilled engineers and architects, many from India, and it is home to some of the world's leading construction companies. Third, Dubai is a global city, and its buildings are seen as symbols of its success. Other cities want to emulate Dubai's success, and they see its buildings as a way to do that.

> "Dubai is a global city, and its buildings are seen as symbols of its success. These buildings are not only impressive feats of engineering, but they are also symbols of Dubai's ambition."

These buildings are not only impressive feats of engineering, but they are also symbols of Dubai's ambition and its status as a global city. It is no wonder that they have been copied in other parts of the world. However, there are also some concerns about the copying in Dubai's buildings. Some critics argue that it is unoriginal and that it contributes to the homogenization of architecture. Others worry that it is a waste of resources, as these buildings are often not suited to the local climate or culture. Despite these concerns, the copying in Dubai's buildings is likely to continue. The city's ambition and its status as a global trendsetter make it an attractive model for other cities. And as long as there is demand for these iconic buildings, there will be people willing to build them.

There were many things that we did during the visit in Dubai, this article is just about the visit that we made to the tallest building in the world, the Burj Khalifa. There were two things that captured my mind - the towering height and second the speed of the lift. We must take tickets to go to the 124th and 125th floor which offers stunning panoramic views of Dubai city. Words come short to explain the feel we get at the top. There are two lifts which take tourists to these floors, which are lightning fast - they travel at the

speed of 36kmph. It takes just one minute to reach the 124th floor. The experience is unmatched, the walls of the lifts come alive during the ascent, with LED walls playing the video about the structure.

The building shape is inspired after Dubai's most widely cultivated flower - the spider lily. 70% of the building is supported by concrete core and the top 25% does not have any concrete core. The building is asymmetric - this is essentially to reduce the vortex shedding due to wind. There is a well designed structural health monitoring system which constantly monitors the vibrations of the building. The building reportedly has a tuned mass damper system. The building does experience vibrations due to wind, and can sway up to 2m at the top!

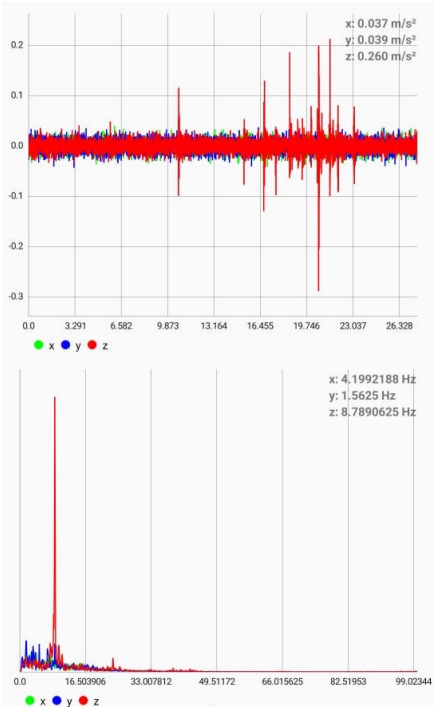
So, what should a civil engineer do when you reach the tallest building? Over a period of time, my interests in vibrations measurements in structures have deepened. I kept thinking - will a human feel the movement of the building in the wind at the top floor? Will there be movement at all? Will it be possible to measure those movements? What can I do to measure the vibrations or movements at the top floor of the building? And so on. Obviously, no one will be permitted to take any equipment or allow anyone to measure anything of this sort. What was the next best thing?

> "The building does experience vibrations due to wind, and can sway up to 2m at the top!"

I knew that my mobile app would be able to capture vibrations using the sensors in it. There are many apps that help to measure vibrations. I have tried a few, though not very accurate, we can still get something out of it. As I waited in the queue, I was planning in my mind - once I reach the top, I will use my mobile to record some vibrations. I was not quite sure if that would be possible with the security people and the tourists. At the end, when I reached the top, I used the opportunity to keep my mobile on the floor and then record the vibrations - my plan was a success!

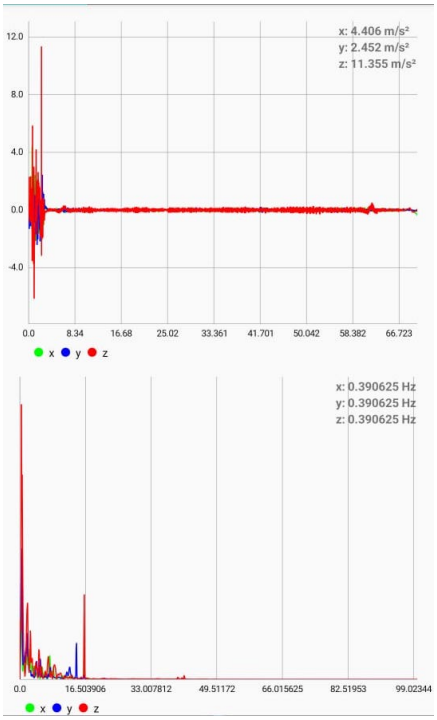
Figure 1 shows the accelerations recorded and the FFT (Fast Fourier Transform) of the signal recorded from the 124 floor, no filters are applied here. FFTs indicated the dominant frequencies in the signal. The spikes in the accelerations are due to the people walking near to the place where the mobile phone was kept. The dominant frequencies in x, y and z axes were 4Hz, 1Hz and 8.8Hz respectively. Does this ring anything in your head? The z direction is the frequency of the vibration of the floor. The x and y are lateral directions. It is reported in literature that Burj Khalifa's natural frequency of vibration

is around 0.2 Hz. Also, the natural frequency of vibration is different for different parts of the building and affected by wind. The top of the building has a higher natural frequency than the bottom. So, are my readings way off? Or is it close to reality? A detailed analysis will be required.



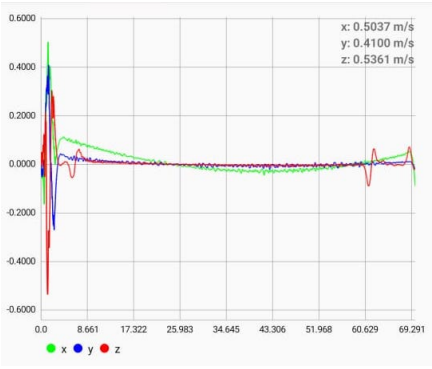
1. Recorded acceleration and FFT at the 124th Floor

On the way back, I kept my mobile on the lift floor to record the motion! I just kept the mobile on the floor and recorded the accelerations. That also worked. The plot below shows the data recorded during the descent. I should have recorded the expressions on the faces of the fellow passengers! Figure 2 shows the accelerations recorded on the floor and the corresponding FFT. Figure 3 and 4 are the velocity and displacements obtained after evaluating the acceleration signal. The recordings from the elevator are not complete and hence the evaluations may not be perfect. Still there is something to think about.

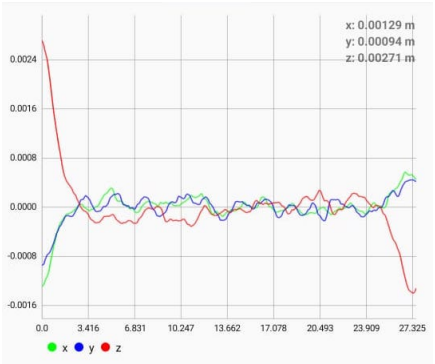


2. Acceleration recordings from the floor of the elevator during descent

It is not attempted to interpret the results here - that story is left for another article. If you are curious, the app that I used was iDynamics, the mobile app provided by University of Kaiserslautern, Germany. The stunning views that my mobile could not capture will remain with me forever ■



3. Velocity profile obtained during descent



4. Displacement profile obtained during descent

□□□□□

Challenge:

In the article above, the results of the vibration data are not interpreted. What do you think these results mean? Ringing any bells? What does the graphical data imply?
Submit yours answers and thoughts to the email address provided in Information Bulletin.

Exploring Nano Homes: A Glimpse into the Future of Sustainable Living


by Abhirami Shaji, S4 CEA
& Aleena Shaji, S4 CEA

Nano Homes, the epitome of compact, sustainable living, offer a visionary solution to contemporary housing challenges. As urban spaces grow scarcer, Nano Homes provide affordable housing options, particularly vital in densely populated areas like India. These pint-sized dwellings envision a sustainable future where efficiency and quality of life coexist, addressing the pressing global housing crisis.

Sometimes we wish to migrate to a place we like. What if we can move the entire house?

What Nano house means?

In an era characterized by rapid urbanization, soaring property prices, and increasing environmental concerns, Nano Homes have emerged as a groundbreaking solution to some of the most pressing challenges in contemporary living. These miniature dwellings represent more than just a reduction in size; they signify a paradigm shift in the way we conceptualize and interact with our living spaces. With their innovative approach to compact design and eco-conscious living, Nano Homes offer a glimpse into the future of housing.

The Nano House: A Sustainable Marvel

At the forefront of the Nano Homes movement is the Nano House, hailed as the world's smallest sustainable house. This Swiss-made architectural wonder challenges conventional notions of what constitutes a home. It is a testament to human ingenuity, offering a blueprint for sustainable living in an increasingly crowded and environmentally conscious world.

The Nano House is designed to be pre-assembled, allowing it to be easily placed in the backyards of existing properties. This adaptability makes Nano Homes a practical addition to urban environments, addressing the ever-growing demand for housing while preserving green spaces.

> The main challenge in bringing a building down is controlling the way it falls. When a building is surrounded by structures that need to be preserved, then demolition is done such that it collapses straight down into its own footprint.

Living Large in a Small Space

One of the most remarkable aspects of Nano Homes is their ingenious use of space. These micro-dwellings are carefully designed to include a multi-functional living-cum-bedroom area, a compact kitchenette, and a snug bathroom. Despite their limited size, Nano Homes are engineered with high ceilings and foldable furniture to create an illusion of spaciousness, ensuring that residents do not feel cramped within their confines.

To address storage concerns, Nano Homes incorporate space-saving features such as foldable Murphy beds and cleverly designed storage solutions. Additionally, these homes often feature outdoor amenities such as swimming pools, gyms, clubhouses, gardens, and party halls, providing residents with a unique blend of compact indoor living and extravagant outdoor spaces.

Meeting the Needs of a Changing World

Nano Homes arrive at a time when cities worldwide grapple with limited space and escalating property costs. These pint-sized residences offer a ray of hope for individuals seeking environmentally friendly and affordable housing options in densely populated urban areas. Furthermore, Nano Homes align with the current market demand for affordable housing, making them an attractive choice for both developers and prospective homeowners.

In countries like India, where the demand for affordable housing is particularly high, apartment sizes have already begun to shrink. Nano Homes are emerging as a practical response to this trend, optimizing available spaces, reducing maintenance costs, and catering to the needs of budget-conscious individuals and families.

Exploring the Possibilities of Nano Homes

The versatility of Nano Homes knows no bounds. Their minimalistic footprint allows them to be placed in a wide variety of settings, from picturesque beachfront locations to serene riversides, lush hillsides, rugged mountain terrain, and even deep within untouched jungles. Nano Homes provide an eco-conscious way to integrate with the natural environment, allowing residents to co-exist with nature while minimizing their ecological footprint. However, it's crucial to note that the regulatory framework for Tiny Homes, including Nano Homes, is still evolving in many countries, creating legal ambiguities surrounding their placement and usage. As these innovative housing solutions gain popularity, governments are expected to adapt their policies to better accommodate and regulate Nano Homes.

Nano House by Phillis Richardson

In Conclusion: A Vision for Tomorrow

Nano Homes represent more than just a response to contemporary challenges; they offer a vision for a sustainable, efficient, and affordable future of living. As cities continue to expand, and available space becomes increasingly scarce, innovative solutions like Nano Homes become not just practical but essential for harmonious coexistence with our environment. The world's tiniest homes may very well hold the key to unlocking a future where sustainability and quality of life go hand in hand, offering a promise of better living for generations to come.

In this article, we have delved into the world of Nano Homes, uncovering the intricate details of their design, their impact on urban development, their potential in addressing the global housing crisis, and the challenges they face on the road to widespread adoption. Nano Homes are reshaping the way we live and paving the way for a more sustainable and efficient future. The construction industry is ever evolving and we hope that they continue to innovate, making adoption of concepts like Nano Homes more accessible to the general public, especially in countries like India ■ □□□□□

Quote:

"Live simply so that others may simply live. "

- Elizabeth Ann Seton

Ethical Dilemmas in Civil Engineering

Civil engineers face complex ethical dilemmas in their profession, encompassing environmental impact, safety, and social responsibility. These challenges involve balancing sustainable practices with economic constraints, ensuring public safety while resisting cost-cutting pressures, and advocating for equity and accessibility in infrastructure design. Navigating these ethical quandaries requires adherence to frameworks discussed in the article.

by SONA M S, S4 CEB

Ethical Quandary?

CIVIL engineering, as a profession, plays a pivotal role in shaping the world we live in. It involves the design, construction, and maintenance of critical infrastructure such as roads, bridges, buildings and water supply systems. However, with great power comes great responsibility. Civil engineers often find themselves facing complex ethical dilemmas that revolve around environmental impact, safety, and social responsibility. This article delves into the multifaceted ethical challenges encountered by civil engineers and explores how they strive to balance progress with ethics in their decision-making processes.

> "Civil engineers often find themselves facing complex ethical dilemmas that revolve around environmental impact, safety, and social responsibility."

Environmental Impact

Sustainable Practices vs. Economic Constraints

One of the most pressing ethical dilemmas in civil engineering revolves around the environment. Balancing sustainable practices with economic constraints can be a challenging tightrope walk. Engineers often grapple with the choice between using eco-friendly materials and construction methods, which may be more expensive initially, and opting for cost-effective but environmentally detrimental alternatives. For example, when designing a bridge, should engineers choose to use recycled steel, which is more environmentally friendly but pricier, or opt for conventional steel, which is cheaper but requires extensive mining and resource extraction?

Mitigating Harm to Natural Ecosystems

Civil engineering projects can have a profound impact on natural ecosystems. Dams, for instance, provide vital water resources but can disrupt river ecosystems, leading to habitat loss and species endangerment. Ethical dilemmas arise when engineers must weigh the benefits of such projects against their environmental consequences. Civil engineers must consider alternative solutions, such as fish ladders or ecosystem restoration efforts, to mitigate the harm caused by their projects. Striking a balance between human needs and environmental preservation becomes an ethical imperative.

Safety

Public Safety vs. Cost-Cutting

Ensuring the safety of the public is a fundamental ethical obligation for civil engineers. However, economic pressures often tempt project managers to cut corners in construction or maintenance, potentially jeopardizing safety. The infamous collapse of the Morandi Bridge in Genoa, Italy, in 2018, serves as a stark reminder of the consequences of compromising safety for cost savings.

Engineers face a moral dilemma: do they prioritize public safety by adhering to strict construction standards, even if it increases project costs, or do they succumb to budget constraints and risk potential disasters?

Whistle-blowing and Professional Integrity

When engineers become aware of safety concerns or unethical practices within their projects or organizations, they may face the ethical dilemma of whether to blow the whistle. Whistleblowing can have significant personal and professional consequences, including retaliation and damage to one's career.

Engineers must weigh their duty to protect public safety and uphold professional integrity against the potential harm they may suffer personally for speaking out.

Social Responsibility

Equity and Accessibility

Civil engineers play a crucial role in designing infrastructure that impacts society at large. Ensuring equity and accessibility for all citizens is an ethical imperative. However, financial constraints and political pressures can lead to the creation of infrastructure that caters more to the affluent while neglecting marginalized communities.

Engineers must confront the ethical dilemma of whether to advocate for inclusive design solutions that prioritize accessibility and affordability for all, even if these may face resistance from stakeholders who prioritize profit.

> "Engineers face a moral dilemma: do they prioritize public safety by adhering to strict construction standards, even if it increases project costs, or do they succumb to budget constraints and risk potential disasters?"

Cultural and Historical Preservation

Preserving cultural heritage and historical landmarks is another ethical dilemma for civil engineers. Modernization often involves the destruction or alteration of historical structures. Engineers must balance the need for progress with the responsibility to protect structures of cultural and historical significance.

Decisions related to whether to demolish, preserve, or restore a historical site require careful consideration of the societal value and the engineer's role in safeguarding cultural heritage.

Ethical Frameworks for Civil Engineers

Navigating ethical dilemmas in civil engineering requires a solid ethical framework. Here are some commonly used frameworks that help guide engineers through these complex decisions:

Utilitarianism:

This framework evaluates the ethicality of actions based on the greatest overall benefit. Engineers using utilitarian principles would consider which course of action maximizes the collective good, such as safety, environmental sustainability, or social equity.

Deontology:

Deontological ethics focuses on duty and moral principles. Engineers employing this framework prioritize adherence to professional codes of ethics and standards, regardless of the potential consequences. For example, they would prioritize safety regardless of cost considerations.

Virtue Ethics:

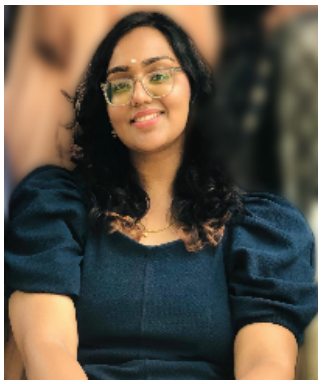
Virtue ethics emphasizes the development of moral character and values. Engineers adopting this approach aim to cultivate virtues such as honesty, integrity, and empathy in their professional practice, which can guide them through ethical dilemmas.

Rights-Based Ethics:

This framework centers on the protection of individual rights. Engineers applying this approach would prioritize actions that respect the rights and well-being of all stakeholders, ensuring that no one is unjustly harmed.

Conclusions:

Civil engineering is an indispensable profession that shapes the physical and societal landscape. However, it is fraught with ethical dilemmas, particularly regarding environmental impact, safety, and social responsibility. Engineers must navigate these ethical challenges with careful consideration, guided by established ethical frameworks, to strike a balance between progress and ethical responsibility. Ultimately, it is their commitment to the greater good and the well-being of society that can help them make decisions that are not only technically sound but also morally upright ■ □□□□□



by CAROLINE P JOSEPH, S6 CE

The Future of infrastructure with 5G technology

The integration of 5G technology into infrastructure promises to revolutionize various sectors, from healthcare to transportation and energy management. With its lightning-fast speeds and capacity to connect countless devices, 5G is set to transform how we live and work. However, this transformation also brings challenges, such as cybersecurity and data privacy concerns. As we usher in this era of innovation, addressing these issues will be pivotal in harnessing the full potential of 5G to create a more connected, sustainable, and efficient world.

5G: Infrastructure's Next Frontier

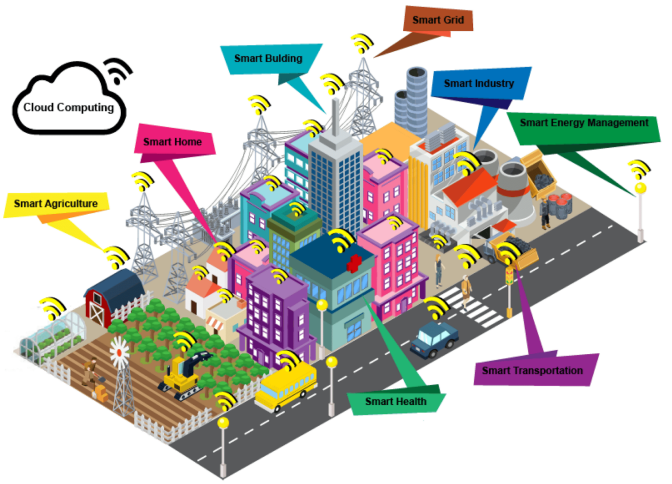
Introduction to 5G Technology and its Impact on Infrastructure

THE advent of 5G technology has brought about a new era of possibilities and transformations across various sectors. With its unprecedented speed, low latency, and high capacity, 5G is set to revolutionize the way we interact with technology and reshape the infrastructure landscape. This article delves into the future of infrastructure with 5G technology, exploring its impact on communication, transportation, healthcare, energy, and urban development. Additionally, it examines the challenges and opportunities related to security and privacy in this interconnected ecosystem. Brace yourself for a journey into the exciting world of 5G and its potential to reshape the very foundation of our infrastructure systems.

Understanding the basics of 5G technology

5G technology has been a hot topic in recent years, promising faster speeds and better connectivity than ever before. But what exactly is 5G and how does it work? In simple terms, 5G stands for fifth-generation wireless technology, which aims to revolutionize the way we use the internet and interact with technology.

While previous generations of wireless technology focused primarily on mobile communication, 5G takes it a step further by creating an interconnected network that can support a wide range of applications. It uses higher-frequency bands and smaller cells, enabling faster data transfer speeds and lower latency. This means that downloading movies, streaming videos, and playing online games will become even smoother and more seamless.



Exploring the potential impact of 5G on infrastructure

The impact of 5G on infrastructure is not limited to faster internet speeds for smartphones. It has the potential to transform various sectors, including transportation, communication, and urban planning. With its ability to handle massive amounts of data and support a vast number of connected devices, 5G can pave the way for groundbreaking advancements.

As cities become smarter and more connected, 5G can play a crucial role in enhancing communication infrastructure. This means improved network speed and capacity, enabling seamless video conferencing, online collaboration, and efficient data transfer. Moreover, the IoT can reach its full potential with 5G, as it can connect and control a wide range of devices, from smart homes to industrial sensors.

In the following sections, we will delve deeper into how 5G can enhance connectivity, revolutionize transportation infrastructure, and shape the future of urban development.

Enhancing Connectivity: 5G's Role in Transforming Communication Infrastructure

How 5G Improves Network Speed and Capacity

We've all experienced the frustration of slow internet speeds and dropped connections. Well, 5G aims to change that. With its higher-frequency bands and more efficient use of spectrum, 5G can offer lightning-fast speeds and significantly increased capacity. Imagine being able to download a high-definition movie in mere seconds or stream your favourite shows without buffering. 5G can provide download speeds up to 10 gigabits per second, which is a massive leap compared to previous generations. This means quicker downloads, smoother streaming, and a more responsive online experience.

Unlocking the Potential of Internet of Things (IoT) through 5G

The Internet of Things (IoT) refers to the network of interconnected devices that can communicate and share data with each other. From wearables to smart home appliances, IoT has already started to change the way we live and work. However, its true potential can only be realized with the help of 5G technology.

With its low latency and high capacity, 5G can handle the massive data traffic generated by IoT devices. This means more stable connections, faster response times, and improved reliability. From smart cities to industrial automation, 5G can empower a whole new wave of IoT applications, revolutionizing the way we interact with our environment.

> As cities become smarter and more connected, 5G can play a crucial role in enhancing communication infrastructure.

Revolutionizing Transportation Infrastructure With 5G

5G's Contribution to Autonomous Vehicles and Smart Transportation

Autonomous vehicles and smart transportation systems have long been the stuff of science fiction. But with 5G, they are becoming a reality. 5G's low latency and high reliability are essential for enabling real-time communication between vehicles, infrastructure, and pedestrians. This is crucial for the safe and efficient operation of autonomous cars.

Moreover, 5G can facilitate vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, allowing vehicles to share data with each other and with traffic management systems. This can lead to smoother traffic flow, reduced congestion, and improved safety on the roads. Get ready to sit back, relax, and let your car do the driving.

Intelligent Traffic Management Systems Powered by 5G

In addition to autonomous vehicles, 5G can also revolutionize traffic management systems. By integrating real-time data from connected vehicles, road sensors, and traffic cameras, 5G can enable intelligent traffic management. This means adaptive traffic signals, dynamic route guidance, and efficient use of road infrastructure. So picture this: you're cruising down the road, jamming to your favourite tunes when all of a sudden, traffic comes to a screeching halt. Frustrating, right? Well, fear not my friends, because intelligent traffic management systems powered by 5G are here to save the day! These cutting-edge systems utilize the power of 5G technology to revolutionize how we navigate through traffic. With lightning-fast connectivity and ultra-low latency, these smart systems can collect real-time data from various sources like sensors, cameras, and even smartphones to analyse traffic patterns and make instant adjustments. They can automatically reroute vehicles based on current conditions, optimize traffic light timings for smoother flow, and even detect accidents or hazards ahead of time. No more be-

ing stuck in never-ending gridlock – thanks to these intelligent systems driven by 5G technology, our commutes will become a breeze!

Smart Cities and 5G: The Future of Urban Infrastructure

Building Sustainable and Efficient Cities with 5G

Smart cities aim to leverage technology and data to create sustainable and efficient urban environments. 5G is set to play a vital role in making this vision a reality. With its ability to handle massive data traffic, 5G can enable smart energy grids, intelligent waste management systems, and efficient resource allocation.

By connecting various infrastructure elements, such as buildings, transportation networks, and utilities, 5G can enable real-time monitoring and control. This means optimized energy consumption, reduced environmental impact, and improved quality of life for city dwellers. The possibilities are endless when it comes to building smart and sustainable cities with 5G.

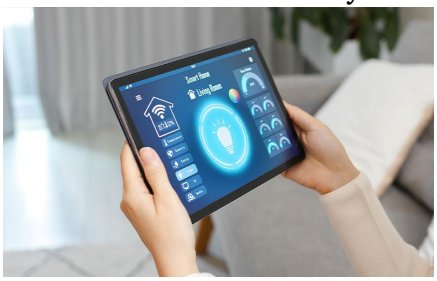
Empowering Smart Infrastructure Solutions through 5G Connectivity

In addition to sustainability, 5G can empower a wide range of smart infrastructure solutions. From smart lighting and parking systems to remote healthcare and emergency services, 5G can provide the necessary connectivity and bandwidth for these applications.

For example, imagine , improving energy efficiency and ensuring safety in public spaces. With 5G, such solutions can become a reality, enhancing our urban environments and making them more liveable and enjoyable. Self-driving cars seamlessly communicating with each other to prevent accidents. Beyond that, 5G also enables advanced analytics and artificial intelligence algorithms to process massive amounts of data collected by sensors embedded in our surroundings. This means better urban planning, improved energy efficiency, and enhanced public safety measures.

In conclusion, 5G technology has the potential to transform infrastructure as we know it. From enhancing connectivity to revolutionizing transportation and shaping smart cities, 5G opens up a world of possibilities. As this technology continues to evolve, we can look forward to a future where our infrastructure is faster, smarter, and more connected than ever before. In a nutshell, 5G is unleashing the full potential of our infrastructure by connecting it all together in ways we couldn't have imagined before.

It's time to buckle up because we're heading into an era of smarter cities fueled by 5G!



5G and the Evolution of Healthcare Infrastructure

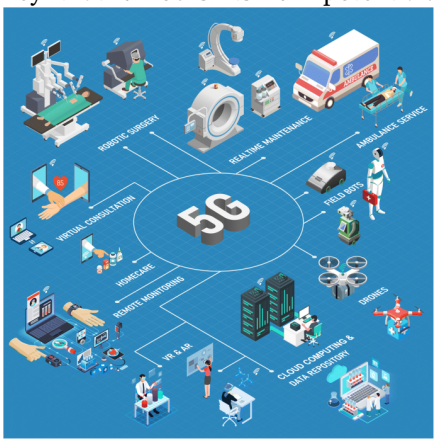
Enhancing Telemedicine and Remote Patient Monitoring with 5G

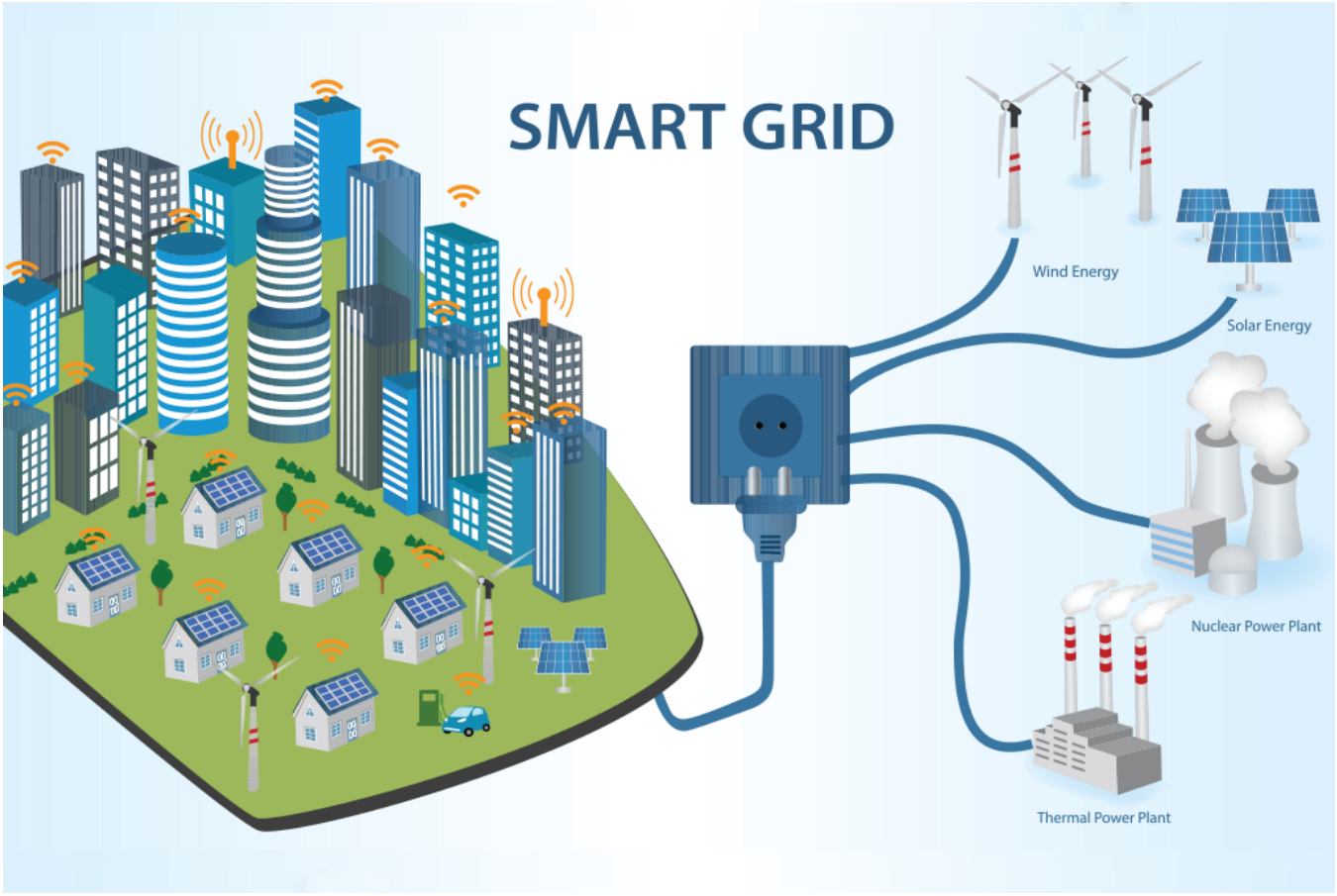
Picture this: You're sitting comfortably at home, a cup of tea in hand, while your doctor appears on your smartphone screen. With the power of 5G technology, telemedicine is set to revolutionize the way we access healthcare. No more long waits in crowded waiting rooms - you can now have remote consultations with your doctor from the comfort of your own couch. Not only does this save you time and money, but it also opens up access to healthcare for those in remote areas who may not have easy access to medical facilities.

But that's not all. 5G also enables remote patient monitoring, allowing healthcare professionals to keep an eye on patients with chronic conditions or those recovering from surgery. From monitoring vital signs to tracking medication adherence, 5G technology ensures that patients receive the care they need, wherever they are. It's like having a personal healthcare assistant right in your pocket.

Enabling Precision Medicine through High-Speed 5G Networks

Gone are the days of "one size fits all" medicine. With the advent of precision medicine, treatment plans can now be tailored to an individual's unique genetic makeup. But to unlock the full potential of precision medicine, we need high-speed networks that can handle vast amounts of data and facilitate real-time analysis. 5G networks provide the lightning-fast speeds and low latency required for processing and analysing genetic data. This means that doctors and researchers can quickly identify personalized treatment options based on an individual's genetic profile. The future of healthcare lies in precision medicine, and 5G technology is the key that unlocks its full potential.





Transforming Energy Infrastructure with 5G Technology

Optimizing Energy Distribution and Management with 5G

It's time to say goodbye to guesswork when it comes to energy distribution. With 5G technology, we can optimize energy distribution and management like never before. By connecting various components of the energy grid, such as power plants, transformers, and smart meters, through high-speed 5G networks, we can achieve real-time monitoring and control of energy flow. This means that energy providers can identify and rectify issues faster, minimizing disruptions and reducing wastage. Plus, with 5G-enabled smart meters, consumers can track their energy usage in real-time and adjust their consumption habits accordingly. It's a win-win situation for both energy providers and consumers, leading to more efficient and sustainable energy management.

Implementing Smart Grids and Renewable Energy Solutions with 5G

The world is embracing renewable energy sources like never before, but to fully integrate them into our energy infrastructure, we need a reliable and efficient communication system. Enter 5G technology-with its high capacity and low latency, 5G enables the seamless integration of renewable energy solutions into our existing power grids.

Imagine a world where solar panels on your roof are connected to the grid through wireless networks, allowing homes to generate their own electricity and sell excess power back to the system. With 5G's superfast speed and ultra-low latency, this dream is becoming a reality. Smart grids powered by 5G can efficiently manage energy distribution, monitor usage in real-time, and even predict demand patterns. This means fewer blackout incidents because the system can self-heal and reroute power instantly. Plus, renewable energy sources like wind farms can be seamlessly integrated into the grid using 5G communication channels. It's an exciting time indeed – thanks to 5G, renewable energy solutions are about to revolutionize our electric grids!

Security, Privacy, and 5G: Challenges and Opportunities for Infrastructure

Addressing Cybersecurity Concerns in the 5G Era

As with any technological advancement, 5G comes with its fair share of cybersecurity concerns. With more devices connected to the internet and an exponential increase in data transmission, securing our infrastructure becomes critical. However, 5G also presents opportunities to enhance cybersecurity.

By leveraging the speed and capacity of 5G networks, we can im-

plement advanced security measures such as real-time threat detection and response systems. Additionally, 5G enables network slicing, which allows us to create separate virtual networks for different applications, enhancing security and preventing unauthorized access to critical infrastructure. With the right measures in place, we can navigate the cybersecurity challenges of the 5G era and build a secure and resilient infrastructure.

Ensuring Privacy and Data Protection in 5G-enabled Infrastructure

With the vast amount of data being generated and transmitted through 5G networks, privacy and data protection become paramount. As we embrace the future of infrastructure with 5G, it is crucial to establish strong privacy frameworks and regulations to safeguard personal information.

By implementing robust encryption mechanisms and enforcing strict data protection policies, we can ensure that sensitive data remains secure. Additionally, empowering individuals with control over their data and providing transparent consent mechanisms can help maintain privacy in the 5G-enabled infrastructure. It's a balancing act, but with the right approach, we can embrace the benefits of 5G technology while safeguarding privacy.

> By connecting various components of the energy grid, such as power plants, transformers, and smart meters, through high-speed 5G networks, we can achieve real-time monitoring and control of energy flow.

Conclusion: Embracing the Future of Infrastructure with 5G Technology

The future of infrastructure is exciting, and 5G technology is at the forefront of this revolution. From transforming healthcare and energy infrastructure to addressing security and privacy concerns, 5G holds immense potential, with its high-speed connectivity, low latency, and capacity for handling massive amounts of data, 5G enables us to create a more efficient, sustainable, and connected world. It's time to embrace the possibilities and leverage 5G technology to build the infrastructure of tomorrow. So, let's raise our glasses to the future, where infrastructure is not just a necessary evil but a dynamic and innovative force that propels us forward. Cheers to 5G and the possibilities it brings!

In conclusion, the integration of 5G technology into infrastructure holds immense potential for transforming our cities, transportation systems, healthcare services, energy grids, and communication networks. With faster speeds, enhanced connectivity, and the ability to support a massive number of connected devices, 5G is poised to unlock unprecedented opportunities for innovation and efficiency. However, as we embrace this future, it is crucial to address the challenges surrounding security, privacy, and equitable access to ensure that the benefits of 5G technology are harnessed for the betterment of society as a whole. By leveraging the power of 5G, we can build a more connected, sustainable, and resilient infrastructure that paves the way for a truly transformative future ■ □□□□□

Quote:

"Cost-effective houses are not just for the poor,they are for everyone."

- Laurie Baker

A British-born Indian architect, renowned for his initiatives in cost-effective energy-efficient architecture', was Director of COSTFORD, Thiruvananthapuram

E. Sreedharan - The "Metro Man"

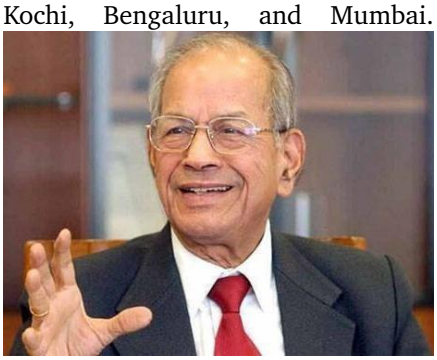
by ARUNDHATHI SASI, S8 CEB

In this article we delve briefly into the background of Mr. E Sreedharan, a renowned engineer popularly known as the "Metro Man". He was instrumental in developing the urban transportation infrastructure in the country. He was instrumental in the creation of the Delhi metro and subsequent metro projects. He has received various awards in recognition of his work to the growth of the country. Hoping to inspire budding civil engineers with this snippet.

Inspiration

E.Sreedharan, popularly known as the "Metro Man" of India, is a renowned civil engineer and public servant who has made significant contributions to the development of modern transportation systems in the country. Born on June 12, 1932, in Karukaputhur, Kerala, his journey has been marked by dedication, innovation, and a relentless pursuit of excellence. Sreedharan's career began with his studies at the Government Engineering College, Kakinada, and later at the Indian Institute of Technology (IIT) Kharagpur.

His engineering prowess quickly became evident as he played a pivotal role in the planning, execution, and completion of the ambitious Konkan Railway project. Under his leadership, the project overcame numerous challenges, including rugged terrain, tunnels, and bridges, to connect the west coast of India. However, Sreedharan's most iconic achievements are in the field of urban transportation. His visionary leadership was instrumental in the creation of the Delhi Metro – a modern, efficient, and sustainable mass transit system that revolutionized public transportation in the country's capital. Sreedharan's ability to manage complex projects with impeccable planning, budgeting, and execution earned him widespread acclaim. The Delhi Metro's success not only eased traffic congestion but also set a precedent for other cities to emulate. Sreedharan's legacy extended beyond Delhi. He played a crucial role in implementing metro projects in various Indian cities, including Kochi, Bengaluru, and Mumbai.



> "Sreedharan's most iconic achievements are in the field of urban transportation."

His approach emphasized the importance of public-private partnerships, ensuring that these projects were completed on time and within budget while maintaining high standards of quality and safety.

Throughout his career, he remained an exemplar of honesty and accountability, traits that earned him the respect and trust of colleagues, superiors, and the public. His transparent and principled approach to governance served as a model for the entire nation. Sreedharan's influence extended beyond engineering and transportation. His leadership and dedication inspired countless individuals to take up challenges, pursue innovation, and contribute to the nation's development. He became a symbol of the possibilities that emerge when expertise, determination, and a sense of purpose converge.

In recognition of his exceptional contributions, Sreedharan has received numerous awards and honors, including the Padma Shri and the Padma Vibhushan, two of India's highest civilian awards. His legacy continues to inspire future generations of engineers, leaders, and change-makers. E. Sreedharan's life and work embody the spirit of innovation, leadership, and integrity. His transformative impact on India's transportation landscape, particularly through the Delhi Metro and other metro projects, has left an indelible mark. Beyond infrastructure, his legacy serves as a reminder that individual dedication, combined with a commitment to public service, can drive lasting change and shape the future of a nation ■ □□□□□

Contest alert:

Identify the bridge and it's significance to participate in the contest.
You may email the answer to civil@fisat.ac.in and **cc** to asce@fisat.ac.in with the subject line **Srishti-Contest**. In the content body, submit the answer along with your name, class and roll number. Maximum of two(2) participants in one entry is permitted. First correct entry will be featured in the next issue of the magazine.
Clue: It is a famous landmark in Kerala.

Contest answer:

The answer to the contest in last edition is **Bascule Bridge, an example of which is Thoppumpady Bridge**.

Can you get it right?

Chronic ailments like COPD can be attributed to ?
Which year did construction 3D printing start?:
Pallava architecture's distinct sytle is:
The Moon's surface is covered in ?
Speed of lift in Burj Khalifa?
Name few professsional bodies.
Expand V2V.

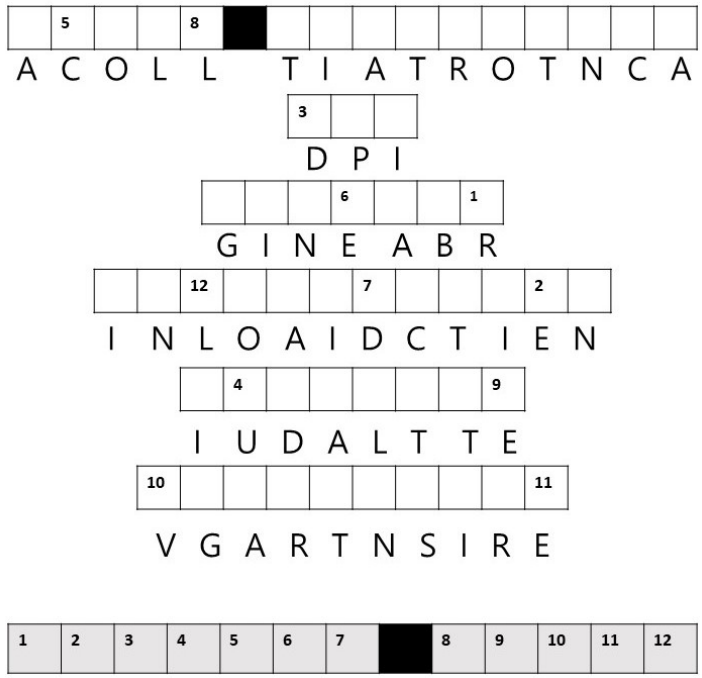
Write to us:

We are looking forward to your feedback. Email us at the information provided above, to submit your feedback and suggestions for improvement.
To make contributions to the upcoming issues, contact the magazine team. They can provide you with further details. The magazine team members and their communication info have been provided in the cover page.

SCRAMBLE

Deduce the word related to the theme given below in the puzzle. Unscramble the words to find the letters and the ultimate word.

Surveying



LOCALATTRACTION
DIP BEARING DECLINATION LATITUDE TRAVERSING

INCEPTO
NIRMAN
AAVISHKAR
SECON
CIVIL HOUSE
CONNECT.CHAT.INSPIRE
CUBIX

Department of Civil Engineering

Happenings around the world!!!

- Indian Railways has undertaken a mega-infrastructure project of two dedicated freight corridors namely Eastern and Western Dedicated Freight Corridors (EDFC WDFC) to facilitate faster evacuation of freight traffic. A total route length of 1,610 km (799 km of EDFC and 811 km of WDFC) has been commissioned out of total 2,843 km till October, 2022.
- Kochi Water Metro, the first-of-its-kind in the country,was opened to public on 25 April 2023. The Kochi water metro project envisages the development of 15 identified routes, connecting 10 islands along a network of routes that span 78 km.
- The new Parliament House in New Delhi, India was inaugurated on May 28, 2023. The new Parliament House has a built-up area of about 65,000 sq. mt. Its unique triangular shape ensures optimum space utilization. The building houses both the Lok Sabha and the Rajya Sabha, which are the lower and upper houses respectively in India's bicameral parliament.
- The world's tallest 3D printed building is located in Saudi Arabia. This three-story smart villa was constructed by Dar Al Arkan, a leading real estate developer in Riyadh, using a 3D construction printer from COBOD International. The building is situated in Shams Al Riyadh, a development project covering about 12 million m^2 of land, which is part of Saudi Arabia's Vision 2030. The building has a total height of 9.9 meters, making it the tallest on-site 3D printed building in the world. The 345 m^2 building was printed with low-cost local materials at a cost of less than €10,000.

Answers to "Can you get it right?"

Vehicle to Vehicle
ICE, ICI, ASCE
36Kmph
Regolith
Rock cut temples
1997
$PM_{2.5}$, PM_{10}, VOCs and NO_2

Focus on Excellence

STUDENT CHAPTER
Federal Institute of Science and Technology

Estd. 1941

IGBC MEMBER

TEN YEAR ANNIVERSARY 2023

Department of Civil Engineering

Federal Institute of Science and Technology (FISAT)

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