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**Fortifying Breakwaters**  
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**Forecasting Landslides**  
Assessing & Warning Systems

**Foundation Failure**  
Causes & Remedies

**C&D Waste Management**  
Navigating the Challenges





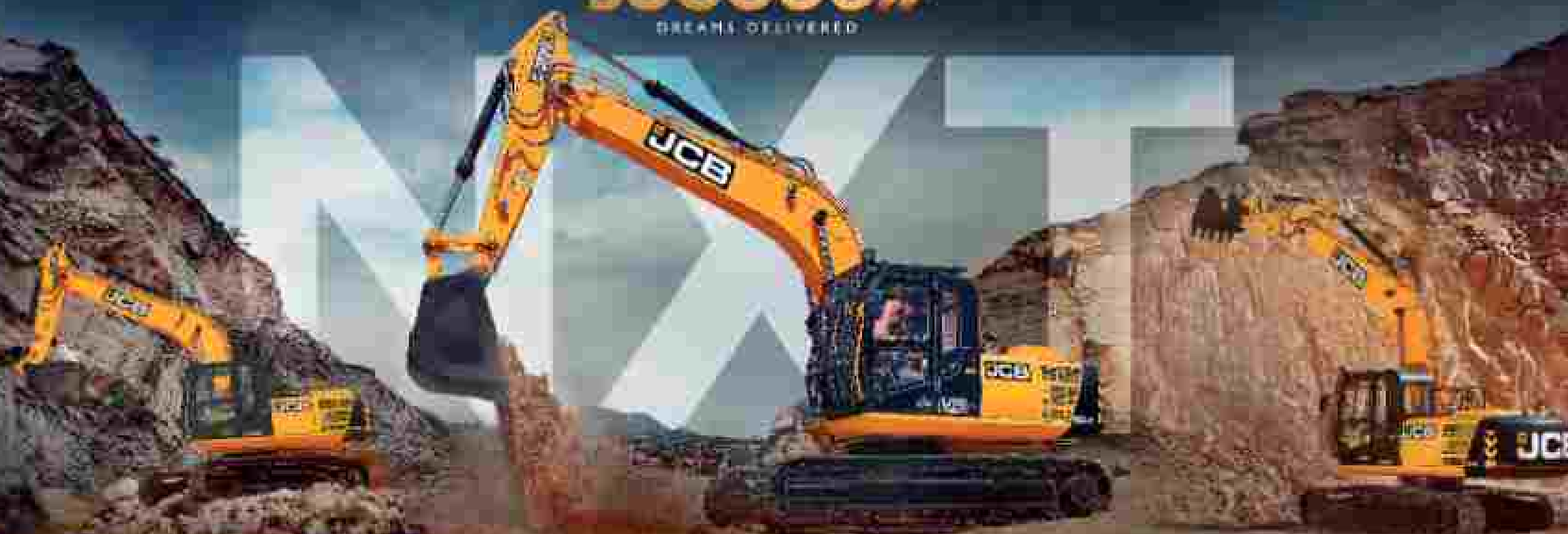


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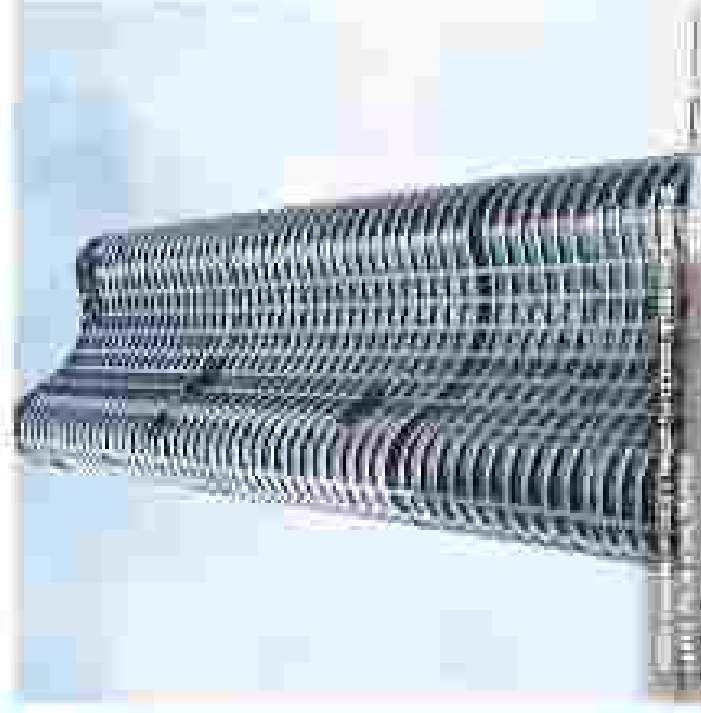
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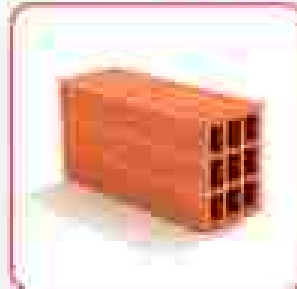
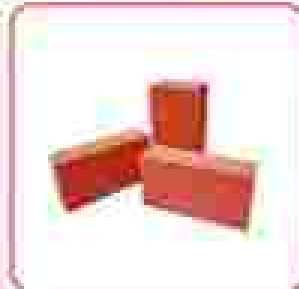
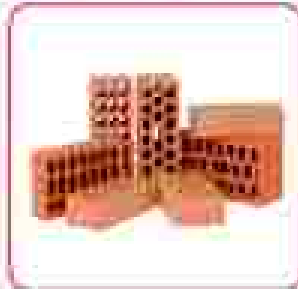
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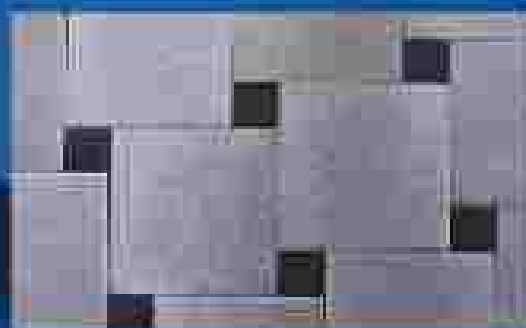




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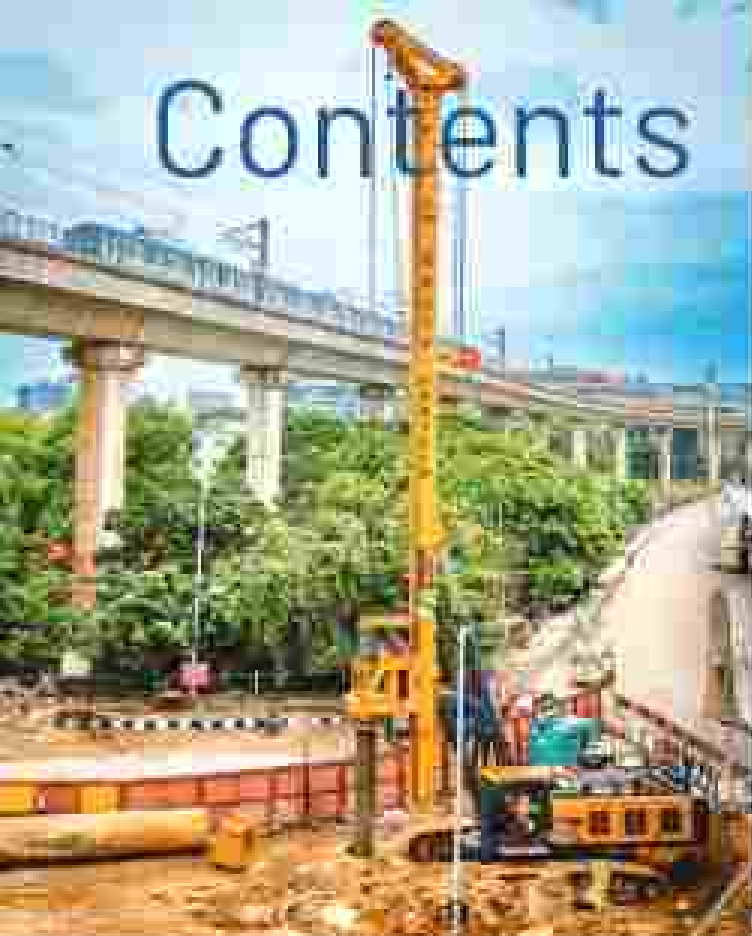


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## Infrastructure Development

### Anil Shah Inaugurates ₹1,000 Cr Development Projects in Ahmedabad

Union Home Minister Anil Shah inaugurated and laid the foundation stone for various development projects worth ₹1,000 crore in Ahmedabad, Gujarat. The initiative aligns with the government's commitment to making Ahmedabad a future-ready, fully developed city.

### IndoSpace to Invest Over Rs 580 Cr in 2 Logistics Parks in Karnataka

IndoSpace plans to invest more than Rs. 580 crore to develop two logistics parks across 75 acres in Karnataka. The parks, aimed at the automotive, engineering, electronics, and ITI sectors, will have a combined development corridor of 1.5 miles by 5.

### Andhra Pradesh CM Inaugurates & Signs Deals Worth ₹3,580 Cr in SRI City

Andhra Pradesh Chief Minister N. Chandrababu Naidu has laid the foundation stone, inaugurated, and signed agreements for multiple industrial projects in SRI City, totaling ₹3,580 crore in investments. Fifteen projects with a combined investment of ₹1,500 crore were inaugurated, while the foundation was laid for seven projects worth ₹600 crore. Additionally, five agreements were signed, bringing in another ₹1,245 crore in investments.

### ₹3,500 Cr Approved for Power Infra Upgrade in Guwahati & Faridabad

The Ministry of Power has approved projects worth ₹3,500 crore for modernizing and upgrading power distribution infrastructure in Guwahati and Faridabad districts. These initiatives under the Government of India's Revamped Distribution Sector Scheme aim to meet growing power demand and ensure reliable electricity supply.

### L&T Wins Order for Infra Development in Navi Mumbai's NAINA Project

Larsen & Toubro (L&T) Transportation Infrastructure has secured a significant order for the Integrated Infrastructure Development project within Maharashtra's Navi Mumbai Region Influence Market Area (NAINA). The City and Industrial Development Corporation of Maharashtra Limited (CIDCO) awarded the project, which includes the development of essential road and utility infrastructure.

### Govt Approves 12 Industrial Smart Cities With An Outlay of Rs 28,602 Cr

The Cabinet Committee on Economic Affairs, chaired by Prime Minister Shri Narendra Modi, has approved 12 new project proposals under the National Industrial Corridor Development Programme (NICDP) with an estimated outlay of Rs. 28,602 crore. These projects are set to transform India's industrial landscape by creating a robust network of industrial nodes and corridors, significantly boosting economic growth and global competitiveness.

These industrial projects will be strategically located across 10 states and are planned along strategic industrial corridors. The new industrial areas will be developed in Khushi (Uttaranchal), Rajpur-Palera (Punjab), Digni (Bihar), Palam (Karnataka), Agri and Rajapur (Uttar Pradesh), Gurgaon, Dehleez (Delhi), Chokkai and Koodachy (Andhra Pradesh), and Jodhpur-Rajasthan. The establishment of these nodes marks a significant leap forward in enhancing India's manufacturing capabilities and fostering economic growth.

The new industrial sites will be developed as greenfield smart cities, built on 'plug-and-play' and 'lease-and-grow' concepts. This approach ensures that these cities will be equipped with state-of-the-art infrastructure that supports sustainable and efficient industrial operations. Additionally, the projects align with the PM GatiShakti National Master Plan, incorporating multimodal connectivity infrastructure to facilitate the seamless movement of people, goods, and services. These industrial cities are envisioned to become growth centres that will catalyse the transformation of entire regions.

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## Roads & Highways



### HG Infra Secures MoRTH Project in Gujarat for Rs 781 Cr

HG Infra Engineering has been selected the lowest bidder (L1) by the Ministry of Road Transport and Highways (MoRTH) for a road upgradation project in Gujarat. The project involves upgrading the existing state-level road, including an elevated portion, from Nadi Junction to Barchi Junction on NH-47. The project awarded under the hybrid annuity mode (HAM) is valued at Rs 781.11 crore and is expected to be completed within 30 months.

### Government to Finalize Policy for Extending Lifespan of National Highways

The government is set to finalize a policy to strengthen ageing national highways through "over-lapping," a method that enhances their durability. The policy will focus on rehabilitating flexible or asphalt pavements, which form a significant part of the national highway network.

### North Andhra to Get Four-Lane Roads for Enhanced Connectivity

The state government is evaluating the feasibility of developing four major roads in North Andhra districts as four-lane highways. This initiative aims to enhance connectivity, boost spiritual tourism, and alleviate traffic issues in the region. The proposed roads will link tribal areas, interstate routes, and various parts of Visakhapatnam and Bhubaneswar districts, while also connecting with roads in neighbouring Odisha.

### Kerala Government Allocates ₹1,523 Cr for Outer Ring Road Project

In a major boost to the Outer Ring Road (ORR) project under the Capital Region Development Programme, the Kerala government has allocated ₹1,523.24 crore for its construction. The ORR will connect Vazhappalam and in the south to Neyyattinkal in Thiruvananthapuram.

### Maharashtra Approves Rs 26,954 Cr for Cement Concrete Roads Construction

The Maharashtra Cabinet, led by Chief Minister Eknath Shinde, has approved an expenditure of Rs 26,954 crore for the construction of 5,000 kilometres of cement concrete roads. These roads will be built under the Revised Hybrid Annuity Mode by the newly formed Maharashtra State Infrastructure Development Corporation (MSIDC), operating under the Public Works Department.

### Gujarat CM Approves ₹381 Cr for High-Speed Road Corridor

Gujarat Chief Minister Bhupendra Patel has sanctioned ₹381.18 crore for developing a high-speed corridor connecting Vadodra to Ekta Nagar. The project includes the construction of a six-lane road from the Vadodra National Highway-48 junction to Wada Haddi, with service roads on both sides, and a standard four-lane route for the remaining 2.5 km from Wada Haddi to Dahisar as part of Phase-2.

### KCC Buildcon Wins Bid for Rs 340 Cr Rewa Bypass Construction in MP

KCC Buildcon has been named the lowest bidder by MoRTH for constructing a 19.20 km Rewa bypass in Madhya Pradesh. The Rs 340.36 crore project involves building a four-lane bypass with paved shoulders and service roads, connecting Rajmura Chowk to Chakrata Chowk on NH-30. It will be executed under the Hybrid Annuity Mode (HAM) as part of a public-private partnership (PPP).

### Ashoka Buildcon Wins Rs 478 Cr MMRDA Elevated Road Project

Ashoka Buildcon has emerged as the lowest bidder for an MMRDA project to design and construct an elevated road from Kalyan Mirzapur Road to Pande Lane Road, spanning the Vasthani River and Kalyan-Kopra railway line.



### Meerut to Get First Green Road Under CM-GRIDS

Uttar Pradesh's first green road project under the Chief Minister Green Road Infrastructure Development Scheme (CM-GRIDS) will be built in Meerut. The 2.15-km stretch of Dash Road, between Sanku Ashram and Tegaji, will be transformed at an estimated cost of Rs 45 crore.



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## Metro & Rail



### L&T Wins ₹1,465.49 Cr Contract for Agra Metro Line-2 Construction

Larsen & Toubro (L&T) has been declared the lowest bidder by Uttar Pradesh Metro Rail Corporation (UPMRC) for the civil construction of Agra Metro Line-2 Package ABCD-07. The ₹1,465.49 crore contract includes building an elevated viaduct with 14 stations, a 530-meter viaduct to Kailash Ushar Depot, and a 2.81 km viaduct extension from Sadar-Bazar Metro station to Ushar's P&C Depot.

### Cabinet Approves Eight New Rail Projects Across Seven States

The Cabinet Committee on Economic Affairs has approved eight new rail projects across seven states, including Odisha, Maharashtra, Jharkhand, Bihar, Andhra Pradesh, Telangana, and West Bengal, with an estimated cost of ₹24,687 crore. These projects aim to improve connectivity, reduce logistical costs, minimize oil imports, and cut carbon footprints.

### Union Cabinet Approves Thane Integral Ring Metro Rail Project

The Union Cabinet, led by PM Narendra Modi, has approved the Thane Integral Ring Metro Rail Project (TIRMP), a public-private set to transform urban mobility and real estate in Thane. The Maharashtra Metro Railways Corporation Limited (MMRCL) will oversee the first-of-its-kind greenfield project in the metropolitan region.

### Jharkhand Nirman Wins Bid for Bhataspur Railway Station Upgradation

Jharkhand Nirman has secured an EPC contract worth ₹632.34 crore from the South East Central Railway (SECR) for the major upgrade of Bhataspur railway station in Chhatrapur under the Amrit Bharat Station Scheme.

### Celgal India Wins Bhubaneswar Metro Phase 1 Project Package

Celgal India Ltd. has been awarded the contract for Package ABCD-04 of the Bhubaneswar Metro Phase 1 project. This package is the largest of the three civil packages and spans 10.37 km, linking Kirt Square to Traula Square (near elevated stations).

### Rs 700 Cr Secunderabad Railway Station Modernisation Project 27% Complete

The ₹700 crore modernisation of Secunderabad Railway Station is advancing, with 27% of the work finished. The project, initiated under Prime Minister Narendra Modi's vision, aims to upgrade the station to world-class standards, integrating traditional design with modern architecture and facilities.

## Cabinet Approves ₹6,456 Cr Rail Projects to Boost Connectivity

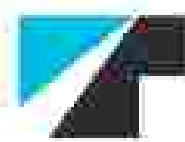
The Cabinet Committee on Economic Affairs (CCEA) has approved three railway projects worth ₹6,456 crore. These initiatives aim to improve logistical efficiency, enhance transportation networks, and support economic growth by connecting previously unconnected areas and increasing the capacity.

The projects, covering seven districts in Odisha, Jharkhand, West Bengal, and Chhattisgarh, will extend the Indian Railways network by approximately 300 km. Fourteen new stations will be constructed, improving connectivity for two operational districts, Nuapada and East Singhbhum, and reaching about 1,300 villages and 11 lakh people.

These projects, aligned with the PM-Gati Shakti National Master Plan, will provide seamless multi-modal connectivity, easing operations and reducing congestion at some of the busiest sections of Indian Railways. The initiatives are part of the government's broader vision to promote regional development and self-reliance, enhancing employment and self-employment opportunities in the affected areas.





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## Tunnels & Bridges

### Gadkari to Fast-Track Double-Decker Bridge Between Telangana & Andhra

Union Road Transport and Highways Minister Nitin Gadkari has pledged to expedite the construction of a long-pending double-decker cable-stayed bridge over the Krishna River connecting Bandarpur in Telangana and Bengareshwar in Andhra Pradesh. The Rs 1,552 crore project, delayed for two years, aims to boost environmental and female tourism, provide a safer commute, and shorten the travel distance to Tirupathi by 70-80 km, saving up to 80 minutes of travel time.

### Karnataka Cabinet Approves Bengaluru's Rs 12,690 Cr Tunnel Road Project

The Karnataka cabinet has approved Bengaluru's first tunnel road project, aimed at easing the city's notorious traffic congestion. The project, estimated to cost Rs 12,690 crore, includes the construction of a four-lane, 1.8 km corridor from Hebbal Tunnel to Central Silk Board junction, with five interchange points.

### MMRDA Invites Bids for Creek Bridge Construction in Palghar

The Mumbai Metropolitan Region Development Authority (MMRDA) has invited bids for the design and construction of a 1.125 km creek bridge between Mulde and Palghar in Maharashtra's Palghar district.

## Real Estate

### Anihant Foundations to Develop Grade-A Commercial Space in Chennai

Anihant Foundations and Housing, through its GPU Village, has partnered with Grand Hotels, owner of Hotel Chennai, to develop a Grade-A commercial space next to the hotel. The project will span approximately 3,00,000 sq ft, combining office space with housing services to create a dynamic city hub.

### Valor Partners with L&T Realty & Lodha Group for Major Developments

Valor Space (Pvt.) has signed strategic agreements with L&T Realty and Lodha Group to develop 6.7 million sq ft of carpet area, with a potential revenue stream of 66,000 crore.

### Brigade Group to Develop Rs 750 Cr Commercial Space in Bengaluru

Bengaluru-based Brigade Group, through its wholly-owned subsidiary Brigade Partners, plans to develop a Rs 750-crore commercial space in the city. The project, spanning 1.4 million sq ft of estate area, will feature world-class, reimagined spaces and amenities to meet the dynamic needs of businesses.

## WIRTGEN launches two VÖGELE pavers in India

The WIRTGEN GROUP has announced the launch of two new ultrahigh class VÖGELE pavers: SUPER 1900-3 G and SUPER 1900-3 P for India, during an event held at the Wirtgen Group Pune facility.

The launch was attended by around 250 customers, who were also taken on a tour to view most innovative machines and a live demonstration of its Paving technologies. Wirtgen aims to introduce smarter, safer and more sustainable technologies that meet customers' requirements.





# RE/MAGINEERING INNER STRENGTH WITH THE POWER OF MAGNESIUM.

## Introducing **Optigal**®

Optigal® is India's first ever innovative zinc-aluminum-magnesium alloy based technology, brought to you by AM/NS India. Tested in various natural environments, Optigal® is setting the standard for a new generation of better performing and more sustainable, colour coated steels.



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OUTSIDE PROTECTION



BEST GENERATION  
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ECO-FRIENDLY AND  
SUSTAINABLE CHOICE



REGAL-100



## Construction Equipment Manufacturers

### CASE India Expands Footprint in Southern Region with new Dealership in Vijayawada

CASE Construction Equipment, a brand of CNH, has extended its network by appointing a new dealer partner in Vijayawada. The new facility, SSPS (Sri Sai Power Services), is located in Annamma Nagar East Colony, Vijayawada, offering a wide range of products along with comprehensive after-sales support and spare parts. The new dealership will also cater to the neighbouring regions such as Guntur, Kakinada, East and West Godavari, Visakhapatnam, Vijayanagara and Srisailem.

Speaking about the strategic partnership, Anilash Chaturvedi, Managing Director, CASE Construction Equipment – India & SAARC Region, said, "The opening of this dealership in Vijayawada marks a significant enhancement of our market footprint in southern India. This facility is strategically located to serve the growing demands of the regional construction sector, offering a complete range of innovative products and services. As at CASE, are committed to support the government's focus on infrastructural development in the country by providing reliable equipment and robust after-sales support, ensuring our customers are fully equipped to meet the challenges of modern construction projects."

The dealership will offer CASE's full range of construction equipment and deliver a comprehensive customer experience. It will have amenities such as a fully equipped workshop, a training and conference room, availability of genuine parts, a team of skilled sales & service engineers, an upcoming telematics centre, and a customer lounge.

CASE, present in India since 1988, is positioned as a market leader in the Material Handling segment and a leading player in the Machine Tool segment. The company produces Made-in-India products in its state-of-the-art manufacturing facility in Pithampur, Madhya Pradesh, for both domestic and export markets in over 100 countries.

### Action Construction Equipment Secures Major Order from MoD

Action Construction Equipment Limited has secured a significant order from the Ministry of Defence (MoD) for the supply of 688 special forklifts and six rough terrain cranes with a 20-tonne lifting capacity. This order highlights the company's commitment to the "Make in India" and "Atmanirbhar Bharat" initiatives.

### Gautam Eunny Appointed as new CMO of AJAX Engineering

AJAX Engineering has appointed Gautam Eunny as its new Chief Marketing Officer (CMO). With 25 years of experience in business development, strategy, operations, and B2B sales and marketing, Gautam will lead business development, marketing strategy, and efforts to enhance the company's market presence.

### Escorts Kubota to Invest Over ₹4,500 Cr in New UP Manufacturing Facility

Escorts Kubota has unveiled plans to establish a state-of-the-art greenfield manufacturing facility in Uttar Pradesh, aimed at expanding its production capacities to accommodate future growth. The project, set to roll out in phases, will involve an investment exceeding ₹4,500 crore, including the cost of land acquisition.

The company plans to acquire approximately 430-500 acres of land, with part of it dedicated to increasing tractor and engine manufacturing capacity, while the remainder will support future expansion. The implementation of this ambitious project is scheduled to begin in 2023.

## Ports & Airports

### Union Minister Sonowal Unveils Sustainable Initiatives at JN Port Mumbai

Union Minister Sarbananda Sonowal inaugurated three rejuvenated freshwater lakes at Jawahar Nehru Port, named after Mahatma Gandhi—Sant Dyaneshwar Mahara, Sant Eknath Mahara, and Sant Haridas Mahara. These lakes support rainwater harvesting and coastal restoration as part of the port's sustainable development efforts. Sonowal emphasized the role of ports in advancing India's economic growth under the Atmanirbhar Bharat and Vision Bharat 2047.

### Kerala Government Fast-Tracks Kattur Greenfield Port Project

The Kerala government has expedited the development of the Kattur Artificial International Greenfield Port, aimed at driving industrial and economic growth in the Malabar region. The state cabinet, led by Chief Minister Pinarayi Vijayan, approved a swift project report by Malabar International Port and SEZ Limited (MIPSL), the entity formed for the port's development.









## AM/NS India launches Optigal<sup>®</sup>, a world-class product with longest warranty



CEO Dilip Gommur and Director Tarun Chak at the launch event.

**A** world-class Indian Steel maker (AM/NS India), a joint venture between ArcelorMittal and Nucor Steel, two of the world's leading steelmakers, has announced the launch of Optigal<sup>®</sup> - a world-class colour-coated steel, based with an innovative Zinc-Aluminum-Magnesium (ZAM) metallic coating.

The highest value-added steel, Optigal<sup>®</sup> (ArcelorMittal Europe's patented brand) currently available only in global markets, is now being produced and distributed in India for the first time by AM/NS India. The new offering reinforces the company's pioneering efforts to introduce internationally benchmarked quality products to meet the growing need for ingenious superior quality coated steel.

Launched by Dilip Gommur, CEO, at an event held in Kochi, Kerala, the product also underscores AM/NS India's commitment to the Make in India Initiative. Optigal<sup>®</sup> provides the longest warranty of any colour-coated steel product in India, extending up to 25 years, thus making a distinctive entry into India's specialty steel sector.

The annual demand for colour-coated products in India, currently at 3.3 million tonnes, is projected to grow at a CAGR of 8-10%. Optigal's production has commenced at the company's plant in Feroz, marking the first phase of a broader production strategy that will extend to other facilities in the near future.

AM/NS India currently has a colour-coated capacity of about 720,000 tonnes, with plans

to ramp up the capacity to 1 million tonnes by 2026. With this capacity expansion, the company's market share is projected to grow from the current 20-22% to 25-27%.

The new offering's production process uses a unique ZAM alloy technology that involves hot dip coating of steel strip in a bath of zinc, aluminum, and magnesium alloy. The inclusion of magnesium enhances coil performance and durability. The steel composition of substrate and paint ensures high formability and inherent corrosion protection for construction products. Optigal<sup>®</sup> is an eco-friendly product, free of hexavalent chromium and heavy metals, designed to reduce environmental impact and promote safety and sustainability.

Ranjay Chak, Director & VP - Sales & Marketing at AM/NS India, said, "The introduction of Optigal<sup>®</sup> is an important addition to our growing product portfolio. This launch reaffirms our commitment to delivering zero-defect, innovative, and sustainable steel to our customers nationwide in the truest of our brand promise - Stronger Steels, Smarter Policies. The effort also highlights our contribution to Make in India Initiative."

The versatility of Optigal<sup>®</sup> makes it a highly attractive option for a wide range of applications, such as roofing, fencing, and cladding for residential and commercial projects, as a reliable material for pre-engineered buildings, and high-performance steel for architecture facades, airports, industrial warehouses, and stadiums.

### Key benefits of Optigal<sup>®</sup>

- Exceptional cut-edge protection, leading to much lower paint consumption on edges and stretches with a performance that is at least 50% better than other metal coatings.
- Optigal's unique alloy composition, with an optimal balance of zinc, aluminum, and magnesium, offers superior corrosion resistance.
- The highly resistant adherent inorganic layer of specially designed Optigal<sup>®</sup> coating can be processed through bending, roll-forming, profiling, and other form processes without developing cracks in the bonds.
- The product is internationally tested and certified.

## RE/ENGINEERING INNER STRENGTH WITH THE POWER OF MAGNESIUM

# Optigal<sup>®</sup>

WORLD-CLASS COLOUR-COATED STEEL WITH AN INNOVATIVE ZINC-ALUMINUM-MAGNESIUM (ZAM) METALLIC COATING

WARRANTY GUARANTEED FIRST TIME IN INDIA.





CONCRETE CURING SOLUTIONS FOR THE CONCRETE INDUSTRY

## ACCELERATED CURING FOR YOUR CONCRETE PRODUCT



### KRAFT CURING SYSTEMS

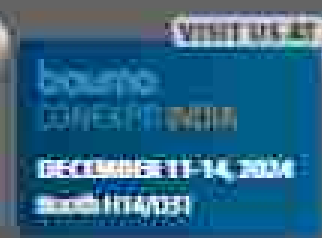
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## BKT to present Advanced Tire Solutions for Mining Sector at 17<sup>th</sup> IMME in Kolkata

**B**ridgestone Industries Ltd. (BIL) a leading global force in the Off-Highway tire market and an Indian multinational group, has announced its participation in the 17<sup>th</sup> edition of the International Mining and Machinery Exhibition (IMME), which is being organised by the Confederation of Indian Industry (CII) from October 23 to 26, 2024, at the Science City Exhibition Ground in Kolkata.



As one of the most prominent players in the Off-Highway tire industry, BKT will showcase its 'Smart Ka Tire' extensive product portfolio, featuring cutting-edge solutions tailored to meet the diverse needs of the Indian mining sector. Attendees at IMME

2024 will have the opportunity to connect with the BKT team at Booth C05 and witness the latest advancements in the company's tire solutions. The BKT team will be available

to discuss how their products can enhance mining operations and meet specific industry needs.



Commenting on the company's participation, Rajiv Poddar, Joint Managing Director, BKT, remarked, "IMME offers us a valuable opportunity to connect with industry leaders, exchange ideas, and align our innovations with the future needs of the mining industry in India. Our robust, high-performance tires are engineered to ensure efficiency and safety in challenging mining environments."

With the government's focus on boosting domestic production and modernizing mining operations, our latest tire technologies are designed to meet these evolving demands.

With over three decades of expertise in the Off-Highway tire segment, BKT is recognized as a leader in innovation and reliability, with its offering of a large and always updated production range of Off-Highway tires, especially designed for vehicles in the agricultural, industrial, earthmoving, mining, ATV and gardening sectors. BKT's extensive solutions designed for the most differing user needs include more than 2,500 SKU's, which extends to over 140 countries worldwide. BKT has recently started production of rubber tracks.

To learn more visit [www.bkt-tires.com](http://www.bkt-tires.com).

## JCB Introduces Telescopic Boom Platform T 65D in India

**J**CB, the world's leading manufacturer of Material Handling Equipment, inaugurated its first-ever Telescopic Boom Platform, the T 65D in India, during the India Platform Association of India (APIAI) conference. The machine, manufactured at JCB's factory in Jaipur, is designed to offer higher standards of Reliability, Efficiency, Comfort And, most importantly, Safety.

JCB India's CEO & Managing Director, Deepak Shetty, said, "The T 65D is a world-class machine designed around aspects of Safety and Productivity. It gives our customers the option to buy a world-class machine that comes with full product support. Our customers can now buy JCB equipment with full certainty, and JCB's support network, and not depend on used imports. We have invested significantly in our Jaipur facility so that these machines can be built in one-piece-quality standard."

The machine has a platform height of 23 ft 6 in and has a reach of 26 ft 6 in with 450 kgs maximum lift. The machine is powered by a JCB diesel engine and comes with two work times: it reaches 6 ft platform and a maximum weight of 12,500 kgs. It has four-wheel-drive as a standard feature and enhanced safety features like the secondary guarding system and a crush fence that protects the operator. It offers higher productivity through intuitive controls, including steering angle, and a joystick with an ergonomically designed operator seat for fatigue-free working.

He added, "There is a strong economy in the world today. As business and trade increase, so will the opportunities for products such as the Telescopic Boom Lift. The T 65D is available not only for the domestic market (which is expected to grow over the next few years) but is being exported to developed markets, where it is used in Construction, Cement, Oil & Gas industries. It is also extremely popular for use at Airports and Warehouses, among applications that involve working at heights."

JCB has invested in creating a distribution network specifically for its Telescopic Boom Platforms. It has 11 dedicated dealers and trained engineers and parts skilled to provide timely support to users of its machines.



17<sup>th</sup> IMME SEPTEMBER 2024





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# Powerscreen Service Team Overcomes Extreme Conditions to Complete Installation in Ladakh, India



Powerscreen equipment is being loaded and taken to remote clients, operating under the toughest rigors, due to its robust engineering and state-of-the-art technology.

**P**owerscreen, a global leader in mobile crushing, screening, and conveying equipment, has announced successful installation and commissioning of its equipment in Ladakh, which is one of the world's most challenging environments.

A Powerscreen FT400X Jaw Crusher, 1600 Maximal Size Crusher, and Chieftain 1750 Screen were commissioned to work on a Border Roads Organisation (BRO) project near Demchok, close to the China border at Uning La, Leh, Ladakh (UT). At an altitude of 13,524 feet, the project is at the world's highest motorable pass and aims to produce road construction materials such as Granular Base Base (GBB), Wet Mix Macadam (WMM), and aggregates of 20mm, 10mm, and 50mm.

The site's high altitude presented significant challenges due to low oxygen levels and temperatures that dropped to -22°C. The high terrain, with steep slopes and lack of proper roads, further complicated the transportation and installation of the equipment at the project site.

Powerscreen equipment is designed to work reliably in extreme climatic conditions. Robust engineering and advanced technology, rigorous testing and high quality materials use in the

equipment enable it to withstand harsh environments and high-altitude conditions. What more the innovative design of Powerscreen equipment allows for quick dismantling for transportation and reassembly and installation in rough, inaccessible terrain. To navigate the rough terrain, the company's service team expertly dismantled the Powerscreen equipment for transport and reassembled it on site. Despite the extreme conditions, the team completed the installation and commissioning in 10 days.

The Powerscreen FT400X Jaw Crusher has been set up as the primary crusher and feeds large and various sized feed material to be fed into the 1600 Maximal Size Crusher, which uses Autostar® crusher technology to provide high volumes of excellently shaped, consistent product. This material is then screened by the Chieftain 1750 Screen to separate the product into its various sizes.

The successful deployment of Powerscreen equipment at Uning La has enabled the BRO to produce the necessary materials for their road project, ensuring the continuation of vital infrastructure development in the region. The road infrastructure will improve access to remote villages, making it easier for residents to

travel for medical care, education, and other essential services. The road will also facilitate the delivery of goods and services, contributing to the overall socio-economic development of the region. The enhanced connectivity also boosts local businesses and tourism, with many tourists attracted to the world's highest motorable pass, providing new income opportunities for locals through homestays, guided tours, and local crafts.

"The project underscores Powerscreen's commitment to delivering high-performance solutions in the most challenging environments," said Ranga Ravary, Director – Customer and Product Support. "We are incredibly proud of our service team's exceptional efforts and resilience in overcoming the extreme conditions at Uning La. Their dedication and technical expertise were crucial in achieving this high-altitude installation."

"The combination of durability, adaptability, and high performance along with the knowledgeable and skilled service team makes Powerscreen the preferred choice for challenging projects worldwide," he added.

For more information, please visit [www.powerscreen.com](http://www.powerscreen.com)



To navigate the rough terrain, the service team expertly dismantled the Powerscreen equipment for transport and reassembled it on site.



The innovative design of Powerscreen equipment allows for easy dismantling and reassembly, facilitating transportation and installation in rough, inaccessible terrain.



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## Kobelco Announces Launch of SK80 Excavator

**K**obelco Construction Equipment India has announced the launch of its latest new model in 2024 SK80 Excavator. This highly anticipated addition to the Kobelco excavator family was unveiled by the company's Managing Director, Takeshiro Hirakawa, at a grand event in Coimbatore – an event that marked a milestone in the company's 174 years in the Indian CE industry and the company's commitment to innovation and its place in India's drive.

The launch was attended by the company's channel partners and media representatives, who witnessed the SK80 Excavator's features and capabilities through presentations by technical experts from Kobelco and Japanese engine manufacturer Yanmar.

### Features and Benefits of SK80 Excavator

The SK80, an 8-ton category mid-sized excavator, is designed to deliver superior performance with better fuel efficiency and best-in-class reliability. As construction

projects become more demanding and complex, the need for balanced machinery that can handle diverse tasks with ease and efficiency has grown considerably. The SK80 is Kobelco's answer to these evolving needs, combining cutting-edge technology and robust engineering that provide powerful and reliable performance.

- **Superior Technology:** The SK80 is equipped with Yanmar Engine which reflects the Japanese technology.
- **Best in class, providing best-in-class performance.**
- **Advanced Hydraulic System:** A state-of-the-art hydraulic system ensures smooth and precise operation. It enhances the machine's digging and lifting capabilities, making it ideal for a variety of applications.
- **Fuel Efficiency:** In line with Kobelco's commitment to sustainability, the SK80 features an eco-friendly engine that reduces fuel consumption and emissions. This not only lowers operational costs but also minimizes the environmental impact.

- **Operator Comfort:** The spacious and ergonomic cabin features adjustable seating, large touchscreens (color) monitor, and intuitive controls so that operators can work comfortably and efficiently for extended periods.

- **Durability and Maintenance:** The SK80 is built to withstand the toughest working conditions. High-quality materials and robust construction mean that the machine requires minimal maintenance, ensuring maximum uptime and productivity.
- **Versatility:** With a range of attachments available, the SK80 can be easily adapted to perform a variety of tasks including digging, lifting, or grading with ease.

Kobelco's product range includes excavators and cranes designed to deliver superior performance and reliability. The SK80 Excavator will be a game-changer in the mid-range excavator market, making the Kobelco brand a "True Solution Provider" in the excavator industry.







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## 'Pioneer' TBM achieves Breakthrough in Eastern Line and First Connecting Passage of Guangzhou Haizhu Bay Tunnel

The first super-large diameter municipal TBM tunnel in the Pearl River South - Guangzhou Haizhu Bay Tunnel project successfully achieved overline breakthrough on July 12th.

The super-large diameter TBM, named "Pioneer" and developed by China Railway Construction Heavy Industry Corporation Limited (CRCHI), was applied in the project. The Pioneer was launched later, but it completed the project earlier.

Reinforced concrete, on July 8th, with the main body of the tunnel connecting passage TBM already entering the receiving sleeve, the first connecting passage of the Guangzhou Haizhu Bay Tunnel project achieved a high-precision breakthrough. This is also the first engineering application of the super-large diameter tunnel connecting passage TBM made by China. The TBM, produced by CRCHI, has an excavation diameter of 3,880 mm.

Haizhu Bay Tunnel project is the first super-large diameter TBM tunnel in Guangzhou, known as "Largest TBM tunnel of Guangzhou". The total length of the route is 4.35km, including the 2,100-meter TBM section. The TBM is to pass through the fault zone and the Pearl River Channel side, and pass through a long-distance in mudstone, mostly siltystone formation, and undercross a group of buildings and pipes.

The project has the features of a complex construction environment, with multiple tunneling control factors and high construction difficulties, so it has very high requirements for a TBM. The lengths of the total 6 connecting passages range from 14.2 meters to 18.1 m. The main tunnel segments are Ø80 high-

strength segments, the connecting passage is about more than 45 meters in depth, and there is a large oblique angle with the main tunnel. The connecting passage TBM needs to carry out synchronous and interacting construction with the main tunnel TBM.

With an excavation diameter of 3,880 mm, a total length of 130 meters, and a total weight of 4,300 tons, the Pioneer Super TBM was assembled since February 20, 2023, and all the processes from the assembly to launching of the TBM have been completed in less than 5 months. Its launch date is 2 months later than the TBM for the western line, but it took 12 months to complete the tunneling work of the eastern line, which is one month earlier than the western line TBM. During the tunneling period, the maximum daily advance rate of the Pioneer is 15 meters and the maximum monthly advance rate is 324 meters.



Breakthrough of Pioneer (one of Guangzhou Haizhu Bay Tunnel)

The tunnel connecting passage TBM has several key core technologies such as rapid breaking of outside interconnection ring, synchronous construction adjustment, high-pressure sealing, rapid posture adjustment, and high-precision guidance correction. It achieved the highest daily progress of 2 ring segments, completed the unique breaking of the 600 high-strength segments in less than 3 hours, and created a new record for cutting the main line tunnel segments.

The total investment of the Haizhu Bay Tunnel project is about 11.88 billion yuan. In the future, the Haizhu Bay Tunnel will shorten the driving time from downtown to Guangzhou South Railway Station to 15 minutes. It is scheduled to open to traffic in 2025.



CRCHI super-large diameter TBM, named Pioneer



The breakthrough of the first connecting passage of the Guangzhou Haizhu Bay Tunnel project





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### TUNNELS

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## Strategic Slowdown in Assets Monetization

**The flagship programme of the Central Government-Assets Monetization through divestment of public sector undertakings has entered a slow lane as the Centre is reworking its divestment strategy in the changed scenario.**

**Vinod Bhat**

**T**he Central Government realises that the time is not right for fast-tracking divestment especially as PSUs have turned profitable and are giving high dividends to the Centre. PSUs are having high valuations amidst the stock market boom. The June 2024 quarter net profit of PSUs grew by 18 percent to Rs 39874/- crore. Public sector sales (PSES) cumulative profit topped Rs 1.4 lakh crore in FY 24. The 2024 General Elections and the subsequent coalition compulsions have been other reasons for the Centre to go easy on its privatisation programme.

As the Indian economy continues to gain strength, the government has taken to course correction, shifting gears on its policy to divest PSUs and is instead focusing on strengthening state-owned companies to maximise overall value of public sector enterprises (PSEs) in strategic sectors like mining, insurance and financial services, transport and telecommunications, power, petroleum, coal, minerals, defence, space, and atomic energy.

As the state-run companies are outperforming the private sector in most of the financial parameters over the last 3 financial years, the government thinks it is a favourable time to consolidate and maximise the gains of the PSUs. The statistics provide tell-tale evidence. The 55 listed CPSEs registered a 4 percent increase in their profits which topped 5 billion rupees. CPSEs including Oil & Natural Gas Limited, LIC, Indian Oil, and Coal India, have emerged quite profitable. Being in good health, CPSEs are paying high dividends to the Central Government. The 12 PSU banks have shown 45 times profits in the last 3 years - from Rs 211 crore in FY 21 to Rs 1.4 billion in FY 24 - with SBI emerging as the most profitable.

Furthermore, the combined market capitalization (M-Cap) of 55 listed CPSEs rose 2.56 times to Rs 65.5 billion in the last 3 years, until July 12, 2024. On the other hand, private sector peers have witnessed M-Cap growth of 155 percent to Rs 213.35 billion.

The government had taken to divestment as it needed huge funding for physical and social infrastructure, including education and health, without upsetting fiscal consolidation achieved by it. Asset monetization through divestment is estimated to account for 3.4 percent of the total infrastructure investment envisaged under the Rs 111 billion National Infrastructure Pipeline for FY 21-25. The divestment proceeds will also help in retiring a part of government debt that has reached undesirable levels. According to Aniruddh Karmakar, former CEO, NIP Aayog, the idea of asset monetization was to attract the private sector to bring in equity and raise more debt for creating more assets, thereby creating a virtuous cycle of growth, and in turn creating jobs.

According to Finance Ministry statistics, over the last 3 years, assets worth Rs 3.3 lakh crore have been monetized (in FY 24). This included asset monetization worth over Rs 1.54 lakh crore in the coal sector, followed by roads (Rs 21,238 crore), power (Rs 22,912 crore), mines (Rs 22,691 crore), petroleum & natural gas (Rs 22,337 crore), railways (Rs 20,417 crore), shipping (Rs 12,579 crore), urban sector (Rs 8,200 crore), warehousing (Rs 6,223 crore), sanitation (Rs 2,669 crore), and telecom (Rs 1,452 crore). In FY 24, the Central Government could manage only Rs 20,000 crore from divestment, and for FY 25, also, it has kept a low target of Rs 50,000 crore. The Centre is looking to ease Rs 10,000 crore divestment process through half a dozen port projects in FY 25.



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aiming to increase the share of PPP in ports. Though the Shipping Ministry has suggested a Rs 12,000 crore monetisation target, yet industry experts believe that, going forward, monetisation of ports will be a challenging task as most of the unencumbered and revenue-generating facilities have already been let out.

Meanwhile, NHAI has set up an asset monetisation cell, headed by NHAI's Member, Finance to steer its future monetisation plans, including monetisation of completed and operational highway assets, by engaging with all stakeholders, including investors, government and financial institutions. NHAI has identified 12 operational highway stretches with a combined length of 330 km for transfer to the National Highway Infrastructure Trust (NHIT) in FY23 as part of its asset monetisation programme. It hopes to raise a revenue of Rs 20,000 crore against Rs 16,000 crore of revenue mobilised in 2023-24 through NHIT route by leasing out 328 km of roads. It is committed to ensure that in 2023-24, NHAI raised Rs 40,314 crore from monetization of its projects.

As far as monetisation of airports is concerned, the government is reassessing the privatisation of airports in the near third phase, though it will continue to adopt the PPP approach, which is helpful to plug funding gaps and bring in private sector efficiency and expertise, thereby putting airport modernisation programme on fast track. Currently, 14 out of more than 135 airports are operational under the PPP model.

As per National Monetisation Pipeline (NMP), developed by NTA, 38 airports of Airport Authority of India (AAI) are earmarked for leasing over 2023-2028. These include Cochin, Coimbatore, Nagpur, Patna, Raipur, Bhubaneswar, Jaipur, Chennai, Madurai, Varanasi, Bhopal, Thiruvananthapuram, Lucknow, and Guwahati. It may be noted that in the first phase, privatisation of Delhi and Mumbai airports had taken place, followed by privatisation of 8 airports viz. Ahmedabad, Jaipur, Thiruvananthapuram, Mangalore, Lucknow, and Guwahati in 2019.

In the telecom sector, instead of disinvestment, the focus is on revamping the state-owned telecom operator Bharat Sanchar Nigam Limited (BSNL). For reviving BSNL, the Centre has provided Rs 32 billion in 2 packages. Soften Consulting Group has been hired by the government to prepare BSNL's revival plan by studying it to improve its customer experience, sales and marketing strategies. Meanwhile, BSNL is working on a plan to roll out 5G services in early 2023 and is targeting 20 million mobile subscribers prior to 2024-end by ramping up 4G. It is also looking to revitalize its business in the enterprise segment through cloud solutions, 5G digital networks, and Internet of Things (IoT). The state-run telecom operator is also taking the land monetisation route to revive its fortunes.

Despite this calibrated approach by the Central government, the asset monetisation programme of the government remains on track. The first phase of the National Monetisation Pipeline (NMP), unveiled in FY22 had set an ambitious Rs 6 trillion asset recycling target for 4 years in FY 22 through long-term leasing of awarded assets in roads, mining, power, petroleum, and airport sectors. Notably, in the first 3 years (FY 22-24), 90 percent target has been successfully achieved. The second phase (FY25-30) target of NMP is set to be raised to Rs 12 trillion over the next 5 years, with highways, mining, power, and petroleum sectors in the forefront.

With a healthy outlook for the Indian economy that is set to become the third largest in the world by 2030, the road ahead for the asset monetization looks smoother, redefining the roadblocks.

## Right Outlook for Land Monetisation

The monetisation of natural resources of land goes with various public government approved body significance as it will better the Rs 113 billion National Infrastructure Pipeline. In addition to the first phase, collectively involving, besides housing projects. To do this process, NAIIP (National Land Monetisation Corporation) has been set up with a mandate to monetise land and other non-core assets of PSUs.

The Indian Railways has a massive land monetisation opportunity as it has 10 lakh acres of vacant idle land. The Railway Ministry is seeking to generate substantial income by leasing out part parcels, vacant land for commercial purposes, besides monetising railway corridor land. The Railways has identified 247,00 hectares of prime land across the country to be given out to private developers at a 99 percent lease, hoped to generate Rs 7000 crore. According to NAIIP (National Land Monetisation Corporation), the Railways has nearly 45,000 hectares of vacant land.

The Ministry is staying behind in its asset monetisation target, generating only Rs 21,000 crore against the target of Rs 35,000 crore set for FY April. In 2021-22, the original NMP had fixed a monetisation target of Rs 35,000 crore. To meet the target, besides monetising vacant and idle land, the Ministry is focusing on monetising railway stations with unencumbered parcels in PPP mode, for which a lot of interest has been shown by big investors, and real estate companies like Adani Real Estate, GMR, Sobha Properties, and DLF Realty.

Box offices like DTH, IPTV, STB, along with STB, have a monetisation potential of 5,000 acres of land. The Defense Ministry has 20,000 acres of land in the form of military farms, abandoned airfields, etc. for monetisation through NAIIP. Then there is 50,000 acres of land per land is naturally forming reserves covered with soil and other minerals) located over Karnataka, Odisha, and Gujarat for monetisation.

The Insurance Corporation (LIC) is working on a plan to lease 100-150 acres from the park of its public and commercial buildings in Mumbai, New Delhi, and others. The total value of LIC assets has been put at Rs 71.25 billion, and to leverage this potential, LIC may well consider forming a separate entity to monetise its real estate assets, though there are funds needed as many LIC properties are under litigation.

Airport Authority of India (AAI) has 55,000-60,000 acres of land across 124+ locations, including airports and air strips. It is looking to monetise 50 airports through unencumbered.

ISIL is set to monetise its land parcels including telephone exchanges, administrative buildings, staff quarters complexes, besides vacant land. It has already put up for sale 27 land parcels across 11 states and union territories. It has also taken 2,54 of 800 land parcels and buildings for sale.





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# DFI-India to Present Cutting-Edge Technologies and Global Best Practices in Geotechnical Engineering and Deep Foundations at its 13<sup>th</sup> Annual Conference

DFI-India 2024 Conference Core team, of the upcoming 13<sup>th</sup> Annual Conference to be held in Goa from 19-21 Sept'24, share their views on the positive impact of the conference through knowledge sharing, opportunity for networking with experts from across the world, and the insightful topics that will be covered at the sessions to address the challenges in the industry.

How is the DFI-India Annual Conference advancing the Deep Foundation Industry in India?



Mahesh Ramanathan, Chair, DFI of India: The DFI-India conference, organized annually, is a testament of the organization's efforts to advance the deep foundation industry, ensuring that it remains innovative, collaborative, and aligned with the highest global standards and best practices through knowledge exchange. Its primary objective is to facilitate sharing of cutting-edge research, innovative solutions, and best practices among professionals, researchers, and industry leaders.

Moreover, the conference plays a significant role in driving the adoption of new technologies and techniques in India, particularly in the face of the country's unique challenges in deep foundations. By showcasing the latest advancements, we encourage industry-wide adoption, which ultimately leads to improved safety and quality in infrastructure projects.

The DFI conference also serves as a vital networking hub, bringing together diverse range of stakeholders. These interactions often lead to fruitful collaborations, joint ventures, and research partnerships that propel the industry forward. Another important objective is to influence policy and standards. The insights and discussions generated during the conference contribute to the development of industry standards and inform policymaking, ensuring that the deep foundation sector in India operates in line with global best practices.

The conference is also instrumental in the professional development of engineers and practitioners. Through keynote lectures, paper presentations, etc., participants gain new insights and skills that they can apply directly to their work, thereby enhancing the overall competency and expertise within the industry.

DFI of India has been instrumental in promoting best practices and standards in the field. How does the organization intend to address the emerging challenges and opportunities in India's rapidly evolving infrastructure landscape?

Mohar Ramanujam, DFI of India: It is well-positioned to lead the deep foundation industry in navigating the challenges and opportunities of India's rapidly evolving infrastructure landscape. It is committed to addressing emerging challenges and capitalizing on new opportunities through a multifaceted approach. Urbanization is one of the most significant challenges we face, particularly in constructing complex infrastructure in densely populated areas. To meet this challenge, DFI of India is focused on promoting innovative foundation solutions, such as deep excavations and borrowed construction methods, which are essential for projects like high-rise buildings and metro systems. Sustainability is another crucial area, and we are advocating for the use of environmentally friendly materials and practices to minimize the environmental impact of construction activities. This includes encouraging techniques that reduce carbon footprints and minimize environmental disturbances during construction.

The increasing frequency of natural disasters highlights the need for resilient infrastructure. DFI of India is prioritizing resilience-enhancing technologies to ensure that our infrastructure can withstand future risks.

Continuous skill development and capacity building are also central to our strategy. Through targeted training programs and certification courses, we are equipping professionals with the expertise needed to meet the evolving demands of the industry.

Your leadership has been pivotal in establishing DFI of India as a leading authority in the deep foundation industry. What were some of the initial challenges you faced in building the organization?



Dr. V. Anirudhan, Founder & Director, Immediate Past Chair, DFI of India: I want to highlight the great support DFI of India has received from the Foundation Construction Industry since the launch of the organization. We set our goal for a well-educated, organized, and unified foundation construction fraternity. We believe that this is achievable by investing skills in the entire spectrum of players in the field, from geotechnical investigation teams to structural design and construction teams.

The initial challenge was to showcase that the DFI of India could help the foundation construction industry with speedy advancement of modern technologies in infrastructure development. DFI of India was convinced that well-planned annual conferences and workshops would attract young engineers and encourage them to achieve their goals, and it was even generating funds for more concentrated training and skill development programmes.

We realised that the small business groups suffered from a lack of funds to begin their engineers' skill training programmes. Motivated by the goal of generating funds to conduct the much-needed skilling programs, and even exceeding the programs for small players, was challenging for the organization. Though DFI of India succeeded in attracting young engineers in large numbers, generating funds for skill development programs and training remains a challenge.



**What new initiatives or strategic directions do you envisage for the organisation? How do you plan to ensure that DFI of India remains at the forefront of innovation and best practices in the industry?**

**Dr. N. Ananthan:** The most crucial action that DFI of India needs to focus on is on helping the industry update its technologies and skills. Small companies that constitute a significant portion of the industry need financial support to improve their skills and update the technologies, because of the lack of funds for such activities.

DFI of India is trying to tie funds from the CSR allocation of large organisations. However, there is a gap of awareness among large organisations that the activities of DFI of India benefit society as a whole and not just for large projects. DFI of India aims to educate the stakeholders. DFI's activities will help develop a socially responsible construction industry that relies sustainably and national growth.

**What are the key benefits for professionals attending the DFI India conference?**



**Prof. Purnanand Sarin (Chair, DFI India 2014 13<sup>th</sup> Annual Conference):** The entire world is experiencing colossal growth in infrastructural development and the large-scale construction of underground metros, bridges, tall structures, and tunnels, has compelled the construction industry to explore the deep undergrounds in search of suitable foundations and usable spaces, without affecting the existing structures and their foundations.

Deep Foundation Institutes' conferences reveal treasures of knowledge in the field



of geotechnical engineering and deep foundations. Technical sessions by world leaders in the field reveal cutting-edge technologies and latest advancements. Here, delegates gain insights into the latest research and innovations as regards advanced technologies, machines, materials and techniques in deep foundations.

Experts from all over the world share relevant case studies, research papers based on field studies, success stories, and experiences in challenging ground situations, providing valuable insights into deep foundation technologies.

All the conference activities encompass much are also centres of knowledge, where professionals in the construction field can further hone their skills. Personal interactions with the international experts provide the necessary connect with leaders in deep foundation technologies, enabling young engineers to explore future career options.

**What objectives will be highlighted at DFI India's 13<sup>th</sup> Annual Conference this year and what would be the impact on the future of deep foundation engineering in India?**

**Prof. Purnanand Sarin (Chair, 13<sup>th</sup> Annual Conference):** Infrastructure development in India has made rapid strides over the past few years, which has resulted in growing challenges, advancements and opportunities in deep foundation works.

This year, a special session on "Foundations for Tall Buildings" will have sessions by Indian and international students in the field. Sustainability and safety will be the focus areas of discussions. Key themes of discussions will be on automation, artificial intelligence, and machine learning in sub-surface characterization and testing for foundation performance, innovative methods and equipment used for special foundations such as large diameter piles, helical piles, and micro piles, technologies for offshore and marine deep foundations, and analysis and deep-ground improvement techniques.

A presentation of research papers, case studies, and success stories will also be a major feature. All the techniques are going to play a significant role in deep foundation technologies in India in near future. I look forward to the 13<sup>th</sup> Edition of the DFI conference this year, to bring out more participation, interaction and collaboration from academia and students with the world leaders in research, technology and construction of deep foundations. Youngsters in the field of foundation engineering, especially UG and PG students and faculty will gain lot of knowledge from these interactions which will help shape the future of budding engineers in the field and I am confident that senior leaders the field will leave no stone unturned in enlightening and shaping the young minds and fostering their professional growth, in whom we see the future of Indian Bharat.







The technical committee within CFI of India plays a crucial role in shaping the direction of research and practice in the deep foundation industry. Past & (past & recent) accomplishments & ongoing initiatives of the committee which could have a significant impact on the field?



Dr. Samir E. Basankar, Vice-Chair, CFI & CFI-India 2024 Conference Technical Co-Chair, CFI of India, technical committee, includes Geotechnical Characterisation of Foundations (GOCOF), Training committee, Innovation/Foundation Technologies, Students Outreach programme (Boudashan), and committee for Continuous Flight Auger (CFA) pile technology implementation.

The technical committee aims to catalyze the existing construction practices in a measure extent in order to meet India's growing infrastructural requirements more

efficiently. The committee also focuses on skill enhancement and improvement in construction practices in order to ensure minimal errors at project sites.

The GOCOF committee has conducted 6 workshops on geotechnical laboratory testing and on-site development. From August 2024 onwards, there will be annual series on "Practices for Efficient Subsurface Characterisation" as a template test.

In 2023, the CFI Training Committee had conducted highly successful programmes on "Support Piles for Foundation Construction and Pileless Cores for Deep Foundations". This year, it continues to the training program on "Ground Improvement for Foundation Construction" on 12 May 2024 at Park Hotel, Chennai. The programme also facilitated remote audience through an on-line mode. In the coming months, programmes will be held on "Groutmix Wall, Working Platform, Top Management in Construction Equipment" etc.

The CFI Student Outreach Committee conducted three "Groundwork" online webinar series in Jan, March, and July 2024. More seminars have been planned under this series. There will also be a student competition and awards program "Gear Project for Masters Students" and for "Best Research by PhD Scholars" at CFI's Annual conference this year.

The CFI technology implementation committee has come a long way after successful demonstration of CFA piles during 2017. This committee organized a webinar on 30th March 2024 in collaboration with IIS Kolkata Chapter for disseminating this technology in the eastern parts of India where this pile is highly feasible. The draft guideline for CFA piles prepared by this committee is already in circulation amongst CSDAS committee of BIS, and a second line of meeting is scheduled for 6th September. Many Indian engineering firms have already executed CFA piles at project sites.

CFI India's technical committees owe a lot to the support & facilities from sponsors, expert speakers, and the organizers, including the committee chair and the members.

**With your extensive experience in the field, how do you see technical education and knowledge-sharing evolving in the industry, especially in context of the themes being explored at CFI-India 2024?**

Dr. Samir E. Basankar: Given my balanced exposure to both industry and academia alike, CFI-India 2024 is a platform for a blend of the industry's experience with the design and analytical excellence for wonder, a high potential exists for knowledge sharing, networking amongst industry experts, academicians, equipment manufacturers, service providers and visiting engineers during the conference.

Technical themes for CFI-India 2024 are chosen to enhance the design and execution capabilities, showcase future technologies and practices for assessment and dissemination amongst a wide spectrum of conference delegates.

While themes like Pile foundations, Ground improvement, Deep excavation support systems are retained as a regular feature, this conference aims to bring state-of-the-art practices, cutting-edge technologies in these areas through carefully selected keynote addresses. The Technical committee have included special presentations like Seepage prevention hydraulic structures through deep pull-off trials, advanced Ground improvement techniques for soft soils, a novel method for the lateral resistance assessment and evaluation of pile-soil interaction from pile load trials.







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Marine foundations, covering deep sea, keel shafts and related to marine experiences in the challenging scenarios and advanced geospatial technologies that are lesser known. This year we have included a keynote address on Offshore Construction that aims to focus on the design, installation and its future strategies. Sustainability, safety and foundation re-use are themes that are intended to address the target Zero Carbon emission, and thoughtfully Indian and Global context of the current issue will be addressed by a globally acclaimed expert.

You will note that special theme is included to address the future trends like use of AI in foundations, use of special foundations like Helical piles, measures to encourage their use in India. DFI India strives in integration of design, analyses and research with the industry practice. Hence, research and numerical tasks that can lead to significant impact on the practice is part of the conference technical deliberation.

Highlight of this conference is inclusion of a dedicated 4-hour slot for a Special session on 'Foundations for Tall Structures' - a theme decided through valuable feedback received during previous conferences. This session will witness lectures from five acclaimed experts, and clear guidelines are expected to emerge from this session. I thank the technical committee and the technical committee co-chair Dr. Jayaram Bhusale for putting their unwavering effort in developing the technical program for the conference and reaching out to experts and industry for the same.

**How are DFI of India's activities such as its annual conferences, contributing to the growth and development of the deep foundation industry in India? Please share some key outcomes from recent conferences.**



**Ravindra Valiya, Core Committee Member, DFI of India:** The deep foundation industry has considerably evolved in the past two decades since the first pile hydraulic testing rigs were used in India in 1985. Today, we see a boom in the industry with the type of deep foundations, their designs, equipment being used and their application, which is at par with the developments and methods used worldwide.

DFI of India has kept pace with the developments in the deep foundation industry worldwide. The core objective of DFI of India is to keep track of the latest developments in deep foundations, analyse their requirements for the infrastructure industry in India, and do as a bridge or medium to propagate and disseminate this information to the stakeholders.

The annual conference is a major event towards this objective and the core committee spends considerable time to ensure that every year the conference presents a new vision, a new perspective, and new ideas to the attendees. As a core committee member, it is also our effort to ensure that the selection of topics, speakers, and special sessions are in sync with the developments in India and worldwide.

The DFI conference is one of the most eagerly awaited gatherings by geotechnical professionals and academicians. I have been attending almost every annual conference of DFI India and each conference has added to my technical understanding. Listening to experts from across the world and networking with the experts in the industry is an invaluable opportunity. As a core committee member, I take this as a responsibility to ensure that the Conference continues to be the torch bearer of the deep foundation industry and that it continues to deliver as a meaningful platform for all stakeholders in the construction industry to collectively strive towards building a strong and resilient infrastructure for our country.

**In your view, what other topics should also be covered in future DFI India conferences to address the evolving needs and challenges of the industry?**

The DFI of India conference has several keynotes and sessions, which cover several areas. In the past we have seen sessions on Continuous Flight Auger Piles, Tie Foundations, Graphtight Walls, Deep Excavations, and many more.

However, I have seen very little advancement by equipment manufacturers, developers and suppliers. Even though an understanding of new technologies and construction techniques is a prerequisite to ensure a good end-product.

I hope that DFI of India will consider highlighting use of the right equipment to ensure better foundations. Other emerging topics such as curing sustainable foundations, re-qualification of existing deep foundations, utilising foundation repairs or piles based on design and observational methods, are topics which could be included in future conferences. ■





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SCAN FOR ENQUIRY





# Foundation Equipment in Greater Demand

Contractors undertaking complex urban infra projects are looking for foundation and piling equipment with faster drilling speeds, product reliability, flexibility in operations, lower operating costs, higher productivity, and a long lifespan. This is driving manufacturers of such specialized machines to enhance their products with new features and technologies to cater to the emerging applications. PP Basistha reports.

**D**emand for foundation and piling equipment is surging, following a period of stagnation during the Covid-19 pandemic's shutdown of construction activities. Ongoing and upcoming metro rail, access-controlled elevated roads, bridges, ports, and real estate developments across the country are driving the need for advanced ground improvement techniques. This new demand is translating into a requirement for a higher volume of equipment with state-of-the-art technology. More importantly, the industry is evolving to focus on solutions that bring significant value. Project consultants, builders, and contractors are looking for innovative foundation technologies like diaphragm wall systems, CFA, displacement piles, stone columns, and soil mixing, etc., in order to execute projects with greater quality and faster completion timelines.



Tarang Basistha, CEO, Sany India, informs that in many regions of India, soil conditions are less than ideal for standard foundation methods. "Areas with weak or highly variable soil, high water tables, or explosive clay require specialised piling and ground improvement techniques to ensure stability and performance. Managing groundwater and mitigating its impact on construction is increasingly important, especially in urban environments."

"Techniques like jet grouting and soil mixing are used to treat the ground effectively for high groundwater levels. Instances of jet piling and ground improvement techniques such as CFA (Cast-in-place)

Pilot Auger piles, micro piles, and stone column mixing are expanding the range of solutions available for ground improvement. These technologies offer more efficient, cost-effective, and less invasive methods for dealing with complex ground conditions." He adds, "At Sany India, we are well-positioned to cater to the varied ground improvement jobs through our wide range of advanced products, with the backing of technical support. We have advanced solutions for diaphragm wall construction, particularly for applications requiring shorter cycle times and deeper walls. In diaphragm wall construction, CFA piles are critical for drilling and installing various soil and rock columns. For shorter cycle times (400-800 mm) and deeper depths (40-45 m), we have the suspended Grab D-800 with casing of 800, 900, 1000 and 1200 mm with retaining wall construction and can reach 30 m depth, while the D-700 is capable of 800, 1000, 1200, 1500 and 1800 mm with retaining wall construction."

To cater to the new applications, Sany has introduced several variants of Continuous Flight Auger (CFA) designed to enhance





performance and efficiency in construction, particularly in ground improvement and foundation work. The company's models (SR100M, SR120M, SR150M) are tailored to a variety of the CFA requirements. Some of the key applications areas of CFA are: piling foundations, ground improvement and stabilization, etc.

Says Sauria, "CFA play a significant role in soil displacement, particularly in ground improvement and foundation work. CFA technology, traditionally used for creating piles, can be adapted for various soil displacement applications to improve soil stability and enhance load-bearing capacities."

The CFA auger displaces soil and injects grout or concrete to create a pile that reinforces weak soil. The displaced soil is effectively replaced by a strong grout or concrete column, enhancing soil strength and load-bearing capacity. By creating a continuous column of grout or concrete, CFA piles improve the load distribution and stability of the ground, which is crucial for supporting structures like buildings and bridges.

For delivering flexibility in operations, Sauria's case machines are designed with versatility and adaptability in mind, enabling them to work with a range of attachments and specialized Kelly bars, continuous flight augers (CFAs), and other specialized tools. This flexibility is achieved through precise engineering and integration of advanced

technologies. The case machines are built with modular components that allow for easy interchangeability of different attachments. The modularity ensures that the same case machine can be configured for various applications, including drilling with Kelly bars, drilling with CFA, or other specialized tasks. Standardized mounting systems and connector joints facilitate the quick and secure attachment of different tools and bits. This design allows for easy switching between different operational modes.

Sauria machines are equipped with advanced hydraulic systems that can be adjusted to accommodate different attachments. The hydraulic flow and pressure settings can be modified to match the requirements of various tools, such as Kelly bars or CFA equipment. The case machines have powerful engines that provide the necessary power for a wide range of attachments. The engine's performance can be fine-tuned to meet the demands of specific applications, ensuring optimal efficiency and effectiveness. The load-bearing capacity of the case machines is engineered to support different attachments and operational requirements. This includes accommodating the weight and forces exerted by Kelly bars, CFAs, and other tools," informs Sauria.

Based on emerging complexities in ground improvement works and projects that require a combination of technologies such as piling and diaphragm walls, Sauria has been attempting to provide support to better meet the needs of its clients. The company provides tailored engineering solutions that integrate various technologies like piling and diaphragm wall systems. This includes designing customized configurations that address

the specific challenges of a project before its initiation.

Says Sauria, "We undertake feasibility studies to assess the suitability of different technologies and equipment combinations for the site conditions and project requirements. Our technical experts can provide in-depth consultation on the use of combined technologies, and guidance on optimal equipment configurations and operational strategies. We can prepare customized proposals that outline the recommended combination of technologies and equipment for a project, and include technical specifications, operational plans, and expected outcomes."

We also have training programs for operators and project teams on the usage of combined technologies, besides hands-on training on piling rigs and diaphragm wall systems. Our technical team is available to provide detailed information about the equipment, its performance capabilities, and technology integration. The team also addresses any questions or concerns before a job is finalized.

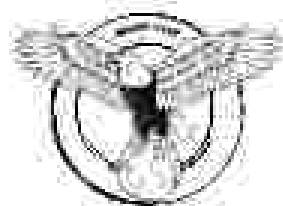
With its acquisition of foundation equipment division, the company is enhancing its after-sales support, its parts supply, and maintenance. It has a network of strategically located parts distribution centres around the world that ensure timely delivery of parts for different models and types of equipment.

The company's scheduled preventive maintenance programs help clients avoid unexpected breakdowns and extend the lifespan of their equipment. These programs include regular inspections, servicing, and parts replacement. All Sauria machines are equipped with telemetry systems that allow for remote monitoring and diagnostics, and provide real-time data on equipment performance, usage, and potential issues.

"We part of our sales support, we actively seek customer feedback on post-sales support services to identify areas for improvement and ensure high levels of customer satisfaction. Based on feedback and performance data, we continuously enhance our maintenance support to better meet client needs," says Sauria.







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Schwab Steiner also has introduced a new range of continuous flight augers (CFA) that offer enhanced performance, greater drilling depth, and improved soil extraction capabilities. informs V.G. Barthelmeier, MD, managing Steiner India. "These new variants are designed for urban infrastructure projects, large-scale residential developments, and industrial foundation tasks in challenging soil conditions. These CFAs are optimized for faster drilling speeds and reduced downtime, providing a cost-effective solution for contractors facing tight project timelines."

He adds, "Increasing urbanization and the push for smart cities will drive demand for specialized solutions, particularly in construction of high-rise building

foundations, urban infrastructure, and renewable energy projects. As the landscape of construction evolves, areas such as underground parking structures, water treatment plants, and coastal protection projects will also become significant demand drivers for foundation and drilling equipment."

"We are fully geared to cater to the new demand order with our specialized products that include CFAs for high-density housing projects, bridge foundations, and retaining walls in city centers. Our soil displacement technologies are integral to our portfolio. We see them as essential tools for meeting the demands of modern construction projects that prioritize environmental considerations."

Schwab Steiner's Kelly bars are engineered to perform efficiently in shorter cycles of 400-600 mm, ensuring precise and consistent performance. For deep, extended press operating at depths beyond 40-45 meters, the company offers solutions that guarantee operational stability and safety at greater depths.

"Our solutions are designed to enhance productivity and minimize cycle times, making them ideal for complex and deep foundation projects. Our Kelly bars are crafted with superior materials and advanced engineering to meet the stringent demands of modern construction sites," says Barthelmeier.

He informs that Schwab Steiner is promoting its soil displacement solutions and construction stone columns for use in urban areas where minimizing vibration and noise is crucial. Soil displacement techniques help in enhancing soil stability without the need for extensive excavation, while non-vibration stone columns offer an effective method for improving load-bearing capacities in soft soils.

To ensure the foundation contractor faces operations smoothly in projects, ensuring varied complexities, the company's base machines are engineered keeping in mind their versatility and adaptability.

They can work seamlessly with a variety of attachments, including Kelly bars, continuous flight augers (CFA), and other specialized kits.

"Our machines are equipped with advanced hydraulic systems and robust frames that ensure compatibility and optimal performance across different applications. To further enhance operational flexibility, our base machines come with pre-installed software designed to accommodate the specific requirements of various attachments. This software is user-friendly and enables operators to switch between different applications with minimal setup time, ensuring that the equipment can adapt quickly to the needs of any project."

Schwab Steiner is promoting its specialized equipment through product seminars, support. Says Barthelmeier, "We have tailored our product support to provide comprehensive solutions to meet the specific needs of each project. We offer detailed site assessments, customized equipment recommendations, and expert consultations to ensure that our clients are equipped with the right combination of technologies for piling and diaphragm walls."

Product support includes technical feasibility studies, tender/RFI analysis, and simulation modes that help clients visualize the potential outcomes of various approaches. "By combining our deep expertise with cutting-edge tools, we ensure that our clients receive the most efficient and effective solutions for their complex ground improvement tasks," adds Barthelmeier.

The company is also strengthening its after-sales support to the population of its VCMIS foundation equipment group. It has expanded its parts distribution network for faster delivery and increased availability of critical components. It has introduced a proactive maintenance program, which leverages IoT and predictive analytics to monitor equipment performance in real-time for comprehensive maintenance solutions. "Our customer service teams are also equipped with advanced tools and training to provide rapid and accurate technical support, ensuring that our clients can maintain peak operational efficiency at all times," says Barthelmeier.





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Raja Rakesh Raina, Country Head, Casagrande India, "It is interesting to see emerging applications for foundation equipment in India led by new technologies and processes. The aim is to attain higher productivity with lower cost as the equipment deployed in the challenging infrastructure construction projects. At Casagrande, we have wide range of soil foundation solutions to meet specific project requirement which is complete to given soil strata and other related project requirements. Casagrande technology department is continuously evaluating the advances in civil engineering, industry and working on economical mechanical solutions which are environment friendly, safe, reliable and having faster execution time lines and accordingly develop high-end technology application solutions."

He informs that the state of Gujarat has made mandatory the use of diaphragm walls in the construction of all parking basements in residential and commercial buildings which ensures safe and faster execution timelines.

The consultants and contractors prefer fully guided hydraulic grabs for top-down construction methodology for construction of basements. Casagrande grabs are contractors' preferred and first choice and we have supplied more than 40 nos of our diaphragm wall equipments in the state of Gujarat during last five years which is interesting a huge infrastructure and real estate development. The municipal authorities have made it mandatory for builders to construct underground parking to avoid road congestion and thereby we see a consistent demand for Casagrande grabs. We are observing a similar demand trend in the National Capital Region having favourable soil strata for adopting Casagrande wall excavation methodology.

Foundation equipment specialist Casagrande is having wide range of diaphragm wall equipment and in particular its smaller fully guided grabs having faster cycle time are a preferred choice for economical excavation with stringent vertically control for 2-4 level basements. These machines can accomplish Grab panels from 300mm upto 1500mm thickness and upto an excavation depth upto 45.0 m. Casagrande also has rope suspended grabs for deep shaft excavation.

Same information the equipment is finding many applications in the construction of Retaining wall for Road, Port projects, Jetty, underpasses besides underground metro station buildings.

Casagrande is also promoting its continuous flight augers (CFA) and non-slurry bored columns application etc. "Our solutions are proven technologies are finding usage in urban construction, for instance, our vibratory stone columns application it was used for ground improvement of Dedicated Freight Corridor (df) project. Casagrande has also successfully supplied application of for installing CFA piles and it is able to show case that for a suitable soil strata,

CFA piles are more economic and faster ground improvement methodology compared to bored pile. We are also keen to introduce our steel pipe foundation technologies in long life Soil displacement and Box piling which already are well established in Europe and other developed countries. As per the new technologies, one can achieve ground improvement without extracting the soil from the ground and is environment-friendly.

"Casagrande machines find favor with specialized civil foundation contractor due to their flexibility in operation for multiple foundation applications, higher productivity, precise reliability and low total life cycle cost. The machines can facilitate easy fitting and integration of the separate application etc for a variety of civil foundation solutions. Our customers do have to pay higher initial capital cost to acquire our machines, but are able to get better ROI" adds Raina.

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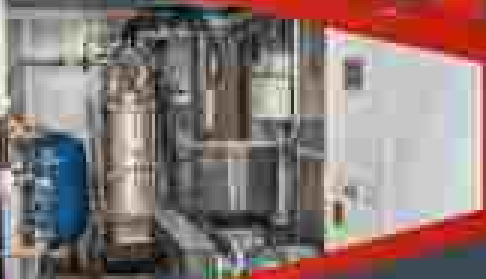






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# Offshore Experiences - A Case Study

Anand Islam, Anandeevan Vignayakumar, Theodore Paul, ITD Cementation India Pvt. Ltd.

## Details of Offshore Structure

A new port is under construction at Coimputi island of Tuticorin in Tamil Nadu, India, to serve a Thermal Power project. The project involves creation of a 555 m long and 25 m wide berth for coal handling which is located about 3 km from the shoreline for a natural draught of around 18m to accommodate a vessel of 50,000 DWT. The berth is connected with the shoreline through a 10 km to 15 km wide and 2km long approach bridge which carries coal handling side conveyors and a traffic catwalkway. To facilitate the fishing community, the approach bridge design was finalized with 34 m span and 7 m air gap to let fishing vessels pass through. Construction of pile foundations in deep-sea conditions presents numerous challenges,

beginning from geological complexities to the harsh marine environment. The project also includes Asia's first offshore island breakwater to ensure tranquility within the berth during port operations.

## Design Considerations & Loads

Design of the pile foundation for the berthing structure considered a multitude of loads, including berthing loads for 50,000 to 1,20,000 DWT vessels, ship unloader wheel loads of 500 tons per corner and various environmental factors such as wind speed (20m/s operation & 25 m/s extreme condition), wave load due to significant wave height of 5.5m, and seismic zone of Zone II as per IS 1893.

Pile spacing at the berth is 8m transverse and 7m longitudinal, and it carries 545 ton

of compression and 13.4 ton of horizontal forces at the pile cut off level.

## Subsoil Information and Pile Foundation Design

Subsoil profile consisting of an overburden sand layer followed by weak limestone sedimentary rock deposits. The axial capacity of the rock socketed bored pile is estimated as per the Coir and Blood method, considering SPT value of 120 for weak rock. The initial test pile result matches with this calculation. LFCE strategy, with its ability to model the pile response to lateral loads and varying conditions, proved to be useful for determining the depth of fixity. The final design of the piles consisted with 1,200mm diameter bored piles, socketed 4.0 to 4.5 times the diameter into the weak bedrock.



Figure 1: Island Breakwater and Coal Berth - at the end of the pier



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Figure 2: View of End Pier & Approach



Figure 3: Pile Installation with in Bore Location

## Construction of Pile Foundation

The project was unimpacted from severe sea conditions of wave height from 2 to 3.8m, which caused immense difficulty during construction. Two advanced jack-up barges of around 30m x 20m size were imported from Netherlands and they were used to install initial piles and subsequent piling was done through piling gantries by percussion method using a crane & crane.

Establishing termination criteria for rock socketing was a crucial aspect, and the pile penetration rate (PPR) was used to determine the rock level and where to terminate the piles. Additionally, SPT was also conducted in each pile to verify the rock touch level.

Two significant and unexpected challenges were encountered during the installation of piles which are presented here.

Case 1: In a specific zone, a collapsible stratum was encountered sandwiched between rock layers and the pile bore was unstable in this layer during coaming operations. Permanent they could not be advanced due to the top rock layer where the liner was getting a refusal. The issue was solved by going up to the bottom of this 2 to 3m collapsible layer, pouring concrete of M10 grade, and re-coaming the pile after sitting for 24 hours until the required termination level was reached.

Case 2: Permanent muds were drawn up to the top of weathered rock. However, in some piles, the liner was further penetrating weathered rock shafts at

the time of going for rock socketing. Looking the pile liner fit with the piling gantry is not recommended as it could cause instability of the piling gantry itself. As



Figure 4: View of Approach Bridge

a result, the liner was allowed to penetrate till it stopped sitting and the rest socket length was considered from the bottom of the liner instead of the actual rock top level. This consideration is influenced by the fact that the shaft friction of rock will not increase adequately where the steel liner is in direct contact with rock, therefore the portion was deducted for pile capacity calculations.

## Field Load Test

Besides the pile integrity test (PIT) in all working piles, high-stress dynamic load tests were conducted on selected working piles using Pile Driving Analyzer (PDA) and analyzed using CAPWAP. These tests provided essential data for validating the

load-carrying capacity of the piles and the distribution of resistance along the shaft and at the toe. The results confirmed that the installed capacity of the piles exceeded the calculated pile capacity thus providing confidence in the structural integrity of the foundation system. The load below capacity the dynamic pile load test results at the berth location.

## Conclusion

Employing advanced design methods, field quality control measures including pile tests, and practical on-site solutions for unique challenges, engineers and construction teams can deliver resilient infrastructure for rising demands of a rapidly developing India. 🌊

Pile No.	Modified Skin Friction (kN)	Modified End Bearing (kN)	Total Modified Capacity (kN)	Total Settlement (mm)	Net Settlement (mm)
E300	881	185	1066	0.5	1.0
E702	1274	462	1736	13.1	





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# Menard

## Adding Value to Projects with Ground Improvement Technology



The market for Ground Improvement Technology in India is dynamic and growing due to the country's rapid urbanization and infrastructure development, observes **Ian White, Business Head (India & Sri Lanka), Menard**

**How do you perceive the market for Ground Improvement Technology in India, including the emerging trends and the challenges?**

With 3.4% GDP Capex for infrastructure, the market for Ground Improvement Technology in India presents significant opportunities due to ongoing infrastructure development and technological advancements. But it also faces challenges related to expertise and regulatory complexities. Addressing these challenges through education, innovation, and streamlined processes will be key to leveraging the full potential of ground improvement technologies in India. Here's a detailed perspective on the emerging trends and challenges in the Indian market.

**Urbanization and Infrastructure Development:** India's rapid urbanization and infrastructure projects such as smart cities, highways, and metro systems, there's a rising demand for ground improvement solutions to support large-scale constructions on varied soil types.

**Technological Advancements:** Advances in ground improvement technologies, such as vibroreplacement, SMC (Soil Mixing Columns), DSM (Deep Soil Mixing), and accelerated compaction methods like Dynamic Compaction and Rapid Impact Compaction, are gaining traction with innovations becoming more common in the privately owned structures.

**Regulatory and Bureaucratic Hurdles:** Navigating regulatory requirements and obtaining necessary approvals can be time-consuming and cumbersome, potentially delaying project timelines and increasing costs.

**Awareness and Acceptance:** There may be a lack of awareness or resistance to adopting newer technologies due to traditional practices or skepticism about their effectiveness, mostly from the academic community and government bodies. This can slow down the market penetration of advanced ground improvement methods.

**Lack of Skilled Workforce:** There is a shortage of trained professionals and experts in advanced ground improvement techniques. This skills gap can affect



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the quality and efficiency of their implementation, which can be addressed through specialized training.

**Soil Variability:** Many diverse soil conditions present a challenge. Techniques need to be tailored to specific soil types and conditions, requiring customized solutions and in-depth site knowledge.

### What is the significance of ground improvement in construction and what are the various methods employed to enhance soil quality?

Ground improvement is crucial in construction as it ensures the stability, strength, and durability of structures by enhancing the properties of the soil on which they are built. Ground improvement gives enhanced Load-Bearing Capacity, Reduces Settlement, Improves Drainage, Mitigates Liquefaction and is cost-effective compared to traditional methods such as Piling.

Ground improvement techniques are essential for adapting to various soil conditions and ensuring the safety and stability of construction projects. By choosing the appropriate method based on soil characteristics and project requirements, engineers can significantly enhance soil quality and mitigate potential risks associated with construction. Ground improvement techniques can be divided into 3 types:

#### 1. Inclusion Techniques:

- Grouted (soil-cement) Columns
- Stone Columns
- Embedded Columns
- Soil Nailing
- Dynamic Replacement
- Jet Grouting

#### 2. Compaction Techniques:

- Dynamic Compaction
- Dynamic Replacement
- Rapid Impact Compaction
- Vibrocompaction

#### 3. Consolidation:

- Pre-Fabricated Vertical Drains (PVD)
- Vacuum Vacuum

It is believed that the benefits of ground improvement are not fully understood in the construction industry, so what could be the consequences if geotechnical investigations and ground improvement are not carried out before the design or construction phase, particularly in hilly or coastal regions?

Regarding geotechnical investigations and ground improvement before the design or construction phase, particularly in hilly or coastal regions, can have significant and potentially disastrous consequences:

**Structural Instability:** Without proper ground improvement, the soil may not be able to sustain the loads imposed by the structure. This can lead to uneven settlement, foundation failures, or even catastrophic structural collapse. In hilly regions, this risk is exacerbated by the potential for landslides and slope failures, which can undermine foundations and destabilize structures.

**Increased Costs:** Failing to conduct geotechnical investigations early on can result in unexpected ground conditions being discovered during construction. This often leads to costly design changes, delays, and even the need for repeated ground improvement measures that could have been more efficiently and cheaply implemented earlier in the project.

**Environmental Impact:** In coastal areas, the lack of proper ground improvement can lead to issues such as erosion, saltwater intrusion, and loss of coastal lands. Poorly understood ground conditions may also result in inadequate drainage and water management, leading to flooding and other environmental degradation.

**Safety Hazards:** Unstable ground conditions pose significant safety risks not only to the construction workers but also to the end-users of the facility. For instance, in seismic zones, insufficient ground improvement can exacerbate the effects of an earthquake, leading to liquefaction and severe damage to structures.

**Regulatory and Legal Consequences:** Eliminating these crucial steps can lead to non-compliance with local building codes and regulations. This may result in legal

disputes, fines, or even the suspension of non-compliant structures, all of which can severely impact the project's financial viability and reputation.

### How is ground improvement distinct from piling, and what are the ecological advantages of soil improvement over piling?

Ground improvement and piling are both techniques used to enhance the bearing capacity of soil and ensure the stability of structures. Ground improvement and piling serve different purposes in construction, with ground improvement modifying existing soil conditions and piling providing deep foundation support. They offer significantly different advantages, applications, and environmental impacts.

#### Distinctions Between Ground Improvement and Piling

##### Methodology:

Ground improvement involves modifying the existing soil properties to increase its strength, stability, and load-bearing capacity. Techniques such as Vibrocompaction, Dynamic Compaction, OVD, and Stone Columns are commonly used. The goal is to enhance the nature soil to meet the requirements of the construction project.

Piling involves driving or drilling long, slender columns (piles) made of concrete, steel, or timber into the ground to transfer loads from the structure above to deeper, more stable soil or rock layers. Piles bypass weaker soils and reach strata capable of supporting the load.

##### Applications:

The Ground improvement method is typically used in situations where improving the in-situ soil is sufficient to support the structure. It is often applied in areas with loose or soft soils, such as sandy or silty regions, or where shallow foundations are desired.

Piling is preferred in areas where the surface soil is too weak to support the structure, even after ground improvement, or where deep foundations are necessary due to heavy loads or significant variations in soil strata.



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#### Cost and Time

Ground improvement is generally more cost-effective and quicker to implement than piling, especially for large areas or where the soil improvement can be achieved near the surface.

Piling is typically more extensive and time-consuming due to the materials, equipment, and labor involved in driving or drilling piles to considerable depths.

#### Ecological Advantages of Soil Improvement Over Piling

**Reduced Material Use:** Ground improvement often involves treating the existing soil, which reduces the need for importing large quantities of materials like concrete and steel used in piling. This results in a lower carbon footprint and less resource consumption.

**Minimized Disruption to Environment:** Ground improvement methods, such as vibrocompaction or dynamic compaction, work with the existing soil, minimizing the disturbance to the surrounding environment. In contrast, piling can disrupt ecosystems, particularly if it involves driving piles through sensitive or sensitive habitats.

**Lower Energy Consumption:** Ground improvement techniques generally require less energy compared to the heavy machinery and processes involved in driving piles deep into the ground. This makes ground improvement a more energy-efficient option.

**Reduction in Waste Generation:** Since ground improvement focuses on enhancing the existing soil rather than replacing or bypassing it, there is less waste generation. Piling, especially when it involves bored piles, produces significant amounts of excavated soil that needs to be disposed of.

**Enhanced Sustainability:** Ground improvement methods can often be tailored to enhance the natural properties of the soil, promoting sustainability. Techniques like bio-remediation or the use of natural additives (e.g., lime or enzymes) can further reduce environmental impacts compared to the more invasive piling methods.

Ground improvement offers various ecological benefits, including reduced material use, minimal environmental disruption, lower energy consumption, and waste reduction, making it a more

sustainable option in many scenarios. While piling is necessary in certain conditions, ground improvement should always be the first option considered for every project.

#### What environmentally friendly practices and technologies does Mawad offer for ground improvement to add value to a project and how is waste handled on construction sites?

Ground improvement adds value to a project and contributes to sustainability through enhanced foundation performance, reducing risk of structural issues caused due to settlement, cost efficiency and a reduced environmental impact.

Quality and safety. Mawad is fully focused on sustainable plant, equipment and techniques and uses safety-oriented equipment and reduced using practices. We are also focussed on low carbon concrete, reduced water usage, segregated and reduced waste management, local manufacturing to reduce import and export, and minimizing storage by reusing materials, containers and tools. We encourage our supply chain partners to align with our environmental goals of sustainable development, operations and growth.







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### Menard's 4-point program to handle waste disposal on project sites

- Minimizing waste generation through precise planning and efficient use of materials
- Reuse wherever possible, recycling and reusing materials on-site. For instance, excavated soil can be reused for backfilling or part of soil improvement processes. This reduces the need for off-site disposal and the associated environmental impact
- Any waste that cannot be reused or recycled is disposed of in accordance with local regulations and environmental standards. Menard ensures that hazardous materials, such as contaminated soils or chemical waste, are handled with care and disposed of at certified facilities to prevent environmental contamination
- Menard employs rigorous environmental monitoring to ensure that waste management practices do not adversely affect the surrounding environment. This includes tracking waste generation, transportation, and disposal to ensure compliance with local environmental standards.

### Please elaborate on the regulatory solutions that are enhancing Menard's performance, even in challenging state conditions?

Menard specializes in a wide range of ground improvement techniques that cater to various soil conditions and project requirements. These methods are designed to enhance the load-bearing capacity, stability, and overall performance of the ground, making it suitable for construction. Some of the key ground improvement techniques include Inclusion Techniques, Compaction Techniques and Consolidation, Grouted StoneTech and Rammed aggregate concrete. Menard's technological capabilities worldwide. CoreTech is a leader in geotechnical site investigation, utilizing high-resolution data on subsurface conditions. CoreTech's technology includes Core Penetration Testing (CPT), and other in-situ testing methods, which are critical for

understanding soil behavior and designing effective ground improvement strategies. The detailed data provided by CoreTech allows Menard to accurately assess ground conditions, predict soil responses to various treatments, and tailor solutions to meet specific project needs, even in complex geological environments.

Rammed aggregate concrete (RAC) is a specialized in-situ and grout-based remediation technique, particularly in challenging and contaminated sites. RAC employs innovative techniques such as in-situ concrete placement, consolidation, and thermal desorption to treat and stabilize contaminated soils. These technologies not only enhance the environmental performance of ground improvement projects but also allow Menard to work effectively in sensitive sites and other environmentally sensitive areas.

We foresee introducing both these concepts in India and soon given the extreme and drastically growing landfill and soil contamination situation in India.

### How does Menard ensure compliance with local building codes and regulations? What quality control measures are in place during construction?

Since its inception in 1960 and now as a part of MDC Group, Menard has always maintained the highest international Quality & Safety standards. Menard is ISO 9001:2015-QMS, ISO 14001:2015-EMS & ISO 45001:2018-OSMS certified.

Menard has a comprehensive quality policy that aims to achieve the highest standards of performance and delivery of top-level service to its clients. To achieve this, we have developed strong management systems for safety, financial, quality, environment, and human resources. Our Quality Management System encapsulates these aims and our continuous analysis of the feedback generated from our business cycle through the operation of the system, and the actions taken to ensure that our own high standards are met, enables our clients to be confident that we will achieve the service they require.

Ensuring compliance with local building codes and regulations is a critical aspect of Menard's operations. While we respect and

follow the local codes wherever applicable, we also ensure strict compliance with international codes, such as codes, ASTM, etc. to provide the best quality solution at the most optimized rates.

### The Indian infrastructure development sector has the potential to disregard new technologies and global engineering expertise. However, the reluctance of contractors with outdated training and the presence of an unstable workforce hinders the adoption of new technologies. Can this issue be addressed through collaborative efforts between project owners and contractors?

Addressing the reluctance of contractors to adopt new technologies in the Indian infrastructure development sector requires a strategic and collaborative approach. By fostering partnerships, investing in education, and demonstrating the tangible benefits of modern techniques, we can overcome these challenges. Working with

#### Promoting Education and Training:

- Skill Development Programs: Implement targeted skill development programs that focus on training the unskilled workforce in the latest construction technologies. This can be done through partnerships between industry bodies, educational institutions, and government initiatives. By equipping workers with new skills, contractors will have a more capable workforce ready to embrace advanced techniques.
- Workshops and Seminars: Organize regular workshops, seminars, and on-site demonstrations that showcase the benefits of new technologies. These events should be aimed at both contractors and their workforce, providing hands-on experience with the tools and methods that can improve project outcomes.

#### Demonstrating the Value of New Technologies

- Pilot Projects: Collaborate with forward-thinking contractors and project owners to implement pilot projects that demonstrate the effectiveness of new technologies. By showcasing successful



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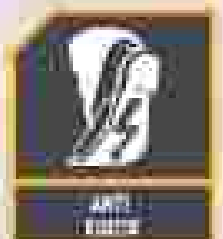
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**CL-03**





examples of innovation leading to cost savings, improved efficiency, and enhanced quality, reluctant contractors can see the tangible benefits of modernization.

- **Case Studies and ROI Analysis:** Develop and share case studies that highlight the return on investment (ROI) of adopting new technologies. Presenting data on how these innovations lead to faster project completion, reduced costs, and better sustainability can help change the mindset of traditional contractors.

### Encouraging Collaborative Efforts Between Owners and Contractors

- **Streamlining Innovation:** Project owners can play a crucial role in motivating contractors to adopt new technologies. This can include offering financial rewards, bonuses, or preferential selection for future projects to contractors who successfully integrate modern techniques into their work.
- **Joint Ventures and Alliances:** Encourage the formation of joint ventures between international firms with advanced technology expertise and local contractors. Such alliances can facilitate knowledge transfer, reduce the perceived risks associated with adopting new methods, and enhance the skill capabilities of local contractors.

### Leveraging Government and Industry Support

- **Government Policies and Incentives:** Advocate for government policies that support the adoption of new technologies, such as tax incentives, subsidies, or grants for contractors willing to invest in modernization. The government can also play a role in setting standards and regulations that encourage or mandate the use of advanced techniques in public infrastructure projects.
- **Industry Associations:** Collaborate with industry associations to create platforms where contractors can share experiences, learn from each other, and gain access to the latest technologies. These associations can also lobby for industry-wide adoption of best practices and new methodologies.

### Bridging the Knowledge Gap

- **Knowledge Exchange Programs:** Establish knowledge exchange programs where contractors can learn from global engineering experts and experienced professionals. This can include international training, exchange visits, or partnerships with global engineering firms that have successfully implemented modern technologies in other markets.

- **Digital Learning Platforms:** Develop online learning platforms that provide easy access to training materials, tutorials, and resources on new technologies. These platforms can be tailored to the Indian market and made accessible to contractors and workers across the country.

**How can the industry address the issue of skill development and training to facilitate adoption of advanced technology? What changes or developments are necessary in the education system, particularly in the civil engineering stream (structural, ground improvement, and foundation) to provide practical knowledge to students?**

B) Updating the education system to focus on practical, hands-on experience, fostering industry-academia collaboration, and encouraging continuous professional development, the industry can equip its workforce with the skills necessary to embrace modern technologies. Government support and policy reforms will also play a crucial role in facilitating these changes, ensuring that the Indian infrastructure sector is prepared to meet the demands of the future. The solution can be explained in the following -

### Collaborative Training Programs

- **Industry-Academia Partnerships:** Establish partnerships between construction companies, industry bodies, and educational institutions to create training programs that are directly aligned with industry needs. These programs should focus on hands-on experience with the latest technologies, such as BIM, geospatial instrumentation, and advanced foundation systems.
- **On-the-Job Training (OJT):** Encourage companies to implement structured on-the-job training programs where students and young professionals can work alongside experienced engineers on live projects. This practical exposure is invaluable for understanding the application of advanced technologies in real-world scenarios.





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## Certification and Accreditation

• **Specialized Certification Programs:** Develop and offer certification programs that recognize expertise in specific areas of geotechnical engineering and ground improvement. These certifications can be achieved through completing industry-recognized courses, which would enhance the employability of graduates and professionals.

## Curriculum Overhaul

• **Integrating Modern Technology:** Update civil engineering curricula to include the latest technologies and practices in geotechnical engineering, ground improvement, and foundation design. This should cover topics like digital modeling, soil mechanics, and the use of advanced materials and techniques.

• **Practical Focus:** Shift the focus of education from theoretical knowledge to practical application. This can be achieved by integrating more lab work, field studies, and project-based learning into the curriculum. Students should be exposed to real-life problems and encouraged to develop solutions using modern technologies.

## Research and Development Integration

• **Industry-Sponsored Research:** Promote collaboration between industry and academia in research and development. Companies can sponsor research projects that focus on solving specific industry challenges using advanced technologies. This not only helps in advancing the field but also provides students with practical experience.

• **Innovation Labs:** Establish innovation labs within educational institutions where students can work on cutting-edge projects in collaboration with industry partners. These labs can focus on areas like smart construction materials, automated surveying techniques, and sustainable engineering practices.

**Currently, geotechnical investigation and soil improvement receive minimal attention in tenders, particularly in government projects. What is the geotechnical and foundation industry addressing the urgent need for the development of standardized tender practices to promote adoption of new technologies during the pre-bid phase?**

This is a significant challenge that the industry is currently grappling with. However, I see immense potential and a gradual shift towards ground improvement. While progress is slow, more tenders are beginning

to require at least one GFI test per project and are beginning open to at least some ground improvement methods like Stone Columns and PVD. Although it may take into some time to become a mature market for advanced geotechnical techniques, I believe it is steadily growing and gradually catching up with related markets.

Especially platforms like GFI and GSB are also playing a crucial role in showcasing good technological advancements and helping bridge the gap between industry, academia, and the government.

**To expedite implementation of large infrastructure projects across the country, government support is needed in terms of expediting tender provisions for new techniques, providing support for trials, and relaxing import duties to encourage introduction of new technologies into the country. What initiatives is the industry taking to seek government support?**

This requires not just a collaborative industry effort but also a total shift in the mindset of the government and agencies to accept good practices. I have worked on technologies like GFI in 1999 in the UK, but it is still not accepted in India even 35 years later. The industry will continue to send representatives to the panel committee to accept and incorporate newer techniques. Getting a change that will have to be driven by the sourcing consultants through to the government. 🌟





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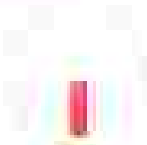
Vibro Stone  
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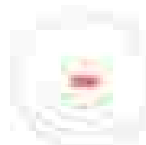
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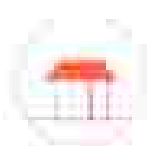
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# ArcelorMittal Projects India

## Enabling Quality Construction

**Yogesh Berwal, Commercial Director – India, ArcelorMittal Projects**, shares information on the company's products and applications, and its customized solutions, design and installation support, for enabling faster completion times of developers' projects in India.

With the Indian government's focus on infrastructure development and its initiative to make India a global manufacturing hub, how do you assess the future demand for value-added steel in construction projects?

Steel plays a construction segment like Housing, Industrial and Marine construction offer tremendous growth opportunities for value-added steel solutions due to their inherent advantages of durability, quick completion timelines, and reduced environmental impact due to their potential for recyclability. Ordinary is the Indian take-make-dispose economy, steel encourages salvage of large

amounts of embedded materials, energy, and labour. At the end of its lifecycle, 100% steel can be recycled.

What technologies and R&D does ArcelorMittal employ for decarbonisation, including waste reduction and zero waste in its manufacturing plants?

We have committed in 2021 to reduce European CO<sub>2</sub> emissions to 28% by 2030 and to carbon neutral by 2050. In fact, decarbonisation is the most important aspect of ArcelorMittal's long-term strategy. We align with the Paris Agreement's goals and the European Green Deal. Our new brand iCO<sub>2</sub> is designed to bring together

under one umbrella all of ArcelorMittal's reduced, low and zero-carbon products in steelmaking activities.

ArcelorMittal EcoSteelFit™ range of steel sheet piles are manufactured through the Electric Arc Furnace (EAF) route, with relatively low CO<sub>2</sub> emissions, compared to the average emissions for the global steel industry, which is around 2.3 tonnes of CO<sub>2</sub> per tonne of primary steel produced. The Environmental Product Declaration (EPD) of the EcoSteelFit™ product range is based on a Life Cycle Assessment (LCA) with the EAF route using 100% recycled material.

With ~700 full-time researchers, 14 research and development sites in 9 countries around the world, and \$556 million spending in 2022 (of which around 20% was spent in Europe), ArcelorMittal's global R&D (R&D) programs (in progress) is a testament of sustainable development. It ensures a constantly evolving and expanding portfolio of ArcelorMittal products.

What is ArcelorMittal Foundation Solutions?

ArcelorMittal Foundation Solutions is part of ArcelorMittal Projects, a global supplier of complete, customized and sustainable steel solutions. The ArcelorMittal Group is the worldwide leader in the production of steel sheet piles, with ArcelorMittal Foundation Solutions as its exclusive sales organisation. We also specialize in the production and supply of foundation piles as well as the design of various steel structures.

The use of steel sheet foundations or walls is growing at a steady pace but has not yet reached its full potential. What reasons or challenges do you think are hindering its growth?

Global manufacturing of Hot Rolled Steel pile started in early 20th century and this unique solution has evolved to be competitive with continuous improvements in steel grades, shapes, weight optimization and availability of crilling equipment.





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India remains a hotbed for market expansion where project owners and contractors prefer to replicate established construction methods. Other reasons are some myths surrounding steel construction, belief that steel is limited availability, lack of design know-how, local project references, and perceived high costs due to imports.

EC is keen awareness among developers and builders on the benefits of steel sheet pile foundations, via regular stakeholder engagements, provide design know-how and support, precast and shoo-case of the methodology ensure steel availability, timely and timely site delivery, and provide necessary certifications.

**What types of hot rolled steel sheet piles does the company provide and what are their application areas?**

Hot Rolled Sheet Piles are manufactured in various shapes and sizes like:

- Z & U types to cater to Section Modulus up to 5150 CM<sup>3</sup>/m
- Flat Head Sheet Pile, thickness 5.5mm to 15mm offering interlock resistance from 5500-6000kN/m
- HZ-41 King Pile with mixed groups of flanges & thickness up to 40mm to cater to Section Modulus up to 45500 CM<sup>3</sup>/m

- Foundation Piles of high wall thickness, large diameter and long lengths up to 30 metres

Steel grade, length, surface finish etc. are based on specific site requirement. Applications include coaly wash, flood, land excavations, retaining walls, tunnels, underground car ports, observatories, and embankments of rivers and canals.

**How does Environmental steel sheet piling solutions enable faster construction and lower costs compared to concrete alternatives?**

Steel Pile is a perforated steel retaining wall built with suitable piling and retaining equipment. If it is less labour oriented, EC

temporarily use applications, steel pile can be installed across 100m within a week. Extraction rate for basement can be expedited quick by slowing work progress of 200-250 sqm/day is feasible with steel piles, which are also available on lease at competitive prices. For permanent use applications, steel pile delivery timelines are pre-speed with the buyers.

**Please name some of the company's notable projects where the steel piles have been customised and used extensively.**

We have a diverse product range to cater to various requirements. We also customise the steel pile to meet specific project requirements of the project owners and developers by optimising design. We also undertake geotechnical reviews and recommendations. Quick delivery is possible from our stock in India. We also provide piling support to the third-party, and maintenance support. Our notable projects include the following:

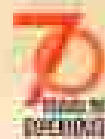
- GCRTL, Durgam Cheru Piling Piles
- Cochin Shipyard – Drydock Project Cochin
- JCB India Ore Berth, Parade
- JCB Best Quality Coal Terminal, Parade
- Groundwater Shore Protection, Thane
- New Steel Framing River Redevelopment Project, Windsor
- Essar Steel, Hazira (Now AlMHE)
- Shriest US Oil Ref. Port, Kolkata
- Nuclear Power Plant, Kudankulam
- MIDC Chakan







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# Case Study: Supply of HZM Solution for Oxagon Port Phase I



## Introduction

NEOM, a visionary project, is set to become Saudi Arabia's primary economic and trading hub. Given the NEOM framework, the Oxagon project is a groundbreaking initiative poised to become the world's largest floating structure. Designed as an ecological floating port, Oxagon houses a port with a capacity of 1.8 million TEUs, serving as a critical export hub for the region.

## Project Highlights

- The Oxagon project stands as the largest foundation project in the history of AMEC.
- HZM steel, critical structural elements for Oxagon, will be installed in the vessel lengths of up to 47 meters.
- Steel sizes in metric from 422x770 to 434x700.
- An impressive achievement was the first shipment, which was dispatched 47 days ahead of schedule, reflecting exceptional project management and dedication.



Client: NEOM, Gheradeh, Bahrain (KSA)

Product: HZM Solution, Quantity: Approx. 40,000 MT

- The project marks a milestone as the first H-Beam project under the name of EcoSteel®. Plus, in the Middle East, aligning with NEOM's sustainability goals.

## Journey & Challenges

- Sustainability as a Priority: In the early NEOM's commitment to sustainability, EcoSteel® was identified as a top solution. The advantages of low carbon emissions were presented during the tender stage.
- Competing Solutions: Contractors were exploring Pipe Column® solutions with an Environmental Product Declaration (EPD) value and key advantages from Asia compared against our high cost solution from Europe.
- Regulations and Team Efforts: With unwavering support from Management and RFQ team, the advantages of the HZM solution were showcased through various levels of regulations. This dedication eventually led to the successful booking of the project.
- Execution and Supply Chain Management: Post-steel booking, negotiations for a smoother journey were quickly met with challenges. The execution and supply chain management emerged as one of the most significant hurdles in this ambitious project.
- Weather Preparedness: Data past, being virtually new, posed challenges in securing weather forecasts of accommodating full-length piles, which are crucial to the project's structural integrity.
- Regulatory Compliance: NEOM, governed by a unique set of rules and regulations, required extensive documentation approvals before any shipments could be initiated, adding complexity to the logistical process.

## Conclusion

The supply of HZM Solution for Oxagon Phase I exemplifies not only a groundbreaking engineering project but also a testament to the significance of sustainability in modern construction. Despite facing significant challenges in execution and supply chain management, the dedication of the team and the advantages of the chosen solution led to a successful project booking. This case study underscores the importance of innovative engineering solutions and adaptability in facing the logistical complexities of ambitious projects like Oxagon. 🌱



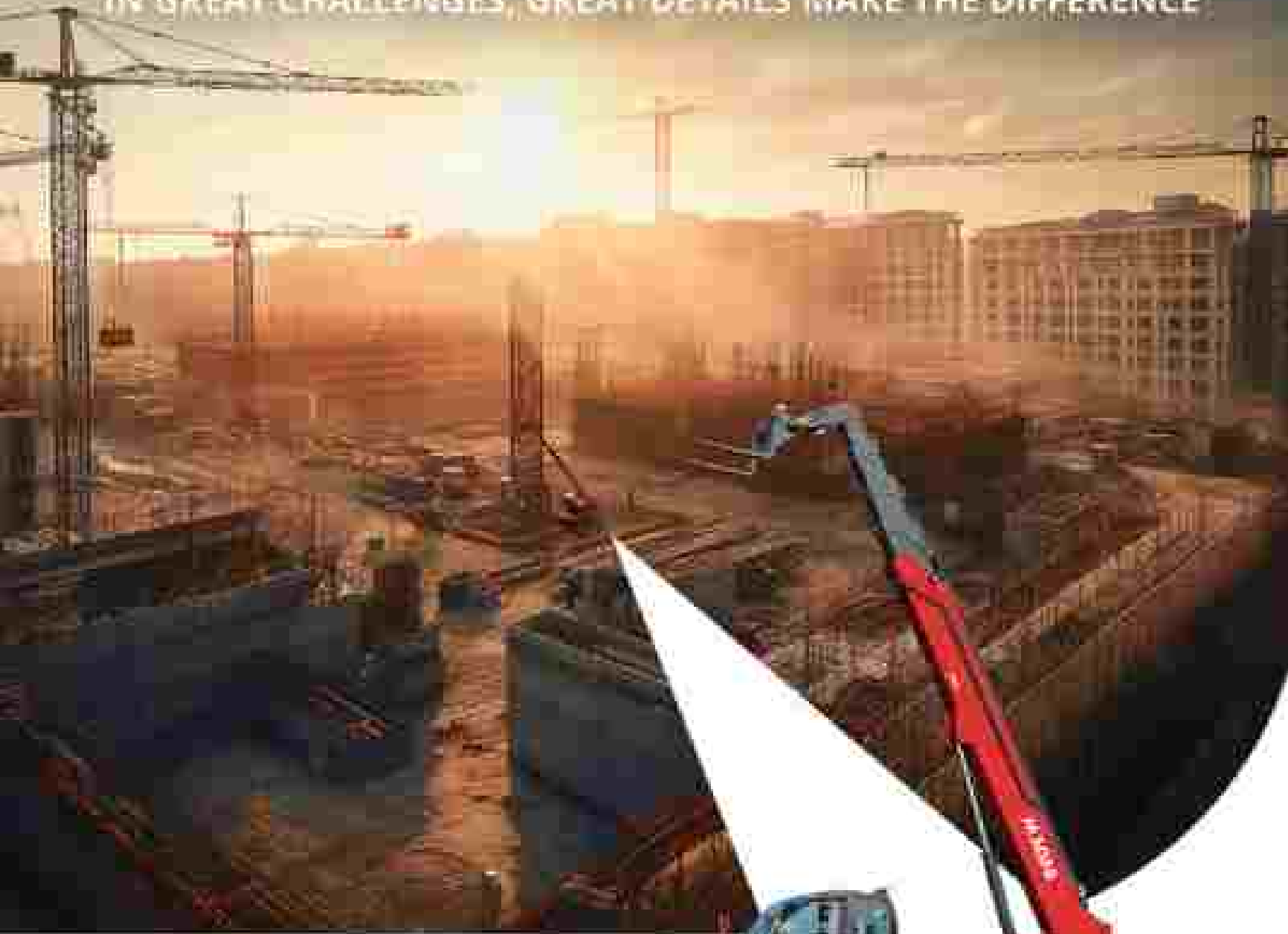




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# Determination of Cement Content for Soil-Cement Stabilization

Gurpreet Ahluja, Scientific Officer 'E', Nuclear Power Corporation of India Limited

**A**t the onset of any construction project, it is essentially desired to evaluate the properties of founding media in order to assess its suitability. In some cases, where founding media do not satisfy the required characteristics, ground improvement techniques can be employed to improve the properties of founding media. Different ground improvement techniques can be used depending upon their technical feasibility and in-situ site requirements. One such technique is mixing cement with excavated soil and compacting it in layers to improve its mechanical properties.

Soil stabilization using cement is the permanent alteration of properties

of the soil to improve its engineering performance. However, deciding on percentage of cement to be added to soil is a challenging task. Percentage of cement to be added to soil shall be decided so that it is both technically feasible and commercially viable.

Amount of cement to be added to soil can be determined by subjecting the soil-cement samples to alternate cycles of wetting and drying (IS 4332 (Part-4) set out the procedure for determining the soil-cement losses, moisture changes and volume changes (swell and shrinkage) produced by repeated wetting and drying of hardened soil-cement samples.

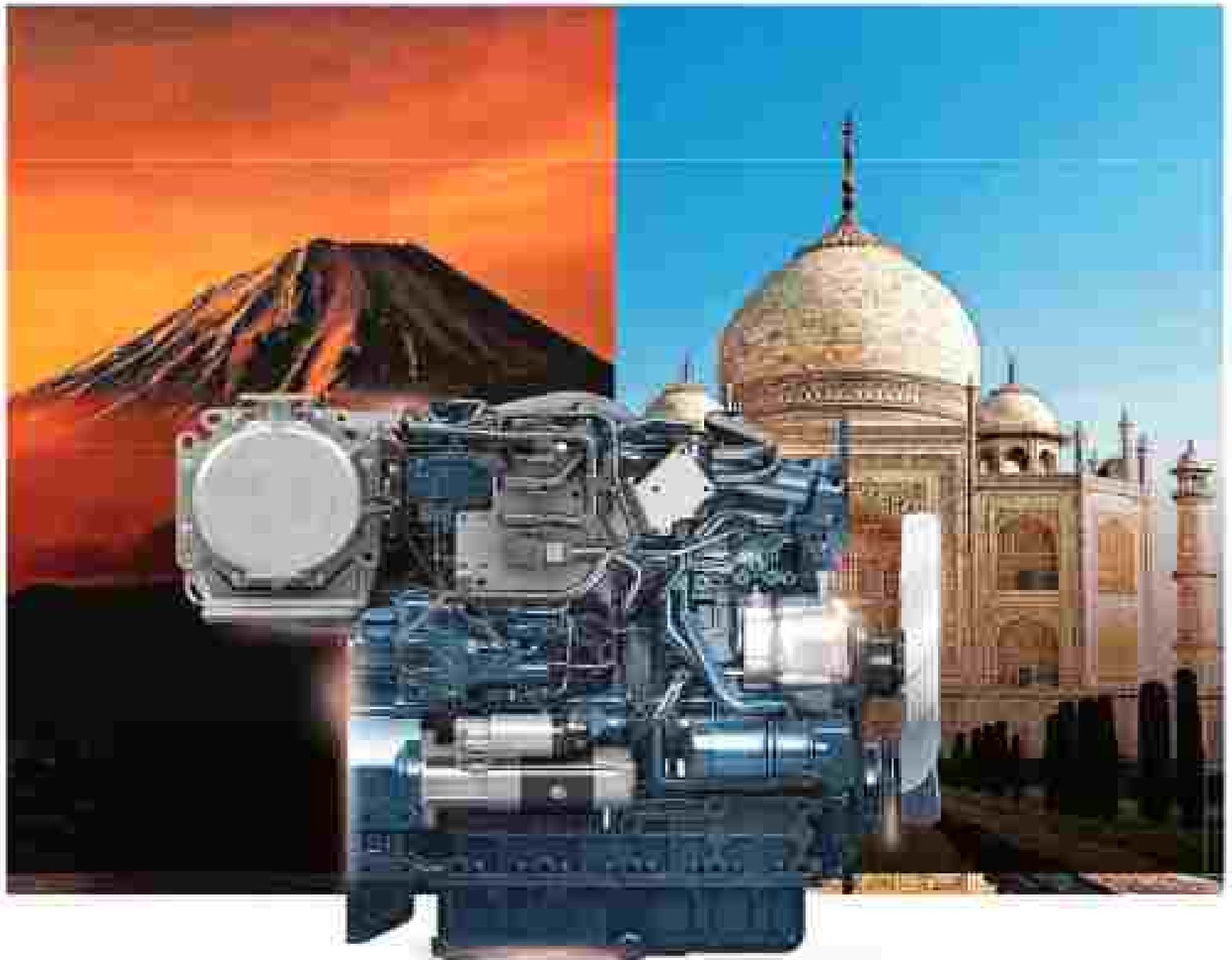
Four cylindrical specimens of dia. 100mm and length 150mm are prepared at density and moisture content obtained through modified compaction test in laboratory. Specimens shall be prepared in three layers and each layer shall be compacted before placing the material of another layer in order to have proper bonding between two subsequent layers.

Moisture content of the specimen's stratum II is recorded along with specimen weight shall be noted before proceeding further. Out of these 4 specimens, specimen 1 & 2 will be used to calculate volume loss while Specimen 3 & 4 will be used to calculate weight loss. All the four specimens shall be



Figure 1: Soil-Cement Stabilization Ground Improvement Method





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Figure 1. Soil-Cement specimens in a tray with different percentages of cement



Figure 2. Condition of specimens after submergence of 12 cycles

Table 1: IRC SP-35 recommendation for maximum allowable weight loss for different types of soil

AASHTO Soil Group	Unified Soil Group	Maximum Allowable Weight Loss %
A-1-a	GM, GP, GMA, GMAH, GMAH	14
A-1-b	GM, GP, GMA, GP	14
A-2	GM, GP, GMA, GP	14
A-3	GP	14
A-4	CL, ML	18
A-5	ML, MH, CH	10
A-6	CL, CH	7
A-7	OH, MH, CH	7

100% is the maximum allowable weight loss for A-3-4 and A-5-7 soils

Table 2: The results of present study

Sample	Specimen No.	Observation	% change	Remarks
Soil + 2% Cement	Specimen 1	% change in Volume	4.8	After 12 cycles submerged during 12 Cycles
	Specimen 2	% change in Volume	4.1	
	Specimen 3	% change in Weight	27.34	
	Specimen 4	% change in Weight	31.88	
Soil + 3% Cement	Specimen 1	% change in Volume	2.3	After 12 cycles submerged during 12 Cycles
	Specimen 2	% change in Volume	2.4	
	Specimen 3	% change in Weight	11.26	
	Specimen 4	% change in Weight	21.75	
Soil + 4% Cement	Specimen 1	% change in Volume	2.3	After 12 cycles submerged during 12 Cycles
	Specimen 2	% change in Volume	2.5	
	Specimen 3	% change in Weight	11.08	
	Specimen 4	% change in Weight	17.71	
Soil + 5% Cement	Specimen 1	% change in Volume	1.0	After 12 Cycles
	Specimen 2	% change in Volume	1.1	
	Specimen 3	% change in Weight	11.17	
	Specimen 4	% change in Weight	12.08	
Soil + 7% Cement	Specimen 1	% change in Volume	0.7	After 12 Cycles
	Specimen 2	% change in Volume	0.1	
	Specimen 3	% change in Weight	11.5	
	Specimen 4	% change in Weight	15.6	
Soil + 9% Cement	Specimen 1	% change in Volume	0.4	After 12 Cycles
	Specimen 2	% change in Volume	0.9	
	Specimen 3	% change in Weight	8.9	
	Specimen 4	% change in Weight	6.1	

placed in moist chamber and shall be protected from free water for a period of seven days.

At the end of 7 days, specimens shall be submerged in clean water at room temperature for a period of 5hrs and removed. Weight and dimensions of specimens shall be measured before proceeding further.

All four specimens shall then be placed in an oven at 10 degree Celsius for a period of 42 hrs. Weight and dimensions of specimens shall be measured and noted.

Specimen 2 & 4 shall then be given 18 to 22 vertical crush strokes with an 18 steel with the wire scratch brush by applying a force of 11.4kgf.

The entire procedure of 48hrs comprise of one cycle of the test. The specimens shall again be submerged in water and the procedure continued for 12 cycles. Weight of specimens before and after soaking is noted at the end of each cycle. After end of 12 cycles of test, specimens are dried to constant weight at 110 degree Celsius to determine oven dried weight of specimen.

At the end of test, maximum volume change, in percent and maximum moisture content during test of specimen No. 1 & 2 is noted. For specimen No. 3 & 4, soil-cement loss in percent is calculated.

IRC SP-35 recommends maximum allowable weight loss for different types of soil as given in table 1. Percentage of cement that satisfies the criteria can be used for soil-cement stabilization provided all other technical conditions laid down in project are satisfied.

The soil type in this study is B30 Sand (SM). The optimum specimens at varying percentages of cement starting from 2%, was prepared at DRC & MCC. The result of weight & volume loss after 12 cycles of test or up to their intermediate final cycle is presented in the below table 2. As per the results, the cement content less than 6% is not recommended. However, this criteria can be suitably modified, based on specific requirements of project site, if required. @



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# Ground Improvement for Seawall and Reclamation at Mumbai Coastal Road Project Package-1

Shrikar Nayak, Vipul Dobhalda, Raj Kumar K, K S Bhat, T Vijayakumar, L&T Construction

The Mumbai Coastal Road Project Package-1 includes the construction of a 3.82 km long 8-lane road section over reclaimed land. To create green spaces, in the congested city, an area of approximately 75 hectares from the sea is reclaimed and protected from the sea by seawall. The challenge for reclamation in the Harbour Bay area is the presence of marine deposits of thickness varying from 1m to 6m on rock stratum. Shear strength requirements of marine deposits are not satisfied and settlement issues will be occurred during service. Hence ground improvement by stone columns was suggested with the design of stone column being done to restrict total residual settlement at 100 years to 50mm.

## Parameters Affecting Design

**Design Life:** The design life of sea wall is 100 years. Further, the design life of rigid pavement and flexible pavements are considered as 30 years and 15 years respectively.

**Design Load:** Uniform surcharge of 25kPa is considered on reclaimed area.



Figure 1: Area of Harbour Bay showing extent of reclaimed area in the sea

## Settlement Limits

### Settlement of reclamation fill

- Within the design life, total settlement of reclamation under the uniform surcharge including creep due to settlement of exploration fill shall not exceed 300mm.
- Angular distortion (differential settlement) to be less than 1 in 200 over a 10m length (50mm in 10m length).

- In case of any ground improvement, the residual settlement shall not exceed 10% of the estimated total ground settlement.

### Settlement of seawall

- Total settlement shall not be more than 50 mm over 100 years; and
- Angular distortion shall be less than 1 in 500 over a 10m length (20mm in 10m).

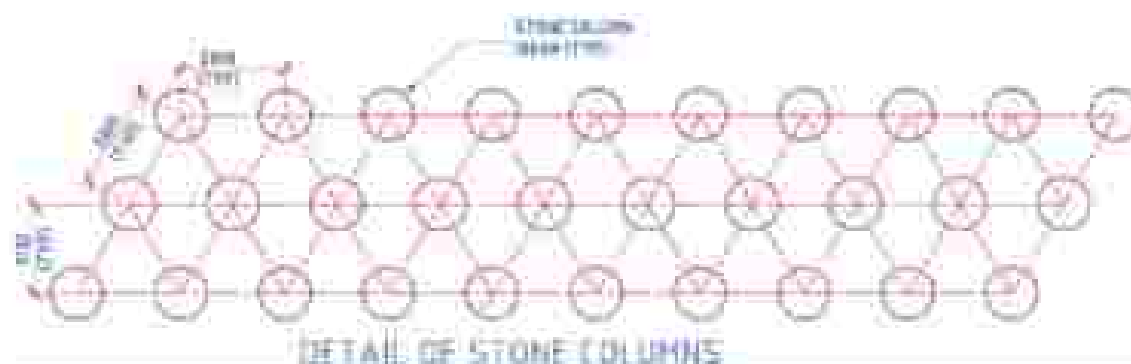


Figure 2: Layout of stone columns with a circular inter stone columns gaps





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Figure 2: Drilling of stone column with rig (refill)

The time required to achieve 55% consolidation without ground improvement is too high. Hence ground improvement by stone column is proposed to accelerate the consolidation process and to improve the bearing capacity of soil.

**Design methodology of Stone Column:**  
Ground improvement proposed is in the form of stone column of 1m diameter at 2m centre to centre spacing in triangular pattern.

Construction sequence of stone column is as follows:

**Stage 1:**

- Placement of vibrated fill up to  $\sim 15.50m$  CD.

**Stage 2:**

- Installation of stone column.
- Post installation of stone column, a waiting period of 72 days shall be maintained before proceeding to further filling the material.

- CMBV testing at  $\sim 15.50m$  CD is ensure 75% relative density of the fill below MWL.

- For formation of stone column, loose soaked level, the stone column material (crushed rock fill) can be used.

**Stage 3:**

- Raising of vibration fill its level to  $\sim 16.50m$  CD.
- Post filling a waiting of period of 72 days shall be maintained to allow the 55% consolidation of the subsoil.

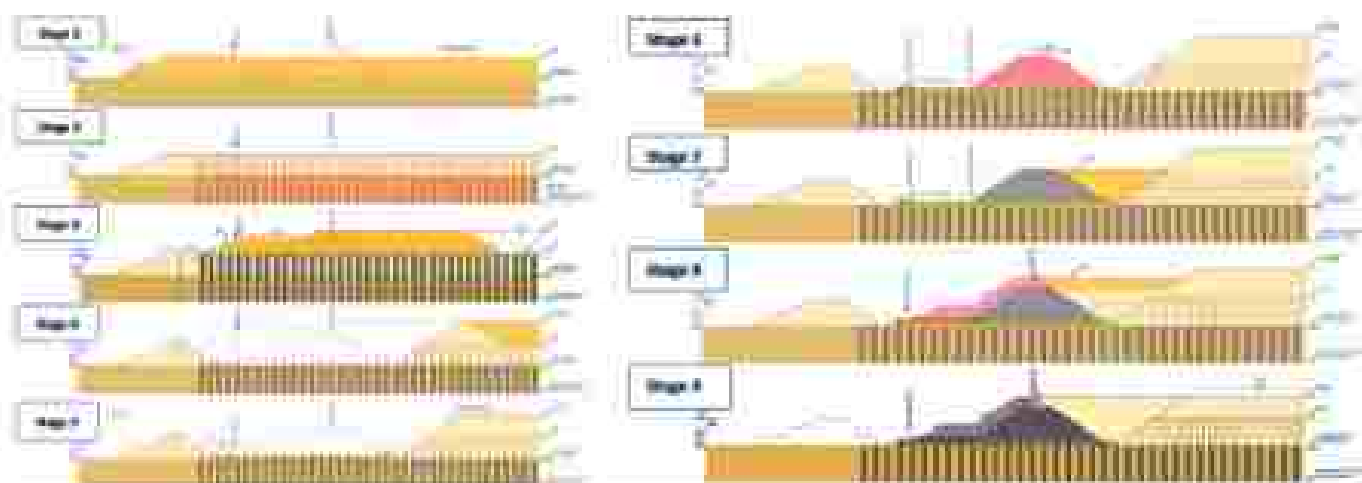


Figure 3: Construction sequence of stone column





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Figure 2: Tunneling completion of ground movement

- Installation of instrumentation at (+)E00m CD to monitor the deformations and pore pressures to ensure 98% of consolidation

- Increase in shear strength and progress of settlement shall be monitored through instrumentation and monitoring

#### Stage 4

- Excavation of surcharge fill for the construction of access
- Placement of excavated material on the reclamation side as surcharge from (+)E 00mCD to (+)E 05mCD
- Sequence of filling shown above (+)E00 m CD is tentative and can be modified to suit the construction methodology and schedule

#### Stage 5

- Placement of 250mm thick granular material

- Placement of first layer of geogrid
- Placement of 250mm thick granular material over the first layer of geogrid
- Placement of second layer of geogrid
- Placement of 250mm thick granular material over the second layer of geogrid
- Placement of additional 250mm thick granular material on the outside of the underlayer

#### Stage 6

- Placement of core material up to the core top level

#### Stage 7

- Laying off geotextile over the top surface back of the core material and sealing the gap between land and the reclamation fill

#### Stage 8

- Construction of sea and armour of the seabed

- Positioning of wave wall followed by the placement of reclamation fill up to (+)E 05mCD

#### Stage 9

- Removal of temporary reclamation on seabed
- Removal of surcharge fill of about 1.5m thickness to achieve the design formation level of (+)E 05mCD

For the different construction stages, time required for 98% consolidation, improved cohesion, bearing capacity of the improved ground is checked.

The estimated maximum residual settlement at the reclamation is 55.45mm, which is less than the allowable residual settlement of 100mm. The estimated maximum residual settlement at the seabed location is 29.45mm, which is less than the allowable residual settlement of 50mm, hence meeting the employer's requirements. •

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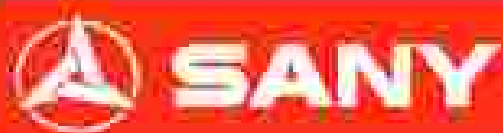
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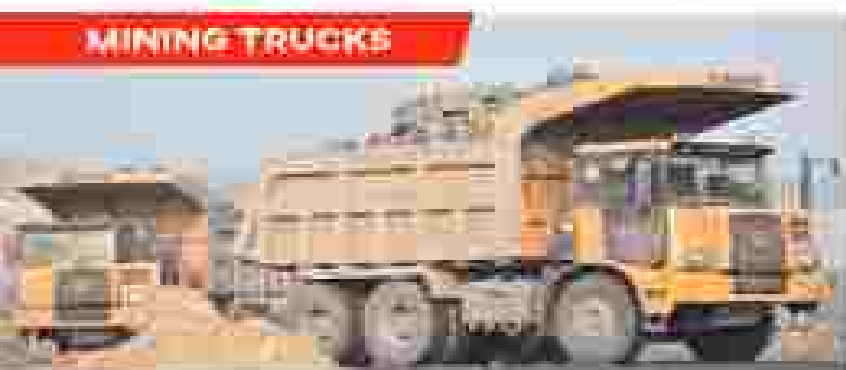
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# Advancing Landslide Research in India

Dr. Neelima Satyam, Professor, Department of Civil Engineering, IIT Indore, presents an overview of the research done on landslides across various regions of India in order to come up with forecasting, modeling, and early warning strategies.

## Introduction

Landslides threaten a major portion of rural, emerging infrastructure, communities, and the environment through loss of life, property damage, and degradation. Landslides can be triggered by various factors like rainfall, seismic activity and human actions. Key factors influencing landslides include slope steepness, geological and hydrological conditions, soil properties, and land use practices.

Effective landslide hazard management requires a multidisciplinary approach and technological advancements. Remote sensing and numerical modeling have significantly improved our ability to assess landslide susceptibility, predict events, and develop early warning systems (EWS). Rainfall, a primary trigger for landslides, has been extensively studied, with critical rainfall thresholds for debris flows and shallow landslides established decades ago. Earthquakes also contribute to slope instability. Accelerating integrated risk assessment strategies.

Landslide susceptibility mapping (LSM) and EWSs are vital tools in hazard management, identifying vulnerable areas by analyzing topography, geology, seismic activity, and rainfall patterns. Geographic Information Systems (GIS) and statistical modeling play key roles in these assessments, with machine learning techniques increasingly being used to predict landslides.

Rainfall thresholds are crucial in landslide prediction, helping identify precipitation levels that could trigger landslides. By analyzing historical events and rainfall data, researchers have developed predictive models and EWSs. Integrating this information with GIS and remote sensing is crucial for spatial and temporal variations, thereby enhancing system effectiveness. While sensor-based monitoring systems further contribute by providing real-time data that improve landslide hazard assessment and early warning capabilities.

Despite significant global research on rainfall and earthquake-induced LSM and EWS development, critical gaps

persist in landslide hazard management in regions like the Indian Himalayas, Western Ghats, and Garo-Khasi-Jaintia Himalayas. There is a lack of a comprehensive framework that integrates susceptibility mapping with landslide monitoring for local and regional EWS development. Furthermore, there is a significant gap in research combining landslide susceptibility maps with rainfall thresholds to develop region-specific EWSs. Despite the pressing need, efficient, operational, and cost-effective landslide early warning systems remain largely absent in these regions. Addressing these research gaps is crucial to improving landslide hazard management and mitigating the devastating impacts of landslides in vulnerable areas.

The research at IIT Indore is focused on addressing these critical gaps, particularly in the context of the Indian Himalayas, Western Ghats, and Garo-Khasi-Jaintia Himalayas. The team is working on developing integrated models that combine landslide susceptibility mapping with rainfall thresholds and real-time monitoring





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systems. This includes studying the complex interactions between geological, hydrological, and climatic factors that contribute to landslide risk. Additionally, IoT models research aims to enhance the accuracy of machine learning models used for landslide prediction by incorporating more diverse and precise datasets. The ultimate goal is to create a robust and cost-effective early warning system that can be deployed in landslide-prone regions, significantly improving hazard management and reducing the impact of landslides on lives. Here is an overview of IoT models research on landslides across various regions of India.

## Darjeeling Himalayas

Our research in the Darjeeling Himalayas has aimed to address the severe issue of rainfall-induced landslides, which pose significant risks to life, property, and infrastructure in this region. The Indian Himalayan region, known for its complex geological features, steep slopes, and intense monsoonal rainfall, presents local conditions for landslides. The damage caused by these landslides necessitates effective strategies to minimize their impact and enhance disaster preparedness.

To tackle this issue, we have focused on developing and refining early warning systems and rainfall thresholds specific to the Kalimpong area within the Darjeeling Himalayas (Ghosh et al. 2013a; Ansham et al. 2020a, 2022a). Our research involved studying and testing several models and methodologies to better predict and manage landslide risks. One of the core components of our study was the application of the SIGMA (Statistical Integrated Seasonal Monitoring Alerts) model, which was originally developed for Enna Barrage in Italy. This model uses statistical distributions of cumulative rainfall (used to predict landslide occurrences).

We tailored this model to the Kalimpong context by utilizing a calibration dataset of daily rainfall and landslide occurrences from 2013 to 2018. The results were validated with independent data from 2016 and 2017. The SIGMA model demonstrated high efficiency in predicting landslides, achieving 82% accuracy with a likelihood

ratio of 11.33. This performance highlights the model's potential for integration with existing forecasting systems, offering a robust tool for early warning in landslide-prone areas (Ansham et al. 2022a).

In addition to the SIGMA model, we focused on estimating specific rainfall intensity-duration thresholds for landslide occurrences in Kalimpong. By using a point (as equation), we determined that rainfall events with an intensity of 1.88 mm over a duration of 24 hours are associated with a high risk of landslides. Furthermore, our study identified that antecedent rainfall volumes of 10 and 20 days require intensities of 11.27 mm and ~13.5 mm, respectively, to trigger landslides. These findings are crucial for refining early warning systems and improving predictive accuracy for landslide events (Ghosh and Sengupta 2018; Ghosh et al. 2020).

We also explored the applicability of the hydrological FLRF (Forecasting of Landslides Induced by Rainfall) model, which incorporates two modules: Rainfall-Landslide (RL) and Rainfall-Forecasting (RF). The RL module correlates rainfall amounts with landslide occurrences, while the RF module simulates future rainfall events. By analyzing the monthly function  $f(t)$  with data from the July 1, 2018 landslide event and validating it with 2018 monsoon data, we demonstrated the model's potential for predicting landslides. This analysis underscores the need for more detailed data to further refine the thresholds and enhance prediction accuracy.

Additionally, we installed an early warning and monitoring system in the Chhat Pashor region of West Bengal, incorporating MicroElectroMechanical Systems (MEMS) and volumetric water content sensors. The slopes monitored are located on the banks of mountain rivers (nadas), known as slaking zones in Kalimpong, which are highly affected by sulfate discharges during the monsoon season due to heavy rainfall and soil damage. This study represents the first year-long field monitoring effort in this area, evaluating the applicability of IoT sensors. The sensors, embedded

within the soil, measured tilt angles and moisture content at shallow depths.

Data collected during the 2017–2018 monsoon seasons were correlated with field observations and digital soil, revealing that considering long-term rainfall conditions is more effective than focusing solely on immediate rainfall events when developing rainfall thresholds. This research contributes to refining early warning systems by incorporating detailed, real-time monitoring data to better predict and manage landslide risks. This approach supports the development of a cost-effective early warning system for slope stability, addressing the challenge of identifying which slope sections are at risk of failure during heavy rainfall (Ghosh et al. 2013a; Ansham et al. 2020a).

Moreover, we explored the integration of real-time monitoring data from MicroElectroMechanical systems (MEMS) to sensors with the SIGMA model to improve its predictive capabilities. The SIGMA model, which uses statistical distributions of rainfall to forecasting landslide occurrences, was enhanced by combining it with tilt meter readings through a decisional algorithm. We compared three approaches: the SIGMA model alone, tilt meter readings alone, and the combination of both, using precipitation and landslide data from Kalimpong between July 2017 and September 2020. The integration of tilt meter readings reduced the number of false alarms issued by the SIGMA model from 70 to 34 and increased the likelihood ratio from 12.10 to 20.22.

The Receiver Operating Characteristic (ROC) curves indicated that the combined approach provided the best performance, with an area under the curve of 0.975. This proposed method outperformed previous rainfall thresholds for the Kalimpong region and holds promise for further refinement into an operational Landslide Early Warning System (LEWS) for the area (Ansham et al. 2022a).

Further enhancing our research, we employed Bayesian analysis to assess the probability of landslide occurrences based on rainfall severity and antecedent soil moisture content. Using the SHETRAN





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(Soiltype - Hydrogeomorphic Erosion Transport) model for simulating soil moisture and applying event rainfall-duration (ERD) thresholds, we derived two-dimensional Bayesian procedures for landslides in Kaibang. This approach highlighted the applicability of the SHETRAN model in improving the prediction capabilities of empirical thresholds and provided a more nuanced understanding of landslide risk (Aghamir et al. 2020c).

Lastly, we addressed the limitations of deterministic rainfall thresholds by evaluating probabilistic thresholds using statistical methods. By analyzing single and multiple rainfall parameters through variants of Bayes' theorem, we calculated the probabilities of landslide occurrences for Kaibang. Our study found that the possibility of landslide initiation increases with higher rainfall intensity, underscoring the importance of considering rainfall event parameters, particularly intensity, in landslide prediction (Chen et al. 2018c).

## Western Ghats

In the Western Ghats, our research was focused on forecasting the occurrence of rainfall-induced landslides, a critical issue due to the extensive damage such events cause worldwide. Our research aimed to contribute to the development of operational landslide early warning systems (LEWS) by providing detailed spatial and temporal forecasts. The forecasting method was tailored to the unique topographic, hydrological, and

meteorological conditions of our study areas, with rainfall identified as the primary trigger for landslides.

To achieve temporal forecasting, we derived rainfall thresholds using multiple approaches. These thresholds were based on historical data that linked rainfall to landslide frequencies, with the aim of predicting future landslides. Initially, we derived intensity-duration thresholds using historical relationships between landslides and rainfall. An algorithm-based approach, the Calculation of Thresholds for Rainfall-induced Landslides Tool (CTRIL-Tool) was employed to define event/duration (ED) thresholds (Aghamir et al. 2019).

Additionally, we developed probabilistic thresholds using a Bayesian approach, which involved calculating the posterior probability of landslide occurrence based on marginal and conditional probabilities of control parameters along with the prior probability of occurrence. We also explored the LSTM model to create thresholds that considered both long-term and short-term rainfall, tailored for applications within the study area (Aghamir et al. 2021e).

After comparing these thresholds quantitatively, we found that probabilistic thresholds incorporating both rainfall severity and antecedent soil wetness performed better than other models across both districts in the study area (Aghamir et al. 2021d). These findings open new avenues for developing an operational LEWS in the region, particularly by integrating rainfall and soil moisture

data. Moreover, this study provides valuable insights from a mountain region, highlighting the effectiveness of hydro-meteorological thresholds based on soil moisture—a critically underserved area in LEWS development for the study area (Aghamir et al. 2020d).

The next stage of our research involved identifying locations susceptible to landslides. We developed Landslide Susceptibility Maps (LSMs) using both data-driven and process-based approaches. Advanced machine learning algorithms played a crucial role, with the different algorithms employed to create LSMs for our study areas. Physically based models were also developed to understand the hydrological mechanisms and assess terrain stability primarily through factors of safety values (Aghamir et al. 2021c). These models are valuable for both spatial and temporal forecasting, as they use precipitation and spatial properties as inputs.

However, while physically-based models, data-driven approaches only consider the spatial probability of landslide occurrence, which requires integrating LSMs with spatial forecasting models for dynamic forecasting—the complex process. For spatial forecasting, the digital elevation model (DEM) of the study area served as the primary input for our data-driven and physically based approaches. We used two DEMs: one from Asia Pacific with a 12.5 m resolution and another from the National Remote Sensing Centre with a 1 arc second resolution (30.4 m). The DEM quality critically affected the output in both methods. Our results indicated that the Random Forest (RF) model performed better for both districts when using the 12.5 m DEM, with effectiveness values of 0.81 and 0.83 for Kuvshin and Wajirah, respectively. The resolution of the DEM was found to be crucial in the RF model's performance, with finer resolution data leading to better results. The study also demonstrated that process-based approaches' performances were comparable to data-driven models and could be effectively applied for regional-scale forecasting with more precise data collection and the ongoing spring





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linear comparing the mutual agreement between the models, we observed that the deep-learning model satisfactorily classified the green and red alert classes, which were similarly categorized by processed-based models. However, there was more disagreement in the orange and yellow alerts, which is significant as orange alerts are considered positive predictions and yellow alerts negative (Abraham et al. 2023b).

The study proposes a spatio-temporal framework for landslide forecasting in the study areas, which can be a crucial input for delineating an LEAS in the region. The developed maps can be refined using local administrative boundaries, such as panchayats and municipalities, tribal district with 54 local self-governments, and Vajpayee district with 28 local self-governments, can issue alerts based on the pre-ware delineation of each alert within a local area.

The proposed framework involves integrating rainfall forecasts, antecedent soil moisture data, and the GSI for landslide forecasting, ensuring a clear understanding of threshold conditions, expert decision-making teams, and detailed communication strategies and response plans. These steps are vital for developing an early warning system that can significantly aid regional planning and development activities to minimize the risk of landslides (Abraham et al. 2023a).

Our study in the Indian district faced the challenge of obtaining landcover, particularly in extremely sensitive areas of the Western Ghats. We developed a forecasting model using machine learning to assess the likelihood of landslides based on critical factors. The model provides two warning levels tailored for different areas in the district. It proved highly effective, with a 97% accuracy in smaller, uniform areas, although performance decreases in larger, more diverse regions. This model can be integrated with rainfall forecasting systems to enhance early warning capabilities for landslide risks (Abraham et al. 2024).

In addition to delineating critical sectors, we produced detailed studies on debris flow, defining rheological parameters

for the region and assessing the potential for future failures. At a debris flow location in Guwahati, data collection was limited to lower elevation zones due to site constraints. Some analysis was carried out for four debris flow sites in Vajpayee district (Abraham et al. 2023a). The subsurface was divided into three distinct layers: a topsoil layer of loose debris with boulders and fragmented rocks, a semi-clayey matriculation, and the bedrock beneath the overburden. Air samples were tested for engineering properties, revealing that consolidated particles were more prone to erosion, while the grain content increased with depth. The debris volume at the sites varied, with significant amounts at sites 1 and 2, indicating a higher risk of future debris flows.

We employed confidence index analysis to quantify the similarity between sites, finding an overall similarity greater than 0.5. The calibration from parameters from one site satisfactorily predicted the shape of other debris flows, indicating that these parameters can be used for regional debris flow simulation (Abraham et al. 2023c).

Given the complexities associated with existing numerical models, we developed an easy-to-use simulation tool, Debris Flow Simulation 2D (DFS 2D), which considers multiple rheologies and bed entrainment. DFS 2D simplifies the modeling process by using predefined equations and provides information on each model parameter through a user-friendly interface. The model was evaluated using a case study from the Chengdu gully in Sichuan, China, where it provided satisfactory results in simulating debris flows despite the challenges posed by coarse-grained debris. The study advocates for highlighting the multiple aspects of landslide forecasting addressed for Vajpayee and Guwahati districts in the Western Ghats of India.

Our research developed a spatio-temporal landslide forecasting framework, evaluated rheological parameters for debris flow simulation, and created a user-friendly numerical model for debris flow modeling, all of which can significantly aid in hazard assessment and regional planning (Abraham et al. 2023c).

Our research was focused on developing advanced data-driven approaches to assess landslide hazards in response to the increasing risks posed by urbanization in hilly regions. To address this, we employed a random forest algorithm to estimate critical landslide parameters—such as projected area, length, peak distance, and width—using elevation and slope information. This approach was tested in Guwahati and Vajpayee, two landslide-prone areas, with three different combinations of input features: bounding elevation, tangential slope, and height, angle of reach, and profile curvature.

Out of 144 models evaluated, our method showed significant improvements in accuracy. For instance, in Vajpayee, the RMSE value for estimating the length of flow-ice landslides was reduced from 472.74 m to 224.84 m using elevation and tangential slope as inputs. Only a few cases showed minor increases in error values, highlighting the model's robustness. To make our findings accessible, we developed an easy-to-use tool based on predefined models, allowing untrained personnel to perform preliminary hazard assessments. This tool simplifies complex statistical methods, offering a practical solution for disaster management and risk assessment in landslide-prone areas.

Our work represents a significant step forward in applying machine learning to natural hazard management, providing effective tools for enhancing landslide risk mitigation strategies in rapidly urbanizing hilly regions (Abraham et al. 2023b).

Our research also extends to the critical analysis of land use and land cover (LULU) changes, which are essential for regional planning and disaster risk reduction, particularly in rapidly urbanizing hilly regions. Recognizing the challenges posed by population growth and urbanization in landslide-prone areas, we developed a novel tool using a random forest classifier that automatically generates LULU classification maps from natural color satellite imagery without requiring any training input from the end user.

The innovative approach demonstrated an overall accuracy of DFS and an AUC



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score of 0.95, making it a reliable tool for mapping wildfire area expansion in regions susceptible to rain-induced landslides. We applied the framework to the rural block (panchayat) in Kinna, India, comparing LULU data from 2012 and 2022. Our findings revealed a significant increase in built-up areas, from 12.73% of the total area in 2012 to 28.49% in 2022. This rapid expansion occurred predominantly in zones classified as very high in landslide susceptibility. These results highlight the urgent need for robust decision-making and continuous monitoring of LULU changes to effectively mitigate landslide risks in such vulnerable regions (Suri et al. 2024).

## Western Himalayas

In the Western Himalayas, we focused on addressing significant gaps in landslide hazard management, particularly within the highly vulnerable Uttarakhand state. Landslides are a critical geohazard with immense potential to damage infrastructure, displace communities, and cause environmental degradation. They can be triggered by various factors, including rainfall, seismic activity, and human intervention, necessitating a deep understanding of the underlying influences such as slope steepness, geological and hydrological characteristics, soil properties, and land use practices. These factors are essential in assessing and mitigating landslide risks.

Our research began with an extensive data collection phase, focused on Uttarakhand and the Chamoli district, utilizing field visits, secondary analyses, subsurface explorations, and collaborations with governmental agencies. The comprehensive approach aimed to capture the region's geological, geomorphological, hydrological, and seismotectonic characteristics, which are crucial for understanding landslide susceptibility and hazards in Chamoli. We conducted a thorough examination of the district's geological formations, geomorphological features, hydrological components, seismotectonic activity, historical landslide data, and local meteorological conditions.

This detailed regional analysis provided crucial insights into the specific geological characteristics of Chamoli and identified the rock types and structures influencing stability and susceptibility to landslides.

In the subsequent phase, we conducted a detailed seismic landslide hazard assessment across Uttarakhand, employing both Probabilistic Seismic Hazard Assessment (PSHA) and Scenario-Based Seismic Hazard Assessment methodologies (Gupta and Selvam 2022a, 2022). These approaches provided valuable insights into the spatial distribution of seismic hazards, highlighting the areas which are most susceptible to landslides.

We further optimized our methodology by evaluating the performance of various models, including the Conventional and Modified Neumann Models, using metrics like the Area Under the Receiver Operating Characteristic Curve (AUC-ROC). Our findings revealed that the Modified Neumann model demonstrated superior predictive capacity for rain-induced landslides in the region (Gupta and Selvam 2022a; Gupta et al. 2022b).

Building on this, we refined the model through seismic correlation, incorporating Monte Carlo simulations to address uncertainties in geotechnical and geological parameters. We also considered multiple seismic inputs, including those derived from PSHA, to ensure a comprehensive seismic hazard characterization. The optimized methodology demonstrated high predictive accuracy, particularly with PSHA-based inputs, making it a reliable framework for assessing seismic landslide hazards in Uttarakhand (Gupta and Selvam 2024c).

Recognizing that Chamoli district would be one of the most severely affected areas, we expanded our study to focus on landslide susceptibility mapping (LSM) and the development of a dynamic early warning system (EWS) for the region. We employed five distinct machine learning models, rigorously evaluating their performance using AUC-ROC, Accuracy, Precision, Recall, and F1-Score. The Random Forest (RF) model emerged as the most effective, achieving an AUC of 0.8704 and an accuracy of 93.16%.

Further analyses using classified data from the National Landslide Susceptibility Mapping (NLSM) database highlighted the importance of integrating comprehensive datasets for more accurate susceptibility assessments (Rishi et al. 2024).

The study also focused on defining optimal thresholds tailored specifically for Chamoli, comparing empirical, probabilistic, and B-Gina thresholds to determine the most effective for landslide prediction and early warning. We developed a code with-based dynamic early warning system, incorporating the best-performing machine learning model and optimal thresh-





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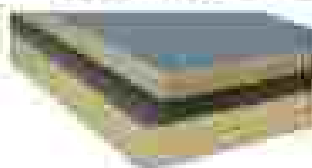


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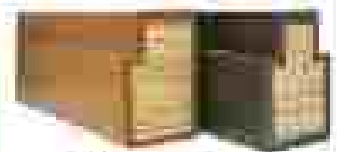
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Additionally, we developed a site-specific watershed-based landslide EWS for the Jashimnagar-Badami Highway, utilizing an AI-based framework that accounted for the hydrological dynamics of undisturbed slopes. Our findings underscore the importance of calibrated hydrogeological models, particularly in reflecting the complex interactions between climate, vegetation, and slope stability. The integration of machine learning techniques further enhanced the system's ability to assess slope stability in real-time, contributing to more effective risk mitigation (Gupta and Sathyan 2024a).

In addition to this, our research also tackled the challenge of accurately determining soil thickness in steep, heterogeneous areas—an essential yet difficult parameter in environmental modeling. The study focused on three key areas in the Jashimnagar region of the Indian Himalayas, employing three different methods to create soil thickness maps: a geospatial version of the conventional geomorphology-based soil thickness (GST) model, the GST model embedded with wavelet analysis (GST-WCA), and the random forest algorithm integrated with the GST model (GST-RF).

By comparing the errors and validating the results with geotechnical tests, the study found that while the standard GST model struggled to account for the steep slope variations, the GST-WCA model showed improvement, and the GST-RF model demonstrated the best performance, yielding the most accurate soil thickness maps. These maps are crucial for future geotechnical assessments and environmental modeling (Gupta et al. 2024).

In the Jashimnagar region, we also examined the impact of a landslide-triggered debris flow that struck the Ranganga-Chaudhanga valley in Chamoli district, Uttarakhand, on February 7, 2021. To investigate this event, we utilized a dense seismic monitoring network in the region and applied advanced signal processing

techniques—including band-pass filtering, Ensemble Empirical Mode Decomposition (EEMD), Short-Time Fourier Transform (STFT), and Power Spectrum Density (PSD). By analyzing seismic signals from nine stations and integrating these with satellite imagery, we aimed to improve the understanding of the hazard chain and enhance landslide detection systems (Gupta et al. 2023a).

The research conducted in debris flow dynamics has focused extensively on understanding the entrainment and deposition processes and the rheological behavior of debris materials. Keeping the Western Himalayas as the study area, we have modeled some important debris flows along Himachal Pradesh and Uttarakhand. At the same time, we have experimentally validated our findings using a laboratory flume setup with IT model.

This study provides a comprehensive analysis of debris flow dynamics through a combination of flume-based experiments and advanced numerical modeling, offering valuable insights into how debris flows interact with obstacle beds and replicate real-world scenarios. The flume experiments revealed that the entrainment process typically begins with the arrival of the first surge (S<sub>1</sub>), which exerts the highest scouring potential. This initial surge led to significant gully formations, particularly between 0.1 m and 0.2 m from the start of the obstacle bed, mimicking natural debris flows observed in the field. The deposition process, especially at the tail end of the flow, was also observed to closely correspond with the behavior of real debris flows, thereby validating the experimental setup and the results obtained.

The entrainment volume varied significantly based on the water content of the debris flow mixture, with tests conducted at higher water content levels. This variation underscored the complex interactions between flow dynamics and bed composition, providing a deeper understanding of the scouring and deposition mechanisms in debris flows. The experimental findings highlight the critical role of water content in determining the extent of entrainment and its subsequent impact on deposition

patterns. These insights are crucial for predicting debris flow behavior in different environmental conditions and for devising effective mitigation strategies.

Building on these experimental and computational findings, the study employed the Lagrangian simulation tool to model the Kashmir debris flow event in Himachal Pradesh, India. This numerical model accurately reproduced key characteristics of the event, including a peak velocity of 13.7 m/s and a maximum flow height of 7.54 m. The model's ability to closely match observed channel widths and deposition patterns further validated its use as a reliable tool for simulating real-world debris flows. The integration of experimental data with numerical simulations provided a robust framework for understanding debris flow behavior, highlighting the importance of combining multiple methodologies to capture the complexities of such natural hazards (Pandey et al. 2024). The findings provide critical insights that can inform the development of more effective hazard prediction and mitigation strategies in regions prone to debris flows, ensuring better preparedness and response in these destructive natural events.

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# Innovative Application of Geogrid to Make Tsunami Resilient Rubble Mound Breakwaters

Researchers from the Geo-Disaster Prevention Laboratory at the National Institute of Technology, Karnataka, have pioneered a range of innovative reinforcement techniques to fortify breakwaters against tsunami-induced forces and minimize the risk of catastrophic failure.

**Manu K. Sajan & Akarsh P.K., Geo-Disaster Prevention Lab, and Dr. Babloo Chaudhary, Asst. Prof, Dept of Civil Engg., NIT Karnataka**

## Introduction

Tsunamis, among nature's most ferocious phenomena, strike with devastating force, leaving behind trails of destruction and human suffering. These colossal waves, often triggered by seismic events beneath the ocean floor, unleash unimaginable energy as they surge across vast expanses of water, culminating in catastrophic impacts upon coastal regions. In the wake of such disasters, the imperative to fortify coastal defense against the ravages of tsunamis becomes very clear.

Among the primary structures designed to mitigate the impact of tsunamis are rubble mound (RM) breakwaters, which are strategically positioned barriers engineered

to absorb and dissipate the energy of incoming waves (Figure 1). Rubble mound is defined as a flexible heterogeneous assemblage structure of natural rubble consisting of quarried rocks in the core and natural or artificial armour as a protection cover. Its generally trapezoidal in shape with batter slopes on its seaward and steeper slopes on the harbour side. However, the efficacy of conventional RM breakwaters in withstanding extreme tsunami conditions remains a subject of concern, spurring the quest for innovative reinforcement strategies to bolster coastal resilience. Several breakwaters have been damaged under the tsunami impact in the past (Figure 2).

The vulnerability of conventional RM breakwaters to the ferocity of tsunamis stems from their susceptibility to erosion, scouring, and structural failure under extreme events like tsunamis (Figure 3). The past few decades have witnessed the 2004 Indian Ocean and 2011 Great East Japan tsunamis, among which coastal communities face an urgent need to develop and implement robust defense mechanisms capable of withstanding future tsunamis.

In response to this imperative, researchers from the Geo-Disaster Prevention Laboratory at the National Institute of Technology, Karnataka, have pioneered a range of innovative reinforcement



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Figure 2: Port breakwater protecting the coastal port area



Figure 3: Damage occurred to breakwaters during the last typhoon



Figure 4: Breakwater damages during the past typhoons

technique aimed at enhancing the resilience and effectiveness of RR breakwaters in mitigating the impact of tsunamis. By integrating advanced materials, structural components, and reinforcing methods, these techniques seek to fortify breakwaters against tsunami-induced forces and minimize the risk of catastrophic failure.

Key among these reinforcement strategies is the incorporation of geogrid layers along the slopes of the breakwater. Steel piles in the seabed, and crown walls with shear keys (vs. the conventional RR breakwaters). Geogrid layers, composed of high-tensile polymers, serve as interlock with the rubble, enhancing the stability of the breakwater while minimizing settlement and lateral displacement of the crest. Steel piles, strategically positioned along the seabed adjacent to the breakwater, act as impermeable barriers, preventing excess seepage and erosion of the foundation seabed. Crown walls, equipped with shear keys embedded in the core layer, provide additional protection against tsunami impact forces, reducing the crown wall and minimizing displacement during tsunami events.

Through a combination of physical model tests and advanced numerical analyses, the research sought to validate and compare these innovative reinforcement techniques. By subjecting both conventional and reinforced breakwater models to simulated tsunami overtopping scenarios, the performance benefits of various reinforcement schemes were quantified in terms of reduced settlement, minimal lateral displacement, and enhanced stability under tsunami loads. The proposed reinforcing techniques were based on real-world applications, further underscoring the effectiveness of these techniques in fortifying coastal defense infrastructure and protecting vulnerable communities from the devastating impact of tsunamis.

### Application of Geogrid

The proposed reinforcing technique aims to enhance the resilience of RR breakwaters against the destructive forces of tsunamis by incorporating innovative elements such



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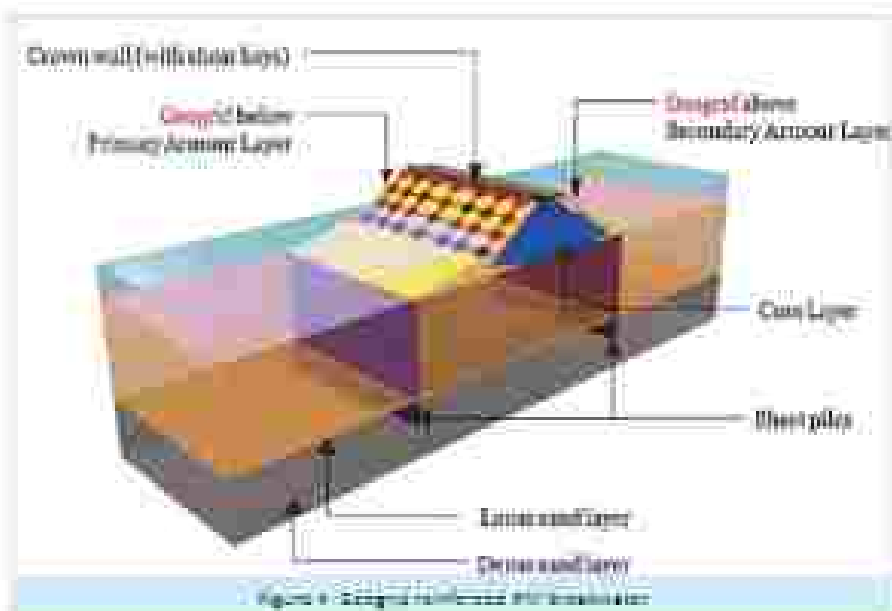


Figure 4: Geogrid reinforced breakwater



Geogrid Configuration I



Geogrid Configuration II



Geogrid Configuration III

Figure 5: Geogrid configurations investigated

as geogrids, steel piles, and down walls with shear keys. Geogrids play a pivotal role in stabilizing the breakwater by interlocking with the rubble, thereby reducing the likelihood of displacement during tsunami overflow. These geogrid layers, strategically placed along the slopes of the breakwater on both seaward and harbour sides, provide additional structural integrity while allowing water to pass through, minimizing excess seepage-induced damages (Figure 4).

The most effective configuration of geogrids was investigated by performing several experiments and numerical studies. The geogrid layers provided above the armour layer on the harbour side and below the

armour on the seaward formed the first configuration. Owing to the limitations of the first configuration in preventing the rolling down of rubble from the harbour side, an extension of the geogrid layer was provided through the toe rubbles in the second configuration. The damages observed from the experimental analysis on the second configuration resulted in an enhanced third configuration, where double-layer geogrid was applied above and below the harbour side armour layer (Figure 5).

Furthermore, the inclusion of steel piles at both ends of the RC breakwater serves as cutoff walls, effectively preventing seawater from seeping through seabed

soils beneath the mound during surging. This reduction in seepage helps maintain the shear strength of the foundation soils, which is crucial for preventing settlement and failure of the breakwater. Additionally, down walls with shear keys are introduced to protect the crest of the breakwater from scouring and sliding forces caused by tsunami waves. The shear keys enhance the stability of the down walls, further bolstering the overall resistance of the breakwater structure.

### Model Test

The model tests conducted to evaluate the effectiveness of the proposed reinforcing technique involved meticulous planning and execution to simulate realistic tsunami overflow scenarios. The physical model, developed in the Geotek Disaster Prevention Laboratory at the National Institute of Technology, Karnataka, Surathkal, India, comprised an apparatus designed for continuous reproduction of water to generate tsunami-like waves. The apparatus, constructed with acrylic plates and steel frames, allowed for precise control and monitoring of water flow to simulate overflowing tsunami waves accurately. The physical model incorporated layers of interlocked stone to mimic seabed soils with varying densities and simulate different soil conditions. Additionally, crushed stones of various sizes were utilized to construct the RC breakwater, with coloured stones distinguishing different layers for detailed analysis. During testing, instrumentation such as displacement transducers and pore water pressure transducers were deployed to monitor lateral displacement, lateral settlement, and incremental pore water pressure within the breakwater and seabed soils. The physical model tests enabled a comprehensive analysis of the reinforced and conventional RC breakwater performance under tsunami overflow conditions. Data collected from the instrumentation provided insights into the effectiveness of the reinforcing technique in reducing settlement, minimizing lateral displacement, and mitigating incremental pore water pressure. These model tests served as a crucial step in validating the proposed reinforcing techniques' efficacy.



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Figure 6. Damage of conventional breakwater model after tsunami overflow test



Figure 7. Damage of reinforced breakwater model after tsunami overflow test

opening the way for its potential application in real-world coastal protection projects to enhance resilience against tsunamis.

The results from the study on reinforcing RM breakwaters against tsunami-induced damage reveal promising advancements in coastal protection strategies. Through meticulous physical model tests, analytical studies, and numerical simulations, the study evaluated the effectiveness of various countermeasure techniques, mainly focusing on the incorporation of geogrids, sheet piles, and core walls with shear keys. One of the key findings of the study is the significant reduction in the average settlement of the RM breakwater crest during tsunami overflow with the implementation of reinforced models. The conventional RM breakwater experienced severe deformation, with notable settling away and settling vertically due to excess seepage and intense lateral forces from tsunami waves (Figure 6). In contrast, the reinforced models, particularly the third configuration with a geogrid-bound core, demonstrated remarkable resistance to displacement, resulting in a reduction of up to 57% in crest settlement (Figure 7).

Moreover, the study assessed the lateral displacement of the breakwater crest, which is crucial for preventing exposure of the

core layer to overtopping tsunami waves. Reinforced models effectively minimized lateral displacement, with the third configuration of geogrid-bound cores exerting the lateral displacement of the crest wall. This highlights the importance of incorporating reinforcing elements such as geogrids and sheet piles to enhance the resilience of breakwaters against tsunamis. Furthermore, the analysis of incremental pore water pressure along the breakwater length elucidates the role of reinforcement in mitigating instability and failure risks. The reinforced models exhibited an average 48% reduction in the incremental pore water pressure during tsunami overflow, indicating improved stability. The inclusion

of sheet piles as cut-off walls proved effective in reducing seepage through seepage zones, contributing to the overall reduction in pore water pressure.

## Damage Analysis

The damage analysis conducted on the breakwater models provides valuable insights into their performance under tsunami overflow conditions. Two key parameters, the relative displacement of armor units and compressions modes area, were utilized to quantify the extent of damage inflicted on the breakwaters. In the case of the conventional breakwater model, the relative displacement of armor units was remarkably high, reaching nearly 28%, indicating significant instability and vulnerability to slumping.

This high level of displacement underscores the breakwater's inability to withstand the impact of tsunami waves effectively, leading to extensive damage.

The introduction of reinforcing elements in the breakwater models resulted in notable improvements in damage mitigation. The first reinforced model demonstrated a significant reduction in the relative displacement of armor units, indicating enhanced stability compared to the conventional model. The placement of geogrid layers on

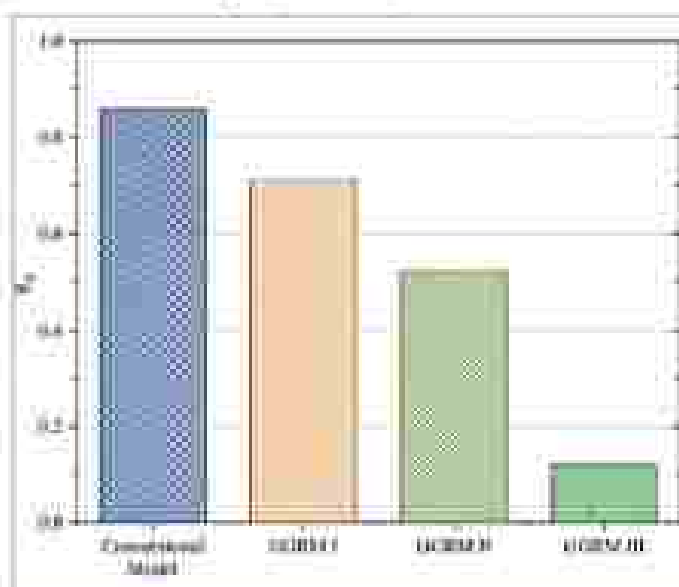


Figure 8. Relative displacement of armor units of conventional and reinforced models





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either side of the breakwater continued to the improvement by providing additional structural support and preventing the dislocation of the rubble.

Subsequent reinforced models showed further reductions in relative displacement, with the third reinforced model with a double-layer geogrid configuration achieving the most significant reduction of 66% (Figure 6). This underscores the effectiveness of the reinforcing technique in enhancing breakwater resilience against tsunami-induced damage.

Dimensionless model area analysis further corroborated the efficacy of the reinforcing technique in reducing damage to the breakwaters. The conventional breakwater model exhibited a fully damaged state after tsunami overflow, as indicated by the high DCA value. However, the incorporation of reinforcements led to substantial reductions in DCA values for the reinforced models. The double-layered geogrid configuration, in particular, demonstrated exceptional resilience, withstanding tsunami overflow without undergoing significant deformations. These findings highlight the crucial role of reinforcing elements, such as geogrid layers, in mitigating damage and enhancing the overall stability of breakwater structures in tsunami-prone coastal areas.

The damage analysis underscores the importance of adopting innovative engineering solutions, such as the proposed reinforcing technique, to improve the resilience of coastal infrastructure against natural disasters like tsunamis. By quantifying the extent of damage and evaluating the effectiveness of reinforcement measures, engineers and policymakers can make informed decisions to enhance coastal protection strategies and mitigate the potential impact of tsunamis on vulnerable communities and ecosystems.

## Numerical Simulation

The numerical analysis conducted in this study provided insightful results regarding the performance of both conventional and

reinforced models of RM breakwaters under tsunami overflow conditions. By simulating seepage flow and deformations, the analysis highlighted the vulnerability of conventional breakwaters to failure during tsunami events. Specifically, the numerical models demonstrated that conventional breakwaters experienced significant displacement and deformation, leading to compromised structural integrity under the impact of tsunami waves.

Moreover, the numerical analysis effectively validated the efficacy of innovative reinforcement techniques in enhancing breakwater stability. Results showed that the incorporation of reinforcement elements, such as geogrid layers and steel piles, significantly improved the performance of RM breakwaters under tsunami overflow conditions. In particular, the numerical models revealed that reinforced breakwaters exhibited reduced displacement and deformation compared to their conventional counterparts, indicating enhanced resilience against tsunami-induced forces.

Additionally, the numerical analysis provided quantitative insights, such as displacement contours and force of safety calculations, which further corroborated the stability and failure mechanisms of RM breakwaters. These results corroborated findings from physical model tests, validating the efficacy of numerical simulations in predicting structural behaviour under extreme loading conditions. The numerical analysis complemented experimental observations, offering a comprehensive understanding of RM breakwater performance and providing valuable insights for engineering design and disaster mitigation strategies in coastal areas prone to tsunamis.

## Conclusion

Incorporation of novel reinforcement techniques for reinforcing conventional RM breakwaters to mitigate damage caused by tsunamis. Through a series of physical model tests and numerical analyses, the effectiveness of these novel reinforcement

methods was evaluated under tsunami overflow conditions. The findings highlight the vulnerability of conventional RM breakwaters, with significant erosion observed in the crest when subjected to tsunami waves. However, with the implementation of reinforcement techniques such as geogrid layers, steel piles, and crown walls with shear keys, the performance of RM breakwaters was notably improved, demonstrating better stability and resistance against tsunami-induced forces.

Furthermore, the study investigated three reinforced models, focusing on the optimal placement of geogrid layers to enhance breakwater stability. Results indicate that the placement of geogrid layers along harbour and seaside slopes, particularly in the double-layer geogrid reinforced model, significantly reduced vertical settlement and arrested lateral displacements. Moreover, the incorporation of steel piles effectively mitigated excess seepage through the seabed, preserving seabed soil strength beneath the breakwater. Numerical analysis further supported these findings, confirming the stability of the reinforced models against tsunami overflow and highlighting the effectiveness of the three geogrid configuration with the reinforced model, in particular.

This research represents a pioneering application of geogrid in RM breakwaters to mitigate the adverse effects of tsunamis. By proposing and validating these novel reinforcement techniques, the study provides a sustainable solution for strengthening RM breakwaters and enhancing their resilience to potential future tsunamis. The outcomes of this research hold significant promise in advancing coastal engineering practices and contributing to the development of robust infrastructure capable of withstanding extreme natural events.

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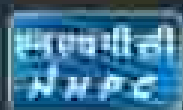
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# Foundation Failure Causes & Remedies

Failure of foundations may occur due to poor soil conditions, improper drainage, changes in the water table, free rocks, construction errors, weather conditions or expansive soils. Signs of foundation must be studied closely by structural engineers and remedial measures taken at the earliest.

**Dr. N. Subramaniam, Ph.D., FNAE, Consulting Engineer, Maryland, USA**

**R**C foundations are the most important elements in any type of structure, as they transfer all the loads that come on the superstructure to the ground below. RC foundations are designed such that the safe bearing capacity of the soil at the site is not exceeded and have adequate safety against sliding, overturning, or pull-out, and keep the total and the differential settlements within allowable limits.

Foundation failure is difficult to copy and may endanger the entire building. In addition, as foundations will be buried under the ground, it is difficult to monitor or repair them. Failure of foundations may occur due to poor soil conditions, improper drainage, changes in the water table, free rocks, construction errors, weather conditions or expansive soils. If any foundation failure is noticed or suspected, it is important to have the foundation inspected by a qualified geotechnical engineer and remedial measures undertaken. Soil failures are classified as bearing capacity

failure, bulging or sliding of soil, sliding, subsidence, and lateral spreading. A few common soil failures are discussed. Foundation engineers are urged to study such failures in order to avoid repeating such mistakes in their projects.

## Introduction

Civil engineering is one of the most important professions today, but when civil engineers make mistakes, the consequences can be catastrophic as they can result in loss of property and human life and may even affect the economy of the state. Structural engineers must also consider the environmental and economic outcomes of their work.

A major concern is safety. The safety of structure is achieved by analyzing the building using appropriate software to reach various possible loads and their combinations as specified in the codes released by the Bureau of Indian Standards (e.g. various parts of IS 875 and IS 1893). Then the different elements of the building

have to be designed and detailed properly using IS 456:2000. Finally, the building has to be executed at the site using quality materials under strict supervision.

RC foundations are the most important elements in any type of structure as they transfer all the loads that come on the superstructure to the ground below. Due to the complex nature of soils and their behaviour, a hybrid approach is usually adopted in foundation design in which soil bearing pressures are checked based on the working stress method and members of the foundation are designed using the limit stress method (Subramaniam, 2012). There should not be any compromise in their analysis, design, and execution as any error in them may lead to the failure of the whole structure.

RC foundations are to be designed keeping in mind the following (Verghese, 2000):

1. All the applied vertical and horizontal loads and moments have to be resisted by the soil pressure, which should not exceed the safe bearing capacity of the soil at the site.



2. The foundation should have adequate safety against sliding, overturning, or pull-out in case of tensile loads due to wind or earthquake.

3. The total settlement and the differential settlements of the structure should be within the allowable limits as prescribed in IS 1904.

It must be remembered that a non-uniform pressure under the foundation in compressible clay/silt can lead to long-term effect of tilting of the foundation. It is also important to consult enough soil investigations at the site using geotechnical engineers, and determine soil properties at foundation level; the type of soil below the foundation up to the required level of dispersion of load, and to determine the type of foundation for the structural need. Usually, the factor of safety adopted for the soil is in the range of 2.0 to 4.0, depending on the type of structure as compared with the factor of safety of 1.3 adopted for concrete or steel structures. In general, foundations in clays should be given a larger factor of safety against shear failure than foundations in sands (Ranghese, 2008). A higher factor of safety for soils is used because the properties of soil can vary greatly depending on its location, the type of soil, and the depth of the soil. This variability makes it difficult to accurately predict the behavior of soil under load. Foundation failures are difficult to repair and may endanger the entire building. In addition, as the foundation will be at a depth from the ground level, it will not be visible for monitoring. Hence, it is important to design them conservatively.

### Causes of Building Foundation Failures

If the footing is not of the required thickness, there is a danger of the column punching through the foundation (punching failure). Several failures (both partial and total) in the past have demonstrated the importance of foundation failures, especially in poor soils. There may be many causes of building foundation failure. Some of the most common are given below:

- **Poor soil conditions:** If the soil beneath a foundation is not strong enough to support the weight of the building, it can cause the foundation to fail. This can happen if the soil is too soft, too sandy, or too wet.
- **Improper drainage:** If water is not properly drained away from the foundation, it can seep into the soil and cause the foundation to become weak and unstable.
- **Changes in the water table:** If the water table rises, it can put extra pressure on the foundation and cause it to fail. This can happen due to heavy rains, melting of excessive snow, or other factors.
- **Tree roots:** Tree roots can grow under a foundation and cause it to heave or shift. This can damage the foundation and make it unstable (Niles and Surmanian, 2021). Trees near a building may also affect the moisture in the soil below foundations and cause problems associated with expansive soils (Niles, 1988).
- **Construction errors:** If a foundation is not built properly, it can be more likely to fail. This can happen due to mistakes in the design, construction, or materials used.
- **Weather events:** Severe weather events, such as earthquakes, floods, or hurricanes, can damage foundations. This can happen due to the force of the wind or water, or due to the shaking of the ground.
- **Expansive soils:** Some clays, such as kaolinite, illite, and smectite, shrink and swell in the presence of moisture. Expansive soils can cause foundations to crack, heave, or tilt. This can lead to damage of the structure above the foundation, such as walls, floors, and ceilings, especially in single-story buildings or light outbuildings (Niles), (1988). In expansive soils, it is better to select under-reamed piles.

Some signs of foundation failure:

- **Cracks:** Cracks in the foundation are a common sign of failure. These cracks can be small or large, and they may be vertical, horizontal, or diagonal.

- **Sagging floors:** If the floors of a building are sagging, it may be a sign that the foundation is failing. This is especially true if the sagging is only in one area of the home.
- **Water leaks:** If there is water leaking in the basement, it may be a sign that the foundation is failing. This is because water can seep into the soil and cause the foundation to become weak.
- **Doors and windows that stick:** Floors and windows in a building are sticking, it may be a sign that the foundation is failing. This is because the foundation is shifting, which can cause the doors and windows to become misaligned.

If any of these signs are noticed or suspected, it is important to have the foundation inspected by a qualified geotechnical engineer who will be able to assess the damage and recommend the best course of action.

### Types of Soil Failure

There are many different types of soil failures, but some of the most common include:

- **Bearing capacity failure:** There are two types of this failure: General shear failure and local shear failure. General shear failure occurs when the shear stresses in the soil are evenly distributed over a large area. This type of failure is more common in dense soils. Local shear failure occurs when the shear stresses in the soil are concentrated in a small area. This type of failure is more common in loose soils. Shear failure can be caused by a number of factors, including the weight of a building, the force of water, or the shaking of an earthquake. Bearing capacity failure can have serious consequences, including structural damage, flooding, and loss of life.
- **Bulging or swelling of soil:** This type of failure occurs when the soil is unable to support the weight of a building and starts to bulge out. Bulging can be caused by the same factors that cause shear failure, as well as by the expansion of clay soils when they are wet.
- **Sliding:** This type of failure occurs when the soil or a single story is slide down





Figure 1. Chattering failure of apartment complex buildings during 1985 earthquake (Cutter 1993)



Figure 2. Tower of Pisa, considered as typical foundation failure (Photo by A. Ghafari)

the slope. Sliding can be caused by the weight of the soil, the force of water or earthquakes.

- **Liquefaction:** This type of failure occurs when saturated soil loses its strength and behaves like a liquid. Liquefaction can be caused by earthquakes or by the sudden release of water from the soil (see Fig. 3).
- **Lateral spreading:** This type of failure occurs when the soil on a slope starts to move sideways. Lateral spreading can be caused by the weight of the soil, the force of water or earthquakes.

The type of soil failure that occurs will depend on the specific conditions of the soil and the loading conditions. It is important to have a qualified engineer test and evaluate the soil conditions before building on a site to determine the risk of any possible soil failure.

## Case Studies of Foundation Failures

A few notable foundation failures are discussed below.

### The Tower of Pisa, Italy (year 1173)

The Tower of Pisa is a freestanding bell tower of the cathedral of the Italian city of Pisa. The tower is a 55.4m tall, circular, eight-story structure made of white marble. Although intended to stand vertically, the tower began leaning to the southeast soon after the onset of

construction in the year 1173 due to a poorly laid 3m deep foundation and weak, unstable soil. Prior to restoration work performed between 1950 and 1990, the tower leaned at an angle of 5.5 degrees, but the tower now leans at about 5.99 degrees. This means that the top of the tower is 3.9m away from the vertical plane through the tower (see Fig. 4).

Several attempts have been made to stabilize the foundation. However, details of these may be found in Ruggieri and Mustupuri (1988) and Burard et al. (2008). After a decade of corrective reconstruction and stabilization efforts, the tower was declared stable in 2008 and is expected to stand for at least another 200 years.

It may be of interest to note that in June 2010, the Capital Gate building in Abu Dhabi, UAE, was certified as the "World's Furthest Leaning Manmade Tower." It has a 18-degree slope, almost five times as that of the Leaning Tower of Pisa; however, this tower is deliberately engineered to lean.

### Transcona Grain Elevator, Canada (Year 1912)

The Transcona Grain Elevator was a grain storage facility, whose construction started in 1911 at North Transcona, near Winnipeg, Manitoba, for use by the Canadian Pacific Railway. It consisted of a RC core-house and adjoining bin-house. In plan, the core-house measured 21 m x 28 m. The structure was 65 m tall and was founded

on a raft foundation, 2.5 m below ground level. The bin-house consisted of five rows of sixteen bins each 4.3 m diameter and 28 m high and rested on a concrete framework, which was supported by RC raft. The bin-house raft measured 23m x 55m and was also founded at a depth of 1.7 m below Ground Level (Peck and Bryant, 1968). The construction was completed in September 1912.

Immediately after completion, sinking of the elevator commenced, and about 17,500 kN of wheat was destroyed as it fell as fast as it could in all the time. On October 11, 1912 the sinking began to settle uniformly at the rate of 0.3 m per hour. On the next day, the sinking began rising and the inclination reached about 27 degrees to the vertical (see Fig. 5). The subsoil below consisted of a uniform deposit of clay of thickness 5 m to 6 m, which was due to the accumulation of waters of local Lake Agassiz. No borrowings were known to have been made for the design of foundation. In 1961, comprehensive geotechnical investigations were undertaken by Peck and Bryant who drilled additional exploratory borings, took undisturbed soil samples, and conducted vial tests (Peck and Bryant, 1968). Based on these tests, it was concluded that the elevator foundation had failed due to a bearing failure in the underlying clay. It has to be noted that during 1911, the state-of-the-art in geotechnical engineering had not



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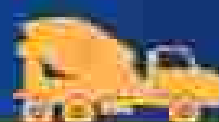
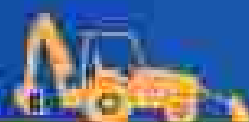






Figure 3: Collapse of Transcona Grain Elevator, Canada. Photo Source: [enr.com](http://enr.com)



Figure 4: Penick & Harmsacker Grain Elevator. Source: [www.penick.com](http://www.penick.com)

reached the point that ultimate bearing capacity of the foundation could be simplified (Bishop and Frost, 1939). Terzaghi developed his bearing capacity theory only in 1945 (Terzaghi, 1943).

After the accident, remedial work was carried out by the Foundation Company Limited. This remedial work consisted of building supporting structures, gradually excavating the foundation soils, and building the piles in order to return the building to its original position. The Transcona grain elevator was purchased by the Penick & Harmsacker Company in 1976. It is still in operation today under the name Penick & Harmsacker Grain Elevator (See Fig. 4).

#### The Ocean Tower, USA (Pier 2008)

Another example of a famous foundation failure in Texas, USA, is the Gulf Pacific

Bank's Ocean Tower, which was dubbed later as the leaning tower of South Pacific. Ocean Tower was originally designed to be a 17-story luxury high-rise building with fused high-end condominiums (see Fig. 5). It features 147 residences, a gym, swimming pools, spa, and a media room, with a height of 136 m. The building was designed to withstand extreme winds with three massively reinforced core walls. Each unit was sold for \$2 million.

The construction of Ocean Tower began on April 8, 2006, after soil testing. The exploratory borings were no deeper than 20 m. It continued for two years with much of the main structure completed until differential settlement made the building of 404 to over 500 mm. The 40th floors 400 mm diameter super-cast piles of length 22.25 m in the expansive clay caused problems, twisting, tilting, and rotating,

causing cracking, scaling, and leaking (see Fig. 6). The building leaned towards the northwest corner, cracking the rest of the adjacent garage, which caused the tower to topple. There was a differential settlement due to which the towers' core sank 350 to 410 mm, while the attached ceiling had sunk less than half that amount. Construction was halted in the summer of 2008.

During the forensic investigation, the company Walter P Moore performed a detailed evaluation and used computer modeling to analyze the causes of failure, as well as predict any future failure of structural elements. On November 4, 2008, it was felt that the way needed to fix the building would prevent the project from becoming economically viable. Hence, the development was stopped and on December 12, 2008, the tower



Figure 5: The Ocean Tower, Texas, and the failure of columns of foundation. Source: [www.enr.com](http://www.enr.com). Figure 6: The Ocean Tower, Texas, and the failure of columns of foundation. Source: [www.enr.com](http://www.enr.com)



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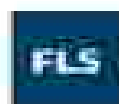
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Figure 6: Tilting of a concrete 13-story building in China. (Source: Failure, Cause, Building collapse in Shanghai" 20 Apr 2008, [www.enr.construction.com/resources/special/](http://www.enr.construction.com/resources/special/))



Figure 7: Sequence of foundation failure of a tall building in Shanghai, China

rest included 30,000 tons. Completed, Demolition, Inc. The building weighed 50,000 tons when it fell, and became the tallest and largest vertical concrete structure to be imploded in China.

The developers had a \$138 million lawsuit against geotechnical engineering firm RSC-Carter Engineering and Consulting of San Antonio and structural engineers, Baum Engineers of Austin and Dallas (an independent entity Ocean Tower). In 2012, the Chinese County District Court

dismissed all claims against the structural engineering firm.

#### Rare Foundation Failure in China (2008)

On June 27, 2008, an unoccupied 13-story dock of a building, with under construction, at Lianhuashan Road in the Minhang district of Shanghai, China, toppled over and ended up lying on its side in a muddy construction site (see Fig. 6). One worker was killed.

The cause of this building collapse was due to a pressure difference on two sides of the structure, according to an investigation report. The report claimed that the collapse was caused by earth, excavated along the building on one side with a beam of 4.8 m, for an underground car park, and piled up to a height of 16 to 18 m on the other side of the structure. The weight of overburden earth created a pressure differential, which led to a shift in the substructure, eventually weakening the pile foundation and causing it to fail. This situation might have been appreciated by several days of heavy rain leading up to the collapse, but investigators did not cite this as a crucial factor. The sequence of failure of this building is shown in Fig. 7. More details about this failure may be found in Suominen (2008). This failure underscored the importance of not disturbing the soil near a construction, even if the building is supported on piles.

#### The Millennium Tower 4-Moat Extensive Foundation Failure (2018-22)

The Millennium Tower is located in the South of Market district of downtown San Francisco, USA. It is a multi-use, primarily residential high rise and is the sixth tallest building in San Francisco. It is a 58-story, 157m tall building, with 369



Figure 8: The 58-story Millennium Tower, San Francisco (Source: [www.4moat.com](http://www.4moat.com))



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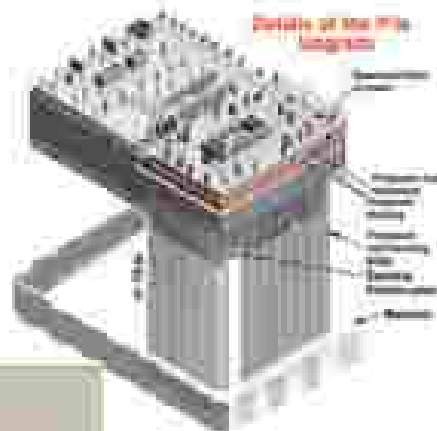
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to see the doctor.



## Millennium Tower Perimeter Pile Upgrade



Figure 4: Diagram illustrating the construction of the steel pile upgrade for the Millennium Tower (S&B&P Engineering)



heavy chromium units (see Fig. 4). The adjacent 42-story tower in the same property has 85 units and is a 13-m tall, two-faced glass atrium connecting these two towers. This US\$355 million (originally estimated steel amount was doubled by Hatcher Architects, engineered by Geotechnical Consulting Engineers, built by Western Builders, and developed by Mission Street Development LLC, an affiliate of Millennium Partners, Redwood & Rolo acted as the geotechnical engineer. This is a slender tower with each floor taking an area of ~1,300 m<sup>2</sup>. The tower opened to residents in 2009. But the building was slowly sinking into the ground and had tilted to one side. In May 2016, residents were informed that the tower was still sinking and tilting, resulting in nine separate lawsuits involving 400 individuals. As of 2016, the sinking had increased to 400 mm with a lean of 330 mm. Measurements in 2022 showed that the tilt increased to 710 mm, as measured from the building's first floor ([en.wikipedia.org](https://en.wikipedia.org)). The sinking and tilting of The Millennium Tower was believed to have been caused by a number of factors, including the building's pile foundation not reaching the bedrock, the soft soil on which it was built, and the heavy weight of the building.

The Millennium Tower's foundation consisted of a 3 m-thick concrete raft and

supported by 342 numbers precasted concrete friction piles (see Fig. 5). These piles extended only to a depth of 13–27 m below the ground into Goma sand formation, which consists of dense clay and silty sand. Between the Goma Formation, there is a 60 m of marine and coastal deposit, the upper layers of which are a stiff clay material, known locally as Old Bay Clay ([geotechnical.org](https://geotechnical.org)). If end-bearing piles had been used for the Millennium Tower, they would have been up to three times longer than the existing piles.

In May 2008, the \$100m remediation plan was suggested by Robert Hamaugen, the senior principal engineer at Simpson Gumpertz & Heger and his team. This plan proposed the construction of a perimeter pile upgrade of 52 concrete piles with 1.3 m spacing, to anchor the building to a stable bedrock layer 70 m below the ground (see Fig. 6). Also, an extension of the existing raft foundation was decided, to encompass the new piles together with jacking of 2500 kN of load from the existing building onto each of the new piles. The design goal was to relieve a portion of the stress on the Old Bay Clay soils along the building's north and west sides, to stop further settlement, and to recover a portion of the building's tilt. Shortly after the works began, the tilting and the sinking of the tower accelerated.

In May 2021, crews began to dig down to install 310 mm diameter pile casings along Fremont Street and by June 2021 the building had tilted approximately 83 mm more to the west (in 2011). July the contractor started to install 310 mm diameter pile casings along Mission Street, which resulted in a small increase in the rate of sinking to the north. In February, the contractor started to install 310 mm diameter piles along Fremont Street, which again resulted in an increase in the tilt rate to the west.

The repair project was halted in August 2021 when it was found that the building had unexpectedly sunk an additional 28 mm on the Fremont Street side, after 18 of the 52 piles were installed ([en.wikipedia.org](https://en.wikipedia.org)). The engineer and contractor then developed a revised design comprising just 18 piles as opposed to the original 52 pile design and involved techniques for their installations. The fix involved driving 18 concrete piles into bedrock deep under the property at 501 Mission Street and shifting a portion of the building's load onto the new piles. The steel went designed to support the building for the next 100 years. The \$100 million engineering fix, which was completed in June 2022, has successfully stabilized the building. The building has not sunk or tilted any further since the fix was completed. The fix has also been praised by city officials, who said that it is a success story for San Francisco. The cost of compensating residents for their losses is still being determined, but it is estimated to be in the tens of millions of dollars ([en.wikipedia.org](https://en.wikipedia.org)).

The Millennium Tower subsidence problems prompted San Francisco Department of Building Inspection to issue guidelines for foundation peer review and monitoring of new buildings, taller than 73 m. New guidelines include procedures for structural, geotechnical, and seismic-based engineering design review.

## Summary and Conclusion

In any structure, RC foundations transfer all the loads that come on the superstructure to the ground below, and hence are most important for the proper functioning of the structure. They are designed such that the









# HD Hyundai Wheel Loaders

## Catering to Diverse Businesses



HD Hyundai India is making advancements in the mining industry with its wheel loaders that are integrated with cutting-edge technologies to enhance operational efficiency and increase productivity, says **Shantanu Agnihotri, Head - Mining & International Business, HD Hyundai Construction Equipment (India).**

### **What are your observations on the overall trends in the wheel loader market?**

The wheel loader market experienced a significant surge in sales, rising from about 3,000 units in 2022 to nearly 4,000 units in 2023, reflecting a growth rate of about 33% annually. This achievement is commendable, considering the typical influence of external economic factors on equipment sales. Moving forward, the segment is expected to maintain sales volumes in the range of 4,000 - 4,500 units annually over the next five years. Fluctuations in sales numbers are common in capital equipment markets that are often subject to economic cycles and governmental policy shifts.

The dominance of the 3- and 7-ton categories in the wheel loader segment, comprising about 70% of total sales, underscores their crucial role in operations. Despite shifts in category demand, there's a clear preference for 3-ton models, with 45% of sales attributed to them. This versatility and suitability for a wide range of applications

are primary factors driving demand for wheel loaders, accounting for 45% of the output. These sectors prioritise reliability and heavy-duty capabilities in their equipment, with wheel loaders accounting for 45% of loading and handling applications. The mining contributes to 40% of wheel loader sales, followed by 400's construction (15%), 400's (10%), and 400's (5%), indicating a larger market for similar tasks.

### **What models of wheel loaders does your company offer and why?**

HD Hyundai is proud to introduce a premier line of wheel loaders, the H450-7N and H450-3N, designed for superior performance and versatility. These models represent innovative solutions in the construction equipment industry. From tackling rugged earth operations to facilitating seamless road construction, HD Hyundai wheel loaders can meet the diverse needs of modern businesses.



# HL950I

## WHEEL LOADER

Mining and Quarry Solution



OPERATING WEIGHT

18140 kgs

GROSS POWER

227 HP @2100 rpm

BUCKET CAPACITY

2.7-5.0m<sup>3</sup>





The HL300 (3T) wheel loader is known for its compact yet powerful design, making it ideal for maneuvering in tight spaces and delivering exceptional performance. It is perfectly suited for tasks requiring agility and precision, such as material handling at construction sites or loading operations in warehouses.

The HL500 (5T) wheel loader is built for heavy-duty applications that demand superior strength and efficiency. With its robust construction and ample power, it can effortlessly handle demanding tasks such as bulk material transport in mining operations or in heavily-duty construction projects.

**What are the key specifications of your wheel loaders in terms of load capacity, engine power, and bucket size?**

One of the key innovations incorporated into our wheel loaders is the advanced engine technology. The loaders are equipped with high-pressure common rail diesel engines, complemented by electronic control units (ECUs). The advanced engine technology optimizes fuel injection based on load conditions, improving fuel efficiency and reducing emissions. By precisely controlling the fuel delivery process, the engines achieve superior fuel economy without compromising on power output.

Our wheel loaders also feature electronic engines with multiple working modes (Low/Medium/High). This flexibility allows operators to adjust performance settings based on task requirements, optimizing fuel consumption and reducing engine noise levels. Whether its loading heavy-duty loads or performing light-duty operations, the loaders adapt to meet the demands of the job while minimizing fuel consumption and emissions.

Furthermore, the loaders are equipped with turbocharged, after-cooled engines, which

enhance engine performance and reduce emissions. The turbocharging technology ensures optimal air intake, resulting in improved combustion efficiency and power output. At the same time, the after-cooling mechanism cools the compressed air before it enters the engine, further enhancing fuel efficiency and reducing emissions.

**What safety features does the wheel loader include (e.g., ROPS, FOPS)?**

In the construction industry, ensuring safety is of utmost importance. The fundamental need is recognized at HJ Hyundai, hence the wheel loaders are equipped with advanced safety features to protect operators and bystanders.

The wheel loaders come standard with ROPS and FOPS, essential for preventing accidents caused by rollovers or falling objects. A cabin from guard provides extra protection to the cab from impacts by external objects. For emergencies, operators can quickly disconnect the battery using the Safety Cut-Off Switch, minimizing electrical hazards and ensuring the safety of maintenance personnel.

**How extensive is your after-sales support network, including spare parts availability and technical assistance?**

In the world of heavy machinery and construction equipment, reliability and support from manufacturers aren't just nice-to-haves; they're critical elements upon which successful operations are built. They serve as the backbone of operational success for businesses investing in such equipment. Understanding the inherent risk that they play, HJ Hyundai ensures timely after-sales support to its customers. It starts ensuring availability of genuine parts that guarantee peak operational reliability. These

parts, identical to those used in the original manufacturing process, ensure supply and consistency, minimizing machine downtime and maximizing productivity for customers.

Technical assistance is another fundamental aspect of HJ Hyundai's after-sales support. A dedicated team is available to provide prompt and knowledgeable assistance whenever customers encounter issues or have questions about their equipment. Whether its troubleshooting, maintenance guidance, or general inquiries, HJ Hyundai's team is committed to efficiently resolving concerns, ensuring that their equipment operates smoothly and effectively.

HJ Hyundai's extensive customer support network further enhances its after-sales service. With over 200 touchpoints across India and a 24x7 HJEE customer care team, assistance is always within reach. From addressing inquiries and concerns to handling warranty-related matters, its support team is dedicated to providing prompt and attentive service, strengthening trust in the brand and nurturing long-lasting relationships with customers.

**How do you envision the future of wheel loader technology and its role in construction projects?**

As the demand for construction equipment evolves, wheel loaders are becoming increasingly crucial on construction and mining sites. Over the next five years, wheel loader technology is set to see significant advancements, particularly within the context of sustainable future for road.

The industry's shift toward sustainability is evident, with a growing emphasis on manufacturing electric vehicles (EVs) and integrating eco-friendly practices. In this context, wheel loaders are at the forefront of technological innovation. These machines are enhancing operational efficiency and adapting to the pressing need for reduced environmental impact.

With construction and mining activities projected to surge, the role of wheel loaders is expected to become even more crucial. Their advanced technology promises to drive significant gains in productivity and efficiency, supporting the industry's shift toward greener and more sustainable operations. The future of wheel loader technology is about setting new standards for sustainability and performance in the construction sector. ■







## Tata Hitachi At The Forefront of Innovation

**Goldworth Chinnoroli, General Manager, Marketing, Tata Hitachi,** emphasises the importance of developing technologically advanced, emission-free, and versatile machines to meet the growing demand for efficiency in performance and sustainability in infra construction.

**What is driving demand for backhoe loaders in India?**

Backhoe loaders are versatile machines capable of performing multiple tasks in various construction and infrastructure projects. Plus, they are highly efficient and cost-effective.

Government initiatives like the Bharatmala Project, Pradhan Mantri Gram Sadak Yojana (PMGSY), and the Pradhan Mantri Kadam Shiksha Yojana (PMKSY) are focused on improving road connectivity in rural and remote areas – all of which are driving demand for backhoe loaders for road construction and maintenance.

India is poised to become a USD 5 trillion economy, and the Government is placing a bet of emphasis on infrastructure growth. Most of the state governments are allocating funds in key infrastructure sectors such as roads, water supply and sanitation, urban development, rural housing, solar renewal and in waste-based developments. An increasing number of cities are building a network of metro rails, and a rapid

number of houses are being built through PMAY (Pradhan Mantri Awas Yojana).

**How do you foresee the market for backhoe loaders evolving in the next 5 years, especially in view of environmental concerns?**

Over the next five years, the market of backhoe loaders will be increasing considering the number of thriving sectors. Also, looking at the reliability of the machine, the market for backhoe loaders is expected to undergo several notable changes, particularly in response to environmental concerns and the need for greater energy efficiency.

I foresee a rise in adoption of alternative fuels like electric, hydrogen, or compressed natural gas (CNG) in backhoe loaders. Tata Hitachi has introduced a CNG-powered Backhoe Loader in Exion 2021. All these alternative fuels help reduce carbon emission. However, the construction equipment industry is still in its early stage of adoption.

Manufacturers are also focusing on improving the energy efficiency of their backhoe loaders by integrating technological advancements in their engines, hydraulic systems, and machine design. The aim is not only to reduce fuel consumption but also to create productivity and lower the operating cost of the assets.

Overall, the market for backhoe loaders is likely to evolve towards more environmentally friendly and energy-efficient solutions over the next five years, driven by regulatory requirements, technological advancements, and growing awareness of sustainability goals.

**What are your thoughts on the potential of hydrogen-powered backhoe loaders in the Indian market?**

Manufacturers are evaluating multiple options of adopting alternate fuel, particularly as the country strives to address environmental concerns and transition towards cleaner energy sources. Hydrogen-powered backhoe loaders offer



zero-emission operation, emitting only water vapor as a byproduct. This aligns with India's commitment to reduce carbon emissions and combat air pollution, making hydrogen technology an attractive option for sustainable construction equipment.

Hydrogen has high energy efficiency and can provide long operating ranges without the need for frequent refueling. This enhances the productivity and operational efficiency of backhoe loaders, particularly in remote or off-grid construction sites where access to traditional fuel sources may be limited.

However, despite their potential, the adoption of hydrogen-powered backhoe loaders in India may face challenges related to infrastructure cost and technology maturity. Establishing hydrogen refueling infrastructure and addressing the high initial costs of hydrogen fuel cells and storage systems will be crucial for widespread adoption. Here, government incentives, subsidies, and policy frameworks can help promote hydrogen-powered backhoe loaders in India.

#### **Mini excavators vs Backhoe Loaders?**

Mini excavators and backhoe loaders are both versatile machines, commonly

used in construction and excavation projects, each offering distinct advantages depending on the specific task at hand.

The backhoe, with its combination of a front loader bucket and a rear-mounted digging arm, offers greater flexibility for tasks that require both digging and material handling capabilities. It is often preferred for jobs that involve excavating, loading trucks, and moving materials on construction sites.

The mini excavator is a compact machine that is increasingly being used as the industry moves toward more modern equipment requiring less fuel consumption and ability to use a range of attachments, particularly in urban environments. However, the backhoe loader, due to its ease of mobility, will continue to be popular in the foreseeable future.

#### **Do you see the scope of application of backhoe loaders widening across infra development projects in India?**

As India undergoes rapid urbanization, infrastructure development, and technological advancements, there will be growing application opportunities for backhoe loaders in construction as well as agriculture sectors. However, I would like to emphasize the importance of continuous

innovation and adaptation to meet the evolving infra project demands.

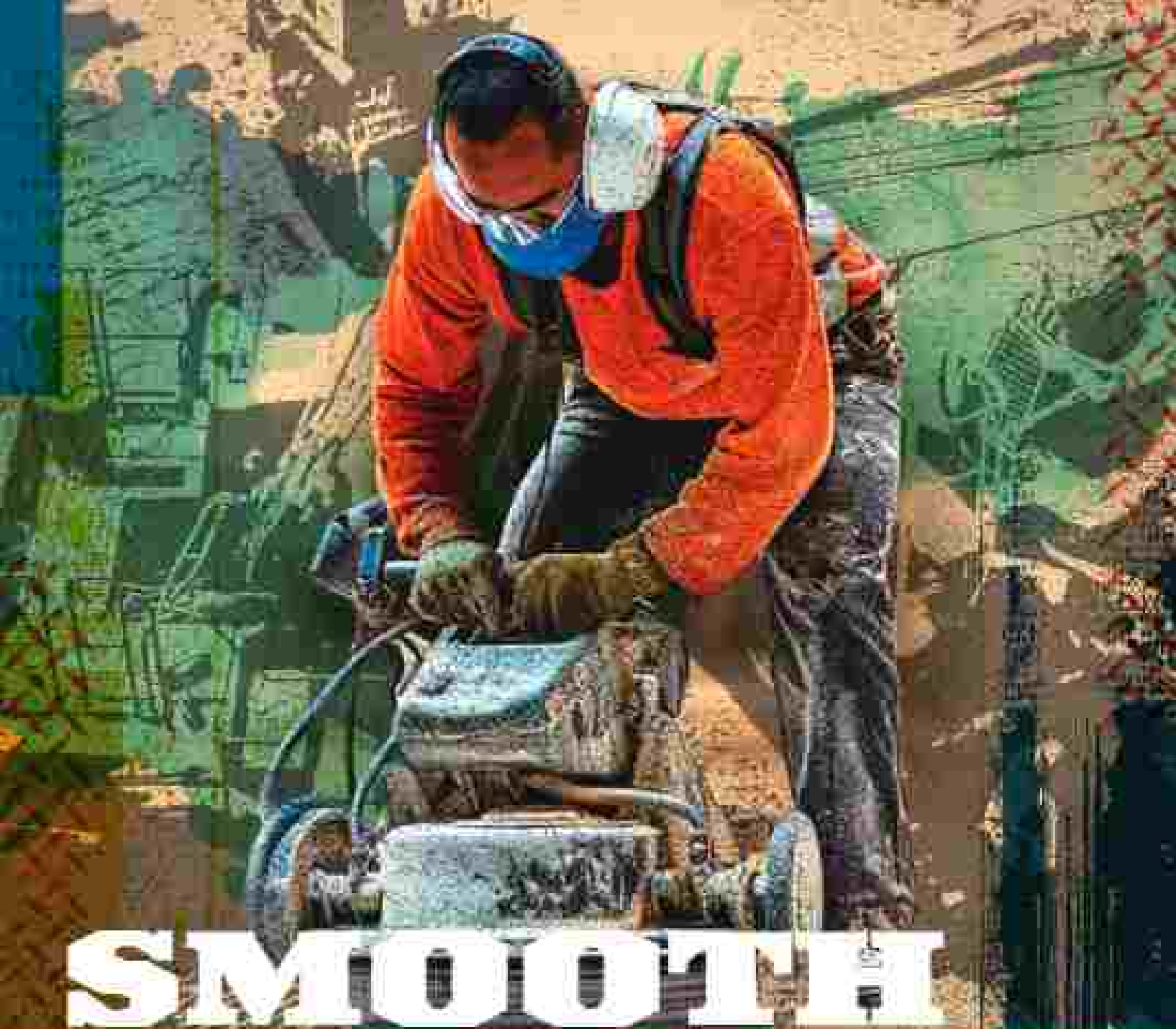
Furthermore, as environmental concerns become more pressing, there will be a greater emphasis on sustainability and energy efficiency in the construction equipment industry. Companies therefore need to invest in research and development to develop cleaner, more efficient, and technologically advanced machine models that align with these trends. This includes exploring alternative power sources such as electric, CNG etc., as well as improving overall machine design and efficiency.

At Tata Hitachi, we aim to stay at the forefront of innovation and sustainability by developing cutting-edge solutions that meet customer demands for superior performance, reliability, and a positive environmental impact.

Overall, we see a bright future for backhoe loaders in India, driven by technological advancements, infrastructure development, and a growing focus on sustainability. By embracing these opportunities and challenges, we are confident of our ability to contribute positively to India's construction equipment industry and help shape a more sustainable and prosperous future.







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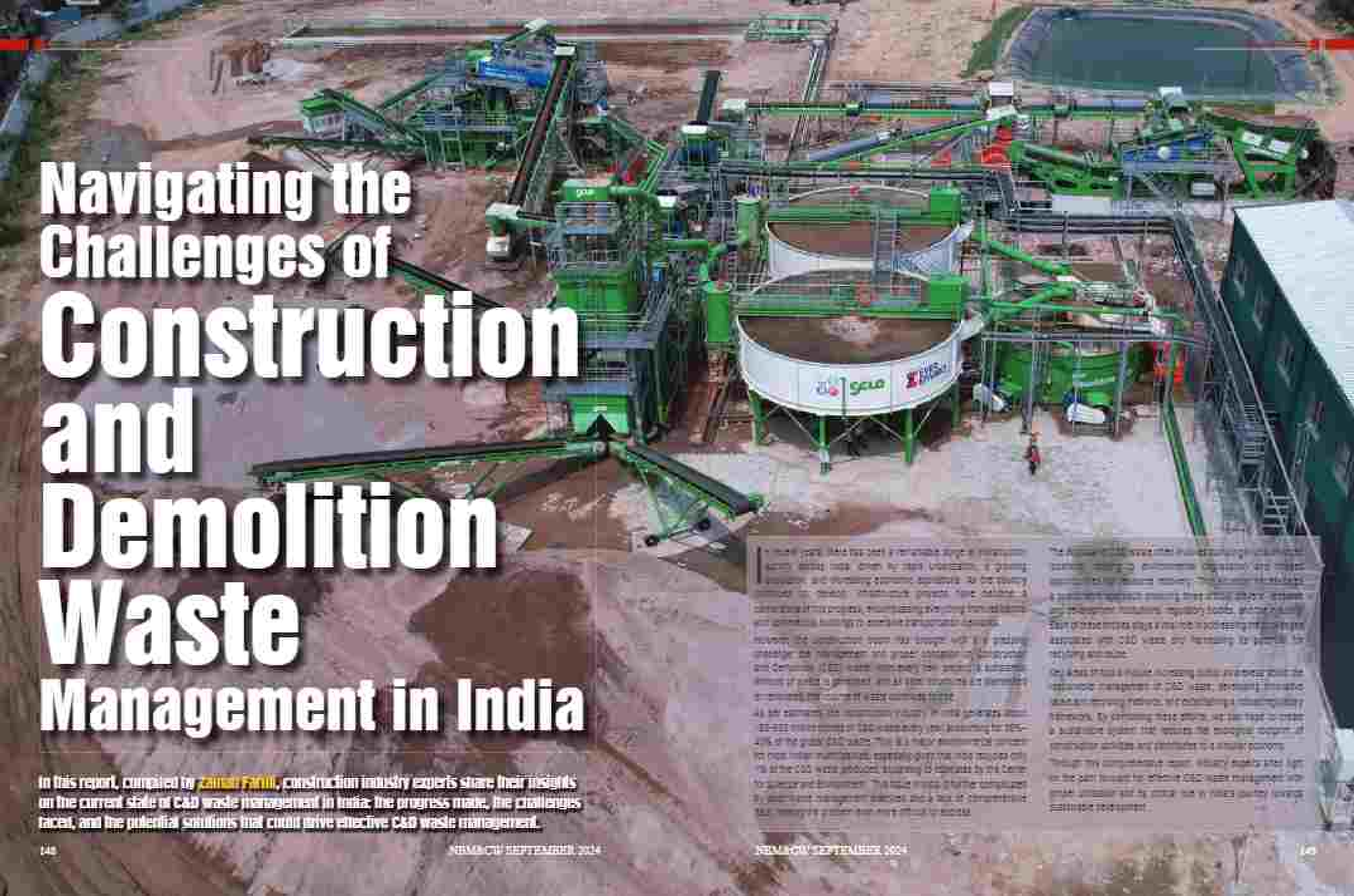
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# Navigating the Challenges of Construction and Demolition Waste Management in India

In this report, compiled by **Zainul Faridi**, construction industry experts share their insights on the current state of C&D waste management in India: the progress made, the challenges faced, and the potential solutions that could drive effective C&D waste management.

In India, the construction and demolition (C&D) waste management sector is a complex and rapidly growing industry. It involves the handling of vast amounts of waste generated during the construction and demolition of buildings, infrastructure, and other structures. The sector is characterized by a high volume of waste, a lack of standardized practices, and a growing awareness of the environmental and health risks associated with improper waste management. The industry is currently facing several challenges, including a lack of regulatory framework, inadequate infrastructure, and a need for more effective waste management practices. However, there are also opportunities for growth and improvement, such as the adoption of sustainable practices, the use of technology, and the involvement of the private sector. This report aims to provide a comprehensive overview of the C&D waste management sector in India, highlighting the current state of the industry, the challenges it faces, and the potential solutions that could drive effective waste management.

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## Research, Regulation, and Industry Collaboration



**Prof. R. Pradeep Kumar, Director, CSIR-CMERI, focuses on the role of R&D institutions, government regulation, and industry collaboration. He highlights the need for raising awareness, conducting targeted research, and establishing a robust regulatory framework to enable sustainable C&D waste management.**

In recent decades, our country has seen rapidly escalating to become the largest economy in the world. We have already reached the 7th stage in this journey, and we are on track to achieve Stage 8 and beyond soon. As the country continues to grow, there will be a significant demand for infrastructure. Since gaining independence in 1947, many buildings have been constructed, and as time passes, these structures will either be replaced, demolished, or possibly have their interiors extended. However, the real challenge arises when these buildings are demolished, creating what is known as Construction and Demolition (C&D)

waste. While various statistics suggest that approximately 1 million tons of C&D waste are generated daily worldwide, there is no reliable scientific method to accurately measure how much is being discarded. For many, including contractors, it is often easier to simply dump the waste somewhere, which is not only irresponsible but also a crime. There is untapped wealth in this waste, and by dumping it in undesirable locations, we are missing valuable opportunities.

There are three key players in addressing this issue: first, the knowledge base, which includes R&D institutions like CSIR;

CSIR. Second, the regulatory mechanism, which is the role of the government. Third, and equally important, is the industry, which drives the entire process. These three entities are crucial for sustainable management of C&D waste.

Recognizing the need for a sustainable approach, a group of scientists at CSIR-CMERI decided to come together and discuss the challenges. The first issue identified was the lack of awareness, both among the general public and stakeholders. Raising awareness about the responsible use of C&D waste is the first step. The next step involves sorting out how to reuse the waste, which requires dedicated R&D. Without this, R&D organizations might focus solely on producing publications or patents, which, while valuable, do not necessarily yield immediate benefits to society at large. Therefore, we must identify the challenges faced by the industry, which is the second priority. Finally, and most crucially, the entire process must be brought under a regulatory framework. Without this, sustainable management of C&D waste is impossible. These three elements—awareness, industry collaboration, and regulation—are all essential for success.





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## Enhancing Standards for Recycled Aggregates in Concrete



**S. Divya, Assistant Director, Civil Engineering Department, IIT,** discusses the inclusion of C&D waste in concrete standards through IS 388:2018 and the development of guidelines for recycled aggregates that highlights ongoing efforts to refine processing stages and maximize the use of C&D waste effectively in construction materials.

The standard provides basic guidelines for processing these aggregates. Manufactured aggregates are expected to match the quality of conventional aggregates. They must undergo the same tests, with additional checks for abrasion, surface water absorption, chloride water absorption, and specific gravity to ensure they do not negatively impact the concrete. We are conducting further studies to refine the processing stages and revise standards and adoption values. Our goal is to maximize the use of C&D waste effectively.

Recent studies have shown that C&D waste can be utilized to an increased extent in concrete and the same will be reflected in the ongoing revision of the standard. In addition to C&D waste, the standard also covers the utilization of other industrial byproducts like steel slag, iron slag, and copper slag, as aggregates in concrete.

**W**e have IS 388:2018 for aggregates used in concrete, which introduces the term "manufactured aggregates." This category includes C&D waste and other industrial byproducts. These materials can be processed and used in concrete, including RCC, RCC, and lean concrete, up to a certain percentage.

Currently, C&D waste is classified into two categories: RA (Recycled Aggregates) and RCA (Recycled Concrete Aggregates). RA includes bricks, tiles, and stones, while RCA consists of original aggregated covered with a layer of hydrated concrete paste. This paste can be removed, and the aggregates can be washed, segregated, and processed as needed.

## Improving Accuracy in Estimating C&D Waste Generation



**Dr. Ajith, Joint Director & Head, C&D, NCCRM,** highlights the need for revised methods to estimate C&D waste generation, focusing on correlating estimates with cement consumption. He argues that current per capita-based estimates are flawed and advocates for more accurate measurement techniques.

**A**mounts of estimates of C&D waste generation to date have been based on per capita data, which is not accurate. The assumption that per capita generation alone can estimate C&D waste is flawed. Instead, estimates should be related to cement consumption in the area, as data on this is available. By correlating cement consumption with construction activities, which partially replace cement, a more accurate estimate can be derived. Therefore, current methods based solely on per capita generation are incorrect and need to be revised for better accuracy.





## Evolving Guidelines and Challenges



**Dr. Shashank K. Agrawal, Executive Director, BAPPC, emphasizes the need for accurate estimation and segregation of C&D waste to improve recycling and management practices.**

It all began on October 2, 2014, when the Swachh Bharat Mission was launched with the aim of making India clean. Among its various initiatives, the mission envisioned 100% processing of solid waste generated in cities by October 2, 2019. A key objective was the effective management of Construction and Demolition (C&D) waste. My first encounter with C&D waste involved estimating its quantity. Initially, we found that existing literature and Indian documents estimated C&D waste at 10 to 15 million tons. However, after

some trials/jobs, along with Dr. Vinodh and Dr. Vinod Kumar, we calculated that approximately 30 kg of waste is generated per square meter of housing, leading us to estimate a total of 100 to 240 million tons at that time. This revised figure was later pointed out by the Ministry of Housing and Urban Affairs and recognized by the Central Pollution Control Board (CPCB) in their environmental management guidelines for C&D waste. This shows that accurate estimation is crucial—what gets measured gets managed.



C&D waste segregation is vital. During a visit to Australia, I saw their advanced, automated systems where C&D waste is efficiently collected and processed. In most developed countries, C&D waste is segregated at its source and, with minimal processing, much of it is reprocessed for manufacturing building components. Unfortunately, in our country, most C&D waste still ends up in landfills, causing environmental issues, with only a small percentage being reused or recycled.

Certi is leading the way with three to four C&D waste processing plants, followed by cities like Ahmedabad and Nashik Municipal through Camiware about Hyderabad.

The year 2016 marked a watershed moment for C&D waste management in India. Prior to this, the Government of India had issued some waste management guidelines. In 2000, Recognizing the growing issue of C&D waste, the government released separate guidelines in 2016 through the Ministry of Environment, Forest and Climate Change. These comprehensive guidelines clearly defined the duties and responsibilities of waste generators, service providers, contractors, local authorities, state pollution control boards, and both central and state governments. The guidelines emphasized the proper management of C&D waste, from collection to disposal.

In 2017, the CPCB released additional guidelines titled "Environment Management of C&D Waste," which focused on mitigating the adverse environmental impacts of C&D waste management activities. These guidelines are available for download on the websites of the Ministry of Environment, Forest and Climate Change (MoEF) and the CPCB. Around the same time, I realized there was still a lack of comprehensive guidelines for C&D waste, so I incorporated with scientists and experts to develop new guidelines in 2017 and 2018. These are also available for download on our website.



## Policy Implementation and Public Awareness



**Ajay K. Agrawal, Deputy Engineer-I, South Zone, MCO, New Delhi, addresses the challenges in public awareness and proper disposal of C&D waste. He emphasizes the importance of public cooperation and the implementation of policies to manage waste effectively.**

**I** represent the Municipal Corporation. As a civic agency, I have a few points to address, particularly regarding Delhi. We estimate the total quantity of C&D (Construction and Demolition) waste at over 10,000 tons per day. Currently, we are processing 5,000 tons of C&D waste daily, yet we believe that 80 to 90% of the waste remains untreated or wasted. This highlights the magnitude of the problem.

The core issue lies in the mindset. The CPWD and BSE have made significant progress by incorporating recycled products into their standards. The common understanding among engineers is that recycled products can be safely used for non-structural applications. For those who are unaware, it's simply a matter of

raising awareness. However, in Delhi, the challenge is public awareness and proper waste disposal. We have implemented a very liberal policy with collection centers across the city where people can dispose of their waste. Unfortunately, many still choose to dump waste on the roadside, forcing us to collect it from multiple locations. I would like to see collecting waste from a single designated spot, but changing public behavior is key. The Ministry of Housing and Urban Affairs (MoHUA) has been actively promoting the use of recycled products. We regularly host meetings, and there are provisions and guidelines from the Government of India that must be implemented by all cities with a population of over one million. We are definitely working on this.

The waste management problem in Delhi extends beyond C&D waste to municipal solid waste. We generate approximately 12,000 tons of municipal solid waste daily, of which we are processing 5,000 tons. However, over 5,000 tons are still being dumped at landfill sites. The aim is the process of establishing two more waste-to-energy plants. My main concern is the collection process. People need to be made aware of how to properly dispose of waste and take instructions from government bodies, including municipal corporations, seriously.

The Municipal Corporation of Delhi (MCD) has mandated the use of 30% recycled products. We have committed to our C&D waste plant operators that we will purchase whatever they produce. Currently, 70% of the paper boards used by the Municipal Corporation are made from C&D waste. However, there are still issues with the acceptance of earth materials from these plants, as people are uncomfortable with the idea. The key challenge remains the collection of waste in a city like Delhi. The mindset must change: waste disposal impacts ecology, the environment, and everything around us. People continue to dump waste indiscriminately, and this is the issue we must address.







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## Technological Adoption and Incentives



**N.A. Faridi, Managing Editor, ENR Media, highlights the slow progress in C&D waste utilization, stressing the need for technological adoption, tax incentives, and better coordination between the industry and government to enhance the use of recycled materials.**

**W**e've been discussing C&D (Construction and Demolition) waste utilization for the past 15-20 years, but progress on the ground isn't taking place. There's a lot of energy and enthusiasm in the country to address this issue, it hasn't yet translated into real widespread action. For example, while we can designate a single collection point for C&D waste, the reality is that much of this waste is generated from small-scale repairs and demolitions. Often, people pay a small fee to have the waste dumped anywhere, rather than taking it to the designated site. To truly create an ecosystem where C&D waste is utilized, we need to establish designated zones close to residential areas.

Currently, Cam has four plants processing 4,000 to 5,000 tons of C&D waste daily. However, the real issue is the gap between the amount of waste generated and the capacity to process it. With continuous developments, we must anticipate future needs. The Prime Minister's vision of making India a developed nation by 2047 is just 22 years away, but the current system won't get us there. Policy and a realistic understanding of the ground situation are two different things. From an outsider's perspective, we still have a long way to go. India has only 27 plants across 10 to 12 cities, with a combined capacity of 12,000 to 14,000 tons per day, but the amount of waste generated requires at least 250 modern plants.

The issue isn't merely of fly ash reuse; for instance, steel from a lack of technological adoption. After over 20 years in the industry, I've observed that India invests very little in technology and infrastructure. The government needs to step in with tax rebates and incentives. C&D waste collection and processing cannot rely on private companies alone—they operate on a profit basis, not charity. The government must facilitate setting up of plants by minimizing costs, offering tax benefits, and encouraging the production of recycled products.

India is fortunate to have the technology, skilled people, and vision to succeed. The last decade has seen phenomenal growth, but our shortcomings (be it coordination, clear guidelines, and accountability). There are guidelines for using C&D waste, brick soil, and other materials in construction, but implementation is inconsistent. Only a few contractors and government offices are taking the seriously. We need to bring the industry together with the government to ensure that technology is adopted and widely used in India.

A significant challenge in India is the lack of civic sense—50% of the population doesn't follow basic civic responsibilities. For instance, you might see someone driving a luxury car and casually throwing trash out of the window. We need to learn from countries like China, where I've traveled over 40 times in the last 25 years. They've developed a sense of responsibility among their population, which now contributes to the country's growth. Here in India, the burden of development falls almost entirely on the government, but that's not sustainable. While the government and NGOs are making efforts, real change won't happen unless the people are on board. Awareness needs to be raised, technology needs to be utilized, and C&D waste utilization must be enforced through incentives to the private sector.

Private contractors and developers are hesitant to use recycled products because they fear inconsistent quality or slower responses. However, if they see a 20% cost benefit, they're likely open to recycled products, realizing the savings and meeting goals by using these materials.





# Investment and Utilization Challenges in C&D Waste Management



**Manoj Kumar, Director, Rise Eleven, highlights the challenges faced by entrepreneurs in the C&D waste processing sector, including issues with waste availability and market acceptance. He discusses the importance of accountability, incentives, and proper utilization of processed materials to achieve best out of waste and contribute to environmental protection and conservation of natural resources. In a nutshell, realize the Circular Economy in this segment of Building materials.**

**A**s a concessionaire, we entered the C&D waste management field a few years ago, starting with Delhi. Currently, we operate three plants and are in the process of setting up a fourth. We established our first plant having 1000 TPD (Tons Per Day) capacity in 2020 in Delhi. In the year 2021, we started our second plant of 225 TPD in Greater Noida, And in April, we are running a small plant besides setting up a 160 TPD plant. In Lucknow, we are setting up a 200 TPD plant.

Where the technology is available, and there are concessionaires willing to invest—primarily through Public-Private Partnership (PPP) model—we are facing significant challenges. The most pressing issue, especially outside of Delhi, is the availability of waste. In a PPP model, where we invest in setting up the project, we expect a certain return on our investment

and efforts. However, these returns are contingent on the proper utilization of recycled materials, which in turn depends on the availability of waste.

Although we are working in four different cities, including Agra and Lucknow, we are concerned about the quantity of waste we will receive. My revenue largely depends on the volume of waste, so I am building a plant with specific capacity requirements.

Determining the quantity of waste being generated is another major challenge. There is currently no accountability for waste generation—no tracking of how much waste they produce during construction or demolition. This issue is particularly acute in smaller cities, where C&D waste management is a newer concept. In Delhi, C&D waste management has been in place since 2005, so there's a system in place. However, in cities where



these projects have only recently been implemented, the availability of waste remains a significant concern.

Another critical issue is the utilization of the processed waste. Although C&D waste management rules mandate that all government departments should utilize 10 to 20% of recycled materials in their projects, the reality is often quite different.

In my view, beyond being businesses about C&D waste, it is crucial to sensitize government officials and policymakers. Accountability must be established regarding who is generating the waste, where it is being disposed, and where it is being used in subsequent projects. Additionally, incentives for the utilization of C&D waste in upcoming projects are essential for creating a sustainable waste management ecosystem.





## Standardization and Material Quality



**Sanjay Patel, DGG, BGS, discusses the integration of C&D waste into building materials, focusing on standards and the challenges of maintaining quality, particularly in durability and consistency. He mentions the revisions to IS 383, which now include provisions for using C&D-derived aggregates.**

**A**ggregates from Construction and Demolition (C&D) waste fall under the category of recyclable materials. For instance, there are various types of cement tiles that utilize fly ash or slag as supplementary cementitious materials, which can also be incorporated directly into concrete. Additionally, we have a range of other materials like bricks and blocks, and significant innovations have been made in this area. For example, there are standards like IS 12894 for fly ash lime bricks, IS 13121 for fly ash clay bricks, and IS 14720 for fly ash cement bricks. These standards support the effective use of

fly ash. Other examples include concrete blocks, brick hollow and solid, lightweight aggregate-based blocks, preformed framed concrete blocks, and autoclaved aerated concrete (AAC) blocks. There's also IS 12440, which allows the use of stone waste to partially replace concrete matrices, leading to the production of stone concrete masonry blocks.

However, the key question is: can these materials also incorporate aggregates derived from C&D waste? Can concrete be produced using or around it like C&D-derived aggregates along with fly ash or slag? This is a complex topic with

many potential applications, but also challenges, particularly regarding quality. Nevertheless, significant progress has been made in utilizing fly ash and slag on a large scale in the country. The incorporation of aggregates is another critical consideration. IS 383 is the Indian Standard that specifies requirements for aggregates for concrete from natural sources. This standard was revised around 2016, and we received extensive feedback and suggestions for modification.

Given the rapid increase in construction activities and the corresponding generation of C&D waste after 2014, the possibility of using C&D-derived aggregates has widely increased. One of the solutions proposed was to refine and convert C&D waste into aggregates. The challenge was whether a specification for aggregates derived from C&D waste could be developed. Instead of creating a separate specification, we decided to incorporate these provisions into IS 383. Since IS 383 is referenced in all types of concrete specifications and codes of practice, we revised it once more to include guidelines for the use of C&D-based aggregates, rather than publishing a separate standard.





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## Risk Management and Material Acceptance



**D.V.R. Prasad, AVP, Puzosana Machinery, highlights the risks involved in setting up C&D waste plants due to inconsistent material supply.**

**I**n Hyderabad, there are two operational C&D waste plants of Puzosana, with another one about to be commissioned in Kotha for a customer. We've also supplied a plant in Kotha and another to a local company in Hyderabad. However, the latter company is facing difficulties due to lack of C&D waste, and they are not planning to reinvest in the plant for aggregate manufacturing. This situation highlights a significant issue: despite substantial investments in capital expenditure (Capex), if companies do not receive enough material to process, they cannot sustain their operations. Consequently, they may be forced to explore alternative uses of their plants.

Similar challenges are observed in Hyderabad. For instance, the plant we

set up in Hyderabad operates only 10 to 15 days per month due to shortage of input material. The remaining days, the plant remains idle, waiting for materials. For any company setting up a C&D waste plant, a consistent supply of input material is critical for sustaining their business, as without it, the business model becomes unsustainable.

To manage this risk, we can only provide a few suggestions, such as the power crisis, where many companies, including fertilizer and cement plants, invest in waste heat recovery systems to generate their own captive power. This approach ensures a steady energy supply for their operations. A similar strategy could be considered for C&D waste management, particularly in building structures and other construction projects.

Another challenge is the acceptance of recycled materials, especially in major cities. While some architects and builders are open to using these materials, the larger portion that account for about 70% of construction projects are often reluctant to accept them. This reluctance creates a significant barrier for those processing C&D waste, as they struggle to sell their products. Additionally, in smaller municipalities, where significant waste is generated, there's little motivation to establish processing systems due to uncertainty about market acceptance.

Addressing this issue requires a shift in mindset. The common practice of paying \$200 to a politician or gatekeeper to dump construction waste anywhere should be discouraged. Government/local authorities should bring strict measures including penalties to stop this unauthorized dumping of C&D waste. Only then people will take the proper disposal of waste seriously.

Furthermore, there needs to be greater information and education by central bodies like the CGPI. Builders must be assured that the strength and quality of the recycled materials are at par with virgin materials. Some efforts are already underway; the message needs to penetrate deeper into the minds of people. Only then we can expect a meaningful change in the adoption and utilization of recycled C&D material.





# Challenges in Establishing and Operating C&D Waste Processing Facilities in India



**Sangay Singh, Associate Director, CDE Asia Limited, discusses the opportunities and challenges in establishing and operating C&D (Construction and Demolition) waste recycling plants. He addresses issues related to waste availability and accountability, emphasizing the necessity for improved tracking, enforcement, and incentives to ensure the successful operation of recycling facilities. Singh also elaborates on the features and advantages of CDE's C&D Waste Processing technology, which aims to contribute to waste-free cities.**

In 2016, a regulation mandated that all corporations establish at least one recycling plant within a four-year timeframe. Despite over 100 municipalities and corporations identified across the country, only a few dozen recycling plants are truly operational. This clearly underscores an alarmingly slow pace of progress in the sector.

Our aspirations for more stations, everywhere, across-class, across extensive road networks, and scaling for all require significant amounts of sand and aggregates. Unfortunately, our rivers are being exhausted of sand, mountains are vanishing, and global temperatures are

rising. We are engaging in unsustainable practices with nature, posing consequences for future generations. Recycling emerges as a crucial solution, with global recycling rates reaching 80-85%, and Singapore reaching 92%. In contrast, our recycling rate for C&D waste is only 1-5%, and we lack accurate data on the total waste generated.

C&D waste is generated in every household. Even minor renovations, such as changing plaster or replacing tiles, produce waste. However, this waste often ends up mixed with general municipal solid waste, exacerbating the recycling challenge.

The situation is further complicated by a complex network of issues. C&D waste plant operators frequently struggle to obtain sufficient waste to keep their facilities operational, despite substantial investments. As a result, many plants remain idle. However, the recent introduction of Extended Producer Responsibility (EPR) in 2024 may offer a resolution to this problem. The EPR coalition stipulates:

- **Registration:** All producers, intermediate waste storage facilities, and recyclers must register on the EPR online portal.
- **Waste Management:** Producers must divert 100% of their waste into processing facilities or intermediate storage if no direct facility is available.







## Technological Solution

GF's C&D Waste Processing Technology offers several advantages and advanced features with its comprehensive solution for waste management. This all-in-one machine being, grades and recycles up to 25% of water, ensuring efficient resource usage. It also facilitates the simultaneous production of recycled aggregates and sand, with the sand meeting the IS-555 specification of containing less than 5% silt. The system also includes a mechanism for the removal of ferrous particles from the feed, ensuring the purity of the output materials.

The system is designed for ease of use and maintenance, eliminating the need for cutting, welding, or painting activities onsite. It features patented stabilisers and ballows throughout, ensuring both safety and durability. A standout feature of the plant is the use of the 30-series range of redundancy motion systems during processing, which effectively removes surface contamination from the aggregates. Additionally, the plant is equipped with wear-resistant liners, further enhancing durability and extending the operational lifespan of the equipment.

The mobile capability is another significant advantage, as it can be dismantled and reinstalled in less than four weeks,

offering flexibility in operations. The plant is built with European safety features and high-quality components, ensuring reliable performance. Its compact design minimises land requirements, and the system is pre-wired and pre-tested at the factory before dispatch, reducing installation time on-site. The plant also ensures a clean and environmentally friendly operation, with no dust, noise, or wastewater pollution. This allows for continuous operation, even in urban areas, due to its extremely low noise levels.

## A huge step toward sustainability

GF's C&D Waste Processing plants have been deployed across the country, demonstrating their versatility and effectiveness. Over the past decade, GF has established facilities with a combined processing capacity of over 2 million tons per annum. This impressive figure highlights the company's impact on improving C&D waste management across various locations. Key installations include:

- Buxton, North Devon Municipal Corporation - 2500 TPD
- Buxton, Buxton Municipality Corporation - 300 TPD
- Jeddah, Greater Hyderabad Municipal Corporation - 300 TPD
- Delhian, Thane Municipal Corporation - 300 TPD
- Buxton Park, East Devon Municipal Corporation - 300 TPD
- Buxtonville, South Devon Municipal Corporation - 300 TPD
- Patergoude, Greater Hyderabad Municipal Corporation - 300 TPD
- Nympha, Municipal Corporation - 300 TPD
- Pune, Pimpri Chinchwad Municipal Corporation (PCMC) - 300 TPD
- New Town, Kolkata Municipal Corporation - 300 TPD
- Kalyanesh, Hindustan Unilever Remediation Project - 100 TPD
- Thane, Bhiwandri Municipal Corporation - 300 TPD
- Dahanu, Bhiwandri Municipal Corporation - 300 TPD

These regional installations not only highlight the effectiveness of GF's C&D Waste Processing Technology but also its significant contribution to enhancing recycling capabilities nationwide, marking a crucial step towards sustainable waste management.





PM Hoist Double Cage, Hyderabad



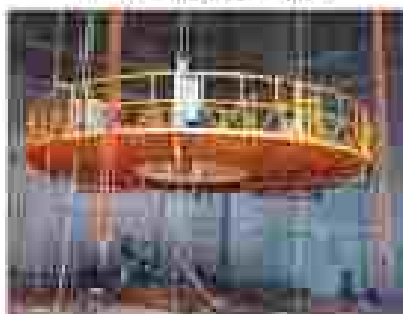
PM Hoist with 12m Vertical clearance/Vijaywada



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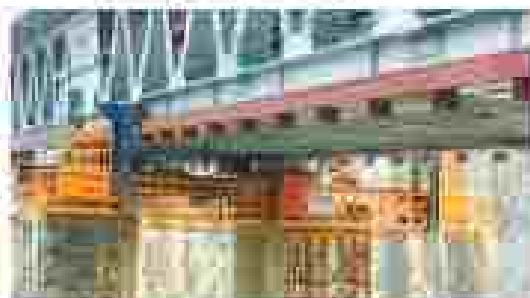
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## Promoting Sustainable Technology & Education



Deepak Pandit, Country Manager, Erick Cruthers, Keenbeck India, highlights the critical role of technology in sustainable construction and demolition (C&D) waste management, while also calling for government support to make these advanced technologies more accessible. He stressed that while Erick Cruthers manufactures crushers, screens, and other eco-friendly machines designed to reduce environmental impact, the cost of such technology can be a barrier. Government incentives and subsidies could help bridge this gap, enabling broader adoption among contractors.

One of the key challenges is the inconsistency in material availability. Often, the actual quantity of materials differs significantly from initial estimates. For instance, a larger city might estimate 20,000 metric tons of waste daily, but only 10,000 to 12,000 tons may be available in reality. This shortfall can disrupt financial planning and cost projections. To mitigate this, stricter enforcement of waste management practices is necessary, including penalties for non-compliance to ensure accountability.

Education is also crucial in addressing the issue. By educating students, residents, and contractors about proper waste segregation and the benefits of recycled materials, we can significantly reduce waste-related challenges. Starting at the

grassroots level, such as in schools and Resident Welfare Associations (RWAs), we could gove up to 50% of the problem by making waste easier to manage and segregated.

Furthermore, contractors need to be informed about the technologies and solutions available in the market. Many are unaware of the economic uses for processed C&D waste, such as granular sub-base (GSB) for road construction, or as raw material for bricks, boundary walls, and pavement blocks. By making these technologies and solutions more accessible and ensuring that contractors understand their benefits, we can transform C&D materials from waste into valuable resources, unlocking new opportunities for sustainable construction.

### Equipment and Solutions

At Keenbeck India, we offer a range of innovative equipment tailored for C&D waste management needs. Our product line-up includes mobile jaw crushers, screens (scalpers), S classifiers, and stackers designed to turn waste into valuable materials.

One of our key offerings is the Keenbeck R36, a fully electric impact crusher known for its zero-emission operation. This machine, along with the R36 screen, is used for recycling C&D waste into reusable products like aggregates for construction.

Our machines are built for efficiency, sustainability, and ease of operation, making it easier for contractors to manage waste on-site and reduce the need for transporting materials to landfills.

### Project Examples

Keenbeck's equipment has been successfully deployed in several C&D waste management projects globally, highlighting its efficiency and reliability. For instance, our R36 impact crusher and GSB screen were instrumental at a recycling site, where they processed rubble on a massive scale.

This project demonstrated how C&D waste could be transformed into high-quality materials using zero-emission equipment. Similarly, our S8 jaw crusher helped a contractor significantly reduce operational costs by recycling materials directly on-site, eliminating the need for transport and disposal, and reusing the processed materials in new constructions.





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### About ISOG

The Indian Symposium on Offshore Geotechnics (ISOG) is a flagship event of ISSMGE TC204 supported by Indian Geotechnical Society. The first symposium in the series was held at IT BHUBANESHWAR in 2019, and the second was held at IIT Madras in 2023. The responsibility of hosting ISOG 2024 is entrusted to NIT Surathkal jointly with IIS Surathkal & Bangalore Chapters. ISOG 2024 aims to explore the diverse dimensions of offshore geotechnics; it encourages knowledge exchange within offshore and geotechnical communities fostering an integrative and innovative approach.

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- Ten best paper award



### Important Dates

- Last Date of Abstract Submission: 15<sup>th</sup> July 2024
- Abstract Acceptance: 25<sup>th</sup> July 2024
- Submission of Full papers (Optional): 28<sup>th</sup> Aug. 2024
- Review reports & Paper Acceptance: 15<sup>th</sup> Sept. 2024
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- Last date of Registration: 30<sup>th</sup> Oct. 2024



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## Hailstone: Offers Crushing & Screening Equipment for C&D Industry



**Souraj Cherkol, DGM, Business Development, Hailstone** innovations throw light on the current scenario of C&D waste collection, processing, and utilization in the Indian construction industry, and the way forward.

In many Indian communities, the disposal of construction and demolition waste poses a serious environmental problem. The country generated 130 million tons of waste annually, accounting for 35-40% of the world's total C&D waste. Based on estimates from the Center for Architecture and Environment, India recycles only 1% of the total waste generated from construction and demolition.

One of the biggest solid waste streams in the world is construction and demolition waste (C&D waste), which presents both potential and challenges for India. India's building sector is estimated to produce between 150 and 300 million tonnes of C&D garbage annually. This Hailstone is

number of issues like incorrect mixing with biodegradable garbage, illegal dumping, and a shortage of disposal spots.

Even with India's legislation and schemes in place for waste management of building and demolition debris, the execution on-site poses challenges. Hence, we see poor collection rates, little recycling, and an increase in open dumping of the waste. Plus, waste collection, transport, and recycling/utilization is thought to require a large capital investment.

India needs to add about 700-800 million sq. meter of commercial and residential space every year by 2030. The real incentive for technology that facilitate waste reduction and material recycling is enormous in this setting.

Hailstone offers all kinds of crushing equipment for the C&D industry. As one of the pioneers in sand manufacturing, we have setup several plants and fine aggregate manufacturing plants. Our product range also includes mobile screens and other waste separation solutions, jaw crushers, crushers of various sizes, screens from 100 mesh and below, washing solutions, tyre crushers, and thickeners.

Hailstone has completed several projects in sand manufacturing, specifically in coal and steel C&D projects. Our machines are working in 150W across some booming sites where the sand is extracted.







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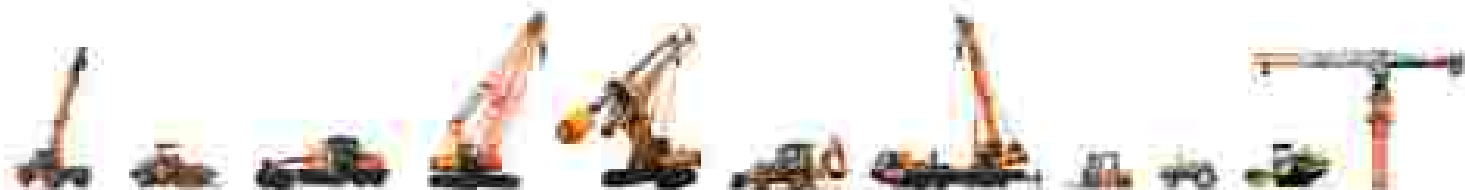
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## Ensuring Accountability and Accuracy



Anish Anandhi, Deputy General Manager at Terra India, emphasizes the need for accurate reporting and accountability in managing C&D waste. He highlights the importance of clear guidelines in tenders and project reports to ensure proper collection and recycling of waste, as well as the critical role of contractors in managing waste responsibly.

The 2016 Rule 24H specifies that anyone generating more than 30 cubic meters of waste during demolition must recycle it. This is a crucial step in ensuring accountability for construction and demolition waste. The responsibility lies with those carrying out the construction and demolition to segregate and recycle the waste they generate.

Currently, all Class A and Class B sites, especially state capitals, have some form of C&D waste processing facilities. Additionally, municipal solid waste, of which roughly 15% consists of stones and construction debris, presents a quality comparable to that of C&D waste. Contractors need to declare the amount of waste generated from demolition and

subsequent construction to ensure proper accounting.

Anandhi says it is the "scope of work" mentioned in the tenders and Detailed Project Reports (DPR) regarding collective C&D waste. This allows for consistent calculations that can declare the actual amount of waste collected. Furthermore, as municipal solid waste renders the



Feeding Station and Sorter for Waste Conveyor from Terra Recycling Systems (TRS) - Coimbatore, India





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loading for good earth, C&D waste, and RDF (Refuse-Derived Fuel) material should be accounted for more accurately. A realistic estimate of collection efficiency, perhaps in the range of 60% to 70%, should be factored into the calculations.

## Equipment & Solutions

Terex offers a comprehensive range of equipment and solutions for the C&D waste management industry. They include mobile and modular crushers, screens, separators, shredders, and washing systems. Our machines, such as the Eurolux and Finlay crushers and screens, process and recycle construction and demolition waste into reusable aggregates. The Terex Eurolux line provides advanced screening and sorting screening solutions for waste reduction and separation, while Terex Washing Systems have specialized equipment for washing and classifying materials, ensuring high-quality clean aggregates.

Terex Recycling Systems (TRS) specialize in the design and build of modular recycling solutions, offering customizable and project-focused systems that serve as a one-stop shop to meet diverse recycling needs. These products are designed to maximize efficiency, reduce environmental impact, and support sustainable waste management practices across project scales. Recognizing the growing demand for onsite C&D waste crushing, Terex has expanded its mobile product portfolio to include global mobile C&D crushing solutions, catering specifically to smaller C&D sites.

## Project Examples

Terex has played a crucial role in numerous successful Construction & Demolition (C&D) waste management projects worldwide, providing equipment and solutions that make a significant impact. In India, our Eurolux Impact machine helped the centrally powered urban strip of Hyderabad convert C&D waste into reusable materials for local construction. In the UK, the Oxford Group, a leading recycling and waste management company, chose a Terex Recycling Systems mobile plant to enhance their processing capacity and recover high-value cleaner products, demonstrating Terex's capability to deliver tailored solutions in complex environments.

Our Powerscreen Crusher and Screen plant were used in the UK to process and recycle demolition waste, reducing landfill use by over 30%. In North America, Terex Washing Systems plants efficiently washed and classified mixed C&D waste, producing clean aggregates and significantly increasing recycling rates. These examples underscore Terex's commitment to providing effective, sustainable solutions for diverse C&D waste management challenges globally.



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## ANNUAL SESSION 2024



# ICEMA's Annual Session 2024 Highlights India's CE Industry's Importance in Driving Economic Growth in Alignment with Viksit Bharat@2047

ICEMA (Indian Construction Equipment Manufacturers Association) held its annual session on the theme "CE Industry: Transforming India's Tomorrow – From Vision to Reality, Viksit Bharat 2047" on August 1st, 2024, in New Delhi. The day-long event included discussions and deliberations on the ambitious vision of the government to transform India into a completely developed nation by 2047, wherein the Construction Equipment Industry is slated to play a crucial role.



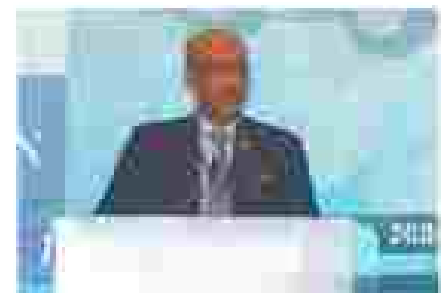
**D**uring the event, Chief Guest Shri. Atkin Bakshi, Road Transport & Highways Minister, announced that the Ministry of Road Transport and Highways (MORTH) will award road contracts worth Rs 3 lakh crore within the next three months. He emphasised the crucial role of the Construction Equipment (CE) industry in India's infrastructure development and stated that the ministry aims to finalize contracts worth 25 lakh crore by the end of March 2025, a target that was well received by the delegates of the manufacturing companies present.

Shri Gopal Kishore also addressed the issues concerning customs duties on imports, which would be reviewed as the government will extend all support possible to improve productivity in the CE industry, which is contributing significantly to the country's economy and is also an important source of job creation. He said that the Budget's allocation of 2.3% of GDP to the infrastructure sector underscored its importance.

The Hon'ble Minister also spoke of the importance of Skills, Economy, and Ecology as the three imperatives for India's development in the times to come, and urged the CE industry to aggressively pursue sustainability in its products and processes. He expressed his confidence that the Indian CE industry has the potential to become the largest in the world.

The ICEMA Annual Session 2024 commenced with the Annual General Meeting of the Association, where the report of activities for FY 2023-24 was presented to the members. Addressed by

impartive, thought-provoking, deliberations and presentations by thought leaders from the industry as well as the policy ecosystem.



Deepak Shetty, President Designate, ICEMA, CEO & Managing Director of JCB India, congratulated Shri Gopal Kishore on his first term and thanked him for the Ministry's confidence and support of the CE industry even in challenging times. "Over the last two years, our industry has achieved remarkable growth, with a 26% increase, largely driven by significant investments in roads and highways. The recent Budget allocations have



## ANNUAL SESSION 2024

### Session I

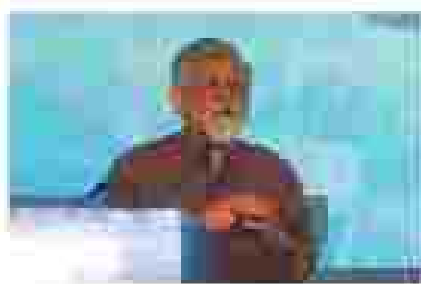
## Global & Domestic Economic Trends: Charting the Future of India's Journey Towards 2047



continued to focus on infrastructure, which is very encouraging. Despite good challenges, India remains a nation of hope, consistently demonstrating its GDP growth. This vision inspires us to invest further and expand our industry," he said.

"India was once visited by the word as a low-cost country. Our focus, with our focus on product quality and investment in technology development, India stands out as a high-value market. We are dedicated not only to advancing our industry domestically but also expanding our global presence. We are now expanding to more than 135 countries, aligning with the government's vision of 'Atmanirbhar Bharat' or 'Make in India for the World'. The CE industry is committed to driving progress and contributing to India's growth story. Our products are competitive, and the emission norms are appropriate. As we continue to advance, now is the time to leverage Free Trade Agreements (FTAs) to achieve further growth and maximize their benefits," added Bhukte.

Dr. Arvind Virmani, Member, NITI Aayog and Guest of Honour at the first session, presented data showing the improving performance of the Indian economy, rising employment, and real wages for casual workers. Registration in industry is both rural and urban areas by 8 to 10%, as well as



industry of income distribution. He said that India can easily become a middle-income country by 2030 and a high-income country by 2050, or so. The session on Global & Domestic Economic Trends was guided by Dr. Sachidanand Bhukte, Group Chief Economist, L&T India, and Jeevinder Botani, Vice-President, ICEMA.



H.D. Kumaraswamy, Minister of Heavy Industries, informed: "The Indian Construction Equipment (CE) industry, valued at \$5.5 billion, is currently the world's third-largest market, following

USA and China. The sector is crucial for infrastructure development in the country, supplying essential and critical heavy equipment for infrastructure projects. It plays a significant role in the government's nation-building efforts, contributing to the realization of the Vision Bharat 2047 goals."

"The CE industry is also a significant job creator, providing employment to over 3 million people, both directly and indirectly. Given its importance, the CE sector is integral to national development and economic growth. The areas of focus for the CE industry should be developing smarter, technologically green machines, becoming globally competitive, and growing its exports while reducing import dependence," he said.



Dr. Vivekananda, President, ICEMA and Managing Director, Caterpillar India, observed: "The sustainability of infrastructure projects and the development of state and urban infrastructure are crucial. We need a





policy framework that supports and extends beyond the current scope to promote state and urban infrastructure development. On the supply side, India stands out as a high spot in the global economy. However, as the global economy evolves, it is essential to address redundancies and strategically shift manufacturing capacities. We must explore options to diversify the relocation of manufacturing capacities from different parts of the world. The supply of labour is another area that requires focus. We need to emphasise not only the quality of employment but also improve the quality of work and life for individuals in the sector. Since the sector houses a significant amount of informal employment, we need a framework to facilitate the transition from informal to formal employment, which will enhance quality of life and provide better working conditions."



And, Munir Khanjani, Member - Infrastructure of the Railway Board, shared insights on the country's railway sector expansion plans. He stated that

India is now constructing rail lines every year, which are more than the entire Asian rail network. "Over the last 10 years, 31,700 km of track length has been added to the network, with 8,300 km added in 2023-24 alone. However, one major area of concern that remains is India's network density, which is low compared to the major economies."

It was also highlighted that the Indian Construction Equipment (CE) industry faces several critical challenges that necessitate substantial investments in the value chain and technological innovation. An important concern is the high import dependency, with approximately 80% of

input materials for manufacturing sourced from abroad. This reliance on imports undermines the industry's self-sufficiency and economic resilience. The industry's export competitiveness is further impacted due to higher manufacturing costs and outdated technology compared to China. Rapid technological advancements further compound the issue, as the absence of a clear technology roadmap and limited R&D expenditure leave the industry lagging behind global standards.

Moreover, logistics costs in India are disproportionately high, accounting for 12% of GDP compared to 8% in other parts of the world. Addressing these challenges through strategic investments and innovation is crucial for the Indian CE industry to reduce import dependence, enhance export competitiveness, and achieve global parity.



V.G. Anantharam, Treasurer, ICEMA, Chairman and Managing Director, Jodhpur Steels India, highlighted the critical aspects of the ecosystem supporting domestic demand, such as extending logistics and reducing costs.





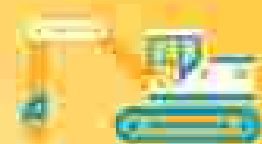
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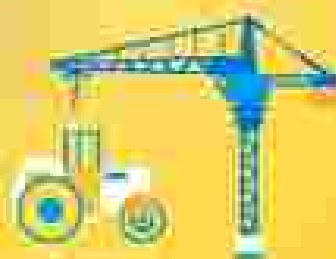


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## ICEMA Organises First CE Human Capital Summit in New Delhi

In view of the sustainable role of the Indian CE industry in infrastructure and urban development projects, the first CE Human Capital Summit (CE-HCS) 2024, held in the capital of the nation, Economic Growth & Highlighted Human Resource Development as a critical enabler of the CE industry's development and growth.

The Summit was organised by the ICEMA Human Capital Panel, which aims towards promoting collaboration on Human Capital issues within the Construction Equipment sector and facilitating knowledge, discussion and policy pertaining to Human Resource Development.

The theme of the Summit, "Human Capital: Enabling Future Growth of the CE Industry" was dedicated to uncovering the transformative potential of human capital in the CE sector and strategic solutions to workforce challenges by creating rich, comprehensive discussions amongst CE industry stakeholders. The event was well attended by representatives of OEMs, policymakers, industry leaders, CHROs, senior executives, HR/HRD leaders and subject matter experts.

Shashi Chaturvedi, Chairman, ICEMA Human Capital Panel and Managing Director, India & SAARC, Tata Construction Equipment India, unveiled the role of human capital as the driver for the future success of the industry. Speaking at the inaugural session of the first CE Human Capital Summit, "It is a reminder to the industry to focus on the human capital, which is the most sophisticated equipment needed for the sector that is going to be a part of the future. We need to invest in the human capital and ensure that the industry is not left behind. We need to ensure that the industry is not left behind. We need to ensure that the industry is not left behind."

Dr. Anil Kumar, Managing Director, India & SAARC, Tata Construction Equipment India, also addressed the summit, highlighting the role of human capital in the industry's growth. He emphasized the need to attract, retain, and develop talent in the CE industry and to ensure the industry remains a critical enabler of the nation's growth.



for being targeted and more employee-centric in academic and vocational training initiatives."

Recognizing the growing importance of the workers in organizations, the role of HR professionals in creating a skilled, motivated workforce that supports industry advancements is gaining prominence. Sharing his insights on this, V. Viswanath, President, ICEMA and Managing Director, Caterpillar India, said, "The formal segment of the industry is doing making progress in creating a skilled workforce for the industry. It is important to look at the informal sector which needs to be looked at."

Dr. Anil Kumar, Immediate Past President, ICEMA, Member, ICEMA Human Capital Panel and Managing Director, Value Construction Equipment India, said that the National Apprenticeship Program will make a great impact on the industry. However, for CE industry, there is a better and a more sustainable solution, which is understanding."

Deepak Shetty, President Designate, ICEMA and CEO & Managing Director, CE India, welcomed the need to create and get skilled workforce from the formalities as well. "Along with the CE industry's efforts for growth of equipment, there is also tremendous efforts for talent of talent in the industry," he said.

A highlight of the Summit was the release of the ICEMA CE-HCS 2024, "Human Capital: Enabling Future Growth of the CE Industry" – a compendium of HR best practices and insights from member organizations of ICEMA.

The Summit was an informal and focused strengthening India's manufacturing industry and enhancing its global competitiveness as it relates to education, skill development, and workforce development. The outcomes of the Summit will be shared through the summit with the industry and the government, which will be a critical enabler of the industry's growth.

He emphasized the importance of creating a suitable export environment for the Construction Equipment industry, noting that tax duties and import duties in the destination country are crucial factors.

A CEO Session also featured interactive interactions between the CEOs of OEMs (past ICEMA members). Topics such as anti-dumping measures for components, foreign trade agreements (FTA), on electric vehicle parts, government support to electric vehicles and green hydrogen, staying up of quality and selling in Medium Small and Micro Enterprises (MSME) sector.

scope for Artificial Intelligence and Machine Learning (AI/ML) in the industry, and Culture Assimilation of Overseas Firms, signing to operate in India, kept the audience entertained.

A report titled "2024 Construction Equipment Market Outlook for India" was released during the event. Presentations were made on India-Japanese collaborations in the CE industry by Kazuyo Nomura from Kato Corporation, Japan, and by Yash Kashyap from Yash Engineering Manufacturing India. There were discussions on building a strong and innovative supply chain

ecosystem, enhancing domestic demand and boosting exports for the construction equipment industry. The event concluded with an agreement between ICEMA and NITI to finalize the CE Industry Vision Plan document for 2047 in alignment with the Government of India's vision 2047 mission, incorporating the elements and learnings from the Annual Session 2024.

The Annual Session 2024 served as a valuable platform for networking and idea exchange among its players in the industry. The day concluded on a high note with a musical entertainment program followed by dinner. ■





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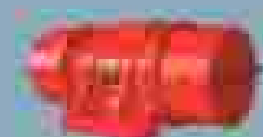
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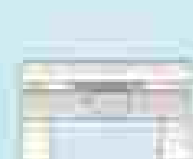
Feeder with the drive  
 Portion of Motor



Feeder with the drive  
 Portion of Motor



Feeder with the drive  
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Feeder with the drive  
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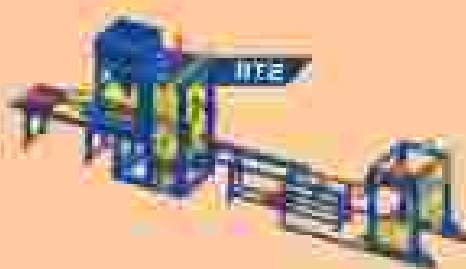


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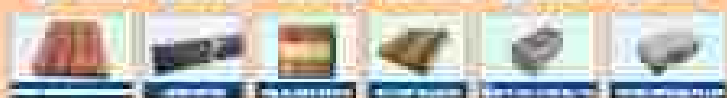
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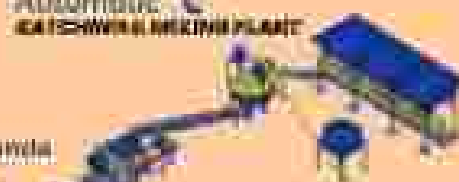
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## Nilang Asphalt Equipment Launches Innovative Asphalt Batch Mix Plant with 60% Recycling Addition

Nilang's groundbreaking addition to its product range – the ABP 160 – sets a new standard in sustainable asphalt production, offering a significant reduction in environmental impact without compromising on quality or performance. The fast growing manufacturing company is D&E registered, and has four well-equipped manufacturing facilities spread across over 45,000 sq.ft area. With its manufacturing experience of 26+ years, the company has proven competence in customizing its plants as per customer's project requirements.

### Features that set the ABP 160 apart

- **Environmentally Friendly:** With the capacity to incorporate up to 60% recycled asphalt pavement (RAP), the plant significantly reduces consumption of virgin materials, minimizes waste, and lowers carbon emissions.
- **Cost-Efficiency:** By utilizing recycled materials, the plant helps users save costs associated with purchasing new aggregates and binder, making it a financially attractive solution for sustainable asphalt production.
- **High-Quality Output:** Along with its focus on sustainability, the plant delivers asphalt mixes of the highest quality that make construction projects more durable and reliable.
- **Versatile Performance:** The ABP 160, with 60% Recycling Addition, offers the versatility to adapt to various applications and project requirements, whether used for rehabilitating maintenance projects, or new constructions.
- **Other Features:** Walk-in-less design, economical and fast installation, fuel efficient, user-friendly, lifetime support with spares and maintenance.

"At Nilang Asphalt, we are committed to driving positive change in the construction industry, and our new Asphalt Batch Mix Plant reflects this dedication," says Kamlesh Patel, Head – Operations at Nilang. "We believe that this innovative addition to our product line-up will not only benefit your business but also contribute to a greener and more sustainable future for the industry. We, at Nilang thank our customers for their continued partnership and support."

To learn how Nilang's new Asphalt Batch Mix Plant can enhance your asphalt production capabilities, please visit [www.nilangasphalt.com](http://www.nilangasphalt.com) or contact Kamlesh Patel on +91 98253-10370.

### Nilang Asphalt Equipments Pvt. Ltd.

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