Innovative and **Sustainable Construction Materials** & Practices can lead to **60% Reduced** Carbon Emission & **50% Increased** Productivity

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Introduction

Ms. Pragya Priyadarshini

Managing Director, Primus Partners

Innovation and Sustainability have become buzzwords across industries; the Indian infrastructure sector has been relatively slower in embracing these shifts at scale. Despite the evident accelerated productivity, environmental and economic benefits, sustainable practices and novel materials often remain underutilized in infrastructure development. However, recent years have seen a growing momentum—led by forward-thinking organizations and public-private partnerships—toward integrating resilience, circularity, and innovation into core infrastructure planning and execution.

This Point of View paper captures some of the most promising practices, pathbreaking materials, and sustainable approaches being implemented across India. The featured case studies are drawn from the nominees of the Build India Infra Awards 2025, showcasing projects that stand out not only for their engineering excellence but also for their commitment to building a greener, smarter future.

Instituted to recognize and encourage such forward-looking efforts, the Build India Infra Awards have become a barometer for transformative change in the sector. By highlighting exemplary projects that successfully embed sustainability and innovation into infrastructure delivery, the awards aim to set new benchmarks and inspire replication at scale. The nominated projects featured in this paper reflect not only technological and design breakthroughs but also a broader shift in mindset—one that places long-term environmental and social impact at the heart of infrastructure development.

Infrastructure at the core of
Viksit Bharat 2047

The Government's roadmap to making India a fully developed nation by 2047 and become a $30 trillion dollar economy predominantly depends on the accelerated infrastructural transformation. Infrastructure is the backbone of a nation's economic growth, and India's progress is deeply tied to the strength and expansion of its infrastructure landscape. From efficient transportation networks to robust power transmission systems and sustainable water management, each sector plays a pivotal role in accelerating industrial growth, enhancing connectivity, and improving the quality of life for millions.

India, the world's fifth-largest economy, has made remarkable progress in infrastructure development over the past decade through landmark initiatives such as Bharatmala Pariyojana, UDAN, PM Gati Shakt National Master plan, Vande Bharat trains, Jal Jeevan Mission, Sagarmala, Cruise Mission, AMRUT , Smart City mission and so on. In last decade, India has also etched its mark on the global platform through Trailblazing, milestone projects such as Mumbai Trans harbour link, upcoming Mumbai- Ahmedabad High speed rail, Chenab rail bridge, Dedicated freight Corridor (DFC), Udhampur-Srinagar-Baramulla-Rail Link, Mumbai Coastal road, Yashobhoomi Convention center etc.

Trailing Construction Productivity

Construction industry is a pivotal lever in a country's economic growth, significantly contributing towards GDP and employment generation. However, Construction sector continues to remain laggard in terms of productivity compared to other sectors globally. If the Global construction productivity growth averaging at 1% over the past two decades is accelerated to 2.8% which is the productivity average of total world economy, the industry's value add shall become a whopping $1.6 trillion every year, boosting global GDP by 2%.

Indian Construction Industry, the 4th largest in the world, poised to become the 3rd largest by end of 2025, contributes 9% of the India's GDP and is projected to grow at a CAGR of 9.6% between 2024-2028. However, according to the Ministry of Statistics and Programme Implementation (MoSPI) latest report in 2024, out of the 1837 major and mega projects worth INR 150 Cr and above, 449 projects have cost overruns, and 779 projects have time overruns with respect to baseline plan. For ongoing projects as on 1st March 2024, the overall cost overrun is approximately 19% of original cost and the average time overrun is between 35-40 months. The top 3 sectors contributing cost overruns are Roads & Highways, Urban Development and Railways and the top 3 sectors contributing time overruns are Roads & Highways, Railways and Power.

4 levers to Strengthen the foundation of Construction Productivity

Industry experts suggest that optimistically **50-60% of construction productivity** may be increased while also **reducing carbon emissions by 60%** by taking action across 4 levers **powered by sustainability and innovation**

Design Augmentation – Sustainability and Innovation in Design approach at the inception of a project have cascading effects in terms of cost, time and carbon emission. Innovation in Design approach may include vertical development, standardization of construction methodology etc. leading to reduced materials and resource utilization. Design augmentation may impact both embodied and operational carbon emissions.

Material Permutation – Substitution of traditional materials with innovative, locally available and low carbon alternatives has vast potential to diminish emissions.

Construction Optimization – The adoption of sustainable approach to on-site construction from material movement, storage, disposal to alternate fuel adoption for the equipment/ vehicles during construction.

Process decarbonization – Viewing the construction value chain in its entirety i.e., from raw material stage (manufacture, transport), construction stage (transportation, construction), operational stage (maintenance, repair, refurbishment, replacement) to end of life stage (waste processing, disposal)

Sustainability: Optimizing Mix Grade ratio with green materials and technology

According to the World Green Building Council, built environment is currently responsible for 39% of global energy related carbon emissions: 28% from operational emissions, from energy needed to heat, cool and power them, and the remaining 11% from materials and construction. It is imperative for rapidly growing countries like India that focus immensely on infrastructure development to prioritize reduction of embodied carbon in building practices and advocate its inclusion in the construction codes. **Why focus on embodied carbon? Embodied carbon accounts for the carbon emissions from extraction, manufacturing, transportation, construction, installation, maintenance and disposal of building materials.** Unlike other forms of carbon emission, the mitigation of embodied carbon emission is to commence from the inception stage of any infrastructure development. **Across the life cycle of a project, typically 50–70% of total embodied carbon is emitted before completion. Of this, 85–90% of embodied 'upfront' emissions arise during the manufacturing stage, 7–10% during transportation and 3–5% during the construction stage. The need of the hour is a shift in the approach of the collective construction ecosystem.**

Build India Infrastructure Awards: A Celebration of Infrastructure Excellence

From its inception in 2024, the Build India Infrastructure Awards has served as a platform that unites industry leaders, innovators, and key stakeholders, creating a collaborative space to showcase impactful projects and groundbreaking practices across various sectors. The awards highlight sustainability, innovations and impactful practices in critical fields such as roads and highways, water infrastructure, aviation, ports, power transmission, railways, urban transport, and trailblazing special infrastructure. By recognizing excellence and offering well-deserved recognition to outstanding contributions, the awards emphasize transformative ideas that drive sustainable development while addressing emerging industry challenges. The Build India Infrastructure Awards 2025 turned the spotlight on some innovative, effective, impact sustainable practices adopted by the industry changemakers in their landmark projects. In this paper, we attempt to capture the essence of some of these sustainable materials and practices.

1 Bio bitumen

Used by CSIR-Central Road Research Institute, Biobitumen is an innovative material developed as a sustainable alternative to traditional bitumen. India is facing shortage of bitumen required for road construction, **every year about 49% of bitumen is imported which costs India about INR 25,000 crores annually**. Biobitumen is created by leveraging **renewable biological materials, such as rice straw, which reduces dependency on fossil fuels and lowers greenhouse gas emissions.** Upto 30% of the petroleum bitumen can be replaced with bio-bitumen. **This innovation will support global sustainability goals by generating revenue for biomass, mitigating stubble burning, and cutting greenhouse gas emissions by at least 70% compared to fossil-based bitumen.** This material has the potential to significantly decrease the environmental impact associated with road construction and maintenance.

The process of producing bio bitumen utilizes agricultural waste and other renewable resources, which creates both environmental and economic value. As rice straw is abundantly available, this method of production can be scaled up for large-scale road construction projects, contributing to sustainability. **If India begins replacing even 15% of conventional fossil-based bitumen with bio-bitumen, the country can save at least INR 4,000–4,500 Crs annually while also reducing the overall carbon footprint.**

Considering that 1 km of road requires approximately 12,000 kg to 21,300 kgs of bitumen, the Cost of conventional fossil fuel-based bitumen is approximately INR 48-50/kg which amounts to INR 6-10.6 lakhs per km of road. The cost of rice bio-bitumen will be around INR 38-40/ Kg which amounts to INR 4.8 – 8.5 lakhs per kms of road implying a 20% lower road construction cost per km with ~70% lower carbon emissions.

20% ↓
Cost Reduction/Km

↓ **70%**
Lower Carbon Emissons

2 BitChem Tailor-Made Cold Binder

BitChem Asphalt Technologies Ltd. employs BitChem Tailor-Made Cold Binder, a patented bitumen emulsion with performance additives and anti-stripping agents, which **enhances the durability and efficiency of road construction**. This Cold Mix technology eliminates the need for bitumen reheating, ensuring a consistent mix ratio regardless of weather conditions, making it highly suitable for quick repairs and urgent projects.

The Cold Mix process is **23%** more cost-effective than Hotmix, Cold Mix saves up to **5,000 L fuel** and **3,000 L water per km**, **cuts CO_2** emissions by **6.5 lakh tons annually**, enables traffic access within 2 hours (vs. 24–48 hrs), and **reduces energy use by up to 60%.**

The process is safer, reducing accident risks, while promoting sustainable construction practices by requiring minimal resources and no skilled labour. **The fact that Existing Hotmix plants can also be converted to Cold Mix production is an added bonus.**

3 Cold Central Plant Recycling Technology

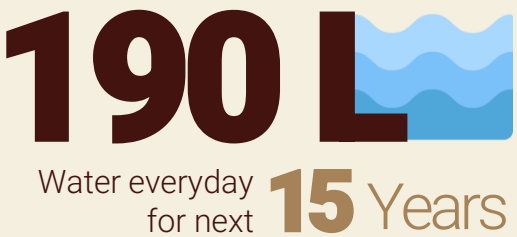
Ghaziabad-Aligarh Expressway by L&T has adopted **cutting-edge Cold Central Plant recycling technology by reusing 0.6 million MT of asphalt, reducing 78,000 tonnes of CO_2 emissions, and saving 4.7 million Liters of diesel.** Technology has helped in eliminating the requirement of disposal for approximately 6 Lakh MT of the dismantled pavement material, re-used approximately 5 lakh MT of dismantled RAP material in CCPR. Remaining 1 Lakh MT has been used in bituminous layers. It saves 4707 KL of HSD, **resulting in an emission reduction of 12700 tonnes of CO2.** Designed using IRC:37 and IRC:115 guidelines with IITPAVE software, it achieved 92-100% RAP utilization, far surpassing conventional methods. A custom mix design, developed with IIT Madras, incorporated international standards, ensuring superior durability. The use of SS-2 emulsion and VG-30 binder enhanced performance, while CCPR demonstrated better rut resistance than Hot Mix Asphalt.

4 Sequencing Batch Reactor for Wastewater Treatment

Dharavi Wastewater Treatment by Welspun Enterprises Limited is India's first multi-storeyed wastewater treatment plant (418 MLD), featuring a 45-meter-high Sequencing Batch Reactor (SBR) unit. **The sludge digesters will generate biogas, which will be used for power generation, reducing reliance on grid power by approximately 30%.** This cutting-edge structure optimizes space vertically, allowing efficient treatment of sewage within just 12.7 acres, making it the **lowest footprint per MLD facility in India. The facility will save 152,570,000 kWh annually, reducing CO_2 emissions by 1,09,240 metric tons each year, 65,600 cubic meters Carbon Credits through biogas contributing to a significant reduction in carbon footprint.** The entire plant is designed for automated operations through the latest SCADA systems to maximize operational efficiency with minimal human intervention

Vishvaraj Environment Pvt Ltd (VEPL) has also adopted SBR in their construction of a **200 MLD STP at Bhandewadi, Nagpur.**

By reusing the tertiary treated water to the power plants, **The project saves 190 million liters of fresh water daily, meeting the city's needs for the next 15 years.**



Executed under the Public-Private Partnership (PPP) model, the project ensures financial self-sustainability through **revenue generation from treated water sales.** This eliminates financial burden on the Nagpur Municipal Corporation while guaranteeing high-quality treatment, as the operator's revenue is directly linked to water quality.

5 MSGP Leachate Plant at Bengaluru

The implementation of **TRITRON** *(formerly known as Aquatron)*-**FPSTAR technology by Scalene Livprotec Pvt Ltd** follows a modern, modular, and highly automated construction methodology that enhances efficiency, scalability, and sustainability. The system is designed with a **compact and space-efficient layout,** making it ideal for installation in areas with limited land availability, such as urban environments and industrial zones. Unlike traditional wastewater treatment plants that require extensive civil works, **Tritron's prefabricated modular units reduce construction time and site disruptions, allowing for rapid deployment and phased expansion as needed. The construction methodology also focuses on adaptive retrofitting,** meaning the technology can be integrated into existing treatment plants without a complete overhaul. **This approach minimizes capital expenditure (CAPEX) while enhancing the efficiency of conventional ZLD systems.** The automated operations ensure consistent performance with minimal human intervention, improving reliability and reducing operational costs. The technology recovers water at reuse standards.

Energy efficiency is achieved by treating leachate and recovering water at a lower power consumption—around 12 to 15 units of electricity per 1,000 litres. This amounts to a power saving of INR 4000-5000 *(INR 5.8/ unit in Bengaluru)* **per day for the 50KLD TRITRON plant.** It is designed to deliver customised solutions, depending on the nature of leachate and the specific contaminants present, with 70% recovery (Out of 30%, 20% will be in recirculation, and other 10% will be lost along with sludge and natural evaporation). With its **scalability, operational flexibility, and sustainability-focused approach**, TRITRON sets a new benchmark in the construction methodology of advanced wastewater treatment facilities.

6 Mitigation of Lambagarh landslide

Maccaferri India's approach to slope stabilization involved an innovative reinforced soil wall construction (with gabions as facia) and rockfall embankment, ensuring the road's protection from landslides and rockfalls. The project was completed within a limited 5 month period, overcoming challenges such as restricted access and maintaining road traffic. The solution involved flexible construction methodologies, including RCC jacketing to protect structures from scour and boulder impact, and the creation of a new flexible pavement. **Innovative materials such as Terramesh and ParaLink geogrids to construct reinforced soil (RS) walls and rockfall embankments, offered a flexible, cost-effective, and resilient solution for the Lambagarh landslide zone. These materials were reinforced with high-strength geogrids, and locally sourced stones and backfill made the solution both economical and sustainable. The methodology ensured sustainable construction, durability (120-year design life),** and minimal environmental disruption during execution. The use of these advanced materials allowed for stabilization of steep slopes and effective counteraction against destabilizing forces like water seepage and heavy hill surcharge ensuring all-weather connectivity to Badrinath Dham.

This technology adopted enroute the Char Dham Yatra has **Reduced travel time by 30 mins**, improved safety for **14.35 lakh annual pilgrims**, and **cut carbon emissions by 30–40%** through lower fuel use and congestion.

7 Sustainable Practices at JNPA

Jawaharlal Nehru Port Authority is a frontrunner Port not only in port operations but also in adopting innovating technologies and sustainable practices. JNPA has introduced many innovative sustainable solutions in addition to the usual solutions of energy efficient lighting etc. such as :

a. An **unmanned solar-powered boat** for floating trash collection, which can handle 500 kg loads, operate autonomously, and provide real-time data tracking via an online dashboard,

b. Deployment of 2 **battery-swapping eTrucks** with dedicated swapping stations, allowing quick battery changes for terminal operations and minimizing downtime.

c. Presently JNPA operates **16 E-Cars and 35 CNG-Cars** amounting to an approximate **CO2 saving of 201 tons/year**

d. Providing **shore power supply to tugs and port crafts, reducing CO2 emissions by approximately 500 tons per year**

e. Established a **Tier-1 Oil Spill Response Facility** at Jawahar Dweep, utilizing a Multi-Purpose Utility Launch (MPUL) for pollution control, debris collection, and routine oil spill drills

f. **100% electrification goal**, the railway tracks from Jasai to JN Port were electrified in December 2023, **eliminating diesel locomotive emissions and saving approximately 203 tons of CO2 per year**.

g. The **Inter-Terminal Tractor (ITT) Movement Facility** saves a **7.5 km road trip per transaction**, improving turnaround times.

h. Additionally, vessel turnaround **time (TAT) has been reduced from 25.60 hours to 24.18 hours in 2023-24, saving berth stay time and reducing noise and CO2 emissions by approximately 3,750 tons annually.**

Carbon savings rose from **10,000** to **53,700 tons/year** in 2024; **JNPA** now runs on **50% renewable energy**, targeting **60% by 2030**.

8 Floating Solar PV Power Project

This project by L&T integrates cutting-edge construction materials and advanced technology to enhance efficiency and durability. FRP floating barges with a load-bearing capacity of approximately 40 tonnes were used for mounting electrical equipment like inverters and transformers, marking their first use in India. About 15 km of cabling was laid in an open reservoir area for power evacuation, designed to withstand challenging site conditions such as water level variations, water currents, and high winds. **Bifacial Solar PV modules** were deployed to improve reliability and energy efficiency in floating solar applications, leveraging the water-cooling effect to boost performance while reducing water evaporation and preserving resources. Additionally, the VRT method was employed to determine the optimal resistance for grounding electrical systems in water, ensuring stable grounding despite fluctuating water conditions.

The Project saved 650 acres of land, cut water evaporation by up to 70% under panel-covered areas, and reduced CO_2 emissions by 85 lakh tons, significantly aiding climate action.

Land Saved by Project

With an annual net generation of 196 million units in its first year of operation, the plant not only contributes substantially to global renewable energy targets but also brings tangible benefits by electrifying over 100,000 households.

9 Geogreen Erosion Control Blanket

Adopted by **Ravi Infrabuild Projects Limited, the Geogreen Erosion Control Blanket (GECB)** is a non-woven composite material, **made of 85% natural Coconut fiber (also known as Coco Fiber, Coir), reinforced with 15% UV stabilized HDPE polymer.** These are mechanically bonded and Biodegradable. The GECB provides as an interlay over compacted embankment slopes for the purpose of soil retention, enhancement of surface stability, permeability of the turfs and vegetation developed from the Native Grass Seeds, or Vetiver Grass. The product approximately contains 500-510gms of Coconut Fibre and 90-100gms of PP/HDPE per Sqm. The minimum nominal weight of the blanket should be 600-650GSM and thickness 7-8 mm. Smart meters with GSM/GPRS communication were installed to monitor flow and control pressure, preventing future leaks.

The Geogreen Erosion Control Blanket (GECB) is provided over embankment slopes of 1(V):2(H) for the **purpose of slope stability, soil retention, and enhancement of surface stability. After full growth of vegetation on Embankment Slope, a complex network of root system has developed, act as control barrier.** The coir fibers protect steep surfaces from heavy rainfall, surface runoff with high tensile strength. Geotextiles have permeability property used for prevention of soil movement from migration, and maintaining the water flow without any obstruction. The Non- Woven Green Geocomposite Blanket (Coconut coir mat) is able to hold water and moisture for long time for the growth of plant, and it is biodegradable so, after decomposition it act as manure to soil for planation growth. The coconut fibers have a long life and so, **GECB can support up to 3 years.** GECB has higher tensile strength and performs well on steep slopes of 60 degree.

The use of GECB coir blanket has resulted in **32.7% reduction in costs** i.e., approx. **INR 100-150 per sqm** reduction vis-à-vis a conventional stone pitching for slope protection work.

10 Array of Sustainable Practices adopted at the Goa International Airport

The New Goa Airport is located in Northern Goa in Pernem municipal council, 35 KM from the capital Panjim. Operational since January 2023, GGIAL is the **first dual airport scenario under the Public Private Partnership (PPP) model. It operates on a Design, Build, Finance, Operate, and Transfer (DBFOT)** basis. The total Area is 2,132 acres, out of which 381 acres are set aside for the City Side Development for commercial purposes. From the inception, GMR has been very specific about making the Goa International Airport sustainable and has succeeded by receiving the Platinum Certificate for Green Building by Indian Green Building Council (IGBC). Some of the sustainable practices adopted at the airport includes:

- **A 5 MWp Solar PV generation unit** with 9184 high-efficiency mono-crystalline modules (545 Wp each) was installed at the airside to promote renewable energy generation and has managed to **reduce 5761 tons of carbon emission.**
- **LED lighting** across all buildings and Airfield Ground Lighting (AGL) systems.
- A rainwater harvesting system, approved by the Water Resources Department (WRD), Goa, incorporates stormwater drains and inline harvesting pits, recharging up to 30% of rainwater during monsoons.
- Deployment of EV buses **(reducing 170 tonnes of Carbon emission)**
- Sustainable ground handling equipment,
- A complete ban on single-use plastics (SUP),
- Provision of **Bridge Mounted Equipment such as Fixed Electrical Ground Power (FEGP)** and **Pre-Conditioned Air (PCA) systems** to reduce greenhouse gas (GHG) emissions (almost 1758 tonnes) from Auxiliary Power Units (APUs) of aircraft.
- An underground fuel hydrant system, eliminating the need for road movement of Aviation Turbine Fuel (ATF) bowsers.
- Additionally, **100% of treated sewage treatment plant (STP)** water is reused for cooling tower make-up, toilet flushing through a dual plumbing system, and irrigation, ensuring the **airport operates as a Zero Liquid Discharge Unit.**

11 Unaccounted For Water (UFW) & Leakage Control in Central Division, Bangalore

SPML Infra implemented a water loss reduction project across 43 District Metered Areas (DMAs) in Bengaluru. The project utilized advanced helium leak detection technology combined with innovative execution methodologies to identify and resolve a wide range of issues, including both minor and major leaks as well as deteriorated pipeline sections. The project targeted a reduction of UFW levels to an average of 16% across all established DMAs. Aging pipelines, some over 50–60 years old, were replaced, and advanced leak detection technology was used to identify and seal leaks.

These **43 optimally sized zone design** approaches not only improved efficiency but also **Saved ₹17.78 Cr in CAPEX, cut water loss from 52.78% to 18.82%, conserving 51.12 million liters/day (worth ₹42,000 per MLD) to supply 110 new and extended city colonies**

17.78 Cr.

Saved in **CAPEX**

in the city. The project demonstrated financial viability by achieving full cost recovery within less than two years. In addition to reducing water losses, the project contributed to revenue generation for BWSSB by accounting for 17.37 MLD of previously non-revenue water (NRW), which now brings in an additional INR 26.63 Cr annually.

Innovation & Technology in Construction: A Blueprint for the Future of Growing Nations

Innovation and Technology has the potential to significantly increase efficiency, productivity, and safety of Construction Projects. While Construction industry continues to be labor intensive and capital intensive, innovation and technology facilitate in optimal utilization of these resources. Technological advancements enable the creation of smarter, more resilient structures that meet the evolving needs of communities and industries. In a rapidly changing world, innovation ensures that infrastructure remains adaptable, future-ready, and capable of supporting long-term growth and development. In this section, we present the innovation and technology in materials and construction methodology that have changed the phase of construction in the last few years.

1 Birla Copper Upgradation (Innovation)

The **copper smelter plant transformation project by L&T** is a prime example of innovation in construction technology. By leveraging **cutting-edge tools like 3D laser scanning and digital twins,** the project ensures precision in capturing existing structural conditions and accurately planning upgrades.

3D modeling and 2D drawing generation allowed for seamless integration of new systems while addressing structural health through advanced distress mapping and health evaluations. This technology-driven approach ensures accurate assessments and a smooth execution process, reducing risks and optimizing the design and construction phases. **The plant's health was revived without affecting its production or operations, demonstrating a unique execution model that prioritizes operational continuity**.

2 Predictive Analytics for Efficiency - Data Lake Project Monitoring Software

Adopted by **Amnex Infotechnologies Pvt. Ltd**, the Data Lake software **enhances project monitoring and decision-making by forecasting risks, delays, and inefficiencies.** This data-driven methodology empowers stakeholders to anticipate challenges and take corrective actions early. The platform's integration with GIS-based geotagging and automated reporting further streamlines the management of infrastructure projects, ensuring that milestones are met efficiently and without unnecessary delays. This approach improves project outcomes and reduces the likelihood of cost overruns. The Data Lake software introduces **AI-driven insights that predict project delays, cost overruns, and inefficiencies before they occur, enabling better resource management and timely interventions.** It **automates approval workflows and integrates data seamlessly from various systems, enhancing operational efficiency and minimizing human errors**. Basis the success at NHAI, the platform is now being rolled out at the Ministry of Road Transport and Highways (MORTH) and National Highways and Infrastructure Development Corporation Limited (NHIDCL).

3 Fast connector for shore crane GSU grab rope end locking

In modern ports, bulk cargo handling cranes have been developed to be grabs, and capacity featuring advanced and sophisticated operation systems for handling bulk cargo. Consequently, the sizes of cargo handling grabs and wire ropes have increased from 12 mm / 10 CBM to 55 mm / 44 CBM and beyond. The grabs are designed with a clamp shell-based open and close mechanism, requiring an additional two ropes with a pulley system for open – close operation. During the wire rope winding inside the grab, one end must be connected to the crane's wire rope, while the other end needs to be locked inside the grab, either on the lower or upper side, depending on the number of folds in the system.

Adani has adopted a fast-connecting method that features a slot with a permanent locking arrangement, allowing a wire rope with an end-casting setup to be securely locked in place without the need to remove the major connecting block, unlike conventional wedge locking systems.

This innovation **cuts working time by 80%,** halves manpower costs, boosts safety, and **reduces operation time from 10 to 5 hours**. With a **₹36 lakh cost and 20 MT capacity**, the Fast Connector greatly improves port efficiency and cost-effectiveness.

4 A constellation of Innovative Construction technologies adopted at Udhampur–Srinagar–Baramula Rail Link (USBRL)

The USBRL Project is an engineering marvel, undertaken in the challenging Himalayan terrain and regarded as the most complex infrastructure project post-independence by Indian Railways. To enhance safety and operational efficiency, an integrated SCADA (Supervisory Control & Data Acquisition) system has been implemented. For the first time in Indian Railways, **ballastless track (BLT) technology was being used across bridges, tunnels, yards, embankments, and cuttings in the Katra-Banihal section, ensuring durability and reduced maintenance.** The section is **fully electrified with a Rigid Overhead Conductor System (ROCS) inside tunnels**, improving reliability and simplifying infrastructure maintenance. Canted turnouts with thick web switches and weldable CMS crossings have been introduced in station yards, offering smoother and faster rides compared to conventional turnouts. **High-altitude traction substations at Qazigund, Budgam, and Baramulla** have been designed with specific modifications such as increased air clearance and customized insulating oil requirements.

Advanced safety and communication systems have been deployed, including the use of FR-LSZH (Fire Retardant Low Smoke Zero Halogen) cables per UIC standards. Tunnel communication is facilitated through VHF leaky cables for both MT and ET, with emergency call (SOS) phones and service telephones (ST) every 200 meters, and a public address (PA) system every 50 meters in a staggered manner. **Additionally, Multi-Section Digital Axle Counters (MSDAC) have been implemented across the Katra-Banihal section, eliminating glued joints and rail holes.**

5 Computable General Equilibrium (CGE) model

Adopted by the **University of New South Wales, Australia**, this **national-scale Computable General Equilibrium (CGE) model** serves as a cutting-edge technological tool for **assessing the economic impact of transport infrastructure, with a focus on freight movement, GDP growth, and regional equity.** This model has been instrumental in analyzing major infrastructure projects such as **India's Dedicated Freight Corridor (WDFC) and expressways like Amritsar–Jamnagar and Delhi–Katra**, offering valuable insights into transport efficiency and investment planning. By leveraging data-driven analytics, the CGE model enables policymakers to optimize infrastructure investments, enhance freight logistics, and create a balanced regional economic strategy. It supports strategic infrastructure planning by demonstrating how transport projects contribute to economic productivity, trade efficiency, and national growth. Additionally, it plays a crucial role in improving freight movement, optimizing supply chains, and enhancing logistics efficiency through advanced modeling techniques. The model provides a data-backed framework for informed policy and investment decisions, allowing government agencies like the Ministry of Transport, NITI Aayog, and Indian Railways, as well as private sector stakeholders, to forecast market dynamics, assess freight demand, and optimize transport networks effectively.

6 Structural Health Monitoring for Bridges

Medulla Soft Technologies has adopted this monitoring tool, at the Jagannath Shankarseth and Keshavasoot Flyovers, Dadar (Mumbai), which integrates advanced fiber-optic technologies and vibrating wire sensors to deliver **comprehensive structural health monitoring solutions for bridges**. By providing real-time, reliable data, these systems **enhance security and maintenance efforts**, ensuring the ongoing structural integrity of bridges. The use of such technology helps **extend the lifespan of aging bridges by accurately assessing their condition and identifying the need for repairs**. Additionally, it ensures quality assurance by verifying that both new and existing bridges meet design specifications. This approach also improves the understanding of complex and unique bridges, facilitating better management and safety. Moreover, the system enables immediate assessment of bridge safety following major events like earthquakes, impacts, storms, or explosions, ensuring swift responses to potential damage.

7 Unconventional Construction approach of the Mumbai Trans Harbor Link powered by Innovation

The L&T team opted for the utilization of **specially designed back to back piling gantries for the construction of the Temporary Access Bridge (TAB).** Equipped with hydraulic rigs and cranes, these gantries replaced traditional methods.

The outcome was remarkable with a notable improvement in the time cycle, reducing it to just

1.5 days per span

To tackle piling challenges effectively, integrated Reverse Circulation Drilling (RCD) Rigs, were adopted yielding significant advantages. This foresighted approach successfully navigated geological uncertainties, enabling the completion of approximately 6.3 kilometers of boring in Strong Basalt (hard rock) with a remarkable Rock Quality Designation (RQD) surpassing 60%, reaching depths of up to 47 meters. **Moreover, the utilization of RCD Rigs led to reduced noise and vibrations, showcasing its eco-friendly attributes. Furthermore, this upgraded technology streamlined operations, resulting in an optimized time cycle of just 3 days per pile per RCD, accelerating the construction process.**

The adoption of sacrificial precast shells method for OSD (Orthotropic Steel Deck) Pile Caps eliminated the need for constructing coffer dams, which typically demands substantial resources, effort, and time. As a result, the Project realized considerable time savings, with at least 60 days saved for each pile cap. The Team implemented an array of cutting-edge tools such as PROCUBE for online progress monitoring, pre-cast segment tracking, E-Tap, OSD panels tracking, drone photogrammetry, GIS live tracking, IoT-AIS, and Conease. **This real-time tracking of manpower, materials, and P&M assets minimized idling and wastage, while improving utilization and productivity.**

8 Double Decker Viaduct in Nagpur Metro Rail Project Phase-I

The Double Decker Viaduct by MahaMetro has Metro Rail at the top, Highway Flyover in the middle level and the existing road at the ground level for a length of 5.637 km. This engineering feat, constructed amidst heavy vehicular traffic, has eliminated additional land acquisition thereby saving land cost, resettlement & rehabilitation cost and enabled early start of construction.

This innovative design has also minimized the effect on urban landscape and footprint on land while also reducing construction time & cost and Travel time by

50%

Structurally, the viaduct includes a spine and rib structure for the 4-lane carriageway, supported by POT-PTFE bearings. It features approach ramps, an 80m obligatory truss span, and varying pier sizes depending on the section. A pile foundation (1,200 mm dia.) supports the structure, while the highway flyover utilizes a Spine & Rib type superstructure, with prestressed spine and rib segments carefully erected and stitched to ensure stability.

9 India's first Precast Track slab system for High-Speed Urban Transit

L&T has executed the Ballastless Slab track works including manufacturing, supply, and installation for the entire stretch of 81 rkm/209 tkm (137 tkm on Viaduct, 23 tkm in UG and 49 tkm of Depot Tracks) of the RRTS Delhi -Ghaziabad –Meerut track.

Through Technology transfer from PORR (Austria), L&T has adopted **a Pre-Cast Slab Track System to enable higher speed, increased service life and maintainability**. The Pre-Cast Slabs, each measuring over 5 m x 2.5m and weighing over 4 tons are **produced in a factory-controlled setup**.

The project incorporates high level of Digital Technologies for sub-system management, Slab Traceability and Supply Chain Management. Digital innovations, such as the SDS Precast Slab Tracking Application and the FARO® Vantage E6 Laser Tracker system, enhance slab quality control and reduce rejections. The construction process also features innovative methods, including concrete transportation via RRV pumps and a concrete flying bucket for efficient filling of moulds. The bidirectional gantry system offers operational flexibility, eliminating the need for additional equipment to move slabs. Furthermore, a 20-ton self-propelled rail-cum-road crane is used for installing track slabs, ensuring smooth and efficient operations across varied environments.

The project achieved significant cost savings through innovations such as **Achieved 15% lower linear TCB costs** via optimized plant, land, and fuel use; **20% savings with localized moulds**; and **50% savings through indigenous CAM injection** car production. **Modular formwork allowed 10x reuse**, while automation and dual slab handling cut gantry costs and boosted efficiency.

Environmentally, Trolley-based movements and **battery-operated equipment saved 5 lakh L diesel and 3.35 lakh L LDO, cutting CO_2 emissions by 2,100+ metric tonnes.**

Productivity more than doubled, with slab output rising from 30 to 66 per day, handling time halved, and transport capacity doubled.

Modular systems and the Yard on Viaduct setup further improved efficiency and consistency. This combination of advanced technology and innovative construction techniques makes the RRTS project a milestone in India's infrastructure development.

10 Japanese Shinkarisen technology adopted at Mumbai- Ahmedabad High Speed Rail T3

The Mumbai-Ahmedabad High-Speed Rail (MAHSR) T3 project, executed by L&T, marks a significant milestone in India's infrastructure journey, introducing **world-class high-speed rail systems based on Japanese Shinkansen technology**. Encompassing 116 route kilometres, the T3 package has set new benchmarks in sustainability, innovation, and localization. **For the first time in India, Linear Track Construction Bases (TCBs), automated slab casting systems, indigenously developed advanced track laying machinery, and digitally controlled steam curing technologies were implemented to enhance operational efficiency and significantly reduce environmental impact.**

The project realized several measurable outcomes in terms of productivity, cost and sustainability.

Cost Savings through adoption of

- **Linear TCBs:** 15% cost reduction achieved by optimising the requirement of P&M, additional land and fuel.
- **Localized moulds:** 20% cost reduction by indigenising track slab moulds also improved service.
- **CAM Injection Cars:** 50% cost reduction, via indigenous production.
- **Dual slab handling and automation**: Avoided costs of additional gantries and improved resource utilization.

Sustainable impact through

- **Linear TCBs and trolley-based slab movement** saved **~5 lakh litres of diesel, reducing CO_2 emissions by 1250 metric tonnes.**
- **Battery-operated rebar trolley** saved 23,400 litres of diesel: **100% carbon emission reduction in that operation.**
- **Automated steam curing** eliminated 3,35,800 litres of LDO, **reducing the carbon footprint by 900 metric tonnes.**

Conventional to Sustainable and Innovative Approach: A Costly transition?

Voice of Contractors / Developers / Manufacturers:

On contrary to the belief that the transition from conventional methods to sustainable and innovative solutions is hindered only because of the **High initial cost** involved, some of leading Infrastructure Contractors and Developers of the country have brought to focus the finer bottlenecks impeding this transition.

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> Lack of Awareness, acceptance hindering Mindset shift for adoption of new, innovative, sustainable methods/ materials

> Lack of flexibility in Indian Construction Codes that allow adoption or exploration of innovative and sustainable materials/ methods / technologies.
>
> Dearth in training and upskilling of construction workforce on modern, innovative practices and the gap in enforcement of such trainings from the top level.
>
> The existing mix of manual and fragmented processes in mega infrastructure construction affecting the speed, precision and quality standards of the project execution

LARSEN & TOUBRO LIMITED Engineering Construction & Contracts Division

Welspun ENTERPRISES

> Achieving the appropriate balance between innovative design elements and regulatory norms

In the rapidly evolving urban fabric, growing population and congestion, Infrastructure development without disturbing the normal city or rural life, traffic movement has become rudimentary.

Recommendations to the Government

Sources suggest that the real estate and construction sectors amount to 32% of the total green house gas emission in India. However, the Nationally Determined Contribution (NDC), a significant part of the UN's Paris Climate Agreement , has not setforth specific targets for the Built Environment. The ongoing initiatives and codes under the GoI such as AMRUT, Swach Bharat Mission, Energy Conservation Building Code, Eco Niwas Samhita (ENS) focus predominantly on the carbon emissions during operational phase and not on the embodied carbon. **There is a need for a foresighted regulatory approach to progressively reduce carbon emissions instead of spending on upfront emissions.**

- While construction continues to be labour intensive, the skillset requirement has changed drastically over the years with the intervention of modern technology and AI. Nonprofit and government organizations like the National Skill Development Corporation and Skill Council for Green Jobs can **drive upskilling initiatives through a mix of classroom and on-the-job trainings for construction workers**.

- The Indian Net zero target is hinged upon the efficacy of the Construction industry's policy and regulatory framework. There is a need for a top-down approach from the Government in mandating policies that address the construction value chain focused on

    a. Incentives for adoption of material
    b. Alternate procurement methods to prinnovative, sustainable practices
    c. Encourage low carbon construction omote low carbon contractors/ developers/ vendors – Sustainability, Quality cum Cost Based selection (SQCBS) instead of the QCBS
    d. Promoting circularity in construction
    e. Strengthening reporting and governance protocols

Infrastructure Construction codes need to be revamped with focus on the entire construction lifecycle such as specifications of sustainable materials, defined limits for maximum carbon emission per unit at source of raw material extraction, specifications for sustainable alternatives for vehicles, plants and machinery used in

construction, standardization of practices for recording carbon capture during construction. In comparison to Infrastructure construction, real estate construction is more aligned to sustainable and innovative construction through codes and initiatives such as National Building code of India 2016, Eco Niwas Samhita, Star rating of Commercial buildings by Bureau of Energy Efficiency, Green rating of Integrated Habitat Assessment (GRIHA) etc.

Conclusion

Mr. Vaibhav Dange

Founder Build India
Public Policy Expert on Infrastructure,
Green Fuels & Sustainable Mobility

As India charts its course toward becoming a $30 trillion economy by 2047, infrastructure will remain a critical lever in realizing the aspirations of a Viksit Bharat. However, the journey from ambition to achievement will demand not just scale—but a deep-rooted shift in the way we build.

Through this paper, we have seen how innovation and sustainability are no longer future aspirations; they are present-day imperatives. The stories showcased—from bio-bitumen to floating solar, cold mix roads to modular STPs—demonstrate that India is already home to solutions that cut emissions, reduce costs, and accelerate productivity. What we now need is a more enabling ecosystem that helps these innovations become the norm, not the exception.

While high initial cost is often cited as the biggest roadblock to sustainable construction, our interactions with industry leaders tell a deeper story. The lack of awareness, the rigidity of our construction codes, the fragmented nature of execution, and insufficient skilling at the grassroots level are the real bottlenecks. These are not technical limitations—they are systemic and structural in nature. And therefore, they require systemic and structural solutions.

We must rethink how we evaluate bids—not just on the basis of cost and time, but through the lens of long-term sustainability. We must empower our codes to allow innovation rather than stifle it. We must recognize and reward circularity, carbon accounting, and lifecycle impact. Most importantly, we must invest in building a future-ready workforce—equipped not only to adopt modern materials and methods, but to advocate for them.

To address these challenges, it is imperative to adopt a comprehensive policy approach that reflects the full lifecycle of infrastructure—from raw material sourcing to end-of-life disposal. A clear integration of embodied carbon accounting, into regulatory frameworks is essential to achieving our Net Zero goals.

The Build India Infra Awards aim not just to celebrate excellence, but to catalyze a larger movement. A movement that champions a construction culture where **efficiency does not come at the cost of sustainability, and where innovation is not seen as risk, but as responsibility**.

Let us move from pilots to policies, from best practices to standard practices. The time to act is now—not just to build infrastructure, but to build the India we aspire to become.

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for providing solutions to help clients achieve their goals

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for all and alternate viewpoints

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of thoughts and actions

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India Offices

Bengaluru
91 Springboard
Business Hub 175, 176
Bannerghatta Rd,
Dollars Colony,
Bengaluru – 560076

Chandigarh
2nd Floor, Netsmartz,
Plot No. 10, Rajiv
Gandhi Chandigarh
Technology Park,
Chandigarh – 160019

Chennai
147, Pathari Rd, Door #3,
WorkEz Hansa Building,
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Chennai, TN - 600006

Delhi
1 to 7, UG Floor,
Tolstoy House,
Tolstoy Road,
Connaught Place
New Delhi - 110001

Kolkata
Siddhartha Apartments
4th Floor, 188/2,
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601, 6th floor,
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MH - 400021

International Offices

Dubai
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www.primuspartners.in | info@primuspartners.in | Primus Partners India | @partners_primus | @primuspartners7128

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