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Revolutionizing India's Road Infrastructure: A Vision for the Future

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Revolutionizing
India's Road Infrastructure:

A Vision for the Future

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MINISTRY OF ROAD TRANSPORT HIGHWAYS

Message

I am pleased to learn that the Highway Operators Association of India (HOAI) has prepared a White Paper titled *"Revolutionizing India's Road Infrastructure: A Vision for the Future"*, which reflects key submissions from the day-long seminar held on 03rd March 2025. As India takes rapid strides towards becoming one of the largest economies in the world by 2047, robust operations and maintenance of the National Highway framework plays a critical role in ensuring that the network remains reliable and effective in supporting economic growth.

Over the years a strong foundation of National Highway development has been laid in the country. Today, around 71 percent of India's freight is transported through road, making it one of the most critical components of infrastructure for driving economic growth.

To ensure improved riding experience for National Highway users, emphasis is laid on the use of technology for predictive maintenance through Network Survey Vehicles, Drone based analytics, Advanced Traffic Management System, Electronic Toll Collection and mobile applications like NHAI One app and *Rajmargyatra* app. These initiatives have further transformed India's transportation and logistics landscape, making travel and freight movement more efficient, and sustainable.

Providing a holistic methodology for future infrastructure growth in the country, the Government of India is developing 'Vision 2047' for implementing high-speed corridor network with a focus on enhancing ease of commuting, logistics efficiency and multi-modal connectivity. Under 'Vision 2047' the high-speed corridor network will increase from 11,308 km at present, to over 50,000 km by 2047.

I am pleased to note that this White Paper offers insights into the integration of technological innovation, ecological responsibility, and inclusive growth for the operation of National Highway framework.

Creation of this white paper by HOAI is a welcome step as this approach will not only help to enhance efficiency but also present a roadmap that will advance transformative and sustainable growth for a future-ready National Highway network across the country.

(Santosh Kumar Yadav)

विशाल चौहान, आईएएस
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सड़क परिवहन और राजमार्ग मंत्रालय

National Highways Authority of India
MINISTRY OF ROAD TRANSPORT HIGHWAYS

Message

It gives me immense pleasure to extend my heartfelt congratulations to the Highway Operators Association of India (HOAI) on the release of their white paper for the National Conference **"Revolutionizing India's Road Infrastructure: A Vision for the Future,"** held on March 3, 2025. This initiative is a testament to HOAI's commitment to fostering crucial dialogue among the industry, government, and academia, all working towards the shared goal of enhancing road safety and significantly reducing accidents across our nation.

I had the distinct honor of chairing the session on **"Innovation & Safety,"** a segment that truly underscored the transformative potential of advanced technologies in our road infrastructure. The discussions were particularly insightful, especially those revolving around **"Smart Roads and AI Solutions."** We delved into how artificial intelligence can revolutionize traffic monitoring, providing real-time data and actionable insights that were once unimaginable. Furthermore, the exploration of **predictive safety systems** highlighted a proactive approach to accident prevention, moving us from reactive measures to foresighted interventions.

Our esteemed speakers shed light on critical aspects of **"Safety, Systems & Audit."** Their expertise illuminated the importance of robust frameworks and rigorous audits in ensuring the highest standards of road safety. The session also benefited greatly from the discussions on **"Best Practices Aligning Policies with Technological Advancements,"** reinforced by compelling case studies from the West. These examples provided valuable blueprints for how we can integrate cutting-edge technologies into our existing policies and regulatory frameworks, ensuring that innovation translates directly into tangible improvements on our roads.

The insights gleaned from this conference and encapsulated in this white paper are invaluable. They serve as a powerful catalyst for collaborative action, guiding us towards a future where India's road network is not only expansive but also exceptionally safe and efficient. I commend HOAI for taking this vital step and look forward to the continued implementation of these revolutionary ideas for the betterment of every road user.

(Vishal Chauhan)

Message from **President** and **Vice President**

It is with great pride and gratitude that we forward herewith a copy of the White Paper titled **"Revolutionising India's Road Infrastructure – A Vision for the Future"**, jointly developed as part of the initiative organised by MoRTH and NHAI.

We extend our sincere thanks to the Secretary – Ministry of Road Transport & Highways, Chairman – NHAI, all esteemed members of HOAI and Govt. authorities who actively participated and demonstrated their commitment to shaping the future of India's road infrastructure.

This White Paper captures the transformative potential of emerging and future-ready developments shaping India's road ecosystem. These include the use of **sustainable and alternative materials** such as **Reclaimed Asphalt Pavement (RAP)** and **plastic waste,** as well as innovations like **geosynthetics, cold mix technologies,** and **low-carbon concrete solutions** that can drastically reduce the environmental footprint of highway construction and maintenance. On the operational front, advancements such as **Multi-Lane Free Flow (MLFF) tolling,** the **integration of drone technology** for real-time monitoring and asset management, and the proposed **Annual Pass Scheme** are expected to usher in a new era of efficiency, transparency, and user-centricity. For road operators like us, these initiatives are a welcome step toward streamlining tolling systems, minimising congestion, improving safety, and elevating the overall road user experience to international standards.

As the Highways Operators Association of India (HOAI), we reaffirm our strong commitment to working alongside the government to bring in the best technologies, systems, and operational practices. Our focus remains on improving India's road ecology and delivering road infrastructure at par with global standards.

We look forward to furthering this partnership and contributing meaningfully to the journey ahead.

Dr. Harikishan K. Reddy
President - HOA(I)
Chairman - Cube Highways and
Transportation Assets Advisors Pvt. Ltd.

Dr. Zafar Khan
Vice president – HOA(I)
Joint CEO - Highway Concessions One

Acknowledgement

A Vision for India's Highways:
Reflections from the National Seminar

Dear Colleagues of Indian Highways Infrastructure Fraternity,

It is with immense pleasure that I reflect upon the resounding success of the National Seminar, **"Revolutionizing India's Road Infrastructure: A Vision for the Future,"** jointly organized by the Highway Operators Association of India (HOAI), the National Highways Authority of India (NHAI), and the Ministry of Road Transport & Highways (MoRTH). This pivotal event provided a crucial platform for robust discussions and collaborative foresight into India's highway trajectory.

The seminar explored vital themes, from current **policies and regulatory frameworks** and **asset monetization** strategies like InvITs, to cutting-edge **technological advancements.** We delved into leveraging **drone and NSV analytics,** implementing **advanced tolling systems** such as Multi-Lane Free Flow (MLFF), and harnessing **AI and IoT** for smarter operations and maintenance. Crucially, sessions also focused on **skill development,** fostering **industry-academia collaboration,** and prioritizing **highway safety** through smart systems and audits.

My vision for India's highways, strongly echoed during the seminar, rests on five key pillars:

Key Pillars for the Future

- **Building Connectivity and Resilience:** Expanding our national highway network for economic boost and social inclusion, while prioritizing **climate resilience** and **multimodal integration** with other transport systems.
- **Driving Innovation and Technology Adoption:** Embracing **smart highways** with AI and IoT for optimized traffic and safety, accelerating **advanced tolling systems,** and promoting **sustainable construction practices.**
- **Strengthening Policy and Regulatory Framework:** Streamlining processes, maximizing **asset monetization,** developing a robust **sustainability framework,** and bolstering **Public-Private Partnerships.**
- **Bridging the Skills Gap and Empowering the Workforce:** Investing in **skill development programs** and fostering **industry-academia collaboration** to build a future-ready workforce.
- **Prioritizing Highway Safety:** Implementing **smart safety systems,** conducting regular **road safety audits,** and launching impactful **public awareness campaigns.**

The white paper resulting from this seminar has consolidated these invaluable insights, serving as a comprehensive roadmap for a future where India's highways are not just vital arteries of commerce, but exemplars of progress, safety, and technological leadership. I extend my sincere gratitude to all participants for their invaluable contributions. Together, we are paving the way for a more connected, resilient, and sustainable India.

Best Wishes

Col Rajeev Sood (Retd)
Secretary General
Highway Operators Association of India

Message from
Global CEO, ROADIS

India's road infrastructure sector is undergoing a powerful transformation, driven by ambition, innovation, and scale. With a rapidly expanding national highway network and a bold embrace of innovation, the sector is setting new global benchmarks in quality, safety, and impact.

Flagship programs like PM Gati Shakti, Bharatmala, and the National Infrastructure Pipeline have accelerated world-class road construction, enhanced mobility, and unlocked new avenues for investment and economic growth. This momentum is powered by strong public-private collaboration.

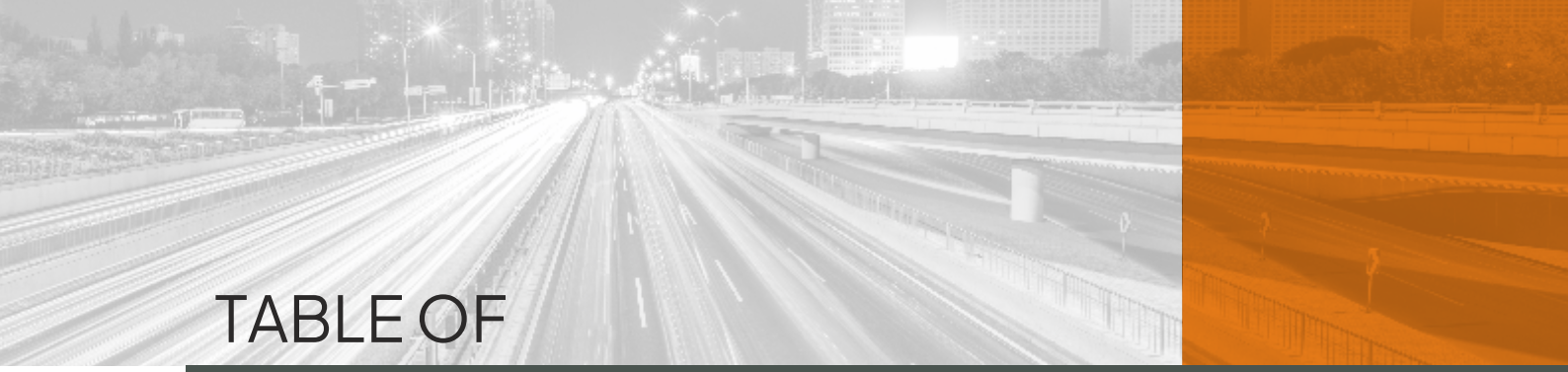
Safety is at the forefront, reinforced by cutting-edge technologies such as AI-driven traffic monitoring, predictive maintenance, and rapid emergency response systems. These innovations are not only enhancing operational efficiency but are also critical to achieving our shared vision of zero road fatalities by 2040.

As we celebrate this remarkable progress, it's vital to address the challenges that come with scale. Execution bottlenecks and regulatory hurdles call for urgent reforms, including streamlined single-window clearances and supportive policies.

Beyond highways, roads are catalysts for socio-economic progress. Industry efforts in local skill development, improved healthcare access, and educational outreach are driving more equitable and sustainable outcomes.

As we look ahead, HOAI and its member organizations reaffirm their commitment to building infrastructure that is not just world-class in scale, but also in safety, sustainability, and social impact. Through continued innovation, responsible policies, and united action across government and private sectors, we are confident in realizing India's vision of intelligent, inclusive, and resilient road networks that will power the nation's growth for decades to come.

Shri José Antonio Labarra Blanco
Global CEO, ROADIS



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CHAPTER 1.

PREAMBLE

1.1 Background

India's road infrastructure serves as the backbone of its economic growth, with a vast network spanning over 1.46 lakh kilometers of national highways. This critical infrastructure handles a substantial portion of the nation's traffic and freight movement, directly supporting the economy. The National Highways Authority of India (NHAI) has achieved remarkable progress in highway construction, with ambitious plans for continued network expansion.

However, this growth faces multiple challenges. The sector grapples with sustainability concerns, safety issues, and a widening gap between infrastructure demands and available skilled workforce. Maintenance of existing assets remains an ongoing concern, requiring significant investments and innovative approaches.

To address these challenges, the sector is embracing modernization through technological adoption and policy innovations. Asset monetization initiatives are creating new funding avenues, while advanced solutions are being implemented to enhance efficiency and sustainability. collaborative efforts between government, industry and educational institutions are being strengthened to develop future-ready infrastructure and workforce capabilities.

With this intention of collaboration, the Highway Operator's Association of India (HOAI) in association with the Ministry of Road Transport and Highways (MoRTH) has arranged a one-day conference on "Revolutionizing India's Road Infrastructure: A Vision for the Future". The conference has seen effective stakeholder participation of more than 200 participants from the highway industry including key policymakers and senior members of authorities such as MoRTH and NHAI, leaders and project teams of HOAI member organizations, researchers, representatives of financial institutions and consultants across the country.

1.2 Themes of Panel Discussion

A series of five compelling and thought-provoking panel discussions were convened, featuring eminent experts and senior leaders in their respective fields. The discussions centered on transforming India's road infrastructure through technology adoption, sustainable practices, and collaborative governance while addressing critical gaps in skilling, asset monetization, and maintenance efficiency. Experts emphasized public-private partnerships and innovative financing models to build future-ready highways that balance economic growth with social and environmental responsibility. The panels collectively charted a roadmap for safe, smart, and inclusive road networks to support India's development ambitions:

- **Panel Discussion 1**- Policy and Regulatory Framework – A Vision for the Future
- **Panel Discussion 2**-The Future of Asset Management Financing: Trends, Challenges, and Opportunities
- **Panel Discussion 3**- Smart Roads, Safer Journeys - Innovations in Highway Safety
- **Panel Discussion 4**- Roads of Tomorrow - Pioneering the Future with Technology
- **Panel Discussion 5**- Bridging the Skills Gap - Preparing India's Workforce

1.2.1 Agenda of the Conference

Inaugural Session

Welcome Address

Dr. Harikishan K. Reddy, President, HOAI & Chairman, Cube Highways and Transportation Assets Advisors Pvt. Ltd.

Industry Address

Shri José Antonio Labarra Blanco, Global CEO, ROADIS

Keynote Addresses

Shri Santosh Kumar Yadav IAS, Chairman, National Highways Authority of India (NHAI)

Shri Vinay Kumar IAS, Additional Secretary, Ministry of Road Transport and Highways (MoRTH)

Panel Discussion

1

Policy and Regulatory Framework – A Vision for the Future

Chair – **Shri Alok Dipankar,** Member -Technical, National Highways Authority of India

1. MoRTH/NHAI Current Policies/Circulars - Gaps and Suggestions for the Future -**Smt. Esther Malini Victor**, Head Contracts & Client Relations, Sekura India Management Ltd
2. Roadmap for Asset Monetisation- **Shri Abhishek Chhajer**, CFO, Highways Infrastructure Trust
3. Model InvITs – How will they Impact the Road Scenario?- **Shri Kranti Mohan**, Partner, Head - REITs and InvITs, Cyril Amarchand Mangaldas
4. Policy and Framework for Sustainability - **Shri Bidur Kant Jha**, Director (New Technology for Highway Development), Ministry of Road Transport & Highways

Panel Discussion

2

The Future of Asset Management Financing: Trends, Challenges, and Opportunities

Chair - **Shri Rajendra Kumar**, Member -Finance, National Highways Authority of India

1. Innovative Financing Models for Sustainable Asset Management- **Shri Pradeep Ramakrishnan**, Executive Director, International Financial Services Centres Authority
2. Unlocking Capital through Asset Monetization: Lessons from the National Highway Monetization Programme- **Shri Ankit Jain**, CFO, Cube Highways Growth Advisory Pvt. Ltd.
3. Monetisation Pipeline vs Appetite of Investors - **Shri Muraleemohan M**, COO, Maple Highways

Panel Discussion

3

Smart Roads, Safer Journeys - Innovations in Highway Safety

Chair - **Shri Vishal Chauhan**, Member -Administration, National Highways Authority of India

1. Smart Roads and AI Solutions - AI for Traffic Monitoring, and Predictive Safety Systems- **Shri Dhiraj Sethi**, President - Safety, Systems & Audit, Cube Highways Technologies
2. Best Practices aligning Policies with Technological Advancements: Case Studies from the West- **Shri Anup Vikal**, CEO, Maple Highways
3. Interplay of International Best Practices in Indian Landscape: Learnings, Challenges and Benefits- **Shri Ramon Chessa**, CEO, Isadak

Panel Discussion

4

Roads of Tomorrow - Pioneering the Future with Technology

Chair - **Shri Rakhshit Jain**, CEO, Nxt-Infra

1. NHAI's Unified Digital Stack for Highway Monitoring and Management- **Shri Harsh Nisar**, Advisor IT, NHAI
2. Net-Zero Roads: Innovations in Sustainable Construction- **Shri Bovin Kumar**, CEO, Cube Highways and Transportation Assets Advisors Pvt. Ltd.
3. Navigating the Future of Tolling: The Impact and Opportunities of MLFF Technology - **Shri Amit Ranjan Chitranshi**, COO, Indian Highway Management Company Limited
4. Emerging Technologies in Highway Maintenance: AI, IoT, and Predictive Analytics - **Shri Ashwani Sharma**, Operations - Head, India, ROADIS

Panel Discussion

5

Bridging the Skills Gap - Preparing India's Workforce

Chair - **Shri Pawan Parikh**, CEO, Safeway Concessions

1. Construction Skills - Gap Analysis and Solution - **Shri Gaurav Bhasin**, VP-Strategy & Business Excellence, Safeway Concessions
2. Identifying Training and Skill Development Needs- A Case Study- **Shri Santosh Parulekar**, Co-Founder and CEO, Pipal Tree Ventures Private Ltd.
3. Fostering Industry-Academia Collaborations- **Dr. Ambika Behl**, Senior Principal Scientist - Flexible Pavements, CRRI
4. Empowering Communities: Impact on Skills and Livelihood- **Shri Anuj Maitrey,** Head - Operations, Cube Highways and Transport Assets Advisors Pvt. Ltd.

Valedictory Session

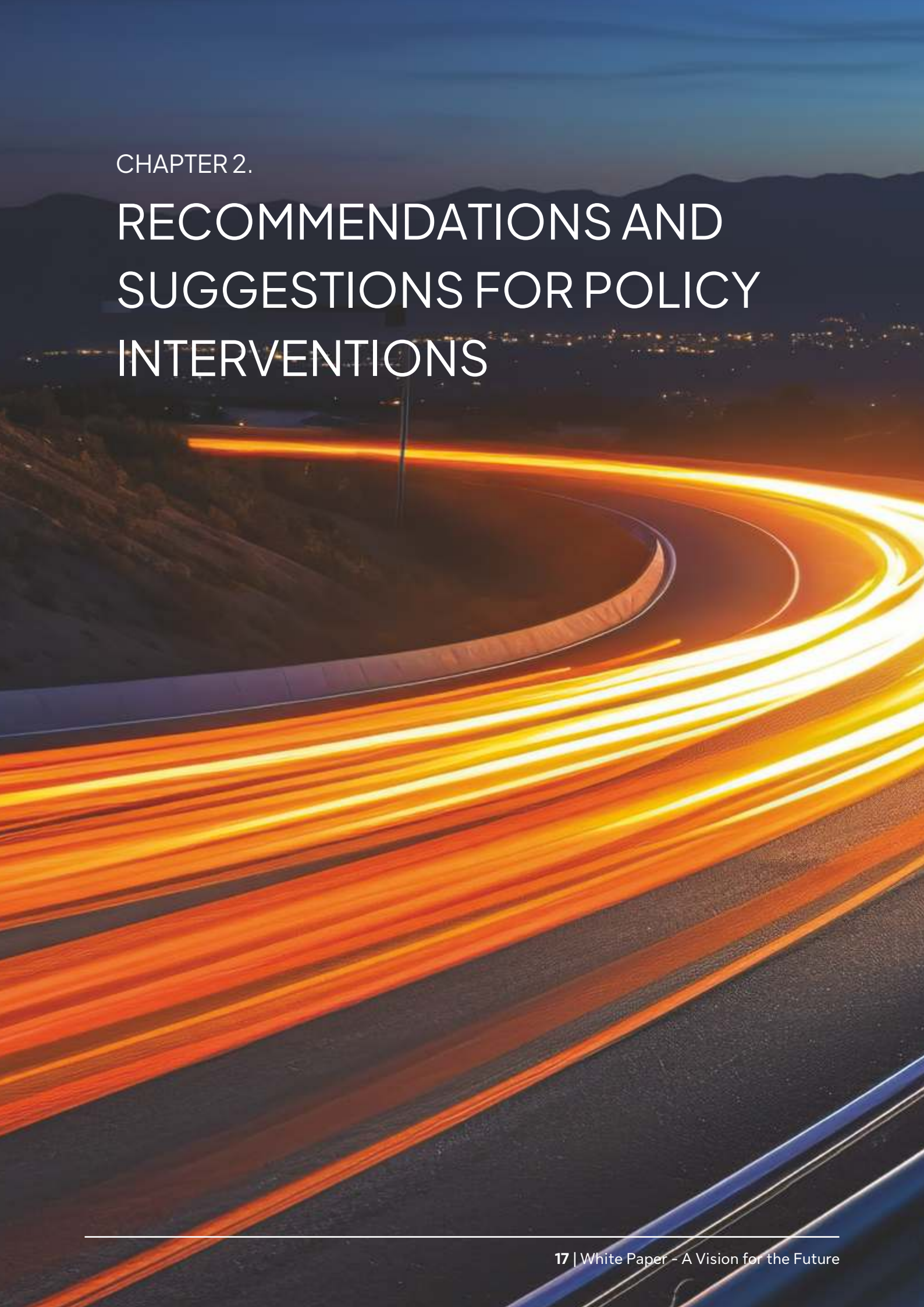
- Reflections on key takeaways and future direction for HOAI– **Shri Alvaro Santos Higuera**, CEO - Asia, ROADIS
- Vote of Thanks - **Col Rajeev Sood (Retd),** Secretary General, HOAI

1.3 Content of the White Paper

Highway Operators Association of India has appointed Cube Highways Technologies Pvt Ltd to summarise the conference proceedings and prepare the White Paper containing Revolutionizing India's Road Infrastructure: A Vision for the Future.

The structure of the White Paper is as below:

1. **Chapter 1:** Preamble- This chapter presents the theme and detailed agenda of the conference
2. **Chapter 2:** Recommendations and suggestions for policy interventions. Key recommendations and suggestions identified based on panel discussions and brainstorming are summarised in this Chapter for easy reference.
3. **Chapter 3:** A Vision for the Future. Key aspects of road sector development include policy frameworks, financing models, technology integration, construction practices, and skill development. It highlights emerging trends, challenges, and opportunities shaping a more sustainable, efficient, and inclusive infrastructure.



CHAPTER 2.

RECOMMENDATIONS AND SUGGESTIONS FOR POLICY INTERVENTIONS

2.1 Key Recommendations and Suggestions

Based on the discussion and brainstorming within key industry stakeholders consisting of senior leaders from investor platforms of HOAI members, lenders, practitioners, and researchers, following key recommendations and suggestions are put forward for the consideration of policymakers to move closer towards the objective of Revolutionizing India's Road Infrastructure.

Key Recommendations and Suggestions towards Policy and Regulatory Framework

Strategic Policy Interventions for a Robust and Future-Ready PPP Framework

- **Delink ownership changes** from contractual disputes and ensure efficient processing through high-level monitoring within NHAI.
- Standardize and expedite refinancing by introducing a structured checklist/guardrail and allowing provisional approvals based on concessionaire undertakings.
- Designate the **finance department** as the single point of contact for the entire process, including the signing of supplementary agreements, to avoid inter-departmental delays.
- Include **refurbishment and energy costs** in the COS framework, as these are integral to maintaining assets and are already factored into dispute resolutions.
- **Discourage outsourcing COS** works to third-party contractors when a concessionaire is active, to ensure quality and accountability.
- Acknowledge the value of concessionaire-executed works, given their design, operational role, and vested interest in long-term quality.
- Rationalize termination payment formula
- Address the lack of a compensation framework for delayed toll revision to avoid investor concerns
- Review and enhance the state support agreement, including standardizing stamp duty treatment and harmonizing tariff structures for highway lighting across states
- Industry-government joint task force for drafting and reviewing policy circulars

Optimizing Asset Monetization through Policy and Process Reforms

- **Ensure Project Transparency and Time-bound Process in Bidding:** Share complete project details (traffic/technical studies) at NIT stage and adopt a single annual pre-qualification process.
- **Unify Concession Terms across Models:** Standardize maintenance obligations and criteria across TOT and HAM to ensure fairness in bidding.
- **Streamline Refinancing and Ownership Norms:** Replace NHAI refinancing approval with simple intimation if debt terms are unchanged and allow InvIT ownership transfer without the two-year lock-in if the sponsor is the bidder.
- **Strengthen Revenue and Cost Baselines:** Use actual ETC/Schedule V revenues as a base and account for overlay, structural, and past O&M costs in DPR assessments.

Sustainable Road Development: Policy and Framework

- **Integrated Sustainability Principles:** Promote a balance of profit, people, and planet by aligning road development with Net Zero goals and ecological conservation.
- Adoption of eco-friendly materials &advanced technologies.
- **Green Construction Standards & Policies:** Implement IRC guidelines and national mandates for material innovation, resilience, recycling, and low-carbon construction.
- Encourage Quality-Cost Sustainability-Based Selection (QCS-BS) and R&D to drive durable, cost-effective, and climate-aligned infrastructure.

Key Recommendations and Suggestions for Asset Management Financing

Strategic Enhancements for Resilient Asset Monetization

- Ensure effective functioning of the Asset Monetization Committee to ensure realistic, market-aligned valuations by curbing inflated consultant estimates.
- **Mitigate Traffic Diversion Risks:** Reassess and recalibrate traffic loss thresholds dynamically based on concession period, regional patterns, and emerging competing infrastructure.
- Foster continuous dialogue with stakeholders to integrate feedback in bid processes, technical standards, and policy refinements for improved investor trust.
- **Promote Transparent and Adaptive Frameworks:** Uphold transparency and adaptability in asset monetization policies to attract long-term private investments.

Aligning Asset Pipeline with Investor Appetite

- Streamline bid execution and reinforce policy consistency to maintain momentum and facilitate smoother investor participation.
- Encourage new market entrants and re-engagement of previous bidders to widen the investor base and support healthy competition

Key Recommendations and Suggestions for Smart Roads and Safer Journeys

Strategic Roadmap for AI-driven Smart Road Ecosystems

- **Adopt and scale AI-powered safety system** including predictive crash analytics, real-time hazard detection, and ADAS/V2X technologies to improve safety.
- **Upgrade to smart infrastructure** with I2V systems and adaptive road designs (dynamic alerts, automatic braking zones) to enable predictive traffic management.
- **Implement AI-driven asset monitoring** through smart dashcams and IoT solutions for proactive maintenance and defect resolution.
- **Pilot and refine emerging monitoring technologies** such as DAS (for highways) and AI fog alerts, while addressing calibration challenges and implementation gaps.
- **Establish governance frameworks** addressing privacy concerns in vehicle monitoring systems and promoting standardization through stakeholder consultations.

Global Best Practices for Local Road Safety Challenges

- **Implement Vision Zero's ethical framework** with data-driven designs and shared responsibility models.
- **Usage of safety hardware** like TMAs with local features (LEDs, reflective markings) at high-risk locations.
- **Develop behavior-based interventions** targeting high-risk groups (truckers/motorcyclists), addressing fatigue and training gaps.
- **Apply Haddon matrix** analysis to implement cost-effective, human-centric safety designs addressing infrastructure-vehicle-user interactions

Roadmap for Enhancing Vehicle Safety

- Stricter implementation and robust compliance of vehicle safety regulations, including mandatory audits and penalties for non-adherence by manufacturers and fleet operators

Key Recommendations and Suggestions for Pioneering the Future with Technology

Sustainable & Tech-driven Infrastructure Solutions

- Adoption of existing sustainable road development practices and continuous R&D on alternative materials and technologies and their testing on a pilot project basis.
- **Regulatory Policies:** Strengthening regulations and providing incentives for the adoption of sustainable materials and technologies.
- **Upskill workforce** through training programs on sustainable techniques (automation, ITS) and launch public awareness campaigns to drive industry acceptance.
- Implement real-time monitoring systems to track emissions, material durability, and lifecycle sustainability metrics.

Reinventing Tolling for a Seamless Future

- Adoption of MLFF tolling with IHMCL-led technical support, ensuring revenue integrity through automated enforcement to create a frictionless tolling experience

Smart Maintenance of Highways

- Deploy AI-powered predictive maintenance using IoT/drones to detect defects 40% faster, prioritizing high-risk repairs for safer, cost-efficient highways.
- Mandate drone-based bridge inspections and embed smart sensors nationwide, automating 50% of manual checks and extending infrastructure life spans.
- Upskill workers in smart maintenance and establish "Smart Highway Standards" to ensure interoperability, data security, and scalable tech adoption.

Key Recommendations and Suggestions for Bridging the Skills Gap

Closing the Construction Skills Gap in Highway Infrastructure	- **Enhance productivity** through mechanization and targeted upskilling programs to enhance workforce efficiency. - **Increase industry appeal** by offering competitive wages and ensuring safe, migrant-friendly working conditions. - **Strengthen community partnerships** to align training programs with actual industry job requirements
Strategic Skill Assessment for Next-Gen Construction Teams	- Align training programs with industry demand through coordinated efforts among government, institutes, and private stakeholders. - Implement tiered training: Certify unskilled workers in safety basics, upskill experienced workers as supervisors, and develop in-house trainer teams with incentive wages. - Equip supervisors with AI tools: Provide mobile dashboards for defect detection, mandate video documentation, and automate discrepancy alerts.
Bridging the Innovation Gap	- Establish joint research centers with industry funding to focus on applied projects like sustainable materials and AI-powered infrastructure monitoring. - Create government incentives including tax breaks and grants to encourage private sector participation in collaborative R&D initiatives. - Launch technology testbeds on active infrastructure projects to pilot innovations like IoT sensors and climate-resilient designs before scaling.
Community-centric Highway Development	- Partner with ITIs and the government schemes to provide localized vocational training in toll operations, healthcare, and digital skills for rural communities near highways. - **Co-develop community infrastructure** including schools, women's hygiene facilities, and sustainable public spaces with local stakeholders. - **Drive local employment** by reserving highway jobs for locals and launch "Adopt-a-Highway" programs for community-led maintenance partnerships.

CHAPTER 3.

A VISION FOR THE FUTURE

3.1 General

This chapter presents an overview of key themes shaping the future of road infrastructure, policy, and technology. It covers a range of topics including policy frameworks, innovative financing models, advancements in construction practices, evolving tolling and maintenance technologies, and the growing role of digital systems in highway management. It also highlights the importance of aligning skills and training with industry needs, fostering collaboration between institutions and the sector, and supporting community development through skill-building initiatives. Each section offers a brief insight into current trends, challenges, and opportunities relevant to the sustainable and efficient growth of the road sector.

3.2 Policy and Regulatory Framework – A Vision for the Future

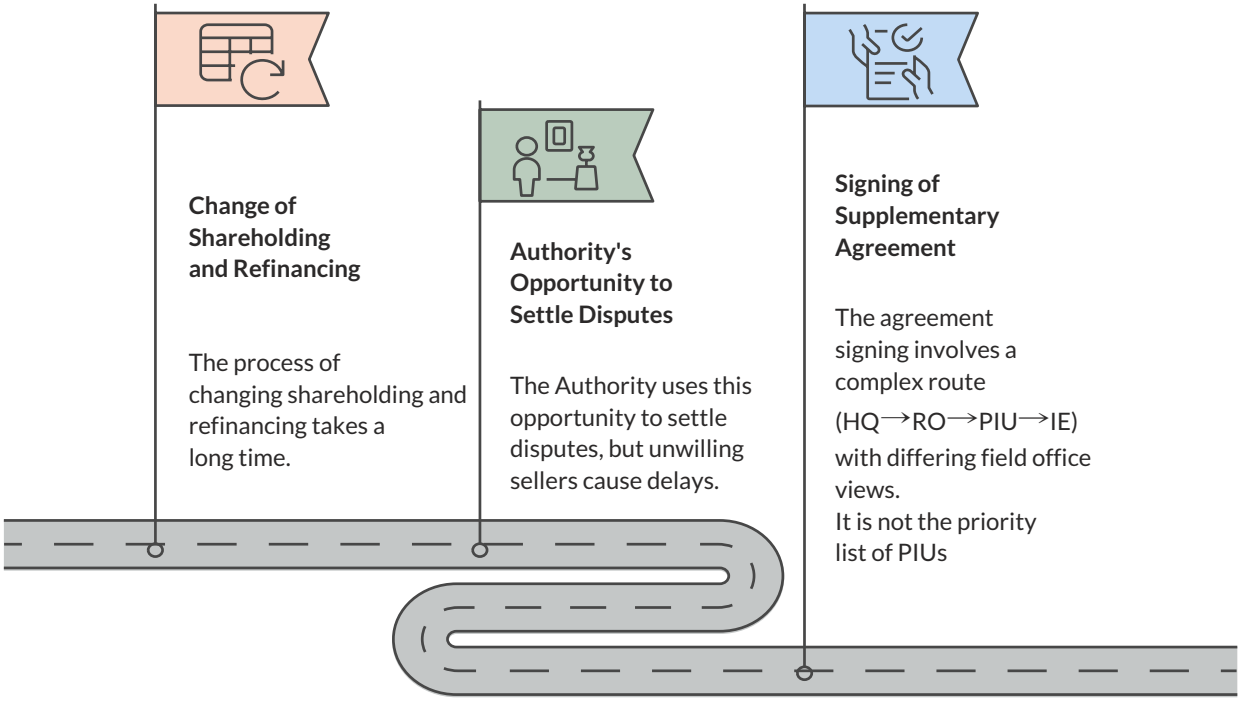
India's road infrastructure sector is undergoing significant transformation, driven by evolving policies and strategic regulatory reforms. A critical review of the current policies and circulars issued by authorities such as MoRTH and NHAI reveals areas where improvements can strengthen implementation, transparency, and long-term planning. At the same time, asset monetisation is emerging as a key instrument to unlock capital and ensure sustainable funding for future projects. The introduction of model InvITs (Infrastructure Investment Trusts) represents a shift in how road assets are managed and financed, potentially redefining operational efficiency and stakeholder engagement. Parallelly, there is a growing emphasis on formulating a comprehensive policy and framework for sustainability to ensure that infrastructure development is environmentally responsible and resilient. Together, these elements are shaping a progressive and future-ready regulatory landscape for the road sector.

3.2.1 MoRTH/NHAI Current Policies/Circular – Gaps and Suggestions for the Future

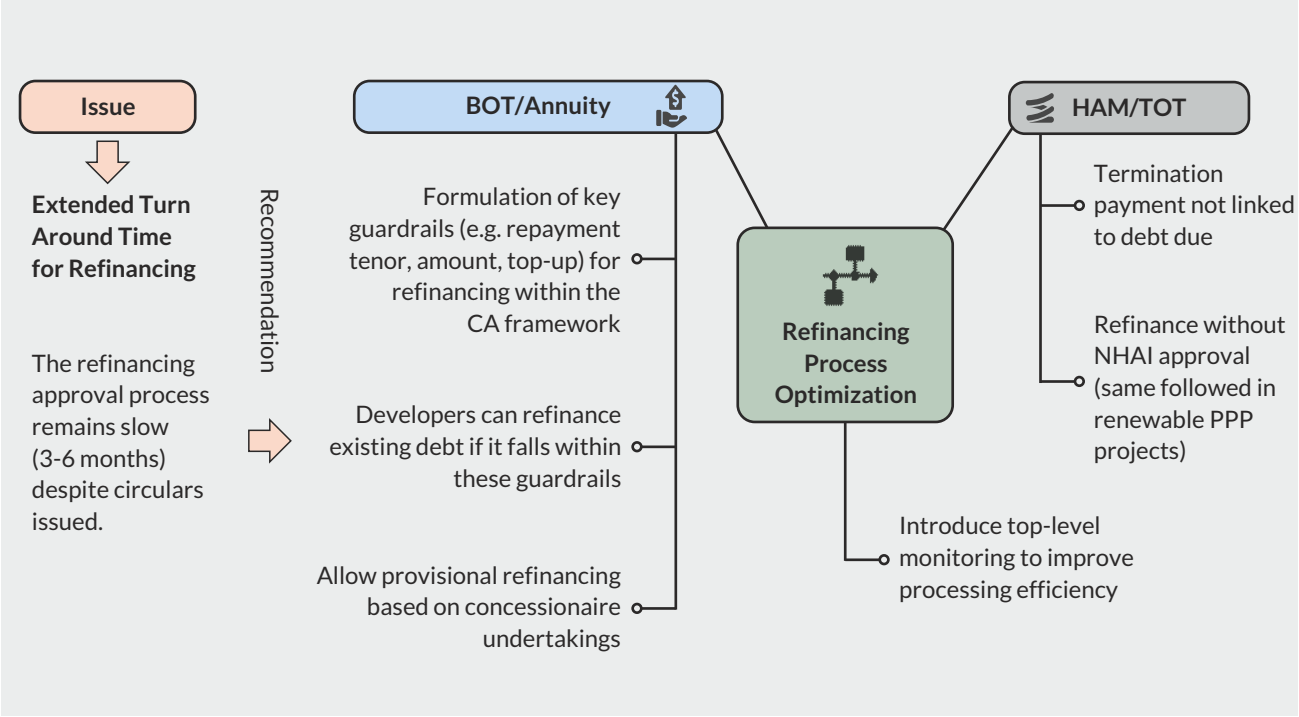
The effective implementation of infrastructure projects under public-private partnerships (PPPs) hinges on clear policies, streamlined processes, and balanced risk-sharing between authorities and concessionaires. Recent circulars and guidelines issued by the Authority aim to address critical aspects like shareholding changes, refinancing, scope variations, and termination payments. However, operational challenges in execution - including procedural delays, ambiguous cost calculations, and inconsistent enforcement - continue to impact project timelines and investor confidence. Identifying key gaps in current policies and procedures, particularly in three focal areas: shareholding/refinancing approvals, change of scope implementations, and termination payment computations, while proposing practical solutions will enhance the efficiency and fairness of contractual frameworks while protecting the interests of all stakeholders in highway development projects. The challenges faced by the Concessionaire with respect to NHAI circulars and SOPs are listed below.

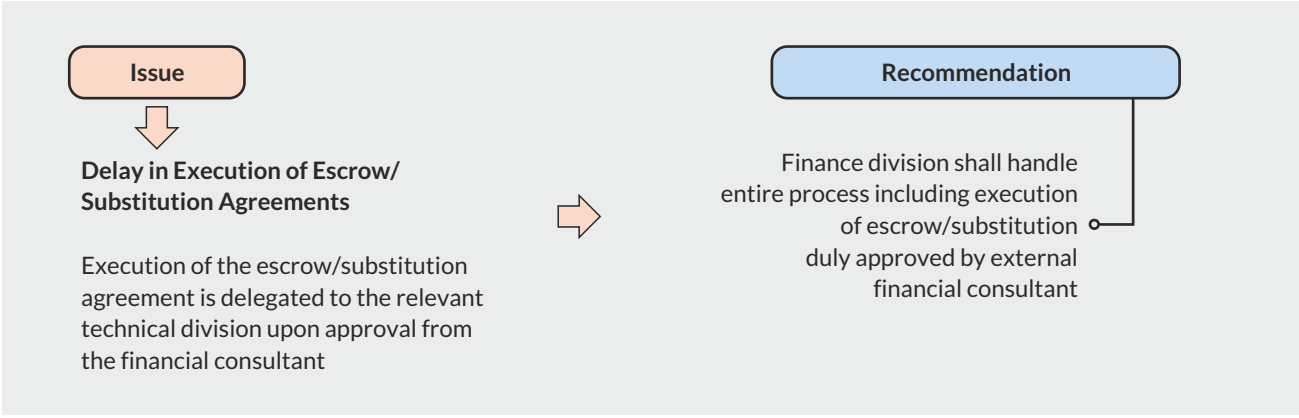
A. Change in Shareholding & Refinancing Challenges

The challenges encountered in 100% change of shareholding & refinancing in respect of PPP projects with respect to Circular No. NHAI/Policy Guidelines /PPP/2023 Policy Circular no. 8.4.38 dated February 13, 2023, is as follows.



Similarly, issues encountered concerning refinancing circulars/policies and suggested improvements are as follows.





B. Change of Scope (COS) Implementation Issues

COS guidelines in Circular No. NHAI/Policy Guidelines/PPP (DBFOT) No 8.3.36 dated 10.07.2020, lacks clarity on a few of the issues mentioned below.

- **Uncompensated Recurring Costs:** Concessionaires bear ongoing maintenance costs (OPEX) for added assets (signage, furniture, gantries) and lighting (energy/refurbishment costs), despite the Authority covering only one-time capex.
- **Unfair Cost-sharing:** Concessionaires are required to cover 50% of design charges for COS structures, even when Independent Engineers (IEs) handle the design.
- **Quality Compromises:** Awarding COS works to low-cost third-party EPC contractors leads to delays, poor traffic management, and user dissatisfaction.

Recommendations:

- **Include refurbishment costs for non-structural additions** (e.g., signage, road appurtenances) in the COS framework.
- **Incorporate energy costs** in COS circulars, as these are already considered during dispute settlements.
- **Discourage the practice of outsourcing COS works** to third-party contractors where an existing concessionaire is in place, to maintain quality and accountability.
- Recognize the **importance of concessionaire-led works,** where they have design and operational responsibilities and are committed to quality outcomes.

C. Flaw in Termination Cost Calculation

The current formula (Circular No. NHAI/Policy Guidelines/Financial Matters/2021 Policy Guidelines No. 8.4.24/2021 dated February 3, 2021) for Base Total Project Cost in under-construction BOT (Toll) projects is flawed as it deducts incomplete works costs from Actual Cost (which already reflects progress percentage), effectively double counting the deduction. This unfairly reduces termination payouts to concessionaires.

Base Total Project Cost = Min (FC cost, Actual cost, NHAI TPC) – cost of incomplete works

The formula should be revised to ensure accurate, fair compensation aligned with work completion status.

Base Total Project Cost = Min {FC cost, Actual cost, (NHAI TPC – cost of incomplete works)}

Key Challenges due to the Absence of Clear SOPs/Circulars:

- **User Fee Implementation Delays:** Postponement of revised user fees during elections (01.04.2024 to 02.06.2024) under the Model Code of Conduct has impacted industry trust in the Authority's contractual reliability.
- **Lack of State Support Framework:** Lack of uniform State Support Agreements leads to disputes over streetlight tariffs, concession classifications, and arbitrary local demands.
- **PCOD/COD Approval Bottlenecks:** Recent circulars, though aimed at quality, involve complex processes that delay project completion and discourage investment.
- **Inconsistent Sustainability Mandates:** Sustainability circulars (RAP, renewables, new materials) lack clear enforcement and implementation guidelines.
- **Unbalanced Maintenance Penalties:** Current penalty structures fail to proportionally account for concessionaires' actual maintenance efforts and expenditures.

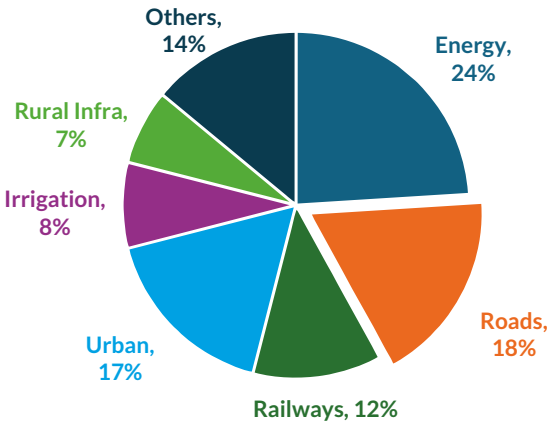
Recommendations:

- **On broader Policy and Circular Frameworks:**
  - Address the lack of a **compensation framework** for delayed toll revision to avoid investor concerns.
  - **Review and enhance the State Support Agreement,** including:
    - Standardizing **stamp duty treatment.**
    - Harmonizing **tariff structures for highway lighting** across states.
- **Structural & Collaborative Suggestions:**
  - Collaborative efforts of the Industry bodies in the formulation of Circulars/SOPs
  - Task force formation with members of Authority and Industry in reviewing the Circulars/SOPs and revising if required

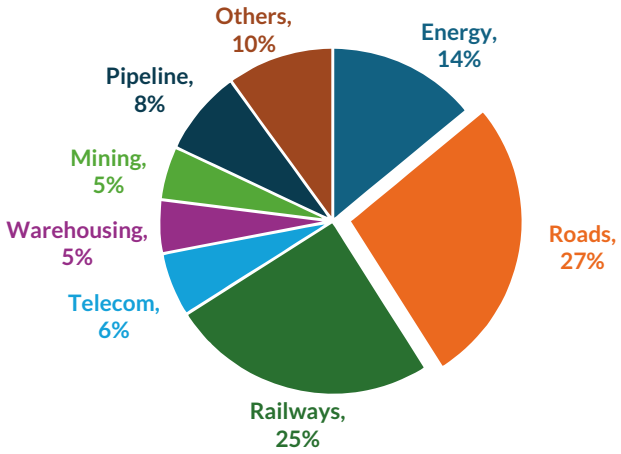
3.2.2 Roadmap for Asset Monetisation

Asset monetization involves unlocking the economic value of underutilized or idle public assets by leasing or selling them to private entities. This process is critical for bridging India's infrastructure deficit, particularly in the roads sector, which forms a significant part of the National Infrastructure Pipeline (NIP) and National Monetization Pipeline (NMP). With 1.46 lakh km of national highways, MoRTH and NHAI aim to build 41,000 km by FY 2031-32 at an estimated cost of ₹19.5 lakh crore, requiring substantial private sector participation (35-40% through BOT Toll and HAM models).

NIP target (₹111 lakh crore) by 2025 sector-wise break-up

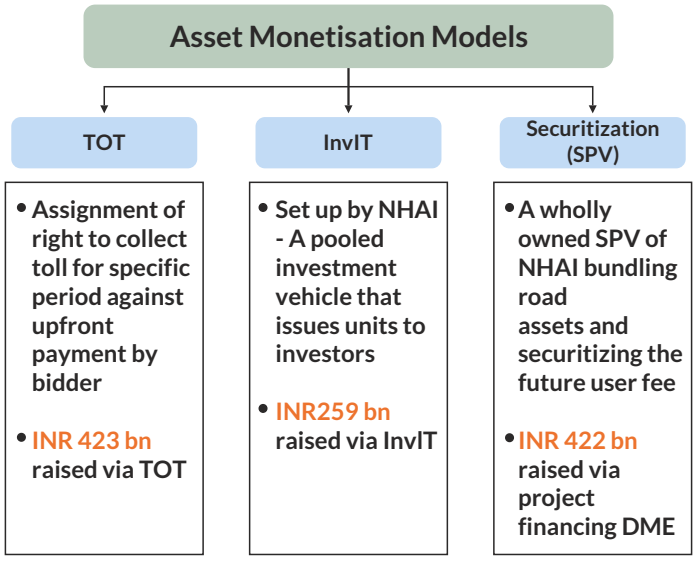


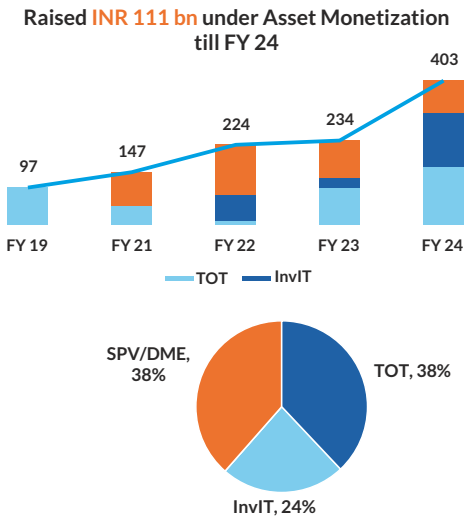
NMP target (₹6 lakh crore) by 2025 sector-wise break-up



The NIP targets ₹111 lakh crore by 2025, while the NMP aims for ₹6 lakh crore in the same period. Key road infrastructure projects include high-speed corridors (₹10-11 lakh crore), highway expansion (₹5-6 lakh crore), rural connectivity (₹2 lakh crore), and sustainability initiatives (₹0.5-1 lakh crore). Till FY24, ₹111 billion has been raised through asset monetization, highlighting its role in funding these ambitious projects.

Asset Monetization – Model & Journey





Actions Taken to Improve Participation

Identification of Road Assets for Monetization

- 24 identified assets (1,472 km) via the TOT model for monetization in FY 25-26
- Projected annual revenue: ₹1,863 crore

Policy Clarifications by NHAI

- Stamp duty impact for Toll Operate Transfer (TOT) concessions borne by NHAI (TOT-17)
- Loss of toll revenue due to ongoing capacity augmentation (TOT-16)

Development of Asset Monetisation Cell

- Dedicated Asset Monetization Cell (AMC) established (July 2024) under Member (Finance)

Overhaul BOT Model Concession Agreement (MCA)

- Guaranteed 90% land access at project start
- Flexible concession periods based on traffic variance (±1% adjustment beyond ±5% target)
- Construction grants replacing toll revenue during the build phase
- Early termination payouts for projects >40% complete

Way Forward to Improve Private Sector Participation

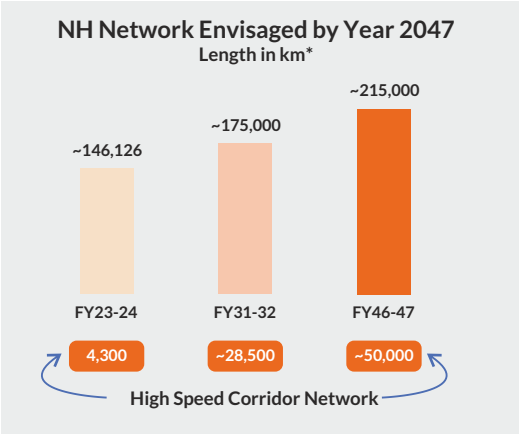
Time-bound Bidding Process	Standardizing Concession Terms	Improving Ease of Doing Business	Key Commercial Considerations
› Provide complete project info (traffic/tech studies) upfront at NIT issuance › Single annual pre-qualification submission per financial year	› Standardize maintenance obligations across TOT/HAM models › Uniform maintenance criteria ensure bid Integrity across players	› **Refinancing Simplification:** Replace NHAI approval with "NHAI intimation" if repayment aligns with existing debt. › **Ownership Flexibility:** Shareholding transfer to InvIT is allowed if the bidder is the sponsor, with no 2-year restriction.	› Accurate Revenue Base: DPR consultants to consider ETC revenues/Schedule V reported revenues as base revenues. › Cost Assessment: DPR consultants to factor overlay costs, structural assessments, and past maintenance works into O&M and major maintenance estimates.

3.2.3 Model Invits – How will they Impact the Road Scenario?

National Highways Development Vision 2047

India targets a ~2.15 lakh km National Highway (NH) network by 2047, requiring ~$600 Bn (₹50 Lakh Cr) investment (~0.6% of GDP annually from FY25-FY37). Funding will comprise:

- 50% government budget
- 30% PPP in construction
- 20% asset monetization



Asset Monetization Progress & Models

Toll-Operate-Transfer (TOT)

- Private players pay NHAI an upfront sum for toll collection rights and O&M duties.
- Raised $5.6Bn (₹48,995Cr) by Feb 2025 via 2,689 km monetization.

InvIT

- Direct investment by investors through trust sponsored by the Authority.
- Raised $3Bn (₹25,900Cr) by Feb 2025 vis 1,526 km of roads monetization and $2Bn (₹17,600Cr) for 820 km underway.

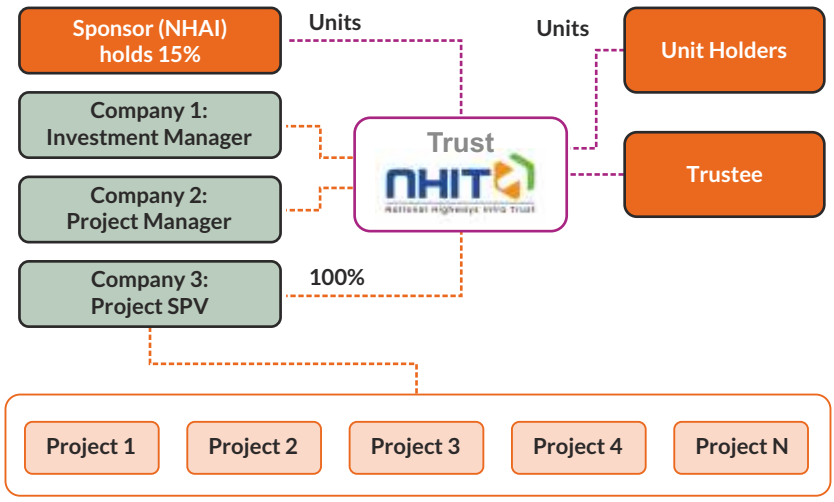
In FY2025-26, NHAI plans to monetize 1,472 km of assets with a potential of $2.5 Bn (Rs 22,000 Cr)

Asset Monetization Progress & Models

Project Completion	Bundle Finalization	Bundle Evaluation	Bundle Bidding	Bundle Award
Completed projects with stable toll collections (typically **I year post completion**) considered	Projects with sufficient revenue, i.e., **$95,000 per km** per year (Rs. 80 Lakh per km per year)	**Technical evaluation** to assess bundle quality. **Financial evaluation** to determine minimum bidding amount (Initial Estimated Concession Value)	**RFP floated** to invite bids for proposed bundle	Eligible bidder with **highest upfront bid** awarded TOT contract of bundle

Overview of the InvIT Model

Structure of InvIT:



Key features:

- **Long term** underlying **concession period** (20-30 years) for each asset
- **Diversified asset base,** efficient distributions
- NHAI as sponsor provides **comfort to investors on concession compliance**

Policy Improvements to Stimulate Private Investments

- **Pipeline Identification:** Detailed asset monetization pipeline shared by NHAI at the start of every FY
- **Standardization of Processes and Documents:** Standardized bidding and contract documents for consistency and clarity for the bidders
- **Long-term Contracts:** 15-30 years concession period for TOT models, long-term rewards for investors
- **Risk-Reward Optimization:** Clauses in MCA to safeguard investor interests (e.g., provision to increase/ decrease concession period in case of decrease/ increase of actual revenue vs target)
- **Enhanced Transparency:** Public disclosure of monetization pipeline and assumptions used in the estimation of IECV (reserve price)
- **Stakeholder Engagement:** Continuous engagement with concessionaires, lenders, banks, e t c . , t o refine processes

O&M of National Highways

As India's National Highway network expands under MoRTH's development plan, robust Operations and Maintenance (O&M) becomes critical to preserve asset value, ensure user safety, and maximize economic returns. Effective O&M enhances road longevity, reduces lifecycle costs, and minimizes disruptions for commuters and freight movement. NHAI has identified and prioritized key focus areas, implementing several strategic initiatives to address them effectively.

Quality of National Highways	1
Safety of NH Passengers	2
Sustainability	3
User Convenience	4

1. Quality of National Highways — Key Steps by NHAI

Pre-construction Phase

- **Dedicated DPR Cell** at HO to streamline and standardize DPRs
- **Standardization of DPR RFPs** to deploy quality consultants
  - Selection based on **Quality Parameters**
  - **Specialized Agencies** for LA & geotechnical investigation
- **Design cell** created at HQ for focused approach on design aspect of structures

Construction Phase

- Modifications in contractors/ **concessionaire selection** criteria
- Institutionalizing **Kick-off, Follow up & Project closure meetings**
- Intelligent **machine-aided** construction (IK4C)
- Robust **quality testing** & monitoring
  - **Digital inspection** — Drone monitoring, NHAI One app integration
  - **Regional quality** offices

O&M Phase

- **Tech enabled NH quality** monitoring
  - **Centralized Network Survey Vehicles** (NSV) agency
  - **Drone Analytics Monitoring System** leveraging **AI/ML**
  - **Road signage assessment** using **AI**
- Concessionaire **rating mechanism**
- Exclusive **Corridor Management Units** (CMU)

2. Safety of NH Passengers — Key Steps by NHAI

NHAI targets 50% reduction in fatalities due to accidents on national highways by 2030

Key steps undertaken:

- Establishment of **dedicated Road Safety Division**
- **Road safety audits** of each NH at DPR, construction and O&M stage in line with NHAI Road Safety Policy
- **E-DAR portal** to collect road accidents data for prompt safety remedial measures
- Decentralization of powers to undertake **rectification of black spots**/ accident spot points by field officers
- **Centralized ambulance contracts** for deployment of ambulances across national highways
- Measures to **reduce encroachment on national highways** - surveillance and monitoring, enforcement of laws, public awareness, etc.
- **Strict enforcement of rules** - traffic laws (speed limit, lane discipline, non-use of mobile phones, etc,) through **awareness, enforcement** and **surveillance**

3. Sustainability — Key Steps by NHAI

EV charging stations for commercial and passenger vehicles at WSAs across India

Sustainable material for NH construction and O&M - Bio bitumen, recycled material, etc.

Tree plantation along NHs to enhance green cover and reduce carbon footprint

Efficient tolling mechanisms to minimize congestion, lower fuel consumption, reduce emissions

4. User Convenience — Key Steps by NHAI

Wayside Amenities

- **Facilities** at **frequent intervals** on both side
  - Petrol stations
  - Food & beverage
  - Washrooms
  - Vehicle repair, etc.

Barrier-less Tolling

- Barrier-less tolling
  - Distance based tolling
  - Congestion free toll plazas
  - Smooth movement

Highway Patrolling and Assistance

- Assist vehicles under break down
- **Roadside emergency help** for quick medical assistance

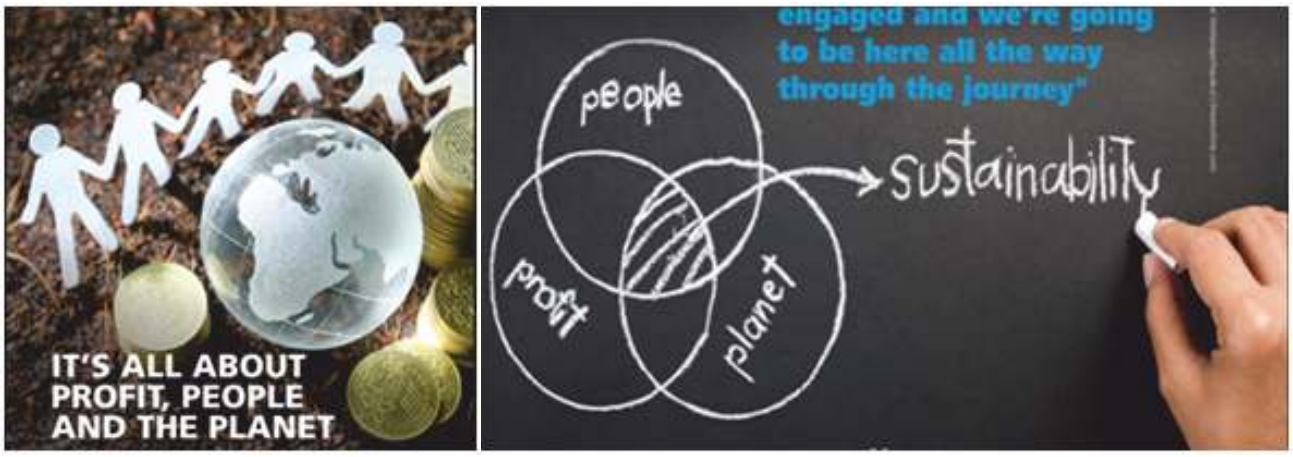
3.2.4 Policy and Framework for Sustainability

Sustainable development emphasizes meeting present needs without compromising the ability of future generations to meet theirs, requiring a balance between **profit, people,** and **the planet.** This principle is especially critical in road infrastructure, where sustainability is essential for long-term socioeconomic growth, ensuring faster mobility, safety, logistic efficiency, and user convenience. However, road construction poses significant environmental challenges, including the depletion of natural resources (e.g., stone, soil, sand), deforestation, and greenhouse gas emissions. Addressing these critical issues by integrating eco-friendly materials, minimizing ecological disruption, and adopting low-emission technologies is key to aligning infrastructure development with sustainable goals. Ultimately, harmonizing economic progress, societal benefits, and environmental protection is the cornerstone of sustainable road infrastructure and broader development efforts.

Sustainable road development shall prioritize ecological conservation while advancing infrastructure, aligning with India's Net Zero 2070 goal. Key strategies include the 3Rs (Reduce, Reuse, Recycle), optimized designs with advanced materials, and minimal resource consumption. Emphasizing local materials, eco-friendly alternatives, and waste upcycling, it shall integrate green construction methods, low-carbon technologies, and energy-efficient machinery. Landscaping, emission controls, and life-cycle cost evaluations ensure long-term sustainability, balancing progress with planetary health.

Sustainable road development utilizes cutting-edge materials like geosynthetics, fly ash, waste plastic, and industrial by-products (GGBS, steel slag, alccofine) to reduce environmental harm. Key technologies include modified bitumen (CRMB/PMB), soil stabilization, recycled aggregates (RAP), and warm mix asphalt for eco-friendly construction. Innovations like self-healing concrete, graphene-enhanced asphalt (GIPAVE), and perpetual pavements enhance longevity, while bamboo crash barriers, bio-bitumen, and municipal waste repurposing promote circularity. Advanced methods such as precast concrete, textile-reinforced concrete, and cold recycling (HIPR) optimize efficiency. These solutions support India's Net Zero 2070 vision, ensuring robust infrastructure with minimal ecological impact.

The Indian Roads Congress (IRC) has established comprehensive guidelines to promote eco-friendly, disaster-resilient, and low-carbon road construction. Key focus areas include:



- **Material Innovation:** Use of industrial wastes (slag, fly ash, C&D waste), geosynthetics (coir/jute), waste plastic, and fiber-reinforced polymers (GFRP) to reduce virgin resource dependency.
- **Green Technologies:** Adoption of warm mix asphalt, cold mix, rubberized bitumen, and bitumen recycling to cut emissions and energy use.
- **Resilience & Sustainability:** Guidelines for disaster-proof highways, carbon footprint reduction, green highway ratings, and rural roads using natural fibers.
- **Stabilization & Recycling:** Soil stabilization with cement/lime/fly ash, and reuse of RAP, C&D waste, and phospho-gypsum in embankments/pavements.

In addition to the above, a number of policies have been formulated to complement its sustainability initiatives in road construction, such as mandates for using waste plastic in bituminous mixes, inert materials in construction, white topping technology for road rehabilitation, and reclaimed materials in pavement layers. The policies also promote advanced solutions like Ultra High-Performance Fiber Reinforced Concrete (UHPFRC) for bridges and structures, along with the adoption of new alternative materials and technologies. These standards and policies align with India's goals, ensuring roads are durable, resource-efficient, climate-resilient, and innovation-driven while balancing economic viability.

To accelerate sustainable road development, India must prioritize wider adoption of high-strength materials, greener alternatives, and circular technologies. Integrating sustainability into procurement via Quality, Cost & Sustainability-Based Selection (QCS-BS) will incentivize eco-friendly solutions. Continuous evaluation of existing materials and technologies focusing on carbon reduction, durability, and service ability must be paired with committed R&D to identify and scale innovative solutions. This approach will ensure infrastructure aligns with Net Zero goals while maintaining cost-effectiveness and performance.

3.3 The Future of Asset Management Financing: Trends, Challenges, and Opportunities

A collaborative and transparent approach in policymaking is essential, supported by regular engagement with all relevant stakeholders. A few key concerns, such as delays in decision-making, changes in shareholding, refinancing challenges, and varying stamp duty rates across states, are on top of the Authority's agenda. Efforts are underway to streamline processes, reduce approval timelines, improve data systems, and standardize technical schedules. The Authority is committed to ensuring fairness in asset monetization through both TOT and InvIT models, with an assurance of improved efficiency, consistency, and openness in all operations moving forward.

Sustainable asset management in the road sector increasingly depends on the adoption of innovative financing models that go beyond traditional budgetary allocations. Leveraging market-driven instruments and structured financial mechanisms can enhance efficiency, ensure asset longevity, and support long-term infrastructure goals. In this context, the National Highway Monetization Programme serves as a significant case study, offering valuable insights into how capital can be effectively unlocked through the strategic monetisation of operational assets. However, aligning the monetisation pipeline with actual investor appetite remains a critical challenge, requiring careful assessment of risk-sharing frameworks, return expectations, and regulatory confidence. Understanding these dynamics is essential for developing resilient and scalable financing strategies for the future.

3.3.1 Innovative Financing Models for Sustainable Asset Management

India's Economic Growth & Investment Potential

India, the world's 5th largest economy (targeting 3rd by FY28), offers robust opportunities with:

- 8.2% GDP growth (FY 23-24) and ~ $4Tn economy.
- Young population (65% under 35) and 50% rise in real incomes (2014–2024).
- Manufacturing growth (15% GVA) and $779Bn exports (FY24).
- **Vision 2047:** 35Tn projected economy, 7%+ annual growth, rise in per capita income by 9x to $22,000, rise in industry share from 17% to 25% of GDP, growth in exports to $8Tn and net-zero transition by 2070 which requires $10Tn investment.

Key Achievements

- **GDP currently at ~ USD 4 Tn**
- **Exports of USD 779 Bn in FY23-24**

High real GDP growth rate of 8.2% FY 23-24

5th largest economy; To be 3rd largest by FY 28

Gross FDI inflows reached USD 70.09 Bn in FY 24

Key Achievements

- **77 years of Democracy**
- **Strong Institutions - Parliament, Media, Judiciary**

Youngest population : 65% of population under 35 years of age

Average real income of citizens has increased by 50% in the last decade

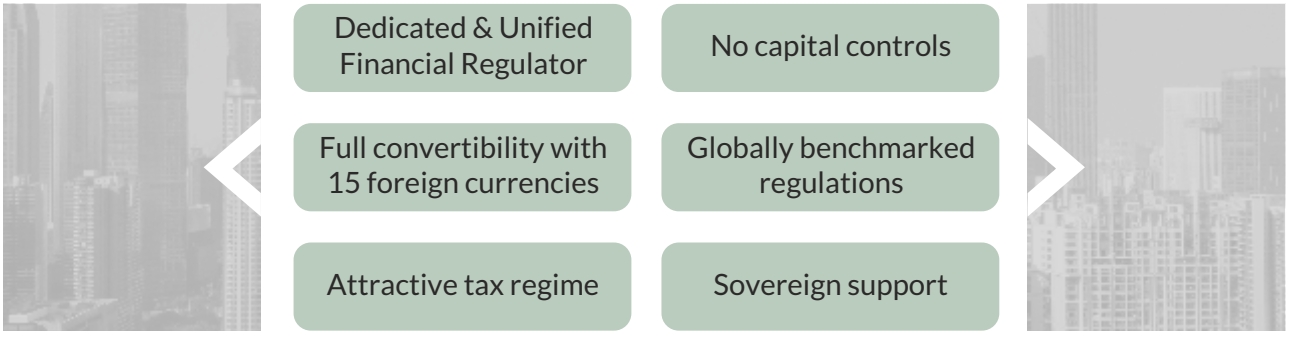
Manufacturing sector contributed 15% to nominal GVA in Q4. FY 24

GIFT City: Gateway to Global Finance

Prime Minister envisions GIFT City as the global nerve center for next-generation financial and technology services, leveraging its cutting-edge digital infrastructure to enhance business efficiency and competitiveness. Positioned as a gateway connecting India to global opportunities, GIFT City's integrated ecosystem combining regulatory ease, tax benefits, and world-class connectivity aims to establish India as a hub for innovation and sustainable finance. This vision aligns with India's broader economic ambitions, fostering international Infrastructure.

The regulatory framework is benchmarked with **the best global practices, offering** a business-friendly environment with streamlined policies across banking, fintech, insurance, and capital markets. Complementing this robust architecture is a **competitive tax regime** designed to attract global investors.

This combination of cutting-edge regulations and tax efficiency positions it as a premier global financial hub, aligning with India's vision to drive sustainable investments and economic growth.



Competitive Advantage

- Access to large hinterland Indian economy (Hinterland advantage)
- Beneficial cost of operations (Cost advantage)
- Availability of skilled talent pool (Talent advantage)

Regulatory architecture

Regulations Benchmarked with Global BBC best Practices

Banking Regulations 2020	Bullion Exchange Regulations 2020	Global In-House Regulations 2020	FinTech Entity Framework 2022	Listing Regulations, 2024	Finance Company Regulations, 2021
Market Infrastructure Institutions Regulations 2021	Framework for Aircraft Lease 2022	Framework for Ancillary Services 2021	Framework for Global Corporate Treasury Centres 2021	Fund Management (Regulations) 2022	Capital Market Intermediaries Regulations 2021
Registration of Insurance Business Regulations 2021	Insurance Intermediary Regulations 2021	Framework for setting up ITFS 2021	Framework for Ship Lease 2022	Foreign University Regulations 2022	AML, CFT and KYC Guidelines 2022
Insurance Products and Pricing Regulations 2022	Payment & Receipt of Premium Regulations 2022	Insurance Web Aggregator, 2022	Investment by IFSC Insurance Office Regulations 2022	Framework for Global Administrative Office 2022	Re-Insurance Regulations 2023

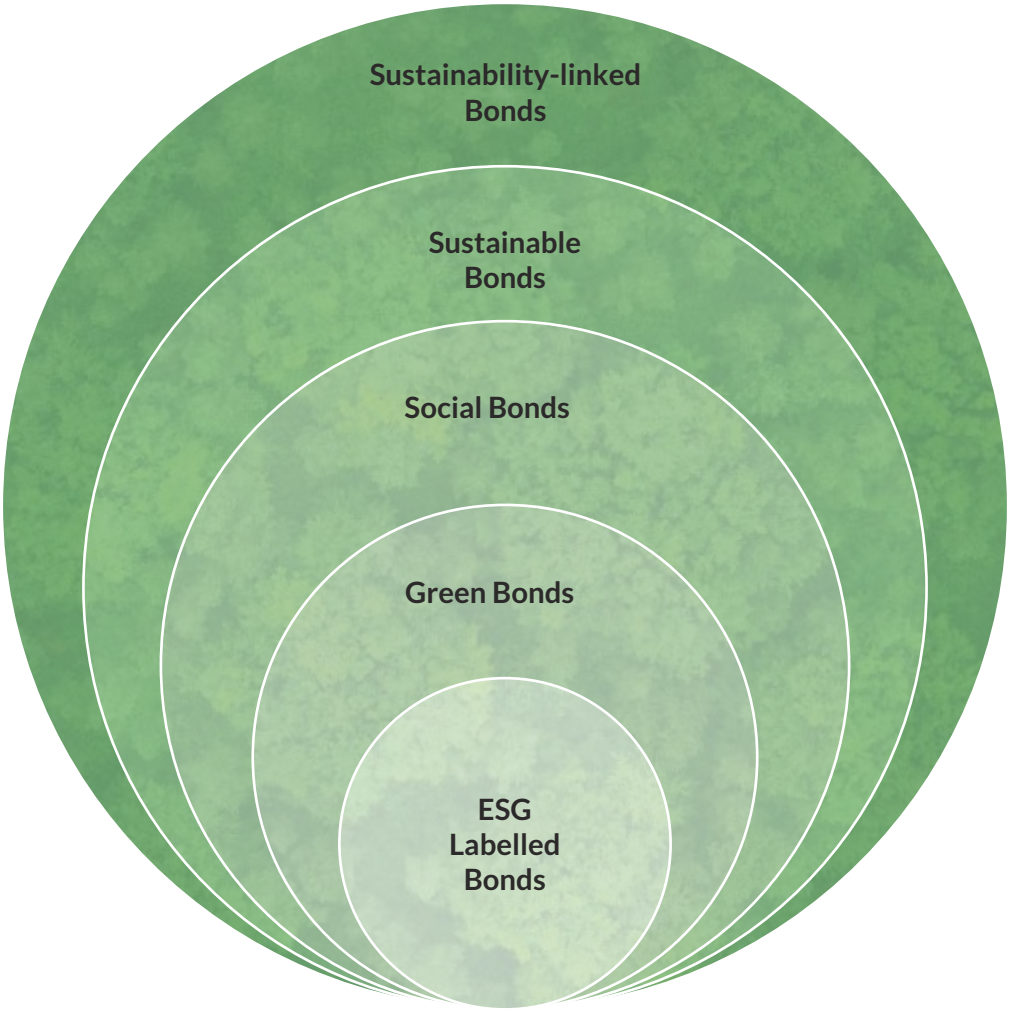
Competitive tax regime

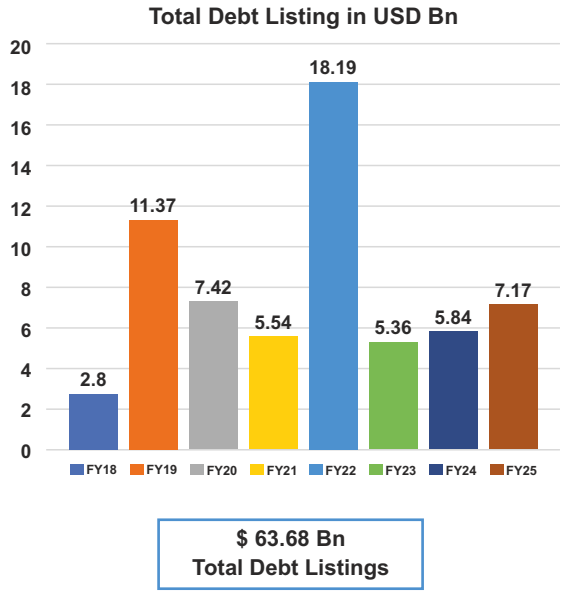
1. Tax Holiday on Business Income for 10 out of 15 years
2. Minimum Alternate Tax* @ 9%
3. No CTT**/STT**/GST**/Stamp Duty
4. Reduced withholding Tax of 9% on interest paid on Debt Instruments
5. Competitive Tax Regime for Funds
6. Incentives under Gujarat IT/ITeS Policy (2022-27)

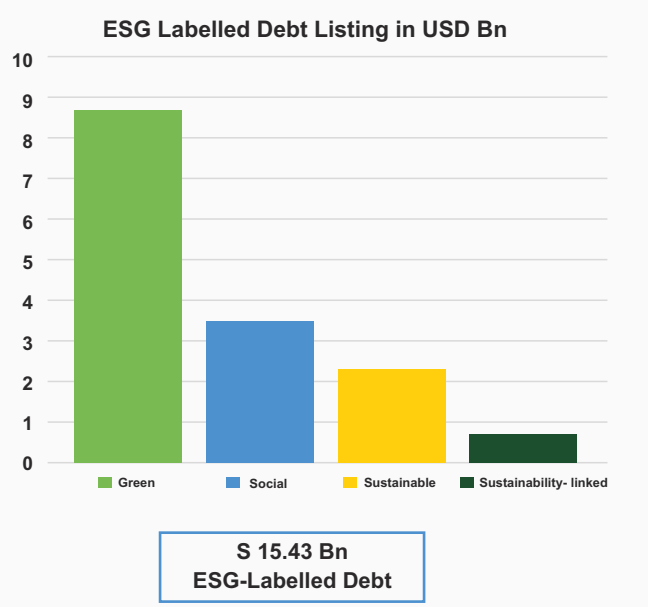
*MAT provisions not applicable for companies opting for concessional tax rate under Sec. 115 BA of Income Tax Act, 1961
**CTT- Commodity Transaction Tax, STT- Securities Transaction Tax, GST- Goods and Service Tax

Financing Tools

India has established a comprehensive capital markets infrastructure, anchored by two international exchanges (INDIA INX and NSE - International exchange) and supported by clearing corporations (INDIA ICC, NSE - International clearing) and an international depository (IIDI). This ecosystem enables seamless global access through initiatives like the NSE IFSC-SGX Connect (live since July 2023), facilitating cross-border liquidity. The platform supports diverse instruments, including bonds (with globally benchmarked regulations, competitive pricing, and mandatory credit ratings) and ESG-labelled bonds (green, social, sustainable, sustainability linked), aligned with frameworks from Climate Bonds Standard, ICMA, ASEAN Capital Markets Forum, and the EU. The government has formulated/ amended regulatory frameworks to enable the direct listing of listed/unlisted companies on IFSC exchanges, enabling start-ups and companies of like nature to access the global market through GIFT IFSC that will facilitate access to global capital and result in better valuation for Indian companies. Together with the direct listing of Indian stocks, this integrated structure positions India as a gateway for efficient global capital flow, combining regulatory rigor with sustainability-focused innovation. The debt listing at IFSC as of December 31, 2024, is shown below.







IFSCA Listing Regulations

The IFSCA Listing Regulations seamlessly integrate IOSCO principles with global best practices to create a robust yet business-friendly framework for both Indian and foreign issuers. Designed to enhance ease of doing business, the regulations offer flexible eligibility criteria including revenue, profit, or market capitalization tests, while streamlining processes for smaller issuers (exempting sub-USD 50M offerings from full documentation). By mandating transparent underwriting disclosures, lockup periods (180 days for promoters), and adaptable public offer rules (10% minimum for foreign companies), IFSCA strikes a balance between market integrity and investor accessibility, positioning GIFT IFSC as a globally competitive financial hub that aligns with international standards while catering to diverse issuer needs.

Eligibility Criteria

- **Revenue Test:** USD 20 million in last financial year or averaged over last three financial years (or)
- **Profit Test:** Pre-tax profit of USD 1 million in last financial year or averaged over last three financial years (or)
- **Market Cap Test:** Post issue market capitalisation of USD 25 million

Minimum Public Offer

- **Indian Company:** In accordance with the Securities Contracts (Regulation) Rules, 1957.
- **Foreign Company:** Minimum public offer as well as minimum public shareholding of 10 percent of the post issue capital.

Underwriter

- May be underwritten (adequate disclosures regarding underwriting arrangements shall be disclosed in the offer document).

Filing of Offer Document

- Issuers required to file offer document with IFSCA for observations.
- Issuers with issue size of USD 50 million or less exempted.

Lockup

- Pre-issue shareholding of promoters and controlling shareholders of the issuer shall be locked up for a period of 180 days from the date of allotment in the initial public offer.

3.3.2 Unlocking Capital through Asset Monetization: Lessons from the National Highway Monetization Programme

Evolution of Monetization Models

NHAI's monetization journey began with BOT models in the 1990s, which not only provided capital but also brought private sector expertise in road development. The program evolved with infrastructure funds entering as equity partners around 2004/2005 and later transitioned to TOT (Toll-Operate-Transfer) and InvITs, enabling direct asset sales to investors. Early challenges, like uncertainty over 30-year revenue streams and capacity augmentation risks, were addressed through policy interventions NHAI now bears augmentation costs without impacting investor returns.

Process Improvements & Market Confidence

NHAI's asset monetization program has undergone significant refinements to enhance transparency, predictability, and investor confidence. One of the most critical improvements has been the standardization of Initial Estimated Concession Value (IECV) calculations. In the early phases of the TOT (Toll-Operate-Transfer) program, inconsistencies arose due to consultants using divergent assumptions for key economic indicators like Wholesale Price Index (WPI) and GDP growth. Recognizing this challenge, NHAI took a proactive role by issuing official forecasts for these metrics, ensuring uniformity across evaluations. This move not only streamlined bid assessments but also minimized discrepancies between projected and actual revenues, fostering greater trust among investors.

The integration of **FASTag** technology further bolstered market confidence by addressing long-standing issues of revenue leakage and cash-based toll collection. With electronic tolling, NHAI achieved higher accuracy in traffic and revenue data, reducing uncertainties for investors. Additionally, the shift toward flexible pavements in monetized assets replacing rigid ones simplified maintenance and improved long-term viability, making projects more attractive to private players.

Ongoing Challenges & Solutions

Despite these advancements, the program faces persistent challenges that require targeted solutions. **Cost rationalization** remains a priority, as inflated estimates by consultants have historically distorted IECV calculations. To address this, NHAI established an **Asset Monetization Committee** to review and standardize cost benchmarks, ensuring realistic valuations aligned with market conditions.

Another critical issue is **traffic diversion** due to competing infrastructure. As new highways are developed near monetized corridors, toll revenues may decline. NHAI has partially mitigated this by lowering traffic loss thresholds, reducing the permissible drop from 20-30% to more flexible levels and adjusting concession terms. However, further refinements are needed, particularly in recalibrating thresholds to account for dynamic factors like **remaining concession periods** and regional traffic patterns.

Lastly, **investor engagement** remains pivotal. NHAI's willingness to incorporate industry feedback such as revising pavement standards and refining bid documents has been instrumental in maintaining stakeholder trust. Continued dialogue with developers and funds will be essential to fine-tuning policies and ensuring the program's long-term success.

NHAI's collaborative approach to balancing investor concerns with public interest has established India as a leader in infrastructure monetization. Continued focus on transparent processes and adaptive policies will sustain investor confidence and support the sector's growth.

3.3.3 Monetization Pipeline vs Appetite of Investors

Monetization Progress

The Toll-Operate-Transfer (TOT) model has demonstrated strong investor interest, with around ₹50,000 crores invested across 16 bundles. While initial phases saw mixed results, the program has gained steady momentum since 2024, with each subsequent bundle attracting competitive bids. This growth can be attributed to faster bid processing, policy refinement, and better engagement between NHAI and industry stakeholders. Similarly, the Infrastructure Investment Trust (InvIT) model under the National Highways Infra Trust (NHIT) has complemented the government's asset monetisation efforts by offering an InvIT-based structure that attracts long-term institutional investors. Alongside the TOT model, NHIT has played a vital role in diversifying monetisation avenues, thereby strengthening the overall investment ecosystem in the highway sector.

Recent media reports suggest that the Ministry of Road Transport & Highways (MoRTH) has directed the National Highways Authority of India (NHAI) to pause the ongoing Toll-Operate-Transfer (TOT) bundle auctions and assess the comparative benefits of monetisation through TOT and the Infrastructure Investment Trust (InvIT) mode of monetization [through NHAI InvIT (NHIT)] models. It has also been proposed that toll monetisation could be expanded via five-year tolling rights or securitisation of toll receivables. In view of these developments, the industry finds it necessary to present a balanced and fact-based assessment of the two models and their role in achieving the government's long-term infrastructure financing goals. HOAI's perspective towards the importance of the TOT model is summarized below:

HOAI's perspective towards the importance of the TOT model for Indian Highways

Sectoral Contribution and Impact of Policy Shift	➢ The roads sector contributed ₹1 lakh crore in NMP Phase 1, mainly through the TOT model. ➢ TOT auctions attracted long-term investors and supported monetization goals. ➢ Suspending TOT may derail Phase 2 targets and reduce investor interest.
Success and Inclusivity of TOT Auctions	➢ TOT model has seen a strong response across 16 auctions, with 4–5 bidders per bundle on average. ➢ Awards have gone to a mix of fund-based platforms, private developers, and InvITs (excluding NHIT). ➢ This reflects broad-based investor confidence and sustained interest in the model.
Impact on InvIT Ecosystem and Retail Capital	➢ Limiting TOT auctions risks weakening the credibility and pipeline of operational assets vital for InvIT growth. ➢ The roads sector accounts for 14 of 25 InvITs and 37% of total AUM. ➢ With ₹7,400+ crore in retail investment, TOT is key to sustaining capital flow and investor trust.
Alternative Investment Vehicles and Potential Impact	➢ A stable regulatory environment and steady returns have made Indian highways attractive to global pension and sovereign funds seeking long-term investments. ➢ Discontinuing TOT monetization may divert this capital to secondary market assets or foreign infrastructure, reducing fresh investments in India and disrupting current momentum.

Additionally, HOAI has carried out a detailed comparative assessment TOT Model and InvIT (NHIT and the like) under the following points:

A. Effectiveness of the TOT monetization model compared to InvIT (NHIT and the like)

B. Contractual and financial superiority of TOT

C. Assessment of monetization models proposed by the government

A. Effectiveness of the TOT Monetisation model compared to InvIT (NHIT and the like)

Since 2018, the TOT model has contributed nearly ₹50,000 crore and has evolved to offer market-driven, transparent price discovery through competitive bidding. Key enhancements by NHAI include model concession revisions, effective bundling, and size customization of TOT packages. Notably, recent TOT auctions (TOT 11 onwards) have achieved 100% award success.

The TOT model has consistently delivered strong returns to the government, with higher average EV/Revenue multiples of 16.6x for 30-year and 13.7x for 20-year concessions compared to 15.2x and 12.4x respectively under the NHAI InvIT (NHIT) model. This valuation premium in TOT arises from greater market competition, even though government estimates for both models are based on similar assumptions. NHIT has also delivered attractive unit holder returns of ~14.7% p.a. since listing, outperforming other InvITs and indicating a lower cost of capital for such investors, which benefits NHAI through better valuations. Therefore, concerns about the TOT model's attractiveness to the exchequer are unfounded. Thus, concerns about the TOT model's attractiveness to the exchequer are unfounded. **A unified TOT monetization program with NHIT participation is recommended to ensure a level playing field and improve bidding competitiveness.**

Table 1 : Valuation in TOT awards

Bundle	Concession Period	Bid Value (INR cr)	NHAI Capex per DPR (INR cr)	Enterprise Value (INR cr)	Latest FY Revenue (at the time of issue of bid) (INR cr)	EV/Revenue (x)- trailing
TOT 1, 3	30	14,693	1,474	16,167	976	16.6x
TOT 5A1 5A2, 7, 11, 12, 13, 14, 16	20	31,158	1,133	32,291	2,357	13.7x
TOT 9	15	3,144	-	3,144	232	13.6x

Source: Market information

Table 2 : Valuation in transfer to NHAI InVIT (NHIT)

Series	Concession Period	Value (INR cr)	NHAI Capex (INR cr)	Enterprise Value (INR cr)	Revenue* (FY of bid) (INR cr)	EV/Revenue (x)- trailing
1	30	7,451	60	7,511	495	15.2x
2	20	2,850	857	3,707	298	12.4x
3	20	15,700	342	16,042	1,242	12.9x
4	20	17,641	541	18,182	1,529	11.9x
4	Round 2-4 (20 year concessions	36,191	1,740	37,931	3,069	12.4x

** Revenue estimated basis valuation report released by NHIT, Forward revenues are considered as trailing revenues by reducing the revenues by 8% Capex numbers also considered from valuation report.*

B. Contractual and financial superiority of TOT

a. Risk Allocation:

- In the TOT model, project and financial risks are borne entirely by the private concessionaire.
- In contrast, under NHIT, NHAI as the sponsor may need to underwrite/support certain project assumptions, increasing its contingent liabilities.

b. Capital Availability & Flexibility

- TOT provides 100% of the monetization value upfront, enabling NHAI to deploy proceeds immediately for infrastructure development.
- Under InvIT, a portion of the value remains locked due to sponsor unit obligations, limiting immediate liquidity for NHAI.

c. Asset Value and Investor Participation

i. Asset and Cashflow Adjustments

- NHIT assets are mostly from HAM projects, where maintenance for 15 years is handled by existing concessionaires. This inflates NHIT cashflows and valuations. Hence, NHAI should deduct these cost savings from NHIT's IECV for fair comparison with TOT bids, where such costs are already accounted for.

ii. Investor Base and Valuation Realization

- TOT auctions are highly competitive, involving diverse investor classes including global funds, domestic institutions, and private developers driven by recurring bid opportunities.
- NHAI realizes approximately 85% upfront under NHIT, with 15% capital locked due to its sponsor role, unlike TOT, where 100% is realized upfront.

C. Assessment of monetisation models proposed by the government

Monetisation through NHAI's InvIT (NHIT) - Limitations	Monetisation through medium-term toll monetization under 5-year tolling rights	Securitisation of toll road receivables
Lack of market-based price discovery: NHIT deals miss competitive valuations of TOT bids.	Short-term nature misaligns with the long-term Investment horizon of institutional capital.	Involve higher financial risk and increase NHAI's debt burden.
Loss of market efficiency and innovation: NHIT bypasses private sector cost and innovation benefits	May divert interest away from greenfield BOT projects, undermining PPP objectives.	Typically limited to partial cashflows and backed by NHAI guarantees, in contrast to full monetisation under TOT.
Limited investor participation: It restricts active and strategic investor participation.		
Not suited for complex or higher-risk projects: NHIT investors prefer low-risk assets, unlike TOT-suited projects.		

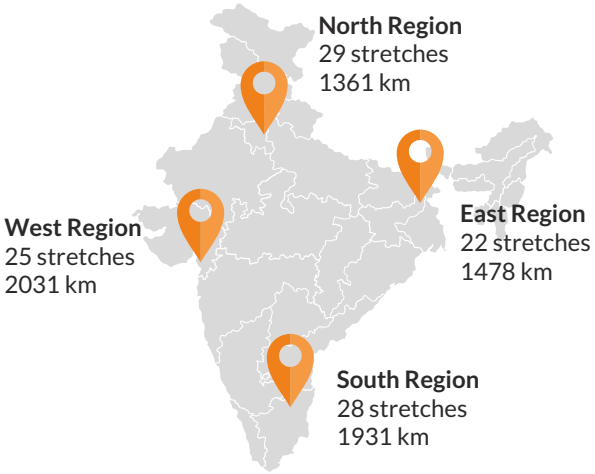
The TOT model has proven to be an effective, inclusive, and financially rewarding monetisation approach. It ensures fair asset valuation through competitive bidding and attracts a wide investor base. Rather than discontinuing TOT, the government should adopt a complementary monetisation strategy involving both TOT and InvIT (NHIT) models to maximise Investor interest and meet ambitious NMP Phase 2 targets. Doing so will preserve sector momentum, ensure fiscal prudence, and maintain investor confidence in Indian highways.

Asset Pipeline & Future Opportunities

Looking ahead, the pipeline for future monetization remains substantial, particularly with the National Monetization Pipeline (NMP) Phase 2 expected to more than double the value of NMP Phase 1,valued at ₹3.5 lakh crore. While NMP Phase 1's stretches are partially monetized (including via NHAI InvIT), significant inventory remains. For the upcoming financial year, 24 assets spanning 1,472 km are already pipeline-ready, ensuring a robust near-term pipeline for investors. Also, the rapid growth of EPC and HAM projects over the past decade will soon translate into a pipeline of monetizable highway assets. Meanwhile, a unique hybrid model has emerged where **TOT and HAM concessions coexist within a single asset,** structured under two separate SPVs. This approach is particularly attractive for investors seeking exposure to highway assets without heavy O&M or construction responsibilities. By allowing simultaneous HAM and TOT operations, the model broadens participation, offering flexibility for different risk-return preferences while optimizing asset monetization.

National Monetisation Pipeline Phase-1

Market...



- INR 1.6 Lakh Cr worth assets
- 104 stretches identified (6,801 Km)
- 3 bundles in progress
- 24 assets - 1472 km identified for FY 26
- Stable and strong pipeline
- Steady EPC and HAM awards to turn out as future monetisation opportunities

National Monetisation Pipeline

Market Dynamics & Investor Participation

Market appetite is clearly expanding, with growing interest from both traditional investors and new road developers. Recent bidding rounds have attracted first-time participants, including new funds and platforms, while unsuccessful bidders are likely to return stronger. NHAI's enhanced engagement efforts and HOAI's expanding membership reflect this momentum, with many investors still in observation mode testing the waters before committing. The pipeline remains robust, with fresh capital poised to enter future rounds

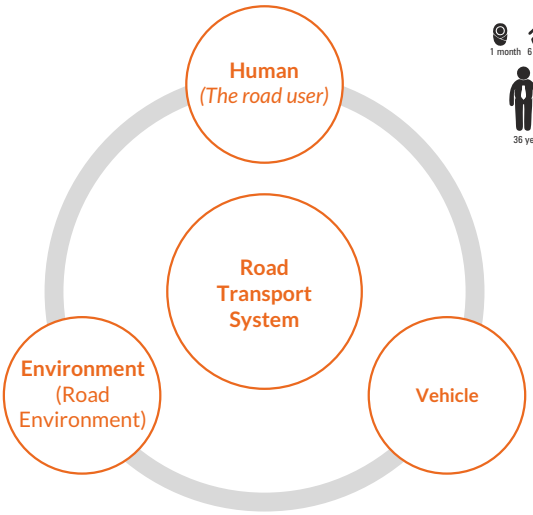
Continued success depends on maintaining an efficient and transparent ecosystem. Collaborative efforts between NHAI and industry bodies have already improved processes, but further enhancements in policy clarity and execution will be key. With a strong pipeline and growing investor confidence, the highway monetization initiative is well-positioned for sustained expansion in the coming years.

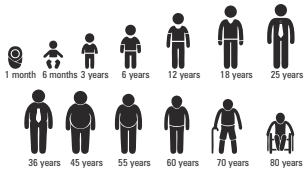
3.4 Smart Roads, Safer Journeys – Innovations in Highway Safety

The integration of advanced technologies in road infrastructure is transforming the way mobility, safety, and efficiency are approached. Smart roads, powered by AI-based solutions for traffic monitoring and predictive safety systems, are paving the way for data-driven decision-making and real-time responsiveness. As global innovation accelerates, aligning national policies with these technological advancements becomes crucial. Examining case studies from technologically advanced nations offers valuable insights into effective regulatory frameworks and implementation models. Furthermore, the application of international best practices within the Indian context presents both opportunities and challenges, highlighting the importance of adapting global learnings to suit local needs while maximizing long-term benefits. This evolving interplay between technology, policy, and practice underscores the need for a forward-looking and adaptable approach to infrastructure development.

3.4.1 Smart Roads and AI Solutions – AI for Traffic Monitoring, and Predictive Safety Systems

A modern transport system integrates three core components - humans (road users), vehicles, and the road environment into a cohesive ecosystem. While humans remain central to mobility, they are vulnerable to errors, necessitating intelligent systems that enhance safety. AI-powered solutions like predictive traffic monitoring, smart infrastructure, and vehicle-to-everything (V2X) communication bridge these elements, proactively mitigating risks. From driver-assistance technologies to real-time hazard detection, AI transforms roads into responsive networks that compensate for human limitations while optimizing efficiency. This synergy of human-centric design and cutting-edge technology embodies the Safe Systems Approach, where smart roads don't just host traffic but actively safeguard it

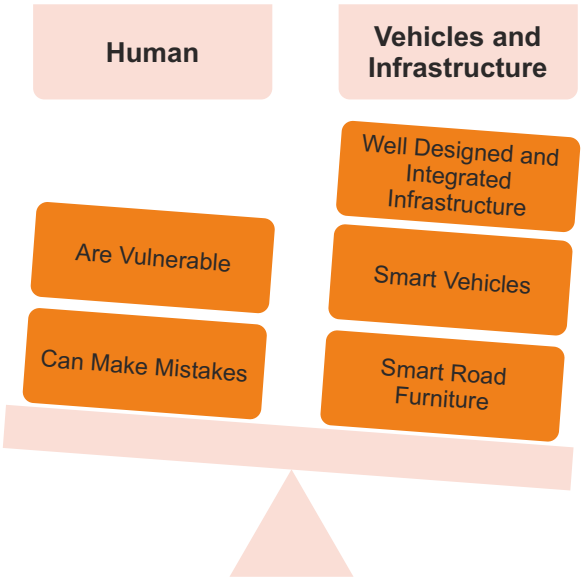




Safe System Approach

The Safe System Approach is a holistic framework that prioritizes eliminating road fatalities and serious injuries by acknowledging human vulnerability and fallibility. Built on core principles like shared responsibility and proactive safety measures, it integrates redundant protections across vehicles, infrastructure, and user behaviour. By designing systems that anticipate mistakes (e.g., AI-driven alerts, forgiving road designs), this approach transforms roads into inherently safer spaces, where technology and policy work together to mitigate risks before crashes occur.

Smart infrastructure serves as the backbone of the Safe Systems Approach by proactively addressing human vulnerability and error through technology-integrated design. It combines intelligent road features (adaptive signage, IoT-enabled furniture), connected vehicles (V2X communication), and data-driven systems (AI-powered monitoring) to create self-regulating transport ecosystems. This infrastructure doesn't merely respond to incidents—it anticipates risks by influencing driver behaviour (dynamic speed alerts) or assuming partial control (automatic braking zones). By seamlessly blending physical and digital elements, smart infrastructure delivers the redundancy and proactive protection demanded by the safe systems framework, turning roads into collaborative spaces where human limitations are mitigated by design.

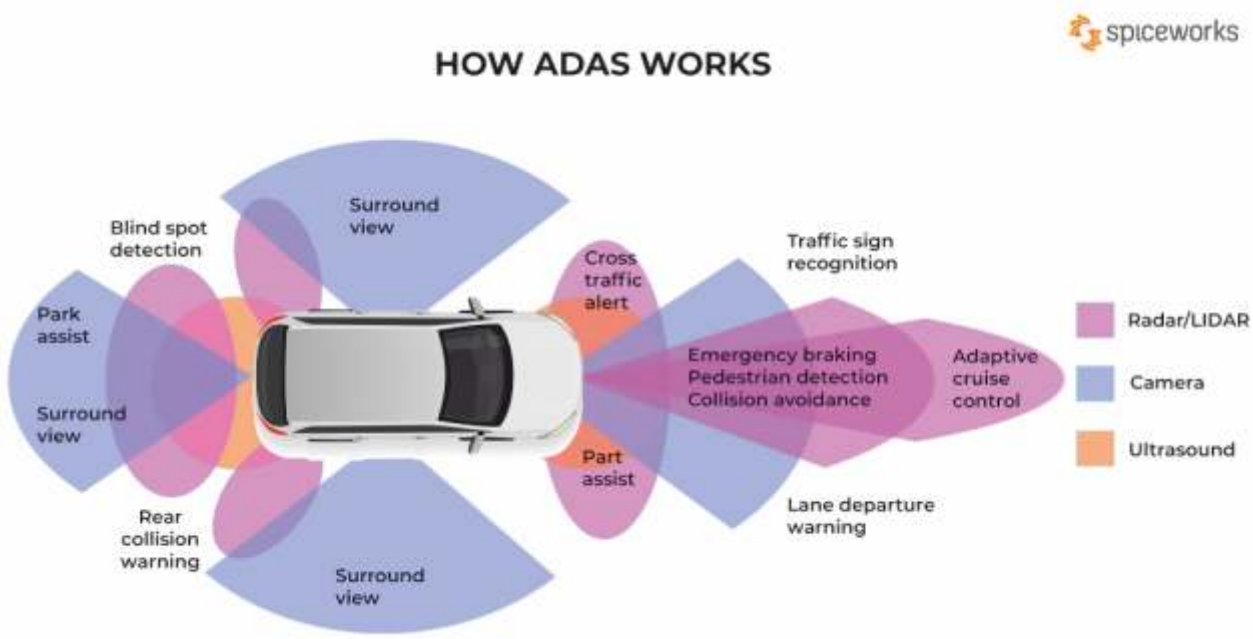


Role of Artificial Intelligence in Safety

In 2021, the International Telecommunication Union (ITU), in collaboration with the UN Secretary-General's special envoy for road safety and the UN envoy on technology, launched the groundbreaking "AI for Road Safety" initiative. This program prioritizes inclusive, technology-driven solutions tailored for low- and middle-income countries, which account for the majority of global road fatalities. By leveraging artificial intelligence, the initiative aims to develop scalable tools such as predictive crash analytics, real-time hazard detection, and driver behavior monitoring to address systemic safety gaps. Focused on equity and accessibility, it represents a critical step toward reducing disparities in road safety outcomes worldwide through innovative, context-aware interventions.

Artificial Intelligence is revolutionizing road safety through predictive and real-time interventions that address risks before accidents occur. By leveraging Advanced Driver Assistance Systems (ADAS) equipped with cameras, radar, and sensors, AI enhances vehicle responsiveness to hazards. Driver Monitoring Systems detect fatigue or distraction, while V2X (Vehicle-to-Everything) communication enables coordination between vehicles, infrastructure, and pedestrians. AI-powered incident detection and highway condition assessment allow for swift emergency responses, and predictive traffic modeling optimizes flow to prevent congestion-related collisions. Together, these technologies create a proactive safety net, significantly reducing accidents by compensating for human error and environmental unpredictability.

ADAS — Advanced Driver Assistance Systems



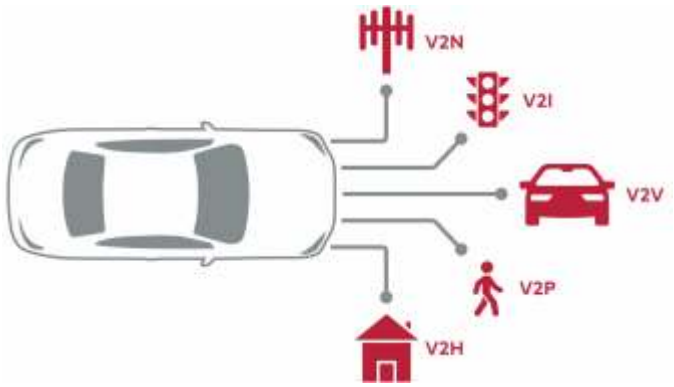
https://www.spiceworks.com/tech/iot/articles/what-is-adas/

Current ADAS Technology is primarily focusing on Individual Intelligent Vehicle

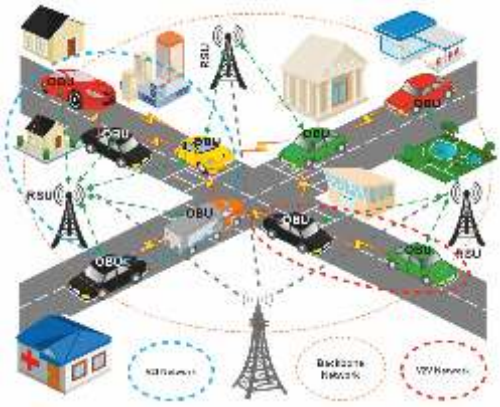
C-ITS: Cooperative Intelligent Transport Systems

Consists of Intelligent Vehicles / Infrastructure communicating with other objects

- V2V (Vehicle-to-Vehicle) Communication
- V2I (Vehicle-to-Infrastructure) Communication
- V2N (Vehicle-to-Network) Communication
- V2P (Vehicle-to-Pedestrian) Communication
- V2H (Vehicle-to-Home) Communication



https://www.vector.com/in/en/know-how/v2x/



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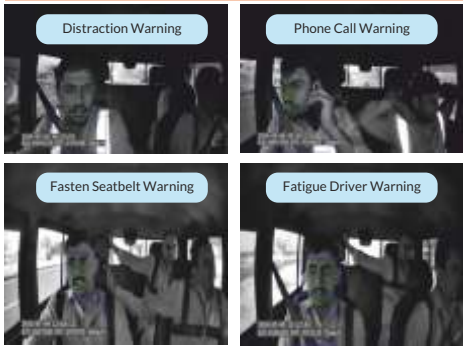
HOAI Initiatives

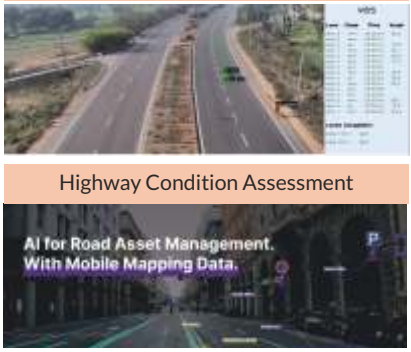
HOAI members have implemented a few of the advanced technologies on their assets and have observed significant results.

VTS and Driver Monitoring System



Traffic Counting and Classification

Incident Detection and Response



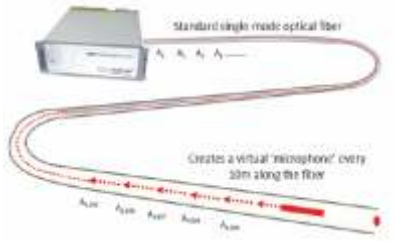
Highway Condition Assessment

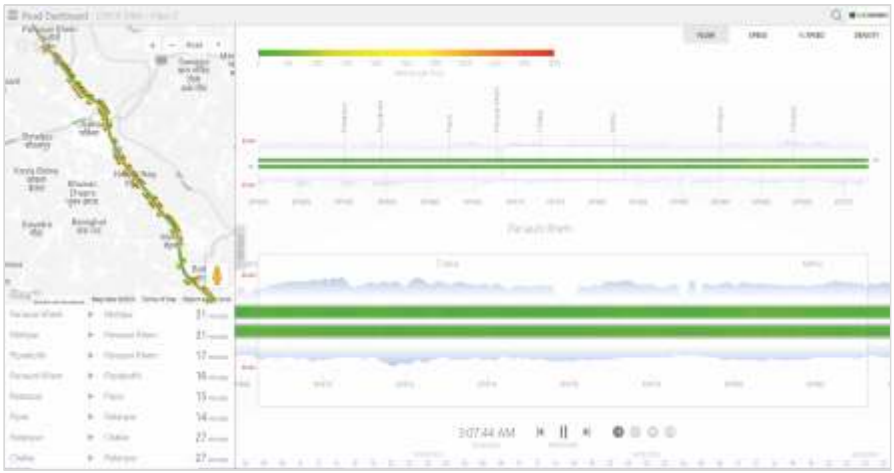
AI-powered dashboard cameras installed on project vehicles leverage computer vision to automatically detect and document road assets, enabling real-time condition monitoring and maintenance prioritization. These systems generate geo-tagged records of infrastructure defects while optimizing operational efficiency through automated reporting and predictive analytics. By integrating machine learning, the technology continuously improves detection accuracy, establishing a data-driven approach for proactive asset management and rapid response to maintenance needs.

A pioneering pilot project by a HOAI member is testing Distributed Acoustic Sensing (DAS) technology for 24/7 traffic monitoring and incident detection, potentially revolutionizing highway surveillance systems. This innovative approach transforms existing fibre optic cables into thousands of virtual sensors that provide continuous, real-time measurements along entire roadways without additional roadside hardware. The system offers precise traffic flow analysis, instant incident detection, and structural health monitoring while significantly reducing equipment clutter, presenting a cost-effective, scalable alternative to traditional monitoring methods that could redefine global standards for smart highway management through its infrastructure-embedded intelligence.

Early DAS implementation shows successful detection of major vehicles and monitoring of traffic flow. However, calibration challenges remain in detecting smaller vehicles and complex scenarios like junctions or dense surroundings. While currently best suited for controlled expressway environments, these limitations highlight the need for further pilot testing and system refinements before wider deployment.

Truck-mounted attenuators (TMAs) have been deployed by the members on their assets for maintenance activities and have played a critical role in preventing injuries and safeguarding maintenance workers' lives.





Evolution of Intelligent Infrastructure on Indian Highways

India's highway systems are progressively integrating smarter technologies, transitioning from basic Emergency Call Boxes (ECBs) and limited variable message signs (ATMS 2016) to advanced AI-powered solutions (ATMS 2023) like automated traffic monitoring cameras, radar systems, and video analytics (VIDES). The current focus is shifting toward Infrastructure-to-Vehicle (I2V) communication, enabling real-time data exchange between roads and vehicles to enhance safety and efficiency. While enforcement remains critical, this tech-driven evolution signifies a strategic move toward predictive, rather than reactive, highway management.

Emerging Technologies for Enhanced Safety: Opportunities and Challenges

To significantly improve safety on high-speed corridors, several promising technologies require thorough evaluation for their viability and implementation potential:

- **Advanced Monitoring Systems**
  - Tyre Temperature Monitoring: Real-time tracking of tyre heat levels to prevent blowouts
  - Visibility and Fog Alert Systems: AI-powered sensors for early detection of fog patches
- **Critical Implementation Questions**
  - How can continuous tyre health monitoring be ensured for all vehicles, especially those without pressure sensors? How do we detect non-stop driving on Expressways?
  - What systems can effectively mitigate collision risks from sudden fog conditions?
  - What maintenance strategies will sustain large-scale ATMS infrastructure?
- **Additional Considerations**
  - Identification of cost-effective, scalable technologies to augment existing ATMS
  - Privacy implications of mandatory driver monitoring systems in commercial/ passenger vehicles

These innovations could transform expressway safety but require structured pilots, stakeholder consultations, and phased implementation plans to address technical and operational challenges effectively

3.4.2 Best Practices Aligning Policies with Technological Advancements: Case Studies from the West

Evolving Road Safety Paradigms

Road safety strategies are transitioning from traditional regulatory approaches to technology-driven solutions that integrate behavioral science and hardware innovations. While conventional methods relied on speed limits, infrastructure upgrades, and enforcement, emerging tools now address human psychology and systemic risks, offering more proactive interventions. The conventional approach to road safety has primarily relied on regulatory measures like speed limits, traffic signals, and road signs, combined with engineering solutions such as wider lanes, improved lighting, and pedestrian crossings. While these methods have contributed to reducing accidents, they operate on the assumption of perfectly rational driver behavior, failing to account for the complexities of human psychology, such as distractions, fatigue, or risk-taking tendencies. This one-dimensional focus on infrastructure and rules often overlooks the need for adaptive systems that can anticipate and mitigate human errors, highlighting the necessity for more holistic, behavior-integrated safety strategies.

Vision Zero: An Ethical Framework

Pioneered by Sweden (1997), Vision Zero redefines safety as an ethical obligation, asserting that no road death is acceptable. It contrasts the traditional approach to road safety which treated fatalities as inevitable and focused on individual responsibility with Vision Zero, which asserts that no traffic death is acceptable. Vision Zero emphasizes systemic design over blame and integrates human fallibility into infrastructure (e.g., 30 km/h urban speed limits that boost pedestrian survival rates from 50% to 90%). Where traditional methods viewed lifesaving as costly, Vision Zero proves that prevention is affordable through data-driven, human-centric systems. The declining death rates post-1990 underscore its effectiveness.

Hardware Innovations:

Truck-Mounted Attenuators (TMAs) represent a critical advancement in road safety hardware, designed to absorb and dissipate crash impacts, thereby protecting both roadside workers and drivers. These energy-absorbing systems are particularly effective in high-risk zones such as construction areas and toll plazas. In the Indian context, TMAs have been adapted with enhanced visibility features like LED lights and reflective markings to suit local conditions, while their strategic deployment at accident-prone locations including exit ramps and sharp curves demonstrates a proactive approach to mitigating collision risks. By integrating such innovations, India aligns with global safety best practices while addressing its unique infrastructure challenges.

Behavioral Psychology Approach to Road User Safety

Understanding road user behavior through behavioral psychology is essential for improving traffic safety. Research identifies high-risk groups such as long-haul truck drivers and urban motorcyclists, who often face challenges like fatigue, limited training, and socioeconomic constraints. By analyzing factors like work hours, income levels, and driving conditions, safety interventions can be tailored to specific needs. The Haddon matrix framework helps examine interactions between road infrastructure, vehicles, and human factors to develop targeted solutions. This approach moves beyond generic measures to address the root causes of unsafe behaviors, enabling more effective, data-driven policies that protect vulnerable road users and create safer transportation systems for all.

3.4.3 Interplay of International Best Practices in Indian Landscape: Learnings, Challenges and Benefits

The National Highways Authority of India (NHAI) has prioritized road safety as a core component of its national highway development and management strategy. NHAI implements comprehensive measures to reduce accidents, fatalities and injuries through infrastructure upgrades, technology integration, and public awareness programs

Key Road Safety Initiatives

Awareness and Education Campaigns	Road Safety Infrastructure Upgradation	ATMS
Sadak Suraksha Abhiyan 2025 - Targeting students and citizens to promote awareness and safe practices	**Road Expansion & Strengthening**	Make highways a safer place
Training and Education - Training programs on traffic rules, safe driving, and accident prevention for all road users.	**Safety Upgrades: Short-term:** Crash barriers, rumble strips, reflective markers.	Over speeding penalization
Social media initiatives (#RoadSafetyIndia) to promote road safety awareness.	**Long-term:** Flyovers, vehicular underpasses	Lane discipline and cross overs
	Regular Audits	Identifying obstacles on the highway
		Highway Command Centre for Operations and Response

NHAI has successfully deployed ATMS across **326 projects** covering approximately **20,000 km** of national highways, significantly enhancing traffic monitoring and enforcement capabilities. Building on this infrastructure, the authority plans to integrate **VIDES Gantry systems** similar to those implemented on the Bengaluru-Mysuru Expressway to enable automated e-challan generation for violations like over speeding. For high-speed corridors, this will be complemented with **Traffic Monitoring and Control Systems (TMCS)** to detect stalled vehicles at shorter intervals, ensuring real-time incident response. These upgrades aim to create a **seamless, tech-driven enforcement ecosystem**, improving compliance and safety across India's highway network.

Traffic Monitoring Camera Systems (TMCS) — Eyes on Highway

- Pan-Tilt-Zoom cameras
- At least 1 every kilometre
- 100m night range minimum
- Placement should be such that entire highway stretch is visible
- Basic intelligence included (accident + stalled vehicles)
- AI can be centralized or edge-based
- One Traffic Operator manually viewing per 15 cameras

Video Incident Detection and Enforcement Systems (VIDES) —Enforcement Gantries

- System of camera (s):
  - Overview camera
  - Side camera
  - ANPR camera(s)
  - Radar (if needed)
  - IR and Thermal if needed
- Generally every 10 kilometre in accident prone areas or areas with likely over-speeding or traffic rule violations
- 14 kinds of incidents to be detected using AI, 8 of which are eChallan based

Vehicle Actuated Speed Display (VASD) — Speed Calming Measures

- Radar and Lane-wise displays
- No number plate recognition therefore no challan
- Every 20 km and separated from VIDES
- This is inexpensive way to warn before punishing offender through VIDES

ATMS implementation and enabled automated penalty systems have demonstrated remarkable success in deterring traffic violations and enhancing road safety compliance.

Regulations for Improving Vehicle Safety by MoRTH

Vehicle Safety Measures for Passenger Cars

The Ministry of Road Transport has mandated critical safety features for cars (M1 category) since July 2019, including dual front airbags, side/curtain airbags, and three-point seatbelts with reminders for all occupants. Additional requirements include reverse parking sensors, an Anti-lock Braking System (ABS), Electronic Stability Control (ESC), a Brake Assist System and over speed warnings to prevent collisions. These measures address both passive safety (impact protection) and active prevention (driver alerts), significantly reducing accident risks.

The Bharat New Car Assessment Programme (BNCAP) regulations standardize vehicle safety ratings in India. Under this program, cars undergo rigorous testing as per AIS 197 standards, evaluating three key areas: Adult Occupant Protection (AOP), Child Occupant Protection (COP), and Safety Assist Technologies (SAT). Based on performance, vehicles receive a 1 to 5-star rating, empowering consumers to make informed choices about crash protection levels. This initiative aligns India with global safety benchmarks while promoting safer vehicle design and manufacturing practices.

Safety Standards for Heavy-Duty Vehicles

For buses and trucks (N2/N3 categories), new regulations effective October 2025 enforce cabin air-conditioning, speed limiters, Anti-lock Braking Systems (ABS), Electronic Stability Control (ESC) and Brake Assist Systems. School and Type III buses require fire alarm/protection systems to extend evacuation time during emergencies. Revised mirror standards and manufacturing rules for OEMs/bodybuilders ensure consistent safety compliance across commercial vehicle segments.


NHAI

3.5 Roads of Tomorrow – Pioneering the Future with Technology

Technological integration in the road sector is reshaping traditional approaches to monitoring, management, and maintenance. Digital platforms are enabling seamless oversight of highway operations through centralized data systems and real-time analytics. At the same time, there is a growing emphasis on incorporating design and construction practices that contribute to safer road environments, with the objective of reducing accidents and enhancing overall user safety. In the area of tolling, evolving technologies and processes are offering new opportunities to improve traffic flow, enhance user convenience, and streamline revenue systems. Moreover, the application of technologies such as Artificial Intelligence, the Internet of Things, and predictive analytics is transforming highway maintenance by enabling timely interventions, optimizing resources, and ensuring long-term infrastructure resilience. These developments collectively signal a shift towards smarter, safer, and more efficient road networks.

3.5.1 NHAI's Unified Digital Stack for Highway Monitoring and Management

Modern highway infrastructure management is increasingly being shaped by data-driven processes and digital monitoring tools. In India, the transition from manual oversight to technology-enabled systems has significantly improved the tracking and accountability of field-level activities across the highway network.

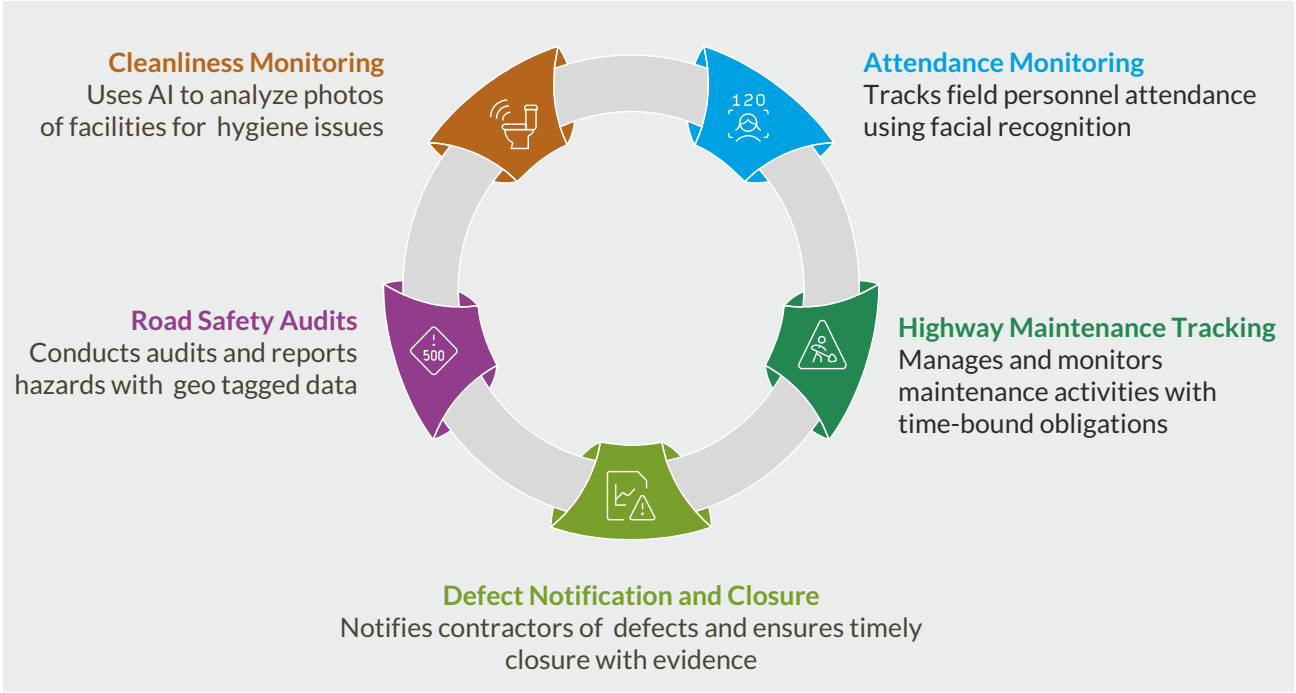
Initial Phase – Digitizing Construction Outputs

The early digital efforts focused on capturing high-level construction data, such as the number of kilometres built. While this provided aggregated outputs, it lacked field-level granularity and real-time visibility. Field activities, which form the core of highway operations, were often reported with delays. For example, work such as Road Formation Inspections (RFIs) was recorded at the end of each month, limiting opportunities for timely interventions. Additionally, contractor teams typically operated through a single user login, making it difficult to attribute responsibilities or track individual performance.

Shift to Real-time, Field-based Data Capture

To address these limitations, a field-integrated approach was adopted. The solution involved deploying a mobile-based platform known as **NHAI One**, aimed at enabling real-time reporting from the site itself. This marked a significant shift, ensuring data was captured precisely when and where the activity occurred, accompanied by photographic or GPS-based evidence. The platform supports a wide range of critical highway activities:

As of now, over 15,000 users actively operate within the system. Daily attendance is marked by approximately 6,000 individuals. Over 140,000 defects have been digitally closed with photographic proof, and around 1 million RFIs have been logged using the platform. Road safety audits have exceeded 100,000 records, and AI-driven cleanliness tracking has yielded measurable improvements, with a 30% drop in unclean assessments after implementation.



Addressing Under-reporting with Automation

Despite the success, under-reporting remains a concern — only about 60% of joint inspections are digitally recorded, and certain locations with multiple issues are under-represented in defect counts.

To overcome this, a **Drone Analytics and Monitoring System (DAMS)** has been introduced. Drones now conduct regular monthly surveys of highway stretches. The footage is uploaded to a centralized portal and analyzed using AI and machine learning to detect issues like:

- Construction progress
- Unauthorized median openings
- Road safety concerns
- Encroachments
- Visual road defects
- Plantation status

The drone data is supplemented by Network Survey Vehicles (NSVs), which provide detailed reports including photographic evidence, ride quality (IRI), and pavement condition (PCI).

Multi-Source Integration and Unified Reporting

To consolidate various data streams, NHAI has begun integrating inputs from all monitoring sources — mobile app reports, drone imagery, NSV assessments, and even citizen complaints via the Rajmarg Yatra app. These are all channelled into the same central defect management workflow, ensuring consistent tracking and accountability. Reports from Advanced Traffic Management Systems (ATMS), such as non-functioning streetlights or barrier issues, are also being funnelled directly into this system.

Future Expansion – Crowd-Sourced Data and Public Integration

Plans are underway to collaborate with mapping platforms like Google Maps and MapMyIndia to allow the public to report defects, which will be routed through the same internal systems for timely resolution. Public alerts, such as blackspot warnings, will also be disseminated back through these platforms for user safety.

Performance Monitoring and Real-time Dashboards

A real-time dashboard enables monitoring of defect status across all channels. It provides role-based views for internal teams, contractors, and concessionaires. The dashboard allows filtering by specific highways or contractors, tracking defect closure rates, and ensuring compliance with timelines. In recent months, the number of defects identified through automated systems (e.g., drones and AI) has surpassed manual reports, indicating a growing reliance on and trust in machine-based monitoring.

3.5.2 Net-Zero Roads: Innovations in Sustainable Construction

India, home to the world's second-largest road network spanning over 6.4 million kilometers, is at a pivotal stage where traditional road construction methods—heavily dependent on non-renewable resources have caused considerable environmental, economic, and social repercussions, including increased carbon emissions, deforestation, and pollution. As the pace of infrastructure development accelerates, the shift towards sustainable road construction has become an urgent necessity rather than a choice. This transition involves adopting eco-friendly materials, carbon-neutral alternatives like recycled aggregates and low-carbon asphalt and integrating renewable energy sources into construction processes. By employing advanced techniques such as energy-efficient methods and carbon sequestration, the industry can significantly reduce its carbon footprint while preserving durability and performance. Sustainable road construction thus offers a balanced approach one, that supports economic progress while aligning with global environmental responsibilities and long-term resource conservation.

Key Principles of Sustainable Road Construction

Sustainable road construction incorporates practices that reduce environmental impact throughout a road's life cycle. Core principles include building durable and climate-resilient roads, adopting preventive maintenance to extend service life, conserving natural resources through material recycling, and minimizing greenhouse gas emissions using cleaner technologies and construction methods.

Reduce, Reuse, Recycle

- Minimize wastage of resources
- Maximize the reuse of materials like Reclaimed Asphalt Pavement (RAP), plastic waste, fly ash etc.

Resource Efficiency

- Process automation, renewable materials and use of local available material
- Use low-carbon and alternative binders

Energy Efficiency & Low Carbon Footprint

- Implementing energy-saving techniques and materials like Warm Mix Asphalts (WMA)
- Optimize construction equipment efficiency to minimize fuel use
- Encourage electric and hybrid machinery

Eco-friendly Materials and Design

- Adopting Eco-friendly design concept from new material and techniques.
- Enhancing drainage systems and use cool pavements for reducing urban heat.

Durability & Resilience

- Designing roads integrating climate assessment for longer life with minimal maintenance interventions
- Implement preventive maintenance strategies to reduce frequent repairs

Sustainable Road Development Practices

Sustainable road development practices collectively contribute towards reducing environmental impact and promoting sustainable infrastructure. These include:

- **Pavement Recycling**: Reuses existing materials (hot/cold in-plant or in-place) to reduce waste and conserve natural resources.
- **High Performance Materials**: Utilizes advanced materials like SMA, HiMA, PMB, and Perpetual Pavement to build durable roads requiring fewer repairs.
- **Energy Efficient Materials:** Incorporates cold mixes and fiber-based micro-surfacing that require minimal heating, leading to lower emissions.
- **Warm Mix Asphalt:** Uses lower temperatures than traditional asphalt, cutting down on fuel use and greenhouse gas emissions.
- **Plastic Roads:** Integrates plastic waste into asphalt for greater durability and sustainability.
- **Intelligent Transportation Systems (ITS):** Implements smart technologies to improve traffic flow and reduce emissions.

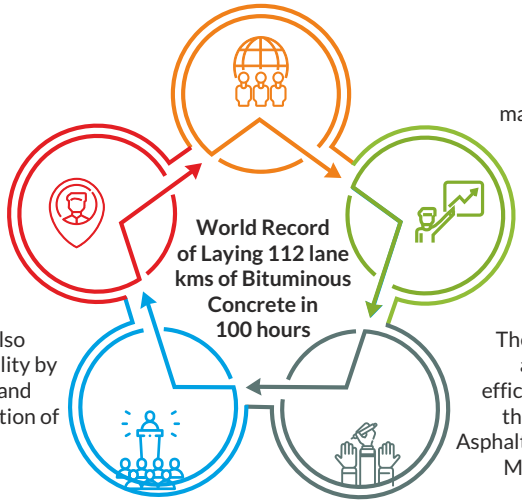
In a landmark milestone, an HOAI member has demonstrated the power of CCPR by laying 112 lane kilometers of bituminous concrete in just 100 hours—a world record. Utilizing nearly 90% Recycled Asphalt Pavement (RAP), this approach saved approximately 4.25 lakh metric tonnes of natural resources and reduced CO_2 emissions by 78,000 tonnes. CCPR represents a paradigm shift in road construction by enabling efficient material use, lowering fuel consumption, and promoting circular economy practices in infrastructure development.

Cold Central Plant Recycling (CCPR) technology produces high quality economical paving material preventing valuable resources from being landfilled. It is the process in which the asphalt recycling takes place at a central location using a stationary cold mix plant and an existing stockpile of Recycled Asphalt Pavement

State-of-the-art green technology
CCPR technology implemented in this project represents a groundbreaking innovation in the Indian construction industry. focusing on sustainable recycling of deteriorated pavement resulting in reduced bitumen and fuel consumption

Saving of natural resources
The project resulted in a significant saving of —4.25 lakh metric tonnes of natural resources, emphasizing a responsible and resource-efficient construction methodology

Efficient Material Utilization
CCPR efficiently recycles 90% of milled material (RAP), reducing the demand for new resources and reduce reliance on virgin materials. with consumption limited to a mere 10%



Greenhouse Gas Emission Reduction
CCPR not only promotes recycling but also contributes to environmental sustainability by significantly reducing fuel consumption and associated GHG emissions. Led to reduction of over —78,000 tonnes of C02 emissions

Sustainable Model
The project extends a holistic and sustainable approach, including deployment of energy-efficient equipment and machinery throughout the construction cycle and usage of Recycled Asphalt Pavement (RAP) in the Dense Bituminous Macadam (DBM) layer through hot recycling

52,000 MT BC was produced with approximate 3000MT bituminous materials delivered at site just in 76 hours through 3 layered QMS at Refinery, Modification Plant and at Construction site.

Innovations in Sustainable Construction

To meet the growing demands of infrastructure while addressing environmental concerns, the road construction industry is rapidly embracing innovative and sustainable technologies. These forward-looking approaches aim to reduce resource consumption, lower emissions, and enhance the durability and efficiency of road networks. The following table highlights key innovations that are shaping the future of sustainable road development.

Green and Recycled Materials	➢ Recycled Asphalt Pavement (RAP): Reusing higher percentage of RAP to reduce the need for virgin materials. ➢ Reclaimed Concrete Aggregate (RCA): Crushed old concrete used in new road bases. ➢ Fly Ash and Steel Slag: Industrial by-products that replace traditional cement, aggregate reducing CO_2 emissions.
Self-healing Roads	➢ Self-healing roads are roads that can repair their own cracks without human intervention. ➢ Using micro encapsulated healing agents & steel fibres and epoxy capsules to repair cracks.
Permeable Pavements	➢ Allow water to pass through, reducing runoff and enhancing groundwater recharge. ➢ Helps prevent urban flooding and minimizes heat absorption.
Carbon-neutral Binders	➢ Utilizing bio-based or carbon-neutral binders instead of petroleum-based asphalt. ➢ Examples include lignin-based (plant-based polymers) and algae-based binders. ➢ Trials have already been done in India.
Renewable Energy Integration	➢ Solar roadways: Embedding solar panels within road surfaces to generate electricity. ➢ Kinetic energy harvesting: Generating power from vehicle movement using piezoelectric technology. ➢ Integration of electric vehicle (EV) charging infrastructure in roads.
Automation in Construction Industry	➢ Intelligent machines are helping in better quality control and hence improving the durability. ➢ Construction times are being reduce. ➢ AI-based road monitoring systems to optimize materials & maintenance. ➢ Increased use of AI and machine learning in road design for optimal material usage and energy efficiency.
3D-printed Roads	➢ Reduces material wastage and improves precision in road design. ➢ Uses automated 3D printers to lay down concrete or asphalt with precision, reducing material waste.

Challenges and Way Forward

3.5.3 Navigating the Future of Tolling: The Impact and Opportunities of MLFF Technology

Tolling Challenges in India's Highway Ecosystem

Despite India's advanced road infrastructure and electronic toll collection (ETC), congestion at toll plazas and the "pay-as-you-use" model (especially for private vehicles) remain key pain points. The focus is on reducing logistical costs through a barrier-free tolling ecosystem, leveraging existing technologies like RFID and ANPR cameras to transition to Multi-Lane Free Flow (MLFF) systems.

Pilot Projects and Industry Adoption

MLFF pilot testing is underway at a few toll plazas to test enforcement mechanisms for pan-India scalability. A HOAI member has already implemented MLFF, highlighting its potential to cut operational inefficiencies (currently ~15% of toll revenue). The shift aims to eliminate stoppages, ensuring seamless traffic flow.

Enforcement and Revenue Assurance

To address revenue leakage, NHAI has integrated with NIC's e-Challan portal for violator enforcement. Post the "One Vehicle, One FASTag" policy, non-payers will face FASTag blocking. The ministry is amending CMVR rules to link fitness certificates, NOCs, and national permits with toll compliance, backed by legal provisions under Section 14 of NH Fee Rules.

The Authority urges concessioners to adopt MLFF, with IHMCL providing implementation support. The goal is to create a frictionless tolling experience while ensuring revenue integrity, marking a transformative leap in India's highway efficiency.

3.5.4 Emerging Technologies in Highway Maintenance: AI, IoT, and Predictive Analytics

Introduction to Tech-driven Maintenance

With 145,000 km of highways (world's second-largest network), India has added 56,700 km in five years, despite NHs constituting just 2% of roads while carrying 40% of traffic and 60% of freight, fuelling more than $3.5 trillion economy. The target to expand to 200,000 km by 2037 faces dual pressures: ₹15,000 crore in annual maintenance costs and 40% of highways needing urgent repairs, exacerbated by 50% projected traffic growth by 2030 and monsoon damage. Additionally, India's highway maintenance has long been reactive addressing potholes and bridge defects only after they emerge leading to delayed repairs, rising costs (₹15,000 crore annually), and safety risks. Aging infrastructure and manual inspections further exacerbate inefficiencies. Globally, predictive maintenance slashes costs by 20-30% (potentially ₹3,000-4,500 crore yearly savings for India) and aligns with NHAI's upgrade plans in a $100B market by 2030. The opportunity lies in leveraging AI and IoT to transition from patchwork fixes to proactive prevention, optimizing both safety and budgets.

The highway maintenance sector is undergoing a technological revolution through the integration of Artificial Intelligence (AI), Internet of Things (IoT) networks, and predictive analytics. These innovations enable self-healing road concepts, intelligent lighting systems, and real-time environmental monitoring via temperature/humidity sensors, transforming traditional reactive maintenance into proactive asset management.

Tech Innovations in Highway Maintenance

AI is revolutionizing road maintenance by enabling predictive analytics to identify defects like potholes and cracks before they worsen. Using machine learning on data from IoT sensors, drones, and traffic cameras, AI forecasts maintenance needs with high accuracy reducing costs and minimizing disruptions. By shifting from reactive repairs to preventive action, AI ensures safer, longer-lasting roads while optimizing budgets.

First, Artificial Intelligence.
AI helps to process huge data-traffic flows, weather patterns, pavement stress-to spot issues before they are escalated. Globally, California using AI to analyze drone footage, detecting cracks 40% faster than humans. Imagine scaling this-AI could save ₹1,000 crore yearly by slashing repair delays, while making stretches safer. Many Indian firms already AI pioneers in logistics, could lead this charge.

Next, The Internet of Things.
The Internet of Things (IoT) refers to interconnected sensors, devices, and systems that collect and share real-time data. IoT is like a highway's nervous system—sensors embedded in roads and bridges, talking to us in real-time.

Finally, Predictive Analytics.
This marries AI and IoT to forecast when and where maintenance strikes. The UK's National Highways uses it to prioritize repairs, reducing emergencies by 15%.

Intelligent lighting

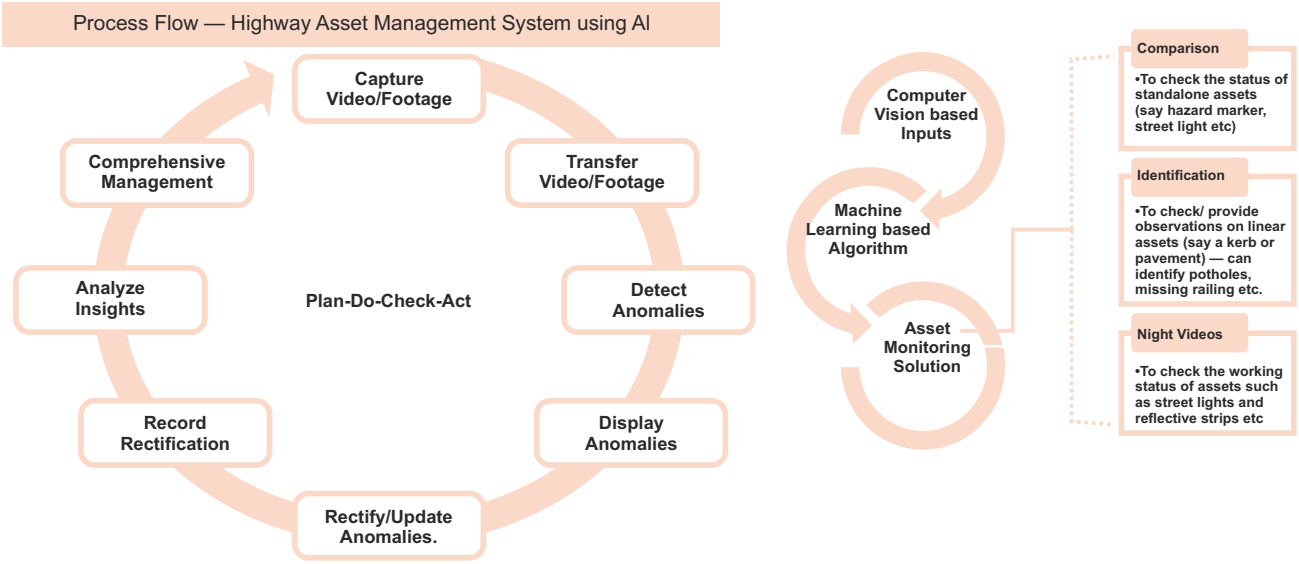
Temperature and humidity sensors

Using artificial intelligence and big data

Self-Healing Roads with AI Integration

AI-Powered Highway Asset Management

Pavement Maintenance: Machine learning algorithms analyze historical data to predict maintenance needs, optimizing budget allocation and repair scheduling.



Bridge Maintenance: Modern bridge management leverages AI and drone technology to transform inspections and maintenance planning. Drones capture high-resolution photos and videos of bridge components, which are synchronized into a centralized system for element-wise rating and documentation. Machine learning algorithms analyze this data to detect structural flaws, corrosion, or wear, generating customized dashboards with visual maps, tables, and trends. AI further assists in prioritizing repairs by ranking bridges based on risk and condition, enabling precise work orders aligned with BOQ (Bill of Quantities). Contractors are assigned tasks via automated scheduling, while real-time progress tracking ensures timely interventions. This data-driven approach enhances accuracy, reduces manual effort, and extends bridge lifespan through proactive maintenance.

The integration of AI-driven defect detection and drone-based monitoring marks just the first step in revolutionizing India's highway infrastructure. The future lies in scaling IoT, predictive analytics, and smart sensors to create self-monitoring roads that prevent potholes and cracks before they form. This tech-enabled approach promises 20% lower emissions, annual savings of ₹10,000 crore, and 50,000+ lives saved by pre-empting accidents. Beyond safety, smart highways will catalyze economic growth through efficient freight corridors and autonomous mobility. This transformative vision, already actionable through pilots and strategic investments, can redefine India’s infrastructure legacy, turning highways into engines of national progress.

3.6 Bridging the Skills Gap – Preparing India's Workforce

Human resource development plays a critical role in strengthening the infrastructure sector, particularly in the context of construction and allied services. A comprehensive analysis of existing skill gaps is essential to understand workforce readiness and identify areas requiring targeted intervention. Addressing these gaps involves not only enhancing technical competencies but also establishing structured training and skill development programs aligned with industry needs. Collaboration between academic institutions and the industry can serve as a catalyst in bridging this divide by aligning the curriculum with practical demands and fostering innovation. Furthermore, empowering local communities through skill-building initiatives can have a lasting impact on livelihoods, promoting inclusive growth and sustainable employment opportunities within the sector. Together, these efforts contribute to building a capable and future-ready workforce.

3.6.1 Construction Skills – Gap Analysis and Solution

India's Construction Industry Landscape

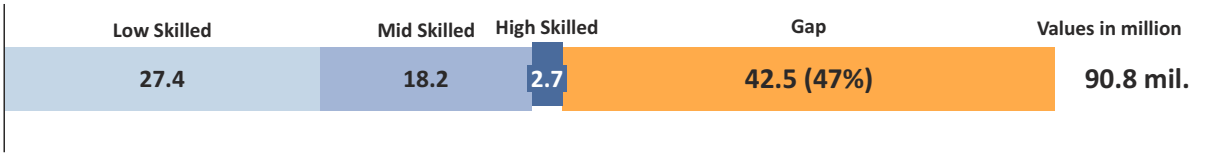
India's infrastructure sector is witnessing unprecedented growth, with a capex outlay of ₹11.21 lakh crore in FY25-26, of which over ₹6 lakh crore is allocated to construction-heavy sectors like roads, railways, and housing. Despite constructing 30+ km of national highways daily, the industry faces a severe skill gap: only 5% of engineering graduates (80,000 out of 1.5 million) pursue civil engineering. With 70 million workers currently employed and projections of 100 million by 2030, addressing workforce challenges is critical to sustaining this growth.

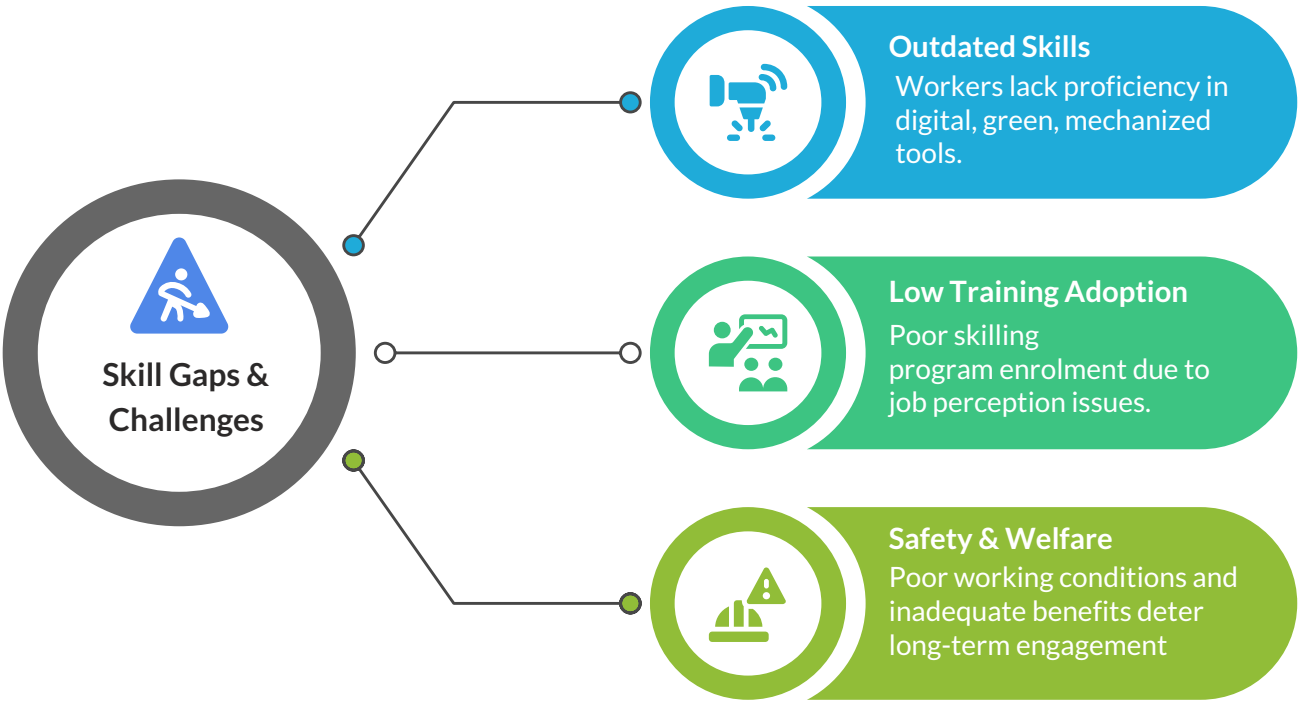
Demand-Supply Mismatch in Workforce

A 47% shortfall (42.5 million workers) exists across skill levels (low, mid, and high), as per CSDC 2022 data. Key issues include:

- **Geographic Imbalance:** 60% of investments are concentrated in 7 states, while 50% of workers reside in 6 states (UP, Bihar, Tamil Nadu, Rajasthan, MP, West Bengal, etc.).
- **Skill Relevance:** Outdated training programs fail to address modern needs like ATMS (Advanced Traffic Management Systems) and TCMS (Toll Collection & Management Systems).

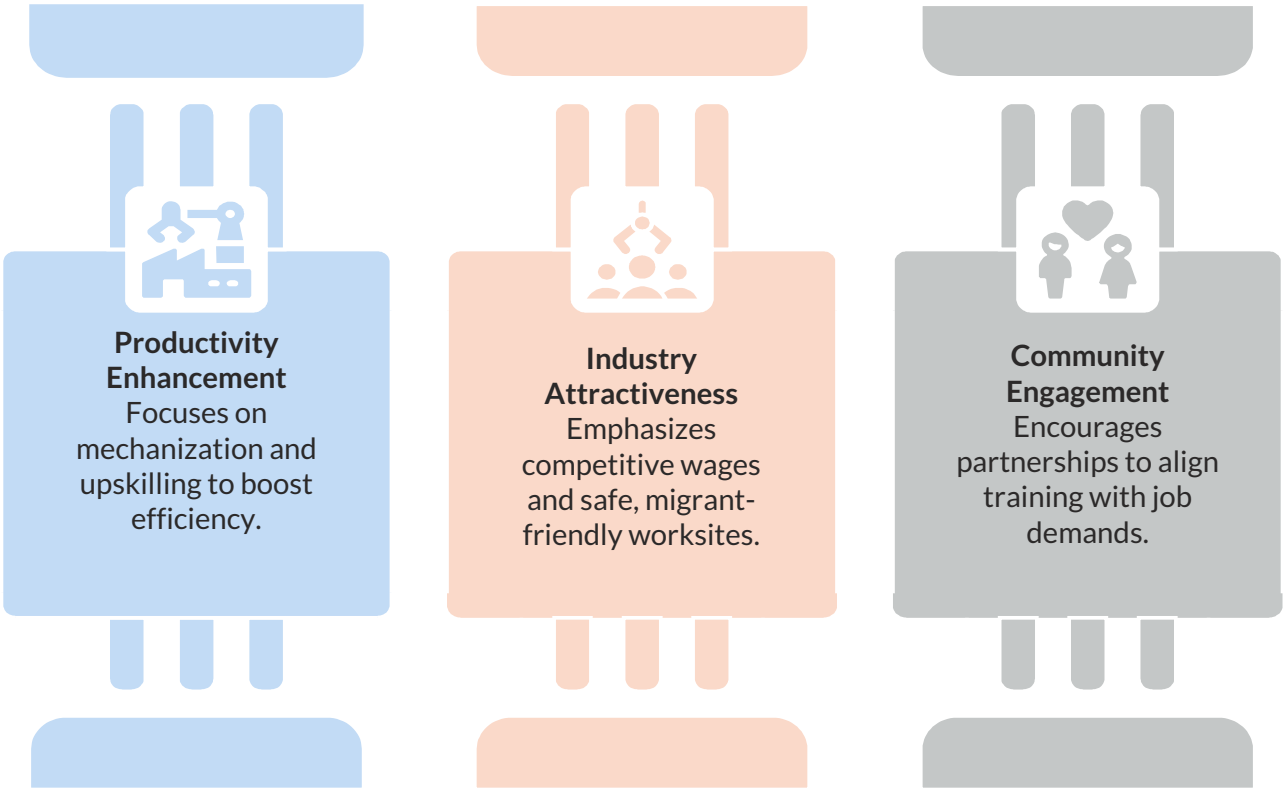
1 **45% Shortfall in Construction Workforce (2022)**





Call to Action: Strategic Interventions

To bridge these gaps, HOAI proposes the following actions:



3.6.2 Identifying Training and Skill Development Needs

Construction Skill Gaps

There are critical skill deficiencies in India's infrastructure construction sector, particularly in highway development. Drawing from RICS Knight Frank reports, it emphasizes how the rapid growth of infrastructure projects has outpaced the availability of technically skilled workers, resulting in quality compromises across NHAI projects. The sector faces a paradoxical situation where 15,000+ it is, specialized construction institutes (like NICMAR, IIIC, CMTI, NAC – Hyderabad, L&T CSTI), Central and State Government skill training programs (PMKVY, PMKK, etc.)and RPL training programs by government & private players coexist with persistent workforce skill shortages.

Employment in construction sector is estimated to grow to 100 mn to attain economic growth targets

	Unit in 000s				% Share			
Occupation	2005	2011	2023E	2030E	2005	2011	2023E	2030E
Engineers	822	1050	2200	3309	2.7%	2.6%	3.1%	3.3%
Technicians/Foremen	573	1120	2271	3811	1.8%	2.7%	3.2%	3.8%
Clericals	738	930	1916	2908	2.4%	2.3%	2.7%	2.9%
Skilled Force	3267	3730	6884	10530	10.5%	9.1%	9.7%	10.5%
Semi-skilled	25600	34200	57695	79724	82.6%	83.4%	81.3%	79.5%
Total	31000	41030	70966	100282	100.0%	100.0%	100.0%	100.0%

Source: NSDC, CMIE, Knight frank research

Construction Skill Training Challenges

The construction sector faces multifaceted skill development challenges that impact productivity, sustainability, and worker welfare. A staggering **75% of the workforce remains unskilled,** leading to cost overruns, delays, and wage stagnation. Simultaneously, the industry grapples with **sustainability imperatives** (contributing 22% of India's CO_2 emissions) and **digital transformation** (66% of firms prioritizing digitization), both of which demand updated training curricula. **Sub-contracting** (65% of the workforce) exacerbates issues like delayed payments and safety lapses, while **informality** drives high fatality rates (25% of occupational deaths). Addressing these gaps requires urgent upskilling in **green technologies, digital tools,** and **ethical labor practices** to enhance productivity, reduce emissions, and improve worker conditions.

			Construction companies	Construction workers	Skilling ecosystem
Poor supply of skilled labour	75%	of the workforce in the industry is unskilled	Cost overruns. project delays, and limited productivity	Stagnation in overall wages and limited bargaining power	Growing need to train semi-skilled workers to skilled workers
Growing focus on Sustainability and Greening	22%	of India's total annual Co2 emissions are from the construction industry:	Higher need to create Green and sustainability jobs	Increased skill gap for workers	Growing need for skilling agencies to update course curriculum
Digitisation of construction operations	66%	of construction companies plan to prioritise digitisation	Higher short term costs in procurement and integration	Increased skill gap for workers	Growing demand for digital skilling by micro-contractors and workers
Extensive use Of sub-contracting engagements	85%	of all construction workers are engaged through labour sub-contracting*	Project delays, limited productivity. and risks of unethical worker treatment	Delayed payments and poor provision of amenities at sites	Increasing need to train small and micro-contractors in ethical management
High levels of informality with limited focus on worker safety, living conditions and social security	25%	of all occupational fatalities in India come from the construction industry	Low productivity and minimal retention of workers	Poor health and safety conditions and financial precariousness	Increasing need to train small and micro-contractors in ethical management

Quality Challenges in Highway Construction

Despite achieving international standards in core construction, Indian highways show recurring quality issues in:

- Finishing issues (pavement smoothness, signage alignment, quality of signage, cleanliness, etc.)
- Poor maintenance practices (over-reliance on patchwork repairs costing ₹10-20 crore per instance)
- Serious safety issues

Pipal Tree's Role in Bridging Construction Skill Gaps

Pipal Tree Ventures is a social enterprise founded in 2007 with the aim of uplifting underprivileged youth, particularly school dropouts from rural areas, by providing them with skill-based education and employment opportunities. Recognizing that the construction workforce in India is largely unorganized and comprised of migrant laborers facing poor working conditions and low wages, Pipal Tree established modern training centers across the country. These centers, equipped with industry-grade machinery and guided by veterans, have successfully trained over 60,000 individuals in quality construction practices.

Beyond training, Pipal Tree also took the initiative to operate as a contractor to ensure the creation of organized, dignified jobs that offer regular income and insurance. While the organization initially focused on construction, it later expanded into retail skill training to overcome challenges related to the migratory nature of the labor force. The enterprise serves as a model for sustainable workforce development by converting unskilled individuals into competent, confident, and employable professionals.

Pipal Tree is addressing critical skill shortages in India's infrastructure sector through targeted vocational training programs that align with industry needs. By partnering with construction firms, technology providers, and government initiatives like PMKVY, it focuses on upskilling unskilled laborers (who comprise 75% of the workforce) and developing specialized supervisors to improve highway construction quality. Its curriculum integrates green construction practices (to combat the sector's 22% CO_2 emissions) and digital tools (AI, checklists) to modernize quality control. Through collaborations with ITIs and micro-contractors, Pipal Tree also tackles subcontracting challenges (65% workforce) by promoting ethical labor practices and safety training, thereby enhancing productivity while reducing occupational fatalities (25% of India's total). These efforts create a pipeline of job-ready workers while supporting sustainable infrastructure growth. Since 2007, Pipal Tree has created job opportunities for around 1,00,000 youths.

Proposed Training Framework for HOAI

To enhance workforce capabilities in highway construction, HOAI should adopt a structured training framework with two core components:

Workforce Upskilling

- Mandatory safety and skill certification for unskilled laborers
- Development of in-house trainers from experienced workers
- Wage incentives for certified skilled teams

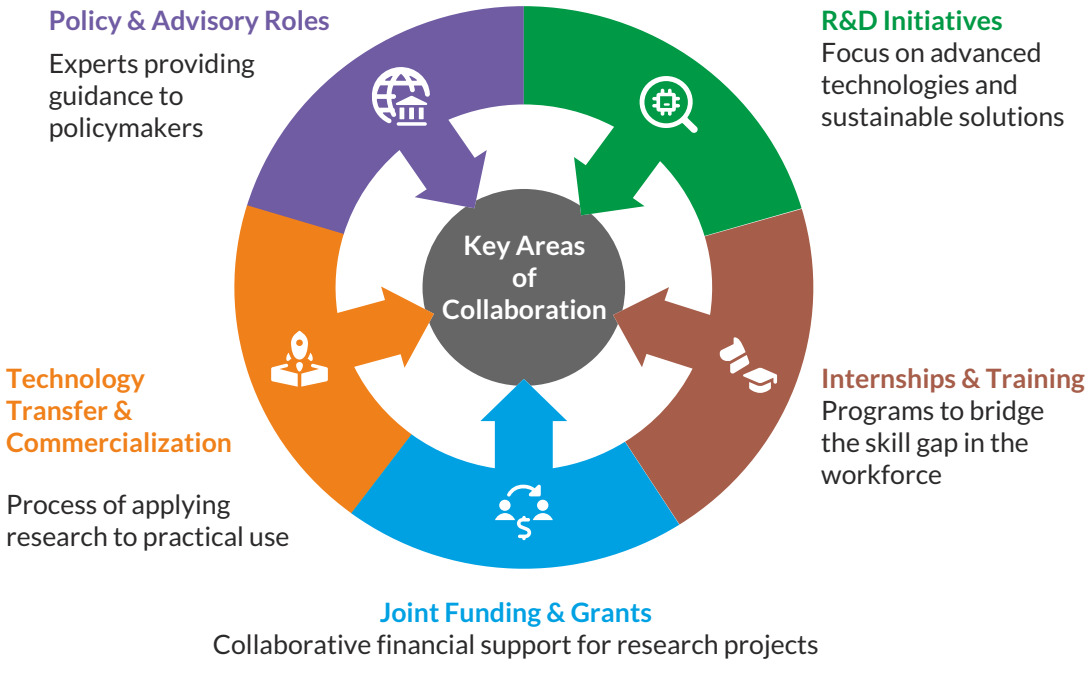
Supervisory Training

- Specialized programs for finishing, pavement, and maintenance supervisors
- Integration of AI tools for quality monitoring and defect detection
- Digital documentation through checklists and visual evidence
- Centralized dashboards to track recurring quality issues

3.6.3 Fostering Industry–Academia Collaborations

The Need for Collaboration

Road infrastructure plays a pivotal role in economic growth and public safety, yet challenges like aging pavements, material shortages, and lack of innovation persist. Bridging the gap between industry expertise and academic research is critical to developing sustainable, tech-driven solutions. Such partnerships enable cutting-edge R&D while providing academia with real-world problem statements, creating a symbiotic ecosystem that benefits governments through evidence-based policymaking.



Challenges in Collaboration

- Misaligned Goals: Academia's theoretical focus vs. industry's profit-driven approach.
- Funding Gaps: Limited investment in joint R&D projects.
- Regulatory and bureaucratic hurdles: Bureaucratic delays in adopting research outcomes.
- Slow adoption of research outcomes in the industry.

The construction sector, particularly in road infrastructure, faces significant challenges stemming from its disorganized nature and the widening skills gap between academic training and industry requirements. While students undergo four years of theoretical education, they often lack the practical, job-ready skills needed to address real-world construction challenges, such as material innovation, project management, and technology integration. This disconnect between "what is taught" and "what is expected" leads to inefficiencies, delays, and compromised project quality. Additionally, the sector's fragmented structure hinders standardized training and career progression, exacerbating workforce shortages. Addressing these issues requires structured partnerships with educational institutions, tailored vocational programs, and investment in continuous skill development to align academia with industry demands and streamline the sector's growth.

Strategies for Effective Collaboration

Dedicated Research Hubs

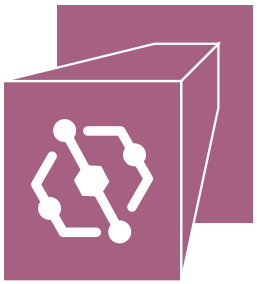
Establishing centres for industry-sponsored research.

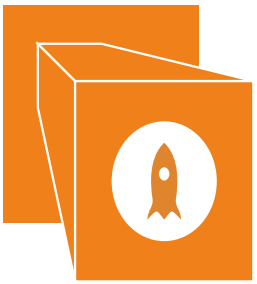
Government Incentives

Government tax benefits and grants for collaborative projects

Networking Events & Conferences

Bridging the gap between researchers and industry leaders.



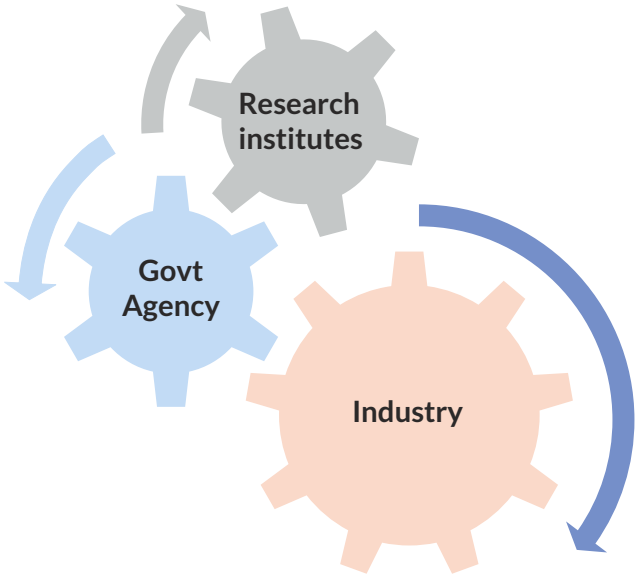


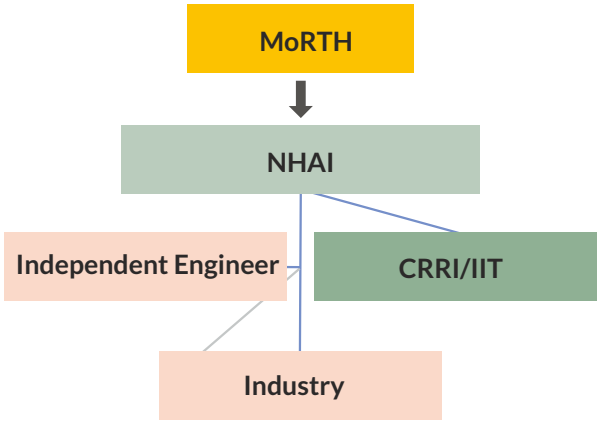
Pilot Projects & Testbeds

Small scale testing before full implementation

The Need: Collaborate towards a Common Goal of Sustainable Roads

Achieving sustainable road infrastructure demands unified collaboration across stakeholders, including MoRTH, NHAI, research institutes (CRRI/IITs), independent engineers, government agencies, and private industry. Each entity brings critical expertise, policymakers provide regulatory frameworks, academia contributes cutting-edge R&D, and the industry implements practical solutions. By aligning their efforts toward shared objectives like decarbonization, material innovation, and climate resilience, these partners can address systemic challenges such as aging pavements and extreme weather vulnerabilities. Such synergy ensures that sustainable roads transition from concept to reality, balancing economic growth with environmental stewardship.





Future Roadmap for Collaboration

- **Scaled Partnerships:** Expanding ties between institutes and corporations.
- **Tech Integration:** Leveraging AI, IoT, and big data analytics for smarter infrastructure.
- **Sustainability Focus:** Green materials and climate-resilient designs to combat challenges like extreme weather and overloading.

The road sector must prioritize long-lasting, sustainable pavements through unified efforts. By addressing collaboration barriers and fostering innovation, industry-academia partnerships can transform challenges like heavy rainfall and overloading into opportunities for future-ready infrastructure.

3.6.4 Empowering Communities: Impact on Skills and Livelihood

Highway development is not just about constructing roads, it's about transforming lives and fostering inclusive growth. The Highway Operators Association of India (HOAI) recognizes that sustainable infrastructure must go hand-in-hand with community empowerment, skill development, and livelihood creation. By bridging the gap between infrastructure projects and local needs, HOAI is pioneering a model where highways become catalysts for socio-economic progress, aligning with national goals like Skill India and global commitments such as the Sustainable Development Goals (SDGs). HOAI has taken initiatives to uplift communities, enhance skills, and create lasting impact proving that roads can pave the way for a brighter future.

Empowering Communities

Communities: Bridging the gap	› Highway Operator's image improvement › Long term association › Key stakeholder - Involving them as partners › Employment generation at local level › Addressing larger problems of urbanization › Contributing towards SDGs
Areas of Engagement	› Understanding their needs › Customizing our programs in line with localized problems › Education and educational infrastructure › Skill upgradation › Creating livelihood opportunities
Initiatives	› Creating educational infrastructure › Developing facilities for communities › Restoring existing and building sustainable infrastructure for communities › Taking care of female hygiene at public places › Facilities for cattle stock › Drinking water and sanitation facilities › Medical aid through camps and mobile clinics
Leveraging for HOAI	› Toll operations › Road safety › Maintenance activities › Medical training › Basic accounting skills › Computer skills
Ideas for Association	› Creating tailored programs aligned with business objectives › Tapping into govt. schemes such as PMKVY/Lakhpati Didi Scheme for women empowerment in rural areas › Collaboration with ITIs

HOAI members can collaborate with local educational institutes to develop customized skill development programs, equipping nearby communities with the technical expertise required for day-to-day highway operations and maintenance. This initiative creates a dual benefit: generating meaningful employment opportunities for local residents while ensuring a readily available, skilled workforce for HOAI members' asset management needs - effectively addressing the industry's talent shortage while fostering inclusive regional development.












July 18, 2025

Highway Operators Association of India, New Delhi

For the attention of **Dr. Zafar Khan, Vice President, HOAI**

Subject: Preparation of White Paper based on Annual National Conference on "Revolutionizing India's Road Infrastructure: A Vision for the Future"

Dear Sir,

With reference to the assignment awarded to us on 02nd March 2025, we are pleased to submit **"White Paper – A Vision for the Future"** on Revolutionizing India's Road Infrastructure: A Vision for the Future based on the One-day Conference arranged by Highway Operator's Association of India (HOAI) in association with Ministry of Road Transport and Highways (MoRTH) on 03rd March 2025 in New Delhi.

We thank you very much for the opportunity to work on preparation of White Paper based on the proceedings of the prestigious conference which has seen effective stakeholder participation of more than 200 participants from highway industry including key policymakers and senior members of authorities - MoRTH and NHAI, leaders and projects teams of HOAI member organizations, researchers, representatives of lenders and consultants across the country.

Should you require any clarification, you are requested to contact the undersigned.

Warm Regards

For Cube Highways Technologies Private Limited

Dhiraj Prakash Sethi

President – Safety, Systems & Audit

Disclaimer

The contents of this White Paper are based on the facts and representations collected during the conference. If any of these facts or representations is not entirely complete or accurate, the conclusions drawn therein could undergo material change and the incompleteness or inaccuracy could cause change in the Recommendations presented here.

The assertions and recommendations are based on the discussions and brainstorming during the Conference. Cube Highways Technologies Pvt Ltd (CubeTech) disclaims all liability to any third party who may place reliance on this report and therefore does not assume responsibility for any loss or damage suffered by any such third party in reliance thereon.

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HOAI
COMMITTED TO SAFE AND SUSTAINABLE MOBILITY

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