INTERNATIONAL ROAD FEDERATION
INDIA CHAPTER



SAFE ROADS & SAFE MOBILITY

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Yearbook 2026

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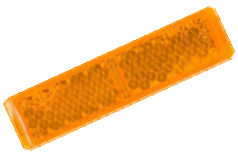
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सत्यमेव जयते

राष्ट्रपति
भारत गणतंत्र
PRESIDENT
REPUBLIC OF INDIA



MESSAGE

I am happy to know that the International Road Federation-India Chapter (IRF-IC) is bringing out its Yearbook 2026 on the theme of 'Safe Roads and Safe Mobility'.

Road safety remains a critical issue and a key component of sustainable development. Every life lost on roads is not just a statistic but a profound national concern that calls for urgent, sustained and collective action. Ensuring safer roads requires a comprehensive and coordinated approach involving robust infrastructure design, effective traffic management, strict enforcement of rules and greater awareness among citizens. The theme appropriately highlights the need to build a secure and inclusive system for transportation. I am confident that IRF-IC will continue to make dedicated efforts in promoting knowledge exchange, capacity building and best practices in the road sector.

I extend my best wishes for the success of this publication.

(Droupadi Murmu)

नितिन गडकरी
NITIN GADKARI



सत्यमेव जयते

मंत्री
सड़क परिवहन एवं राजमार्ग
भारत सरकार
Minister
Road Transport and Highways
Government of India

MESSAGE

It gives me great pleasure to convey my greetings to the International Road Federation (India Chapter) on the publication of the IRF IC Year Book 2026 on the theme "Safer Roads & Safer Mobility."

2. Road safety remains one of the foremost priorities of the Government of India. Our vision is clear—to significantly reduce road accidents and fatalities through a comprehensive, technology-driven, and citizen-centric approach. We are committed to transforming India's road infrastructure into a system that is not only world-class in quality but also among the safest globally.

3. The rapid growth of mobility in India calls for a paradigm shift in how we plan and manage transportation. In this context, the integration of Artificial Intelligence (AI) is emerging as a powerful enabler. AI-driven solutions such as intelligent traffic management systems, predictive analytics for accident prevention, automated enforcement, and real-time monitoring are helping improve efficiency, transparency, and safety across our road networks.

4. At the same time, transition towards electric mobility is gaining momentum in India. Promotion of electric vehicles (EVs), development of charging infrastructure, and adoption of clean and sustainable transport solutions are key pillars of our strategy to reduce carbon emissions and build a greener future. Safer mobility must go hand in hand with sustainable mobility.

5. We are also focusing on engineering improvements through safer highway design, black spot rectification, enhanced signage, and adoption of global best practices. Capacity building, public awareness, and strict enforcement remain critical components of our multi-pronged strategy.

6. I appreciate the efforts of the International Road Federation (India Chapter) in promoting knowledge sharing, innovation, and best practices in the road sector. This Year Book will serve as a valuable platform for disseminating ideas and inspiring collective action.

(Nitin Gadkari)

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अजय टम्टा
AJAY TAMTA

सत्यमेव जयते

राज्य मंत्री
सड़क परिवहन एवं राजमार्ग मंत्रालय
भारत सरकार
Minister of State for
Road Transport & Highways
Government of India



MESSAGE

It gives me immense pleasure to extend my greetings to the IRF India Chapter on the publication of the IRF India Chapter Yearbook 2026 focusing on **"Safe Roads & Safe Mobility"** with special emphasis on the safety of vulnerable road users, particularly two – wheeler riders.

India has one of the largest road networks in the world and road transport plays a vital role in the country's economic growth and social connectivity. However, ensuring road safety remains a critical challenge. Two-wheelers constitute a significant share of vehicles on Indian roads and unfortunately account for a large proportion of road accident fatalities and injuries. Protecting this vulnerable segment is therefore essential for achieving safer mobility for all.

The Ministry of Road Transport & Highways has been taking several proactive steps to improve road safety through a comprehensive approach encompassing engineering, enforcement, education, and emergency care. Initiatives such as strengthening road safety regulations, promoting helmet usage, improving road infrastructure, implementing blackspot rectification, and encouraging adoption of advanced vehicle safety standards are contributing towards making our roads safer.

Awareness and responsible road user behavior are equally important. In this regard, the role of institution such as the **IRF India Chapter** in promoting knowledge sharing, capacity building, and dialogue among policymakers, industry experts, and stakeholders is highly commendable. Publications like the IRF India Chapter Yearbook serve as valuable platforms for disseminating best practices, innovations, and policy perspectives aimed at enhancing road safety.

I am confident that the **IRF India Chapter Yearbook 2026** will provide important insights and encourage collective efforts towards safer roads and sustainable mobility in the country, particularly for vulnerable road users such as two-wheeler riders.

I congratulate the IRF India Chapter for this initiative and extend my best wishes for the success of the publication.

(Ajay Tamta)

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Parvesh Sahib Singh
कैबिनेट मंत्री राष्ट्रीय राजधानी क्षेत्र, दिल्ली सरकार
Cabinet Minister Govt. of NCT of Delhi

MESSAGE

I am glad to know that The International Road Federation-India Chapter (IRF-IC) is bringing out the IRF India Chapter Yearbook 2026. I appreciate the efforts of IRF India Chapter for bring out the Yearbook 2026, which focuses on strengthening awareness and action toward safer road infrastructure and mobility systems.

The Government of NCT of Delhi, through the Public Works Department and other concerned agencies, continue to undertake initiatives aimed at improving road engineering, traffic calming measures, better signage and markings, safer intersections, and enhanced lighting on city roads. Special attention is being given to designing forgiving road infrastructure, improving lane discipline, and strengthening awareness campaigns that encourage responsible riding practices such as helmet use and adherence to traffic regulations.

I am confident that such initiatives will contribute to building safer roads and a stronger culture of responsible mobility across the country.

I extend my best wishes for the success of the IRF India Chapter Yearbook 2026 and hope that it continues to serve as an important platform for advancing road safety and sustainable mobility in India.

(PARVESH SAHIB SINGH)

मंत्री–लोक निर्माण विभाग, विधायी मामले, सिंचाई एवं बाढ़ नियंत्रण, जल, गुरुद्वारा चुनाव
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Secretary

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भारत सरकार/Government of India
सड़क परिवहन और राजमार्ग मंत्रालय
Ministry of Road Transport & Highways

MESSAGE

Roads are the backbone of India's economic and social development. As the nation rapidly expands its road infrastructure and embraces new forms of mobility, ensuring safety of the journey must remain at the core of the transport development agenda.

Road safety can no longer be viewed through the lens of individual responsibility alone. The systemic approach which recognises human shortcomings and ensures safe road transport system is essential so that precious human lives are saved. This requires a comprehensive, integrated and multi-pronged strategy to address the issue of road safety. The Government of India's approach of '5Es' across the country, i.e., Engineering, Education, Enforcement, Emergency Care, and Empathy is essentially aimed towards attaining this goal. While the resilient road engineering will take care of the human behaviour, the vehicle engineering will provide safer vehicles to protect the occupants of the vehicle. However, unless Education on both these aspects of responsible mobility and Enforcement of traffic Rules and Regulations through use of technology is ensured, the primary objective of saving human lives cannot be achieved. In addition to this, providing Emergency care and showing Empathy to the victims of road accidents is the responsibility of every citizen of the country. The Ministry of Road Transport & Highways is consistently working towards translating these goals into outcomes.

The future of road safety will increasingly be shaped by data-driven decision-making, intelligent transport systems, safer speed management, pedestrian and two-wheeler protection, school-zone safety, advanced vehicle safety technologies, and faster post-crash care. To realise this vision, sustained collaboration among governments, road agencies, industry, academia, civil society, and institutions like International Road Federation India Chapter is required to promote road safety through knowledge sharing, capacity building, road safety audits, awareness, and evidence-based action.

I appreciate the efforts of the International Road Federation India Chapter in promoting knowledge exchange and best practices in road safety with alacrity through multi-stakeholder engagement. This Year Book serves not only as a record of progress but also as a platform for knowledge-sharing, innovation, and collective resolve to make every journey in the country faster and more connected with safer mobility ecosystem.

Umashankar

(V. Umashankar)

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Prof. P K Sikdar
Advisor, IRF-IC
Chairman, Editorial Board

Preface

It is an honour to present the Yearbook 2026 of the International Road Federation, India Chapter on the theme “Safer Roads and Safer Mobility”.

India stands at a critical juncture in its mobility journey, where rapid infrastructure expansion must be complemented by a strong and sustained focus on safety. Road safety today is not limited to better engineering alone—it requires a holistic approach integrating enforcement, education, emergency response, and the effective deployment of technology. Our goal with this Yearbook 2026 is to raise awareness about the importance of safe roads and sustainable mobility with advance level infrastructure.

The present framework reflects the next phase of this evolution—driven by data, digital innovation, and a human-centric approach. The increasing adoption of Intelligent Transportation Systems (ITS), Artificial Intelligence (AI), and data-led decision-making is enabling safer, smarter, and more efficient road networks. At the same time, it will ensure the safety of vulnerable road users, which remains central to our collective efforts.

This Yearbook brings together insights from industry leaders and domain experts, highlighting practical solutions, best practices, and policy directions that can accelerate progress towards technically advanced asset management and for reducing road fatalities in India. The authors are responsible for the authenticity of data and their sources and IRF-IC is not responsible for correctness of those.

At IRF India Chapter, we believe that achieving sustainable road infrastructure and safer mobility requires strong collaboration between government, industry, and civil society. It is only through shared responsibility and sustained commitment that we can translate vision into measurable outcomes.

I sincerely thank all contributors of the articles and partners for their valuable support in bringing out this publication. We hope this edition serves as a useful reference and inspires continued action towards building a safer and more resilient ecosystem for road transport.

I take this opportunity to place on record my sincere appreciation of the support extended by my colleagues in the Editorial Board, especially Mr. Akhilesh Srivastava and Ms. Aruna Shankari. Their suggestions and help in putting this Yearbook 2026 are duly acknowledged.

P. K. Sikdar



Kiran K. Kapila
President (Emeritus), International Road Federation, Geneva
Founder President, International Road Federation - India Chapter

Message

It gives me immense pleasure to share my message for the Yearbook 2026 of the International Road Federation India Chapter, centred on the theme “Safer Roads and Safer Mobility”.

Road safety continues to be one of the most pressing global challenges, demanding urgent, sustained, and collective action. While significant progress has been made in expanding road infrastructure across the nation, safety outcomes must keep pace with this growth. The next phase of mobility must, therefore, be anchored in resilience, inclusivity, and innovation.

The concept of “Safer Mobility” reflects a decisive shift towards integrated, technology-enabled, and human-centric mobility systems. The convergence of Artificial Intelligence, Intelligent Transportation Systems, and data-driven governance offers unprecedented opportunities to anticipate risks, enhance enforcement, and create forgiving road environments. At the same time, our approach must remain deeply rooted in protecting vulnerable road users and promoting responsible road behaviour.

India has demonstrated strong commitment towards improving road safety through progressive policies, capacity building, and infrastructure developments. The IRF India Chapter has played a pivotal role in advancing this agenda by fostering knowledge exchange, strengthening institutional capacities, and promoting global best practices adapted to local needs.

As we look ahead, the challenge is not only to innovate but to implement at scale. This requires stronger collaboration among government, industry, academia, and civil society, along with a shared sense of accountability.

I commend the IRF India Chapter for its continued leadership and for bringing out this comprehensive Yearbook 2026. I am confident that it will serve as a valuable resource and inspire actionable pathways towards achieving safer roads and safer mobility for all.

K K Kapila

Dr. Anilkumar B. Gaikwad
Vice Chairman and Managing Director

MSRDC
(A Govt. of Maharashtra Undertaking)

President's Message



It gives me immense pleasure to note that the International Road Federation – India Chapter (IRF-IC) has once again brought out its Annual Yearbook 2026, continuing a commendable tradition of knowledge creation and dissemination in the field of road safety, safe mobility and sustainable road infrastructure.

Having assumed the responsibility as President of the Federation in May this year, I have had the opportunity to acquaint myself with several of IRF-IC's flagship initiatives. Among these, the Yearbook stands out as one of the most valuable intellectual contributions of the Federation. On perusing the earlier editions, I was deeply impressed by the quality, depth and diversity of the articles contributed by eminent policymakers, academicians, researchers, industry leaders and road safety professionals. Their collective wisdom not only chronicles the evolution of road safety in India but also provides meaningful perspectives on the policy, institutional and technological interventions that continue to shape our journey towards safer roads.

The Yearbook has evolved into a credible repository of knowledge and best practices, documenting India's progress while highlighting emerging challenges and opportunities. At a time when the nation is committed to reducing road fatalities and building resilient, smart and sustainable transport infrastructure, such a publication serves as an important reference for governments, practitioners, researchers and young professionals alike.

The 2026 edition assumes even greater significance as India accelerates its efforts towards achieving the objectives of Vision Zero through integrated approaches encompassing engineering, enforcement, education, emergency care and technology. Innovations in intelligent transport systems, digital infrastructure, climate-resilient roads, asset management and future mobility are transforming the way road infrastructure is planned, designed, operated and maintained. Capturing these developments through informed discourse is essential for translating vision into measurable impact.

I place on record my sincere appreciation for the Editor, whose meticulous efforts in curating every article have ensured that the publication maintains its high standards of quality, relevance and intellectual rigour. My compliments also go to the distinguished contributors who have generously shared their expertise and practical insights, enriching this edition with contemporary perspectives and thought leadership.

I am confident that the IRF-IC Yearbook 2026 will continue to serve as an authoritative knowledge resource and inspire meaningful dialogue, innovation and collaboration among all stakeholders committed to making India's roads safer, smarter and more sustainable.

I congratulate the Editorial Team and everyone associated with this publication, and extend my best wishes for its continued success in advancing the cause of road safety and sustainable mobility.

Dr. Anilkumar B. Gaikwad
President
International Road Federation – India Chapter

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ABOUT INTERNATIONAL ROAD FEDERATION - INDIA CHAPTER

International Road Federation (IRF):

International Road Federation (IRF), founded in 1948, is the only world forum advocating for better and safer roads through improved design, construction, maintenance and management. It is a not-for-profit organization bringing together members engaged in road infrastructure from both private and public sectors. It contributes to the credibility, recognition and qualities of road professionals worldwide. IRF promotes sustainable mobility and campaigns for regulations to ensure sustainability.

IRF believes that safe, economically viable and ecologically friendly and sound road network, covering rural and urban areas as well as motorways and expressways brings prosperity, fights poverty, promotes education and gives better access to health services.

The range of IRF members encompasses civil engineering companies, transport planners, road and traffic safety devices suppliers, road construction enterprises, highway/ expressway concessionaires and operators, manufacturers of construction equipment, universities and research institutes, government ministries, road authorities and financial institutions. The membership is drawn from over 146 countries.

IRF has been granted a special Consultative Status at the United Nations Economic and Social Council (UN ECOSOC) in 1951. It is an institutional partner with UN, WHO, World Bank, EU and many other international organizations.

International Road Federation – India Chapter (IRF-IC):

International Road Federation – India Chapter (IRF-IC) was formally incorporated in early 2011 under the Registrar of Societies Act. IRF-IC collaborates with government bodies, Corporates and international organizations to enhance road safety and mobility across India. Our initiatives focus on implementing global best practices in road safety through road safety engineering and audits, policy interventions, and training programs.

With a strong emphasis on capacity building, IRF-IC works closely with road authorities, infrastructure developers, and enforcement agencies to drive road safety improvements. Through research, advocacy, and on-ground implementation, we aim to reduce road accidents and improve overall transportation safety.

Our Mission:

Better and Safer Roads, Safer Mobility and Safer INDIA

Our Initiatives:

IRF-IC provides comprehensive solutions to enhance road safety and ensure compliance with national and international standards. Our core services include:

- Road Safety Audits (RSA) – Conducting safety assessments at various stages of road projects, including planning, design, construction and post-construction phases to identify and mitigate potential risks.
- Environment, Health & Safety (EHS) Audits – Evaluating compliance with environmental and workplace safety norms to enhance operational sustainability and to minimize hazards.
- 5E Road Safety Programme (Safe System Approach) – A holistic approach integrating Engineering of Roads, Engineering of Vehicles, Education, Enforcement & Emergency Care to systematically address road safety challenges.
- Capacity Building & Training – Specialized training programs for engineers, enforcement agencies, commercial drivers and road users community to enhance road safety awareness.
- Policy Advocacy & Implementation – Advising on road safety policies, promoting legislative reforms, and supporting government initiatives for safer roads.
- Technology & Innovation in Road Safety – Encouraging and providing a platform to showcase the use of AI, IoT, real-time traffic management and emergency response systems.

- School Zone Safety Programme: The programme addresses the growing concern of traffic risks around schools. IRF-IC adopts a two-pronged approach to ensure child safety in school zones:
  - School Zone Safety Audits – Conducted as per IRC:SP:32 guidelines, SZS audits assess road design, signage and marking, pedestrian infrastructure, and to identify risks from vehicular movement, and to recommend improvements.
  - School Zone Safety Portal & Auditor Certification Course – IRF-IC has developed a dedicated digital portal for managing school zone audits, tracking the interventions, and uploading findings. The IRF-IC School Zone Safety Auditor Certification Course is intended to build the capacity of professionals to carry out standard-compliant audits across the country.

KEY ACTIVITIES

IRF-IC actively supports highway developers by ensuring their projects to meet safety, operational, and environmental standards. Our major activities include:

1. ENVIRONMENT, HEALTH & SAFETY (EHS) AUDIT

- Comprehensive evaluation of health and safety management systems to ensure compliance with legal and regulatory requirements.
- Assessment of occupational health and safety measures to enhance protection of worker and mitigate workplace hazards.
- Compliance with environment and pollution control regulations, including waste management and air quality monitoring.
- Identification of potential hazards, risk mitigation strategies, and implementation of corrective measures to improve overall project safety.
- Recommendations for safe work practices, emergency preparedness and incident management to minimize workplace accidents.

2. 5E PROGRAMME (SAFE SYSTEM APPROACH)

A structured approach to improving road safety through:

- **Engineering of Roads –** Conducting safety audits to identify hazardous locations, improving road design, and implementing traffic calming measures to reduce accident risks.
- **Engineering of Vehicles & Policy Intervention –** Advocating for vehicle safety enhancements, regulatory improvements, and policy interventions to enforce stricter safety measures.
- **Education & Mass Awareness –** Implementing large-scale community road safety campaigns, road safety education in schools, Sensitizing for road safety to commercial drivers and pedestrians.
- **Enforcement –** Training of law enforcement personnel in traffic regulation and traffic management, smart enforcement technologies and developing frameworks for better compliance.
- **Emergency Care –** Enhancing trauma care infrastructure, training of bystanders and commercial drivers in first aid.

3. FIRST AID TRAUMA CARE TRAINING FOR EMPLOYEES OF GOVT. AND PRIVATE ORGANIZATIONS/INDUSTRIES.

- Train Drivers, Police personnel, School Children, from October to March every year in association with its membership.
- Training of volunteers from Member companies of IRF-IC.

4. SCHOOL ZONE SAFETY

IRF-IC School Zone Safety Audit & Safety Ranking Program, which aligns with IRC: SP: 32 and is designed exclusively for Indian traffic conditions. This program represents a significant leap toward ensuring the safety of children during their daily commute to school and employs a two-pronged approach, combining the School Zone Safety Portal and Capacity Building Modules.

- The School Zone Safety Portal - a web-based public platform to audit, score, and display school zone safety ratings, enabling parental awareness and administrative accountability.
- Capacity Building and Certification Programme - an online course comprising 10 rigorous modules designed to train and certify School Zone Safety Auditors across India.
- IRF-IC undertook a Pilot Project in the 5 States of Assam, Bihar, Karnataka, Tamil Nadu and Uttar Pradesh. 10 Higher Secondary Schools were identified by the State Education Departments where the Audit of school zones as undertaken and Safety Performance Scores of all 10 schools were assessed for each of these school zones.

5. GOVERNING COUNCIL of International Road Federation – India Chapter

The Governing Council as of 2025 is shown in the chart below for the information.

6. MEMBERSHIP OF INTERNATIONAL ROAD FEDERATION – INDA CHAPTER

There are different categories of Membership of IRF – India Chapter, and those are described along with the benefits in the following pages.

INTERNATIONAL ROAD FEDERATION

INDIA CHAPTER

GOVERNING COUNCIL 2026

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Chief Engineer, MSRDC Ltd.

MEMBER IRF–GC
Mr. Danny Samuel
CEO, Roadstar Investment Management Ltd

ORGANIZATIONAL MEMBERSHIP:

Membership Benefits of the International Road Federation-India Chapter (IRF-IC)

Who Can Become a Member ?

IRF-IC brings together a diverse membership, including:

- Consulting engineers, planners, and management professionals
- Construction companies and equipment manufacturers
- Road infrastructure operators and concessionaires
- Government ministries, road directorates, and transportation agencies
- Automobile manufacturers and distributors
- Educational institutions, research organizations, and think tanks
- ITS and traffic management companies
- Safety device manufacturers

Key Benefits of Membership

1. Catalyst for New Business Opportunities

IRF serves as an ideal platform for fostering partnerships and joint ventures, enabling members to access investment opportunities, connect with stakeholders, and accelerate their business growth.

2. Strategic Collaboration Opportunities

- Invitations to exclusive strategic partnerships in national road safety campaigns and projects.
- Co-branding opportunities on major national and state-level safety initiatives.
- Participation in cross-sector alliances to address safety challenges (e.g., helmet use, speeding, pedestrian safety).

3. Advocacy and Policy Support

IRF-IC advocates for policies that enhance road safety and mobility, supporting members in navigating regulatory landscapes and amplifying their voice with stakeholders. The **5E Programme** (Engineering of Roads, Engineering of Vehicles & Policy Intervention, Education, Enforcement and Emergency Care) provides members with a powerful avenue to influence policy-making at the National and State levels.

4. Promoter of Innovation and Solutions

IRF identifies and promotes cutting-edge innovations, such as fog safety solutions implemented on the **Bundelkhand Expressway**, and **research on luminescent plants** in collaboration with leading institutions like Pant Agriculture University and MIT Boston.

5. Co-branding & Visibility

- Opportunity to co-publish knowledge products (toolkits, manuals, case studies).
- Logo placement and acknowledgement on the website, annual reports, and events.
- Highlighting members' best practices in road safety through curated success stories.

6. Platform for Corporate Social Responsibility (CSR)

IRF-IC enables members to contribute to impactful initiatives such as:

- **School Zone Safety Programme**: Adopting schools to improve road safety in collaboration with IRF-IC as well as capacity building.
- **Community Outreach**: Supporting education and emergency care initiatives aligned with the UN Decade of Action.

7. Grant Facilitation & CSR Integration

- Assistance in designing and implementing CSR-aligned road safety programs.
- Access to a network of funders, government schemes, and multilateral partnerships.
- Guidance on grant applications, project reporting, and impact metrics.

8. Knowledge Hub / Research & Data Access

IRF is a global center of expertise, offering members access to:

- **World Road Statistics (WRS)**: Comprehensive datasets from over 200 countries.
- **Year Book** Compilation of articles & relevant details.
- Presentation & relevant material of eminent professionals on the website.
- Access to curated road safety data insights, trends, and analytics reports.
- Priority collaboration on impact assessments, pilot projects, and research grants.
- Involvement in joint research programs with academic and government institutions.

9. Training and Capacity Building

IRF-IC offers training programs for:

- Drivers' training
- Pre-hospital First Responder Program
- Road safety education for schools

Notable initiatives include integrating **road safety curriculum** into school syllabi and creating **road safety films** in collaboration with its membership.

10. Advertising and Networking Opportunities

Members can participate in IRF's **road shows**, Lectures, Webinars etc. conferences and exclusive publications, such as the **Yearbook.** They can also drive Lectures and Webinars based on Industry trends.

11. Statutory and Leadership Opportunities

Membership grants rights to participate in governance at both national and global levels, including the

Governing Council and **Governing Body** of IRF.

12. Committees for Sectoral Focus

Members can join specialized committees aligned with their expertise, such as:

- Engineering & Infrastructure
- Transportation & Logistics
- Automotive & Vehicle Safety
- Education & Awareness
- Enforcement & Legislation
- Emergency Response & Medical
- Research & Innovation

13. Recognition and Awards

IRF's **Awards Program** introduced from 2025 will recognize members' contributions to road safety and mobility, providing global visibility to exemplary initiatives and projects.

For more details, visit www.indiairf.com. Join IRF-IC today and be part of a transformative movement for safer, more sustainable roads.

This version emphasizes professionalism, clarity, and member value, while aligning with IRF-IC's mission and objectives.

INDIVIDUAL MEMBERSHIP PLAN:

PREMIUM–Rs 7,000 + GST/Year / 56,000 + GST for Lifetime **Age Eligibility: Upto 50 Years**

Benefits:

- To get our Bi-Monthly Digital News Bulletin.
- Write articles in the IRF-IC Newsletters.
- One page Advertisement space free in Digital News Bulletin - once a year.
- Access to webinars, workshops, and training programs to enhance skills and knowledge.
- Reduced fees for events and conferences.
- Advisory roles on committees and projects to share expertise and insights.
- Opportunities to lead or participate in specialized committees and working groups.
- Priority consideration for speaking engagements.
- Recognition and awards for outstanding contributions to road safety.
- Leads Mentorship Program and Trainings.
- Form and lead a Young Professionals Forum.

PRO – Rs 5,000/Year + GST / Rs 40,000 + GST for Lifetime **Age Eligibility: 50-70 Years**

Benefits:

- To get our Bi-Monthly Digital News Bulletin.
- Write articles in the IRF-IC Newsletters.
- Access to webinars, workshops, and training programs to enhance skills and knowledge.
- Networking opportunities with experienced professionals in the field of road safety.
- Participation in Mentorship.
- Reduced fees for events and conferences.
- A platform for voicing opinions through events.

PRO SENIOR – Rs 2500/Year + GST / Rs 20,000 + GST for Lifetime Age Eligibility: 70 & Above

Benefits:

- To get our Bi-Monthly Digital News Bulletin.
- Write articles in the IRF-IC Newsletters.
- One page Advertisement space free in Digital News Bulletin - once a year.
- Access to webinars, workshops, and training programs to enhance skills and knowledge.
- Reduced fees for events and conferences.
- Advisory roles on committees and projects to share expertise and insights.
- Leads Mentorship Program and Trainings.

STUDENTS–Rs 1,000/Year + GST **Min. Eligibility: 18 Years & maximum 23 Years (Student ID Card required)**

Benefits:

- Internship Opportunities
- Knowledge Access & Dissemination
- Innovation & Incubation Support
- Placement & Career Support
- Young Leaders' Forum
- Recognition & Awards
- Poster Competitions
- Access to conferences, seminars, and training at discounted rates
- Communication and Information Sharing - Monthly newsletters, Podcasts, Social Media leverage

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INITIATIVES OF IRF- INDIA CHAPTER

A. 5E's OF SAFE SYSTEM

In year 2021, during COVID lockdown, IRF-IC started its renewed efforts to address the road safety concerns in the extended decade of Action (2021-2030), i.e. the "5E program for Safe System of Road Safety". A two pronged approach was adopted. In the first approach, 12 webinars were organised to cover each of the five Es, i.e., E1 (Engineering of Roads), E2 (Engineering of Vehicles and Policy Interventions), E3 (Education and Mass Awareness), E4 (Enforcement) and E5 (Emergency care). These webinars were presented and participated by Road Safety experts from India and abroad, which paved the way for preparation of a National Road Safety Action Plan on each of the Es. The Action Plan was presented to multiple stakeholders of road safety in the Government encompassing Ministry of Road Transport and Highways, Home Ministry, Ministry of Health and Family Welfare, & Ministry of Education.

The Action Plan also adopts a **5Es approach—Engineering of Roads, Engineering of Vehicles, Education, Enforcement and Emergency Care aspects of road safety —** recommending systematic and coordinated actions in the Plan for ensuring **simultaneous, coordinated and outcome-oriented interventions by** across Ministries, States and implementing agencies.

E1 – Road Safety Engineering & Management

Making Roads Forgiving, Predictable and Safe

IRF-IC proposes systematic engineering interventions to eliminate design-induced risks and improve operational safety across highways and urban roads.

Key Interventions

- Identification and rectification of **black spots and high-risk corridors** using crash data, road safety audits and GIS mapping
- Mandatory **Road Safety Audits** at planning, design, construction and operation stages
- Standardisation of **signage, markings, junction design, pedestrian facilities and traffic calming**
- Strengthening **road asset management systems** with safety performance indicators
- Integration of **safe system principles** into DPRs and concession agreements

Outcome: Reduction in crashes caused by road design deficiencies and predictable driver errors.

E2 – Vehicular Engineering & Policy Interventions

Ensuring Safer Vehicles on Indian Roads

IRF-IC highlights that vehicle safety technology is a critical yet underutilised pillar of road safety.

Key Interventions

- Mandatory adoption of **advanced safety features** (ABS, airbags, seat-belt reminders, including retro-fitting of underrun protection devices in all in-use commercial vehicles)
- **Retrofitting of other modern safety devices** in all commercial and public transport vehicles, like seat belts, airbags, etc.
- Stronger **vehicle inspection and fitness certification regimes**
- Linking **Driving Licences with Aadhaar** to curb duplication and improve enforcement
- Promotion of **crash-worthy vehicle design** (including mandatory adoption of bus-body code) and pedestrian protection norms

Outcome: Significant reduction in severity of injuries and fatalities during crashes.

E3 – Road Safety Education (School, Youth & Mass Education)

Building a Culture of Safe Road Behaviour

Education is positioned as a **lifelong behavioural intervention**, beginning from early childhood.

Key Interventions

- Integration of **road safety education** into school curricula (primary to secondary levels)
- Nationwide **School Zone Safety Audits** and corrective engineering measures
- Capacity building of **teachers, students and parents**
- Structured **youth engagement, driver sensitisation and community outreach programs**
- Use of **digital platforms, media campaigns and experiential learning tools**

Outcome: Long-term behavioural change and responsible road users.

E4 – Enforcement & Data-Driven Policing

From Reactive Policing to Predictive Enforcement

IRF-IC emphasises that enforcement must be **visible, technology-enabled and intelligence-driven**.

Key Interventions

- Strengthening **traffic police capacity, training and equipment**
- Adoption of **AI-based surveillance, speed enforcement and red-light violation systems**
- Standardised **accident data collection, analysis and sharing** across States
- Linking enforcement outcomes with **engineering corrections and education campaigns**
- Targeted enforcement against **drunk driving, overspeeding, helmet and seat-belt violations, and distracted driving (use of mobile phone).**

Outcome: Deterrence of risky behaviour and improved compliance with traffic laws.

E5 – Emergency Care & Trauma Response

Saving Lives in the Golden Hour

IRF-IC identifies post-crash response as the most **time-critical and life-saving component**.

Key Interventions

- Strengthening **trauma care infrastructure** along highways and high-risk corridors
- Mapping and upgrading **district hospitals and trauma centres**
- Training of **first responders, police, drivers, bystanders and able bodied community volunteers** in trauma care
- Integration of **ambulance services, emergency numbers and referral protocols**
- Implementation of **Good Samaritan Law** with awareness and system for protection.

Outcome: Reduced fatalities and disabilities through faster, organised emergency response.

Implementation Approach

- **Multi-Ministry coordination** (MoRTH, MHA, MoHFW, Education, States, Urban Local Bodies)
- **Pilot corridors and high-burden States** for phased rollout
- Monitoring through **measurable KPIs, crash reduction targets and independent evaluation**
- Strong emphasis on **capacity building, stakeholder ownership and scalability**

5E program Safe System Approach – Demonstration Corridors in 7 States

The webinars and the preparation of the Action Plan were followed up with a project titled "5Es Demonstration Corridor" to showcase that once desired work of interventions are carried out on all the 5Es simultaneously, the road infrastructure can be made forgiving, i.e., even if any accidents occur there will be restricted fatalities and injuries. For this purpose, the **Hon'ble Minister Shri Nitin Gadkari ji** had written to the Chief Ministers of 7 States, which were having worst road safety records in terms of yearly fatalities and injuries at that point in time, - namely, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Uttar Pradesh. A request was made through Hon'ble Minister's letter to identify a 150-200 km road stretch worst affected by road traffic accidents in those states. IRF India Chapter undertook 5Es activities on these stretches and prepared extensive reports with observations, recommendations and BoQs and submitted to the Road Authorities for correction. We had undertaken similar 5Es program for road sections given to Highway concessionaires.

(a) The 5Es program in a nutshell is as under:

- **Engineering of Roads –** Conducting road safety audits to identify hazardous locations identifying the risks, for improving road design, and implementing traffic calming measures to reduce accident risks. Such audit reports are submitted to the Road Authority for corrections in the network.
- **Engineering of Vehicles & Policy Intervention –** Advocating for vehicle safety enhancements, regulatory improvements, and policy interventions to enforce stricter vehicle safety measures. Based on a sample survey of the vehicles on the road section, a set of recommendations are provided to the RTO and State Authority about the enforcement needs for vehicle safety.
- **Education & Mass Awareness –** Implementing large-scale community road safety campaigns, road safety education in schools, Sensitizing commercial drivers and pedestrians for road safety. This is done in all schools within a 2 km buffer zone of the highway corridor and existing other educational institutions.
- **Enforcement –** Training of law enforcement personnel in technically correct traffic control, regulation and traffic management, including smart enforcement methods and technologies, and developing frameworks for better compliance.
- **Emergency Care –** Enhancing trauma care infrastructure (by survey and assessment of health care facilities along a given highway section with a 5km buffer zone of the highway corridor), training of bystanders and commercial drivers in first aid trauma care.

(b) Creation of First Responders for Pre-Hospital Care of Accident Victims

First Aid Trauma Care Training for Employees of Govt. and Private Organization / Industries: The non-standard trauma-care course run by various organizations in the country was changed by IRF-IC and WHO for uniform adoption cross all Departments and Organizations in Private and Government. This is now used uniformly for all First-Aid

Trauma Care training across the country. Besides focusing on Emergency care as part of the 5E programs, IRF-IC has been undertaking, since last few years, dedicated training program for drivers at Maruti Suzuki's IDTRs at Delhi, Haryana, Bihar, Chhattisgarh and Uttarakhand. From a capacity for 3,500 drivers in the past, IRF-IC presently trains 12,500 drivers in a 4-6 months period.

(c) Environment, Health & Safety (EHS Audit)

Background

Highway development and operation projects are inherently **high-risk environments**, involving large workforces, heavy construction machinery, high-speed traffic, hazardous materials and continuous interaction between construction activities and live traffic. Such conditions significantly increase the likelihood of **occupational injuries, road crashes, environmental degradation and regulatory non-compliance** if Environment, Health & Safety (EHS) systems are not systematically planned, implemented and monitored.

With increasing emphasis by the **Government of India, MoRTH, NHAI, State PWDs and Independent Engineers**, highway developers and operators are now required to demonstrate **strict compliance with statutory EHS regulations**, environmental clearances, and safety obligations throughout the project lifecycle — from construction to operations and maintenance.

Further, concession agreements clearly mandate:

- Compliance with **environmental and pollution control norms**
- Protection of **workers' health and safety**
- Implementation of **traffic and work zone safety measures**
- Establishment of **emergency preparedness and incident response systems**
- Regular **monitoring, reporting and third-party audits**

Non-compliance can lead to **penalties, work stoppages, reputational damage and serious human and environmental consequences**.

Need for Structured EHS Audits in Highway Projects

While most highway projects have EHS provisions on paper, practical implementation often faces challenges such as:

- Inconsistent compliance by contractors and subcontractors
- Gaps between approved safety plans and site practices
- Inadequate hazard identification and risk mitigation
- Weak emergency response preparedness
- Poor documentation and statutory record maintenance

A structured, independent EHS Audit therefore becomes essential to:

- Assess actual on-ground compliance against legal and contractual requirements
- Identify gaps, risks, and unsafe practices at various locations
- Strengthen safety governance and contractor accountability
- Reduce incidents, accidents, and environmental impacts
- Support highway operators in meeting **regulatory, lender and independent engineer expectations**

IRF-IC's Role in Supporting EHS Compliance

The International Road Federation – India Chapter (IRF-IC) has been actively supporting **highway developers, concessionaires, EPC contractors and toll operators** in strengthening their EHS frameworks and ensuring compliance with applicable government regulations and best practices. IRF_IC has certified EHS Expert for carrying out this work.

IRF-IC's approach goes beyond checklist-based inspections and focuses on:

- Risk-based auditing
- Practical, implementable recommendations
- Alignment with Indian regulations and global best practices
- Capacity building of site teams and contractors

Highway Operators Assisted by IRF-IC

IRF-IC undertakes EHS audits, safety reviews and compliance assessments for highway projects for our members (like Interise Management trust), which is a highway operator company having more than 15 concession projects). We had undertaken several projects like Amberi Puliya to Gomti Chouraha stretch of NH 58 in Udaipur, Rajasthan, Dhule to Palesner of NH 52 in Maharashtra and Vadape to Gonde Stretch of NH 03 in Maharashtra, and others.

Nature and Extent of an EHS Audit

Based on the complexity and risk profile of highway projects, an **EHS Audit is an extensive and multidisciplinary exercise**, covering environmental compliances, occupational health and safety, traffic safety, emergency response, contractor management and statutory obligations.

Accordingly, the EHS Audit encompasses a **comprehensive evaluation of systems, processes, practices and site conditions** as detailed in the following paragraphs.

EHS Management System Review

- Review of EHS policies, objectives, organizational structure, and roles & responsibilities.
- Assessment of statutory compliance framework, approvals, permits, and licenses.
- Evaluation of EHS documentation, records, registers, and reporting mechanisms.
- Review of alignment with relevant standards such as **ISO 14001 and ISO 45001**, where applicable.

Occupational Health & Safety Assessment

- Evaluation of workplace safety practices including work at height, confined space entry, hot work, lifting operations, electrical safety, and material handling.
- Assessment of availability, adequacy, and usage of **Personal Protective Equipment (PPE)**.
- Review of safety induction programs, toolbox talks, training records, and competency of workforce.
- Identification of unsafe acts and conditions through site inspections and worker interactions.

Hazard Identification & Risk Assessment (HIRA)

- Review of Hazard Identification and Risk Assessment processes and risk registers.
- Identification of physical, chemical, biological, ergonomic, and psychosocial hazards.
- Assessment of risk control measures based on the **hierarchy of controls**.

- Evaluation of effectiveness of implemented mitigation measures.

Environmental Compliance & Pollution Control

- Assessment of compliance with environmental clearances, consent conditions, and pollution control norms.
- Review of air, noise, water, and wastewater management practices.
- Evaluation of solid waste, hazardous waste, and waste disposal mechanisms.
- Assessment of spill prevention, fuel storage, and contamination control measures.

Contractor & Subcontractor EHS Compliance

- Review of contractor EHS plans, statutory compliance, and safety performance.
- Assessment of labour licenses, insurance coverage, medical fitness records, and training certifications.
- Evaluation of contractor monitoring, audits, and corrective action processes.

Traffic & Work Zone Safety

- Review of Traffic Management Plans (TMP) and on-site implementation.
- Assessment of work zone signages, barricading, lighting, reflectors, and flagmen deployment.
- Identification of high-risk locations and recommendations for enhanced road user and worker safety.

Emergency Preparedness & Incident Management

- Assessment of Emergency Response Plans (ERP) for accidents, fire, medical emergencies, and natural disasters.
- Evaluation of availability and condition of firefighting equipment, first aid facilities, and emergency response resources.
- Review of mock drills, emergency training, and response effectiveness.
- Assessment of incident reporting, investigation, and corrective/preventive action mechanisms.

Health Surveillance & Welfare Measures

- Review of occupational health surveillance programs and periodic medical examinations.
- Assessment of worker welfare facilities including drinking water, sanitation, rest areas, and lighting.
- Evaluation of measures related to heat stress, fatigue management, and worker well-being

B. SCHOOL ZONE SAFETY

Children are among the most vulnerable road users due to their limited cognitive ability, developing perception, smaller stature, and higher susceptibility to severe injuries. Roads around schools must therefore be designed for children's limitations, and not for vehicular convenience alone.

What is a School Zone?

A **School Zone** is a child-priority safety area encompassing roads, footpaths, pedestrian crossings, parking, and public transport access around a school. As per IRC: SP:32, it is structured into three layers:

1. **School Access Zone (SAZ)**
    - Extends **100 m on either side of school gates**
    - Highest concentration of children
    - **Speed limit: 20–25 kmph**
    - Strictest enforcement, traffic calming, and pedestrian priority
2. **School Proximal Zone (SPZ)**
    - Extends up to **150–500 m**, depending on road type and student age
    - Covers routes used for walking, cycling, and public transport access
    - **Speed limit: up to 30 kmph**
3. **Transition Zone (TZ)**
    - Buffer before SPZ (about 100 to 200m in the network link)
    - Prepares drivers to slow down through advance signage, markings, and rumble effects

Core Design Principles

School zones must follow three non-negotiable safety principles:

- **Simplify:** Reduce visual clutter and cognitive load for children and drivers
- **Shield:** Physically separate children from moving traffic
- **Cushion:** Reduce crash severity through low speeds, raised crossings, and forgiving design

Governance & Shared Responsibility

School zone safety requires coordination among:

- Road-owning agencies and urban local bodies
- Traffic police and enforcement agencies
- School Management Committees
- Parents, students and civil society

Why School Zone Safety — The 2023 Reality

- India reported **~5 lakh road crashes** and **~1.73 lakh fatalities in 2023**.
- **Overspeeding contributes to ~70%** of fatalities; vulnerable road users— including **school-going children**—remain highly vulnerable.
- NCRB place-of-occurrence data indicates **~8–9% of fatalities occur near schools/educational institutions**, underscoring an urgent need to systematically make school approaches safe.
- Haryana recorded **~9,000 road accidents and ~4,500 deaths in 2023**, placing it among states with high fatality risk relative to its vehicle population. This highlights the urgent need for systematic interventions in vulnerable zones, including schools.

IRF-IC School Zone Safety (SZS) Program

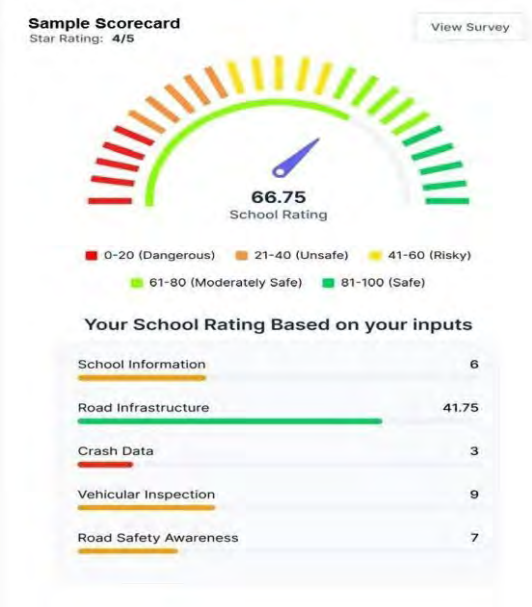
The program launched by Hon'ble Minister Shri Nitin Garkari Ji, a structured framework to safeguard school children and communities, aligned as per **IRC:SP:32 Guidelines,** which covers:

- **School Infrastructure:** Safe transport arrangements, parking, school bus marshals, patrol teams, dispersal systems, pick-up and drop-off areas and their safety.

- **Traffic Characteristics & Road Geometry:** Speed profile, carriageway width, pedestrian crossings, visibility, encroachment, traffic volume, including history of crashes in the school zone.
- **Road Safety Infrastructure:** Signage, markings, speed calming, footpaths, guardrails, lighting.
- **Vehicular Inspection & Drivers:** School bus fitness, driver licensing, medical fitness, behavioural compliance. Safety in other modes of travel used by children for school trips.
- **Crash Data:** Review of past 3 years' accidents around school zones.
- **Road Safety Awareness:** Student, teacher and parent sensitization modules.

How it Works

- The checklist is filled during a **ground-level school zone safety audit by IRF-IC certified Auditors** and upload findings on the IRF-IC **School Zone Safety Portal**.
- The portal generates a **digital scorecard**, rating each school's safety performance and identifying gaps.
- Schools can thus be benchmarked as "Dangerous /Unsafe/ Risky/ Moderately Safe/ Safe" in the scale of Safety Rating.



0–20: Dangerous – Critical risk; no basic safety measures. Immediate action is needed.

21–40: Unsafe – High risk; major gaps in infrastructure and enforcement.

41–60: Risky – Some measures exist, but are not adequate; needs upgrades.

61–80: Moderately Safe – Mostly safe with minor gaps; needs maintenance.

81–100: Safe – Well-equipped, child-friendly; model school zone

Pilot Program for the Ministry of Education by IRF-IC

The Ministry of Education entrusted IRF-IC with a **multi-state pilot** covering **5 States: Assam, Bihar, Karnataka, Tamil Nadu and Uttar Pradesh**, along with a list of 1.5 lakh secondary schools, where IRF-IC to spread this program nationwide. For the pilot study, 10 schools in each of the five states were taken and a detailed audit was carried out based on SZS audit framework developed by IRF-IC as per IRC:SP:32-2023.

Pilot Highlights

- **On-Ground Audits:** A detailed audit was carried out at each school chosen by filling the Checklists at school sites covering all parts of the school zone as per the IRC:SP:32-2023, and the data were uploaded to the SZS Portal.
- **Scorecards Generated:** The portal has internal software to consider all the data reported in the audit to compute the scopre. Schools generally scored between **15 to 70 points across the 5 States**, highlighting disparities in safety readiness.

- The Secretary, Ministry of Education acknowledged this report to be truly revealing the safety status around the existing 50 schools in five states, in a high level meeting with the concerned stakeholders from States, and urged all of those States and officials for taking up and to implement this program across the entire state.

The **IRF-IC School Zone Safety Program** offers a structured, data-driven path to protect children on their way to school. Through the SZS Portal, the State can benchmark, monitor, and continuously improve safety across thousands of schools in their own provisions and also to work with local authority to improve the safety in the surroundings of the school — an essential step towards achieving Vision Zero.

C. OUR IMPACT (THROUGH PAST ACTIVITIES)

- Conducted over 100 Road Safety Audits across India, leading to significant infrastructure improvements and accident reductions.
- Successfully implemented the 5E Program on several high-risk corridors in seven States improving road safety for all road users by road safety engineering measures and other Safe System activities to ensure safety.
- Till date around 80,000 Drivers and Bystanders at Maruti Suzuki IDTRs and on State Highways and Corporate Offices have been trained on First-Aid Trauma Care skills.
- School Zone Safety Audit in 50 Higher Secondary Schools in the states of Assam, Bihar, Karnataka, Tamil Nadu & Uttar Pradesh under the aegis of Ministry of Education. This has already created a pool of 100 School Zone Safety Auditors and this group is going to grow huge when 1.5 lakh schools are to be audited for rating.
- In a strategic intent with NITI Aayog, formulated the initial ITS strategy for India with inputs from key stakeholders from the Govt. & Industry for developing the ITS Master Plan along with National Standards.
- A most demanding National Road Safety Action Plan on all the 5Es (in a Safe System Approach) was always required, which the Government did not prioritise as the requirement. But, IRF-IC engaged itself in a very special way for the first of the 12 voluntary goals decided for the 2nd Decade of Road Safety Action, which was targeted for 2020 only. This is a prize document for the country to be guided for achieving the desired road safety targets.

D. NOTABLE ACTIVITIES OF IRF-INDIA CHAPTER OVER THE YEARS

a) In the formative years of IRF-IC organized 9 (nine) Regional Conferences organized in association its Headquarters at Geneva, and a number of other seminars to promote Road Safety and exchange the latest developments among the engineers for creating their technological awareness. The 9 Regional Conferences organised from 2006 till 2015 were intended to clearly bring out the critical issues, aspects and factors contributing to road safety, besides creating a mass awareness to this social cause in the Civil Society. Efforts were also on to bring together the stakeholders, road safety professionals and build knowledge base to address the issue on a continual basis. From extensive recommendations legitimate requirements were submitted to the policy makers for supportive policies and legislations for addressal of ground level concerns. The Regional Conferences of IRF-IC had played a major role in changing the mindset of Government Authorities and policy makers towards this grave issue of road safety in India. Each of these nine conferences were attended by international delegates for rich contributions suggesting the ways and means for ameliorating the huge socio-technical problem in India since several decades. All of these were on several aspects of engineering, enforcement, management and behavioural concerns of road safety.

    - 9th IRF Regional Conference: Oct 5-6, 2015, Road Safety Initiatives: Status and the way forward.

- 8th IRF Regional Conference: Oct 3-5, 2013, Road Infrastructure for safe Mobility
- 7th IRF Regional Conference: Nov. 1-2, 2012, Road Safety in Urban and Rural Roads
- 6th IRF Regional Conference: Oct 3-5, 2011, Road Safety Strategy in India – Action Plan
- 5th IRF Regional Conference: Nov 25-26, 2010, Institutional Arrangements for Reduction of Road Fatalities.
- 4th IRF Regional Conference: Oct 23-24, 2009, Accident Prevention: Road Safety Measures
- 3rd IRF Regional Conference: Oct 3-4, 2008, Mobility and Safety in Road Transport
- 2nd IRF Regional Conference: Oct 5-6, 2007, Road Safety – Design, Construction and Operation of Roads
- 1st IRF Regional Conference: Oct 3-5, 2006, Business & Environment for future road development in India

b) IRF organized 4 Round Tables (RTs) on Intelligent Transport Systems in the nascent Indian market from November 2016 to October 2017. The RTs brought together the Government and the Industry together to tap the Indian market. The Ministry of Road Transport and Highways, NITI Aayog, the premier planning agency of the Government of India, the National Highway Infrastructure Development Corporation Ltd and the National Highways Authority of India were supporting these Roundtables. Senior Management from leading companies including BMW, Price Waterhouse Coopers, PTV, INRIX, IPS, Larsen and Toubro, Infrastructure Leasing and Financial Services Corporation (IL&FS), Autostrada and Shell Corporation attended the roundtables.

The objective of these series of roundtables was to develop a concrete action plan to accelerate and facilitate the use of ITS solutions to address the problems of urban and inter-urban transport in India. Mr. Amitabh Kant, the then CEO of NITI Aayog who was present at the roundtable shared that the Union Government of India was working full time to leapfrog and stimulate the deployment of safe, smart and sustainable solutions for road networks using technology in the country including setting up of National Intelligent Transport System (ITS) standards, an ITS clearing house to design and adopt best ITS practices and setting up of Advanced Traffic Management System (ATMS). He further called on global and Indian ITS companies to come forward and contribute to developing an action plan for use of ITS especially on National Highways and the forthcoming dedicated freight corridor operationalized on the National Highways and 100 smart cities. It was imperative for companies to work for better, faster and efficient exploitation of ITS to promote “SMART Mobility” in India. The action plan which followed the Round Tables also provided a strategy for ITS in India to facilitate and accelerate the uptake of ITS and the manufacturing of ITS equipment in the country to contribute to the “Make in India” initiative.

The RTs paved the way for signing a strategic intent with NITI Aayog to formulate a structured ITS policy for India. This brought together various stakeholders from the Govt. Departments working in the area of ITS in silos. IRF Geneva was able to bring together a select group of executives and government representatives who are willing and capable to address the hurdles, facing wider deployment of ITS in India. The first session of the High Level Round Tables was successful and could not have come at a more appropriate time. All participants from the public and private sector agreed that technology solutions and intelligence exist, and when deployed, these solutions will lead to efficient, clean, safe and sustainable mobility in India.

c) 18th World Road Meeting in India: IRF globally has been organising a World Road Meet every 4 years in different geographies of the world. IRF-IC bid for the global meet and were awarded the 2017 World Road Meeting, a global conference and exhibition. The

event titled World Road Meeting 2017 or WRM 2017 was organised in Greater Noida's Expo Mart, during Nov. 14-18, 2017 with participation of 800 delegates. The WRM 2017 had high level Conference and Exhibition running concurrently. Packed with simultaneous parallel technical sessions, on the theme of Safe Roads and Safe Mobility for Sustained Growth. WRM 2017 was a landmark event in India.

d) WRM 2017 was preceded by a 1 day Global Transport Ministers' Meet in New Delhi on 13th November 2017. Chaired by the then Hon'ble Union Health Minister Shri J. P. Nadda who was deputed by the Hon'ble Union Minister for Road Transport and Highways Shri Nitin Gadkari, Transport Ministers representatives from Countries like Finland, Russia, UAE, Vietnam, Canada, Lesotho, UN representatives, etc. participated in the Meeting and Jointly signed a document titled "Delhi Declaration".

e) IRF India Chapter in Association with Australian Road Research Board (ARRB) had taken initiative for delivering Certification Courses for "Road Safety Auditors". With the aim of building capacity for road safety audit works in the country by creating trained experts for road safety audit works and to certify them for international level recognition. These one-week duration courses were organized successfully 12 times with about 25 participants in each course, and 300 engineers were trained in road safety audit during 2010-2012. These courses had exclusive components of practical audit works in groups guided by mentors, which provided real world audit experience to the participants. The course material is given to the participants at the beginning of the course as a bound volume. In addition, they have been given a CD with complete set of course materials. Further, they have been given the Austroad RSA Checklists and the Checklist of IRC Manual for Road Safety Audit. The courses have been supported by Ministry of Road Transport & Highways, Govt. of India, International Road Federation (India Chapter), and gTKP (Global Transport knowledge Partnership) financially in addition to the course fee charged from the participants.

f) Preparation of Road Safety curriculum for class VI to X. The Road Safety curriculum for respective classes was prepared jointly with Institute of Road Traffic Education (IRTE). A group of school teachers from prominent schools were engaged to prepare the road safety materials for CBSE books, which were integrated into the existing text books of Science, Mathematics, Social Science, English and Hindi. The objective was to consistently sensitise the children about Road Safety while learning their regular subjects. Some States like Rajasthan had adopted this a long time back.

g) Safeguarding lives of vulnerable road users like cyclists by fixing retro-reflective tapes on appropriate locations on bicycles to make them conspicuous during dark hours. IRF-IC had facilitated standardized retro-reflective tapes after testing of the tapes of AIS 400 standards at ICAT labs and had also taken this up at national level, which was later provided in BIS Code on bicycle conspicuity.

- Carried out the Bicycle Conspicuity Drive covering 12 locations in Delhi from December 2012 to March 2014.
- Bicycles were affixed with Retro-reflective Tapes of Red, Yellow and White Colour.
- Covered 2,00,000 Bicycles with Retro-reflective Tapes to improve their visibility during dark hours.
- Awarded Maruti Suzuki's Times Now Best NGO Award for this initiative.

h) IRF-IC had also undertaken towards Mass Awareness creation through Posters, Short films promoting seat belt, helmets usage, non-usage of Mobile phones, taking up issues of Drunken Driving, Jingoism with Motorcycle, being a Good Samaritan, etc.

i) IRF-IC have undertaken dedicated integrated road safety projects under CSR initiative for a number of corporates like Shell at Hazira Port, Jindal Steel, Safe Road Demonstration Corridor Project, School Zone Safety Pilot Programs, etc.

j) IRF-IC has won accolades, notable among them being Maruti Suzuki – Times Now Award for bicycle conspicuity activity, and Prince Michael International Award for First Aid Trauma Care Initiatives.

k) Webinar and Lecture Series: The International Road Federation (IRF) India Chapter organizes monthly webinars and lecture series throughout the year to address critical issues related to road safety, infrastructure development, asset management, traffic management and enforcement, with road safety including sustainable infrastructure development using new materials, etc. These events feature expert speakers from various fields, offering insights into best practices, technological advancements, and regulatory frameworks.

These programs promote knowledge sharing, raise awareness about road safety, and sustainable infrastructure developments to foster collaboration among stakeholders in the road and mobility domain. Participants can access valuable resources and stay updated on industry trends through these sessions.

i. IRF Policy Statement on Environment: In January 2011, IRF released its Policy Statement on Environment, IRF's Position and Recommendations included: Achieving sound environmental and sustainability outcomes is an integral part of IRF members' policy and practice. They are fully committed to:

- Safeguarding the environment whenever possible;
- Mitigating adverse effects through proactive consideration of environmental issues at every stage of planning and implementation;
- Managing and using resources efficiently;
- Continually improving infrastructure environmental performance.

IRF recognized the multiple benefits of sound environmental impact assessment and management, incorporating the efficient use of materials and energy. It was further committed to ensuring that the road infrastructure sector increasingly contributed at the forefront of global efforts to reduce greenhouse gas emissions.

In this context, IRF advocated that sustainable management was most effective when environmental challenges and opportunities were taken into consideration early and pro-actively at every stage of the life-cycle of road infrastructure. The Return on Investment (ROI) metrics should broaden the range of metrics to include mobility and access.

GRIS 2026: EXECUTIVE SUMMARY

ABOUT GRIS-2026

The Global Road Infratech Summit 2026 (GRIS-2026), the third edition of this flagship initiative, was successfully organised by the International Road Federation India Chapter in association with International Road Federation, Bitumen Forum India and ITS India Forum with CSIR-Central Road Research Institute as the Knowledge Partner. The Summit was held on 5–6 February 2026 at Hotel The Ashok, New Delhi, bringing together a powerful confluence of policymakers, engineers, researchers, contractors, industry leaders and global experts.

GRIS-2026 was conceived as a dynamic blend of a high-level technical conference and a concurrent exhibition, creating a platform that seamlessly connected policy, practice, innovation and industry. The Summit witnessed expanded international participation this year, with distinguished delegates from Australia, Namibia, Russia, Singapore, Switzerland, Turkey and several other countries, reflecting its growing global stature and collaborative spirit.

The core objective of GRIS has consistently been to explore, deliberate and bring to the forefront critical aspects that influence and strengthen sustainability in road infrastructure and road safety in India. In alignment with national and global sustainability and road safety goals, the Summit reaffirmed that sustainable infrastructure development must be firmly anchored in safety, resilience and innovation.

The deliberations were guided by the principles of the Safe System approach, built upon the foundational framework of the 5Es — Engineering for roads and vehicles, Enforcement, Education, and Emergency Care. GRIS-2026 emphasised that the effectiveness of the 5Es lies not merely in their conceptual understanding but in contextualising and customising them to India's unique road transport ecosystem. By identifying gaps, sharing best practices, and showcasing technological advancements, the Summit worked towards reinforcing these pillars for tangible and measurable outcomes.

As the third edition, GRIS-2026 marks a significant step forward in strengthening global partnerships, fostering technical excellence and accelerating India's journey toward safer, smarter and more sustainable road infrastructure.

TECHNICAL SESSIONS

GRIS-2026 featured a thoughtfully curated technical programme comprising a Special Executive Session, two Plenary Sessions (one on each day), eight Core Technical Sessions, a Panel Discussion, and a Valedictory Session.

The sessions were led by pre-identified domain experts and enriched through invited paper presentations aligned to eight core thematic areas. The response to the call for papers was highly encouraging, with 75 abstracts received, of which 53 were shortlisted for in-person presentation and one for online presentation, ensuring both quality and thematic relevance.

Special Executive Session

Theme: Development and Management of Infrastructure Assets

The Conference formally opened with a Special Executive Session centred on the strategic theme of infrastructure asset development and management. The session was chaired by S K Puri, Executive Director, ICT Pvt Ltd.

The session showcased impactful case studies and technology-driven approaches for asset management:

- Technology Driven Asset Management – Integrated High-Speed Road Surveys by NTRO, demonstrating advanced, data-rich survey methodologies for informed decision-making.

- Missing Link Project of Mumbai–Pune Expressway by MSRDC, highlighting engineering innovation in eliminating bottlenecks and enhancing corridor efficiency.
- Facilitating Climate-Informed Prioritisation of Road Maintenance through a Road Asset Management System – The Case of Kerala RMMS by TRL Technologies, presenting a sustainability-focused framework integrating climate resilience into maintenance planning.

The session underscored how digitalisation, analytics, and climate sensitivity are transforming infrastructure lifecycle management.

First Plenary Session

Theme: Vision Zero India – Building Safe, Sustainable and Carbon-Free Infrastructure

The first Plenary Session, held on Day 1, focused on advancing the Vision Zero agenda within India's infrastructure landscape. The session was chaired by Gonzalo Alcaraz, Director General, International Road Federation.

The plenary featured distinguished addresses by:

T G Sitharam, Former Director, IIT Guwahati and Former Chairman, AICTE

Venkataramana N Heggade, CEO, DECon Complete Solutions

The speakers presented forward-looking perspectives on achieving Vision Zero India, emphasising safer design philosophies, sustainability integration, innovation-led policy frameworks, and the urgent need to align infrastructure growth with carbon neutrality and systemic safety principles.

Together, the Special Executive and First Plenary Sessions set a strong intellectual and strategic foundation for the subsequent core technical discussions, reinforcing GRIS-2026's commitment to strengthening road safety through evidence-based approaches, innovation, and global collaboration.

Eight Core Technical Sessions

Parallel Thematic Deliberations at GRIS-2026

The eight Core Technical Sessions at GRIS-2026 were conducted as parallel tracks, enabling focused, in-depth deliberations across critical dimensions of road infrastructure and safety. Designed to integrate innovation, policy, engineering practice, and sustainability, these sessions reflected the evolving priorities of India's mobility ecosystem.

1. Digital Transformation of Highway Infrastructure through Asset Management
This session explored how digital tools, GIS mapping, high-speed surveys, and predictive analytics are reshaping lifecycle management of highway assets. Emphasis was placed on data integration, performance monitoring, and proactive maintenance planning to improve efficiency and safety outcomes.

2. Scaling Intelligent Transportation Systems (ITS) for Safer, Smarter Mobility
Focused on mainstreaming ITS solutions, this session examined scalable deployment models, integrated command-and-control centres, adaptive traffic systems, and corridor-level digital integration aimed at reducing congestion and crashes.

3. Data-Driven Approaches in Road Safety for Forgiving Roads
Presentations highlighted the use of crash data analytics, black spot mapping, safety audits, and evidence-based interventions to create forgiving road environments that minimise the severity of damages due to human error.

4. Next-Generation Pavement Materials and Design for Durability and Performance
This theme addressed advancements in pavement engineering, including modified binders, perpetual pavement concepts, sustainable asphalt technologies, and performance-based design strategies for enhanced longevity.

5. Decarbonising Roads: Building Resilient and Climate-Smart Infrastructure
The session underscored strategies to reduce carbon footprints in road construction, integrate resilience planning, and adapt infrastructure to climate variability while maintaining safety and serviceability.

6. Future of Infrastructure Engineering: Smart and Sustainable Materials
Experts deliberated on emerging materials, recycling innovations, circular economy approaches, and smart material applications that promise long-term sustainability and cost efficiency.

7. Making School Zones Safer: Evidence-Based Approaches
Recognising child safety as a critical priority, this session focused on traffic calming, safe crossing design, signage standards, enforcement integration, and community-led interventions rooted in empirical research.

8. Mobility Design: Safer and Sustainable Mobility Ecosystem
The final theme addressed integrated mobility planning, complete streets concepts, multimodal transport integration, and design frameworks that prioritise safety, accessibility, and environmental sustainability.

Collectively, the eight parallel sessions reflected the Summit's commitment to strengthening the 5Es of the Safe System approach through research-backed insights, technology adoption, and contextualised implementation strategies tailored to India's diverse mobility landscape.

Second Plenary Session

The Core Technical Sessions culminated in the Second Plenary Session on "Reimagining the Future of Mobility in India – Towards Vision Zero Safety and Sustainability." The session was chaired by Mr. Durga Shankar Mishra, Former Chief Secretary, Government of Uttar Pradesh, who set the tone for a forward-looking dialogue on transforming India's mobility landscape through the principles of safety, sustainability, and inclusive planning.

The distinguished plenary panel comprised Mr. Venkata Chunduru, Director, ARCADIS-IBI Group, and Ms. Sarika Panda Bhatt, Founder Trustee, Raahgiri Foundation. The speakers underscored the urgent need for a Safe System approach, integrated urban mobility planning, and citizen-centric initiatives to achieve Vision Zero road safety goals. The discussion highlighted how data-driven planning, institutional collaboration, and people-first mobility policies can together shape a safer, greener, and more resilient transport future for India.

PANEL DISCUSSION

The Summit also featured a high-level Panel Discussion on "Policy to Practice: Enabling Vision Zero through Sustainable Infrastructure and Smart Mobility." The session was moderated by K. K. Kapila, a globally recognised road safety leader and former Chairman of the International Road Federation, who has long advocated safer and more sustainable road infrastructure worldwide.

The panel brought together eminent experts including Prof. P. K. Sikdar, along with Richard Yei, Gonzalo Alcaraz, Ashalatha R., D. O. Tawade, Dipak Dash, Akhilesh Srivastava, and Prof. A. Veeraraghavan. The discussion focused on translating Vision Zero principles into

actionable strategies, highlighting the role of safe system design, sustainable infrastructure, intelligent mobility solutions, and stronger institutional coordination.

The panel emphasised that achieving zero fatalities on Indian roads requires a decisive shift from policy intent to on-ground implementation, supported by data-driven decision making, advanced technology, and integrated planning across engineering, enforcement, education, and emergency response.

The Summit also provided a valuable platform for young researchers and emerging professionals through a dedicated Poster Presentation Session. A total of 28 abstracts were submitted by postgraduate students and research scholars on themes aligned with the focus areas of GRIS 2026.

Following a rigorous screening process, 22 posters were shortlisted and presented before an Expert Committee. The presentations showcased innovative research, fresh perspectives, and practical solutions addressing contemporary challenges in road infrastructure, mobility, and road safety. Based on the technical merit, originality, and relevance of the work, the Expert Committee selected three outstanding entries for the Best Poster Awards.

The success of GRIS-2026 was reflected not only in its rich and diverse conference's technical programme but also in the concurrent Exhibition, which served as a dynamic platform for showcasing cutting-edge technologies, innovative materials, and solutions shaping the future of road infrastructure. The Exhibition featured participation from select organisations including Kataline, CTM, Hindcon Chemicals Ltd., Citizen Buechel, AISIN Motors, Pragati Pavetech, DHI Mobility, SAI Rubber, Hindustan Road Technologies, 7 Star Impex, and the IRF India Chapter, highlighting advancements across road construction technologies, materials, mobility systems, and infrastructure solutions.

The Summit was further strengthened by the generous support of Sponsors and Industry Partners, whose commitment enabled the successful organisation of the event. Sponsors across various categories included IDTR, Navayuga, MSRDC, DRA, Montecarlo, PNC, Aakshya Infra, Interise, GTF, JCB, SRM Contractors, Arcadis, Kent, Ajax Engineering, Dashmesh, and ACE. Their timely support and partnership played a vital role in facilitating GRIS-2026 and reinforcing industry collaboration towards advancing safe, sustainable, and resilient road infrastructure.

The Valedictory Session marked the formal conclusion of GRIS-2026, beginning with a comprehensive summary of the Summit proceedings presented by Prof. M. Parida, who highlighted the key deliberations, insights, and outcomes emerging from the plenary and technical sessions.

This was followed by the Valedictory Address by Mr. Vaibhav Dange, Founder, Better India, who reflected on the importance of collective action, innovation, and responsible infrastructure development in shaping a safer and more sustainable mobility future for India.

During the session, awards were also presented to the top three Poster Presentations, selected by the Expert Committee in recognition of outstanding research contributions by young scholars.

The Global Road Infratech Summit-2026 concluded with a formal Vote of Thanks, expressing appreciation to the distinguished speakers, delegates, exhibitors, sponsors, and organisers whose contributions and support made the Summit a resounding success.



MSRDC
(A Govt. of Maharashtra Undertaking)

Transforming Maharashtra's Transport Landscape

For nearly three decades, MSRDC has been at the forefront of Maharashtra's infrastructure evolution.

From the landmark Hindu Hrudaysamrat Balasaheb Thackeray Maharashtra Samruddhi Mahamarg to several state-of-the-art engineering achievements, MSRDC has consistently delivered projects of national significance.

Its portfolio includes India's first six-lane concrete, high-speed, access-controlled expressway connecting Mumbai and Pune, the country's first cable-stayed sea link, and 55 flyovers that have eased urban congestion. With a legacy of managing mega projects since inception, MSRDC continues to drive progress, connectivity, and growth across the State.



MSRDC: Roads to Prosperity, Pathways to Global Investment



The Maharashtra State Road Development Corporation (MSRDC) stands as the backbone of Maharashtra's transformation: boosting communication, transportation, fueling industries, supporting agriculture, tourism, infrastructure, employment and social advancement. From iconic sea links to world-class expressways, MSRDC has bridged markets, accelerated industrial expansion, and unlocked new avenues for prosperity—driving Maharashtra's economy forward as India's leading state.

MSRDC- Creating Infrastructure, Building Connections, Creating Opportunities.

Maharashtra—The Investment Hub of India

Maharashtra **sets a benchmark** with world-class infrastructure, making it the prime destination for global investors. MSRDC plays a pivotal role as the state's infrastructure backbone, enabling seamless connectivity that supports industrial corridors, agro-processing zones, and rural & urban development. This has propelled the state's GDP growth, created millions of jobs, and attracted foreign direct investment (FDI) exceeding USD 10 billion in recent years.

MSRDC's Legacy – Completed Projects & Their Returns

MSRDC has delivered landmark projects that have redefined Maharashtra's landscape, each an engineering marvel and a catalyst for economic acceleration. As the backbone of the state's growth, MSRDC's initiatives have generated substantial returns through toll revenues, land value appreciation, and enhanced trade.



MSRDC — the Maharashtra State Road Development Corporation — was formed through a Government of Maharashtra resolution on 9th July 1996, and was formally incorporated as a limited company on 2nd August 1996 under the Companies Act of 1956.

For nearly three decades, MSRDC has been the driving force behind Maharashtra's modern infrastructure transformation. From creating world-class expressways and sea links to pioneering urban mobility solutions, the corporation has consistently delivered projects that connect people, accelerate economic growth, and shape the future of the state. MSRDC has constructed 55 flyovers in Mumbai and also 5 flyovers in Chhatrapati Sambhaji Nagar and 5 Flyovers in Nagpur boosting the economy and development.

With each landmark project, MSRDC has strengthened Maharashtra's position as a national leader in infrastructure development — building not just roads and bridges, but pathways to progress.

1. Bandra–Worli Sea Link

India's first cable-stayed sea link bridge was completed by the MSRDC.

The project reduced travel time from 1 hour to 30 minutes,providing traffic congestion free path through urban sector catalyzing infrastructure growth in Mumbai's western suburbs. It has strengthened property values producing lasting economic ripple effects.

2. Mumbai–Pune Expressway

The Mumbai-Pune Expressway having length of 94.5 km was completed by MSRDC. India's first six-lane expressway, linking Mumbai, the financial capital, with Pune, capital city of education, automotive manufacturing and IT. It slashed travel time from 4.5 hours to 2.5 hours, fueling Pune's IT and industrial infrastructure boom. It provides stable toll revenue streams and enduring logistics efficiencies, supporting Maharashtra's role as India's manufacturing powerhouse. Daily more than 1.5 lakhs vehicles travel through this expressway.

3. Hindu Hrudaysamrat Balasaheb Thackeray Maharashtra Samruddhi Mahamarg (Nagpur – Mumbai Expressway)



The Hindu Hrudaysamrat Balasaheb Thackeray Samruddhi Mahamar from Nagpur to Mumbai cities was completed by MSRDC with a vision to transform Maharashtra. A mission to unlock the future. Stretching across 701 kilometers, this world-class access-controlled expressway connects Nagpur to Mumbai — linking the state's capital with its emerging logistics and industrial powerhouse in the east. But Samruddhi Mahamarg is more than just a road. It is **Maharashtra's second expressway,** after the iconic Mumbai–Pune Expressway. A monumental infrastructure project created by MSRDC to reshape the economic landscape of the state. It cuts across **10 districts, 26 tehsils, and over 392 villages** and links 14 districts indirectly. The expressway opens doors for regions that were once considered remote and underdeveloped.

Today, these areas stand connected to major cities, ports, growth centers, industries and global markets.

The Samruddhi Mahamarg has triggered the rise of **industrial clusters, growth centers, logistics hubs, agro-processing zones, warehousing corridors, and new townships** along its route — creating jobs, boosting entrepreneurship, enhancing the GDP and accelerating development.

Travel time between Nagpur and Mumbai, once 16 hours is now reduced to just 7–8 hours, bringing people, businesses, and opportunities closer than ever before which is beyond imagination.

Engineered with international safety standards, intelligent systems, wildlife crossings, and high-speed design, the expressway represents the finest of modern infrastructure. For Maharashtra, this is more than connectivity. It is progress... it is prosperity.

The Expressway named as “Hindu Hrudaysamrat Balasaheb Thackeray Maharashtra Samruddhi Mahamarg” stands as a symbol of MSRDC’s commitment — building not just roads, but shaping the future of a stronger, faster, and more prosperous Maharashtra.

4. Thane Creek Bridge (TCB-III)

The 1.8 km six-lane bridge constructed on creek by the MSRDC, eases congestion in Mumbai Metropolitan city and shortens travel time to business hubs, JNPT Port, and Navi Mumbai Airport.

5. Mumbai–Pune Expressway Missing Link



The Mumbai-Pune Expressway missing link is nearing completion. The project includes 13.3 km stretch with 8.9 km and 1.64 Km World’s widest twin tunnels of width 23.5 mtr and two viaducts having length of 900 mtr and 650 mtr viaduct. It includes the bridge which is the tallest in India having 182 mtr Pylon height and 125 mtr Deck slab height.

The will eliminate hazardous ghat sections, reducing travel time from 1hr to 25–30 minutes and ensuring seamless and safer freight movement. It enhances logistics for auto exports and IT supply chains and increases toll revenues from diverted heavy traffic. Reinforces Maharashtra’s status as India’s auto and IT hub, enabling just-in-time delivery for global industries and supporting GDP growth.

6. Versova–Bandra Sea Link (under progress)



Overview: A 20.2 km sea link, including a 9.8 km main link, designed to alleviate congestion in Mumbai’s western suburbs.

Impact: Enhances urban mobility and supports sustainable development. MSRDC initiatives drive sustainable economic growth by enhancing fastest connectivity, strengthening industries, and promoting tourism across Maharashtra. It is set to become an iconic structure of Mumbai city.

Current Projects & Investment Opportunities



1. Nagpur–Goa Shaktipeeth Expressway

Overview: This 856 km expressway connects 13 districts, linking key religious tourism hubs and reducing travel time from 20 hours to 10 hours

Impact: Enhances pilgrimage tourism, streamlines logistics, and boosts agro- export opportunities.

2. Virar–Alibaug Multi-Modal Corridor



Overview: A proposed and undertaken high-capacity corridor of 96.40 km with metro connectivity, developed under a build-operate-transfer model.

Impact: Supports toll and metro ridership revenues while catalyzing real estate and economic growth in the Mumbai Metropolitan Region. It will cater to all heavy vehicle traffic from JNPT and act as a ring to Mumbai, Thane and Navi Mumbai.

3. Jalna–Nanded Expressway



Overview: A 184 km expressway is under construction, connecting under developed Marathwada region to Nagpur Mumbai Expressway.

Impact: Reduces travel time by half from 4 hrs to 2 hrs, strengthens logistics and connectivity along the Hyderabad corridor and will boost economy of underdeveloped region.

4. Pune Ring Road

Overview: A 168 km ring road under construction across 09 construction packages is designed to decongest Pune city core.

Impact: Enhances logistics efficiency and supports commercial expansion in the region which will reduce accidents resulting from city traffic congestion.

5. Bhandara–Gadchiroli Expressway

Overview: A 94 km expressway providing access to mineral-rich belts.

Impact: Uplifts the agro-economy and strengthens connectivity to Mumbai metropolitan, and other commercial centers. It helps to increase industrial growth.

6. Nagpur–Gondia Expressway

Overview: A proposed and undertaken 162 km expressway linking Vidarbha's economic hubs.

Impact: Boosts agro-exports, tourism and trade through enhanced Samruddhi connectivity.

7. Nagpur–Chandrapur Expressway

Overview: A proposed and undertaken 205 km corridor serving Vidarbha, part of the Maharashtra State's coal and mineral regions.

Impact: Strengthens industrial and logistics networks in the region.



8. Vadhvan to Igatpuri Expressway

Overview: A proposed and undertaken 104 km expressway connecting key port and economic zones.
Impact: Drives port-led growth and supports real estate development in Nashik and the Mumbai Metropolitan Region.

9. Gadchiroli Mining Roads

Overview: A proposed and undertaken 103 km greenfield road for mineral transport, with environmental clearances in progress.

Impact: Facilitates efficient mineral logistics and regional economic growth.

10. Jan Kalyan Expressway

Overview : Mumbai-Hydrabad Jankalyan Expressway having length of 576 Km joins Maharashtra, Karnataka and Telagana states. The MSRDC will construct the 442 km length from Kalyan to Latur in Maharashtra State.

Impact : It will bring the connectivity to JNPA, Vadhavan Port, Navi Mumbai International Airport boosting the economical and industrial growth.

11. Revas–Redi Coastal Highway (MSRDC)

Overview : Revas to Redi Coastal Highway construction—a landmark 523-kilometre development— will seamlessly connect Mumbai, Raigad, Ratnagiri and Sindhudurg coastal districts through a world- class four-lane coastal corridor. With 9 major creek bridges and upgraded two-lane paved shoulders, this project will accelerate connectivity to local ports and unlock new opportunities for coastal and tribal communities. Iconic tourist destinations like Alibaug, Murud, Janjira, Harihareshwar, Dapoli, Ganpatipule, Malvan and Devgad will be connected faster than ever.

Impact: It will reduce travel time by coastal road from 20 hrs. to 12 hrs. increase tourism, agro-economy, fisheries.

12. Konkan Expressway

The journey through Konkan is about to be redefined with MSRDC's Konkan Expressway, a 388-kilometre access-controlled superhighway. It is set to become one of Maharashtra's most ambitious infrastructure corridors. The expressway is engineered for speed, safety, and reliability.

Impact : This project will cut travel time from Mumbai to Goa down from 12 hrs to just 4-5 hours, boosting economic activity across the region. It will strengthen connectivity to major and minor ports, and give a massive push to coastal, eco, and cultural tourism in the coastal Konkan region of Maharashtra.

Total length of the Bridges: 31.43km.

Renewable Energy Initiatives

Pioneering a sustainable future, the Samruddhi Expressway will generate over 210 MW of solar power, aligning with Honorable Prime Minister Shri Narendra Modi's net-zero vision. This presents a USD 120 million investment opportunity in renewables, enabling MSRDC to secure carbon credits and



access low-interest financing from global institutions like the World Bank— paving the way for a greener India. At present 9 MW Solar power generation is started. For 37 MW generation, the work is in progress and for 164 MW generation, the process in underway.



Special Planning Authority

Investment prospects in Maharashtra's special planning zones beckon visionary investors. These zones, spanning 7376 sq km across regions like Panvel-Khalapur & Karjat (310 sq km), Satara (2097 sq km), 19 Growth centers along Konkan Coast (2963 sq km), Bhiwandi SPA (374 sq km), Pune Growth center (668 sq km) and 18 New Towns along samruddhi Mahamarg (295 sq km) are primed for rapid urban and economic expansion. Strategically located near Expressways and corridors, they offer modern infrastructure, streamlined regulations, and high-growth potential—ensuring robust capital appreciation and a stake in Maharashtra's thriving urban ecosystem.



Financing Models & ROI

MSRDC projects totalling over USD 35 billion. Investors can leverage proven models like EPC, Annuity, and BOT, generating consistent toll revenues, ancillary commercial ventures, and land monetization opportunities.



Leadership

Under the visionary leadership of Hon'ble Prime Minister Shri Narendra Modi, Chief Minister Shri Devendra Fadnavis and Deputy Chief Minister Shri Eknath Shinde and Deputy Chief Minister Smt. Sunetra Pawar, Maharashtra has emerged as a global benchmark for governance and infrastructure excellence. The strategic guidance of Hon'ble Minister of State (Public Works) and Co-Chairman, MSRDC, Smt. Meghna Sakore-Bordikar and Shri Anilkumar Gaikwad (Vice-Chairman & Managing Director, MSRDC) ensures the flawless execution of transformative projects that align with sustainable development goals.

With a robust governance framework, expedited clearances, and impeccable and fastest execution, MSRDC projects guarantee assured returns. Maharashtra isn't merely constructing Expressways—it's forging growth corridors, industrial hubs and sustainable futures that amplify the state's GDP and global stature.

MSRDC transcends road-building; it architects Maharashtra's and India's future.

For more information
Please scan the QR code



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ARTICLES

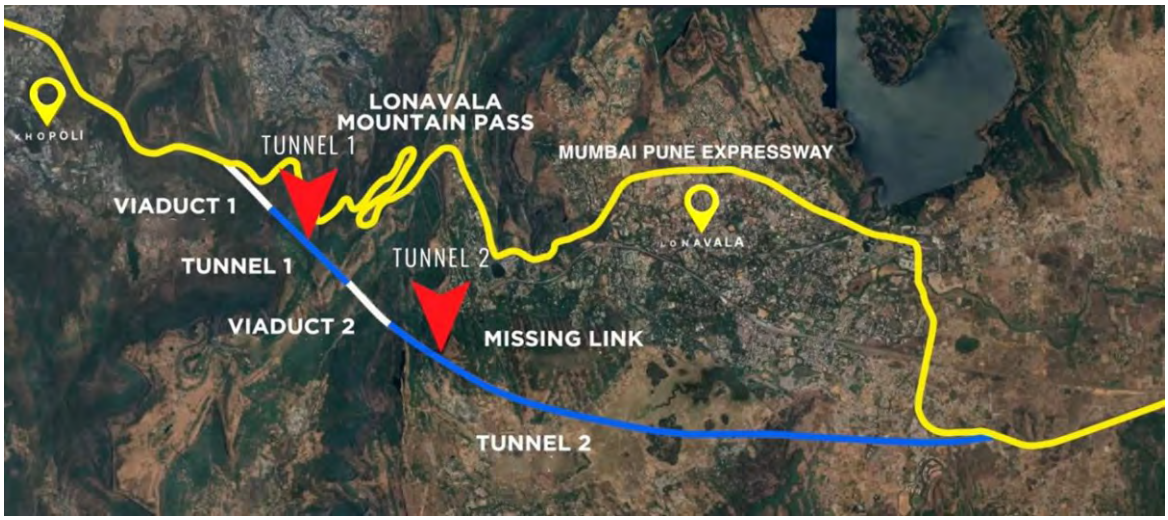
Mumbai–Pune Expressway Missing Link Project: Redefining Highway Engineering in India

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The **Mumbai–Pune Expressway Missing Link Project**, developed by the **Maharashtra State Road Development Corporation** (MSRDC), marks a new milestone in India's highway infrastructure. Conceived to eliminate the accident-prone Borghat section of the Mumbai–Pune Expressway, the project combines advanced tunnelling technology, high-level viaducts and a landmark cable-stayed bridge to create a safer, faster and more reliable transport corridor.

Stretching over **13.3 km** with width of 23.5M (8 Lane Twin Tunnel Configuration) and constructed at an estimated cost of **₹6,700–7,180 crore**, the Missing Link significantly improves connectivity between Mumbai and Pune by reducing the travel distance by approximately **6 km** and cutting journey time by **20–30 minutes**. More importantly, it replaces a section notorious for steep gradients, sharp curves and frequent traffic congestion with a modern expressway designed to international standards**.**



One of the project's defining features is its twin-tunnel system, consisting of the **1.64 km** Kusgaon–Khopoli Tunnel and the **8.92 km** Borghat–Tiger Valley Tunnel. Constructed through the challenging geology of the





Sahyadri ranges using the **New Austrian Tunnelling Method** (NATM) and controlled drill-and-blast techniques, these tunnels represent one of India's most complex underground infrastructure achievements.

The wider tunnel configuration, modern ventilation systems, emergency cross-passages, CCTV surveillance, fire detection and suppression systems, and intelligent traffic monitoring ensure a high level of operational safety and commuter comfort.



Complementing the tunnel network are two major viaducts and a spectacular **cable-stayed bridge** supported by **182-metre-high pylons and 240 stay cables.** These iconic structures not only overcome the difficult mountainous terrain but also stand as symbols of India's growing expertise in bridge engineering and long-span construction.

The Missing Link has been designed with safety as its foremost priority. **Advanced Intelligent Traffic Management Systems (ITMS)** continuously monitor traffic movement through CCTV cameras, variable message signs, emergency communication networks and automatic incident detection systems. Dedicated refuge areas, smoke extraction systems and emergency evacuation passages further enhance safety, particularly during the monsoon season when the old ghat section often experienced disruptions.



Beyond engineering excellence, the project delivers substantial **economic** and **environmental** benefits. The smoother alignment reduces fuel consumption, vehicle operating costs and greenhouse gas emissions while improving travel reliability for passenger vehicles and freight transport. **Faster movement** of goods between Mumbai, Pune and the industrial corridors of western Maharashtra is expected to **strengthen logistics** efficiency, support manufacturing and tourism, and contribute to sustained regional economic growth.

The Missing Link Project also reflects MSRDC's commitment to adopting world-class construction practices and innovative engineering solutions. From overcoming **difficult geological formations** to integrating sophisticated safety technologies, every aspect of the project demonstrates meticulous planning and execution. The project serves as a **Benchmark** for future expressway development across India and reinforces Maharashtra's leadership in modern transportation infrastructure.

Today, the Mumbai–Pune Expressway Missing Link, **Now Known as Connecting Link**, is far more than an infrastructure project—it is a **transformational investment** in mobility, safety and economic development. By reducing travel time, enhancing commuter safety and improving operational efficiency, the project sets a new standard for **Highway Engineering in India.**

Acknowledgement

The successful planning, execution, and completion of the Mumbai–Pune Expressway Missing Link Project was made possible under the visionary leadership of **Shri Anil Kumar Gaikwad, Vice Chairman & Managing Director, MSRDC**. The dedicated efforts of the **entire MSRDC team**, whose technical expertise, project management, and continuous monitoring were instrumental, ensured the delivery of this landmark infrastructure project.

Project Delivery Partners

- **Project Owner: Maharashtra State Road Development Corporation (MSRDC)**
- **General Consultant:** Geodata (Pini Group) Italy/Switzerland & Louis Berger (USA) -Consortium
- **Package I (Twin Tunnels):** Navayuga Engineering Company Ltd.
- **Package II (Cable-Stayed Bridge, Viaducts & Expressway Widening):** Afcons Infrastructure Ltd.

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Road Safety Audit and Design an Imperative for National Wellbeing Case Studies from Karnataka and Andhra Pradesh

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ABSTRACT

Road traffic accidents remain one of the India's most pressing public health and infrastructure challenges, claiming over 150,000 lives annually. State and rural highways contribute disproportionately to these fatalities due to mixed traffic, inadequate enforcement and sub-optimal infrastructure design. This article presents two large-scale initiatives from Andhra Pradesh and Karnataka that demonstrate how systematic Road Safety Audits (RSAs), International Road Assessment Programme (iRAP) Assessment and Star Ratings, data-driven Blackspot identification and preparing targeted engineering designs can significantly reduce crash risks. These studies highlight the importance of integrating safety concerns in to planning, design operation stages. Through predictive assessment and data-driven prioritisation and context specific engineering improvements, high-risk accident-prone areas, in creating safer roads and more forgiving environments. The case studies underline the critical role of design in reducing cash severity, protecting vulnerable road users and contributing to National Wellbeing.

Keywords: *Road Safety Audit, iRAP Assessment, iRAP Star Rating, Crash analysis, Blackspots, Safe System Approach, Safety Improvement Designs, National Wellbeing.*

1 INTRODUCTION

Road Safety is closely linked with National Wellbeing, Economic Productivity and Public Health. Each Road crash represents not only a personal tragedy but also significant socio-economic loss. In India, the economic cost of road accidents estimated at 3–5% of the National GDP. Beyond fatalities, countless individuals suffer life-changing injuries each year, placing a heavy burden on healthcare systems while diminishing national productivity. Globally, the adoption of Safe Systems Approach has shown that road crash risks can be substantially reduced. This approach recognises that human errors are inevitable and therefore road infrastructure must be designed to anticipate and accommodate these errors and mitigate their consequences by reducing the likelihood and severity of crashes. Safer road infrastructure, combined with enforcement, education, and emergency response systems, forms the foundation of sustainable road safety management. In doing so, road safety evolves from a mere technical obligation in to a critical public health priority that calls for consideration of the road user behaviour apathetically and development of forgiving road environments which protect live and support National Wellbeing.

In India, Andhra Pradesh and Karnataka have initiated state-wide Road Safety Audit (RSA) programmes to ensure safety in to infrastructure planning, design, construction and maintenance of roads. These states demonstrated how structured road safety assessments, systematic data analysis and targeted engineering interventions and context specific designs can transform high-risk accident-prone areas into forgiving and safer roads networks, setting benchmarks for sustainable and human centred infrastructure development.

2 METHODOLOGY

The methodology adopted in the case studies followed by International good practices, IRC Staards and iRAP protocols:

- Conducting Road Safety Audits (RSA) in accordance with IRC SP:88 (2019) – Manual on Road Safety Audit.
- Preparation of GIS-based corridor mapping and chainage referencing using tablet-based data collection tools.
- Conducting day and night corridor audits using GPS-enabled cameras and video recording.
- Geo-referencing corridor videos at 20 m intervals for detailed safety assessment.
- Analysis of historical crash data to identify blackspots and accident-prone sections.
- Traffic surveys including traffic volume counts, speed studies, and behavioural observations.
- Conducting iRAP star rating assessments and preparing Safe Road Investment Plans (SRIP) using ViDA software.
- Prioritisation of high-risk sections using multi-criteria decision analysis.
- Preparation of detailed engineering designs and cost estimates for safety improvements.
- Capacity building through training programmes and knowledge dissemination for engineers and stakeholders.

This systematic approach ensured that safety interventions were **data-driven, cost-effective, and technically robust**.

3 CASE STUDIES

Present paper discusses, how the State Governments handled the road safety concerns of the states, how resources allocated and how narrowed down the problem to solution are explained in subsequent sections.

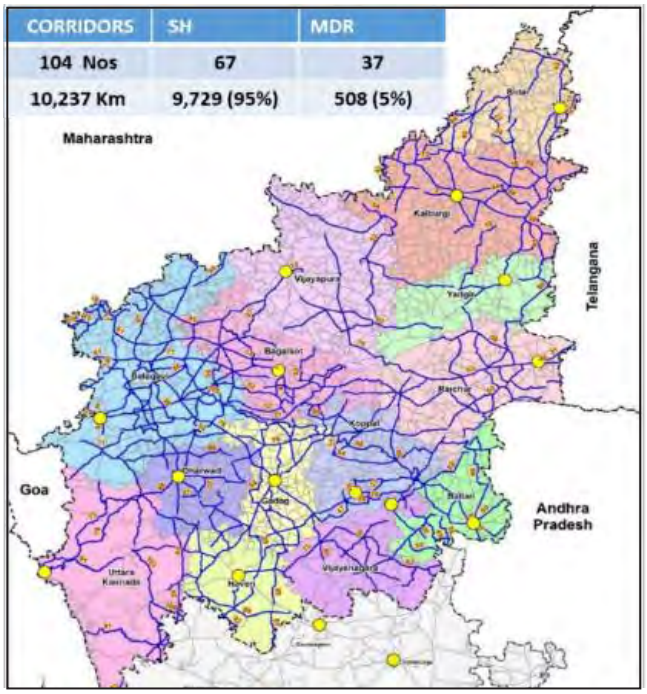
3.1 Karnataka: Core Road Network Safety Improvement

Karnataka State identified Core Road Network (CRN) under Asian Development Bank (ADB) funded project totalling 24,226 km, comprising 4,491 km of National Highways, 18,470 km of State Highways, and 1,265 km of Major District Roads. During the study period (2018-2021), Karnataka recorded 34,647 road crashes (8.4% of India's total, 4th rank) with 10,038 fatalities (6th rank in fatalities). Fatal accidents numbered 9,458, with additional grievous, minor and non-injury cases.

The PIU-KSHIP engaged a consortium led LEA Associates South Asia Pvt Ltd in JV with CSIR Central Road Research Institute, GeoVista Technologies Pvt Ltd (LASA-CRRI- GVT) for RSC1 – Road Safety and Design of North Karnataka PWD Roads spread over 14 districts, covering 104 corridors (SH -67 and MDR- 37) of 10,237 km. The details of the study area and road network covered under various districts are shown in Figure 1. The key findings of RSA and iRAP:

Road Safety Audit Findings	iRAP Assessment
• 227 Black Spots • 9,098Sharp Curves with Deficiency • 1,137 Critical Junctions require improvements • 9,458 Road Side Hazards (narrow culverts, bridges) • 1,482 Built up areas require traffic calming measures	• 6,833 km (66%) less than 3 stars require safety improvement • SRIP for 12,439 Cr • FSI Saved 1,90,000 over 20 years

The primary objective was to asses road safety concerns through comprehensive Safety Audits including crash analysis and iRAP assessment and to prioritise Safety Improvement Measures using Multi Criteria Decision Analysis (MCDA). The interventions are aimed at achieving 3-star or higher iRAP ratings for all road users, aligning with UN Global Road Safety Targets. Considering the substantial investment required to address the safety concerns in North Karnataka, the implementation of safety improvements will be taken up in a phased manner. Accordingly, safety designs have been prepared for prioritised 1500 kms accident prone stretches and 27 blackspots and the procurement process for implementation of contracts been initiated.



District	Length (km)	RSA Reports
Bagalkote	880	19
Belagavi	1,883	31
Vijayapura	568	8
Dharwad	474	13
Gadag	711	13
Haveri	516	12
Uttara Kannada	818	11
Bellary	537	12
Vijayanagara	456	7
Koppal	672	14
Raichur	876	14
Bidar	506	11
Kalaburgi	1,069	19
Yadgir	270	6

Figure 1 PWD North Karnataka Roads

The estimated cost for the safety improvements is Rs. 2,348 Crore. Upon implementation, the programme is expected to eliminate 67 blackspots, improve 993 sharp curves, upgrade 189 critical junctions, remove 1,506 roadside hazards, and introduce traffic calming measures in 189 built-up areas/villages. These interventions are projected to prevent approximately 30,063 Fatalities and Serious Injuries (FSIs) and transform 1,500 km of road network into safe corridors. Under the KSHIP, similar study was carried out by other consultants for Central and South Karnataka Roads and designs were prepared for 1500 km of roads and 20 Blackspots.

As part of the study, extensive capacity building and awareness programmes were undertaken. A Series (5) of Road Safety and iRAP disseminations sessions, along with 5-day Road Safety Audit (RSA) and 2-day iRAP Training cum Workshops were organised to disseminate typical safety concerns and improvement measures, benefiting over 1000+ engineers, police personnel and consultants and school children. In addition, work zone safety training was organised for 50+ workmen and site engineers to promote safe construction practices. Public road safety awareness campaigns were also held at schools, bus stands,

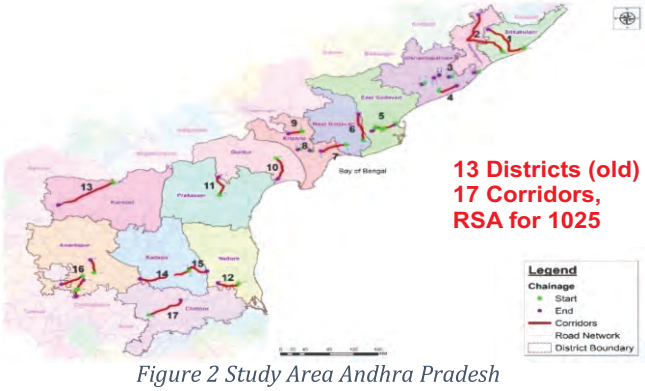


Figure 2 Study Area Andhra Pradesh

municipal office and other public places, reaching more than 500 road users and children. These initiatives significantly strengthened institutional capacity and promoted safer road user behaviour.

3.2 Andhra Pradesh

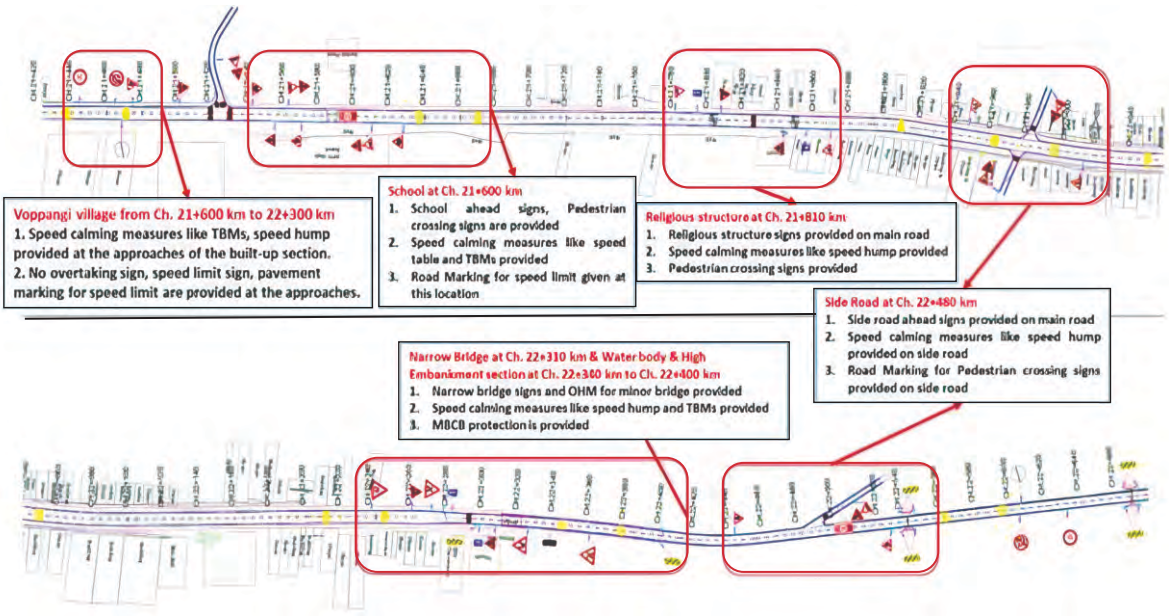
The Andhra Pradesh Road Development Corporation (APRDC) selected 17 State Highway corridors totalling 1,025 km for a Comprehensive Road Safety Audit and Design study, with an objective to developing **District Demo Corridors** (DDCs) to showcase best practices in Road Safety Design and develop model safe state highways. The corridors were identified, one from each district (old), based on crash history and traffic density with aim of developing replicable and sustainable Road Safety Improvement strategies.

Under this initiative, Road Safety Audits were conducted along with on job traing to the department egnineers. The Road Safety Audit Findings and critical safety concerns include 42 Blackspots, 163 Geometric issues at sharp curves and 162 critical junctions, along with Inadequate pedestrian facilities near schools, hospitals and built-up areas, Roadside hazards and unprotected structures, Poor delineation, faded markings and inadequate lighting.

To strenthen institutional capacity, three regional level Road Safety Training cum Workshops(3) were organised, imparting training to over 250 engineers. These were followed by dessimination sessions with the respective eginners incharge to discuss road safety audit findings and to priortise the proposed safety improvements. Based on these consultations, critical road safety interventions were selected for preparation of detailed project reports (DPRs) alongwith typical improvement designs and detailed cost estimates. The client proposes to undertake procurement and implementation in phased manner.

Detailed safety designs were prepared for works estimated at Rs. 1,271 crores (approximately Rs 1.25 crore/km), with most interventions retrofitted within the existing Right of Way (ROW), thereby minimising additional land acquisition requirements. These improvements are expected to prevent approximately 162 fatalities, 110 grievous injuries and 311 minor injuries, significantly enhancing road safety outcomes on the selected corridors.

Typical Safety Improvements suggested at various location are presented in Figure 3



(a) Typical Corridor showing settlements, schools, religious structures and cross drainage structures



(b) SH1 -Srikakulam – Calingapatnam – Blackspot Improvements (Km 21+600 – Km 22+500)

4 LESSIONS LEARNED FROM CASE STUDIES

a. **Design is the first line of defence –** improved road geometry, access management and roadside protection significantly reduce crashes.
b. **Data-driven prioritisation** ensures funds are directed to locations where the safety interventions can deliver greatest impact
c. **Day & night RSAs** reveal different hazard profiles, making both are essential for comprehensive safety assessments
d. **Capacity building** of engineers, contractors and enforcement agencies is essential for long-term sustainable adoptions and implementation of safe road practices.
e. **Low-cost measures** such as improved signages, markings, removal of road side hazards removal can deliver immediate safety benefits while larger infrastructure improvements are planned and implemented.

5 SUMMAR & WAY FORWARD

The Karnataka and Andhra Pradesh case studies demonstrate that systematic RSAs, iRAP Assessments, data-driven design approaches and targeted interventions can transform high risk, dangerous corridors into safer, more efficient and inclusive and economically productive road networks. Beyond reducing fatalities and injuries, such initiatives foster safer mobility, economic productivity and public trust and confidence in infrastructure. These initiatives were also supported by institutional capacity building and awareness, to promote a strong road safety culture and practices among the road users, engineers and enforcing agencies enabling stakeholders to better understand and address safety challenges.

Scaling such approaches Nationwide will be a decisive step towards achieving India's Vision Zero and fulfilling its commitments under the **UN Decade of Action for Road Safety**. Road safety, when embedded into design as a core principle in road planning and design, it evolves beyond a technical requirement to become a fundamental contributor to National wellbeing imperative.

Ultimately, Road safety is not merely an engineering task but a societal responsibility, one that directly impacts national wellbeing.

6 ACKNOWLEDGEMENTS

The authors thank to Authorities of Karnataka & Andhra Pradesh, Director CSIR-CRRI and The Management LASA, the teams/individuals participated in successful completion of the project. The authors also thank to clients/sponsors of the studies for both projects i.e. Karnataka and Andhra Pradesh Governments.

7 REFERENCES

- IRC: SP-88 *(2019)* “Manual on Road Safety Audit *(First Revision)*”, IRC, New Delhi.
- IRC 131 – 2022: Guidelines for Identifying and Treating Blackspots, IRC, New Delhi.
- IRC: SP-41 (1994), “Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas”, IRC, New Delhi
- IRC: 79 (2019), “Recommended Practice for Road Delineators (First Revision)”, IRC, New Delhi.
- IRC:67 (2022) “Code of Practice for Road Signs (Fourth Revision)”, IRC, New Delhi.
- IRC:35 (2015), “Code of Practice for Road Markings (First Revision)”, IRC, New Delhi.
- IRC: SP-55 (2014), “Guidelines for Traffic Management in Work Zones (First Revision)”, IRC, Delhi.
- IRC: 119 (2015), “Guidelines for Traffic Safety Barriers”, IRC, New Delhi.
- IRC: 99 (2018), “Guidelines for Traffic Calming Measures in Urban and Rural Areas (First Revision)”, IRC, New Delhi.
- MORT&H Circular no. RW/NH-15017/109/2015/P&M(RSCE) dated 28 October 2015 (Protocol for identification and rectification of road accident blackspots on National Highways.
- MORTH Manual for Safety in Road Design
- Star rating computation by ViDA Software and iRAP Star Rating and Investment Plan Manual Version 1.4 (2023)

Leveraging Generative and Vision AI for Intelligent and Scalable Road Asset Management in India

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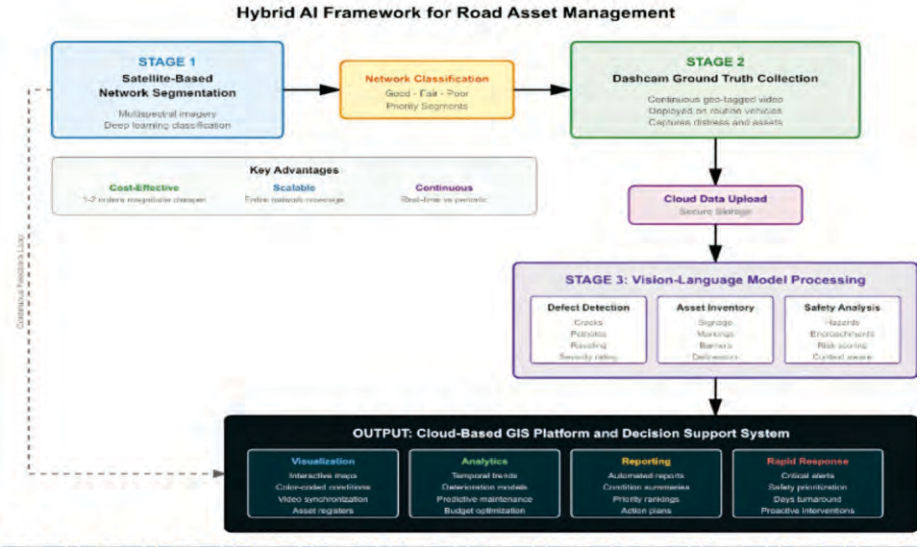
1. INTRODUCTION

India maintains one of the world's largest road networks, spanning over 6.6 million kilometres. Ensuring the safety and sustainability of this vast infrastructure requires systematic and continuous monitoring. However, most road agencies rely on manual visual inspections - methods increasingly inadequate for modern infrastructure demands.

Manual surveys are slow, resource-intensive, subjective and impossible to scale across hundreds of thousands of kilometres. They provide only snapshot assessments, often missing critical deterioration between inspection cycles. This challenge intensifies with mounting pressures from increasing traffic, extreme climate, and rapid urbanization. Without timely assessments, minor defects escalate into major failures, costs multiply, and safety risks heighten.

Ministry policy mandates Network Survey Vehicles (NSV) with LiDAR for recording highway conditions. While NSVs offer precise measurements of roughness, rutting, texture, and distresses, their high costs limit deployment primarily to NHAI corridors, leaving state highways, urban roads, and rural networks—over 90% of India's road infrastructure—largely unmonitored.

This article proposes a hybrid framework leveraging three complementary technologies: satellite imagery for network-level segmentation, dashcam video surveys for detailed inspection, and Vision-Language Models (VLMs) for automated analysis. This approach prioritizes affordability, scalability, and continuity—enabling data-driven maintenance strategies without traditional high-precision system costs.



2. CRITICAL ASSESSMENT OF CURRENT SURVEY METHODOLOGIES

2.1 Manual Visual Inspection: Practical Limitations

Manual surveys exhibit significant assessment variability - different inspectors interpret distress severity inconsistently, undermining network-level reliability. Resource intensity severely constrains coverage; teams assess only 20-30 kilometres daily, making

comprehensive monitoring impractical and leaving large portions uninspected for extended periods.

By the time data is collected, processed, and reported - often weeks or months - conditions may have changed substantially, undermining proactive maintenance. Manual methods also produce incomplete or outdated asset inventories of signage, guardrails, and lighting fixtures.

2.2 LiDAR and Network Survey Vehicles: The Precision-Cost Trade-off

NSVs with LiDAR, high-resolution cameras, accelerometers, and GPS represent the gold standard, collecting comprehensive data including International Roughness Index, rut depth, macrotexture, and distress imagery at highway speeds. However, capital costs of Rs. 2-5 crores per vehicle and huge survey costs create significant scalability barriers.

NSV adoption remains limited to NHAI corridors and select state highways. District roads, urban streets, and rural connections remain largely unmonitored. Even where deployed, biannual survey frequency may be insufficient to capture rapid deterioration, particularly during monsoons.

This creates a critical monitoring gap: the vast majority of India's road infrastructure lacks systematic condition assessment, while the available high-precision technology remains economically unviable for most road-owning agencies.

3. THE HYBRID AI FRAMEWORK: ARCHITECTURE AND IMPLEMENTATION

3.1 Satellite-Based Network Segmentation for Strategic Prioritization

The framework employs satellite imagery analysis for network-level condition segmentation and strategic prioritization. Modern satellites provide multispectral imagery at 3-10 metre resolution with frequent revisit frequencies. While insufficient for detecting individual cracks, this captures macro-level indicators: pavement tone, edge deterioration, vegetation encroachment, drainage anomalies, and patching patterns.

Deep learning models classify segments as good (consistent surface), fair (patchy appearance, early distress), or poor (visible failures, severe patching, vegetation intrusion). This serves as a screening tool to identify priority corridors for detailed IRC-compliant assessment, not as a substitute for IRC standards. Ground-based dashcam and VLM analysis then generate IRC-compliant metrics including distress types, severity, and extent as per guidelines.

Satellite segmentation provides comprehensive coverage at minimal cost - single images assess thousands of kilometres simultaneously. Monthly or quarterly monitoring enables trend analysis and optimizes resource allocation by directing expensive surveys only to priority segments.

3.2 Dashcam-Based Ground Truth Collection

Once satellite analysis identifies priority segments, the second tier deploys dashcam-based video surveys for detailed condition assessment. Unlike specialized survey vehicles, dashcams are inexpensive (Rs. 5,000-20,000), widely available, and easily installed on any vehicle including patrol cars, contractor equipment, public transport buses, or maintenance vehicles.

Dashcam surveys capture continuous, geo-tagged video footage during routine vehicle operations, eliminating the need for dedicated survey deployments. The video streams document pavement surface conditions, road markings, signage, roadside assets, safety hazards, and geometric features at high temporal resolution.

This approach fundamentally changes the economics and logistics of road condition monitoring. Rather than requiring specialized surveys at discrete intervals, dashcam data accumulates continuously through normal agency operations. A highway patrol vehicle recording daily routes generates comprehensive corridor documentation without additional

operational costs. Municipal buses equipped with dashcams systematically map urban road networks through their regular service patterns.

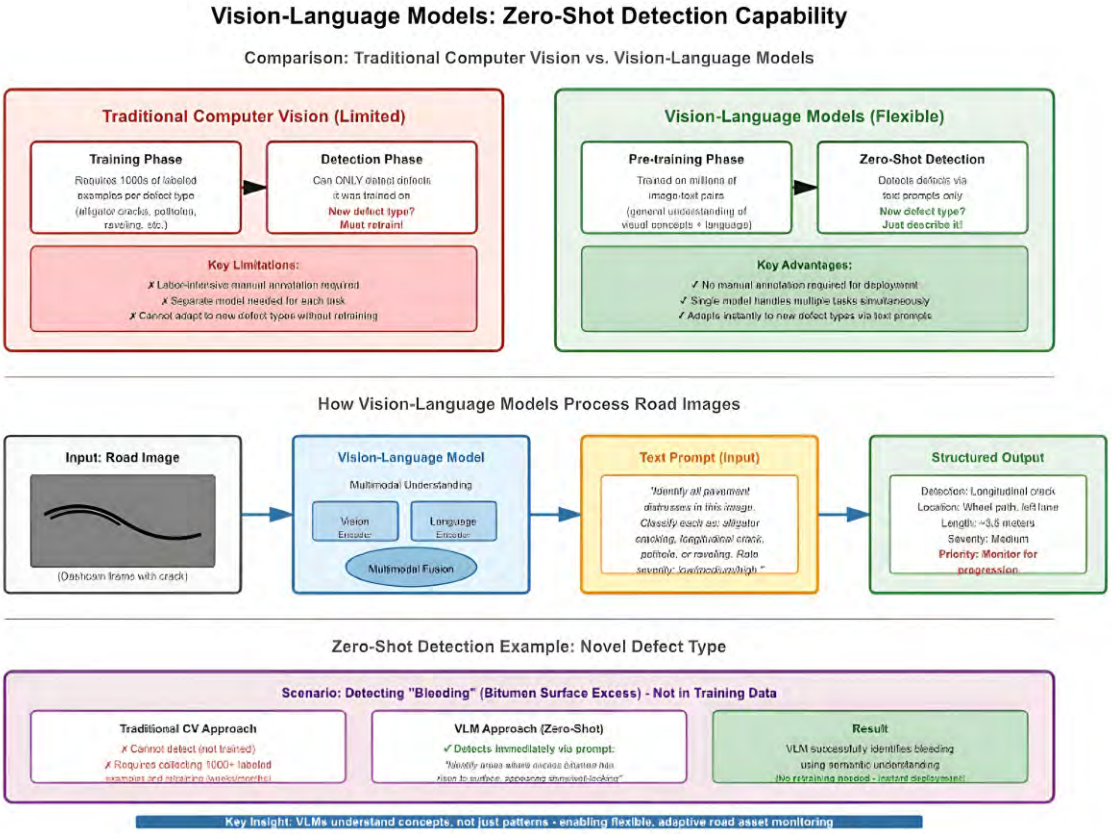
The continuous nature of dashcam collection also captures temporal dynamics that periodic surveys miss-the gradual formation of potholes, progressive marking deterioration.

3.3 Vision-Language Models: The Analytical Core

The critical innovation enabling this framework is the application of Vision-Language Models to automated video analysis. VLMs represent a fundamental advance over traditional computer vision approaches, offering capabilities that bridge the gap between raw imagery and actionable engineering intelligence.

Traditional computer vision models require extensive supervised training with thousands of manually annotated examples for each defect class. They function as narrow specialists - a model trained to detect alligator cracking cannot identify potholes without additional labelled data and retraining. This creates significant barriers to deployment, particularly for agencies with limited technical capacity or diverse pavement types requiring detection of uncommon distress modes.

Vision-Language Models overcome these limitations through their multimodal training on massive datasets pairing images with textual descriptions. This training enables them to understand both visual patterns and semantic concepts expressed in natural language. Consequently, VLMs can perform zero-shot or few-shot detection - identifying defect types they have never explicitly seen during training, simply by being prompted with textual descriptions.



For road asset management, this capability is transformative. A VLM can be prompted: "Identify and describe all pavement distresses visible in this image, including cracks, potholes, ravelling, bleeding, and any unusual surface anomalies. Classify severity as low, moderate, or high based on extent and structural implications." The model responds with structured detections, natural language descriptions, and severity assessments - without requiring thousands of labelled training examples for each distress type.

Beyond detection, VLMs provide contextual understanding. They can differentiate between a longitudinal crack in a wheel path (potentially structural, requiring immediate attention) versus a transverse thermal crack (less critical, monitor for progression). They recognize that a faded stop sign at a school crossing presents higher risk than the samef defect on a low-volume rural road. This contextual reasoning - incorporating location, traffic characteristics, and safety implications - enables genuinely intelligent prioritization.

VLMs also excel at multi-task processing. From a single video frame, they simultaneously detect pavement distresses, inventory roadside assets (signage, delineators, barriers), identify safety hazards (debris, encroachments, ponding water), assess marking visibility, and generate structured summaries. Traditional systems would require separate models for each task; VLMs integrate them seamlessly.

3.4 Automated Processing Pipeline and GIS Integration

The operational workflow integrates these technologies into a seamless pipeline. Dashcam videos uploaded to secure cloud storage trigger automated processing. Vision-Language Models analyse each frame, extracting detections with precise GPS coordinates. Generative AI components synthesize individual detections into structured reports - pavement condition summaries, asset inventory registers, safety audit findings, and maintenance recommendations.

All outputs populate a cloud-based GIS platform providing decision-makers with interactive visualization. Users can view road segments color-coded by condition, filter by distress type or severity, play synchronized video footage at any location, and generate customized reports for planning and procurement. The platform tracks temporal trends, enabling deterioration modelling and predictive maintenance scheduling.

This end-to-end automation compresses the assessment cycle from months to days.

A video uploaded Monday morning generates analysed results and recommendations by Tuesday afternoon, enabling rapid response to critical defects.

4. IMPLICATIONS FOR VISION ZERO INDIA

Continuous monitoring directly supports India's Vision Zero initiative. Many crashes result from infrastructure defects—potholes causing loss of control, faded markings creating confusion, missing delineators, inadequate drainage causing hydroplaning. Traditional surveys may detect these months after development, exposing thousands of vehicles to risk. The AI-driven approach identifies emerging hazards within days, enabling rapid remediation. Prioritization of high-risk locations - school zones, high-speed curves, pedestrian crossings—focuses interventions where they generate maximum benefit.

Comprehensive asset inventory enables systematic safety audits, identifying entire corridors with substandard delineation, inadequate signage, or geometric deficiencies for coordinated improvements rather than reactive spot fixes.

5. PATH FORWARD

India's road infrastructure demands monitoring systems matching its scale and diversity. The traditional dichotomy between inexpensive manual surveys and costly automated systems has created a monitoring gap affecting 90% of the network. This AI-driven hybrid framework - combining satellite intelligence, dashcam accessibility, and VLM sophistication - delivers scalable, affordable, continuous monitoring. Encouragingly, NHAI recently plans to implement dashcam video analytics using AI and machine learning to assess National Highway conditions.

The technologies exist, the framework is proven, the economic case is compelling. What remains is institutional will to embrace intelligent automation and unlock data-driven governance of the nation's most critical infrastructure asset—its roads.

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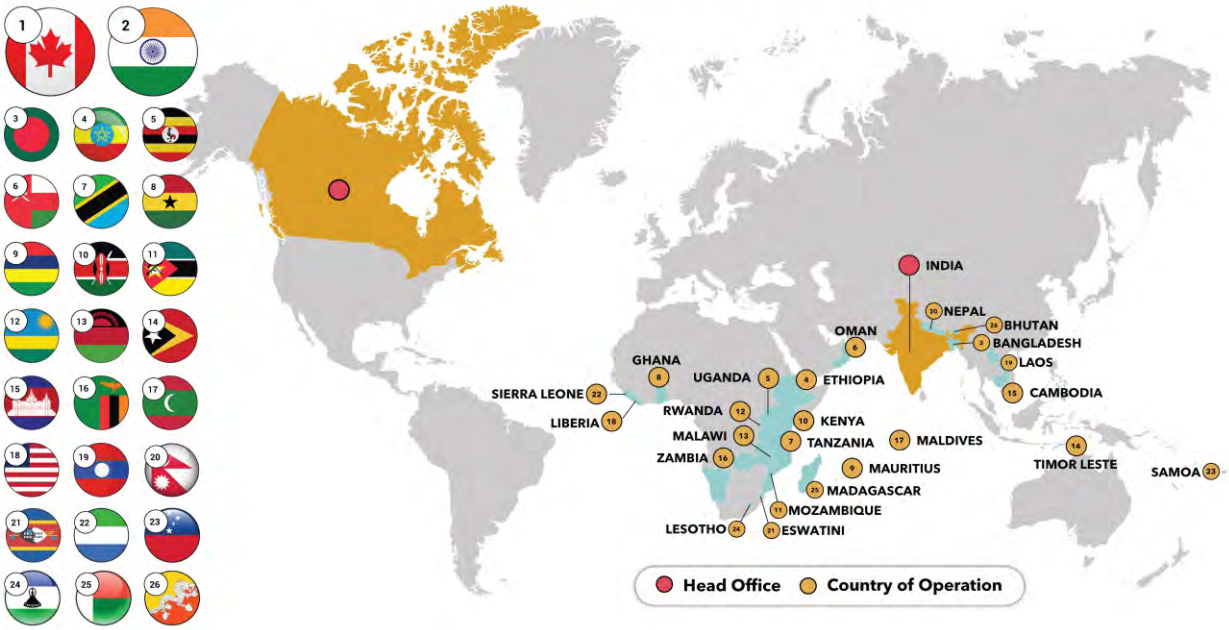
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SOME PROJECTS:



INTERNATIONAL

- Regional Spatial Strategies and National Transport Survey, **Oman**
- Feasibility, Design of Bugente-Kasulo Road, **Tanzania**
- Road Network Upgrading Project, **Timor Leste**
- Design of Kitgum-Kidepo Road, **Uganda**
- Design, Procurement support and Supervision in Tete
- Province, **Mozambique**
- Supervision of Kewatkhali Bridge, **Bangladesh**
- Design and Construction Supervision of
- Chinsali-Nakonde Road Rehabilitation Project, **Zambia**
- Design Review and Supervision of East Cost Trunk Road Project, **Mauritius**
- Design and Procurement of a Pilot Contract for OPRC,
- **Ethiopia**
- Botswana Integrated Transport Project (BITP),
- **Botswana**
- Outer Ring Road Improvement, **Kenya**
- Road Asset Management, **Cambodia**
- Majanji Port Feasibility Study, **Uganda**
- Design and Supervision of
- Butwal-Gorusinghe-Chanauta section, **Nepal**
- Designs for MR14 & MRI21 Roads, **Swaziland**
- Design Review and Supervision of the
- Thaba-TsekaKatse Road Upgrading Project, **Lesotho**
- Monitoring and Evaluation for Sierra Leone Roads
- Authority, **Sierra Leone**
- Design, Procurement Assistance & Supervision for
- Alafaalava Road, **Samoa**

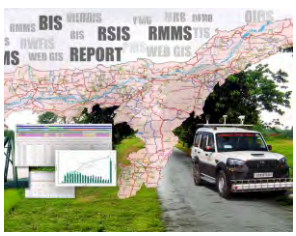
INDIA

- Feasibility Studies & Transaction Advisory Services for Procurement and Bid Process Management for Construction, Up-Gradation, Strengthening and Maintenance of SHs, MDRs, ODRs and Rural roads, Telangana (HAM Project)
- Preparation of Comprehensive Mobility Plan (CMP) for Hyderabad Metropolitan Area (HMA), 2050
- Traffic Studies for Ph-I and Ph-II Metro Corridors for Ridership Estimation and Evaluation of Operational Linkages between Ph-I & Ph-II Metro Corridors
- Development of Skywalk near Secunderabad Railway Station
- PMC for Warangal Smart City and Faridabad Smart City.
- Independent Engineer Services for Operation and Maintenance of Narketpally - Addanki - Medarametla Road (SH-2), Telangana and Andhra Pradesh
- Viskhapatnam metropolitan Region Development Authority (VMRDA) (Revising VMR Master Plan -2041 in its Entirety & preparation OF Zonal Development Plant for Kambalkonda ESZ)
- ADCLPreparation of Detailed Project Report (DPR) for Connecting Amaravati-Trunk Infrastructure with IRR, Amaravati Capital City of Andhra Pradesh
- Vision document for the Master Plan for Chennai
- Road Safety Audit and Design for the PWD North and North East Zone Road in the State of Karnataka (Package I) under KSHIP -III project

Some Unique Projects



Majanji Port Feasibility Study in Uganda



Asset Management System for Road, Assam



Majherhat Cable-Stayed Bridge



Ayodhya Development Plan

Sustainable Infratech for Transformative Change in India: Vision Zero for Safety and Carbon-Free Developments

Prof. T. G. Sitharam

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It is a decisive moment in India's development journey—when infrastructure is no longer judged merely by kilometres built or budgets spent, but by **lives saved, carbon avoided, and futures secured**. Vision Zero is a global road safety strategy aiming to eliminate all traffic fatalities and severe injuries, based on the ethical principle that no loss of life is acceptable in the transport system, shifting responsibility from road users to system designers to create forgiving environments for human error.

India's road infrastructure transformation is deeply aligned with the theme of Sustainable Infratech for Transformative Change by prioritising Vision Zero safety principles, climate-aligned construction, and inclusive connectivity. Major national programmes—from high-speed expressways and greenfield corridors to rural accessibility and last-mile linkages—are increasingly designed with crash-preventive geometry, digital monitoring, and smart traffic management systems that aim to reduce fatalities and serious injuries. Concurrently, low-carbon materials, electrification of freight and passenger movement, and carbon accounting frameworks are being embedded into project planning to support India's net-zero commitments. By integrating multimodal linkages, resilient design standards, and community-centric development, India's road infra is not just expanding lengths of pavement but building safe, sustainable, and people-centric transport networks that reflect the very objectives of this summit.

The highlights of Vision Zero, carbon-free infrastructure, are the national icons like the Chenab Bridge, major water–transport initiatives like Kochi Water Metro, and other net-zero construction approaches. These are some of the projects for India's infrastructure transformation. Mahatma Gandhi said *"The future depends on what we do in the present".* Today, what we choose to design, finance, and construct will define India's safety record and climate footprint for the next half-century. Therefore, the **Sustainable Infratech for Transformative Change** is not aspirational rhetoric. It is an engineering mandate.

In India, road safety remains a pressing concern: in 2024 alone an estimated 1.77 lakh people lost their lives in road crashes, averaging about 485 deaths every day, with speeding contributing to nearly 70 % of these fatalities and non-use of helmets and seatbelts causing roughly 39 % of deaths—underscoring the urgent need for robust design and enforcement under Vision Zero. At the same time, India, now one of the world's top emitters of greenhouse gases, has pledged to achieve net-zero carbon emissions by 2070, with intermediate goals to cut emissions intensity and expand clean energy capacity by 2030. The transport sector alone contributes roughly 12 % of national energy-related CO_2 emissions, driving electrification and low-carbon infrastructure as key enablers of India's decarbonisation and sustainability agenda.

Vision Zero & Carbon-Free Development – Across the world, **Vision Zero** is reshaping transport policy—aiming for **zero fatalities and serious injuries** on our roads. India has embraced this challenge at unprecedented scale. But Vision Zero in India must go further. It must also mean:

- **Zero tolerance for unsafe design**
- **Zero avoidable emissions in construction**

- **Zero compromise on resilience**

Engineering is not about making things bigger or faster—it is about making life better. Sustainable infratech is exactly that: **designing systems where safety, durability, and decarbonisation are engineered from the first sketch onward**—through life-cycle analysis, digital twins, low-carbon materials, AI-enabled monitoring, and circular construction practices. **National Icons of Sustainable Engineering –** India already offers world-class case studies.

The Chenab Bridge

Rising above one of the world's deepest gorges, the **Chenab Bridge** is not merely a structural marvel—it is a lesson in **climate-adaptive and safety-driven design**:

- Wind-resistant arch geometry
- Extreme seismic considerations
- Long-life corrosion protection systems
- Reduced maintenance-related emissions over its lifecycle

It embodies what 21st-century infrastructure must achieve—**engineering excellence married to environmental prudence**.

Kochi Water Metro

India's pursuit of sustainable mobility has taken an innovative turn with the Kochi Water Metro—the first water metro system in the country and one of Asia's largest integrated water-based transit networks. Operational since 2023, this project connects 10 island communities in the Greater Kochi region with the mainland using a fleet of electric and hybrid ferries across roughly 78 km of routes, serving tens of thousands of passengers daily and helping to reduce road congestion and urban emissions by shifting commuters from road to waterways. Its environment friendly design and integration with metro rail and bus systems represent a replicable model of sustainable urban mobility for cities across India seeking to lower carbon footprints and improved access for underserved populations. Moreover, international recognition—such as an honourable mention in a global sustainable transport award—underscores its contribution to greener transit solutions that align with India's long-term carbon-neutral goals.

Waterways, Transport & Net-Zero Corridors – India's integrated programmes linking ports, rivers, highways, and logistics corridors—often described as the Bharat-**Sagarmala vision**—are transforming freight movement while reducing carbon intensity:

- Shifting cargo from road to waterways
- EV-ready highway corridors
- Green tolling systems
- Solar-powered operations
- Nature-based flood buffers

Globally, transport contributes nearly a quarter of energy-related emissions. India's response is bold: **build faster, but build cleaner**.

Ram Janmabhoomi Development

Similarly, the Ram Janmabhoomi precinct in Ayodhya demonstrates how **heritage, sustainability, and modern construction technologies** can coexist:

- Energy-efficient planning
- Water-sensitive urban design

- Durable local materials
- Crowd-safety-first circulation systems
-

Such projects remind us that **sustainability is not in conflict with culture or scale—it elevates them both**. In this context, **net-zero infrastructure** is no longer experimental—it is becoming mainstream:

- Low-clinker and geopolymer concretes
- Bio-bitumen pavements
- Recycled aggregates
- Carbon-optimised bridge decks
- Sensor-embedded structures for predictive maintenance

Much of this transformation is driven by engineers who bridge academia, policy, and practice. **India's infrastructure leap is being powered not only by capital—but by knowledge.** And knowledge, when embedded in codes, standards, and training ecosystems, becomes the strongest climate-action tool we possess.

The Road Ahead – Call to Action

So what must we, as this community of policymakers, contractors, financiers, researchers, and technologists, commit to? Let me suggest five imperatives:

1. **Design for forgiveness –** roads and bridges that protect even when humans err.
2. **Account for carbon from day one –** life-cycle assessment must become routine.
3. **Digitise everything –** sensors, twins, AI inspections, asset dashboards.
4. **Invest in people –** skilling engineers for sustainability and safety.
5. **Collaborate relentlessly –** government, academia, startups, and global partners together.

As the poet Rabindranath Tagore wrote: *"Faith is the bird that feels the light when the dawn is still dark".* India's infratech sector already feels that dawn.

In Conclusion

Vision Zero is not a slogan. Carbon-free development is not optional. Sustainable infratech is not the future—it is the present.

If we succeed, the bridges we build will connect more than valleys; the highways we lay will carry more than vehicles; the cities we shape will protect more than economies— **they will safeguard generations.** And the collective efforts will have every success in shaping India's safer, greener, and more resilient infrastructure future.

(This is based on the recording of the Plenary Talk of Prof. T. G. Sitharam at the GRIS-2026)

Towards Safer Hill Roads: A Multi-Faceted Approach Integrating Engineering, Behavior, and Technology

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Abstract

Road safety is essential in hilly and mountainous areas due to the higher risk of fatalities and catastrophic accidents, and the areas' aesthetic appeal and engineering challenges. Given the frequency of landslides, the severity of collisions, and the often-limited access to rescue services, it is clear that a one-size-fits-all approach will not be practical in this situation. Instead, there is a real need for transport and infrastructure planning tailored to these unique conditions. This study recommends a comprehensive "safe system" strategy to increase the robustness and security of hill roads. This approach incorporates state-of-the-art monitoring and response technologies, behavioural interventions to improve driver safety, and thoughtfully designed engineering solutions suitable for rugged terrains. The study also emphasises using data-driven approaches and learning from successful global models to meet "vision zero," which calls for eliminating fatalities and serious injuries on the most vulnerable mountain roads.

1. Introduction

As India's road network expands into complex and ecologically sensitive terrain, it becomes a national concern to ensure the safety of hilly and mountainous roads. States like Himachal Pradesh, Uttarakhand, Sikkim, and those in the Northeast continue to struggle with road safety because of their high grades, unstable terrain, sharp curves, and numerous natural hazards. According to the World Health Organisation (2023), traffic incidents are more severe per kilometre in hilly locations than in flat terrain. The Ministry of Road Transport and Highways claims that hill states are responsible for over 10% of traffic deaths (MoRTH, 2022), even though they contribute very little to India's road network. When building hill roads, these numbers demonstrate the critical necessity for integrated planning, resilient engineering methods, and terrain-responsive safety interventions.

Sharp curves, steep grades, limited carriageways, and frequent natural disruptions like landslides, snow, and dense fog are characteristics of hilly terrains, as opposed to plains or metropolitan settings where standard design and enforcement procedures are more practical. These circumstances increase the likelihood of human error and the consequences of a system failure. The danger of fatalities is further increased in these circumstances by the lack of emergency care and the delayed detection of occurrences (World Bank, 2022). As a result, the conventional reactive strategy for road safety is inadequate. Instead, even in the face of inevitable human error, a proactive, integrated paradigm like the Safe System Approach is needed to reduce fatal crashes and serious injuries systematically (OECD/ITF, 2016).

2. Understanding the Terrain-Behavior Nexus

Hilly roads often defy standard geometric design due to topographic constraints. Tight horizontal curves, steep vertical profiles, and short sight distances make vehicle control challenging. In these situations, infrastructure and driver behaviour are interdependent. For instance, studies reveal that fatigued drivers from constant manoeuvring, speeding on ostensibly "safe" downhill sections, and a lack of familiarity with the terrain's features are all major contributors to collisions (Sikdar & Velmurugan, 2020). Seasonal weather variations like heavy rain, snowfall, and fog further reduce visibility and surface traction. Interventions must address the entire system, including road users, vehicles, infrastructure, and the

operating environment, because human, environmental, and structural vulnerabilities compound each other.

3. Engineering Adaptation in Complex Terrains

Customised infrastructure interventions are necessary due to the intricacy of mountainous regions. Hill roads necessitate adaptable alignment solutions considering steep grades, sharp curves, and constrained right-of-way, unlike plains where geometric design principles can be applied more consistently. Standard road safety audits provide helpful information for site-specific improvements when carried out with terrain-specific parameters. Numerous regional and global case studies have shown that shoulder widening, increased curve radii, and curve realignments can significantly lower rollover hazards and enhance visibility (Ahmed & Chandra, 2020). For instance, on the Guwahati-Shillong highway (NH-6), lane widening and curve realignments were carried out close to accident-prone regions like Umiam and Nongpoh in response to road safety audits and accident risk assessments (MoRTH, 2022; NERSA, 2021). These modifications increased manoeuvrability and safety by improving sight distance and lessening the sharpness of bends.

When designing hill roads, landslip mitigation must be taken into account. Numerous high-altitude corridors have effectively used technologies including soil nailing, rockfall netting, reinforced earth barriers, and bioengineering solutions like vetiver grass plants (Roy et al., 2021). Roadside safety elements, including guardrails, crash cushions, chevron boards, and retro-reflective signage, are also essential to warn and guide drivers, especially in blind spots and at night. Ensuring adequate drainage through catchwater drains and cross-drainage structures can help prevent water accumulation, a common cause of skid-related collisions. Since the consequences of climate change are already making weather events in mountainous locations more severe and unpredictable, it is crucial to emphasise that these solutions must be designed for both physical durability and climate resilience.

4. Role of Technology and Smart Systems

Modern technical developments are crucial for bridging the gap between danger identification and successful action. Nowadays, it is standard procedure to use satellite data and Geographic Information Systems (GIS) to identify high-risk corridors and prioritise safety investments. Rapid terrain modelling and monitoring are made possible in many nations by UAVs and Light Detection and Ranging (LiDAR) technologies, which support both pre-emptive and post-disaster planning (Sarma & Kalita, 2022). Organisations like NESAC and the Meghalaya Public Works Department have used GIS data layers to prioritise road safety investments and better plan slope stabilisation work in the Guwahati-Shillong corridor.

Dynamic traffic control is made possible by real-time environmental monitoring via automated weather stations, fog detectors, and rainfall gauges. This is especially important on high-altitude highways where weather patterns might vary abruptly (Thakur & Singh, 2020). Intelligent Transport Systems (ITS) are increasing rapidly in metropolitan hill regions with high tourist corridors. Modern AI-enabled technology promotes compliance and speeds up incident response times, such as traffic enforcement, automatic number plate recognition (ANPR), and closed-circuit television (CCTV). Centralised traffic control centres can integrate these systems to provide coordinated emergency responses and ongoing monitoring. Such data-rich approaches are essential for the Bharat Mala and PM Gati Shakti programs to incorporate road safety into digital infrastructure strategies successfully and further align with India's larger digital governance and smart mobility goals.

5. Role of AVs in Hill Road Safety

Research and technological advancement in the potential of autonomous vehicles (AVs) to increase the safety of hill roads is auspicious. AVs' sophisticated sensors, artificial intelligence, and vehicle-to-everything (V2X) connectivity provide several benefits in tackling all the difficulties associated with mountainous terrain. A few of them are as follows:

1. Improved Sensing and Perception in Low-Vision Conditions. Rain, snow, and fog typically impair vision on hill routes. Even in bad weather, AVs can detect obstacles thanks to sensor fusion technologies like LiDAR, radar, and infrared cameras (Jo et al., 2015).
2. Real-Time Risk Detection and Response: AVs can lessen the chance of collision or rollover accidents by utilising onboard processing and real-time course planning to identify stalled vehicles, falling boulders, and sharp curves (Thrun, S., 2010).
3. Accurate Control on Narrow and Curved Roads: By outperforming human drivers in lane discipline, braking effectiveness, and speed control on twisting and steep roads, autonomous vehicles (AVs) lower the risk of off-roading (Badue et al., 2021).
4. Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) Communication: AVs with V2X capabilities can detect approaching cars in hilly regions with blind curves or insufficient signage, as well as road hazards and construction zones (Campolo et al., 2015).
5. Reduced Driver Fatigue and Error: Driving uphill wears a driver out because it demands constant attention. By taking over all or part of the control, AVs can prevent accidents caused by drowsiness or inattention (Paddeu et al., 2020).

Difficulties in Implementing Hill

- GPS accuracy is low in remote or mountainous areas
- AV technology is expensive
- There are ethical and legal issues with employing AVs in hazardous areas
- There are inadequate amenities, such as high-definition maps or weak connectivity.

Autonomous cars can fundamentally alter road safety on hills by lowering human error, enhancing danger recognition, and reacting more consistently to shifting road conditions. However, their success will require careful policy planning, investment in digital infrastructure, and adaptation to the specific terrain.

6. Behavioural Interventions and Institutional Measures

Without considering the human factor, no road safety intervention is comprehensive. The driver's conduct in steep terrain is a significant risk factor and a characteristic that can be changed. Education programs must be customised for various drivers, commodity operators, local transit providers, and tourists who are not familiar with the area. According to research, safety results are enhanced by awareness campaigns that highlight driving skills specific to a given terrain, such as engine braking, gear management on hills, and safe overtaking strategies.

Institutional measures must also guarantee the upkeep of vehicles operating in these locations. Overloading, inadequate braking systems, and tyre degradation drastically impair vehicle control on hills and curves. In industrial corridors and during periods of high travel demand, it is imperative to enforce axle-load limitations and vehicle fitness certification (Singh & Verma, 2018).

In areas where stationary checkpoints are impractical, mobile enforcement units with radar guns, GPS trackers, and breath analysers provide flexibility. Enforcement procedures are now more effective and transparent due to the expanding usage of e-challan systems and AI-based infraction detection. There have been noticeable improvements in compliance with the e-challan systems in Sikkim and Himachal Pradesh (NITI Aayog, 2021).

At the legislative level, it is becoming clear that long-term sustainability and safety are facilitated by terrain-specific advisories, dynamic vehicle movement schedules under unfavourable conditions, and incentives for electric or fuel-efficient vehicles in

environmentally sensitive locations. For implementation to be successful, law enforcement, municipal governments, and road authorities must work together across agencies.

7. Role of Driver Workload in Hilly Road Safety

One of the most challenging driving conditions is on a mountainous road, where the driver's workload significantly affects safety results. Drivers' physical and mental strain is increased by the usual features of these terrains, which include steep hills, sharp curves, limited roads, unpredictable weather, and inadequate road infrastructure. Overloaded drivers are more likely to make mistakes, respond slowly, and get into accidents because they are tired.

1. Cognitive load is increased by complex terrain.

- Steering, braking, and shifting gears require continuous decision-making when driving on hilly roads, increasing the driver's cognitive load.
- Several studies have shown that driving on mountain roads significantly increases mental workload, lowering driver performance and the risk of accidents.
- Drivers must anticipate curves, control speed on descents, and navigate limited visibility or roadside distractions, which increase the risk of decision fatigue.

2. Fatigue and Physical Stress

- Physical strain can affect a driver's posture, reaction time, and coordination, especially in manual gearbox vehicles frequently used in hilly areas.
- Constant gear shifting, clutch use, and steering adjustments on steep and winding roads contribute to physical fatigue, especially for long-haul drivers.

3. The Effect of Adverse Weather on Visual and Auditory Load

- While traffic, engine noise, and alerts can cause auditory overload, fog, glare, and darkness raise visual demands.
- Numerous studies showed that visual distraction and high workload were associated with increased lane deviation and crash risk on winding mountain roads. • A high sensory load can cause a driver to lose focus on pertinent cues, delaying hazard responses.

4. Emotional and Psychological Stress

- Tunnel vision, overcorrection, and a higher chance of speeding or making poor decisions under pressure are all associated with stress.
- Anxiety about steep descents, falling rocks, or the possibility of brake failure can all increase stress and mental workload.

5. Reduced Situation Awareness

- A heavy driver workload impairs situation awareness, making monitoring mirrors, pedestrians, or roadside signage more challenging.
- This can result in late braking, missed traffic signs, or an inability to react to unexpected dangers like animals or landslides.

Countermeasures for Driver Workload Management

- Enhancements to road design, such as guardrails, signage, and banking curves.

- Lane-keeping assistance, hill descent control, and fatigue detection are in-car driver assistance systems (ADAS) examples.

- Rest periods were planned on lengthy, hilly routes to lessen cumulative fatigue; driver training programs addressed mental and physical workload management.

Driver workload is one crucial factor affecting safety on hilly roads. Workload increases the likelihood of mistakes, distractions, and fatigue. Designing roads and vehicles to reduce driver demand and ensuring drivers get the required rest and training are essential to making hill road travel safer.

8. Conclusion

Road safety is a unique and urgent problem in India's hilly and mountainous regions. The combination of rough terrain, unpredictable weather, and lack of emergency services makes serious accidents much more likely than in the plains. Traditional, reactive safety techniques must be replaced with an integrated, proactive "Safe System Approach" tailored to the needs of steep terrains. This approach should incorporate context-sensitive engineering modifications, advanced technology (like GIS, ITS, and emerging autonomous vehicles), behavioural interventions tailored to the terrain, and robust institutional frameworks.

Slope stabilisation, curve realignment, and improved signage are engineering solutions that must coexist with climate-resilient design and data-driven risk assessment. Technologies like real-time monitoring, AI-enabled enforcement, and smart infrastructure can greatly enhance risk mitigation and incident response if the government supports and invests in digital infrastructure. Although there are still technical, financial, and regulatory obstacles to adoption, autonomous vehicles have a lot of promise to increase safety in the future.

Human factors remain essential, particularly driver workload and attitude. Effective safety initiatives must include driver education, vehicle fitness enforcement, and locally tailored interventions. Digital enforcement is as crucial for improving accountability and compliance as dynamic regulations and institutional coordination. The long-term safety and resilience of hill roads will ultimately depend on a thorough, systems-based approach considering topography, human factors, environment, and technology. These principles must be fully implemented to achieve "vision zero", zero fatalities and major injuries in India's perilous mountain passages.

References

Badue, C., Guidolini, R., Carneiro, R. V., et al. (2021). Self-driving cars: A survey. *Expert Systems with Applications, 165*, 113816. DOI: 10.1016/j.eswa.2020.113816

Campolo, C., Molinaro, A., Scopigno, R. (2015). Vehicular Ad Hoc Networks: Standards, Solutions, and Research. Springer. DOI: 10.1007/978-3-319-10702-0

International Transport Forum. (2016). *Zero Road Deaths and Serious Injuries: Leading a Paradigm Shift to a Safe System*. OECD Publishing. https://doi.org/10.1787/9789282108055-en.

IRC: SP: 48-1998. Hill Road Manual. Indian Roads Congress.

K. Jo, J. Kim, D. Kim, C. Jang and M. Sunwoo, "Development of Autonomous Car, Part II: A Case Study on the Implementation of an Autonomous Driving System Based on Distributed Architecture," in *IEEE Transactions on Industrial Electronics*, vol. 62, no. 8, pp. 5119-5132, Aug. 2015, DOI: 10.1109/TIE.2015.2410258

MoRTH. (2022). Road Safety Audit Reports. Ministry of Road Transport and Highways, Government of India.

Paddeu, D., Parkhurst, G., & Shergold, I. (2020). Passenger comfort and trust on autonomous vehicles: A review. *Transport Reviews, 40*(3), 291–306. DOI: 10.1016/j.trc.2020.02.026

Roy, R., Bhattacharya, S., & Das, A. (2021). Role of LiDAR in hill road alignment planning. *Remote Sensing Applications: Society and Environment*, 21, 100472. DOI: 10.1016/j.rsase.2020.100472

Sarma, P., & Kalita, D. (2022). Application of satellite data for road hazard mapping in NE India. *ISPRS International Journal of Geo-Information*, 11(9), 488. DOI: 10.3390/ijgi11090488

Sikdar, P. K., & Velmurugan, S. (2020). Human factors and road safety in Indian hill regions. *Transport Reviews*, 40(5), 628–647. DOI: 10.1080/01441647.2019.1670536

Singh, K., & Verma, M. (2018). Vehicle overloading and safety performance on hill roads. *Case Studies on Transport Policy*, 6(4), 667–673. DOI: 10.1016/j.cstp.2018.08.012

Thakur, V., & Singh, J. (2020). Weather-responsive traffic management in hill roads: Rohtang case study. *Journal of Transportation Engineering, Part A: Systems*, 146(6), 04020057. DOI: 10.1061/JTEPBS.0000450

Thrun, S. (2010). Toward Robotic Cars. *Communications of the ACM, 53*(4), 99–106. DOI: 10.1145/1721654.1721679

World Bank. (2022). Road Safety Management Capacity Review for Indian Hill States. World Bank Transport Global Practice

Indian Roads are Safe (?)

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India has, now, the dubious distinction of highest number of annual fatalities, on its roads, globally. India accounts for 10% of all crash related deaths with only 1% of world's vehicles.

Despite huge investments in the country during last a few decades, on the development of roads, highways and expressways, the, the fatalities have more than doubled from around 79,000 in the year 2000 to around 180,000 now in 2024. More serious concern is that people dying in every 100 traffic crashes has also almost doubled from 20 to 37 in the same period.

A global comparison would clearly indicate that we have to cover an extensive ground. WHO Report on Global Status of Road Safety, 2023 tells us that, deaths from road crashes globally, have fallen slightly to 1.19 million per year, since 2010. Reductions in the number of deaths were observed in as many 108 countries. Ten countries (Belarus, Brunei Darussalam, Denmark, Japan, Lithuania, Norway, Russian Federation, Trinidad and Tobago, United Arab Emirates, and Venezuela) have achieved reduction to the extent of 50% and some of these are not necessarily developed countries. Regrettably, India had increased fatalities by 22%.

All those countries having much better safety on their roads had recognised as early as 1950s that human (user) is bound to commit mistakes and it is the road infrastructure which has to cope up with human failings and short comings. This thinking and approach had brought the concept of forgiving highways. They also have been practicing the safe system approach in the development of their road network. Countries like Sweden, Denmark, New Zealand which have received significant reduction in their road crash fatalities vouch for the 'System's Approach' which is not just a theory anymore.

When we aspire to be a developed country by the year 2047, we have no option but to tackle this menace as a public health concern and adopt a mission mode approach. World Bank Study has shown that achieving a 50 percent fatality reduction target in India would result in an estimated 14 percent increase in GDP over the analysis timeframe of 24 years. Study has shown that over 40% of the households in rural areas reported at least one death after a road crash compared to 12% of households in urban areas. Victims from low-income households and rural areas are also twice more likely to suffer a disability after a crash than their high-income counterparts. The study emphasised the need to tailor the road safety initiatives to focus on vulnerable road users, most of whom are poor.

There is need for identifying the problems first so that appropriate approach and solutions can be planned.

The reasons for such high number of road traffic crashes and fatalities are not very difficult to identify.

These can be broadly categorised into poor professional capacity and capabilities, lack of focus on safety issues in standards, emphasis on building more roads and not necessarily safe roads, compromise on safety measures, poor system of post-crash response, ineffective enforcement mechanism and poor driving culture. This article will focus on engineering aspects.

It has been very unfortunate development that capabilities and capacities of professionals engaged in the development of roads in the country, has been declining as the importance and focus on road sector has increased. More emphasis is required on capacity building.

Most of the professionals believe that there is difference in theory and practice. and that country has shortage of land and funding for road development. These myths are to be broken. There is no difference in theory and practice and the obvious example is that theory requires provision of bus bays if the road has movement of buses. Not providing bus bay due to problem of land and fund would obviously require the bus to stop at the carriageway thereby reducing its available width and resulting into hazard for commuters and other road users.

The measure/ yardstick of land shortage is the population density. India's density is comparable to that of Netherland and South Korea and both countries have highly safe roads having quite low fatalities of 4.2 and 4.9 respectively per 100,000 people, compared to 12.6 on Indian roads. The shortage of funds is more in the minds rather than reality. Therefore, the first lesson to be learnt is that whatever standards have prescribed has to be implemented on ground without any compromise.

There are number of wrong concepts needing correct understanding. There are highways having 'intermediate lane'. The term is not only wrong in English but in concept, since one vehicle requires one lane and there cannot be one and a half vehicle. India still has 21% of National Highways with so called 'intermediate lane', which requires to be upgraded to minimum two lanes in a time bound manner for better and safe travel.

The concept and term 'traffic calming' is for urban streets and is area wide approach. Use of this term for highways and in linear approach is conceptually wrong. Appropriate approach and term should be speed management.

International safe practice (NCHRP Report 504) is to keep speed limit lower than the design speed whereas we have speed limit for expressways (120 kmph) and 4/6 lane highways (100 kmph) equal to design speed. Regrettably increasing the speed limit to 150 kmph is reportedly under consideration. WHO has found that every 1% increase in mean speed produces 4% increase in fatal crash risk and 3% increase in serious crash risk.

Many experts adopt the approach of rectification of black spots based on 'Road Safety Audit' forgetting the basic concept that Road Safety Audit/ Inspection is proactive approach where as black spot rectification is reactive.

Some documents prescribing design standards contain hazardous provisions. Some examples are, IRC SP 73 which not only wrongly termed as two lanes with paved shoulder (as if shoulders are not part of basic highway feature) which provides paving of 2.5 m width of shoulder but no edge line. This could give user 12 m width of carriageway encouraging overtaking and cause of head on collision. Manual for 6- lane highway (itself unwise to have, instead of more access-controlled expressways) provides for hazardous provision of raised median and at grade pedestrian crossing besides many other technically wrong provisions. It virtually discourages any improvement in geometrics by stating 'within available RoW'. Manual for expressways provides for contraflow and interchange even if there is no cross road. All such hazardous provisions need correction.

We need to have paradigm shift in our design approach to develop safer highways. Foremost is fixing the road system (safe System approach) rather than fixing the road user (simply putting signs such as accident-prone area). It has to be always kept in mind that road is developed for human and they are vulnerable to injury; and that road should be clearly understood by the first time user in night driving. Adoption of some other measures can significantly reduce road traffic crashes; these are well designed intersection (compulsorily part of improvement project), well designed correct system of signs and markings with clear night visibility, segregation/ protection/ provisions for vulnerable road users, provision of crash barriers especially on hill roads. Use of technology can be beneficial. Speed camera can be tool for checking over speeding, raised profile edge line and shoulder rumble can check run off the road incidents, chevron markings on pavement can check rear end collision

Towards Vision Zero Kerala: Integrating Safety, Sustainability and Spatial Planning Across the Rural–Urban Continuum

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ABSTRACT

Kerala presents both a unique challenge and an opportunity for achieving Vision Zero. Being one among the most densely populated states in India and regardless of high rate of continuous rural-urban settlement, the state has a complex safety dynamics where crashes are high but severity rates are low due to the efficient healthcare and enforcement systems. This article discusses how Kerala can implement a safe system approach and combine it with sustainability and spatial planning to achieve the goals of Vision Zero. Kerala can be one among the first Vision Zero States in India by creating multi-modal integration and inter-agency coordination for categorizing roads based on a functional classification framework that will ensure safe, sustainable, and inclusive mobility across the rural-urban continuum.

1. INTRODUCTION

Road safety in India is a critical issue as more than 1.5 lakh people lose their lives on roads every year. The fatalities on roads which could have been averted cannot be prevented by conventional approaches which focus on enforcement, awareness and regulations. As a way forward, a new strategy known as Vision Zero was first proposed and implemented in Sweden(1). Vision Zero accepts that human beings make mistakes and therefore, the design of road systems should be in such a manner that they forgive the errors and never cause serious injuries and deaths.

Kerala has one among the highest population densities in India with an average value of over 860 persons per km^2 (6,7). It has a unique arrangement of continuous settlements of rural and urban areas known as “rural–urban continuum”. The state is interconnected by a continuous stretch of closely spaced towns, villages and mixed-use activity centres along the major transport links which is commonly referred to as the “ribbon development”. These roads serve as high-speed traffic routes and local transportation routes for walking, cycling and for other everyday activities. This leads to mixed traffic conditions with a high traffic interaction between the local and through-traffic leading to increased crash risks.

Kerala is making steady progress in improving road safety through stringent enforcement measures based on technology driven applications such as vehicle actuated speed displays, AI enabled ANPR cameras as well as effective emergency medical care. However, the number of road crashes still remains high. As per the statistics, road crashes increased from 43,910 to 48,834 though the fatalities reported decreased from 4,317 to 3,880 between 2022 and 2024 (2). This suggests that Kerala is already saving more lives following a crash; but there is a new opportunity to redesign the system based on a preventive approach to avoid such crashes. This article describes how Kerala can adopt to the framework of Vision Zero in the unique context of “rural-urban continuum”. It also discusses how integration of safety, sustainability and spatial planning can achieve a more people-friendly and safe road environment in Kerala.

2. THE KERALA PARADOX: EFFICIENCY IN THE FACE OF A ROAD SAFETY CRISIS

The road safety scenario of Kerala presents a unique paradox. Despite having one of the highest numbers of road accidents reported annually, the severity of the accidents calculated as the number of deaths per 100 accidents is one of the worst in India (2,4,5). The accident rate in the state is approximately 10% compared to the national average of approximately 36% (9,10). This indicates that the probability of survival after a crash is significantly high regardless of the crash occurrences. This can be attributed to effective trauma care system, and quick and well-equipped emergency response.

Since the percentage of accidents is high, this can be pointed to various structural and systemic issues that need urgent attention. Nearly 60 percent of all road accidents in Kerala are caused by over-speeding ([2,5]). The unsafe interactions among the fast-moving vehicles and the vulnerable road users (VRU) like pedestrians, cyclists, and two-wheeler riders, create high-risk situations. To this end, Kerala must change from being a reactive state (save lives post-crash) but to be proactive so as to prevent the occurrence of crash. Table 1 gives a comparative statistics of safety indicators with respect to India and Kerala.

Table 1: Comparative Safety Indicators (2023)

Parameter	Kerala (2023)	All-India Average (2023)	Interpretation
Population Density (per sq km)	~922	~415	High exposure risk due to continuous settlements
Total Number of Crashes Per Lakh Population	134.4	34.6	High frequency of crashes
Fatalities	4,084	1,72,890	High in absolute terms
Crash Severity (%)	8.5	36	76.4 % lower than national average
Fatalities per Lakh Population	11.4	12.5	Lower than national average

3. THE INTEGRATED SOLUTION: A THREE-DIMENSIONED APPROACH FOR VISION ZERO KERALA

In Kerala, the goal of Vision Zero requires a complete paradigm change from isolated interventions to a coordinated and people-oriented mobility system. The proposed integrated system framework is based on three mutually supporting dimensions viz, the Safe System Approach, Sustainable Mobility and Integrated Spatial Planning. This integrated system thus provides Kerala with a systematic roadmap to safer and sustainable transport.

Dimension I: The Safe System Approach[3]: Vision Zero is founded on the principles of Safe Systems. The roads must be designed such that the system must be able to forgive and correct itself and thus no life should perish on the road or cause any serious injury. The safe systems approach is thus based on the five core components viz., Safe Roads, Safe Speed, Safe Vehicle, Safe User and Post Crash Care.

Safe Speeds and Roads: Speed is the most critical variable, which predetermines the magnitude and likelihood of a crash. One of the key principles of design is the control of kinetic energy to a level that a human can endure i.e., less than 30 km/hr, beyond which the risk of fatality will be disproportionately high [8]. Therefore, as a key point, the safety plan must entail management of speed by designing traffic calming measures which involve median barricades, elevated crosswalks and roundabouts. It is mandatory in the mixed-use and residential areas that speeds are restricted to 30km/h. Stringent speed enforcement measures by means of automated enforcement and community-based surveillance should also be ensured.

Safe Road Users and Safe Vehicles: The safe system approach focuses on forgiving environment and vehicle safety technology as the emphasized components despite education, awareness and enforcement being the most important factors. Enforcing helmets and seat belt compliance, the use of the speed limiting devices, deterrence of drunken driving, and the promotion of safer cars (with Anti-lock Braking Systems, Electronic Stability Control, and reinforced vehicle structure with crumple zones and side intrusion beams) together help in reducing the impact of human error.

Existence of Shared Responsibility and System Resilience: The systems of shared responsibility should be worked upon by transport operators, law enforcement, designers, and government agencies through active collaboration. In a bid to streamline policy and

practice, transparency of crash-data, and integration of behavioral research into the planning are needed along with safety auditing of all road works.

Dimension II: Promotion of Sustainable Mobility [11]: Sustainability and safety are closely related. Switching to sustainable modes results in the decrease of crashes, reduction of emissions and betterment of public health. The dependency on two wheelers in Kerala has increased crash risks on the roads. A Vision Zero based mobility plan aimed at reducing these high-risk trips should prioritize the use of public and non-motorized means of transportation.

Revitalizing Public Transport: The public transport sector in Kerala is characterized by private and state-owned stage carriers. Kerala needs an integrated, sustainable transport policy that gives priority to public transport for economic, environment, and social reasons. This means a proper integration of Kerala State Road Transport Corporation (KSRTC) buses, private buses, metro rail, IPT, and non-motorized modes into one seamless, multimodal system. This should be integrated with timetable, ticketing, and real-time information display. Also, it requires modernization of fleet to electric and low emission fleet. Moving forward, technology driven route planning and smart digital platforms will play a major role in improving the efficiency of public transit operations.

Integrated Land Use and Mobility (Transit-Oriented Development): Small, mixed-use, and walkable neighborhoods should be promoted through Transit-Oriented Development (TOD) that ensures high-quality public transport of high density. Travel distances can be significantly reduced by locating the housing, commerce and services within walkable catchments of bus, metro and rail stations. There will be long-term benefits of safety and environmental benefits as the number of private vehicles will be reduced. Therefore, the conflicts on the road and the probability of crash occurrence will also be reduced.

Infrastructure Improvement for Walking and Cycling: Under Vision Zero Kerala, walking and cycling should be prioritized especially for short trips. The infrastructure investments should include high-quality and continuous pavements, cycle tracks, safe crossings in the streets and intersections, which are pedestrian-based. Even a 10% shift to walking and bicycling can immensely reduce the number of two-wheeler trips which results in fewer crashes, safe neighborhoods and healthier communities.

Dimension III: Integrated Spatial Planning [12,13]**:** Spatial planning influences the travel behavior of the people by determining how far and how often they must travel. In Kerala, spatial planning needs to apply a rural-urban continuum-based approach that differentiates planning objectives according to the settlement intensity, connectivity requirements and traffic characteristics.

Functional Road Classification: A critical reform pertaining to the classification of roads based on function is the need of the hour. The classification must not be restricted on the basis of administrative categories such as National Highway or Local Road. The classification based on function shall take the form of through roads (for high-speed through-traffic), distributor Roads (arterial and sub arterial roads which link traffic to through roads) and access roads (for local movement within neighborhoods). In the context of Kerala, such a classification shall bring in a single standard design.

Context-Sensitive Planning for the Continuum: In addition to promoting low-speed zones and active street margins, urban hubs require "Complete Streets" that prioritize cyclists, pedestrians and public transportation[14]. In order to avoid direct building-to-road conflicts, peri-urban and highway corridors must prioritize access control, provide service roads, construct safe crossing facilities, and regulate land use to avoid unchecked ribbon development.

4. CONCLUSION

Kerala has achieved a high level of success in mitigating the severity of accidents to a significant degree. This demonstrates the effectiveness of Kerala's post-crash care systems, as well as their response to trauma care. The increasing number of crashes, however, validates the need to switch the reactive lifesaving operation to a proactive operation that aims at preventing collisions. A change towards a prevention-oriented approach is necessary for achieving the goal of Vision Zero. The AI-powered traffic enforcement cameras have already been implemented, and this has led to improved speed compliance and better road user behavior. This shall be followed by an application of technological enhancement to other infrastructure design, implementation, space planning and community involvement, hence creating a holistic safe ecosystem. To change what may be referred to as "Kerala Paradox" of high crash frequency and low fatality rates into some form of preventive, sustainable and inclusive road safety model. The state should integrate the three-dimensioned approach based on the aspects of safe system approach, sustainable mobility and spatial planning. Kerala can be one of the first Vision Zero States in India, with an example of safe, sustainable, and equitable mobility across the rural-urban spectrum through inter-agency coordination and engagement.

REFERENCES

1. Johansson, R. (2009). Vision Zero—Implementing a policy for traffic safety. Safety Science, 47(6), 826–831. https://doi.org/10.1016/j.ssci.2008.10.023
2. Kerala Police. (2025). Road accident statistics in Kerala. Government of Kerala. Accessed on 3-11-2025 from https://keralapolice.gov.in/crime/road-accidents
3. Turner, B., Job, S. and Mitra, S. (2021). Guide for Road Safety Interventions: Evidence of What Works and What Does Not Work. Washington, DC., USA: World Bank.
4. Ministry of Road Transport and Highways. (2024). Road Accidents in India 2023. Transport Research Wing, Govt. of India, New Delhi. Accessed on 3-11-2025 from https://morth.nic.in/sites/ default/files/Road-Accident-in-India-2023-Publications.pdf.
5. Tiwari, G., Goel, R., and Bhalla, K. (2023). "Road Safety in India: Status Report 2023." Transportation Research & Injury Prevention Centre, Indian Institute of Technology Delhi, New Delhi. Accessed on 3-11-2025 from https://tripc.iitd.ac.in/assets/publication/RSI_2023_web.pdf
6. Registrar General & Census Commissioner, India. (2011). Census of India 2011: Primary Census Abstract. Ministry of Home Affairs, Government of India, New Delhi.
7. Department of Economics and Statistics, Government of Kerala. (2017). Statistical Handbook Kerala 2017. Government of Kerala, Thiruvananthapuram, India.
8. Yannis, G., & Michelaraki, E. (2024). Review of City-Wide 30 km/h Speed Limit Benefits in Europe. *Sustainability*, *16*(11), 4382. https://doi.org/10.3390/su16114382
9. Worldometer. India Population (2025) / India Demographics 2025 (Population, Age, Sex, Trends)." Worldometer. Accessed on 3-11-2025 from https://www.worldometers.info/world-population/india-population/.
10. Technical Group on Population Projections. (2020). *Population projections for India and states 2011–2036*. National Commission on Population, Ministry of Health and Family Welfare, Government of India.
11. Noordveld, M., Fil Kristensen, I., & Adjei, E. K. (2025). Sustainable mobility policy on a rural-urban spectrum: exploring spatial differentiation within the Swedish context. *European Planning Studies*, *33*(10), 1779–1800. https://doi.org/10.1080/09654313.2025.2525486
12. Schermers, G., & van Vliet, P. (2001). *Sustainable Safety. A preventative road Safety Strategy for the Future* (2nd ed.). AVV Transport Research Centre, Ministry of Transport, Public Works and Water Management, Rotterdam, The Netherlands.
13. United Nations Economic Commission for Europe (UNECE). (2020). *A Handbook on Sustainable Urban Mobility and Spatial Planning: Promoting Active Mobility*. UN.
14. Jordan, S. W., & Ivey, S. (2021). Complete streets: Promises and proof. Journal of urban planning and development, 147(2), 04021011.

Leveraging Driving Simulators to Strengthen Road Safety Research in India

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Abstract

Driving simulators in various configurations have become an essential tool in the area of driver training, education and road safety research, providing controlled environments to evaluate driver behavior as well as the vehicle dynamics without the risks linked with actual driving scenarios. They have been developed as advanced systems, with use of immersive technologies such as high-resolution displays and stereophonic sound, allowing the researchers and trainers to understand the complexities related to driver performance, road design, and the effect external factors on safety outcomes [1][2][3].

The use of driving simulators in road safety research has become quite significant due to their capability to replicate real-world road and traffic situations without any risk of accidents or harm. Researchers uses these systems for carrying out experimentations to understand driver behavior, analyze effectiveness of safety measures, and also evaluate effect of varying driving conditions [4][5][6]. Although the driving simulators find their origin from Europe, they are now being used quite extensively in India considering their immense potential for their efficacy in providing cost-effective solutions in road and the vehicle design, and traffic and road safety evaluations [4][7].

While driving simulators have proved their usefulness, there exist the challenges owing to complexity involved in correlating driving-simulator data with on-road performance in conditions similar to ones used in simulator as well as due to the requirement of robust, inclusive research methodologies [6][8][9]. The usefulness and efficacy of simulators in diverse educational contexts required wider studies to understand their effectiveness on various driver demographics [10]. The indigenous development of car simulator by CSIR-CRRI provides a new benchmark in India for assessing driver performance including the psychological and skill aspects [4][11]. Thus by understanding the local driving challenges and encouraging digital learning, such developments promise improvements in driver education contributing to Road safety research [12][13][14].

1. Background

Driving simulators provide a safe and controlled setup to carry out studies on driver behavior under various environments and roadway design. They typically comprise of high-resolution displays, advanced sound systems, interactive interfaces etc. to build an immersive experience, for example, available simulators provide a 135° forward field-of-view, stereophonic sound to create realism of the driving experience, as well as simulate the presence of other vehicles, people, and objects on the road [1][2]. In Europe, United States, and now in India, driving simulators are now used extensively in research to understand the performance and behavior of novice and experienced drivers, relevant especially in studies carried out to understand the effects of human factors such as inattention and familiarity in roadways domain on driving performance [3]. The increasing use of driving simulation technology for driver education is evident from numerous initiatives like technology & driving skills study zone, where young and new drivers use driving simulators to learn and grow their driving and traffic skills in a responsive and related environment [8].

2. Driving Simulators in Safety Research

Driving simulators have become as an important tool in road and traffic safety research, providing a safe setting to understand driver behavior and performance as well as efficacy of

envisaged safety measures. Thus, now it is now possible to mimic near real traffic scenarios with no risk of physical injury [4][5].

a. Applications of driving simulators

There are several uses of the driving simulator: New and professional drivers training and evaluation, training in multiple traffic and driving situations/scenarios, study of effects of impairment of driver performance in certain scenarios, study of driver behavior and responses in varying scenarios in handling controls in real time, assessment of driver fitness, evaluation of future vehicle instrumentation and technologies on driving performance and safety, and entertainment and fun.

b. Methodologies, challenges and considerations in simulator-based research

It involves advanced data collection and analysis techniques, and use of driver physiological indicators to understand and evaluate the efficacy of simulators in risky and complex driving scenarios [15]. Simulators are configured to study specific driving situations, such as, study of the effect of road marking schemes on driver performance and responses in horizontal curves, hence it is possible to fine-tune safety measures customized to real-world scenarios.

There are challenges in using driving simulators, major being the difficulty in establishing a valid correlation among simulator data and real-world traffic performance. It is because of variable characteristics of driving environments, simulator configurations, data sample characteristics and size, which results in restricted generalization of research findings [3] [6] [16]. There are various t*ypes of simulators built such as a*mbulance simulator, car simulator, desktop simulator, multi-station driving simulator, truck & bus simulator, game simulators, and static and dynamic simulators with motion control and feedback.

3. Traffic and Road Safety Research using Indigenous Driving Simulator

The indigenous driving simulator of CSIR-CRRI is configured to study, test and evaluate driving skills, behavioral and psycho-physical performance, thus providing a comprehensive assessment of driver's capabilities. Fig. 1 shows the driving simulator basics, Fig. 2 indicates the Functional blocks of car driving simulator while Fig. 3 shows the Driving scenario on RTO tracks. An account of various studies performed using the above driving simulator is provided below.

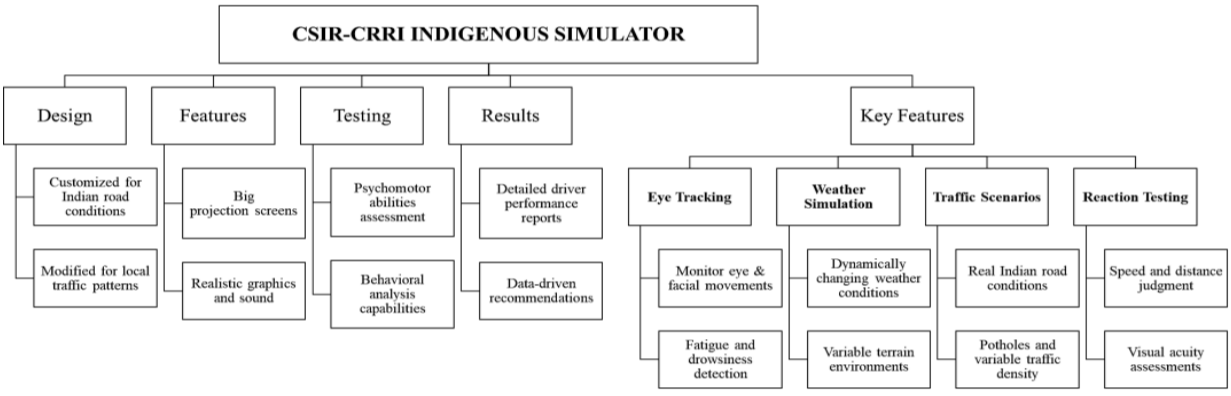


Fig. 1. Description of indigenous driving simulator



Fig. 2. Functional blocks of car driving simulator developed by CSIR-CRRI



Fig. 3. ***Driving scenario with RTO tracks in indigenous simulator***

a. Professional vs. novice driver applications

The requirements in terms of driving training and assessment of professional and new drivers having different experience levels and skill requirements, are quite different. The driving simulators enable professional drivers to engage in specialized training involving advanced techniques such as trip planning, navigating in complex traffic scenarios, response times, etc. Studies have shown that novice drivers exhibit susceptibility to manual-visual distractions, which significantly affect their performance while the professional drivers are more equipped to handle distractions are also not immune to their effects, for example, distractions caused by mobiles, or viewing dashboard for navigation, etc. [17][18][19][20][21][22]. Few test cases where driving simulator have been used for advanced research, are discussed in this section. Fig. 4. Shows the research statistics of driver simulator used at CSIR-CRRI.

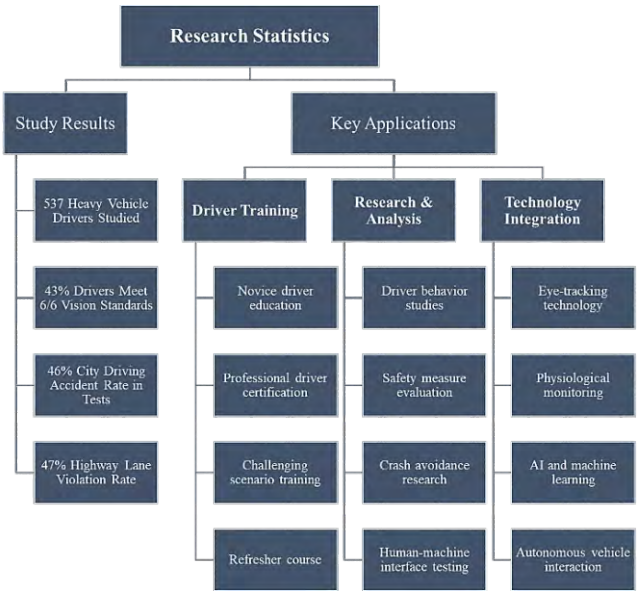


Fig. 4. Research statistics of driver simulator used at CSIR-CRRI

b. Experiential evidence from Indian driver assessment studies done at CRRI

i. Comprehensive assessment of heavy vehicle driver capabilities using driving simulator, Vienna Test System (VTS) and eye test equipment

The comprehensive studies by CRRI, which involved 537 heavy vehicle drivers from three major transport establishments indicate deficiencies in basic driving abilities. This study employed standardized psychophysical test protocols namely Reaction Time Tests (RT), Determination Tests (DT), Adaptive Tachistoscopic Traffic Perception Tests (ATAVT), Cognitrone Attention Assessments, and Intelligence Tests (INSSV). The results depicts some worrying statistics: Drivers constantly scored in the 'poor' category over all psychomotor parameters irrespective of age group or driving experience. This was specifically true for drivers below 30 years who scored mean scores of 67.98 for reaction time percentile ranking, 34.78 for motor time, and 55.73 for correct responses in attention

tests. Drivers above 30 years exhibited slightly worse performance with reaction time percentile rankings of 66.55 and motor time scores of 31.69. Most alarming was the general 'poor' grading for both long-distance (282 drivers) and short-distance (255 drivers) categories. This shows general deficiencies in driver competency irrespective of experience type.

Visual acuity assessment indicated that amongst 100 drivers assessed, only 43% had 6/6 vision standards, 31% required corrective measures (6/9 vision) and 21% needed retesting. For drivers with age > 30 years, failure rates reached 11%. These are essentially stress and age-related visual deterioration which the present current licensing process is not able to identify. Glare recovery tests revealed that 47.37% of long-distance drivers and 9.76% of short-distance drivers scored below average, the recovery times was beyond 4.6 seconds, which has the potential to significantly affect night driving safety [23]. The results in simulator based and field based studies matched as discussed above.

ii. Diagnostic testing framework and implementation challenges

A comprehensive diagnostic assessment done on 162 professional drivers employing driving simulator followed by field based assessments indicated substantial gaps in present licensing procedures vis-à-vis real driving competency requirements. In this study, Porto Clinic system was used for visual acuity assessment, Porto Glare apparatus was employed to assess glare tolerance, and the indigenous driving simulator for detailed skill assessment. Psychometric evaluation finding depicted worrying disparities. While 98.14% of drivers attained satisfactory visual acuity (6/6 vision), only 61.11% performed excellently in depth perception tests, and 35.80% attained very good ratings in glare recovery evaluations. The results of night vision assessment depicted 46.91% drivers attaining very good performance while 4.32% scoring good, showing possibility of risks while driving under low-light conditions. Simulator-based evaluation indicated significant performance deficiencies in simulating real-world driving environments. 46% drivers in city driving and 39% in highway driving environment caused one or more accidents during testing. Lane violation analysis showed that 21% drivers erred in following lane discipline while performing city driving, whereas 47% highway driving violations were observed. Signal violation rates was relatively low, 5% for city and 11% for, due to the specialized training background of test subjects [24].

iii. Research validation and statistical significance

While performing simulator and corresponding field based studies, the statistical analysis of driver performance data employed ANOVA testing protocols to establish significance levels and categorize performance variations across demographic categories. The study constantly demonstrate F observed values below F critical thresholds (3.68), representing no statistically significant differences within age groups 25-40 years for professional driver categories, though there were variations across driver groups and experience levels. Analysis of variance in reaction times, attention spans, and visual processing capabilities showed distinctive performance patterns which can be correlated with training backgrounds, experience levels, and professional responsibilities.

Linear regression analysis shows strong correlations among various performance metrics, thus supporting predictive models development for driver competency assessment. The Correlation coefficients of $R^2 = 0.96$ for median reaction time Vs. saccadic duration relationships shows strong statistical grounds for performance prediction algorithms. These statistical relationships facilitate development of inclusive scoring systems that can help predict real-world driving performance evaluation based on simulator evaluation outcomes, to result in objective criteria for licensing decisions and training program effectiveness assessment.

4. Challenges and Limitations

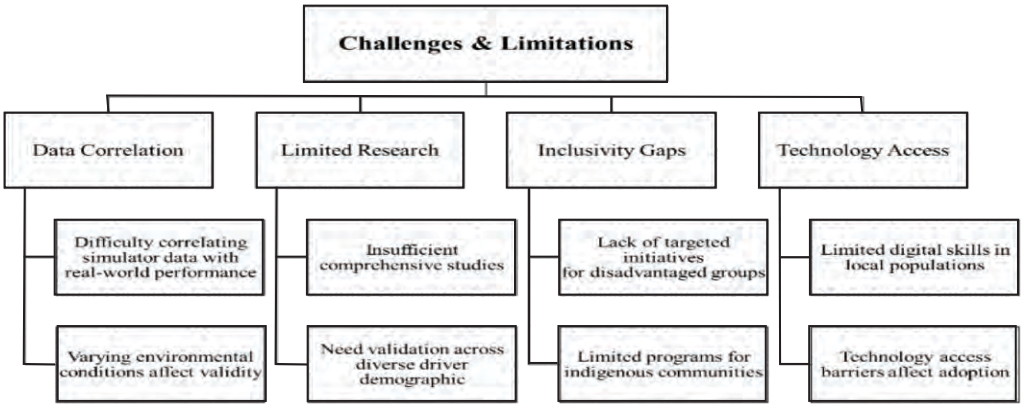


Fig. 5. Challenges and limitations of driving simulator

Driving simulators are progressively being accepted for their prospects of enhancing driver education and road safety research. There are, though, various challenges and limitations, especially in relation to the disadvantaged populations and the efficacy of various educational initiatives. Fig. 5. shows challenges and limitations of driving simulator.

5. Conclusion

With approximately 1.80 lakh road fatalities recorded in India in 2025 and with 66% of victims in the 18-34 age group, the requirement for evidence-based driver assessment has never been greater. The experimental studies performed by CRRI quantify these challenges: only 43% of heavy vehicle drivers had 6/6 vision, 46% caused accidents in simulated city driving environments, highway lane violations touched 47%, and a robust R^2 of 0.96 corroborated predictive models linked simulator performance to real-world competency. These findings is uniform among novice and professional driver categories, showing systemic deficiencies regardless of experience or age or gender.

To address these concerns, a structured national implementation framework is needed. Standardized protocols need to include India's linguistic multiplicity, literacy disparities, regional traffic patterns, varying road conditions and traffic density/volumes, reinforced by accredited equipment calibration, trained assessors, and strict quality assurance procedures on all test locations. Unified integration with current RTO infrastructure needs comprehensively designed transition protocols which should be able to maintain continuity in licensing services while gradually embedding improved diagnostic and assessment methods.

The AI-enabled driving simulators can dynamically adapt traffic environments to individual performance metrics, allowing personalized and effective training experiences. Given that over-speeding alone accounts for 75.2% of road deaths, this technologically driven, institutionally integrated approach presents a statistically grounded and scalable pathway toward achieving India's target of halving road fatalities by 2030.

Future directions: (1) AI Integration: Advanced AI algorithms for personalized driver training, Adaptive scenario generation as per individual need, and Individual performance-based customization (software configurable) (2) Enhanced Technology: Real-time environmental changes (weather, lighting, time-of-day), Enhanced graphics and realism, Automated feedback during training, and Autonomous vehicle technology adaptation/integration (3) National Implementation: Standardized protocols for nationwide implementation, Integration with RTO setup, Socially relevant training framework/programs, and Policy framework development.

References

[1] Symposium on Simulator Platform for Safe Driving in Indian Road Conditions, IIIT-Hyderabad, 21-22 December 2023.
[2] Using VR-Based Driving Simulators to Study People, Honda's R&D Facilities Chapter 11, 2025.08.25. https://global.honda/en/tech/serial/Hondas_RandD_Facilities_part11/.
[3] Mary Anne Bertola, Stacy A. Balk, Jim Shurbutt, Evaluating Driver Performance on Rural Two-Lane Horizontal Curved Roadways Using a Driving Simulator, **Report No.** FHWA-HRT-12-073, 2012-01-01, SAIC, Office of Safety Research and Development, Federal Highway Administration, 6300 Georgetown Pike, McLean, VA 22101. URL: https://rosap.ntl.bts.gov/view/dot/41952.
[4] Indigenous Car Driving Simulator. 2018. https://crridom.gov.in/sites/default/files/news/Indigenous%20Car%20Driving%20Simulator%20final%20brochure.pdf.
[5] Ayan Kumar Naskar & Pritam Saha (2025). Controlled experiments for road safety assessment – A conceptual framework, Next Research, Volume 2, Issue 2, 2025, 100277, ISSN 3050-4759, https://doi.org/10.1016/j.nexres.2025.100277.
[6] ALFDC'S Technology & Skills Exploration Zone | ALFDC | Aboriginal Labour Force Development Circle, https://alfdc.on.ca/tech/.
[7] Malone Sarah & Brünken Roland. Hazard Perception, Presence, and Simulation Sickness—A Comparison of Desktop and Head-Mounted Display for Driving Simulation. Frontiers in Psychology. Volume 12 – 2021 (2021). DOI=10.3389/fpsyg.2021.647723.
[8] Pirdavani, A.; Bajestani, M.S.; Bunjong, S.; Delbare, L. The Impact of Perceptual Road Markings on Driving Behavior in Horizontal Curves: A Driving Simulator Study. *Appl. Sci.* 2025, *15*, 4584. https://doi.org/10.3390/app15084584
[9] Driving Simulation, CRC, https://www.cogres.com/driving-simulation.
[10] The Exploratory Advanced Research Program Fact Sheet, Driving Simulation Forward: Making Driving Simulators More Useful for Behavioral Research, Publication No. FHWA-HRT-10-060 HRTM-04/06-10(1M)E, U.S. Department of Transportation, Federal Highway Administration. https://www.fhwa.dot.gov/publications/research/ear/10060/10060.pdf.
[11] https://crridom.gov.in/traffic-engineering-and-safety.
[12] Chen, L.; Fang, J.; Li, J.; Xie, J. Research on the Effectiveness of Driving Simulation Systems in Risky Traffic Environments. *Systems* 2025, *13*, 329. https://doi.org/10.3390/systems13050329.
[13] Brown, T., Marshall, D., Roe, C., Schmitt, R., La Velle, A., Schwarz, C., & Burt, T. (2023, March). A systematic review of profiles of speed and lane keeping for driving simulator data (DOT HS 813 414). National Highway Traffic Safety Administration. University of Iowa. National Advanced Driving Simulator. United States. Department of Transportation. National Highway Traffic Safety Administration. Office of Behavioral Safety Research. Report Number: DOT HS 813 414. URL: https://rosap.ntl.bts.gov/view/dot/66719.
[14] Devos, Hannes; Nieuwboer, Alice; Vandenberghe, Wim; Tant, Mark; de Weerdt, Willy; and Uc, Ergun. Validation of DrivingSimulation to Assess On-Road Performance in Huntington Disease. In: Proceedings of the Seventh International Driving Symposiumon Human Factors in Driver Assessment, Training and Vehicle Design, June 17-20, 2013, Bolton Landing, New York. Iowa City, IA:Public Policy Center, University of Iowa, 2013: 241-247.https://doi.org/10.17077/drivingassessment.1495.
[15] https://www.facebook.com/INDIA.CSIR/posts/indigenous-car-driving-simulator-roadsafetydr-harsh-vardhan-mygov-indiawith-a-hi/573965606109017/.
[16] National Dissemination Workshop on Development and Application of Technologies for Sustainable Transportation, March 2017. CSIR-CRRI Newsletter. Iss. 53. URL: https://crridom.gov.in/sites/default/files/publication/English-%20Jan-March%202017-53.pdf.
[17] Mansoureh Jeihani, Ramina Javid, Eazaz Sadeghvaziri, Educating the Public about Distracted Driving and Evaluating Distraction-Prevention Technologies, October 25, 2022, Final report, National Transportation Center, Morgan State University.
[18] https://injury.research.chop.edu/research/research-tools-and-data-resources/driving-simulators.
[19] Alonso, F.; Faus, M.; Riera, J.V.; Fernandez-Marin, M.; Useche, S.A. Effectiveness of Driving Simulators for Drivers' Training: A Systematic Review. *Appl. Sci.* 2023, *13*, 5266. https://doi.org/10.3390/app13095266.
[20] Sarah Krasniuk, Ryan Toxopeus, Melissa Knott, Mackenzie McKeown, Alexander M. Crizzle, The effectiveness of driving simulator training on driving skills and safety in young novice drivers: A systematic review of interventions, Journal of Safety Research, Volume 91, 2024, Pages 20-37, ISSN 0022-4375, https://doi.org/10.1016/j.jsr.2024.08.002.
[21] https://www.exponent.com/case-studies/can-eye-tracking-data-support-driver-safety.
[22] Anshika Gupta, Siddhartha Rokade, Kamini Gupta, Vinod Karar and S. Velmurugan, Assessment of Traffic-Relevant Personality Traits in Commercial Drivers (forklift drivers) Using the Inventory of Driving-Related Personality Traits – Revision (IVPE-R) Test, CTSEM, 2025, MANIT, Bhopal, 5-7 July 2025.
[23] Vikas Thakur, Kamini Gupta, Dr. Neelima Chakrabarty & Dr. Tanuj Chopra, Approach to Driver Visual behaviour using Eye tracker & driving skills using Simulator, , Sixth Colloquium on Transportation Systems Engineering & Management , at SVNIT Surat on 14-15 June 2019.
[24] Anshika Gupta, Siddartha Rokade, Kamini Gupta, Vinod Karar and S. Velmurugan, Evaluating the Impact of Distraction due to Music & Phone Conversation on Driving Performance & Perceived Risks, TIPCE 2025 (3rd International Conference on Transportation Infrastructure Projects: Conception to Execution) IIT Roorkee, from 18-21September, 2025.

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About Us

DCC Infra Projects Ltd. (DIPL), a closely held Public Ltd Company, having its registered office at Kaithal (Haryana) was originally established in the year 2007 by the two great visionaries Mr Baljit Singh and Mr Harjit Singh as a partnership firm named “Diamond Construction Company (DCC)” which was later converted into the current corporate entity i.e.; DCC Infra Projects Ltd. w.e.f. 25.06.2021. It is an ISO-certified company and proudly adheres to the prescribed standards in the industry. DIPL provides end-to-end infrastructure implementation solutions that include engineering, procurement and construction ("EPC") services on a fixed-sum turnkey basis as well as on an item rate basis.

Established initially as a firm, specializing in smaller construction projects, DIPL passed the test of time and expanded in leaps and bounds and has been successful in establishing itself as one of the Region’s leading infrastructure companies with a rich and diverse experience and expertise in both construction and ownership of infrastructure assets. The company has a strong presence in the EPC (Engineering Procurement and Construction) construction of roads & highways. It has been working with the Principal Deptts like the National Highway Authority of India (NHAI), Madhya Pradesh Road Development Corporation (MPRDC), Haryana State Road Development Corporation and various other Central and State Government Authorities. The Company has also expanded with its geographical perimeters, presently it is functioning across M.P., Rajasthan, Chhattisgarh, Gujarat, U.P., Haryana, Punjab & Himachal and more recently in North Ease States to execute a HAM project allotted to it by NHIDCL in the State of Assam.

With a total manpower of appx. 2000 including 300 professionals, DIPL has been instrumental in executing large and challenging infrastructure projects. The Company has a long-standing commitment to creating responsible infrastructure. Sustainability is an integral part of its approach

to business and work ethics. DIPL has invested in the early adoption of advanced engineering equipment, new innovative technologies and above all, in strategic associations.

Vision

To become among the top infrastructure development and construction solution providers in the country. We the management of DIPL, are committed to the safe and efficient operation of our facilities. The highest standards of equipment integrity and reliability are maintained to avoid the risk to people and the environment.

Mission

We at DCC Infra Projects Limited, strictly focus on the development, construction and management of infrastructure projects by continuously achieving excellence in all areas of activities by way of -

- Working TOGETHER
- Making it SIMPLER & SAFER
- Doing it BETTER
- Delivering FASTER

Growth Strategy

- Continue our focus on EPC contracts as well as penetration in HAM projects.
- Maintain performance and competitiveness.
- Develop and maintain strong relationships with our clients and strategic partners; and
- Strengthening the construction and management of projects with progressive vision and integrity.

WE REPRESENT

Quality and Versatility

While safety is our top priority, we are earnestly dedicated to quality as well as performance. We handle every task with utmost dedication, enthusiasm and excellence. Our adequately skilled technical team enables us to offer design-build & value-engineered solutions from District roads to National Highways to the respective clients, and our experienced site staff delivers the completed projects with equal brilliance.

Awards and Achievements

- We received bonuses from Madhya Pradesh Road Development Corporation (MPRDC) for early completion of Madhya Pradesh Major District Roads upgradation (MPMDRUP) Package No. 1: Degoda Mohan Garh Road (MP-MDR-34-07), Bada Gaon Kakarwaha (MP-MDR-34-09), Majna Palera Road (MP-MDR-34-08) and Bada Gaon Baldeogarh (MP-MDR-06).
- We also received a bonus from MPRDC for early completion of Madhya Pradesh Major District Roads upgradation (MPMDRUP) PKG-12 Shahgarh Baraytha Road (MP-MDR-31-18), Banda Shahpur Parosiya Road (MP-MDR-31-27).
- Also, received an ISO 9001:2015 Certificate for Quality Assurance from Magnitude Management Service Pvt. Ltd.

Our Strength

- Expertise and experience in Project Management.
- Strong financial performance and credit profile.
- Integrated In-house design and engineer expertise, a large fleet of sophisticated equipment and an experienced & vintage employee base.
- Highly qualified and experienced management team.

- Reputation for Excellence is built through quality and cost-effective contractual services.

Management

1. Mr. Baljit Singh (Managing Director)
2. Mr. Harjit Singh (Director)
3. Mr. Simranjit Singh (Director)
4. Mr. Gurbachan Singh (Director)
5. Mr. Laxman Dass (Director)
6. Mrs. Amandeep Kaur (Woman Director)
7. Mr. K.L. Pasricha (Independent Director)
8. Mr. Shyam Sachdeva (Independent Director)

Brief of DCC Infra Projects Limited:

- DCC Infra Projects Limited (DIPL) is a closely held Public Limited Company. Initially established as a partnership firm in the year 2007 by Mr. Baljit Singh and Mr. Harjit Singh it was later converted into the current corporate entity with effect from 25-06-2021.
- It is registered as a Class-1 contractor with various government departments, and has successfully completed infrastructure projects for various Govt. and Non-Govt. departments.
- The company has been growing at a CAGR of ~ 25%.

Our Key Clients:

- National Highways Authority of India.
- National Highways & Infrastructure Development Corporation Limited
- Madhya Pradesh Road Development Corporation (Projects funded by New Development Bank having its head office in Shanghai, (China)).
- Haryana State Road Development Corporation.
- PWD B & R Department of Haryana and Madhya Pradesh states.
- Haryana State Agricultural Marketing Board.
- Maharashtra State Electricity Distribution Company Limited.

DCC INFRA PROJECTS LIMITED ***(Formerly Known as Diamond Construction Company)***

An ISO 9001:2015 Certified Company

WHERE QUALITY & SAFETY MEET EXCELLENCE

Building India's Infrastructure. Connecting Tomorrow.

Since 2007, DCC Infra Projects Limited has been delivering world-class infrastructure solutions that drive economic growth and strengthen connectivity across India. From highways and bridges to railways and renewable energy projects, we are committed to engineering excellence, innovation, safety, and timely project delivery.

OUR CORE EXPERTISE

Roads & Highways | Bridges & Transport Infrastructure | Railway Projects | EPC & HAM Projects | Solar & Renewable Energy

WHY DCC INFRA?

✓ 2,000+ Skilled Workforce & 300+ Professionals
✓ Advanced Construction Equipment Fleet
✓ Strong Engineering & Project Management Capabilities
✓ In-house Design & Technical Expertise
✓ Proven Track Record of Quality & Timely Delivery
✓ Robust Financial Strength & Execution Capability

TRUSTED BY LEADING GOVERNMENT AGENCIES

NHAI • NHIDCL • MPRDC • HSRDC • State PWDs • Haryana State Agricultural Marketing Board • MSEDCL

PAN-INDIA PRESENCE

Haryana | Rajasthan | Gujarat | Uttar Pradesh | Madhya Pradesh | Chhattisgarh | Punjab | Jharkhand | Assam | Andhra Pradesh | Telangana | Maharashtra | Odisha

OUR VISION

To be among India's leading infrastructure development companies by delivering sustainable, innovative, and high-quality solutions that create lasting value.

LEADERSHIP THAT INSPIRES

Led by Mr. Baljit Singh (Managing Director) and Mr. Harjit Singh (Director), with over 26 years of industry experience, DCC Infra continues to set benchmarks in infrastructure development and project execution.

"WE ARE EARNESTLY DEDICATED TO OUR PERFORMANCE"

Delivering Infrastructure. Creating Value. Building the Future.

DCC INFRA PROJECTS LIMITED

Quality • Safety • Integrity • Excellence

Registered Office: Kaithal, Haryana, India

Concrete 3D Printing: A Digital Construction Pathway for Sustainable Road Safety Infrastructure

Dhrutiman Dey[1] and Biranchi Panda[2]

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ABSTRACT

Concrete 3D printing, as an emerging digital construction technology, offers innovative solutions for developing sustainable and safe road infrastructure. From modular crash barriers to pedestrian facilities and resilient urban mobility structures, this technology enhances design flexibility, reduces material wastage, and accelerates construction, thereby aligning with the Vision Zero framework of integrating safety, sustainability, and technology in infrastructure.

1. INTRODUCTION

Road safety is a growing concern in India, where rising vehicle density, urban expansion, and infrastructure gaps contribute to one of the highest accident rates in the world. The "Vision Zero" approach emphasizes the elimination of fatalities and serious injuries on roads through safe design, technology integration, and sustainability. Achieving this vision requires rethinking conventional methods of infrastructure development and embracing innovative technologies that address both safety and sustainability.

Concrete 3D printing—also referred to as additive manufacturing of cementitious materials—is one such technology that is rapidly gaining global attention. Unlike traditional construction methods that rely on formwork, labour-intensive processes, and significant material wastage, concrete 3D printing automates the placement of concrete layer by layer under computer control. This enables faster construction, reduced environmental impact, and enhanced design flexibility.

When integrated into road safety infrastructure, concrete 3D printing provides a digital pathway to create adaptive, cost-effective, and safe structures. Its ability to design and deploy modular elements aligns with India's goals of sustainable infrastructure growth and safer mobility systems.

2. DIGITAL CONSTRUCTION AND ITS RELEVANCE TO ROAD SAFETY INFRASTRUCTURE

Digital construction is a paradigm that integrates advanced technologies like Building Information Modeling (BIM), robotics, artificial intelligence, and automation into the construction sector. Concrete 3D printing sits at the heart of this transition, bringing together digital design and physical execution.

For road safety infrastructure, digital construction offers:

- Customization and adaptability: Components such as crash barriers or pedestrian facilities can be tailored to specific site requirements without significant cost escalation.
- Reduced time-to-installation: Prefabricated 3D-printed elements can be quickly deployed, minimizing disruption to traffic and improving safety during construction.
- Sustainability integration: Optimized material usage, recycled raw materials (such as industrial slag or construction waste), and energy-efficient processes contribute to lower carbon footprints.
- Enhanced precision and quality: Automated processes reduce human error and ensure consistent quality, essential for safety-critical applications.

- Thus, digital construction technologies like concrete 3D printing act as enablers for safer and more resilient road ecosystems.

3. APPLICATIONS OF CONCRETE 3D PRINTING IN ROAD SAFETY INFRASTRUCTURE

3.1 Crash Barriers and Road Dividers

Crash barriers are vital safety elements on highways and urban roads, reducing the severity of accidents. Conventional methods of producing these structures are labor- and time-intensive. With concrete 3D printing, barriers can be manufactured with optimized geometries that absorb impact energy more effectively. Hollow or cellular designs can reduce material usage while maintaining structural performance. Prefabricated segments can be printed off-site and assembled along highways, ensuring uniformity and rapid deployment.

3.2 Pedestrian Crossings and Safety Islands

Pedestrian safety remains a critical challenge in India. 3D printing enables the production of modular raised crossings, median safety islands, and protective bollards that improve visibility and provide safe refuge for pedestrians. These can be designed to integrate aesthetic elements, tactile paving for the visually impaired, and embedded lighting systems.

3.3 Roadside Furniture and Traffic Calming Devices

Elements such as bus shelters, road signs, speed humps, and traffic-calming chicanes can be fabricated using 3D printing. Unlike conventional cast-in-place methods, this allows rapid prototyping and deployment of user-centred designs. Smart integration (e.g., solar panels, charging points) is also feasible.

3.4 Noise Barriers and Urban Mobility Infrastructure

Noise pollution along highways is a growing environmental and health concern. Concrete 3D printing offers opportunities for producing acoustically optimized noise barrier walls with intricate surface patterns. Similarly, cycling tracks, wheelchair-friendly ramps, and modular mobility features can be 3D printed, promoting inclusivity and safer urban transport.

3.5 Emergency Infrastructure and Disaster Response

During accidents or disasters, rapid deployment of safety infrastructure is crucial. Portable barriers, shelters, and retaining structures can be 3D printed near sites using mobile printers, reducing response time and enhancing resilience.

4. SUSTAINABILITY DIMENSION: ALIGNING WITH VISION ZERO

Vision Zero emphasizes not only safety but also sustainability. Concrete 3D printing contributes to this goal through:

- Material efficiency: Elimination of formwork reduces waste; optimized geometries minimize raw material consumption.
- Use of recycled materials: Industrial by-products like slag, fly ash, and recycled aggregates can be integrated into printable mixes, lowering environmental footprints.
- Carbon reduction: Localized production reduces transportation-related emissions, while digital optimization reduces embodied carbon.
- Water savings: Compared to conventional concrete methods, 3D printing can be adapted to use less water, a crucial factor in water-stressed regions.
- Such attributes position concrete 3D printing as a sustainable solution for scaling road safety infrastructure without compromising environmental goals

5. TECHNOLOGY INTEGRATION AND FUTURE PROSPECTS

The road safety domain is increasingly embracing technology—ranging from intelligent transport systems (ITS) to sensor-based monitoring of road conditions. Concrete 3D printing complements this trend through:

- Digital twins and BIM: Printable designs can be directly integrated into digital twins of road networks, enabling predictive maintenance and lifecycle management.
- Smart infrastructure: Embedded sensors within 3D-printed structures can monitor impact loads, vibrations, or material degradation, feeding data into road safety management systems.
- Automation and robotics: Combined with robotic arms and mobile printing systems, on-site printing of small-scale infrastructure elements will soon be possible along highways.
- Circular economy approach: Decommissioned printed elements can be recycled into fresh printable material, closing the material loop.
- With continued research in printable material formulations and large-scale printers, the scope of applications will expand significantly in the coming decade.

6. CASE STUDIES AND GLOBAL LEARNINGS`

Globally, several pilot projects have demonstrated how concrete 3D printing can be harnessed for safe, sustainable, and rapid infrastructure development. These examples serve as proof-of-concept for integrating digital construction technologies into mainstream infrastructure:

(a) World's First 3D-Printed Pedestrian Bridge – Netherlands

A cyclist and pedestrian bridge constructed in Eindhoven, Netherlands, marked the world's first fully functional 3D-printed concrete bridge. It showcased how additive manufacturing can deliver structurally safe, sustainable, and scalable mobility solutions.

(b) World's Largest 3D-Printed Pedestrian Bridge – China

A 26.3-meter-long pedestrian bridge was 3D printed in Shanghai using optimized design and digital workflows. This project demonstrated how large-scale additive manufacturing can reduce material use while ensuring safety and durability.

(c) India's 3D-Printed Pedestrian Bridge Prototype – IIT Hyderabad & Simpliforge Creations

Designed as a pedestrian bridge, the prototype is currently undergoing load testing. The bridge has been designed broadly following form optimisation principles to minimise concrete usage, demonstrating a step towards resource-efficient structural applications of 3D printing.

(d) 3D-Printed Bus Shelter – Godrej Construction & Tvasta Manufacturing Solutions

India's first 3D-printed bus stop, jointly developed by Godrej Construction and Tvasta, demonstrates how urban mobility infrastructure can be built faster, safer, and more sustainably. This project shows the potential of 3D printing in roadside and public-use infrastructure.



Figure 1 (a) World's First 3D-Printed Pedestrian Bridge [1], (b) World's Largest 3D-Printed Pedestrian Bridge [2], (c) India's 3D-Printed Pedestrian Bridge Prototype [3], (d) India's first 3D-Printed Bus Shelter [4].

7. POLICY, INDUSTRY, AND ACADEMIC COLLABORATION

To accelerate the adoption of concrete 3D printing in road safety infrastructure, collaboration between policymakers, industry, and academia is essential:

- Policymakers: Need to create enabling codes, standards, and incentives for digital construction in road safety.
- Industry: Should invest in scalable 3D printing systems, pilot projects, and localized manufacturing hubs.
- Academia: Plays a crucial role in material development, structural testing, and sustainability assessment.
- Public–private partnerships can serve as catalysts, while pilot projects in urban mobility zones, smart cities, and highway modernization programs can demonstrate feasibility.

8. CONCLUSION

Concrete 3D printing represents a digital construction pathway that integrates safety, sustainability, and technology in road infrastructure. Its ability to produce modular, customized, and eco-efficient safety structures aligns with India's Vision Zero agenda. From crash barriers to pedestrian facilities and noise control solutions, 3D-printed infrastructure can revolutionize how roads are designed and maintained. By embracing this technology, India can not only enhance road safety outcomes but also lead globally in the adoption of sustainable digital construction practices. The convergence of innovation, sustainability, and safety in concrete 3D printing makes it a pivotal tool in building a safer and more resilient road future.

Agile Highway Innovations - A Way Forward

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ABSTRACT

Need for Agile highway innovations stems from necessity for highway to become more adaptive, efficient and responsive to changing demands to move quickly/easily. *Integration of New Technologies are vital for incorporating "smart" technologies to make it a flexible, customer-centric and sustainable. New age binders in road construction primarily refer to sustainable and performance-enhanced alternatives to traditional petroleum-based bitumen. The viscosity grade bituminous binders may be modified with graphene/- ultra fine/nano size mineral admixtures or alternatively pyro based using waste rubber or bio-based bituminous materials may be also adopted to improve performance and sustainability with less reliance on fossil fuels/ environmental impact.*

Similar to the above asphalt binders, ultra fine/nano size mineral admixtures (industrial wastes/byproducts), structural/non-structural fibres in conjunction other materials which are also being used in 3D printing cement concrete & ultra high-performance fibre reinforced concrete (UHPFRC)/in precast concrete pavement industry to improve road durability, performance and to sustain very heavy traffic and lessen lime stone, and environmental impact. The paper thus covers agile highway technologies adaptive in the field of roads, bridges, toll plaza, tunnel safety etc supplementing with codal provision/International practice, digital technologies in survey/safety etc, their objective, advantages with limitations for making them sustainable.

Key Words: *Modified bitumen, high performance concrete, green house gas, binder.*

1. INTRODUCTION

Recent studies have worked towards addressing environmental issues such as global warming and greenhouse gas emissions due to the increasing awareness of the depletion of natural resources. With a population of ~1.45 billion and being one of the fastest growing world economies, India is trying to ensure security and sustainability of energy systems using solar systems on highways to sustain the economic growth. India is the third largest consumer of petroleum crude after China and the US [(1)]. Holistically the status of construction materials and after its effect on emissions of GHG gases are shown in Fig.1.

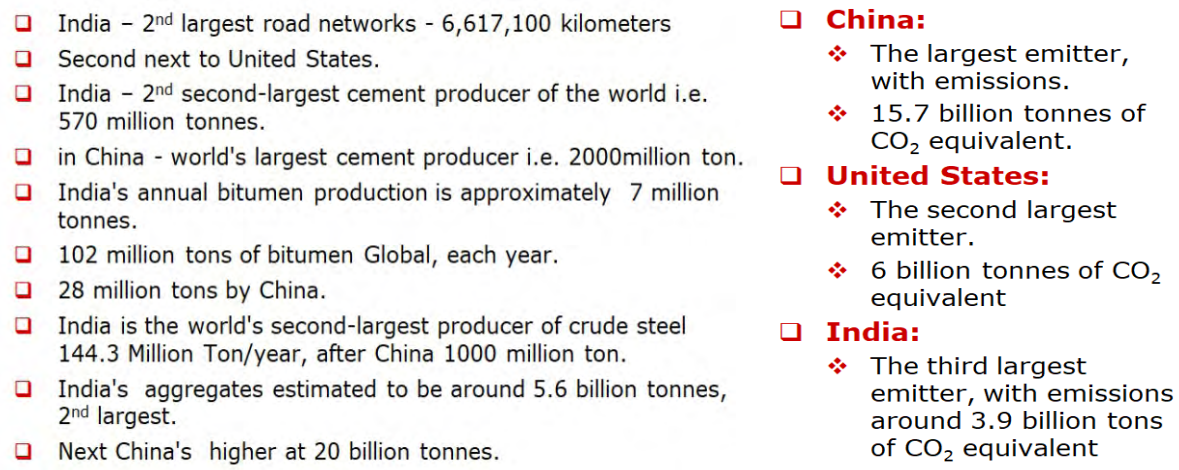


Fig 1: Construction Materials and Emission of GHG - a Global View

2. GLOBAL VIEWS ON INNOVATION IN HIGHWAYS

Solar Roads (Netherlands, France, China, India, USA): Solar panels are embedded into road surfaces, protected by durable glass to generate electricity for streetlights or charging electric vehicles. **Plastic & Recycled Roads** (India, Australia): India is widely using plastic/rubber and industrial wastes waste to build more durable highways. Australia has developed roads using recycled plastic bags and glass bottles. **Smart & Interactive Infrastructure** (Belgium, UAE, Australia): Belgium: Employs **AI-driven traffic systems** to optimize flow and reduce accidents.

UAE: Utilizes AI for futuristic, **smart traffic management**. Australia: Uses **"Smart Lane Movable Barriers" (SLMB)** with **LED lights that can be remotely adjusted for traffic flow**.

Safety & Maintenance (Japan, Canada, Mexico): Japan: Implements advanced maintenance systems and rapid repair techniques for high-quality, safe roads. Canada: Has tested interactive, **smart pedestrian crosswalks** that can visually change. Mexico: Focuses on AI-driven data analysis for traffic management, notes Inter-traffic. Eco-friendly & Energy-Harvesting (Israel): An Israeli firm is developing technology **to collect energy from the kinetic movement of vehicles on roads**. Switzerland: Utilizes advanced construction, such as elevated movable bridges, to minimize disruptions. (Ref. AICEP-Portugal Global - Trade and Investment Agency)

3. INNOVATIONS IN ASPHALT PAVEMENTS

Realizing the nature of fossil fuel reserves and reserves of lime stone etc there is a strong motivation to use alternative resources, particularly bio, pyro bitumen from waste tyres, use waste plastic or graphite-based graphene including use of geopolymer now a days alternate to Portland cement as a filler.

Terminology used:

a) Bi**o-ethanol petrol** - a renewable, biodegradable, high-octane biofuel produced by fermenting sugars or starches from agricultural feedstocks (corn, sugarcane).

b) **Biomass-** renewable organic material that comes from plants and animals as bio-oil, biochar, and bio-fibers derived from agricultural waste- sustainable, eco-friendly modifier or partial binder replacement.

c) **Biodiesel/Fatty Acid Methyl Ester** (FAME)- a renewable, biodegradable fuel produced from vegetable oils soybean, animal fats, recycled cooking oil/yellow grease through a trans-**esterification process** as partial substitute for petroleum-based diesel (Fig. 2) used in asphalt roads. D6751.

d) **Renewable Diesel** - produced from biomass feedstock- those used for biodiesel production similar to biodiesel but with important differences is, it is a hydrocarbon fuel (HVO-Hydrotreated Vegetable Oil). That is chemically equivalent to petroleum diesel, uses a **hydrogenation process** rather than the esterification process used to produce biodiesel. (ASTM D975).

e) **Bio-Bitumen**- a sustainable, eco-friendly, and renewable binder produced from organic waste—such as crop straw, lignin, or plant-based oils—using pyrolysis to replace conventional, fossil-fuel-based petroleum bitumen. Fig 3 (a)

f) **Pyrobitumen**- a natural, solid, and largely insoluble hydrocarbon that can be used in asphalt road construction- high-performance **binder modifier/filler** rather than a direct, 100% replacement for liquid petroleum bitumen, generated from waste tyres through thermal or catalytic degradation. Fig 3 (b)

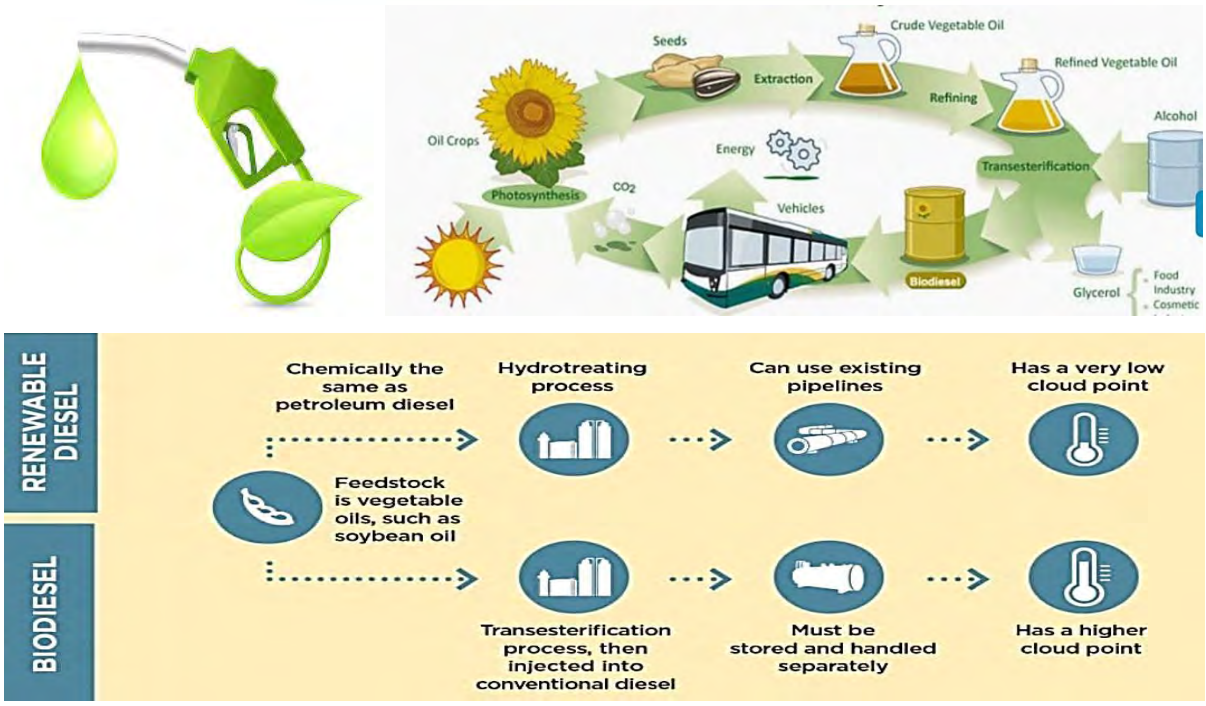


Fig. 2 Renewable Diesel Vs Biodiesel

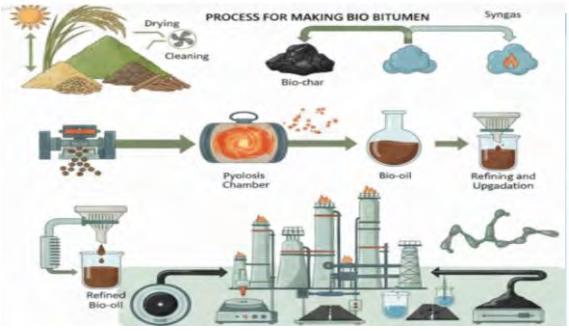


Fig. 3 (a) Bio Bitumen



Fig 3 (b) Pyro Bitumen

4. INNOVATIONS IN RIGID PAVEMENTS

Portland cement is highly greenhouse gas (GHG) intensive, responsible for 7-8% of global CO_2 emissions. M**ine**ral admixtures alternate to Portland cement can make greener/ cheaper product along with geopolymer concrete- M 40 (IS:17452), ready mix prepacked concrete (IS:18685-2024), and micro fine cement (IS:16993-2018), ultra fine fly ash (IS:19058-2024) and ultra fine granulated slag (IS:16715-2018). By using ultra fine materials/fly ash/slag/silica fume in concrete, one can use marginal materials viz. construction and demolition (C&D), low strength aggregates, recycled concrete as aggregates as per IS:383 using their potential energy and compensate required properties. Use of silica fume (brilliant material) alone as partial replacement of cement is widely being for making high performance concrete (HPC), ultra-high performance fibre concrete (UHPFRC), one can make good roads having life more than the conventional concrete or for early opening to traffic as per IRCSP:83 or even without reinforcement using steel fibres in making **Unique Bridge in Latur (Masalga):** (A 111-meter-long, first-of-its-kind bridge in India commissioned in Masalga, Latur in 2021 using **Ultra-High-Performance Fibre Reinforced Concrete (UHPFRC)** technology. Instead of conventional steel rebar, this technology uses steel fibres within the concrete to provide strength.

Similar to above agile techniques, some additional technique's are as- (i) Re-cycling of rigid pavement as aggregates and stone pitching, (ii) High performance, early opening to

traffic and short panel rigid pavement, (iii) White topping, (iv) Bonded & jointless concrete pavement, (v) Asphalt paver blocks, (vi) Pre cast pre-stressed concrete road vii. Porous vegetation concrete using C&D waste etc. with minimum material, spillage, space and man-days and stabilised subgrade/sub base or base course to reduce thickness as well.

5. INNOVATIONS IN INVESTIGATION AND DIGITAL TECHNOLOGIES

Non-destructive tests -being carried out are- electrical resistivity, seismic refraction, ground penetrating radar, electromagnetic resistivity, in digital technologies- 3D printers, GPS fitted intelligent roller and motor-grader (IS:1892-2021, IRC123-2017, IRC:134-2022, IRC:115-2014, IRC: SP:16-2019, IRC:75. Now Network Survey Vehicle focuses on integrating AI, 3D Laser/LiDAR (Light Detection and Ranging), precise road data collection (cracks, potholes, roughness). Advancements in road texture measurement are focused on automated, non-contact 3D Technologies. A multi-lane free flow tolling using Automatic number plate recognition RFID (Radio frequency Identification) and Fast tag being started in Haryana and Gujarat besides Global Navigation Satellite Systems (GNSS). In Uttarakhand (2023) and Telangana Srisailam Left Bank Canal (SLBC) (2025), robots were deployed to navigate debris, cut stones, and clear paths for rescue. AI/Robots can also be used for communication and checking on trapped workers' health and for predictive geology and drilling/bolting, though full-scale robotic Tunnel Boring Machines (TBMs) which are less common than manual/semi-automated systems.

6. CODAL PROVISIONS ON INNOVATIVE TECHNOLOGIES

Initiatives have been taken on use of waste plastic (IRC:SP:98-2020), warm/cold mix (IRC:SP:101-2019/ IRC:SP:100-2014), jute/coir geo textile (IRC:SP:126-2019/IRC:SP:129-2022), PMB (Polymer modified Bitumen) (MORTH Circular 19th April 2024), ultra-high performance concrete (MORTH Circular 22nd February 2022), glass fibre reinforced polymer bars (IRC:137-2022/ IS:18256-2023**)** cost saving 15%, construction and demolition /Industrial waste (IRC:SP:132-2022) geopolymer (fly-ash/slag +alkalis) concrete (IS:17452-2020)/ Draft IS 456, recycling of asphalt pavement (IRC:120-2015), high performance bituminous pavements (IRC:SP:139-2023), Bio engineering as per Himachal Pradesh Government sp., short panel concrete pavement (IRC:SP:140-2024)/white topping (IRCSP:76-2015) being used in Karnataka, Mahastra and West Bengal, precast concrete pavement in Nagpur, bonded rigid pavement in Bihar, mix design based as per **SUPER PAVE** (**Su**perior **Per**formance **Pave**ment), refusal density in case of asphalt pavement simulating with field conditions as per IRCSP:135-2022, interlayer shear strength (1 MPa) of tack/prime coat and advanced digital technologies. All these are gaining momentum to make wider use.

7. CONCLUSION

Developing binders from bio/pyro- bitumen, modification with graphene to potentially replace petroleum-based bitumen, reducing reliance on fossil fuels, use of ultra fine materials and geopolymer i.e. without cement binder use in rigid pavement and precast technology/short panel/bonded rigid pavements and modern digital/robotic/3D printing in survey/construction/ safety/toll plaza are good initiatives for the growth of a country.

8. REFERENCES:

1. Sharma, S. (2020). Modi's broken dream of cutting India's dependence on oil imports; data reveals opposite story. Accessed from: https://www. financialexpress.com/ economy/modis-broken-dream-of-cutting-indiasdependence-on-oil-imports-data-reveals-opposite-story/1855834.
2. Su, N., Xiao, F., Wang, J., Cong, L., and Amirkhanian, S. (2018). Productions and applications of bio-asphalts–A review. Construction and Building Materials, 183, 578-591

Hero VIDA

RIDE SAFE INDIA
A Hero MotoCorp CSR INITIATIVE

BEYOND MOBILITY, TOWARDS SAFER COMMUNITIES

BUILDING A ROAD SAFETY ECOSYSTEM FOR INDIA



Ride Safe India, a Hero MotoCorp CSR initiative, is rooted in the belief that every journey deserves to be a safe one. Through awareness, education, and community action, we strive to create a culture where safety becomes a shared responsibility.



CREATING SAFER JOURNEYS FOR EVERY CHILD

Shaping safer road users of tomorrow by embedding responsible mobility behaviour at an early age.

63,000+
Road Safety Pledges

150,000+
Students, Parents & Guardians sensitized

10
Safe School Zones Created Across 3 Cities

Safe Street Corridor
160+ Road Safety Signages Across 8 Strategic Intersections









REACHING PEOPLE WHERE THEY ARE

RECEIVED
1st Prize
BY THE CM OF HARYANA FOR REPUBLIC DAY TABLEAU

Harnessing the power of media, partnerships, and public spaces to amplify road safety messages.

5.3 Million+
Awareness Impressions Through Radio

14+
Road Safety Modules Produced

500+
Petrol Pump Safety Messages

2.51 Million+
People Reached Through Tableau













*Disclaimer: The figures presented are approximate and are based on the best guesstimate. They are intended for informational purposes only, and actual values may vary.

SURAKSHIT SAATHI
EMPOWERING GIG WORKERS AS FIRST RESPONDERS

For gig workers, the road was not merely a route - it was their workplace. Through **Surakshit Saathi**, Hero MotoCorp transformed one of India's most exposed rider communities into a trained network of safety champions and first responders. By equipping riders with critical road safety knowledge, defensive riding practices, first-aid skills, and emergency response capabilities, the initiative enabled them not only to protect themselves but also to provide life-saving support during the critical golden hour following a crash.

2500+
Gig workers trained across **4 cities**

30+
Training Sessions Conducted







#SheRidesForSafety
WOMEN'S NIGHT RALLY

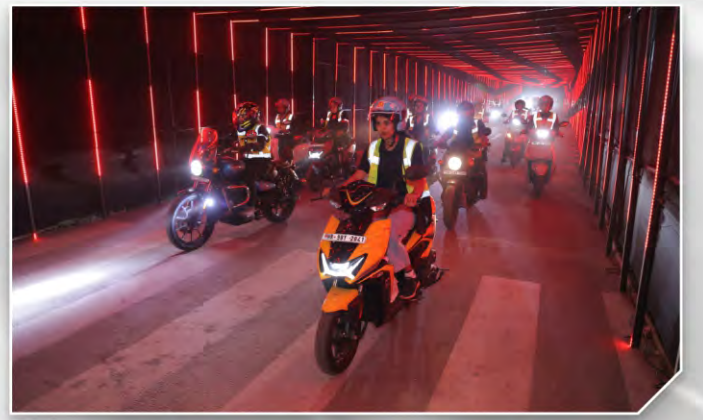
Encouraging women to lead by example & inspire safer road behaviour through responsible riding.

The **#SheRidesForSafety** Women's Night Rally brought together women riders, traffic police, and community leaders in support of inclusive road safety. By placing women at the centre of the conversation, the initiative highlighted their role in shaping safer roads while reinforcing the message that road safety is a shared responsibility.

200+
Women Riders Participated

2.7 Million+
Awareness Impressions





*Disclaimer: The figures presented are approximate and are based on the best guesstimate. They are intended for informational purposes only, and actual values may vary.

Hero VIDA

RIDE SAFE INDIA
A Hero MotoCorp CSR INITIATIVE



THE JOURNEY *Ahead*

Because safer roads are built not by a few, but by all of us.

Ride Safe India: Building the Road Safety Culture India Needs

A Hero MotoCorp CSR Initiative

Road safety is often understood through numbers—rashes, injuries, fatalities and economic losses. While these statistics help quantify the challenge, they rarely capture its deeper human impact. Behind every collision is a family waiting for someone who may never return home. Behind every serious injury is a life permanently altered. Behind every preventable death lies a simple question that society must continue to ask itself: could this have been avoided?

For years, road safety efforts across the country have focused on creating awareness, yet awareness alone does not always translate into safer behaviour. People know the rules but do not always follow them. Infrastructure improves, but risky practices continue. Enforcement exists, yet lasting change remains dependent on everyday decisions made by millions of road users.

Ride Safe India, Hero MotoCorp's decade-long road safety initiative, has increasingly evolved from an awareness campaign into a behaviour-led movement that focuses on creating safer habits, safer environments and stronger community participation reaching more than 1.6 million people in the last decade. Through sustained interventions across schools, communities and high-risk rider groups, the programme continues to reinforce the idea that road safety is most effective when it becomes part of everyday life rather than an occasional reminder.

The three month campaign announced on National Road Safety Month , brought together schools, government agencies, traffic police departments, road safety experts and local communities across Delhi, Gurugram, Lucknow, Hyderabad, Jaipur, Nagpur and Haridwar.

The campaign focused on three key groups—chool students, gig economy riders and women riders—ach representing a critical part of India's evolving mobility landscape.

Building Safer Habits from an Early Age

Creating a lasting road safety culture begins with young minds. Schools provide one of the strongest opportunities to shape responsible behaviour before unsafe habits become routine.

Through workshops, drawing competitions, pledge activities and interactive learning modules, Ride Safe India engaged **43,000+ students** and 1,000+ teachers across **60+ schools,** encouraging children to become ambassadors of safe mobility within their families and communities. The programme introduced experiential learning that encouraged students to understand road situations, make informed decisions and appreciate the importance of responsible behaviour both as pedestrians and future riders.

Designing Safer Roads Through Better Infrastructure

Behavioural change becomes more effective when it is supported by an environment

designed for safety. Recognising this, Ride Safe India complemented educational initiatives

with visible infrastructure interventions that encourage responsible road use.

The programme established Safe School Zones around 10 key institutions across Delhi, Gurugram and Jaipur, introducing traffic-calming measures and safety-focused infrastructure that create safer environments for children regardless of individual road user behaviour. In addition, an Ideal Road Safety Corridor was developed along Vikas Marg in Gurugram, with 160 strategically positioned road safety signages installed across eight intersections to improve visibility, reinforce safe driving practices and strengthen compliance through constant visual cues.

Together, these initiatives demonstrate that safer roads are created not only through awareness but through thoughtful design that supports safer choices every day.

Strengthening Community Preparedness - Gig Economy

Road safety extends beyond prevention to preparedness. Every trained individual has the potential to become the first point of support during a road emergency, reducing response time and improving outcomes when accidents occur.

Through the Surakshit Saathi initiative, 2,500+ gig economy riders received structured emergency response awareness and first-responder training, equipping them with practical knowledge in road safety, first aid and emergency decision-making. By empowering riders who spend the most time on urban roads, the programme strengthens community resilience while embedding safety leadership within one of India's fastest-growing workforce segments.

Inclusivity In Road Safety Is The Need of the Hour

As mobility patterns evolve, road safety conversations must become more inclusive. Women are increasingly independent riders, yet their representation within road safety initiatives has often remained limited.

The Women's Night Bike Rally—SheRidesForSafety—rought together 200+ women riders, influencers and community advocates to champion responsible riding and safer mobility. Beyond the rally itself, the initiative highlighted the role women play as powerful advocates for behavioural change, encouraging safer commuting practices within families, workplaces and communities while promoting greater confidence and visibility on the road.

Building a Shared Responsibility for Safer Roads

Throughout the campaign, partnerships with Delhi Traffic Police, Gurugram Traffic Police, Jaipur Traffic Police, Regional Transport Offices, schools and subject matter experts strengthened the programme's integrated approach across the five pillars of road safety—ducation, Engineering, Enforcement, Emergency Response and Engagement. These collaborations demonstrate that sustainable road safety outcomes are achieved when institutions, communities and individuals work together towards a common objective

As India continues its journey towards becoming a global mobility leader, the need for a stronger road safety culture has never been greater. Safer roads are built not only through better infrastructure or stricter enforcement, but through education, preparedness,

Ride Safe India continues to reaffirm this commitment by moving beyond awareness towards action—reating safer environments, empowering communities and encouraging responsible choices that protect lives. Because at its core, road safety is about people, and every life saved is a reminder that meaningful change is possible when responsibility becomes a shared habit rather than an individual choice.

Ride Safe India 2026 —Impact at a Glance

- **1.6 million+** people reached through Hero MotoCorp' decade-long road safety efforts-
- **2,500+** gig workers trained and certified as first responders under Surakshit Saathi
- **60+** schools covered through awareness and training programmes
- **10** Safe School Zones established with physical infrastructure
- **200+** women riders participated in the #SheRidesForSafety Night Rally, Gurugram
- **500** safety message standees across 100 fuel stations covered through community awareness drives
- **250** mobile billboards deployed as on-road safety reminders
- **7** cities Delhi, Gurugram, Lucknow, Hyderabad, Jaipur, Nagpur and Haridwar

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Engineering the Nation's Landmark Assets — Partnering with Leaders, Building for Generations

Company Profile: Navayuga Engineering Company Limited

Built on Execution. Proven at Scale

Infrastructure reveals its true value over time. In performance, in resilience, and in the ability to withstand real-world conditions. **Navayuga Engineering Company Limited** has built its journey around this principle, delivering projects defined by engineering precision and execution discipline.

Founded in 1986 by Dr. C. Visweswara Rao, the company has grown into a diversified infrastructure organisation with capabilities across *transportation, marine works, irrigation, and energy-linked sectors.* **Over four decades,** it has consistently operated in environments where complexity is high and execution demands absolute control.

Navayuga Engineering is also recognised as the ***force behind the large-span tunnel on the Mumbai-Pune Missing Link,*** recognised by **Guinness World Records** as the **"World's Widest Road Tunnel."** This milestone showcases the company's ability to deliver engineering at a global scale.

Leadership

Navayuga Engineering functions under the leadership of **Dr. C. Visweswara Rao,** *Founder and Chairman,* whose long-term vision has shaped the organisation's expansion across critical infrastructure sectors.

Mr. Chinta Sridhar, *Managing Director,* leads the company's execution strategy. With over two decades of experience, he has strengthened *Navayuga's position as a delivery-focused organisation, with emphasis on engineering clarity, cost discipline, and on-ground control.*

Execution Capability & Engineering Approach

Navayuga Engineering operates across roads & expressways, bridges, marine works, irrigation systems, and power-linked infrastructure, as part of the broader **Navayuga Group.** Its strength lies in executing complex projects that demand close alignment between design, engineering, and on-ground delivery. The company follows an engineering-led approach, guided by site conditions and long-term performance, integrating modern construction methods with real-time decisions to manage terrain, environment, and logistics with precision.

Landmark Projects

Navayuga Engineering's *portfolio includes several* ***high-impact infrastructure projects*** across *India:*

- **Mumbai-Pune Missing Link Tunnel**

  Construction of twin tunnels spanning over 10 km as part of expressway capacity augmentation

- **Polavaram Irrigation Project (Andhra Pradesh)**

One of India's largest national irrigation projects, where the company achieved a Guinness World Record for the largest continuous concrete pour in 24 hours in January, 2019.

- **Krishnapatnam Port (Andhra Pradesh)**

Developed by Navayuga Engineering under a public-private model, this is one of India's major deep-water ports.

- **Dhola-Sadiya Bridge (Assam)**

It was India's longest bridge over water when ii was inaugurated in 2017, executed as part of strategic connectivity infrastructure. It still remains the longest river bridge in India, spanning over 9.15 kms.

- **Teesta Stage III Hydroelectric Project (Sikkim)**

Complex tunneling and underground works executed under extreme weather and terrain conditions

- **Kaleshwaram and Dindi Irrigation Systems (Telangana)**

Large-scale water management infrastructure involving barrages, tunnels, and lift irrigation systems

- **Urban and Transport Infrastructure Projects**

Including elevated corridors, expressways, and metro-linked developments across multiple states

- **Deonar Bioremediation Project (Mumbai)**

One of India's largest waste management and land reclamation projects, aimed at transforming legacy landfill sites.

- **Quazigund to Banihal Project (Jammu & Kashmir)**

One of India's longest road tunnel that includes a 2-lane twin tunnel of 8.45 km each and 10 m in dia. aimed at shortening the distance between Srinagar and Jammu.

Outlook

India's infrastructure development is entering a phase defined by scale, integration, and technical complexity. **Navayuga Engineering** continues to align its capabilities with these demands. With a strong foundation in execution, sectoral diversity, and engineering depth, the company remains focused on delivering infrastructure that supports connectivity, resource management, and long-term economic growth. *It is focused upon executing complex projects with precision & delivering infrastructure that performs over time.*

Need for Collaborative Approach for Demarcating Speed Limit Zones in India: Enhancing Road Safety and Compliance

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1. Road Accidents and the Impact of Overspeeding in India

Road safety continues to be a major challenge in India, with the country recording one of the highest numbers of road accidents and fatalities in the world. According to data from the Ministry of Road Transport and Highways (MoRTH), in 2023, India reported a staggering 4,80,583 road accidents, resulting in 1,72,890 deaths. The leading cause of road deaths was overspeeding, which claimed over 1,17,000 lives, making up 68.1% of total fatalities - underscoring the urgent need for robust and scientifically planned speed management strategies.

High speeds reduce a driver's reaction time, increase braking distance, and magnify accident severity. Despite the existence of technical guidelines, inconsistent speed limits and improper installation of speed limit boards continue to contribute to overspeeding incidents. As the first line of communication between traffic authorities and road users, speed limit boards play a vital role in ensuring compliance and promoting safer driving behaviour. Therefore, the scientific placement, design, and visibility of these boards must be treated as an essential component of India's road safety strategy.

2. Importance of Speed Limit Zones and Planning Requirements

Speed limit zones are designated stretches of road where maximum - and sometimes minimum - speeds are prescribed based on a scientific evaluation of road characteristics and traffic behavior. These zones form a critical part of a comprehensive road safety management system, ensuring that speed regulations are not only enforceable but also logical and context sensitive. Well-planned speed limit zones serve multiple purposes:

a. **Safety Enhancement:** By reducing and limiting high speeds, these zones lower the likelihood as well as severity of accidents.
b. **Traffic Management:** Speed limits regulate vehicle flow, reducing congestion and enabling smoother traffic movement.
c. **Road User Awareness:** Clearly marked zones inform drivers about safe driving expectations, especially in transition areas such as school zones, built-up areas, curve sections, workzones and accident-prone stretches.
d. **Integration with Enforcement:** Speed zones provide legal backing for enforcement through fines, penalties, and automated speed monitoring systems.

Planning speed limit zones requires a comprehensive evaluation of multiple factors, including - road geometry, traffic composition, accident data, surrounding land use, environmental conditions, etc.

3. International Insights and Applicability

Nations like Sweden[1], the Netherlands[2], and Japan[3] demonstrate how science and collaboration can shape safer roads. Their success lies in combining evidence-based speed zoning, coordinated action between highway and enforcement agencies, clear and consistent signage, and strong public education. These efforts create what experts call “self-explaining roads,” where the road itself communicates safe speeds - reducing violations and promoting responsible driving naturally.

4. Current Practice of Speed Limits in India: Absence of Scientific Approach

Indian Roads Congress (IRC) guidelines provide technical specifications of speed limit sign board design in terms of size, shape, color, sitting warrants with respect to carriageway, etc [4]. It also specifies spacing of repeater and terminal speed limit signs for rural and urban situations. However, it does not specify the process of selection and installation of speed limit zones.

Due to absence of process of demarcation of speed limit zones in IRC or any other guidelines, practical application of speed limit boards often lacks scientific rigor in the Country. Many boards are installed based on administrative convenience rather than evidence-based assessment. Due to such practcies, following such issues are generally observed along Indian roads :

- **Arbitrary Speed Limits:** Roads with similar geometric and traffic characteristics may have vastly different speed limits due to administrative decisions rather than safety considerations.
- **Inconsistent Signage:** Speed limit boards are sometimes missing, poorly visible, or placed too close to curves or junctions, giving drivers insufficient reaction time. Also, the speeds are suddenly reduced from 100 kmph to 60 kmph or 40 kmph merely with the help of boards without any geometrical changes in road environment creating confusion in the road users and might lead to accidents.



Figure: 40 kmph speed limits boards installed along straight sections of National Highway

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1 https://www.itf-oecd.org/sites/default/files/sweden-road-safety.pdf

2 https://www.itf-oecd.org/sites/default/files/itf-safe-system-case-study-netherlands.pdf

3 https://www8.cao.go.jp/koutu/kihon/keikaku11/pdf/kihon_keikaku-g_en.pdf

4 https://www.scribd.com/document/616872076/IRC-67-2022

Across the country it is observed that, 40 kmph speed limit boards are suddenly installed at number of blackspot locations, accident prone locations and even at straight sections along the national highways with anticipation of engineering measure towards reducing traffic speed at such locations. Number of such arbitrarily installed speed limit boards were studied by safety team of Cube Highways Technologies to understand response of road users near these sign boards.



To evaluate the effect of 40kmph sign board, spot speed study has been carried out at two locations where these sign boards were installed along straight sections of national highways. Speed Study was carried out for three cases at same location to evaluate the effect of speed limit sign board on traffic stream.

a) About 100m after visible 40kmph speed limit sign board
b) About 100m after hiding 40kmph speed limit sign board
c) About 300m ahead of visible 40kmph speed limit sign board

Table: Results of Spot Speed Survey at 40kmph speed limit board along straight section of National Highway (Location-1)

Vehicle Type	About 100m after visible 40kmph speed limit sign board				About 100m after hiding 40kmph speed limit sign board				About 300m ahead of 40kmph speed limit sign board			
	50th Percentile Speed	85th Percentile Speed	98th Percentile Speed	Sample Size	50th Percentile Speed	85th Percentile Speed	98th Percentile Speed	Sample Size	50th Percentile Speed	85th Percentile Speed	98th Percentile Speed	Sample Size
Two Wheeler	52.9	65.3	86.9	154	53.9	65.1	80.8	158	52.2	64.4	77.8	142
Car	78.1	95.5	108.5	192	79.8	93.2	106.6	222	80.1	94.6	108.7	234
Bus	71.6	79.3	89.5	31	72.8	79.4	89.3	27	67.0	77.8	84.5	36
Truck	44.5	53.5	66.0	101	47.0	60.3	71.1	112	46.7	57.6	68.8	114
All Vehicles	**59.8**	**84.2**	**102.4**	**478**	**63.1**	**84.8**	**101.4**	**519**	**63.8**	**85.3**	**105.1**	**526**

Table: Results of Spot Speed Survey at 40kmph speed limit board along straight section of National Highway (Location-2)

Vehicle Type	About 100m after visible 40kmph speed limit sign board				About 100m after hiding 40kmph speed limit sign board				About 300m ahead of 40kmph speed limit sign board			
	50th Percentile Speed	85th Percentile Speed	98th Percentile Speed	Sample Size	50th Percentile Speed	85th Percentile Speed	98th Percentile Speed	Sample Size	50th Percentile Speed	85th Percentile Speed	98th Percentile Speed	Sample Size
Two Wheeler	50.2	62.1	73.4	178	50.6	67.0	83.2	153	49.7	60.6	80.5	144
Car	76.2	90.1	111.0	173	78.3	91.7	109.7	147	81.6	97.5	112.2	200
Bus	63.4	71.8	84.5	28	67.0	75.8	85.6	28	65.6	78.0	86.2	32
Truck	47.9	59.5	74.1	87	51.4	68.7	79.5	89	48.2	61.5	78.8	114
All Vehicles	**56.7**	**79.7**	**100.2**	**475**	**60.6**	**81.8**	**101.7**	**423**	**60.9**	**85.8**	**107.7**	**502**

From the above tables it can be observed that, 50th percentile speed and 85th percentile speed for all the three cases is almost similar at both the study locations. This shows that just by providing speed limit sign board we cannot reduce the traffic speed at locations.

Such installations resulting from absence of a structured, evidence-based approach leads to a fundamental problem that road users begin to perceive speed limits as advisory rather than mandatory. At the heart of this problem lies human psychology and behaviour. Road safety devices only work when drivers believe in their relevance. Unfortunately, overuse or improper use erodes that trust owing to following reasons: -

- **Familiarity Breeds Disregard:** On Indian highways, speed limit signs are placed anywhere - even in places without real hazards. Drivers, therefore, stop associating them with actual danger.
- **False Alarms and Selective Attention:** If every kilometer or two has a “Drive Slow” or non-related “Speed Limit” sign, the brain quickly learns to ignore them. When a real danger finally appears, the driver’s attention is already conditioned to dismiss warnings. This false alarm effect undermines safety intent.
- **Perceived Poor Planning:** When road furniture appears haphazardly - mismatched sizes, different fonts, or random placement - it gives the impression that safety is being managed reactively rather than intelligently. This perception, though subtle, affects how seriously drivers take official instructions.
- **Cultural Context:** In India, driver behavior is also shaped by peer movement, informal rules, and local knowledge rather than strict adherence to signs. Therefore, behavioral change cannot rely solely on hardware; it must be supported by engineering measures to influence behaviour and additionally through enforcement and education.

Effective communication, supported by engineering logic, is the key to restoring driver respect for speed control measures and enhancing compliance across India’s roads.

5. Need for Collaborative Strategy for Speed Limit zones in Inda

To rebuild credibility, speed limit boards must be scientifically justified, clearly visible, and context appropriate. When coupled with targeted enforcement and driver education, they regain their authority as credible safety tools rather than ignored road furniture.

A sustainable and effective speed limit strategy requires close coordination between highway authorities and enforcement agencies. The role of each stakeholder is critical. Highway Authorities shall be responsible for conducting road safety audits, analyzing traffic patterns, identifying high-risk zones, and installing speed limit boards based on engineering studies. They must ensure boards are strategically placed for maximum visibility and comprehension, following IRC standards for design, height, reflectivity, and distance between successive boards. Whereas Police and traffic enforcement departments need to ensure that posted speed limits are respected. Their role includes monitoring speeds through patrols, speed cameras, and other automated devices. Enforcement must be visible and consistent; without it, even perfectly placed boards may fail to influence driver’s behavior.



Decisions about speed limits should not be unilateral and should be based on integrated approach between authorities. Highway authorities must consult enforcement agencies to understand practical enforcement constraints, while enforcement teams should provide feedback on areas where drivers habitually exceed limits. Additionally, public awareness campaigns can reinforce compliance by educating drivers on the rationale behind specific speed limits.

6. Conclusion

- The high incidence of road accidents and fatalities in India, particularly those caused by overspeeding, underscores the urgent need to optimize design of speed limit zones and speed limit board installation practices. **Properly planned and**

strategically placed speed limit boards, developed through a scientific and evidence-based approach supported by engineering measures, can significantly enhance road safety and driver compliance.

- Effective speed management in India requires coordinated action among highway authorities, enforcement agencies, and public awareness programs. When guided by evidence, supported by road environment and enforced consistently, speed limits become a visible symbol of safety and responsibility, transforming compliance into culture and saving lives on the road. Speed limit zone transitions shall be ensured in Scientific and Collaborative manner by avoiding abrupt and sudden changes along the section of national or state highway.
- **To bring uniformity and credibility to speed management, the IRC must develop a scientific and transparent process for identifying, defining, and implementing speed limit zones.** Such a framework - driven by collaboration between highway authorities, enforcement agencies, and planners - should be mandated across India, with particular emphasis on national and state highways.

CITIZEN BUECHEL BIKETECH PVT. LTD.

Driving Innovation in Road Safety & Automotive Solutions

Citizen Buechel Biketech Pvt. Ltd. is a progressive Indo-German joint venture established in 2017 between Buchel GmbH & Co. KG, Germany, and Citizen Auto Components Pvt Ltd, India. With a strong foundation in precision manufacturing and advanced engineering, the company is committed to delivering high-quality automotive and road safety solutions aligned with global standards.

Backed by German technology and Indian manufacturing excellence, the company specializes in high-precision injection moulding, ultrasonic welding, and innovative product development. Its state-of-the-art manufacturing facility in Ludhiana, Punjab is equipped with advanced Industry 4.0-enabled systems, robotics, and process monitoring technologies to ensure efficiency, quality, and reliability.

Citizen Buechel has successfully developed and approved critical road safety products including Road Pavement Markers (Road Studs) certified by ARAI as per ASTM standards, along with Warning Triangles approved by ICAT under AIS-037 norms. These products are designed to enhance highway visibility, traffic guidance, and driver safety across India's rapidly expanding road infrastructure network.

The company's vision is to become one of the most preferred suppliers for Original Equipment Manufacturers (OEMs) globally by consistently delivering innovation, manufacturing excellence, and customer-centric solutions.

With continuous growth, strong R&D capabilities, and a commitment to safer mobility, Citizen Buechel Biketech Pvt. Ltd. is steadily emerging as a trusted contributor to India's road safety and automotive ecosystem.

IndiaRAP: Driving Safer Roads in India through Evidence-Based Infrastructure Assessment

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Introduction

India has one of the largest road networks in the world and plays a critical role in global mobility, economic development, and regional connectivity. However, road traffic injuries remain a major public health and development challenge. Each year more than **216,000**[5] **people lose their lives on India's roads**, and millions more suffer serious injuries. The socio-economic cost of road crashes is estimated at **USD 131 billion annually—around 4.2% of GDP**[6].

While progress has been made in enforcement, vehicle safety and post-crash care, a significant share of road trauma is associated with **unsafe road infrastructure**, particularly for vulnerable road users such as pedestrians, motorcyclists and cyclists.

IndiaRAP (Indian Road Assessment Programme) was established as a collaborative initiative led by the **Automotive Institute of Technology and Development (AITD)** in partnership with the **International Road Assessment Programme (iRAP),** initially supported by partners including the FIA Foundation and FedEx. IndiaRAP works with governments, development banks, research institutions and mobility organizations to improve road safety outcomes across the country.

Using globally recognized iRAP methodologies, IndiaRAP helps identify high-risk road environments, prioritize safety improvements, and support governments in delivering infrastructure aligned with the **Safe System approach**.

What IndiaRAP Does

IndiaRAP applies a structured methodology to identify high-risk road environments and prioritize cost-effective safety investments.

Road inspections collect geo-referenced imagery and information on key road attributes such as lane configuration, roadside hazards, intersections, pedestrian facilities, and speed environment. These data are analysed using the **ViDA platform**, which produces **Star Ratings** ranging from **1-star (highest risk)** to **5-star (safest)** for different road users including vehicle occupants, motorcyclists, pedestrians and cyclists.

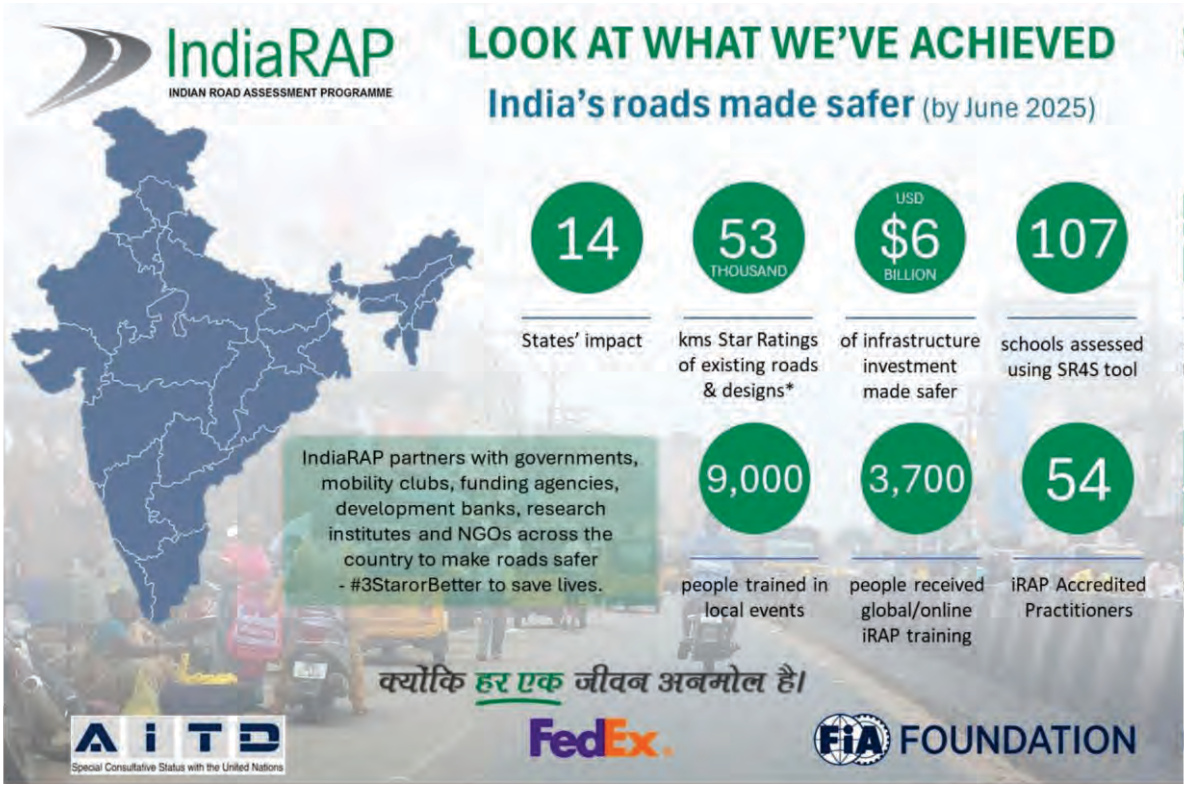
Based on this analysis, **Safer Roads Investment Plans (SRIPs)** identify engineering treatments that can raise road safety performance toward a **minimum 3-star standard**. Typical treatments include improved delineation, safer intersections, median separation, roadside protection, pedestrian crossings, and speed management measures.

This systematic approach enables governments to prioritize investments that deliver the greatest safety benefits relative to cost.

Progress of IndiaRAP

[5] Global status report on road safety 2023, WHO
[6] Safety Insights Explorer – iRAP. https://irap.org/safety-insights-explorer/

Since its launch, IndiaRAP has supported governments, development partners and infrastructure agencies across India in strengthening the safety performance of road infrastructure.



IndiaRAP as a Road Safety Management Tool

The iRAP methodology provides a practical tool for governments to manage road infrastructure safety systematically.

Unlike traditional approaches that rely mainly on crash history, iRAP assessments identify **high-risk road environments proactively**, enabling preventive action before crashes occur. The approach allows road agencies to measure infrastructure risk, prioritize investments using economic analysis, and evaluate the safety performance of both existing roads and new designs.

In India, these assessments are increasingly used to support planning, design review and investment prioritization within national and state road programmes.

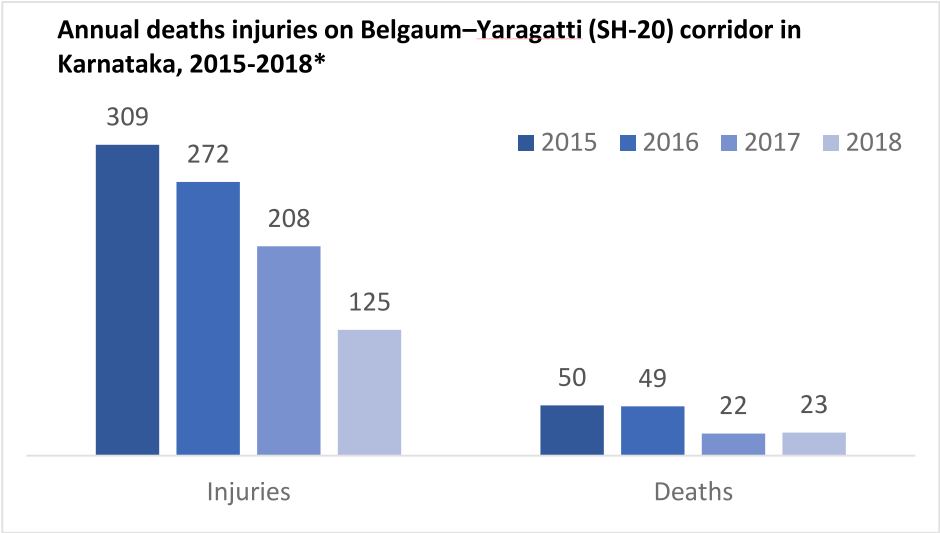
Case Studies from India

a) Karnataka – SH-20 Demonstration Corridor

The SH-20 Belgaum–Yaragatti corridor in Karnataka applied a **3-star or better safety target** with measures such as improved markings, safer intersections, pedestrian crossings and speed management.



The project recorded significant safety improvements, including **over 50% reduction in deaths and serious injuries**[7].



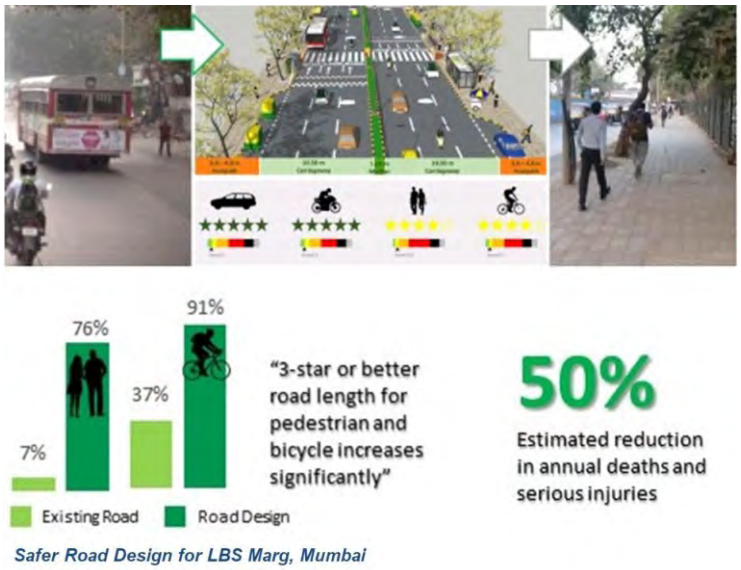
b) Gujarat – SH-55 Corridor

In Gujarat, iRAP assessments supported the upgrade of the SH-55 corridor, integrating median separation, improved intersections and pedestrian facilities. These improvements increased the proportion of the corridor achieving **3-star or better safety performance**.

[7] Sharief, M. & Reddy, K.S.K. (2018). Safe Corridor Demonstration Program on SH-20 (Yaragatti–Belgaum). Journal of the Indian Roads Congress, 79(3), Paper 682
Human lives need not be lost in road crashes—much less at current levels. https://blogs.worldbank.org/transport/human-lives-need-not-be-lost-road-crashes-much-less-current-levels-0

c) Mumbai – LBS Marg

In Mumbai, the LBS Marg corridor was redesigned to improve safety for pedestrians and cyclists through better sidewalks, crossings and traffic calming measures. The redesign significantly improved safety performance and is estimated to reduce **serious crashes by around 50%**.



Safer Road Design for LBS Marg, Mumbai

Supporting Global Road Safety Targets

IndiaRAP directly supports the **United Nations Global Road Safety Performance Targets**, particularly **Target 3 and Target 4**.

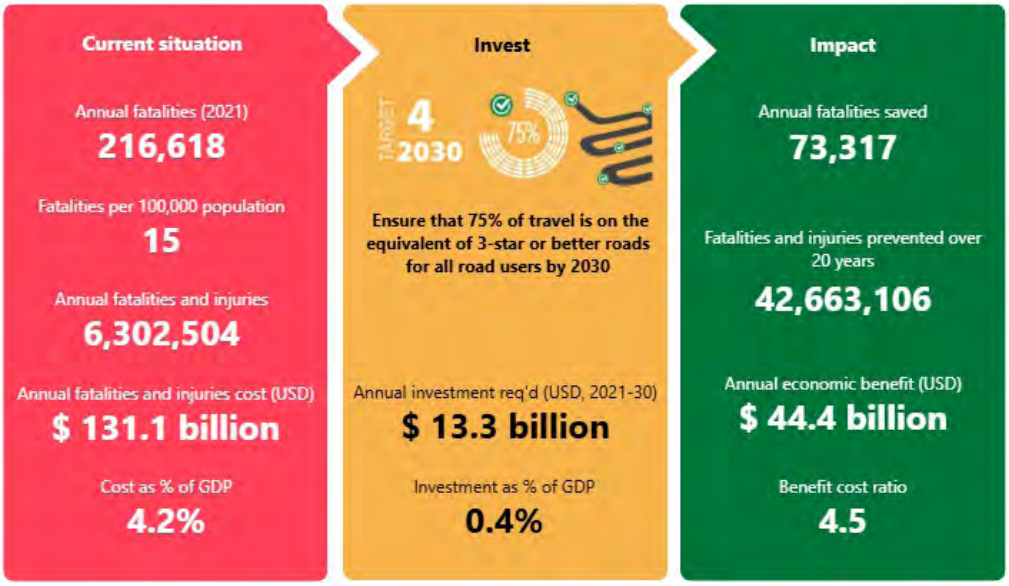
Target 3 calls for all new roads to achieve at least a **3-star safety rating** for all road users.

Target 4 aims to ensure that **75% of travel occurs on roads rated 3-star or better by 2030**.

Achieving these targets requires systematic assessment and upgrading of road infrastructure—an area where IndiaRAP provides a practical implementation framework.

The Business Case for Safer Roads in India[8]

Road crashes impose a major economic and social burden in India. Achieving **UN Target 4 — ensuring 75% of travel occurs on 3-star or better roads by 2030 — requires about USD 13.3 billion annually (0.4% of GDP)**. However, the investment would deliver substantial returns, saving **over 73,000 lives each year**, preventing **42.7 million deaths and injuries over 20 years**, and generating an estimated **USD 44.4 billion in annual economic benefits**.



[8] Safety Insights Explorer – iRAP. https://irap.org/safety-insights-explorer/

Looking Ahead

India has made substantial progress in expanding its road infrastructure, and programmes such as IndiaRAP have been established to support the systematic integration of safety into this development.

With a growing presence across states, IndiaRAP is well positioned to support the institutionalisation of proactive road safety management through risk assessment, economic analysis and capacity building.

Continued adoption of this approach will be critical for achieving national road safety ambitions and contributing to global efforts to reduce road traffic deaths and injuries.

User Acceptance of Autonomous Shuttles under Controlled Environments in India

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Introduction

Advancements in vehicle automation have accelerated the development of autonomous vehicles (AVs), which hold the potential to reduce human error-related crashes and enhance traffic efficiency. Despite the benefits of autonomous vehicles, the large-scale deployment of these vehicles is subject to existing traffic conditions, infrastructural readiness, inclusion guidelines, and public acceptance. User perception and acceptance play a critical role in determining the success and effectiveness of such technologies.

Past research has effectively employed theoretical frameworks such as the Technology Acceptance Model (TAM), the Theory of Planned Behaviour (TPB), and the Unified Theory of Acceptance and Use of Technology (UTAUT) to assess public behavioral intentions toward emerging technologies.

In this study, the UTAUT framework was adopted to evaluate user acceptance of a recently inaugurated Level-3 autonomous shuttle service at the Indian Institute of Technology Hyderabad (IITH). The framework considers performance expectancy, effort expectancy, social influence, hedonic motivation, and facilitating conditions as key predictors of adoption, moderated by demographic factors such as age, gender, and prior autonomous shuttle experience.

Methodology

A total of 228 participants were recruited from individuals who voluntarily boarded the autonomous shuttle operating within the institute campus. Participants completed a UTAUT-based questionnaire at the end of their trip, with optional assistance from a research assistant if needed. The survey employed a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) to evaluate items under each construct. **Table 1** summarizes the measurement items considered in the study. The questionnaire required approximately 12 minutes to complete, and responses were recorded anonymously. The travel route and shuttle operation have been presented in



Figure 2. (a.) Study route, (b.) Autonomous shuttle at roundabout, (c.) Autonomous shuttle at midblock section (yellow dashed line indicates the empty operator's seat).

Table 1. UTAUT questionnaire items used in the study.

Construct	Items (questions)
performance expectancy	**PE1:** Autonomous driving will make reaching destinations easier than conventional transportation **PE2:** Autonomous driving is safer compared to conventional transportation
effort expectancy	**EE1: The interaction** with the autonomous shuttle is simple and easy to understand **EE2:** Using the autonomous shuttle for transportation is easy
social influence	**SI1:** People whose views I trust would want me to use the autonomous shuttle **SI2:** People who influence my decisions believe **I** should use the autonomous shuttle
hedonistic motivation	**HM1:** Riding the autonomous shuttle is enjoyable **HM2:** Riding the autonomous shuttle is entertaining
facilitating conditions	**FC1: I have the knowledge needed to use the autonomous shuttle** **FC2: I have the resources to use the autonomous shuttle**
behavioural intention	**BI1:** If **I** had access to an autonomous shuttle, **I** would use it in the future **BI2:** If the autonomous shuttle becomes a permanent choice, **I** intend to use it

Results and Analysis

The mean values for each construct item have been presented in **Figure 2**. The error bars represent the standard deviation values.

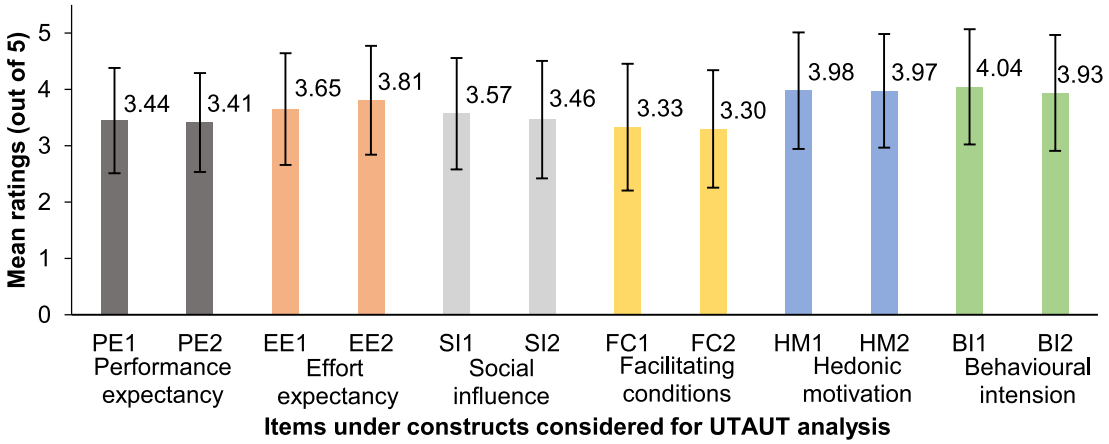


Figure 3. Mean and standard deviation ratings of items under the UTAUT constructs.

Principal Component Analysis (PCA) with varimax rotation was employed to perform factor analysis, and no cross-loadings were observed. Correlation analysis further indicated that all values were below 0.7, suggesting the absence of strong inter-construct relationships. Hierarchical multiple regression was then conducted to evaluate the UTAUT model (see Table 5). To address multicollinearity, all independent variables were mean-centered, and interaction terms for moderation analysis were derived from these centered variables.

The regression analysis was carried out in three steps (as shown in **Table 2**),
Step-1: Predictor variables (social influence, hedonic motivation, facilitating conditions, performance expectancy, and effort expectancy).
Step-2: Moderator variables (gender, age, and ride experience).
Step-3: Interaction terms (for moderation analysis).

Table 2. Results from Hierarchical multiple regression.

Step		Step 1 β	Step 2 β	Step 3 β	R^2	ΔR^2
1	*Performance expectancy*	0.024	0.005	-0.038		
	Effort expectancy	0.129*	0.125*	0.124		
	Social influence	0.039	0.047	0.112	0.523	0.523
	Facilitating conditions	0.12*	0.126*	0.137		
	Hedonistic motivation	0.579**	0.592**	0.529**		
2	*Age*		-0.128**	-0.182**		
	Gender		-0.102*	-0.099	0.546	0.023
	Ride experience		0.076	0.122		

Dependent variable = *Behavioural intention*.
* $p < 0.05$, ** $p < 0.01$.

Findings

The findings of the study revealed that facilitating conditions, effort expectancy, and hedonic motivation positively influenced users' behavioral intentions toward autonomous shuttle use. Among these, hedonic motivation emerged as the strongest predictor, suggesting that users' intentions were primarily driven by the enjoyment associated with the TACS ride. However, as this technology becomes common and easily accessible to the public, the willingness to use the autonomous shuttles for travel based on pure excitement alone may diminish.

The significant effect of facilitating conditions highlighted the importance of providing supporting resources for enhancing autonomous shuttle usage. The knowledge about the benefits of autonomous shuttles, user guidelines, and availability of resources could positively impact the autonomous shuttle. Also, the focus on setting up the necessary infrastructure for these systems and broad advertisement of the vehicle's capabilities through public outreach could further strengthen acceptance and long-term use of such services.

The positive influence of effort expectancy underscores the role of a simple, user-friendly interface in improving willingness to use autonomous shuttles. This finding suggests that users prefer travel modes requiring minimal effort, reinforcing the need for intuitive system design and ease of operation.

When examining moderation effects, age and gender were found to significantly influence behavioral intentions. The findings revealed that younger users demonstrated a higher

willingness to use the autonomous shuttle than their older counterparts. This could be due to the early exposure of high-end technology among youngsters, leading to their strong belief and excitement towards using newer technology. Also, the significant effect of gender indicated that female users tend to display a lower willingness to use the shuttle service compared to male users. This could be because the female users perceived higher risks with the AS than with conventional vehicles, or they lacked trust in this newly introduced autonomous technology. Over time, as autonomous vehicles become more prevalent and familiar under similar traffic conditions in India, it is expected that female users' willingness to adopt such systems will increase.

Practical Applications

The study is among the first of its kind in India, addressing a critical research gap present due to the lack of technology and infrastructure for autonomous mobility. The findings from the study could support government organizations in formulating policies for autonomous shuttle operations within controlled environments such as university campuses, ports, airports, military bases, and industrial complexes with comparable infrastructure, travel characteristics, and user demographics.

The findings also provide practical insights for technology developers, transport planners, and service providers to facilitate the effective deployment of autonomous shuttles in similar environments in India. Furthermore, the insights could be utilized by insurance companies in designing suitable coverage and compensation schemes tailored for autonomous shuttle operations.

Overall, the study provides valuable region-specific insights for similar road environments, enabling the cross-country comparative research on autonomous shuttles between similar regions.

Study limitations and future scope

The study was conducted within the IITH campus using the autonomous shuttle service operating on a 4.4 km internal road network. This could be considered a limitation, as the study findings may be applicable to autonomous shuttle services running in similar road environments but may not fully reflect the Indian traffic and road conditions in general, considering differences in traffic flow, density, and composition.

The autonomous shuttle service was provided free of charge to all users within the institute campus, which could have affected the acceptance of the TACS service. Future studies should examine the impact of the travel cost on the user perception and acceptance of autonomous shuttle services in similar environments.

The relatively limited sample size was another constraint of the present study. Expanding the sample in future investigations, while incorporating additional variables such as education level and income, could provide a more comprehensive understanding of autonomous shuttle acceptance behavior. Future studies could also examine the influence of operational factors such as service trip frequency and timing, as well as the perceptions of other road users sharing the same route.

Opportunities, Challenges, and the Road Ahead for ADAS in India

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Introduction

The total number of fatalities related to crash in India account 1.68 lac which is 11% of the total road fatalities around the world. Unfortunately, India ranks at the top in this regard (MoRTH, 2023). Various initiatives such as the enhanced vehicular technologies (by adopting international standards) and infrastructure engineering (ITS measures and safer conditions for vulnerable road users) as well as raising awareness towards the road safety have been adopted by Government of India. But these initiatives fail to meet the expected outcomes. While infrastructure expansion has been significant, road safety outcomes remain a major concern. Emerging vehicle technologies, especially Advanced Driving Assistant System (ADAS) has the potential to be the market shifter towards safer and efficient transport system. However, their development and deployment customised to Indian mixed traffic conditions remain limited. Longitudinal and lateral controls are two fundamental components of driving task, both of which require continuous monitoring by driver to prevent crashes (Gupta, 2024). In these context, ADAS supports drivers in assisting these tasks to prevent crashes.

Understanding ADAS

ADAS is designed to assist drivers in preforming driving tasks safely. They do not replace drivers instead support them in enhancing situational awareness and reducing crash risk while driving. The commonly used ADAS systems (presented in Figure 1) are as follow

- Adaptive Cruise Control (ACC): Maintain predefined distance from front vehicle and adjust speed accordingly.
- Forward Collision Warning (FCW): Warn driver about potential collision from front.
- Automatic Emergency Braking (AEB): Sense imminent collisions and automatically engage the brakes
- Lane Departure Warning System (LDWS): Notifies driver if he/ she unintentionally starts deviating from lane.
- Lane Keep Assist (LKA): Keeps the vehicle within lane markings automatically
- Blind Spot Detection (BSD): Helps drivers to avoid unsafe lane changes when objects are vicinity to vehicle (in blind spots).

Multiple types of sensors are used for deployment of ADAS system in vehicle such as LiDAR (high-resolution 3D perception), radar (distance and speed measurement), camera (object detection, classification, lane marking tracking, etc.) and ultrasonic sensors (detect short range obstruction). Further, many of the systems used sensor fusion technique to get precise real time information of vehicle's surroundings (Gupta et al., 2024).



Figure 1 Different type of ADAS used for improving safety

Driving automation levels and current status of ADAS in India

As per the global classification described by Society of Automotive Engineers (SAE), driving automation is divided in six levels starting from no-automation (level 0) to full automation (level 5) (SAE Standard, 2014). Figure 2 describes the difference in various automation levels. According to SAE, Level 0-2 are described as driver assisting features where human drivers must continuously driving the vehicle and remain responsible for dynamic driving tasks (DDT). On contrary, level 3-5 are defined as automated driving features in which system will conduct all the required DDT with monitoring responsibility shifting from humans to machines. Majority of vehicles provide level 1 and 2 automation levels only. These systems are used to assist drivers in providing steering control and acceleration and deceleration, and continuous driver supervision.

The development of autonomous vehicles in India is still in early stages, and currently, country only operates at SAE level 1-2 automation by utilizing ADAS. ADAS penetration in India has become prominent in past few years, especially in mid to high end cars. The ADAS system often face challenges on Indian highway environments with faded or missing lane markings, poor lane discipline, sudden cut-ins by two-wheelers, undefined vehicle classes, pedestrian jaywalking, etc.

Further, there are no comprehensive regulatory framework/ guidelines available regarding Levels 3–5 automated driving by Ministry of Road Transport and Highways. Therefore, at present, autonomous vehicle deployment remains largely limited to research, testing and ADAS based driving assistance technology development. The major concerns of deployment of autonomous vehicles on Indian roads are public acceptance, employment impacts, mixed traffic conditions, and infrastructure readiness. As India is rapidly progressing across multiple fronts, the adoption of advanced automation technology is expected in the near future.

Developing India specific Lane Departure Warning System (LDWS)

In the context of India, ADAS are often directly transposed from developed nations, overlooking the driving behaviours and conditions specific to the Indian context. It is well recognized that there exist considerable cultural differences in driving habits. Among the advancements in driver assistance systems, Lane Departure Warning Systems (LDWS) have a critical role in monitoring the position of a vehicle in its lane. Lane departure occurs when a vehicle unintentionally changes lanes due to driver distraction or fatigue. Such occurrences have been identified as major contributors to road accidents.

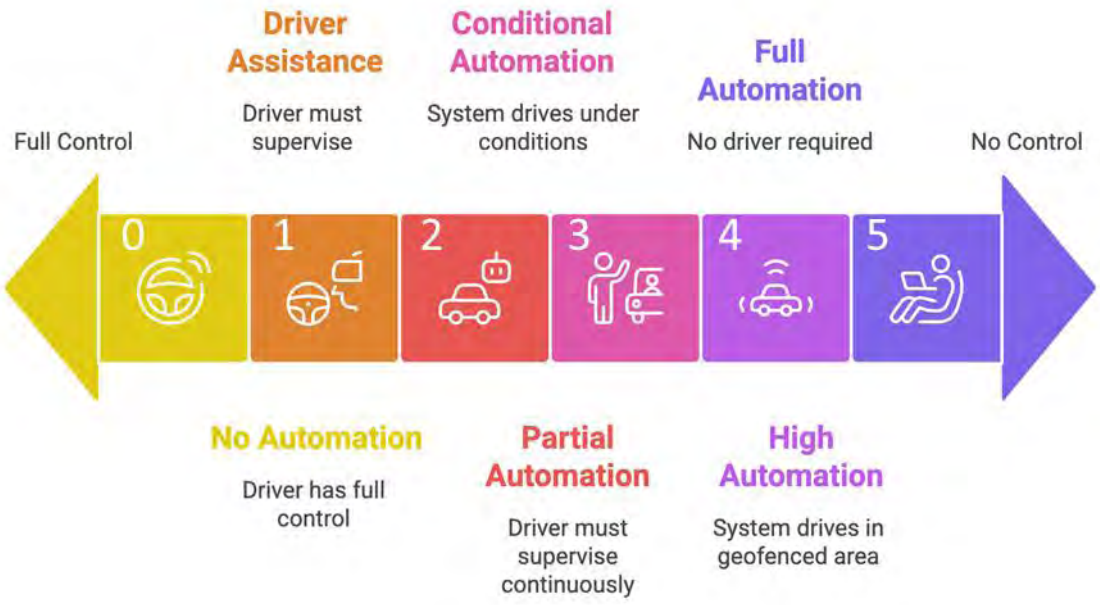


Figure 2: Different level of automation as per SAE

LDWS continuously captures the lane marking and vehicle trajectory, and this will help to get the vehicle's position corresponding to lane markings. When the system detects that vehicle is drifting from the lane without initiating the turn indicator, the system starts generating warning which can be in various forms such as visual, audible, or haptic warnings, enabling timely corrective action and reduce the risk of potential crashes. This technology or system majorly works on camera or LiDAR sensors to get the perception of surroundings and detect vehicle's drifting from lane and immediately generate warning to prevent unintentional drifts. Among these technologies, LiDAR-based systems offer a few advantages in lane detection and environmental perception. LiDAR sensors generate detailed 3D representations of the surroundings, enabling more accurate detection of lane boundaries and improving reliability across different driving conditions including low light conditions. Given the unique characteristics of Indian traffic including heterogeneous vehicles, varying infrastructure quality, and diverse driving behaviour, the development of ADAS solutions tailored specifically to Indian conditions is essential for achieving effective and reliable deployment (Gupta et al., 2024). Recognizing this need, development of an ADAS tailored to Indian drivers, designed to operate effectively under various lighting conditions has been initiated. The overall process for developing LDWS using sparse LiDAR is presented in Figure 3. The proposed system utilizes sparse point cloud data obtained from a **16-beam LiDAR sensor** mounted. The system supports lane discipline and enhances road safety by detecting potential lane departures and warning drivers before such events occur.

This research addresses an important gap in the development of **Lane Departure Warning Systems (LDWS)** under diverse driving conditions while contributing to the broader objective of improving roadway safety. The system considers three types of lateral vehicle movements:

(a) Driving over lane markings without using indicators, which reflects poor lane discipline;
(b) Lateral drifting within the lane, often associated with inattentive driving; and
(c) Unintended lane changes without indicator usage.

Warnings are generated based on the severity of these movements.

Figure 3 Overall process for developing LDWS using sparse LiDAR

Closing Remark

While ADAS technologies are progressively moving into the Indian automotive market, their effectiveness is constrained due to mixed traffic conditions, driving behaviour complexity and infrastructural variability of India roads. These challenges present the need to develop ADAS solutions customised for Indian conditions which can work effectively in Indian driving scenarios. Further, it is also recommended to develop the comprehensive regulatory and testing framework for higher levels of vehicle automation which can guide the safe and advanced automated mobility in India.

References

Gupta, A. (2024). Driving Behaviour Assessment and Safety Analysis on Expressways in India. Doctoral Thesis,Indian Institute of Technology Roorkee.

Gupta, A., Jain, S., Choudhary, P., & Parida, M. (2024). Dynamic object detection using sparse LiDAR data for autonomous machine driving and road safety applications. Expert Systems With Applications, 255(PB), 124636. https://doi.org/10.1016/j.eswa.2024.124636

Gupta, A., Jain, S., & Choudhary, Pushpa, Parida, M. (2024). Development of a Real-Time Lane Departure Warning System for Varying Severity Levels Using a Sparse 3-D Lidar Sensor. Transportation Research Record, 2679(2), 1–23. https://doi.org/10.1177/03611981241277752

MoRTH. (2023). Road Accidents in India (Vol. 33, Number 1). https://doi.org/10.1016/s0386-1112(14)60239-9

SAE Standard. (2014). Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. SAE International. https://doi.org/https://doi.org/10.4271/J3016_202104

Himachal Pradesh: A Data-Driven Transformation in Road Safety

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Introduction

For nearly a decade (2011–2020), Himachal Pradesh recorded over 1,100 road crash deaths annually—equivalent to 15–16 deaths per 100,000 population, significantly above the national average of 11.4 in 2019. Despite investments in blackspot rectification before 2015, the absence of systematic, reliable crash data meant these interventions did not yield substantial improvements.

A shift occurred in 2015 when the Government of Himachal Pradesh (GoHP), through HPRIDCL, adopted a **data-driven and evidence-based approach** to road safety. This strategic change has delivered measurable results. By 2024, the State achieved a **30% reduction in road traffic fatalities and injuries**, despite a sharp rise in exposure—reflected in increased road travel, tourist arrivals (1.72 Cr in 2019 to 1.85 Cr in 2024), and a 37% growth in GSDP (₹1.65 Lakh Cr to ₹2.27 Lakh Cr).

This progress is the outcome of two phases supported by the World Bank:

- **Phase 1 (2015 – 2019 and continuing) –** Data collection or evidence gathering phase
- **Phase 2 (2021 – continuing):** Implementing targeted, evidence-based safety interventions across engineering, enforcement, and emergency response.

Phase 1: Establishing the Evidence Base (2015–2019)

To build a scientific foundation for road safety, HPRIDCL engaged TRL to implement a customized version of the iMAAP crash data system—**HP RADMS**, completed in 2016. Tablets were supplied to all police stations, and extensive training was delivered to police, PWD engineers, and transport officials.

Between 2016 and 2019, HP RADMS enabled:

- Statewide training on digital crash reporting and data analytics
- Evidence-driven identification of crash types, risk locations, and key behavioural/ engineering issues
- Institutional strengthening and development of analytical capacity within police and PWD

This period laid the groundwork for targeted interventions in the subsequent phase.

Phase 2: Implementing Evidence-Based Road Safety Improvements (2021–ongoing)

The project “Himachal Pradesh Road Safety Advisory Services (HP RSAS)” launched in 2021, aims to build multi-sectoral capacity across road engineering, enforcement, emergency response, and policy implementation. TRL led the programme with support from CEG and Sherwood.

The scope of work covered six major components:

Task 1: Road Infrastructure Safety Surveys & iRAP Assessments

Analysis of HP RADMS crash data from 2016 to 2021 led to identification of the pilot districts - Shimla, Kangra, and Mandi and major risks on the road network. In-depth crash data analysis laid the foundation of the various interventions and strategies adopted at different stages throughout the project. Four predominant crash types—**single vehicle run-off,**

head-on, pedestrian impacts, and junction crashes—accounted for **95%** of death and severe injuries. **Star rating** for **7,000 km (NHs + MDRs)** using iRAP and preparation of Safer Road Investment Plans (SRIP) were prepared. **Mass Action Plans** for 285 high-risk clusters and **Corridor Plans** for 16 priority corridors (566 km) were developed. Statewide guidelines for engineering safety improvements were documented and trainings for **200 engineers** on iRAP **methodology & measures to carry out road safety improvements utilizing crash data**. The iRAP assessments and plans were successfully embedded in the State's road safety improvement roadmap for **PWD, NHAI, MoRTH, and BRO.**

Task 2: Strengthening Patrol and Emergency Response

This task focused on enhancing enforcement capabilities aligned with MVAA 2019. The key outputs:

- Identified the surveillance, patrol, enforcement, rescue and emergency response equipment to be procured in each police station in all districts. This included Integrated Road Safety Enforcement System (IRSES) to detect violations viz., seat belts, helmets, hazardous overtaking, over speeds, use of mobile phones, etc., through a single control centre linked to AI based cameras installed in 3 pilot districts across the network.
- Recommended procurement value: **₹86 Cr**, including **₹56.56 Cr** for the IRSES, featuring AI-enabled violation detection across three pilot districts.

This has reinforced the district-level enforcement capability through surveillance, patrol, enforcement, and and improved readiness for rescue and emergency response.

Task 3: Community-Driven Road Safety Program

Two key initiatives were delivered under this task

- **Good Samaritan Law Campaigns** - Good Samaritan Law campaigns across 7 districts (Shimla, Kangra, Mandi, Solan, Simrour, Una & Kullu) were conducted, with the team reaching out directly to around 5,000 citizens across 7 districts distributing pamphlets and creating awareness about Good Samaritan Law. These 7 districts account for more than 85% road traffic deaths and injuries in Himachal.
- **First Responder Training** - Comprehensive training programme was conducted in 11 sessions covering 7 Districts. 130 Home Guards, 151 Police Officers (including 34 State Disaster Response Force (SDRF) Officers) received training as First responders & Trainers. First responder training booklets were issued to trainees. Senior management of Police and Home Guards in the districts attended the opening and closing ceremony of each training programs. This developed a trained cadre capable of cascading emergency response skills statewide.

Task 4: Organisational Strengthening & Training of Police

This included assessment of of the existing organizational structure of Police, development of district-wise enforcement plans and annual procurement strategies, recommendations for restructuring traffic enforcement units and training of **300 police & home guard personnel** in traffic enforcement, crash investigation, and MVA compliance via Institute of Road Traffic Education (IRTE). This task led to a more structured and strategic enforcement framework aligned with the Safe System approach.

Task 5: Safe Corridor Demonstration Program (SCDP)

Four most vulnerable corridors were assessed using iRAP star ratings, audits, user surveys, and speed studies. The **Palampur–Sheela Chowk (34 km)** corridor was selected for SCDP implementation. As part of this exercise Detailed Project Report (DPR) elaborating engineering treatments to improve road safety on the corridor including bidding documents, Environment and Social Management Plan (ESMP), enforcement & emergency response

equipment plan, various road safety targets to be achieved in the corridor, details of the enforcement equipment (cameras, patrol vehicles, etc.), emergency response equipment to be procured for the corridor including the location of installations and the implementation plan were prepared.

Task 6: Statewide Road Safety Action Plan & MVAA 2019 Advisory

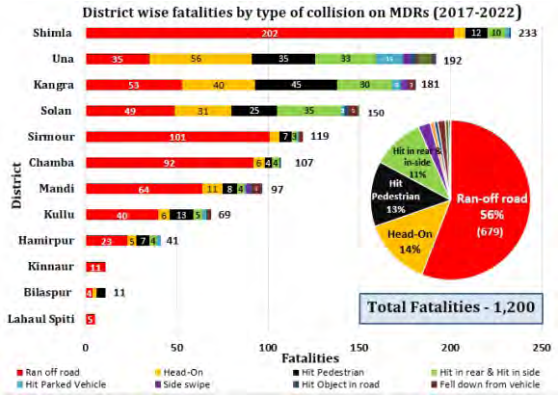
A comprehensive road safety roadmap and action plan covering road safety targets, various plans for institutional framework, safer road users, safer road infrastructure and improved post-crash care to be implemented by respective agencies viz., Lead Agency/ Transport Department, PWD, Police and Health department. The action plan included:

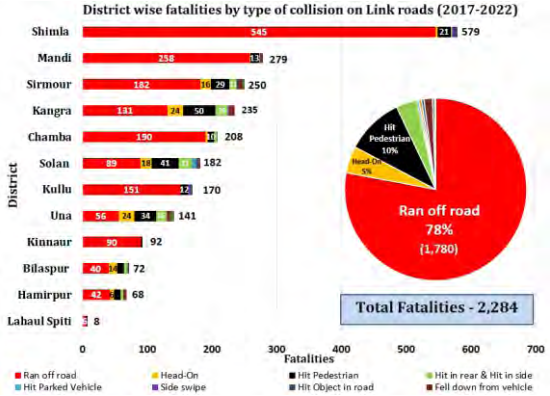
- Policy reforms, behavioural programmes, and institutional strengthening
- Engineering interventions for road agencies viz., Safe infrastructure plans for **NHs, MDRs, and Link Roads**
    - MDRs: ₹167 Cr over 5 years
    - NHs: ₹343 Cr over 5 years
    - Link roads: ₹3,200 Cr over 10 years (20% of network)
- Action plans for police department
- Post-crash care improvement programs and measures for health department.

The action plan was prepared aiming to achieve the following targets:



Discussion: What Enabled Himachal's Success?





Himachal's progress, especially the 30% fatality reduction from 2019 to 2024, can be attributed to:

- **High-quality crash data -** HP RADMS enabled the Police and PWD to identify the key risks leading to deaths and injuries on different types of the road network, as shown in the Figures below. This was possible due to the implementation of a robust crash data management and in-depth crash data analysis. This lead to the identification of high-risk corridors, predominant crash types, at-risk road users (cars, two-wheelers, pedestrians = 76% of KSIs)
- **Evidence-based engineering interventions** - Significant reduction in run-off crashes due to targeted crash barrier installation (PWD-NH, PMGSY, MoRTH). Reduced head-on and pedestrian crashes on MDRs due to enforcement and minor safety treatments.
- **Strengthened enforcement** - Active enforcement (helmets, seat belts, parking violations) coincided with fatality reduction, especially on MDRs lacking major engineering upgrades.
- **Recognised gaps on the road network** - Crash increases on NHs highlight the need for better speed management, junction design, pedestrian facilities

These are addressed in the 2025–2030 action plans.

Safeguarding the project outcomes

Key recommendations include:

- Ensuring correct use of surveillance and emergency equipment
- Establishing an asset management system for police equipment
- Ensuring adequate police staffing for enforcement plans
- Phased rollout of enforcement improvements across remaining districts
- Empowering the Lead Agency with statutory authority
- Sustained funding (~₹4,000 Cr over 10 years) for engineering upgrades across networks

Recognition

HPRIDCL was awarded the **"Shining Star" iRAP Gary Liddle Memorial Trophy (2025)** for global excellence in eliminating high-risk roads. TRL was also honoured by the Governor of Himachal Pradesh for its contributions in deploying HP RADMS and enabling evidence - based enforcement and engineering.

Himachal Pradesh now stands as a **national leader in road safety**, breaking the trend of rising crashes across most Indian states.



TRL accepting the "Shining Star" iRAP Gary Liddle Memorial Trophy on behalf of HPRIDCL in Feb' 2025 at Marrakech



TRL receiving the award from the Governor of Himachal Pradesh

Sustainable Urbanism in a Greenfield Context: The Integrated Transport Blueprint of Amaravati, Andhra Pradesh, India

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Abstract

The bifurcation of erstwhile Andhra Pradesh in 2014 created an opportunity to plan a new capital city on a greenfield site along the southern bank of the River Krishna. This article examines the Amaravati Traffic and Transportation (T&T) Master Plan as a prototype for sustainable urban mobility in the Global South. The plan aims to achieve an 80% sustainable modal share through integrated land-use and transport planning, Transit-Oriented Development (TOD), extensive non-motorised transport (NMT) networks, and technology-enabled infrastructure. The paper analyses how Amaravati operationalises the Avoid–Shift–Improve framework and integrates intelligent transport systems with long-term infrastructure planning. The discussion compares Amaravati with earlier Indian planned capitals and highlights both the opportunities and governance risks of greenfield megaprojects. While implementation challenges remain, Amaravati's transport blueprint provides an important reference for emerging cities seeking to embed low-carbon, people-centric mobility from the outset.

Keywords: Amaravati; sustainable urban transport; greenfield planning; Transit-Oriented Development; non-motorised transport; Intelligent Transport Systems; modal shift.

1. Introduction

Urban transport planning in most large cities involves retrofitting modern mobility systems into already congested urban environments. Cities such as Delhi, Bengaluru, and Hyderabad have struggled to integrate metro systems, bus rapid transit (BRT), and safe pedestrian infrastructure into dense urban fabrics dominated by private vehicles. Andhra Pradesh Capital Region Development Authority (APCRDA) is Authority for the Development of new green field capital city (in 217 sq km), Amaravati along the River Krishna, located within a larger 8603 sq km capital region influenced by the urban centres of Vijayawada, Guntur, Tenali, Mangalagiri, and Tadepalli.

Within this context, the Traffic and Transport (T&T) Master Plan proposes a long-term strategy to prevent car dependency by prioritising public transport, non-motorised mobility, and integrated urban infrastructure from the earliest phases of development. Rather than addressing congestion after it emerges, Amaravati seeks to design a transport system that promotes sustainable and people-centric mobility from the outset.

2. Conceptual and Policy Background

2.1 Sustainable Mobility and the Avoid–Shift–Improve Framework

Contemporary sustainable mobility policy is frequently organised around the Avoid–Shift–Improve (ASI) framework. The approach emphasises reducing unnecessary travel, shifting trips toward sustainable modes such as public transport and active mobility, and improving vehicle technology and fuel efficiency. In India, national policy frameworks such as the National Urban Transport Policy (NUTP) emphasise the need to prioritise people rather than vehicles. However, many cities have continued to expand road infrastructure while underinvesting in mass transit and pedestrian environments, contributing to rising congestion, pollution, and road safety risks. Greenfield developments like Amaravati offer the opportunity to embed sustainable mobility principles directly into urban structure, avoiding the need for costly retrofitting later.

2.2 Transit-Oriented Development and Active Mobility

Transit-Oriented Development (TOD) integrates land use with high-capacity transit networks by promoting compact, mixed-use development around stations. TOD strategies encourage walking, cycling, and public transport use while reducing dependence on private vehicles. Active mobility is central to this model. In Indian cities, non-motorised transport includes walking, cycling, and informal modes such as cycle rickshaws and handcarts. Effective NMT planning therefore requires continuous pedestrian networks, safe cycling infrastructure, and street designs that prioritise vulnerable road users.

2.3 Intelligent Transport Systems

Intelligent Transport Systems (ITS) enable real-time monitoring and management of urban mobility networks. In Amaravati, ITS technologies—including Area Traffic Control Systems (ATCS), Automated Number Plate Recognition (ANPR), Red-Light Violation Detection (RLVD), and Variable Message Signs (VMS)—are proposed as part of an integrated traffic management platform supporting safety, efficiency, and user information.

3. Study Area and Planning Framework

3.1 The Amaravati Capital City

The Amaravati Capital City occupies 217 sq km in Guntur district, with development planned across 24 revenue villages and part of Tadepalli Municipality. The broader Capital Region includes 953 villages and 12 urban local bodies. The capital city plan structures development into multiple townships and thematic zones connected by major transport corridors. Existing settlements such as Thullur, Tadepalli, and Mangalagiri are expected to anchor early phases of urban growth.

3.2 Population and Employment Projections

The T&T Master Plan adopts a planning horizon extending to 2050. By that year Amaravati is projected to reach approximately 3.96 million residents and 2.47 million jobs, making it one of India's largest planned cities. The model assumes a per capita trip rate of around two trips per person per day, indicating significant growth in mobility demand as the city develops.

3.3 Travel Demand and Mode Split

Extensive household travel surveys and traffic studies were conducted across the capital region. The surveys revealed a motorised per capita trip rate of approximately 0.87, with an additional 0.52 trips made by non-motorised modes. About 35 percent of trips were already made using NMT, highlighting the importance of preserving and strengthening walking and cycling infrastructure to prevent a shift toward private motorisation.

4. Strategic Goal: Achieving 80 Percent Sustainable Modal Share

A defining feature of Amaravati's transport strategy is the target that 80 percent of all trips be made by public transport and non-motorised modes, while private motorised travel remains limited to about 20 percent. The plan aims for approximately 50 percent public transport share and 30 percent NMT share at full development. Achieving this goal requires a combination of incentives and restrictions. High-quality transit networks, integrated ticketing, and pedestrian-friendly streets act as "pull" measures, while parking management and the strategic placement of transport terminals act as "push" measures discouraging excessive car use. To operationalise these goals, the plan adopts the 5–10–15 accessibility rule as mentioned below. Embedding this rule within land-use planning ensures that most daily trips can be made without private vehicles.

- Residents should be within a 5-minute walk (300–500 m) of a local bus or feeder stop.

- Major activity centres should lie within a 10-minute walk (800–1000 m) of a BRT corridor.
- High-density corridors should be within a 15-minute walk of mass rapid transit stations.

5. Multi-Modal Integration and Network Design

5.1 Regional Connectivity

Amaravati is strategically located at the intersection of National Highways 16 and 65 and forms part of the East Coast Economic Corridor. Regional connectivity is supported by highways, rail networks, and proposed inland water transport along the Krishna River.

5.2 Hierarchical Road Network

The city's road system follows a clear hierarchy of major arterial, arterial, sub-arterial, and collector roads. Major corridors have right-of-way between 50 and 60 metres, accommodating mixed traffic lanes, BRT corridors, wide sidewalks, and segregated cycle tracks along with planation including avenue plantation to make city as sustainable. The Seed Access Road, a 60-metre road connecting the initial development area to regional networks, demonstrates this integrated approach by combining bus rapid transit infrastructure, pedestrian pathways, cycling lanes, and green buffers within a single cross-section.

6. Reclaiming Streets for People

Pedestrian and cycling infrastructure form the foundation of Amaravati's Street design philosophy. Street guidelines prioritise pedestrians first, followed by public transport and non-motorised transport, with private vehicles receiving the lowest priority. Typical arterial road sections allocate three metres each for sidewalks and cycle tracks on both sides, separated from vehicle lanes by landscaped buffers. Native tree planting provides shade and reduces heat stress, improving walking conditions in Andhra Pradesh's hot climate. Intersections incorporate pedestrian priority features, while ITS technologies such as pedestrian signals and smart crossings further enhance safety.

7. The "Invisible City": Underground Infrastructure and Canal Network

A distinctive feature of the Amaravati plan is the creation of integrated underground utility corridors. Indian cities frequently face repeated road excavations for infrastructure maintenance, causing traffic disruption and infrastructure damage. Amaravati addresses this issue through pre-planned subterranean utility systems carrying electricity, water supply, sewerage, gas pipelines, and ICT networks. This approach allows maintenance and upgrades without disturbing surface infrastructure. Stormwater drains and sewer systems are placed along outer corridors, while electrical and communication ducts run beneath medians and sidewalks. Dedicated ITS infrastructure chambers ensure the reliability of digital transport systems. As a part of Flood Mitigation Plan, 48.3 km canal network is planned and under implementation. Upon completion of the canal network the same shall also be utilised for the movement of passenger and cargo similar to European countries.

8. Discussion: Opportunities and Challenges

Compared with earlier planned capitals such as Chandigarh and Gandhinagar, which were designed around automobile-oriented modernist planning principles, Amaravati represents a shift toward transit-oriented and people-centric urban design. However, implementation depends on strong governance and sustained political commitment. Coordinating multiple agencies responsible for roads, transit, policing, and land-use regulation will require institutional capacity and long-term policy consistency. Financing also remains one of the key challenges. With many large greenfield projects, delays or partial implementation could create path dependency toward private vehicle use.

9. Conclusions

The Amaravati transport blueprint illustrates how sustainable mobility principles can be embedded within the planning of a new city. By linking explicit modal share targets with transit-oriented land use, integrated street design, and advanced digital infrastructure, the plan attempts to create a mobility system centred on public transport and active travel.Greenfield planning allows the early integration of pedestrian networks, cycle infrastructure, and high-capacity transit, avoiding many retrofitting challenges faced by existing cities. At the same time, the project highlights the importance of financing mechanisms, and institutional coordination. With the successful completion, Amaravati could provide an important model for emerging cities seeking to build low-carbon, inclusive, and resilient mobility systems from the ground up.

References

1. Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy*, 15(2), 73–80.
2. Chaudhary, R., et al. (2019). BEST: Blockchain-based secure energy trading in SDN-enabled intelligent transportation system. *Computers & Security*, 85, 299–317.
3. Lamia, A., & Youssef, T. (2024). Modal shift as a lever for sustainable urban development: Issues and perspectives. *Atlantis Press*.
4. Nurmandi, A. (2022). Sustainable transport development strategy in developed and developing countries. In *Human Interaction and Emerging Technologies (IHIET 2022)*.
5. Rodrigue, J.-P. (2020). *The geography of transport systems* (4th ed.). Routledge.
6. Andhra Pradesh Capital Region Development Authority (APCRDA). (2016). *Traffic and Transportation Master Plan Main Report: Amaravati Capital City*.

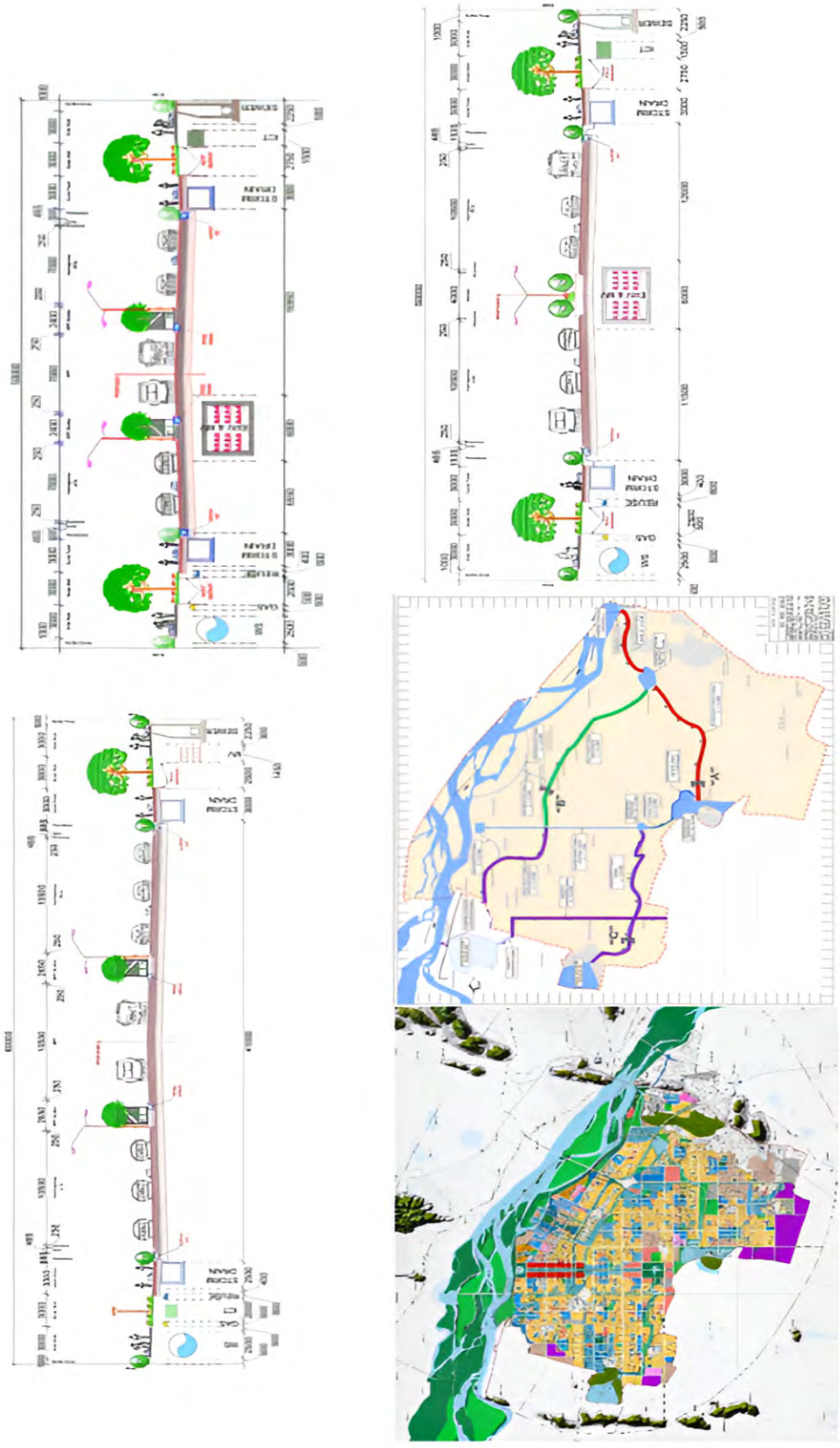


Figure Amaravati Master Plan with Trunk Roads Typical Cross Sections including Canal Network

Rollback on Seismic Code of India By BIS – Is this step in the right direction?

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Abstract

Bureau of Indian Standards (BIS) has reverted to the 2016 seismic code after withdrawing IS 1893 (2025), sparking debate over earthquake safety. While the 2025 version offered stronger, internationally aligned standards, the concerns of higher costs and enforceability issues raised by Ministry of Housing & Urban Affairs (MoHUA) led to this withdrawal. There are divergent opinions amongst the Experts on this issue. Proponents of the 2025 revision argue that the new code reduced the technological gap which exists currently with the US, European, and New Zealand practices by introducing probabilistic hazard assessment, shear-wave velocity-based soil classes, and vertical response spectra. On the other end of the counter-argument spectrum are cost and enforceability concerns. Critics fear that stricter design requirements for high-hazard may delay or halt progress in infrastructure developments in dams, bridges, metros, mountain roads, schools, hospitals, and housing, straining budgets in Zone VI, hill states and plains of Zones IV-V. This short article highlights the genesis of the withdrawn code, analyses reasons for its withdrawal and suggests way forward.

1. Introduction

BIS has recently (March 2026) withdrawn its 2025 version of seismic code (i.e. IS 1893: 2025 (Part-1) and IS 1893: 2025 (Part-5)), just after 4 months of its publication (published in November 2025). India has reverted back to the 2016 version of seismic code, despite the fact that experts found many lacunas in the 2016 version necessitating a revision, which was eventually published after nearly a decade (though it was short lived). While the 2025 version offered stronger, internationally aligned standard, which would have led to construction of resilient and robust infrastructure, higher costs and enforceability issues raised concerns of the MoHUA. The government's intervention was driven by concerns that the stricter standards of the 2025 version would impede infrastructure development. Withdrawal of this code has triggered a significant debate in the infrastructure industry regarding the prioritization of technical safety versus economic considerations. It has raised several fundamental questions in the minds of civil and structural engineers and also various stakeholders who are involved in the infrastructure industry. Some of these key questions are:

a) Why this new code was withdrawn by BIS ?

b) What is the genesis for framing this withdrawn seismic code?

c) Is this rollback an unprecedented move by BIS or there is precedence in the past of similar moves by BIS?

d) Is the withdrawal of seismic code justified ?

This brief article is an attempt by the author to answer the above questions for the benefit of all stakeholders, including public at large.

2. Why this new code was withdrawn by BIS?

The Government of India has issued an Office Memorandum (March 2026) advising withdrawal of the Gazette Notification dated 6th November 2025 that notified:

a) IS 1893 (Part 1): 2025 – Design Earthquake Hazard and Criteria for Earthquake-Resistant Design of Structures – Part-1 : General Provisions87

b) IS 1893 (Part 5): 2025 – Design Earthquake Hazard and Criteria for Earthquake-Resistant Design of Structures – Part-5 : Buildings

This development follows concerns raised by MoHUA regarding increase in cost of infrastructure. MoHUA claimed that resulting impact on awarded and ongoing metro rail infrastructure projects is of the order of 30-50%. Feasibility and funding of the future metro projects will be adversely affected in case this code is implemented

3. What is the genesis for framing this withdrawn seismic code?

3.1 Key Concerns driving the amendment in Seismic Code :

Key concerns which had driven this amendment in IS 1893 are following:

a) Surprise earthquakes in India at Koyna (1967) and at Killari (1993). The 1967 Koyna earthquake (Magnitude 6.3) occurred in a region of India previously considered geologically stable and seismically quiet. There was no significant history of earthquakes before the construction of the Koyna Dam, making it the most prominent example of Reservoir Triggered Seismicity (RTS) globally. Killari EQ was a surprise since it happened in a region which is geologically a part of the Deccan Plateau (Trap) which has been widely regarded as a stable continental region (SCR). These earthquakes have proved that currently used zoning map (which is in existence since 2002), is an underestimation of seismic hazard and it requires upgradation.

b) During the last 35 years, the country has experienced several major earthquakes that have resulted in over 2 lakh deaths.

c) Nearly 80% of the population is living in High Seismic Zone. 20 States & 4 UTs are in vulnerable zones. The population in urban areas are going to multiply further increasing the vulnerability further.

3.2 Why India is lagging behind in reducing Seismic Risk ?

It is well known that over the last 5 decades, several countries have significantly reduced earthquake risk vis-à-vis number of deaths, (e.g. New Zealand, USA, Japan, Chile etc..). Earthquakes however continue to cause huge number of deaths in some countries (e.g., India, Pakistan, China, Iran, Turkey, Haiti, etc.). The gap between the two sets of countries in this respect has widened significantly in last 5 decades.

India is lagging behind in reducing the seismic risk due to following :

a) Insufficient data of the Past Earthquakes

b) Underestimated earthquake hazards in the past.

c) Insufficient instruments to record strong ground motions for future earthquakes

Table 1 shows comparison of the number of strong motion accelerographs (SMA) and broad band seismometers (BBS) available in different countries per sq. km of geographical area. It can be seen from this table that India needs more instruments for measuring EQ so that the EQ demand assessment can be more accurate. India's geographical area is 8.5 times that of Japan, but number of EQ measuring instrument in Japan is 17 times more than in India.

The natural disaster vulnerability ratings of select EQ prone countries by WORLD RISK INDEX 2023, USA puts India in bottom 3 (Refer Table 2). Vulnerability Index is based on 3 parameters, namely:

- Social inequality & lack of development
- Insufficient political stability, healthcare and infrastructure

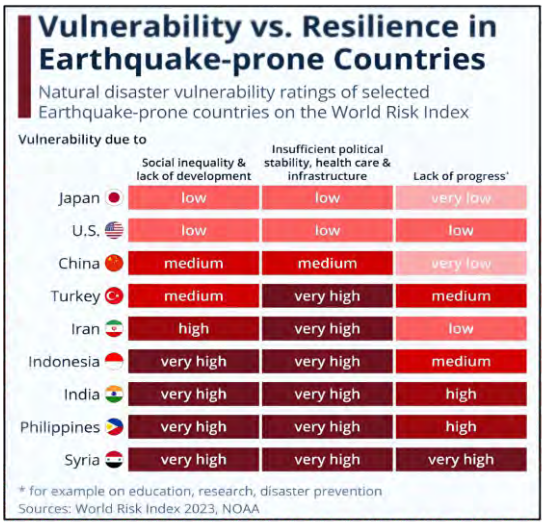
- Lack of progress in education, research & disaster prevention

India's vulnerability is rated "Very High" in two parameters and "High" in 3rd parameter, as shown in Table 2.

Table 1 : Comparison of number of EQ measuring instruments in various countries

Country	Area ($\times 10^5$ km^2)	Instruments	Area per Instrument (km^2)
India	32	152	**21,000**
Japan	3.8	2,600	**150**
USA	98	2,600	**3,700**
Taiwan	0.36	500	**72**
Italy	3	550	**550**
Iran	16.5	1,200	**1,400**

Table 2 : Vulnerability Index of Seismic Prone Countries



3.3 What are the substantive changes brought out in the withdrawn code

a) The title of the standard modified to "Design EQ Hazard and criteria for EQ resistant design of structures: Part 1 : General Provisions"

b) A revised EQ zoning map introduced, which is based on probabilistic EQ hazard assessment. It is 16 years of long journey for Earthquake hazard assessment (2006 to 2022), carried out by the Expert Map Committee of BIS. The work was carried out in 3 phases with involvement of best earthquake scientists in the country.

c) The design acceleration response spectra are defined upto natural period 10s.

d) Structures classified in 4 Categories depending upon severity of the negative consequences.

e) The design horizontal acceleration coeff. are specified for each EQ zone corresponding to different return periods for use in design

f) The response history method is strengthened by providing suites of far-fault ground motions for earthquake zones II, III, IV, V and VI, and of near-fault ground motions for EQ zones V and VI whose response spectra envelope is to be the target design response spectrum

g) A method is provided to account for soil flexibility in analysis and design. Coverage to Geotechnical Aspect has been significant in this revision of the code

h) The method to estimate liquefaction potential at a site is revised.

i) The clause on protection of architectural elements & utilities in structures is introduced

4. Is this roll back of the code, an unprecedented move by BIS or there is precedence in the past of similar moves?

Yes, there are significant and recent precedents for the withdrawal, rescission, or rollback of new BIS codes and associated Quality Control Orders (QCOs), particularly between 2024 and 2026. These withdrawals typically occur when new standards face strong industry opposition, cause compliance challenges, or are deemed to hinder trade. **Key Precedents for Withdrawal/Rollback of BIS Standards prior to IS 1893 (2025) are:**

a) **Omnibus Technical Regulation (OTR) 2024:** The Government of India formally rescinded the machinery and electrical equipment safety omnibus technical regulation order in January 2026, which had been intended to make BIS certification mandatory for various industrial products.

b) **Viscose Staple Fibres QCO (2025):** The government revoked the 2022 QCO on viscose staple fibre, which had mandated BIS certification, due to challenges faced by the textile industry regarding compliance and supply constraints.

c) **Non-Ferrous Metals & Chemicals (2025):** In November 2025, the Ministry of Mines and Ministry of Chemicals withdrew mandatory BIS certification for several products, including copper and aluminium alloys, primary lead, and several industrial chemicals.

5. Is the withdrawal of 1893 (2025) justified?

There are no two opinions amongst the experts that the science used in the withdrawn code was sound. For a rapidly growing economy like India, aiming to build productive assets worth trillions of dollars over the coming decades, can we afford to take the risk of massive failures in case a major earthquake occurs? Earthquake loss studies worldwide, and post-Bhuj assessments at home consistently show that modest increases in upfront structural cost are outweighed by the avoided losses from building collapse, business interruption and long-term displacement.

In light of the above, the need for improvement in the seismic code was necessary. By choosing to withdraw this new code on the grounds of 'increase in cost', the government is perhaps taking a huge risk and choosing affordability and progress at the cost of safety. The rollback of this code and other BIS standards as mentioned in clause 4 above seems to indicate that government is removing many 'obstacles' for achieving 'short term targets' in infrastructure development without caring for the 'long term' objective of public safety.

As Civil and Structural Engineer, the whole ethos of our profession is safeguarding the built habitat and delivering solutions which provide benefits to society. It is our duty and responsibility to look after (and be mindful of) the safety of the public. What we do is provide solution for society, the public. By compromising on safety, we are actually loosing the public trust and this is the heavy price that we pay when we decided to withdraw 1893 (2025).

I sincerely hope that the authorities and BIS will review this decision soon and bring back the withdrawn code, after wide consultation with various authorities, with amendments which are possible without any compromise on safety.

6. Conclusion

Viksit Bharat 2047 is envisioned not merely through economic metrics, but by building a resilient, robust, and sustainable built environment with a long design life. To achieve developed nation status, India is shifting from reactive, paper-driven construction to data-centric, intelligent, and proactive infrastructure planning. Seismic safety is paramount in this concept of development and any compromise on seismic safety should not be allowed to happen.

A Study on Assessing the Effectiveness of Rejuvenator for Hot Mix Recycling

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Abstract

This study investigates the role of rejuvenator characteristics in restoring the properties of aged asphalt binders derived from reclaimed asphalt pavement (RAP). Three commercial rejuvenators (A, B, and C) were evaluated based on physical, rheological, and diffusion properties. Results indicate that rejuvenator type significantly influences binder performance, diffusion efficiency, and mixture-level behavior. Rejuvenator A demonstrated superior diffusivity attributed to its lower viscosity and low volatility. Two stage extraction method is recommended for evaluating the diffusivity characteristics of rejuvenators.

1. Introduction

The global construction industry is increasingly transitioning toward a circular economy, with the pavement sector at the forefront of this shift through the integration of Reclaimed Asphalt Pavement (RAP). The utilization of RAP is no longer merely an economic alternative, but a primary sustainability mandate aimed at reducing the carbon footprint of road infrastructure [1]. By recycling existing pavement layers, the industry significantly curtails the depletion of virgin aggregates and reduces the demand for bitumen, a petroleum-derived product with high embodied energy. However, despite the clear environmental and logistical advantages, the high-rate incorporation of RAP presents significant rheological challenges that must be addressed to ensure long-term structural integrity [2]. The primary technical barrier in maximizing RAP content is the oxidative aging of the asphalt binder. During its service life, the binder undergoes a complex chemical transformation characterized by the loss of volatile components and the oxidation of its constituent molecules. This process alters the colloidal balance of the bitumen, specifically increasing the ratio of asphaltenes (the polar, high-molecular-weight fraction) relative to maltenes (the oily, lower-molecular-weight fraction) [3]. This chemical shift manifests physically as a significant increase in binder viscosity and stiffness. While a stiffer binder may offer improved resistance to permanent deformation (rutting) at high temperatures, it becomes critically susceptible to non-load-associated cracking and fatigue failure at intermediate and low temperatures. Without intervention, these "aged" binders behave like "black rock," failing to provide the necessary cohesion and flexibility required for a durable pavement structure. To mitigate the adverse effects of aging, rejuvenators are introduced into the recycling process [4]. Unlike simple softening agents, which merely reduce viscosity, true rejuvenators are engineered additives rich in maltene-equivalent fractions. By reconstituting the chemical composition of the aged bitumen, rejuvenators aim to restore the binder's original viscoelastic properties, effectively "extending" the fatigue life of the recycled mixture. While the benefits of rejuvenators are well-documented, their effectiveness is fundamentally governed by their diffusivity: the ability of the additive to penetrate the aged binder film coating the RAP aggregates [5–7]. If a rejuvenator lacks sufficient diffusion potential, it remains on the surface of the RAP particles, resulting in a non-homogeneous blend where the "core" of the aged binder remains brittle.

This study provides a rational evaluation of three commercially available rejuvenators (A, B, and C) categorized by their distinct chemical and physical profiles. By analyzing their intrinsic properties, specifically absolute viscosity and aging indices, this research seeks to establish a link between the rejuvenator's characteristics and its diffusion efficiency. The ultimate goal is to provide a performance-based framework for selecting rejuvenators that not only soften the binder but also ensure a uniform restoration of the recycled asphalt mixture's mechanical properties.

2. Materials and Experimental Program

2.1 Materials

A VG 40 binder, as per IS 73-2013, served as the target. RAP was sourced from a five-year-old pavement in Bihar, India. RAP binder had a softening point of 85.2 °C and the high temperature performance grade was PG 88-XX. Three commercial rejuvenators were selected, with their basic properties summarized in Table 1.

Table 1: Physical Properties of Selected Rejuvenators

Characteristics	Rejuvenator A	Rejuvenator B	Rejuvenator C
Appearance	Green	Brown	Yellow
Absolute Viscosity @ 60°C (cSt)	211	214	258
Flashpoint (°C)	325	160	160
Specific Gravity @ 27°C (g/cc)	0.782	0.792	0.832
STA Mass Loss (%)	0.199	2.749	0.814

2.2 Methodology

The optimum rejuvenator dosage was determined using high-temperature Performance Grade (PG) criteria. An average dosage of 10% by weight of RAP binder was used as a reference. Diffusion was assessed via a stage extraction and recovery test, which separates the "outer" and "inner" binder layers using toluene soaking [6]. RAP aggregates were heated to 150 °C and blended with the reference dosage of rejuvenator (10% by weight of RAP binder) for one minute. The rejuvenated mixture was then cooled and subjected to the first phase of extraction, wherein the mix was soaked in toluene for 45 minutes, and the binder recovered from this solution was assumed to represent the outer binder layer. In the second phase, the residual mix was soaked in fresh toluene for another 45 minutes, and the recovered binder was assumed to represent the inner binder layer.

At the binder level, softening point and high temperature PG were assessed in unaged, short term aged (STA), and long-term aged (LTA) conditions. Aging indices (ratio of property in aged to unaged condition) were evaluated using these properties. Further multiple stress creep and recovery (MSCR) test was conducted at 70 °C on STA samples while linear amplitude sweep (LAS) test was conducted in LTA condition (25 °C) to study the performance characteristics of the binders. The non-recoverable creep compliance (J_{nr}) was determined as an indicator of rutting resistance, whereas the number of cycles to failure (N_f) at a 5% strain level was estimated to characterize the fatigue performance of the binders.

A dense graded asphalt mix was designed as per MS-2 guidelines using Marshall compaction. Two mixes were studies: a control mix with 0% RAP and a recycled mix with 40% RAP (15% coarse RAP and 25% fine RAP). The optimum binder content was found to be 5.2% by weight of the mix. Mixture performance was evaluated using wheel tracking for rutting (70°C) and IDEAL-CT for cracking (25°C). The rutting and cracking performances of binders were compared based on the rut depth value after 20,000-wheel passes and asphalt flexibility ratio (AFR) (refer equation 1), respectively.

$$\mathrm{AFR} = \frac{\mathrm{t}}{62} \times \frac{\mathrm{l}_{75}}{|\mathrm{m}_{75}|} \qquad (1)$$

Where,

$|m_{75}|$: absolute value of post-peak slope at 75% of the peak load (N/m)

l_{75}: post-peak displacement at 75% of the peak load (mm)

t: specimen thickness (mm)

3. Results and Discussion

3.1 Diffusion Characteristics

The binders acquired from stage 1 and stage 2 extraction were subjected to rheological assessment using dynamic shear rheometer. The true high fail temperature was studied to assess the extent of diffusion. Superior diffusion leads to a smaller temperature difference between binder layers. As can be seen from Table 2, Rejuvenator A showed the highest efficiency (6°C difference), while C's high viscosity restricted penetration (18°C difference).

Table 2: Stage Extraction Results - True Fail Temperature

Sample	Outer Layer (°C)	Inner Layer (°C)	Difference (°C)
RAP (Control)	98	103	5
R + A	74	80	6
R + B	73	88	15
R + C	83	101	18

3.2 Binder and Mixture Performance

The short term aging index (STAI) and long term aging index (LTAI) derived from softening point and true high PG temperature showed (Figure 1) that R+A had the highest resistance to aging. Statistical analysis at 95% confidence level revealed that the differences in AI were statistically significant. LAS test results showed that Rejuvenator A significantly improved fatigue resistance (1.5 times of VG 40 at 5% strain) due to its high diffusivity and uniform softening. Conversely, Rejuvenators B and C, which had higher aging indices, provided better rutting resistance as indicated by the lower values of unrecoverable creep compliance obtained from MSCR data analysis.

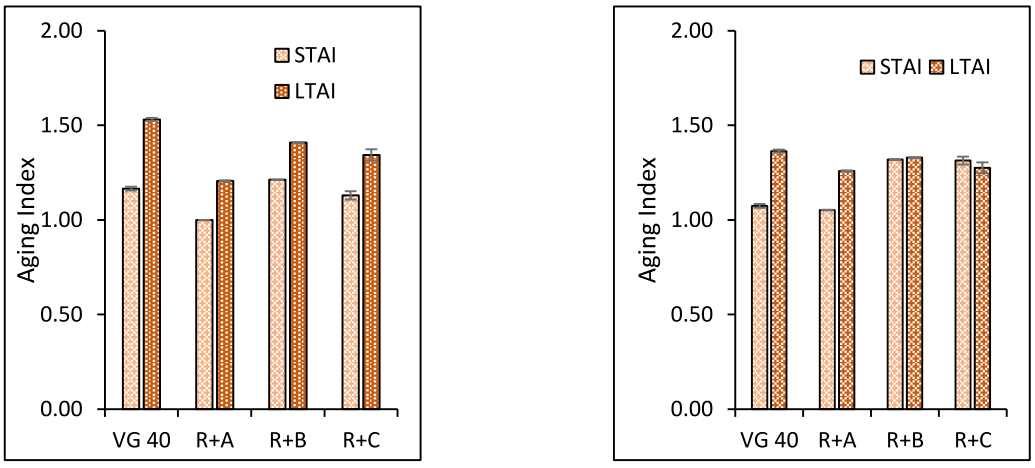


Figure 1: Aging indices of binders based on (a)softening point and (b) true fail temperature

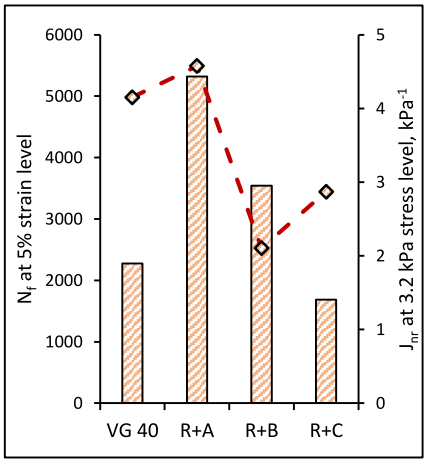


Figure 2: J_{nr} and N_f values of base and rejuvenated binders

4. Mixture Performance Summary:

4.1 Rutting: Recycled mixtures outperformed the control (VG40) (Figure 3). R+B showed the highest resistance with a 54% reduction in rut depth. This also indicates that use of Rejuvenator B, due to least diffusivity led to increase in the stiffness of the mix, thus improving the rutting resistance. This is in line with the MSCR test results.

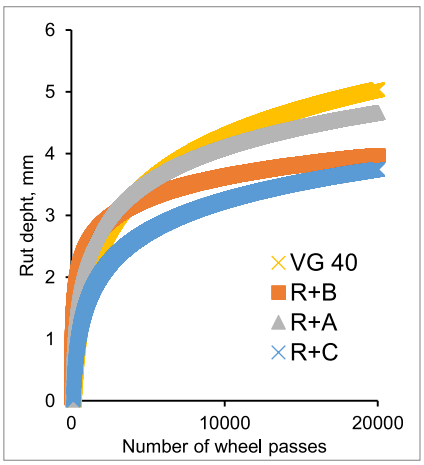


Figure 3: Rut depth versus wheel passes curves of control and recycled asphalt mixtures

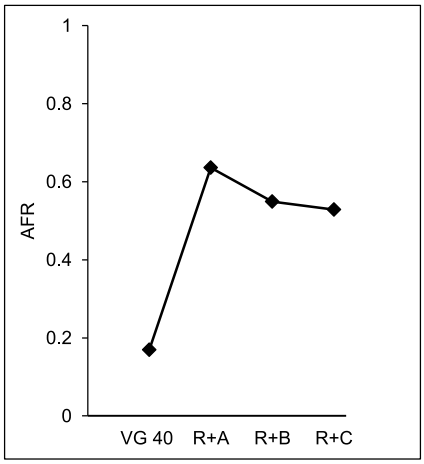


Figure 4: IDEAL-CT test results of asphalt mixtures: variation in AFR

4.2 Cracking: R+A provided the greatest improvement in asphalt flexibility ratio (AFR) (Figure 4), followed by R+B and R+C. This is complimentary to the binder level test results which showed that Rejuvenator A, due to its lower viscosity and mass loss provides effective diffusion characteristics, improving the durability of the RAP binder.

4. Conclusions

The study highlights that rejuvenator properties, specifically viscosity and aging index, govern their effectiveness.

1. Rejuvenator A (low viscosity) facilitates deeper penetration and superior cracking resistance.
2. Rejuvenators B and C (higher volatility/stiffness) enhance rutting resistance but may limit long-term durability.

3. Selection should consider diffusivity testing via stage extraction to ensure a balanced mixture performance.

References

1. Yao Y, Yang J, Gao J, et al (2025) Blending behavior of reclaimed asphalt and virgin asphalt in recycled asphalt mixtures: A comprehensive analysis on material composition and mixing process. Constr Build Mater 465:140229. https://doi.org/10.1016/J.CONBUILDMAT.2025.140229
2. Sukhija M, Coleri E (2025) A review on the incorporation of reclaimed asphalt pavement material in asphalt pavements: management practices and strategic techniques. Road Materials and Pavement Design. https://doi.org/10.1080/14680629.2025.2470889
3. Chen H, Zeng Z, Wei Z, et al (2024) Assessment of the effectiveness of binder fatigue, rheology and chemistry parameters in evaluating cracking resistance in high RAP mixtures modified with recycling agents. Constr Build Mater 432:136572. https://doi.org/10.1016/J.CONBUILDMAT.2024.136572
4. Prasad AN, Saboo N, Pani · Agnivesh (2025) Comparative evaluation of commercial and recycled rejuvenators for hot mix asphalt recycling. Mechanics of Time-Dependent Materials 2025 29:4 29:1–18. https://doi.org/10.1007/S11043-025-09827-3
5. Huang B, Li G, Vukosavljevic D, et al (2005) Laboratory Investigation of Mixing Hot-Mix Asphalt with Reclaimed Asphalt Pavement. Transp Res Rec 1929:37–45. https://doi.org/10.1177/0361198105192900105
6. Ma T, Huang X, Zhao Y, Zhang Y (2015) Evaluation of the diffusion and distribution of the rejuvenator for hot asphalt recycling. Constr Build Mater 98:530–536. https://doi.org/10.1016/J.CONBUILDMAT.2015.08.135
7. Zhao S, Huang B, Shu X (2015) Investigation on binder homogeneity of RAP/RAS mixtures through staged extraction. Constr Build Mater 82:184–191. https://doi.org/10.1016/J.CONBUILDMAT.2015.02.013

Modified Mix Seal Surfacing (MSS+): A Sustainable Thin Bituminous Surfacing For Rural Roads

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Road infrastructure development in developing countries requires technologies that are not only durable and cost-effective but also environmentally sustainable. Conventional hot mix bituminous surfacing methods involve heating of aggregates and binders, which leads to high fuel consumption, increased greenhouse gas emissions, and dependence on sophisticated infrastructure. These limitations are particularly significant in rural and semi-urban areas where road construction projects are often small and geographically dispersed.

Modified Mix Seal Surfacing (MSS+) has been developed as an innovative thin dense graded surfacing technology to address these challenges. The technology utilizes a customized modified bitumen emulsion, dense graded aggregates, and mineral fillers to produce a high-performance wearing course for low- to medium-volume traffic roads. Unlike conventional hot mix methods, MSS+ can be prepared and laid at ambient temperatures, eliminating the need for heating aggregates and binders.

The absence of heating significantly reduces energy consumption, fuel usage, and carbon emissions, making MSS+ a sustainable alternative for rural road construction. In addition, the technology allows faster construction using existing road construction equipment, thereby improving productivity and reducing project costs.

Technology Background

Thin bituminous surfacing for rural roads traditionally includes techniques such as Open Graded Premix Carpet (OGPC), Mix Seal Surfacing (MSS), and Semi-Dense Bituminous Concrete (SDBC). Although these techniques have been widely used, they often rely on hot mix production or recipe-based cold mix designs, which may lead to issues such as moisture susceptibility, rutting, and inconsistent performance.

Cold mix technologies using bitumen emulsions have gained popularity due to their lower energy requirements and ease of construction. However, dense graded cold mixes often face challenges such as slow curing, inadequate compaction, and instability due to high fines content.

To overcome these limitations, CSIR-Central Road Research Institute (CSIR-CRRI), in collaboration with JMVD Industries, Lucknow, developed the Modified Mix Seal Surfacing (MSS+) technology. The technology is based on a specially formulated modified bitumen emulsion that improves adhesion, cohesion development, and high-temperature stiffness of the mix.

The modified emulsion allows better coating of aggregates and faster strength development, enabling the construction of a durable and dense graded surfacing layer.

Materials and Mix Design

The aggregates used in MSS+ consist of crushed angular aggregates conforming to dense graded specifications suitable for thin surfacing applications. Mineral fillers such as hydrated cement are incorporated to enhance adhesion between aggregates and the binder and to improve the stiffness of the resultant asphalt mix.

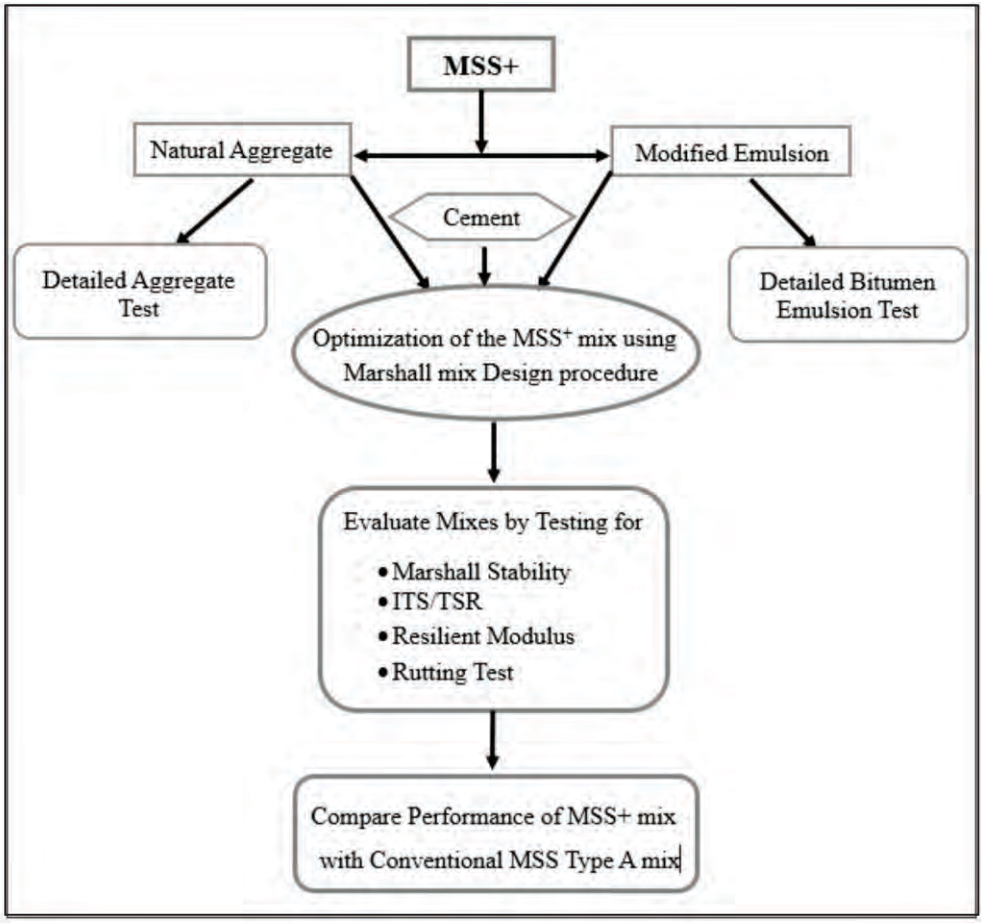
A customized modified bitumen emulsion is used as the binder. The emulsion properties such as viscosity, residue content, and stability are tested according to Indian standards to ensure quality and performance.

The gradation requirements for MSS+ differ from conventional Mix Seal Surfacing, providing a denser aggregate skeleton and improved structural performance. The mix design followed a dense-graded aggregate envelope to achieve optimum Voids in Mineral Aggregate (VMA) and density, as presented in Table 1.

Table 1: Aggregate Gradation for Modified Mix Seal Surfacing

IS Sieve Size (mm)	MSS Type A (% Passing)	MSS+ (% Passing)
13.2	—	100
11.2	100	95–100
5.6	52–88	65–80
2.8	14–38	24-40
0.09	0–5	2–7

Trial mixtures were prepared with different emulsion contents of 7%, 8%, 9%, and 10% to determine the optimum binder requirement. The specimens were compacted using a modified Marshall compaction procedure suitable for emulsion-based mixes. The curing process consisted of two stages: initial ambient curing for 24 hours, followed by oven curing at 40°C for 72 hours, to ensure adequate strength development and stable material properties. Following is the flow chart for the MSS+ laboratory work.



Methodological Framework for MSS+ Laboratory Evaluation

Performance Evaluation

Laboratory investigations demonstrate that MSS+ provides significant improvements in strength, durability, and deformation resistance compared to conventional Mix Seal Surfacing (MSS Type-A).

Table 2: Marshall Stability Test Results

Type of Bitumen Emulsion	Type of Mix Gradation	Bitumen Emulsion (%)	Bulk Density (g/cc)	Theoretical Maximum Density (g/cc)	Marshall Stability (kN)	Flow (mm)
SS-2	MSS Type A	9	2.197	2.381	3.85	5.12
MSS+	Customized gradation	8	2.241	2.390	7.57	3.19

The results indicate that MSS+ provides approximately 97% higher Marshall stability and 38% lower flow values, indicating improved resistance to deformation under traffic loading as presented in Table 2.

Moisture susceptibility tests also show significant improvement in durability. Resilient modulus improved by 64%, enhancing the structural performance of the surfacing and contributing to longer service life as given below in Table 3.

Table 3: Moisture Resistance and Structural Properties

Type of Bitumen Emulsion	Type of Mix Gradation	TSR %	Rut Depth in mm	MR Value MPa
SS-2	MSS Type A	43.14	9.29	458
MSS+	Customized gradation	83.22	5.61	750

The results indicate that MSS+ demonstrates 93% improvement in moisture resistance, 40% reduction in rut depth, and 64% higher resilient modulus, highlighting its superior structural performance.

Field Implementation

To evaluate the field performance of MSS+, a demonstration project was carried out on a 300 m long test section near Lucknow in June 2022 under the supervision of CSIR-CRRI. The project was implemented with the support of the Uttar Pradesh Rural Road Development Authority (UPRRDA). Encouraged by the satisfactory performance of the trial section, MSS+ technology has been implemented on several rural roads in districts including Lucknow, Gonda, Prayagraj, Raebareli, and Barabanki. A notable project includes the construction of a 5 km road stretch in Gonda district, where the surfacing was successfully completed using MSS+ technology.

Environmental and Economic Benefits

One of the key advantages of MSS+ is its environmental sustainability. Since the technology does not require heating of aggregates or binders, it significantly reduces fuel consumption and emissions. Key environmental benefits include:

- Up to 90% reduction in energy consumption
- Savings of approximately 1500 litres of fuel per kilometre
- Reduction of nearly 4000 kg of CO_2 emissions per kilometre
- Reduced environmental footprint of road construction activities

In addition to environmental benefits, MSS+ also offers economic advantages such as reduced material consumption, lower production costs, and faster construction time.



MSS+ Road near Lucknow



MSS+ Road Laid in June 2022



MSS+ Road cLaying in Gonda June, 2025



View of Laid MSS+ Section in Gonda



View of MSS+ Section after Rolling in Gonda



Inspection of Laid MSS+ Section in Gonda

Photo 1: Glimpse of the Road Built through MSS+ Technology at Lucknow and Gonda, U.P.

Conclusions

Modified Mix Seal Surfacing (MSS+) represents an important advancement in sustainable road construction technologies for rural and low-volume traffic roads. Laboratory and field

evaluations demonstrate that MSS+ provides significantly improved strength, durability, and resistance to moisture damage compared to conventional Mix Seal Surfacing.

The technology also contributes to environmental sustainability through substantial reductions in energy consumption and greenhouse gas emissions. Successful implementation of MSS+ on rural roads in Uttar Pradesh highlights its practical feasibility and long-term performance potential.

With its combination of performance, sustainability, and cost-effectiveness, MSS+ can play a vital role in promoting durable and environmentally responsible road infrastructure development in rural and semi-urban regions.

Acknowledgements

The authors acknowledge the support of JMVD Industries, Lucknow, for sponsoring the research project and the Uttar Pradesh Rural Road Development Authority (UPRRDA) for providing the test section for field implementation of MSS+ technology.

References

1. IRC: SP:100-2014 "*Use of Cold Mix Technology in Construction and Maintenance of Roads Using Bitumen Emulsion.*"
2. MoRTH (2013) "*Specifications for Road and Bridge Works*," 5th Revision, Ministry of Road Transport & Highways, New Delhi.

Performance Evaluation of Concrete Bridges Using Non-Destructive Testing

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1.0 INTRODUCTION

In India, Concrete bridges are designed for a period of 100 years as per IRC Standards. During their Service Life, several factors such as inadequate structural design and detailing, poor execution, improper maintenance, structure-environment interaction, overloading, Force Majeure Events, i.e. earthquakes, flash floods due to cloud burst, etc, affect their performance adversely. These factors, single or in combination, may give way to various distresses such as cracking, spalling, honeycombing, carbonation, chloride ingress, sulphate attack, corrosion of reinforcement. These distresses may cause significant weakening of bridges, sometimes leading to their premature failure. Hence, there is a need for the structural condition assessment of bridges during the service life, i.e. during the Operation and Maintenance phase.



(a) Longitudinal Girders **(b)** Foundation **(c)** Deck Slab

Photo 1[(a), (b), (c)]: Distressed Structural Components of Bridge

2.0 ROLE OF NON-DESTRUCTIVE TESTING (NDT) IN CONDITION ASSESSMENT OF BRIDGES

Non-Destructive Testing plays an important role in the condition assessment of bridges during the Operation and Maintenance Phase of an infrastructure Project. In addition to the regular preventive maintenance, depending upon the requirement with respect to the occurrence of distresses, Repairs / Rehabilitation of the distressed structural components are also required. The ultimate goal of the condition assessment exercise on a bridge is to determine its present Load Carrying Capacity as it directly affects the safety of the Road Users.

For preparing a Repair / Rehabilitation scheme of a bridge, identification of the type and extent of observed distresses on a structural component is very essential to know the probable causes of its occurrence. For concrete bridges, the Load Carrying Capacity (LCC) gets directly affected by the in-situ compressive strength of concrete and the area of cross section of active and passive steel reinforcement as follows.

$M_{LL} = F_1 (A_s)$ or $M_{LL} = F_2 (F_{ck})$, whichever is less, wherein -

M_{LL} (Moment of Resistance), F1, F_2 (Functions (Equations) for Under-reinforced / Over-reinforced Section), A_s (Area of Steel), F_{ck} (In-Situ equivalent Characteristic Compressive Strength of Concrete)

For assessing the Load Carrying Capacity of a bridge, following In-Situ Data is required, which can be collected from the site making use of NDT.

Table 1: Required In-Situ Data and NDT Technique

Required In-Situ Data	NDT Technique
(i) As Built Geometry (ii) Location, Identification, and Quantification of observed Distresses	Visual Inspection, Drone Survey, Mobile Bridge Inspection Unit (MBIU) Survey Crack Measuring Microscope, Crack Monitoring Gauge, Ultrasonic Pulse Velocity (UPV) Test, Impact Echo / Pulse Echo Test, Acoustic Emission Test
(iii) In-Situ Compressive Strength of Concrete	Rebound Hammer (RH) Test, Windsor Probe Test, LOK Test, CAPO Test, Break-off Test, Pull-off Test, Core Test
(iv) Quality of Concrete in terms of Homogeneity	Ultrasonic Pulse Velocity (UPV)Test, Impact Echo / Pulse Echo Test, GPR, Infrared Thermography, Radiography
(v) Concrete Cover	Cover Meter / Profo Meter
(vi) Corrosion of Steel Reinforcement	Carbonation Test; Chloride Ingress Test, Half Cell Potential Test, GPR, Electrical Resistivity Test, Radiography
(vii) Depth of Foundation	Parallel Bore Hole seismic Test, Electrical Resistivity Test, Impact Echo Test
(viii) Structural Behaviour	Load Test

3.0 METHODOLOGY FOR EVALUATION OF LCC OF BRIDGES

The Methodology is as follows.

(i) Scrutiny of the available records related to structural design, drawings, earlier inspection and repairs / rehabilitation of the bridge under consideration, (ii) Visual Inspection, (iii) NDT, (iv) Analysis and Interpretation of NDT Results, (v) Cause – Effect Analysis of the observed distresses, (vi) Theoretical Evaluation of the LCC, (vii) Load Testing of the identified Spans, (viii) Interpretation of the NDT Results and the Load Testing Performance, (ix) Evaluation of the LCC; (x) Finalisation of the Repairs / Rehabilitation Scheme.

4.0 CASE STUDY

The R.C.C. Girder type bridge located over a canal somewhere in the northern part of India having two spans is shown in Photo 2. After constructing one span in 2011, the Contractor did not complete the work. No records of Materials' Testing at site, Wells' concreting and sinking were available, hence the quality of concrete used and execution of Wells' Foundation upto the design depth were questionable. Accordingly, the structural parameters of the bridge determined using NDT were – (a) Depth of Well Foundation of Abutments and Piers, (b) Compressive Strength and Homogeneity of Concrete, (c) LCC of the Bridge.

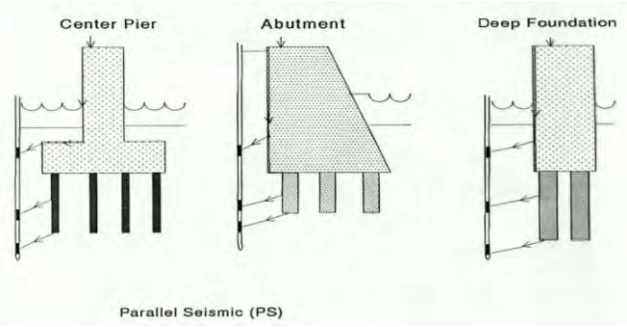


Fig. 1(a): Parallel Bore Hole Seismic Test

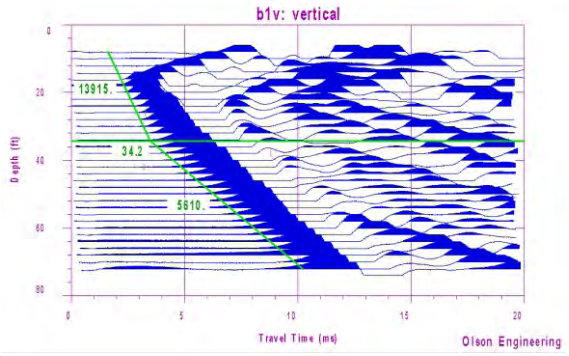


Fig. 1 (b): Results of Parallel Bore Hole Seismic Test

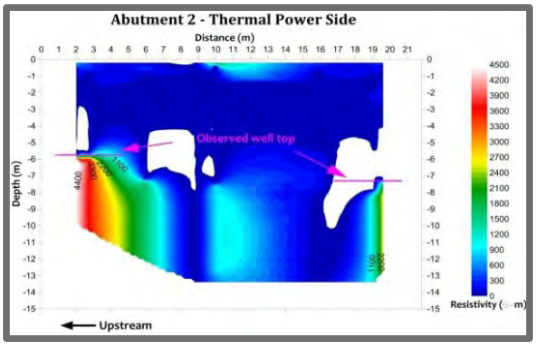


Fig. 1 (c): Results of Electrical Resistivity Test

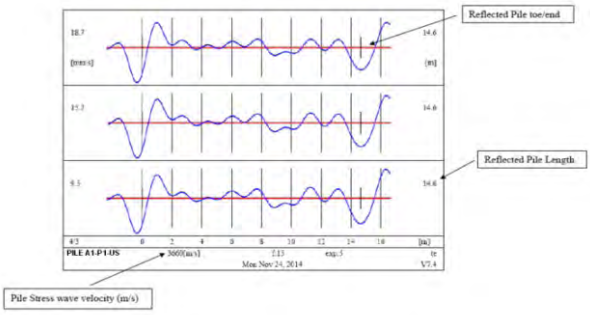


Fig. 1 (c): Results of Impact Echo Test



Photo 2: Load Testing of Bridge Span using MBIU

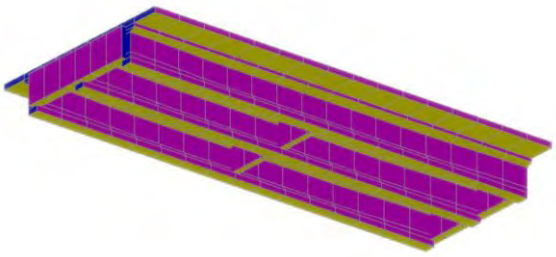


Fig. 2: Theoretical Evaluation of LCC

Depths of Foundation of Abutments and Pier were determined using – (a) Parallel Bore Hole Seismic Test, (b) Electrical Resistivity Test, (c) Impact Echo Test, as shown on Fig.1. Quality of Concrete in terms of Compressive Strength and Homogeneity was determined by RH Test and UPV Test on Deck Slab, Longitudinal Girder, Cross Girders, Pier and Abutment, Bearing Pedestals. Carbonation Test was also carried out at a few identified locations.

Global Response of the bridge span was determined by conducting Load Test wherein the measured deflection under the superimposed loading were compared with the theoretical deflections. Keeping in view the limitation of flowing water in the canal, an improvised superimposed loading was designed for the Load Test wherein the MBIU's weight was also considered along with the additional superimposed Loads comprising of sand filled gunny bags (Photo 2, Fig. 2).

Conclusions:

(i) Depth of Well Foundation of Abutment – 2 determined by Electrical Resistivity Test is 10.5 m.

(ii) Depth of Well Foundation of Abutment – 1 determined by Impact Echo is 14.10 m as against design depth of 12.255 m.

(iii) Depth of Well Foundation of Abutment – 2 determined by Impact Echo is 12.20 m as against design depth of 9.5 m.

(iv) Depth of Well Foundation of Pier determined by Impact Echo is 12.01 m as against design depth of 13.255 m.

(v) Depth of Well Foundation of Abutment – 2 determined by Parallel Seismic Bore Hole Test is 8.945 m as against design depth of 9.5 m.

(vi) RH and UPV Test Results on longitudinal girders, abutments and pier are satisfactory.

(vii) RH and UPV Test Results on deck slab, cross girders, and bearing pedestals are not satisfactory, hence require proper rehabilitation / replacement.

(viii) Structural Performance of the bridge span during the Load Test was satisfactory.

(ix) Localized effect of carbonation was observed only at a few locations.

ACKNOWLEDGEMENTS

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REFERENCES

1. IRC: SP-51
2. SPECIAL REPORT, “State of Art: Non-Destructive Testing Techniques of Concrete Bridges”, IRC HIGHWAY RERSEARCH BOARD, NEW DELHI, 1996
3. J.H. Bungey, “The Testing of Concrete in Structures”, Surrey University Pres
4. Baldev Raj, T. Jayakumar, M. Thavasimuthu, “Practical Nondestructive Testing”, Narosa Publishing House
5. IS: 456: 2000
6. IRC: 6

Engineering the AI (Artificial Intelligence) for Saving Lives on Road

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Digital Public Infrastructure (DPI) of India has shown to the world about how digitalization can be developed for public good. Here is another opportunity to develop Artificial Intelligence for real world societal good – to save life on road. Generative and Agentic AI models must be developed for solving societal problems. At this time people are developing AI for enterprises, intelligent automation, and so on. But there are enormous possibilities to assist and solve our hundreds of societal problems which need advanced AI-based solutions. The next public good, which can be helped by AI is the road safety.

It is right that AI is based on large personal databases, and we have now DPDP (Digital Personal Data Protection) Act to safeguard our personal data for any misuse. Therefore, all the personal data to be used for addressing societal problems through AI interventions are expected to be strictly in compliance to DPDP Act in all letter and spirit. The violations to be handled with extreme and exemplary strictness.

One of the area where AI can be extensively used, and being used, is Healthcare with required intelligence based on huge databases designed and deployed responsibly. This must control the healthcare cost burdens of the population in every possible way. At this time healthcare has grown to a very nasty business, which must be arrested by this technology as soon as possible. Then why not AI for saving lives? With professional connection only to civil engineering and specialization in the area of traffic and transportation, it is felt that there are enormous possibilities for road safety. Today the road use behavior is just like the anarchy of smaller vehicles conveniently labeled as economically poorer class of the society.

Traffic control and enforcement by official enforcement system is completely missing, and if it is there anywhere, it is for another purpose. AI based technology must replace the corrupt and insensitive official enforcement system completely. For this, of course, valid personnel data for the entire population will be required, which is easy to have, if the government wants. Of course, for such committed effort, the political and personal ambitions and privileges have to be set aside, as this AI will bite everyone equally. Aim of this AI-based enforcement shall be to correct the behavior of everyone on road once for all, and those showing smartness to AI shall have to suffer for their sins. This level of AI will only make a difference. This is just one example of a totally democratic use of AI. There are many more examples of possible AI-based social services, which can make life of every citizen a golden one, which we often refer and aspire as the “Ram Rajya”.

AI can transform 24x7 surveillance and public safety systems, from reactive systems to proactive systems, making them more efficient, and scalable (making it indiscriminate, efficient, and with zero tolerance).

- AI enhances real-time monitoring, facial recognition, ANPR, and so on.
- Cloud-based cameras offer scalable AI integration

-Integration with IoT and smart systems enables coordinated responses.

The Key Risks include privacy concerns, bias in AI algorithms, and the potential misuse of data. That’s why transparency, oversight, and ethical use are essential when applying AI in public safety.

Rampant violations of traffic rules by smaller modes and their indiscipline making things worse, day by day. Their number is so large on the road (Pedestrians, Cyclists, 2-Wheelers, e-Rickshaws, Auto-Rickshaws, etc), any manual enforcement humanly not possible. AI-

based enforcement to make every road user accountable by catching all (100%) of their behavioral faults and violations is required. We have to make all such road users to remain in the lane behind a car or bus or truck – and not to go in between cars, trucks and buses to overtake from right or left or by any means (by hook or by crook)

As of today rampant violations are seen in terms of

- Red-light violations
- Overtaking from right, left and anywhere
- Contraflow (Driving in the wrong direction)

On 23 March 2026, Times of India published the traffic story of Delhi.

Driving behavior is the root cause of all safety probelems, and the bigger vehicles are NOT the Danger on Delhi roads (Figure 1). This is the story of Delhi only given here. India has more than 400 million motor vehicles and 80-85% of these are smaller vehicles, and they are ruling the road with unsafe behaviors and violations. The story of India is full of such behaviours and violations. In 2023, 10,000 people were killed in contraflow driving and another 10,000 were injured, may be severely.



TIMES CITY

How Driving Behaviour, And Not Vehicle Size, Is Defining Danger On Delhi Roads

Two-Wheelers Overtake Heavy Vehicles As Second-Largest Contributors To Fatalities After 'Unknown' Category

VIOLATIONS HIGH, ENFORCEMENT LOW

AFTER STAYING NEARLY FLAT BETWEEN 2022 AND 2025, FATALITIES ON ROADS HAVE STEADILY INCREASED

245 Total fatal crashes

TIMES Special

1,504 Total fatal crashes

1,578 Total fatal crashes

1,432 Total fatal crashes

1,428 Total fatal crashes

WHY TWO-WHEELERS AND HTVs HAVE SWAPPED POSITIONS

FIFTH SPOT CHANGES HANDS, FROM BUSES TO E-RICKSHAWS

Fatal crashes by e-rickshaws (Over 5 years)

3 arrested for illegal hoarding and supply of LPG cylinders

`the lane behind one another – not to go in between cars, trucks and buses to overtake from right or left or by any means. Therefore, it is recommended that

- AI systems be provided in every vehicle so that it will immobilize the vehicle, when it violates and for all unsafe behaviors in road traffic.
- If all vehicles are equipped with AI for monitoring the behavior, the road safety scenario in the country will change in no time.
- Invisible and indiscriminate enforcement of rules by AI will make all of us safe on road.

Road-user category	Persons killed 2022	Persons killed 2023	% Change 2023 over 2022
Pedestrian	32,825	35,221	7.30
share in Total	19.5	20.4	
Bicycles	4,836	4,560	-5.71
share in Total	2.9	2.6	
Two-wheelers	74,897	77,539	3.53
share in Total	44.5	44.8	
Auto-Rickshaws	6,596	6,308	-4.37
share in Total	3.9	3.6	
Cars, Taxis, Vans & LMVs	21,040	21,496	2.17
share in Total	12.5	12.4	
Trucks/Lorries	10,584	10,066	-4.89
share in Total	6.3	5.8	
Buses	4,004	3,956	-1.2
share in Total	2.4	2.3	
Other Non- Motor Vehicles (including e-rickshaw)	2,372	2,006	-15.43
share in Total	1.4	1.2	
Others (other motor vehicles, animals drawn vehicle, cycle rickshaws, hand carts, & other persons)	11,337	11,738	3.54
share in Total	6.7	6.8	
Total	**1,68,491**	**1,72,890**	

Figure 2: Categories of Road Users (VRUs) Killed in 2023

Road Accident Deaths to 2-Wheeler Riders

Year	2-W Death	% Share in Total Road Deaths
2012	35,767	25.9
2013	39,353	28.6
2014	40,926	29.3
2015	46,070	31.5
2016	52,500	35.4
2017	48,746	32.9
2018	55,336	36.54
2019	58,265	38.55
2020	56,873	43.20
2021	69,385	45.03
2022	74,897	44.50
2023	77,539	44.80



Source: Road Accidents in India, MoRTH, (2012-2023), GoI

During last 20 years, more than 25 lakh people died in road crashes and another 10-15 million people injured, and a major group of whom might be left disabled for life

Figure 3: Road Accident Fatalities to 2-Wheeler Riders (Motorcycles/Scooters)

Dualsafe the World's First Two-in-one Helmet

Arvind Sethi and Anupama Sethi

DualSafe Private Limited
Email: arvind.sethi@dualsafe.in

The Problem with Helmets has Never Been Awareness

Every Indian two-wheeler rider knows a helmet can save his/her life. The statistics are not a secret. Over 52,000 lives are lost every year to helmet non-compliance on Indian roads. Nearly 71.8% of all two-wheeler fatalities involve riders or pillion passengers who were not wearing a helmet at the time of the accident.

And yet, adoption of helmets remains stubbornly low. Enforcement campaigns come and go. Fines go up. Awareness drives run on repeat. The numbers barely move.

The reason is not carelessness. It is not ignorance. It is something far more fundamental, and far more solvable: the helmet, as a product, has never been designed for the way people actually ride. The motorcyclists in India are no different; but they wear helmet for the strict enforcement; unless there is enforcement behaviours cannot be changed.

Born from Personal Experience

The story of DualSafe begins in Chandigarh, a city known for its disciplined traffic culture. Arvind Sethi, Co-Founder and CEO, experienced a near-fatal accident that left him shaken but unscathed, thanks to a properly strapped helmet

That incident, combined with the daily frustration of managing helmets for himself and his wife Anupama, planted the seed. Even one helmet can be a hassle, let alone two. The problem compounds for pillion riders, who are often handed substandard helmets if any at all, leaving them disproportionately vulnerable. Add sun exposure, pollution, moisture, hygiene concerns, and the logistical challenge of storage, and it becomes clear why so many riders skip this critical safety gear altogether.

Arvind and Anupama Sethi co-founded DualSafe in 2020 with a single conviction: the product itself was the problem, and a better product was the solution.

Why the Pillion Rider is Always the Afterthought

India has over 240 million two-wheelers on its roads. In most cases, the rider wears a helmet. The pillion rider, in most cases, does not. A standard two-wheeler boot fits one helmet. There is simply no practical place to keep a second one. Most end up leaving it at home, and over time, that stops feeling like a compromise and starts feeling like the norm.

In 2019 alone, over 14,500 pillion riders lost their lives in accidents linked to helmet non-compliance. They remain the most under-protected people on Indian roads, and the product gap is the reason.

The Science Behind the Solution

What makes head injuries so catastrophic in road accidents is not just the force of impact. It is the direction. In most two-wheeler accidents, the blow comes from the side. The skull absorbs it. The brain, suspended in cerebrospinal fluid, slams against the inner wall.

This is the same fluid that naturally cushions the brain in everyday movement. DualSafe's design draws directly from this principle. The dual-layer protection architecture mirrors how the skull and brain interact: an outer shell that takes the impact, an inner shell that distributes

and absorbs it, with the space between them doing what cerebrospinal fluid does in the body. The result is MIPS-like multi-directional protection, without the premium price tag.

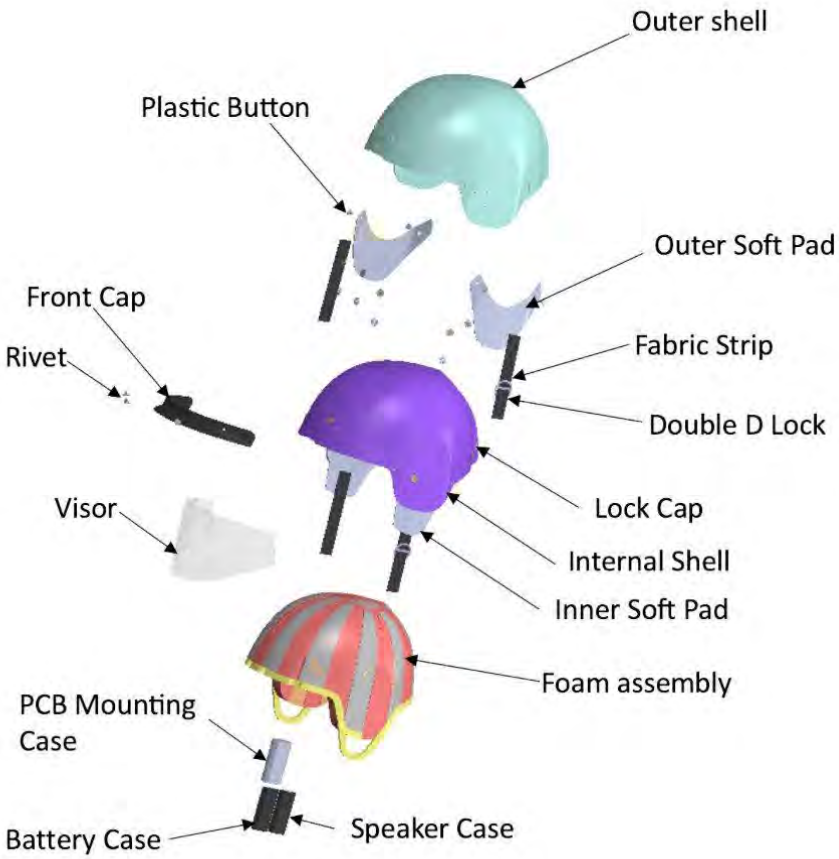


Figure 1: DualSafe helmet component architecture exploded view

Hidden Barriers Most People Do Not Talk About

Hygiene and Environmental Damage

Sharing a helmet is not something most people want to do. Sweat, odour, and hair damage are real deterrents, particularly for women riders. At the same time, helmets left strapped to a two-wheeler are exposed to UV radiation, moisture, and road debris daily. The outer shell degrades. The inner foam weakens. The helmet still looks fine. Most riders never know their protection has been quietly compromised.

Distraction

Riders increasingly rely on phones for GPS, music, and calls while riding. Every glance at a screen is a moment of lost focus. The problem is not the phone. It is that the helmet offers no alternative. If navigation, calls, and rider-pillion communication were built in, the phone would stay in the pocket.

The Compliance Trap

When a helmet is worn only to avoid a challan, it is not being worn safely. The chin strap stays loose. The fit is wrong. The rider has technically complied and physically remained unprotected. Compliance without conviction is not safety. It is the appearance of safety.

What DualSafe Changes

DualSafe is a patented 2-in-1 helmet system. One compact unit integrates two fully ISI-compliant helmets, fits into the storage compartment of any two-wheeler without modification, and is embedded with a suite of IoT features.

- Splits into two certified helmets in under 10 seconds
- Fits the standard two-wheeler boot — no modification needed
- Bluetooth connectivity: rider-pillion intercom, music, GPS, calls
- Chinstrap alarm: alerts if the retention system is not secured correctly before the ride begins
- Advanced ventilation: airy, tropical-ready design that does not trap heat
- MIPS-like multi-directional impact protection built in
- High-resolution camera capability, with future features including geospatial photography and RFID sensor scanning

The chinstrap alarm addresses one of the most persistent problems in helmet safety: the rider who buckles loosely to avoid discomfort and ends up unprotected in the very accident the helmet was meant to prevent. A quiet alert before the ride begins. A small intervention with potentially enormous consequences.



Figure 2: Outer shell design direction and IoT integration — PCB, speaker, and battery placement

The Organic Adoption Curve

When a helmet fits in the boot, is always available, comes with features that riders actually want, and costs no more than an ordinary helmet, the calculus changes. The pillion rider stops being an afterthought. The second helmet stops being a burden.

And then something more powerful happens. Peer pressure, which has historically worked against helmet adoption, begins to work in its favour. A rider who has a DualSafe unit normalises two-helmet riding. Their passengers expect it. Their friends notice it. The behaviour spreads without a campaign, without a fine, without a mandate, doing the heavy lifting. This is how helmet culture gets built: not top-down through enforcement alone, but bottom-up through products that make safety the default and technology that makes it desirable.

The Policy Tailwind and OEM Opportunity

From January 2026, the Ministry of Road Transport and Highways mandates that all two-wheeler vehicles be sold with two helmets. OEMs now have both the obligation and the opportunity to bundle a dual-helmet solution at the point of sale. DualSafe has NDAs in place with TVS Motors and Hero MotoCorp. The mandate gives that conversation urgency.

Globally, DualSafe has identified 62 countries with significant two-wheeler populations, 34 of which mandate helmets for both rider and pillion. A royalty and licensing model is being developed for markets requiring country-specific certifications, allowing local manufacturers to produce under the DualSafe patent.

Towards Zero Fatality Corridors

India has set a national target of reducing road fatalities by 50% by 2030. The number of lives that depends on that, nearly 75,000 two-wheeler deaths in 2023 alone, makes the stakes clear. Enforcement and infrastructure improvements are part of the answer. Product innovation is another.

The concept of a zero fatality corridor, a stretch of road where design, enforcement, and behaviour align to eliminate deaths, has long been discussed as an aspiration. DualSafe's proposition is that technology-led adoption can make that aspiration scalable. When helmets become devices that people want to use, rather than accessories they are compelled to carry, compliance stops being the ceiling and becomes the floor.

As smart wearables, DualSafe helmets gain traction globally, much as wristwatches evolved into fitness trackers, safety headgear is following the same path. DualSafe's vision is not a better helmet. It is a better relationship between riders and safety. One where the product does the persuading, the technology does the nudging, and the community does the rest.

Safe School Zones: Building Safer Roads for Every Child in Delhi

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Background

Every morning, children leave their homes carrying school bags, lunch boxes and dreams for the future. Parents send them off with one simple expectation that they will reach school safely and return home safely. Yet, for far too many children, the road outside the school gate remains one of the most dangerous and challenging parts of the road network they have to travel and negotiate every day. Fast-moving vehicles, missing or faded pedestrian crossings, vehicles parked along footpaths, chaotic pick-up and drop-off arrangements at schools, inadequate signage and poorly designed pedestrian infrastructure routinely expose children to risks that should be prevented. A school cannot truly be considered safe if the road leading to it is not.

Recognizing this critical gap, the **International Road Federation – India Chapter (IRF-IC)** undertook a comprehensive **School Zone Safety Programme in Delhi**, aimed at understanding the risks children face during their daily commute and demonstrating how practical, low-cost and high-impact interventions can make surroundings of the school safer. The programme was taken up strictly as per the recommended guidelines provided by **IRC: SP:32–2023 – Guidelines for Safer Commute to Schools**, bringing a structured, evidence-based approach to school zone safety.

Why Safer School Zones Cannot Wait

India's road safety challenge remains enormous. According to the Road Accidents in India **2024** report, approximately **4,87,707** road crashes were recorded across the country, resulting in **1,77,175** fatalities and **4,71,441** injuries**.** Delhi recorded **1,551 road accident fatalities in 2024**, the highest in the preceding five years. Of particular concern is the safety of children in and around educational institutions, where road crashes contribute to nearly 12,000 fatalities. Children experience roads differently from adults. They may find it difficult to accurately judge the speed or distance of an approaching vehicle. Their smaller physical stature can make them less visible to motorists, particularly around parked vehicles. Their movements can also be less predictable.

This means road infrastructure around schools must be designed with children in mind, and not simply to facilitate the movement of vehicles alone. Creating safer school zones is therefore more than a traffic-management exercise. It is about protecting children, improving public health and creating streets where walking and other sustainable modes of transport become safer and more accessible.

Taking Safety from Assumption to Evidence

Effective road safety begins with understanding what is actually happening on the ground. IRF-IC selected four schools in Delhi representing different urban road environments:

- Govt. Co-Education Senior Secondary School, Sector 22, Dwarka
- Prudence School, Sector 22, Dwarka

- M. L. Khanna DAV Public School, Sector 6, Dwarka
- Mount Carmel School, Anand Niketan

Detailed road safety audits were undertaken during the most critical periods, i.e. school opening and dispersal hours. Rather than examining roads in isolation, the audits looked at the complete environment experienced by the children, in terms of footpaths, pedestrian crossings, traffic movement, vehicle speeds, road geometry, parking behaviour, signage and markings, pick-up and drop-off activity, and locations where children and vehicles frequently come into conflict.

What We Found Outside the School Gates

Each school presented its own challenges, but a clear pattern emerged across the locations.

1. Footpaths existed — but were not always walkable

In several locations, footpaths were discontinuous or obstructed by utility poles, transformers, trees, parked vehicles and encroachments. Differences in height between the carriageway and footpath also created accessibility challenges. When a footpath becomes unusable, a child has little choice but to step onto the road. Pedestrian crossings presented another concern, as some were missing, faded or positioned away from the paths pedestrians naturally used.

2. Drivers were not always being told they were entering a school zone

School zones should immediately communicate one message to all motorists to **slow down as children are present**. Yet warning signs, speed-limit signs, pavement markings and school-zone identification were either absent or inadequately installed at several locations. Without clear visual cues, the transition from an ordinary urban road to a child-sensitive environment can easily go unnoticed.

3. Vehicle speeds remained a serious concern

Roads adjoining schools frequently carried vehicles at speeds unsuitable for areas with significant child pedestrian movement. Where effective traffic-calming measures were absent, motorists could approach school gates without sufficient physical or visual cues encouraging them to reduce speed. For a child crossing the road, that difference in speed can have life-changing consequences.

4. The school rush created its own risks

Pick-up and drop-off periods transformed the road environment around school. Vehicles stopping on the carriageway, parents waiting near school gates, buses manoeuvring through limited space and pedestrians moving between parked vehicles contributed to congestion and reduced visibility. What appears to be a parking or congestion problem can quickly become a child-safety problem.

5. Encroachment reduced already-limited safe space

Unauthorised parking, roadside activity and temporary encroachments occupied pedestrian areas and obstructed sightlines. Children were consequently pushed closer to moving traffic precisely where they should not have to be.

6. Infrastructure and behaviour were closely connected

Speeding, wrong-side driving, improper parking and unsafe pedestrian movements were also observed as routine penomena. These findings reinforced an important lesson: **safer roads require engineering, enforcement and responsible road-user behaviour to work together.**

From Identifying Problems to Making Streets Safer

The purpose of a safety audit should not end with identifying deficiencies. It should lead to visible change on the ground through corrections to the deficiencies. Based on the findings at each school, IRF-IC developed **location-specific, low-cost and high-impact engineering interventions** aligned with applicable IRC standards. The interventions included high-visibility pedestrian crossings, transverse bar markings and traffic-calming treatments, school-zone warning and speed-limit signs, restoration of pavement markings, reflective road studs, zigzag hazard markings, improved parking management and enhanced road delineation and visibility measures.

Individually, many of these measures may appear simple. Together, however, they change how a road feels and functions. They tell motorists where greater caution is required. They make pedestrian movement more visible and predictable. They encourage lower speeds. Most importantly, they give children a safer and more clearly defined space within the road environment. That is the power of **low-cost, high-impact road safety engineering**.



A Safe School Zone is More than Infrastructure

Paint markings and signs alone cannot create lasting safety. Road-owning agencies, traffic police, school administrations, parents and communities all have a role to play. Engineering improvements need to be supported by effective enforcement. Schools can help organise pick-up and drop-off operations with better safety. Parents can avoid unsafe parking and stopping practices. Students can be educated about safer pedestrian behaviour. Authorities can ensure that footpaths, signs and markings remain functional over time. When these elements work together, road safety stops being a one-time intervention and becomes part of the everyday culture in the network surrounding a school.

From Four Schools to a Model for Indian Cities

The Delhi experience carries a larger message. Even in established urban areas, roads surrounding schools can contain significant safety gaps. But improving them does not always require expensive reconstruction or major infrastructure projects. It begins with observing how children actually use the road, identifying risks scientifically and responding with targeted interventions. The approach demonstrated through IRF-IC's School Zone Safety Programme: in terms of **audit, identify the safety problems, intervene with low-cost measures and sustain** the safe environment, which can provide a practical framework for cities across India.

With nationally recognised guidelines already available, the opportunity now is to translate those standards into visible improvements outside school gates across the country. Because the true measure of a safe school zone is not the number of signs installed or markings painted. It is whether a parent can watch their child walk towards the school gate with confidence. It is whether a driver instinctively slows down when entering a school environment. And ultimately, it is whether every child can make the journey to learn by going to school and return home safely.

As India works towards reducing road fatalities, child-friendly streets and safer school zones must become a national priority. Every child deserves a safe road to school. Making that road safe is a responsibility we all share.

ABOUT THE AUTHORS



Dr. Anilkumar B. Gaikwad is Vice Chairman and Managing Director, MSRDC (A Government of Maharashtra Undertaking). During his service life he was responsible for construction of many prestigious projects of buildings, National Highways and State Highway projects. Dr. Gaikwad became Secretary, Public Works Department (Maharashtra) in 2020 and was made responsible for mega-projects like Mumbai - Nagpur Samruddhi Expressway and several others. Dr. Gaikwad is recipient of Best Engineer Award of Govt. of Maharashtra and also Honorary Doctorate from Shridhar University, Pilani, Rajasthan in 2023.



Dr. M.P. Raju with over 38 years of experience is serving as the Managing Director of LEA Associates South Asia Private Limited. He is a qualified Civil Engineer and has Master's and PhD in Transport Planning. Dr. Raju is Transport Specialist with multi-faceted experience at the preparation of Policies, Programs, Plans and on Institutional strengthening and reforms across wide spectrum in a multi-modal environment.



Mr. JVR Reddy, CEng, MIEI, Chief General Manager at LEA Associates South Asia Pvt. Ltd., has 30+ years of experience, including 13 years internationally across Ireland, the UK, UAE, Qatar, Saudi Arabia, Oman, and Bahrain. A Chartered Engineer (Engineers Ireland) and Certified Senior Road Safety Auditor, he has led major highway, urban infrastructure, and road safety initiatives (15,000+ km) in India and contributed to the Bahrain Road Design Manual and Abu Dhabi Roads Manuals (A18, A20).



Dr. A. Mohan Rao, Chief Scientist and Head, Traffic Engineering and Safety at Central Road Research Institute, has over 27 years of experience in traffic engineering, transport planning, and road safety. He has led numerous projects in mobility planning, road safety audits, and traffic studies, published over 100 technical papers, and guided more than 100 undergraduate and postgraduate dissertations across reputed acadeMrmic institutions.



Dr. Jaya R. Shinganmakki is Professor of Transportation Engg., Dept of Civil Engineering, BMS College of Engineering, Bangalore. Dr. Shinganmakki has 24 years of experience in Teaching, Research & Consultancy Her research interests include Sustainable Pavement materials, Pavement Design, Construction Quality and Durability studies, Pavement Evaluation, Pavement Maintenance Management, Road safety design and Rural roads. She has led several funded research projects by NRiDA.



Mr. Hardik Dave is an AI entrepreneur and Founder & CEO of RoadVision AI, a company specializing in vision and generative AI solutions for road asset management and safety, leveraging dashcam, drone, and satellite imagery. RoadVision AI has achieved strong international traction with deployments across Africa, the Middle East, the United Kingdom, Australia, and India. He is a serial entrepreneur who previously built and exited Indika AI, a full-stack AI services company delivering end-to-end data pipelines, model development, and scalable human-in-the-loop training for global enterprises.



Prof. T. G. Sitharam is a civil engineer, professor at IISc Bangalore, former director at IIT Guwahati. He has served as Chairman of the All India Council for Technical Education from 2022 to 2025. He is known for his works in the fields of rock mechanics, rock engineering and geotechnical earthquake engineering. Dr. T. G. Sitharam is a distinguish *globally respected academic leader, scientist, administrator and policy expert* with over 35 years of transformative contributions to India's educational developments primarily on Civil Engineering and several other disciplines.



Mr. A.P.Bahadur is a highway professional with more than 55 years of experience. After retiring from MoRTH, he has worked for World Bank, and ADB. He has also worked for State Government in Nigeria, as Director, NITHE (now IAHE), as General Manager NHAI and as Director Indian Roads Congress. He was member of Technical Committee of World Road Congress and has been awarded the prize for best paper (co-authored), by World Road Congress (PIARC) in its Mexico Congress Session, 2011.



Mr. Shashi Raj is a research scholar in Transportation Systems Engineering in the Department of Civil Engineering at IIT Guwahati. He holds an M.Tech. in Transport Science and Engineering from the Central University of Jharkhand. His research focuses on driver workload assessment, integrating roadway geometry, driver behaviour, and safety. He applies statistical and machine learning methods, with interests in traffic safety, human factors, and intelligent transportation systems.



Prof. Akhilesh Kumar Maurya is a Professor of Civil Engineering at IIT Guwahati. He holds a PhD from IIT Kanpur and an M.Tech. from IIT Roorkee. With over two decades of experience, his research focuses on traffic flow modelling, driver behaviour, and road safety. He has published 100+ papers in international journals and conferences. He is President of TRG, a member of WCTRS & IRC, and a certified Road Safety Auditor



Dr. Anila Cyril is working as Junior Scientist in the Transportation Planning Division of KSCSTE - National Transportation Planning and Research Centre (NATPAC). She has more than 4 years of academic experience and 3 years of industrial experience. She graduated in Civil Engineering from Government Engineering College, Thrissur and holds Master's degree in Transportation Engineering from RIT Kottayam. She did her Ph.D. from NIT Surathkal, Karnataka. Her area of research includes public transportation, electric mobility, and urban planning.



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Dr. Vinod Karar is Chief Scientist, Traffic Engineering & Safety Division and Head, Planning, Monitoring & Evaluation Division, CSIR-Central Road Research Institute, New Delhi, India. An alumnus of NIT Bhopal with a doctoral degree in image processing, he has led a number of R&D projects and field implemented/commercialized 23 technologies. His research spans Augmented/Virtual Reality for Transportation, Glare Measurement for Road Safety, Women Safety in Public Transport, Driving Simulators, Driver Behaviour, Sensor Fusion, and Traffic Engineering. A Fellow of IRC, IETE, IEI and OSI, he is a recipient of various prestigious awards including the IEEE Technologist of the Year Award 2021 and CSIR Technology Awards.



Ms. Kamini Gupta is Sr. Technical Officer in Traffic Engineering & Safety Division, CSIR-Central Road Research Institute. She is having experience of R&D of Driver Behaviour, Driver distractions and Evaluation using Driver Simulator, VTS, Eye Tracker. She is involved in Road Safety works, Psychological study of drivers. She has done R & D and Consultancy Projects in many areas including Planning and Management of road network, transport economics including HDM-4, GIS applications in Database Management, and so on. She is recipient of Young Women Engineer award from Swiss government (International Society of Women Engineers) and Awardees of best paper in many National and International Conferences.



Prof. Manoranjan Parida, is Former Director of CSIR-Central Road Research Institute. He was Deputy Director at IIT Roorkee before joining CSIR-CRRI. He has also been the MoRTH Chair Professor on Development of Highway System in India at IIT Roorkee. As a Director of CRRI he has played a crucial role in the development of Steel Slag Road Technology, AI based Road Safety Solutions (iRASTE Projects), Promotion of Usage of Industrial Waste in Road Construction and many others. He is recipient of Pt. Jawaharlal Nehru Birth Centenary Award of IRC and Outstanding Teacher Award of IIT Roorkee.



Dr. Dhrutiman Dey is Co-founder and Chief Operating Officer of Stratify 3D Pvt. Ltd. He received his PhD from IIT Guwahati and established the startup to deliver scalable concrete 3D printing solutions. His research focuses on sustainable 3D printable material development, physics-informed lattice design, and its thermo-mechanical performance evaluation, with a strong emphasis on translating these innovations into commercially viable products.



Dr Biranchi Panda is an Assistant Professor at Department of Mechanical Engineering, Indian Institute of Technology (IIT) Guwahati, India. Dr Panda received his Ph.D. from Nanyang Technological University (NTU) Singapore and joined IIT to continue his research focusing on Sustainable resources for additive manufacturing (SReAM). His research interests include development of additive manufacturing, material characterizatio and concrete printing using local waste materials

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Mr. Satander Kumar, MSc/ AMIE., Scientist in CBRI 8 years, Central Road Research Institute- 29 years Working-Member of IRC/IS committees

Consultant/Faculty Member- IAHE

Author- 124 papers, Book- Development in Highway,
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Mr. Dhiraj Sethi is an M. Tech. Transportation Engineer, Certified Road Safety Auditor, and a qualified NEBOSH-IGC & BBS Professional with 17+ years in the highway sector in India and overseas. He is President – Safety, Systems & Audits and Head – ITS at Cube Highways Technologies. Since 2017, he is associated as an expert faculty at IAHE. “Rising Star of Safety 2021” awardee from National Safety Council, USA and currently serving as Technical Member on the IRC:H-7 Safety & Design Committee



Mr. Jigesh Bhavsar is a transportation engineer and road safety specialist with over 20 years of professional experience. A post-graduate from IIT Bombay, he has worked extensively on road safety assessments using the iRAP methodology, school zone safety, and transport planning studies across India and several countries in Central Asia, South-East Asia and Africa. He has served as a road safety consultant to the World Bank and Asian Development Bank, supporting governments in strengthening institutional capacity to proactively manage road infrastructure safety. He received the CEAI National Young Engineer Award in 2016.



Dr. Digvijay Sampatrao Pawar is an Associate Professor in the Department of Civil Engineering at IIT Hyderabad, specializing in Transportation Engineering. He earned his M.Tech. and Ph.D. from IIT Bombay. His research focuses on traffic operations, road safety, human factors, and Intelligent Transportation Systems, including naturalistic driving studies. He has received multiple awards for research excellence and contributions to transportation safety.



Mr. Ankit Singh is a Ph.D. Scholar in the Department of Civil Engineering at IIT Hyderabad, specializing in Transportation Engineering. His research focuses on driver behavior, gaze analysis, advanced driver assistance systems, and autonomous vehicles. His research was featured at the Transportation Research Board Annual Meeting (2023-2025) and other international conferences, and has been published in reputed journals such as Transportation Research Part-F.



Dr. Akshay Gupta is an Assistant Professor in the Department of Civil and Infrastructure Engineering at IIT Jodhpur. He earned his Master's and Ph.D. from IIT Roorkee. His research focuses on road safety, driving behaviour, human factors, crash-risk analysis, and intelligent transportation systems, with particular interest in LiDAR- and camera-based sensing for safer mobility.



Dr. Pushpa Choudhary is an Assistant Professor in the Department of Civil Engineering at IIT Indore. She earned her Ph.D. in Transportation Systems Engineering from IIT Bombay. Her research focuses on human factors in road safety, behaviour modelling, intelligent transportation systems, and risk assessment, with particular emphasis on understanding driver and pedestrian behaviour in complex traffic environments.



Ms. Reva Dileep is a Road Safety Consultant at TRL supporting projects across Asia and Africa. She plays a key role in delivering data-driven safety solutions and contributes to technology-transfer initiatives. Reva leads the implementation and support of TRL's iMAAP - road-crash database system and the delivery of road safety advisory programmes, helping client organizations strengthen evidence-based decision-making and adopt global best practices in road-safety management.



Mr. Tony Mathew is head of TRL s India business and oversees the delivery of advisory programmes and TRL software projects across Asia and Africa, driving data-led transformation in transport safety and performance. A road-safety and infrastructure specialist with over 26 years of experience in road asset management. Tony has successfully delivered road-safety and asset-management systems for clients across Europe, Africa and Asia, bringing global best practices into regional implementations.



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Mr. Alok Bhowmick is an eminent structural engineer with over 4 decades of experience in the field of bridge and structural engineering. He is active in many professional bodies. He is a fellow of the Indian National Academy of Engineering, President of IAStructE, Vice President of CEAI and Vice President of Indian national group of IABSE. He is a certified International professional engineer from IE(I) and a FIDIC Certified Consulting Professional.



Dr. Nikhil Saboo is as an Associate Professor in the Department of Civil Engineering at IIT Roorkee. He has more than 14 years of experience in the area of Pavement Engineering. His research interest includes characterization of pavement materials, pavement analysis and design, and pavement evaluation. He is closely working with industry and highway agencies on several field related problems, and providing technical support and solutions through forensic and laboratory investigations.



Ms. Muskan Verma is a research scholar in the Department of Civil Engineering at IIT Roorkee. Her research focusses on the use of anti-oxidants to improve the ageing resistance of asphalt binders and mixtures. She is also actively working on various industrial projects ranging from binder characterization to mix evaluation.



Mr. Satish Pandey is Senior Principal Scientist and Head, Flexible Pavement Division of CSIR-Central Road Research Institute, New-Delhi. He is also a Professor at the Academy of Scientific and Industrial Research. Mr. Pandey has 20 years of experience in Transportation and Highway engineering. He has developed “Steel Slag Road Technology” with India’s First Steel Slag Road at Hazira, Surat, Gujarat. He is also the inventor of MSS+, ECOFIX and Rejuapve, a eco-friendly technology for road construction and maintenance.



Mr. S.S. Gaharwar is Sr. Vice President, Project Monitoring Unit, at M/s Intercontinental Consultants & Technocrats, Pvt. Ltd., New Delhi. He had worked as the Chief Scientist & Head, Bridges & Structures, CSIR-Central Road Research Institute, New Delhi, INDIA. He had also worked as the General Manager (Technical) with National Highways Authority of India. He has more than 37 years of Professional Experience in the field of R&D, Teaching, and Field Works (Planning, Procurement and Execution) in the field of Bridge Engineering and Highway Engineering. He is the Member of several professional bodies like IRC, ICI, ISCMS, IGI, IRF, BIS, NRRDA. He has received a number of prestigious Awards to his credit



Prof. P. K. Sikdar is advisor, International Road Federation – India Chapter. He is former Professor of Civil Engineering at IIT Mumbai, former Director at CSIR-Central Road Research Institute (CRRI), and former President at multi-national consultancy organization Intercontinental Consultants & Technocrats Pvt. Ltd., New Delhi. With a long experience of teaching, research and consultancy for more than 40 years, Dr. Sikdar is recipient of Commonwealth Scholarship (Canada) for doctoral study and Leverhulme Foundation Fellowship (UK) for post-doctoral research (1981-82).



Arvind Sethi *Co-Founder & CEO, DualSafe Private Limited*
Arvind Sethi is the Co-Founder and CEO of DualSafe, the world's first patented 2-in-1 helmet system. Before DualSafe, he spent over three decades in global technology and operations roles at Tesco, Intel, and Manthan. A near-fatal accident in Chandigarh, survived because of a properly strapped helmet, gave him the conviction to build something that could change rider behaviour at scale. Under his leadership, DualSafe has secured patents in India, the USA, and the UK, signed NDAs with TVS Motors and Hero MotoCorp, and been recognised by SiliconIndia as a Top 10 Wearable Startup in 2023.



Anupama Sethi is the Co-Founder of DualSafe, bringing nearly two decades of experience in education to the company's core question: why do people avoid things that are good for them, and what does it take to change that? Her understanding of habit formation and behaviour change has shaped DualSafe's focus on comfort and convenience from day one.



Jasvinder Duhan is an engineer with a legal background, a Master's in Traffic Management and a Nationally & Internationally Certified Road Safety Auditor. His multidisciplinary expertise bridges engineering, traffic management, law and policy to deliver practical solutions for safer roads. He has played a pivotal role in implementing IRC-compliant School Zone Safety interventions nationwide, improving child safety through engineering, traffic calming and stakeholder collaboration

IRF-IC PAST EVENTS PHOTOS GALLERY

















Celebrating IRF-IC's Foundation Day, held on 19th January 2026
India International Centre, Kamala Devi Complex, New Delhi

















National Road Safety *Mission* For Schools - IRF-IC & Academia Axis Edtech
held on 20th November 2025, India International Centre, Kamala Devi Complex, New Delhi

















Global Road Infratech Summit & Expo (GRIS 2026)
held on 5th & 6th February 2026 at Hotel The Ashok, New Delhi

Global Road Infratech Summit & Expo

14-15 JANUARY 2027

Dr. Ambedkar International Centre | New Delhi | India

From Vision to Impact: Transforming Road Infrastructure for a Safer, Smarter and Sustainable India

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INDIA CHAPTER

GLOBAL ROAD INFRATECH SUMMIT & EXPO (GRIS-

From Vision to Impact: Transforming Road Infrastructure for a Safer, Smarter and Sustainable India

THE ANNUAL FLAGSHIP EVENT OF IRF- INDIA CHAPTER

14-15 January | **Dr. Ambedkar International Centre, New Delhi**

The Annual Flagship Event of IRF-India Chapter **Global Road Infratech Summit & Expo (GRIS-2027**) is planned during **14-15 January 2027 at Ambedkar International Centre, New Delhi.** The theme of this year's Summit is "From Vision to Impact: Transforming Road Infrastructure for a Safer, Smarter and Sustainable India".

The infrastructure journey of India has been unprecedented during the last quarter century, which has driven the country to become a global economic power. It is now provides the opportunity to examine the quality and performance of the systems along with the opportunity to embed AI for smart mobility and sustainable management of the assets. All these are expected to provide the future direction with way forward.

The Conference will have a structure of Plenary Sessions and also the Parallel Sessions for the delegates to present their ideas and vision for the future of the infrastructure development and management in the country. Conference aims to cover entire gamut of areas from planning, design, construction and management of the mobility network using efficient technologies at every stage. There is a parallel Exhibition for exposition of the latest and promising technologies and sustainable material inputs for development of high quality and durable infrastructure.

POSTER SUBMISSION DATES

It is proposed to invite innovative ideas or research and developments from the post graduate students and research scholars working in academia and industries in the form of posters. For this, a 400 words detailed abstract of the R&D idea shall be submitted, based on which the selection will be done by a review committee for poster presentations at the Conference. The deadlines are as follows:

Poster details in 400 words to be submitted	**30 October 2026**
Review comments and acceptance of poster	**30 November 2026**
Submission of final poster (as per guideline)	**15 December 2026**

For More Information Contact 9205994744 or write to us at gris2027@irf.org.in

The Programme structure of GRIS-2027 as of August 2026 is given here for your reference.

Day 01: 14 January 2027: Thursday

10.00 – 11.00 hr.	Inauguration		
11.00 – 11.45 hr.	Tea/Coffee & Networking Break		
11.45 – 13.00 hr.	**Plenary Session 1- Road Safety Management Innovation**		
13.00 – 14.00 hr.	Lunch & Networking Break		
14.00 – 15.15 hr.	**Plenary Session 2- Development of Sustainable Infrastructure**		
15.15 – 16.00 hr.	Tea/Coffee & Networking Break		
16.00 – 17.15 hr.	**Plenary Session 3 – Procurement & Contracts –The Way Forward**		
18.00 – 19.00 hr.	Cultural Programme		
19.00 – 21.30 hr.	Cocktail & Dinner		

Day 02: 15 January 2027: Friday

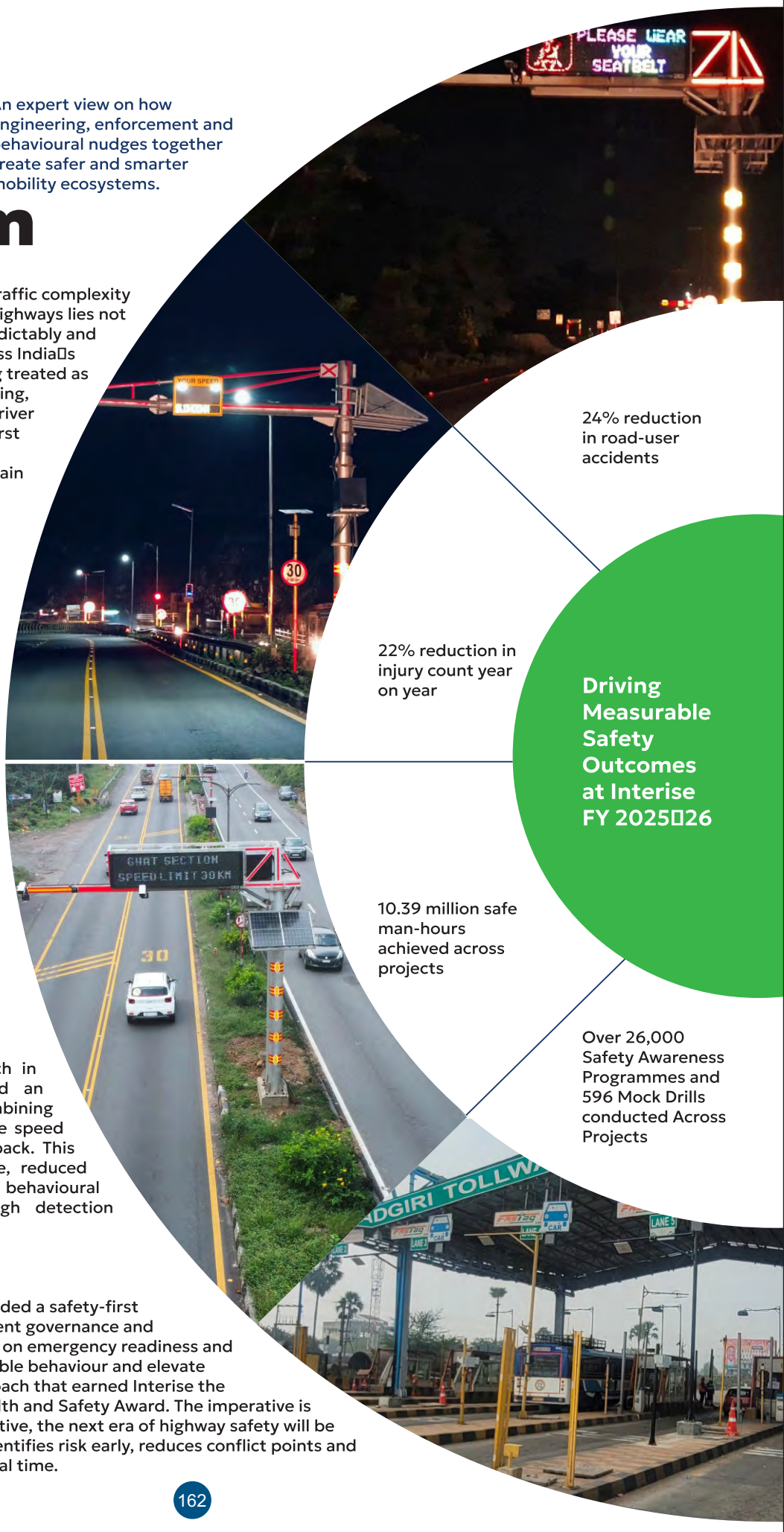
10.00 – 11.15 hr.	**Plenary Session 4 - AI & Digitalization in Infrastructure**		
11.15 – 12.00 hr.	Tea/Coffee & Networking Break		
12.00 – 13.15 hr.	**Plenary Session 5 - Future of Mobility with AI**		
13.15 – 14.00 hr.	Lunch & Networking Break		
14.00 – 15.15 hr.	**Parallel Session 1 - Safety in Mobility**	**Parallel Session 2 - Modern Construction Equipment**	**Parallel Session 3 - Digital Transformation in Infrastructure**
15.15 – 16.00 hr.	Tea/Coffee & Networking Break		
16.00 – 17.15 hr.	**Parallel Session 4 - ITS & Smart Mobility**	**Parallel Session 5 - Procurement & Contracts for Sustainability**	**Parallel Session 6 - Institutional Strengthening of Stakeholders**

Also see the Summit Brochure for other participation opportunities (www.indiairf.com)

INTERISE

Building a Safer Mobility Ecosystem

An expert view on how engineering, enforcement and behavioural nudges together create safer and smarter mobility ecosystems.



As global mobility networks expand and traffic complexity increases, the benchmark of world-class highways lies not only in connectivity, but in how safely, predictably and sustainably people and goods move. Across India's highways, road safety is increasingly being treated as a system outcome, built through engineering, enforcement, operational discipline and driver behaviour. Experts from Interise: India's first Infrastructure Investment Trust with a Self-Sponsored Investment Manager, explain how toll optimisation, predictive speed systems and behaviour-led enforcement have reduced risk across high-traffic corridors.

Smart Tolling for Safer Flow - TL Booster | Toll Lane Optimisation:

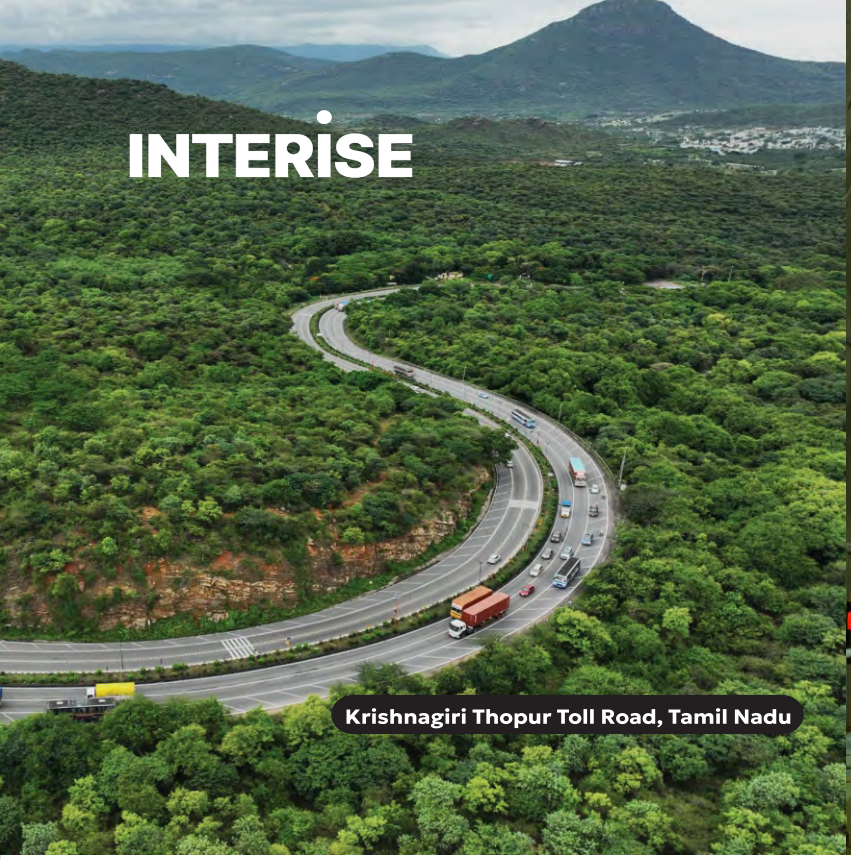
Conventional toll plazas have often experienced stop-and-go movement, queue spillbacks and increased emissions, creating congestion and safety risks. On the Hyderabad–Yadgiri corridor in Telangana, Interise has deployed Toll Lane (TL) Booster, a real-time toll lane optimisation solution designed to improve throughput while reducing conflict points. Initially piloted on two lanes and later scaled to seven, TL Booster has delivered a 35% increase in peak-hour processing capacity, shortened queues and reduced vehicle idling, enabling safer, faster and greener toll operations.

Predictive Speed Management in High-Risk Terrain:

On the Krishnagiri–Thoppur ghat stretch in Tamil Nadu, Interise has implemented an integrated speed calming system combining radar detection, ANPR cameras, real-time speed displays, analytics and VMS-based feedback. This system has improved speed compliance, reduced speed variance and delivered real-time behavioural nudges, with validation confirming high detection accuracy.

A Systemic Approach to Road Safety:

Beyond infrastructure, Interise has embedded a safety-first approach into operations through consistent governance and workforce engagement. A sustained focus on emergency readiness and awareness continues to reinforce responsible behaviour and elevate standards across the ecosystem—an approach that earned Interise the Economic Times Best in Class Quality, Health and Safety Award. The imperative is clear: from an asset management perspective, the next era of highway safety will be defined by system-led compliance that identifies risk early, reduces conflict points and positively influences driver behaviour in real time.



Krishnagiri Thopur Toll Road, Tamil Nadu


Shreenathji - Udaipur Tollway, Rajasthan

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16 BOT/Annuity Road Projects	Daily Traffic Flow of 5,00,000 Passenger Car Units (PCU)	6900 Lane Kms	5 Excellence Awards from NHAI
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Our road assets serve as pathways to opportunity by connecting people, enabling commerce, and laying the foundation for inclusive and sustainable growth.

Guided by a vision of an India where progress touches every community, we continue to drive purposeful infrastructure that elevates both economic and human development.

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