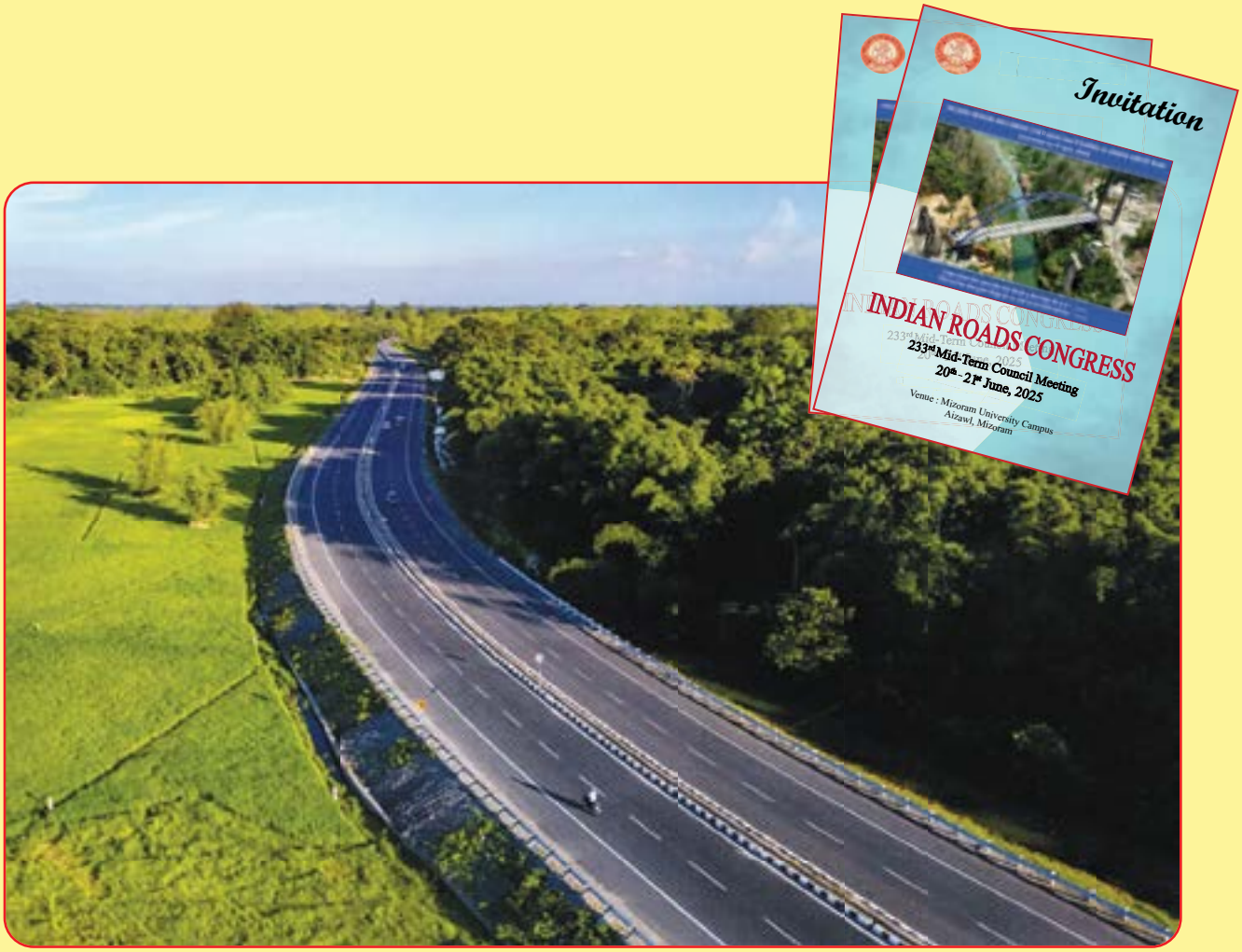
INDIAN HIGHWAYS

JUNE 2025

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SPECIAL NUMBER



A view of NH - 315 Dibrugarh - Ledo Section in the State of Assam

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Indian Roads Congress
Founded : On 10th December, 1934

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FEEDBACK

Suggestion/Observation on editorial and Technical Papers are welcome and may be sent to IRC Secretariat on Email-indhighways@gmail.com/dd.irc-morth@gov.in

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84th Annual Session of IRC to be held at Bhubaneswar (Odisha) from 7th to 10th November, 2025

On the invitation of Government of Odisha, the 84thAnnual Session of the Indian Roads Congress will be held at Janata Maidan, Bhubaneswar (Odisha) from 7th to 10th November, 2025. The Invitation Booklet containing the Tentative Programme, Registration Form, Accommodation Form etc. will be available in our website www.irc.nic.in shortly. Accommodation is available on first come first serve basis. All members of IRC are invited to attend the 84th Annual Session.

It is expected that more than 4000 Highway Engineers from all over the country and abroad will attend this Session. During the Annual Session of IRC, there has been a practice for various firms/organizations to make Technical Presentations on their products/technologies & case studies (with innovative construction methods or technologies or having special problems requiring out of the box thinking and special solutions). The presenters will get an opportunity to address a large gathering of highway professionals from Private Sector as well as decision makers in the Govt. Sector. These presentations evoke lively interaction among the participants.

A time slot of about 12-15 minutes is normally allocated for each Technical Presentation. Time is also given for floor intervention. During such Technical Presentation Session, no other meetings will be held parallel so as to ensure maximum attendance during the Technical Presentation Session. The stakeholders are, therefore, requested to participate in the event and book slots at the earliest.

Interested Organizations may write to IRC conveying their willingness for participation and send the topics of their Technical Presentation by E-mail: indhighways@gmail.com/ad.irc-morth@gov.in or through Speed Post alongwith a Demand Draft for **Rs.2,50,000/- (Rupees Two Lakhs Fifty Thousand only) + 18 % GST drawn in favour of Secretary General, Indian Roads Congress, New Delhi latest by 30th September, 2025** so that necessary arrangements can be made by IRC.

For any enquiry about the 84th Annual Session like Registration, Advertisement in Souvenir, Membership, Technical Presentation, please address to Secretary General, Indian Roads Congress, IDA Building, Jamnagar House, Shahjahan Road, New Delhi-110 011. For assistance the contact details are given as under:

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For Accommodation and Technical Exhibition you may contact to following:		
Local Organising Secretary	**Accommodation**	**Technical Exhibition**
Shri Manas Ranjan Behera Local Organising Secretary, 84th IRC Session Chief Engineer, Design O/o EIC (Civil-cum-Roads), Bhubaneswar (Odisha) Mobile No. 9437082101 Email: los84thircbhubaneswar2025@gmail.com	Er. Trinath Behera, Chief Construction Engineer, Cuttack (R&B) Circle, Cuttack (Odisha) Phone No. 9437011000 Email: btrinatha@gmail.com	Er. Rama Chandra Sethi, Chief Construction Engineer, Khordha (R&B) Circle (Odisha) Phone No. 9437111283, 7978742449 Email: irc84bbsrtechnicalcommittee@gmail.com

HILL ROADS : BALANCING GROWTH & ECOLOGY



Shri Rahul Gupta
Secretary General, IRC & Chief Engineer, Ministry of Road Transport & Highways, Government of India

Highway projects are pivotal for economic growth and connectivity as these serve as vital arteries of economic activity, facilitating trade, commuting and overall development. The pace of highway infrastructure development is directly proportional to the socioeconomic growth of the nation. However, the construction and operation of highways can severely disrupt ecosystems, alter landscapes and contribute to environmental degradation. In the era of climate consciousness, environmental impact of infrastructure projects, especially highways, cannot be overlooked.

Roads in hilly areas have a special place considering their strategic significance due to their proximity to international borders and defence establishments. Providing good hill roads has been the main contributing factor for development of tourism all along the Himalayas and other important hill stations in India. On the other hand, the hilly regions, including road networks, are affected frequently by flash floods due to high intensity rainfall, cloud burst and snow avalanche. These often result in many sections remaining closed for some days.

In addition, every year we hear about the incidences of landslides, slope failures from some or other parts of the country which cost several human lives and huge monetary losses due to destruction of infrastructure and settlements. So, the new challenge before the highway engineers is to anticipate plausible multi-hazard scenarios associated with the highway routes and ensure that these vital always remain safe and resilient to multiple hazards. Road to growth should not be at the cost of destruction, which can have long lasting impact.

It's well known that nature-friendly engineering interventions are superior and most essential for disaster resilient green highways. Nature-friendly interventions for slope protection are preferred because they, by design, aim at internally strengthening the potentially unstable slope masses in hazardous areas. The engineering aspect covers the geometric design and construction of roads, bridges, flyovers, culverts, underpasses, footpaths, foot over bridges, tunnels and road junctions with proper signaling system, rotaries, roundabouts, proper lighting, etc. in accordance with standards, guidelines and norms set forth by IRC or other user ministry/road department.

Although IRC Codes, guidelines, manuals have been made keeping in mind the diverse needs of land and terrain available, climatic and terrain condition, environment, category of road, available technology, material, machinery, advancement in vehicles, need and safety of road users, etc. All these IRC documents are being updated time to time to meet the dynamic requirement of industry and users. But there is a greater need to ensure that the IRC norms are followed in both letter and spirit. None should take a shortcut when it comes to adoption and implementation of these norms. For Survey, Investigation and Preparation of Road Projects for hill roads detailed guidelines are available in IRC:SP:19-2020 and for Geometric Design of hill roads and road tunnels, reference may be made to IRC:52 "Recommendations about the Alignment, Survey and Geometric Design of Hill Roads", IRC:SP:48 "Hill Road Manual" and IRC:SP:91 "Guidelines for Road Tunnels".

By utilizing resilient materials and innovative construction methods, these highways act as a shield against the unpredictable forces of nature. The deployment of smart technologies adds another layer of resilience, enabling real-time monitoring and rapid response during emergencies. IRC has published IRC:138 "Guidelines for Highway Engineers on Disaster Resilient Green Highways in Multi Hazard Ecosystem" which gives guidance on concept of resilient roads in planning, design, construction and maintenance of highways incorporating the lessons learnt from the past.

Rahul Gupta

(Rahul Gupta)
Secretary General, IRC

Highlights of Seminar on "Best Practices, Emerging Trends and Technologies in Planning, Construction & Maintenance of Bridges" held on 25th & 26th April, 2025 organised by IRC in association with Public Works Department, Govt. of Assam at Guwahati

The Indian Roads Congress (IRC) in association with Public Works Department, Govt. of Assam organized a two-day Seminar on "Best Practices, Emerging Trends & Technologies in Planning, Construction & Maintenance of Bridges" on 25th & 26th April, 2025 at Hotel Radisson Blu, Guwahati (Assam). During this two-day Seminar 19 presentations were made by experts in Five Technical Sessions followed by a Panel Discussion & Closing Session. The Seminar was attended by more than 500 delegates from across the country. Hon'ble Chief Minister of Assam, Dr. Himanta Biswa Sarma was the Chief Guest at the Inaugural Session. Prof Manoranjan Parida, President, IRC; Shri Sudip Chaudhary, Additional Director General, Ministry of Road Transport & Highways; Shri Rahul Gupta, Secretary General, IRC; Shri Kamlesh Kumar Pipri, Immediate Past President, IRC; Shri A.K. Patel, Vice- President, IRC; Shri S.F. Patil, Vice-President, IRC; Shri Vishal Aggarwal, Vice-President, IRC; Shri Raj Chakraborty, Spl. Commissioner & Spl. Secretary PWD NH, Govt. of Assam; Shri Paban Terang, Commissioner & Spl. Secretary PWD Roads, Govt. of Assam; Shri Chandan Sarma, Spl. Commissioner & Spl. Secretary PWD (Health & Education), Govt. of Assam; Shri Bibhutia Saikia, Spl. Commissioner PWRD, Govt. of Assam and Shri Hemanta Dewri Bharali, Local Organising Secretary & Additional Chief Engineer (Planning), PWD, Assam shared the dais during the inaugural session.



A view of Dais during the Inaugural Function





View of Audience during Inaugural Function

Inaugural Session: Hon'ble Chief Minister, Assam and other dignitaries were welcomed by presenting bouquet, IRC Memento, Assamese Gamcha & traditional Assamese Japi.





Prof. Manoranjan Parida, President IRC welcoming Hon'ble Chief Minister of Assam, Dr. Himanta Biswa Sarma



Shri Sanjiv Shyam, Chief Engineer (Roads) PWD Assam welcoming Prof. Manoranjan Parida, President IRC



Shri Debojit Das, Chief Engineer (NH) PWD Assam welcoming Shri Sudip Chaudhury, Additional Director General, MoRTH



Shri Jewal Timung, Chief Engineer (Building) PWD Assam welcoming Shri Rahul Gupta, Secretary General, IRC



Shri Dipak Kumar Baishya, Addl. Chief Engineer PWD Assam welcoming Shri Kamlesh Kumar Pipri, Imm. Past President, IRC



Shri Pranab Rabha, Addl. Chief Engineer, PWD Assam welcoming Shri A.K. Patel, Vice President, IRC



Shri Rati Kanta Pagu, Addl. Chief Engineer, PWD Assam welcoming Shri S.F. Patil, Vice President, IRC



Shri Jogendra Das, Chief Engineer, (EAP) PWD Assam welcoming Shri Vishal Aggarwal, Vice President, IRC



The Programme was Inaugurated by Lighting of Ceremonial Lamp



Welcome Address by Shri Rahul Gupta, Secretary General, IRC

Shri Rahul Gupta, Secretary General, IRC delivered the Welcome Address highlighting the pre-eminent role of IRC in development of Roads, Bridges and Tunnels in the country over the last 91 years and it's continued endeavour in this missionary zeal. He gave a brief overview of the technical presentations and deliberations to be made during the seminar. He also emphasised on tackling the challenges faced during bridge construction, maintenance and management by leveraging available apt and appropriate technologies.

Shri Sudip Chaudhary, Additional Director General, Ministry of Road Transport & Highways, Government of India, during his address, highlighted that the presence of the Hon'ble Chief Minister of Assam has provided lot of encouragement to everyone present in the seminar and working in the field of bridge construction and maintenance. He also emphasised that the country is investing heavily in infrastructure, especially in highways, with a budget of around ₹ 3 lakh crore for National Highways per annum out of which over ₹ 30,000 crore specifically for the north-eastern region. The budget amount needs to be spent efficiently for planning, design and construction of robust infrastructure.

He also highlighted that in the next 5 to 10 years, the focus of highway management will shift towards maintenance and upkeep of the newly built infrastructure containing a large number of bridges and structures. Preventive maintenance will be crucial including health monitoring of structures and bridges. It is important to incorporate modern technologies like AI and other digital tools in the maintenance and management process.



**Address by Shri Sudip Chaudhary,
Additional Director General,
Ministry of Road Transport & Highways**

Prof. Manoranjan Parida, President, IRC delivered presidential address and mentioned that innovations are not only improving the safety, efficiency, and sustainability of bridge infrastructure but also ensuring that our bridges stand the test of time, serving communities and contributing to economic growth. He observed that as we look to the future, the potential for smarter, more resilient infrastructure is limitless, and he encouraged all officers of central and state governments to give serious considerations to these emerging trends.



**Presidential Address by Prof. Manoranjan Parida,
President, IRC**

Hon'ble Chief Minister of Assam Dr. Himanta Biswa Sarma delivered the Inaugural Address and mentioned that bridges are more than infrastructure, they represent connectivity, resilience & progress. He emphasised that Assam Govt remains committed to transformative, future-ready infrastructure and highlighted achievements made by Assam Govt. in momentous development of road infrastructure in last 9 years including majestic bridges over mighty Brahmaputra. He assured full support for development of National Highways and expressed his continued commitment for development of road infrastructure in Assam.

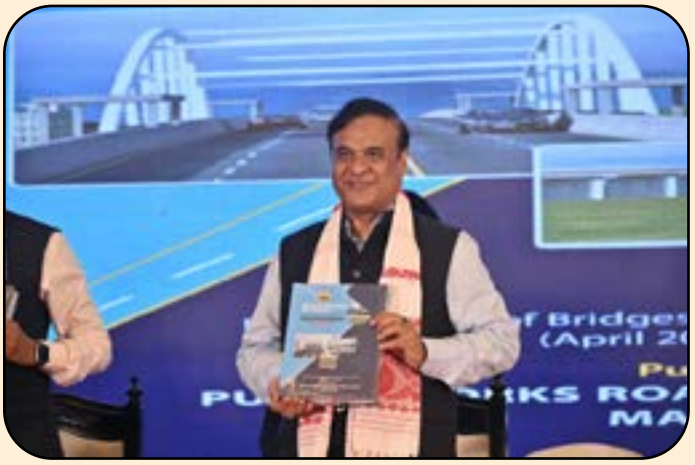


**Inaugural Address by Hon'ble Chief Minister of Assam
Dr. Himanta Biswa Sarma**





Paying tribute to the persons lost their life in the Pahalgam terror attack on April 22, Dignitaries on the dais, IRC members & delegates observed a two-minute silence.





Hon'ble Chief Minister of Assam Dr. Himanta Biswa Sarma released Souvenir containing technical articles by eminent engineers and coffee table book 'Bridge Archive of Assam' containing Photographs of Bridges Constructed in Assam by PWRD from April 2021 to March 2024.



A Dais view of Technical Session-1

The Technical Session-1 was chaired by Shri Sudip Chaudhury, ADG, MoRT&H and Co-Chaired by Dr. (Mrs.) Lakshmy Parameswaran, Chief Scientist (Retd.), CSIR-CRRI. During the Session following four presentations were made by renowned experts:

Presentation 1: "Overviews of Road Bridges & Its Components - Indian Codal Provisions" by Shri Sanjay Garg, Cheif Engineer, MoRT&H

Presentation 2: "New Era of Bridge Monitoring Mechanism for Sustainability Ensuring Safety and Longevity of Infratructure" by Shri S.F. Patil, CPO KSHIP, Govt. of Karnataka

Presentation 3: "Experience by MORTH on Bridges" by Shri Amiyanshu Pathak, Executive Engineer, MoRT&H

Presentation 4: "New Material" by Shri Rakesh Patel, Technical Manager, M/s Penetron India Pvt. Ltd



A Dais view of Technical Session-2

The Technical Session-2 was chaired by Shri D. Sarangi, Former DG(RD) & SS, MoRT&H and Co-Chaired by Shri Raj Chakraborty, Special Commissioner and Special Secretary to the Govt of Assam, PW (Building & NH), Assam. During the Session following three presentations were made by renowned experts:

Presentation 1: "Geotechnical Investigation for Bridges" by Shri Ravi Sundaram, Director, M/s Cengrs Geotechnical Pvt. Ltd., Noida

Presentation 2: "Design Principles of Deep Foundation (Pile)" by Shri R.K. Jaigopal, CEO, M/s CFSC, Bengaluru

Presentation 3: "Seismic Performance Evaluation of a Highway Bridge with Fe-based Shape Memory Alloy Retrofitted Piers" by Dr Monjusha Sarmah, IIT Guwahati



A Dais view of Technical Session-3

The Technical Session-3 was Chaired by Shri R.P. Indoria, Former DG(RD) & SS, MoRT&H and Co-Chaired by Shri Pankaj Aggarwal, Chief Engineer, MoRT&H. During the Session following three presentations were made by renowned experts:

Presentation 1: "Design of Deep Foundation (Well)" by Shri R.S. Sharma, Managing Director, M/s Sugam Tech Pvt. Ltd.

Presentation 2: **"**Case Studies for Better Understanding of Bridge Design LSM Concept" by Prof Mahesh Tandon, Chairman, M/s Tandon Consultants Pvt Ltd

Presentation 3: "Why do Bridges in our Part of the World Crack and Distress Much Earlier than in Many 1st World Countries" by Dr. V.K. Raina,Senior Expert & Consultant: The United Nations & The World Bank

During second day, Saturday, 26th April, 2025, 2 Technical Sessions and Panel discussion on "Sustainability in Bridge Design, Construction and Maintenance" were held.



A Dais view of Technical Session-4

The Technical Session-4 was Chaired by Shri G. Sharan, Former DG(RD) & SS, MoRT&H and Co-Chaired by Dr. N.C. Pal, E-in-C (Retd.) PWD, Odisha. During the Session following four presentations were made by renowned experts:

Presentation 1: "Case Presentation on Dhubri-Phulbari Bridge Projects" by Shri Abhirup Deshmukh, Senior Manager (Planning), M/s L&T

Presentation 2: "Construction Aspects of 6 Lane Extradosed Bridge over River Brahmaputra" by Shri Madhav Singla, Manager Projects, M/s S.P. Singla Construction India Pvt. Ltd

Presentation 3: "New Materials/Technology for Construction of Bridges" by Dr. Ravi Sinha, IIT Bombay

Presentation 4: "Modern Bridge Construction Practices (Launching Girders)" by Shri Kaustuv Ghosh,Vice President, M/s L&T



A Dais view of Technical Session-5

The Technical Session-5 was Chaired by Prof. M. Parida, President, IRC & Director, CSIR-CRRI and Co-Chaired by Shri R.K. Jaigopal, CEO, M/s CFSC, Bengaluru. During the Session following five presentations were made by renowned experts:

Presentation 1: "Quality Assurance & Control During Construction of Bridges" by Shri D. Sarangi, Former DG(RD) &SS, MoRTH

Presentation 2: "Overview of BMS & IRC: SP:35" by Dr. Sanjay Wakchaure, Superintending Engineer, MoRT&H

Presentation 3: "Construction Defects and Remedial Measures of Bridges" by Dr. G.K. Sahu, Chief Scientist, CRRI

Presentation 4: "New Material" by Shri Pratik Sen, M/s Jindal Stainless Limited

Presentation 5: "Bridge over Brahmaputra connecting Guwahati and North Guwahati and the Challenges" Shri S. Das Gupta, Executive Engineer, PWRD, Assam



Dais View of Panel Discussion

Panel discussion on "Sustainability in Bridge Design, Construction and Maintenance" was held and moderator of the discussion was Shri D. Sarangi, Former DG(RD) & SS, MoRT&H. The following Panellists participated in the discussion:

1. Resilient Design by Prof Mahesh Tandon
2. Materials for Sustainability by Dr. N.C. Pal
3. Durability issues during Construction by Shri R.S Sharma
4. Sustainability in Bridge Maintenance by Shri Rahul Gupta
5. Design Focus to address Climate Change by Dr. Rajeev Goel
6. Corrosion Prevention for Bridges by Dr. Naveet Kaur
7. Sustainability Aspects of Bridges over River Brahmaputra in Assam by Shri Raj Chakraborty
8. Sustainability in Bridge Management by Shri D Sarangi

The Seminar was a grand success as it had a strong participation of engineers from Govt. Departments, contractors and consultants and the presentations were of very high quality followed by incisive discussions. The deliberations are also to help in updating IRC Codes on this subject.







LOC Team facilitated by IRC Office Bearers during the Valedictory Function



Shri Raj Chakraborty, Spl. Commissioner & Spl. Secretary PWD NH, Govt. of Assam congratulated Shri Hemanta Dewri Bharali, Local Organising Secretary & Additional Chief Engineer (Planning), PWD, Assam for the successful event



Vote of thanks was delivered by Shri A.K. Patel, Vice President, IRC



View of Cultural Programme

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Orafol India recently hosted key customers on a visit to Orafol Europe's manufacturing facility at Oranienburg, Germany. The tour offered valuable insights into advanced production processes and quality standards. It also facilitated meaningful knowledge exchange between the Indian customers and the European team, strengthening collaboration and trust.

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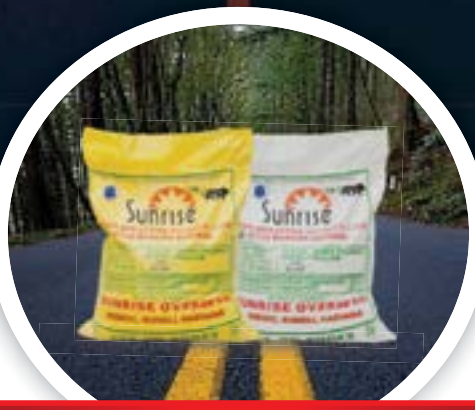
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Mr Ankur Aggarwal, Director, Sunrise Overseas, Welcoming **Sh. Nitin Gadkari Union** Minister for Road Transport and Highways of India along with S**h. Bhupendra Patel,** Chief Minister of Gujarat at our stall in 82nd session of Indian Road Congress at Gandhi Nagar, Gujarat, INDIA

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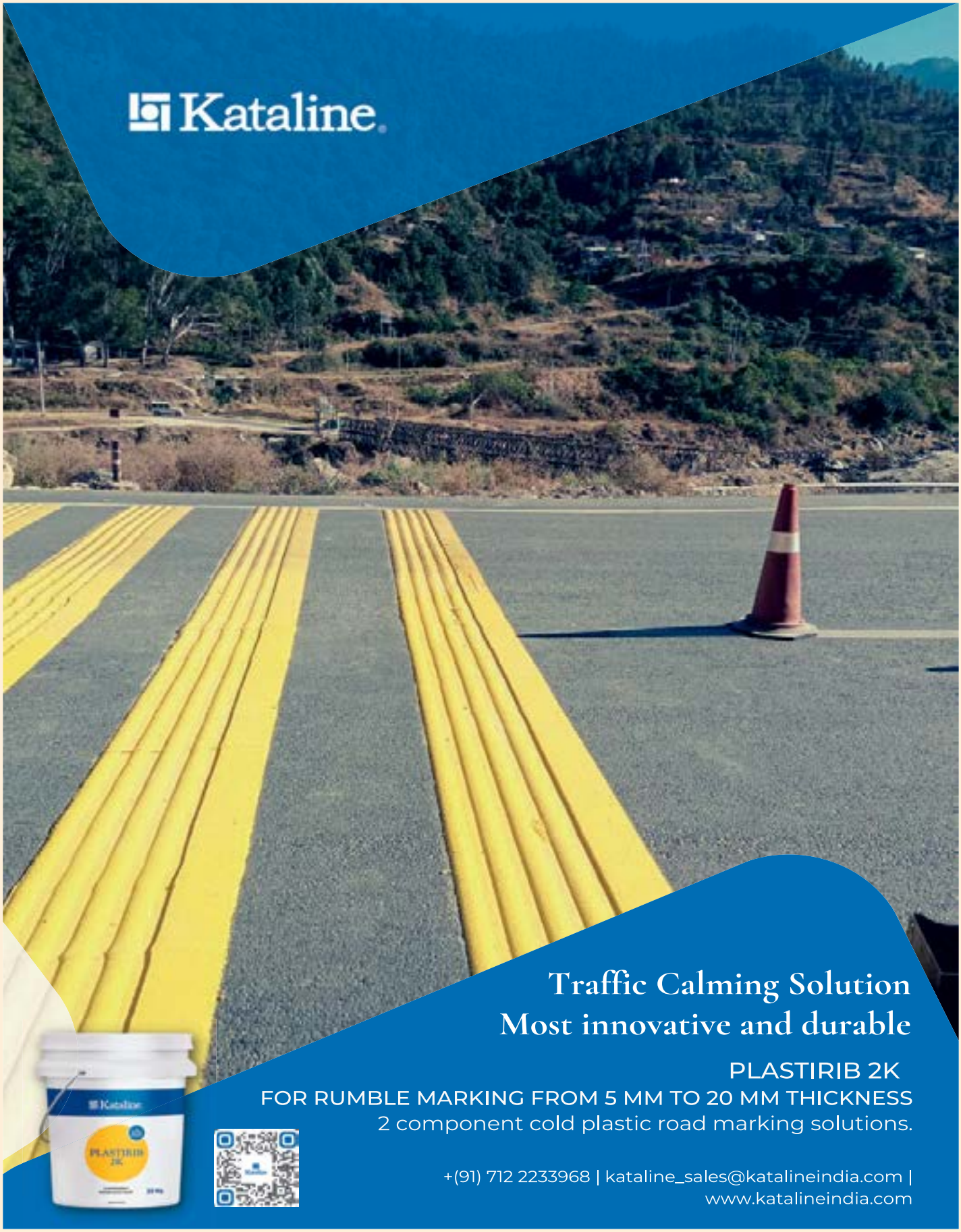


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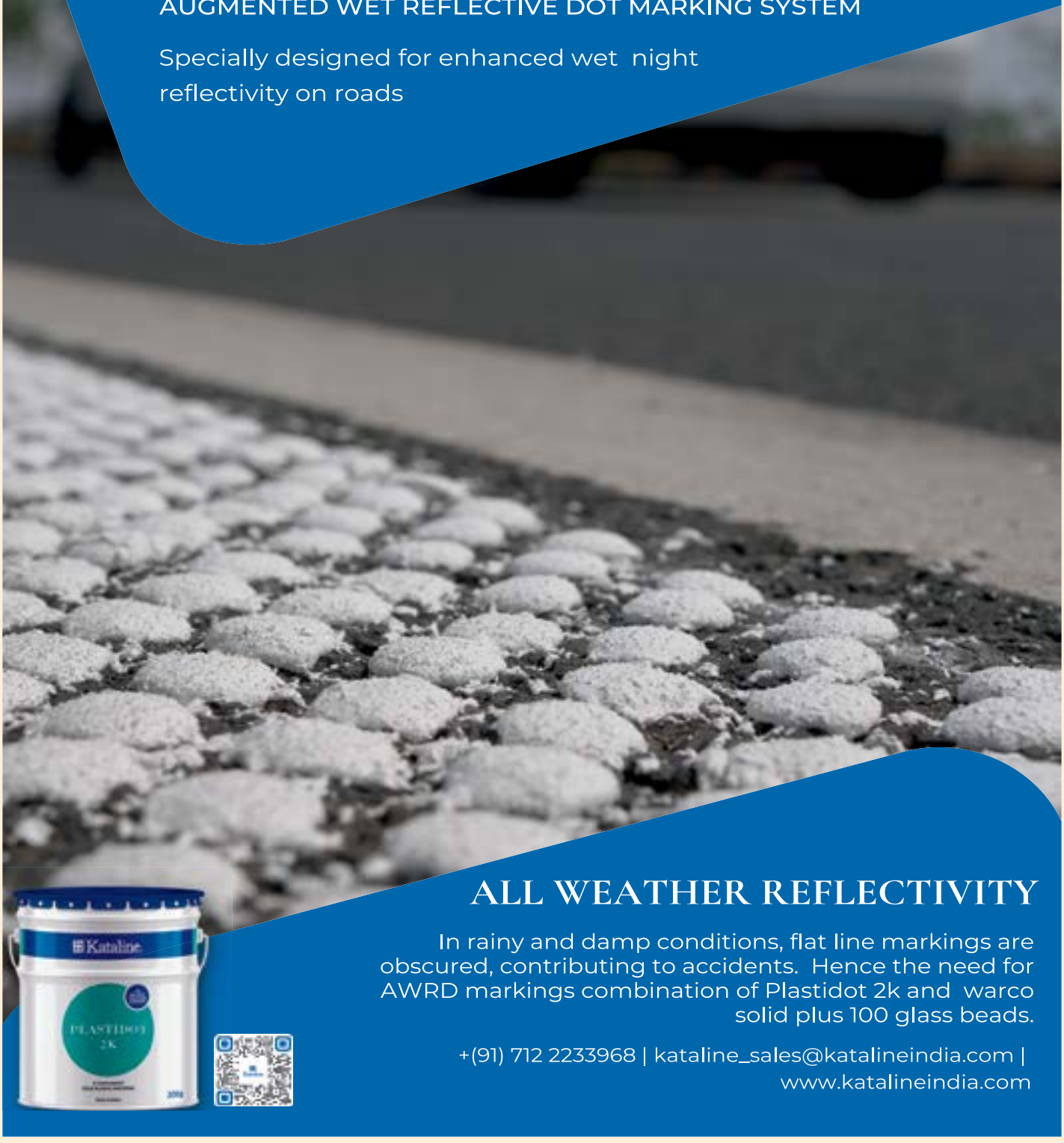

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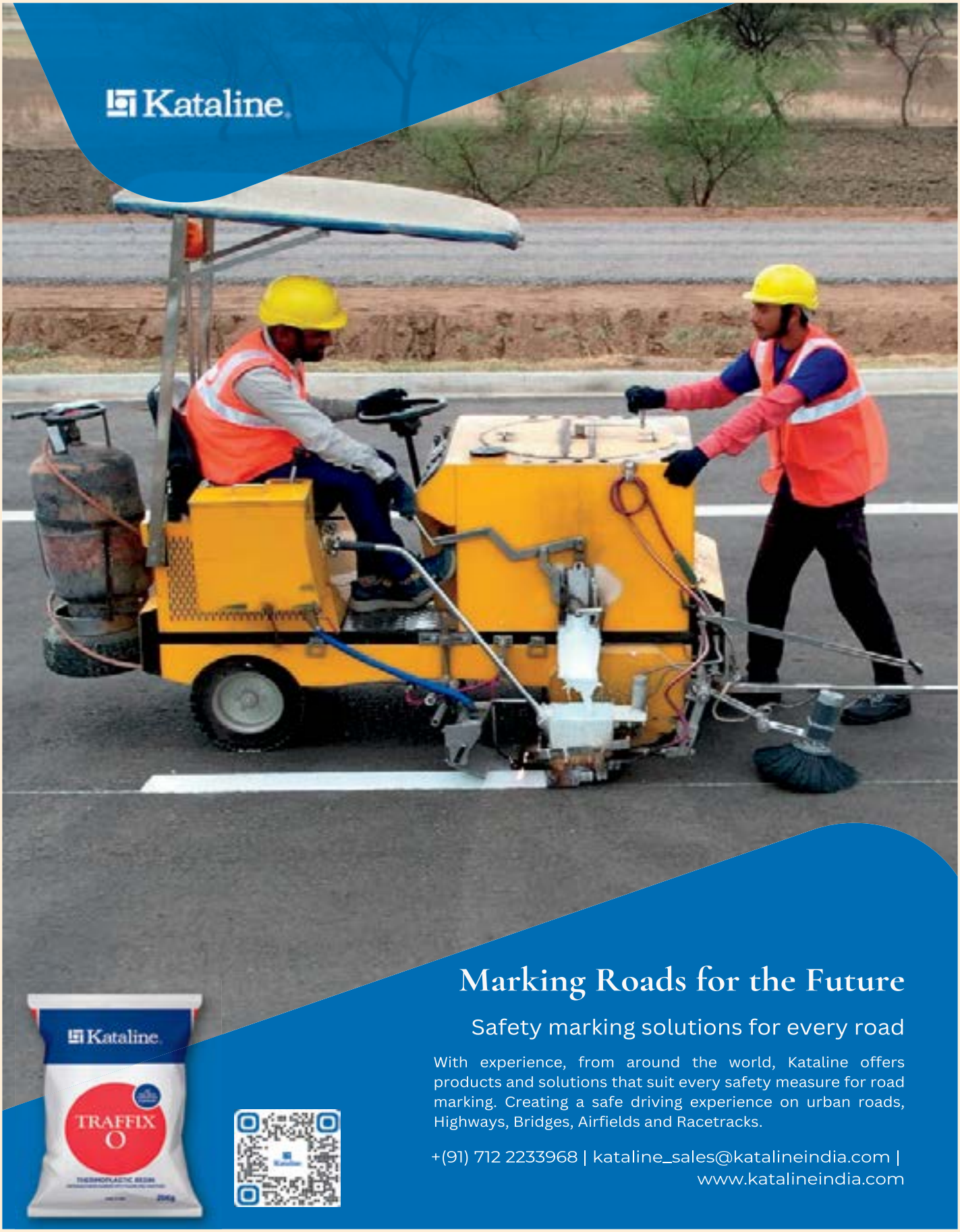
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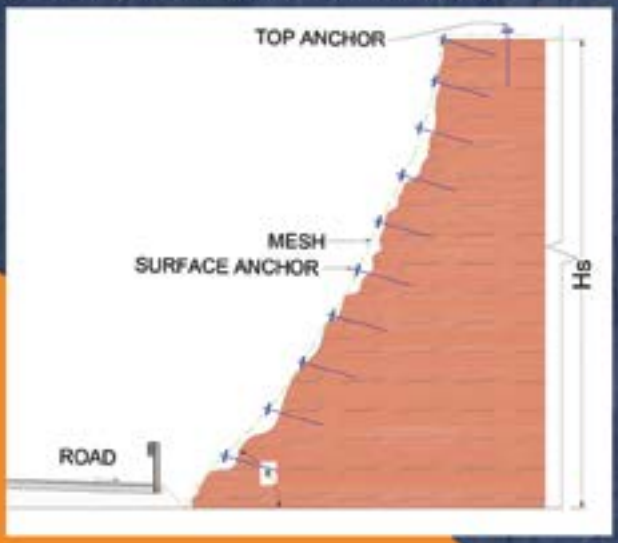
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GRID CONNECTED SOLAR POWER GENERATION SYSTEM USED FOR ILLUMINATION OF DR. BHUPEN HAZARIKA SETU (DHOLA-SADIYA BRIDGE) – A SUSTAINABLE CLEAN GREEN ENERGY SOLUTION WITH ZERO CARBON FOOTPRINT SOLUTION FOR STREET LIGHTING OF STANDALONE BRIDGES/HIGHWAYS IN INDIA


Raj Chakrabarty[1]


Devapradatta Nath[2]


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Dr. Vivek Bhore Renurao[4]

ABSTRACT

The Dhola–Sadiya Bridge, over river Brahmaputra also referred to as the Dr. Bhupen Hazarika Setu, serves as a backbone for interconnectivity between the northeast states of Assam and Arunachal Pradesh. The bridge spans the Lohit River, a major tributary of the Brahmaputra River, from the village of Dhola (Tinsukia District) in the south to Sadiya in the north. The bridge is the first permanent road connection between the northern Assam and eastern frontier state of Arunachal Pradesh and has huge strategic importance. The length of the bridge is 9.15 kilometers, it is the second longest bridge in India over water. The Approach roads on the southern side (Dhola) is 7.296 km and on northern side (Sadiya) it is 12.065 km. Width of the Bridge is 14.0 Meter.

The main importance of the Dhola Sadiya Bridge is primarily from strategic point of view as this bridge connects rest of India with it's Easternmost Frontier State of Arunachal Pradesh which shares a staggering 1126 km length of International Border with China. The Dhola Sadiya Bridge is also very important for development of the Tourism sector as the state of Arunachal Pradesh, due to its very rich bio-geography and biodiversity hot spots, rain forests, diverse wildlife, unique aesthetic and scenic beauties, it possesses great potential on the tourism sector.


Photo 1


Photo 2

1 Special Commissioner & Special Secretary to the Govt. of Assam, Public Works (Bldg. & NH) Department,
2 Executive Engineer (NH), Assam PWD
3 Assistant Executive Engineer (Electrical), Assam PWD
4 Solar Energy Designer & Consultant, Nagpur

1. BACKGROUND OF THE DHOLA SADIYA BRIDGE PROJECT

The project was implemented on hybrid BOT (Annuity) model. The Total Project Cost (TPC) is Rs 876 crore of which the Civil cost of Construction is Rs 740 crore. The Date of Start of work was 19.1.2011with the Appointed date declared as 17.06.2011and the Inauguration and dedication of the bridge to the service of the Nation was done by the Hon'ble Prime Minister of India on 26.05.2017 in presence of Hon'ble Union Minister, MORT&H, Hon'ble Chief Minister, Assam and several dignitaries.



Photo 3



Photo 3 & 4 Inauguration by Hon'ble Prime Minister of India in Presence of Hon'ble Union Minister MORT&H

2. IMPORTANCE & NECESSITY ILLUMINATION OF THE BRIDGE

Although the Bridge was dedicated to the service of the nation, a prime concern remained that this stretch of Highway fell in an isolated area and remained dark due to absence of provisions of illumination and it was also always acknowledged that the Bridge being strategically a very important one as it is supposed to be used during emergency for defense use, the safety of the bridge is the prime concern and lighting of the bridge would enhance the security of the surrounding of the bridge. As the bridge is very long, it is very important to have proper illumination at the bridge for general public users travelling at night and absence of back-ground objects throughout its long stretch of the bridge, there may create illusion on the part of the driver of vehicle and without illumination it might cause un-wanted accidents.

3. JUSTIFICATION OF BRIDGE ILLUMINATION USING GRID TIED SOLAR LIGHTING SYSTEM

For illumination of the Dhola Sadiya Bridge, numerous options were worked upon as follows:

i. Conventional System of luminaries which are connected to the Grid.

ii. Stand-alone Solar Street lighting.

iii. All-in-one Solar Street lighting

iv. Grid Tied (or ON Grid) Solar Street Lighting

v. Solar Hybrid - Grid Tied (with Battery Back-up Power) Solar Street Lighting

Based on it's merits the option (v) was opted to be most suitable for use in illumination of such long bridges along with its approaches which not only assures economic savings but also is important in assuring Eco-Friendly Net Zero Carbon Footprint.

4. DESIGN OF THE GRID TIED (OR ON GRID) SOLAR STREET LIGHTING FOR THE DHOLA SADIYA BRIDGE

4.1 Solar Plant

The Design of the plant is based on the energy requirements with an intention to generate as much of Solar Energy to keep the Net Recurring Charges at "Net-Zero" thereby ensuring "zero recurring charges".

A grid-connected Ground Mounted solar PV system includes different components that are selected depending on the system type, site location and application.

The major components of a solar PV system are:

i. Solar Photovoltaic Module

ii. Inverter (Power Conditioning Unit)

iii. Mounting Structure

iv. Balance of System (BoS)

Salient Features along with the technical details of the Solar System are given in table below:

Table 1

Site Location		
a.	State	Assam
b.	District	Tinsukia
c.	Taluka	Chapakhowa
d.	Village	DisaiNadiyal
e.	Latitude	27.7885° N
f.	Longitude	95.6759° E
g.	Site Elevation	1200 Meters above sea level
h.	Nearest Railway Station	Dangari Railway Station (16.4 km)
i.	Nearest Airport	Dibrugarh Airport (95 Km)
Solar Photo Voltaic System		
a.	Proposed Technology	Mono-Crystalline
b.	Module Capacity	545 Wp
c.	Total PV Plant Capacity	700KW
d.	No. of Modules	1248
e.	Inverter Capacity	80 KW
f.	No. Of Inverter	8 Nos
g.	Annual Generation	900,000 kWh
i.	Expected Plant Life	25 Years
j.	Power Evacuation	440, 3 Phase Supply (Captive Use)

4.2 Key Benefits and Risks Key Benefits

i. No pollution. Saving of 0.8 kg carbon dioxide per kwh generation=720000 kg of carbon dioxide per year.

ii. Low Operation and Maintenance Cost.

iii. No fuel Cost, Sunlight is available in sufficient quantity throughout

iv. Employment generation for the people living in nearby villages due to coming up of a solar power plant.

v. Diversify the source of energy from Coal to Renewable.

vi. Reducing the dependency on coal for auxiliary consumption specially during the coal scarcity.

4.3 Comparison of Various Options for PV Modules Considered

In the world of Photovoltaic (PV) solar power, there are several types of semiconductor technologies currently in use for solar panels. But the two most widely accepted technologies are Crystalline Silicon and Thin Films.

Modules

Plant design and analysis has been performed considering Mono CrystallineModules with power rating 545 Wp.

General technical specifications of the module available in the market is given below:

Mono-crystalline Modules are selected and recommended on the basis of whether data of the site, that is operating temperature and wind velocity. These modules will have better efficiency over the other types of PV modules.

Table 2 Showing General Comparison of Module Technology

Parameter	Crystalline	Thin Film	Thin Film
Types of Materials	Mono/Poly crystalline	Amorphous Silicon, CdS, CdTe etc.	Micro Amorphous
Handling	Better protection against breakage	Not Guaranteed	Guaranteed but notproven
Power Efficiency	18-21%	6-8%	9-11 %
Technology	Well Developed	Stable for Proven Performance	Developed
Module Weight	Light modules weight	Heavier modules	Heavy modules
Area utilization	Higher power generated per unit area due to high efficiency	Less power per unit area	Less power per unit area
Temperature Effects	Temperature variations output affect	Least impact of Temperature variations	Lesser impact of Temperature variations
Irradiance	Used particularly for Normal radiations	Better performance with Diffuse radiations	Better performance with Direct and Diffuse radiations
Module quantity	Lesser number required due to higher capacity	More modules required	Moderate number of modules required
Output per MW installed	High	Highest Output in Indian Conditions	Varies as per sunlight condition and various locations
Transportation Cost	Lower Transportation cost	Higher cost	Lesser cost compared toamorphous
Mounting Structure	Fewer Mounting Structure required per KW power	More Mounting structures required	More Mounting structures required
Land Requirement	Lesser space required per MW	Largest space requirement	Larger space required per MW
Inverter	High inverter flexibility	Limited inverter flexibility	Limited inverter flexibility
Cost	Moderate cost per watt	Lower cost Per watt	Higher Cost per watt
Stabilization	Stable power output at initial stages	Stability achieved after 4-6 months	Stability achieved after 4-6 months
Power Degradation	Less Degradation	Lower degradation	Lower Degradation
Plant Maintenance	Less maintenance required after installation so lower cost	Highest maintenance required, so highest maintenance cost	Less maintenance required after installation solower cost
Cooling Requirement	Not required	Not required	Not required
Cabling	Well known, andlower cabling losses	Well, Understood but yet difficult due to higher number of arrays	Well Understood but yet difficult dueto higher number of arrays

Table 3 Showing Module Technical Specification

Head	Specifications
Maximum Power (Pmax)	545 W
Power Tolerance	0 ~ +5W
Module Efficiency	21.29%
Maximum Power Current (lmp)	12.81 A
Maximum Power Voltage (Vmp)	42.55 V
Short Circuit Current (lsc)	13.32A
Open Circuit Voltage (Voc)	49.6V
Temperature Coefficient of Voc	-0.28%/C
Temperature Coefficient of Isc	0.05%/C
Temperature Coefficient of Pmax	-0.36%/C
Cell Type	MONO PERC BIFACIAL
Cell Arrangement	144 nos/ (182x91) mm
Frame	Anodized aluminum frame with twin wall profile
Junction Box	IP68
Dimension	2278^{x}1134^{x} 35 mm
Output Cable	1000 mm length cables, SOLARLOK PV4 connectors (MC4 compatible)
Weight	29±1 kg



Photo 5 Solar Panel

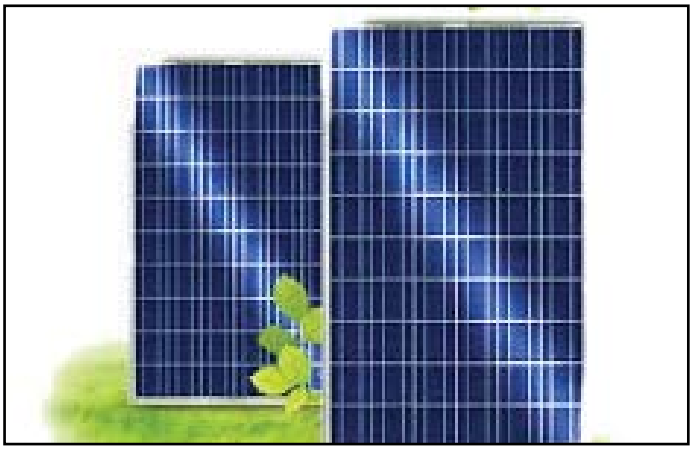


Photo 6

5. MODULE STRING/ARRAYLAYOUT

The PV plant is designed to connect Modules in series to form strings and strings are connected in parallel. Each inverter will take load of multiple strings. This arrangement ensures the current and voltage levels match the specification of the inverters.

Table 4 Represents the Design Parameters

Head	Specification
Peak Power	545 Wp
Modules per String	13
Orientation (Tilt/Azimuth)	27°/0°
Total Number of Modules	1248
Total Number of Strings	96
Number of Inverters	8

6. INVERTER

Investors in Indian market come with innovative, global system solution for commercial and industrial PV plants. Their High efficiency, flexible system design, easy installation, simple commissioning and low maintenance requirements contribute decisively to reducing the operating costs for the entire system.

6.1 General Parameters of Invertors in Indian Market.

Efficient:

i. Maximum efficiency of 98.8%

ii. Superior power density

iii. Compact IP65 casing ideal for PV plant

Safe:

i. Integrated DC and AC surge protection for highest safety.

ii. Separate wiring compartment for convenient and reliable installation

Flexible:

i. RS485 and Modbus RTU communications.

ii. Easy handling for installation and management.

Innovative

i Complete grid and plant management functions Eight inverters of 80 KW each have been proposed for the project.

A snapshot of the technical specifications has been illustrated in the table below:

Table 5 Technical Specification

Parameter	Specification
Max. DC input Power [KW]	80
Max. DC voltage [V]	1100
MPPT voltage range [V]	200-1000
Max. DC current per MPPT [A]	44
Rated power [KW]	80
Max. AC output power [KVA]	80
Operating range, grid frequency [Hz]	50/60
Max. AC current [A]	133
Power factor (cosφ)	1 default
Dimensions (WxHxD) [mm]	586x788x267
Weight [kg]	70
Installation environment	Indoor/Outdoor
Operating temperature range	-30°C... +60°C
IP protection type	IP65
Insulation type	Transformer-less
Cooling concept	Fan cooling
Communication interface	RS485, Wifi, PLC
Certificates and approvals	A3 50566021 0001 Report No. CN22TDIZ 001 TUVRheinl and



Photo 7 Some Pics of Gadgets

7. MOUNTING STRUCTURE & FOUNDATION

i. Fixed tilt module mounting system is proposed for Project.

ii. Angle of inclination has been chosen @ 26 Deg using NASA simulation to achieve maximum incident radiation on collector plane.

iii. At the proposed tilt angle pitch/inter row spacing is worked out at 700 mm to keep shading at minimum level.

iv. Since no area constraints are there hence Modules should face true south direction.

v. The structures shall be made of MS hot dip galvanized with at least 85 Micron of Galvanization. Material of Structure shall be as per IS 2062 and Galvanization shall be as per IS4759.

vi. All nuts & bolts considered for fastening of Structure Parts and Modules shall be Stainless Steel – 304 grade.

vii. The array structure shall be designed to withstand severe wind speed up to 150 kmph.

viii. It is proposed to have Circular Concrete pile foundation for fixing the structure to the ground.

ix. Size, Shapes and thickness of structural components shall be based on STAAD analysis. Design of structure and foundation shall be based on IS 875 Part III, IS 801, IS800.

8. CABLING

All the DC and AC cables have been designed for outdoor application with a continuous ambient temperature of 50°C. They are sized for a power loss below 1.5% and a voltage drop less than 2%.

8.1 DC Cabling

All the modules have been equipped with junction boxes including 4 mm^2 single core copper connecting leads.

Modules are interconnected using MC4 connectors to form a string of 20 modules using these leads. Power from strings are carried to SMB using 2R, 1C, 4 sq mm, Multistrand, XLPE Insulated, Tinned Copper cable.

8.2 AC Cabling

The three phase AC output from inverter have been connected to Injection Point via AL (AR) XLPE insulated cables having voltage rating of 1100 V. Entry and exit of AC Cables into any system has been made through Double Compression SS Gland.

9. CIRCUIT BREAKERS

Inverters have been equipped with 1100 V, 500 Amps AC MCB at its output. The MCB and accessories are in general conforming to IEC: 56 and IS: 13118. Output of transformer have also been provided with ACB of suitable rating.

The circuit breaker is totally re-strike free under all the duty conditions and is capable of breaking magnetizing current of transformer and capacitive current of unloaded overhead lines without causing over voltages of abnormal magnitudes.

10 LIGHTNIN GARRESTER

Lightning protection system has been provided for solar PV array and other equipment including inverters. The protection consists of air terminals, roof and down conductors, which are provided for the taller structures of the solar PV power plant. ESE Type lightning Arrestor of suitable “Radius of Protection” based on total plant area has been installed.

11. OTHER PLANT COMPONENTS

PV power plant shall also consist of:

i. Security and Surveillance System

ii. Water Drainage Network

iii. Cleaning Water Distribution System

iv. Fire & Safety Devices

v. Earthling of all electrical components

vi. Lighting

12 MONITORING

Cloud-based monitoring and management platform has been installed to track details on the performance of the entire solar system. This platform will regularly monitor, collect and transmit production data of photovoltaic

systems. It will provide a real- time email alert so that problems can be quickly addressed. It will display key performance data including current yields information, energy data, financial benefits, event logs and real income management.

Also, it will allow to access current data from any browser and smart devices (Android or iOS) at anytime and anywhere. Project Owner will be able to login to view their report, receive an event alert and daily report. It is a simpler, more reliable way to effectively manage inverter, maintain optimal performance and maximize returns.

Monitoring system includes the following on-site components:

i. Software based real time monitoring interface.

ii. Remote Monitoring

iii. Plant Management software customized to plant requirement

iv. Electric Meters with communication ports to interact with software

v. Data Logging &storage

vi. The following parameters can be accessible through the operating interface display:-

vii. String – Current, Voltage, Fuse status

viii. Inverter – On/Off time, status, input voltage/ current/power, output voltage/current/power, fault alarms

ix. Energy Meter – KW, KWh, KVAH, PF

x. Reports – Real time PR, Daily/Monthly/Yearly reports

Typical schematic of the monitoring system architecture is indicated in **Fig 1.**

13. SAFETY STANDARDS USED IN THE POWER PLANT

13. 1 Safety Features

i. Inverters are having internal protection arrangement against any sustained fault in feeder line and against lightning in the feeder line.

ii. Inverter has the required protection arrangement against earth leakage faults.

iii. Protection against over current, over temperature, DC bus over voltage and synchronization loss.

iv. The injection of DC power into the grid is avoided by using an isolation transformer at the output of theinverter.

v. Over-voltage protection is provided by using varistors at the output of the inverter.

vi. Another set of varistors at the input of the inverters provides lightning protection.

13.2 Lightning and Over Voltage Protection

i. Total array yard (module mounting area) is provided with lightning and over voltage protection connected to proper earth pits.

ii. The main aim of over voltage protection is to reduce the over voltage to a tolerable level before it reaches the PV or sub-systems components. The source of over voltage can be lightning or other atmospheric disturbance.

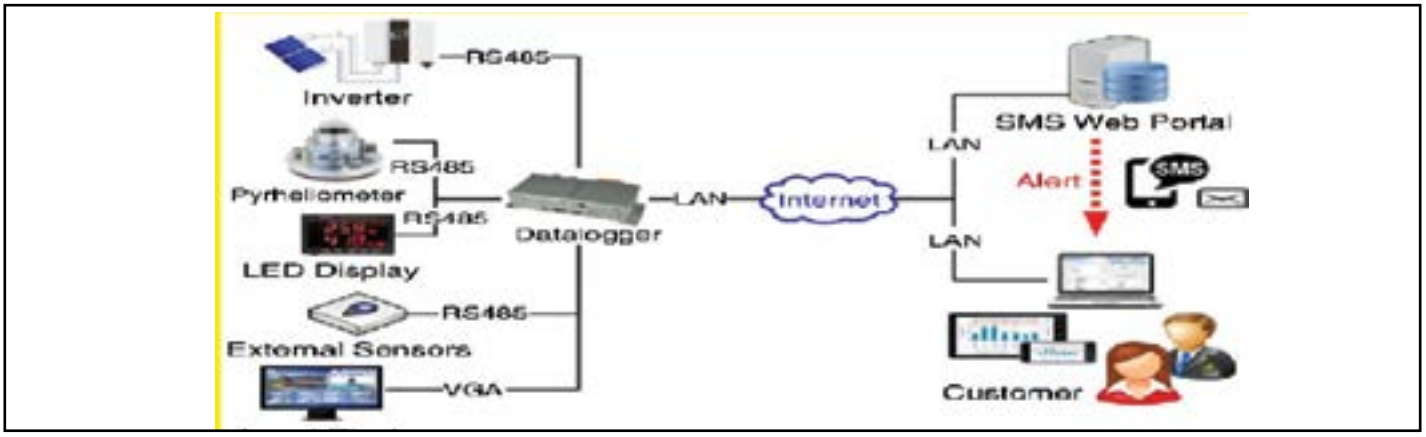


Fig. 1 Information Flow Chart

13.3 Earthing System

The earthing is provided to all the module mounting structures. 4 sq.mm Cu. Conductor is provided for module mounting structure earthing. The conductors are connected to the nearest pipe earth electrode installed in earth pit. Pipe Earth electrode typical arrangement will be as per IS: 3043. The calculation of number of Earth pits has been done on a conservative basis. The location of earth pits has been finalized after detailed engineering. All the earth pits are connected together by 25 x 2 mm Cu. Strip for equi-potentialbonding.

13.4 Fire Fighting System

Firefighting equipment to take care of fire at various locations in line with the guidelines has been provided. Portable firefighting equipment's have also been provided at strategic locations in the solar plant as well as outdoor yard.

13.5 Wind Speed

For wind loading analysis and design strength of mounting structure the wind zone map illustrated below is used, which indicates that the site is in a Moderate damage risk zone having a maximum wind speed under 39 – 44m/s.

13.6 Precipitation

General rain fall map of India shown below indicates that project site fall under low rainfall zone. Project site is expected to witness long dry & hot periods at the same time during monsoon also there can be poor downpour. This indicates that a moderate water drainage arrangement shall be sufficient atsite.

The rainy period of the year lasts for 8.2 months, from March 5 to November 10, with a sliding 31-day rainfall of at least 0.5 inches. The most rain falls during the 31 days centered around July 9, with an average total accumulation of 13.6 inches. The rainless period of the year lasts for 3.8 months, from November 10 to March 5. The least rain falls around December 14, with an average total accumulation of 0.1 inches.

13.7 Temperature

Temperature is one of the highest system losses due to most critical site parameter because it contributes to –ve temp co-efficient of module output. Temperature rises rapidly after March till May which is the hottest month of the year. In March-May, the mean daily maximum temperature at Tinsukia is 34°C high and 26°C low. Days are hot in the summer season and the nights are comparatively tolerable. During the period from November to February, the maximum temperature is about28°C high and13C low. The day temperature increases gradually after the withdrawal of the monsoon.

This section discusses the total daily incident solar energy reaching the surface of the ground over a wide area, taking full account of seasonal variations in the length of the day, the elevation of the Sun above the horizon, and absorption by clouds and other atmospheric constituents.

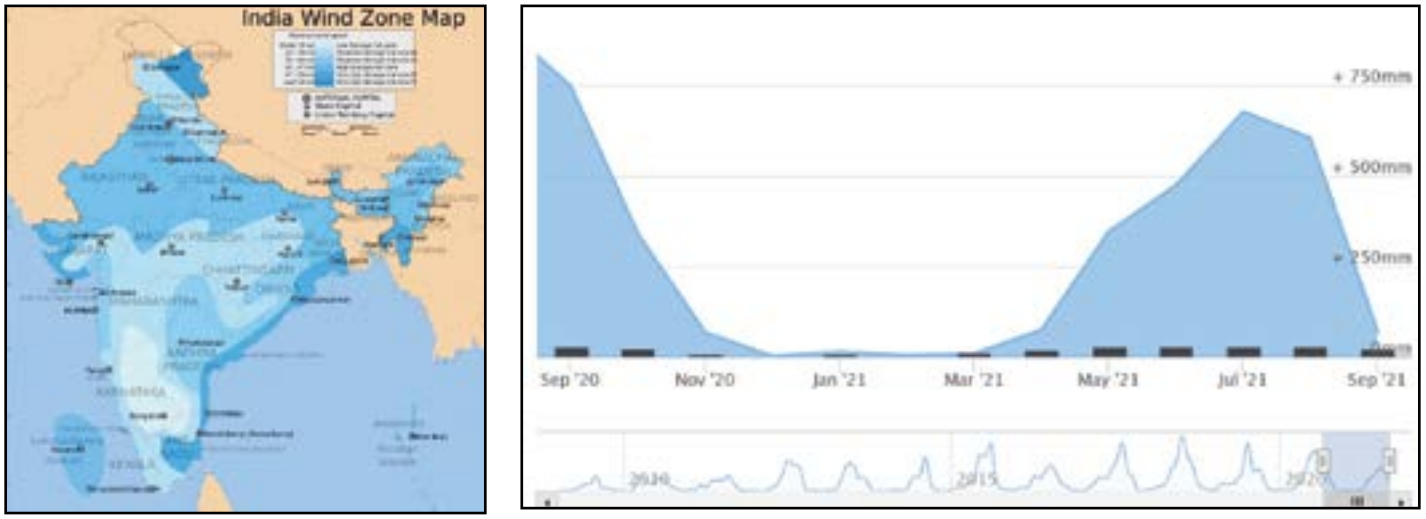


Fig. 2 Showing Wind Zone Map of India & Month Wise Wind Speed Pattern in District Tinsukia

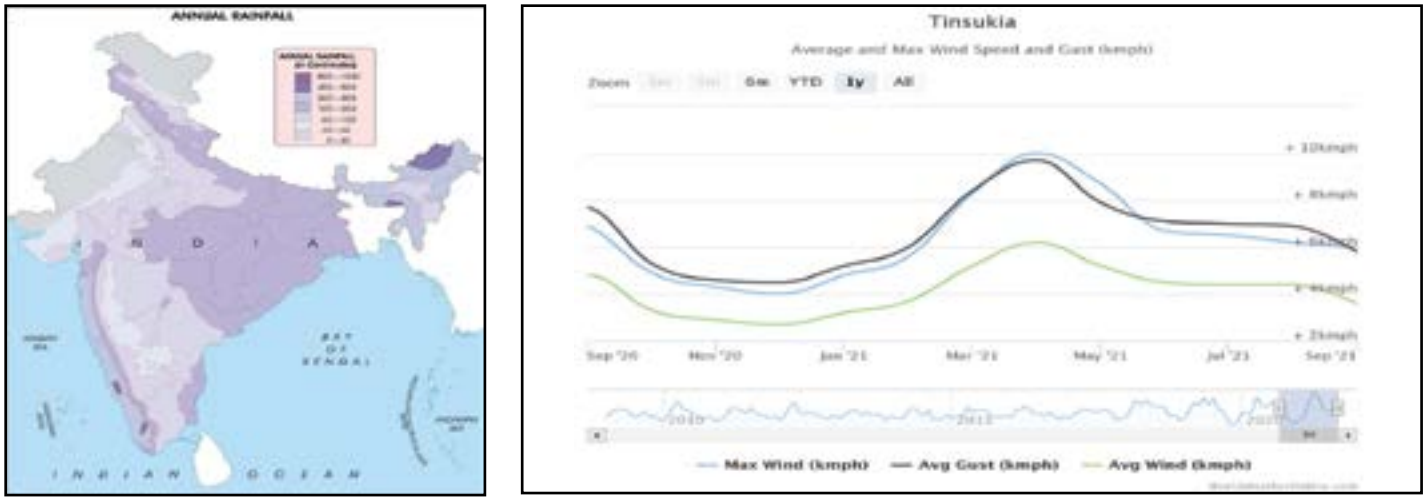


Fig. 3 Showing Annual Rainfall Map of India & Month Wise Rainfall Pattern in District Tinsukia

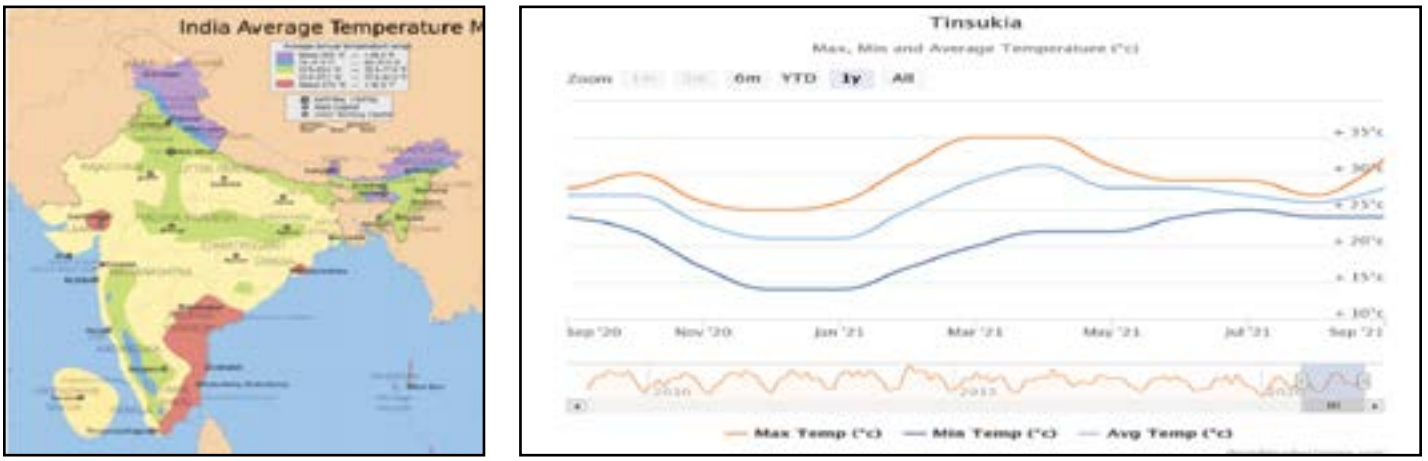


Fig. 4 Showing Average Temperature in India & Month Wise Temperature Variation in District Tinsukia

Table 6 Solar Irradiation

Solar Irradiation at Tinsukia	
Month	**(KWh/m²/day)**
January	4.0
February	4.4
March	4.7
April	4.5
May	3.9
June	3.24
July	3.08
August	3.33
September	3.29
October	4.0
November	4.17
December	3.98
Year	**3.88**

The average daily incident solar energy experiences some seasonal variation over the course of the year.

The brighter period of the year lasts for 4 months, from January to April, with an average daily incident shortwave energy per square meter above 3.88 kWh.

14. CORRECTIONS AND LOSSES

Data obtained for irradiation on collector plane, PV module and inverter specifications and plant configuration are input into the PV modeling software to calculate DC energy generated from the modules in hourly time steps throughout the year. This direct current is converted to AC in the inverter.

A number of losses occur during the process of converting irradiated solar energy into AC electricity fed into the grid/ self-consumption. The losses may be described. Asayield loss factor. They are calculated within the PV modeling

software, calculated from the cable dimensions and from information gathered during the site visits. Others are nominal figures applied from knowledge of performance of similar PV plants.

Table 7

Description of Losses	
Shading	Three types of shading losses are considered in the PV energy yield model: horizon shading, shading between rows of modules and near shading due to trees and buildings.
Incident Angle	The incidence angle loss accounts for losses in radiation penetrating the front glass of the PV modules due to angles of incidence other than perpendicular.
Low Irradiance	The conversion efficiency of a PV module reduces at low light intensities.
Module Temp.	The characteristics of a PV module are determined at standard temperature conditions of 25˚C. For every ˚C temperature rise above this, module efficiency reduces according to their temperature coefficient.
Soiling	Losses due to dust and bird droppings; soiling the module.
Module Quality	Most PV modules do not match exactly the manufacturer's nominal specifications. Modules are sold with a nominal peak power and a given tolerance within which the actual power is guaranteed to lie.
Module Mismatch	Losses due to "mismatch" are related to the fact that the real modules in an array do not all rigorously present the same current/voltage profiles: there is a statistical variation between them.
DC Wire Resistance	Electrical resistance in wires between the power available at the modules and at the terminals of the array gives rise toohmic losses(I^2R).
Inverter Performance	Inverters convert from DC into AC with a certain specified maximum efficiency. Depending on the inverter load, they will not always operate at maximum efficiency.
Degradation	The performance of a PV module decreases with time.
MPP Tracking	The inverters are constantly seeking the Maximum Power Point (MPP) of the array by shifting inverter voltage to the maximum power point voltage. Different inverters do this with varying efficiency.

15. CAPACITY UTILIZATION FACTOR

The Capacity Utilization Factor (CUF) also known as Plant Load Factor (PLF) of a PV power plant (usually expressed as a percentage) is the ratio of the actual output over the period of a year and its output if it had operated at nominal power the entire year, as described in the formula below:

$$CUF = \frac{Energy\ generated\ per\ annum}{8760\ (hours\ /\ annum) \times Installed\ Capacity\ (kWp)}$$

The CUF of the plant is computed to be 14.67%.

$$PR = \frac{AC\ Yield}{Installed\ Capacity\ \times\ Plane\ of\ Array\ Irradiation} \times 100\%$$

16. PERFORMANCE RATIO

The quality of a PV power plant may be described by its Performance Ratio (PR). The PR, usually expressed as a percentage, can be used to compare PV systems independent of size and solar resource. The PR may be expressed as:

PR for the PV plant is computed to be 60.00%

17. DEGRADATION

Degradation is an inherent property of PV modules with the passage of time effective output of module gets reduced. This estimate is provided by module supplier at the time of supply which is of the order of 10% in first 10 years and 10% in next 15 years.

18. CONCLUSION

The Project was completed in due time successfully by the contractor under the supervision of the Assam Public Works (Bldg & NH) Department including it's PWD Electrical Wing and dedicated to the service of the country by the Hon'ble Chief Minister of Assam Dr Himanta Biswa Sarma on the 5th of September, 2024 in a function attended by several top dignitaries of Assam. It is to be noted that land required for setting up the Solar Plant of 19,600 sqm (1.96 Hectares or 15 Bigha) has been made available by Govt of Assam near the Bridge Site itself.



Photo 8 Project Completion under the Supervision of Assam PWD



Photo 9 Function attended by the Hon'ble CM of Assam



Photo 10 Concept of Highway lighting by Solar Plant

Table 8 Energy Consumption Bill

STATEMENT OF POWER CONSUMPTION & SOLAR POWER PRODUCTION IN PROJECT "PROVIDING ILLUMINATION TO THE DHOLA-SADIYA BRIDGE OVER RIVER BRAHMAPUTRA INCLUDING IT'S APPROACHES, WITH ON-GRID SOLAR POWER TIE UP USING NET METERING				
	Qnty of Light Fixtures	**Wattage in Watt**	**Sub Total Power in watt**	**Power in kW**
Nos of Street Light	483	120	57960	58
Numbers of Flood Light	732	70	51240	51.2
Utility	2	5000	10000	10
Qtr for operator	2	5000	10000	10
Grand Total	-	-	(A)	**129.2**
CONSUMPTION				**REMARKS**
Average Running Hours / Day	12.5	Hours / Day	-	-
Power consumed in a day	1615	kwh		Total Power x 12.5 Hrs
Power consumed in a month	48450	kwh	-	Total Power x 12.5 Hrs x 30 Days
Consumption Bill / Month (FC Rs. 210/kva/month + RC Rs 9.39 / kWh)	Rs. 6,75,445	-	-	Rs 210 x 1050 KVA + Total Power x 12.5 Hrs x 30 Days x Rs 6.60/ kWh
SOLAR PRODUCTION				
-	**Power in kWp**	**Average Solar Hours/ Day**	**Energy generated per day (kWh)**	**Remarks**
Energy produced	700.00	3.5	2450	Considering 3.5 hrs/day
Cable & other losses 6% ,Dust losses 3%	-	(-)	220.5	-
Net Energy produced by 700kWP			2229.50	
Note	Powergenerated during day time by solar is 2229.50 kWh which is surplus to the power consumed during night which is 1615 kWh. Thus, the energy consumed will be 100% adjusted under net metering system and therefore, no Recurring Charges are needed to be borne except the fixed charges on meters,but considering electric bill +/-5% as per extreme weather conditions , the demand charges may perhaps be extra.			
Consumption Bill to be paid monthly under Net Metering = Fixed Charges @ Rs 210/Kva/Month	**Rs. 2,14,200**	-	-	-
Savings in Consumption Bill due to the Solar Plant using Net Metering = Rs 6,75,445.00 - Rs 2,14,200.00	**Rs 4,61,245**	-	-	-

The Concept of Highway Lighting/Bridge Lighting using its own Solar Plants should be encouraged to be taken up with this very concept in every Highway/Bridge Project as each project will generate clean, green, zero carbon footprint energy which will not only be sufficient for the consumption in the Highway/Bridge project thereby ensuring minimum recurring charge and also the excess green electricity may then be pumped into the Grid to benefit the nearby villages as well. With such a vision, Ministry with the success story of the project of "Illumination of Dhola-Sadiya Bridge using Grid Tied Solar Power Generation Plant using Net Metering" may perhaps make it mandatory for the future DPRs to incorporate this Green Technology Concept.

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INNOVATIVE APPROACH FOR SUSTAINABLE DEVELOPMENT OF HILL ROADS



Dr. Ram Asra Khural

ABSTRACT

Now a days, sustainability of hill roads is a hot topic of discussion among road engineers, scientists due to various post construction effects such as formation breach, landslides, soil erosion, etc. Almost same roadway width is being adopted for hill roads as for plain roads. Whereas, neither, it is economical nor it is required to adopt the same road width due to various factors like cost involved in hill cutting, disposal of surplus debris, destabilization of hill slopes, use of more resources for construction of wider roads, etc. The adverse impact of destabilizing hills has been seen recently in Himachal Pradesh, Uttrakhand and Jammu & Kashmir.

Based on data analysis, sustainable practices have been divided into three major categories such as Sustainable Design, Sustainable Materials and Sustainable Construction. Training on sustainability needs to be imparted for sustainable development of hill roads. By adopting, minimum formation width as 8.5 m instead of 12 m for double lane roads, the cost of development of roadway width can be reduced by about 60%.

The sustainable construction practices for sustainable development of hill roads have been suggested based on a study. The author intends to draw attention of policy makers to create "Hill Road Engineering" a separate subject of study for highway engineers. Optimum Roadway Width for development of double lane Hill Roads has been suggested in the paper.

1. INTRODUCTION

Indian Himalayas are young mountains and are more susceptible to landslides. Almost 30% of landslides in the world occur within the Himalayan region (Ministry of Home Affairs, 2012). More than 5,000 people are buried alive under landslides resulting in an annual economic loss of more than INR 26,000 crores globally (India Today Webdesk, 2021). Moreover, the Indian Himalayas are prone to various natural disasters like flash floods, avalanches, landslides earthquakes, etc. (Takar and Kumar, 2019).

India is having second largest road network in the world and is continuing further widening of existing roads whether in plains or in hills in addition to development of new roads. The road transport plays a vital road especially in hilly region where road transport is the only mode of transport. All economic activities depend upon the road development. Roads have positive as well as negative impacts on the environment and society.

Now a days, the sustainability of roads and their economic and environmental performance has taken significant intention among researchers, practitioners, and stakeholders (Basu and Basu, 2018; Yin et al., 2018; Hasan et al., 2019). Hence, the new concepts of sustainability, like "eco-build", "green build" and "green roads" in the construction industry have evolved over the years to deal with the issue of inadequate resources (Balasubramanian and Shukla, 2017) and to ensure minimum disturbance to the natural cycles at all levels (Vezzoli and Manzini, 2008).

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Construction of hill roads is a challenging task for civil engineers in any part of the world compared to roads in plains because lots of problems are being faced during construction and maintenance. Roads with same width are being constructed on hill as in plains. Whereas, neither the wider roads are required on hills nor are economically viable due to various reasons like geography, height of cut, landslides due to de-stabilization of hill slopes, rainfall intensity and frequency, temperature variation, etc. It has been experienced that more landslides and accidents take place after widening of the same road. For example, Kalka Shimla road was not experiencing any landslide before widening to four lanes.

Environment, society, and economy **(Fig. 1)** are three pillars of sustainable development. All three must be balanced so that one does not destroy another **(Fig. 2).** Still, it is not possible at all times. Hence, to balance three components of sustainability for future generations, all-natural and human resources should be placed and regulated properly to maximise benefits.

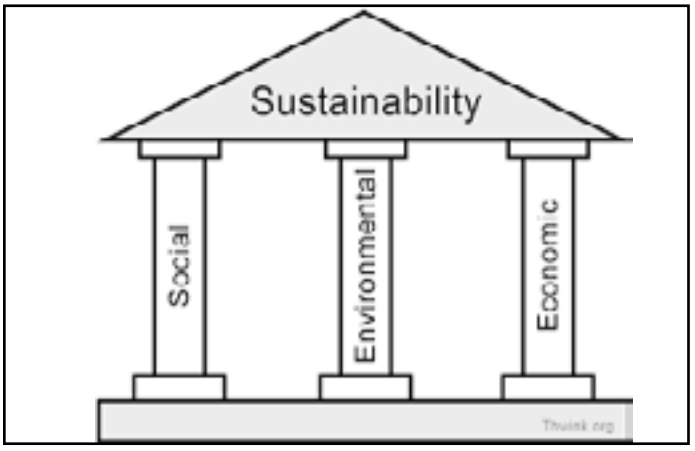


Fig. 1 Three Pillars of Sustainability



Fig. 2 Relation between Three Pillars

Sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED-987). A sustainable transportation system is one that minimizes the use of land in addition to other benefits (Centre for Sustainable Transport -2005). Following are six basic principles of sustainable construction (Koranda et al., 2011; Davies and Davies, 2017):

i. Minimization of resource consumption,

ii. Maximization of resource reuse,

iii. Use of renewable and recyclable resources,

iv. To protect and preserve natural environment,

v. Develop a healthy and non-toxic environment and

vi. To ensure quality control.

Study reveals that there is shortage of funds for maintenance of roads not only in India but also in other countries. In India, only one third funds are available for maintenance **(Fig.3)**, hence, proper techno-economic analysis is required to be carried out before taking any decision regarding further widening of the Hill Roads. Based on traffic Intensity, if there is need to widen the existing roads, optimum roadway width should be adopted for sustainable development of the hilly states.

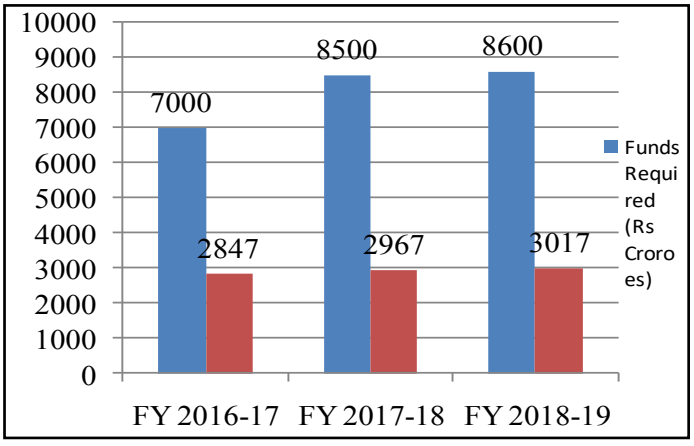


Fig. 3 Maintenance Funds Required vs Allotted (Source: Times of India, 27 Dec 2019)

The objective of research paper is to find optimum width of hill roads based on three parameters of sustainability i.e. Economic, Social and Environmental. In this paper optimum width of double lane Hill Roads has been suggested which is not only cost effective but sustainable also.

2. LITERATURE REVIEW

As per Hill Road manual IRC:SP-48, capacity of road can be increased by 15% by providing paved shoulders of 1.5 m (minimum) width all along the road. But, if shoulders are not maintained properly, then these can cause drainage along the edge of the pavement resulting into caving and penetration of moisture to the subgrade. As per Manual on Maintenance, IRC:SP-82, shoulders play following functions provided these are maintained properly:

i. To provide lateral support to the pavement.

ii. To be used for parking of vehicles.

iii. To be used as track by slow moving vehicles, if required.

iv. To help drainage of surface water to drains.

The lane width of a roadway greatly influences the safety and comfort of driving. According to AASTHO, the lane width of a road significantly affects driving safety and comfort. In the USA, lane widths between 2.7 and 3.6 metres are being used. On most major roadways, lane width of 3.6 m has been adopted. For commercial vehicles on two-lane road with two-way commercial vehicles traffic, 3.6 m lane is generally adopted. There are no median lane-width roads in the USA like in India. The minimum turning radii of hair pin bends is calculated at a speed less than 15 km/h (AASTHO). The world's safest highways are in Singapore, which has an average Lane width of 2.85 m to 3.25 m and an average speed of 60 kmph. As per the Road Traffic Act, the speed limit for Singapore vehicles is 50 kmph.

In India, lane width varies from 3 m to 3.75 m. The capacity of Hill Roads as prescribed in IRC:SP:48 is shown in **Table 1.** As per Hill Road Manual IRC:SP:48, Para 4.3.3, capacity of Hill Roads can be enhanced by 15% by providing shoulders of 1.5 m minimum width all along the road. But practically, it is not possible to maintain the uniform width of 1.5 m of shoulders all along the road on Hills due to various reasons such as Hard Rock, Vertical Cliffs, Landslide prone areas, horizontal curves, etc.

Table 1 Capacity of Hill Roads

Sl. No.	Type of Road	Carriage Width (m)	Design Service Volume (PCU/day)	
			For Low Curvature (0-200 degree /km)	For High Curvature (Above 200 degree/km)
a	Single Lane Road	3.75	1600	1400
b	Intermediate Lane	5.5	5200	4500
c	Double Lane	7.0	7000	5000

From Table 1 it is seen that capacity of roads increases almost three times when carriageway width increases from 3.75 m to 5.5 m known as the median lane in India. Further capacity can be enhanced by 11% by adopting 7 m carriage from 5.5 m. Generally, carriage width of double lane Hill Roads is 7 m with equal shoulders on both sides and 10m formation width including side drains and parapet walls as per IRC:SP-48. It means shoulders of equal width of 0.9 m have to be provided on both sides. But, as per Table 2.8 of IRC:SP-73, Shoulders are provided as 1m on Hill Side and 2 m on Valley Side out of total Formation Width of 10 m (Exclusive of Parapets and Drain).

IRC:SP:73, Guidelines and specifications for two laning of highways are also being followed in our country to design hill roads. A formation width of 10m, exclusive of drain and parapet walls, is being adopted with paved or unpaved shoulders in hilly regions for two-lane roads. Paved shoulders are being adopted for more than 8000 passenger car units/day traffic intensity. Shoulders of 1m width on the hill side and 2 m wide on the valley side are to be provisioned.

As per Transport Research Record, for roads with 2.7 m lane width, accident rates were not affected by wider shoulders. One possible explanation for these findings is that vehicle speeds are lower on roads with 2.7 m lanes than on roads with wider lanes, regardless of the shoulder width. The accident rate for roads with 2.7 m lanes with narrow shoulder having width ranging from 0 to 1.2 m was lower than for roads with 3.1 m lanes with narrow shoulders. Roads with wider shoulders greater than 1.5 m and road lane width with 3.1 m lanes had lower accident rates.

As per prevailing practice, almost all roads are being improved to higher specifications irrespective of the assessment of necessity especially in Hill States. The development of roads is not always beneficial for the public, but there may be some negative impacts like forest degradation, soil erosion, sedimentation, landsides, etc. (Mohammed Alamgir and others, 2017).

Landslides are one of the major natural hazards in India, which are responsible for significant loss of life and damage to roads, agricultural fields, forests and property, blocking of roads and rivers, etc. (Banerjee and Ghose, 2016). Cutting of hills for the construction of roads, results in several landslide-prone sites (Abderahman, 2007; Zhang et al., 2012). Rainfall-induced landslides are about two times within 100m of a road than landslides triggered by an earthquake (McAdoo et al., 2018).

Liquefaction and toe erosion are some of the causes of landslides (Bayan, 2013). The roadway width of hill roads has a significant impact on hill slope vulnerability (Banerjee and Ghose, 2016; Shrestha, 2018) and to protect the disturbed hill slope, lots of protective structures are required to be constructed during the widening of existing roads (Othman et al., 2009; Singh et al., 2016). Additional work and the use of extra fuel affect environmental sustainability by releasing more carbon emissions A growing number of road development projects have increased landslide risk (Gorum and Fidan, 2021). Many hill road projects are underway in the hilly region, all of which must be assessed for long-term viability at each stage, from inception to completion, to ensure sustainability (Gorum and Fidan, 2021).

In addition to environmental pollution, human activities have resulted in land degradation, climatic change, etc (Arora et al., 2018). Further, the construction and demolition waste has resulted in the deterioration of land, noise, air and dust, etc.; hence, minimisation of construction and demolition waste is a must (Blaisi, 2019). Rainfall throughout the execution phase causes significant damage to the road (Gupta, 2014). For mountainous roads, adequate drainage should be planned and implemented (Phogat and Singh, 2013). Rosser et al. (2021) and Jones et al. (2019) report that from 2016 onwards, there has been an increase in landslide rates, due to increasing road-construction efforts. This has also been confirmed by Arya and Joshi, (2021). Adaptive Design Speed should be adopted for hill roads which may result into cost effective and environmental friendly hill roads (R. Basu and S. Basu)

3. PREVAILING PRACTICE

The geometrics of hill roads have major impact not only on the cost but also on the environment, hence construction approach need to be revised or adaptive in view of safety of road users, to preserve environment, for better stability of hill slopes, etc. As per prevailing practice, almost all roads are being improved to higher specifications irrespective of the assessment of necessity especially in respect of Hill Roads. This will result in enhancement of the cost of construction and more damage to the environment further causing numerous problems like global warming, climate change, manmade hazards like landslides, soil erosion, flash floods, etc. which have been recently seen in Himachal Pradesh and Uttrakhand. The development of roads is not always beneficial for the public but there may be some negative impacts like forest degradation, soil erosion, sedimentation, landsides, etc. (Mohammed Alamgir and others, 2017). Roads are designed to fulfill following objectives:

i. To accommodate desired number of vehicles.

ii. To ensure safety of road users.

iii. To save travel time.

iv. To reduce cost of transportation of passenger and freight traffic.

v. To reduce cost of construction and maintenance.

vi. To have pleasure of travel as well driving.

Hill roads are designed as per Hill Road Manual, IRC:SP:48 Carriage width of 3.75 m for single lane road and 7.00 m for National Highway Double Lane roads is being adopted in India. Shoulders are provided on all type of roads whether in plain or on hills. However, shoulders are sometimes constructed as paved one of the same material and crust thickness as of main carriage way. Although NPV and Environmental analysis are being carried out but all roads are being improved to NHDL Specifications without analyzing sustainability and design of the road.

Earthen shoulders are being provisioned on all hill roads whereas there is no requirement of lateral support which

is the basic function of shoulders. As on hill side, lined drain is there and on valley side generally retaining wall is constructed. The various components of roads whether in Plains or in Hills can be seen from **Fig. 4 & 5.** Presently, same roadway width is being adopted as per IRC:SP:48, Hill Road Manual and IRC:SP:73.

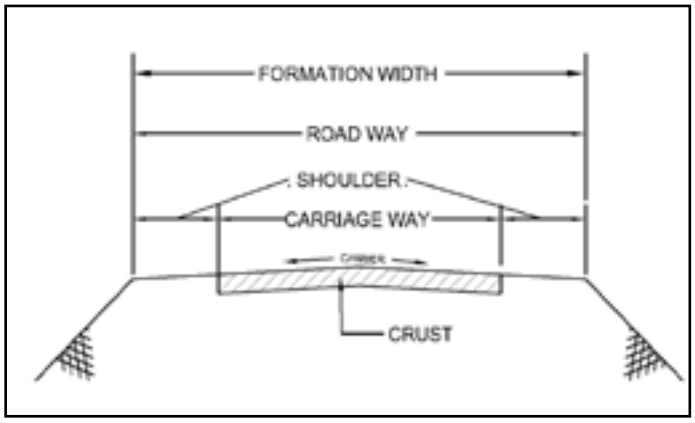


Fig. 4 Cross-Section of a Plain Road

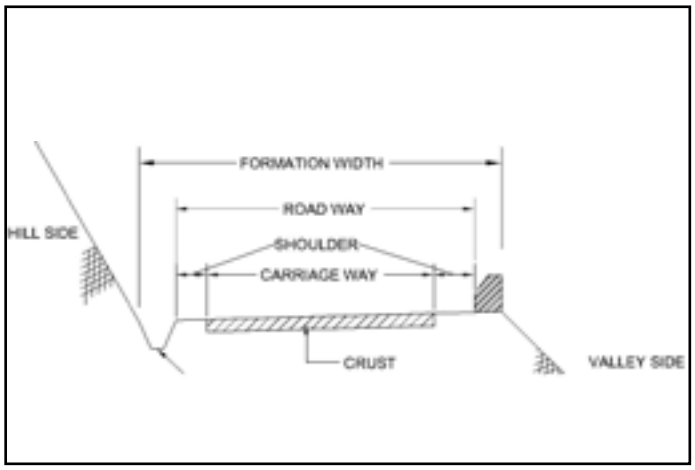


Fig. 5 Cross-Section of a Hill Road

4. MODIFIED PROPOSAL

Keeping in view the same objective of construction of roads, it has been proposed that no earthen shoulders be provisioned on hill roads to avoid chances of water accumulation, percolation of water into pavement, creation of pot holes, etc. as shown in **Fig. 6.** Hence, to reduce the cost & time of construction, damage to environment and for sustainable development of Hill Roads, following actions are proposed:

i. Optimum formation width of 8.5 m including 7 m carriage width, 0.6 m parapet walls and 0.9 m for lined drain may be adopted for double lane hill roads.

ii. Lined drain along the entire road length for proper drainage and safety of road users.

iii. Retaining walls/ edge walls should be constructed along the entire road length for better geometrics and to avoid damage to the pavement/ formation.

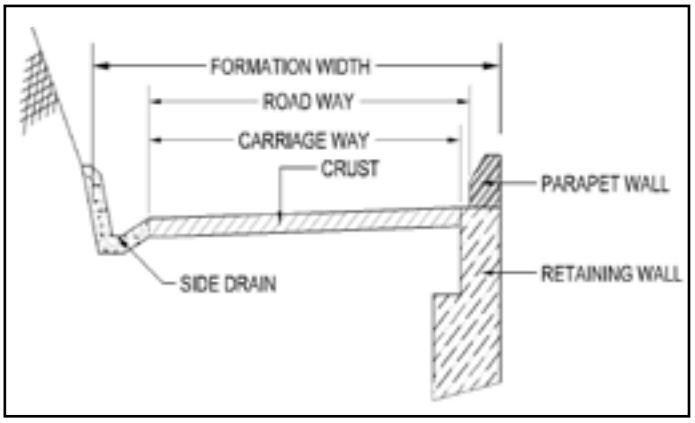


Fig. 6 Proposed Cross Section of Hill Road

Where ever four laning is required as per traffic intensity, another road with optimum roadway width at different level should be planned instead of widening and de-stabilization of the stabilized hill slopes. It will result in following benefits:

i. Earth work quantities will reduce drastically.

ii. Stability will improve.

iii. Chances of Landslides will reduce.

iv. Chances of accidents (head on collusion) will reduce.

v. Visibility during night will be better.

vi. Drainage will be more effective due to less surface area.

vii. In case of blockage of one road, another can be used as alternate road.

5. FINANCIAL ANALYSIS

The earth work quantities increase many fold with change in hill slope as well as roadway width. The earthwork quantities increase by about two times on increasing the width from 8.5 m to 12 m. The effect of cutting towards

hill side on the earthwork quantities can be seen from **Fig. 7.** When the hill slope changes from 30^0 to 60^0, the quantity increases about 11 times and the changing pattern may be seen from **Fig. 8.**

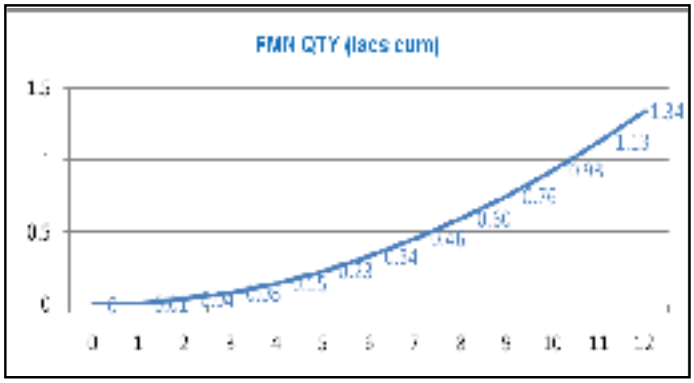


Fig. 7 Effect of Width on Formation Quantities

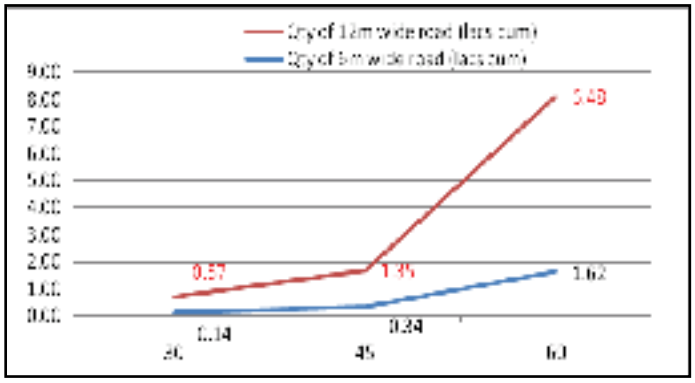


Fig. 8 Effect of Hill Slope on Formation Quantities

As per cost analysis, it has been revealed that construction of roads as proposed (Fig. 5) in the paper, will not be only environmental friendly, but also be cost effective. Cost of formation cutting of one km road length assuming 60% SMB, 20% SR and 20% HR has been worked out and it has been observed that there will be about 66% saving in addition to multiple benefits. The cost comparison of 12 m wide road with 8.5 m wide road can be seen from **Fig. 9.**

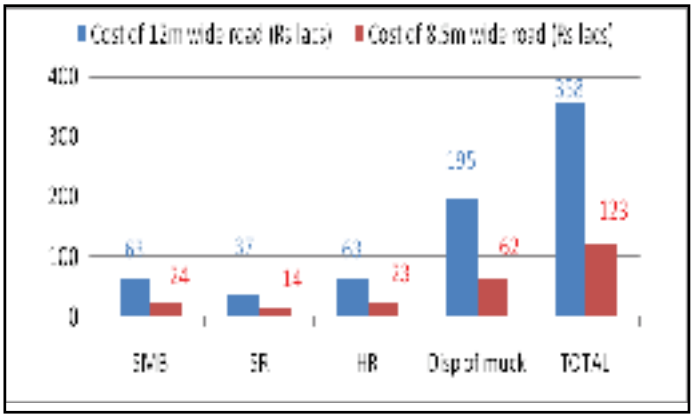


Fig. 9 Cost Comparison of Proposed Double Lane Road with Conventional Double Lane Road

6. DISCUSSIONS AND RECOMMENDATIONS

Primary data were also collected through an online survey questionnaire to identify the sustainable practices to be

Table 2 Identified Sustainable Practices

Sustainable Design	Sustainable Materials	Sustainable Construction
Optimization of road alignment (gradient)	Use of excavated materials	Minimisation of blasting
Optimization of roadway width	Use of cement-treated layers in pavement	Soil stabilisation
Optimization of turning radius of curves/zigs	Use of plastics/geo-textiles/chemicals, etc.	Use of modern equipments/technology
Edge-to-edge carpeting or full-width black topping	Use of local/marginal materials	Use of crash barriers/ parapet walls
Modified design of structures	-	Use of signboards and road marking
Modified design of pavements	-	Legal framework and enforcement
Construction of lined drain throughout	-	Sustainable measurement and reporting
Construction of retaining /edge wall throughout	-	-
Training on sustainability	-	-
Sustainable guidelines	-	-

adopted on hill roads. Based on data analysis, sustainable practices were divided into three major categories as under:

i. Sustainable Design

ii. Sustainable Materials

iii. Sustainable Construction

Sustainable design has been found most important category of sustainable practices. Out of ten sustainable practices under Sustainable design and training category, (Table 2), Training on sustainability has been adjudged as the most effective and important sustainable practice. It is strongly recommended that the identified sustainable practices tabulated in Table 2 should be implemented during planning, design and construction of sustainable hill roads.

7. CONCLUSION

Based on results and discussion, following is recommended:

i. Training on sustainable development should be given to all concerned for effective implementation of sustainable practices on ground.

ii. Guidelines on sustainability should be issued for implementation of sustainable practices.

iii. Cost benefit analysis should be carried out for all hill road projects.

iv. To minimize damage to the environment and for sustainable development of roads, optimum roadway width should be adopted.

v. Edge to edge carpeting should be adopted to avoid penetration of water from earthen shoulders.

vi. For development of four lane highways, two intermediate width lanes divided with new zersy barriers may be adopted instead of two double lane roads in the hilly states to minimize land use and damage to the environment.

vii. A new double lane road at different levels should be constructed instead of widening of existing two-lane highway to four lane highway.

viii. Hill Road Engineering should be created a separate subject of study for highway engineers.

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STRATEGIC DEVELOPMENTAL ROAD MAP FOR INTELLIGENT TRANSPORTATION SYSTEMS: A CASE STUDY OF KEY CITIES IN GUJARAT


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ABSTRACT

This study conducts a systematic exploration of Intelligent Transportation Systems (ITS) through a structured literature review. The primary objective is to critically analyze existing research and methodologies related to ITS to assess their current relevance. The research proposes a strategic roadmap for ITS development in key cities of Gujarat, India. Using the Z-score method, 16 barriers to ITS implementation are quantified across four selected cities. A performance index is then calculated by applying Z-score normalization and assigning weights using analytical hierarchical method to these barriers. This index aids stakeholders in evaluating city-level ITS performance and provides phased guidance for future policies. Results indicate that Gandhinagar achieves the highest performance score, currently in Phase IV, and is recommended to advance to Phase V by implementing an Automated Intelligent Transportation System (AITS) powered by smart card data. Surat, ranked second and in Phase III, should prioritize pedestrian safety through measures like pelican crossings (pedestrian traffic signals) and converting existing parking areas into smart parking systems to transition to Phase IV. Ahmedabad and Vadodara, ranked third and fourth (in Phases II and III, respectively), are advised to enhance roadside safety by deploying emergency phone systems, Pan-Tilt-Zoom (PTZ) cameras for automated vehicle detection, and Point-to-Point (PTP) cameras to improve traffic monitoring. These steps will expedite their progression to higher development phases. The proposed interventions offer a practical framework for advancing ITS in Gujarat's cities toward more advanced stages of implementation.

1. INTRODUCTION

In the dynamic landscape of India's rapidly advancing economy, road traffic congestion in major cities has escalated to critical levels, posing severe economic, environmental, and social challenges. The exponential growth of private vehicles—fueled by urbanization and rising incomes—has outpaced infrastructure development, exacerbating delays, fuel waste, and air pollution. Such congestion costs India approximately ₹1.47 lakh crore annually, undermining productivity and public health, necessitating urgent intervention. Traditional solutions, such as road expansion or infrastructure upgrades, have proven inadequate due to high costs, spatial constraints, and prolonged implementation time lines. Furthermore, these methods often neglect real-time traffic adaptability,

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worsening inefficiencies in rapidly evolving urban environments. Globally, Intelligent Transportation Systems (ITS) have emerged as a transformative approach to mitigate congestion by optimizing existing infrastructure. By integrating information and communication technologies, ITS enables real time data exchange between vehicles, roads, traffic signals, and users, enhancing decision-making and operational efficiency. For instance, sensor-equipped traffic lights adjust signal timings dynamically, reducing idle emissions, while connected vehicles reroute based on live congestion updates. Such innovations not only improve traffic flow but also align with sustainability goals by curbing fuel consumption and greenhouse gas emissions.

While ITS has seen success in countries like Singapore and the U.S., its adoption in India remains limited due to fragmented policies, funding gaps, and technological barriers. This paper explores global ITS frameworks, evaluates their relevance to India's unique challenges such as mixed traffic conditions and informal transport modes and proposes context-sensitive strategies. By addressing these gaps, India can harness ITS to build resilient, equitable, and sustainable urban mobility systems. The subsequent sections analyze global best practices and contextualize solutions for India's complex transportation ecosystem.

1.1. ITS Application in Gujarat

Intelligent Transportation Systems (ITS) have substantial influence over crucial aspects of transportation performance globally, encompassing safety, mobility, productivity, energy, environment, and customer satisfaction. Performance metrics for ITS evaluation range from crash rates and vehicle speeds to productivity gains and environmental impact. In the context of Gujarat, four cities Ahmedabad, Surat, Vadodara, and Gandhinagar have been designated as smart cities under a mission, reflecting a comprehensive geographical distribution across the state. The strengths and challenges of all five cities is describe in **Table 1.**

Gujarat's smart cities initiative is graceful to receive significant financial support, with an anticipated grant of ₹2000–3000 crores from the Centre, increased by ₹100 crores for each identified smart city. However, the disbursement of funds from 2015 to 2018 has been modest, totalling a mere ₹563 crores. Each city, recognized under the mission, has established a Special Purpose Vehicle (SPV) to oversee its development initiatives.

Table 1 Strengths and Challenges of four Smart Cities in Gujarat

City	Strengths of the City	Possible Challenges
Ahmedabad	● A major center for commerce and trade. ● Major manufacturing hub for automobile, chemical, textile, pharmaceutical, and other industries. ● BRTS and AMTS as local publictransports. ● Excellent internet and communication facilities.	● Too many vehicles on roads ● Lack of traffic discipline among people ● Roadside shops and vendors ● Too much encroachment on roads.
Gandhinagar	● Highly planned and lush green city with only limited encroachments on roads ● Well connected by roads and well maintained roads ● The software technology Park of India (Gandhinagar) is located here. ● Small and manageable size. ● Proposed Metro Train project will improve connectivity with Ahmedabad.	● Fewer employment opportunities ● Limited industrialization ● Commercially not so developed ● Digital literacy is lower.
Surat	● Stands among top 10 biggest urban agglomeration in India. ● Dominates in diamond, textile, chemical, oil and gas industries. ● Important center of trade and commerce. ● Recently developed flyovers on roads have improved traffic in the city.	● Overflow of river Tapi causes loss of life and property on a regular basis due to floods. ● Too many slums. ● Too much encroachment on roads.
Vadodara	● Chemical, textile, petro chemicals, plastic, fertilizer, and engineering industries are well developed ones. ● IT hub.	● Slums and poverty.

Table 2 Release of Funds by GOI under Smart Cities Mission (Amount in ₹ crore)

Name of City	2015–16	2016–17	2017–18	Total
Gandhinagar	2	-	18	20
Ahmedabad	2	194	-	196
Surat	2	194	-	196
Vadodara	2	-	109	111
Total	8	388	163	563

Source: Drawn data sourced from the official website of smart cities of India

Table 2 underscores the financial landscape, revealing that, similar to other smart cities in India, Gujarat's cities were allocated ₹2 crores each as seed money in 2015–16. Ahmedabad and Surat successfully secured ₹194 crores each, while the remaining cities collectively received ₹163 crores in the subsequent year. Over the five-year mission, a cumulative investment of ₹563 crores was directed toward projects for all six cities, emphasizing the irregularity in fund disbursement. This financial constraint necessitates innovative financing avenues for ambitious projects, further complicating the developmental trajectory of these cities.

1.2. Literature Review

To initiate a comprehensive exploration of Intelligent Transportation Systems (ITS), we conducted an exhaustive search across prominent digital libraries, including IEEE (Institute of Electrical and Electronics Engineers), ACM (Association for Computing Machinery), Springer, Elsevier, and Google Scholar databases. This search, employing a well-crafted query, yielded 2100 results. Subsequently, through a rigorous screening process involving the evaluation of titles, abstracts, years of publication and conclusions, we identified and selected 12 most relevant papers deemed most relevant to our research objectives. The selection criteria prioritized papers that not only addressed the core themes of our review but also demonstrated a robust methodology and depth of analysis. Papers lacking relevance or exhibiting methodological shortcomings were systematically excluded to ensure the integrity of our review. The forthcoming review synthesizes insights from the 12 precisely chosen papers, providing an understanding of the most pressing issues within the domain of Intelligent Transportation Systems. By combining findings from these selected works, we aim to contribute to the existing body of knowledge, offering a focused and insightful analysis of the common transport-related challenges addressed in the literature.

1.3. Traffic Issues

The surge in traffic volume, forced by population growth, has given rise to a spectrum of complex challenges, encompassing traffic control, air pollution, crime prevention, disaster management, congestion alleviation, and the optimization of navigation systems. A comprehensive review of existing literature, as summarized in Table 3, illuminates the multifaceted nature of these challenges. Notably, the major focus in the literature is directed towards traffic control, congestion management, and disaster response as primary concerns within Intelligent Transportation Systems (ITS). Conversely, there is a noticeable gap in the importance placed on addressing issues such as air pollution mitigation, crime prevention strategies, efficient navigation systems, and resource management. This gap suggests an opportunity for further exploration and research to comprehensively address the broader spectrum of challenges within the region of ITS, thereby contributing to a more holistic and effective approach to urban mobility and transportation systems.

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1.4. ITS Techniques for Solving Transport Issues

Table 3 highlights a spectrum of issues within the transportation domain, demanding real-time information for effective resolution. A multitude of technologies and methodologies have been proposed by researchers to address these challenges. The integration of active Closed-Circuit Television (CCTV) cameras and sensors has emerged as a pivotal approach for real-time data

acquisition. The fusion of Global Positioning System (GPS) technology with advanced image processing techniques has propelled the evolution of sophisticated navigation systems. Furthermore, the transportation landscape has witnessed the infusion of cutting-edge technologies, including Vehicular adhoc Networks (VANETs), cloud computing, and agent-based computing, aimed at enhancing system efficiency and intelligence. The synthesis of these technologies seeks to optimize information flow, mitigate challenges, and elevate the overall performance of transport systems. **Table 4** provides a comprehensive summary of the diverse techniques employed by researchers to tackle transportation issues. Many methods are being tested to improve transportation systems, but sensors, VANETs (vehicular networks), cloud computing for vehicles, and agent-based tools are currently the most promising. This study focuses on how well these technologies work and how they can solve today's transportation problems, like traffic congestion and safety issues

Table 3 Transport Related Issues

Ref.No.	Transport Related Issues						
	Traffic Control	Public Transport	Crime control	Efficient navigation	Pedestrian traffic	Parking management	Emergency Management
1	Yes						
7		Yes					
2	Yes						Yes
10	Yes						
3			Yes				
4							Yes
5	Yes						
11	Yes	Yes			Yes		
8	Yes	Yes		Yes		Yes	
6					Yes		
9					Yes		

Table 4 Summary of Techniques and Technologies used to Solve Transport Related Issues

Author's	Techniques and Technologies						
	Sensors & Wi-Fi connectivity	Control room computing	Pedestrian crossings	e-challan, RLVD	Smart parking	PA &VMS system	Smart traffic lights
1	Yes					Yes	
2	Yes				Yes		
10		Yes					
3	Yes				Yes		
4			Yes	Yes			
9				Yes			Yes
5	Yes		Yes		Yes	Yes	
6				Yes		Yes	
11		Yes			Yes		
3		Yes	Yes			Yes	Yes
7		Yes					
8			Yes				
13	Yes	Yes		Yes		Yes	

2. CLASSIFICATION OF BARRIERS

Drawing insights from extensive literature reviews and India's Intelligent Transport System (ITS) guidelines, this study classifies ITS into four main criteria and sixteen s ub-criteria and showcased the same in **Table 5.** This framework systematically addresses 16 barriers (also regarded as sub-criteria) hindering ITS implementation. These 16 technologies or approaches are further analyzed and quantified across four Indian cities. As the study progresses, the subsequent sections clarify the nuanced phases of this classification and their corresponding implementation strategies.

Table 5 Different Types of Barriers

Different Types of barriers				
Main Criteria	**Infrastructural Barriers**	**Technical barriers**	**Transport authority enforcement barriers**	**Intelligent monitoring barriers**
Sub Criteria	Control rooms	E-challan system	Police patrolling	Automatic traffic Counter
	VMS	Public announcement System	Red light violation detection System	Pelican crossings
	Emergency Road side Telephone system	Control room connectivity	Traffic police stations	Real-time passenger Information
	Smart parking	Wi-fi-connectivity	Automatic number plate recognition system	-
	-	-	Automatic speed detection System	-

The literature emphasizes the importance of understanding these categories and barriers to enable effective ITS deployment. By aligning with government guidelines and global research, this study refines strategies and policies for intelligent transportation. Through a synthesis of literature insights and analytical evaluation, we navigate the complexities of ITS classification, offering a structured perspective to inform implementation phases. The following Phases are established based on the guidelines given by IRC:SP:110-2017. Phase I establishes connectivity between control rooms and city junctions, enabling real-time storage and sharing of traffic data. This connectivity ensures instantaneous updates, improving the responsiveness of traffic management systems. Phase II becomes feasible when a city adopts a computerized traffic database, a critical step toward building advanced infrastructure for complex traffic management. Phase III mandates the presence of a trauma center and emergency response system, ensuring swift reactions to accidents and enhancing urban safety. Phase IV addresses cities where pedestrian traffic poses significant risks, prioritizing safety measures to improve overall traffic management. Phase V integrates public transport systems with traffic management, streamlining operations and fostering coordination between transit modes. This integration is critical for creating a seamless, interconnected urban mobility network.

3. METHODOLOGY

Our research methodology unfolds in two distinct phases:

Phase 1: Commencing with a comprehensive literature review, our focus lies in exploring diverse real-time traffic analysis methods. Drawing insights from this review, we proffer recommendations aimed at alleviating traffic congestion effectively. The study encompasses an in-depth examination and documentation of Intelligent Transportation Systems (ITS) methodologies. Observing the transformative impact of ITS on transportation performance, congestion, pollution, safety, and traveler convenience in leading cities forms a crucial aspect. This phase not only delineates the overarching purpose of ITS but also delves into the various methods for implementing intelligent traffic systems, thereby enhancing the overall capacity of road systems.

Phase 2: Transitioning to the second phase, our research narrows its focus to the comprehensive examination and analysis of the current growth and development trajectories of key cities, constituting our primary investigative domain. This phase involves a systematic approach to measuring and scoring progress against established benchmarks.

The government data, reports, online resources, etc is considered to collect the data related to 16 barriers for all four cities. Later, Sort listed 16 technologies/sub criteria/ barriers are assessed based on their performance relative to the benchmark, which, in turn, is evaluated against its current performance for four cities. The computation includes a strategic assessment of the implementation phases of ITS in four cities, translating plans into action, and evaluating the current state of urban development. Additionally, we compute an ITS performance index for cities, thereby proposing strategic pathways for cities situated at intermediate stages of development. This dual phase approach ensures a robust and multifaceted examination of the real time traffic analysis landscape and urban development dynamics.

3.1. Methodology of Index Ranking

In this section, we outline the methodology employed for the index ranking, aiming to provide a systematic and comprehensive approach. The process unfolds in the following steps:

Step 1: Quantification and Score Calculation

Evaluate the score for all 16 technologies/sub criteria/ barries in each city, determined by the ratio of the quantifier to the unit value of the parameter. Calculate the score using the quantifier value for the unit value of each parameter.

Step 2: Normalization Using Z-Score

Obtain means and standard deviations for all 16 barriers and calculated scores for all four cities. Normalize the scores using the Z-score normalization method.

Step 3: Barrier Weightage Determination

Evaluate the weightage of barriers through an analytical hierarchy process.

Step 4: Barrier-wise Performance Calculation

Calculate the performance of each city for each barrier.

Step 5: Overall Performance Index Calculation

Evaluate the performance index for all cities based on the summation of individual barrier performances.

Sum up the performance of all barriers for each city.

This methodology aims to establish a robust foundation for index ranking, incorporating quantifiable parameters, normalization techniques, analytical hierarchy processes, and comprehensive performance evaluations.

3.2 Z-score Normalization Method

In the methodology section of our research, we employ Z-score normalization as a statistical technique to standardize each value within the dataset. This process ensures that the mean of the entire dataset is centered at 0, while the standard deviation becomes 1. The Z-score normalization is executed using the following formula for each value (x) in the dataset: New value = $(x - \mu) / \sigma$, where μ represents the mean and σ represents the standard deviation of the dataset. This statistical transformation is integral to our data preprocessing strategy, enhancing comparability and facilitating a standardized scale for subsequent analyses.

3.3 Ranking of Barriers

3.3.1 Determining Weightage of Main criteria's and Sub criteria's (Local and Global Barriers):

Barrier weights are calculated by comparing factors in pairs (pairwise comparison). For a detailed method, refer to Patel et al. (2023). **Table 6** shows an example of a pairwise comparison matrix for sub-barriers under Infrastructure Barriers. Five matrices are needed: One matrix is to compare the four main criteria. Similarly, Four other matrices is required to compare sub-barriers under each main criterion

Table 6 Pairwise Comparison for sub criteria of Infrastructural Barriers and its Normalization

	Control rooms	VMS	Emergency road side telephone system	Smart Parking	Average
Control rooms	0.2206	0.4412	0.2500	0.1923	0.2760
VMS	0.0441	0.0882	0.2500	0.1154	0.1244
Emergency road side telephone system	0.0735	0.0294	0.0833	0.1154	0.0754
Smart Parking	0.6618	0.4412	0.4167	0.5769	0.5241
Total	1.0000	1.0000	1.0000	1.0000	1.0000

3.3.2 Assessment of global barrier weightage

After calculating weights from pair wise comparisons, global weights are found by multiplying each sub-barrier's weight with its main criterion's weight. This step calculates the final weights for all 16 barriers

3.3.3 Normalization of global barrier weightage

To ensure consistency, the normalization process involves dividing each cell value by the total of its respective column. The row averages are then calculated, with the summation always equaling 1. Using the fuzzy method, local weights are computed by first constructing a cumulative weightage matrix, which is normalized to derive the final local weightage. This process is repeated iteratively to calculate the weightage for all global barriers, resulting in the final local and global weightage values. Any deviation from the summation equaling 1 necessitates revalidation of the process until consistency is achieved.

3.4 Performance Score & Index

To evaluate how each city performs, a standardized method was used to calculate a performance score. This score is derived by multiplying the z-score of each barrier with its assigned weight: Performance = z-score × weight of the barrier.

Z-scores help in comparing data across cities by converting different units into a common scale. The values were calculated using reliable and consistent data sources. A positive z-score indicates that the barrier has a positive impact on Intelligent Transportation System (ITS) implementation meaning the condition in the city supports ITS. Conversely, a negative z-score shows that the barrier is negatively affecting the implementation of ITS, highlighting areas where improvement is needed.

Weights were assigned to each barrier based on its significance, and when combined with z-scores, they provided a clear performance score for each city. These scores help in ranking and comparing cities based on their readiness or challenges related to ITS. A more detailed explanation of this method is provided in Sections 3.2 and 3.3.2. The final performance scores, reflecting both positive and negative influences on ITS implementation, are summarized in **Table 7.**

4. FINAL OBSERVATIONS AND CONCLUSIONS

This section presents conclusive insights from the developmental assessment of four Indian cities

Table 7 Performance index

S. No	Sub-System (ITS – Tools)	Ahmedabad	Surat	Vadodara	Gandhinagar
1	Control room connectivity	-0.0180	0.1783	-0.3918	0.2315
2	VMS System	-0.0039	- 0.0030	0.0116	-0.0046
3	Emergency road side phone system	-0.0023	0.0070	-0.0023	-0.0023
4	e- Challan system	-0.0140	- 0.0518	-0.0329	0.0987
5	CCTV system for Automatic Speed detection system	-0.0360	- 0.0681	0.0446	0.0594
6	Automatic number plate recognition system	-0.0112	- 0.0457	-0.0272	0.0841
7	Red Light violation detection system	-0.0104	- 0.0352	-0.0238	0.0694
8	IP-based public announcement (PA) system	-0.0302	- 0.0302	0.0812	-0.0208
9	Police patrol monitoring system	0.0147	0.0061	-0.0105	-0.0102
10	Traffic police (squad, post) Traffic interceptorvans	0.0032	0.0033	-0.0027	-0.0038
11	Maintain and manage communication system,control room	-0.0056	- 0.0068	-0.0129	0.0253
12	Automatic traffic counter and classifiers	0.0000	0.0000	0.0000	0.0000
13	Wi-Fi connectivity	-0.1977	0.0285	-0.0960	0.2652
14	Intelligent parking lot management system	-0.0155	- 0.0022	0.0462	-0.0284
15	Pedestrian / biker detection system	-0.0251	- 0.0251	-0.0251	0.0754
16	Passenger information system	0.0668	0.0148	-0.0408	-0.0408
	Total	**-0.2854**	**- 0.0301**	**-0.4826**	**0.7981**
	Rank	**3**	**2**	**4**	**1**

Gandhinagar, Ahmedabad, Vadodara, and Surat. Key findings reveal that Gandhinagar outperformed other cities with an overall performance score of 0.798, securing the highest rank. Surat, Ahmedabad, and Vadodara followed, ranking 2nd, 3rd, and 4th, respectively. Phase wise analysis further highlights disparities in urban mobility readiness for better understanding. Gandhinagar currently resides in Phase IV, Ahmedabad in Phase II, and both Vadodara and Surat in Phase III. Adhering to these findings, a clear trajectory for advancement to the next developmental stages is delineated.

Specific recommendations emerge:

For Gandhinagar's progression from Phase IV to Phase V, the implementation of an Automated Intelligent Transportation System (AITS) is proposed. This entails the collection of smart card data from passengers, necessitating operationalization, maintenance, and shared dissemination of the acquired information within the city.

In Surat, enhancing pedestrian safety is crucial. Initiatives such as installing pelican crossings and transforming existing authorized parking spots into smart parking are suggested for an effective transition from Phase III to Phase IV.

Ahmedabad and Vadodara are advised to prioritize roadside safety measures. This includes the installation of emergency roadside phone systems and the deployment of PT2 cameras for automated vehicle detection, facilitating their progression from Phase II to III.

These findings outline a road-map for comprehensive strategy for the targeted development of Intelligent Transportation Systems in the assessed cities, laying the groundwork for their seamless transition to more advanced phases.

5. FUTURE RESEARCH DIRECTIONS

In considering the future trajectory of Intelligent Transportation Systems (ITS) in urban environments, several recommendations emerge from the insights garnered in this research. First and foremost, the development of a user-friendly application for urban dwellers stands out as a pivotal initiative. Such an application would facilitate direct communication with control rooms managing traffic flow, providing real-time updates and notifications to enhance traffic management.

A strategic shift is proposed towards the conversion of existing parking spaces into smart ones rather than investing in new constructions. This not only augments city infrastructure but also contributes to the economic growth of established cities.

To bolster the efficiency of ITS, the implementation of Automatic Traffic Counter systems for each city and the incorporation of Transit Oriented Development in new areas are imperative. These measures are vital for the seamless performance of ITS across diverse urban landscapes.

Ensuring direct communication with the public is essential, prompting the recommendation for installing Variable Message Systems (VMS) and Public Address Systems (PA) in every city. Additionally, the deployment of i-poles equipped with wireless internet services enhances accessibility for the general populace.

Furthermore, the incorporation of a pedestrian detection system and a dedicated bicycle system is strongly advocated. Allocating space for the development of these systems in each city is integral to fostering a comprehensive and inclusive ITS framework. These recommendations collectively offer a roadmap for the progressive evolution of intelligent transportation systems, aligning with the dynamic needs of urban environments.

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Notification No. 76

Amendment No. 6/IRC:SP:114-2018/November, 2024 (Effective from 1st June, 2025)

To

IRC:SP:114-2018 "Guidelines for Seismic Design of Road Bridges"

Sl. No.	Clause No. Page No.	For	Read
1	Clause No. 3.4.1 Page No. 21	When seismic links/stoppers are used, elastomeric bearings placed vertically shall be used in between the stoppers and the Superstructure to mitigate the dynamic effects. The behaviour of the structure as a whole needs to be modelled properly in the analysis, duly taking into account the force-displacement relationship of the linked structure.	When seismic links/stoppers are used, irrespective of whether these are used as primary members to transmit seismic actions or as anti-dislodgement blocks, elastomeric bearings shall be placed vertically between the stoppers and the Superstructure. The behaviour of the structure as a whole need to be modelled properly in the analysis, duly taking into account the force-displacement relationship of the linked structure.
2	Clause No. 3.7 Page No. 23	Multi Span Bridges, with continuous superstructure, are generally provided with fixed bearing over one pier or abutment. In order to distribute the seismic force generated by superstructure to other piers/abutments STU's may be used between superstructure and other piers/ abutments where free bearings are used.	Multi Span Bridges, with continuous superstructure, are generally provided with fixity over one pier or abutment. In order to distribute the seismic force generated by superstructure to other piers/abutments STU's may be used between superstructure and other piers/ abutments where free bearings are used.
3	Notes below Table 4.1- Amended Vide Notification No. 25 published in IH Oct 2019 Page No. 26 & 27	Notes: i) to ix)	Add following notes after note no. ix): x) For RCC piers/abutments, R for ductile detailing given in Table 4.1 shall be modified by multiplying it by $\lambda(\alpha_s)$ where α_s = h/b is the shear span ratio of the pier, where h is the distance from the plastic hinge to the point of zero moment and b is the depth of the cross-section in the direction of flexure of the plastic hinge. For $\alpha_s \geq 3$ $\lambda(\alpha_s) = 1.0$ $3 > \alpha_s > 1.0$ $\lambda(\alpha_s) = \sqrt{\alpha_s}/3$ If $\alpha_s \leq 1$, R=1 shall be considered.

Sl. No.	Clause No. Page No.	For	Read
			xi) R>1 for RCC piers/abutments shall be considered only when plastic hinge is formed and the following conditions are satisfied: (a) Plastic hinge shall not be formed in reinforced concrete sections where the normalised axial force n_k exceeds 0.48. A value for R=1.0 should be used for bridges in which the seismic force resisting system contains members with $n_k \geq 0.48$ where $n_k = N_{Ed}/(A_c f_{ck})$ as defined in Clause 7.3.4.2 (b). (b) For reinforced concrete ductile members, the values of R specified in Table 4.1 are valid when the normalised axial force n_k does not exceed 0.24. If $0.24 < n_k \leq 0.48$, the value of R factor shall be reduced to: $R_r = R - [(R-1) X (n_k-0.24)/0.24)] \geq 1$ (c) For bridges where the seismic response may be dominated by higher mode effects (e.g. Cable-Stayed Bridges), or where the detailing of plastic hinges for ductility may not be reliable (e.g. due to a high axial force or a low shear-span ratio, $\alpha_s \leq 1.0$), R = 1 is recommended. (d) The values of R specified in Table 4.1 for ductile behaviour may be used without any special verification of the available ductility, provided that the detailing requirements specified in Chapter 7 and 9 are met. e) For short rigid structural components like short piers and rigid abutments, the value of Sa/g shall be taken as 1. The component is considered as rigid in case the time period is less than 0.03 seconds. Also, the response reduction factor R shall be taken as 1.0 for seismic design of such structural components.

Sl. No.	Clause No. Page No.	For	Read
4	Clause No. 6.6 Page No. 44	**6.6 Special Types of Bridges** These bridges shall be designed for site-specific spectrum for which no separate importance factor shall be specified. The site specific spectrum, time history of design earthquakes, DBE and MCE shall be specified for seismic design.	**6.6 Special Types of Bridges** These bridges shall be designed for site-specific spectrum for which no separate importance factor shall be specified i.e., Importance factor shall be taken as 1.0. The site-specific spectrum, time history of design earthquakes, DBE and MCE (if considered) shall be specified for seismic design.
5	Clause No. 7.3.4.2 (f) Page No. 50	(f) The capacity design effects need not be taken greater than the elastic design effects resulting from the design seismic combinations considered with Response Reduction factor, R=1.0	(f) The capacity design effects need not be taken greater than the elastic design effects resulting from the design seismic combinations considered in each orthogonal direction (longitudinal and transverse) separately with Response Reduction factor, R=1.0 i.e., the lower of the capacity design effects and the elastic design effects with R=1 in the each selected direction shall be considered.

Notification No. 77

Amendment No. 1/IRC:78 (Part-1)2024/November, 2024 (Effective from 1st June, 2025)

To

IRC:78 (Part-1)-2024 "Standard Specifications and Code of Practice for Road Bridges Foundations and Substructure Part-1: General Features and Working Stress Design *(Third Revision)"*

Sl. No.	Clause No. Page No.	For	Read
1	Clause No. 701.4 Page No. 3	**701.4 Bearing Capacity** The supporting power of the soil/rock is referred to as its bearing capacity 701.4.1 Allowable bearing pressure It is the maximum gross pressure intensity at which neither the soil fails in shear, (after accounting for appropriate factor of safety) nor there is excessive settlement beyond permissible limits, which is expected to be detrimental to the structure.	**701.4 Bearing Capacity** The supporting power of the soil/rock is referred to as its bearing capacity 701.4.1 Net Loading Intensity The net loading intensity on the foundation is the gross intensity of loading minus the weight of displaced soil above the foundation base.

Sl. No.	Clause No. Page No.	For	Read
		701.4.2 Net safe bearing capacity It is the net ultimate bearing capacity divided by a factor of safety as per Clause 706.3.1.1.1 **701.4.3 Net ultimate bearing capacity** It is the minimum net pressure intensity causing shear failure of the soil. **701.4.4 Safe bearing capacity** The maximum pressure, which the soil can carry safely without risk of shear failure and it is equal to the net safe bearing capacity plus original overburden pressure. **701.4.5 Gross Ultimate gross bearing capacity** It is the minimum gross pressure intensity at the base of the foundation at which the soil fails in shear	**701.4.2 Net Ultimate Bearing Capacity** The net loading intensity at the base of the foundation which would cause shear failure of the soil support. **701.4.3 Net safe bearing capacity** It is the net ultimate bearing capacity divided by a factor of safety as per Clause 706.3.1.1.1 **701.4.4 Safe Bearing Capacity** The maximum intensity of loading that the foundation will safely carry without the risk of shear failure of soil irrespective of any settlement that may occur. **701.4.5 Safe Bearing Pressure or Net Soil Pressure for Specified Settlement** The intensity of loading that will cause a permissible settlement or specified settlement of the structure. **701.4.6 Allowable Bearing Capacity** The net intensity of loading which the foundation will carry without undergoing settlement in excess of the permissible value for the structure under consideration but not exceeding net safe bearing capacity.
2	Clause No. 701.5 Page No. 4	**701.5 Bearing pressure** **701.5.1 Gross Pressure Intensity** It is the total pressure at the base of the foundation on soil due to the possible combinations of load and the weight of the earth fill. **701.5.2 Net Pressure Intensity** It is the difference in intensities of the gross pressure and the original overburden pressure.	**701.5 Bearing pressure** **701.5.1 Gross Pressure Intensity** It is the total pressure at the base of the foundation on soil due to the possible combinations of load and the weight of the earth fill. **701.5.2 Net Pressure Intensity** It is the difference in intensities of the gross pressure and the original overburden pressure.

Sl. No.	Clause No. Page No.	For	Read
			701.5.3 Allowable bearing pressure It is the maximum gross pressure intensity at which neither the soil fails in shear, (after accounting for appropriate factor of safety) nor there is excessive settlement beyond permissible limits.
3	Clause No. 703 and Appendix 9 Page No. 8	**703 Discharge and Depth of Scour for Foundation Design and Appendix-9**	**Deleted, Refer IRC 5**
4	Clause No. 706.3.1 Page No. 14	**706.3.1** The allowable bearing pressure and the settlement characteristics under different loads and stresses may be determined on the basis of sub-soil exploration and testing. Though,the help of relevant Indian Standard Code of Practice may be taken, the allowable bearing pressure may be calculated as gross so that the gross pressure at the base without deducting the soil displaced the soil displace can be computed.	**706.3.1** The allowable bearing pressure and the settlement characteristics under different loads and stresses may be determined based on sub-soil exploration and testing.
5	Clause No. 706.3.2.2 Page No. 15	**706.3.2.2** For foundations resting on soil, the maximum allowable total settlement due to loads from superstructure, shall be as below: For open foundations – 75 mm For Well foundation – 150 mm	**706.3.2.2** For foundations resting on soil, the maximum allowable total settlement shall be as below: For open foundations – 75 mm For Well foundation – 150 mm
6	Clause No. 707.1.3 Page No. 16	**707.1.3** To ensure proper load transfer, the ratio of depth to length/width of footing shall not exceed 1:3.	**707.1.3** To ensure proper load transfer, the ratio of depth to length/width of footing beyond the pier/column face shall not exceed 1:3.

Notification No. 78
Errata No. 1/IRC:78 (Part-1)2024/November, 2024 (Effective from 1st June, 2025)
To
IRC:78 (Part-1)-2024 "Standard Specifications and Code of Practice for Road Bridges Foundations and Substructure Part-1: General Features and Working Stress Design *(Third Revision)"*

Sl. No.	Clause No. Page No.	For	Read
1	Background Page No. 1	Subsequently, the Revised Edition of IRC:78 "Standard Specifications and Code of Practice for Road Bridges" Section VII-Foundation incorporating all Amendments and Errata published till 2013 was approved by Foundations and Substructure Foundation Substructure Protective Works and Masonry Structures Committee (B-3) in its meeting held on 16.10.2013.	Subsequently, the Revised Edition of IRC:78 "Standard Specifications and Code of Practice for Road Bridges" Section VII-Foundation incorporating all Amendments and Errata published till 2013 was approved by Foundation, Sub-Structure, Protective Works, and Masonry Structures Committee (B-3) in its meeting held on 16.10.2013.
2	Clause No. 701.10.1 Page No. 5	Flared up increase the width and raised up to the top of road.	Flared up to increase the width and raised up to the top of road.
3	Clause No. 701.12.1 Page No. 6	701.12.1 Till of Well	701.12.1 Tilt of Well
4	Clause No. 703.1.1 Page No. 8	Located near to the existing bridge	Located near the existing bridge
5	Clause No.706.3.1.1 Page No. 14	For open foundations and well foundation resting on soil, the allowable bearing pressure on ultimate bearing capacity may be taken as 2.5 for soil.	For open foundations and well foundation resting on soil, for calculating allowable bearing pressure the factor of Safety on ultimate bearing capacity may be taken as 2.5.
6	Clause No. 707.3.2 Page No. 16	The distance between the two foundations at different levels may be decided in such a way to minimize this effect taking into account the nature of soil.	Deleted.
7	Clause No. 707.4.4 Page No. 17	Condition for laying of foundations	Conditions for Laying of foundations
8	Clause No. 707.4.4.1 Page No. 17	Normally, the open foundations should be laid dry and every available method of dewatering by pumping or depression of water by well point, etc. may be resorted to.	Normally, the open foundation should be laid under dry conditions and every available method of dewatering by pumping or depression of water by well point, etc. may be resorted to.
9	Clause No. 707.4.4.2 Page No. 17	No pumping of water shall be permitted form the time of placing of concrete upto 24 hours after placement.	No pumping of water shall be permitted from the time of placing of concrete upto 24 hours after placement.

Sl. No.	Clause No. Page No.	For	Read
10	Clause No. 708.2.3.3 (a) Page No. 19	Very soft clay strata: Main criteria for reduction in steining thickness in to prevent the well penetrating by its own weight. When the thickness is so reduced, the steining shall be adequately reinforced, to get sufficient strength.	Very soft clay strata: Main criteria for reduction in steining thickness is to prevent the well penetrating by its own weight. When the thickness is so reduced, the steining shall be adequately reinforced, to get sufficient strength.
11	Clause No. 708.5.2 Page No. 21	If the actual tilts and shifts exceed the above limits, then the remedial measures have to be resorted to bring the well within than limit.	If the actual tilts and shifts exceed the above limits, then the remedial measures have to be resorted to bring the well within that limit.
12	Clause No. 708.6.2 Page No. 21	When there are two or more compartments in a well, the lover end of the cutting edge of the middle stems of such wells shall be kept about 300 mm above that of the outer stems to prevent rocking, as shown in the **Appendix-3 (Fig.2).**	When there are two or more compartments in a well, the lower end of the cutting edge of the middle stems of such wells shall be kept about 300 mm above that of the outer stems to prevent rocking, as shown in the **Appendix-3 (Fig.2).**
13	Clause No. 708.14.2 Page No. 23	In case if concreate steining is provided, it shall be rendered air tight by restricting the tension in concreate which will not exceed 318^{th} of the modulus of rupture. For the circular wells, the tension in steining may be evaluated by assuming it to be a thick- walled cylinder.	In case, concreate steining is provided, it shall be rendered air tight by restricting the tension in concreate which will not exceed $3/8^{th}$ of the modulus of rupture. For the circular wells, the tension in steining may be evaluated by assuming it to be a thick-walled cylinder.
14	Clause No. 709.3.1 (b) Page No. 28	Granular soil (sand, gravel or non-plastic silt with N (average within layer) 150 blows 10.3 m (50 blows 130 cms);	Granular soil (sand, gravel or non-plastic silt with N (average within layer) $\leq$ 50 blows /0.3 m (50 blows/30 cms);
15	Clause No. 709.3.1 (c) Page No. 28	Intermediate Geometrical Cohesive: e.g. clay shales or mudstones with 0.25 MPa (2.5 tsf) < Su < 2.5 MPa. Cohesion less: e. g. granular tills, granular residual soils N > 50 blows/0.3m (50 blows 130 cm);	Intermediate Geomaterial Cohesive: e.g. clay shales or mudstones with 0.25 MPa (2.5 tsf) < Su < 2.5 MPa. Cohesion less: e.g. granular tills, granular residual soils N > 50 blows/0.3m (50 blows /30 cm);
16	Clause No. 709.3.3 (ii) (b) Page No. 29	The capacity of the group based on block failure concept, where the ultimate load carrying capacity of the block enclosing the piles in estimated.	The capacity of the group based on block failure concept, where the ultimate load carrying capacity of the block enclosing the piles is estimated.
17	Clause No. 710.4.1 Page No. 34	The abutments will carry superstructure from one side. t should be designed/dimensioned to retain earth from the approach embankment.	The abutments will carry superstructure from one side. It should be designed/dimensioned to retain earth from the approach embankment.

Sl. No.	Clause No. Page No.	For	Read
18	Clause No. 710.4.9 Page No. 34	In case of spill through type abutment, it should be ensured that the slope in front of the abutment is well protected by means of suitably designed ston pitching and launching aprons.	In case of spill through type abutment, it should be ensured that the slope in front of the abutment is well protected by means of suitably designed stone pitching and launching aprons.
19	Clause No. 710.4.11 Page No. 34	In case of box type abutments, weep holes shall be provide similar to hollow piers as per Clause 710.2.9.	In case of box type abutments, weep holes shall be provided similar to hollow piers as per Clause 710.2.9.
20	Clause No. 710.5.2 Page No. 35	For multiple span arch bridges, Intermediate heavy piers shall be provided after every fifth span or closer. It is designed for condition that even if arch on one side of it collapses, the pier and arches on other side will remain safe.	For multiple span arch bridges, Intermediate heavy piers shall be provided after three to five spans. It is designed for condition that even if arch on one side of it collapses, the pier and arches on other side will remain safe.
21	Clause No. 710.6.5 Page No. 35	The wing walls should be designed primarily to withstand the arth pressure in addition to self-weight.	The wing walls should be designed primarily to withstand the earth pressure in addition to self-weight.
22	Appendix-2 (Fig. 2) Page No. 63	In Appendix-2 Fig. 2 Typical Details of Raft showing reduction in width	In Appendix-2 Fig. 2 Typical Details of Raft showing reduction in width
23	Appendix-3 (Fig.3) Page No. 67	In Appendix-3 Fig. 3 Details of Well Curbs and Cutting Edge	In Appendix-3 Fig. 3 Details of Well Curbs and Cutting Edge

Notification No. 79
Amendment No. 8/IRC:112-2020/November, 2024 (Effective from 1st June, 2025)
To
IRC:112-2020 Code of Practice for Concrete Road Bridges *(First Revision)*
Modification in IRC:112-2020 due to transfer of clauses pertaining to well foundation of IRC:78 (Part-1)-2024

Sl. No.	Existing Clause No. in IRC:78	For	New Clause No. in IRC:112	Read
1	Clause No. 708.3.3 Page No. 20	For plain concrete wells, vertical reinforcements (whether mild steel or deformed bars) in the steining shall not be less than 0.12 percent of gross sectional area of the actual thickness provided. This shall be equally distributed on both faces of the steining. The vertical reinforcements shall be tied up with hoop steel not less than 0.04 percent	Clause No. 16.15.3.1	For plain concrete caissons, vertical reinforcements (whether mild steel or HYSD bars) in the steining shall not be less than 0.12 percent of gross sectional area of the actual thickness provided. The vertical reinforcements shall be tied up with horizontal steel not less than 0.04 percent of the volume per unit length of the steining. These shall be equally distributed on both faces of the

Sl. No.	Existing Clause No. in IRC:78	For	New Clause No. in IRC:112	Read
		of the volume per unit length of the steining, as shown in the **Appendix-3 (Fig. 2).**		steining. The design of such caissons shall be done using the **ANNEXURE A10 -** "Plain and Lightly Reinforced Concrete Structures" The horizontal annular section of caissons steining shall also be checked for ovalisation moments by any rational method taking account of side earth pressures.
2	Clause No. 708.3.4 Page No. 20	In case where the well steining is designed as a reinforced concrete element, it shall be considered as a column section subjected to combined axial load and bending. However, the amount of vertical reinforcement provided in the steining shall not be less than 0.2 percent (for either mild steel or deformed bars) of the actual gross sectional area of the steining. On the inner face, a minimum of 0.06 percent (of gross area) steel shall be provided. The transverse reinforcement in the steining shall be provided in accordance with the provisions for a column but in no case shall be less than 0.04 percent of the volume per unit length of the steining. The horizontal annular section of well steining shall also be checked for ovalisation moments by any rational method taking account of side earth pressures evaluated as per Clause 708.4.	Clause No. 16.15.3.2	In case where the caissons steining is designed as a reinforced concrete element, it shall be as per all the relevant clauses of the Code. The horizontal annular section of caissons steining shall also be checked for ovalisation moments by any rational method taking account of side earth pressures.
3	Clause No. 708.3.6 Page No. 20	The stresses in well steining shall be checked at such critical sections where tensile and compressive stresses are likely to be maximum and also where there is change in the area of reinforcement or in the concrete mix.	Clause No. 16.15.3.3	The caissons steining shall be checked at such critical sections including where there is change in the cross section or grade of concrete or area of reinforcement.

Efile No.RW/NH-33044/34/2024-S&R (P&B) (Computer No.-246283)
Government of India
Ministry of Road Transport & Highways
(S&R (P&B/New Technology) Zone)
Transport Bhawan, 1, Parliament Street, New Delhi-110001

130.242

Dated: 30th April, 2025

CIRCULAR

Subject: - Seeking Additional Performance Security for the bidders who have quoted abnormally low bid price – Reg.

Madam/Sir,

Reference is drawn towards Ministry's Circular No. NH 37015/01/2022-H dated 26.08.2022 (computer no. 208778) vide which Ministry has issued guidelines for seeking additional performance security in the Para 4 (i), (ii) & (iii):

(i) If the Bid price offered by the selected bidder is lower than 20% of the Estimated Project Cost/cost put to tender, the additional performance security shall be calculated @ 20% of the difference in the (i) Estimated Project Cost (as mentioned in RFP)-20% of the Estimated Project Cost and (ii) the Bid Price offered by the selected Bidder.

(ii) Maximum limit of additional performance security shall be limited to 3% of the Bid price offered by the selected bidder.

(iii) The additional performance security shall be treated as part of the performance security.

2. It was further conveyed that Additional performance security shall be taken only after approval of Secretary, Ministry of Road Transport & Highways, mentioning specific reasons justifying the requirement of additional performance security along with track record of the bidder. The circular was issued in pursuance to Department of Expenditure Circular no. F.9/4/2020-PPD dated 12.11.2020.

3. The matter has been reviewed considering the trend of abnormally low bid prices in National Highways projects and it has been decided that, henceforth, additional performance security will be taken from selected bidder for low bid as under:

(i) where the bid price is **below 10% but not below 20%** of the project cost put to bid, the additional performance guarantee/security percentage shall be incremented by 0.1% for every percentage of bid price below 10% of the project cost put to bid starting at 11% with the additional bid performance guarantee being 0.1% and this additional performance guarantee percentage shall be applied on the bid price;

(ii) where the bid price is **20% or more below** of the project cost put to bid, the additional performance guarantee percentage shall be incremented by 0.2% for every percentage of bid price below 20% of the project cost put to bid in addition to 1% of the bid price and this additional performance guarantee percentage shall be applied on the bid price;

(iii) The additional performance guarantee percentage shall be rounded off to the next lower percentage based on whether the decimal point of the percentage of bid price is below 0.5% or next higher percentage based on whether the decimal point of the percentage of bid price is 0.5% or more.

(iv) The additional performance security shall be treated as part of the performance security.

(v) An illustrative example for calculation of additional performance guarantee/security for a notional project where the project cost put to bid is Rs.1000 crore is given in **Annexure** for ready reference.

4. In respect of projects under Road Wing, Additional Performance Security shall be taken with approval from DG (RD) & SS, MoRTH.

5. These guidelines shall come into force with immediate effect. All the implementing agencies of the MoRT&H are requested to take action accordingly.

6. This issues with the approval of the Competent Authority.

Yours sincerely,
Bidur Kant Jha
30/04/2025
(Bidur Kant Jha)
Director
(New Technology for Highway development)
For DG (RD) & SS

Annexure of the circular is available on MoRTH Website : morth.nic.in

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