3rd International Transport Conference

Towards Safe, Sustainable, Efficient, and Resilient Mobility

11-13 April, 2025
Kathmandu, Nepal

CONFERENCE PROCEEDING

Jointly Organized By:

Society of Transport Engineers Nepal

Ministry of Physical Infrastructure and Transport

Ministry of Urban Development

3rd International Transport Conference

SOTEN | 2025

Collaborating Organization

Construction Business Development Implementation Committee

Department of Roads

Department of Railways

Department of Local Infrastructure Development

Investment Board Nepal

Federation of Contractors' Associations of Nepal

Roads Board Nepal

Civil Aviation Authority of Nepal

National Association of Rural Municipalities in Nepal

Municipal Association of Nepal

Kathmandu Metropolitan City

Lalitpur Metropolitan City

International Collaborating Organization

International Road Assessment Programme

Eastern Asia Society for Transportation Studies

International Road Federation

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Preface

The Third International Transport Conference, convened under **Society of Transport Engineers Nepal (SOTEN),** jointly with Ministry of Physical Infrastructure and Transport (MoPIT) and Ministry of Urban Development (MoUD); represented a significant milestone in Nepal's ongoing journey toward advancing its transportation infrastructure and policy framework. This landmark gathering wasthe culmination of nine months of meticulous planning, coordination, and collaboration among a wide array of national and international stakeholders. It stood as a testament to Nepal's commitment to embracing global best practices while addressing its unique developmental challenges in the transport sector.

The event was further strengthened by the support and participation of four prominent international organizations—EAST, iRAP, IRF, and ATO—each bringing specialized expertisein transport sector. In addition, there was collaboration with different government organization ranging from federal to local agencies along with professional societies and academia which has contributedvaluable insights and scholarly rigor to the proceedings. Over the course of three dynamic days, the conference attracted nearly **357 participants from 13 countries, creating a vibrant platform for cross-border dialogue and knowledge sharing. The agenda was thoughtfully structured into 15 technical sessions, which included both opening and closing ceremonies, and featured 23 international presentations delivered by a diverse group of 52 speakers and panelists.** The conference's thematic progression was strategically designed: the first day focused on absorbing insights and innovations from global experts; the second day shifted to examining national issues through parallel sessions dedicated to local challenges and opportunities; and the final day synthesizedthese perspectives to collaboratively outline a forward - looking agenda for transport safety, efficiency, and sustainability.

The conference concluded on a note of renewed commitment and shared purpose. It was unanimously reaffirmed that the resolutions and recommendations emerging from the deliberations would be actively pursued in close collaborationwith MoPIT and MoUD, ensuringthat the insights gained translate into tangiblepolicy initiatives and project implementations. This collectivepledge underscored thevital importance of sustained partnership between government entities, professional networks, academia, and the international community in shaping a safer, more sustainable, and resilient transport future for Nepal. A call for papers was issued in advance of the conference, inviting research and case studies aligned with the conference themes. From the submissions, **12 high-quality papers were selected for publication in a special edition of the SOTEN Journal of Transport Science and Engineering (JOTSE), Volume 1, Special Issue**, thereby extending the conference's intellectual contribution to a wider academic and professional audience and hence have not been added in the proceeding.

In essence, the Third International Transport Conference served not only as a forum for exchange but also as a catalyst for actionable change, reinforcing Nepal's role as an engaged and proactive participant in the global discourse on transportation development.

Dr. Hareram Shrestha
President, SOTEN

Er. Hemant Tiwari
Conference Convenar

The Third International Transportation Conference was a significant professional gathering focused on the future of transport, held under the theme "Towards Safe, Sustainable, Efficient, and Resilient Mobility" from April 11-13, 2025, at the Hotel Yak and Yeti in Kathmandu, Nepal. The event was organized by the Society of Transport Engineers Nepal (SOTEN) in collaboration with the Government of Nepal's Ministry of Physical Infrastructure and Transport (MoPIT) and Ministry of Urban Development (MoUD).

The conference successfully attracted financial and promotional support from a range of organizations through a structured Sponsorship Scheme. Support was tiered into multiple levels, each offering a corresponding set of privileges. The premier Diamond Sponsors, who made the highest contribution, received extensive benefits including multiple delegate registrations, a dedicated exhibition stall at the venue, prominent advertisement placement in the conference materials, and substantial presentation time during the sessions. Platinum, Gold, Silver, and Bronze Sponsors also provided crucial support, with privileges scaling to their level of contribution, such as fewer registrations, smaller advertisement spaces, and logo recognition on conference banners.

In addition to the tiered sponsors, the conference offered a separate Advertisement Scheme for organizations that wished to secure promotional space in the conference souvenir without taking a full sponsorship package. These advertisers had their logos and information featured in the Pre-Conference Souvenir, a key publication distributed to all delegates, which contained both academic abstracts and a dedicated business promotion section.

Conference Theme:

"Towards Safe, Sustainable, Efficient & Resilient Mobility"

This international gathering brings together policymakers, industry leaders, and innovators to redefine transportation systems for the 21st century. We're advancing mobility solutions that prioritize human safety, environmental sustainability, operational efficiency, and climate resilience, creating transportation networks that serve both present needs and future generations.

Sessions:

- Keynote Session on Integrated and Sustainable
- Transport International Experience Sharing on Road
- Session on Integrated and Sustainable Transport Road
  Safety
- Sustainability of Road
- Road Safety
- Pavement Management
- Research and
- Innovation Civil
- Aviation Sector
  Urban Planning and Associated Infrastructure
- Technology and Innovation in Transport Sector
- Sustainable Urban Mobility

- Panel discussion on issues and challenges on implementation of federalization in context of transport infrastructure
- Asset Management
- Way forward Discussion

Organizing Committee

Conference Chair

- Dr. Hare Ram Shrestha – President, Society of Transport Engineers Nepal

Convene

- Mr. Hemant Tiwari – General Secretary, SOTEN

Co-Chairs

- Mr. Padam Mainali – Joint Secretary, Ministry of Urban Development
- Mr. Sushil Babu Dhakal – Joint Secretary, Ministry of Physical Infrastructure and Transport

Members

- Mr. Ram Hari Pokharel – Director General, Department of Roads
- Mr. Melvin Ahuja – Co-Team Leader, Asian Transport Outlook
- Mr. Pradeep Adhikari – Director General, Civil Aviation Authority Nepal

Conference Committees

Advisory Committee

- Mr. Rajendra Raj Sharma, Immediate Past President, SOTEN
- Mr. Gopal Sigdel – Secretary, Ministry of Urban Development
- Mr. Keshab Kumar Sharma – Secretary, Ministry of Physical Infrastructure and Transport
- Mr. Sushil Gyawali – CEO, Investment Board Nepal
- Prof. Dr. Padma Bahadur Shahi – Chairman, Nepal Engineering Council
- Prof. Akimasa Fujiwara – President, Eastern Asia Society of Transport
- Mr. Tulasi Sitaula – Founding President, SOTEN
- Mr. Lal Krishna KC – Past President, SOTEN
- Mr. Greg Smith – Global Program Director, iRAP
- Ms. Susanna Zammataro – Director General, International Road Federation
- Mr. Sudhir Gota – Team Leader, Asian Transport Observatory
- Er. Thakur Prasad Sharma – President, Society of Consulting Architectural & Engineering Firms
- Er. Mandip Subedi, PhD – President, Nepal Geotechnical Society
- Dr. Ranjan Kumar Dahal – President, Nepal Society of Engineering Geology

- Mr. Maheshwor Neupane – Director General, Department of Local Infrastructure Development
- Mr. Rajeev Pokharel – Director General, Department of Transport Management
- Mr. Ajay Kumar Mull – Director General, Department of Railways
- Mr. Ganesh Bahadur KC – Executive Director, Roads Board Nepal

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- Er. Shrawan Kumar Thapa – Secretary, SOTEN
- Er. Bindu Adhikari – Treasurer, SOTEN

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- Er. Ram Kumar Shrestha – Department of Roads
- Er. Saujanya Nepal – Department of Roads
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- Er. Nal Bahadur Thapa – Civil Aviation Authority Nepal
- Er. Binod Bhattarai – Department of Roads

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- Dr. Partha Mani Prajuli, Road Safety Expert
- Dr. Rojee Pradhananga – Assistant Professor, Institute of Engineering
- Prof. Dr. Thuisita Chadani Shahi – nec-CPS, Nepal Engineering College
- Mr. Parth Bosu – Principal, DFAG LLP
- Mr. Minh Vo – Coordinator, Star Rating for School, iRAP
- Dr. Bhoj Raj Panta – Senior Researcher
- Mr. Kamal Pande – Senior Transport Specialist
- Er. Vibek Gupta – Chairman, SSTN
- Ms. Subha Sharma – Professional Lead, Scott Wilson Nepal

Resolution Committee

- Mr. Kamal Pande – Senior Transport Specialist
- Mr. Anil Marsani – Institute of Engineering, Pulchowk Campus

- Dr. Robin Workman-TRL
- Dr. Nitesh Acharya

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- Er. Sandesh Acharya
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- Er. Sudarshan Auji
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- Er. Tunisha Gyawali
- Er. Aanchal Tiwari
- SOTEN Secretariat: Er. Samridhi Singh

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Inaugural Session

The Inaugural Session of the conference was chaired by Dr. Hare Ram Shrestha, President of the Society of Transport Engineers Nepal (SOTEN). The session was graced by Honorable Minister Devendra Dahal from the Ministry of Physical Infrastructure and Transport, who attended as the Chief Guest.

Dr. Bindu Lohani, Chancellor of Nepal University and President of Clean Air Asia, participated as one of the keynote speakers. Er. Keshav Kumar Sharma, Secretary of the Ministry of Physical Infrastructure and Transport, also joined the session as a special guest and keynote speaker. Additionally, Prof. Dr. Kiyoyuki Kaito from Osaka University attended as a keynote speaker and special guest. Prof. Dr. Padma Bahadur Shahi, Chairperson of the Nepal Engineering Council, joined the event as a special guest. Prof. Dr. Akimasa Fujiwara, President of the Eastern Asia Society for Transportation Studies, joined the conference virtually from Japan as a Guest of Honor.

The opening session was also attended by the Immediate Past President of SOTEN, Director Generals of various government departments, Joint Secretaries from different ministries, officials from the Civil Aviation Authority of Nepal, representatives from various professional societies, the Presidents of the Nepal Engineers' Association and the Society for Consulting Architects and Firms, along with the conference coordinator.

Er. Hemant Tiwari General Secretary and Conference Convenar of SOTEN deliver the welcome address and present a brief overview of the program. He explained that as we gathered at the conference, we were joined by 20 international speakers and 45 national speakers and panelists. They shared their expertise on critical aspects of transportation, including road safety, sustainability, asset management, transport planning, regional planning, and more. What stood out was the diversity of the group, representing 10 different countries.

The conference was officially inaugurated by the Chief Guest, Honorable Minister Devendra Dahal. The inauguration was followed by the playing of the National Anthem, marking the formal commencement of the event.

A special video message was delivered by **Ms. Susanna Zammataro**, Director General of the International Road Federation (IRF), who acknowledged the relevance of the conference and applauded SOTEN's efforts in fostering dialogue and collaboration around sustainable transport in Nepal and the broader South Asian region.

This was followed by remarks from the Guest of Honor, **Prof. Dr. Akimasa Fujiwara**, President of the Eastern Asia Society of Transportation Studies (EASTS). Joining virtually from Japan, Dr. Fujiwara emphasized the role of research-based collaboration in addressing evolving transport challenges and praised Nepal's efforts in integrating international expertise into its transport development discourse.

One of the key highlights of the session was the keynote speech by **Er. Keshab Kumar Sharma**, Secretary at the Ministry of Physical Infrastructure and Transport (MoPIT). He highlighted the pressing need to rethink and reimagine urban transportation, focusing not just on building infrastructure but on designing transport systems that are safe, sustainable, inclusive, and resilient. He underlined the critical role of international partnerships in adopting advanced technologies and emphasized the importance of inter-agency collaboration in shaping the future of Nepal's transport sector.

In the next keynote address, **Prof. Dr. Kiyoyuki Kaito** from Osaka University delivered a presentation on "Infrastructure Asset Management for Safer, Sustainable, and Resilient Transportation." He shared insights on modern asset management practices and data-driven strategies to maintain and upgrade transport infrastructure, reinforcing the theme of long-term resilience.

The third keynote speaker, **Dr. Bindu Lohani**, President of Clean Air Asia and Chancellor of Nepal University, spoke on the theme "Navigating the Future: Sustainable and Inclusive Transport for a Connected World." Dr. Lohani highlighted the intersection of transport, environment, and equity, urging a future-forward, people-centered approach to urban mobility that minimizes environmental impacts and enhances connectivity.

The inaugural address was delivered by the Chief Guest, **Hon'ble Minister Devendra Dahal**, Ministry of Physical Infrastructure and Transport. In his speech, Minister Dahal acknowledged the increasing global emphasis on safe, reliable, and environmentally responsible transport systems, and emphasized the Government of Nepal's active efforts in this direction. He highlighted several major infrastructure initiatives, including the construction of three major East-West highways, an Asian standard highway, and strategically important road corridors, as well as the commencement of several tunnel projects and the establishment of two additional international airports. The minister reaffirmed the government's commitment to upgrading the transport sector through projects that are technologically advanced, environmentally sustainable, and inclusive—particularly for persons with disabilities. He praised the conference for addressing these timely issues and fostering much-needed discourse on the future of transportation in Nepal.

As a gesture of appreciation, tokens of recognition were presented to the attending dignitaries and special guests.

The session concluded with closing remarks from the Chair, **Dr. Hare Ram Shrestha**, President of SOTEN, who extended heartfelt thanks on behalf of the organizing committee to all dignitaries, speakers, partners, and participants. He expressed confidence that the sessions to follow would provide a platform for vibrant dialogue, insightful discussions, and impactful collaboration, and officially opened the technical sessions of the conference.

Presentation of Papers

Keynote Session on Integrated And Sustainable Transport

Session Chair: Prof. Dr. Jagadish Chandra Pokhrel, Former Vice-Chair, National Planning Commission
Session Moderator: Dr. Rojee Pradhananga, Assistant Professor, IOE, Pulchowk Campus

Three research papers were presented during this session, with contributions from Asia, Japan, and England. The topics included the conditional assessment of road safety, simulation of pedestrian behavior, and the use of innovative technologies for national road condition reporting.

Following the presentations, the session chair, Prof. Dr. Pokhrel, remarked that the session effectively highlighted the importance of sharing advanced tools and practices for road condition monitoring and reporting. He also noted the rich exchange of experiences related to transport policy, sustainability indicators, and regional development strategies across Asia. Additionally, he appreciated the detailed insights into pedestrian behavior modeling. He extended his gratitude to all the presenters and emphasized that the papers contribute significantly to the advancement of integrated and sustainable transport.

Session moderator Dr. Pradhananga acknowledged the value of the presented papers, particularly for young researchers. She thanked all the speakers for their contributions and active participation in the conference.

Session on International Experience Sharing on Road Safety

Session Chair: Er. Arjun Jung Thapa, Former Secretary, Government of Nepal
Session Moderator: Er. Saroj Pradhan, Advisor, National Road Safety Council

This session featured four presentations focused on global road safety practices. Ms. Anusha Rajasooriya shared insights on school zone safety implementation from England. Mr. Ali Zayerzadeh discussed pedestrian safety improvements using the Safe System Approach. Mr. Manpreet Darroch highlighted the role of youth in promoting road safety, while Er.Albin Tharakan provided an overview of iRAP, IndiaRAP, and safety assessments in Nepal.

Session Chair Er. Thapa emphasized the importance of learning from international experiences to improve Nepal’s road safety framework. He appreciated the practical relevance of the topics covered. Session Moderator Er. Pradhan thanked the speakers for their informative presentations and encouraged continued collaboration and knowledge sharing in this vital area.

Session on Integrated and Sustainable Transport

Session Chair: Er. Bhimarjun Adhikari, Joint Secretary, Ministry of Physical Infrastructure and Transport
Session Moderator: Er. Anil Marsani, Program Coordinator, MSc. in Transportation Engineering, IOE Pulchowk Campus

This session included four presentations covering diverse approaches to sustainable transport.

Er. Kevin McPherson introduced the application of accessibility indicators in Nepal's transport planning. Dr. Chaiwat Sangsrichan from Thailand presented a case study evaluating Transit - Oriented Development (TOD) indicators using the Fuzzy Delphi Method. Er. Daniel L. Mabazza explored the push-pull effects of expressways through a case study of the TPLEX expressway and its impact on Baguio City in the Philippines. Dr. Jagat Kumar Shrestha discussed rural road development strategies in developing countries with a focus on Nepal's context.

In his closing remarks, Er. Adhikari acknowledged the session's strength in blending practical insights with academic rigor, underscoring the importance of integrated solutions for sustainable transport. Er. Marsani reflected on the diversity of topics and emphasized how such knowledge-sharing platforms can inspire more localized, data-driven planning efforts. Both expressed their appreciation to the presenters for sparking thoughtful discussions and contributing meaningfully to the conference agenda.

Parallel Session (1A): Road Safety

<u>Session Chair</u>: Dr. Bijay Jaisi, Deputy Director General, Department of Roads
<u>Session Moderator</u>: Er. Pranita Rana, Associate Researcher, National Injury Research Center

This session focused on road safety challenges and strategies, with a particular emphasis on Nepal's high-risk corridors. Er. Nemi Bhattarai opened the session with a case study highlighting key issues in crash data collection and usage along the Nagdhunga-Naubise-Mugling (NNM) and Kamala-Dhalkebar-Pathlaiya (KDP) corridors. Er. Anil Marsani followed with a presentation on the application of the Nepal Road Safety Action Plan (NeRSAP) within the SRCTIP-funded Safe Corridor Demonstration Program. Er. Aditya Paudel shared findings from a road safety infrastructure assessment for the NNM corridor, identifying challenges and proposing strategic interventions.

Further contributions included a presentation by Prof. Dr. Padma Bahadur Shahi on the training needs for promoting road safety in Nepal. Dr. Ashok Ratna Bajracharya introduced a pilot model for post-crash response and care along the NNM road, while Dr. Badri Prakash Ojha discussed the need for targeted safety campaigns in the same corridor.

The session offered a comprehensive view of corridor-focused road safety efforts in Nepal. Session Chair Dr. Jaisi emphasized the urgency of systematic improvements in safety management, while Moderator Er. Rana acknowledged the practical relevance of the studies and thanked the presenters for their important contributions to Nepal's road safety discourse.

Parallel Session (2A): Sustainability of Road

<u>Session Chair</u>: Dr. Mandip Subedi, President, Nepal Geotechnical Society

<u>Session Moderator</u>: Er. Bindu Adhikari, Treasurer, SOTEN

This session focused on the sustainability and resilience of road infrastructure, particularly in the context of Nepal's challenging geographies and climatic conditions. Er. Santosh Panthe began with a presentation on the use of Nature-Based Solutions (NBS) to enhance the resilience of road transport systems in Nepal. Er. Tunisha Gyawali followed with a region-specific assessment of

road cut slope stability under varying rainfall scenarios in the mid-hill regions.
Ms. Laxmi Adhikari shared a case study analyzing the effects of monsoon rainfall on roadside slopes along the Dakshinkali-Kulekhani road segment. Mr. Ujjwal Krishna Raghubansha presented the application of geophysical methods to identify slope mass conditions at Chandram Bhir, while Er. Suresh Neupane discussed rainfall thresholds for shallow landslides along roadside slopes in mid-Himalayan Nepal.

Session Chair Dr. Subedi highlighted the significance of these technical insights for improving slope stability and long-term road sustainability. Session Moderator Er. Adhikari expressed appreciation for the presenter's research efforts and noted the importance of integrating such findings into practical infrastructure planning and disaster mitigation strategies.

Parallel Session (3A): Road Safety

Session Chair: Er. Sushil Babu Dhakal, Joint Secretary, Ministry of Physical Infrastructure and Transport
Session Moderator: Er. Subhash Dhungel, Chairman, Traffic & Transport Unlimited Solution

This session featured six diverse presentations focusing on both infrastructure-based and human-centered approaches to road safety. Mr. Vidheya Rao presented a study on the effectiveness of cold-applied plastic transverse bars and colored signage in reducing speed and improving driver awareness. Er. Saroj Kumar Pradhan discussed the potential for public-private partnerships in strengthening road safety infrastructure.

Dr. Partha Mani Parajuli introduced the Nepal Road Crash Database System, highlighting its role in systematic crash data collection and storage. Dr. Nitesh Acharya shared an analytical study exploring the link between road environments, safety measures, and crash occurrence. Dr. Satish Prasad Barnawal presented a deeply human perspective through a review of the clinical and social impacts of traffic crashes, particularly those leading to amputations. Finally, Er. Asmita Pokhrel discussed the implementation of the Star Rating for Schools program in Nepal, aimed at enhancing safety around educational institutions.

Session Chair Er. Dhakal emphasized the importance of integrating data, technology, and community awareness to improve road safety outcomes. Session Moderator Er. Dhungel praised

the practical relevance of the studies and thanked all presenters for their thoughtful contributions to the ongoing effort to make Nepal's roads safer.

Parallel Session (4A): Pavement Management

Session Chair: Er. Lal Krishna KC, Past President, SOTEN
Session Moderator: Er. Ghanshyam Gautam, Transport & Contract Management Specialist

This session brought together innovative research and practical solutions aimed at improving pavement performance and longevity. Er. Jose Espinos opened the session by presenting a novel accelerated settlement system designed to eliminate bumps and the need for approach slabs near bridges and culverts, offering a practical approach to a long-standing infrastructure issue.

Focusing on user experience, Er. Prakriti Pandey shared findings from a study evaluating road surface conditions in relation to the safety and comfort of scooter riders—an often-overlooked group in pavement design. Er. Aanchal Tiwari presented research on geotextile and geogrid reinforcement under dynamic vehicle loads, highlighting its potential in enhancing pavement durability, especially in high-traffic areas.

The session concluded with a presentation from Er. Krishna Singh Basnet along with the team at the Institute of Engineering, Pulchowk Campus, on predictive modeling for pavement deterioration using artificial neural networks and multiple linear regression. The approach showed promise in supporting data-driven maintenance planning.

Session Chair Er. KC commended the presenters for addressing both practical challenges and forward-looking solutions in pavement management. Moderator Er. Gautam noted the session's strong emphasis on innovation and evidence-based practices, encouraging further research and implementation in the field.

Parallel Session (1B): Research and Innovation

Session Chair: Dr. Surya Raj Acharya, Infrastructure Specialist Session Moderator: Er. Vibek Gupta, Chairman, SSTN

This session highlighted a range of research initiatives and innovative approaches focused on sustainability, safety, and performance improvement in transportation and construction. Er. Aakanshya Ghimire opened with a presentation on the use of multi-layered plastic waste in road construction, examining its technical, economic, and environmental implications. Er. Maheshwari Dhami followed with a study analyzing the cost of road traffic crashes in Kailali District using the human capital approach.

Er. Divya Shahi shared strategies to enhance pedestrian safety and walkability on urban roads in Kathmandu. Dr. Chhabi Lal Paudel presented a review of arbitration practices in highway projects, offering insights into contract dispute resolutions in Nepal. Er. Amar Kumar Deo discussed the optimization of hydrolysis lignin dosage in asphalt mixtures to improve sustainability and performance. The session concluded with Er. Moti Ram Giri's presentation on applying machine learning techniques to evaluate Marshall's volumetric properties of hot mix asphalt.

Session Chair Dr. Acharya commended the relevance and technical depth of the presentations, emphasizing their value for future infrastructure planning. Moderator Er. Gupta appreciated the diversity of topics and active engagement from participants.

Parallel Session (2B): Civil Aviation Sector

Session Chair: Er. Sugat Ratna Kansakar, Former Managing Director, Nepal Airlines Corporation
Session Moderator: Er. Sambriddhi Shrestha, Deputy Manager, Civil Aviation Authority of Nepal (CAAN)

This session focused on pressing issues and forward -looking strategies in Nepal's civil aviation sector. Dr. Patcharida Sungtrisearn from Chiang Mai University presented a case study on air traffic noise assessment at Chiang Mai International Airport, providing a comparative basis for addressing similar challenges in Nepal. Er. Dipendra Shrestha, Project Director of the Air

Transport Capacity Enhancement Project at CAAN, discussed the ongoing expansion of Tribhuvan International Airport, highlighting the challenges and progress made. Er. Sanjeev Singh Kathayat emphasized the strategic importance of Nijgadh International Airport for Nepal's aviation modernization, economic connectivity, and sustainable development.

Session Chair Er. Kansakar noted the relevance of each presentation in the context of Nepal's growing air transport needs and the importance of forward planning. Moderator Er. Shrestha appreciated the technical depth and strategic insights shared by the speakers.

Parallel Session (3B): Urban Planning and Associated Infrastructure

Session Chair: Dr, Hare Ram Shrestha , President, SOTEN

Session Moderator: Dr. Pradeep K. Shrestha, Assistant Professor, IOE, Pulchowk Campus

This session brought together diverse perspectives on improving urban infrastructure and transport systems in Nepal's growing cities. Er. Shree Ram Dhakal began with an assessment of public transport operations in Kathmandu Valley, identifying gaps in service quality and reliability. Mr. Rubin Singh Maharjan presented a vision for transforming Patan Durbar Square into a pedestrian- and cycle-friendly heritage zone, emphasizing community-led urban design.

Er. Bishnu Prasad Devkota evaluated the suitability of current road infrastructure for bicycles, focusing on Ring Road and the Satdobato-Godawari corridor. Er. Alex Karki shared insights from New South Wales' speed management strategies and their applicability to urban placemaking efforts in Kathmandu. Finally, Er. Binod Bhattarai discussed how investments in road transport infrastructure can enhance accessibility and stimulate job creation, especially in urbanizing regions.

Session Chair Er. Mainali praised the relevance of the presented topics to Nepal's urban development priorities, noting the importance of inclusive and sustainable infrastructure planning. Moderator Dr. Shrestha commended the presenters for their practical insights and encouraged further interdisciplinary collaboration.

Parallel Session (4B): Technology and Innovation in Transport Sector

Session Chair: Dr. Partha Mani Parajuli, Senior Transport Expert
Session Moderator: Er. Binod Bhattarai, Senior Divisional Engineer, Department of Roads

This session showcased emerging technologies and innovative approaches shaping the future of transport in Nepal and beyond. Dr. Robin Workman from the Transport Research Laboratory (TRL), England, shared insights from the TRL Smart Mobility Living Lab, emphasizing the role of real-time data and experimentation in driving smart mobility solutions. Er. Subhash Dhungel presented a case study on network-wide intelligent signal operations implemented in Lalitpur Metropolitan City, highlighting improved traffic flow and coordination.

Er. Ishop Amatya discussed Nepal's first Intelligent Traffic Signal (ITS) system, focusing on implementation challenges, early observations, and the system's potential for scalability. The session concluded with Er. Paribesh Parajuli introducing "Podway" as an alternative urban mobility technology, exploring its feasibility within Nepal's urban context.

Session Chair Dr. Parajuli commended the presenters for their forward -thinking contributions and stressed the importance of adopting and localizing technological innovations. Moderator Er. Bhattarai highlighted the potential of these initiatives to enhance system efficiency and public mobility.

Session on Sustainable Urban Mobility

Session Chair: Prof. Dr. Padma Bahadur Shahi, Chairman, Nepal Engineering Council
Session Moderator: Er. Kuber Nepali, CEO, Federal Capital City Public Transport Authority

This session brought together regional and international perspectives on building sustainable and resilient urban transport systems. Mr. Alvin Mejia opened the session with a presentation on benchmarking urban transport across Asian cities, offering comparative insights into policy effectiveness and system performance. Er. Vijaya Lakshmi Kandala followed with a case study from the Hyderabad Metropolitan Region, highlighting the role of Multi-Modal Integration (MMI) and Transit-Oriented Development (TOD) in creating efficient and sustainable transport networks. Dr. Madan B. Regmi concluded the session with a roadmap for developing a sustainable and resilient public transport system for the Kathmandu Valley, underscoring the role of governance, investment, and planning.

Session Chair Prof. Dr. Shahi appreciated the relevance of the presentations in addressing urban mobility challenges in Nepal. Moderator Er. Nepali highlighted the importance of regional collaboration and policy innovation.

Panel Discussion: Issues and Challenges on Implementation of Federalization in Context of Transport Infrastructure

Session Moderator: Dr. Chandra Bahadur Shrestha, Senior Infrastructure Specialist

This panel discussion brought together key voices from federal, provincial, and local levels to examine the complexities of implementing federalism in Nepal's transport infrastructure sector. Hon'ble Dr. Ganga Dutta Nepal highlighted the need for clarity in jurisdictional roles and improved coordination among the three tiers of government. Hon'ble Dr. Shila Mishra shared experiences from Madhesh Province, emphasizing the challenges of capacity and resource allocation at the provincial level.

Mr. Bhim Prasad Dhungana, President of the Municipal Association of Nepal, stressed the importance of empowering municipalities with technical expertise and funding to execute infrastructure projects effectively. Ms. Laxmi Devi Pandey, representing rural municipalities, pointed out the structural and administrative gaps hindering infrastructure development in remote areas. Er. Mahesh Chandra Neupane spoke about the role of the Department of Local Infrastructure Development in supporting local bodies, while Er. Bhimarjun Pandey discussed policy and implementation challenges from the perspective of Lumbini Province.

The panel generated an engaging discussion on governance gaps, overlapping mandates, and the need for a unified strategic vision. Moderator Dr. Shrestha summarized the key takeaways, calling for stronger intergovernmental mechanisms, streamlined funding channels, and institutional capacity building. The session concluded with a Q&A, token of love distribution, and a group photograph.

Session on Asset Management

Session Chair: Er. Rajendra Raj Sharma, Immediate Past President, SOTEN
Session Moderator: Ms. Chetana Thapa, Director, Roads Board Nepal

This session explored innovative frameworks and global perspectives on asset management systems to ensure long-term sustainability and efficiency of road infrastructure. Prof. Dr. Kazuya AOKI opened the session by sharing case studies that demonstrated the potential for applying strategic road asset management approaches in the Nepalese context. Prof. Dr. Tanuj Chopra presented a comprehensive roadmap for developing a sustainable Road Asset Management System (RAMS) for national highway networks.

Dr. Kazuya Tomiyama introduced a human-centered approach to pavement management, emphasizing safety, comfort, and user experience. Er. Manish Man Shakya discussed Nepal's efforts to optimize national highway pavement management through life cycle cost minimization, presenting both challenges and data-driven strategies.

Expanding the scope of the session, Ms. Farida Haddou Rahou from Morocco presented an integrated analysis of road traffic accidents, combining epidemiological and legal perspectives to better understand road user behavior and risk factors.

Session Chair Er. Sharma acknowledged the value of these diverse insights and underscored the importance of adopting data-informed and people-focused asset management practices. Moderator Ms. Thapa thanked the speakers for their contributions and encouraged collaborative implementation of the discussed strategies.

Way Forward Discussion

Session Moderator: Er. Kamal Pande, Senior Infrastructure Specialist

This concluding session brought together high-level representatives from key government departments and professional organizations to reflect on insights from the conference and chart the way forward for Nepal's transport and infrastructure development. Er. Ram Hari Pokharel, Director General of the Department of Roads, emphasized the need for integrated planning and investment in resilient road networks. Er. Ajay Mul, Director General of the Department of Railways, highlighted the importance of diversifying transport modes and accelerating progress in railway infrastructure.

Er. Machakaji Maharjan, Director General of the Department of Urban Development and Building Construction, stressed the role of coordinated urban planning in achieving sustainable transport outcomes. Er. Thakur P. Sharma, President of the Society of Consulting Architectural and Engineering Firms, called for strengthening the role of the consulting sector through capacity building and clear policy frameworks. Mr. Bishnu Bhai Shrestha from the Federation of Contractor Associations of Nepal (FCAN) advocated for timely payments, transparent project execution, and stronger partnerships between the government and private sector.

Moderator Er. Kamal Pande facilitated a focused and constructive exchange among the panelists. The session concluded with a Q&A segment, where participants shared perspectives and raised practical implementation concerns. Final remarks were delivered by the session chair, followed by token of love distribution and a group photograph, marking the closing of the discussion with a collective commitment to progress.

Closing Ceremony

The Closing Ceremony of the 3rd International Conference on Integrated Transport for Sustainable Mobility commenced with a warm invitation extended by Dr. Hare Ram Shrestha, President of the Society of Transport Engineers Nepal (SOTEN), who served as the Chair of the session. He welcomed the dignitaries to the dais, including Chief Guest Hon'ble Prof. Dr. Shiva Raj Adhikari, Vice Chairman of the National Planning Commission; Special Guest Hon'ble Aman Maskey, Ministry of Physical Infrastructure and Development, Bagmati Province; Er. Keshab Kumar Sharma, Secretary, Ministry of Physical Infrastructure and Transport (MoPIT); Prof. Dr. Padma Bahadur Shahi, Chairperson of NEC; Er. Sushil Gyawali, CEO of the Investment Board Nepal; and Mr. Alvin Mejia, Co-Team Lead, Asian Transport Observatory (ATO), as the Guest of Honor.

The ceremony began with an overview of the three-day conference presented by **Er. Hemant Tiwari**, General Secretary of SOTEN and the Conference Convener. He expressed sincere appreciation to all participants, organizing partners, and supporting institutions. Er. Tiwari emphasized that the conference was the culmination of over nine months of dedicated preparation and coordination with national and international institutions. He recognized the instrumental collaboration with MoPIT, Ministry of Urban Development (MoUD), local governments, and international organizations such as EASTS, iRAP, International Road Federation, and ATO.

Reflecting on the event's scope and impact, he proudly shared that the conference had drawn around 350 participants from 13 countries, featured 15 technical sessions, including the opening and closing events, and hosted 23 international presentations. In total, over 52 speakers and panelists contributed, spanning key areas of sustainable mobility, infrastructure resilience, safety, planning, and innovation.

Er. Tiwari elaborated on the thematic flow of the conference: the first day focused on learning from global experts; the second day spotlighted national challenges and research contributions through multiple parallel sessions; and the final day brought together both international and local voices to reflect on actionable strategies and multi-level governance. He concluded by stressing the importance of ensuring that the conference resolutions are not only recorded but also integrated into policy and practice with the help of MoPIT and MoUD.

Following this, **Er. Kamal Pande**, Chair of the Resolution Committee, presented the conference resolution, a document capturing key recommendations that emerged from discussions over the three days. These recommendations aim to guide future actions toward building a safe, sustainable, efficient, and resilient transport system in Nepal, while aligning with global best practices and national priorities.

Mr. Greg Smith, Acting CEO and Global Programme Director of iRAP, delivered his remarks virtually. He appreciated the quality and vision of the conference, noting the importance of using globally-tested tools and methodologies to assess and improve road safety. He acknowledged SOTEN's efforts to advance the cause of sustainable and inclusive mobility and expressed enthusiasm for continued collaboration with Nepal in this domain.

A significant milestone in the ceremony was the signing of the **Memorandum of Understanding** (MoU) between the Asian Transport Observatory (ATO) and SOTEN, represented by Mr. Alvin Mejia and Dr. Hare Ram Shrestha. The MoU signifies a strategic partnership aimed at knowledge sharing, capacity building, and collaborative research in transport and mobility.

Mr. Alvin Mejia, Guest of Honor and Co-Team Lead of ATO, in his speech, reflected on the richness of insights shared during the conference. He highlighted the critical role of partnerships and collaboration in addressing regional transport challenges and emphasized the importance of the MoU as a step toward more impactful cooperation. He thanked SOTEN, MoPIT, MoUD, and all supporting institutions for hosting a highly engaging and impactful event.

Delivering his remarks, **Er. Sushil Gyawali**, CEO of the Investment Board Nepal, emphasized the comprehensive nature of the conference resolutions, which integrate multiple aspects of transport planning—from safety and sustainability to inclusivity and governance. He welcomed the practical, solution-oriented outcomes of the discussions and acknowledged the importance of aligning efforts across federal, provincial, and local governments. He reaffirmed the Investment Board's commitment to working closely with the private sector to promote sustainable transport infrastructure development in Nepal.

Er. Keshab Kumar Sharma, Secretary of MoPIT, extended his congratulations to all participants for a successful and thought-provoking conference. Although unable to attend every session due to official commitments, he recognized the depth and diversity of the ideas presented over the three days. He acknowledged the valuable role of such conferences in shaping policy and implementation strategies, and assured continued support from MoPIT to integrate the resolutions into the government's transport agenda. He also took a moment to extend warm New Year wishes (2082 BS) to all participants, especially the international delegates.

Representing the Bagmati Province, **Hon'ble Aman Maskey**, Special Guest, praised the conference's focus on innovation and resilience. She emphasized the importance of low -carbon mobility, AI- and IoT-driven transport solutions, and disaster-resilient infrastructure. She pointed out potential areas for transformative transport in the province, such as mass transit development, ropeway system upgrades, and the use of river corridors for alternative transport.

Hon'ble Maskey expressed optimism that the conclusions from the conference would directly benefit transport planning and policy in Bagmati Province.

In his keynote closing address, Chief Guest **Hon'ble Prof. Dr. Shiva Raj Adhikari**, Vice Chairman of the National Planning Commission, applauded the conference for fostering rich dialogue and forward-thinking ideas. He framed transport not just as a sectoral concern but as a national and social issue—one that is intrinsically linked to climate change, energy use, urbanization, and economic development. He shared the National Planning Commission's move toward a systems-based approach, focusing on inter-sectoral integration rather than siloed planning. Dr. Adhikari emphasized the need for inclusive, climate-resilient, and smart transport systems, and encouraged continued collaboration between stakeholders to implement the insights gained during the conference. He thanked SOTEN, the organizing committees, and every contributor for making the event meaningful and impactful.

The vote of thanks was delivered by **Er. Anga Lal Rokaya**, Vice President of SOTEN, who acknowledged the collective efforts of organizing committee members, speakers, technical partners, sponsors, and volunteers. He offered heartfelt gratitude to the government agencies, professional societies, academic institutions, and the many international participants who made time to contribute. He underscored the importance of building on this momentum for future knowledge-sharing platforms and reiterated SOTEN's commitment to continuing its work in advancing the transport sector of Nepal.

Finally, **Dr. Hare Ram Shrestha**, President of SOTEN, delivered the closing remarks, formally concluding the three-day conference. He expressed his satisfaction with the high level of participation, quality of presentations, and strength of collaborations formed. He reaffirmed SOTEN's vision to serve as a platform for dialogue, policy influence, and professional development in transport engineering and extended his best wishes to all participants for a safe journey home-and a Happy Nepali New Year 2082.

Conference Resolutions:

As the 3rd International Transport Conference, themed "Towards Safe, Sustainable, Efficient, and Resilient Mobility," nears its conclusion, I, on behalf of the Resolution Committee, present the following resolutions for adoption:

1. Recognizing the transport sector as a key driver of Nepal's economic growth, contributing to trade facilitation, job creation, rural-urban integration, regional connectivity, infrastructure development, and enhanced supply chain efficiency.

2. Acknowledging the urgent need for strategic reforms to develop an inclusive, safe, sustainable, and climate-resilient transport system that keeps pace with technological advancements and addresses the mobility needs of growing urban and rural populations.

3. Emphasizing that urbanization's growing economic impact necessitates a coordinated approach to transport and land-use planning, investment in public transit, promotion of non-motorized and shared mobility, smart traffic management, and the adoption of innovative solutions to improve service efficiency and reduce environmental impacts. Enhancing connectivity between urban and rural areas to stimulate business, agriculture, and tourism is equally challenging.

4. Affirming the need for data-driven, evidence-based planning in transport infrastructure development, particularly in Nepal's hilly regions, incorporating local knowledge, addressing climate risks, and engaging communities to ensure safety, inclusivity, and sustainability.

5. Recommending that future transport planning and investment strategies align with Nepal's diverse geographic and socio-economic contexts. Comprehensive impact assessments should be institutionalized to ensure infrastructure projects promote balanced regional development, environmental conservation, and social equity.

6. Urging the integration of climate risk assessments into road infrastructure planning, embracing a modern asset management approach to operating the road network, which accounts for climate resilience and road safety, and delivers a level of service supporting the sector's growth potential.

7. Noting the significant body of research on pavement performance, slope stabilization, road safety, geotechnical design, design standards, and guidance, and calling for clear institutional pathways to apply these findings in policy development, project planning, and implementation.

8. Leveraging the potential of new technologies and innovations to maximize the cost-effective assessment of road condition, safety, resilience, and provide a robust data set upon which to plan, monitor, and operate the road network.

9. Implementing a digitized geo referenced road crash data collection system and road safety guidelines for enforcing the existing safety regulations, with adequate budgetary provision on enhancing capacity and creating awareness. Private sector participation in financing road safety activities could further be explored.

10. Coordinating network-level planning among federal, provincial, and local authorities significantly enhances the transport system, improves safety and asset preservation, combats disasters, and fosters cooperation in maintaining vehicular mobility during road failures.

11. Transforming the road environment in Nepal towards a safer experience for pedestrians, drivers, passengers, and those living within the road corridor, by aiming for ambitious goals to save lives and

make journeys in Nepal safer.

These resolutions aim to guide the Government of Nepal in shaping transport policies, infrastructure development, and institutional reforms aligned with national development goals and global sustainability commitments.

We emphasize that the proposed actions substantially reform the country's transport agenda, making road transport safe, reliable, affordable, resilient, and sustainable.

Full Papers

The Following papers have been selected for publication in the special edition of Journal on Transport System and Engineering (JoTSE) Volume 1.

1. Assessment of Air Traffic Noise level: A Case Study of Chiang Mai International Airport
2. Artificial Neural Networks and Multiple Linear Regression in Pavement Deterioration Forecasting
3. Enhancing at Crosswalks and Sidewalks: A Case Study of Kathmandu Metropolitan City
4. Evaluating Geogrid-Reinforced Pavements with Field-Validated Soil Models under Vehicle Load Dynamics
5. Exploring The Effectiveness of Safety Interventions For Reducing Road Crash Occurrence in Different Road Environments
6. Nepal's National Highway Pavement Optimal Management Through Life Cycle Cost Minimization
7. Rainfall Threshold for Roadside Shallow Landslide in Mid-Himalayan Region of Nepal
8. Review of Arbitration Practices in Construction Projects: A Case Study of Highway Projects in Nepal
9. Road Cut Slope Stability Assessment under Region-Specific Rainfall Scenarios in Middle Hills of Nepal
10. Road Traffic Crash Cost Human Capital Approach: A Case Study of Kailali District
11. Transit-Oriented Development Indicators for Suburban Railway Stations in Thailand: A Context-Specific Fuzzy Delphi Approach
12. The Push-Pull Effects of Expressways: The Case of TPLEX for Baguio City, Philippines

Evaluation of Transit-Oriented Development Indicators Using the Fuzzy Delphi Method: A Case Study of Suburban Railway Stations in Thailand

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Abstract

This study aims to identify suitable indicators for Transit-Oriented Development (TOD) in suburban areas of Thailand by applying the Fuzzy Delphi Method to gather expert opinions. The research examined 48 indicators across three main components: transit system indicators, connectivity indicators, and development indicators, compiled through a comprehensive review of the literature related to Transit-Oriented Development (TOD). The study presents a systematic framework for screening suitable indicators through a structured expert consultation process. The findings reveal that 44 indicators met the acceptance criteria, with train service frequency (0.950), pedestrian walkway width (0.940), and mixed land use (0.940) emerging as the most significant indicators. Conversely, four indicators failed to meet the acceptance threshold: number of retail outlets in stations (0.710), pedestrian pathway gradient (0.670), high-rise building areas (0.670), and government service centers (0.677), highlighting the distinct developmental contexts between suburban and urban core areas. These findings can be effectively applied to evaluate and plan TOD initiatives in Thailand's sub urban transit station areas.

Keywords: Transit-Oriented Development Indicators; Transit-Oriented Development; Fuzzy Delphi Method; Suburban; Railway Station

1. Introduction

Transit-oriented development (TOD) has emerged as a crucial concept in urban planning and the development of public transportation systems, emphasizing the creation of dense communities, mixed land -use patterns, and pedestrian- friendly environments (Ibraeva, A., et al., 2012; Vale, 2015). This approach has gained widespread recognition as a key strategy for reducing private vehicle dependency and promoting sustainable mobility (Loo, B. P. Y., & du Verle, F., 2016). However, while most TOD studies and applications focus on urban core areas, suburban regions with their distinct characteristics and challenges have received relatively little attention (Pengjun, Z., & Shengxiao, L., 2018).

Thailand is currently experiencing rapid urbanization and suburban expansion, particularly in peripheral metropolitan areas. This growth presents significant challenges in transportation planning and land -use management, characterized by low population density, high private vehicle dependency, and land -use patterns that differ substantially from those in urban cores (Kamruzzaman et al., 2014; Singh et al., 2014). Research by Bolleter, J., & Ramalho, C.E. (2020) indicates that implementing Transit-Oriented Development (TOD) in suburban areas is more complex than in urban cores, requiring consideration of distinct accessibility factors and diverse transit connectivity needs.

The absence of appropriate indicators hinders urban planners' and policymakers' ability to accurately evaluate Transit - Oriented Development (TOD) projects in suburban contexts, potentially leading to suboptimal development strategies (Schlossberg, M., et al., 2004). Developing suitable indicators for suburban TOD assessment is crucial, as indicators designed for urban cores may not fully capture the specific context and challenges of suburban areas.

To address these challenges, this study applies the Fuzzy Delphi Method, which has proven effective in urban planning and transportation research (Abdullah, R., et al., 2024). This approach combines expert knowledge with fuzzy logic to manage uncertainty and subjectivity in expert opinions. The study examines three critical components: transit systems, accessibility and connectivity, and spatial development, providing a comprehensive framework for evaluating TOD potential in suburban contexts.

2. Research Methodology

This study applies the Fuzzy Delphi Method through a seven-step research process: (1) Delineation of the study area along Thailand's regional railway network, encompassing four main corridors; (2) Compilation of Transit -Oriented Development (TOD) indicators; (3) Collection of expert opinions; (4) Conversion of linguistic variables into triangular fuzzy numbers; (5) Aggregation of fuzzy evaluations; (6) Defuzzification to convert fuzzy values back to crisp numbers using arithmetic mean method; and (7) Assessment of expert consensus and finalization of indicators.

21 *Step 1: Study Area Delineation*

This research focuses on evaluating Transit-Oriented Development (TOD) indicators for suburban railway stations along Thailand's regional railway network, using a comprehensive assessment framework that prioritizes stations based on transportation significance (high-speed rail, light rail, provincial stations), economic positioning (special economic zones), appropriate land use within 500-meters (favoring urban zones over environmental conservation areas), and population density thresholds, while excluding standalone bus terminals due to their limited TOD potential, which comprises four main corridors:

1) Northern Line: From BanPhachi Junction to Chiang Mai Station (661 kilometers, 29 stations), passing through maor cities including Lopburi, Nakhon Sawan, Phitsanulok, and Lampang. This corridor serves a s avital economic and tourism link between the Central and Northern regions.

2) Northeastern Line: From Ban Phachi Junction to Nong Khai Station (531 kilometers, 20 stations), passing through Saraburi, Nakhon Ratchasima, Khon Kaen, a nd Udon Thani, connecting to the Thai-Lao Friendship Bridge. A branch line extends from Thanon Chira Junction to Ubon Ra tcha tha ni Station , covering 309 kilometers a nd serving five stations, including Buriram, Surin, and SiSa Ket.

3) Eastern Line: From Chachoengsao Junction to Aranyaprathet Station (194 kilometers, five stations), passing through Prachinburi and Sa Kaeo, facilitating international transport a t the Klong Luek border crossingin Aranyaprathet District. A branch line extends from Chachoengsao Junction to Ban Chang Station (125 kilometers, eight stations), serving the provinces of Chonburi and Rayong.

4) Southern & Western Line: From Ban Pong to Ha t Yai Junction (860 kilometers, 25 stations), passing through Phetchaburi, Prachuap Khiri Khan, Chumphon, and Surat Thani, serving a s the leading freight and tourism corridor between the Central and Southern regions.

The entire network, comprising these four corridors (a total of 92 stations and 2,680 kilometers), currently operates on single-track, meter-gauge (1.0 meter) infrastructure. The network is undergoing modernization with double-tracking projects and automated signaling system upgrades.

22 *Step 2: Indicator Data Collection*

A comprehensive literature review of suburban Transit-Oriented Development (TOD) within the framework of sustainable development identified 48 TOD indicators from 14 relevant studies, with their frequencies documented in Table 1. The researchers developed an evaluation framework categorizing these indicators into three primary components: Transit System Indicators (TS), comprising 16 indicators (Table 2) covering service operations (e.g., service frequency, multimodal transit connectivity), infrastructure facilities (e.g., park-and-ride capacity, transit interchange facilities), and station amenities; Oriented System Indicators (OS), consisting of 15 indicators (Table 3) focusing on pedestrian infrastructure, access environment, and non-motorized transport; and Development System Indicators (DS), including 17 indicators (Table 4) addressing land use and development, community facilities and services, and infrastructure and environmental aspects. Each indicator was carefully selected to align with the specific context of suburban TOD implementation and includes explicit measurement methodologies for practical assessment. The framework encompasses essential elements of transit system operation, connectivity, and spatial development, providing a comprehensive tool for evaluating suburban Transit-Oriented Development (TOD) initiatives that reflect the unique characteristics and requirements of peripheral urban areas.

Table 1. Literature Review of Transit-Oriented Development (TOD) Indicators

No.	TOD Indicators	Ivan, I., et al. (2012)	Chatman, D. G. (2013)	Kamruzzaman, M., et al. (2014)	Singh, Y.J., et al. (2014)	Vale, D.S. (2015)	Lyu, G., et al. (2016)	Li, Z., et al. (2019)	Ahmad, M. S. (2020)	Ahmad, S., et al. (2022)	Chen, X., et al. (2024)	Dow, Kyle (2024)	Gao, W., et al. (2024)	Yang, W., et al. (2024)	Xia, Z., et al. (2024)	Frequency

No.	TOD Indicators	Ivan, I., et al. (2012)	Chatman, D. G. (2013)	Kamruzzaman, M., et al. (2014)	Singh, Y.J., et al. (2014)	Vale, D.S. (2015)	Lyu, G., et al. (2016)	Li, Z., et al. (2019)	Ahmad, M. S. (2020)	Ahmad, S., et al. (2022)	Chen, X., et al. (2024)	Dow, Kyle (2024)	Gao, W., et al. (2024)	Yang, W., et al. (2024)	Xia, Z., et al. (2024)	Frequency
1	Train service frequency	•	•	•	•	•	•	•	•	•	•	•		•	•	13
2	Mixed land use	•	•	•	•	•	•	•	•	•	•	•		•	•	13
3	Cycling network			•	•	•	•	•	•	•		•	•	•	•	11
4	Residential density	•		•	•	•	•	•	•	•	•			•	•	11
5	Bicycle parking	•			•	•	•		•	•	•	•	•	•	•	11
6	Transit connection points			•	•		•	•	•	•	•	•	•	•	•	11
7	Connecting transit services	•			•	•	•	•	•	•	•			•	•	10
8	Park & Ride facilities	•	•	•	•	•	•	•				•			•	9
9	Pedestrian walkway width			•	•		•	•		•		•	•	•	•	9
10	Public green space			•		•	•		•	•		•		•	•	8
11	Vehicle/motorcycle parking	•			•	•	•		•				•		•	7
12	Walking Distance to key points		•		•			•			•	•	•		•	7
13	Local employment	•		•		•			•		•			•	•	7
14	Recreational areas		•		•					•	•	•			•	6
15	Multimodal transport integration				•	•	•	•	•			•				6
16	Continuous walkways			•	•					•		•	•		•	6
17	Land value	•		•	•		•	•			•					6
18	Street crossings			•	•							•	•		•	5
19	Universal design implementation			•	•		•	•					•			5
20	Shared pedestrian-cycling paths				•		•	•							•	4
21	Vacant land development	•			•							•			•	4
22	Educational facilities				•						•	•			•	4
23	Route safety			•			•	•								3
24	Kiss & Ride Areas	•					•	•								3
25	Walking surface quality							•		•				•		3
26	Covered walkways							•				•	•			3
27	Route lighting			•			•	•								3
28	Commercial distribution											•			•	2
29	High-rise building areas											•			•	2
30	Community centers		•									•				2
31	Rest points along routes		•									•				2
32	Community market areas											•			•	2
41	Directional signage		•												•	2
44	Station signage and symbols		•												•	2
33	Healthcare facilities											•				1
34	Religious facilities											•				1
35	Service information system		•													1
36	Service hours		•													1
37	Ramps and elevators		•													1
38	Information service points		•													1
39	Basic amenities		•													1
40	Station retail outlets		•													1
42	Security systems		•													1
43	Walkway gradient		•													1

No.	TOD Indicators	Ivan, I., et al. (2012)	Chatman, D. G. (2013)	Kamruzzaman, M., et al. (2014)	Singh, Y.J., et al. (2014)	Vale, D.S. (2015)	Lyu, G., et al. (2016)	Li, Z., et al. (2019)	Ahmad, M. S. (2020)	Ahmad, S., et al. (2022)	Chen, X., et al. (2024)	Dow, Kyle (2024)	Gao, W., et al. (2024)	Yang, W., et al. (2024)	Xia, Z., et al. (2024)	Frequency
45	Basic infrastructure		•													1
46	Ticketing system		•													1
47	Government service centers											•				1
48	Environmental management														•	1

Table 2. Transit System Indicators (TS)

Code	Indicator	Description	Measurement Method
1.1 Service Operations (TSO)			
TSO1	Train service frequency	Peak/off-peak service frequency	Count of daily services
TSO2	Connecting transit services	Number and frequency of connecting bus routes	Count routes and frequencies
TSO3	Multimodal transport integration	Number of connected transport modes	Count transport connections
TSO4	Ticketing system	Ticket counters and automated ticket machines	Count service points
TSO5	Service information system	Real-time information displays and announcement systems	Evaluate system effectiveness
TSO6	Service hours	Daily service duration and flexibility	Analyze timetable
1.2 Infrastructure Facilities (TSF)			
TSF1	Park & Ride facilities	Parking area with amenities	Measure area and capacity
TSF2	Kiss & Ride Areas	Temporary parking for passenger drop-off	Measure parking area
TSF3	Vehicle/motorcycle parking	Number of covered parking spaces	Count parking slots
TSF4	Transit connection points	Transit interchange areas and facilities	Assess quality
TSF5	Information service points	Information counters and travel information boards	Evaluate service provision
1.3 Station Amenities (TSA)			
TSA1	Basic amenities	Restrooms, waiting areas, etc.	Count/assess quality.
TSA2	Station retail outlets	Basic retail and service shops	Measure usage area
TSA3	Station signage and symbols	Wayfinding system and symbols	Assess completeness
TSA4	Ramps and elevators	Ramps, elevators, and accessibility features	Check standards compliance
TSA5	Security systems	CCTV and emergency help points	Assess coverage

Table 3. Oriented System Indicators (OS)

Code	Indicator	Description	Measurement Method
2.1 Pedestrian Infrastructure (OSP)			
OSP1	Pedestrian walkway width	Main walkway width connecting to station	Measure effective width
OSP2	Covered walkways	Length of covered pedestrian paths	Measure covered Distance
OSP3	Street crossings	Number of signalized crossings and zebra crossings	Count crossing points
OSP4	Continuous walkways	Walkway connectivity to key points	Assess connectivity
OSP5	Walking surface quality	Surface condition and maintenance	Assess quality
OSP6	Universal design implementation	Accessibility features along routes	Check standards compliance
OSP7	Walkway gradient	Walkway and ramp slopes	Measure gradient angles
2.2 Access Environment (OSE)			
OSE1	Route lighting	Light pole spacing and illumination levels	Measure spacing and brightness
OSE2	Rest points along routes	Covered rest areas with seating	Count rest points
OSE3	Directional signage	Wayfinding signs from community to station	Assess coverage
OSE4	Route safety	Lighting, CCTV, emergency help points	Assess coverage
23 Non-Motorized Transport (OSN)			
OSN1	Cycling network	Community-connected cycling routes	Measure route length

Code	Indicator	Description	Measurement Method
OSN2	Bicycle parking	Bicycle parking facilities at key points	Count parking points
OSN3	Shared pedestrian-cycling paths	Combined pedestrian-cycling routes	Measure length and quality
OSN4	Walking Distance to key points	Walking Distance to community and key locations	Measure actual Distance

Table 4. Development System Indicators (DS)

Code	Indicator	Description	Measurement Method
3.1 Land Use and Development (DSL)			
DSL1	Mixed land use	Proportion of different land uses	GIS analysis
DSL2	Residential density	Number of households per area	Survey and analysis
DSL3	Commercial distribution	Distribution of retail and services	Count and distribution analysis
DSL4	High-rise building areas	Proportion and distribution of high-rise buildings	GIS analysis
DSL5	Vacant land development	Rate of vacant land development	Assess development changes
DSL6	Land value	Land price changes in the area	Analyze price trends
DSL7	Local employment	Workforce and employment rate in the area	Count area workforce
3.2 Community Facilities and Services (DSC)			
DSC1	Educational facilities	Distribution and accessibility of educational institutions	Count and measure Distance
DSC2	Healthcare facilities	Distribution and accessibility of healthcare facilities	Count and measure Distance
DSC3	Religious facilities	Number and accessibility of religious places	Count and measure Distance
DSC4	Recreational areas	Parks and activity areas	Measure area and usage
DSC5	Community centers	Location and size of community activity centers	Measure area and usage
DSC6	Government service centers	Distribution of government facilities	Survey service provision
DSC7	Community market areas	Fresh markets and periodic markets	Count and measure area
3.3 Infrastructure and Environment (DSE)			
DSE1	Public green space	Ratio of green space to total area	GIS analysis
DSE2	Basic infrastructure	Coverage of electricity, water, and communications	Assess coverage
DSE3	Environmental management	Efficiency of Waste Management and Air and Noise Pollution Control Systems	Evaluate system

2.3 Step 3: Expert Data Collection

The data collection was conducted through a systematic expert consultation process. A panel of 10 experts participated in evaluating and providing recommendations on the proposed indicators. A 7 -point Likert scale questionnaire was used, ranging from "Extremely Important" to "Extremely Unimportant." Each expert assessed the significance level of individual indicators while providing qualitative feedback for improving definitions and measurement criteria. The collected data was analyzed to determine expert consensus using statistical methods combined with fuzzy logic to handle ambiguity in expert opinions, as shown in Table 5.

Table 5. Triangular fuzzy numbers for seven-point scale

Level	Linguistic expressions	Fuzzy number
7	Extremely Important	(0.9, 1, 1)
6	Very Important	(0.75, 0.9, 1)
5	Important	(0.5, 0.75, 0.9)
4	Moderately Important	(0.3, 0.5, 0.75)
3	Unimportant	(0.1, 0.3, 0.5)
2	Very Unimportant	(0, 0.1, 0.3)
1	Extremely Unimportant	(0, 0, 0.1)

Source: Habibi, A., et al. (2015)

2.4 Step 4: Conversion of Variables into Fuzzy Numbers

The conversion of linguistic variables into triangular fuzzy numbers in this study followed the methodology proposed by Habibi et al.. (2015). The conversion format was specified as (l, m, u), where l represents the lower bound, m

represents the most probable value, and u Represents the upper bound. The application of fuzzy measurement scales with odd-numbered levels bears similarities to Likert scales but offers greater flexibility in handling ambiguity in opinion expression. The data accuracy varies proportionally with the increasing number of measurement scale levels. The relationship between the membership function and opinion levels is illustrated in Figure 1.

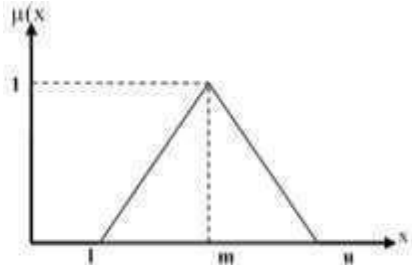

Figure 1. Triangular fuzzy number

2.5 *Step 5: Aggregation of Fuzzy Evaluation Values*

The processing of fuzzy evaluation values was conducted through matrix analysis. Matrix A was defined to consist of elements A_1 to A_m, where each element A_1 is calculated from the product of the evaluation value (r_i) and its corresponding weight (w_i), as shown in Equation 1. This method enables the aggregation of evaluation values while considering both the importance level of each criterion and the uncertainty in expert decision -making (Abdullah & Othman, 2023). This approach is particularly suitable for evaluating Transit-Oriented Development (TOD) indicators, which involve complex and multidimensional characteristics.

$$A = \begin{bmatrix} \tilde{A}_1 \\ \tilde{A}_2 \\ \vdots \\ \tilde{A}_i \\ \vdots \\ \tilde{A}_m \end{bmatrix}, \quad \tilde{A}_i = \tilde{r}_{i1} \otimes \tilde{w}_1 \oplus \tilde{r}_{i2} \otimes \tilde{w}_2 \oplus \cdots \oplus \tilde{r}_{in} \otimes \tilde{w}_n, \quad i = 1,\ldots,m \tag{1}$$

2.6 *Step 6: Defuzzification*

The conversion of fuzzy values back to crisp values and the indicator summarization were performed through a defuzzification process using the arithmetic mean method, following the approach of Wu and Fang (2011). Equation 2 was used to calculate the crisp value from the average of the lower bound (l), most probable value (m), and upper bound (u) of the triangular fuzzy numbers. The resulting values were then used to prioritize indicators, with a selection criterion set at a crisp value of 0.75 or higher, to obtain an appropriate set of indicators for evaluating TOD in suburban areas.

$$\text{if } \tilde{F} = (l, m, u) \text{ Then } F = \frac{l + m + u}{3} \tag{2}$$

2.7 *Step 7: Expert Consensus Analysis and Indicator Finalization*

The analysis of expert opinion consistency using the Fuzzy Delphi Method employed a consensus acceptance criterion of at least 75% agreement, following the approaches of Murray and Hammons (1995) and Chu and Hwang (2008). The analysis was conducted at both structural and individual indicator levels. This consensus evaluation was performed after converting linguistic variables into fuzzy numbers and aggregating the assessment values. The results were then sent back to the experts for verification, and the process was iterated until consensus was achieved. This iterative process ensured the selection of appropriate indicators for application in Transit-Oriented Development around suburban railway stations.

3. Analysis Results

The compilation of expert opinions on TOD indicators involved converting linguistic variables into triangular fuzzy numbers through importance levelassessments from 10 experts. Each expert's opinion was transformed into fuzzy values in the form of (l , m , u), representing the minimum, acceptable, and maximum values, respectively. This conversion was based on a 7-point rating scale, ranging from "Extremely Important" [(0.9, 1.0, 1.0)] to "Extremely Unimportant" [(0.0, 0.0, 0.1)]. This methodology was employed to analyze and evaluate the significance of TOD indicators for suburban railway stations in Thailand, a s shown in Table 6.

Table 6. Conversion of linguistic variables for criteria importance levels

Code	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
TSO1	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)
TSO2	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
TSO3	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
TSO4	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
TSO5	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)
TSO6	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
TSF1	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
TSF2	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
TSF3	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
TSF4	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
TSF5	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
TSA1	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)
TSA2**	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)
	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
TSA3*	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.9,1.0,1.0)
TSA4	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)
TSA5	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)
OSP1	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)
OSP2*	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)
	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)
OSP3	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
OSP4	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
OSP5	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
OSP6	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)
OSP7**	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)
	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)
OSE1	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
OSE2	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
OSE3	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
OSE4	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
OSN1	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)
OSN2	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)
OSN3	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)
OSN4	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
DSL1	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)
DSL2	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
DSL3	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)

Code	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
DSL4**	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)
	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)
DSL5	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
DSL6	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)
DSL7	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
DSC1	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)
DSC2	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
DSC3	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
DSC4	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)
DSC5	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
DSC6**	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)
	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.5,0.75,0.9)	(0.3,0.5,0.75)	(0.3,0.5,0.75)	(0.5,0.75,0.9)	(0.75,0.9,1.0)
DSC7	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)
DSE1	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.9,1.0,1.0)	(0.75,0.9,1.0)
DSE2	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)
DSE3	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)	(0.5,0.75,0.9)	(0.75,0.9,1.0)	(0.75,0.9,1.0)

Note: *, ** Indicators requiring two rounds of evaluation

The expert consensus evaluation using the Fuzzy Delphi Method for screening Transit -Oriented Development (TOD) indicators for suburban railway stations revealed that high-priority indicators (crisp value ≥ 0.75) include operational indicators such as train service frequency (TSO1: 0.950), multimodal transport connectivity (TSO3: 0.893), and Park & Ride facilities (TSF1: 0.910), as well as pedestrian walkway width (OSP1: 0.940) and mixed land use development (DSL1: 0.940). However, certain indicators specific to suburban areas, such as the number of retail outlets in stations (TSA2: 0.710), pedestrian pathway gradient (OSP7: 0.670), high-rise building areas (DSL4: 0.670), and government service centers (DSC6: 0.677), did not meet the acceptance criteria. This reflects the distinct requirements and contextual differences in TOD implementation between suburban and inner-city areas, as shown in Table 7.

Table 7. Results of Expert Consensus Evaluation

Code	Opinion's mean	Crisp value	Result	Code	Opinion's mean	Crisp value	Result	Code	Opinion's mean	Crisp value	Result
TSO1	(0.87,0.98,1.00)	0.950	Accepted	OSP1	(0.85,0.97,1.00)	0.940	Accepted	DSL1	(0.85,0.97,1.00)	0.940	Accepted
TSO2	(0.80,0.93,1.00)	0.910	Accepted	OSP2*	(0.50,0.75,0.90)	0.717	Rejected	DSL2	(0.78,0.91,1.00)	0.897	Accepted
TSO3	(0.77,0.91,1.00)	0.893	Accepted		(0.60,0.82,0.94)	0.787	Accepted	DSL3	(0.70,0.87,0.98)	0.850	Accepted
TSO4	(0.68,0.86,0.97)	0.837	Accepted	OSP3	(0.70,0.87,0.98)	0.850	Accepted	DSL4**	(0.42,0.65,0.83)	0.633	Rejected
TSO5	(0.68,0.86,0.97)	0.837	Accepted	OSP4	(0.65,0.84,0.96)	0.817	Accepted		(0.46,0.69,0.86)	0.670	Rejected
TSO6	(0.65,0.84,0.96)	0.817	Accepted	OSP5	(0.78,0.91,1.00)	0.897	Accepted	DSL5	(0.68,0.86,0.97)	0.837	Accepted
TSF1	(0.80,0.93,1.00)	0.910	Accepted	OSP6	(0.65,0.84,0.96)	0.817	Accepted	DSL6	(0.65,0.84,0.96)	0.817	Accepted
TSF2	(0.70,0.87,0.98)	0.850	Accepted	OSP7**	(0.42,0.65,0.83)	0.633	Rejected	DSL7	(0.80,0.93,1.00)	0.908	Accepted
TSF3	(0.65,0.84,0.96)	0.817	Accepted		(0.46,0.69,0.86)	0.670	Rejected	DSC1	(0.78,0.91,1.00)	0.897	Accepted
TSF4	(0.68,0.86,0.97)	0.837	Accepted	OSE1	(0.70,0.87,0.98)	0.850	Accepted	DSC2	(0.70,0.87,0.98)	0.850	Accepted
TSF5	(0.65,0.84,0.96)	0.817	Accepted	OSE2	(0.65,0.84,0.96)	0.817	Accepted	DSC3	(0.65,0.84,0.96)	0.817	Accepted
TSA1	(0.65,0.84,0.96)	0.817	Accepted	OSE3	(0.68,0.86,0.97)	0.837	Accepted	DSC4	(0.68,0.86,0.97)	0.837	Accepted
TSA2**	(0.42,0.65,0.83)	0.633	Rejected	OSE4	(0.65,0.84,0.96)	0.817	Accepted	DSC5	(0.65,0.84,0.96)	0.817	Accepted
	(0.51,0.73,0.89)	0.710	Rejected	OSN1	(0.80,0.93,1.00)	0.910	Accepted	DSC6**	(0.40,0.63,0.82)	0.617	Rejected
TSA3*	(0.53,0.75,0.90)	0.727	Rejected	OSN2	(0.78,0.91,1.00)	0.897	Accepted		(0.47,0.69,0.87)	0.677	Rejected
	(0.72,0.89,0.98)	0.863	Accepted	OSN3	(0.65,0.84,0.96)	0.817	Accepted	DSC7	(0.80,0.93,1.00)	0.910	Accepted
TSA4	(0.78,0.91,1.00)	0.897	Accepted	OSN4	(0.68,0.86,0.97)	0.837	Accepted	DSE1	(0.78,0.91,1.00)	0.897	Accepted
TSA5	(0.80,0.93,1.00)	0.910	Accepted					DSE2	(0.65,0.84,0.96)	0.817	Accepted
								DSE3	(0.68,0.86,0.97)	0.837	Accepted

Note: Result, Accepted if Crisp value ≥ 0.75, Rejected if Crisp value < 0.75

* Indicators not meeting criteria in the first round

** Indicators not meeting criteria in both first and second rounds

"Number of retail outlets in stations"
In suburban areas, passengers primarily use stations as transit points rather than spending extended time within The station, thus, reduces the necessity for numerous retail establishments.

"Station signage and symbols"
Suburban stations tend to be smaller and less complex, requiring less sophisticated wayfinding systems.

"Rest points along routes"
In suburban areas, destinations are typically far apart, and people prefer private vehicles or shuttle services .
Over long-distance walking.

"Pedestrian walkway gradient"
Most suburban areas are on level terrain, making slope considerations less critical than in urban areas.

"High-rise building areas"
Suburban areas should maintain moderate density and building heights appropriate to their context,
Without emphasizing high-rise development as in urban zones.

"Government service centers"
Due to lower population density in suburban areas, a high concentration of government service centers is not essential.

The indicator analysis, conducted using the Fuzzy Delphi Method, was completed in two rounds. In the first round, 42 indicators met the acceptance criteria, while six indicators did not meet the threshold. These comprised indicators from Transit System Indicators (TSO: 6, TSF: 5, TSA: 3), Oriented System Indicators (OSP: 5, OSE: 4, OSN: 4), and Development System Indicators (DSL: 6, DSC: 6, DSE: 3). After review and re-eva luation in the second round, the number of accepted indicators increased to 44, with notable improvements in station amenities (TSA) and pedestrian infrastructure (OSP) categories. However, four indicators still failed to meet the criteria, most of which were explicitly context-dependent for suburban areas, as shown in Table 8.

Table 8. Summary of Consensus-Based Accepted Indicators

Round	Result	Transit System Indicators (TS)			Oriented System Indicators (OS)			Development System Indicators (DS)			Total
		TSO	TSF	TSA	OSP	OSE	OSN	DSL	DSC	DSE	
1	Accepted	6	5	3	5	4	4	6	6	3	42
	Rejected			(2)	(2)			(1)	(1)		(6)
2	Accepted	6	5	4	6	4	4	6	6	3	44
	Rejected			(1)	(1)			(1)	(1)		(4)

4. Conclusions

The application of the Fuzzy Delphi Method to collect opinions from ten experts for evaluating the importance of 48 indicators across three main components-transit system indicators, connectivity indicators, and development indicators-yielded significant findings. In the first round of assessment, 42 indicators met the acceptance criteria (crisp value ≥ 0.75), while six indicators did not meet the threshold. After review and re-eva luation in the second round, the number of accepted indicators increased to 44, with only four indicators failing to meet the criteria. The highest -ranking indicators were train service frequency (TSO1: 0.950), pedestrian walkway width (OSP1: 0.940), and mixed land use (DSL1: 0.940), demonstrating that fundamental factors in transit service provision, station accessibility, and land use remain crucial components for TOD in suburban areas. Conversely, indicators that did not meet the acceptance criteria included the number of retail outlets in stations (TSA2: 0.710), pedestrian pathway gradient (OSP7: 0.670), high -rise building areas (DSL4: 0.670), and government service centers (DSC6: 0.677), reflecting the distinct developmental contexts between suburban and urban core areas, particularly in terms of commercial facility requirements, physical infrastructure characteristics, real estate development patterns, and government service distribution.

The findings suggest that TOD in suburban areas should prioritize the development of efficient transit systems, particularly in terms of service frequency and multimodal public transportation connectivity, as well as infrastructure provision that facilitates pedestrian and bicycle access to stations. Additionally, land use planning should be aligned with suburban contexts, rather than emphasizing commercial development or high density. The set of indicators derived from this study can serve as a tool for assessing potential and establishing development guidelines for Transit -Oriented Development around suburban transit stations in Thailand, promoting sustainable mass transit system development.

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How Safe are School Area from road Safety Perspective: A Study of School at Butwal, Nepal

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Society of Transport Engineers Nepal

Abstract

This study employs the international Star Rating for Schools (SR4S) methodology to diagnose road safety conditions in a school zone and identify targeted interventions for improvement. Applied at Kalika Manavgyan Higher Secondary School, the tool generated a baseline pedestrian safety rating of 2.9 stars—just below the United Nations' minimum 3-star standard. This near-threshold rating presents a clear opportunity for achieving the recommended benchmark through specific countermeasures. The analysis identifies three critical areas for intervention: reducing vehicle operating speeds, supervising and formalizing pedestrian crossings, and improving sidewalk infrastructure. The discussion, therefore, focuses on evidence-based measures—such as targeted traffic calming, installation of supervised crosswalks, and sidewalk enhancements—that can directly bridge the 0.1-star gap to a 3-star rating. The findings provide an actionable framework for deploying cost-effective upgrades to foster safer school zones across school zones in Nepal.

Keywords: *Road Safety, School Zone, Star Rating for Schools (SR4S), Pedestrian Safety, Safety improvement*

1. Introduction

The Road Safety is a critical concern for the whole world with approximately 1.19 million fatalities from road crashes on the year 2021 alone. For the age group of people 5 -29 years, road crashes is the number one cause of fatality (WHO, 2023). It means that children and young people are at a greater risk of road deaths. In specific areas where children spend their time, such as schools, there is a need for significant measures to be implemented concerning their safety on roads.

In Nepal, road safety around schools remains a largely neglected issue. With little to no concerns on road safety around school areas, the vulnerability for school going children further exacerbates. Star rating for school is an award-winning analytical tool for measuring, managing, and communicating the risks children are exposed to on a journey to school (SR4S, n.d.). The rating ranges from 1 to 5 where 1 star indicates the lowest road safety scenario and 5 star represents the safest. The assessment considers factors such as vehicle speeds, pedestrian infrastructure, road design, and traffic flow to generate a comprehensive safety rating. United Nations has clarified that the school areas should have at least 3 rating to be considered safe (3-sta r or better roads for all, n.d.). Many schools in Nepal, however, do not fit this standard with reference to school zones safety. This presents a severe threat to a child's life. Measurement of condition using SR4S can inform about the road safety conditions to enable policymakers, urban planners, and community leaders to undertake informed actions toward improving safety standards.

2. Literature Review

Targeted safety interventions are desperately needed, especially in school zones, given the growing global crisis of road traffic fatalities, especially among children and adolescents. Every day, approximately 500 children are killed in traffic accidents, which are the world's leading cause of death for people aged 5 to 29 (WHO, 2023). Road traffic fatalities rose by 155% in Nepal between 2008 and 2022, a stark reflection of this trend (WHO, 2023). Children are disproportionately impacted by the alarming concentration of crashes in the Kathmandu Valley, according to the data (Hemant Tiwari, 2024). As a result, evidence-based methods for evaluating and enhancing pedestrian infrastructure have become more important.

Internationally, SR4S applications have demonstrated significant success. In Iran, assessments at seven schools led to targeted treatments, improving ratings from 1 star to up to 4 stars (Ali Zayerzadeha, 2019). Similarly, large-scale studies in the Philippines utilized the SR4S system demonstrator to virtually test interventions and plan upgrades (Sahid Kamid, 2021).

An increasing amount of research has used the SR4S methodology in the Nepalese context, exposing structural flaws in the infrastructure of school zones. The lack of basic road safety features like sidewalks, official pedestrian crossings, speed control measures, and sufficient signage is the main reason why initial evaluations

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consistently produce low ratings, frequently between 1 and 2 stars (Sanjay Luitel, 2023). Cost-effective interventions, such as the installation of zebra crossings, speed limit (30 km/h) signs, and crossing supervisors, could significantly improve safety outcomes, according to a crucial pilot study conducted across eight schools in Kathmandu. Following implementation, operating speeds decreased by 20–40% while star ratings rose to 3, 4, and even 5 stars (Hemant Tiwari, 2024). Even when risk factors decline, the literature also identifies instances in which interventions result in only modest improvements in star ratings. According to a study conducted at Shree Sahid Jung Prakash Shah Sanskrit Secondary School in Nuwakot, more extensive physical interventions (such as speed-calming infrastructure) are required to reach a 5-star benchmark, even though implemented signage and markings decreased the risk factor (Asmita Pokhrel, 2025). This demonstrates that although awareness and signage are fundamental, engineered traffic calming techniques are necessary to meet the highest safety standards.

3. **About School**

Located in the bustling urban center of Butwal, Rupandehi District, Kalika Manavgyan Higher Secondary School (coordinates: 27°40'53" N, 83°27'58" E) is a major public institution serving approximately 5,605 students. Situated in a key transportation hub in the major highway, the area experiences significant mixed traffic and high vehicle speeds, yet lacks essential pedestrian safety infrastructure such as crossings and sidewalks, the bride located is the only way to cross. This high enrollment makes the safety of its school zone a critical public concern. Situated in a key transportation hub near major highways, the area experiences significant mixed traffic and high vehicle speeds, yet lacks essential pedestrian safety infrastructure such as formal crossings, speed calming measures, and adequate sidewalks. The convergence of heavy pedestrian flow and risky road conditions presents a clear and urgent case for applying the Star Rating for Schools (SR4S) methodology to assess risks and plan effective, low-cost interventions.

Figure 1

Figure 2

4. Methodology

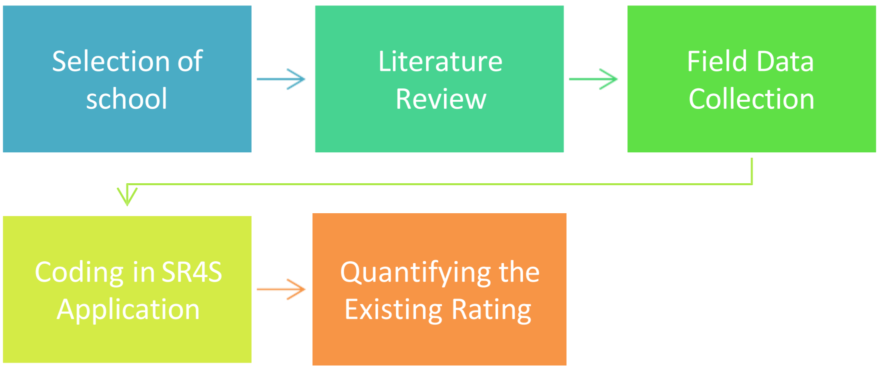

Figure 3. Methodological Framework

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Schools participating in the student awareness training were assessed using the SR4S web application. During field visits, all necessary data —including 39 infrastructure and operational parameters such as road features, signage, markings, and traffic volume—were collected according to the SR4S checklist. Traffic volume figures were fed directly into the application, and a radar gun was used to record operating speed. The collected data was then coded into the SR4S platform to generate safety ratings. It is important to note that the SR4S rating system has recently been updated: while the previous version produced whole-number ratings from 1 (highest risk) to 5 (safest), the new system now uses a decimal scale, making it comparatively harder to achieve higher ratings [4]. This revision, however, ensures a more rigorous and safety-oriented assessment of school zones. The new rating system has updated the rating system to be represented in decimal and it's harder to achieve comparatively higher ratings (iRAP, 2023). This however ensures further safety of the school.

5. Data Coding on SR4S

The field data collected for Kalika Manavgyan Higher Secondary School—encompassing 39 specific parameters such as road geometry, signage, sidewalk conditions, and traffic characteristics—was systematically coded into the SR4S web application. This involved entering the observed traffic volume and the operating speed recorded using a radar gun into the relevant sections of the digital platform. The application's interface guided the input of all checklist items, which were then processed by its underlying algorithm to generate the school's baseline star rating. This digital coding phase translated on-site observations into a standardized, evidence-based safety metric, establishing a clear benchmark for the existing pedestrian risk level at the school zone.

The data used for coding SR4S is summarized as

Land Use Left	Commercial
Land Use Right	School
rea Type	Urban
Vehicle Parking	One side
Sight Distance	Adequate
No of Lane	3 each way
Lane Width	wide
Shoulder Rumble	not present
Road Condition	Good
Grip	Good
Grade	0-7.5%

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Carriage Way Type	divided A (north/east)
Middle of the Road	Separate 1 to 5m
Lines and Signs	adequate
Street Lighting	present
School Warning	no school zone
Crossing Supervisor	no supervisor
Sidewalk Left	0-1, away
Sidewalk Right	no side walk
Road Edge Left	0-1 m wide
Road Edge Right	0-1 m wide
Pedestrian Channelization	not present
Crossing Main Road	bridge/tunnel
Crossing Side Road	none
Crossing Quality	adequate
Vehicle/Day	24000
Crossing Flow	present
Left Side Flow	present
Right Side Flow	not present
Motor Cycle Percent	60-80%
Heavy Vehicle Percent	5-10%
Intersection Type	no intersection
Drive Ways	greater than 2 residential
Intersection Side Flow	not applicable
Intersection Quality	not applicable
Curve Type	straight
Curve Quality	not curve
Speed Limit	50
Speed Limit Unit	kmph
Operating Speed	60
Speed Management	not present

6. Results and Discussion

All collected parameters were coded into the SR4S web application, yielding a star rating of **2.9** for Kalika Manavgyan Higher Secondary School. Certain safety features, such as a pedestrian crossing bridge with ramp access, are present in front of the school, this indicates the presence of measures are the reason the school has almost gained a star rating of 3 which is safe according to UN benchmark. Key interventions—including **controlling operating speed**, enhancing and **extending sidewalks**, and implementing **pedestrian channelization**— substantially elevate safety levels. Introducing these targeted measures would address existing vulnerabilities and help achieve a 3-star or higher safety benchmark, ensuring a safer commute for the school's large student population. The table below discusses effect of such interventions on the Star Rating of the school

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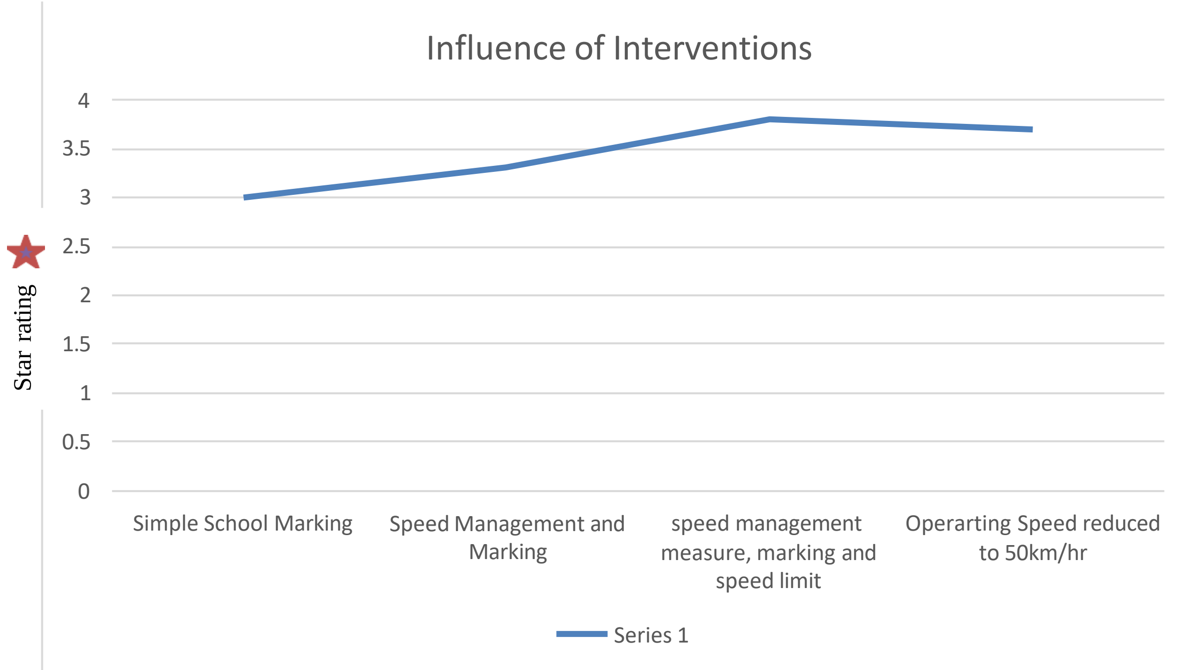

7. Conclusion:

This assessment of Kalika Manavgyan Higher Secondary School using the SR4S methodology yielded a 2.9-star pedestrian safety rating. While the highest among schools studied, this score remains below the 3 -star UN benchmark, indicating significant saffety gaps despite existing features like a pedestrian bridge. Key measures such as controlling vehicle speeds, improving sidewalks, and introducing pedestrian channelization are essential to achieve a safer rating. This case demonstrates the value of evidence-based assessment in guiding targeted interventions for protecting students in high -risk urban school zones.

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Sustainable Transportation Through Multi-Modal Integration (MMI) and Transit-Oriented Development (TOD) In Hyderabad Metropolitan Area

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Abstract

The Hyderabad Metropolitan Area (HMA), one of India's fastest-growing cities, faces challenges of congestion, air pollution and mobility constraints despite an extensive public transport network, including metro rail, buses and the MMTS. The lack of integration, poor first- and last-mile connectivity, and safety concerns hamper its effectiveness. To address these, Multi-Modal Integration (MMI) and Transit-Oriented Development (TOD) pilot project has been proposed in a selected metro study area. The MMI framework aims to integrate transit networks, improve infrastructure and enhance institutional coordination. Key interventions include public bike-sharing, better bus stop locations, uninterrupted pedestrian walkways and urban design improvements to create a transit-friendly environment. TOD principles promote walkable, mixed-use developments around transit hubs to reduce vehicle dependence and improve quality of life.

Leveraging smart mobility solutions, such as electric vehicles (EVs) integrated into public transport, further reduces emissions and supports green mobility. These strategies can be scaled across HMA to enhance regional transport planning and reduce congestion, air pollution and improve urban safety. Additionally, Traffic Impact Assessment (TIA) for the Miyapur corridor, including metro ridership estimation and trip generation, shows potential impacts like employment creation, increased ridership and projected revenue. Success relies on institutional coordination, stakeholder collaboration, and public engagement through awareness campaigns and capacity-building. Economic benefits such as reduced healthcare costs and productivity gains will be key to securing policy and public support for sustainable urban mobility.

Keywords: Multi-Modal Integration (MMI), Transit-Oriented Development (TOD), Sustainable Transportation, Electric Vehicles (EVs), Smart Mobility

1 Introduction

India's urban population is growing rapidly due to migration for employment, education and other opportunities. In 2023, the urban population constituted around 36% of the total population and is projected to reach nearly 40% by 2030. To meet this rising travel demand, India's urban transport ecosystem is expanding through diverse mass transit modes tailored to city size, population density and commuting patterns. Seamless, efficient and environmentally friendly transportation solutions are essential to improve quality of life for urban commuters while supporting national climate goals.

This paper reviews national and state policies that promote sustainable urban transport, with a particular focus on Multi-Modal Integration (MMI), Transit-Oriented Development (TOD) and electric mobility. It assesses the current transport scenario in the Hyderabad Metropolitan Area (HMA), analyses MMI and TOD case studies at key metro stations to identify infrastructure, safety and institutional gaps and develops recommendations to strengthen sustainable mobility planning. The primary objective is to evaluate the effectiveness of MMI and TOD strategies in addressing Hyderabad's mobility challenges and to propose implementable solutions that can serve as a model for other Indian cities.

2 Research Objective

- Review of existing framework / policy in India with respect to Sustainable urban transport.
- Review of Hyderabad transport scenario and the challenges
- Recommendations for Sustainable Urban Transport

3 Methodology

This study adopts a case study–based qualitative and quantitative research methodology to evaluate sustainable mobility strategies for the Hyderabad Metropolitan Area (HMA). The methodological approach is structured in three stages:

i. Review and Data Collection

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Secondary Data: Reviewed key national and state transport policies including the National Urban Transport Policy (NUTP), Transit-Oriented Development (TOD) Policy, National Electric Mobility Mission Plan (NEMMP), Smart City Mission, and Metro Rail Policy to understand sustainable mobility frameworks. Analyzed the Comprehensive Transportation Study (CTS-2041), L&T Hyderabad Metro Rail Limited (LTHMRL) ridership data, TOD plans, and other relevant literature.

- **Primary Data:** Assessed existing transport conditions in HMA with focus on MMI, TOD, NMT, and EV initiatives. Conducted field surveys at Ameerpet Metro Station (for MMI assessment) and Miyapur Metro Depot (for TOD assessment). Observations covered pedestrian movement, bus stop locations, infrastructure quality, parking facilities, and encroachment mapping within a 500 m influence zone.

ii. **Data Analysis**

- **Qualitative & Quantitative Assessment:** Identified challenges with regards to infrastructure, safety, MMI and institutional gaps. Reconnaissance surveys were conducted within the 500 m influence zone to compare existing conditions with ideal capacities as per IRC guidelines. Particular attention was given to pedestrian safety and the integration of metro services with buses at Ameerpet Junction, including the need for seamless ticketing across modes.

- **Impact & Capacity Analysis:** Traffic Impact Assessment (TIA) was conducted for the Miyapur corridor, including estimation of metro ridership and additional trip generation. The potential impacts of TOD-based interventions such as employment creation, increased ridership, and projected revenue were assessed using secondary research and available data.

iii. **Recommendation Development**

- Comprehensive planning measures were proposed to enhance sustainable mobility in India, focusing on mobility plans, ticketing integration, green initiatives and supporting policy interventions. These strategies aim to strengthen Multi-Modal Integration (MMI), Transit-Oriented Development (TOD), Non-Motorized Transport (NMT) and Electric Vehicle (EV) adoption across urban transport systems.

4 Policy framework in India.

The Government of India (GOI) has notified several policies aimed at promoting sustainable urban transportation:

4.1 National Urban Transport Policy (NUTP)

(Ministry of Urban Development, 2006)

The NUTP promotes sustainable, safe, and environment-friendly transport through strategies like Multi-Modal Integration (MMI) and Transit-Oriented Development (TOD), enhancing access to jobs, education, and essential services. Key focus areas include integrating land use with transport for better accessibility, prioritizing public transport and non - motorized modes, ensuring equitable road space use, encouraging clean technologies like electric mobility and renewables, and enforcing emission norms to control pollution.

4.2 The Other Related Policies

The other related policies given below support and reinforce NUTP goals in achieving sustainable mobility

- National Transit-Oriented Development (TOD) Policy
- Smart City Mission
- Metro Rail Policy
- National Electric Mobility Mission Plan (NEMMP)

5 Overview of Mass Transit Systems in India

(I-Metro, 2022)

Aligned with the National Urban Transport Policy (NUTP) and Metro Rail Policy, the following table presents a summary of the status of Mass Rapid Transit Systems (MRTS) across Indian cities, covering metro rail, suburban rail, Regional Rapid Transit Systems (RRTS), Bus Rapid Transit Systems (BRTS) and monorail networks.

Table 1 Status of diverse mass transit systems in India

Metro Network	• Operational - 1000 km • Under construction -900 km
Suburban Rail Network	• Operational – 2400 km (approximately) • Existing - Chennai, Hyderabad, Kolkata and Mumbai
RRTS	• Corridors length - 349 Km (Phase I – 3 corridors) • Operational – 55 km
BRTS	• Operational – 300 km • Existing – Ahmedabad, Surat, Pune, Bhopal & Indore
Monorail	•First Monorail: Mumbai Monorail (19.5 km) •Phase I – Operational since 2014 •Phase II - Operational since 2019

For all the above MRTS systems there is huge potential to enhance first and last mile connectivity through effective MMI and TOD implementation.

6 Overview of Electric Mobility in India (Ministry of Heavy Industries and Public Enterprises, 2015, 2020; Telangana State Government, 2020)

6.1 National Goals for Electric Mobility

India's nationalgoals for electric mobility aim to promote sustainability and energy security by transforming the transport sector. By 2030, EVs are targeted to be 30% of all new vehicle sales. Initiatives like the PM e-Bus Sewa scheme support the rollout of electric buses in urban areas. India also plans to develop 50+ GWh of battery manufacturing capacity by 2026 under the Production-Linked Incentive (PLI) scheme to boost the domestic EV ecosystem. These efforts are key to reducing emissions and advancing clean mobility nationwide.

6.2 Status of EV Policies in India

In conformity with NEMMP, a s of now, 26 States/ Union Territory (UTs) in India have officially notified and adopted EV policies, while the rest of the States/UT are yet to notify.

6.3 GOI initiatives for Electric Mobility

- FAME-II (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles)
- Production-Linked Incentive (PLI) Schemes
- Battery Swapping Policy
- E- AMRIT Platform (A National digital portal for awareness and engagement on EVs)

7 Hyderabad: A Rapidly Growing Metropolis

(Hyderabad Metro Rail Limited, 2024; Hyderabad Metropolitan Development Authority, 2024)

Hyderabad, the capital of Telangana state located in South India and famously known as the "City of Pearls," has rapidly evolved into a major urban and economic hub, driven by its strong IT, pharmaceutical, research, and entertainment sectors. Spanning 7,257 sq. km, the Hyderabad Metropolitan Area (HMA) now houses around 11 million people (2025), making it India's sixth-largest metropolis. Hyderabad has 69 km of elevated metro network, and it is the one of the largest PPP project, under the Design Built Finance Operate Transfer (DBFOT) basis. It has 3 corridors with an average daily ridership of 4.5 lakhs. The major PT system is provided by Telangana State Road Transport Corporation (TGSRTC) with around 3000 buses in Hyderabad with modal share of 35%. The 123 km MMTS offers most affordable suburban rail services with low ridership due to lack of last and first mile connectivity and accessibility. Despite a diverse public transport system, rising congestion along key corridors underscores the urgent need for enhanced transit infrastructure, smart traffic management, and sustainable mobility solutions.

Figure 1 CTS Proposed Corridors for 2041 in HMA

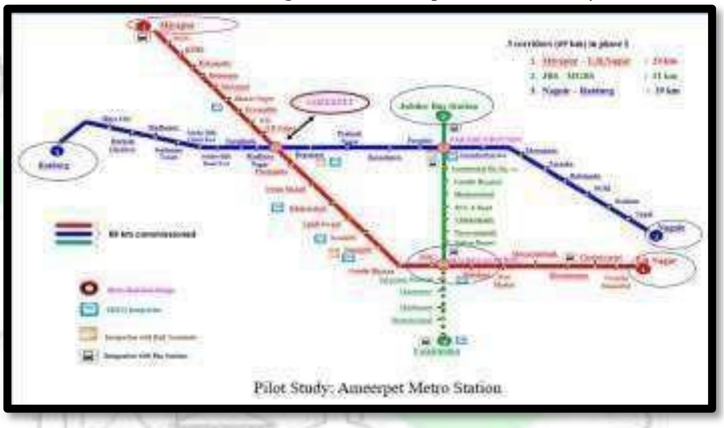


Figure 2 Hyderabad Metro Network Details

The Hyderabad metro system is Integrated with other modes like bus terminals, railway stations, MMTS at given locations as shown in Figure 2. H**owever, there are various metro stations where basic amenities for commuters at ground level are lacking in addition to the first and last mile connectivity. In this context the following section covers a case study of MMI at Ameerpet metro station. which is an interchange of Metro corridor 1 & 3.**

8 <u>Case Study of MMI at Ameerpet Metro Station (Ameerpet Metro Station, 2024)</u>

8.1 Analysis of Existing Conditions at Ameerpet Metro Station

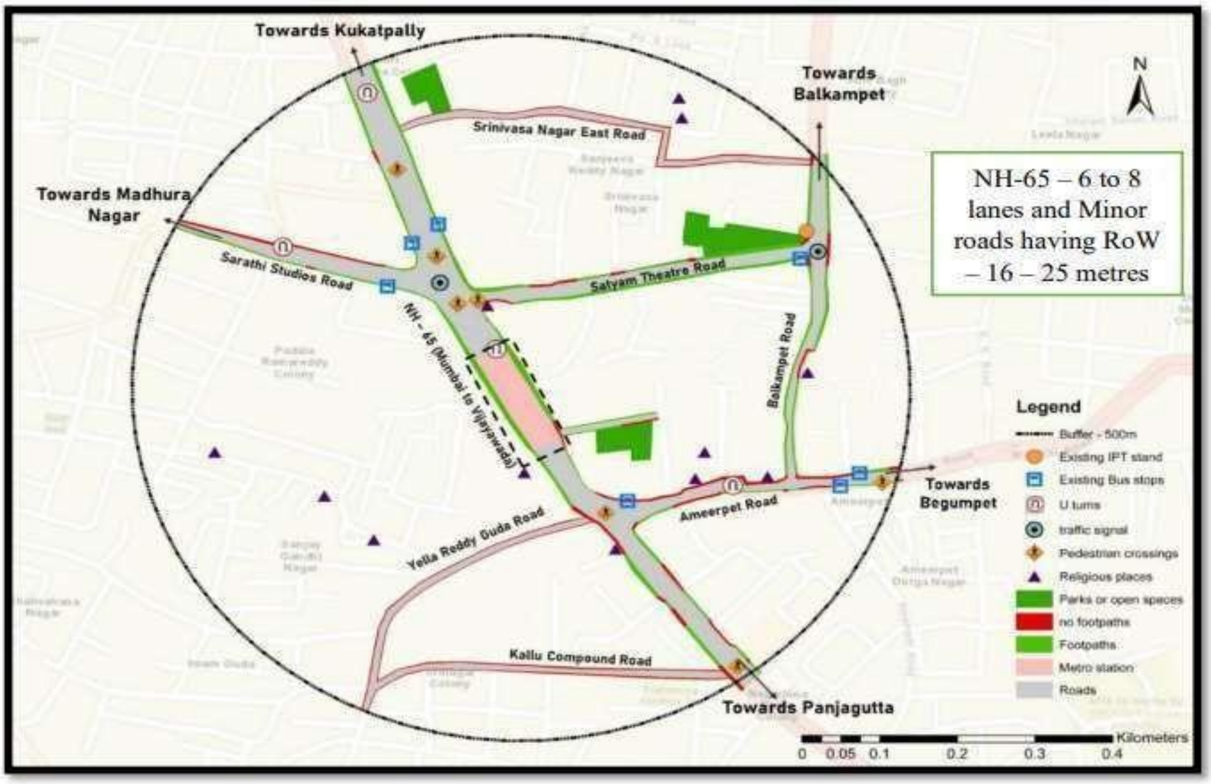
On pilot basis Ameerpet metro station area (0.78 sq.km.) has been considered with an influence area of 500m radius around the interchange station. The station is located on National Highway (NH)-65 (Mumbai–Vijayawada) with Right of Way of 6 lanes towards Punjagutta and 8 lanes towards S.R. Nagar. Land use within the influence area is primarily public-semipublic, institutional, and commercial with street shopping.

While the passenger exchange at elevated levels between Metro Corridors 1 and 3 functions smoothly, at the road or ground level, commuters and pedestrians face several challenges. These include encroachments by vendors, utilities and billboards obstructing pathways, illegal parking, unsafe bus stop locations, unorganized Intermediate Public Transport (IPT) modes and discontinuous footpaths further impact pedestrian safety and convenience. The location of the bus stops was review to provide better integration with metro passengers. The average daily ridership at Ameerpet Metro Station in October 2024 was approximately 10,000 passengers, reflecting significant commuter movement and the need for improved accessibility.

Due to the current physical conditions at road level the capacities of arterial and sub arterial roads in the vicinity has be en impacted thus affecting level of service of pedestrian/commuters and vehicular traffic.

Figure 3 and Map 1 illustrate the existing scenario and identified challenges in the station area

Figure 3 Encroachment on footpath by street vendor, advertisement boards, utilities and Missing footpaths in certain location s



Map 1 Location of Footpaths, Bus stops, Traffic signals, U –turns in the Influence area (500 mts).

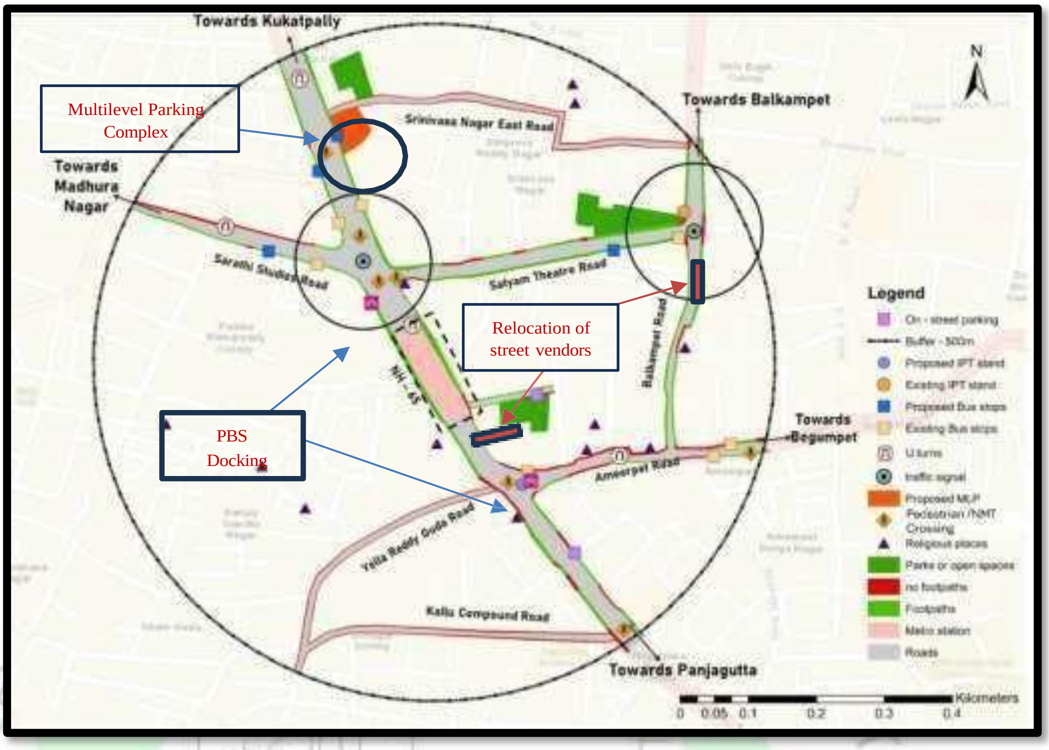
Table 2 Comparison of Existing Right-of-Way (ROW) and Effective width of ROW at Ameerpet Metro Station

Hierarchy of the Roads	ROW (M)	Effective ROW due to Parking/Enchroachment/Hawking	Remarks
Arterial (NH-65)	30 - 45 (6+6 Lanes)	2+2 Lanes	Capacity reduction by 1800 PCU per hr

Sub – Arterial	16 – 25 (2+2 Lanes)	1+1 Lane	Capacity reduction by 1450 PCU perhr

8.2 Proposed Interventions and Improvement Measures at Ameerpet Metro Station

On site inspection some of the potential interventions proposed for Ameerpet station area are continuous footpaths for pedestrian friendly movement, relocation of bus stops at safe locations, designated off street multilevel car parking complex, establishing docking stations for Public Bike Sharing (PBS), IPT stands for pickup and drop of passengers a t safer place for enhancing last mile connectivity , shifting of street vendors to the minor roads within the influence area. In addition to these immediate physical improvement measures, ticketing



Map 2 Shows Immediate Interventions at Ameerpet Metro Stations

integration is proposed through **National Common Mobility Card (NCMC) covering Metro, Bus, IPT, Parking, PBS for retail purposes.** The m a p 2 shows immediate interventions a t Ameerpet to ensure safety a nd seamless connectivity for commuters. Further research may include detailed simulation of vehicular a nd pedestrian movement a nd the impact of suggested interventions**.**

9 Case Study of Transit-Oriented Development (TOD) at Miyapur Metro Depot, Hyderabad (*LTHMRL TOD Team. (2024.).*

Transit-Oriented Development (TOD) promotes high-density, mixed-use developments around transit stations to encourage the use of public transport, reduce car dependency, and create pedestrian-friendly neighborhoods. **Miyapur** metro station is prime location for TOD, given their strategic location within the metro network. Miyapur Metro Station serves a s the terminus for **Corridor-I (Red Line)**, located in the northwestern part of Hyderabad. It is a n area with significant potential for TOD, but the current land use is primarily residential, with limited commercial and recreational developments. Average daily ridership a t Miyapur Metro station is 21000 (Oct 2024).

Hyderabad lacks a formal TOD policy, but some elements like land use, building height, setbacks, open spaces, and parking are guided by government notifications. TOD implementation so far has focused on commercial development including malls, food courts, theatres, gaming zones etc on state -allotted land near metro stations, ensuring direct transit access.

Figure 4 TOD Influence Area at Miyapur Depot

Table 3 Assumptions for TIA of TOD Projects at Miyapur Metro Station (Salini, P. N., & Krishna, A. S. (2019); LTHMRL TOD Team. (2024)

S.No	Description	Miyapur TOD
1.	**Area for TOD**	12,93,732 SQFT
2.	**Built up Area Retail** • Malls- Shopping Complex (70%) • Recreational / Multiplex (30%)	1.20 M SFT
3.	**Built up Area Offices** • IT/ITES/Offices/Financial Institution (60%) • Five Star Hotels (10%) • Educational Institutions (20%) • Conventional Centers (10%)	4.75 M SFT
4.	**Trip Generation Rate**	• For Malls/shopping complex - 6.11 trips sqft/1000/hr • For Multiplex - Total seats- 300; Number of screens- 10; average occupancy- 50% • Offices - 0.83 trips /100 sq f t / hr • Educational Institutions - 6.97 trips / 1000sqft/hr • Conventional Centers - 1.58 trips /1000sqft/hr
5.	**Modal Split for TOD generated Trips**	• By Metro - 50% • By Buses -20% • Four-wheeler - 5% • Two-wheeler -10% • Walking & Cycling – 15%
6.	**Peak hour to daily trips Factor for Conversion**	2

For this paper, the Miyapur depot land near the terminal of Corridor-1 is considered for TOD in consultation with Larsen & Turbo Hyderabad Metro Rail Limited (LTHMRL).

As a terminal node, it offers strong potential for socio-economic growth through improved transit access, walkability, density, mixed-use development and commercial activity.

The challenges of TOD in Hyderabad include lack of TOD policy, absence of Land value capture mechanism, land pooling, and lack of efficient co-ordination amongst various stakeholders.

The area considered for TOD is 29.7 Acres, wherein the built-up area for retail is 1.2 M.SFT (70% is considered for Malls- Shopping Complex and 30 % for Recreational / Multiplex).

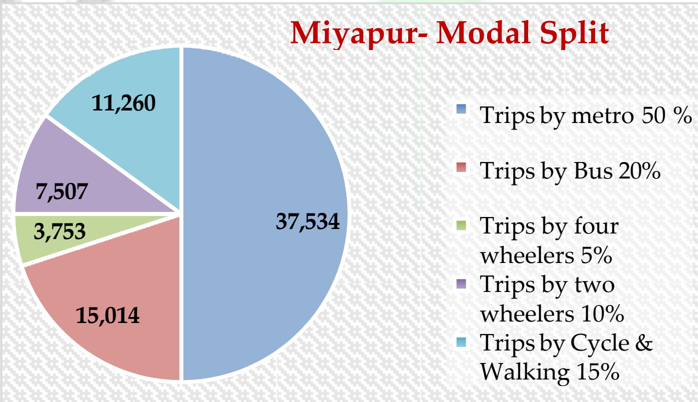


Figure 5 Miyapur Modal Split

Built-up area for offices is around 4.75 M.SFT which includes IT/ITES/Offices/Financial Institution (60%), Five Star Hotels (10%), Educational Institutions (20%), Convention Centers (10%).

In the absence of trip generation rates for different land uses in Hyderabad, the trip generation rates are taken from research paper on another Indian City[16].

9.1 Impact Analysis for Miyapur TOD

- Employment Generation:49,000
- Ridership - 75,000 trips/day
- New rider - 37,000/day
- Fare Box Revenue – INR 500 M./Annum.

- Adds to Govt. income via land value gain capture
- Lowers carbon footprint

10 NMT - India Cycles4Change Challenge (C4C)

Hyderabad took part in Government of India (GoI) C4C initiative, got selected in the top 25 cities under Phase -1(Pilot Project) out of 100 cities participated. It submitted plans for pilot corridors and a scale-up strategy, and implemented a low-cost cycle track along KBR Park and P.V. Narasimha Rao Marg.

10.1 Infrastructure Gaps, Safety Concerns and Absence of NMT Policy

Despite its potential, NMT in India struggles due to inadequate pedestrian and cycling infrastructure, blocked sidewalks, unsafe or missing cycle tracks and poor integration with public transport. Urban planning often prioritizes roads over walkable spaces, with limited institutional support. An online survey of 6,000 respondents highlighted key cycling barriers: fear of accidents from speeding vehicles, lack of dedicated lanes, poor road conditions, traffic congestion, insufficient parking, obstructions, pollution, and poor street lighting all discouraging safe urban cycling.

10.2 21-km Solar-Powered cycle track along Outer Ring Road

To address the above issues, State Government executed a 21 -km Solar-Powered NMT Corridor along the ORR. From Nanakramguda to TSPA Junction. It offers a safe, shaded path for pedestrians and cyclists. Solar panels above the corridor generate electricity while shielding users from sun and rain. This project promotes green mobility and supports the city's climate goals, demonstrating as a replicable urban sustainability model for other Indian cities. **The connectivity to the nearest public transport nodes should be ensured with PBS dock stations.**

Figure 6 Cycle Track at ORR

10.3 State EV Policy: Telangana

Telangana has taken significant steps to promote sustainable mobility through forward -looking policies. The Telangana Electric Vehicle and Energy Storage Policy 2020 –2030 aimsto m ake the state a leading EV manufacturing and adoption hub by offering fiscal and non-fiscalincentives, including road tax and registration fee exemptions, along with support for charging infrastructure and R&D. In November 2024, the state launched its EV policy, extending and 100% tax exemptions for all EVs until December 2026.Key goals include attracting $4 billion in investment, creating 1 .2 lakh jobs, achieving 100% electrification of public transport in Hyderabad by 2030, developing EV parks and charging corridors. Hyderabad is actively moving forward in EV integration across shared mobility, government fleets and logistics.

11 Comprehensive Transportation Strategy for Hyderabad Metropolitan Area (HMA) 2041 (Hyderabad Metropolitan Development Authority, 2013)

The Comprehensive Transportation Study (CTS) for Hyderabad Metropolitan Area (HMA) envisions an integrated, inclusive, and sustainable transport system to support projected population and economic growth by 2041. This strategy aligns infrastructure, policy, and mobility innovations to improve accessibility, reduce congestion, promote green mobility, and foster equitable urban development.

11.1 Sustainable Transport Vision for 2041

- Metro Rail: 258 km across 6 corridors
- MMTS/Suburban Rail: ~90 km, high frequency (10 -min headways)
- Bus Rapid Transit (BRTS): 70+ km
- Intra-City Bus Network: Modernized fleet with >10,000 buses
- NMT Infrastructure: 500+ km dedicated cycle and walkways
- Road Infrastructure: Hierarchical network with signal-free corridors, elevated expressways
- Terminals and Interchanges: 30+ integrated terminals with seamless mode shift

12 Conclusion & Recommendations

Based on the transport scenario analysis in HMA and insights from the Ameerpet MMI and Miyapur TOD case studies, focused recommendations are proposed. Mobility planning should prioritize public transport within city development plans, securing land for depots, stations and rights-of-way while preparing detailed MMI, NMT, parking, TOD and EV infrastructure plans at the DPR stage of each corridor.

At Ameerpet, relocating bus stops to safer locations, creating IPT stands, continuous footpaths, bike -sharing docks, EV charging facility and multilevel parking will resolve existing bottlenecks and improve first - and last-mile connectivity. Ticketing integration through the National Common Mobility Card, real-time passenger information and clear wayfinding maps will able seamless transfers and encourage higher public transport use.

Green mobility must be expanded through citywide NMT initiatives. Hyderabad's cycle track pilots and the 21 -km solar-powered NMT corridor along the ORR provide a model for shaded, safe pedestrian and cycling routes and should be replicated across HMA ensuring the integration with nearest public transport nodes/stations/bus terminals. EV adoption can be accelerated by leveraging Telangana's Electric Vehicle and Energy Storage Policy 2020 –2030, with charging stations at metro stations, bus terminals, and major commercial hubs to support the goal of 100% public transport electrification by 2030.

Finally, improved safety infrastructure, including street lighting, adequate signage system and CCTV surveillance, must be implemented in addition to notifying policies for parking and street vending.

Land value capture to fund infrastructure, Institutional reforms such as establishing a Unified Metropolitan Transport Authority (UMTA), creating Urban Transport Funds, and forming Special purpose vehicles (SPV) for TOD will ensure integrated planning and effective implementation.

The review of HMA's mobility scenario highlights that key challenges - such as encroached pedestrian spaces, unsafe bus stop locations and fragmented connectivity - can be effectively addressed through targeted MMI and TOD strategies. The Ameerpet case study illustrates how interventions like bus stop relocation, creation of safe IPT pick-up zones, and uninterrupted footpaths can dramatically improve accessibility and commuter safety. The Miyapur TOD case study demonstrates the economic and ridership potential of compact, mixed -use development, with the ability to generate approximately 49,000 jobs, attract 37,000 new daily metro riders, and deliver INR 500 million annually in farebox revenue.

Hyderabad's ongoing initiatives, including the solar-powered NMT corridor along the ORR, cycle track pilots and proactive EV policy, reinforce the city's commitment to sustainable mobility. Scaling up these efforts across the metropolitan area, supported by MMI and TOD strategies, will deliver measurable improvements in congestion reduction, air quality, and livability. Together, these measures present a holistic, integrated approach to urban mobility, positioning HMA as a national leader and providing a replicable model for other Indian cities seeking to achieve climate -resilient, commuter-centric transportation systems.

Acknowledgements

The authors here by acknowledge State Government, LTHMRL for relevant information and BARSYL Management for continuous support and motivation.

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EFFECT OF MONSOON RAINFALL ON ROADSIDE SLOPES: A CASE STUDY OF DAKSHINKALI-KULEKHANI ROAD SEGMENT

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Abstract:

Monsoon rainfall severely affects the roadside slope stability in mountainous regions of Nepal causing disruption to highway networks along with deva stating loss of lives and properties every yea r. This study focuses on a 4 km long freshly excavated Da kshinkali-Kulekhani road section to assess and analyze the pre - and post-monsoon characteristics and stability conditions of the road section. A baseline study was conducted across the 4km chainage at the starting point 27.601376N, 85.265494E and concluded at 27.583849N, 85.255289E. Para meters such as geometry of Road section, Orientation along N-S, and pre-existing ECM and Erosion were among the key factors documented in this study. Additional on -site Tests were done post monsoon alongside the baseline study to obtain the soil characteristics. The comparative field observations before and after the monsoon sea son highlighted significant changes in the slope geometry and the occurrence of heavy landslides at several sections along the chainage. The findings suggest increased erosion in the south facing slopes, predomina ntly those of fine-grained soil and soft rocks, with poor drainage conditions. Out of 188 sections studied, 62 sections experienced failure in either uphill, downhill or both sides. The study underscored the need for better slope protection measures in monsoon rainfall-affected regions of Nepal to minimize the detrimental effects on highway networks and public safety.

Keywords:

Monsoon Rainfall, Roadside Slope Stability, Erosion Control Measures (ECMs), landslides

Introduction:

Nepal, being home to a large pa rt of the young and tectonically active Himalayan Range, has rugged topography, unstable geological structures, and soft, fragile rocks. This along with heavy and concentrated rainfalls during monsoon periods subsequently ca use severe landslides lea ding to tremendous loss of life and property. Studies suggest that the economic losses in Nepal due to landslide-related problems account for 30% of the total economic loss due to landslide-related problems in the whole world [Li, 1990].

As per National Disaster Risk Reduction and Management Authority (NDRRMA), this yea r alone (a s per October 3rd 2024), a t least 236 human casualties ha d occurred in monsoon rainfall-induced disasters (floods and landslides), with 19 still missing and 165 injured. According to a preliminary report from Department of Roads (DoR), the combined damage to roads and bridges ha d resulted in a total loss of NPR 2.52 billion. Of this NPR 1.50 billion is attributed to road da mage, while the damage to bridges amounts to NPR 1.02 billion. The floods and landslides ha d damaged 44 bridges and transportation ha d been halted at 24 road sections of 10 major highways. This is the loss in the transporta tion sector alone, if we account for other sectors like irrigation, hydropower, agriculture, telecommunications, etc. a t least NPR 13.4 billion loss was incurred, in addition to the thousands of affected households.

Thus, studying the impact of monsoon rainfallon roadside slope stability is of utmost importance for countries like Nepal, especially with climate change’s effects worsening yearly. This paper emphasizes on studying the effect of monsoon rainfall on various slope parameters, assessing the pre- and post-monsoon characteristics of the study a rea and anlyzing the slope stability for better insight to improve design of robust and climate-resilient slope protection measures.

A 4 km long freshly excavated Dakshinkali-Kulekhaniroad section in Bagmati Province was selected as the study area and pre- and post-monsoon field assessments were conducted to compare the changes brought about by the monsoon rainfall. The study area had faced multiple landslides along the 4 km long section, causing serious damage to the road, adjacent households, agricultural fields, slope protection structures, etc. Lab analyses were conducted on the soil samples collected from various sections along the 4 km long profile.

Fig. 1. Study area - Dakshinkali-Kulekhani Road Section

Methodology:

To understand and analyze the effects of monsoon rainfallon roadside slope stability, a baseline study was conducted in June. During this assessment, data relating to slope geometry, soil type, rock type, land use, vegetation cover, coordinate of chainages etc., was collected using GPS devices, survey equipment, and visual assessments. In October, the post-monsoon assessment was carried out using the same methodology, and the data from pre- and post- monsoon periods were compared. Additionally, soil samples were collected from several locations, mostly from areas with heavy landslides, and analyzed for soil classification. The photograph of road sections before and after the monsoon were compared. Rainfall data for the study area during the monsoon period was obtained from the nearest meteorological station.

Results and Discussion:

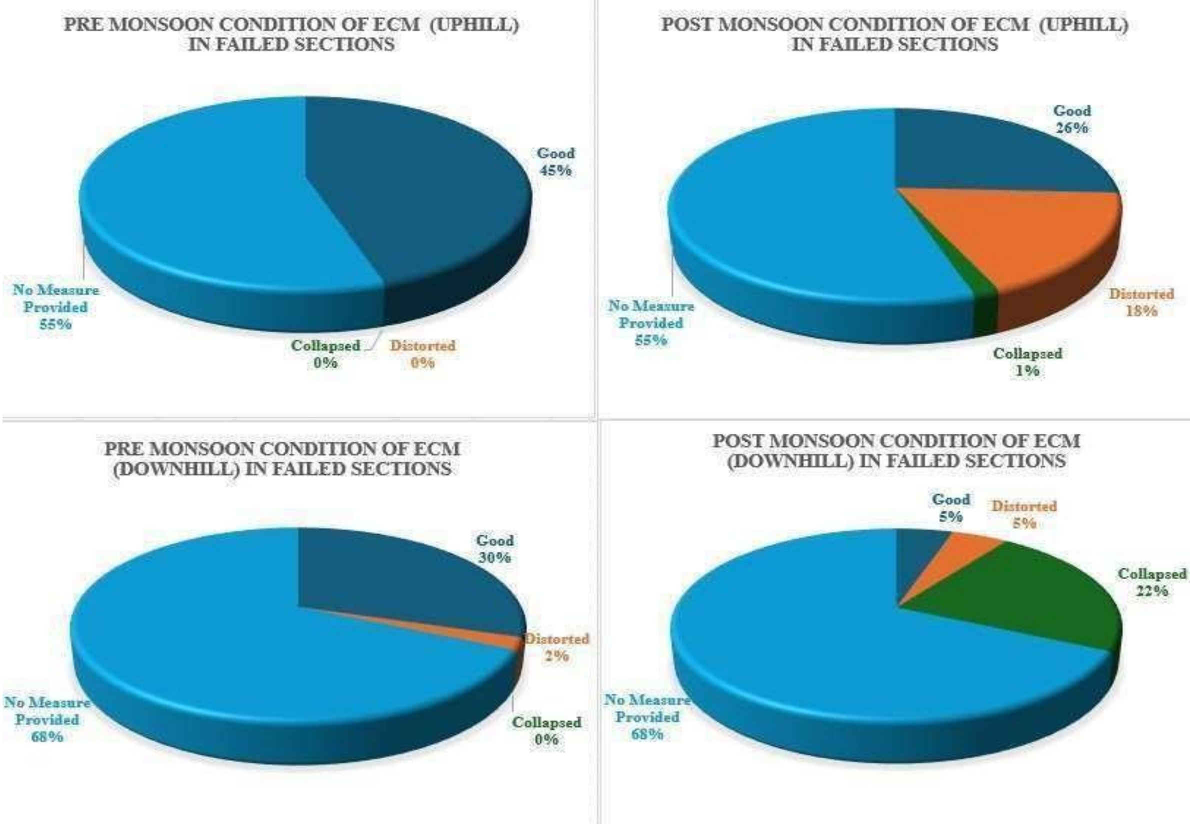
Along the 4 km long profile, 188 sections were studied during the field assessments, out of which 62 sections had undergone erosion (mild to heavy changes in slope geometry) during the monsoon period. The photographic comparisons from the pre- and post-monsoon assessments, highlight some of the major landslides that had occurred during the monsoon period.

Fig. 2.a. Photographic Comparison of Pre- and Post-Monsoon at chainage 3+890m

Fig. 2.b. Photographic Comparison of Pre- and Post-Monsoon at chainage 0+640m

Fig. 2.c. Photographic Comparison of Pre- and Post-Monsoon at chainage 1+777m

Among the 62 sections that faced soil erosion, fine-grained soil type and soft rock types were predominant. The data also showed that majority of the road sections that underwent soil erosion had no ECM provision, and even in the locations where ECMs were provided, only a small percentage remained undamaged.



Comparison of the condition of erosion control measures (retaining walls, gabion walls, masonry walls) before and after the monsoon season in case of failed sections. Additionally, out of 62 total failure sections, 26 sections experienced downhill erosion, 14 sections experienced uphill erosion, while 22 sections experienced erosion in both downhill and uphill portions. Erosion control was largely absent for the vast majority of the failure sections. In the case of uphill slopes, 55% of the total slopes were unsupported, while 45% were supported by retaining walls. Similarly, for downhill slopes, 68% of the total slopes were unsupported, while 22% were supported by gabion walls and 10% were supported by retaining walls.

Post-monsoon assessment also revealed changes in side drains due to landslides. While 55% of the drains were in good condition pre-monsoonand 38% were partially blocked, most drains post-monsoon were either fully blocked (38%) or partially blocked (60%), with almost none being in good condition (2%).

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Conclusion:

In conclusion, the study highlights the effects of the monsoon on roadside slope stability and discusses the occurrence of slope failure with respect to several parameters such as soil properties, drainage conditions, slope geometry and orientation , as well as land use both uphill and downhill. It was found that maximum failure occurred along the south -facing slopes, implying higher insolation, which increases the likelihood of landslides. Furthermore, fine-grained and soft rocks were much more likely to fail than hard rock and coarse-grained soil, with the risk especially increasing under poor drainage conditions. The comparative study also highlights insufficient design as well as the absence of proper ECM, which contributed to the ultimate failure of the slope, the most egregious of which is highlighted in Fig. 2a. Although erosion control measures were largely absent for most of the failed slopes, the retaining walls present were largely structurally intact. The same could not be said for the gabion walls, which either fully failed or were deflected to a great extent.

ROAD SURFACE EVALUATION CONSIDERING SCOOTER RIDER SAFETY AND COMFORT

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Traffic safety and comfort of two-wheeler users are the primary concerns of human-centered infrastructure design approach for daily commuters. Especially in developing countries including Nepal, the issue is crucial because of the predominance of two-wheelers such as motorcycles and motor scooters in urban traffic. The user comfort and safety are affected by the road surface roughness, thereby inducing the prominence in the maintenance of pavement surface corresponding to user satisfaction. The purpose of this study is to improve the maintenance criteria of pavement roughness considering the safety and comfort of motorized two-wheelers. For this purpose, we conduct a driving experiment with a motorized scooter on three types of road surfaces: dense graded asphalt pavement, block pavement, and dense graded asphalt pavement with manholes. In the experiment, we measured the vibration acceleration of both sprung and unsprung masses while riding on the surfaces to identify the excitation characteristics of the scooter interacting pavement roughness. As a result, three distinct peaks in terms of the frequency response which are associated with handlebar, steering component and axle resonance have been identified. The important finding obtained is that the surface wavelength range corresponding to the safety and comfort of two-wheelers differs from four-wheelers.

Key Words: road surface, motor scooter, vibration response, ride safety and comfort

1. INTRODUCTION

A large and growing body of literature shows that the much of the attention has focused on the emergence of human-centered design approach, serving as a central concept to make technology and infrastructure tailored to human needs and preferences (Mitchell et al., 2016). In developing countries including Nepal, traffic data suggests the traffic flow is largely dominated by the motorized two wheelers such as motorcycle and scooters in the urban situation as illustrated in Fig.1. Maintenance of pavement surface is an important role in preserving their quality because the uneven roads are one of the major contributors influencing the safety and comfort of riders during travel. Contextually, user satisfaction and comfort is recognized as the prominent factor in daily commute (Ospina -Mateus & Quintana Jiménez, 2019). In the contemporary context of the Sustainable Development Goals (SDGs), prioritizing ride quality from the user's standpoint is paramount, particularly in developing countries where most users are two-wheeler riders. Efforts have been made to develop the bicycle vibration model for evaluating road surface roughness in relation to the ride quality for cyclists aiming to align this assessment with the International Roughness Index (IRI) (Sasaki et al., 2018). In addition, for the determination of the effect of bus lane surface roughness on bus passengers ride comfort, the Bus Ride Index (BRI) was established using a well-calibrated a 3 degree of freedom (DOF) Quarter Car Model (QCS) of bus and proposed new IRI threshold conditioned on BRI for pavement monitoring and

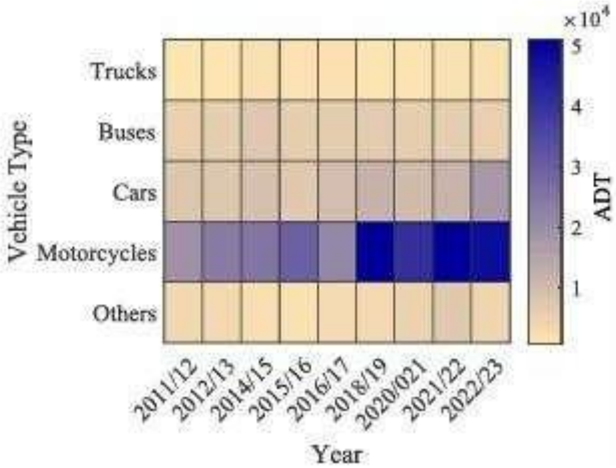


Fig. 1 Traffic data, average daily traffic (ADT), of an urban situation

maintenance (Nguyen et al., 2021). While previous studies have extensively evaluated ride comfort and road maintenance criteria for various vehicle types such as bicycles, buses and micromobilities (Nishigai et al., 2023), very little is currently known about the compatibility of pavement surface maintenance thresholds with the safety and comfort of two -wheeler users. Therefore, this study attempts to comprehensively evaluate the safety and comfort in the case of motorcycle users induced by road roughness and subsequently update the surface mainte nance thresholds. This study, specifically, sets out to investigate the frequency response of the test vehicle in terms of vertical acceleration when it travels over an uneven road section.

2. METHOD

(1) Evaluation of road surface

The three tested road surfaces, as shown in Fig.2, are (a) 150m of dense graded asphalt pavement, (b) 150m of block pavement and (c) 150m of asphalt pavement with manhole within the premises of Shizuoka University, Hamamatsu Campus. Fig.2 also shows the profile of the tested road surfaces which were collected using a calibrated low-speed profiler.

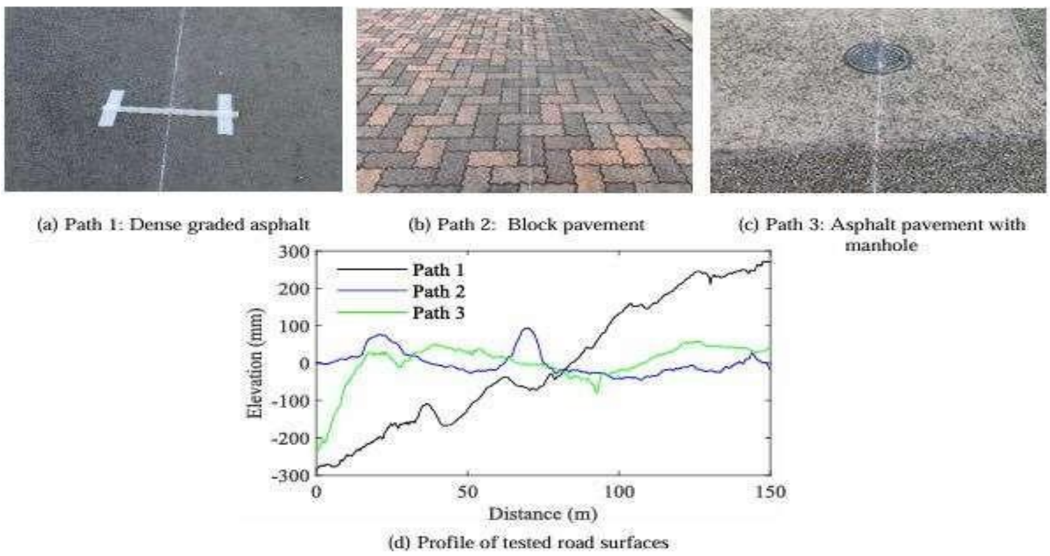


Fig. 2 Tested road surfaces and their profiles

Fig. 3 Measurement Setup

(2) Data acquisition and experimental setup of scooter

a) Motorized scooter used in the experiment

Fig.3 shows an overview of measurement setup for this study using a typical motorized scooter, also called as vehicle here. The vehicle dimensions are 1665mm × 985mm × 600mm, seat height 685mm, and wheel base1200mm. The width of the tire is 80mm. The body weight is approximately 72 kg with all the measuring instruments installed.

b) Measurement Setup

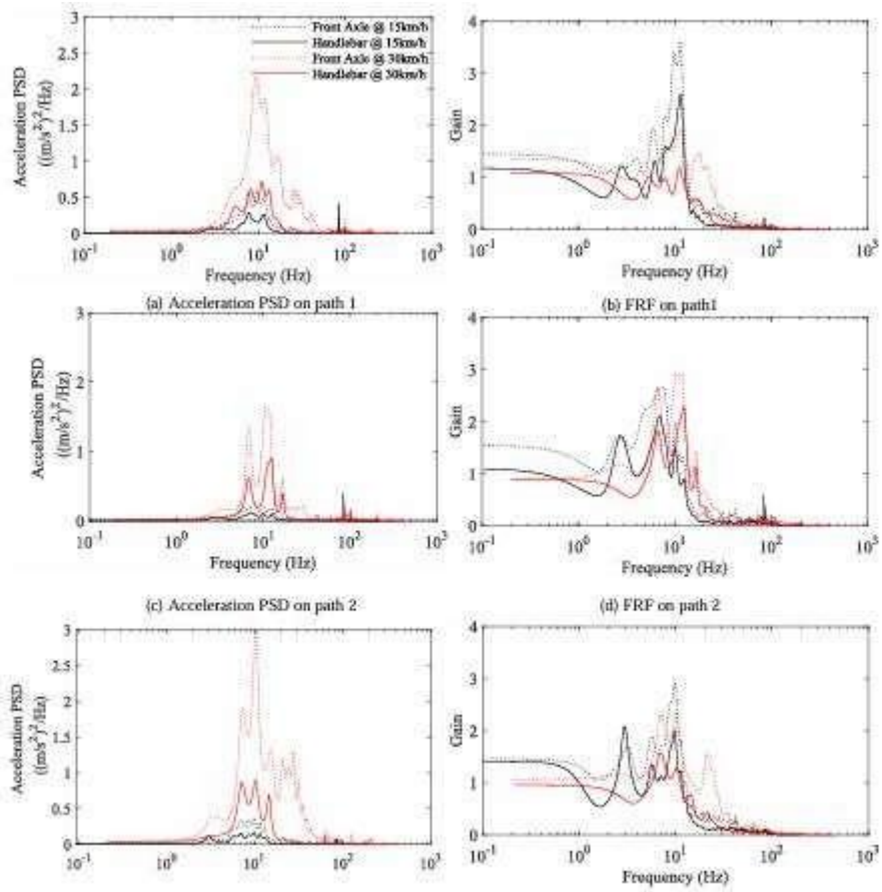
As shown in Fig.3, to obtain data on acceleration, the experiment was conducted by using Kyowa EDS-400A logger and accelerometers. installing at two locations– the handle (sprung mass), front wheel axle (unsprung mass), rear wheel axle (unsprung mass) and license plate (sprung mass). A gyro sensor was installed under the seat of the scooter as shown in Fig.3. The sampling interval for vertical acceleration measurement was set as 500Hz for the accelerometer and 100 Hz for the gyro sensor. In addition, considering the horsepower of the vehicle and safe speed at which rider can ride on road, speed of 15 km/h, and 30 km/h were set for the measurement. Three runs of each speed were performed on the test path in the forward direction followed by another two runs in the same path but in reverse direction.

2. RESULTS AND DISCUSSION

Vibration acceleration characteristics are the most typical measure from the experiment setup discussed before. Study shows that the acceleration values of handle and front axle are considered in this study as it plays a signif icant role in user's experience (Khune & Bhende, 2020). As shown in the power spectral density (PSD) plot in Fig.4, the acceleration amplitude is higher in higher speed, and it has some resonance frequencies. The measured acceleration is analyzed to calculate the frequency response function. In this study, we calculated PSD of the output and input and subsequently the square root of their ratio which is referred to as Gain, also referred as frequency response function (FRF) as shown in Eq. (1).

$$Gain\ |H(w)| = \sqrt{Py(w)\ Px(w)} \,/\, (1)$$

In Eq. (1), $Py(w)$ indicates the acceleration PSD of the vehicle, and $Px(w)$ refers to the acceleration PSD of road surface profile obtained by low-speed profiler. It can be explained from Eq.1 that the larger the gain value, the greater the acceleration output is obtained due to road surface input. As shown in Fig.4, the road to body



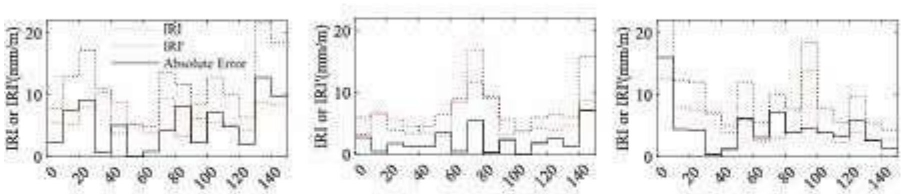
(a) Acceleration PSD on path 1 (b) FRF on path1

(c) Acceleration PSD on path 2 (d) FRF on path 2

(e) Acceleration PSD on path 3 (f) FRF on path 3

Fig. 4 Acceleration PSD and FRF on test paths

transmissibility is amplified in a frequency range from 2Hz to10Hz. The peak value at speed of 15 km/h is greater than that of 30 km/h, which is possibly due to the reason that the vehicle is operating closer to the resonance frequency at the driving speed of 15 km/h.



(a) Error plot for path 1 (b) Error plot for path 2 (c) Error plot for path 3

Fig. 5 Practical application

We then estimated the vibration model of the two-wheeler which enabled calculate the modified IRI (IRI') using the same algorithm for generic motor vehicles. It showed that scooter vibration is more sensitive than a generic motor vehicle and the IRI doesn't correspond linearly to the IRI' as illustrated in error plot of Fig. 5. We also established that the ride quality experienced by two wheelers does not align with the same road characteristics as those affecting the other mobilities which is shown in Fig. 6. The output of this study can be utilized to update the road asset management system, as shown in Fig. 7, in Nepal so as to make it human centric.

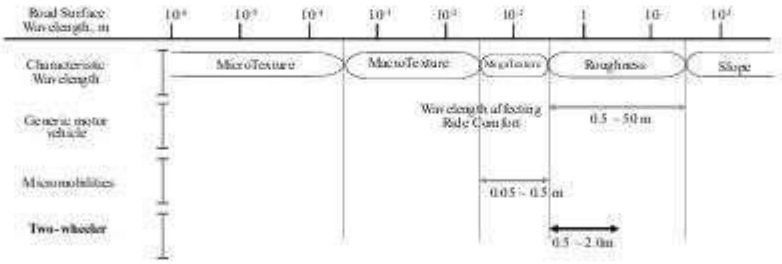


Fig. 6 Characteristic wavelength in different mobilities

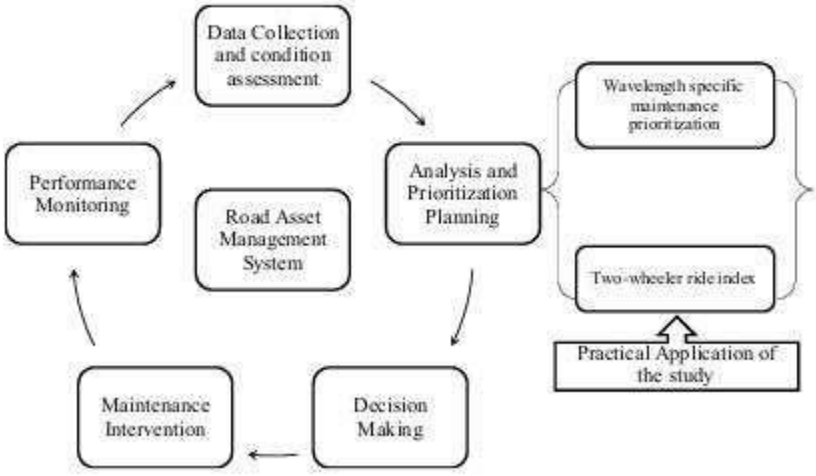


Fig. 7 Practical Application in Road Asset Management System

3. CONCLUSION

This study described the vibration response of a common motorized two-wheeler to understand the impact of road surface roughness. Further studies are required to capture the subjective evaluation of riders on a variety of paths, speed and weight of two wheelers. Future studies are vital to study the psycho-physiological responses of riders to refine ride quality assessments. ACKNOWLEDGMENTS: This research was supported by the Japan International Cooperation Agency (JICA) and Department of Roads, Nepal. This work was partially supported by JST, CREST Grant Number JPMJCR21D2, Japan.

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OPTIMIZATION OF HYDROLYSIS LIGNIN DOSAGE IN ASPHALT MIXTURES FOR ENHANCED SUSTAINABILITY AND PERFORMANCE

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ABSTRACT

Sustainable alternatives to traditional road construction materials are gaining attention due to environmental concerns and the depletion of non-renewable resources. Bitumen, a key binder in asphalt pavements, provides durability and water resistance but is prone to aging, rutting, and environmental impact. Lignin, a natural by - product of biomass, ha s emerged a s a potential modifier and partial replacement for bitumen, offering both performance enhancements a nd sustainability benefits. This study investigates hydrolysis lignin, derived from agricultural residue, in asphalt mixtures to reduce dependence on crude oil-based bitumen while enhancing mechanical properties and long-term durability.

Bitumen was partially replaced with lignin at 10%, 20%, 30%, 40%, and 50% using four methods: dry, wet, additive, and fine removal. Material tests, including XRD, FTIR, and TGA, confirmed lignin's amorphous nature, chemical compatibility, and thermal stability. Binder and Marshall Stability tests evaluated strength, flow, voids, and workability, while TSR and ITS tests assessed moisture resistance and cracking performance.

The wet method achieved the highest stability of 26.87 kN at 5.33% OBC, while the dry method reached 21.87 kN at 20% replacement (5.5% OBC). The best-performing mix, 20% lignin- modified bitumen (wet method), had 22.14 kN stability, 2.39 mm flow, and 70.49% VFB, meeting MoRTH standards. Waste cooking oil (WCO) further improved VFB, stability, and workability at higher replacement levels (40 –50%). TGA analysis confirmed lignin's stability up to 338°C, well above asphalt mixing temperatures (150 –170°C). The mix also showed excellent moisture resistance, with a TSR value of 88.72%, exceeding the required 80%

This study confirms lignin-modified bitumen as a sustainable and high-performance alternative, improving rutting resistance, durability, and viscoelastic properties while reducing reliance on non -renewable materials. Future research should explore long-term field performance, aging studies, rutting resistance, and climatic impact to further optimize lignin's role in green pavement technologies.

KEYWORDS Lignin-modified asphalt, bitumen replacement, sustainable pavements, moisture resistance, cracking resistance

INTRODUCTION

Lignin, the second most abundant biopolymer, enhances bitumen performance by improving aging resistance and stiffness for better rutting resistance. Among its types—kraft, organosolv, and hydrolysis lignin—hydrolysis lignin stands out due to its high thermal stability and ability to improve high-temperature performance. Derived from biomass, it contains phenolic compounds that strengthen bonding with bitumen. As a sulfur-free byproduct of biofuel production, hydrolysis lignin offers a sustainable alternative in asphalt, reducing fossil fuel dependence. This study investigates how hydrolysis lignin affects bitumen and asphalt mixtures as an extender and modifier. Scope of work:

1. Characterization and testing of materials used in asphalt.
2. Mix design with hydrolysis lignin.
3. Assessing binder content reduction due to lignin.
4. Evaluating durability of the modified mixture.

Lignin is a promising bio-binder for asphalt due to its similarity to bitumen, supporting sustainability and reducing CO_2 emissions (Pérez et al., 2019; Arafat et al., 2019; Yatish et al., 2024). It also helps in soil stabilization and dust contro l (Gopalakrishnan et al., 2010). Different types—Kraft, organosolv, Klason, and hydrolysis lignin— affect asphalt performance differently (van Vliet et al., 2016). Lignin improves aging resistance and rutting performance but m a y reduce fatigue resistance at high doses (Zhang et al., 2020; Kalampokis et al., 2022). Studies show that 6% lignin enhances stability, while 20% provides the best balance (Zahedi et al., 2020; Yatish et al., 2024). Successful applications include roads in the Netherlands and a bike path in Iowa (Besamusca et al., 2023).

Figure 1: 12 km road stretch in Netherland made with lignin
(Source: Besamusca et a l 2021)

RESEARCH GAP

Research on lignin-modified bitumen has gaps, particularly in long-term performance evaluation, environmental impact, and economic feasibility. Limited studies explore different lignin types and their molecular interactions with bitumen. Most research focuses on Kraft lignin, while other sources like orgnosolv and hydrolysis lignin need more investigation for sustainable asphalt production. Lignin's potential in pavement applications, such as soil stabilization and cold mix asphalt, remains underexplored. Further studies are needed to optimize bio-binder production, assess asphalt performance, and establish industry standards.

METHODOLOGY

The general methodology of the study is shown in flowchart below.

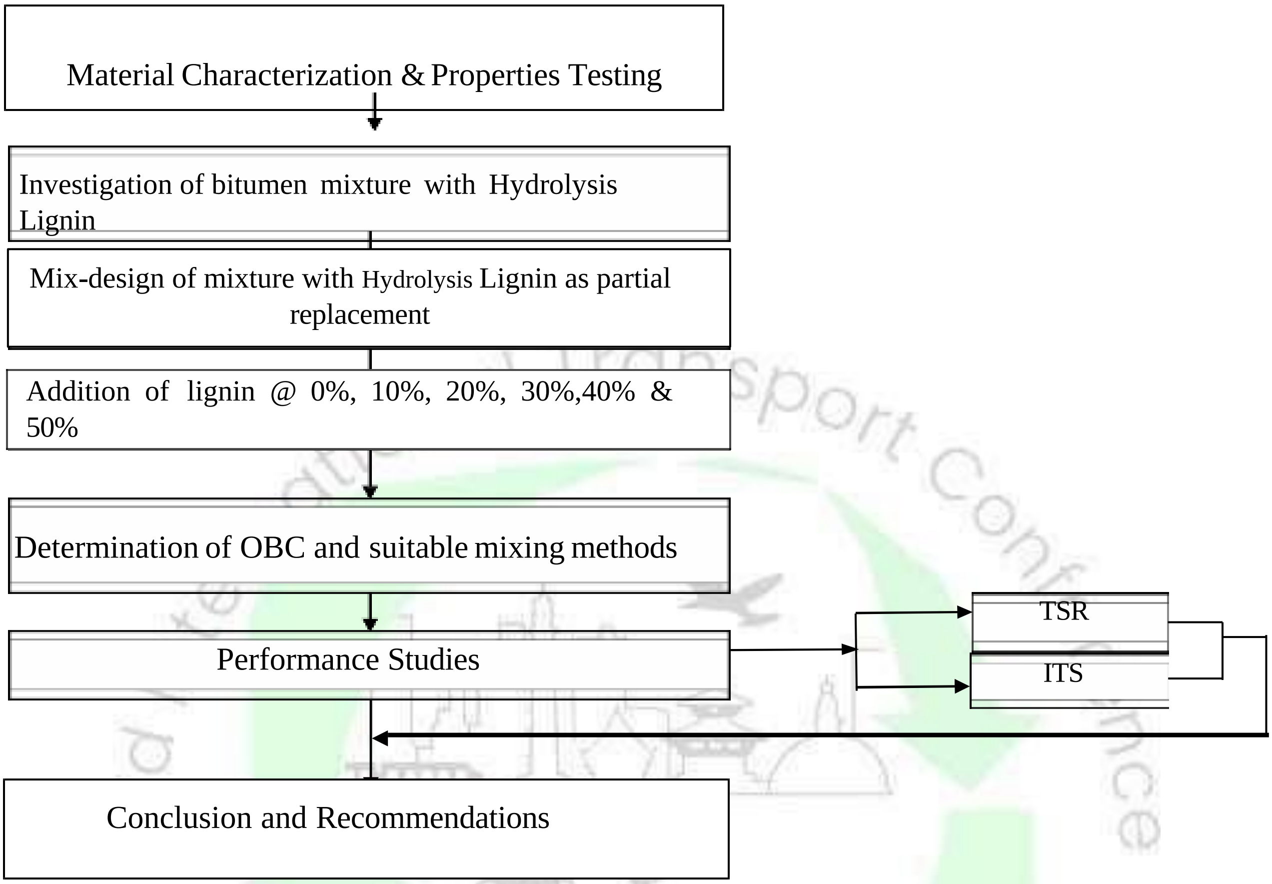

Figure 2: Methodology for the investigation

This study examines hydrolysis lignin as a bitumen modifier using four methods: dry mixing, wet mixing, fine removal, and additive incorporation. In the wet method, lignin was blended with bitumen at 130°C for 20 minutes at 1000 rpm, while in the fine removal method, lignin replaced fine aggregates to enhance workability.

Laboratory tests followed AASHTO and ASTM standards. The Marshall Stability Test measured strength and deformation resistance. Air Voids (Av), VMA, VFB, and Specific Gravity tests assessed compactness and durability. XRD confirmed lignin's amorphous nature, while FTIR identified functional groups improving bitumen bonding.

TGA showed lignin remained stable up to 338°C. TSR tested moisture resistance, and ITS evaluated fatigue resistance under compressive loads.

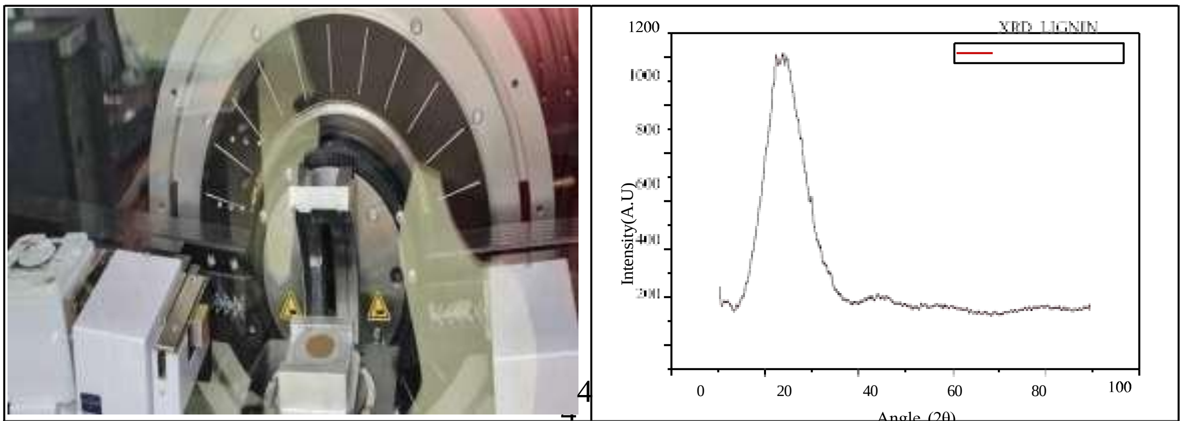

Figure 3: XRD of lignin sample indicating Amorphous Nature

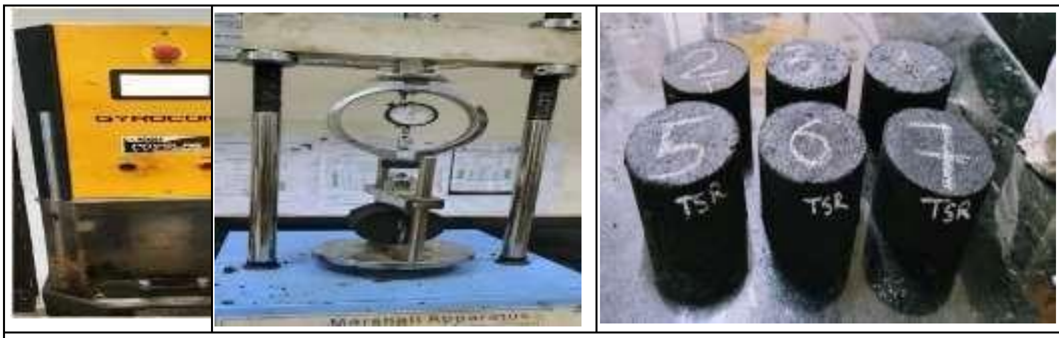

Figure 4(b): ITS and TSR testing procedure

Figure 4(a) : Marshall mix design using dry and wet method

RESULTS AND DISCUSSION

Lignin-modified bitumen improved asphalt performance. The dry method achieved 21.87 kN stability at 20% replacement (5.5% OBC), enhancing strength and flexibility. The wet method provided higher stability (26.87 kN) with better compatibility but lower VFB (62.34%). The best-performing mix (20% LMB_R, wet method) had 22.14 kN stability, 2.39 mm flow, and 70.49% VFB, meeting MoRTH standards.

CONCLUSION AND RECOMMENDATIONS

1. Lignin-modified bitumen improves strength, durability, and flexibility. The wet method provides better stability, while the dry method enhances structural integrity.
2. XRD confirms lignin's amorphous nature, FTIR shows strong bonding, and TGA indicates high thermal stability, ensuring resistance to aging.
3. TSR results show that lignin enhances moisture resistance, making it effective in wet conditions. Despite a slight reduction in ITS, the mix remains strong for long-term use.
4. Waste cooking oil (WCO) improves workability and VFB, especially a t higher replacement levels, making lignin-modified asphalt more balanced.
5. Further research is needed on field performance, fatigue behavior, aging, rutting resistance, and climate impact to optimize lignin in pavements

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Extended Abstracts

Campaign Needs Assessment for Promoting Road Safety in NNM Road Corridor

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Keywords

Road Safety Campaigns, Needs Assessment, Safety Awareness.

Abstract

Road safety campaigns play a crucial role in reducing road fatalities and improving user behavior. This study examines the needs assessment for road safety education and awareness campaigns in Nagdhunga -Naubise - Mungling (NNM) road corridor. The research identified key target groups, risky behaviors, campaign strategies, and the effectiveness of enforcement measures. By analyzing available literatures, field based observations and discussion with stakeholders, this study highlights gaps in awareness programs and suggests improvements for campaign materials, inter-agency coordination, and pilot campaign implementation.

1. Introduction

Road safety is a critical global concern, with traffic crashes being a leading cause of death and disability worldwide (WHO, 2021). In low- and middle-income countries, road traffic injuries account for a high number of fatalities due partly to limited knowledge of traffic laws and low level of awareness (Peden et al., 2004). Nepal is no exception, experiencing rising numbers of road-related fatalities and injuries over the years, necessitating the implementation of targeted road safety awareness campaigns.

The rapid urbanization and motorization in Nepal have significantly contributed to an increase in road crashes, with the Kathmandu Valley and major highways experiencing the highest crash rates (DoTM, 2020). Despite improvements in road infrastructure, user behavior remains a major factor in road crashes, highlighting the urgent need for educational interventions to influence safer road practices.

The Nepali government has recognized the importance of road safety and has integrated awareness programs into national road safety policy documents such as the National Road Safety Action Plan (MoPIT, 2021). However, the effectiveness of these programs remains limited due to fragmented implementation and lack of coordination among key stakeholders (ADB, 2019). Safe Corridor Demonstration

This study aimed to bridge the existing gaps by conducting a comprehensive needs assessment for road safety campaigns in NNM Road. By identifying key risk factors, analyzing the effectiveness of current initiatives, and recommending targeted interventions, this research seeks to contribute to the development of a systematic approach to road safety education and awareness. Furthermore, leveraging best practices from successful international road safety programs will provide valuable insights for improving campaign effectiveness in Nepal.

2. Rationale

Road safety campaigns are crucial for reducing the growing number of crashes, injuries, and fatalities on roads in Nepal. The increasing number of road users, combined with inadequate traffic enforcement and a lack of widespread safety education, has led to a pressing need for structured and impactful awareness programs. The rationale behind this study is to assess the current gaps in road safety awareness, evaluate the effectiveness of existing campaigns, and develop a comprehensive framework for promoting safer road behaviours.

A well-structured campaign needs assessment can help in identifying high-risk groups, such as motorcyclists, pedestrians, and heavy vehicle drivers, who are often involved in road crashes. Additionally, road safety awareness must be integrated with infrastructure development, as improved roads alone do not ensure safer driving practices. Educating users about road signs, traffic laws, and the importance of responsible driving is necessary to maximize the benefits of new and existing road infrastructure.

Furthermore, a lack of coordinated efforts among different stakeholders, including law enforcement agencies, transportation authorities, educational institutions, and local communities, has hindered the effectiveness of road safety campaigns. This study aimed to develop an integrated approach where multiple agencies collaborate to deliver consistent and targeted road safety messages.

Road safety is not only a matter of infrastructure and enforcement but also of behavioural change. Research suggests that behaviour-based interventions, including campaigns that utilize media, interactive workshops, andpeer-led education, have a more significant and lasting impact on road users' behaviour (Peden et al., 2004). Thus, this study has also explored the most effective communication strategies to ensure sustained behavioural change in road users.

3. Campaign Needs Assessment Process

A systematic approach was developed for effective road safety campaigns. The campaign needs assessment process consists of the following key steps (Figure 1).

4. Campaigns Needs Identification

The needs assessment process outlined in Figure 1 identified key gaps in several areas, including campaign development and delivery methods, target audience selection, behavioral studies, crash data analysis, campaign themes. Shortcomings were observed in defining target groups, analyzing crash data, selecting campaign topics, and developing campaign materials. Based on this analysis, several campaign activities were identified across each pillar (Table 1)

Develop Road Safety Campaign Strategy		
objectives and framework for the campaign.	Identify key stakeholders and roles.	the national and international road safety policies.

Identify Potential Road Safety Campaign Areas		
high-risk areas based on crash data.	locations for campaign implementation.	der regional traffic patterns and road conditions.

Assess and Prepare Profile of Potential Campaign Areas		
Conduct on-site assessments.	geographic and behavioral data.	local communities and authorities.

Develop Compendium of Campaign Materials		
educational and promotional content.	multimedia resources for greater reach.	materials are culturally and linguistically appropriate.

Identify Target Audience and Develop Database of Target Group		
Segment road users by risk factors and demographics.	Compile a database of key audiences.	Tailor messages to different groups.

Prepare Campaign Delivery Plan Including Monitoring Framework		
roadmap for campaign rollout.	performance indicators (KPIs).	stablish a monitoring and evaluation mechanism.

Develop and Deliver Pilot Road Safety Awareness Campaigns		
implement small-scale trial campaigns.	feedback and measure effectiveness.	t strategies for broader implementation.

Monitor Performance Outcomes of Road Safety Campaigns		
product post-campaign assessments.	behavioral and statistical changes.	lessons learned and best practices.

Figure1: Road Safety Campaign Needs Assessment Process Table 1: Examples of Pillar wise Awareness Campaigns

Road Safety Pillars	Campaigns	Target Audience
Road Safety Management	Train stakeholders (Safety features, traffic rules, education, and enforcement)	Project managers and engineers at NNM site Site supervisors

Pillar 1: Safer Roads	Campaigns on new road safety features introduced / implemented on NNM Road	All road users Members of NGOs, CBOs, localclubs
Pillar 2: Safer Speeds	Campaigns on speed limit signs, advisory speed signs, traffic calming measures, Check your speed sign etc.	Road users Members of NGOs, CBOs, localclubs
Pillar 3: Safer Vehicles	Promote the use of helmets, seat belts, child restraints, ABS, and other in-vehicle safety features	Motorcyclists Drivers and passengers
Pillar 4: Safer Users	Campaign on how to use road safely (Strictly enforce the rules on the seat-belts, helmets use, public transport safety and develop comprehensive code-of- conduct for all road users) Head First campaign	All road users including motorcyclists and pillion riders Members of NGOs, CBOs, local clubs
Pillar 5: Post-crash response	Campaign on post-crash care activities such as on Good Samaritan Law, First Aid, CPR Duties of crash scene attendants	Length workers, drivers, motorcyclists, community leaders, bystanders Members of NGOs and CBOs

5. Recommendations

- Establish a Centralized Road Safety Authority to coordinate efforts and ensure policy enforcement
- Increase Funding for Road Safety Initiatives to ensure sustained and large-scale awareness campaigns.
- Integrate Road Safety into School Curricula to instill safe road behaviour from an early age.
- Implement stricter traffic law enforcement using automated systems like speed cameras and breathalyzers
- Develop Community-Based Road Safety Programs to engage local stakeholders in advocacy.
- Leverage Digital Platforms for Mass Awareness through targeted social media campaigns and mobile
- applications. Enhance Post-Crash Response Systems by training first responders and improving emergency medical services.

6. Conclusion

The research concludes that road safety awareness programs require a multi-stakeholder approach, integrating education, enforcement, and infrastructure development. Recommendations include strengthening inter-agency collaboration, expanding the use of behavioural change models, incorporating road safety education into school curricula, and enhancing digital and mass media outreach. This study provides a framework for policymakers and stakeholders to develop sustainable and impactful road safety campaigns in NNM.

7. Acknowledgement

The authors sincerely appreciate Development Cooperation Implementation Division for granting permission to present this extended abstract at the conference organized by the Society of Transport Engineers Nepal.

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NIJGADH INTERNATIONAL AIRPORT: A STRATEGIC IMPERATIVE FOR NEPAL'S AVIATION MODERNIZATION, ECONOMIC TRANSFORMATION, AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

This paper examines Nijgadh International Airport's (NIA) pivotal role in addressing Nepal's aviation capacity crisis. Through analysis of operational data and infrastructure requirements, demonstrate how NIA's dual 4,000m runways will resolve Tribhuvan International Airport's chronic congestion while establishing 24/7 all-weather operations. The project delivers transformative economic benefits, including $1.8 billion annual GDP contribution through enhanced tourism and cargo operations, while incorporating sustainable aviation practices. As Nepal's first purpose-built international hub, NIA represents a critical investment in the nation's transportation future and regional connectivity.

Keywords: Aviation infrastructure, Airport capacity, Economic development, Sustainable aviation, Regional connectivity

1. INTRODUCTION

Nepal's aviation sector confronts a critical infrastructure deficit at Tribhuvan International Airport, where a single runway operates at 140% of designed capacity. This severe congestion creates systemic challenges including frequent flight delays, restricted slot availability, and an estimated $300 million in annual economic losses from missed tourism and trade opportunities. The airport's geographic constraints in Kathmandu Valley preclude meaningful expansion, necessitating an alternative solution.

Nijgadh International Airport emerges as the engineered response to these challenges. Located strategically in Nepal's flat Terai region, the proposed facility offers optimal airspace utilization and expansion potential absent at the current international gateway. For aviation professionals, NIA represents a paradigm shift, transitioning Nepal from a constrained single-runway operation to a modern dual-runway hub, enabling reliable operations in all weather conditions.

The project's technical specifications reflect international best practices in airport design, incorporating modular construction approaches and sustainable operational frameworks. This analysis focuses on NIA's operational imperatives, demonstrating how its implementation addresses both immediate capacity requirements and long-term strategic objectives for Nepal's aviation sector.

Fig.1 Conceptual Drawing of Nijgadh International Airport

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2. METHODOLOGY

This study employs a multi-disciplinary analytical approach:

Data Category	Sources	Analysis Focus
Aviation Operations	CAAN reports	Capacity-demand analysis
Economic Impact	World Bank, ADB studies	Cost-benefit evaluation
Technical Specifications	ICAO standards	Infrastructure requirements
Environmental Factors	MoTCA assessments	Sustainability frameworks

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3. CRITICAL NECESSITY ANALYSIS

3.1 TIA's Operational Constraints

Tribhuvan International Airport's limitations present multiple challenges:

- **Capacity Shortfall**: Current 7 million passengers exceeding 3.5 million design capacity
- **Economic Impacts**: $18.7 million annual costs from flight diversions
- **Safety Concerns**: Aging infrastructure and overworked air traffic systems

3.2 NIA's Strategic Advantages

Phase 1 Implementation (2026-2030):

- 6.7 million passenger handling capacity

- 24/7 all-weather operations capability
- 40% reduction in Kathmandu Valley air traffic

Full Development Potential:

- Dual 4,000m parallel runways
- Direct connections to 50+ international destinations
- Generation of 150,000 employment opportunities

3.3 Competitive Positioning

- **Geographic Advantage**: Optimal transit point between China and India
- **Cargo Potential**: 1.5 million ton annual capacity
- **Tourism Growth**: $1.2 billion revenue potential

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4. IMPLEMENTATION FRAMEWORK

Phase 1 Priority Development

1. Core airfield infrastructure construction
2. Essential navigation and ATC systems
3. Initial cargo handling facilities

Phase 2 Strategic Expansion

1. Second parallel runway commissioning
2. Full passenger terminal completion
3. Integrated logistics park development

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5. CONCLUSION

Nijgadh International Airport represents:

1. The only viable solution to TIA's absolute capacity limits
2. Nepal's gateway to regional aviation leadership
3. An economic imperative with $2.3 billion annual opportunity cost

Immediate implementation of Phase 1 with integrated environmental safeguards is critical for Nepal's aviation future.

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Problems in Corridor Level Crash Data Collection, Storage, Analysis, Interpretation and Usage in Nepal: A Case Study from Nagdhunga-Naubise-Mugling (NNM) and Kamala-Dhalkebar –Pathlaiya (KDP) Road

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Abstract

This study examines the challenges faced in collecting, storing, analyzing, and utilizing crash data along the Nagdhunga-Naubise-Mugling (NNM) and Kamala-Dhalkebar-Pathlaiya (KDP) corridors in Nepal. Using 220 Nepal Police Crash Report Forms (CRFs) over four years, the study identifies inconsistencies in paper-based data collection, including missing geocoordinates, incorrect entries, and observer's bias. To address these issues, a Descriptive Crash Coding (DCC) framework was utilized, providing a standardized method for categorizing crashes. A crash geodatabase was also created to enable efficient analysis. The findings highlight the importance of accurate digital data and geocoordinates for improving targeted road safety interventions.

Keywords: Descriptive Crash Coding (DCC), Crash Report Forms (CRF), Fatal and Serious Injury (FSI) Crashes, Crash Geodatabase

Introduction

In Nepal, road safety interventions often lack precision dueto theaggregated crash data collected at the district level, which masks corridor-specific trends. The Nagdhunga -Naubise-Mugling (NNM) and Kamala-Dhalkebar-Pathlaiya (KDP) corridors are critical to understanding road safety dynamics, but current data collection practices are insufficient. The completed paper-based Nepal Police Crash Report Forms (CRFs) face significant limitations, such as incomplete or inconsistent data entries, lack of geocoordinates, and subjective observations. These shortcomings reduce the utility of the data, especially for developingtargeted road safety interventions. This study seeks to address these challenges and improve crash data management for more effective road safety measures.

Methodology

The study utilized 220 CRFs collected over a period of four years from the NNM and KDP corridors. The research involved reviewing the existing paper-based forms to assess the issues related to data quality, consistency, and completeness. A Descriptive Crash Coding (DCC) framework (Parajuli, Eagle 2016) was used to standardize the coding of crash attributes, such as crashtypes and severity. The data was digitized and stored in a newly created database, allowing for better organization and systematic analysis. The digitization process also included the addition of accurate geocoordinates to address gaps in spatial data.

Results and Discussion

The analysis revealed several key challenges in the existing crash data collection methods. Missing geocoordinates and inconsistent entries were prevalent, limiting the ability to conduct spatial analyses and identify high-risk areas. The DCC framework, however, successfully categorized crash types (e.g., head ons, side swipes, T-bones, pedestrian-hit related incidents) and provided a more systematic approach to analyzing crash data. The introduction of digital geodatabases significantly improved data accessibility and locational accuracies allowing for efficient sorting and analysis of crash attributes. Furthermore, the inclusion of geocoordinates allowed for the identification of high -risk locations, which are crucial for identifying and prioritizing interventions.

Conclusion

This study highlights the importance of digitizing crash data, especially with the inclusion of geo coordinates, to enhance road safety research and policymaking in Nepal. The Descriptive Crash Coding (DCC) framework proved effective in standardizing crash data and addressing the limitations of the current practice of paper-based reporting and storing aggregated crash data by severity at district level and inconsistencies in defining crash types. For future improvements, it is essential to prioritize the adoption of open data practices and ensure the consistent inclusion of geospatial data in crash reports. The findings suggest that these measures will support more targeted and data -driven and value for money interventions, ultimately leading to safer highway corridors and better road safety outcomes in Nepal.

Application of NeRSAP in SRCTIP funded Nagdhunga-Naubise Mugling Road under Safe Corridor Demonstration Program

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Abstract

It is crucial for Nepal to use its limited resources in addressing the increasingly concerning road safety issues. This study aimed to apply Nepal Road Safety Assessment Program (NeRSAP) for evaluating relative risks of Nagdhunga Naubise Mugling (NNM) Road with the use of limited road risk attributes than international Road Safety Assessment Program (iRAP). Data pertaining to land use, traffic, geometric and non-geometric road risk attributes were collected and analyzed. The results of NeRSAP were validated using historical crash records collected. NeRSAP star rating has been found to be well aligned with the iRAP star rating thus demonstrating that NeRSAP can offer a promising "quick, easy and cost -effective" risk assessment tool for Nepal.

Keywords

NeRSAP, iRAP, Road risk attributes, Risk assessment tool

Introduction

Nepal with current local road network of more than 63,500 km (Economic survey 2020/21, MoF, GoN) and national highway of more than 11,799 km (Statistics of National Highway 2022/23, DoR) is expanding its road network to meet the people's desire of movement. There is now ongoing debate on constructing quality roads rather than focusing on the expanding roads which obviously requires more emphasis on road safety aspect.

The crash history of Nepal shows that there is an increase in 1294 number of crashes (24%) per year in an average whereas the fatality and vehicles involved in the crashes increase with average rate of 5.49% and 12.58% respectively (Data source: Traffic Police Directorate). The vehicle registration is increasing at an alarming rate of 14% (Data source: DoTM). The roa d safety scenario in Nepal in worsening despite the efforts put to improve it. Nepal's investment need in road safety is USD 879 million over the decade (WB 2020). The allocated budget in road sector is mainly for construction and maintenance rather than for improving the safety scenario which is merely around USD 4 million (Shakya & Marsani, 2020). The budgetary provision for the fiscal year 2023/24 is to the tune of USD 4.8 million. To make roads in the country safer, the already constructed roads should vigorously undergo checks on safety deficiencies whereas new roads should undergo different stages of road safety audits. Road safety audits are being conducted on roads selected in an a d-hoc basis and the implemented measures are not so widely visible. Most of the roads especially owned and managed by local governments are unaudited. It will be hard for government agencies to prioritize roads even for conducting road safety audit without tany prescreening criteria. Among limited researches in road safety in Nepal, most of the previous researches were focused on crash prediction models (Thapa, 2015), (Joshi, 2015), (Dahal & Marsani, 2019). There are limited iRAP star rated roads (around 400 km under ADB and 1457 km under WB). In a resource constraint environment like in Nepal, it will be very hard to conduct such a detailed safety inspection requiring over 70 attributes used in iRAP. Therefore, use of a quantitative risk assessment framework with minimum data input to support prioritized safety audits is the current need and also the focus of this research. This study aims to validate NeRSAP customized for Nepalese condition based on the risk assessment methodology developed by Transport Association of Canada (TAC).

The overall objective of the research is to validate NeRSAP using the data from NNM Road to identify and prioritize high risk sections, which can further be used as a speed limit setting tool. In absence of such tools, speed limits are not signposted or posted only along limited roads but determined on ad-hoc basis.

The specific objectives are:

- To calculate the relative risks based on risk attributes (geometric and non-geometric attributes)
- To compare and validate the relative risk ranking with iRAP star rating result and crash data

Methodology

The proposed research was conducted based on the methodology depicted in Figure 1

Figure 1: Methodological Flow Chart

1. Preparatory Works
   The selected road was divided into subsections considering homogeneity of road attributes as well as operating speed.
2. Data Collection
   For each homogeneous road section, 11 road risk attribute data were collected from primary or secondary sources which includes

a. Road type and class attributes
   land use, carriageway, medians, road type, number of lanes, length of homogenous section

b. Road risk attributes
   Horizontal alignment, vertical alignment, lane width, roadside hazards, pavement surface, private access, number of intersections, number of interchanges, on street parking, etc.

c. Traffic
   Average Daily Traffic (ADT), pedestrian and cyclist exposure

3. Data Analysis and Risk Score Calculation
   For each of the road risk attributes, a risk level categorized into 3 levels that matches prevailing conditions was determined. The weighing factors for each risk attributes were determined not only based on road risk attributes but also non geometric attributes. These attributes together with risk levels and weighing factors were used to calculate risk score.
4. Result Validation and Discussion
   After evaluating the risk score for each homogeneous section, a risk score band was created and a star rating assigned, which was compared with the iRAP star rating. These ratings were further validated by crash records.

Results and Discussion

Among total 95 km of NNM road, analysis reveals a 7.3% and 35.3% increase in 1-star and 2- star, respectively when comparing NeRSAP to iRAP star ratings. Conversely, there is a decrease of 42.5% in 3-star ratings. Over 39.7% of road lengths have similar star ratings. For 3.89% of the road length, the NeRSAP rating is one star higher than the iRAP rating while for 29.68% of the road length, the NeRSAP rating is one star lower than the iRAP rating.

Among the 41 homogeneous sections of NNM road, there were 59 deaths and 99 serious injuries registered during 2021 to 2024 in 29 road segments within 75.9 km of roads. Seven segments of total 3.6 km length had a NeRSAP rating of 1 compared to an iRAP rating of 3, with 11 deaths and 3 serious injuries reported. Similarly, in 13 sections of length 26.8 km the iRAP ratings of 3 dropped to a NeRSAP rating of 2 with 11 deaths and 20 serious injuries reported. Also, in three homogeneous section of length 5.2 km iRAP star rating of 2 dropped to a NeRSAP rating of 1 with 3 deaths 19 serious injuries. There are only 3 homogeneous road sections of length11.9 km where iRAP star rating of 1 increased to NeRSAP star rating of 2 with total 3 deaths and 4 serious injuries.

Conclusion

The NeRSAP rating is generally equal to or lower than the iRAP rating in most homogeneous road sections of road under consideration. This finding was further validated by crash report records obtained suggesting that NeRSAP can be effectively used to prioritize risky road sections for detailed road safety audits, optimizing the use of limited resources. It is recommended that further works be undertaken now to use NeRSAP for establishing risk -based speed limits which can provide robust framework for establishing posted speed limits in the country

ROAD SAFETY INFRASTRUCTURE ASSESSMENT FOR THE NAGDHUNGA-NAUBISE-MUGLING (NNM) CORRIDOR: CHALLENGES AND STRATEGIC INTERVENTIONS

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Abstract

The Nagdhunga-Naubise-Mugling(NNM) Road Section is an important link of Nepal's national highway network, currently undergoing widening and improvement under the Safe Corridor Demonstration Program (SCDP) within the Strategic Road Connectivity and Trade Improvement Project (SRCTIP). This study presents a systematic safety infrastructure needs assessment, identifying existing deficiencies and proposing countermeasures aligned with global best practices. By employing rapid road safety assessment, corridor level crash data analysis, and infrastructure risk assessments, the study evaluates critical safety challenges, including access rationalization and control, speed management and control, roadside hazard mitigation, and protection of vulnerable road users. The findings emphasize the necessity for formalized road safet y standards, enhanced road use skills, Strengthened Enforcement System (SES), and integration of Safe System principles into Nepal's road design policies and practices.

Keywords

Road Safety, Infrastructure Risk Assessment, Safe System Approach, Road Safety Standards, TRSI

Introduction

Road safety remains a pressing concern in Nepal, with increasing traffic volumes and ongoing road expansion projects necessitating robust safety interventions. The NNM Road Section, a pivotal artery connecting Kathmandu to the rest of t he country, experiences high traffic density and frequent crashes. Despite previous road safety initiatives, the effectiveness of implemented measures has been limited due to infrastructural shortcomings and inadequate enforcement. This study assesses existing safety conditions and identifies additional interventions on infrastructure front required to enhance road user safety, reduce crash risks, and promote a sustainable transport system.

Methodology

An integrated and multi-faceted approach was employed to identify and address safety concerns along the NNM corridor. This process began with drive-through inspections and video analysis, enabling systematic documentation and review of real-time traffic conditions to detect roadside hazards. Additionally, a comprehensive review of design and survey data was conducted, analyzing engineering drawings, including plan, profile, and cross-section details, alongside crash history and environmental assessments to assess existing conditions. "Black Spot" identification was carried out using crash data analysis and site-specific investigations to pinpoint high-risk locations requiring targeted interventions. A rapid road safety assessment was undertaken to evaluate he corridor's compliance with both national and international road safety standards, ensuring alignment with best practices. Lastly, Safe System principles were integrated into the assessment, focusing on evidence-based strategies that enhance infrastructure design, improve vehicle safety, and promote safer road user behaviour. This structured methodology ensured a thorough and effective approach to mitigating crash risks and enhancing overall road safety.

Results and Discussion

The assessment revealed several critical road safety challenges, including poorly designed intersections, inadequate pedestrian infrastructure, high-risk speed zones, and a weak enforcement mechanism. A key issue identified was the absence of standardized road safety standards and design guidelines, highlighting the need for comprehensive policies to enhance infrastructure safety across Nepal's road network including in the NNM Road. Additionally, access management deficiencies were observed, with numerous unauthorized road access points contributing to heightened crash risks. The study also underscored the need for better protection of vulnerable road users, as the lack of designated pedestrian crossings, cycling

lanes, and proper roadside hazard management posed significant safety threats. Speed management issues were another major concern, with no formal approach of establishing posted speedlimits, inconsistent enforcement of speed limits and a lack of physical measures, such as speed calming devices, exacerbating crash risks. Finally, black spot remediation emerged as a priority, with the identification of high-risk crash locations requiring immediate safety interventions. These findings emphasize the urgent need for a structured, data-driven approach to improving road safety in Nepal.

Conclusion

The study highlights the urgent need for a structured road safety framework that integrates Safe System principles to enhance overall road transportation safety in Nepal. Key recommendations include the development and implementation of a comprehensive road safety standards and design guide, ensuring consistency in safety standards across all infrastructure projects. Additionally, systematic application of posted speed limits and enforcement measures in managing risky behaviour of road users mustbe strengthened to regulate speed, manage access, and improve compliance with traffic laws. Targeted Road Safety Interventions (TRSIs) are also crucial, addressing high-risk areas through infrastructure modifications and black spot remediation. The findings from this assessment provide a blueprint for future road safety improvements, offering data-driven insights to guide policy development and implementation. Lessons learned from the NNM Road Section can be leveraged to update nationalroad safety plans policies and practices, ultimately fostering a safer and more efficient road network across the country.

Road Crash Database System: An innovative Road Crash Data Collection and Storage System

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Abstract

Crash data is one of the most important information needed for road safety management. Targeted road safety interventions cannot be designed and delivered in absence of good crash data, which could lead to inefficient design and restrict the development of value for money road safety projects. An innovative but highly simple and low-cost road crash database system called Nepal Road Crash Database System (NRCDS) was developed and recommended to the Government of Nepal for implementation. The recommendation was not implemented and instead an entirely new, named Road Accident Information Management System (RAIMS) was developed and piloted. This Paper aims to bring the previously developed but forgotten system, which was considered to be highly relevant for resource scarce low technology and low knowledge base environment of Nepal into light again for reconsideration by the Government in light of the failure of the more conventional but complex yet resource hungry, unsustainable, relatively difficult to manage RAIMS.

Keywords: NRCDS, RAIMS, DCC, Crash report form

Background

In its Global Plan for the Decade of Action (DOA) for Road Safety 2011 -2020, World Health Organization (WHO) emphasized the importance of data systems for on-going monitoring and evaluation of road safety outcomes in all its member countries (WHO, 2021). As a signatory of DOA, Nepal in its Road Safety Action Plan 2013 -2020 (MOPIT, 2013) identified the need to establish the system of collecting and storing crash data in the country to enable reliably and scientifically compile, analyze road crash statistics, and undertake research on remedial measures to reduce road deaths in the country. Development of Road Crash Database System, which represented one of the component programs of the Nepal Road Safety Support Project (RSSP), contributed to the delivery of this key activity of NRSAP 2013 -2020. NRSAP 2021-2030 (MOPIT, 2021), also has emphasis on the need of reliable crash database system and has the plan to fully implement piloted Road Accidents Information Management System (RAIMS) across the country with the nationwide roll-out program included in the ongoing SRCTIP activities.

The creation of road crash database in Nepal started in mid 1990s with an excellent "state of art" data storage and analysis system developed in UK (TRL, 2016). Nepal could not sustain it due to a number of reasons including the absence of institutional, legal, and funding framework. The need for the development of Nepal Road Crash Database System was once again realized in the country in mid 2010s due to sharp rise in road deaths. Following the presentation of the Concept Paper 2 (Parajuli, 2015b) in the meeting of the National Road Safety Council (NRSC) on 12th July 2015, the RSSP initiated a project for the development of Nepal Road Crash Database System (NRCDS) a s one of the components of Nepal Road Safety Management System (Parajuli, 2015a; Nepal and Parajuli, 2015). The failure of RAIMS and complexities involved in its revival and nationwide rollout ha s once again highlighted the need of devising a simple and low-cost solution that can be easily implemented and sustained in Nepal. Crash data collection is currently limited to completing crash report forms on major crashes for use in court cases. In terms of the storage, Nepal Police maintains a record of aggregated crash data in its computer which are of little use for road safety engineers and professionals to formulate and implement countermeasures.

This paper precisely aims to revisit the development of NRCDS and attempts to bring it back in the agenda for discussion. Following the review of the crash data collection and storage system in the country and internationally (N D Lea et al, 2008a, N D Lea et al, 2008b; Lundebye, 2012) a number of issues have been identified as:

- Absence of institutional, legal and funding framework for sustained operation and maintenance of the crash database system;
- Limited understanding on the importance and use of crash data in project benefits assessment, road safety monitoring and evaluation;
- Multi-agency involvement in road crash data collection and management;
- Extensive scope (space and time) of works involved in crash data collection;
- Needs to improve existing Crash Report Form;
- Implement extensive training to Nepal Police officers;

- Absence of Crash Coding System;
- Non-existence of the Government machinery which is accountable for ongoing management of Crash Database System;
- Limited understanding of the nature and scope of works involved in collecting, coding, testing, validating, storing a nd using crash data by road safety professionals in the country.

Methodology

The proposed methodology consisting of 10 key steps/tasks is depicted in Figure 1 (Parajuli and Eagle, 2016).

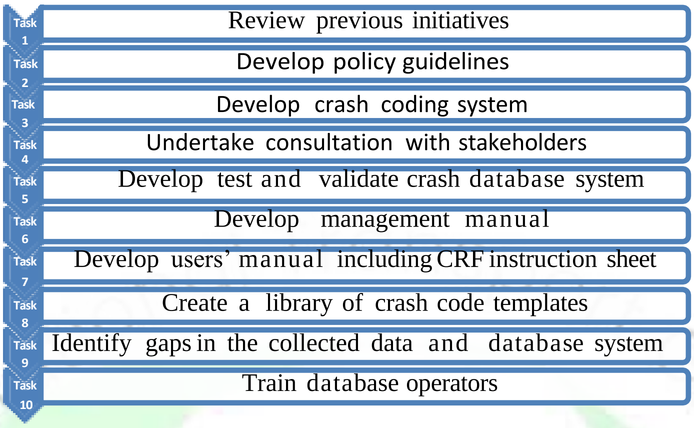

Figure 1: Flow chart of the proposed Methodology

Conclusions

Based on the issues identified and in-depth analysis of the existing situation and likely future scenarios in the management of crash data in Nepal (Methodology), the NRCDS developed a simple but robust crash data collection and storage system and recommended for implementation. The system included a number of components including

- Modified Crash Report Form, a paper-based tool to enable Nepal Police officers to collect crash data at crash scenes a nd to implement improvements gradually over time;
- How to Complete Crash Report Form (HCCRF), a simple tool kit to assist police officers complete crash report forms correctly and consistently;
- An EXCEL based Smart Data Entry System (SDES), that appears in the computer screen to enable Police officers enter raw data (and allow automatically code crashes in most cases) that goes in Nepal Police Road Crash Database System (NPRCDS);
- An EXCEL based Smart Data Checking and Storing System (SDCSS), that appears in the computer screen to enable MOPIT data entry operators and system analyst to check crash data and store in Nepal Road Crash Database System (NRCDS);
- An EXCEL based Data Storage System (DSS), that stores all data entered in NPRCDS and checked and /or MOPIT officers in NRCDS;
- Nepal Road Crash Database Management Manual, to manage NPRCDS and/or NRCDS; and
- Nepal Road Crash Database Users' Manual, for use by road safety professionals and members of public when requesting crash data sets from MOPIT.

Recommendations

A number of recommendations were m a de for immediate consideration by the Government to ensure the sustainability of NRCDS.

- National Transport Policy (NTP) should include a policy statement requiring the establishment of NRCDS to facilitate the road safety performance monitoring and evaluation of all public roads;
- The requirement of maintaining NRCDS should be legislated in Road Safety Act, Public Roads Act, Motor Vehicle Transport Management Act, Provincial Road Safety Act (or equivalent) and Local Self Governance Act;
- A separate study to confirm the causes of underreporting of crashes to develop and implement the process for addressing such issues;
- Nepal Police officers must be trained on completing CRF correctly and completely on a n ongoing basis. It should be included in Nepal Police Academy Curriculum.
- All toolkits prepared should be translated in Nepali for use by Police officers

Future Works

Four follow up works listed below were recommended for consideration by the Government.

- Capacity Enhancement Project for NP officers;
- Capacity Enhancement Project for NRSC and road agencies;
- Development of Nepal Road Safety Information Management System; and
- Development of Web based / Cloud based/ Multi-access Database System.

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Simulating pedestrian behavior with competition between movers and stayers in urban public space

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Abstract:

Urban transportation systems are increasingly shifting toward healthier and more environmentally sustainable modes, such as walking and cycling. Such a shift would also enhance the liveliness of urban public spaces, especially when they are designed to support both easy and safe movement for pedestrians and bikers—¬referred to as the travel function, and for comfort placement of social and cultural activities—referred to as the place function (Jones and Boujenko, 2009). The importance of travel and place functions has long been discussed after the work of Jacobs (1961) who emphasized urban streets as main spaces for social interactions. On the other hand, the coexistence of movers and stayers in a finite urban space often results in competition, creating trade- offs in space use between movers and stayers. While these stayers enjoy observing the artwork and/or chatting with friends, they m ay become obstacles for movers. In this paper, we call people who not only move but also stay in space sojourners, which is different from travelers who do not stay in space. Our focus is on situations where pedestrians comprise both travelers and sojourners. Considering mover-stayer competition can lead to unexpected behavioral phenomena, which can contradict the implications from the existing pedestrian fundamental diagrams (e.g., Vanumu et al., 2017). Specifically, pedestrian fundamental diagrams indicate that an increase in pedestrian density reduces the service level (i.e., walking speed). However, this relationship becomes less straightforward when stayers are present: a certain number of movers would be required to maintain stable pedestrian flow and prevent stayers from encroaching on the space. If this holds true, an increase in movers could actually improve walking speed, contradicting to pedestrian fundamental diagrams.

To consider and model the competition between movers and stayers in urban public space design, this study proposes a pedestrian simulation model with mover-stayer competition based on the dynamic discrete choice modeling framework. The developed model can be characterized as follows. First, we consider two types of agents, i.e., travelers and sojourners. Second, we consider (1) positive and negative internal interactions among stayers, (2) positive internal interactions among stayers, and (3) negative external interactions between movers and stayers, where the negative interaction between stayers and movers represents the competition. Third, the proposed model is developed in a manner consistent with the random utility maximization theory, allowing us to compute the consumer surplus as a performance indicator of the space.

To investigate how urban public space design impacts competition and overall performance, we conduct a simulation analysis under the situations where movers and stayers compete. Scenarios include (1) different object locations — where the object is assumed to attract stayers—, and (2) varying numbers of travelers and sojourners. From the simulation results, we first confirm that, while multiple equilibria (i.e., different locations of concentrated stayers) emerge across trials, the corresponding CS value remains within a certain rang, even as the number of trials increases. Consequently, this proposed model demonstrates relatively stable performance indicators despite existence of multiple equilibria, enabling meaningful inferences for urban public space design. Note that the algorithm of this simulation is designed to narrow down the equilibrium candidates by incorporating exploration behaviors of travelers and sojourners, even when pedestrian models accounting for the complex interactions involve a vast number of potential equilibria. Second, we confirm that an increase in the number of travelers does not necessarily decrease traveler speed in some scenarios, contradicting the implications of pedestrian fundamental diagrams. In terms of CS values, as the number of travelers increases, their CS value decreases, while the CS value of sojourners remains unchanged in m a ny scenarios. The simulations confirm — through both CS values and behavioral indicators—that competition between movers and stayers can lead to unexpected behavioral phenomena. Thus, simulations using this model can provide valuable insights into the design of spaces where movers and stayers compete. Furthermore, the model can be extended to more complex environments, such as mobility hubs, where vehicles, travelers, and sojourners coexist.

Based on the simulation results, placing objects on one side yields better CS values, suggesting that consolidating objects on one side effectively manages competition between movers and stayers. Another promising strategy involves marked segmentation (e.g., painting), which clearly separates moving and staying areas by providing distinct visual cues for travelers and sojourners. This approach is commonly used to designate bicycle lanes. By guiding agents' exploration and narrowing their movement choices, such cues improve spatial organization and reduce conflicts between movers and stayers.

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Exploring the interrelationship between road environment, existing safety interventions, and crash occurrence using different analytical techniques.

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Abstract

Road safety is a critical global issue with significant challenges that must be addressed immediately. Although there has been a decline in the annual crash fatality in recent years, it is still among the top ten most common reasons for human death. Road safety management follows a systematic and planned approach to mitigate road crash occurrence and severities by analyzing the causes and identifying the most effective interventions. Research has shown that the road environment contributes the most to road crash occurrence after human factors. Analyzing human factors and controlling them is complex since human behavior differs from one person to another, hence it is believed that a large portion of crashes can be mitigated by improving the road environment or the driving conditions.

Road environment features can be broadly divided into road geometry, road type and land use, and existing safety features. Among these, road geometry is fixed at the time of construction and generally remains unchanged over time, whereas road type and land use can vary over time due to a variety of external factors. Road safety features, or interventions, are temporary measures designed to enhance safety at a particular road section and, if found effective, may be used permanently. It is thus much easier to modify safety interventions compared to other road features.

This study aims to evaluate the relationship between safety interventions and road crash frequency and severity within road sections with highly similar road environments, and then examine how this relationship varies between different environments. Data taken on 160 kilometers of the Dhulikhel-Sindhuli-Bardibas highway and 61 kilometers of the Yamdi-Maldhunga section of the Midhill highway were used for the analysis. The study highways were divided into 250-meter segments, resulting in the formation of multiple segments (N=883), and data on road geometry, land use, and existing interventions were collected through primary and secondary sources. Three years of crash data were also collected from the respective district traffic offices. Factor Analysis on Mixed Data (FAMD) was performed, followed by data clustering to identify road segments with highly similar road geometries and land use characteristics. Factor analysis is a feature (dimension) reduction technique used when dealing with many interconnected variables and can help to understand the underlying patterns in the data. The features considered in the clustering included carriageway width, left and right shoulder widths and types, longitudinal gradient, whether the segment is straight or curved, radius of curvature for curved segments, percentage of curved portions in a segment, number of accesses in each segment, level of ribbon development, and pavement roughness. The relationship between nine safety interventions (crash barriers, center line markings, edge markings, edge delineation, curve delineation, pedestrian crossings, road signages, footpaths, and streetlights) and the frequency of road crashes and their severity was then examined within each cluster.

From the factor analysis, it was found that six principal components (dimensions) retain 67% of the variance, which was considered sufficient to proceed with the analysis. The road segments were then clustered using agglomerative hierarchical clustering, which produced a dendrogram that revealed the similarity of the road segments with respect to their road geometry and land use. Based on the shape of the dendrogram, seven clusters were considered for further analysis. Cluster 6 (n=43), which can be characterized by road segments without both left and right shoulders, had the highest average crashes per ten thousand vehicles (1.63). Conversely, Cluster 1 (n=24), comprising road segments with either gravel or paved shoulders and without any ribbon development, had the lowest number of crashes per ten thousand vehicles (0.39). Furthermore, Cluster 7 (n=37), which contains road segments with completely straight stretches, had an average of 0.901 crashes per ten thousand vehicles, which is relatively higher. It was found that straight road segments were more likely to experience crashes involving pedestrians, resulting in fataland serious injury crashes. Run-off road crashes and head-on collisions were the predominant crashes in clusters characterized by sharp bends and narrow carriageways. Other notable differences were also identified through a comparison of the crash tendency between clusters.

Next, the relationship between the condition of existing safety measures, which was assessed by experts during field inspection and categorized into three levels (good, fair, and poor), and the type of road crashes was analyzed in each cluste r. For this, datasets were derived for each cluster considering the crashes occurring within those clusters. The initial crash d ata were cleaned by categorizing each crash by its type (hit pedestrian, head -on, rear-end, side-swipe, right-angle, overturned, run-off, hit obstacles, and others).

In this analysis, the crash type was considered the outcome variable, and the condition levels of existing safety interventio ns in the segment where the crash occurred were taken as the explanatory variables. This presents a classification problem; therefore, the resulting datasets were analyzed using decision tree analysis, a supervised machine learning algorithm that builds a tree-like model of decisions and their possible consequences. This analytical tool helps analyze the relationship by generating a tree-like graphical representation of the decision-making stages at different nodes, providing better interpretability.

Cluster 6 (having all segments without left and right shoulders) recorded a total of 73 crashes, and the analysis showed that 66% of the crashes resulted in head-on collisions when the segments had fair or good edge delineation. Furthermore, when they had poor delineation, crashes were more likely to involve pedestrians. Road segments with fair or good edge delineation can sometimes restrict maneuvering width, as drivers tend to maintain lateral clearance from delineator posts. This, in turn, can cause head-on collisions on bends when speeds are relatively high. On the other hand, in the absence of edge delineation, vehicles can drift from the carriageway at higher speeds, resulting in crashes with roadside pedestrians. Cluster 7 (having all straight segments) had 25 crashes, of which 48% were head -on collisions occurring in segments with poor centerline markings. This result is quite relatable because drivers usually tend to speed on straight sections, and in t he absence of centerline markings, head-on collisions are very likely. In a similar way, the relationship was assessed in other clusters, and the results were interpreted accordingly.

Through this study, it was found that certain types of crashes were more common in specific road environments. Furthermore, unique relationships were identified for the same intervention in different environments with respect to crash types; that is, the effectiveness of safety interventions was found to vary across road environments. The outcomes of this study will be helpful to road agencies managing highway infrastructure, as it demonstrates how road segments with similar characteristics can be clustered and how the effectiveness of interventions can be assessed for different road environments. This methodology is believed to be generalizable and can significantly reduce the work effort of road agencies, as similar safety interventions can be proposed for segments within a cluster. In addition, the effectiveness of interventions in different road environments derived from this analysis can be directly related to other analyses.

Effectiveness of Gradual Incremental Thickness Parabolic Cold Plastic Transverse Bar Marking and Coloured Signage: A Study on Speed Reduction and Enhanced Driver Awareness

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Keywords: Road Safety, Coloured Road Surfacing, Transverse Bar Markings, Cold Applied Plastics, Traffic Management.

Introduction

Road safety is a pressing global concern, with approximately 1.19 million lives lost annually due to road traffic accidents. Excessive speed is a major contributor to these accidents, and managing speed is crucial for reducing fatalities. Traditional thermoplastic road markings have limitations in durability and effectiveness, leading to the need for more innovative solutions. This study focuses on the integration of transverse bar markings (TBMs) and coloured road surfacing using cold-applied plastic material to enhance road safety and traffic management.

Objective

The primary objective of this study is to evaluate the effectiveness of cold -applied plastic TBMs and coloured road surfacing in reducing vehicle speeds and enhancing driver awareness. The study aims to compare the performance of cold-applied plastic materials with traditional thermoplastics and assess their suitability for various traffic management applications.

Methodology

The study involved practical implementation at an accident-prone area on the Nagpur–Amravati Highway. TBMs of varying thicknesses (5 mm, 10 mm, 15 mm, and 20 mm) were installed using cold -applied plastic material. Coloured road surfacing was applied for horizontal speed limit signage and pedestrian crossings. Spot speed measurements were conducted using a Dragon Eye Compact Speed Lidar, and distance measurements were taken with a Stanley rodometer. The durability of the markings was evaluated over a period of two years.

Key Findings

a) Cold-applied plastic TBMs demonstrated superior durability and effectiveness compared to thermoplastics, providing consistent auditory and tactile feedback to drivers.
b) The implementation of TBMs with varying thicknesses effectively reduced vehicle speeds, with thicker markings achieving greater speed reductions.
c) Coloured road surfacing enhanced visibility and served as a visual cue to break driver monotony, improving road safety, especially at night.
d) Speed reduction was recorded in the range of 35%–55% across all categories of vehicles, and sustained sight distance was maintained at twice the threshold limit.

Recommendations

Based on the findings, it is recommended to use cold-applied plastic materials for TBMs and coloured road surfacing in traffic management strategies. These materials offer better durability and visibility, making them suitable for both urban and highway applications. The study suggests that TBMs of varying thicknesses can be strategically used to achieve different levels of speed reduction and driver alertness. Additionally, coloured road surfacing can be applied to enhance visibility and safety at critical locations such as intersections and pedestrian crossings. The spacing and thickness of TBMs should be determined based on site conditions and in consultation with relevant agencies.

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CLINICAL, PERSONAL, SOCIAL AND PROFESSIONAL CONSEQUENCES OF ROADTRAFFIC CRASHES IN NEPAL: A REVIEW OF PAINFUL STOREIS BEHIND AND AFTER EXTREMITY AMPUTATION

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ABSTRACT AND KEYWORDS INTRODUCTION:

Road traffic crash (RTC) is a significantly alarming health issue in developing countries such as Nepal, accounting for a disproportionately high number of fatalities and injuries worldwide. It is a leading public health problem.[1] According to the World Health Organization, more than 1.3 million people die annually due to RTCs, with over 90% of these fatalities occurring in lo w- and middle-income countries.

RTC is the most frequent cause of death among individuals below 40 years of age. This age group represents the most productive segment of the population for both family and nation. A direct impact on this group often shatters career prospects, personal life, and social well-being of victims, as frequently observed in clinical practice.

According to the National Road Safety Councilof Nepal, road accidents are the 10th leadingcause of death in the country. Mo re than 2,400 people lost their lives in road crashes in 2017/18, and over 2,700 in 2019/2020. From July 2014 to July 2019, a total o f 54,000 road accidents were recorded in Nepal, resulting in approximately 12,000 deaths, predominantly among individuals aged 15 –40 years. On average, 40 people are injured on roads across the country each day.

With increasing vehicular traffic, morbidity related to severe lower limb injuries from high-velocity collisions has risen.[3] Extremity amputations have become increasingly common following such accidents. This paper reviews recent publications and clinical experience from high-volume trauma centers regarding upper and lower limb amputations following RTCs. Limb amputation has profound effects on personal life, professional capacity, and financial stability. This review aims to highlight these aspect s.

Methodology

This is a review paper focusingon below-knee andbelow-elbow amputations resulting from road traffic crashes, with emphasis on clinical, personal, social, and professional consequences following limb loss.

Primary outcome parameters considered include psychological stress, risk of infection, duration of hospital stay, and time to recovery. Secondary outcome parameters include theimpact on family life and career prospects. Both primary and secondary outcomes are based on subjective observations from a clinician’s perspective.

As this is a review study and no direct patient data were used, ethicalclearance was not sought. Identities in any photographs are not disclosed. Clinical images are included solely to help recognize, comprehend, and visualize the consequences following RTCs. Statistical analysis was not performed.

Results and Discussion

Following RTCs, severe injuries with compromised vascular status significantly increase the likelihood of amputation. One of the major factors influencing the decision between limb salvage and amputation is the time taken to reach a specialized trauma center and the availability of vascular services. However, in Nepal, delayed presentation is common, often resulting in non -viable limbs. The first six hours following RTC are considered the “golden hour,” during which vascular repair is most effective.

A study from a high-volume trauma center in Nepal reported that 13.86% of patients with lower extremity long bone fractures admitted to a high-dependency unit underwent amputation.[4] One major concern that remains insufficiently addressed following RTCs is psychological stress. The immediate and long-term mental impact of limb loss is profound. Amputation of the dominant upper limb, particularly in right-handed individuals, is especially devastating (Figure 1).

Although advanced prosthetic options are available globally and can provide excellent functional outcomes, such prostheses a re not readily accessible in Nepal. Even when available, the cost is prohibitively high for most families.

Primary amputation was performed in approximately 15% of patients as the initial procedure in cases of lower limb fractures associated with vascular injuries.[3] Management of such injuries is prolonged and often requires multiple surgical interventions. Wounds are typically left open following amputation, increasing the risk of infection. Serial debridement, irrigation, and wound care a re required prior to definitive closure. These prolonged treatments impose additional financial burden and negatively affect personal well-being, social life, and professional growth. Family expectations often decline, and when the injured individual is the primary bread winner, the entire family structure m a y be severely disrupted.

Conclusions and Recommendations

A high incidence of upper and lower limb amputations following RTCs is observed in Nepal. Psychological stress, multiple surgical procedures, prolonged hospital stays, and extended recovery periods have long-term negative consequences for affected individuals. These outcomes significantly impact career development, family stability, and financial security.

Most RTCs are preventable. Adherence to traffic rules, disciplined driving behavior, and increased public awareness can prevent a substantial proportion of these injuries and amputations. Public education and road safety enforcement are crucial to reducing the burden of severe RTC-related injuries.

Keywords

Amputation, Limb, Road Traffic Accidents

Private Partnership in Road Safety Infrastructure: Needs and Opportunities

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Abstract

This paper explores the role of Public-Private Partnership (PPP) in enhancing road safety related infrastructure and services in Nepal, drawing on findings from the Needs Assessment Report for the Nagdhunga Naubise Mugling (NNM) Road and Kamala Dhalkebar Pathlaiya (KDP) Road. The study evaluates the application of PPPs in road safety management with focus on road infrastructure and vehicle inspection services, post -crash care, and enforcement operations. By examining global best practices and assessing Nepal's legal and institutional framework, this paper highlights the opportunities and challenges in implementing PPPs for road safety. Potential PPP projects in road safety are identified and most suitable, moderately suitable and less suitable projects are recommended.

Keywords

PPP, PPPI, PPA, Vehicle Inspection, Road Worthiness

Background

Road safety is a critical concern in Nepal, with increasing road crashes leading to severe socio- economic impacts. Despite efforts from government agencies such as the DoR, DoTM, and Traffic Police, infrastructural Limitations and financial constraints hinder effective road safety management. PPPs offer a viable alternative to address some of these challenges by leveraging private sector investment and expertise.

Methodology

The literature review focuses on the global and regional experiences in the application of PPPs in road safety, referencing studies on PPP financing, risk-sharing mechanisms, and institutional frameworks. Key international case studies, such as India's emergency response services and Australia's vehicle inspection PPP models, provide insights into potential applications in Nepal. Additionally, legal instruments such as the Public Private Partnership and Investment (PPPI) Act, 2019 and the Public Procurement Act (PPA), 2007 are reviewed to understand the enabling environment for PPPs in Nepal. A number of projects on roadside infrastructure and services, post - crash response and care and enforcement operations front are identified and these projects are assessed in terms of their legal requirements, institutional capacity for implementation, revenue stream, bankability and risk sharing mechanism to determine their applicability. Their applicability is categorized into three major groups: most suitable, moderately suitable, and less suitable in the current investment environment of the country.

PPP Applications in Road Safety Management

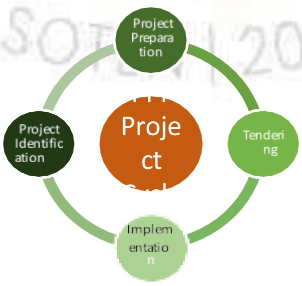

Figure 1: Scale of Strength and Applicability of PPP Project Cycle

The study has identified that Roadside Infrastructure and Refreshment Centers, Heavy Vehicle Driving Schools (for buses and trucks), Tow Truck Licensing Schemes, and Towing and Salvaging Services are most suited for implementation under the PPP model and can proceed to the Pre- Feasibility Stage (PFS). Additionally, if amendments to the Motor Vehicle and Transport Management Act is occurred, Vehicle Inspections and Roadworthiness Certifications could be included in the list of most suitable PPP projects, given their potential for revenue generation, bankability, and risk-sharing mechanisms. Furthermore, the Trauma Hospitals and Healthcare sector, currently classified as a moderately suitable PPP project due to bankability challenges, could achieve greater feasibility for road safety management with appropriate financial and structural enhancements. Processing of traffic offences, operation and maintenance of enforcement equipment, traffic controller accreditation scheme and emergency telephone booth services are less likely to be suitable for PPP applications.

Legal Constraints

The Public Private Partnership and Investment Act 2019, could serve as a foundational framework for PPP infrastructure projects and services in Nepal. However, the Public Procurement Act, 2007, does not define PPP mechanisms, leading to legal ambiguities in public procurement processes. Additionally, the absence of clearly defined PPP-procurement prerequisites within the PPPI legislation can adversely impact project implementation.

Conclusion

PPPs present a viable option for addressing road safety infrastructure gaps in Nepal. By learning from international best practices and strengthening the legal and institutional framework, Nepal can leverage private sector participation to improve road safety outcomes. Further studies and pilot implementations are essential to refine the model in the road safety sector, particularly if the government lacks sufficient financial or technical capacity to deliver the required infrastructure and services.

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NEW ACCELERATED SETTLEMENT SYSTEM TO AVOID 'BUMP' AND APPROACH SLABS IN ACCESS TO BRIDGES ANDCULVERTS

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Abstract

The transition from embankments to bridges and culverts commonly produces a "bump" due to differential settlement between the incompletely consolidated embankment soils and the stable foundations of the bridge or culvert. This issue has long been a challenge in road construction, causing discomfort and hazardous conditions, particularly for high -speed traffic. Traditional solutions, such as approach slabs, aim to mitigate settlement problems but are expensive and require ongoing maintenance because they cannot effectively accommodate long-term settlement.

This paper presents a new accelerated settlement system that eliminates the need for approach slabs by consolidating natural embankment soils within just three weeks. The method is environmentally friendly and economical, requiring no heavy machinery or specialmaterials. By reducing material usage and maintenance costs and shortening the time required for soil compaction, the system enables a smoother and safer transition from embankment to bridge or culvert.

The technique is particularly valuable for road development in resource-constrained regions such as Asia, Africa, and South America, where budgets are limited and even female workers m a y participate in construction. This approach offers a sustainable, efficient, and cost-effective method, enhancing infrastructure quality while generating significant time and cost savings

Keywords: Accelerated settlement, embankment transition, approach slab, road construction, sustainable infrastructure.

Introduction

One of the most common challenges in road construction occurs at the junctions of embankments and bridge structures, where differential settlement often leads to the formation of a "bump." This occurs due to contrasting compaction levels: embankments are composed of soils that have not fully settled, whereas bridge foundations are typically supported on well-compacted soil or deep-pile foundations.

Traditionally, approach slabs—concrete structures laid between the embankment and the bridge—have been used to create a smooth transition. However, these slabs often fail to accommodate long-term settlement occurring over several years, leading to frequent and costly repairs. This paper therefore proposes a novel method that accelerates natural soil settlement, consolidating the embankment in a shorter period and eliminating the need for approach slabs entirely.

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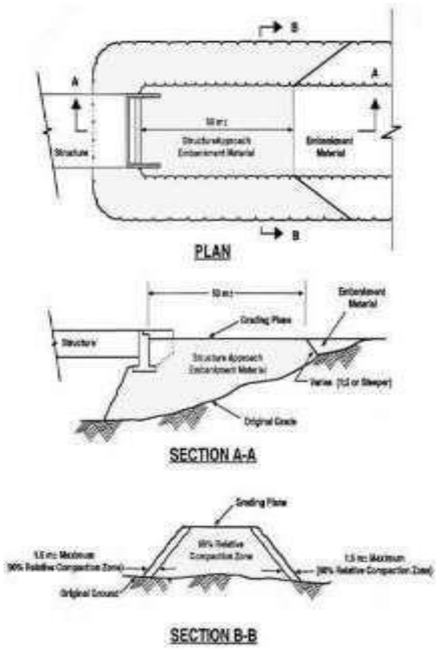
Figure 1, Plan and Section of approach structure



The proposed methodology makes use of the capillary action of water to accelerate the natural process of consolidation. Water applied to the embankment will seep downwards into the soil, with a consequent settlement induced by capillary forces. This principle is observed on beaches where, at low tide, the sand becomes firmer and capable of carrying heavy loads, such as vehicles. This phenomenon has been utilised to successfully accelerate the settlement of soils, and a 10% reduction in embankment height was achieved in one week.

LITERATURE REVIEW AND METHODOLOGY

Traditionally, road construction took a course of selected soils to support pavement and enhance durability. The thickness of the soil layers supporting the pavement is very important for long-term durability. In England, during the 19th century, embankment roads were at least one meter in thickness to a void softening of the original soils by water action, especially when the bearing soils were granular or sandy, or even clayey.

Even with mechanical rollers, embankments seldom reach 100% consolidation during initial construction. Full compaction usually takes several wet and dry seasonal cycles, a process that could be as long as 10 years, especially in states with poor soil conditions.
In Southeast Asia, particularly along the Asian Highway 2, engineers have faced similar challenges, especially in embankment construction near bridges and culverts. Engineer Jose's work in Nepal draws on his early education in Spain, where he studied the capillary properties and surface tension of water. These physical properties are at the very heart of the proposed system, which relies on water as an accelerant of embankment settlement.

RESULTS AND DISCUSSION

Historically, road construction relied on the selection of soils that could bear the pavement and provide a longer life to the roads. In early 19th-century England, embankments were ma de one meter thick to prevent the water- induced softening of the soils. Even with compaction methods, it is well documented that embankments often suffer from long-term settlement, usually requiring several cycles of wet and dry seasons for full consolidation.

It is the continuous settlement that even the approach slabs cannot guarantee comfort to drivers, especially when a settlement a s low a s 5 cm lea ds to a bump. This is all the more risky at high speeds a nd hence safety issues become a concern along with discomfort to the users. As a rule, flexible pavements like asphalt can allow for differentia l settlement due to their flexibility and adjustment without developing any cracks. However, the inflexible pavements like cement concrete tend to develop cracks due to differentia l settlement and often need costly repairs.

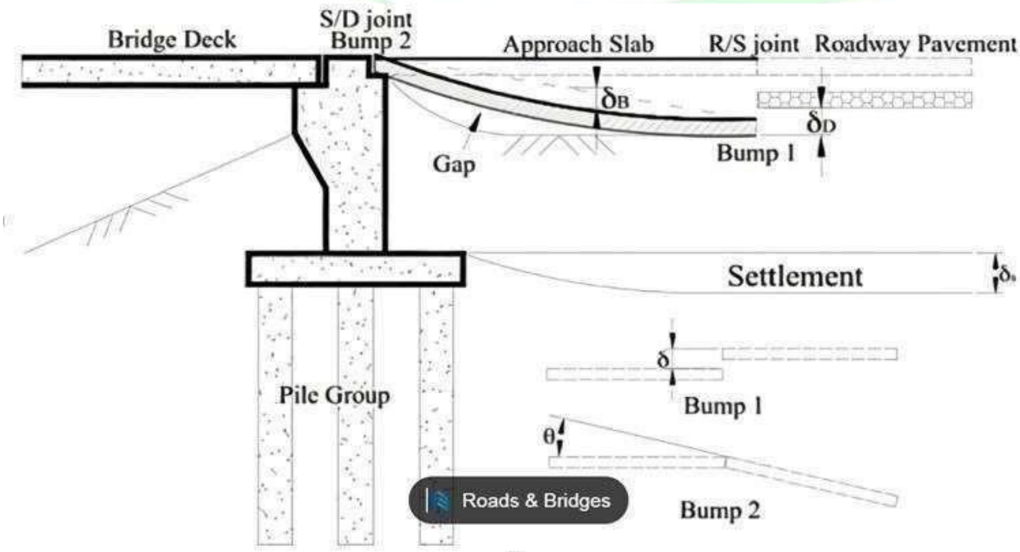


Figure 2 Illustration of approach Slab and its interaction with Soil

The accelerated settlement method proposed in this research will avoid the conventional approach slabs by exploiting inherent characteristics of water. By creating small water-holding "bunds" or barriers around embankments near bridges and culverts, the accelerated settlement process can be achieved as short as three weeks. It requires no heavy machinery, special materials, and massive labor forces, hence it is very cost-effective and environment-friendly. Trials at the onset in Nepal showed this method highly reduced both time and cost of achieving desired embankment settlement with the recorded settlement rates of up to 10% within one week.

PROPOSED SOLUTION: ACCELERATING SETTLEMENT

The new system proposed in this research accelerates embankment settlement by using natural properties of water. Local labor, more precisely female labor, is utilized to construct the small "bunds" or barriers holding water around the embankment area. These bunds help maintain the required water levels and, hence, the capillary action responsible for accelerating the soil consolidation. Water tankers are utilized to replenish water to the required level in the area. This ensures that the embankment undergoes the accelerated settlement process within three weeks.

This approach not only accelerates settlement but also furthers gender equity in construction, to meet the criteria set by multilateral funders such as the Asian Development Bank, which call for 30% of the workforce on construction projects to be women. Construction projects using this methodology go a step further in helping to empower women in developing countries to meet a key infrastructure challenge.

Initial trials carried out in Nepal have been promising, showing that the system is effective in reducing the settlement time, with the additional advantage of eliminating approach slabs. It is a low-cost technique using very minimal materials; it is also environmentally friendly compared to other conventional methods.

CONCLUSION AND RECOMMENDATIONS

Differential settlement of transition embankment-bridge has always been a problem in road construction and is traditionally solved by installation of approach slabs. However, the proposed Accelerated Settlement System offers a very cost -effective and eco-friendly solution that does not involve approach slabs. It takes advantage of capillary properties of water to very significantly accelerate consolidation of soil to achieve the required settlement in weeks instead of years.

This system is all the more adapted for developing countries, which, besides using locallabor and also an opportunity for la dies to be employed, offers much more viability for road construction. Trials in the early stages in Nepal proved promising, and further optimization of this method may perhaps lead to wide-scale use in areas that face similar challenges in road infrastructure development.

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STUDY ON MAKING PATAN DURBAR SQUARE A PEDESTRIAN AND CYCLE FRIENLDY AREA

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Abstract

Mangal Bazar, a historic urban center in the Kathmandu Valley, serves a s a vital cultural and commercial hub but faces challenges such a s traffic congestion, air pollution, and pedestrian safety concerns. This study, conducted by the Nepa l Cycle Society (NCS), explores strategies to transform Mangal Bazar into a pedestrian- and cycle-friendly area, emphasizing sustainable mobility solutions and enhanced urban livability through better use of open space. The research examines existing mobility patterns, the socio-economic impacts of pedestrianization, and the role of cycling infrastructure in improving urban connectivity. Employing a multidisciplinary approach, the study incorporates stakeholder consultations, spatial analysis, and case studies of successful pedestrianization projects in similar heritage sites. It underscores the importance of integrated transport planning, reallocation of road and parking space, and policy recommendations to reduce vehicular dominance in dense urban environments. Community participation is a key aspect, ensuring that mobility solutions align with local needs and priorities. Findings suggest that pedestrianizing Mangal Bazar can significantly enhance urban resilience by improving air quality, fostering economic vibrancy, and promoting cultural tourism. The study also discusses potential challenges, including resistance from local businesses and the need for well-planned alternative transport options. Policy recommendations include developing cycling infrastructure, establishing pedestrian-priority zones, and implementing traffic management strategies that balance heritage conservation with urban mobility needs. By demonstrating the benefits of walkability and cycling, this research contributes to the broader discourse on sustainable urban development in historic city centers and offers insights for replicable models in other South Asian contexts.

Introduction

Lalitpur Metropolitan City (LMC) is renowned for its art, culture, and rich heritage, with numerous monuments, temples, and religious activities that keep the city's cultural roots alive. Over time, however, the area has become overcrowded with a large number of vehicles, disturbing the peaceful environment and diminishing the value of narrow streets that were originally intended for walking and cycling. These narrow streets around the heritage areas were not designed for vehicular traffic. Therefore, protecting heritage zones—especially Patan Durbar Square, which was inscribed as a UNESCO World Heritage Site in 1979—has become increasingly important.

The major objectives of this research were to envision traffic flow patterns that enhance walkability and cycling; to propose suitable locations for two-wheeler and four-wheeler parking to minimize noise and air pollution around the Patan Durbar Square area; to propose street furniture and cycle stands in and around the Durbar Square; to recommend intervention and tactical urbanism measures for project implementation; and to identify community issues and opportunities and propose appropriate recommendations.

Methodology

A mixed-methods (concurrent mixed-methods) research design was adopted, involving the collection of both qualitative and quantitative da ta , integration of the two data forms, and the use of distinct designs that incorporate philosophical assumptions and theoretical frameworks. The core assumption of this approach is that combining qualitative and quantitative methods provides a more comprehensive understanding of a research problem than either approach alone (Creswell, 2014).

The study employed surveys with 181 respondents, seven key informant interviews, field observations, and focus group discussions.

Results and Discussion

The study addressed major challenges such as traffic congestion, illegal parking, and conflicts between pedestrians and vehicles in the narrow streets of the Patan Durbar Square area. The research highlighted the importance of community involvement as a critical factor, along with strict parking regulations and alternative transportation solutions —such as electric trolleys—to ensure the long-term success of the initiative.

The research area was divided into three phases based on spatial coverage:

- Phase 1: 200-meter radius with Krishna Temple as the midpoint around Patan Durbar Square
- Phase 2: Expansion to a 400-meter radius

- Phase 3: Further expansion to an 800-meter radius

Survey findings indicated that more than 50% of respondents found parking around the Mangal Bazar area inconvenient. Most respondents primarily used motorbikes or scooters to access the area. Regarding walkability and cycling comfort, 41% of respondents rated conditions as average, while 37% considered them uncomfortable. More than 50% of respondents believed that expanding the pedestrianization and cycling-friendly area around Mangal Bazar is important. Many respondents also expressed willingness to shift to alternative modes of transportation such as walking or cycling if traffic flow in Mangal Bazar were optimized.

Conclusion and Recommendations

The addition of benches, cycle stands, and trash bins around Mangal Bazar was identified as very important by many respondents. Focus group discussions revealed that parking management is the most significant issue for the local community. Currently, parking is managed informally by community members, but long-term sustainability requires support from local government. Suggested measures included implementing a one-way traffic system, enforcing no-parking zones, restricting four-wheeler entry from 8 a.m. to 8 p.m., and creating children’s play areas in public spaces. Most community members around the Mangal Bazar area support a vehicle-free approach, provided that local parking priorities and access-pass systems for residents are addressed. As a renowned heritage area with narrow roads and active religious practices, Mangal Bazar inherently supports pedestrianization through vehicle restrictions around heritage zones. However, effective implementation requires close collaboration with local communities to address their needs and concerns and to successfully create a vehicle-free environment around the Mangal Bazar area.

Keywords: Pedestrianization, Vehicle-Free, One-Way Traffic, Cycling, Walking, Cultural Heritage, Transport Policy

STUDY OF OPERATIONAL PERFORMANCE OF PUBLIC TRANSPORT SERVICE IN KATHMANDU VALLEY

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[1] *Senior Transportation Engineer, Engineering Centre Nepal P. Ltd.; Co-chair of Advocacy Sub-committee and Former Secretary of SoTEN*

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Abstract:

Public transport service in Kathmandu is fully road based and operated majorly by private operators. A survey conducted for the quantification of the service and the study of its operational performance revealed that the public transport in Kathmandu has a remarkable coverage quantitatively but it lags behind in many aspects in terms of the quality of service. Two third of the users feel the service is does not render the basic comfort. The system suffers from the inadequate routes for accessibility as well as low operating speed for the user's sufficient mobility perspective. Though the ridership is impressive as seen from the higher average occupancy, the financial performance of the operators is not satisfactory because of the fierce competition among the operators. The fleet ownership and the route structure has been the major culprit for the suboptimal service and root of inefficiency through the unregulated competition and lack of standardization in the service among the operators. A systemic reform including the restructuring in the fleet ownership, rationalization of routes and competitive route permit system is recommended for operational efficiency. A strong regulatory mechanism is envisaged for immediate departure.

Keywords: Public Transport, Operational Performance, Kathmandu

Introduction:

Kathmandu Valley, home to over 3 million people, is the capital city and economic hub of Nepal. Rapid urbanization, population growth, and increasing vehicle ownership have exerted immense pressure on the valley's transport system. Public transport, primarily operated by private companies and informal networks, serves as the backbone of daily mobility for a significant portion of the population. However, the public transport system is often complained of the suboptimal operation leading to user dissatisfaction and operational inefficiencies. This study aims to assess the operational performance of public transport service in Kathmandu Valley, identify key challenges, and propose actionable solutions.

Methodology:

The study needed a database regarding the routes, operators and vehicle fleet of the public transport service in Kathmandu valley. As there is no such database maintained by any government agencies, primary data of such were collected interviewing the public transport operators and their associations for the route wise service. With the collected primary database, the public transport supply and the service was quantified with systematic calculation and analysis.

Primary field surveys were conducted to get the information of various operational features of the public transport operation. The field data were collected by conducting four types of surveys separately using the web based Epicollect5 forms and its mobile app.

On-Board Boarding Alighting Survey was conducted to trace the instantaneous occupancy in the vehicles. It was conducted in 44 randomly selected vehicles along the 24 major routes in the peak and off peak hour. The surveyors recorded the boarded and alighted passengers in the terminal and intermediate stops in the app. The net passengers in the vehicles in each stops were compared against the total seating capacity of vehicles to get the occupancy.

On Board Users Perception Survey was conducted on board to trace the satisfaction level of public transport usage for the users. 500 road users were interviewed for their trip making habits and their individual perception regarding the travel time, route comfort, vehicle punctuality, driving behavior, staff behavior, boarding comfort, vehicle cleanliness and overa l travel comfort. The questions were asked to respond on the scale of good/fair/poor for them. Time to reach the stop and waiting time at the stop were asked for accessibility analysis and vehicle availability inference.

Vehicle Speed Survey was conducted in 9 routes in different time of public transport operation. The survey was conducted by travelling in the vehicle with smartphone equipped with GPS application. The GPS application was turned on as the vehicle starts the trip from the terminal and turned off at the destination terminal. The travel distance and time are also captured by the application. The journey speed and moving speed of vehicles were later calculated and also cross-verified with the values determined in GPS logs.

Drivers Interview Survey was conducted for the collection of information of vehicles, daily trips pattern, experience of the drivers and financial performance of daily vehicle operation. The drivers were considered for the survey as they know every aspects of the operational and financial information of public transport operation and easily met for the surveys. In this study 135 different vehicle drivers were interviewed about the service operation and the general financial information of the operation.

Results:

Kathmandu valley's public transport system is composed of at least 132 public transport routes totaling 2700 Km in length being served by at least 46 different operators operating bus, minibus, microbus and tempo to form a total fleet of 5260 public transport vehicles. The public transport supply is estimated to be 617,637 vehicle-km and provides the service output of 12,389,003 passenger- km in daily basis. The coverage can be considered as a good one quantitatively but there are many issues with the quality of service.
The sample survey indicated that the public transport in Kathmandu has impressive ridership with 90% average occupancy in the vehicles but average speed of the public transport vehicles remains as low as 13.5 kmph. The accessibility analysis indicates that about 45% of the people have to walk more than 10 min to reach nearby bus stops indicating an imperfection in the route planning.

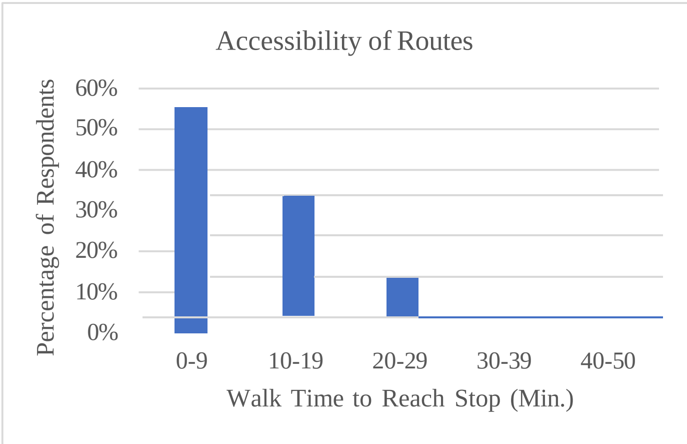

Figure 1 Accessibility of the Public Transport Routes and Stops

The user's perception survey indicates that about two third of the total service users feel the overall service as not good i.e. either fair or poor, indicating a large room for improvement.

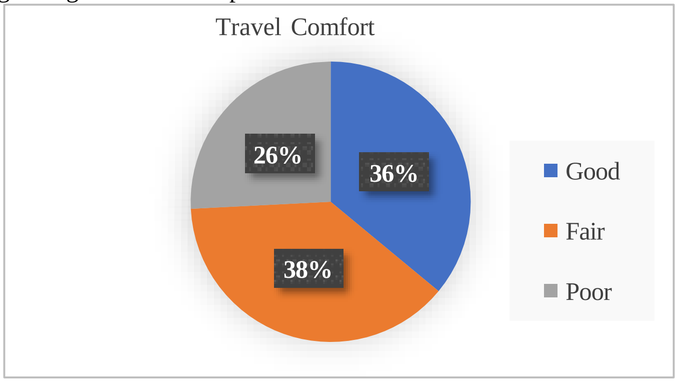

Figure 2 Overall Travel Comfort Perceived by the Public Transport Users

The survey revealed that 50% of the vehicles age more than 17 years and 19% of the total fleet already crossed 20 years' legal age bar yet operating on roads.
Out of the service providers, only 15% of them have corporate ownership of vehicles which makes up 8% of total vehicle fleet. Remaining large share of the fleet has the individual ownership with 1 or 2 vehicles owned by a person in most of the cases.

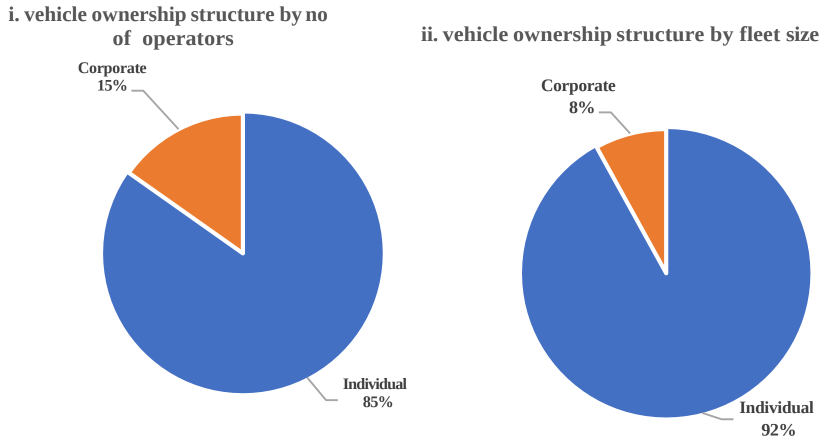

Figure 3 Ownership Structure of Public Transport Vehicle Fleet

Financial analysis of the operator's expenses and revenue reveal the average profit as low as of 9.4% which coupled with user's perception survey can be concluded that the private operators are serving with minimal profit that too extracted at the cost of the quality of service.

Conclusion:

Public transport service in Kathmandu is highly fragmented and uncoordinated leading to significant inefficiencies and user's dissatisfaction. The fleet ownership and the route structure has been the major culprit for the suboptimal service and root of inefficiency through the unregulated competition and lack of standardization in the service among the operators. A systemic reform including the restructuring in the fleet ownership, rationalization of routes and competitive route permit system is recommended for operational efficiency. A strong regulatory mechanism is envisaged for immediate departure. A major intervention is required to frame the regulatory and management system to reform the existing public transport towards a sustainable transport system conducive for the socio-economic upgrade of the region.

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Podway as new and alternate technology and its possibility in context of Nepal

Paribesh Parajuli

Abstract

Podway solutions are based on the technology of creating pre-stressed transport overpasses (elevated transport) of a new generation, where the string rail is a key element. Such a rail is a steel or composite beam containing, in its core, a bundle of wires (strings) pre-stressed by tension and equipped with a rail head, along which passenger and cargo electric vehicles on steel wheels—Pods—move automatically at speeds of up to 150 km/hr (up to 500 km/hr in the future). Steel wheels have independent suspension with a cylindrical wheel-supporting surface and a flat rail working surface, achieving 99.8% efficiency with no slipping at the contact patch. This results in insignificant contact stress (about 200 MPa), minimal wheel rolling resistance, and symmetrical rail head wear.

The string rail does not have joints or temperature seams, providing comfortable and smooth operation even at high speeds, while consuming minimal material during production. The Podway (uST) transport overpass is resistant to frost (up to −60 °C), heat (up to +60 °C), snowdrifts, river floods, earthquakes, storm winds, tsunamis, and other extreme impacts, including vandalism and terrorist attacks, if such incidents are considered in the project with a probability of “once in 100 years.” The design of the string rail overpass makes it possible to lay routes along shorter trajectories. Due to long spans between supports—up to 2 km—the route can cross water bodies or difficult terrain without additional structures. This shortens travel distance, reduces construction costs, and lowers operating expenses. Production of rolling stock —steel-wheeled rail electric vehicles—requires low consumption of structural materials. The absence of massive drives, heavy frames, undercarriages, and wheel pairs significantly reduces production costs. The service life of the overpass before overhaul starts at 50 years, while rolling stock has a service life of 25 years.

The main advantages of Podway include availability, adaptability, safety, and environmental friendliness. It can be implemented in areas with difficult terrain, weak and permafrost soils, earthquake -prone regions, and flood zones. Its infrastructure can be integrated with external communication, electrical, and information networks, and constructed over existing residential, industrial, and communication infrastructure. Additionally, it is adaptive to variations in passenger capacity and traffic intervals based on peak and off-peak demand.

High energy efficiency is ensured by the aerodynamic design of Pods, steel-rail movement, and low resistance due to the absence of hysteresis losses in elastic wheel elements. This enables minimal operating costs. When using flexible track structures, gravitational forces can assist Pod acceleration on descents between adjacent supports. On long stretches, Pods c an accelerate up to 150 km/hr using minimal electricity, further reducing energy consumption.
As the string rail overpass is elevated, collisions with other vehicles, pedestrians, or animals are impossible. Environmental friendliness is achieved through low material consumption, minimal land acquisition, electric operation with low energy demand, and elevated vehicle movement. These features allow Podway Transport and Infrastructure Complexes to operate even in regions with stringent environmental requirements.

Pods are available in five passenger types, ranging from 2 -seaters to 42 seats, with maximum speeds of 150 km/hr. Cargo Pods include truck units (up to 10 tons) and container units (20 - and 40-foot containers, up to 50 tons). For long-distance passenger transport, uFlash Pods can travel up to 500 km/hr. Pods can be coupled as required. Podway (uST) Transport and Infrastructure Complexes can transport up to 50,000 passengers per hour with minimal operating costs, enabled by high speeds and traffic intervals as short as 20 seconds. Automation, energy efficiency, and minimal maintenance staffing significantly reduce the payback period of the system.

Podway is an Automated Transit Network (ATN) transportation technology that provides clean transport without traffic congestion or air pollution. While most ATN projects worldwide remain at Technology Readiness Levels (TRL) 1 –3, Podway technology—developed through more than 40 years of research—has reached TRL 9 and is safety certified, contributing to the achievement of United Nations Sustainable Development Goals.

Podway would be well suited for implementation in Nepal to support the development of transportation infrastructure in urban, suburban, and mountainous hilly areas at comparatively lower costs than existing transportation systems. This mode of transportation is both cost-effective and efficient when compared to conventional transport systems.

Transport Insights from the TRL Smart Mobility Living Lab

Robin Workman, TRL

The **Smart Mobility Living Lab (SMLL)** is a London-based, real-world connected environment for testing and developing future transport and mobility solutions. The testbed serves as a facility for advanced real-world testing, enabling stakeholders to examine the entire connected environment and develop market -ready Connected and Autonomous Vehicle (CAV) technologies, services, solutions, and business models. SMLL is located in the Royal Borough of Greenwich and the Queen Elizabeth Olympic Park in London, providing a complex, uncontrolled testing environment that interacts with live traffic and other road users. London represents an ultimate proving ground due to its challenging layout and transport systems, which reflect conditions found in many towns and cities; if solutions work here, they are likely to work anywhere.

The testbed is designed to demonstrate and evaluate the use, performance, environmental impact, safety, and benefits of connected and automated mobility technologies and future transport services.

SMLL began as a project in 2018 to establish the facility and was part-funded by industry and the UK Government through the Centre for Connected and Autonomous Vehicles (CCAV) and Innovate UK. It was designed and built by a consortium comprising TRL, Cisco, DG Cities, London Legacy Development Corporation (LLDC), Cubic, Loughborough University, and Transport for London (TfL). Today, the facility is fully owned and operated by TRL, with client services delivered in conjunction with DG Cities and LLDC. TRL is responsible for operating, maintaining, and successfully running the facility until 2030.

The facility is primarily used to test CAVs, which integrate digital technologies with automated systems to assist or replace human drivers. These vehicles use sensors and cameras to interpret their surroundings and maintain continuous connections to the internet, GPS tracking systems, and telecommunications networks. This connectivity enables vehicles to make independent driving decisions and control movements through actuators linked to the vehicle's driving systems. CAVs have the potential to play a significant role in traffic management by reducing congestion, improving air quality, and decreasing crash rates. The Centre for Connected and Autonomous Vehicles supports the safe trialling of prototype automated vehicles on UK roads and ensures that the UK remains a preferred global destination for CAV testing.

Self-driving vehicles are expected to be deployed on UK roads by 2026, following the enactment of the Automated Vehicles (AV) Act. The AV Act enables advanced technologies to operate safely on British roads, positioning the UK at the forefront of self-driving vehicle regulation. The legislation has the potential to unlock an industry valued at up to £42 billion and create approximately 38,000 skilled jobs by 2035. Road safety is central to the Act, as automated vehicles are expected to reduce collisions by minimizing human error, which accounts for approximately 88% of road crashes. SMLL supports industry by identifying how different types of infrastructure can facilitate CAV operations and by understanding the requirements of specific applications. Its monitoring facilities provide a rigorous and comprehensive external perspective that cannot be achieved through in-vehicle systems alone. The lab is equipped with more than 150 cameras, numerous sensors, video analytics, and Intelligent Transport Systems (ITS). SMLL can also provide CAV test vehicles to assess the performance of existing and planned infrastructure and to refine infrastructure design. The programme works closely with experts from academia and industry to enable the safe development and deployment of CAV technologies. This presentation explains and demonstrates the capabilities of the Smart Mobility Living Lab, raising awareness of CAV development, real-world testing methodologies, and monitoring approaches for both vehicles and the infrastructure they rely on.

Developing a Sustainable and Resilient Public Transport System for Kathmandu Valley

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Extended Abstract:

Kathmandu Valley has witnessed rapid urbanization and transformation. Rural-urban migration and available economic opportunities are the main drivers of urban growth. There has been growth in frequency and intensity of climate events that has impacted planning and operation public transport systems. Availability of clean energy is encouraging transition to electric mobility. The presentation outlines the existing situation of urbanization and reviews various efforts to improve public transport systems. Kathmandu Valley boasts many narrow streets, combination of public buses, minibuses, and popular electric tempos provide public transport services.
Despite many studies, the Valley is yet to develop a mass public transit system. Leadership, long term vision and policy, institutions and financing are seen as main challenges. Competing interest in institutions and power structure has led to challenges for implementation of National Transport Policy that includes development of a comprehensive mass transit system in the Valley. It will also present some case of improvement of public transport in other Asian cities. An urban transport authority has been created but again it is yet to take shape and start to function. The presentation will highlight some policy options to develop sustainable and resilient urban public transport in Kathmandu valley. Coordination of efforts and exploring new models of project financing could transform public transport and Kathmandu Valley as a sustainable, clean, green, and healthy city.

Using Innovative Technologies for National Road Condition Reporting

Robin Workman, *TRL*

National Highways in England has developed a new specification for the collection and reporting of road condition data, PAS2161, with the assistance of TRL. This marks a pivotal change in condition measurement of local road networks. The PAS2161 standard will enable local authorities to innovate and achieve efficiency in data collection by specifying what road condition monitoring (RCM) data should be collected for national reporting, but without specifying the technologies to be used for collecting the data. PAS2161 allows Local Authorities a greater range of choice in the technologies they can use to collect road condition data. This is intended to open the possibilities of exploiting new condition assessment technologies as they become available and affordable.

TRL are currently undertaking trials to establish an accreditation scheme for new technology providers to demonstrate the performance of their technology. These trials will compare the RCM data reported by new technology providers with benchmark data collected by a group of local authority engineers who will visually assess the road condition using established procedures. Successful technologies will be awarded the status of 'demonstrated', meaning that their technology can be used for national reporting of road condition. The trials are being held in three Local Authorities (LA) in England; Liverpool, Essex and Cumberland. These LAs were selected to provide a range of road types, conditions, rural and urban networks, climatic and geographical environments for the trials. The process involves establishing test sites and benchmark data for assessing RCM technologies, and the role of calibration as a method to improve consistency will also be incorporated. It is expected that the process will enable innovative uses of Big Data, Artificial Intelligence and Remote Sensing for road condition assessment of roads in England.

INTERNATIONAL BEST PRACTICE IN THE IMPLEMENTATION OF SCHOOL ZONES

Er. Anusha Rajasooriya
Transport Research Laboratory, England

Abstract:
Due to their growing developmental capacities, children are less able to see over obstructions and have difficulty estimating the speed of approaching vehicles making them highly vulnerable to road traffic injuries. This makes roads in the vicinity of schools, particularly unsafe and requiring intervening from road safety practitioners. School zones are applied internationally as part of road safety strategies to improve the safety of school children and reduce the likelihood of f atal and serious injury collisions. School zones typically include the application of reduced speed limits and traffic calming. In doing so, road safety practitioners tend to focus on the use of visual cues (flashing beacons, custom -designed traffic signs and road markings) to warn motorists of the presence of vulnerable road users such as young pedestrians and bicyclists. In this presentation, I will show international best practice on the implementation of school zones using ca se studies and published literature. The aim of the presentation is to provide insights on the tools available for Road Administrators to intelligently apply school zones, utilizing a combination of traffic calming, speed and parking management to keep school children safe.

USE OF ACCESSIBILITY INDICATORS FOR TRANSPORT PLANNING IN NEPAL, AND HOW CLIMATE CHANGE MIGHT IMPACT THESE INDICATORS IN FUTURE

Kevin McPherson
Senior Consultant, TRL

Abstract:

Accessibility indicators measure how easily people can reach key destinations—like jobs, schools, health services, or agricultural markets—using available transport options. These indicators help planners understand who is being served well and who is being left behind, and help prioritis smarter, more inclusive transport investments. One key indicator that is often used is the Rural Access Index (RAI), which was adopted as a Sustainable Development Goal (SDG) Indicator 9.1.1. The RAI aims to assess the accessibility of rural populations to road infrastructure, and is therefore also seen as an important development indicator. The “standard” method of measuring RAI (the proportion of rural population living within 2 km of an all-season road) does not adequately cater for mountainous regions like Nepal. But the RAI definition does allow for local variations to accommodate, for example, extreme slopes and pedestrian suspension bridges. This presentation describes how the RAI and other accessibility indicators have been used in Nepal, including in recent provincial transport master plans. It describes the data needed by the indicators, including use of proxy da ta , if necessary, available data sources, and analysis methods and tools that can be used to calculate the indicator values. It also examines how climate change might impact accessibility indicators in future, for example as a result of increased risk of flooding, landslides and other hazards. Through a worked example for Kerala in India, it shows that accessibility indicators are likely to be reduced as a result of increased flood risk under different climate change scenarios. It therefore reinforces the need to improve the resilience of road networks to climate change, through better planning, design, construction and maintenance strategies.

A Pilot Post-Crash Response and Care Model for NNM Road

Prof. Dr. Ashok Ratna Bajracharya
Post-Crash Response and Care Specialist
Project Management Consultant for Road Safety Management

Abstract:
A road corridor–level Post Crash Response and Care (PCRC) Model has been proposed for pilot implementation in the Nagdhunga–Naubise–Mugling (NNM) Road as a part of the Safe Corridor Demonstration Program (SCDP), funded by the Strategic Road Connectivity and Trade Improvement Project (SRCTIP). The model incorporates all essential features of the national-level PCRC system, such as Crash Information and Dispatch Service (Unified Command Centre), initiated by First Responders' Service, followed by Rapid Response Team service incorporating Fire and Rescue Service, Police Law Enforcement Service, victim transfer service by ambulance to trauma care facilities for primary to tertiary trauma care, and finally Towing and Salvaging Service, all of which are needed to respond to a road crash as a complete package. The model is built by integrating all available hospital facilities along the NNM Road corridor to deliver timely trauma care in a cost-effective manner. The proposed model is expected to save lives and prevent disabilities by responding to crash victims within the platinum minutes and/or golden hour. The efficacy of the model in treating crash victims will be tested and validated using the system's Key Performance Indicators (KPIs). An appropriate monitoring and evaluation framework will be used to measure its success. The pilot project can be replicated to other road corridors if successful.
Keywords: Post Crash Response and Care (PCRC) Model, Trauma Care Facilities, Unified Command Centre

Introduction:
NNM is one of the busiest highways in the country, where 15,000 vehicles ply every day on average. An equally proportionate number of road crashes are taking place. There are treatment facilities on either side of this 95 km stretch of road, but there is no formal system for addressing post-crash response and care in this corridor at present. As a result, crash victims are dying or becoming disabled unnecessarily. Therefore, a PCRC model has been developed and proposed to be tested along this corridor.
This PCRC model is a chain system of actions in response to a road crash, activated by notification of a crash by any bystander. Information from this "First Responder" is received by a Unified Command Centre. This centre, in turn, dispatches a Rapid Response Team first, followed by ambulance dispatch to rescue the victim with resuscitation and reach an appropriate trauma care or health facility. This is finally followed by the dispatch of salvaging and towing services to clear the crash site and restore normalcy.

Methodology:
A preliminary study of the prevailing PCRC situation along the road corridor was carried out. A structured survey of all trauma care and hospital facilities, as well as disaster management and training center, was conducted to assess their capacity for delivering the required PCRC services. Needs were assessed, and a PCRC system model was developed by integrating all available facilities. Additional facilities were identified to strengthen and run the system efficiently. The se included capacity building through trauma training at various levels and provision of trauma care medical and ITC equipment.

Results and Discussion:
A baseline study showing the relevant situation and related data is presented, along with a monitoring and progress reporting framework. Twenty persons died and 26 sustained serious injuries in a total of 46 road crashes in the fiscal year 2078–79. Most of the injured were referred to Kathmandu for treatment. There are eight healthcare facilities of various capacities located on either side of this corridor in different localities.
After implementation of this model, ongoing evaluation shows that primary care for most victims is being carried out locally. Referral to Kathmandu has decreased significantly. Final evaluation is planned at the end of the project period using gross indicators such as crash mortality, resultant disability, referral to central hospitals, along with overall evaluation and experience of the system model.

Conclusion:
This is a pilot project. If found effective after evaluation, a similar system model can be planned and developed at a larger scale to be applied at regional, provincial, and eventually at the national level.

Evaluating Marshall's Volumetric Properties of Hot Mix Asphalt Using Machine Learning

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ABSTRACT

The Marshall design process, commonly employed for estimating Optimum Bitumen Content (OBC), is known for its designation as the asphalt mix design and properties of asphalt concrete is determined by the conventional Marshall Mix Design methodology. Which is characterized by its time-intensive nature, labor requirements. This study explores different predictive modeling techniques to predict Volumetric properties of hot mix asphalt based on the different material properties. The study examines Multiple Linear Regression (MLR), Artificial Neural Networks (ANN) models to predict volumetric properties (AV, BSG, VFA, VMA) using variables such as aggregate gradation, specific gravity, and proportions of fine and coarse aggregates in the mix. A comprehensive dataset of 148 Marshall mix design sheets was collected, and 141 valid sets were used after outlier analysis.

The base MLR model demonstrated moderate predictive capabilities with R^2 values ranging from 0.3017 to 0.6794 for various parameters, indicating limitations in accurately predicting complex asphalt properties. To address these limitations, the integration of ANNs significantly improved predictive accuracy, achieving higher R^2 values for all parameters compared to MLR.

Furthermore, the ANN model predicted OBC with R^2 of 0.7964 and other parameters with R^2 values between 0.7206 and 0.91, making it a robust tool for asphalt property estimation. ReLU - Linear and tanh - Linear activation functions as transfer function were identified as optimal for different parameters.

Overall, ANN models emerged as the most effective, offering the highest accuracy and predictive performance across various parameters. The research advocates for adopting ANN in asphalt mix design to reduce reliance on conventional methods, thereby saving time, resources, and labor while maintaining or enhancing the predictive reliability of asphalt mix properties.

Keywords: Hot Mix Asphalt, Marshall Mix Design, Volumetric Properties, Artificial Neural, Predictive Modeling, Aggregate Gradation

3rd International Transport Conference
Venue: Hotel Yak and Yeti
Date: 11 - 13 April
"Towards Safe, Sustainable, Efficient, and Resilient Mobility"

PROGRAM SCHEDULE

Day 1 | 11 April 2025 Friday

Inaugural/ Opening Session

08:45-11:10 CONFERENCE INAUGURAL CEREMONY

8:45-9:30 **Registration with Tea/Coffee and Cookies**

9:30 – 9:35 **Invitation to Dignitaries to the Dias:**
Chair: Dr. Hare Ram Shrestha, President, SOTEN
Chief Guest: Hon'ble Devendra Dahal Minister, MOPIT
Special Guest, Keynote Speaker: Dr. Bindu Lohani, President, Clean Air Asia
Special Guest: Mr. Gopal Prasad Sigdel, Secretary, MOUD
Special Guest, Keynote Speaker: Mr. Keshab Kumar Sharma, Secretary, MOPIT
Special Guest: Prof. Dr. Padma Bahadur Shahi, Chairperson, NEC
Special Guest, Keynote Speaker: Prof. Dr. Kiyoyuki Kaito, Osaka University
Guest of Honor: Prof. Dr. Akimasa Fujiwara, President, EASTS

9:35 – 9:40 **Welcome Address & Program Briefing:** Er. Hemant Tiwari, General Secretary and Conference Convener, **SOTEN**

9:40 – 9:45 **Conference Inauguration and National Anthem**

9:45 – 9:50 **Inaugural Message by** Ms. Susanna Zammataro, Director General, **International Road Federation**

9:50 – 9:55 **Remarks from Guest of Honor:** Prof. Dr. Akimasa Fujiwara, President, **Eastern Asian Society of Transport Studies (EASTS)**

9:55 – 10:05 **Keynote Speech on "National Context Setting of Safety, Sustainability and Resiliency of Transport Infrastructure in Nepal"** - Er. Keshab Kumar Sharma, Secretary, **Ministry of Physical Infrastructure and Transport**

10:05-10:20 **Keynote Speech on "Infrastructure Asset Management for Safer, Sustainable, and Resilient Transportation"** - Prof. Dr. Kiyoyuki Kaito, **Osaka University**

10:20 – 10:40 **Keynote Speech on "Navigating the Future: Sustainable and Inclusive Transport for a Connected World"** – Dr. Bindu Lohani, Chairman of the board, **Clean Air Asia**

10:40 – 10:45 **Address by** Mr. Gopal Prasad Sigdel, Secretary, **Ministry of Urban Development**

10:45 – 10:55 **Inaugural Address by Chief Guest: Hon'ble** Devendra Dahal Minister, **Ministry of Physical Infrastructure and Transport**

10:55- 11:00 **Token of Appreciation to Dignitaries**

11:00 – 11: 05 **Closing Remarks:** Dr. Hare Ram Shrestha, President, **SOTEN**

11:10-12:40 KEYNOTE SESSION ON INTEGRATED AND SUSTAINABLE TRANSPORT

Session Chair: Prof. Dr. Jagadish Chandra Pokhrel, Former VC, National Planning Commission
Session Moderator: Dr. Rojee Pradhananga, Assistant Professor, IOE, Pulchowk Campus

- **The Future of City and Long-Distance Road Transport.**
  Panos D. Prevedouros, PhD, Past Chairman and Professor Emeritus, Civil and Environmental Engineering, University of Hawaii.

- **Stimulating pedestrian behavior with competition between movers and slayers in urban public space**
  (Keishi Fujiwara, Yuki Oyama, Makoto Chikaraishi, Akimasa Fujiwara)
  Prof. Dr. Makoto Chikararaishi, Graduate School of Advanced Science and Engineering, Transdisciplinary Science and Engineering Program, Hiroshima University, Japan
- **Using Innovative Technologies for national road condition reporting.**
  Er. Robin Workman, Senior Transport Consultant, Transport Research Laboratory, England

Question and Answer Session
Session Remarks: Session Chair
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12:40-13:40 **Lunch and Networking (Including Presentation from Sponsors)**

13:40-15:30 INTERNATIONAL EXPERIENCE SHARING ON ROAD SAFETY

Session Chair: Er. Arjun Jung Thapa, Former Secretary, Government of Nepal

Session Moderator: Er. Saroj Pradhan, Advisor, National Road Safety Council

- **International best practice in the implementation of school zone.**
  Ms. Anusha Rajasooriya, Transport Research Laboratory, England.
- **Pedestrian Safety Improvement by Applying Safe System Approach Principles** **Mr. Ali Zayerzadeh,** CEO of Road Safety Pioneers.
- **Role of Youth in Road Safety**
  Mr. Manpreet Darroch, Deputy Director, Youth for Road Safety.
- **Overview of iRAP, IndiaRAP, and iRAP Assessments in Nepal"**
  Er. Albin Tharakan, Road Safety Engineer, iRAP

Question and Answer Session

Session Remarks: Session Chair

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15:30-15:50 Tea Break

15:50-17:30 SESSION ON INTEGRATED AND SUSTAINABLE TRANSPORT

Session Chair: Er. Bhimarjun Adhikari, Joint Secretary, MOPIT

Session Moderator: Er. Anil Marsani, Program Coordinator, MSc. In Transportation Engineering, IOE Pulchowk Campus

- **Use of Accessibility Indicators for Transport Planning in Nepal**
  Er. Kevin McPherson, Senior Consultant, Transport Research Laboratory
- **Evaluation of Transit-Oriented Development Indicators Using the Fuzzy Delphi Method: A Case Study of Suburban Railway Stations in Thailand.**
  (Chaiwat Sangsrichan, Patcharida Sungtrisearn, Nopadon, Kronprasert, Auttawit Upayokin, Preda Pichayapan)
  Dr. Chaiwat Sangsrichan, Chiang Mai University, Thailand
- **The Push-Pull Effects of Expressways: The Case of TPLEX For Baguio City.**
  (Daniel L. Mabazza, Glenn Simon Latonero)
  Er. Daniel L. Mabazza, Department of Geography, College of Social Sciences and Philosophy, University of the Philippines
- **Rural Road Development in Developing Countries with Focus to National Context:**
  Dr. Jagat Kumar Shrestha, IOE, Pulchowk Campus

Question and Answer Session

Session Remarks: Session Chair

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Day 2 | 12 April 2025 Saturday

09:00-10:50 PARALLEL SESSION (1A) - ROAD SAFETY

Session Chair: Dr. Bijay Jaisi, Deputy Director General, Department of Roads

Session Moderator: Er. Pranita Rana, Associate Researcher, National Injury Research Center

- **Problems in Corridor Level Crash Data Collection, Storage, Analysis, Interpretation and Usage in Nepal: A Case Study from Nagdhunga-Naubise-Mugling (NNM) and Kamala-Dhalkebar –Pathlaiya (KDP) Road**
  (Nemi Bhattarai, Anil Marsani, Mohan Pariyar, Jagat Man Shrestha, Partha Mani Parajuli)
  Er. Nemi Bhattarai, Project Management Consultant for Road Safety Management
- **Application of NeRSAP in SRCTIP Funded Nagdhunga-Naubise Mugling Road under Safe Corridor Demonstration Program**
  (Anil Marsani, Partha Mani Parajuli, Aditya Poudel, Nemi Bhattarai, Sandesh Poudel)
  Er. Anil Marsani, IOE, Pulchwok Campus.
- **Road Safety Infrastructure Assessment for the Nagdhunga-Naubise-Mugling (NNM) Corridor: Challenges and Strategic Interventions.**
  (Aditya Paudel, Partha Mani Parajuli
  Er. Aditya Paudel, Project Management consultant for road safety Management.
- **Training Needs Assessment for Promoting Road Safety in Nepal.** (Padma Bahadur Shahi, Partha Mani Parajuli) Prof. Dr. Padma Bahadur Shahi, Management consultant for road safety Management.
- **A Pilot Post-Crash Response and Care Model for NNM Road**. Dr. Ashok Ratna Bajracharya, Post Crash response Specialist.
- **Campaign Needs Assessment for Promoting Road Safety in NNM Road Corridor.** (Badri Prakash Ojha, Partha Mani Parajuli)
  Dr. Badri Prakash Ojha, Project Management consultant for road safety Management**.**

Question and Answer Session
Session Remarks: Session Chair
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09:00-10:50 PARALLEL SESSION (1B) - RESEARCH AND INNOVATION

Session Chair: Dr. Surya Raj Acharya, Infrastructure Specialist
Session Moderator: Er. Vibek Gupta, Chairman, SSTN

- **Multi-Layered Plastic Waste in Road Construction: Technical Performance, Cost Analysis and Environmental Impact Assessment**
  (Aakanshya Ghimire, Bimal Bastola)
  Er, Aakanshya Ghimire, Green Road Waste Management Pvt. Ltd.
- **Analysis of Road Traffic Crash Cost Using Human Capital Approach in Kailali District.**
  (Maheshwari Dhami, Pradeeep Kumar Shrestha, Hemant Tiwari)
  Er. Maheshwari Dhami, Graduate Student, IOE, Pulchowk Campus
- **Enhancing Safety and Walkability at Crosswalks and Sidewalks on Selected Urban Roads of Kathmandu Metropolitan City** (Divya Shahi, Thusitha Chandani Shahi) Er. Divya Shahi, **Nepal Engineering College.**
- **Review Of Arbitration Practices in Construction Projects: A Case Study of Highway Projects in Nepal.**
- **Dr. Chhabi Lal Paudel,** Department of Roads, MoPIT
- **Optimization of Hydrolysis Lignin Dosage in Asphalt Mixtures for Enhanced Sustainability and Performance.**
  (Amar Kumar Deo, Umesh Chandra Sahoo)
  Er. Amar Kumar Deo, M. Tech Transportation, School of Infrastructure, IIT Bhubaneswar
- **Evaluating Marshall's Volumetric Properties of Hot Mix Asphalt Using Machine Learning.**
  (Moti Ram Giri, Kshitiz Dhakal, Gautam Bir Singh Tamrakar)
  Er, Moti Ram Giri, Institute of Engineering, Pulchowk Campus

Question and Answer Session
Session Remarks: Session Chair
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11:00-12:30 PARALLEL SESSION (2A) - SUSTAINABILITY OF ROAD

Session Chair: Dr. Mandip Subedi, President, Nepal Geotechnical Society
Session Moderator: Er. Bindu Adhikari, Treasurer, SOTEN

- **Nature-Based Solutions (NBS) for Resilient Road Transport Infrastructure in Nepal.**
  (Santosh Panthe, Shuva Sharma)
  Er. Santosh Panthe, Scott Wilson Nepal.
- **Road Cut Slope Stability Assessment Under Region-Specific Rainfall Scenarios in Mid Hills of Nepal**
  (Tunisha Gyawali, Bhim Kumar Dahal)
  Er. Tunisha Gyawali, Department of Roads
- **Effect of Monsoon Rainfall on Roadside Slopes: A Case Study of Dakshinkali-Kulekhani Road Segment.**
  (Laxmi Adhikari, Jayant Bhatt, Shreejan Bikram Thapa, Kushal Dahal, Lipika Maharjan, Madan Rimal, Bhim Kumar Dahal)
  Ms. Laxmi Adhikari, Student, IOE, Pulchowk Campus.
- **Application of Various Geophysical Methods for Identification of Slope Mass Condition in Chandram Bhir Slope.**
  (Ujjwal Krishna Raghubansha, Hari Ghimire)
  Mr. Ujjwal Krishna Raghubansha, Central Department of Geology, Tribhuwan University, Nepal
- **Rainfall Threshold for Roadside Shallow Landslide in Mid-Himalayan Nepal.**
  (Suresh Neupane, Netra Prakash Bhandary)
  Er. Suresh Neupane, School of Science and Engineering, Special Graduate Course on Disaster Mitigation Studies.

Question and Answer Session
Session Remarks: Session Chair
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11:00-12:30 PARALLEL SESSION (2B) - CIVIL AVIATION SECTOR

Session Chair: Er. Sugat Ratna Kansakar, Former, MD, Nepal Airlines Corporation
Session Moderator: Er Mohan Dhoj KC, Principanl, LIAST

- **Assessment of Air Traffic Noise level: A Case Study of Chiang Mai International Airport.**
  (Patcharida Sungtrisearn, Chaiwat Sangsrichan, Preda Pichayapan)
  Dr. Patcharida Sungtrisearn, Chiang Mai University, Thailand
- **Expansion of Tribhuvan International Airport, Overcoming the Challenges.**
  Er. Dipendra Shrestha, Project Director, Air Transport Capacity Enhancement Project, CAAN
- **Nijgadh International Airport: A Strategic Imperative for Nepal's Aviation Modernization, Economic Transportation and Sustainable Development**
  Er. Sanjeev Singh Kathayat, Former Director, CAAN

Question and Answer Session
Session Remarks: Session Chair
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12:30-13:40 Lunch and Networking (Including presentation from Sponsors)

13:40-15:30 PARALLEL SESSION (3A) - ROAD SAFETY

Session Chair: Er. Sushil Babu Dhakal, Joint Secretary, MOPIT
Session Moderator: Er. Subhash Dhungel, Chairman, Traffic & Transport Unlimited Solution

- **Cold Applied Plastic Transverse Bar Marking and Colored Horizontal Signage: A Study on Speed Reduction and Enhanced Driver Awareness**
  (Amit Thatte, Vidheya Rao, Pramod Waghmare)
  Mr. Vidheya Rao, M/s Kataline Infra products Pvt. Ltd., Nagpur, India
- **Public-Private Partnership in Road Safety Infrastructure: Needs and Opportunities (Saroj Kumar Pradhan,** Madhab Raj Ghimire and Dr. Partha Mani Parajuli)
  Er. Saroj Kumar Pradhan, Technical Advisory NRSC.
- **Nepal Road Crash Database System: An Innovative Road Crash Data Collection and Storage System**
  (Dr. Partha Mani Parajuli and Anthony Eagle)
  Dr. Partha Mani Parajuli, Team Leader and Road Safety Management Specialist, Project Management Consultancy for Road Safety Management, Nepal.
- **Exploring the Interrelationship between Road Environment, Existing Safety Interventions, and Crash** Occurrence Using Different Analytical Techniques. (Dr. Nitesh Acharya, Michael Henry)
  Dr. Nitesh Acharya, Engineer, Department of Roads
- **Clinical, Personal, Social and Professional Consequences of Road Traffic Crashes in Nepal: A Review of Painful Stories Behind and After Extremity Amputation.**

Dr. Satish Prasad Barnawal, Project Lead, Road Safety, Indaram Health, Kathmandu, Nepal.

- **Enhancing Road Safety Through Star Rating or School in Context of Nepal**
  (Asmita Pokhrel, Hemant Tiwari, Sanjay Luitel, Samridhi Singh)
  Er. Asmita Pokhrel, Civil Engineer, Traffic & Transport Unlimited Solution

Question and Answer Session

Session Remarks: Session Chair

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13:40-15:30 PARALLEL SESSION (3B) - URBAN PLANNING AND ASSOCIATED INFRASTRUCTURE

Session Chair: Er. Padam Mainali, Joint Secretary, Ministry of Urban Development

Session Moderator: Dr. Pradeep K Shrestha, Assistant Professor, IOE, Pulchowk Campus

- **Study of Operational Performance of Public Transport in Kathmandu Valley.**
  (Shree Ram Dhakal, Kuber Nepali)
  Er. Shree Ram Dhakal, Senior Transportation engineer in Engineering Centre Nepal Pvt. Ltd
- **Study on Making Patan Durbar Square a Pedestrian and Cycle Friendly Area**
  (Rubin Singh Maharjan, Som Raj Rana, Chandani Shakya)
  Mr. Rubin Singh Maharjan, Nepal Cycle Society
- **(Bishnu Prasad Devkota, Ramesh Chaudhary, Sushma Chaudhary) Er. Bishnu Prasad Devkota, Nepal Electricity Authority**
- **Integrating Speed Management into Urban Placemaking: Lessons from NSW's Road Safety Strategy for Enhancing Public Spaces in Kathmandu**
  Er. Alex Karki, Principal Traffic Engineer & Road Safety Auditor, Sydney Traffic Engineers Pty. Ltd
- **Investment In Road Transport Infrastructure: Improved Accessibility and a Catalyst for Job Creation**
  Er. Binod Bhattarai, Senior Divisional Engineer, Department of Roads

Question and Answer Session

Session Remarks: Session Chair

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15:30-15:50 Tea Break

15:50-17:30 PARALLEL SESSION (4A) - PAVEMENT MANAGEMENT

Session Chair: Er. Lal Krishna KC, Past President, SOTEN

Session Moderator: Er. Ghanshyam Gautam, Transport & Contract Management Specialist

- **New Accelerated Settlement System to Avoid 'Bump' and Approach Slabs in Access to Bridges and Culverts.**
  (Jose Espinos, Dilman Singh Basnyat)
  Er. Jose Espinos, Team leader, SASEC Highway Enhancement Project
- **Road Surface Evaluation Considering Scooter Rider Safety and Comfort**
  (Prakriti Pandey, Masamitsu Ito, Takuma Sanada, Tomoya Kitani and Kazuya Tomiyama)
  Er. Prakriti Pandey, Graduate Student, Graduate School of Engineering, Kitami Institute of Technology.
- **Enhancing Pavement Performance through Geotextile-Geogrid Reinforcement Under Dynamic Vehicle Loads.**
  (Aanchal Tiwari, Padma Bahadur Shahi, Rajan Suwal, Ram Chandra Tiwari)
  Er. Aanchal Tiwari, Graduate Student, IOE, Pulchowk Campus
- **Artificial Neural Networks and Multiple Linear Regression in Pavement Deterioration Forecasting**
  (Krishna Singh Basnet, Jagat Kumar Shrestha, Rabindranath Shrestha)
  Institute of Engineering, Pulchowk Campus

Question and Answer Session

Session Remarks: Session Chair

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15:50-17:30 PARALLEL SESSION (4B) - TECHNOLOGY AND INNOVATION IN TRANSPORT SECTOR

Session Chair: Dr. Partha Mani Parajuli, Senior Transport Expert

Session Moderator: Er. Binod Bhattarai, Senior Divisional Engineer, DOR

- **Transport Insights from the TRL Smart Mobility Living Lab**
  Dr. Robin Workman, Senior Transport Consultant, Transport Research Laboratory, England
- **Network Wide Intelligent Signal Operation: A Case Study of Lalitpur Metropolitan City**

Er. Subhash Dhungel, Chairman, Traffic & Transport Unlimited Solution

- **Nepal's First Intelligent Traffic Signal (ITS) System: Challenges Opportunities and Initial Observations**
  (Ishop Amatya, Suyash Mathema, Subhash Dhungel, Partha Mani Parajuli)
  Er. Ishop Amatya, Electrical Engineer
- **Podway as New and Alternate Technology and Its Possibility in Context of Nepal**
  Er. Paribesh Parajuli, Chief Technical Officer, Kathmandu Podway

Question and Answer Session

Session Remarks: Session Chair

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Day3 |13 April 2025 Sunday

9:30 – 10:50 SUSTAINABLE URBAN MOBILITY

Session Chair: Prof. Dr. Padma Bahadur Shahi, Chairman, Nepal Engineering Council

Session Moderator: Er. Kuber Nepali, CEO, Federal Capital City Public Transport Authority

- **City to City: Benchmarking Urban Transport in Asia**
  Mr. Alvin Mejia, Co-Team Leader, Asian Transport Observatory
- **Sustainable Transportation through MMI and TOD in Hydrebad Metropolitan Region.(Vijaya Lakshmi Kandala, Raghu Naik, Shivam Sinha)**
  Er. Vijaya Lakshmi Kandala, Advisor Mobility- Balaji Railroad Systems Pvt. Ltd, Secundarabad, India
- **Infrastructure and Transport Emissions-Insight from South Asia and India**
  Mr. Partha Bosu, Principal, DFAG, LLP
- **Developing a Sustainable and Resilient Public Transport System for Kathmandu Valley, Dr. Madan B. Regmi,** Lead, Urban and Low-Carbon Mobility, UNESCAP

Question and Answer Session

Session Remarks: Session Chair

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11:00 – 12:10 PANEL DISCUSSION ON ISSUES AND CHALLENGES ON IMPLEMENTATION OF FEDERALIZATION IN CONTEXT OF TRANSPORT INFRASTRUCTURE

Session Moderator: Dr. Chandra Bahadur Shrestha, Senior Infrastructure Specialist

- Hon'ble **Dr. Ganga Dutta Nepal,** Vice Chairman, Provincial Policy and Planning Commission, Bagmati Province
- Hon'ble **Dr. Shila Mishra, Member,** Provincial Policy and Planning Commission, Madesh Province
- **Mr. Bhim Prasad Dhungana,** Mayor, Neelkantha Municipality and President, Municipal Association of Nepal
- **Ms. Laxmi Devi Pandey,** Chairperson, Hupsekot Rural Municpailty and President, National Association of Rural Municipalities in Nepal
- **Er. Mahesh Chandra Neupane,** Director General, Department of Local Infrastructure Development
- **Er. Bhimarjun Pandey,** Secretary, Ministry of Physical Infrastructure Development, Lumbini Province

Question and Answer Session

Session Remarks: Session Chair

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12:10 – 13:10 Lunch (Including 2 sponsor presentation)

13:10 - 14:50 ASSET MANAGEMENT

Session Chair: Er. Rajendra Raj Sharma, Immediate Past President, SOTEN

Session Moderator: Ms. Chetana Thapa, Director, Roads Board Nepal

- **Road Asset Management Strategy: Lessons Learned from Case Studies and the Potential for Application in Nepal**
  Prof. Dr. Kazuya AOKI, Graduate School of Management, Kyoto University
- **Development of Sustainable Road Asset Management System (RAMS) for the Highway Network**
  Prof. Dr. Tanuj Chopra, Thapar Institute of Engineering & Technology, Patiala
- **Human Centered Pavement Management**
  Dr. Kazuya Tomiyama, Kitami Institute of Technology, Japan
- **Nepals National Highway Pavement Optimal Management Through Life Cycle Cost Minimization**
  (Manish Man Shakya, Kotaro Sasai, Felix Obunguta, Asnake Adraro Angelo and Kiyoyuki)
  Er. Manish Man Shakya, Senior Divisional Engineer, Department of Roads, MOPIT

- **An Integrated Approach to Road Traffic Accidents: Epidemiological and Legal Perspective on Road users Behavior in Morocco.**
  Ms. Farida Haddou Rahou, University ibn Tofail, Kenitra, Morocco.

Question and Answer Session
Session Remarks: Session Chair
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15:00 – 16:10 WAY FORWARD DISCUSSION

Session Moderation: Er. Kamal Pande, Senior Infrastructure Specialist

- **Er. Ram Hari Pokharel,** Director General, Department of Roads
- **Er. Ajay Mul,** Director General, Department of Railways
- **Er. Machakaji Maharjan,** Director General, Department of Urban Development and Building Construction
- **Er. Thakur P Sharma,** President, Society of Consulting Architectural and Engineering Firms
- **Mr. Bishnu Bhai Shrestha,** Federation of Contractor Association Nepal (FCAN)

Question and Answer Session

Session Remarks: Session Chair

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16:10 – 16:50 **Break/Tea Coffee**

16:50 – 18:30 **Closing Ceremony**
16:50 – 16:55 **Invitation to Dignitaries to the Dias:**

Chair: Dr. Hare Ram Shrestha, President, SOTEN
Chief Guest: Hon'ble Prof. Dr. Shiva Raj Adhikari, Vice Chairman, National Planning Commission
Special Guest: Hon'ble Aman Maskey, MOPID, Bagmati Province
Guest: Er. Gopal Prasad Sigdel, Secretary, MOUD
Guest: Er. Keshab Kumar Sharma, Secretary, MOPIT
Guest: Er. Sushil Gyawali, CEO, Investment Board Nepal
Guest of Honor: Mr. Alvin Mejia, Co-Team Lead, Asian Transport Observatory

16:55 – 17:00 **Overview of Conference: Er. Hemant Tiwari,** General Secretary, SOTEN, Conference Convener
17:00 - 17:10 **Conference Resolution: Er. Kamal Pande,** Chair, Resolution Committee
17:10 – 17:15 **Remarks: Greg Smith,** Acting CEO and Global Programme Director, iRAP (Online)
17:15 – 17:20 **MOU Signing Between Asian Transport Observatory (ATO) and SOTEN**
17:20 – 17:25 **Remarks from Guest of Honor: Alvin Mejia,** Co-Team Lead, Asian Transport Observatory
17:25 – 17:30 **Address by Er. Sushil Gyawali, CEO,** Investment Board Nepal
17:30-17:35 **Address by Er. Keshab Kumar Sharma,** Ministry of Physical Infrastructure and Transport
17:40 – 17:45 **Address by** Special Guest: **Hon'ble Aman Maskey,** Ministry of Physical Infrastructure Development, Bagmati Province
17:45 – 17: 55 **Address by** Chief Guest: **Hon'ble Prof. Dr. Shiva Raj Adhikari,** Vice Chairman, National Planning Commission
17: 55 - 18:05 **Token of Appreciation to Guest and Supporting Institution**
18:05 – 18:10 **Vote of Thanks: Er. Angalal Rokaya, Vice President, SOTEN**
18:10 – 18:15 **Closing Remarks: Dr. Hare Ram Shrestha, President, SOTEN**
18:15 – 18:20 **Photo Session**
18:30 – 19:30 **Cultural Program**
19:30 **Onwards Dinner**

List of Participants

S.N.	Name	Designation
		NEA
1	Buddha Maharjan	Manager
2	Lokendra Adhikari	Deputy Manager
3	Shivaram K.C.	Deputy Manager
4	Bishnu Prasad Devkota	Assistant Manager
5	Sagarmani Gyawali	Assistant Manager
6	Ramesh Subedi	Assistant Manager
7	Amita Kumari	Assistant Manager
8	Srijana Pokhrel	Engineer
9	Arjun Sigdel	Engineer
10	Pragya Shrestha	Engineer
		NEC
11	Dr. Padma Bahadur Sahi	Chairman
12	Er. Homa Nath Pokhrel	Member
13	Er. Ambika Mahat	Member
14	Er. Nirjala Shrestha Chaudhary	Member
		CAAN
15	Hari Prasad Adhikari	Director
16	Ramahari Maharjan	Deputy Director
17	Himjyoti Thapa	Manager
18	Satyaram duwal	Manager
19	Kabindra Kaji Bajracharya	AED, CAAN
20	Bishnu Prasad Poudel	AED, CAAN
21	Mahesh Nepali	AED, CAAN
22	Anjana Bhatta	AED, CAAN
23	Esmita Punjuli	AED, CAAN
24	Bijaya Kumar Yadav	AED, CAAN
25	Yogesh Pudasaini	AED, CAAN
26	Arbindra Kumar Gupta	AED, CAAN
27	Bidhyananda Kishwor Shah	AED, CAAN
28	Surendra Ojha	AED, CAAN
29	Shreya Khadka	AED, CAAN
30	Shreya Khana	AED, CAAN
31	Minraj Ojha	AED, CAAN
32	Gagandev Kushwaha	AED, CAAN
33	Yubaraj Rijal	AED, CAAN
34	Shristi Maharjan	AED, CAAN

35	Chandra Mani Sapkota	AED
36	Naresh Sayajy	AED
37	Nirmal poudel	AED
38	Sandhya Aait Aiir	AED

LIAST

39	Dr. Khet Raj Dahal	Senior Civil Engineer

UESC

40	Dr. Mandip Subedi	Director
41	Er. Gajendra Kumar Jha	Vice Principal

MoUD , DUDBC

42	Mr. Jhapper Singh Vishoka	Act. Project Director
43	Mr. Sabin Karmacharya	Deputy Project Director
44	Mr. Sangita Baral	Engineer
45	Mr. Sudeep Shrestha	Engineer
46	Mr. Bishal Dahal	Engineer
47	Mr. Jayesh Shrestha	Engineer
48	Monika Maharjan	

TDF

49	Nabin Tiwari	Engineer
50	Rakesh Sigdel	
51	Rajesh Kumar bhocchibhoya	Deputy Manager
52	Vijay Thapa	

MOUD, RCIP

53	Er. Premdatta Bhatta	PD
54	SDE Shyammani Kafle	SDE

High Powered Committee for Integrated Development of the Bagmati Civilization

55	Udhav Nepal	S.D.E
56	Top Bahadur Baniya	Engineer
57	3 Ajay Bhattarai	Engineer

Department of Local Infrastruture Development

58	Binod Pun	Engineer
59	Rakesh Roshan	Engineer
60	Roshan Thapa	Engineer
61	Shyam mani kaphle	SDE

Vyans RuraL municipality

62	Maheswari Dhami	

DOR

RD Bhaktapur

63	Suman Yogesh	Engineer

64	Durga Prasad	Engineer	✓
65	Shailendra Chaudhary	Engineer	
66	Sitaram Budathoki	Engineer	
67	Deepak Yakami	Engineer	
	RD Damak		
68	Sushant Subedi	Engineer	
69	Jibendra MIshra	Division chief	
70	Suraj Maharjan		
71	Sushmita K.C.	Engineer	
72	Bharat Shrestha	Engineer	
73	Rabin Khadka	Engineer	
74	Posak Nepal	Engineer	
75	Bishal Bhandari	Engineer	
76	Amrit Prasad Yadav	Engineer	
77	Purushottam Bhandari	Engineer	
78	Dilip Kumar Shah	Engineer	
79	Shuvanjan Dahal	Division Chief	
80	Prashant Karki	Engineer	

RD KTM

S.N.	Name	Designation
81	Mahananda Joshi	C.D.E
82	Santaram Pandey	Engineer
83	Arjun Nepali	Engineer
84	Shriyanka Rauniya3	Engineer
85	Ramchandra Phuyal	Engineer

RD Pokhara

S.N.	Name	Designation
89	Navaraj Bastola	Division Head
90	Pratik Pradhan	Engineer
91	Pujan Shrestha	Engineer
92	Bibas Bastola	Sub-Engineer
93	Madhu Kumar Basnet	Engineer
94	Tara Devi Acharya	Sub Engineer
95	Pradip Shrestha	Sub Engineer
96	Bodh Prasad Bhandari	Engineer
97	Nirj Maharjan	Engineer

98	Anupam Kumar	Engineer
99	Preiz Amatya	
100	Tanka Lal Chaudhary	
101	Ram Er. Adwait Bhandari	Engineer
102	Er. Prakash Magar	Engineer
103	Er. Subodh Devkota	Senior Divisional Engin
104	Er. Keshab Prasad Ojha	Senior Divisional Engin
105	Er. Sarala Neupane	Senior Divisional Engin
106	Er. Amit Kumar Sharma	Senior Divisional Engin
107	Er. Chhabi Lal Sharma	Senior Divisional Engin
108	Er. Anil Pokhrel	Senior Divisional Engin
109	Er. Manish Man Shakya	Senior Divisional Engin
110	Er. Shila Shrestha	Senior Divisional Engin
111	Er. Nitesh Acharya	Engineer
112	Er. (Sajit Sharma)	Engineer
113	Er. Ram Hari Pokhrel	Director General
114	Er. Umesh Bindu Shrestha	Deputy General
115	Er. Prabhat Kumar Jha	Superintending Enginee
116	Er. Lalijan Khanal	Deputy General
117	Er. Gyanendra Kumar Jha	Project Director
118	Er. Saujanya Nepal	
119	Er. Aman Chitrakar	Superintending SDE En
120	Er. Bijay Kumar Mahato	
121	Er. Dharmendra Kumar Jha	Senior Divisional Engin
122	Mukunda Raj Adhikari	Senior Divisional Engin
123	Bandana Acharya	Senior Divisional Engin
124	Kushalta Nyoupane	Senior Divisional Engin
125	Kabish Tandulkar	Engineer
126	Mahab Paudel	Engineer
127	Piyush Chataut	Engineer
128	Shankar Khanal	
129	Amit Kumar Sharma	
130	Bijya kumar Mahato	
131	Sudip Pokherel	
132	Suvraj Neupane	
133	Ms. Anukshya Ghimire	Project Manager
134	Mr. Ashish Manandhar	Engineer
135	Ms. Ashima Neupane	Engineer
136	Ms. Anish Shrestha	Engineer
137	Ms. Gita Khadka	Engineer

138	Lila Bahadur Bhandari	Project Manager
139	Shrawan Kumar Mahatara	Engineer
140	Bishmu Babu Pandey	SDE
141	Er. Buddha Ratna Tuladhar	SE
142	Thaneshwor Khatri	Program Director
143	Arati Sah	Project Head
144	TrilokNath Ghimire	Superintending SDE En
145	Gyanendra Prasad Kalaunii	Project Manager
146	Ananta Baral	Engineer
147	Sudip Karki	Engineer
148	Haricase Bdr. Pradhan	Engineer
149	Sunil Ranjitkar	Project Manager
150	Dipesh Rajak	Project Manager
151	Kumar Birkam Parajuli	Engineer
152	Malika Awal	Engineer
153	Bishnu Chapagain	Enginer
154	Bishnu La Shrejtha	Engineer
155	Shankar Poudel	Project Manager
156	Resham Bahadur Oli	Engineer
157	Upendra Maharan	Engineer
158	Rajan Pandey	Engineer
159	Kalpana Mishra	Engineer
160	KomeJA Prasad Adhikan'	EnSiner/ MoPIT
161	Gagal Bahadur Bhandari	Project Manager
162	Govinda Gaire	Engineer
163	Birendra Bahadur Chand	Project Manager
164	Sajana Adhikari	
165	Bibek Pandey	Engineer
166	Bishnu Prasad Khanal	Engineer
167	Avadesh Kumar Shah	Engineer
168	Krishna Nath Ojha	Project Manager
169	Surendra Kumar Singh	Engineer
170	Name	Designation
171	Makoto Chikaraishi	
172	Abhash Acharya	
173	Aditya Khanal	
174	Albin Tharakan	
175	Alvin Mejia	
176	Amar Kumar Deo	
177	Anuradha K.C.	
178	Aiju Acharya	

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179	Assoc. Prof. Dr. Kazuya Tomiyama		
180	Bishnu Prasad Devkota		
181	Chaiwat Sangsrichan		
182	Divya Shahi		
183	Dr Satish Prasad Bamawal		
184	Farida Haddou rahou		
185	Guru Datta Adhikari		
186	Heera Lal Chaudhary		
187	Krishna Singh Basnet		
188	Kshitiz Dhakal		
189	Madan B. Regmi		
190	Maheshwari Dhami		
191	Manish Man Shakya		
192	Mohan Dhoja K. C.		
193	Moti Ram Girif		
194	Moti Ram Girif		
195	Nil bhattarai		
196	Niraj Bohara		
197	Panboshi Parajuli		
198	Partha Parajuli		
199	Patcharida Sungtriseam		
200	Prakriti Pandey		
201	Reeta Khadka		
202	Lal Krishna KC		
203	Pranita Rana		
204	Surakshya Kafle		
205	Vibek Gupta		
206	Shree ram dhakal		
207	Rubin singh maharjan		
208	Tunisha		
209	Aanchal Tiwari		
210	Dipendra Shrestha		
211	Bilalpa Daha	Staff	986363059
212	Dev Shialpakar	NPN	
213	Yadab Kc	Purwadhar Paribexjh	
214	Anjita Thapa		
215	Bhola Kafle		
216	Krishna		
217	Rajkumar Adhikari		
218	Upesh Koirala		
219	Rohit Sharma		

220	Upeesh Kvinah	
221	Khagegdra amgai	
222	Kuber Nepali	CEO
223	Niranjan Thapa	SDE
224	Siddhartha Gautam	
225	Préfif (Dredal)	
226	Sunita Karki	Sr. Reporter
227	Dhana Dhakal	
228	Sangih Baraj	
229	Manik Mahajan	
230	Mohanzhiyfik	
231	Rajesh Khudhidnya	Drimm
232	Arjun Thapa	
233	Rojee Pradhananga	
234	Pradip kumar Patel	GTF
235	Upendra maharjan	GTF
236	Sunil Gupta	GTF
237	Shira Raj Gulman	Asian Concrete
238	Prof. Dr. Jagadish Chandra Pokhrel	
239	Manish Kanda	Asian Concrete
240	Jagat Man Shrestha	Presenter
241	Anil Marasini	
242	Dr. Ganga Dutta	
243	Aman Maskey	Guest
244	Samikshya Adhikari	
245	Hare Ram Shrestha	
246	Hemant Tiwari	
247	Ram Kumar shrestha	
248	Kamal kumar sah	SD-E
249	Rajendra Raj Sharma	
250	Chetana Thapa	
251	Prof. Dr. Tanuj Chopra,	
252	Assoc. Prof. Dr. Kazuya Tomiyama	
253	Prof. Dr. Kazuya AOKI	
254	Er. Robin Workman	
255	Ranjan Kumar Dahal	
256	Krishna Raj Pant	
257	Saroj Pradhan	
258	Er. Anusha Rajasooriya	
259	Er. Farida Haddou Rahou	
260	Ali Zayerzadeh	

261	Raquel Barrios	
262	Dr. Patcharida Sungtrisearn	
263	Krishna Pant	
264	Sunil Poudyal	
265	Videyah Ro	
266	Er. Shree Ram Dhakal	
267	Er. Saroj Pradhan	
268	Dr. Partha Parajuli,	
269	Dr. Nitesh Acharya	
270	Dr. Satish Prasad Barnawal	
271	Bindu Adhikari	
272	Anga Lal rokaya	
273	Dr. Bindu Lohani	
274	Prof. Dr. Kiyoyuki Kaito, Osaka University (Japan)	
275	Mr. Keshab Kumar Sharma, Secreatry, MoPIT	
276	Gopal Prasad Sigdel, Secretary MoUD	
277	krishna Bhattarai	
278	Arju Acharya	
279	Neeva Dahal	
280	Badri Prasad Ojha	
281	Suresh Neupane	
282	Ujjwal Raghubansi	
283	Mahesh Chaulagain	
284	Ramesh Chaudhary	
285	Dr. Bijay Jaisi	
286	Er. Nemi Bhattarai	
287	Ashok Ratna Bajracharya	
288	Sanjeev Singh Kathayat	
289	Subhash Dhungel	
290	Samridhi Singh	
291	Sandesh Acharya	
292	Asmita Pokhrel	
293	Santosh Bhatta	
294	Shesh Raj Kafle	
295	Khsitiz Dhungana	Tere arme
296	Mandakini Karki	
297	Alex Karki	
298	Madhusudhan	Purwadhar Paribexjh
299	Kafle	Photographer 1

300	Arju Thapa	Media
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