HIGH VOLUME TRANSPORT
APPLIED RESEARCH

Technical Recommendations for Road Design Considering Three-Wheeler Slow-Moving Vehicles

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Definitions

FCDO	Foreign, Commonwealth & Development Office
HVT	High Volume Transport
Tri-SMV	Three-Wheeler Slow-Moving Vehicles
AASHTO	American Association of State Highway and Transportation Officials
TRL	Transport Research Laboratory
AADT	Average Annual Daily Traffic
BRTA	Bangladesh Road Transport Authority
CG	Centre of Gravity
PTW	Powered Two and Three-Wheeler
LMIC	Low- and Middle-Income Countries
T-TRIID	Transport-Technology Research Innovation for International Development

1. Introduction

In the bustling streets of Bangladesh, three-wheeler slow-moving vehicles (Tri-SMVs) serve as a lifeline, facilitating essential daily commutes, supporting local economies, and providing an affordable transportation options to millions. Recognizing the pivotal role of Tri-SMVs in urban and rural mobility, and their potential to contribute to sustainable transportation solutions, it is important to address the significant challenges they face due to the existing road infrastructure, which primarily caters to faster, more robust motor vehicles.

These guidelines are designed to bridge the gap in current road design practices by establishing a framework that specifically accommodates the unique needs and safety of Tri-SMVs. The development of these guidelines is a response to the urgent need for an inclusive approach to road design that promotes safety, efficiency, and comfort for all road users, with a particular focus on the vulnerable and often overlooked users of Tri-SMVs. As we navigate the dynamic landscape of urban development, it becomes increasingly imperative to design roads that not only accommodate vehicular traffic efficiently but also prioritize the needs and safety of the broader community.

The road design guidelines that are generally consulted in preparation of national design guides are AASHTO Policy on Geometric Design of Highways and Streets (1993), AASHTO Roadside Design Guide (2011), Overseas Road Note 6 A guide to geometric design – TRL, etc. However, these guidelines are prepared with motorized traffic in mind, with some cases of consideration of public transportation and bicycle traffic. Therefore, they do not provide any design suggestions in the context of the country like Bangladesh where a major part of the traffic (around 80% in some cities, according to some estimates considering number of trips) is comprised of slow-moving three-wheelers. As such design guidelines only consider high speed four (or more) wheeled motorized vehicles, they often fail to ensure the safety and comfort of the passengers of the three-wheelers as well as drivers.

In this situation, it has become imperative to introduce some changes to accommodate the drivers and the users of the tri-SMVs who make up most of the population of the country. Tri-SMVs have widely different dynamic characteristics compared to regular 4 wheeled motorized vehicles (which are generally considered as design vehicles). Tri-SMV passengers confront different degrees of comfort and safety issues resulting from the road geometric, cross-sectional as well as roadside facility design aspects.

‘Technical Recommendations for Road Design Considering Three-Wheeler Slow-Moving Vehicles’ is crafted with the belief that streets are vibrant spaces that shape the quality of life for all who traverse them and thus should be designed in a way that caters to the safety and comfort of all. We believe that this guideline can contribute to near-term and long-term improvement of road facility and user experience and dictate best practices for road design aiming at the comfort and safety of Tri-SMV users.

The genesis of this initiative was the observation of recurring issues faced by Tri-SMV operators and passengers, which include, but are not limited to, inadequate lane widths, unsuitable speed calming measures, and unsafe roadside barriers. These issues not only compromise safety and operational efficiency but also deter the use of Tri-SMVs due to the increased risk and discomfort associated with navigating urban and rural roadways.

The commitment to addressing these challenges is rooted in a broader vision of achieving sustainable urban development goals, which emphasize the importance of accessible and safe transport systems for enhancing the quality of life in cities and communities worldwide. The guidelines presented here are informed by extensive research, including field surveys, stakeholder interviews, and empirical data analysis, ensuring that they are grounded in the realities of the current transportation landscape and the lived experiences of Tri-SMV users.

In today's context, where sustainability, accessibility, and community well-being are at the forefront of urban planning, the design of roads takes on a profound significance. Beyond the conventional considerations of traffic flow and infrastructure, this guideline emphasizes an integrated approach that places people at the heart of the design process.

The roads are shared spaces, connecting neighbourhoods and fostering social interactions. This guideline seeks to empower planners, engineers, and policymakers to create roadways that promote safety, inclusivity, and a sense of community. Whether you are embarking on a new development project or seeking to enhance existing infrastructure, this guideline provides a comprehensive framework that integrates the diverse needs of commuters in developing countries like Bangladesh.

The following sections delve into practical steps and considerations for designing roads that not only facilitate smooth traffic flow but also encourage active transportation, prioritize accessibility for all, and contribute to the overall well-being of communities. The objective is to guide designers that are creating roads that are not just conduits for vehicles but are integral elements of a liveable and thriving urban environment.

2. Objective

This guideline aims to provide direction to engineers, urban designers, and policymakers on how to build roads that are more inclusive and takes into consideration the unique situations where roads are dominated by Tri-SMVs, and such vehicles are the primary mode of transportation to the majority. These vehicles dominate both the urban and rural landscapes of Bangladesh and for many communities are the only mode of transportation and thus this guideline aims to facilitate the construction of inclusive infrastructure.

The data used for formulating the guideline was obtained by running experiments on manual hand pulled rickshaws, battery-operated rickshaws and easy-bikes colloquially known as “Auto” (Figure 1 and 2). These experiments were conducted on diverse types of pavements including both rigid and flexible pavements.

Figure 1 Typical manual rickshaw

Figure 2 Battery-operated rickshaw

For diversification of data, it was ensured that the drivers belonged to all age groups and experiences. Data was collected from those with more than twenty years of experience and from those with less than five years' experience.

This guideline was compiled on the context of Bangladesh. However, similar vehicles have been serving many urban and rural communities in Asia and Africa. The principles described in this guideline may also be used for construction and design in other countries that have a significant number of similar three-wheeler slow moving vehicles in the traffic make up.

The primary objective of these guidelines is to provide road designers, urban planners, and policymakers with practical, scientifically backed recommendations for creating roadways that are not only safe and accessible for Tri-SMVs but also conducive to a smoother integration of these vehicles into the overall traffic system. By rethinking road design from the perspective of Tri-SMV users, these guidelines aim to:

- Enhance Safety: Reduce the frequency and severity of accidents involving Tri-SMVs by introducing road design elements that accommodate their operational characteristics.
- Improve Comfort: Ensure that road infrastructure mitigates the physical discomforts often experienced by Tri-SMV passengers, particularly on routes frequented by vulnerable passengers.

3. Process of Recommendation Establishment

For the compilation of this guideline, we approached the problems in three major stages (Figure 3). While the first stage focused on identification of potential issues, the second stage dealt with the quantification and significance of the issue. In the third stage, focus was put on the solution.

In the identification stage emphasis was given on both qualitative and quantitative data to identify problems. Several pilot surveys and opinion surveys were conducted to get an understanding of the people's perspective. The surveys included people of all educational background and those living in both urban and rural areas. The respondents included drivers, users and mechanics of tri-SMV, doctors and medical staff, engineers and researchers etc. A special focus was given on the pregnant, the elderly and women in general to understand their unique needs and problems.

After collecting the qualitative data, focus was placed on quantification of the road hazards. Measurements of different geometric features were done and at the same time different dynamic characteristics of the tri-SMV were measured. IMU (Inertial measurement Unit) and GPS were used along with other traditional devices to measure velocity, acceleration, breaktime, braking distance etc.

Finally, in the third stage, both the qualitative and quantitative data were used to identify potential problems and their respective solutions. The steps of recommendations establishment are detailed below:

1. Identification of the road hazards for the Tri-SMV

- Opinion survey
- Geometric measurements
- Comfort/Acceleration measurement
- Data Analysis

2. Quantification of the hazards

- Data Analysis
- Expert opinion

3. Development Solutions

- Exploration of options
- Consultation
- Conduct viability evaluation

The processes can be graphically represented in the following figure:

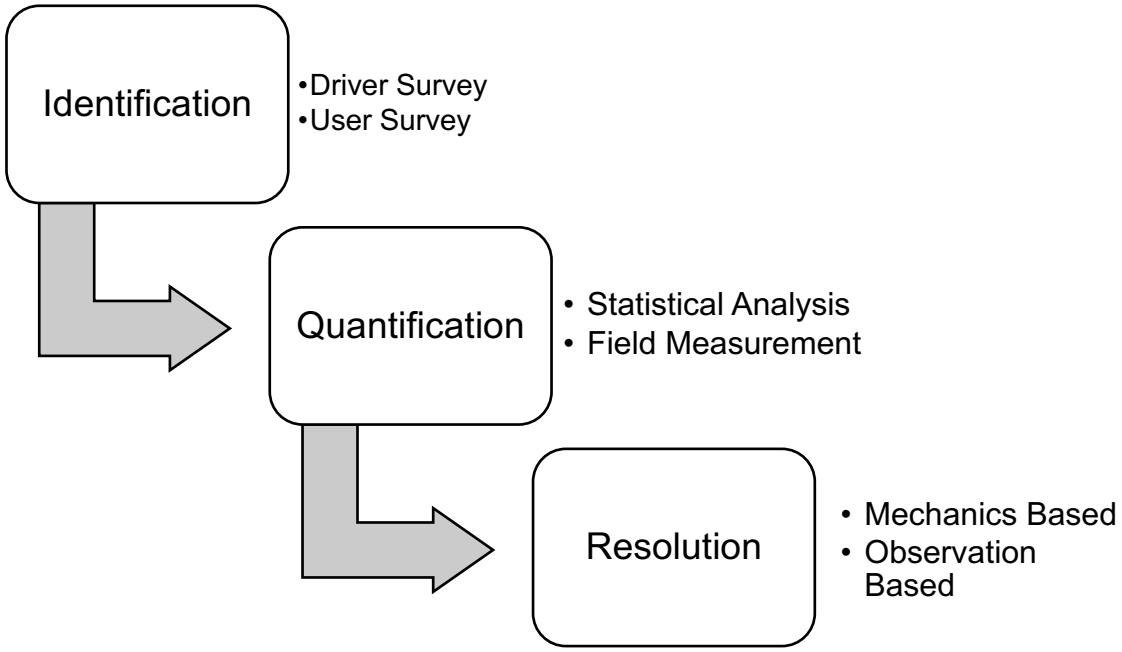

Figure 3 Process of Establishment of Recommendations

4. Technical Recommendations for Transportation Infrastructure for safer Tri-SMV Operation

Using the approach mentioned above, recommendations were developed addressing various aspects of three-wheeler's operational safety involving transportation infrastructure.

1. Pavement Longitudinal and Surface Features
2. Pavement Cross-sectional Features
3. Pavement Vertical Profile Elements
4. Road-Side Features and Signs
5. Traffic Pattern and Signalization
6. General Recommendation regarding Tri-SMV

4.1 Pavement Longitudinal and Surface Features

A World Bank Report[1] identifies the surface condition to be of critical importance as the condition of the road surface poses a distinct crash risk for PTW (Powered Two and Three-Wheeler) users. Factors such as uneven surfaces, deterioration, potholes, unpaved curbs, manhole covers, bumps, drainage issues, spillages, poor road markings, and debris have all been shown to increase the likelihood of crashes for PTW users.

Pothole Management and Surface Maintenance:

To address the issue of accidents caused by potholes and uneven surfaces, regular maintenance schedules should be implemented.

- Pavements should be inspected every six months, and potholes filled promptly to prevent accidents. Potholes more than 1" (25mm) deep or more than 2" (50mm) wide in any direction should be repaired immediately upon notice.
- Effective drainage solutions should be implemented to manage waterlogging, ensuring potholes remain visible and do not cause unexpected hazards for Tri-SMV operators.
- High-quality materials should be used for road construction to ensure a smooth surface, reducing wear and tear over time.

Surface Smoothness:

- Smooth road surfaces are essential for the safety and comfort of Tri-SMV users. The surface should be free of abrupt changes in elevation and rough patches that can cause discomfort or accidents. Using high-quality materials for road construction and ensuring a smooth finish can significantly improve the ride quality for Tri-SMVs.
- Implementing a regular inspection and maintenance schedule will help identify and address surface irregularities promptly.
- Paving blocks and compacted demolition waste should be discouraged as they create undue roughness and hampers ride quality. IRC SP 063-2004[2] noted that the block pavement also creates excessive noise and ride quality deteriorates with higher speed vehicles.

[1] World Health Organization (2022), "Powered two-and three-wheeler safety: a road safety manual for decision-makers and practitioners, 2nd ed".

[2] Indian Road Congress (2004), "Guidelines for the Use of Interlocking Concrete Block Pavement".

4.2 Pavement Cross-sectional Features

The World Bank report[1] mentioned that Lane segregation tends to be advantageous and generally accepted by the public when PTWs (Powered Two and Three Wheelers) constitute more than 20–30% of the total vehicles on the road, which is often the case in many low- and middle-income countries (LMICs).

Lane Widths:

- Lane widths should be adjusted to accommodate Tri-SMVs comfortably alongside other vehicles. This involves creating one-way lanes that are at least an additional 2.2 meters (after regular car width/lane) wide in adequate space and 1.7m additional lane width for space constrained places. These values are taken from the Cycling Embassy of Denmark[3].
- Dedicated lanes for Tri-SMVs should be considered in areas with high traffic volumes of these vehicles to ensure their safe and efficient movement. Above mentioned lane widths should be followed when creating dedicated lanes.
- Dedicated lanes can be marked with distinct colours and symbols to clearly differentiate them from general traffic lanes.

Shoulder and Edge Strengthening:

- In heavy traffic areas with no dedicated tri-SMV lane, the shoulder and pavement edges act as refuge for these slow-moving vehicles. Therefore, the shoulders and edges of roads with heavy Tri-SMV traffic should be strengthened to support the weight and frequent usage by these vehicles. This involves reinforcing the base and sub-base courses and ensuring that the edges are clearly marked and maintained regularly to prevent accidents.
- Shoulders should be at least 1.0 meters wide and constructed with durable materials to withstand the weight of Tri-SMVs.
- Regular inspections and maintenance of shoulders and edges will help ensure they remain in good condition.

4.3 Pavement Vertical Profile Elements

Slope and Ramp Adjustments:

- Slopes and ramps that exceed certain rate of elevation should be redesigned to have longer approach lengths to reduce the effort required by Tri-SMV drivers and enhance passenger comfort.
- Pavement designed for only cyclists[4] should have gradients generally not exceeding 6%, although very short sections with up to 10% might be acceptable. For longer ascends gradients should be reduced to 2-3%. However, Three-wheelers are heavier and need more power. Therefore, for Tr-SMVs, upslopes should not exceed 3-4% with longer slopes limiting to 2-3%.
- Shallower slope will also enable downward moving Tri-SMVS to avoid high acceleration and speed due to gravity.
- Ramps and slopes should be frequently maintained as deteriorating pavement in these segments can cause difficulty and loss-of-control of the vehicle.

Super-elevation and Curves:

- The maximum super-elevation should be set to accommodate the stability of Tri-SMVs, as they have high Centre of gravity.

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[3] https://cyclingsolutions.info/solutions-for-road-stretches/

[4] https://cyclehighways.eu/design-and-build/design-principles/slopes-and-gradients.html

- Too high super-elevation may result inward tilting and turning over of the Tri-SMV.
- When the edge of the pavement needs to be lifted to provide superelevation, Cross-slope should adjust through providing rapid superelevation runoff length to ensure the centrifugal force does not result outward turning over.
- Larger radius curves should be implemented where possible to reduce the risk of vehicles losing control.
- In rural setting, wider curves provide smoother turns, reducing the need for sharp manoeuvring, which can destabilize Tri-SMVs.
- In urban settings or in places with space limitations, active and passive speed control measures should be adopted so that safe turning can be ensured.

Speed Bumps:

Traffic calming measures have successfully reduced the number of crashes involving four-wheeled vehicles. However, the design of these interventions can adversely affect motorcyclists. An OECD report[5] highlights that road obstacles, such as speed humps and small vertical objects intended to reduce speed, can be hazardous for motorcyclists, and three wheelers. IRC 99:2018[6] (as shown in Figure 4 & 5) contains several recommendations for traffic calming devices which may be followed as a good practice guideline.

- Speed bumps should be designed with a gentle slope and wider profile.
- The height should not exceed 10 cm, and the slope should be no steeper than 7.5% at the edge of the bump.

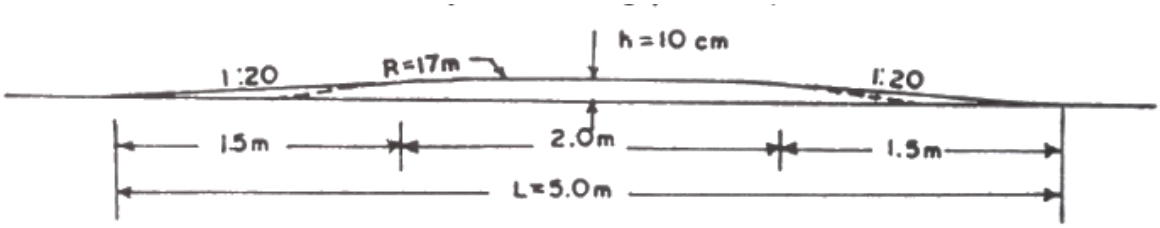


Figure 4 Suggested Speed breaker Profile as per IRC 99:2018

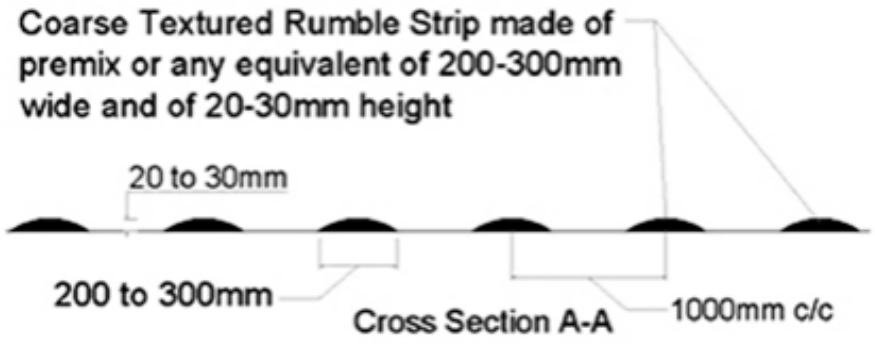


Figure 5 Rumble Strip Profile as per IRC 99:2018

- Speed bumps should be strategically placed to control speed without causing discomfort or accidents.
- Construction of speed bumps by general populace without proper authorization should be prohibited.
- Speed bumps should be clearly marked with reflective paint and warning signs placed ahead to alert drivers.

[5] International Transport Forum (2015), "Improving Safety for Motorcycle, Scooter and Moped Riders"

[6] IRC 099:2018. Guidelines for Traffic Calming Measures in Urban and Rural Areas (First Revision)

- Location of speed bumps should be such that Tri-SMVs can accelerate for adequate intersection clearance speed. It is estimated that 20m distance should be kept between speedbump and intersection or turning point (point of entry) which will enable paddle driven rickshaws 10km/hr speed and electric rickshaws about 20km/hr speed. These speeds are deemed adequate for reasonable clearance time as well as maintaining manoeuvrability while ensuring reasonable breaking distance.
- Placement of high-speed breakers in bridge/elevated intersection approach should be avoided. Rumble strips may be placed in downward path for speed control.
- Speed breakers should be extended to the outer edge of shoulders or embankment (whichever is the widest); otherwise, Tri-SMV may opt for driving over shoulder which will create undue risk for falling over.

Drain and Manhole Covers:

- Open drains should be covered immediately and marked with red flags until permanent covers are installed.
- Manhole covers must be flush with the road surface and should not extend more than 1 cm above the road surface to prevent tripping hazards and accidents. Properly covered drains and manholes prevent accidents and ensure a smooth passage for all vehicles.

4.4 Road-Side Features and Signs

As per the World Bank report[1] cites another study[7] that Roadside hazards, including fixed objects like trees, signposts, guardrails, utility poles, and drainage structures, as well as transient objects such as parked cars, pose significant risks to PTW (Powered Two and Three-Wheeler) users. Crashes involving fixed roadside hazards are 14 times more likely to result in fatalities compared to crashes that do not involve any fixed hazards. The World Bank Report[1] refers to a research[8] which using data from Australia and New Zealand concluded that while many roadside fixtures like guardrails and signposts are designed to protect cars, they can be hazardous for PTW (Powered Two and Three-Wheeler) users. This is primarily because such objects have been designed with the safety of cars and their occupants in mind, rather than for PTWs.

Safety Barriers:

- Roadside barriers, especially on bridges and culverts, should be designed to prevent smaller Tri-SMVs from falling off.
- The spacing between barriers should not exceed 30 cm to ensure that even the smallest vehicles are protected. Such small spacing may be impractical, which indicates it is better to use continuous type road-side barrier.
- Metallic barrier should have rubber edge-protectors so that they do not become Laceration hazard in the event of an accident.
- Bollards should be spaced no more than ¾ of the rear axle dimension of a rickshaw. The typical length of the rear axle of a manual rickshaw is 117.2cm[9]. This spacing ensures that the barriers effectively prevent vehicles from slipping through or getting stuck.

[7] Miggins, M., Lottenberg, L., Liu, H., Moldawer, L., Efron, P., & Ang, D. (2011). Mopeds and scooters: crash outcomes in a high traffic state. Journal of Trauma and Acute Care Surgery, 71(1), 217-222.

[8] Milling, D., Hillier, P., (2015) Infrastructure improvements to reduce motorcycle crash risk and crash severity. Proceedings of the 2015 Australasian Road Safety Conference 14–16 October, Gold Coast, Australia; 2015

[9] Mahmud, M. I., Satter, M., & Rahman, M. (2007). Design of the Rickshaw to Improve Safety and Comfort of Passengers. Journal of Engineering and Technology VoL6.

Signage and Markings:

- Clear and visible road signage is crucial for guiding Tri-SMV operators. Regulatory, warning, and informational signs should be placed at appropriate intervals (some examples can be seen in Figure 6). Speed limit signs, in particular, should be prominently displayed to encourage safe driving practices. Examples are shown below.
- Road markings should be maintained and retouched every three to six months to ensure visibility. Specially, before and after monsoon events should be carefully monitored.
- Signage should include icons and symbols easily recognizable by all drivers, including those who may have low literacy levels.
- Apart from regular and routine signage approved by BRTA, following signs may be considered for inclusion/application focusing Tri-SMVs:

No Tri-SMV Allowed, to be used in arterials and highways

Tri-SMV Allowed; urban and suburban as well as rural streets

Tri-SMV Lane, when dedicated rickshaw/Tri-SMV lanes are provided

No Tri-SMV Overtaking Allowed when single Tri-SMV Lane provided

Sharing a Lane, shows positioning of Tri-SMV Lane

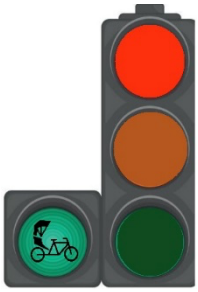
Tipping Hazard; to be used in sharp turns and steep side slopes

Steep Uphill Slope: advisory to reduce Weight/Disembark passengers.

Uneven Manhole ahead

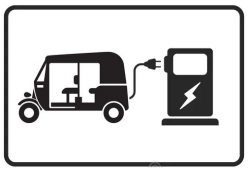
Warning on Rough Surface ahead

Vehicle Specific Speed Limit Sign



Dedicated Rickshaw Green to make turns from rickshaw lane

Designated Tri-SMV parking spots



Electric Tri-SMV Charging Station

Figure 6 Proposed Road Signs Related to Tri-SMV

4.5 Traffic Pattern and Signalization

Speed Regulations:

- Specific speed limits should be enforced for different types of Tri-SMVs and road conditions. For instance, in urban areas with high traffic volumes, battery-operated rickshaws should not exceed 20 km/h, while in rural areas, they can go up to 25 km/h.
- Manual rickshaws should be limited to 15 km/h in urban areas and 20 km/h in rural areas. These limits help in reducing the risk of accidents caused by speeding.

Traffic Signals:

- Traffic signals should be designed to accommodate the slower acceleration and braking times of Tri-SMVs.
- Signal timings should be adjusted to provide sufficient crossing time for these vehicles, particularly at busy intersections.
- Pedestrian signals should also consider the presence of Tri-SMVs, ensuring that both pedestrians and vehicle operators have clear and safe crossing times.
- Signal timings should be extended during peak Tri-SMV usage hours to accommodate their slower speeds.
- Separate Tri-SMV Green may be implemented to give them adequate clearance and headway to avoid conflicting traffic; specially in turning signals. A potential signal image has been provided in the Signage and Markings discussion.
- Separate Tri-SMV signal may work well with dedicated Tri-SMV Lane.

Traffic Flow Management:

- In major cities like Dhaka, Tri-SMVs should be restricted from operating on major roads during peak hours.
- Allowing Tri-SMVs to operate only during non-peak hours can reduce congestion and enhance safety. This restriction helps manage traffic flow more efficiently and reduces the risk of accidents involving slower-moving vehicles.

5. Challenges and Concerns

Implementing the recommendations outlined previously can lead to several financial, geometric, and operational impacts, some of which may negatively affect other road users such as pedestrians, cars, and buses. However, with thoughtful planning and appropriate remedial actions, these challenges can be mitigated.

Financial Aspects:

Implementing dedicated infrastructure and safety measures for Tri-SMVs will require significant financial investments. This includes costs associated with road widening, shoulder strengthening, and the installation of specialized signage and barriers. Regular maintenance and inspection schedules to manage potholes and ensure surface smoothness will also increase operational expenses for road authorities. Funding these initiatives could divert resources from other critical infrastructure projects, potentially slowing overall development.

To mitigate this issue, Flexible budgeting and phased implementation can help manage the financial burden. Prioritizing high-traffic areas for initial investments and gradually extending improvements to other regions can distribute costs over time. Seeking additional funding from international aid organizations, public-private partnerships, and community funding initiatives can also provide financial support for these projects.

Geometric Aspects:

The geometric redesign of roads to accommodate Tri-SMVs, including wider lanes and adjusted slopes, may reduce the available space for other vehicles. For example, creating dedicated lanes for Tri-SMVs can lead to narrower lanes for cars and buses, potentially increasing congestion. The adjustment of slopes and ramps to meet the needs of Tri-SMVs may conflict with existing design standards optimized for higher-speed vehicles, requiring extensive modifications to current road geometries.

To solve this issue, in areas where it is not feasible to provide dedicated lanes for Tri-SMVs due to space constraints, shared lanes can be marked with clear signage and road markings to indicate the presence of Tri-SMVs. This approach can help maintain the flow of traffic while ensuring the safety of all users. Additionally, employing flexible lane usage strategies during peak hours can help manage traffic effectively. For example, allowing Tri-SMVs to use bus lanes during bus off-peak times can reduce congestion on regular lanes.

Impact on Other Transportation Modes:

Pedestrians:

Implementing dedicated lanes for Tri-SMVs can reduce the space available for pedestrian walkways, especially in urban areas with limited right-of-way. This could lead to overcrowded sidewalks and increased pedestrian-vehicle interactions, heightening safety risks.

Enhancing pedestrian infrastructure alongside Tri-SMV lanes, such as wider sidewalks and pedestrian crossings, can mitigate these issues. Designing multi-modal streets that accommodate both pedestrians and Tri-SMVs through careful spatial planning and clear delineation can promote safety for all users.

Cars:

The allocation of road space to Tri-SMVs may reduce the number of lanes available for cars, exacerbating traffic congestion during peak hours. Restrictions on Tri-SMV operations during these times might offer some relief but could also complicate traffic patterns and enforcement efforts.

Implementing smart traffic management systems that dynamically adjust lane usage based on real-time traffic conditions can optimize road space usage. Flexible lane usage policies that allow Tri-SMVs to share lanes with buses during high-demand hours can also alleviate congestion without severely impacting car traffic. However, it is also possible that the peak times for all modalities may peak simultaneously. In such case, smart traffic management may allow certain volume of Tri-SMVs and prioritize buses.

Buses:

Buses, which require consistent speeds and clear lanes to maintain schedules, may experience increased delays due to the integration of slower-moving Tri-SMVs into their routes. This could reduce the efficiency of public transport systems and discourage usage.

Designing dedicated bus lanes and ensuring that Tri-SMV lanes do not overlap with key bus routes can help maintain the efficiency of public transport. Additionally, It is also recommended that Tri-SMV should not share road with buses for safety concerns.

Safety Concerns:

While the recommendations aim to enhance the safety of Tri-SMV users, there are potential negative safety impacts for other road users. For example, the introduction of speed bumps and other traffic calming measures designed for Tri-SMVs might pose hazards to motorcyclists and other two-wheelers. The reconfiguration of road features to prevent tipping hazards for Tri-SMVs may lead to unexpected handling characteristics for cars and buses, especially in emergency maneuvers.

However, it was noted that designing speed bumps and other traffic calming measures with gentle slopes and wider profiles can make them safer for all road users, including motorcyclists and Tri-SMVs. Strategic placement of these measures, along with clear signage, can help manage speeds without causing undue hazards. Enhanced road maintenance, such as regular pothole repairs and drainage management, benefits all road users by ensuring smooth and safe road surfaces.

6. Conclusion

The ‘Technical Recommendations for Road Design Considering Three-Wheeler Slow-Moving Vehicles’ report represents a crucial step towards creating inclusive road infrastructure that enhances the safety and comfort of Tri-SMV users. Supported by the High Volume Transport (HVT) program and the T-TRIID initiative, this guideline is the result of extensive research, stakeholder consultations, and empirical data analysis.

The guideline focus on several key improvements. It emphasizes the mitigation of hazards such as potholes, uneven surfaces, and inadequate signage, aiming to reduce accidents and improve ride quality for Tri-SMVs. The recommendation for dedicated lanes and reinforced shoulders ensures the safe and efficient movement of these vehicles, which are vital for both urban and rural mobility.

In terms of roadside safety, the guideline advocates for improved features like customized barriers and clear signage to protect Tri-SMV users from fixed and transient hazards. It also highlights the importance of tailored traffic calming measures and specific speed regulations to manage the unique dynamics of Tri-SMVs, thereby enhancing overall road safety.

Future research and continuous improvement are essential to keep these guidelines relevant. There is a need for ongoing studies focusing on evolving transportation trends, technological advancements, and their impact on road safety. Specifically, understanding the unique safety issues of Tri-SMVs, such as their high centre of gravity, susceptibility to tipping, inadequacy of breaking, lack of driver’s training, and vulnerability in collisions with larger vehicles, is critical. Addressing these risks requires detailed research into their operational characteristics and accident patterns.

The guideline offers a framework adaptable to other countries, especially in the Global South where similar transportation challenges exist. Countries like India, Pakistan, Indonesia, Nigeria, and Kenya, with prevalent three-wheelers, can benefit from these guidelines. While the principles are broadly applicable, the research was conducted in Bangladesh. Therefore, designers in other countries should use this report as a starting point and adapt the recommendations to local conditions for optimal effectiveness.

Following steps for implementation may be taken for in other countries:

- Assessment of Local Context: Conduct comprehensive assessments of the local transportation landscape to tailor the guidelines to specific needs.
- Stakeholder Engagement: Involve local stakeholders, including authorities, planners, communities, and vehicle operators, to ensure the guidelines are relevant and supported.
- Customization of Guidelines: Adapt the guidelines to reflect local standards, modifying aspects like lane widths, speed limits, and maintenance practices.
- Pilot Projects: Implement pilot projects in selected areas to test and refine the guidelines before broader implementation.
- Capacity Building: Provide training for engineers, planners, and maintenance crews, and raise public awareness about the guidelines and their benefits.
- Monitoring and Evaluation: Establish systems for ongoing monitoring and evaluation to assess the guidelines' impact and ensure continuous improvement.

The support from the HVT program and the T-TRIID initiative underscores the commitment to sustainable and inclusive transportation planning in Bangladesh. By prioritizing the unique needs of Tri-SMV users, this guideline not only promotes safety and comfort but also contributes to broader goals of sustainable urban development. Successful implementation will require collaboration among engineers, planners, policymakers, and the community to ensure that road infrastructure meets the diverse needs of all road users.

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