

Research Article

Application of Occasional Movable Free Standing Road Dividers for Traffic Flow Improvement in Dhaka City

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Abstract

Dhaka is struggling with intense traffic congestion due to rapid, unplanned development, leading to an imbalance between transport demand and available infrastructure. The traffic woes have extended beyond mere inconvenience, significantly impacting the environment. The city experiences two distinct peak periods of congestion. The first peak arises from the daily movement of office workers, business personnel, and schoolchildren during their commutes, while the second is driven by shoppers heading to and from commercial areas. Traffic studies reveal that during peak hours, congestion is prevalent in all directions, with some routes bearing a heavier load than others. One proposed solution to address this imbalance is the implementation of a movable road divider. This innovative approach would enable a dynamic allocation of road space, directing more capacity to the busier lanes and easing the traffic flow during critical times. The effectiveness of such a system could also extend to holiday seasons, such as Eid and Durga Puja, when the city's traffic patterns undergo significant changes. During these times, outbound traffic from Dhaka surges before the holidays, while inbound traffic increases afterward. By adjusting the road divider to accommodate these shifts, the city could ensure a smoother flow of vehicles, reducing delays and alleviating the strain on its road infrastructure. Adjusting the divider to favor the less congested side during these periods would improve traffic flow by providing more space for the heavier traffic.

Keywords

Movable Divider, Traffic Congestion, Traffic Management, Traffic Volume, Peak Hour Congestion

1. Introduction

Road dividers are commonly used to separate lanes of opposing traffic, ensuring an organized flow of vehicles. However, a significant limitation of static road dividers is their inability to adapt to varying traffic patterns, as the number of lanes in each direction remains fixed regardless of changing conditions [1]. With growing populations and increasing

vehicle numbers, optimizing the use of existing road infrastructure, particularly lane distribution, has become crucial [1]. Traffic congestion happens once vehicle interactions slow down traffic flow, often due to high demand during peak hours [2].

Approximately 18.2 million people reside in Dhaka Meg-

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acity, with projections estimating this number will influence 22 million by 2025, at an annual growing rate of 4.4% [2]. Around 63% of this growth is attributed to in-migration, while the rest is due to natural population increase [3]. The population data also shows that 40% of the population consists of dependent age groups, leading to a high reliance ratio and extensive poverty among low-income residents in the city [2]. In many urban areas, especially near industrial or commercial hubs, traffic tends to be heavier in one direction at specific times, such as during morning or evening rush hours. This results in congestion on one side of the road while the lanes in the reverse direction are underutilized. This imbalance leads to traffic delays, wasted time, and inefficient use of road resources [1]. A key contributor to this issue is poor road design, which exacerbates congestion [5].

The Passenger Car Unit (PCU) is used to measure the traffic volume for different vehicle categories in mixed traffic situations, helping address traffic heterogeneity [9]. For example, during the Eid holiday, around 15 million people are predictable to leave the larger Dhaka region, including areas like Dhaka North, Dhaka South, Gazipur, and Narayanganj, causing significant strain on the transportation network [7]. Dhaka is considered one of the world's most densely populated cities, with a population density of 11,910 people per square kilometer [2]. The central areas, including Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC), have seen a sharp increase in density, rising from 34,629 per square kilometer in 2001 to 49,182 per square kilometer in 2011, creating a highly congested and challenging living environment [2].

Traditional road dividers remain fixed, making them ineffective during peak traffic hours when the traffic demand on one side of the road exceeds that of the other. This often results in chaos, confusion, and longer travel times for travelers. To address this issue, moveable barriers, such as those used with zipper machines, have been introduced. These machines transfer the barrier from one lane to another, allowing for better lane allocation. However, the process is manual and labor-intensive, posing additional challenges [8].

Modifying and improving road management systems are essential for creating more dynamic and responsive infrastructure that adapts to fluctuating traffic patterns, thus reducing congestion and improving overall efficiency.

2. Literature Review

With a population of over 18 million, Dhaka ranks as one of

the largest and most densely populated cities globally (UN, 2015). Its rapid growth has led to numerous challenges, with traffic congestion being one of the most significant. Despite being one of Asia's least mechanized capitals, Dhaka's traffic problems are severe and worsening. Over the past five years, more than 420,000 motor vehicles have been registered in the city, yet the road space remains inadequate [2].

Dhaka, the capital of Bangladesh, is located in South Asia and is recognized as the 11th largest megacity in the world (United Nations, 2016). It has recently been identified as one of the fastest-growing megacities (Hossain, 2013). Geographically, the core area of Dhaka, covering both Dhaka North and South City Corporations, is situated between 23.69° and 23.89° North latitudes and 90.33° and 90.44° East longitudes [2]. The central part of the city spans around 127 square kilometers [2]. However, the Dhaka Metropolitan Development Plan covers a much larger area of 1,528 square kilometers, anticipating expansion into six neighboring municipalities—Kadamrasul, Gazipur, Narayanganj, Siddirganj, Savar, and Tongi—forming the greater Dhaka Megacity [2].

A free-standing road divider is an elastic traffic regulator device designed to temporarily or semi-permanently separate traffic lanes or designate specific road sections. Unlike fixed barriers that are secured to the ground, these dividers can be easily moved, making them well-suited for environments where traffic conditions frequently change. Typically made from materials like plastic, rubber, or concrete, they are lightweight yet durable, allowing for easy installation and removal while still withstanding regular traffic demands [10].

These dividers are commonly used in areas where stream of traffic patterns is temporarily altered, such as construction zones, maintenance sites, or during major events that require rerouting. In addition, they serve a critical role in emergencies, providing an immediate and temporary way to manage lane separations [10].

2.1. Purposes

1. Accurate info on the quantity of traffic on the roads is vigorous for the planning of both road maintenance and development strategies [4].
2. Traffic volume system study helps in deciding/planning if here is need for upgrading [4].
3. Growth in standings of construction absent links, by-pass, another road etc. [4].
4. Advanced and constant flow/congestion evidence is crucial for enhancing [4].

Table 1. Total amount of disruptions of vehicle flow for study route [6].

Vehicle Class	Travel Distance	Free Flow	Peak Hour Flow State						
			Typical Working Day				Typical off-day		
			Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Local Bus	7.2 km	24	113	110	121	88	118	55	73
Human hauler	5.6 km	33	201	101	139	113	143	86	106
Passenger car	7.2 km	10	110	99	67	138	65	33	49

2.2. General Observations

Peak Flow Trends: Across all categories, the flow tends to decrease on Fridays and Saturdays, with Sunday & Thursday showing some of the highest numbers, particularly for human haulers and passenger cars.

Weekday Patterns: There's a general pattern of higher traffic flow during the weekdays (Monday to Thursday), with Tuesday or Wednesday often showing the highest flow, depending on the vehicle category.

Free Flow vs. Peak Flow: The free flow conditions for all vehicle types are significantly lower compared to peak hour conditions, especially for human haulers and local buses.

the highest PCU factor of 3, indicating they take up more space and significantly affect traffic conditions.

Cars, utility vehicles, and other unspecified vehicles have a moderate impact, each with a PCU factor of 1.

Light trucks and minibuses have a greater influence on traffic than standard cars but less than large vehicles like buses and trucks.

This breakdown highlights how different vehicle types contribute to traffic congestion and helps in designing effective traffic management strategies.

The data shows that a greater percentage of severe pedestrian injuries (16.6%) takes place on Fridays, while injuries involving non-traditional modes of transport are most common on Thursdays (20.5%). Additionally, pedestrians are more at risk between 11:00 a.m. and noon on weekends [11].

Table 2. PCU by AASHTO for each Vehicle Type [3].

Vehicle Type	PCU Factor
Motorcycle	0.5
Car	1
Utility (Rickshaw, Qing qi),	1
Microbus <30 Seats	1.5
Minibus	3
Bus	3
Light Truck	1.5
Heavy Truck	3
Multi-Axle Truck	3
Others	1

2.3. Key Insights

Motorcycles have the lowest impact on traffic flow, with a PCU factor of 0.5, meaning they occupy less road space compared to other vehicles.

Minibuses, buses, heavy trucks, and multi-axle trucks have

Table 3. Average traffic load in the Mirpur Road (Shyamoli) of Dhaka (peak hour) [14].

Types of vehicles	Traffic Load (Per Hours)	Passenger Car Unit (PCU)
Motor cycles	380	190
Buses	170	510
Private car	320	320
Motor van	110	330
Other	60	42
Total	1040	1392

Table 4. Average traffic load in the Mirpur Road (Shyamoli) of Dhaka (Off peak hour) [14].

Types of vehicles	Traffic Load (Per Hours)	Passenger Car Unit (PCU)
Motor cycles	320	160

Types of vehicles	Traffic Load (Per Hours)	Passenger Car Unit (PCU)
Buses	110	330
Private car	60	60
Motor van	55	165
Other	30	21
Total	575	736

The data reveals a notable difference in traffic load and Passenger Car Unit (PCU) values between peak and off-peak hours on Mirpur Road (Shyamoli) in Dhaka. During peak hours, the total traffic load is significantly higher, reflecting increased demand and congestion. This heightened traffic density is mainly due to the higher number of vehicles on the road, including motorcycles, private cars, buses, motor vans, and other vehicles.

Buses and motor vans, despite being fewer in number compared to other vehicle types, contribute substantially to the overall PCU due to their larger size and capacity. Buses, in particular, have a high PCU value, which indicates their significant impact on road space consumption compared to smaller vehicles like motorcycles and private cars. This suggests that buses play a critical role in causing congestion during peak hours, not necessarily because of their quantity but due to the space they occupy on the road.

Motor vans also contribute a high PCU relative to their numbers, adding to the overall congestion. Meanwhile, motorcycles, though numerous, have a lower individual PCU, meaning they contribute less to overall congestion on a per-vehicle basis. Private cars, while contributing directly to the number of vehicles on the road, have a relatively lower PCU impact compared to buses and motor vans.

During off-peak hours, the traffic load and PCU values are considerably reduced. The number of buses and motor vans decreases, which lowers their impact on congestion. Consequently, overall traffic flows more smoothly as fewer high-PCU vehicles occupy the road, allowing more efficient movement of all vehicle types.

This analysis highlights the critical influence of buses and motor vans on peak-hour congestion, underscoring the need for targeted traffic management strategies. By better managing the flow of high-PCU vehicles, particularly during peak times, it may be possible to alleviate some of the severe congestion issues faced on Mirpur Road and improve overall traffic conditions.

During Eid, Dhaka's traffic patterns undergo dramatic changes. As the holiday approaches, a mass departure of city residents heading to their hometowns causes severe congestion on key exit routes, particularly highways leading out of the city. Bus terminals, train stations, and ferry ghats become extremely busy as people rush to leave Dhaka, creating chaotic traffic conditions.

Roads often become clogged with long lines of vehicles, including private cars, buses, and motorcycles, as everyone tries to travel at the same time. This results in severe traffic jams, sometimes extending for several kilometers. The congestion is worsened by the presence of street vendors, makeshift markets, and increased pedestrian activity around transportation hubs.

After Eid, the scenario reverses as large numbers of people return to Dhaka, causing heavy traffic on entry routes. The surge of incoming vehicles causes significant delays and slow-moving traffic, particularly on highways and major entry points into the city. Despite efforts by traffic management authorities, such as deploying additional personnel and implementing lane control measures, managing the post-Eid traffic influx remains a considerable challenge.

The Dhaka City Corporation (DCC) area, which includes both Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC), is marked by fast-paced urbanization and very high population density. As the capital of Bangladesh, Dhaka functions as the nation's central hub for politics, economy, and culture, drawing a significant influx of migrants from rural regions. Here are the main demographic and urban characteristics of the Dhaka City Corporation area:



Figure 1. Traffic State on Eid [7].



Figure 2. Traffic Disorder on Eid [13].

Table 5. The main demographic and urban structures of Dhaka Metropolitan area [2].

Description	DNCC	DSCC	Total
Area	83 km ²	45 km ²	127 km ²
No. of Ward	36	57	93
Population	3,957,302	2,288,812	6,246,114
Population density	47,886/km ²	50,862/km ²	49,182/km ²
Holdings	172,254	122,780	295,034
Markets	43	78	121
Community Centre	13	36	49
Park	42	27	69
Play Ground	55	9	64
Public Toilet	37	28	65
Hospital/Clinic	239	193	432

A recent study by Bangladesh University of Engineering and Technology (BUET) indicates that approximately three million people will depart from Dhaka each day in the four days leading up to Eid [15]. However, only 1.6 million have secured transportation for their journey so far [12].

2.4. Traffic Control

Traffic control refers to the regulation and supervision of the drive of people, goods, or vehicles to guarantee safety and efficiency. Traffic involves the transportation of individuals and cargo from one point to another, usually along a specific route or facility known as a guideway. This guideway may be a physical structure, like a railroad, or a designated path, marked geographically (as in maritime transport) or electronically (as in aviation). Apart from pedestrian movement, which relies solely on human power, transportation generally requires a vehicle. These vehicles, commonly referred to as modes of transport, can be classified into categories such as road, rail, and air [16].

Traffic develops from the need to transport people and goods from one place to another. This movement is driven by decisions made by individuals to travel or transport items to other locations, either to engage in activities or to move goods to areas where they hold greater value. Unlike other fields of engineering or physical sciences (such as the flow of electrons in a wire), traffic flow is primarily influenced by human behavior. While physical principles, such as those that keep airplanes airborne, are essential, the demand for travel stems from the human desire to relocate [16].

An electronic traffic regulator system consists of four key components: computers, communication devices, traffic signals and related equipment, and vehicle detection sensors. These sensors collect traffic data from roadways and transmit

it to a computer system for analysis. Traffic control helps manage the movement of vehicles and various forms of transportation infrastructure. Without it, vehicles would struggle to move efficiently, leading to accidents [16].

In modern society, traffic control plays a crucial role in ensuring the innocuous and well-organized movement of vehicles. Proper traffic management can mitigate accidents, and effective solutions require skilled professionals trained to monitor and manage traffic systems. Like any specialized field, education and training are essential for those working in traffic control [16].

In addition to relying on traffic signals and controllers, drivers must be aware of traffic rules and regulations to facilitate smooth traffic flow. Whether controlling traffic or driving through controlled zones, understanding basic traffic safety principles is vital for preventing accidents and ensuring overall efficiency [16].

3. Methodology

A temporary free-standing barrier system was built and subjected to full-scale crash testing. A pickup truck was used in one of the crash tests on the longitudinal barrier system, and it met the TL-3 safety performance standards outlined in the updated NCHRP Report No. 350 [10].

Their main purpose is to improve road safety by clearly marking lanes and preventing vehicles from crossing into restricted areas or oncoming traffic. By helping to organize traffic more efficiently, these dividers reduce congestion and minimize the risk of accidents. Their portability makes them ideal for situations that require quick adjustments to traffic flow [10].

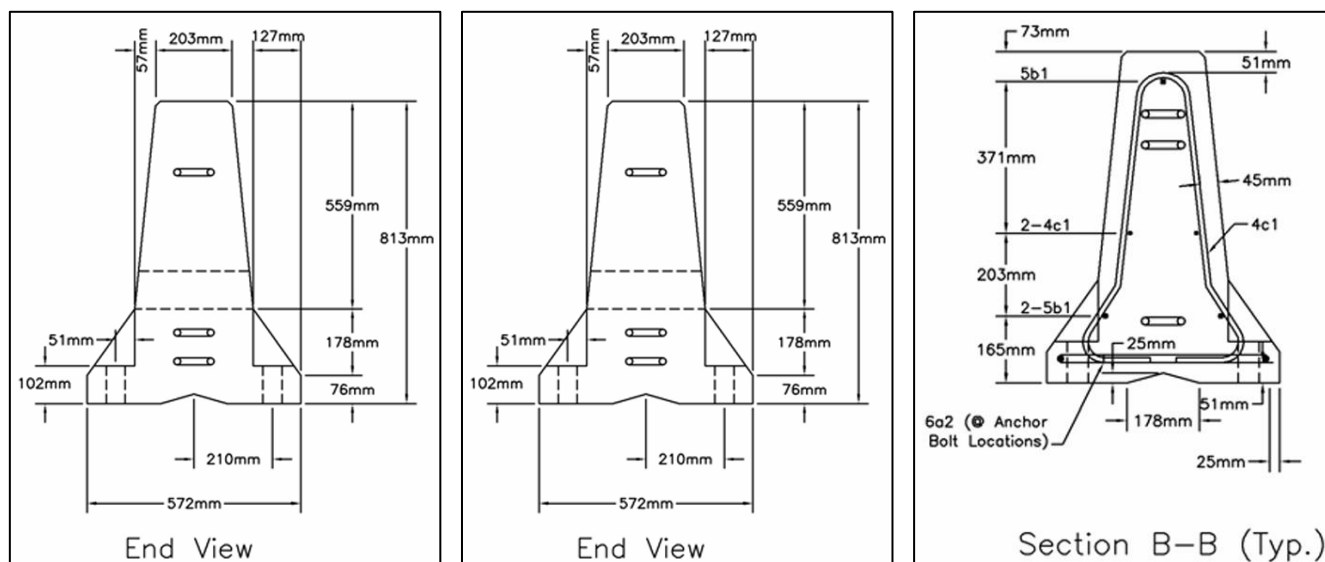


Figure 3. Temporary Barrier Section Details [10].



Figure 4. Temporary Barrier Constructed View [10].

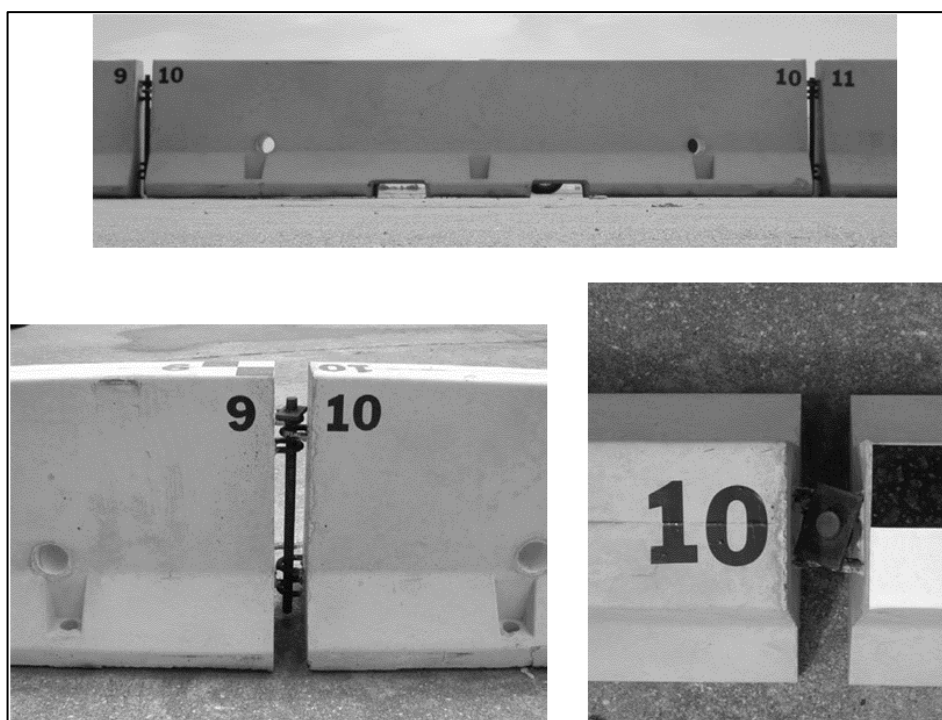


Figure 5. Temporary Barrier Joint Details [10].

3.1. Performance

A 2,268-kg (5,000-lb) pickup truck struck the free-standing temporary barricade system at a rapidity of 99.7 km/h (61.9 mph) and a slant of 25.4 degrees [10].

The safety performance assessment for test 2214TB-2, considering structural capability, dweller hazard, and vehicle path, has been found to be satisfactory [10].

The thorough evaluation of test 2214TB-2 demonstrated that the temporary barricade system performed well across all

criteria examined. It successfully absorbed the high-speed impact, prioritized occupant safety, and effectively guided the vehicle's trajectory after the collision. This performance suggests that the barricade is a dependable option for temporary traffic control, enhancing road safety and reducing the risks linked to vehicle accidents in diverse situations. The favorable results of this assessment underscore the necessity of implementing sturdy barricade systems in locations where vehicles may face potential dangers.

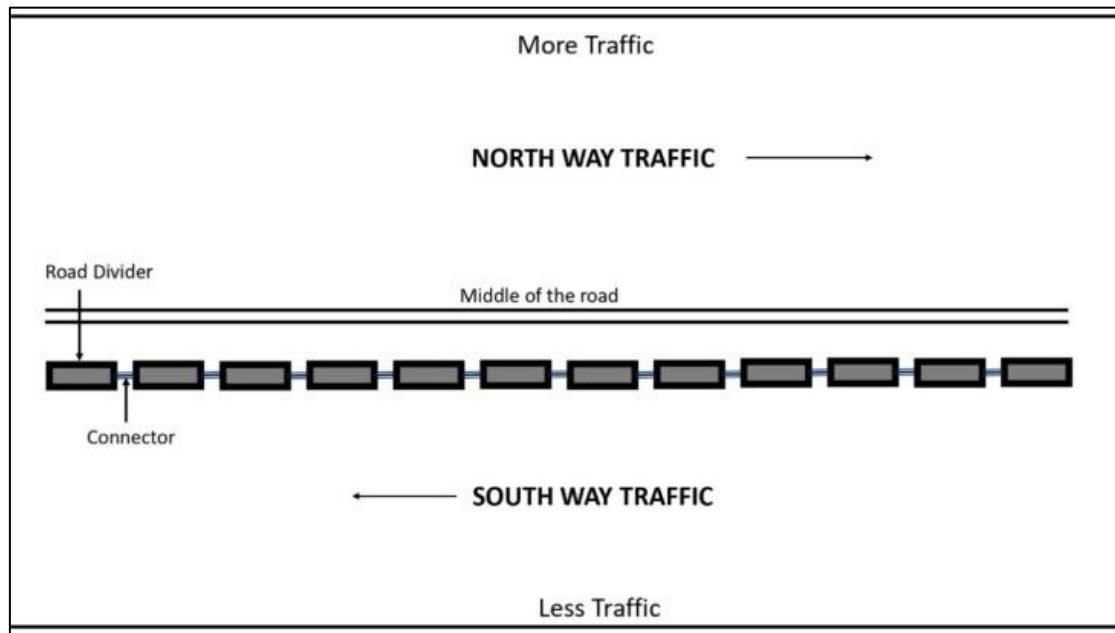


Figure 6. Proposed Road Divider Layout.

The diagram shows a dynamic road divider system designed to optimize road space utilization by shifting the divider based on traffic conditions. This setup aims to enhance traffic flow by reallocating lanes to the side with heavier traffic, thus addressing the imbalance between opposing traffic streams.

Northbound Traffic: The upper section of the illustration illustrates the direction experiencing higher vehicle density, indicating a substantial number of vehicles traveling in this lane. This area is labeled to reflect increased traffic, emphasizing the need for additional lanes to handle the greater demand during peak hours or busy periods.

Southbound Traffic: The lower section depicts the direction with a lower volume of vehicles, characterized by fewer cars on the road. This area is identified as having lighter traffic, suggesting that a reduced number of lanes is adequate for the vehicles moving in this direction.

This design highlights the importance of implementing flexible traffic management approaches that dynamically allocate road space according to current congestion levels,

ensuring smoother traffic flow in both directions.

Road Divider: Positioned along the center of the road, the divider is a movable barrier that can be adjusted to reallocate lanes between the northbound and southbound traffic. This divider is crucial for dynamically managing the available road space to match the varying traffic demands in each direction.

Connectors: These components are likely part of the mechanism that enables the road divider to shift laterally. The connectors link the individual segments of the divider, allowing it to be moved to one side or the other, depending on which direction needs more lanes.

The dynamic divider system is an effective traffic management tool, particularly useful during periods of uneven traffic flow, such as peak hours or during special events and holidays. By adjusting the divider's position, the system provides additional lanes to the direction experiencing higher congestion, allowing more vehicles to pass through. This helps to alleviate traffic jams, improve road efficiency, and enhance the overall driving experience by adapting the road layout to current traffic conditions.

3.2. Performance Evaluation

The effectiveness of Occasional Movable Free-Standing Road Dividers in enhancing traffic flow in Dhaka City can be assessed through both quantitative and qualitative measures. Key performance indicators (KPI) will help gauge the system's impact on traffic congestion and road efficiency.

3.3. Traffic Flow Enhancement

Congestion Reduction: Examine traffic data before and after the implementation of movable dividers to evaluate the decrease in traffic congestion. Metrics such as average vehicle speed, traffic volume, and reduced travel delays during rush hours will serve as critical indicators.

Improved Lane Utilization: Measure how well the movable dividers improve lane usage during peak traffic times. The aim is to enhance the number of vehicles using high-traffic lanes without creating additional traffic jams.

3.4. Effect on Travel Time

Travel Time Changes: Track the variation in average travel times for commuters on roads where the dividers have been introduced. A reduction in travel time indicates improved traffic management.

Peak vs. Off-Peak Performance: Compare travel time savings during peak hours versus non-peak periods to determine the effectiveness of the dividers in alleviating congestion during high-demand times.

3.5. Road Capacity Utilization

Increased Road Capacity: Assess the impact of dynamically reallocating lanes with movable dividers on the overall capacity of the road network. More vehicles should be able to pass through critical corridors without the need for additional infrastructure.

3.6. Safety Enhancements

Accident Frequency: Monitor changes in the rate of traffic accidents before and after the implementation. A reduction in incidents caused by congestion or improper lane changes may indicate improved road safety due to better traffic management.

Lane Discipline: Evaluate how well drivers adhere to new lane configurations introduced by the movable dividers. Improved lane discipline should result in fewer accidents and smoother traffic flow.

3.7. Feedback from Public and Stakeholders

Commuter Satisfaction: Conduct surveys to gather input from drivers on their experiences with the movable dividers. Assess whether they perceive improvements in travel speed,

safety, and overall traffic conditions.

Traffic Personnel Efficiency: Obtain feedback from traffic management staff on the ease of deploying and maintaining the dividers, ensuring the system remains practical for regular use.

3.8. Cost-Benefit Evaluation

Cost-Effectiveness: Compare the financial investment in installing and maintaining the movable divider system against the gains achieved, such as reduced travel time, better road capacity, and enhanced safety.

Scalability: Determine whether the benefits justify extending the system to other traffic-congested areas of Dhaka.

By analyzing these performance indicators, the success of movable dividers in managing Dhaka's traffic can be measured effectively, ensuring the system's potential for broader application across the city.

4. Results and Discussion

Advantages:

1. Enhance safety by reducing the likelihood of accidents through better lane management and clearer road markings.
2. Provide flexibility in traffic flow adjustments, allowing for quick responses to changing traffic conditions or road incidents.
3. Support environmental goals by potentially reducing vehicle idling times and emissions associated with congestion.
4. Offer cost-effective solutions compared to extensive road expansions or permanent infrastructure changes.
5. Improve user satisfaction by creating a more predictable and streamlined driving experience.
6. Integrate with existing traffic management systems to maximize overall road network efficiency.
7. Consider the system's ease of installation and its impact on current road operations and infrastructure.

Disadvantages:

1. The divider operates manually rather than automatically.
2. It does not work well when both sides are severely congested.
3. Maintenance can be challenging.
4. Requires trained staff and technicians for proper management.

5. Conclusion

In conclusion, the system presents numerous advantages, including enhanced road safety through better lane management, more efficient traffic flow adjustments, and support for environmental sustainability by reducing congestion-related emissions. Additionally, its cost-effectiveness and ability to

integrate with existing traffic management infrastructure make it a practical alternative to large-scale road expansions. However, it faces certain challenges, such as the need for manual operation, reduced effectiveness during extreme congestion on both sides, and the requirement for regular maintenance and skilled personnel for optimal performance. Despite these drawbacks, when effectively implemented and maintained, the system remains a valuable tool in improving overall traffic efficiency and user experience on the road.

Abbreviations

DNCC	Dhaka North City Corporation
DSCC	Dhaka South City Corporation
PCU	Passenger Car Unit
TL-3	Test Level 3
NCHRP	National Cooperative Highway Research Program
BRTA	Bangladesh Road Transport Authority
BUET	Bangladesh University of Engineering and Technology
AASHTO	American Association of State Highway and Transportation Officials
KPI	Key Performance Indicators
UN	United Nations

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Author Contributions

Md. Mahbub Alam contributed to Conceptualization – Ideas; formulation or evolution of overarching research goals and aims. Data curation – Management activities to annotate, scrub data and maintain research data for initial use and later re-use. Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection. Methodology – Development or design of methodology; creation of models.

Md Moshir Rahman contributed to Visualization – Preparation, creation and presentation of the published work, specifically data presentation. Acquisition of the financial support for the project leading to this publication.

Md. Shafiu Muznabin contributed to Validation – Verification, whether as a part of the activity or separate, of the overall reproducibility of results and other research outputs. Preparation, creation and presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including post-publication

stages.

Conflicts of Interest

The authors declare no conflicts of interest.

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