Modeling Driver Behavior at Exit Sections of Freeway Using Naturalistic Driving Study (NDS)

KID: 20230310

Freeways play a vital role in the roadway transportation system. With rise of traffic volumes and high speeds on freeways have created serious safety concerns and led to traffic crashes or accidents. Globally, over 1.35 million people are killed in road crashes each year. In India, there were 4,12,432 reported road crashes in 2021, with national highways and freeways accounting for a significant portion of crashes (31.2%) and fatalities (36.4%).

At the exit of freeway ramps, drivers are often at risk due to the diverging traffic operations, which can create traffic interruptions, unsafe conditions, and improper lane changes that can further aggravate the risk of crashes. According to the National Highway Traffic Safety Administration (NHTSA), human errors were responsible for 93% of traffic crashes, whereas lane-changing was responsible for 27% of all crash events. Statistics have showed that 40% of crashes occur in merging or diverging zones. Due to the diverse operating characteristic of freeways, traffic crashes may generate serious consequences. Therefore, real-time prediction of driver behaviour at critical locations of freeways imparts significant improvement in freeway operating efficiency.

To prioritize safety, drivers must perform lane changes and adjust their speed rapidly when exiting a freeway. In a lane change, a vehicle shifts position from one lane to another lane with the same direction of travel. Typically, lane-changing maneuvers are classified as either mandatory or discretionary. Mandatory lane changes occur when the vehicle must change lanes, such as merging through an on-ramp to the freeway or taking an exit from an off-ramp, avoiding an incident, or entering a restricted-use lane. In contrast, discretionary lane changes are performed when drivers are dissatisfied with their existing driving conditions and prefer to shift lanes.

This lane change is a crucial event to consider, particularly due to the higher frequency of lane changes observed near exit ramps. It has been shown that mandatory lane changes near exit ramps can have a significant impact on highway traffic, potentially creating interruptions and bottlenecks.

Figure 1 (a), and (b) depicts the bottleneck condition and diverging behavior.

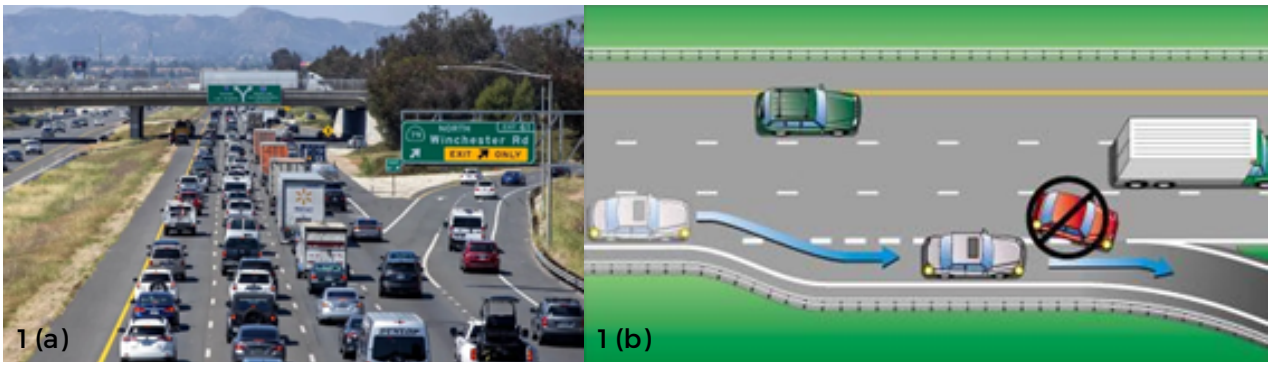

Figure-1: (a) Bottleneck condition (b) Diverging behavior

Lane change behaviour:
The distance prior to the exit is divided into three distinct zones. **Figure 2** on the next page shows that Zone 1 begins at the first information signboard provided to vehicles, located 2 km from the point of the curve, and extends to the second information signboard, located 1 km from the exit. Zone 2 commences at the second information sign board located 1 km from the exit and extends to the sign board located 0.5 km away from the exit. Zone 3 comprises the final information signboard displayed to the driver, which is located 0.5 km from the exit, and extends to the start point of gore.
Note: L1 - lane1, L2 - lane2, L3 – lane3, L 4- lane4, L5 - lane5, and L6 - lane6

Figure 3 on the next page illustrates the distribution of lane changes in each zone for four different exits. It is evident that Zone 3 experiences a higher frequency of lane changes compared to Zone 1 and Zone 2, while Zone 2 falls in the moderate, and Zone 1 has the lowest number of lane changes across all exits. This understanding emphasises that the intensity and severity of lane changes in these zones can make them more vulnerable to potential hazards.

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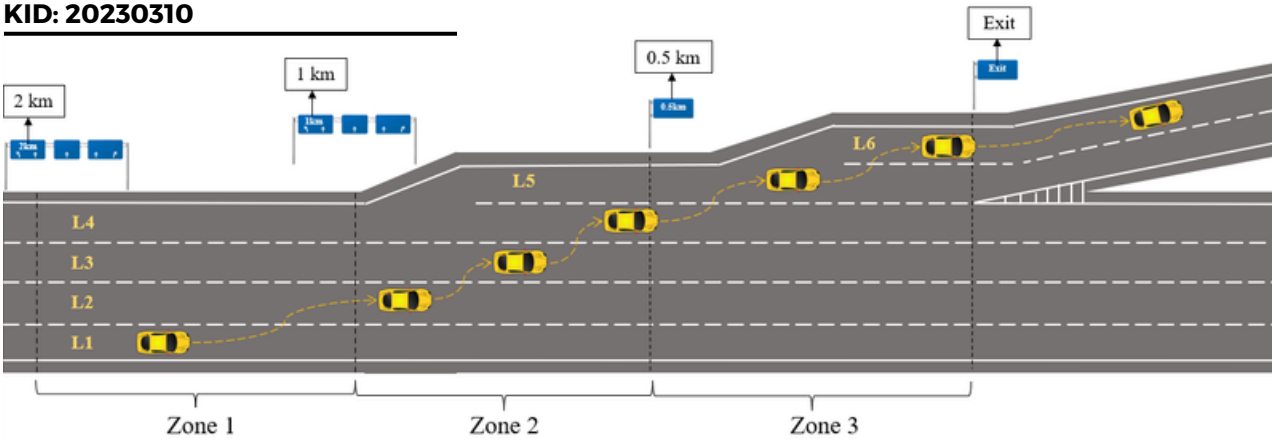

Figure-2: Depiction of Zones

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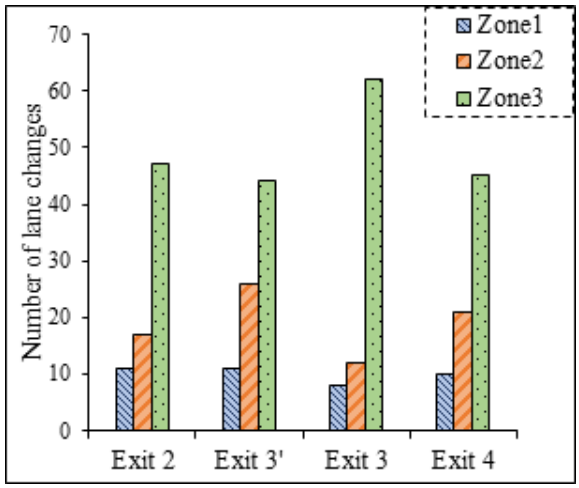

Figure-3: Number of Lane Changes in Each Zone

Conclusion:

The role of exit ramp terminals is to provide smooth diverging operations for off-ramp vehicles from mainstream. The results showed that the intense lane change is taking place 500 m from the entrance gore for all exits. In addition, particularly from L4 to L5 (here L5 indicated the auxiliary lane) is most prevalent in this 500 m zone for all exits. Thus, understanding the significance of lane changes in each zone can avoid the bottleneck conditions near exit areas and contribute to safer diverging operations.

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Modelling Lateral Acceleration: A Data-driven Approach to Interchange Safety

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Interchange ramps play a crucial role in road networks as they serve as connectors between multiple freeways or major roads. To ensure efficient transfer of vehicles between different roadways, interchange ramps are designed with horizontal and vertical curves as displayed in **Figure 1**. However, these curvatures make interchange ramps more complex and crash-prone compared to the mainline segments of the freeway.

To improve safety and articulate significant safety schemes, it is important to analyse driver behaviour measures such as speed and lateral acceleration adaptation on ramp interchanges at a microscopic level. Existing studies on speed and lateral acceleration are limited to horizontal curves, and no few studies were found to deal with ramp interchanges in India.