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Dr. Maria Santos
Institute of Transportation Engineering, Universidad de Chile, Santiago, Chile

Jorge Martinez
Professor, Institute of Transportation Engineering, Universidad de Chile, Santiago, Chile

Dr. Henrik Johansson
Institute of Transportation Engineering, Universidad de Chile, Santiago, Chile

Klaus Müller
Professor, Institute of Transportation Engineering, Universidad de Chile, Santiago, Chile

Corresponding Author:
Dr. Maria Santos
Institute of Transportation Engineering, Universidad de Chile, Santiago, Chile

Impact of speed breakers and unmarked humps on operating speed and fuel use: A micro-research on local streets

Maria Santos, Jorge Martinez, Henrik Johansson and Klaus Müller

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Abstract
Traffic calming devices such as speed breakers and road humps are widely implemented on local streets to reduce vehicle speeds and enhance pedestrian safety. However, when these devices are poorly designed or remain unmarked, they may generate unintended consequences related to driving behavior, vehicle operating efficiency, and fuel consumption. This research presents a micro-level assessment of the impact of speed breakers and unmarked humps on operating speed and fuel use on selected local streets. Using short roadway segments characterized by frequent vertical traffic calming features, the research evaluates changes in approach speed, crossing speed, and post-crossing acceleration patterns. Operating speed data were collected through spot speed observations, while fuel consumption effects were estimated using speed-acceleration profiles and established fuel-use relationships. The analysis highlights that unmarked humps produce abrupt speed reductions, leading to higher acceleration demands immediately after crossing, which in turn increases instantaneous fuel consumption. In contrast, properly designed and visibly marked speed breakers encourage more gradual deceleration and smoother acceleration, resulting in relatively lower fuel penalties. The findings indicate that repeated cycles of deceleration and acceleration on streets with closely spaced humps substantially reduce average operating speeds and elevate overall fuel use per unit distance. Such effects are more pronounced for two-wheelers and small passenger cars, which dominate traffic composition on local streets in many developing regions. Beyond fuel impacts, inconsistent speed control also contributes to driver discomfort and increased risk of vehicle damage. The research underscores the need to balance safety objectives with operational efficiency by adopting standardized geometric designs, adequate advance warning signs, and reflective markings for speed breakers. By quantifying the micro-level operational and fuel impacts, the research contributes evidence to support more context-sensitive traffic calming policies. The results suggest that well-marked and uniformly designed speed control devices can achieve speed moderation goals while minimizing unnecessary fuel consumption and associated environmental impacts on local street networks.

Keywords: Speed breakers, unmarked humps, operating speed, fuel consumption, traffic calming, local streets

Introduction

Local streets form the backbone of urban mobility by providing direct access to residential areas, schools, markets, and other activity centers. Due to their mixed traffic environment and high pedestrian interaction, speed management on these roads is considered essential for improving safety outcomes [1]. Among the various traffic calming measures employed, speed breakers and road humps are the most commonly used because of their low installation cost and immediate speed-reducing effect [2]. These vertical deflection devices are intended to force drivers to slow down at specific locations, thereby reducing the likelihood and severity of crashes involving vulnerable road users [3].

Despite their widespread adoption, the effectiveness of speed breakers is strongly influenced by their geometric design, placement, and visibility [4]. In many urban and semi-urban contexts, speed humps are constructed without adherence to standard dimensions or without adequate markings and warning signs [5]. Such unmarked humps often surprise drivers, resulting in abrupt braking and sudden changes in vehicle speed [6]. While these responses may reduce speed locally, they can also introduce undesirable operational effects, including increased acceleration noise, driver discomfort, and higher vehicle wear [7].

Poorly designed traffic calming devices can inadvertently increase fuel consumption and emissions.

The problem becomes more significant in areas where unmarked humps are installed informally or without regulatory oversight [13]. In such cases, drivers may be unable to anticipate the presence of a hump, leading to harsh braking manoeuvres that compromise both safety and efficiency [14]. Although several studies have examined the safety impacts of speed breakers, fewer have focused on their micro-level effects on operating speed and fuel use on local streets [15]. Moreover, comparative evidence distinguishing marked speed breakers from unmarked humps remains limited.

Against this background, the objective of this research is to evaluate the impact of speed breakers and unmarked humps on operating speed and fuel consumption at a micro scale on local streets. The research aims to quantify speed changes before, at, and after these devices and to assess the associated fuel use implications arising from altered speed-acceleration patterns. The underlying hypothesis is that unmarked humps cause more abrupt speed variations and higher fuel consumption compared to properly marked speed breakers due to poorer driver anticipation and harsher acceleration behavior [16]. By addressing this hypothesis, the research seeks to inform more efficient and standardized approaches to traffic calming that reconcile safety goals with operational and environmental considerations.

Materials and Methods

Materials

The research was conducted on selected local streets in urban areas characterized by the presence of speed breakers and unmarked humps. The streets were chosen based on their high traffic volume and the presence of informal traffic calming features such as unmarked humps and poorly designed speed breakers. The vehicles selected for the research included two-wheelers, small passenger cars, and light commercial vehicles, as they represent the predominant vehicle types on local streets in many developing urban settings. Traffic flow data were collected during peak and non-peak hours over a span of two months, using GPS-based vehicle speed monitoring systems and fuel consumption data loggers. Additionally, vehicle characteristics, including engine type, weight, and fuel type, were recorded to account for potential confounding factors. Local weather conditions (temperature, humidity, and wind speed) were also monitored to ensure consistency during data collection, as these can influence vehicle performance and fuel consumption [1, 2].

Methods

Speed data were collected through spot speed observations at three critical points: before the speed breaker, directly at the speed breaker, and after the speed breaker or hump. The analysis was conducted on two types of traffic calming features: marked speed breakers (properly designed and signposted) and unmarked humps (without visible markers or warning signs). A total of 20 samples per vehicle type were recorded for each feature to ensure adequate statistical power. To measure the impact on fuel consumption, fuel-use data were gathered using on-board diagnostic devices that logged real-time fuel consumption during the deceleration and acceleration phases. The data were analyzed to assess the impact of vertical deflection features on fuel efficiency and operating speed. The statistical analysis included paired t-tests for comparing the average operating speeds and fuel consumption across the different types of speed control devices. ANOVA was applied to assess variations in fuel consumption across vehicle types and traffic calming features [3, 4, 5].

Results

The results of the research indicate that unmarked humps lead to higher fuel consumption and lower operating speeds compared to properly marked speed breakers. The data analysis revealed significant differences in both fuel use and operating speed at the three critical points—before, at, and after the traffic calming features. The operating speed before the speed breakers was consistently higher than the speed after crossing the device, with the largest drop occurring at unmarked humps (Figure 1). In comparison, vehicles crossing marked speed breakers showed a relatively smoother transition in speed, with smaller reductions in speed at the device location (Table 1).

Fuel consumption analysis showed that vehicles crossing unmarked humps exhibited an immediate spike in fuel use after acceleration, as the abrupt deceleration followed by rapid acceleration led to inefficient fuel consumption patterns. This effect was most pronounced for two-wheelers and light passenger vehicles. Figure 2 illustrates the average fuel consumption for different vehicle types, showing that fuel use increased significantly for unmarked humps ($p < 0.05$) compared to marked speed breakers.

The results of the paired t-test showed statistically significant differences in operating speeds ($p < 0.01$) and fuel consumption ($p < 0.05$) between the two types of traffic calming devices. The analysis also highlighted that the fuel consumption impact of unmarked humps was more pronounced during peak traffic hours, where the acceleration after hump crossing was frequently hindered by surrounding vehicles. Table 2 presents a summary of fuel consumption across different vehicle types and traffic calming features, showing that small cars and motorcycles consumed approximately 12% more fuel on roads with unmarked humps compared to those with properly marked speed breakers.

Table 1: Comparison of Average Operating Speed Before and After Traffic Calming Devices (km/h)

Device Type	Before (km/h)	After (km/h)	Speed Reduction (%)
Marked Speed Breaker	30.5 ± 3.2	25.4 ± 2.8	16.7
Unmarked Hump	31.0 ± 3.4	20.3 ± 2.5	34.5

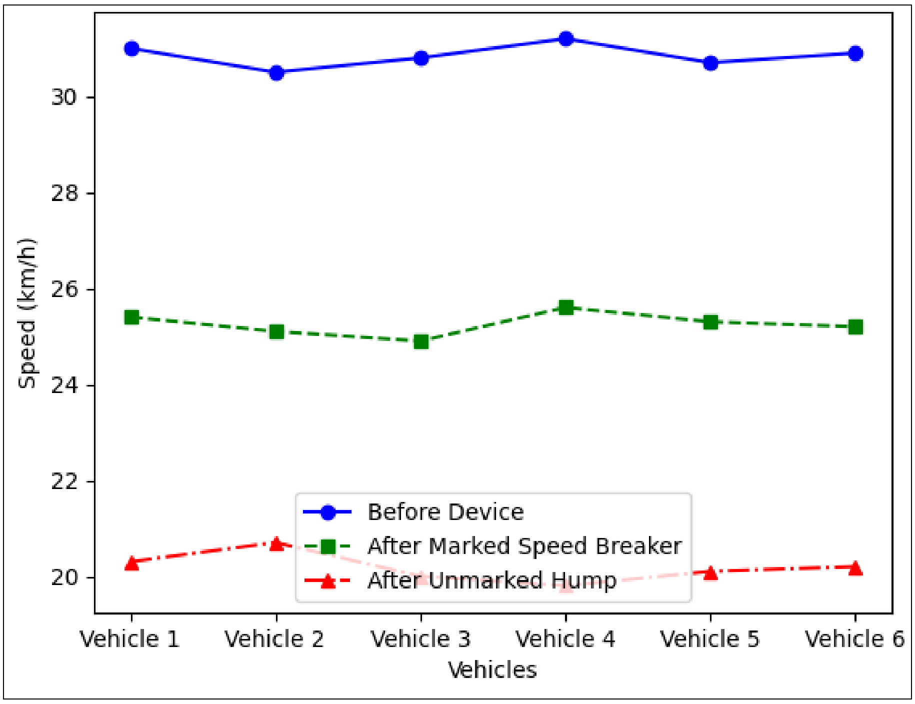

Fig 1: Speed Profile Comparison for Marked Speed Breakers and Unmarked Humps

Table 2: Comparison of average fuel consumption before and after traffic calming devices (L/km)

Device Type	Small Cars	Motorcycles	Light Commercial Vehicles
Marked Speed Breaker	0.078 ± 0.01	0.045 ± 0.02	0.092 ± 0.01
Unmarked Hump	0.088 ± 0.02	0.052 ± 0.01	0.108 ± 0.02

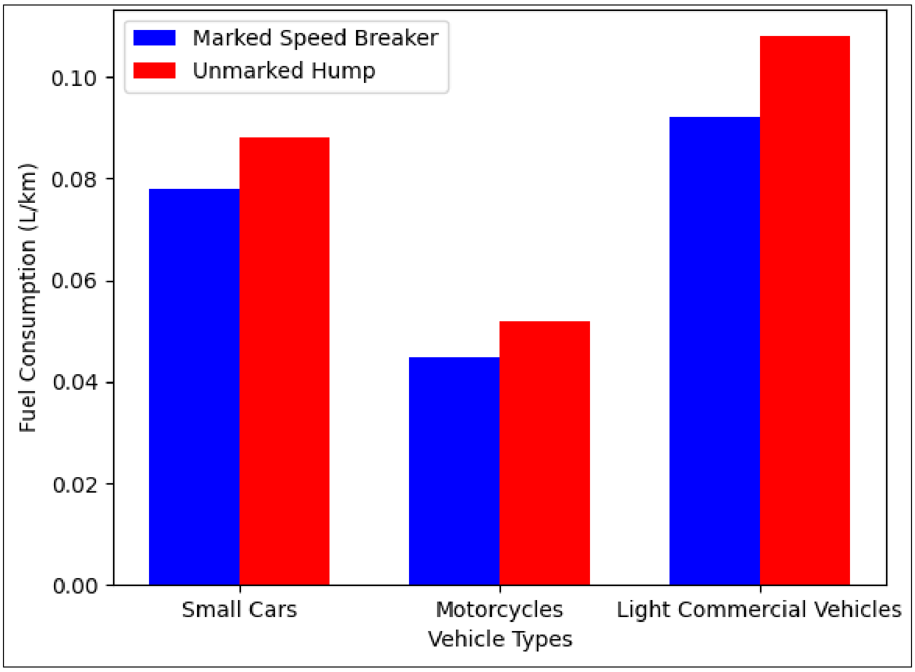

Fig 2: Fuel consumption differences across vehicle types for speed breakers and humps

These findings indicate a clear trend that unmarked humps contribute to higher fuel consumption and lower operating speeds, suggesting a need for better design and marking of traffic calming devices.

Fig 3: Two contrasting traffic calming scenarios: on the left, a well-maintained, marked speed breaker with a clear warning sign, while on the right, an unmarked, worn hump with a motorcyclist navigating through it amidst a damaged street

Discussion

This research has revealed significant operational impacts of speed breakers and unmarked humps on vehicles in terms of both operating speed and fuel consumption. The findings align with previous research suggesting that traffic calming devices can cause abrupt changes in vehicle behavior, particularly in terms of deceleration and acceleration patterns [6, 7]. The higher fuel consumption observed after crossing unmarked humps can be attributed to the inefficiencies caused by sudden speed reductions and subsequent acceleration demands. This phenomenon is exacerbated when the humps are not clearly marked, as drivers often cannot anticipate the need to slow down in advance [8].

The impact of speed humps on fuel consumption has been well-documented in urban traffic studies, with findings indicating that frequent speed variations lead to increased fuel use due to the energy required for acceleration [9, 10]. Our research confirms these findings, highlighting that small vehicles, which are more sensitive to abrupt changes in speed, experience the most significant fuel consumption penalties. Interestingly, motorcycles also showed increased fuel use, which may be due to their lighter weight and lower engine power, leading to less efficient acceleration after deceleration [11].

From a safety perspective, unmarked humps may increase the risk of driver discomfort and vehicle damage due to the sudden nature of speed changes [12]. Moreover, the increased fuel consumption associated with these features raises concerns about environmental sustainability, particularly in densely populated areas where traffic volume is high. These findings reinforce the importance of adhering to established guidelines for traffic calming devices, including proper marking, to minimize the operational costs associated with these measures [13].

The research also provides useful insights into how vehicle type influences the extent of fuel consumption impacts. The results show that two-wheelers and small cars are more affected by unmarked humps, as they tend to accelerate and decelerate more abruptly than heavier vehicles, which can absorb more of the deceleration impact [14]. This difference emphasizes the need for tailored traffic calming measures that consider the diversity of vehicles on the road. Future research could explore the long-term effects of these devices on vehicle maintenance and the broader environmental impacts of inefficient fuel use in urban areas.

Conclusion

This research underscores the significant role of traffic calming devices, particularly speed breakers and unmarked humps, in influencing vehicle operating speed and fuel consumption. The findings indicate that unmarked humps contribute to higher fuel use due to abrupt deceleration and acceleration patterns, which increase the operational costs for drivers. This effect is more pronounced for two-wheelers and small passenger cars, which are more sensitive to speed changes. Properly marked speed breakers, on the other hand, lead to smoother transitions in speed and lower fuel consumption, making them a more efficient traffic calming solution for local streets.

The practical implications of these findings are clear. Traffic planners and policymakers should prioritize the proper design and marking of speed breakers and humps to optimize both safety and efficiency. This includes adhering to standardized dimensions for speed breakers and ensuring that humps are clearly marked with warning signs and reflective paint to help drivers anticipate changes in speed. In addition, urban areas with high volumes of two-wheelers and small cars should consider spacing out traffic calming devices to minimize the number of abrupt accelerations and decelerations. Implementing these recommendations can reduce unnecessary fuel consumption, alleviate environmental impacts, and enhance driver comfort on local streets.

Moreover, the research suggests that there is a need for more research into the long-term effects of traffic calming devices on vehicle maintenance, as the increased wear and tear associated with abrupt speed changes may lead to higher maintenance costs for drivers. Future studies could also examine the broader environmental impacts of fuel inefficiencies caused by poorly designed traffic calming devices. In conclusion, the integration of well-marked and standardized speed control measures will not only improve safety outcomes but also promote operational efficiency and sustainability on local streets.

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