Joint Transportation Research Program

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The Effectiveness of Longitudinal Rumble Strips on Indiana Roads

Introduction

Rumble strips significantly enhance road safety by providing both audible and vibratory warnings to drivers, which reduces the likelihood of crashes caused by fatigue, distraction, and inattention. Their installation on highway centerlines and shoulders encourages corrective actions, such as steering adjustments and speed control, which help prevent crashes or reduce their severity. Studies have shown substantial decreases in single-vehicle run-off-road crashes and overall crash rates following the implementation of rumble strips.

While rumble strips are effective in improving road safety, much research has shown that they produce considerable noise when vehicles make contact, which can be a nuisance to nearby residents. This noise issue has led to the development of sinusoidal rumble strips, which produce lower frequency noise compared to the higher frequency noise produced by conventional rumble strips, significantly reducing exterior noise while still providing sufficient vibrations. For some vehicle types, they also increase the noise inside the cabin, effectively alerting drivers.

Findings

This research includes two complementary studies: statistical analysis of the safety effect of the installed rumble strips, including sinusoidal and conventional, and field observations that compare the sound and vibration generated by the two rumble strip types. There are several observations and outcomes from the statistical analysis.

1. The safety effectiveness of rumble strips varies by their cross-sectional installation locations: centerline, roadside, or both. The results for conventional and sinusoidal rumble strips indicate a significant reduction in the rates of relevant crashes and the crash modification factors (CMF), and KABC CMFs.

a. Rumble strips are installed on the roadside only.
   - CMF = 0.87
   - CMF (KABC) = 0.75
   - CMF (PDO) = 0.92

b. Rumble strips are installed on the center only.
   - CMF = 0.87
   - CMF (KABC) = 0.75
   - CMF (PDO) = 0.92

c. Rumble strips are installed on both center and roadside.
   - CMF = 0.79
   - CMF (KABC) = 0.68
   - CMF (PDO) = 0.84

2. Sinusoidal rumble strips seem to perform less effectively than the conventional ones, probably due to sample selection bias. Sinusoidal rumble strips (generally implemented later than conventional ones) tended to be installed on routes that were not prioritized for receiving rumble strips and often had more dangerous segments where there were narrower shoulders and more roadside hazards. This natural sample selection bias masked the true effectiveness of sinusoidal rumble strips. The comparison of the after-installation safety performance of sinusoidal and conventional rumble strips is very close.
3. The 16″-wide rumble strips show a slightly better crash reduction effect, although the difference is not statistically significant compared to the narrower setting (12″).

For the field noise and vibration observations, the following was concluded.

1. Both types of rumble strips tested in the trials met the Federal Highway Administration (FHWA) recommendation of a minimum 3 dB increase in sound pressure level.
2. Conventional rumble strips increased sound levels by 4.6–7.5 dB, while the newer installed sinusoidal rumble strips provided an increase of 5.1–11 dB inside the vehicle.
3. For all the vehicle speeds considered, the magnitude of intensity was relatively higher for sinusoidal rumble strips when compared to conventional ones.
4. The widths of the rumble strips tested (8″, 10″, and 12″) did not result in a significant difference in the noise and vibration produced inside the vehicle.
5. The presence of vegetation on some segments of the conventional rumble strips reduced the noise levels produced

Implementation

This study has confirmed the safety benefits of the rumble strips in reducing off-road and head-on collisions (target crashes). This countermeasure is recommended as a low-cost, effective intervention in locations where these two types of crashes occur or where there is occurrence risk based on similar cases elsewhere. Joint use of the center and roadside rumble strips provides the highest safety benefits.

The developed CMFs may be applied in cases that need a benefit-cost analysis. When rumble strips are installed only on the roadside, whether on the edge or the shoulder, the expected crash reduction factor for target crashes is 0.87 (CMF (PDO) = 0.92; CMF (KABC) = 0.75); when rumble strips are installed only on the center, the expected crash reduction factor for target crashes is also 0.87 (CMF (PDO) = 0.92; CMF (KABC) = 0.75); when the rumble strips are installed both on the center and roadside, the expected crash reduction factor for target crashes is 0.79 (CMF (PDO) = 0.84; CMF (KABC) = 0.68).

The strip width (12″ vs. 16″) does not seem to affect safety outcomes and does not affect the noise and vibration levels; thus, this dimension may be decided based on the installation cost and/or equipment availability if no bicyclists or pedestrians are expected on the shoulder. The 12″ rumble strips seem to be more justified when the presence of pedestrians or bicycles is expected.

Although field studies confirmed that there is no significant difference in noise and vibration generation between the conventional sinusoidal strips; in some cases, the vegetation presence over the strips reduced the warning effect. Thus, regular inspection and maintenance of rumble strips after implementation should be considered where needed.

Based on this safety analysis, both conventional and sinusoidal rumble strips have similar crash modification factors (CMFs), which indicate comparable effectiveness in reducing crashes. Both types also meet the NCHRP 641 report (Torbic et al., 2009) recommendations for generating adequate noise and vibration inside the vehicle to alert drivers; however, sinusoidal rumble strips have the added benefit of producing lower noise levels outside of vehicles.

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