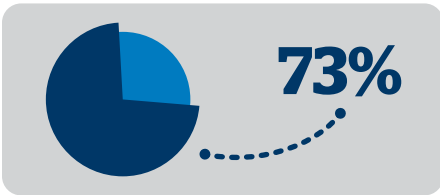




The Problem

While shoulder rumble strips offer an inexpensive and effective way to decrease motorized roadway departure crashes, they can increase safety risks for bicyclists. Rumble strips can reduce or eliminate rideable shoulder space and limit bicyclists' ability to maneuver, increasing the risk of crashes, especially on high-speed and high-traffic roads.

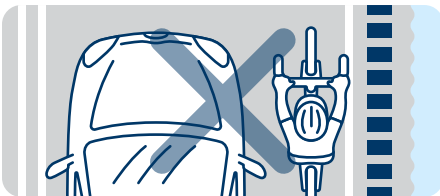


Survey Results

A 2017 survey of over **2,000 people** who have ridden Adventure Cycling routes found that **73%** of respondents have felt **unsafe while riding on roads with rumble strips in all 50 states.**

How are rumble strips dangerous for bicyclists?

Millions of people ride bicycles on America's roadways every year, and cycling continues to increase in popularity.¹ In the last decade, cyclist fatalities have increased 19% (2008: 718, 2018: 853)² with a cost of over \$26 billion.³ People who ride bikes need facilities separate from high-speed traffic to ensure they make it home to their loved ones. States and municipalities that are committed to Vision Zero should actively invest in infrastructure improvements that prevent crashes and protect the most vulnerable road users.



1 | Rumble strips force bicyclists to ride with high-speed traffic.

When placed with less than 4 feet of clear, unobstructed shoulder space, cyclists are forced to take the lane and contend with vehicle traffic at speeds of 50 mph or greater. Motorists don't expect to see slower-moving cyclists in their lane, and cyclists are more at risk of being hit by drowsy, distracted, or impaired motorists.

2 | Rumble strips can cause a bicyclist to lose control, increasing the likelihood of injury or death.

Hitting a rumble strip, especially with a loaded bicycle, can cause a cyclist to lose control and fall into the path of a motor vehicle, causing injury, death, and/or property damage.

3 | Rumble strips can eliminate otherwise separated, rideable space for bicyclists.

Cyclists rely on roadway shoulders to provide a safe space away from high-speed traffic. When rumble strips are placed in a way that negates an otherwise rideable shoulder, what would have been a safer space for cyclists is reduced to unrideable dimensions or eliminated entirely.





The Solution

When 4 feet of clear, paved shoulder space is maintained, rumble strips can enhance the safety of people who bike while also reducing run-off-the-road crashes. Where a minimum of 4 feet of shoulder space isn't feasible, rumble strips should not be installed. Transportation decision makers can accomplish this through the following actions:



1 | Policies and Designs

Best Practices PG. 5-7

Rumble strips should be designed and implemented in a way that considers the safety of all road users, particularly vulnerable road users.

- ▶ Preserve a minimum of 4 feet of clear, paved shoulder space, and more with higher speeds. A separated shoulder not only gives bicyclists a safer place to ride, it provides space for motor vehicles to correct their vehicle if they hit the rumble strip, preventing potential run-off-the-road crashes.
- ▶ Install the rumble strip over the edgeline, not in the shoulder. This placement preserves the maximum amount of space for bicyclists to ride and provides an auditory warning for bicyclists if a motorist hits the rumble strip.
- ▶ Include bicycle safety designs in rumble strip policies and roadway design manuals. Bicycle safety designs should be the standard in policies and manuals, which may require additional budgeting for projects in some cases.



2 | Coordinated Project Development

Best Practices PG. 8

Rumble strip policies and practices should consider vulnerable road users in every step of the project development process.

- ▶ Include the relevant local, regional, or state bicycle and pedestrian coordinator and other bicycle advisory experts throughout the process.
- ▶ Consider whether roads included in the project are part of designated bicycle routes or are popular for recreational or commuting cyclists.
- ▶ Dedicate a percentage of transportation funding for projects that improve vulnerable road user safety, including widening shoulders when installing rumble strips.



3 | Quality Control

Best Practices PG. 9

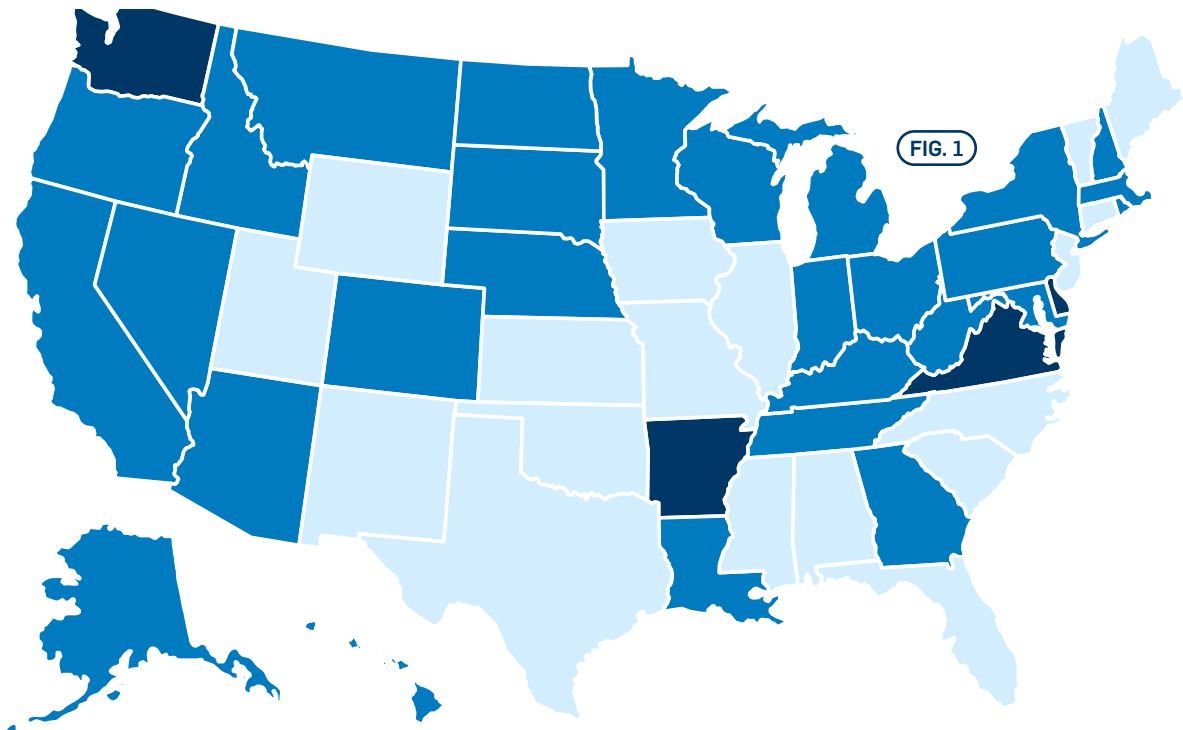
Quality control is an important part of ensuring that rumble strips are installed correctly and don't unintentionally impact bicycle safety.

- ▶ Supervise and inspect any roadway improvement project that involves rumble strips to ensure appropriate rumble strip placement.



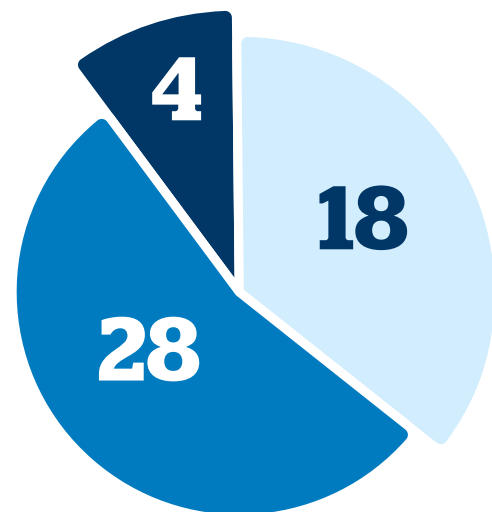
Status of State Rumble Strip Designs

States can reference the model rumble strip policy on **page 4** as an example of how rumble strip designs and project development processes should incorporate bicycle safety. This model policy was used as the standard to grade each state's rumble strip designs using a formulaic approach and awarding points for each bicycle safety feature. This ranking does not take into consideration project development processes including circular review.



Based on this systematic analysis:

- 4** 4 state policies meet all of the minimum model design standards.
- 28** 28 state policies meet some standards but have room for improvement.
- 18** 18 state policies fail minimum model design standards.



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Model Rumble Strip Policy

This model rumble strip policy was compiled using bicycle safety best practices from transportation experts, results of conducted studies, and existing state rumble strip policies. We recommend that states reference and use language from this model policy when considering bicycle safety improvements for rumble strips in their roadway design manuals.

I. Purpose

Studies indicate that both crossover and roadway departure crashes may be reduced significantly by the use of rumble strips. However, rumble strips can be dangerous to bicyclists when placed with less than 4 feet of shoulder space, forcing cyclists to take the lane and contend with high-speed vehicle traffic.

II. Design Guidance

A Shoulder Rumble Strips

Design standards: Rumble strips, when considered for installation on new, reconstructed, or resurfaced outside shoulders of all non-access controlled roadways should accommodate bicyclists by incorporating the following design standards (as shown in fig. 2, pg. 5):

- 1 Shoulder width: A minimum effective clear shoulder width of 4 feet or more should be provided from the outside edge of the rumble strip groove to the outside edge of the paved shoulder, or 5 feet from the outside edge of the rumble strip groove to the front face of a curb or guardrail.
- 2 If this clear area cannot be maintained, then a change of configuration and/or deletion of the rumble strip should be considered. Reducing lane widths if the lanes are 12 feet or wider may be considered to increase shoulder width dimensions.
- 3 Offset: Edgeline rumble stripes should be prioritized. If an offset from the lane marker is necessary, then it should not exceed 6 inches and there should be at least 4 feet of shoulder space from the outside edge of the rumble strip to the outside edge of the paved shoulder.
- 4 Traffic speed: Rumble strips should not be considered on roadways with a posted speed limit of 50 mph or less.
- 5 Gaps: Rumble strips should be installed with gap patterns, consisting of 10- to 12-foot gaps for every 40- to 60-foot rumble strip segment.

B Centerline Rumble Strips

Design Standards: When drivers shift their lane position away from centerline to avoid the rumble strips, they are moving closer to pedestrians and bicyclists on the shoulder. Implementation of centerline rumble strips should follow these design standards:

- 1 In locations where the combined lane and shoulder width in either direction is 14 feet or less, consider the level of bicyclist and pedestrian use along the route before installing centerline rumble strips.
- 2 If centerline rumble strips are installed, follow the AASHTO recommendations of a 6-foot minimum shoulder to ensure space for bicyclists and pedestrians.

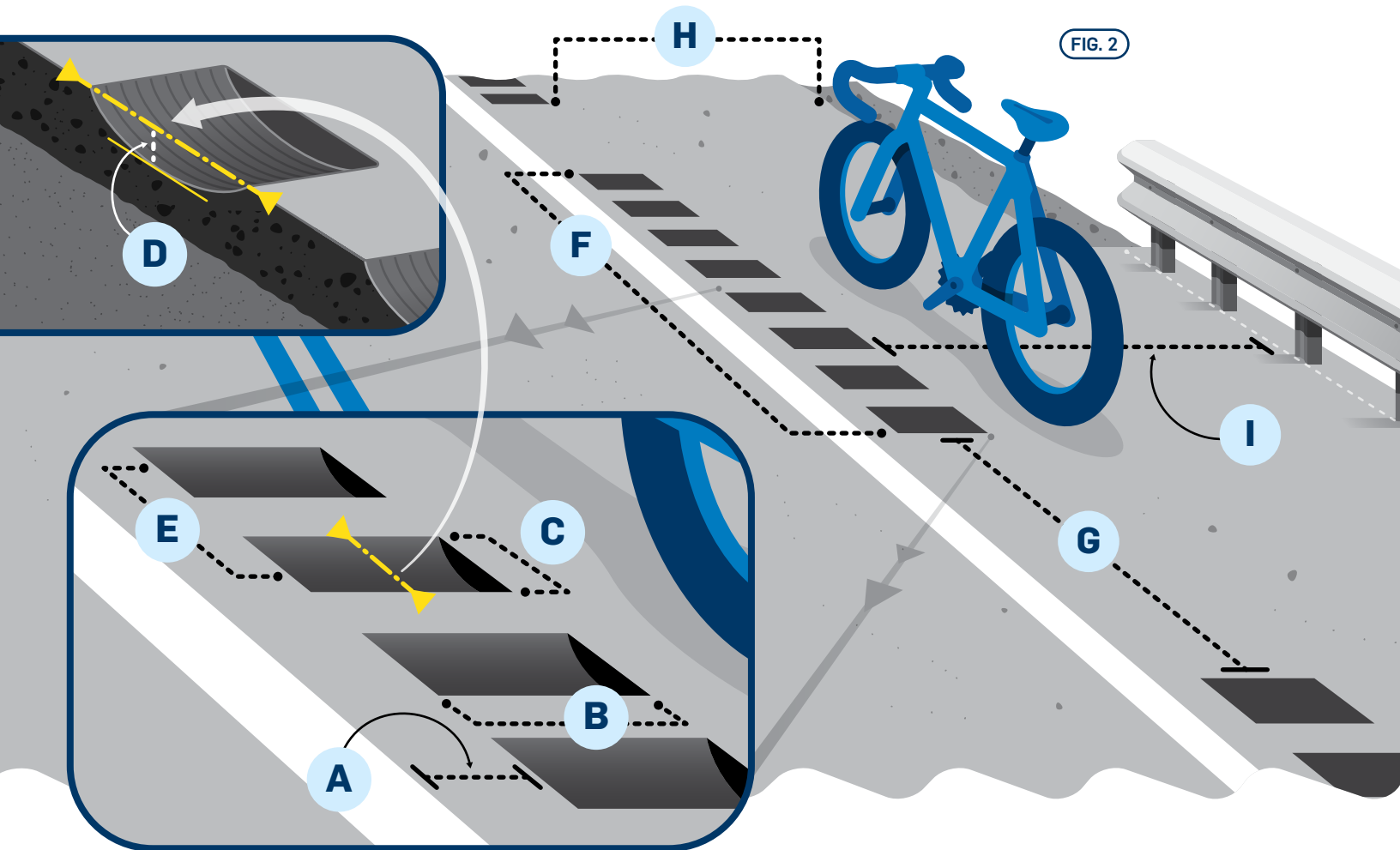
III. Review and Implementation

- A The regional or state bicycle and pedestrian coordinator should be notified of the proposed rumble strips and consulted throughout the project development process.
- B The regional or state bicycle and pedestrian coordinator should review the road segment under consideration for rumble strip application and identify if it:
 - 1 is used by bicyclists
 - 2 comprises the only practical route between two destinations
 - 3 has been identified as part of a current or prospective bicycle route such as a U.S. Bicycle Route, state or local bike route, or route mapped by a bicycling organization
- C If the road segment under review is identified as having current or future bicycle traffic, then rumble strips should not be applied with less than a minimum clear shoulder width of 4 feet and bicycle safety design standards must be applied as described in Section II.



Best Practices: Rumble Strip Designs for Bicycle Safety

There are clear, nationally recognized rumble strip design standards for bicycle safety, including the FHWA and AASHTO guidelines. However, these guidances lack specific dimensions for many key design features. The following design standards are compiled from a variety of studies and guidances that consider bicyclist safety and comfort. Many of these recommendations are minimum standards, and for optimal bicyclist safety and comfort we advise exceeding minimum standards.



A Offset: 0-6"

B Transverse Length: 6"

C Parallel Width: 5-7"

D Depth: 3/8"

E Center to Center Spacing: 10-12"

F Strip Length Before Gap: 40-60'

G Gap Length: 10-12'

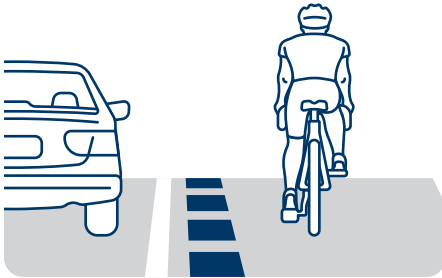
H Minimum Shoulder Width: 4'

I Minimum Shoulder Width w/Guardrail: 5'



Design Justifications

While all dimensions and design aspects of rumble strips are important to consider for bicycle safety, the design dimensions below are described in order of priority and supported by research.



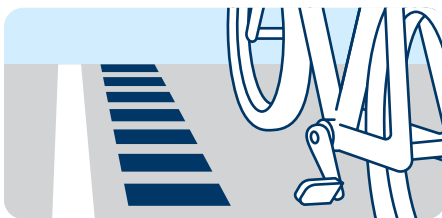
Shoulder Rumble Strips

Shoulder Width

- ▶ The amount of shoulder space provided for people who ride bikes is the most important aspect of bicycle safety in rumble strip design. According to AASHTO, 4 feet of clear shoulder space is the minimum amount to ensure rideable space; however, more space is necessary as traffic numbers and speeds increase.⁴ The Texas A&M Transportation Institute recommends 7 feet minimum with increasing shoulder width correlated to adjacent vehicle speed when rumble strips are present.⁵
- ▶ A minimum of 4 feet of shoulder space benefits road users in several ways, including providing space for bicyclists to maneuver around debris, motorists to recover from crossing over the edgeline, law enforcement to perform duties, and accommodation of wider nonstandard bikes, trikes, and mobility devices.

Shoulder Width with Guardrail

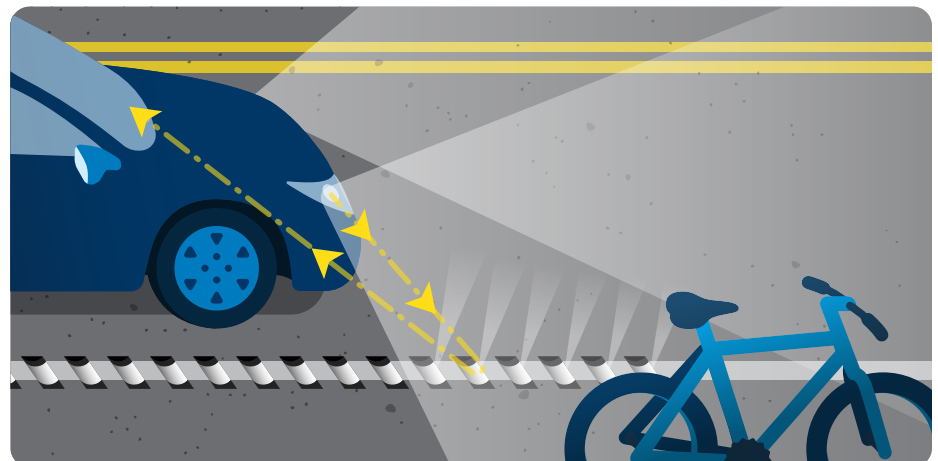
- ▶ If a guardrail, curb, or other obstacle such as a drainage grate is present, a minimum of 5 feet of space should be available.⁴



Offset

- ▶ When installed within six inches of (or under) the travel lane marking, motorists are alerted sooner, and the maximum amount of rideable shoulder space is provided. Regardless of rumble strip placement, at least 4 feet of clear shoulder space should be maintained.
- ▶ Edge-line rumble stripes (**fig. 3**) guarantee the maximum amount of shoulder space because the stripe itself is beneath the travel lane marking. The angled surface also allows for better retroreflectivity at night and in inclement weather while protecting the pavement marking within the rumble strip from wear.

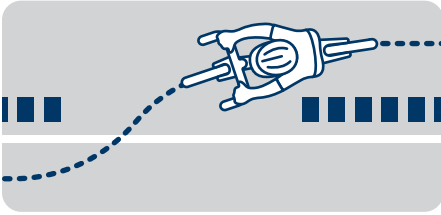
FIG. 3





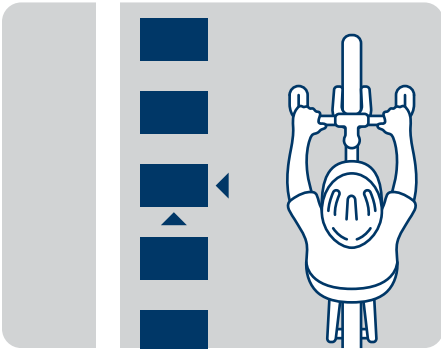
Depth

- ▶ According to a study conducted by the Colorado Department of Transportation, 3/8 of an inch is the optimal depth to balance both cyclist safety and vehicle vibration.⁶ A shallower depth is less jarring to bicyclists who ride over the rumble strip.



Gaps

- ▶ Gaps allow bicyclists to safely exit the shoulder in order to avoid obstacles or navigate turns. A study conducted by the Transportation Research Board found that gaps of 10–12 feet per 40–60 feet of rumble strips are sufficient for typical cyclists' use. On steeper downhill grades, gaps should be larger to compensate for higher bicyclist speeds.⁷

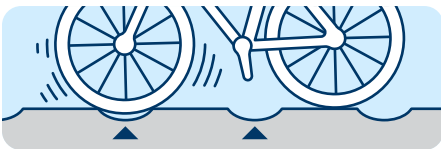


Transverse Length

- ▶ According to a report commissioned for the National Cooperative Highway Research Program (NCHRP), the optimal length of a rumble strip groove where bicyclists are expected is 6–12 inches. However, for areas with minimal shoulder space, narrower designs should be considered to ensure the maximum amount of rideable space for bicyclists.⁸

Parallel Width

- ▶ According to AASHTO, the rumble strip width should be 5 inches to accommodate bicyclists' safety.⁴



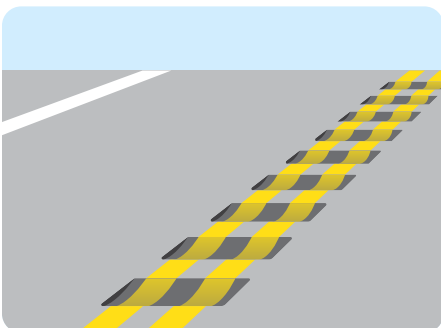
Center to Center Spacing

- ▶ Closer spacing creates less of a jarring effect on people riding bicycles. However, placing them too close together negates their effectiveness for motorists. According to a study conducted by Penn State, 12-inch spacing is ideal for cyclists' comfort.⁹



Minimum Posted Speed

- ▶ According to NCHRP, fatigue-caused run-off-the-road crashes are most likely to occur at higher speeds, particularly 55–65 mph. Additionally, state policies tend to prescribe rumble strips on roads with speeds of 50 mph or greater, most likely to reduce noise in residential areas.⁸



Centerline Rumble Strips

- ▶ AASHTO recommends 6-foot minimum shoulder widths where centerline rumble strips (**fig. 4**) are installed.⁴ This recommendation is backed by research conducted for the Michigan Department of Transportation, which indicates that motorists are less likely to cross the centerline rumble strip when cyclists are present.¹⁰ Anecdotal evidence further suggests that motorists are less likely to cross the centerline rumble strip even when cyclists are forced to ride in the travel lane due to lack of shoulder space.

FIG. 4



Best Practices: Coordinated Project Development

Once bicycle safety best practices have been incorporated into rumble strip design standards and policies, it is important that they are put into practice. To ensure that these best practices are consistently and effectively integrated, coordination and review of roadway projects should include the relevant bicycle and pedestrian coordinator and bicycle advisory experts. While project development processes vary, the following checklist provides recommendations for local and state transportation decision makers to integrate bicycle safety best practices into project delivery.

Step 1 - Planning

- Has the bicycle and pedestrian coordinator reviewed and approved proposed projects that include rumble strips, especially those that affect designated bicycle routes?
- Have these projects been reviewed with bicycle experts such as members of the state bicycle advisory board or a state or national bicycle advocacy organization?
- Have traffic safety experts been consulted on how the proposed project will affect the safety of all road users?

Step 2 - Development

- Has the current and future bicycle use of the road segment(s) been reviewed, including how rumble strips will affect cycling access and safety? Consider if the corridor:
 - is being used by bicyclists or bike tour groups
 - comprises the only practical route between two destinations
 - has been identified as part of a current or prospective bicycle route such as a U.S. Bicycle Route, state or local bike route, or route mapped by a bicycling organization
- Has there been outreach to state and local bicycle groups to identify cyclists' concerns?

Step 3 - Funding

- Is there dedicated transportation funding for projects that address vulnerable road user safety, including widening shoulders with rumble strip installation?
- Have all possible project funding sources for widening shoulders been reviewed?¹¹

Step 4 - Final Design

- Has the bicycle and pedestrian coordinator or similar expert been involved with the review of the final design?
- Does the final design incorporate the bicycle safety practices outlined in the rumble strip policy?

Step 5 - Construction

- Are contractors aware of and following the bike safety design standards in the rumble strip policy?
- Are project managers regularly checking in with on-site construction managers to ensure that installation of rumble strips follows bike safety design standards?

Step 6 - Review

- Have the completed segments of rumble strips been inspected to ensure that the bicycle safety design standards were followed?
- Were clauses added to the contract that hold contractors responsible in the case of an incorrect installation?

Step 7 - Maintenance

- Is shoulder maintenance planned and budgeted for roadways with rumble strips, including sweeping debris and mowing to reduce vegetation, with a priority on roads with higher anticipated bicycle use?



Best Practices: Quality Control

Quality control is important in every phase of planning, implementation, and review to ensure that bicycle safety standards are being followed.

1

Policies and manuals

Design standards and considerations for bicycle safety should be consistent across rumble strip policies and design manuals. Inconsistencies can result in rumble strip installation that does not follow standards and is dangerous for bicyclists.

2

Circular review

The bicycle and pedestrian coordinator should be notified for review if rumble strips are added to a project to ensure that policies and design standards for bicycle safety are met.

3

Contractor oversight

The administrator or construction manager should oversee the process to ensure the bicycle safety policies and design guidelines are followed, especially when contracting with an outside construction firm. This is often the breakdown between a good design standard and the actual placement of the rumble strip.

4

Fixing existing rumble strips that don't meet standards

It is much easier and less expensive to install rumble strips correctly the first time. According to FHWA, rumble strips are generally costly to remove.¹² Some estimates put the figures at 2–26x the cost of installation.¹³



Bicycle Route Conditions Mapping Tool

Adventure Cycling is developing a series of interactive state maps that display crash and roadway data associated with increased risk for bicycle safety along Adventure Cycling and U.S. Bicycle Routes, including bicycle crashes, shoulder widths, lane widths, placement of rumble strips,

speed limits, and average daily traffic. These maps will allow transportation decision makers to use a data-driven approach to identify higher risk corridors for bicycling and prioritize effective countermeasures to meet Vision Zero goals for bicycle safety.



To learn more, contact us at:
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References & Resources

1. PeopleForBikes. (2019, April). *U.S. Bicycling Participation Study - Report of findings from the 2018 survey*. <https://peopleforbikes.org/resources/u-s-bicycling-participation-report/>
2. National Highway Traffic Safety Administration. (n.d.). *FARS Encyclopedia* <https://www-fars.nhtsa.dot.gov/Main/index.aspx>
3. Blincoe, L. J., Miller, T. R., Zaloshnja, E., & Lawrence, B. A. (2015, May). *The economic and societal impact of motor vehicle crashes, 2010. (Revised)* (Report No. DOT HS 812 013). Washington, DC: National Highway Traffic Safety Administration. <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013>
4. American Association of State Highway & Transportation Officials (AASHTO). *Guide for the Development of Bicycle Facilities 4th Edition*, Washington, DC, 2012. <https://store.transportation.org/Item/CollectionDetail?ID=116>
5. Dixon, D., Fitzpatrick, K., Avelar, R., & Das, S. (2017, May). *Analysis of Shoulder Widening Need on the State Highway System: Technical Report*. (Report No. FHWA/TX-15/0-6840-1). College Station, TX: Texas A&M Transportation Institute. <https://tti.tamu.edu/tti-publication/analysis-of-the-shoulder-widening-need-on-the-state-highway-system-technical-report/>
6. Outcalt, W. (2001, May). *Bicycle-Friendly Rumble Strips*. (Report No. CDOT-DTD-R-2001-4). Denver, CO: Colorado Department of Transportation. <https://www.codot.gov/programs/research/pdfs/2001/bfrs.pdf>
7. Moeur, R. C. (2000). "Analysis of Gap Patterns in Longitudinal Rumble Strips to Accommodate Bicycle Travel." In *Transportation Research Record*, No. 1705. TRB, Washington, DC. <https://journals.sagepub.com/doi/10.3141/1705-14>
8. National Academies of Sciences, Engineering, and Medicine. (2009). *Guidance for the Design and Application of Shoulder and Centerline Rumble Strips*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/14323>
9. Elefteriadou, L., et al. (2000). *Bicycle-Friendly Shoulder Rumble Strips*, Office of Planning and Research, Pennsylvania Department of Transportation, Harrisburg, PA. <https://rosap.ntl.bts.gov/view/dot/35756>
10. Datta, T. K., Gates, T. J., & Savolainen, P. T. (2012). *Impact of Non-Freeway Rumble Strips - Phase 1*. (Report No. RC-1575). Lansing, MI: Michigan Department of Transportation Research Administration. https://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC1575_Report_394019_7.pdf
11. U.S. Department of Transportation - Federal Highway Administration. (2018, August 9). *Pedestrian and Bicycle Funding Opportunities*. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/funding/funding_opportunities.cfm
12. ---. *Technical Advisory T 5040.39, Revision 1 - Shoulder and Edge Line Rumble Strips*, U.S. Department of Transportation, 2011. https://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/t504039/t504039.pdf
13. Federal Highway Administration. (August 2015). *Rumble Strips and Rumble Stripes - Frequently Asked Questions*. https://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/faqs.cfm#faq-noise



Contributor Acknowledgments

This best practices guide was written and designed by Adventure Cycling Association staff with the assistance of transportation and bicycle experts. We wish to acknowledge the various contributors who provided editorial feedback and assistance throughout the project:

- ▶ **American Association of State Highway and Transportation Officials**
Sophie Rhoads
- ▶ **Federal Highway Administration**
Cathy Satterfield, Darren Buck, Dick Albin
- ▶ **Michigan Department of Transportation**
Josh DeBruyn
- ▶ **National Highway Traffic Safety Administration**
Ruth Estaban-Muir
- ▶ **Pennsylvania Department of Transportation**
Roy Gothie
- ▶ **Ride Illinois**
Ed Barsotti
- ▶ **Washington Department of Transportation**
Brian Wood
- ▶ **WSP Consulting**
Victoria Brinkley
- ▶ **Adventure Cyclists**
Dave Clement, Gary Dodson, Rita Jensen, and a host of other reviewers and fact checkers. Thank you!



About Adventure Cycling Association

As a nonprofit organization, Adventure Cycling Association's mission is to inspire, empower, and connect people to travel by bicycle. Established in 1973, we are the premier bicycle-travel organization in North America with more than 40 years of experience and 50,000 members.



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