Field Measurements on the Effect of Temporary Rumble Strips in Work Zone Flagging Operations

Final Report
May 2017

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Neal Hawkins and Skylar Knickerbocker

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Iowa State University
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Ames, IA 50010-8664

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16. Abstract

Limited-scale field measurements were collected to quantify the impact of two temporary rumble strip (TRS) layouts at two different two-lane roadway construction projects in Iowa. The field work was not designed to produce statistically valid comparisons for TRS effectiveness, nor contrast between TRS layouts, work zone project locations, or measured locations per site.

The findings are not comprehensive or consistent with any type of before/after or test/control evaluation. However, given the results, the presence of temporary rumble strips were found to have the following impacts as vehicles approached the work zones:

- Increased driver braking
- Minimal driver avoidance (driving around the rumble strips)
- Reduced vehicle speeds

These field data are considered positive and should serve future study efforts in terms of hypothesis development and testing as part of a controlled evaluation.

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Principal Investigator
Neal Hawkins, Associate Director
Institute for Transportation, Iowa State University

Co-Principal Investigator
Skylar Knickerbocker, Engineer
Center for Transportation Research and Education, Iowa State University

Authors
Neal Hawkins and Skylar Knickerbocker

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A report from
Institute for Transportation
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
Phone: 515-294-8103 / Fax: 515-294-0467
www.intrans.iastate.edu

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

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BACKGROUND, OBJECTIVES, AND OVERVIEW

In 2013, the Iowa Department of Transportation (DOT) began working with industry to consider the use of temporary rumble strips (TRS), shown in Figure 1, as part of flagging operations on two-lane roads.

Figure 1. Temporary rumble strips

This issue was brought to the Roadway Industry Safety Consensus (RISC) committee, which includes both Iowa DOT and contractor/industry representatives.

One objective of the group was to further understand the effectiveness of TRS, because the Iowa DOT is considering making them a standard for work zones on two-lane roadways. The group also wanted some field verification on the effectiveness of the rumble strips in alerting drivers to the presence of a work zone and in reducing vehicle speeds as drivers approach the one-way/one-lane flagging operation. However, the group did not have any available funding to conduct an evaluation.

As a starting point, limited-scale field measurements were conducted to quantify the impact of the TRS devices at two different construction projects over different years (one location in 2015 and one in 2016). In both cases, field measurements were coordinated between the project contractor and Iowa DOT construction staff.

Figure 2 shows the Iowa DOT Developmental Specification used by contractors to place the temporary rumble strips.

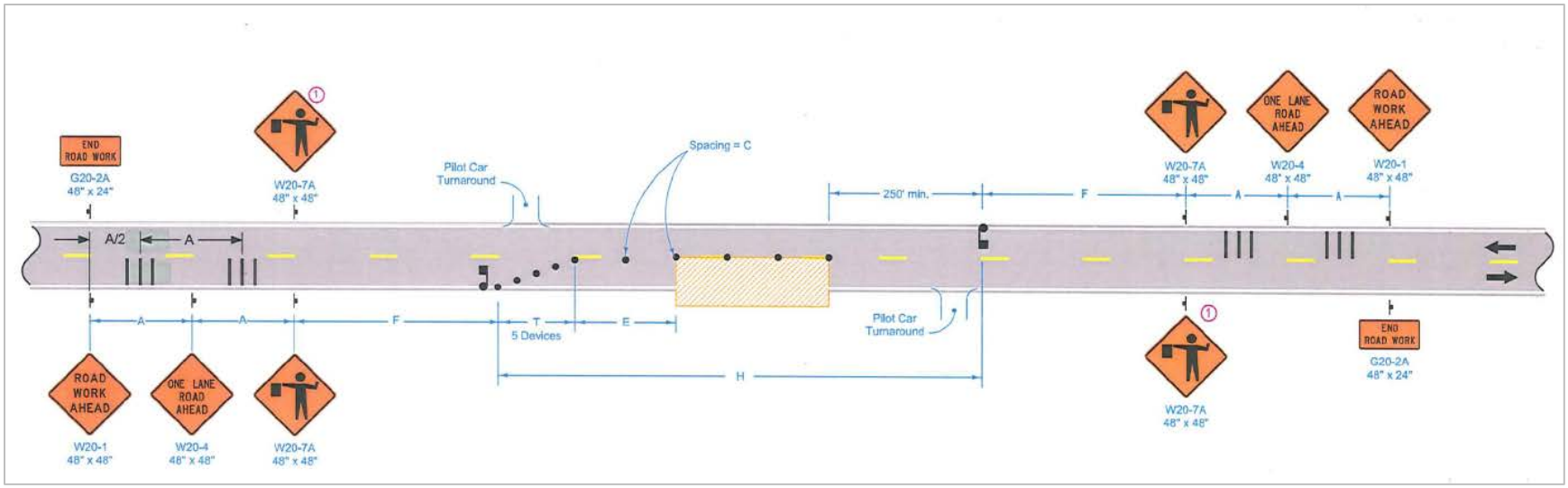

Figure 2. Iowa DOT TRS Developmental Specification

As shown, two sets of three rumble strips are required for each approach direction. The distance between the TRS sets were provided in a table (not shown) and based on roadway posted speed and average daily traffic. For the purpose of this report, the first set of rumble strips encountered by an approaching vehicle is referred to as Upstream and the second set is referred to as Downstream.

The evaluation was originally intended to collect data with and without the DOT TRS layout; however, the RISC group asked that a modified layout also be considered, and the group accepted the limitation that insufficient data would be available to provide for statistically valid samples. Accordingly, the field evaluation included the scenarios shown in Figure 3 through Figure 5.

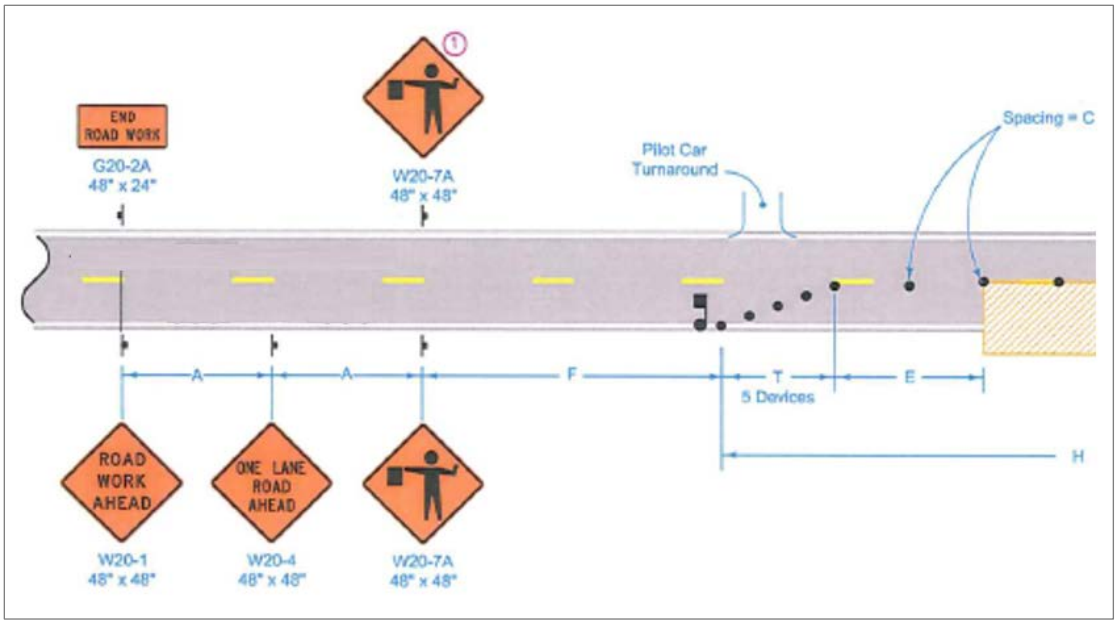

Figure 3. No TRS setup

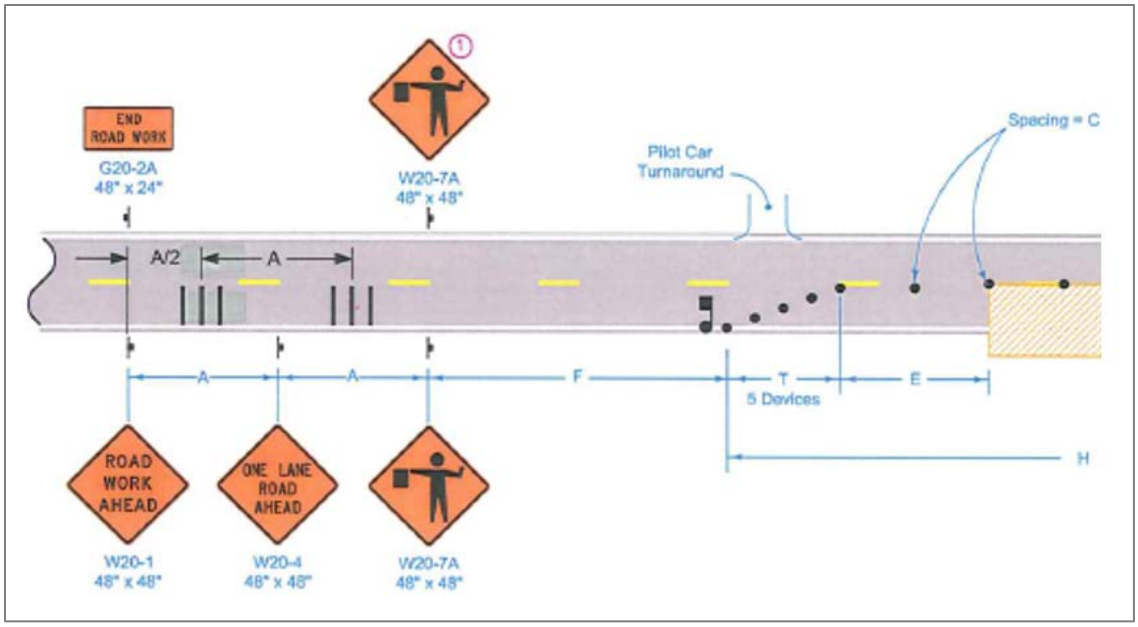

Figure 4. With Iowa DOT TRS layout from Developmental Specification (two sets of temporary rumble strips

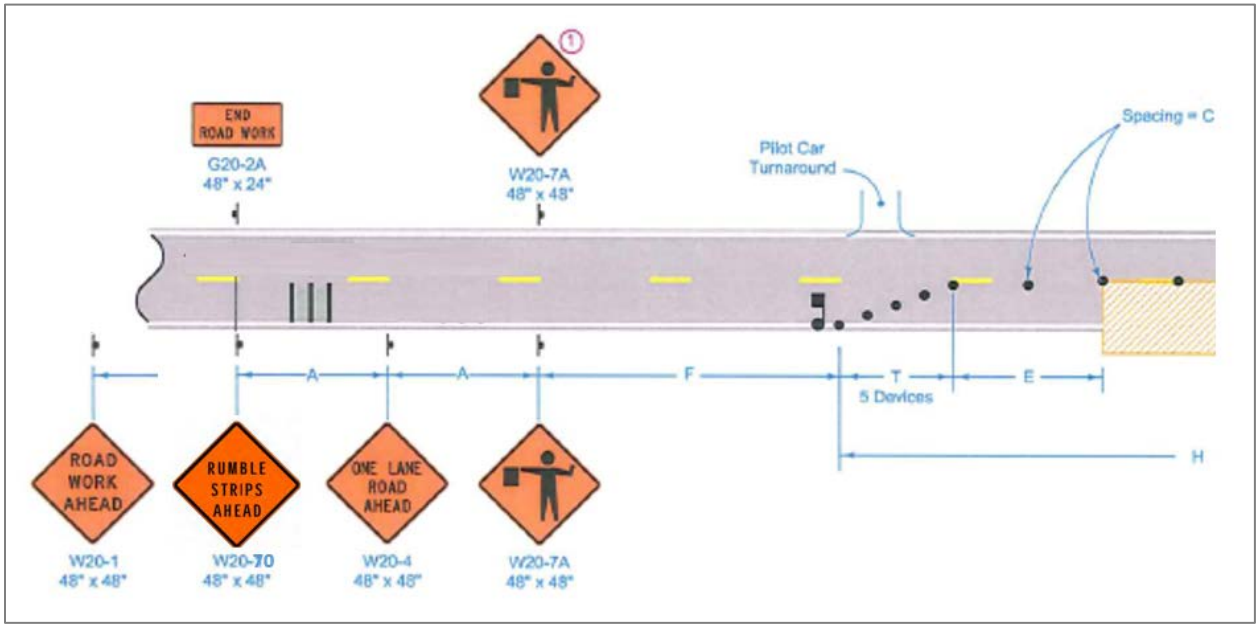

Figure 5. With modified TRS layout/setup (single set of rumble strips and Rumble Strips Ahead advance warning sign)

SCOPE

This limited field evaluation provides some quantification and visual recording of TRS impacts within one-lane flagger-operated work zones in Iowa. The measures of effectiveness include the following:

- Driver braking
- Avoidance (driving around the rumble strips)
- Change in speed

DATA COLLECTION METHODOLOGY

Figure 6 shows how data collection trailers were oriented for both video and speed data, with a trailer placed in advance of each set of TRS.

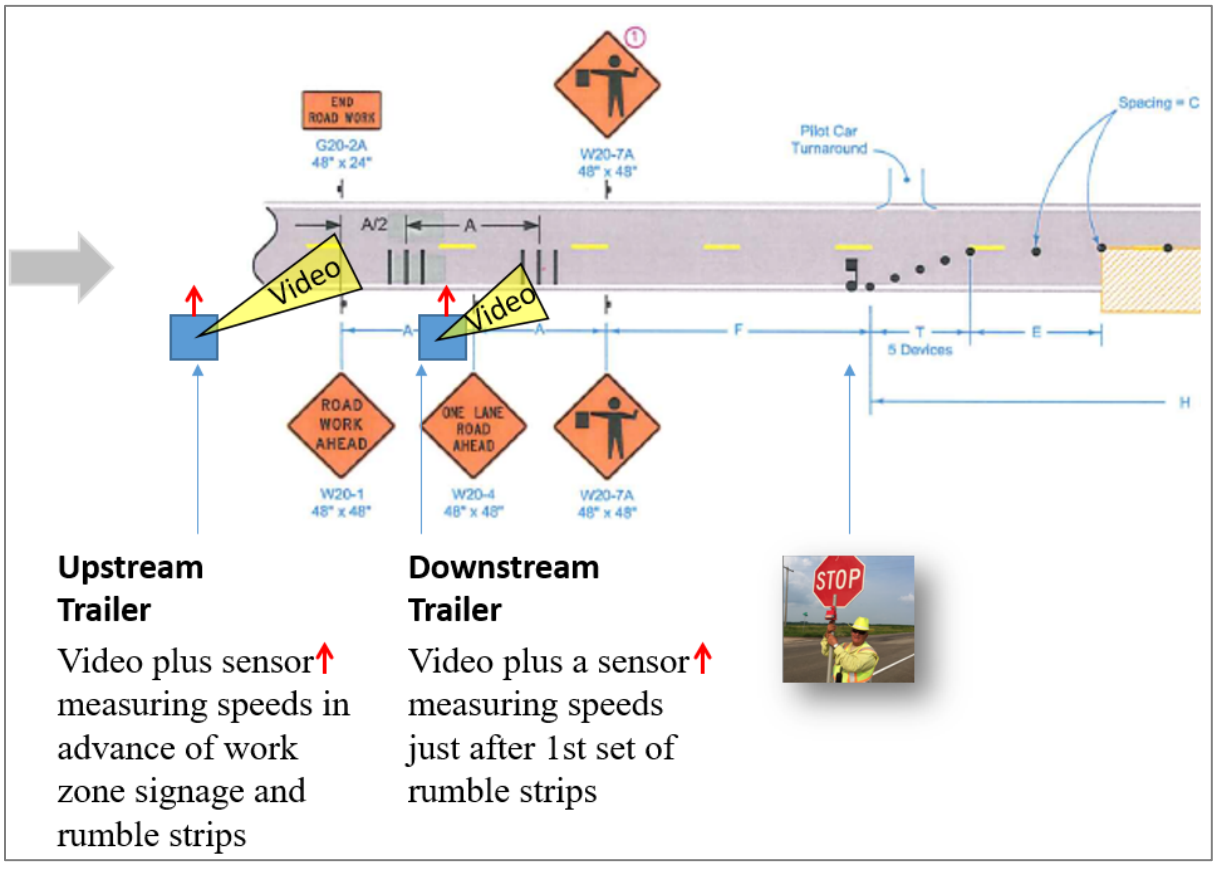

Figure 6. Trailer placement

The field evaluation included only one approach direction per work zone. In each case, the data collection trailer setup was moved along with the work area.

FIELD EVALUATION

The field evaluations were conducted for a different single work zone in 2015 and 2016.

2015 Field Evaluation

- Location: District 2 - US 52 (near Calmar)
- Evaluation Timeframe: June/July 2015

Figure 7. US 52 evaluation in 2015

2016 Field Evaluation

- Location: District 5 - IA 92 (near Oskaloosa)
- Evaluation Timeframe: August 2016

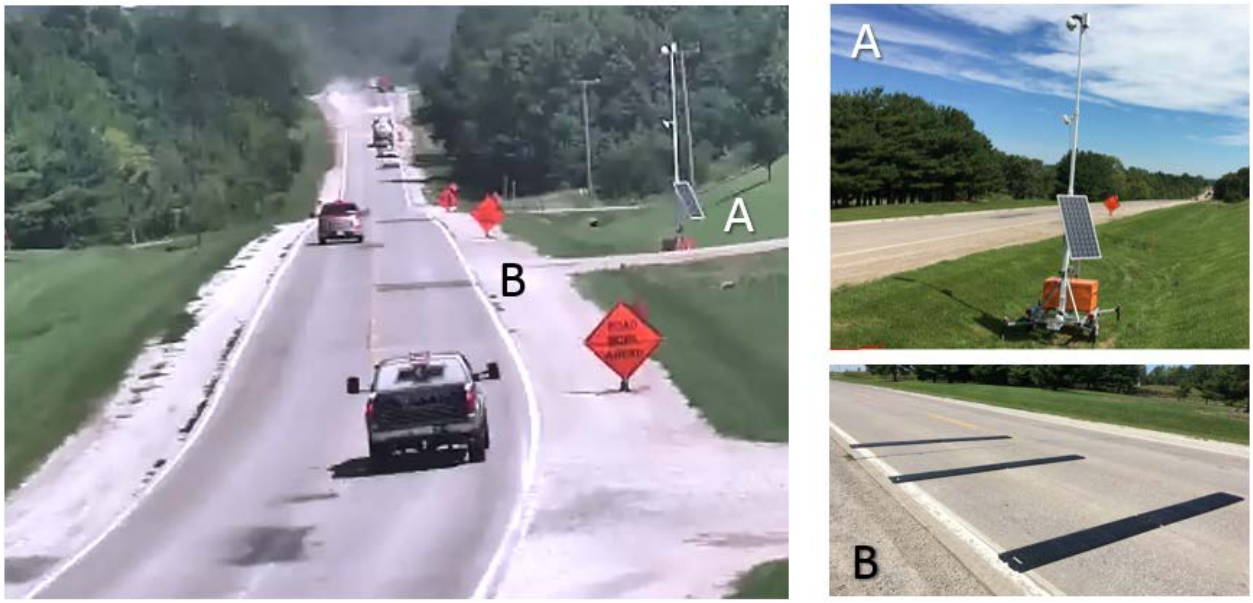

Figure 8. IA 92 evaluation in 2016

RESULTS

The findings from both the 2015 and 2016 field evaluations are presented below for braking, avoidance (driving around the rumble strips), and vehicle speed.

Table 1 lists the number of hours of data collection for each field scenario observed.

Table 1. Hours of data collected

Setup	Hours
No TRS	9.25
Iowa DOT TRS layout	20.50
Modified TRS layout	9.75

Braking Measurement

The braking observations are provided at two different points (upstream and downstream) and contrasted by TRS setup, which included the following:

- No TRS – Without TRS setup (see previous Figure 3)
- Standard – With TRS setup using the Iowa DOT Developmental Specification layout (see previous Figure 4)
- Modified – With modified TRS setup/layout (only one set of rumble strips and advance Rumble Strips Ahead warning sign) (see previous Figure 5)

Figure 9 identifies the observed braking locations for the Iowa DOT layout by number (within a circle) where:

- Location 1: Upstream TRS before the rumble
- Location 2: Upstream TRS after the rumble
- Location 3: Downstream TRS before the rumble
- Location 4: Downstream TRS after the rumble

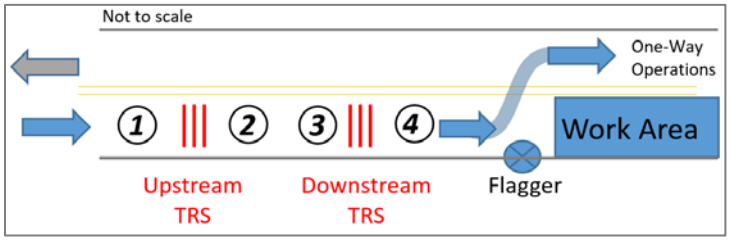

Figure 9. Vehicle braking measurement locations relative to TRS setup locations

Braking and Avoidance Findings

Tables 2 and 3 summarize the results of the video analysis for vehicle braking and driving around the TRS for upstream and downstream, respectively.

Table 2. Upstream braking and avoidance by setup

Setup	No TRS	Standard	Modified
Braking before rumble	9%	18%	26%
Braking after rumble	1%	11%	8%
Overall braking	10%	29%	33%
Driving around rumble	NA	1%	1%
Number driving around rumble	NA	12	3

Table 3. Downstream braking and avoidance by setup

Setup	No TRS	Standard	Modified
Braking before rumble	18%	23%	30%
Braking after rumble	5%	2%	14%
Overall braking	33%	25%	45%
Driving around rumble	NA	3%	NA
Number driving around rumble	NA	27	NA

Upstream TRS Setup Findings

- TRS presence increased braking behavior.
  - In contrast to no TRS setup, drivers hit their brakes twice as much under the standard TRS layout and almost three times as much under the modified TRS layout (which included an advance Rumble Strips Ahead warning sign). The percent of drivers braking after the upstream TRS setup increased from 1 to 11 percent (no TRS setup versus standard layout) and 8 percent under the modified layout. The 3 percent difference between TRS layouts is small but could reflect that, under the modified scenario, more drivers had already hit their brakes prior to the rumble strips.
  - The overall percentage of drivers braking increased by roughly a factor of 3 when rumble strips were present.
- TRS avoidance was minimal (1 percent).

Downstream TRS Setup Findings

- TRS presence increased braking behavior.
  - The modified layout did not have a TRS setup at the downstream location. These observations reflect the general spot where the downstream TRS setup was under the standard layout.
  - In contrast to no TRS setup, drivers hit their brakes 27 to 67 percent more when facing the standard and modified layouts, respectively. The percent of drivers braking after the downstream TRS setup actually decreased from 5 to 2 percent (no TRS setup versus standard layout) and increased to 14 percent under the modified layout. The decrease observed for the standard layout is small but could reflect the visibility of the queue ahead and the implied need to slow down.
  - The overall percentage of drivers braking was 25 percent when rumble strips were present (standard layout).
- TRS avoidance was minimal (3 percent).

Speed Measurement

Vehicle speeds were measured at two different locations—advance and after upstream TRS—as shown by the large red asterisks (*) in Figure 10.

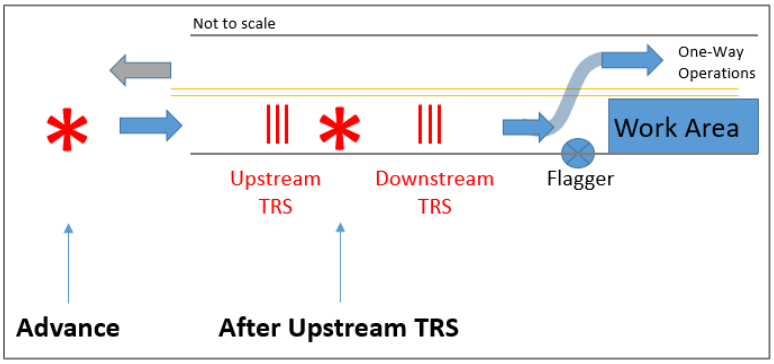

Figure 10. Vehicle speed measurement locations relative to TRS setup locations

Speed Findings

Readers are cautioned to consider the limited number of speed observations per location when reviewing these results. Table 4 summarizes the results of the speed data collected at the advance location by layout, roadway, and overall.

Table 4. Advance location speeds

	Setup		
	No TRS	**Standard**	**Modified**
Advance - IA 92			
Number of Vehicles	196	998	274
Mean (mph)	52.1	53.7*	54.5*
85th Percentile speed (mph)	59.5	60.6	60.8
Standard Deviation	7.6	7.7	6.9
Advance - US 52			
Number of Vehicles	188	485	216
Mean (mph)	49.4	51.5*	51.7*
85th Percentile speed (mph)	60.9	60.2	58.6
Standard Deviation	13.4	11.6	6.4
Advance - All			
Number of Vehicles	384	1483	490
Mean (mph)	50.8	53.0*	53.3*
85th Percentile speed (mph)	60.0	60.4	60.1
Standard Deviation	10.9	9.2	6.8

* Statistically significant change from no rumble strips

Table 5 summarizes the results of the speed data collected after the upstream TRS location by setup, roadway, and overall.

Table 5. After upstream TRS speeds

	Setup		
	No TRS	**Standard**	**Modified**
After upstream TRS - IA 92			
Number of Vehicles	205	908	494
Mean (mph)	56.4	46.8*	49.5*
85th Percentile speed (mph)	61.0	55.5	56.7
Standard Deviation	5.7	8.7	7.5
After upstream TRS - US 52			
Number of Vehicles	253	335	194
Mean (mph)	46.5	49.5*	49.8*
85th Percentile speed (mph)	55.7	59.0	57.3
Standard Deviation	8.8	10.3	7.4
After upstream TRS - All			
Number of Vehicles	458	1243	688
Mean (mph)	50.9	47.5*	49.6*
85th Percentile speed (mph)	59.4	56.6	56.9
Standard Deviation	9.0	9.3	7.4

* Statistically significant change from no rumble strips

Table 6 summarizes the results of the speed data collected by roadway and overall.

Table 6. Impact on mean speeds

	Mean Speed (mph)		
Setup	**Advance**	**After Upstream TRS**	**Change**
IA 92			
No TRS	52.1	56.4	4.3*
Standard	53.7	46.8	-6.9*
Modified	54.5	49.5	-5.0*
US 52			
No TRS	49.4	46.5	-2.9*
Standard	51.5	49.5	-2.0*
Modified	51.7	49.8	-1.9*
All			
No TRS	50.8	50.9	0.1
Standard	53.0	47.5	-5.5*
Modified	53.3	49.6	-3.7*

* Statistically significant change from advance to after upstream TRS setup

These results show that, overall, drivers are slowing down from the advance location to the observed point after the first set of TRS. These reductions were statistically significant at -5.5 mph and -3.7 mph for the standard and modified layout, respectively.

SUMMARY

These limited-scale field measurements were conducted to quantify the impact of the TRS setups at two different construction projects. The field work was not designed to produce statistically valid comparisons for TRS effectiveness, nor contrast between TRS layouts, project locations, or measured locations per site.

It is important the reader does not misinterpret these findings as comprehensive nor consistent with any type of before/after or test/control evaluation (these are only measurements). Given the above limitations, the presence of temporary rumble strips were found to have the following impacts as vehicles approached the work zones:

- Increased driver braking
- Minimal driver avoidance
- Reduced vehicle speeds

These field data are considered positive and should serve future study efforts in terms of hypothesis development and testing as part of a controlled evaluation.