IMPACT OF RED BORDER AROUND A SPEED LIMIT SIGN ON SPEED LIMIT COMPLIANCE

A Thesis Proposal

By

Roma Garg

Submitted to the Office of Graduate Studies of
Texas A&M University

In partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE

September 2005

Major Subject: Civil Engineering
INTRODUCTION

Speeding is a significant safety concern on our highways and contributes to a large number of fatal and non-fatal crashes every year. In 2003, speeding was a contributing factor in thirty one percent of all fatal crashes. The National Highway Traffic Safety Administration (NHTSA) defines speeding as driving too fast for conditions or exceeding the posted speed limit. NHTSA estimates the economic cost of speed related crashes to society to be approximately $40 billion per year. Texas is no exception to national statistics. In-fact, speed related crashes on Texas highways account for forty one percent of all fatal crashes (1). Speeding reduces a driver's ability to steer safely around curves or objects in the roadway, and it extends the distance required to stop a vehicle in emergency situations. Crash severity increases with the speed of the vehicle at impact. Inversely, the effectiveness of restraint devices like air bags and safety belts, and vehicular construction features such as crumple zones and side member beams, declines as impact speed increases. The probability of death, disfigurement, or debilitating injury doubles for every 10 mph over 50 mph that a vehicle travels (2). The faster impact speed is, greater is the likelihood of severe injury or death in a collision.

Despite all the evidence that travel speed affects the severity of a crash, most drivers do not consider speeding as an immediate risk to their personal safety or to the safety of others. They slow down their vehicle in residential areas, or when the weather turns bad. However Reduced Speed Ahead signs and Speed Limit signs often go unnoticed where there are no cues to indicate the need for reduced speed. Endless reasons exist for why a driver may ignore the speed limit, some of which include the driver does not perceive a need to slow down, the driver is in a hurry, and/or most regulatory signs look alike and do not capture driver attention. Due to the severity of the problem, a number of techniques have been devised and are used to reduce speeding and increase speed limit compliance.

PROBLEM STATEMENT

Reduced speed zones well outside the city limits of a rural community usually provide no visual clue to the driver for a need to slow down. Motorists may speed in these reduced speed limit zones because there is no obvious reason to slow down. Law enforcement may be needed in these reduced speed zones to achieve better speed limit compliance. However it is a costly and temporary measure. Traffic signs are by far the most cost effective and permanent way of informing the drivers of a change in speed limit. Standard Speed Limit Signs in these zones sometimes go unnoticed and unheeded by drivers where the roadway geometry does not change or the surroundings do not suggest a reduction in speed is needed. Research is needed to determine if changing the design of the Speed Limit sign and making it more conspicuous will get attention of drivers entering such reduced speed zones and alert them for the need to slow down.

RESEARCH OBJECTIVES

The objective of this research is to study the impact of a red border around a Speed Limit sign on speed limit compliance in a reduced speed area. This study will be conducted at four sites with similar geometric characteristics and speed limits. The long term effects of a similar treatment to the standard Speed Limit sign will be quantified by studying three additional sites from a similar recent Texas Transportation Institute project. The goals for this research are:
• Evaluate the traffic impacts of a red border around a Speed Limit sign with different sheeting materials by conducting a before and after study.
• Compare the effectiveness of red border around a Speed Limit sign with the effectiveness of other speed management measures using results from outside studies.
• Make recommendations for the use of red border around Speed Limit signs and sign conspicuity based on the results of this study.

BACKGROUND

The literature indicates that speed management methods can improve the driver awareness about changes in speed limits. Speed management methods include law enforcement, signs with flashing lights, radar trailers, pavement markings, and changes to design and position of speed limit signs. Law enforcement and radar trailers encourage compliance with the speed limit, but are only effective when enforcement and trailers are in place. Law enforcement is also very costly. Changes to the road geometry, road surface, and Speed Limit signs are the only permanent methods used to reduce the number of speed limit violations. Various sign treatments used to achieve greater speed compliance include larger speed signs, Reduced Speed Ahead signs, speed signs with orange flags attached to them, speed signs with a colored plaque at the top, overhead positioning of speed sign, speed feedback signs, to name a few.

The Traffic Operations and Safety (TOPS) Laboratory studied the effectiveness of overhead mounted regulatory speed signs on operating speed at three different locations along the Milwaukee freeway system (3). Results showed very little change in average operating speeds in the after period. Authors concluded there was no significant evidence to indicate any impact on the operating speeds due to the installation of overhead speed limit sign. Figure 1 shows a Speed Limit sign mounted overhead instead of mounted on the pavement shoulder.

Another study by Maroney and Dewar (4) evaluated the impact of speed feedback sign on speed compliance. The sign was four feet by eight feet guide sign with two phrases and is shown
in Figure 2. The percentage numbers were slots that could be changed everyday. Speed data were collected for four different conditions: before the sign was installed in the field, while the percentage slots were blank, while the percentage slots showed values, and after the sign was removed. The results showed a significant reduction in the mean speed and extreme speeds while the sign showed percentages listed. The authors concluded that speed feedback sign is an effective means of reducing operating speeds.

Figure 2. Speed Feedback Sign

The Department of Transport in the United Kingdom uses vehicle activated signs at sites which have higher speeding and crash statistics (5). When an approaching driver is identified as driving above the speed limit, the sign lights up and flashes the speed limit and “Slow Down”. A picture of a vehicle activated speed limit sign is shown in Figure 3a. The sign has a red, circular border around the posted speed limit which is the case for all Speed Limit signs in UK. Most Speed Limit signs on European highways have red borders as shown in Figure 3b.

Figure 3a. Vehicle Activated Sign               Figure 3b. International Speed Limit Sign

Gates et al. (6) evaluated the traffic operational impacts of higher conspicuity sign materials. The main purpose for this study was “to identify situations in the field where higher-conspicuity sign materials offered safety-related traffic operational benefits” (6). One of the experiments conducted in this study was to evaluate the effect of a three inch microprismatic red
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The red color was chosen based on the findings of a focus group survey which evaluated yellow and red as the options. The Speed Limit sign used for the after period in this study is shown in Figure 4.

The results of this study indicated a significant decrease in the mean speeds of passenger vehicles traveling both during daytime and nighttime. The percentage of vehicles exceeding the speed limit also decreased from 80% to 65.3%, a statistically significant amount. To establish the validity of these promising results, Rose et al. conducted another research study at four more sites (7). Results of this study were found promising and beneficial at three of the four sites but were not conclusive enough to recommend a change in the design of speed limit sign. Further research at additional sites and long term impacts of this treatment are therefore needed to reach definitive conclusions.

![Speed Limit Sign with a Microprismatic Red Border](image)

**Figure 4. Speed Limit Sign with a Microprismatic Red Border**

**RESEARCH STUDY DESIGN**

To accomplish the research objectives, this study is divided into the following tasks.

1. **Review of Related Practice:** The researcher will conduct a thorough literature review of treatments used on signs to achieve better speed compliance. The researcher will pay special attention to the previous research done by Texas Transportation Institute on the use of red border and the survey conducted to select red as the color. The researcher will also study other speed management measures in practice for their relative effectiveness and cost.

2. **Sign Modification:** This study will use a modified Speed Limit sign as the treatment. This modification is described below: Replace the black border around the perimeter of the standard Speed Limit sign (R2-1) by a four inch wide red border while maintaining the same inside curve dimensions and increase the overall width and height by six inches in each direction. The modified sign is shown in Figure 5. The researcher will refer to this modified sign as ‘Modified Red Border Speed Limit sign’ hereafter for the purpose of this study.
This study will also use another sign modification which is to have a three inch microprismatic red border around the perimeter of standard Speed Limit sign (R2-1). The researcher will achieve this modification by placing a 30 x 36 inch blank red microprismatic sheet behind the existing 24 x 30 inch sign. This sign is shown in Figure 4. The researcher will refer to this sign as ‘Standard Speed Limit Sign with Red Border’ for the purpose of this study.

3. **Study Approach**: The basic study approach will be to collect and evaluate traffic speed data at selected sites with various sign treatments in place. The main goal of the study is to quantify the impact of red border around a Speed Limit sign. This study consists of two parts: a short term study and a long term study.

*Short Term Study*: This will evaluate the impact of Modified Red Border Speed Limit signs and different sheeting materials two to four weeks after placement of the sign in the field. Various sign treatments for this study consist of:

i. High Intensity Standard Speed Limit sign
ii. High Intensity Red Border Speed Limit sign
iii. Microprismatic Standard Speed Limit sign

Two or more treatments will be evaluated at any given site to fulfill the goals of this study. Treatments will be implemented at the same location one after the other. The time gap between treatments will be approximately four weeks. After data collection, previous treatment will be replaced by the next treatment.

*Long Term Study*: The researcher will evaluate the long term impacts of Speed Limit sign with Red Border in continuation of a Texas Transportation Institute research study (7) started in 2003. The researcher will use three of the four study sites from this research study. The researchers of the previous study collected traffic operations data on the existing standard Speed Limit sign (Before data). The sign was then replaced by a Standard Speed Limit sign with Red Border. Three weeks after placing the red blank, the researchers collected data (After data). The red blank was left placed behind the sign for these sites. The researcher will collect another data on these signs after nine or more
months (Long After data). The results of this study will quantify the long term impacts of red border around a Speed Limit sign.

4. **Study Sites:** The researcher will select four sites in rural areas based on the following criteria.
   - Speed limit drops by 10 to 15 mph, preferably from 70 mph to 55 mph;
   - There is no apparent sign for the reduction in speed i.e. roadway cross-section does not change;
   - Geometry of the roadway does not change i.e. there are no sharp horizontal or vertical curves visible which might cause the drivers to slow down;
   - All other features of the roadway do not change i.e. no change in land use is visible from the speed limit sign.

Additionally three more sites from a previous Texas Transportation Institute study (7) will be used to establish the long term impacts of this treatment.

5. **Data Collection:** The researcher will make every effort to collect data during weekdays with clear skies i.e. no rain to avoid any bias. For the short term study, speed data and time stamps using pneumatic automatic classifiers will be collected at a control point approximately half a mile upstream of the study sign, at threshold distance (distance at which sign is legible) and at a point approximately 250 feet downstream of the sign. Data will be collected approximately three to four weeks after the implementation of treatment. This ensures that data is not affected by the novelty effects of the treatment.

   For the long term study, the researcher will follow the same field procedure for data collection as was followed for the before and after data. This procedure is: speed data and time stamps using pneumatic automatic classifiers were collected at a control point, at threshold distance, halfway between threshold point and speed limit sign, at speed limit sign, and at a point approximately 250 feet downstream of the sign. The researcher will collect data at different sites using three or more of all the treatments mentioned in study approach. Table 1 shows the plan of various treatments to be used at different sites for data collection.

6. **Data Reduction:** After deleting all the bad hits (anything other than ‘FF’ in the status column indicates recorded data may not be correct and is considered a bad hit), the researcher will reduce the data as follows:
   - Delete all vehicles traveling at speeds 25 mph below the speed limit. This will eliminate any vehicles that have just entered the roadway from a driveway or are in the process of exiting.
   - Delete all vehicles traveling at speeds above 95 mph. This is done to eliminate any vehicles traveling at unreasonable speeds. Here it is assumed that any motorist driving at speed greater than 95 mph is not rational and is not heeding Speed Limit sign irrespective of its conspicuity and design.
   - Delete all vehicles traveling at headways less than or equal to 5 seconds. Vehicles traveling at headways less than 5 seconds are platooned vehicles which are not choosing their own speeds.
   - Classify as passenger vehicles and heavy vehicles, traveling during day time and traveling during night time. Daytime data are from sunrise to sunset and nighttime data are from sunset to sunrise. Vehicles with FHWA vehicle class 2 and class 3 will be regarded as passenger vehicles and of vehicle class 4 and higher will be grouped together as heavy vehicles.
Table 1. Treatments at Different Sites

<table>
<thead>
<tr>
<th>Sheeting type</th>
<th>Sign</th>
<th>Short Term Study Sites</th>
<th>Long Term Study Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
<td>Description</td>
<td>Site 1</td>
</tr>
<tr>
<td>Engineering Grade</td>
<td>R2-1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>R2-1 with Red Border</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>High Intensity</td>
<td>R2-1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Modified R2-1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Micro - prismatic</td>
<td>R2-1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Modified R2-1</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

7. **Data Analysis**: The researcher will divide the data in daytime data and nighttime data for the purpose of examining the effect of different lighting conditions. Primary independent variable for the purpose of this study is sign treatments. Two, three, and four levels of treatments have been identified depending upon the site, as indicated in data collection task above. Dependent variable is the speed downstream of Speed Limit sign. The researcher proposes to use the following statistical procedures to determine the impact of various treatments used.

- Analysis of variance (ANOVA): A univariate two-way ANOVA will be used to test for differences in the mean speeds for short term study. ANOVA allows for testing of differences between mean values of multiple populations as a function of independent variables (i.e. sign treatments, light conditions, headways etc.) and interactions between the independent variables. Upstream control point will be used as a covariate for the analysis. Vehicles traveling faster upstream of the evaluation point are likely to travel faster in the study site also. Using upstream control point speed as a covariate allows for correction due to such occurrences. For long term study, one way ANOVA will be performed to test for differences between before study, after study, and longafter study.
- Z-test of Proportions: Z-test of proportions will be used to test for differences in percent exceeding a specified threshold speed. This test will be able to test the effect of treatment on upper extremities of speed data.
- Bootstrapping Procedure to test for significant differences in 85th percentiles: Bootstrapping procedure will be used to develop 95% confidence intervals for the 85th percentile parameter for various sign treatments. These confidence limits and parameter statistics are then used to compare 85th speed percentiles for various sign treatments (6).
- Using data found in literature, the researcher will make a comparison of effectiveness of red border speed limit signs with other speed management measures used in practice

8. Conclusions and Recommendations: The researcher will provide a summary of the research findings and recommendations on the potential use of red border around a Speed Limit sign in speed zones. Based on the results of this study, recommendations for inclusion in MUTCD will be made.

POTENTIAL BENEFITS OF STUDY
Positive results from this study will provide a permanent and cost effective way of better speed compliance in speed zones and probably in areas with higher crash rates due to speeding.

REFERENCES
2) University of Oklahoma Police Department. The Police Notebook: Speed Shatters Life http://www.ou.edu/oupd/speed.htm May 2005