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Virginia Transportation Research Council

research report

Visibility of Steel Plates Used in Connection with Highway Repairs

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Supplementary Notes

Abstract

Steel plates are used primarily in urban areas where an excavation is made in the roadway for utility work, such as installing or replacing utility lines, pipes, and conduits. The steel plate is positioned on the roadway to cover the excavation and allow traffic to proceed when utility work is not underway. Motorcyclists are challenged when they traverse a plate unexpectedly. Although the Virginia Department of Transportation has policies and procedures in place that all but eliminate the use of steel plates on the roads it maintains, such plates are used frequently in urban areas. House Bill 408 passed by the 2004 Virginia General Assembly required the Virginia Transportation Research Council to examine best practices to improve the visibility of steel plates to help make motorcyclists more aware of their presence. Although the bill was vetoed by the governor because of a technicality on the timing of the two parts of the bill, VTRC proceeded with the examination.

The purpose of this study was to examine best practices for the use of markings to improve the visibility of steel plates. As a secondary objective, the ancillary effects of such markings on skid resistance were examined. State and local transportation agencies were contacted to determine their practices. This information was compiled, and promising means of improving the visibility of steel plates were examined. A stakeholder task group was created to participate in this effort. Task group members included motorcyclists, VDOT and local government staff and representatives, and representatives of utility companies and utility contractors.

No state DOT marked plates to improve visibility. Warning signs such as "BUMP" and "STEEL PLATE" were used by several agencies. The City of Richmond uses a "STEEL PLATE AHEAD" advance warning sign and a plate-marking pattern that delineates the corners of the plate. For plates more than 10 feet long, skip lines are added along the sides.

A warning "STEEL PLATE" sign in combination with corners only pavement markings on the plates was the method selected by the study task group to improve the visibility of steel plates.

The recommendations of the study were implemented in the 2005 *Virginia Work Area Protection Manual.*

FINAL REPORT

VISIBILITY OF STEEL PLATES USED IN CONNECTION WITH HIGHWAY REPAIRS

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Virginia Transportation Research Council
(A partnership of the Virginia Department of Transportation
and the University of Virginia since 1948)

Charlottesville, Virginia

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VTRC 07-R16

DISCLAIMER

The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Virginia Department of Transportation, the Commonwealth Transportation Board, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

PREFACE

House Bill No. 408 directed the Virginia Transportation Research Council (VTRC) to undertake an examination of best practices regarding the improved visibility of steel plates and report its findings to the Chairman of the House Committee on Transportation prior to July 1, 2005.

The stakeholder task group for this project included the following individuals:

Huey Battle, Washington Gas
Bruce Biondo, Virginia Department of Motor Vehicles
Stephen Brich, Mobility Management Division, VDOT
Johnnie Butler, Department of Public Works, City of Richmond
Jim Cannon, Virginia Coalition of Motorcyclists
Mike Edwards, Virginia Municipal League
Mark Hodges, Mobility Management Division, VDOT
Keith Lindgren, Motorcycle Safety League of Virginia Incorporated
Dennis Motley, Construction Division, VDOT
Matt Reynolds, Right of Way & Utilities Division, VDOT
Robert Rummells, Legislative Assistant to the Honorable John Welch
Mark Singer, Virginia Utility & Heavy Contractors Council
Marianne Radcliff, Kemper Consulting

The principal investigator for the study was Benjamin H. Cottrell, Jr., Associate Principal Research Scientist, VTRC. The author gratefully acknowledges the contributions of William Howard and Eddie Isbell of G. L. Howard, Inc., and Lance Dougald of VTRC in conducting the night review; of Kimberly Mattingly of VTRC in performing the survey of state codes; and of Johnnie Butler, City of Richmond, for providing valuable information on his experience with steel plates.

EXECUTIVE SUMMARY

Introduction

Steel plates are used primarily in urban areas where an excavation is made in the roadway for utility work, such as installing or replacing utility lines, pipes, and conduits. The steel plate is positioned on the roadway to cover the excavation and allow traffic to proceed when utility work is not underway. Motorcyclists are challenged when they traverse a plate unexpectedly. Although the Virginia Department of Transportation (VDOT) has policies and procedures in place that all but eliminate the use of steel plates on the roads it maintains, such plates are used frequently in urban areas. House Bill 408 passed by the 2004 Virginia General Assembly required the Virginia Transportation Research Council (VTRC) to examine best practices to improve the visibility of steel plates to help make motorcyclists more aware of their presence. Although the bill was vetoed by the governor because of a technicality on the timing of the two parts of the bill, VTRC proceeded with the examination.

Purpose and Scope

The purpose of this study was to examine best practices for the use of markings to improve the visibility of steel plates. As a secondary objective, the ancillary effects of such markings on skid resistance were examined. State and local transportation agencies were contacted to determine their practices. This information was compiled, and promising means of improving the visibility of steel plates were examined. A stakeholder task group was created to participate in this effort. Task group members included motorcyclists, VDOT and local government staff and representatives, and representatives of utility companies and utility contractors.

Methods

Information was gathered on improving the visibility of steel plates through a review of the literature, a survey of state departments of transportation (DOTs), and an email list serve query. If a best practice was not identified through these efforts, the study team developed alternatives. Alternatives were installed, reviewed, and assessed by the stakeholder task group. Skid measurements were made of the marking materials used.

Results

Best Practices

No state DOT marked plates to improve visibility. Warning signs such as “BUMP” and “STEEL PLATE” were used by several agencies. In Oregon, the Governor’s Council on Motorcycle Safety has as one of its goals making steel plates safer by investigating ways to improve their skid resistance. This effort is ongoing, and the results were not currently available. Washington State codes require the use of the sign “MOTORCYCLES USE EXTREME CAUTION” with several roadwork conditions, including the presence of steel plates. Federal

Highway Administration staff advised the investigator on the use of white pavement markings for steel plates, marking the perimeter of the plate completely, and using "BUMP" or "STEEL PLATE" as a warning or advance warning sign. The City of Richmond uses a "STEEL PLATE AHEAD" advance warning sign and a plate-marking pattern that delineates the corners of the plate. For plates more than 10 feet long, skip lines are added along the sides.

Night Review of Alternative Plate Marking Patterns

Available members of the stakeholder task group reviewed two steel plates with different markings placed side by side. Each plate had dimensions of 8 by 12 feet, which is the common plate size. On one plate, the perimeter was outlined. On the other plate, the corners were marked and a skip line was placed on each side.

The review was conducted at night at the yard of a utility contractor. A survey form was used to record the preferred plate of each participant at four distances (160 and 80 feet from both ends of the plates), under low- and high-beam headlights of a passenger van and a motorcycle, and under lighted and unlighted conditions.

The participants commented that the broken lines of the "corners and skip lines plate" conveyed a message that they preferred, in part because the broken lines provided a contrast against the steel plates. There was some concern about the skip lines being confused with lane lines that exist for two or more lanes in the same direction. This possible confusion was evident during a field visit by the stakeholder task group in Richmond. For some, the "outlined plate" reminded them of a crosswalk marking with the continuous horizontal or transverse lines.

Following some discussion, a third pattern whereby only the corners of the plate were marked was tested. Six of the seven participants chose the "corners only plate" as their preferred choice overall.

Maintenance and Cost of Pavement Markings

Work zones are areas of much activity, and work zone traffic control devices are exposed to environments that accelerate the wear and tear of traffic control devices. Steel plates are used where soil and the pavement surface and subsurface have been removed, and this material ends up on the surrounding pavement and on the plates.

Thus, to be effective, plate markings need to be relatively clean and intact. Those responsible for maintaining the markings should monitor them and determine when maintenance or replacement is needed. Based on observations of steel plates with markings in Richmond, periodic inspections of the plates are needed to determine and address the pavement marking maintenance needs.

The material costs of the three marking patterns are $27 for the corners only, $34 for the corners and skip lines, and $52 for the outline. Not surprisingly, the corners only pattern costs the least since it uses the least amount of marking tape. At $27, the cost is 26 percent lower than that for corners and skip lines and 93 percent lower than for the outline.

Conclusion

A warning "STEEL PLATE" sign in combination with corners only pavement markings on the plates was the method selected by the task group to improve the visibility of steel plates.

Recommendations

VDOT's Traffic Engineering Division should consider adopting the following:

1. Warning signs should be placed in advance of all temporary steel plates used on roadways open to vehicular traffic to advise motorists that they may expect to encounter plates. The advance or warning sign should contain the message "STEEL PLATES."

2. Temporary steel plates installed on roadways open to vehicular traffic should be marked with a durable and highly reflective white pavement marking tape no less than 4 inches in width. The marking pattern used should, at a minimum, include all four corners of the plate, similar to the pattern shown in Figure ES-1. The marking tape dimensions should not be less than those shown in Figure ES-1. The 3-inch distance from the plate's edge to the tape may be varied depending on the conditions.

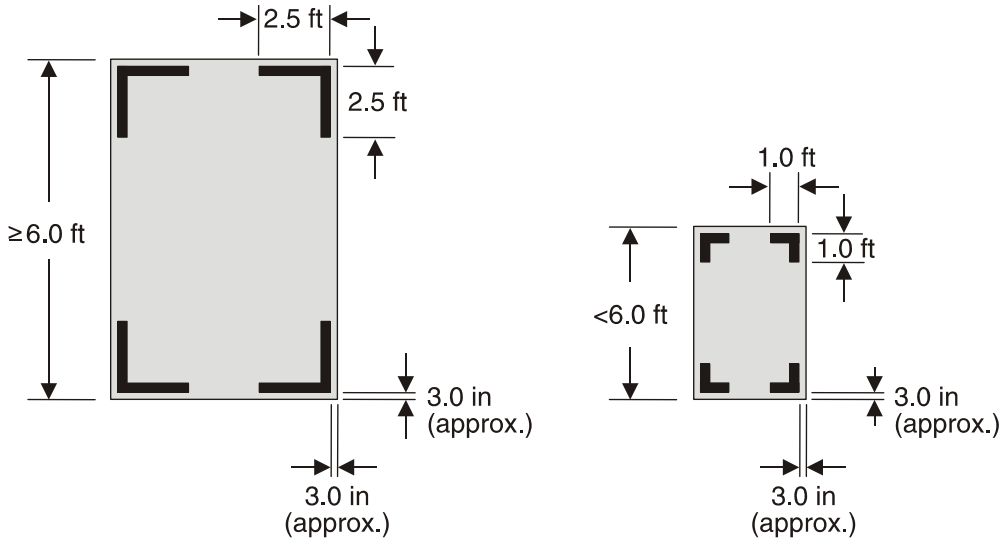


Figure ES-1. Recommended Steel Plate Marking. ***Left:*** **Steel plates greater than or equal to 6 feet in length;** ***right:*** **steel plates less than 6 feet in length.**

3. The warning sign and markings should be maintained in a condition that will satisfy their intended purpose.

FINAL REPORT

VISIBILITY OF STEEL PLATES USED IN CONNECTION WITH HIGHWAY REPAIRS

B. H. Cottrell, Jr.
Associate Principal Research Scientist

INTRODUCTION

Steel plates are used primarily in urban areas where an excavation is made in the roadway for utility work, such as installing or replacing utility lines, pipes, and conduits. The steel plate is positioned on the roadway to cover the excavation and allow traffic to proceed when utility work is not underway. Steel plates are often used in urban areas where the utility infrastructure is under the roadway. The utility work can be performed during off-peak periods and at night. Then, with the steel plates in place, traffic can proceed uninterrupted by utility work during the peak periods.

The steel plate can be difficult to see during both daytime and nighttime. Motorcyclists are challenged more when they traverse a plate unexpectedly. If the surface of the plate has oil deposits or is wet, the skid resistance may decrease, thus worsening the driving conditions, especially for motorcyclists. Motorcyclists and organizations representing their interests have expressed their concern about the visibility of steel plates and other issues. Although the Virginia Department of Transportation (VDOT) has policies and procedures in place that all but eliminate the use of steel plates on the roads it maintains, VDOT agreed to review the issue to identify best practices to improve the visibility of the steel plates. House Bill 408 passed by the 2004 Virginia General Assembly required the Virginia Transportation Research Council (VTRC) to undertake an examination of best practices regarding improving the visibility of steel plates (see the Appendix A). Although the bill was vetoed by the governor because of a technicality regarding the timing of the two parts of the bill, VTRC proceeded with the examination.

PURPOSE AND SCOPE

The purpose of this study was to examine best practices for improving the visibility of steel plates. As a secondary objective, the ancillary effects of those markings on skid resistance were examined. State and local transportation agencies and utilities were contacted to determine their practices. This information was compiled, and promising means of improving the visibility of steel plates were examined. A stakeholder task group was created to participate in this effort. Task group members included motorcyclists, VDOT and local government staff and representatives, and representatives of utility companies and utility contractors.

METHODS

Seven tasks were conducted to achieve the study objectives:

1. *Review the literature.* A search of several computerized databases was conducted to identify any documents relating to steel plates and visibility. "Motorcycle safety" was used as one of the key word combinations for this search.

2. *Survey transportation agencies, and search state codes.* Transportation agencies for state and local governments were surveyed regarding their use of techniques to improve the visibility of steel plates. An email questionnaire survey was sent to the 49 other state DOT traffic engineers. The questions involved the state's use of steel plates, special provisions or specifications for their use, marking of steel plates to improve visibility, use of warning signs, ways to improve skid resistance, and other available information. An email similar to the one sent to the state DOTs was sent to the Institute of Transportation Engineers (ITE) List Serve to target urban traffic engineers. After the first stakeholder task group meeting, additional information from the Federal Highway Administration (FHWA) was sought. In addition, a search of all state codes was conducted to determine if there were any references to marking steel plates. This was done as a supplement to the survey of state traffic engineers to identify any gaps in the survey information for state DOTs that did not respond. Using the Westlaw computerized database of state codes, "steel plates," "highway repairs," "bridging," and other key word combinations were used.

3. *Compile and analyze the findings.* The findings of the literature review, the surveys, and the search of state codes were compiled. The compilation was, in effect, a best practices document. If no best practices were identified or they were found lacking or insufficient, the study team developed alternatives to consider.

4. *Select alternatives to improve the visibility of steel plates and method for their assessment.* Alternative marking patterns and a method to assess techniques for improving the visibility of steel plates were selected.

5. *Measure the skid resistance of the steel plates.* The skid resistance measurements were made in accordance with the ASTM International standard test method for measuring the surface frictional properties using the British Pendulum Tester.[1]

6. *Assess the implemented strategy.* The researcher and stakeholder task group assessed the implemented strategies and determined their potential for application in Virginia.

7. *Develop recommendations to improve the visibility of steel plates.*

RESULTS AND DISCUSSION

Best Practices

Literature Review and State DOT Survey

The review of the literature did not reveal any information on improving the visibility of steel plates.

With the emailed survey to state DOTs, responses were received from 17 of 49 states, for a 35 percent response rate. Thirteen of the 17 state DOTs use steel plates. Of these 13, none marks the plates to improve their visibility. One DOT is considering doing so. Four DOTs install signs to warn of the presence of steel plates. Two states each use these sign messages: "STEEL PLATE(S)" (one uses "PLATES" and the other "PLATE") and "BUMP." None of the states treats steel plates to improve traction or skid resistance. One state, Oregon, has research in progress to investigate means to improve skid resistance.

In Oregon, the Governor's Council on Motorcycle Safety has increasing the safety of steel plates as a goal. The "easy fix" was to add signing: the advance warning sign "STEEL PLATES AHEAD" and a warning sign "STEEL PLATES." The Oregon DOT's position is not to make the plate more visible because motorists may stop or avoid the plate. Their challenge is to identify ways to improve skid resistance. In one case, blackout or removable black tape was used to cover an entire plate in an emergency installation. The plate was used to cover a hole caused by bad concrete on a new bridge on an interstate highway and was used with a "BUMP" sign. They are considering high friction surfaces such as epoxy gravel, Tyregrip, and others. Since this is an ongoing effort, the results were not available at this time.

City of Richmond

An investigation of the structural integrity of steel plates and of ways to improve their visibility by the City of Richmond resulted in substantial changes in its use of steel plates.[2] Richmond adopted a pattern for marking steel plates using pavement marking tape and an advance warning sign with the message "STEEL PLATE AHEAD." The marking pattern delineated the corners of the plate, and for plates more than 10 feet long, skip lines were added along the sides. During the winter, December 1 to March 30, an orange and white drum with the words "STEEL PLATE" on an attached sign or directly on the drum is required near the plate to warn of the presence of the plate if it is covered by snow. Richmond's experience was valuable in advancing the efforts of this study.

The ITE List Serve

Three useful responses were received on the ITE List Serve; all involved signing. Federal Way, Washington, uses a "STEEL PLATE IN ROADWAY" sign and New York City uses a "CAUTION STEEL PLATES IN ROAD" sign. Washington State uses a "MOTORCYCLES USE EXTREME CAUTION" sign. The Washington legislature passed a statute stipulating that the sign must be used when roadwork using grooved pavement, abrupt

lane edges, steel plates, or gravel or earth surfaces is being conducted. The sign is to be used in addition to the signs noting the condition.

FHWA Feedback

FHWA staff who were listed as information sources on the website for the *Manual on Uniform Traffic Control Devices* (http://mutcd.fhwa.dot.gov/res-who-tcd.htm) were contacted by email and asked about the color of the pavement marking recommended for the plates, the marking pattern, and signing. FHWA's staff responded that white is the recommended color and outlining the plate is the recommended pattern. The following describes the rationale behind the recommended pattern.

> Very likely, a motorcycle approaching the plate would want and need to know where the edges are. The leading, sides and trailing side of the plate so they can avoid the sides and if they do cross over the plate, where the front and trailing edges are to be prepared for any elevation differences between the plate and the roadway. So, it would seem that markings completely around the perimeter would be the minimum. As far as the marking material, a non-skid type tape of 4" to 6" in width would probably be a good option.[3]

Coincidentally, the Maryland State Highway Administration queried the FHWA regarding warning signs for steel plates shortly after VDOT's request for guidance on marking them.[4] For signing, two options were suggested: a "BUMP" warning sign with a supplemental plaque "STEEL PLATE" and a "STEEL PLATE" warning sign with an optional advisory speed plaque. An advance warning sign of "STEEL PLATE AHEAD" is also an option. The "STEEL PLATE" signs are acceptable under the option of special warning signs that may be used based on engineering judgment.

The stakeholder task group recommended the use of the warning sign with the specific message of "STEEL PLATE."

Survey of State Codes

Only the state of Washington has language in its code regarding warning of the presence of steel plates. Using the required sign "MOTORCYCLES USE EXTREME CAUTION" in addition to signing stating the condition was noted in the ITE List Serve results.

Skid Resistance Measurements

According to the manufacturer's literature, the BPN (British Pendulum Number) for the pavement marking tape has an initial minimum of 55 and will retain a minimum of 45 after 1 year in non-snow removal areas.[5] The mean BPN and standard deviation for the marking tape as measured were 51 and 2.2, respectively. The mean BPN and standard deviation for the steel plate were 64 and 2.2, respectively. The marking used to mark the steel plates was of a material and had a skid resistance similar to those of the black tape used by Oregon to improve skid resistance. The BPN measurements of the tape appear slightly lower than expected based on the

manufacturer's specification. The marking tape has a slightly lower BPN than did the steel plate.

Night Review of Alternative Plate Marking Patterns

Four members of the stakeholder task group and three guests reviewed two steel plate marking patterns at night on Monday, November 1, 2004. Although reviewing these plates under actual road conditions was desirable, such an opportunity did not present itself. The review was held at the yard of a utility contractor (G. L. Howard, Inc., in Rockville, Virginia). A survey form was used to record the preference of participants regarding the plates at four distances (160 and 80 feet from both ends of the plates), under low- and high-beam headlights of a passenger van and a motorcycle, and for lighted and unlighted conditions. These two vehicles were chosen as sample vehicles only. There is a wide variation in the intensity and configuration of headlights for passenger vehicles and motorcycles. The outside light of a storage building was used to simulate streetlights. One marking pattern provided an outline of the perimeter of an 8 by 12 foot plate. This size plate was chosen because it represents the average and common plate size. A second pattern marked the corners of the same size plate and added a skip line on each side (the pattern used by the City of Richmond). This plate was placed beside the outlined plate. The pavement markings were installed on the plates 3 days before the review, and the plates were stored in a garage until approximately 1 hour before the review.

Figure 1 displays the two marking patterns and the layout of the field review. For distances 1 and 2, the "corners and skip lines plate" was on the right, whereas for distances 3 and 4, the "outlined plate" was on the right. Since headlight beams are aimed to the right, there was some thought that the plate on the right might be preferred since it might be illuminated more.

The results of the night review are shown in Table 1. For the van at distance 1, there was no preference; at distance 2, the outlined plate was preferred except at lighted low-beam conditions where there was a tie. At distances 3 and 4, the corners and skip lines plate was preferred in all conditions except the lighted low-beam condition for which there was a tie for distance 3 and the outlined plate was preferred at distance 4. For the motorcycle, the corners and skip lines plate was preferred for all conditions except the lighted and unlighted low-beam condition at distance 4.

The participants commented that the broken lines of the corners and skip lines plate conveyed a message that they preferred in part because the broken lines added contrast against the steel plates. Figure 2 shows this pattern on the right under low-beam light and zoomed in from 80 foot. This marking was different from others seen. There was some concern about the skip lines being confused with the lane lines that are present when there are two or more lanes in the same direction. This possible confusion was evident at a July 21, 2004, field visit in Richmond by the stakeholder task group. For some, the outlined plate reminded them of a crosswalk marking with the continuous horizontal or transverse lines.

Following some discussion, a third alternative of marking only the corners of the plate was identified and tested as indicated in Figure 3. A rubber material was used to cover the skip lines, and the plates were viewed at distances 3 and 4 using the motorcycle. Figure 4 shows this

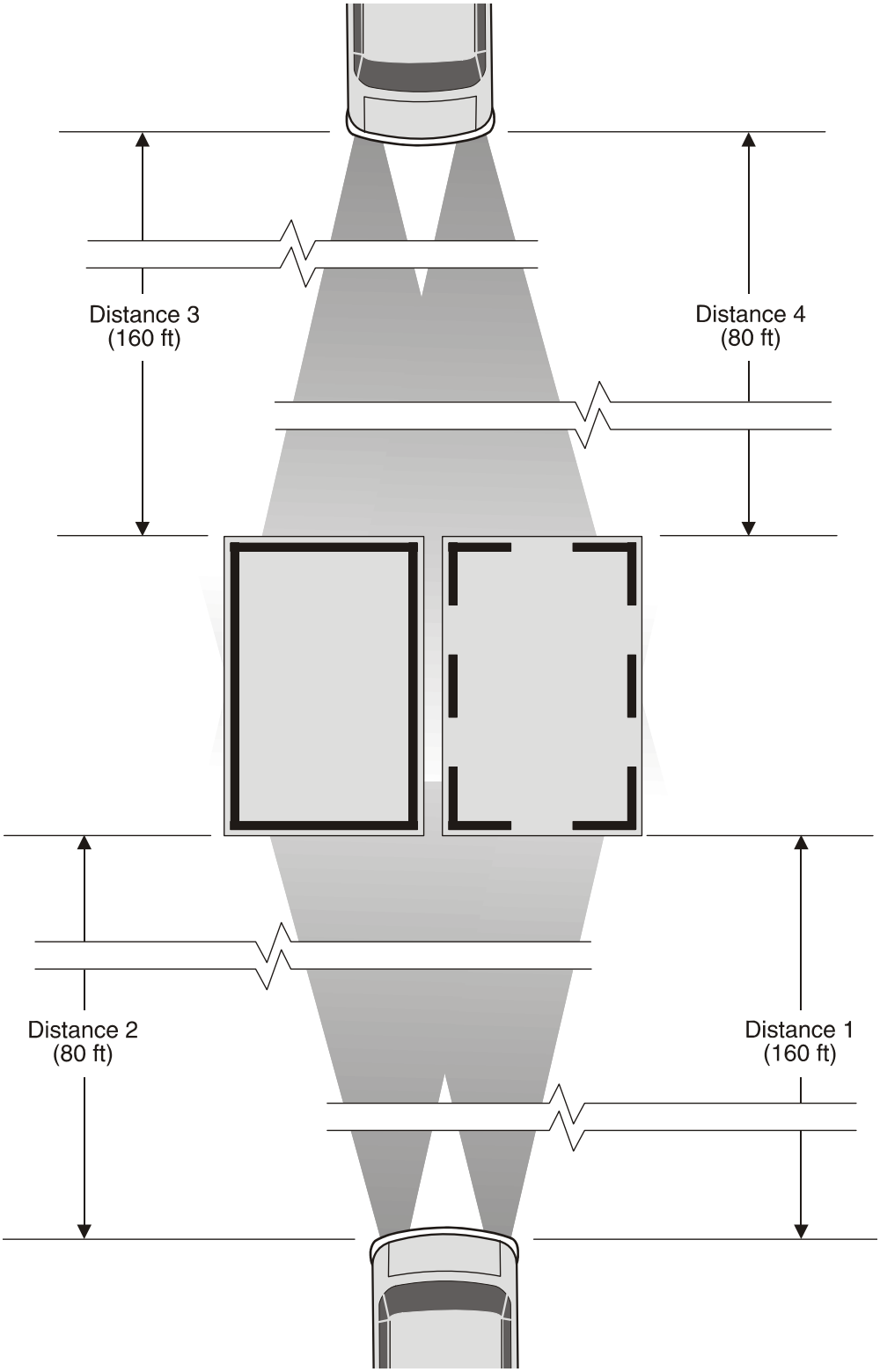


Figure 1. Night Review Layout of Plates

Table 1. Results of Planned Setup for the Night Review

Vehicle	Distance 1	Distance 2	Distance 3	Distance 4
Van	No preference	Lighted low beam: tie All others: outline	Lighted low beam: outline All others: corners and skip lines	Lighted low beam: tie All others: corners and skip lines
Motorcycle	Corners and skips	Corners and skip lines	Corners and skips	Lighted and unlighted low beam: tie All others: corners and skip lines

Figure 2. Outlined Plate and Corners and Skip Lines Plate Under Low-Beam Headlights Zoomed in from 80 Feet

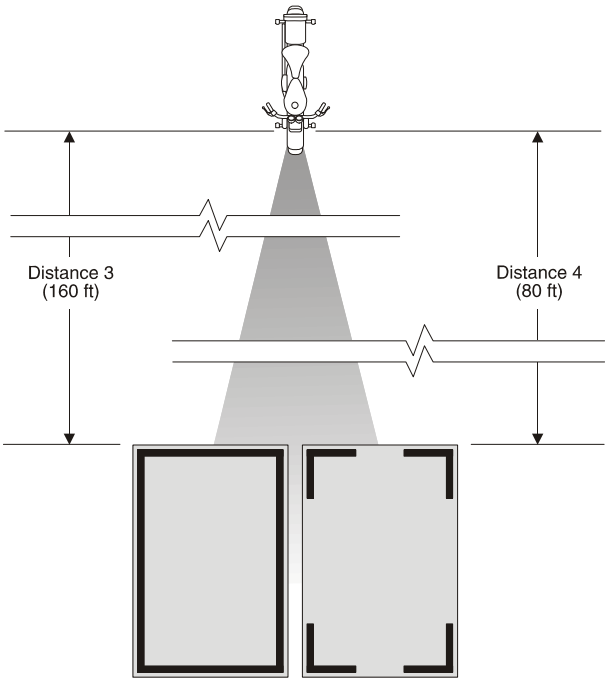


Figure 3. Night Review Layout of Plates with Corners Only

Figure 4. Outlined Plate and Corners Only Plate Under Low-Beam Headlights Zoomed in From 80 Feet

pattern on the right under low-beam light and zoomed in from 80 feet. Six of the seven participants chose the corners only marking as their preferred choice overall. The participant who preferred the outline overall stated that there was not a lot of difference. To him, the outline was preferred at longer distances. At closer distances, the corners only alternative looked better or at least different. A negative comment regarding the corners only alternative was that although it "speaks to the motorists well, less marking material will be visible as it goes bad." Although this is true, it also points out the need to maintain the pavement marking on the steel plates.

Maintenance and Cost of Pavement Markings

Work zones are areas of much activity, and work zone traffic control devices are exposed to environments that accelerate their wear and tear. Steel plates are very strong and durable. Nevertheless, they are likely handled by heavy equipment such as front-end loaders and may be pounded during their handling. Subsequently, there is a concern that any pavement markings installed on steel plates may have a short service life. Steel plates are used where soil and pavement surface and subsurface have been removed, and this material ends up on the surrounding pavement and on the plates. In the City of Richmond, the research team noted that vehicles tracked asphalt onto the tape from the asphalt concrete ramp used to smooth the transition from the pavement to the plate. Thus, the marking tape is soiled almost immediately after the plate is in place and open to traffic. Possible solutions include covering the tape on the front edge of the plate for the first few hours to allow the asphalt to set or to reposition the tape further from the front edge of the plate.

Thus, to be effective, the marking needs to be relatively clean and intact. Those responsible for maintaining the markings should monitor them and determine when maintenance or replacement is needed. Based on the observations of steel plates with markings in Richmond, periodic inspections of the plate are needed to determine and address the pavement marking maintenance needs.

The material costs of the three marking patterns are shown in Table 2. Not surprisingly, the corners only pattern has the lowest cost since it uses the least amount of marking tape. At $27, its cost is 26 percent lower than the cost with corners and skip lines and 93 percent lower than with the outline.

Table 2. Cost of Marking Patterns for an 8 by 12 Plate

Position on Plate	Linear Feet of Tape	Cost	Cost Compared to Corners Only	Cost Compared to Corners and Skip Lines
Outline	37.3	$52.15	+93%	+53%
Corners and skip lines	24.3	$34.06	+26%	
Corners only	19.3	$27.06		

CONCLUSION

- An advance warning "STEEL PLATE AHEAD" sign in combination with "corners only" pavement markings on the steel plates was the method preferred by the stakeholder task group to improve the visibility of steel plates.

RECOMMENDATIONS

VDOT's Traffic Engineering Division should consider adopting the following:

1. Warning signs should be placed in advance of all temporary steel plates used on roadways open to vehicular traffic to advise motorists that they may expect to encounter plates. The advance or warning sign should contain the message "STEEL PLATES."

2. Temporary steel plates installed on roadways open to vehicular traffic should be marked with a durable and highly reflective white pavement marking tape no less than 4 inches in width. The marking pattern used should, at a minimum, include all four corners of the plate, similar to the pattern shown in Figure 5. The marking tape dimensions should not be less than those shown in Figure 5. The 3-inch distance from the plate's edge to the tape may be varied depending on the conditions.

3. The warning sign and markings should be maintained in a condition to satisfy their intended purpose.

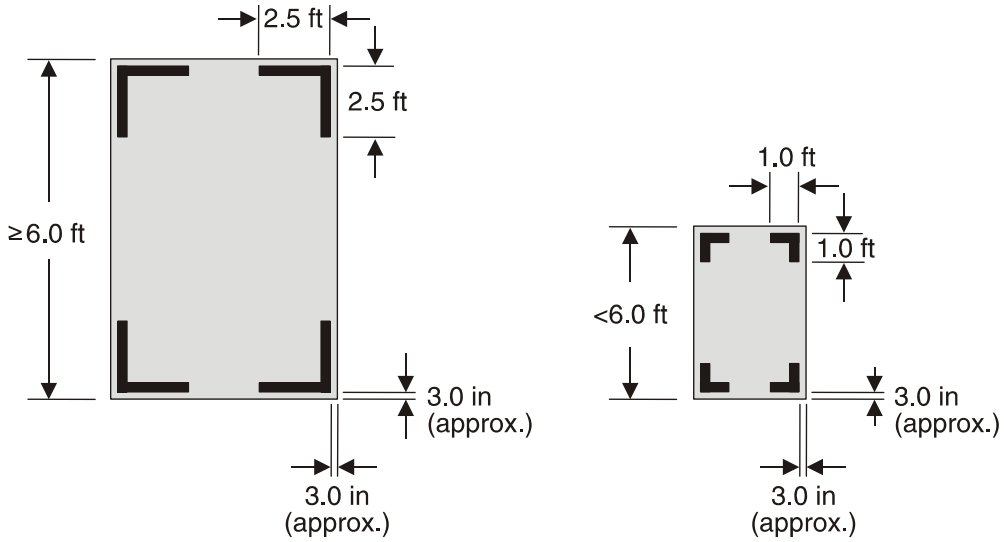


Figure 5. Recommended Steel Plate Markings. *Left:* Steel plates greater than or equal to 6 feet in length; *right:* steel plates less than 6 feet in length.

COSTS AND BENEFITS ASSESSMENT

The proposed recommendations were implemented and now appear in the *Code of Virginia*[8] and the 2005 *Virginia Work Are Protection Manual*[9] (see Appendix B).

The cost of implementing the steel plate marking pattern is about $30 per plate for the larger steel plates. An estimate of the cost of a warning sign and mounting is about $200 to $300. The estimated reduction in potential crashes involving motorcycles is unknown and, therefore, is not quantifiable. The recommended sign and plate markings will substantially improve the visibility of the steel plates. This will, in turn, improve the safety of the plates by making motorcyclists aware of their presence.

REFERENCES

1. ASTM International. Standard Test Method for Measuring the Surface Frictional Properties Using the British Pendulum Tester. Designation: E 303-93 (Reapproved 2003). West Conshohocken, Pa., 2003.

2. City of Richmond. *Policy on the Temporary Steel Plate Bridging.* Richmond, Va., 2004.

3. Federal Highway Administration. Email from Peter Rusch, August 13, 2004.

4. Federal Highway Administration. Email from Peter Rusch, August 23, 2004.

5. 3M Company. 3M High Performance Stamark Tape Series 380IES. *Market Test Product Bulletin 380EIS*. St. Paul, Minn., 2004. http://multimedia.mmm.com/mws/mediawebserver.dyn?bbbbbbL37nqbwFcbPFcbbb93bN8EkCUR. Accessed November 4, 2004.

6. Virginia Department of Transportation. *Virginia Work Area Protection Manual.* Richmond, 2000.

7. Virginia Department of Transportation. *Road and Bridge Specifications.* Richmond, 2002.

8. *Code of Virginia* § 33.1-223.2:14. Use of steel plates in connection with highway repairs. Richmond, 2005. Richmond http://leg1.state.va.us/cgi-bin/legp504.exe?000+coh+33.1-223.2:14+405595. Accessed November 2, 2006.

9. Virginia Department of Transportation. *Virginia Work Area Protection Manual: Standards and Guidelines for Temporary Traffic Control*. Richmond, 2005. http://www.virginiadot.org/business/resources/WAPM20059.pdf. Accessed November 2, 2006.

APPENDIX
HOUSE BILL NO. 408

AMENDMENT IN THE NATURE OF A SUBSTITUTE
(Proposed by the House Committee on Transportation
on February 3, 2004)
(Patron Prior to Substitute—Delegate Welch)

A BILL to amend the Code of Virginia by adding in Article 15 of Chapter 1 of Title 33.1 a section numbered 33.1-223.2:9, relating to use of steel plates in connection with highway repairs.

Be it enacted by the General Assembly of Virginia:

1. That the Code of Virginia is amended by adding in Article 15 of Chapter 1 of Title 33.1 a section numbered 33.1-223.2:9 as follows:

§ 33.1-223.2:9. Use of steel plates in connection with highway repairs.
Prior to July 15 2005, anyone using steel plates in connection with a temporary or permanent repair to the roadway of any highway shall apply a reflective substance to the plate in order to improve visibility to oncoming traffic. The provisions of this section shall not apply to any portion of a roadway that is closed to vehicular traffic.

2. That prior to July 1, 2005, the Virginia Transportation Research Council shall undertake an examination of best practices regarding the improved visibility of steel plates and report its findings to the Chairman of the House Committee on Transportation.

APPENDIX B

IMPLEMENTATION OF THE RECOMMENDATIONS

Code of Virginia

§ 33.1-223.2:14. Use of steel plates in connection with highway repairs.

Any person using steel plates in connection with a temporary or permanent repair to the roadway of any highway shall follow the standards of the Virginia Department of Transportation regarding warnings thereof and the marking of such plates. The provisions of this section shall not apply to any portion of a roadway that is closed to vehicular traffic.

(2005, c. 537.)

Reference

http://leg1.state.va.us/cgi-bin/legp504.exe?000+coh+33.1-223.2:14+405595 Accessed November 2, 2006.

2005 Virginia Work Area Protection Manual: Standards and Guidelines for Temporary Traffic Control

Section 6G.12a Steel Plate Conspicuity and Warning

Support:

Steel plates are occasionally used in areas where an excavation is made in the roadway for repairs or utility work, providing temporary protection to motorists and pedestrians and continued movement of traffic. This situation provides a challenge to motorcyclists when they traverse a steel plate unexpectedly in the roadway.

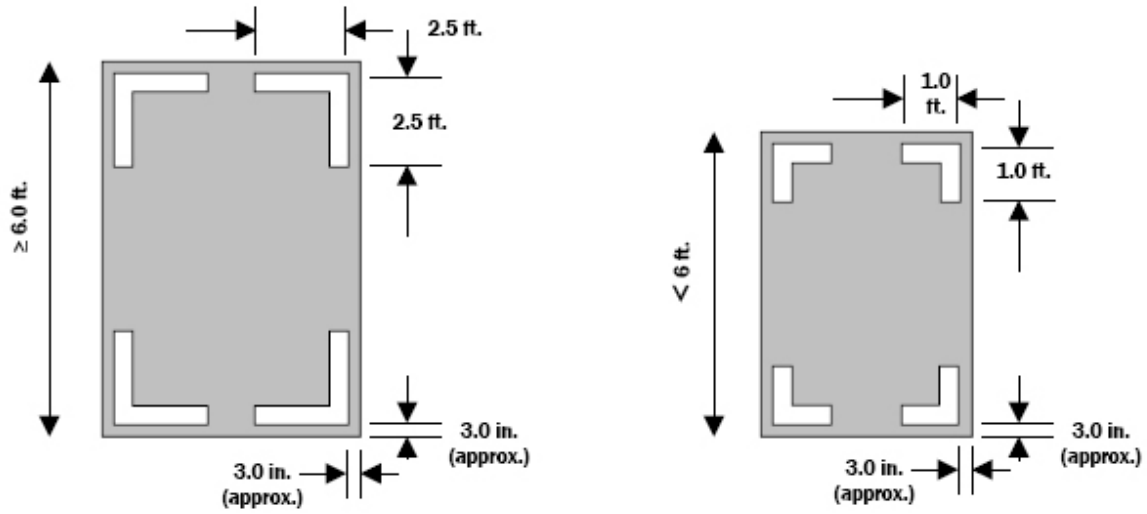
Standard:

Steel plates installed in connection with temporary repairs on roadways open to traffic shall be marked with durable, highly reflective white pavement marking tape, no less than 4 inches in width, conforming to Type B, Class VI of the department's specifications and shall be recommended for turning movements by the manufacturer. Placement of the reflective white pavement marking shall be as shown in Figure 6G-1. The markings shall be maintained throughout the use of the plate in a condition that provides sufficient retroreflectivity to distinguish the corners of the steel plate. Replacement of the markings shall be based on a visual assessment performed periodically at night by a moving inspection vehicle. Any leg of the marking that has lost fifty percent or more of its conspicuity shall be replaced. A STEEL PLATES AHEAD sign shall be placed in advance

of the temporary steel plate to warn approaching motorists of the changed roadway condition (see section 6F.47a).

Option:

Additional warning signs may be needed due to the complexity of the work location and other field conditions.



LEFT: Steel plates with any side greater than or equal to 6 feet in length

RIGHT: Steel plates with all sides less than 6 feet in length

FIGURE 6G-1, STEEL PLATE CONSPICUITY MARKINGS

Reference

Virginia Department of Transportation. *Virginia Work Area Protection Manual: Standards and Guidelines for Temporary Traffic Control.* Richmond, 2005. http://www.virginiadot.org/business/resources/WAPM20059.pdf. Accessed November 2, 2006.