AN EVALUATION OF THE CONVERGING CHEVRON PAVEMENT MARKING PATTERN INSTALLATION ON INTERSTATE 94 AT THE MITCHELL INTERCHANGE South-to-West RAMP IN MILWAUKEE COUNTY, WISCONSIN

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FOREWORD

A report on the Chevron Evaluation, funded by the American Automobile Association for Traffic Safety (AAAFTS), is available on-line at: http://www.aaafoundation.org/projects/index.cfm

The attached report is published independently of the AAAFTS-approved evaluation. It presents the authors' work and includes additional topics; **no implicit or explicit AAAFTS or Wisconsin Department of Transportation (WisDOT) approval should be assumed for presented information**. The attached report provides detailed information about the chevron installation, the data (see Appendices) and methods used in evaluating chevron effectiveness, statistical tests, and conclusions based on these tests. It is intended to provide the technical reader with the detailed information needed to form an independent opinion about the effectiveness of this first device installation in the U.S.

Furthermore, it is the intent of this report to help future evaluations i) avoid pitfalls, and ii) shed light on issues that were uncovered but were left without definitive answers in the course of the present evaluation (for example, different effect on autos and semi-trucks, possible reduction in lane-change behavior, possible differences in effectiveness by lane). Conclusions in this report should be applied judiciously at other locations, because **only one chevron installation was evaluated, the only installation present in the U.S. at this time**.

Speed reduction findings are summarized in **table 7**, page 22 (detector **B** speeds). A **discussion about crashes** (test ramp crashes) can be found on page 41. Crash statistics are presented on pages 45 and 46 and are summarized on page 48.

We had to overcome **a few important limitations**: the project was assigned to the investigators approximately 23 months after the chevrons had been installed: location, test and control ramps had already been decided; the speed analysis was necessarily limited to five-minute archived data whose accuracy could not be independently verified in the field; due to hardware problems, data from the critical detector downstream from the end of the chevrons was not available for one year after chevron installation; and, finally, this was the only installation in the U.S, precluding the design of an evaluation based on evaluating a large number of experimental installations.

An extensive effort was made to verify the validity of available information in order to overcome these limitations: a variety of cross-checks was performed on the available information; additional field data was gathered and compared with detector data; and information from a recently completed speed-related study on a nearby freeway curve was contrasted with available historical information.

The good news was that there was an overabundance of archived information, the choice of the test ramp location was, in our opinion, excellent (no nearby merges/diverges, relatively flat terrain, the study location was a curve where a speed reduction was necessary, congestion effects were minimal) and substantial support was provided by the Wisconsin Department of Transportation (WisDOT) and the Milwaukee County Sheriff's Department. Despite the

limitations stated above, when all available information was examined, there was strong evidence indicating that the chevron markings were very effective in reducing speeds at this location.

The number of crashes on the test ramp was very small, and perhaps the statistical analysis section is too extensive given this small sample size. There were two motivations behind the extensive coverage of this topic:

- To provide an analysis that paralleled a presentation[i] of chevron installation-related crash experience in Japan (the same statistical tests were performed in our report).
- To provide future chevron evaluators with ideas about the types of crashes that may be affected by a chevron installation. (Perhaps **the** most important criterion in choosing a chevron installation location is the presence of a large number of "correctable" crashes.[ii])

The present report is a revision of a report originally submitted to WisDOT in December of 2001. The report was reorganized in order to improve readability. New information was added from various sources: a recently received 1997 Japanese article on a Chevron Evaluation, authored by Mr. Kazuyuki Terada and other information received from Japan; a U.K. evaluation of a different chevron-based device; and from a recently completed Marquette University evaluation of a traffic-actuated sign intended to reduce speeds at a freeway curve on Interstate 43, near downtown Milwaukee, Wisconsin.[iii] Appendices are identical to those in the original report, with the addition of Appendix 13 that presents information received from a Japanese colleague who works for the Japanese National Institute for Land and Infrastructure Management.

The authors are solely responsible for any errors or omissions. **No part of this report reflects AAAFTS or Wisconsin Department of Transportation policies or opinions**. AAAFTS provided $18,134 toward the device evaluation–the authors dedicated a significant part of additional personal time to expand the scope of the original proposal, prepare this report and gather related literature. The report published by AAAFTS is available on-line, as mentioned above.

The help of numerous organizations and individuals, listed in the Acknowledgments, was indispensable in completing this report.

We hope that you find this report thorough and informative. Please communicate any comments directly to me.

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[i] "A review of Two Innovative Pavement Patterns That Have Been Developed to Reduce Traffic Speeds and Crashes," by Lindsay I. Griffin, III and Robert N. Reinhardt, prepared for the AAA Foundation for Traffic Safety, February 1996.

[ii] We chose to put forth the argument that crashes on snow/ice covered pavement and deer crashes would have occurred whether the chevrons were installed or not. One may agree or disagree with this choice; it is important, however, to decide which crashes are expected to be affected by chevron presence during the site selection process.

[iii] "I-43 Speed Warning Sign Evaluation," by Alex Drakopoulos, Sharad Uprety and Georgia Vergou, Final Report submitted to WisDOT, November 2003.

EXECUTIVE SUMMARY

In February 1999, the Wisconsin Department of Transportation (WisDOT) requested authorization from the Federal Highway Administration (FHWA) to install "an Experimental Converging Chevron Pavement Marking Pattern" to reduce speeds on a freeway interchange ramp.

Previous applications of the device in Japan resulted in reduced speeds, attributed to the illusion created by the chevron pattern, intended "...to convince drivers that they are traveling faster than they really are and to create the impression that the road is narrowing..." No other applications of the converging chevrons had been implemented in the United States.

Authorization to experiment with the device was granted to WisDOT and the converging chevron device was installed in May 1999. Device evaluation was sponsored by the AAA Foundation for Traffic Safety (AAAFTS). Dr. Alexander Drakopoulos of Marquette University, was assigned the evaluation in March 2001. A report on the Chevron Evaluation, funded by AAAFTS, is currently available on-line through http://www.aaafoundation.org/.

The attached report is published independently of the AAAFTS-approved evaluation–it presents the authors' work and includes a few additional topics. It provides detailed information about the chevron installation, the data (see Appendices) and methods used in evaluating chevron effectiveness, statistical tests, and conclusions based on these tests. It is intended to provide the technical reader with the detailed information needed to form an independent opinion about the effectiveness of this first device installation in the U.S. **No implicit or explicit AAAFTS or Wisconsin Department of Transportation (WisDOT) approval should be assumed for presented information**.

Motivation for Device Installation

The motivation for device installation was to reduce speed-related crashes, by inducing drivers to drive at lower speeds at the evaluated site. If the device was effective, lower vehicular speeds and a lower number of speed-related crashes would be observed in the period following device installation. The present evaluation addressed device effectiveness on speeds and crashes.

Research Methods

Device evaluation was based on a before-and-after (device installation) comparison of speed and crash statistics. If the device was effective, speeds would be lower for vehicles exiting the experimental pattern on the ramp, compared to speeds at the same location before device installation. Consequently, the number and/or severity of speed-related crashes would also be expected to be lower. Another ramp on the same interchange was used as a control site, in order to estimate the impact of traffic and environmental effects on observed speed and crash experience changes. Before and after periods of equal durations were used for the speed and the crash analyses; before and after periods included the same months of the year.

Results

Speed information was provided by pavement-embedded detectors installed on the ramp where the device was installed (test ramp) and a nearby control ramp. In the period following chevron installation, the 85th percentile speed on the test ramp was 53 mph, 17 mph lower than before the chevrons were installed. It is estimated that approximately 3 mph of this speed reduction was due to increased traffic volume. Device effectiveness accounted for the remaining 14 mph speed reduction.

There were 14 crashes on the test ramp before the chevrons were installed, and 8 crashes after.

The numbers for the control ramp were 73 and 59, respectively. Thus, approximately 36% of all test ramp crashes occurred in the after period, compared to 45% for the control ramp. Although this indicated that the test ramp outperformed the control ramp, this difference was not statistically significantly different. When crashes that occurred on-snow or ice-covered roadways and collisions with deer were excluded from consideration (as irrelevant to the presence of the chevrons), the reduction in the number of crashes on the test ramp was statistically significant at the 10% level of significance.

Study Limitations

When interpreting the findings of this evaluation, it is important to keep in mind the context within which it was conducted, as well as the limitations that were imposed from the outset. The purpose of this effort was to evaluate the first and only installation of this device in the U.S.; no other installations would be permitted before this site was evaluated. Thus, data was only available from this one site; findings extrapolation to other sites should be judicious. At the time the investigator was assigned to the evaluation, twenty-three months after the device was installed, only historical vehicular speed data were available for analysis. It should be noted that, due to mechanical failure, no data was available from the detector located 30 feet past the end of the chevrons, for the year following device installation.

Available historical information was thoroughly reviewed and cross-checked and additional field data were gathered, for cross-checking. This work was meticulously documented, in order to allow the interested reader to form an independent opinion about the validity of the analyzed information. What was impressive about the findings, is that the speed reduction associated with the device was measured 20 months after device installation, indicating a lasting device effectiveness.

Crash information was limited to two years of before and two years of after information. Given that this was the only site where the device was installed, and the short time that had elapsed since device installation, it was not possible to conduct a multi-site data collection, nor was it possible to perform a trend analysis; the evaluation was limited to a before and after comparison between the test and the control ramp.

Recommendations

The identified speed reduction, leads to a recommendation to install the chevron pattern at carefully selected locations and, in the process, validate the findings of the present evaluation. Ideally (from a device evaluation point of view), selected locations should have a substantial speed-related crash experience; comparable untreated sites with similar crash experience, geometry and traffic volumes should be located within close proximity; accurate historical speed information should be available and the facilities should be provided to continue collecting speed data after device installation.

Very few crashes occurred on the test ramp, especially during the after period. It would be desirable to continue monitoring the safety performance of the study ramps for a few more years, in order to accumulate adequate crash statistics.

A number of additional recommendations for future chevron evaluations, based on information gathered from Wisconsin, Japan and the U.K. are included in the body of the report.

ABSTRACT

Special converging chevron pavement markings, intended to induce drivers to reduce their speed, were used in Japan in the early nineties. Before-after crash comparisons from six sites in Japan, with one-year before and after periods, were reported by Griffin and Reinhardt in a 1997 AAA Foundation for Traffic Safety (AAAFTS) report. The periods following converging chevron installations had lower numbers of crashes, however crash reductions were statistically significant at only three of the installations.

Based on the Japanese experience, the Wisconsin Department of Transportation petitioned the Federal Highway Administration for authorization to install converging chevron pavement markings on an urban high-speed urban freeway interchange directional ramp, where it was desirable to reduce vehicular speeds that had been identified as a contributing factor to a number of crashes. Permission to install the device was granted, and the device was installed on May 15, 1999.

AAAFTS sponsored an evaluation of the converging chevron pattern, undertaken by Alex Drakopoulos,[a] and Georgia Vergou[b] with data provided by the Wisconsin Department of Transportation. The AAA report on this evaluation is available on-line at http://www.aaafoundation.org/projects/index.cfm.

The present report furnishes detailed information about the chevron installation, the data and methods used in evaluating chevron effectiveness, statistical tests, and conclusions based on these tests. It includes extensions of the topics addressed in the work funded by AAAFTS and represents the authors' work; **no implicit or explicit AAAFTS approval should be assumed for information presented herein**. The report is intended to provide the technical reader with the detailed information needed to form an independent opinion about the effectiveness of this first device installation in the U.S. Furthermore, it is the intent of this report to help future evaluations avoid pitfalls and shed light on issues that were uncovered but were left without definitive answers in the course of the present evaluation.

Based on the analysis of four-month before and after periods, it was determined that the converging chevron installation contributed to an 85th percentile speed reduction of approximately 14 mph. The crash analysis based on two-year before and after periods, identified a crash reduction during the after period. This reduction **was not** statistically significant when all crashes were considered; when crashes on snow- or ice-covered pavement and collisions with deer were excluded from consideration as irrelevant to the evaluated device, the reduction **was** statistically significant at the 90% level of significance. Because these findings were based on a small number of crashes on the test ramp, it was recommended to continue monitoring the safety performance of the chevron installation for a few more years.

Both the speed and crash analyses contrasted data with data from a control site on the same interchange during the before and the after periods.

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