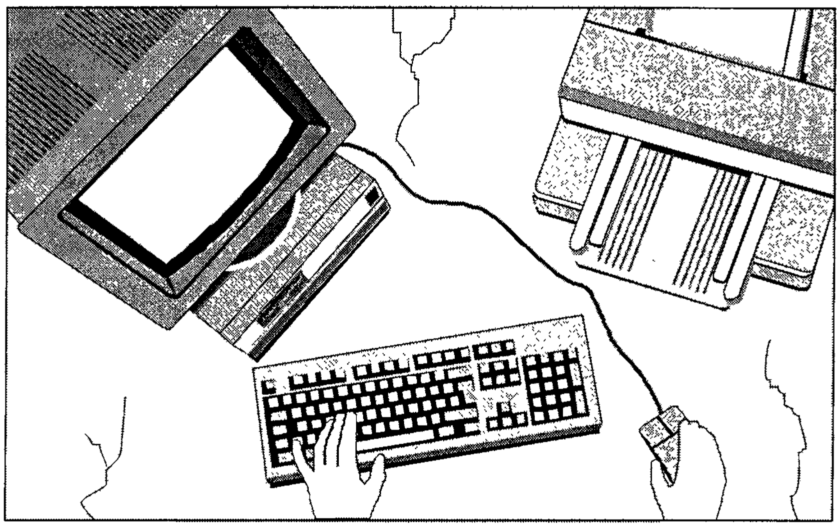
SUMMARY REPORT

A CASE STUDY EVALUATION OF THE USE OF VIDEO TECHNOLOGY IN CONCRETE PAVEMENT EVALUATION



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16. Abstract

This report presents the results of an evaluation of video technology as a possible solution to the problem of safely collecting objective condition data for prioritizing concrete pavement rehabilitation needs in Virginia. The study involved the evaluation of one commercially available video image distress survey system with regard to its capacity to generate objective information about concrete pavement condition. Ratings of the functional and structural condition of 1223 centerline kilometers (758 miles) of concrete-surfaced interstate and primary roadways were derived from visual examinations of the videotapes. Results of the evaluation were used as the basis for determining if sufficiently accurate condition ratings as compared to ratings resulting from direct visual examination in the field (i.e., "control" ratings) were attainable from the video survey method to support a pavement management system for concrete roadways in Virginia.

Results of the distress survey derived from tape-recorded images compared poorly with those results observed directly in the field. The researcher concluded that the inconsistent quality of video images and the human error introduced during the video analysis phase were the primary causes of the discrepancies between the two rating methods. Although the researcher's assessment of this video survey system was not favorable, the study provided useful guidance on needed refinements to improve the viability of the system.

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ABSTRACT

This report presents the results of an evaluation of video technology as a possible solution to the problem of safely collecting objective condition data for prioritizing concrete pavement rehabilitation needs in Virginia. The study involved the evaluation of one commercially available video image distress survey system with regard to its capacity to generate objective information about concrete pavement condition. Ratings of the functional and structural conditions of 1223 centerline kilometers (758 miles) of concrete-surfaced interstate and primary roadways were derived from visual examinations of the videotapes. Results of the evaluation were used as the basis for determining if sufficiently accurate condition ratings as compared to ratings resulting from direct visual examination in the field (i.e., "control" ratings) were attainable from the video survey method to support a pavement management system for concrete roadways in Virginia.

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INTRODUCTION

Increasing demands to identify and implement an objective, rational means of prioritizing the rehabilitation needs of concrete-surfaced roadways in Virginia provided the impetus for an evaluation of video technology as a possible solution to this aspect of pavement management. In Virginia, concrete pavements support some of the highest traffic volumes and heaviest loads on the interstate and primary roadway systems. At the time of the inception of this study, no formal procedure was in place for documenting the pavement condition for concrete roads maintained by the Virginia Department of Transportation (VDOT).

Historically, the rehabilitation priorities of Virginia's flexible pavements have been based on the results of visual condition surveys performed annually on 100 percent of the interstate and primary networks to provide an indication of functional and structural condition. These data are the primary condition input used as the basis for funding allocation decisions and maintenance project planning for the state's asphalt pavement management system, some form of which has been in existence since the 1970s. VDOT's asphalt pavement condition surveys are conducted by teams of evaluators who assign condition indices to uniform pavement sections based on the extent and severity of visibly discernible distress documented during a careful visual examination of the pavement surface from a slow-moving vehicle. Concerns about the safety of the evaluators as well as the objectivity of the distress data became the catalyst for a close examination of the way VDOT should document and assess the conditions and ultimately prioritize the rehabilitation needs of Virginia's concrete pavements.

Mechanisms contributing to visible distress in concrete pavements tend to be relatively complex and can occur with a great deal of variability within a given section. This characteristic demands that sufficient detail be afforded the concrete pavement survey process so that the rating of a section's physical condition yields a true indication of the pavement's capacity to perform. For example, transverse cracking in a continuously reinforced concrete pavement may develop soon after placement of the mixture as a result of normally anticipated concrete shrinkage stresses. In a properly designed and constructed pavement, such cracks do not detract from the structure's ability to provide a long-lasting, smooth riding surface. On the other hand, transverse cracks are often induced by vehicle loads, which, if untreated, can significantly reduce pavement performance. It is imperative that the survey process be definitive enough to make the distinction between distresses that significantly affect the remaining service life of a pavement from those that do not. The need for sufficiently detailed information about the health of Virginia's concrete pavements, in conjunction with the difficulty of surveying these facilities under increasingly hazardous traffic conditions, prompted the search for a safe, objective means of collecting and analyzing distress data. This report summarizes the researcher's effort to evaluate one commercially available videography-based data collection and condition rating system with regard to its capacity to support pavement management decisions regarding VDOT's concrete-surfaced roadways.

PURPOSE AND SCOPE

The purpose of this study was to evaluate the feasibility of using a commercially available video image distress survey system as the basis for prioritizing pavement rehabilitation needs by providing ratings of the functional and structural condition of concrete-surfaced interstate and primary roadways. The results of the evaluation were used as the basis for determining if sufficiently accurate condition ratings as compared to ratings derived from direct visual examination in the field (i.e., manually) were attainable from such a video survey to support a pavement management system for concrete roadways in Virginia.

METHODOLOGY

In keeping with the trend toward privatization of services prevailing in Virginia, and in anticipation of the future use of consultants to manage VDOT's pavement assets, the decision was made to secure a private entity to perform the video condition survey reported herein. By using this approach, an evaluation of the state of the practice of such commercially available services, and, more specifically, the ability of such a system to duplicate the results of a similar survey produced manually, was possible. The scope of the contracted work involved capturing on film continuous, full-lane-width (outside lane only) images of specified pavement surfaces and the subsequent visual analysis of the videographs by classifying type, extent, and severity of distress in accordance with a widely used pavement condition rating procedure.[1] A sample of pavement sections included in the video survey was manually surveyed by direct visual examination in the field to establish the true condition of these control sections, which enabled a comparison of the video survey results with those of the manual survey.

Video Survey

At the time this study was initiated in 1992, concrete-surfaced pavements comprised 1222.56 centerline kilometers (757.99 centerline miles) across the state. The portion of this total belonging to the interstate system, 788.56 km (488.91 mi), was divided into 351 project sections in VDOT's pavement inventory. Likewise, the 434.00 km (269.08 mi) comprising concrete-surfaced primary roadways was divided into 207 sections. The bounds of the sections, which ranged in length from approximately 0.30 km to 13 km (0.10 mi to 8.0 mi), were defined by a number of elements, including route number, lane direction, construction history, county line, intersections, bridges, and pavement type (jointed or continuously reinforced). The project sections ranged in age from approximately 40 years to less than 4 years. Pavement conditions were quite variable, ranging from very visibly distressed with moderate to severe levels of longitudinal and transverse cracking, patching, and punchouts to new, nearly distress-free pavements.

The consultant selected to perform the video survey and image analysis (i.e., condition rating) used a van-mounted three-camera system. One of the cameras was positioned just above the dashboard to film a perspective view of the roadway. The other two cameras were mounted 1.83 m (6.0 ft) above the pavement at the rear of the vehicle and were aimed downward to capture continuous, full-lane-width images of the surface at close range. All images were recorded on 12.5 mm (0.5 in) VHS videotape. Resolution of the images recalled to a monitor was required to be a minimum of 400 lines per inch. For ease of viewing and to ensure that videotapes from all cameras were properly synchronized, the consultant stitched the three films of a given roadway section into one tape. The resulting single tape appeared on the viewing monitor as three images on one screen, with the upper half of the screen displaying the image recorded by the perspective view camera and the lower half displaying images recorded at the same location by the left and right pavement view cameras. Each video frame of the stitched tape was digitally encoded with survey date, frame number, project section code, and distance from the beginning of the project section.

Filming of all concrete-surfaced pavements commenced in April 1992 and was completed in approximately 2 months. The consultant performed processing and analysis of pavement images during June and July 1992. Specific distresses evaluated included longitudinal and transverse cracking; corner cracking; joint spalling; patching; pumping; and, for continuously reinforced concrete pavements, punchouts. The consultant's rotating team of four individuals analyzed the images at an interactive computer/VCR workstation by visually examining and recording specified distresses on each video frame for all surveyed sections. Classification of distress types and determination of severity (low, medium, and high) and extent (length or area inflicted, or number of occurrences) were performed in accordance with procedures set forth in Version 3.0 of the MicroPAVER pavement management system.[1] Results of all documented distress data by type, severity, and extent were summarized and reported in 0.30-km (0.10-mi) increments for each project section. The consultant submitted a final report in July 1992.

Control Survey

Evaluating the accuracy of the video distress survey required the establishment of the true, or baseline, conditions of sample (control) sections against which the video results of the same sections could be compared. Of the 558 project sections specified in the video survey, 30 sections, totaling 70.29 km (43.58 mi), were randomly selected to be control samples and were surveyed manually by direct visual examination in the field. This was accomplished by the research team within 4 weeks after the video survey was conducted; the team drove slowly along the shoulder and manually recorded distresses visible in the outside lane. As with the video survey, distress type, severity, and extent were classified and documented in accordance with the MicroPAVER rating procedure.[1] These results were summarized and reported in 0.30-km

(0.10-mi) increments for each of the 30 control sections to enable a direct comparison of distresses visually documented in the field with those documented by analysis of the videographs.

RESULTS

Several discrepancies were immediately observed upon comparison of the video and control surveys. Most disturbing, perhaps, was that for 21 of the 30 project control sections, the consultant grossly overreported the presence of distress in terms of occurrence, severity, and extent. A careful review of the consultant's reports within these inordinate project sections revealed the prevalence of this trend throughout the level of the 0.30-km (0.10-mi) subsection distress summaries; the tendency to overreport distress was distributed somewhat uniformly throughout the project length. The rather questionable video results suggested that the pavements were in far worse condition than they actually were. The manual field survey did not reveal the occurrence of distress reported by the consultant. In this case, the video survey primarily overstated the occurrence of medium- and high-severity longitudinal and transverse cracking and, to a lesser extent, patching for both jointed and continuously reinforced pavements.

Another surprising observation was that for 6 of the project control sections, the video distress summaries consistently and grossly underreported and in some cases failed to report the presence of obviously visible distress. This trend was also generally observed throughout the subsection summaries. In other words, the consultant's video survey implied these pavements were in far better condition than they actually were throughout the length of the entire section. The inconsistencies between the manual survey results and the consultant's results were observed on both jointed and continuously reinforced pavements across all distress types and severity levels. A search for factors or variables that could have contributed to such sweeping discrepancies was inconclusive. Video and manual survey results were similar for only 3 of the 30 project control sections.

The review of the control section videotapes revealed a broad variation in the quality and consistency of the images. Some images of the more deteriorated project sections were of poor resolution, with distresses not easily discernible. Other videotapes, however, showed images that were comparatively crisp, with moderate to severe distresses being relatively noticeable. It is worth noting that low-severity transverse and longitudinal cracking, corner cracking, and spalling were not consistently discernible on the majority of tapes. Approximately two thirds of the control section videotapes manifested images of sufficiently high quality for the researcher at least to identify distress types consistent with those documented in the manual surveys.

DISCUSSION AND CONCLUSIONS

The inconsistent quality of the video images and the limitations imposed by their overall clarity likely contributed to the unfavorable comparison between the manual and image analysis methods. However, image quality alone was not sufficient to explain the magnitude of the discrepancies observed. Significant human error was probably introduced during the image-processing phase, and although minimum qualifications for the image processors were clearly delineated at the outset of the project, this error was conceivably compounded by the employment of four individuals to perform the task. Based on these results, the data collection and image analysis system evaluated did not yield sufficiently accurate condition ratings to support pavement management decisions for VDOT. Although the researcher's assessment of this video survey system was not favorable, the study provided useful guidance on needed refinements to improve the viability of the system.

Soon after the inception of this study in the early 1990s, momentum for the effort to use automated data collection technology to support a stand-alone concrete pavement management system waned for two reasons. First, passage of the Intermodal Surface Transportation Efficiency Act required all state highway agencies to have one integrated system for managing flexible as well as rigid pavements. The demand for integration altered the direction of VDOT's search toward a single data collection and analysis method that would permit equitable comparisons of condition, and ultimately prioritization of needs, across both concrete and asphalt pavement rehabilitation projects. Second, the remarkable rate at which advances were being made in video imaging technology compelled the researcher to take the time to assess those improvements that could best serve VDOT's needs while solving some of the shortcomings noted in this study. For example, in 1992, after filming had been completed, the consultant developed and installed a synchronized strobe lighting system on the data collection vehicle, which probably would have drastically increased the consistency of image quality. Likewise, while significant strides were being made in the quality of cameras, image storage medium, resolution of monitors, etc., techniques for fully automated image analysis using machine vision were being developed.

Perhaps the most significant lesson learned from this study bears on the importance of quality control in data collection and analysis. VDOT recently placed great emphasis on this topic as part of its commitment to improve its overall program of pavement performance monitoring and single- and multi-year work planning. The reader is referred to *A Structured Approach to Managing the Quality of Pavement Distress Data: Virginia DOT Experience* for a synopsis of VDOT's current activities in this area.[2]

REFERENCES

1. Department of the Army, Construction Engineering Research Laboratory, Corps of Engineers. 1991. *MicroPAVER Software Program, Version 3.0.* Champlaign, Ill.

2. Larson, C.D., Sami, N., and Luhr, D.R. 2000. *A Structured Approach to Managing the Quality of Pavement Distress Data: Virginia DOT Experience.* Paper presented at the 2000 Annual Meeting of the Transportation Research Board, Washington, D.C.