

IMPROVING DATA QUALITY FOR PAVEMENT MANAGEMENT SYSTEM

By

Sui G. Tan, P.E.

Pavement Management Program Manager
Metropolitan Transportation Commission
Oakland, CA 94607

and

DingXin Cheng, Ph.D., P.E.*

Director and Professor
California Pavement Preservation Center
Department of Civil Engineering
California State University, Chico
Chico, CA 95929

* - Corresponding author

Paper Submitted to the 9th International Conference on Managing Pavement Assets

Words: 3291 Tables: 1 Figures: 1 Total: 3791 Date: August 27, 2014
--

ABSTRACT

The Metropolitan Transportation Commission (MTC) has developed a pavement management StreetSaver program with more than 400 users in the United States. MTC uses the program to evaluate street and road condition and perform maintenance needs assessments for the 109 cities and counties in the San Francisco Bay Area. Quality pavement condition survey data is a critical component of a pavement management system. MTC has augmented a new quality acceptance (QA) program as part of its Quality Data Management Plan in 2013. The QA program is geared toward making sure consultants hired by MTC for data collection can provide quality data in a consistent manner. The objectives of the QA program are to provide consistent pavement distress identification, improve data quality, avoid untrained pavement condition raters, while providing industry standards and accountability.

The QA program contains a Rater Certification Program that ensures good quality data by using certified and trained technicians for the PMS; hiring a third party and neutral institution to audit the contractors' quality control plan; and verifying the data collected by consultants and checking data collected against pavement deterioration models and curves used in the PMS database. The process provides feedback to the consultants' quality control plans and significantly improved the quality of the PMS data collected. The MTC's data quality assurance experience is expected to benefit other agencies that are using any pavement management systems.

Keywords: Pavement Condition Survey, Quality Data Acceptance, Pavement Management System

1.0 INTRODUCTION

Quality of pavement condition data is critical to the effectiveness of a pavement management system (PMS). Sometimes, inaccurate or variably assessed pavement data could result in an increase in pavement condition index (PCI) from the survey data without any reason. This can make the pavement management system yield results that are unreliable. Normally, if there is an error in the pavement condition data, it will affect the current condition, rate of deterioration, projection of future condition, maintenance and rehabilitation needs, and the cost to repair pavement segments. It can also affect the maintenance and rehabilitation treatment selection strategies and the budgeting and needs estimation at the network level.

There are many possible errors in pavement condition surveys. As summarized in NCHRP Synthesis 401, sources of variability for pavement condition data collection can generally be related to the equipment used, equipment operation (including rater/operator training and skills), processing of the data collected, environmental conditions, and the shape and condition of the pavement surface. All of these potential sources have to be considered and, if possible, rectified because they directly affect the quality of the data collected (1).

Although many manual distress ratings for agencies are done according to well-defined criteria, a certain amount of subjectivity and the experience of the raters can influence the ratings. Researchers at New Mexico State University proposed an approach to estimate the inter-rater reliability for manual or semi-automated distress data collection. The process acknowledges that a certain degree of variability in the visual distress ratings is likely to occur and, thus, minimum acceptable values of complete and partial agreements of the crews or raters are suggested. The statistical approach to validate the level of agreement between the ratings of two raters was based on the use of the chi-square distribution to test the hypotheses about multinomial experiments (2).

Texas A&M University also studied the impact of error's magnitude and type in pavement condition data on the accuracy of PMS outputs. For example, their case study showed that, with 95% confidence, a ± 10 standard error in a 0-100 condition index can result in a 2-6 % error in estimated portions of the network needing maintenance, rehabilitation, or "do nothing." (3).

The Metropolitan Transportation Commission (MTC) is the developer of the StreetSaver[®] pavement management software with more than 400 users in the United States. Most users are local agencies consisting of cities and counties. In addition to making StreetSaver[®] available to local agencies, MTC uses the software to perform the 43,000 lane miles of street and road condition and maintenance needs assessments for the 109 cities and counties in the San Francisco Bay Area region. To enhance its existing data quality management plan and increase its effective use of pavement management program, MTC implemented a new quality acceptance (QA) program in 2013. This program is expected to significantly improve the quality of the pavement condition data used in the PMS that feeds into the long term regional transportation plan (4).

2.0 OBJECTIVE

The objective of this paper is to present the QA program that MTC developed to effectively manage the pavement condition survey data collected for its PMS program. The aims of the new PMS quality acceptance program are to (1) provide consistent pavement distress identification,

(2) avoid the “Garbage In - Garbage Out” type of data collection, (3) improve data quality, and (4) provide industry standards and accountability.

3.0 MTC PMS DATA QA APPROACH

The QA program includes: (1) developing a Rater Certification Program that ensures good quality data by using certified and trained technicians for the PMS; (2) hiring a third party and neutral institution to audit contractors’ quality control plan; and (3) verifying the data collected by contractors and checking data collected against pavement deterioration models and curves in the PMS database. The methods used in the MTC’s QA program should potentially benefit other agencies, especially local agencies that are using pavement management systems. The CP2C was selected as the group to provide this service to MTC.

3.1 Developing the QA Program

To facilitate ongoing condition and maintenance needs assessments, MTC administers the Pavement Management Technical Assistance Program (P-TAP), a federal-aid funded program designed to provide local jurisdictions with assistance and expertise in maintaining their pavement management program. To ensure quality data from the P-TAP consultants for analysis, MTC has developed procedures and guidelines for managing the quality of pavement data collection activities. MTC’s Data Quality Management Plan includes three components: 1) consultant prequalification, 2) quality control plan--before, during and after production-- and 3) quality acceptance (5). The prequalification process is part of the consultant selection and is an integral part of the data quality plan. The Rater Certification Program ensures that raters are capable of providing the desired level of accuracy on pavement condition ratings, while quality acceptance is to verify the effectiveness of the quality control process by the consultants.

Under the P-TAP, even if a firm has pre-qualified, all of the firm’s raters must be certified by MTC through the Rater Certification Program administered by CP2C.

3.2 Hiring a Third Party and Neutral Institution to Audit

MTC staff communicates with the data collection contractors about issues found such as the sections for which the calculated PCI values do not match the projected PCI values to determine how to approach further steps. If the data collection contractor does not meet the requirements of the data collection quality control plan or if MTC determines that the collected data does not meet the requirements established in the prequalification requirements, MTC can issue a stop work order and require corrective actions. This may include requiring the data collection contractor to re-qualify all of the survey teams being used to collect data under the P-TAP contract, and re-surveying all sections rated since the last checks that showed the contractor was meeting contract requirements. Other onerous corrective actions may be imposed by MTC on the data collection contractor. For example, multiple violations could result in termination of the data collection contract. As stated earlier, MTC has hired the California Pavement Preservation Center (CP2C) of California State University at Chico to administer the Quality Acceptance Plan. The tasks of CP2C include the following:

Task 1: Administer Rater Certification Program. Because contractor qualification for the P-TAP does not ensure that all raters are capable of rating with the desired level of accuracy, all raters employed by the qualified contractors will need to complete rating of the same survey sites used

in the P-TAP qualification tests, or new sites as directed by MTC. The Rater Certification Program consists of a field pavement distress survey test and an online written test. CP2C facilitates pavement distress surveys and online written tests for raters up to twice a year. When needed, CP2C establishes ground truths for pavement distress survey testing. Raters from non-qualified consulting firms and local agencies are also eligible and can be certified. CP2C's services include administering registration, field and online tests, issuance and renewal of certification, and database tracking.

Task 2: Conduct Audits of Contractor's Quality Control Plan. CP2C verifies that the quality control plans (QCP) adopted by the data collection contractors are being completed prior to project sponsor acceptance of survey results. This consists of conducting on-project site audits and audits of the QCP results to ensure that the data collection contractors are meeting the requirements established in their plans. The requirements of the QCP are:

1. Re-survey of "control" sections by survey teams at least once every two weeks.
2. Re-survey of at least five percent of the sections previously rated within one month of completing surveys. The same survey team may do the re-surveys.
3. Re-survey of at least five percent of the rated sections by a supervisor.
4. Checks of collected data against prior survey data and checks of calculated PCI values against PCI values based on prior survey data projected to the survey date for the same section if no treatments have been applied since the prior survey. All of those outside plus or minus 15 PCI point differences should be checked by a supervisor or other person approved by MTC.

CP2C is required to spot check and/or conduct full audits of the QCP from selected projects as directed by MTC. CP2C will begin spot check in early fall 2014.

Task 3: Verify Data Collected by Contractors. CP2C conducts data verification actions including at least some of the following:

1. Checks of collected data against prior survey data and checks of calculated PCI values against PCI values based on prior survey data projected to the survey date for the same section if no treatments have been applied since the prior survey.
2. Survey of sections previously rated by the data collection contractor.

3.3 Rater Certification Program

The Rater Certification Program consists of passing a pavement distress manual field survey exam as well as an online written exam. These exams are designed to evaluate the skills and knowledge of raters on pavement condition rating. At a minimum, raters interested in taking the exam must be familiar with the MTC pavement distress rating procedures for both asphalt pavement and portland cement concrete pavement. These are described in the Seven-Distress protocol based on a modified ASTM D6433 - Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys (6). The distress definitions and descriptions are included in the MTC-published Pavement Condition Index Distress Identification Manual for Asphalt and Surface Treatment Pavements, 3rd Edition (Revised), April 2012 and the Pavement Condition Index Distress Identification Manual for Jointed Portland Cement Concrete Pavements, 2nd Edition, dated October 2002(7, 8).

Manual Field Examination

A rater must rate up to 24 test sites and achieve the required level of accuracy performing ratings as defined by acceptance criteria. Raters from non-P-TAP consulting firms and local agencies can be certified. The rater certification exam is conducted once a year. Upon successful completion of the exams, a certificate is issued that is valid for two years. Renewal is good for another two more years upon successful completion of a refresher course. Every four years, all certified raters must take the field and online exams to be recertified.

Online Knowledge Examination

Successful applicants who passed the field exam also take an online knowledge exam. This exam is designed to evaluate raters' understanding of general inspection procedures and guidelines, as well as identification of pavement surface distresses and their severity.

A minimum score of 80% is required to pass. Only one retesting is allowed. Online exam must be completed within a month after receipt of notification of passing the field exam.

MTC also provides online training classes for raters to help them prepare for the online certification exam.

4.0 IMPLEMENTATION STATUS

MTC started implementing its PMS data quality assurance plan in early 2013. The following are the major accomplishment of the implementation.

4.1 Review P-TAP Contractors' Quality Control Plan

In this task, CP2C helped verify that the quality control plans (QCP) adopted by the data collection contractors. CP2C conducted audits of the QCP results to ensure that the data collection contractors met the requirements established in their plans.

Under the direction of the MTC contract manager, CP2C audited 2013 pavement condition survey QCP and generated reports for the following agencies:

1. Suisan City
2. City of Menlo Park
3. San Mateo County
4. Foster City
5. City of Milpitas
6. City of Woodside

As an example for Suisan City,

Table 1 shows that the survey review results meet the MTC Quality Control Plan (QCP) requirement. 96 percent of sections have PCI differences less than 5 and 100 percent of sections have PCI differences less than 10 from quality control review results.

Table 1. Pavement Condition Data Survey Checking and Review Results

Survey Review		
PCI Difference	# of Sections	Percentage
≤5	24	96%
≤10	25	100%
>10	0	0%
>15	0	0%

The survey results were also checked against historical pavement performance data such as PCI. The PCI family curve (orange line) in Figure 1 represents a typical performance for a family of pavement based on functional class and surface type. The adjusted curve (green line) in Figure 1 shows that the predicted PCI value for this section of Madonna Drive is 70 (blue square dot). The green line was an adjusted curve from the orange line based on past pavement condition survey and maintenance and rehabilitation history. The inspected value for this PCI was 27. The difference between predicted and evaluated PCI is large, approximately 43 PCI. The previous inspection value set the adjusted curve much higher than past inspections points. If the last inspection point was disregarded the difference in PCI would most likely be within ±10 PCI.

The CP2C also conducted a field survey to verify the consultants' field survey results. This is to ensure that the pavement condition results were truly reflecting the field conditions. If the CP2C's survey result were significantly different from a consultant's survey result, CP2C would complete a detailed survey with proper photos to present a ground truth situation. This quality assurance procedure provides a strong support to ensure the accuracy of pavement condition data.

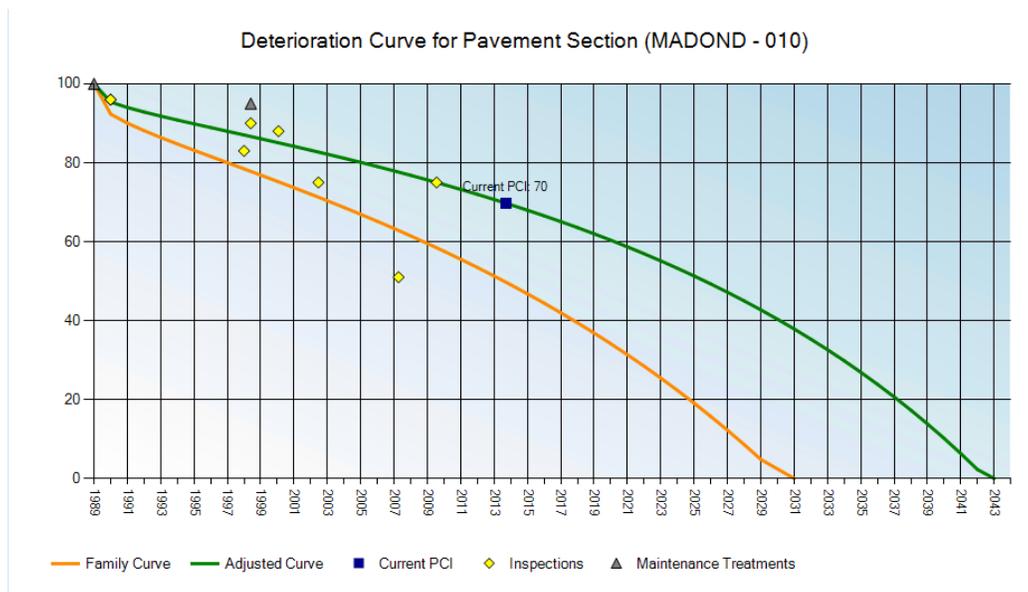


Figure 1. Suisan City PMS Performance Curves for Madonna Dr. - 010

4.2 Implemented Rater Certification Program

The MTC launched the Rater Certification Program, a brand new program designed to improve the quality of pavement management data collected in July 2013. MTC provided both field exam and online knowledge exam to certify the pavement condition raters. The following are the results of this effort.

4.2.1 Field Testing

The first field rater exam was conducted on July 24 and 25, 2013 and the findings are discussed below.

Field Testing Sites. The field testing sites are on residential streets in a small geographic area of the city near the office building where MTC is located. For asphalt pavement, specific segments were selected so that as many of the standard MTC seven asphalt surfaced distress types at the three severity levels (low, medium, and high) as possible are included in at least one of the segments. The segments were carefully rated using a walking survey conducted by an experienced rater. Extensive photographs and distress maps were completed on all segments included in the field test sites. The survey data from these sites were used to calculate the reference or "ground truth" PCI values of the segments. These segments must be full width of the paved surface by 100 feet long for the manual survey segments. The beginning and ending of each segment were marked on the street. Similar concept was used to develop the PCC test sites. In all, 20 flexible pavement sections and four rigid sections were selected to include in the rater field testing process.

Passing Criteria. To pass the field survey of the Rater Certification exam, raters must meet the following two criteria on distress data:

1. At least 50 percent of the PCI values for the rated sections must be within +/- 8 PCI points of the reference, or "ground truth," PCI values.

2. No more than in 12 percent of the PCI values for the rated sections can be greater than +/- 18 PCI points of the reference, or "ground truth," PCI values.

Out of the 28 raters signed up, 26 took the exam. There were 22 raters from consultants and four raters from local agencies. Twenty of the 26 passed the field exam. Raters that failed the exam will need to be supervised by a certified rater when conducting pavement survey.

4.2.2 Online Knowledge Exam

The MTC Rater Certification Program consists of passing a pavement distress manual survey exam and an online knowledge exam. After successfully passing the manual survey exam, raters were given one month to complete an online knowledge exam. They have to achieve a minimum score of 80% to pass. Only one retest is allowed.

An exam question bank was developed to including more than 200 questions, and more questions can be added to the question bank in the future. Each time, 30 random questions were generated from the question bank. The online knowledge exam was used to ensure that raters had broad knowledge on inspection procedure, asphalt pavement distress identification, concrete pavement distress identification, and pavement condition index calculations.

Certifications were awarded to raters who passed both field manual survey exam and online knowledge exam in 2013. Their certification information was stored in a database for references. The 2014 exam is scheduled on November 19 and 20.

5.0 CONCLUSIONS AND RECOMMENDATIONS

To ensure quality data for regional condition and maintenance needs assessments, MTC developed procedures and guidelines for managing the quality of pavement data collection activities by establishing the Data Quality Management Plan. Part of the plan consists of a quality acceptance program that reviews contractor's QCP, audits contractors' field survey results, and provides rater's certification through field and online exams. The Data Quality Management Plan is a work in progress. The following are the major conclusions from this study.

1. Condition data drives many of the recommendations from StreetSaver software. If the distress data is not properly identified and quantified, the PCI values will be incorrect, and the recommendations will be incorrect.
2. A Data Quality Management Plan provides a documented framework for dealing with consultant selection, quality control and quality acceptance.
3. A Quality Control Plan must be established prior to data collection for in-house and contractor. At the minimum, the QCP must include control sites, acceptance criteria, and corrective actions.
4. A formal Rater Certification Program provides industry and agency-wide standards.
5. Some StreetSaver users at the local agency level, within or outside the San Francisco Bay Area region, are requiring that consultants' raters be certified or the firm is prequalified by MTC to perform data collection.

ACKNOWLEDGMENTS

The authors appreciate the support of Dr. Roger E. Smith of Texas A&M University for his ongoing PMS guidance and condition assessment training. The authors also appreciate the review and comments from Dr. R Gary Hicks.

REFERENCES

1. Flintsch, G. and McGhee, K.K. "Quality Management of Pavement Condition Data Collection", NCHRP Synthesis 401. Transportation Research Board, Washington D.C., 2009.
2. Bianchini, A., Bandini, P., and Smith, D.W. "Interrater Reliability of Manual Pavement Distress Evaluations." *J. of Transportation Engineering*, Vol. 136, No. 2, 2010. pp 165–172.
3. Saliminejad, S. and Gharaibeh, N.G. "Impact of Error in Pavement Condition Data on Output of Network-Level Pavement Management Systems", TRB Paper No. 13-4466. The 2013 Transportation Research Board Meeting. Washington D.C., 2013.
4. Tan, S.G. and D. Cheng "Quality Assurance of Performance Data for Pavement Management Systems". 2014 Geohubei International Conference. ASCE GSP 246: Design, Analysis, and Asphalt Material Characterization for Road and Airfield Pavement. July 2014. pp 163 – 169.
5. MTC, "MTC Data Quality Management Plan", <http://www.mtcpms.org/support/QualityMgtProgram.html>. Metropolitan Transportation Commission, Regional Streets and Roads Program, accessed in August 2014.
6. ASTM D6433-11. Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys. By ASTM Subcommittee: E17.42. 2011.
7. MTC, Pavement Condition Index Distress Identification Manual for Asphalt and Surface Treatment Pavements, 3rd Edition (Revised), April 2012.
8. MTC, Pavement Condition Index Distress Identification Manual for Jointed Portland Cement Concrete Pavements, 2nd Edition, October 2002.