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16. Abstract

A condition survey procedure, which has been used to survey all the rural CRC pavements in Texas, is presented in this report. The procedure involves the objective measurement of the most severe and prevalent forms of distress in CRC pavements.

The development of this procedure, from the implementation of an earlier procedure, is described. Some recommendations regarding computerized storage and manipulation of the condition survey data are made.

The survey procedure is described in detail to facilitate its implementation. A further procedure for surveying jointed concrete pavement is also presented. This survey has been used to a limited extent on some Texas highways and is largely based on the experience gained from use of the CRC survey procedure.

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MANUAL FOR CONDITION SURVEY OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS

by

Arthur Taute
B. Frank McCullough

Research Report 177-19

Development and Implementation of the Design, Construction and Rehabilitation of Rigid Pavements

Research Project 3-8-75-177

conducted for

The Texas Highway Department

in cooperation with the
U. S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR TRANSPORTATION RESEARCH

BUREAU OF ENGINEERING RESEARCH

THE UNIVERSITY OF TEXAST AT AUSTIN

February 1981

The contents of this report reflect the views of the authors, who are 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 Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

PREFACE

This report presents the development of a condition survey procedure for continuously reinforced concrete pavements. An initial survey of virtually all the rural CRC pavements in Texas was conducted in 1974. This initial procedure was modified to make the survey more objective and the modified survey was used for the rural CRC pavements in 1978. This report documents the new procedure and details its implementation.

It is envisaged that the existing survey procedure will be used at regular intervals to survey the Texas pavements.

The cooperation of the staff of the Center for Transportation Research of The University of Texas at Austin, in particular Mrs. Marie Fisher, is greatly appreciated. In addition, the cooperation and helpful comments of the personnel of the Texas State Department of Highways and Public Transportation are greatly appreciated.

Arthur Taute
B. Frank McCullough

February 1981

LIST OF REPORTS

Report No. 177-1, "Drying Shrinkage and Temperature Drop Stresses in Jointed Reinforced Concrete Pavement," by Felipe R. Vallejo, B. Frank McCullough, and W. Ronald Hudson, describes the development of a computerized system capable of analysis and design of a concrete pavement slab for drying shrinkage and temperature drop. August 1975.

Report No. 177-2, "A Sensitivity Analysis of Continuously Reinforced Concrete Pavement Model CRCP-1 for Highways," by Chypin Chiang, B. Frank McCullough, and W. Ronald Hudson, describes the overall importance of this model, the relative importance of the input variables of the model and recommendations for efficient use of the computer program. August 1975.

Report No. 177-3, "A Study of the Performance of the Mays Ride Meter," by Yi Chin Hu, Hugh J. Williamson, B. Frank McCullough, and W. Ronald Hudson, discusses the accuracy of measurements made by the Mays Ride Meter and their relationship to roughness measurements made with the Surface Dynamics Profilometer. January 1977.

Report No. 177-4, "Laboratory Study of the Effect of Non-Uniform Foundation Support on CRC Pavements," by Enrique Jiminez, B. Frank McCullough, and W. Ronald Hudson, describes the laboratory tests of CRC slab models with voids beneath them. Deflection, crack width, load transfer, spalling and cracking are considered. Also used is the SLAB 49 computer program that models the CRC laboratory slab as a theoretical approach. The physical laboratory results and the theoretical solutions are compared and analyzed, and the accuracy is determined. August 1977.

Report No. 177-6, "Sixteenth Year Progress Report on Experimental Continuously Reinforced Concrete Pavement in Walker County," by Thomas P. Chesney, and B. Frank McCullough, presents a summary of data collection and analysis over a 16-year period. During that period, numerous findings resulted in changes in specifications and design standards. These data will be valuable for shaping guidelines and for future construction. April 1976.

Report No. 177-7, "Continuously Reinforced Concrete Pavement: Structural Performance and Design/Construction Variables," by Pieter J. Strauss, B. Frank McCullough, and W. Ronald Hudson, describes a detailed analysis of design, construction, and environmental variables that may have an effect on the structural performance of a CRCP. May 1977.

Report No. 177-9, "CRCP-2, An Improved Computer Program for the Analysis of Continuously Reinforced Concrete Pavements," by James Ma and B. Frank McCullough, describes the modification of a computerized system capable of analysis of a continuously reinforced concrete pavement based on drying shrinkage and temperature drop. August 1977.

Report No. 177-10, "Development of Photographic Techniques for Performance Condition Surveys," by Pieter J. Strauss, James Long, and B. Frank McCullough, discusses the development of a technique for surveying heavily trafficked highways without interrupting the flow of traffic. May 1977.

Report No. 177-11, "A Sensitivity Analysis of Rigid Pavement-Overlay Design Procedure," by B. C. Nayak, B. Frank McCullough, and W. Ronald Hudson, gives a sensitivity analysis of input variables of Federal Highway Administration computer-based overlay design procedure RPOD1. June 1977.

Report No. 177-12, "A Study of CRCP Performance: New Construction versus Overlay," by James I. Daniel, B. Frank McCullough, and W. Ronald Hudson, documents the performance of several continuously reinforced concrete pavements (CRCP) in Texas. April 1978.

Report No. 177-13, "A Rigid Pavement Overlay Design Procedure for Texas SDHPT," by Otto Schnitter, B. Frank McCullough, and W. Ronald Hudson, describes a procedure recommended for use by the Texas SDHPT for designing both rigid and flexible overlays on existing rigid pavements. The procedure incorporates the results of condition surveys to predict the existing pavement remaining life, filed and lab testing to determine material properties, and elastic layer theory to predict the critical stresses in the pavement structure. May 1978.

Report No. 177-15, "Precast Repair of Continuously Reinforced Concrete Pavement," by Gary E. Elkins, B. Frank McCullough, and W. Ronald Hudson, describes an investigation into the applicability of using precast slabs to repair CRCP, presents alternate repair strategies, and makes new recommendations on installation and field testing procedures. May 1979.

Report No. 177-16, "Nomographs for the Design of CRCP Steel Reinforcement," by C. S. Noble, B. F. McCullough, and J. C. M. Ma, presents the results of an analytical study undertaken to develop regression equations and nomographs for use as a supplementary tool in the design of steel reinforcement in continuously reinforced concrete pavement by the Texas State Department of Highways and Public Transportation. August 1979.

Report No. 177-17, "Limiting Criteria for the Design of CRCP," by B. Frank McCullough, J. C. M. Ma, and C. S. Noble, presents a set of criteria which limits values of a set of variables to be used in the design of CRCP. These criteria are to be used in conjunction with Report No. 177-16. August 1979.

Report No. 177-18, "Detection of Voids Underneath Continuously Reinforced Concrete Pavements," by John Birkhoff and B. Frank McCullough, presents the results of an investigation in which three methods for detecting voids underneath CRC pavements (deflection, pumping and vibration) are evaluated with respect to reliability of successful void detection. August 1979.

Report No. 177-19, "Manual for Condition Survey of Continuously Reinforced Concrete Pavements," by Arthur Taute and B. Frank McCullough, presents the condition survey method used during the 1978 statewide CRCP condition survey. In addition, proposals for a condition survey procedure for jointed concrete pavement are presented. February 1981.

ABSTRACT

A condition survey procedure, which has been used to survey virtually all the rural CRC pavements in Texas, is presented in this report. The procedure involves the objective measurement of the most severe and prevalent forms of distress in CRC pavements.

The development of this procedure, from the implementation of an earlier procedure, is described. Some recommendations regarding computerized storage and manipulation of the condition survey data are made.

The survey procedure is described in detail to facilitate its implementation. A further procedure for surveying jointed concrete pavement is also presented. This survey has been used to a limited extent on some Texas highways and is largely based on the experience gained from use of the CRC survey procedure.

KEY WORDS: continuously reinforced concrete pavement, pavement evaluation, condition survey, jointed concrete pavements, jointed reinforced concrete pavements, distress

SUMMARY

An important part of any pavement management system is the monitoring of distress development in constructed pavements. To this end, a condition survey was conducted on virtually all the rural CRC pavements in Texas, in 1974 and 1978.

Application and analysis of the 1974 survey procedure indicated that more objectivity was required in the survey and that uncommon distress manifestations should not be recorded. The procedure was modified accordingly and applied to the pavements in 1978.

The implementation of the present survey procedure is described in detail in this report. A further survey procedure for jointed concrete pavement is developed and its implementation described.

IMPLEMENTATION STATEMENT

A condition survey procedure, which has been tested on virtually all the rural CRC pavements in Texas, is documented in this report. Regular application of this procedure should provide data regarding the effectiveness of design, maintenance, and rehabilitation procedures as applied to CRC pavements.

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INTRODUCTION

A large portion of the interstate highways of Texas is paved with continuously reinforced concrete pavement (CRCP). Some of these highways were constructed during the early phases of the interstate program and others at a later date. Thus, the pavement ages vary considerably and some portions require rehabilitation of some form.

In order to monitor the historical development of distress and the various prominent distress types found in these pavements, a condition survey of these pavements was initiated. Virtually all CRCP were surveyed under this program in 1974 and again in 1978. Between 1974 and 1978, the condition survey procedure was modified slightly in order to make the survey more objective. The present survey procedure is objective and can be carried out at a reasonable speed.

Analysis of the results will provide objective data which may improve overall CRCP management in Texas.

This paper describes the development of the present survey procedure and details the procedure for use by the Texas State Department of Highways and Public Transportation.

PURPOSE OF CONDITION SURVEY

Condition surveys provide the pavement planner, engineer, or maintenance personnel with information regarding the various forms of distress which may be present in a pavement. Various condition survey procedures exist, each with its own advantages and disadvantages. Agencies use condition surveys depending on their requirements, resources, and the amount of pavement to be surveyed. Before embarking on a condition survey program, the following questions should be asked:

(1) For what are the survey data going to be used?

(2) Can the data be obtained efficiently?

(3) How will the data be stored and used?

(4) Is the procedure flexible in order to allow for special conditions? The following paragraphs address each of these questions.

For What Are the Survey Data Going to be Used?

Many different forms of distress occur in a pavement structure. Therefore, before deciding on a condition survey procedure, the objectives and uses of the data must be specified. If this were not the case, large amounts of data could clutter the survey and make data analysis impractical. The survey data generally should be used for the following activities.

Corroborating Design Predictions. Design predictions are often made only to be filed away on completion of construction. Condition surveys should provide accurate and useful information to check these predictions. For example, fatigue relationships corresponding to, say, five percent or ten percent cracking could be verified.

Scheduling Maintenance and Rehabilitation Procedures. Minor maintenance is carried out over the life of the pavement as deemed necessary by the pavement manager. Subsequently, pavements are overlayed when the riding quality or structural quality of the pavement reaches a terminal condition. The pavement may also be overlayed if it is apparent that it is rapidly approaching this terminal condition due to ingress of water into the lower unbound layers, or due to pumping. Condition surveys should provide information regarding the effectiveness and timing of all the above procedures.

Information for the design of overlays. Overlay designs depend on both the behavior and condition of the existing pavement. Distress in overlays is directly related to distress in the original pavement and, as such, condition surveys should provide useful data for overlay design.

Can the Data be Obtained Efficiently?

It would be impractical to attempt observation and measurement of all the different distress manifestations which may occur in a pavement. Only the most widely prevalent distress manifestations which can be measured objectively in one way or another should be recorded. Considering the length of pavement to be surveyed, one could survey a small sample in great detail or a larger sample in less detail or some combination of the two extremes.

The survey data should be readily usable and should be suited to computer storage and manipulation. To make the survey, one should be able to make accurate observations with minimum training, and similarly, these data should be reproducible by properly instructed surveyors.

How Will the Data be Stored and Used?

Condition surveys produce masses of data. These data should be stored in a format which permits easy computer manipulation as shown by previous studies. Details omitted from present summaries should also be stored so that later changes or additions to initial summaries can be made.

Is the Procedure Flexible in Order to Allow for Special Conditions?

Not all areas will have the same distribution of the various distress manifestations. A distress manifestation which may be widely prevalent in one area may be nonexistent in another. The survey procedure should readily adapt to such situations, and users of the procedure should be aware of the possibility of making necessary changes in the procedure.

DEVELOPMENT OF THE SURVEY PROCEDURE

Few survey procedures could satisfy most requirements upon initial application. With time, improvements can be made so that the procedure fits the circumstances and useful data result. The CRCP survey procedure used in this project has been developed over a number of years. Initially, the various distress manifestations which occur in CRCP were ascertained. Subsequently, most of these distress manifestations were subjectively recorded with regard to severity and extent. Finally, the present survey procedure records these distress manifestations in as objective a manner possible. In order to substantiate the present procedure, the development of typical CRCP distress manifestations should be examined briefly.

Distress Manifestations

Soon after construction, transverse cracks appear in a pavement. The cracks are generally caused by drying shrinkage, and temperature stresses cause fatigue cracking in the pavement. These fatigue cracks start at the outer edge of the pavement, where the tensile stress is at a maximum, and then slowly progress across the slab. When two transverse cracks are fairly close together (roughly 2 feet, or .61 m apart) the portion of the slab between the cracks acts as a beam in the transverse direction and longitudinal cracks occur. When two or more transverse cracks are linked by a longitudinal crack, a punchout is formed. Concurrently with the above, the slab is flexed under load and the upper edges of the cracks may break off or spall. This spalling may also result from material ingress into a crack and subsequent elongation of the slab due to increased temperatures. Further distress may be caused by pumping. Water may enter the pavement structure through any one of the above cracks. When a load subsequently passes over the pavement, this water may be pumped out along the edge of the concrete. The velocity of the water being pumped out from under the slab may be sufficient to carry fines with it. In which case, voids under the slab may result. These voids result in increased deflections and stresses within the slab.

1974 Survey Procedure

The above distress development is fairly prevalent and led to the observation of the following distress manifestations during the 1974 statewide condition survey: transverse cracks, localized cracks, spalling, pumping, punchouts, and patches.

Once the types of distress manifestations to be recorded had been determined, the question of how to record the severity and extent of each distress manifestation was addressed.

First, a brief description of each type of distress and what was to be gained by its measurement is given.

Transverse Cracks. All CRCP exhibits transverse cracking. Only cracks which changed from the regular pattern and were closer than 18 inches (450 m) were to be considered. The extent of the cracking was recorded as a percent of the pavement length which exhibited such cracking. The cracking was classed as minor or severe depending upon the width and age of the cracks. This was to provide some indication of the fatigued areas in the pavement.

Localized Cracks. This type of cracking was defined as transverse cracking which had deteriorated to form Y cracks. The extent and severity was recorded in a similar manner to the transverse cracking. This also provided an indication of the amount of fatigue in the pavement.

Spalling. The secondary cracking or breaking of the crack edges was defined as spalling. The extent of the spalling was defined by the percentage of the total number of cracks which exhibited spalling. The spalling was divided into two categories, depending on the width of the spall. This measurement provided some indication of the load transfer at the cracks. The more spalled cracks, the less the load transfer and the more fatigued the pavement would be.

Pumping. The water pumped out along the edge of the pavement generally transports some fine material with it. The severity of the pumping was defined by the amount and size of material transported by the water, while the extent was determined by the percentage of the roadway length which exhibited pumping. This provided an indication of the condition of the joint between the shoulder and the pavement. The severity of pumping also gave a rough idea of the condition of the subbase below the pavement.

Punchouts. The development of a punchout has been described earlier. The severity of the punchout is described by grouping the punchouts into two categories: minor, when the block does not move under traffic and when surrounding cracks are narrow and in good condition, or severe, when the block moves under traffic and the surrounding cracks are wide open and spalled. The extent of the punchouts was defined by grouping the punchouts according to size and counting the number of punchouts occurring along a fixed length of road. The punchouts provided an indication of the portions of the roadway which had reached a terminal condition and which needed to be repaired or patched.

Patches. Punchouts may be repaired with either asphalt concrete or portland cement concrete. The number of repair patches, of a specified type, which fall into a specific size category, were counted per fixed length of the road. This provided a further indication of the portion of the roadway which had reached the terminal condition and had to be repaired.

It became apparent that a condition survey utilizing the above procedure could be done rapidly, and, thus, it was decided to apply the procedure to all the rural CRCP in Texas. The procedure was applied to 0.2-mile sections, consecutively. It was felt that this was roughly the maximum length of road to which similar subgrade properties would apply. Similarly, this was estimated to be the minimum length of a road to which a specific construction procedure could be applied. Smaller sections would probably have resulted in unnecessary detail. Only the distress in the outer lane was recorded, as this is the more heavily trafficked lane.

In addition to the above survey procedure, a photo survey was developed for use on urban freeways. This photo-survey procedure is described in CFTR Report 177-10.

1978 Survey Procedure

Application of the 1974 procedure demonstrated the need for more objectivity while still retaining the speed of the survey. The present procedure was developed by modifying the 1974 procedure in order to obtain more objectivity. The recording and observation of the various distress manifestations was changed as follows.

Transverse and Localized Cracking. The 1974 survey showed that only in a few instances was more than 5 percent of the above distress manifestations recorded. It was felt that the change in transverse cracking would not be significant in four years, and, therefore, it was omitted. The localized cracking was associated with problems due to construction in the earlier years of CRCP construction. Apparently, steps taken during the 1960's and 70's had corrected this problem since it was practically nonexistent. Neither of these items was recorded in the present survey procedure. Instead, the crack spacing recorded along a 300-foot sample of the roadway within each construction job was recorded. Although the crack spacing may vary significantly within each job, a 300-foot length was set as the practical limit to be measured.

Spalling. The concept of severity as defined by the 1974 survey was retained; however, the extent of the spalling was recorded by counting the number of spalled cracks per 0.2-mile section. This provided a more objective measurement of the spalled cracks and, when used in conjunction with the crack spacing measurements allowed, an estimate of the percentage of spalled cracks to be obtained.

Pumping. The recording of the pumping along the roadway edge was retained as in the 1974 survey procedure. Although this is not a very objective measurement, it was retained in the interest of speed.

Punchouts. In the interest of speed, it was decided to distinguish only between punchouts shorter or longer than 20 feet. The 1974 survey showed that most punchouts were small, but the distinction is nevertheless made because of the different characteristics of the large and small punchouts. The number of punchouts per 0.2-mile length is recorded.

Patches. A patch is installed to repair a severe punchout. Although the punchout may be fairly small, studies of patching methods have shown that the patch should extend to either side of the punchout for a fair distance. The patch should also be constructed from the shoulder to the center line joint of the roadway. Each patch represents a portion of the roadway which has failed. The size or condition of the patch is not recorded, only the number of patches per 0.2-mile section.

The method of obtaining data for every 0.2-mile section proved successful in 1974 and again in 1978. This survey procedure was applied to all the rural CRCP in Texas during 1978.

The Present Condition Survey Procedure

Application of the present survey procedure during 1978 demonstrated that the survey met most of the requirements described in an earlier chapter. The various questions are satisfied by the survey procedure as described below.

Use of the Data. This survey procedure is not intended to provide an answer to all questions regarding pavement distress. It should provide excellent long-term information which will help to improve existing design and maintenance procedures. It also provides good information regarding the overall condition of the various CRC pavements in Texas and their deterioration with time.

Corroborating design predictions. The CRCP-2 design procedure predicts initial crack spacing, crack width, and steel stress. These predicted cracks result from temperature drop stresses, drying shrinkage, and traffic loading during the early portion of the pavement's life. Subsequently, fatigue cracking may occur as a result of further traffic and environmental stresses. Because it would be impractical to measure crack width and steel stress, this survey provides only an indication of the crack spacing and the condition of the various cracks.

Scheduling Maintenance and Rehabilitation Procedures. Minor maintenance should be performed as deemed necessary by the engineer or maintenance foreman. This survey is not intended to provide information regarding the repair of a specific punchout or spall. This information should be provided by more frequent surveys of the pavement, with attention being paid to the condition of the various punchouts, spalls, etc. This survey should provide information about the long-term effects of various maintenance procedures. Information regarding the effectiveness and timing of large-scale maintenance and rehabilitation procedures may also be obtained. This information, in conjunction with cost studies, may provide information for economic optimization of pavement maintenance and rehabilitation.

Design of Overlays. The present SDHPT overlay design procedure for rigid pavements (RPOD2) takes the remaining life of the existing pavement into consideration. This remaining life has a significant effect on the design overlay thickness. Research is at present being conducted to try and improve present estimates of remaining life by utilizing the condition survey results.

Speed of the Survey and Obtaining Data Efficiency. Only crack spacing, spalled cracks, punchouts, patches, and pumping are observed. The crack spacing is measured along a 300-foot sample of the roadway. The number of spalled cracks, punchouts, and patches per 0.2-mile section are counted. The percentage of the edge of the roadway which exhibits pumping is estimated. Surveys using this procedure have been conducted at speeds of 2 to 5 miles per hour, depending on the amount of distress in the pavement.

These data are recorded on field sheets formatted to resemble computer data cards. This facilitates punching of the required computer input cards. Once the data have been stored on magnetic tape, simple programs can transform the data into summaries as required.

Although some difficulty with the interpretation of the different distress manifestations by different people exists, generally, reproducibility of the survey is fairly good. A separate study is being conducted to check the reproducibility of the procedure.

Storage of the Data. This condition survey procedure includes the following steps in data collection and storage:

(1) Note the various distress manifestations on the field sheets.
(2) Edit the field sheets.
(3) Keypunch computer cards corresponding to the lines of the field sheet.
(4) Read the cards into a computer and store the data on magnetic computer tapes.
(5) Edit these data files.
(6) Transform the data by means of a computer program into usable, informative summaries.
(7) Analyze the data.

This data storage procedure retains the original data on magnetic tapes where they can easily be operated on by a computer program in order to produce a summary at the required level of detail. The original field sheets are also stored. These field sheets may have surveyor's comments on them which are not stored on the computer tapes. These sheets are also used as a model when preparing field sheets for a new survey. The project identification information, mile post, and mile point data are transformed from the old sheets to the new blank sheets.

Flexibility. Both the data collection and storage procedures can be varied to suit the needs of a particular district. For example, should another form of distress be present to a large degree, it may also be recorded. An additional column could be included in the existing field sheet and an objective measurement of this distress manifestation could be noted in this column. The summarizing computer program would then have to be modified to take the additional data into account.

Reporting Condition Survey Data

Once all the data have been obtained and stored as described previously, the necessary summaries need to be made in order to report and analyze the data. The data, as contained on the field survey forms, are too detailed and unorganized to be of use. Summaries are required at different levels of detail for use at the different managerial and analytical levels.

The 1974 data were summaried graphically. The observations of the various distress manifestations per 0.2-mile section were plotted against the length of the roadway. This provided a clear visual indication of the distressed areas (Fig 1). The plotting of the graphs, however, used a large amount of computer time and money. These data were further summarized in the form of histograms. The frequency of occurrence of a level of distress in a job was plotted on the histogram. This provided an indication of the prevalence of a distress manifestation within a job (Fig 2).

Although suitable for the 1974 data, the above presentation methods would be difficult to extend to a historical development of the distress manifestations. New summaries were, thus, made for the 1978 data and the combined 1974 and 78 data. The most detailed summary of the 1978 data presents the quantities of the distress manifestations per one-mile section. For this purpose, the 0.2-mile-section observations are merely added together. Fairly objective measurements of the number of both punchouts and patches were made in 1974 and 1978. These are also regarded as the most significant forms of distress in a CRCP. A further summary of these data is thus made and the punchout and patch data for the 1974 and 1978 surveys are presented in a comparative manner (Fig 3).

It is envisaged that once this condition survey procedure is used more regularly, the present summarizing computer program will be modified in order to present all these historical distress data in a comparative manner. The data for each survey should be summarized on a mile-by-mile basis, as was done with the 1978 data. These data can then be further summarized and added to a comparative summary of all the previous data. This comparative summary would list the different distress manifestations, the date of survey, and the corresponding distress observations for all the surveys done.

Further presentation of the data is accomplished by color coding maps according to the level of distress present along a section of the roadway. At the present, only the punchouts and patches are regarded as significant enough for this form of presentation. The punchouts and patches are placed together into a category called failures. Depending on the average number of failures per mile of pavement for a whole job, a color is assigned to this job on a map. Although this form of presentation does not provide enough

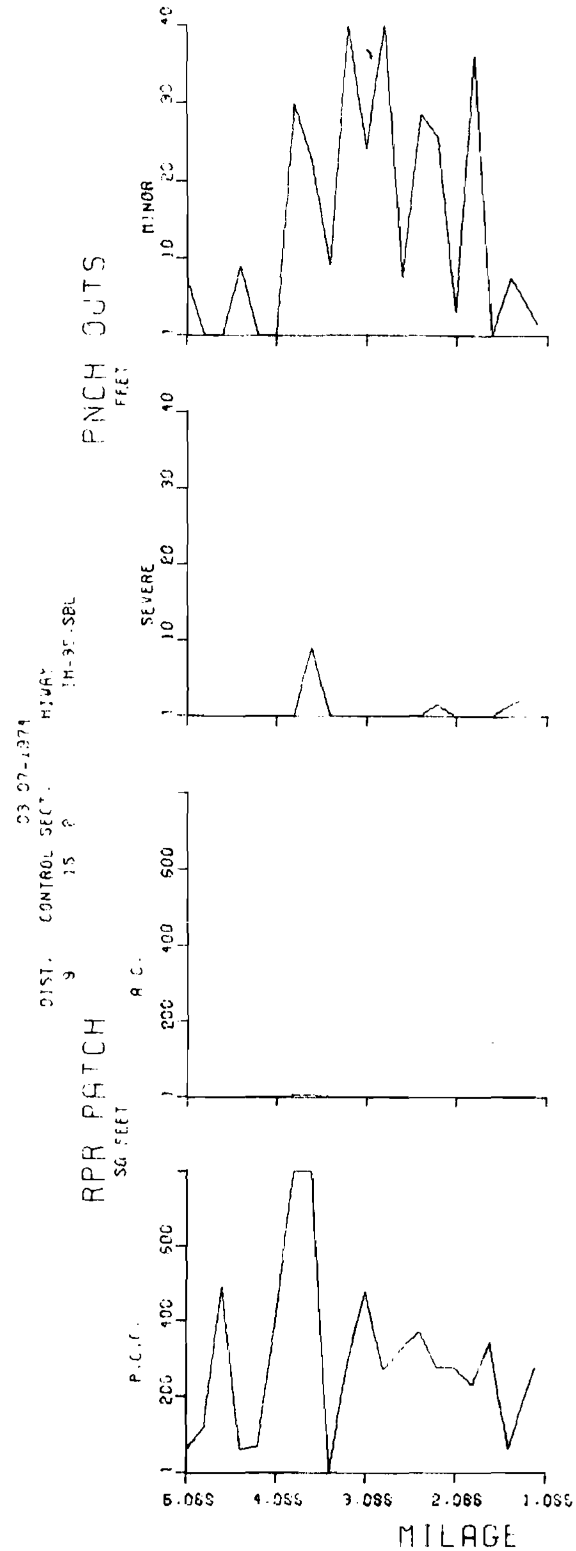
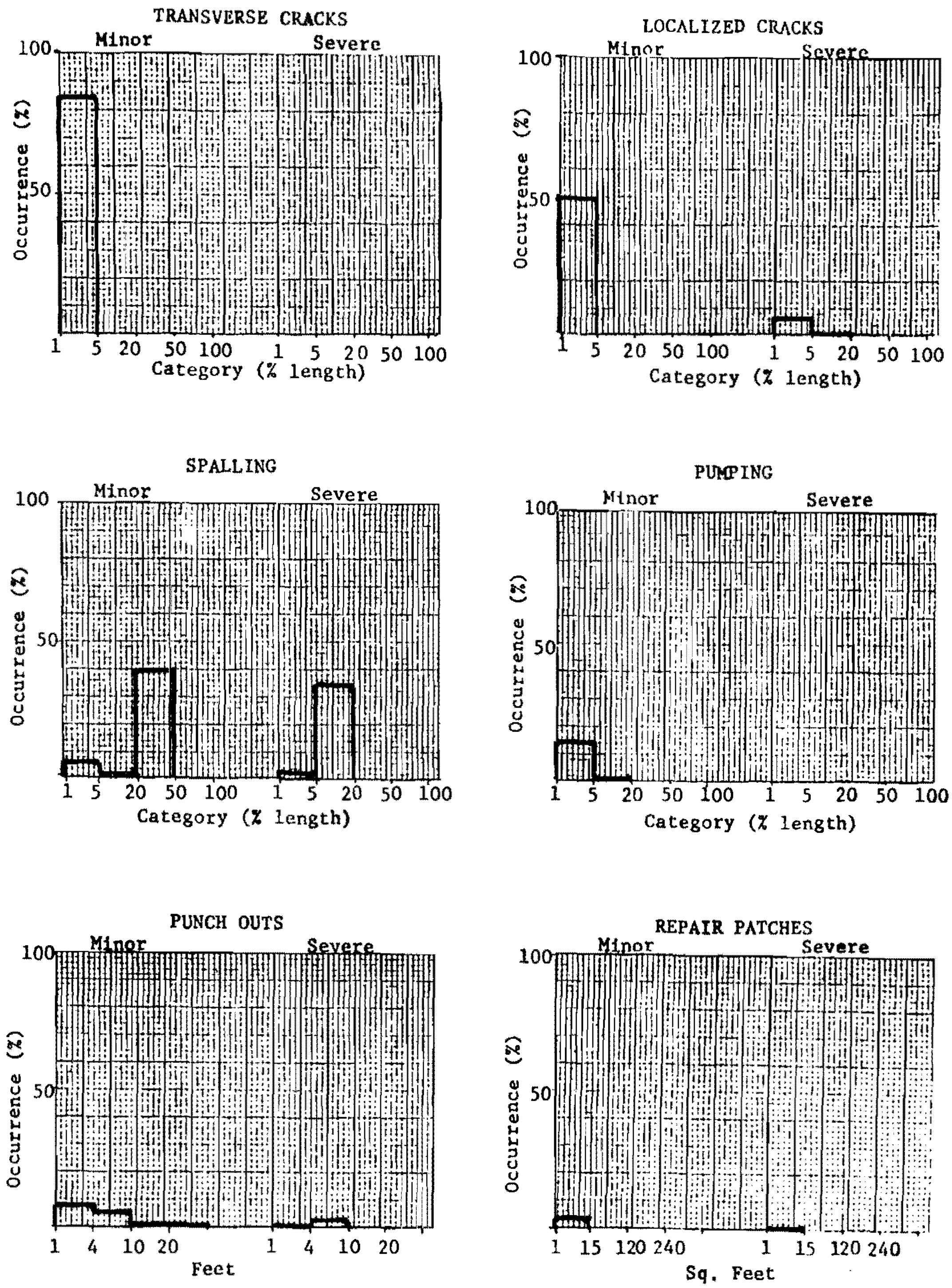


Fig 1. Presentation of distress - 1974 condition survey.



13	535	8	IH-10 EB	Fayette	3/27/74
District	Control	Section	**Highway**	County	**Date**

Fig 2. Presentation of distress - 1974 condition survey.

FAILURE SUMMARY FOR DISTRICT 17

CPHR NO.	AGE	LENGTH	REPAIR PATCHES (NO./MILE) A.C. 1974/1978	REPAIR PATCHES (NO./MILE) P.C.C. 1974/1978	PUNCHOUTS (NO./MILE) 1974/1978	FAILURES (NO./MILE) 1974/1978	FAILURES (TOTAL) 1974/1978
1701 NB *	17.4	11.6	23.8 / 0.0	17.9 / 0.0	9.3 / 0.0	51.0 / 0.0	571 / 0
1701 SB *	17.4	11.4	20.8 / 0.0	17.8 / 0.0	9.9 / 0.0	48.5 / 0.0	553 / 0
1702 NB *	14.9	14.8	1.1 / .2	.1 / .1	.5 / .1	1.7 / .4	26 / 6
1702 SB *	14.9	15.0	.6 / 1.0	.1 / .1	.3 / .3	1.1 / 1.3	16 / 18
1705 NB *	11.0	12.8	.5 / 0.0	4.1 / 0.0	3.1 / 0.0	7.8 / 0.0	100 / 0
1705 SB *	11.0	13.2	.4 / 0.0	6.5 / 0.0	3.1 / 0.0	10.0 / 0.0	132 / 0
1703 NB	11.0	12.8	.5 / 0.0	.2 / .2	.5 / .6	1.2 / .9	15 / 11
1703 SB	11.0	12.8	1.2 / 1.5	.1 / 1.1	.9 / 2.4	2.1 / 5.0	27 / 64
1704 NB	11.0	6.1	.8 / 0.0	0.0 / 0.0	0.0 / .3	.8 / .3	5 / 2
1704 SB	11.0	5.6	0.0 / .2	.2 / 5.0	.5 / 1.4	.7 / 6.6	4 / 37
1707 NB	9.0	16.2	.1 / 0.0	0.0 / 0.0	.1 / .2	.2 / .2	3 / 4
1707 SB	9.0	16.0	.5 / 0.0	.1 / .1	.1 / .9	.7 / 1.0	11 / 16
1710 NB	7.0	17.2	1.0 / .3	.5 / .1	.1 / 2.4	1.6 / 2.8	27 / 49
1710 SB	7.0	17.2	.5 / 1.5	.1 / .3	.1 / 3.5	.6 / 5.3	10 / 92
1709 NB	7.0	.6	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0 / 0

*Projects overlayed between 1974 and 1978

Fig 3. Comparative presentation of distress - 1978 condition survey.

data for analyzing the condition surveys, it provides a good visual indication of potential problem areas.

Application of the above reporting techniques ensures that the condition survey data is properly recorded and that maximum benefit is derived from the data.

Implementation

The application procedure is detailed in the condition survey manual which appears in Appendix 1. As with all general procedures which have to be applied over a wide range of conditions, exceptions will occur which will be difficult to fit to the procedure; for instance, large-scale longitudinal or random cracking. A number of these exceptions are covered in the procedural manual.

Frequency of Surveys. Statewide implementation of this procedure requires many man hours for collection, editing, and summarizing the data. The frequency with which the pavements are surveyed should maintain a balance between the one extreme, where subsequent surveys will detect very little change in the amount of distress, and the other extreme, where the development of a large quantity of distress is undetected. Using the data obtained during the 1974 and 1978 condition surveys, a diagram for the increase in failures (punchouts plus patches) per mile (Fig 4) has been prepared. This figure shows the change in the number of failures per mile, over a four-year period, as a function of pavement age. A subjective examination of this figure, while keeping the objectives of the survey procedure in mind, leads to the following recommendations:

(1) Initial survey of a pavement two years after construction. This will serve to corroborate design predictions regarding initial crack spacing. Two years should be sufficient time to allow most of the initial cracking to occur. This initial survey should also indicate whether any construction faults may be present.

(2) Two subsequent surveys at four-year intervals. At this stage, the pavement will be fairly new and rapid development of distress expected.

(3) All subsequent surveys at two-year intervals. In order to maintain a constant monitoring of the distress development, this would appear to be the optimum interval between surveys. In areas with less damaging climatic and traffic conditions, such as the drier, western portion of Texas, the four-year survey interval may be extended until the pavement is 14 years old.

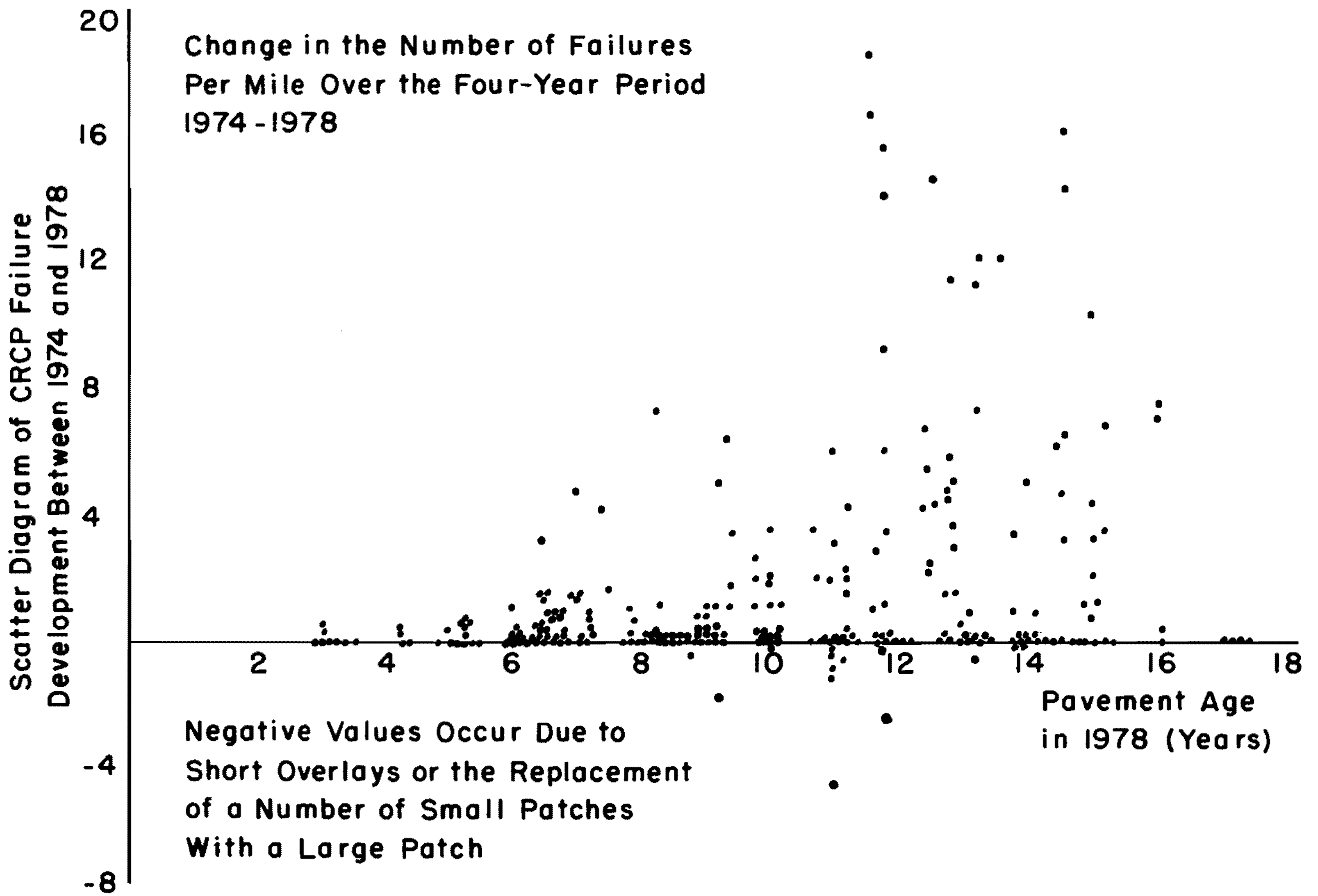


Fig 4. Scatter diagram of CRCP failure development between 1974 and 1978.

Data Collection. Initially, the data should be collected as outlined in the procedural manual in Appendix 1. Once the field sheets have been completed, the computer cards punched, and the data stored on magnetic tape, the data can be summarized by means of a computer program. Appendix 2 contains an input guide for the program which was used to summarize the combined 1974 and 1978 data. It is envisaged that the existing computer program should be modified in order to add any new data to the existing summaries.

Continued application of the survey procedure should lead to streamlining the various activities associated with data collection and storage. Minicomputers taken into the field in the survey vehicle may significantly reduce the time required for editing and storing the data.

Analysis of Data. The summarized condition survey data should provide a valuable record of the historical development of failures in the pavement. At the network level, the data may establish differences in pavement performance in different areas and may help to allocate maintenance costs. On a project for project basis, the data may provide information which would help prioritize large scale maintenance and rehabilitation.

APPENDIX 1

PROCEDURE FOR 1978 CONDITION SURVEY

APPENDIX 1. PROCEDURE FOR 1978 CONDITION SURVEY

The distress manifestations observed are

(1) minor and severely spalled cracks,

(2) the percentage of the road which exhibits minor or severe pumping,

(3) minor or severe punchouts which are either shorter or longer than 20 feet,

(4) asphalt concrete and portland cement concrete patches, and

(5) the crack spacing along a 300-foot sample of the road.

Distress manifestations (1) through (4) are noted on the field sheet, as shown in Fig A1.1. The crack spacing is noted on the field sheet, as shown in Fig A1.2.

The procedure for the survey is as follows. The roadway is divided into sections which correspond to the SDHPT's control sections and job numbers. The road is surveyed by two people who travel in a vehicle on the shoulder at approximately 5 miles per hour. The driver notes the punchouts and pumping along the roadway. The passenger, who sits on the back seat behind the driver, notes the minor and severely spalled cracks and patches. Only the distress manifestations in the outer lane are counted. A tally of the different distress manifestations is kept on mechanical counters mounted on a clipboard. When each 0.2-mile section has been completed, the quantities are transferred to the field sheet and the counters reset.

Pumping is noted as the percentage of the roadway which shows pumping. The CRCP pumps mostly along the edge joint, between the pavement and the shoulder. The length in feet of this joint which shows signs of pumping is noted. On completion of every 0.2-mile section, this figure is divided by 10 to arrive at a percentage (0.2 miles is approximately 1000 feet).

A 300-foot portion of the roadway, roughly in the middle of the section, is selected for measuring crack spacing. If the control section is longer than 6 miles, the crack spacing measurement is taken approximately every 3 miles.

CRCP CONDITION SURVEY

DISTRICT	CONTROL	SECT.	HIGHWAY	AGE (FIO.O)	DIR	COUNTY	JOB	CFHR NO.	MO DAY YEAR
17	675	5	IH-45	11.0	SB	MADISON	6	1704	9-19-72

		LOCATION FROM	TO
152.2	149.8	N JCT US-75 N OF MADISONV.	LEON COUNTY LINE

MILE POST	MILE POINT	COMMENTS [BRIDGES OVERLAYS LANDMARKS]	SPALLING MINOR NO. OF CRACKS	SPALLING SEVERE NO. OF CRACKS	PUMPING MINOR %	PUMPING SEVERE %	PUNCH OUTS MINOR < 20FT	PUNCH OUTS MINOR > 20FT	PUNCH OUTS SEVERE < 20FT	PUNCH OUTS SEVERE > 20FT	REPAIR PATCHES ASPHALT CONCRETE NO. OF OCCURRENCES	REPAIR PATCHES P.C. CONCRETE NO. OF OCCURRENCES	RIDING QUALITY
152.2	18.600		32	33	6	1	7	3	1				3.1
152.0	18.310		53	13	4		3	1				8	3.2
151.8	18.110	BRIDGE	54	34	15	1	4	4				9	3.1
151.6	17.910		31	5	16		1	1	2			3	2.9
151.4	17.710		33	5	9								2.7
151.2	17.510		30	2	8		1					1	3.0
151.0	17.310	RAMP	20	24	6		2	1			1		3.4
150.8	17.120		26	41	10								3.4
150.6	16.920		22	18	7								3.4
150.4	16.720	OVERLAY											4.0
150.2	16.520		15	10	13	1	2	1				1	3.6
150.0	16.320		34	13	4							3	3.3

Fig A1.1. Recording of distress manifestations.

CRACK SPACING SURVEY FORM CRC PAVEMENT

80-COLUMN CARD PUNCH FORMAT

JOB ________ DATE ________ SHEET ___ OF ___

BY ______ CHKD ______ ______ CARDS ON THIS SHEET

STATE	DISTRICT	HIGHWAY	COUNTY	CONTROL	SECTION	JOB NUMBER
TEXAS	3	US-287	WICHITA	43	8	26

DIRECTION OF TRAVEL	LOCATION FROM	TO
WB. IN. WB LANE	MP 14.8	300 FT WEST

7.9	17.0	24.4	29.3	32.9	37.5	49.4	54.8	59.1	60.1	64.9	69.4	71.8	79.6	81.4	86.1
92.2	98.7	99.6	104.6	107.6	110.3	117.3	119.8	122.6	129.9	134.8	140.2	145.1	153.0	155.3	161.6
162.6	165.2	170.2	174.7	177.7	180.2	183.4	185.5	189.8	195.0	199.3	208.8	209.4	213.4	217.2	220.1
223.2	225.4	228.8	233.0	235.5	239.5	245.4	247.0	250.8	256.0	260.4	266.0	268.4	276.0	279.3	280.9
283.4	284.6	287.7	298.8												

Fig A1.2. Recording of crack spacing data.

Crack spacing is measured as follows: a measuring wheel is rolled along the outer edge of the pavement in the direction of oncoming traffic. The position of every transverse crack in the concrete is noted to the nearest 0.1-foot. Should no assistant be available, a tape recorder can be used to record the crack spacing. When one direction of travel is completed, the opposing direction is surveyed.

Since the survey is done at varying speeds, depending on the amount of distress in the pavement, a vehicle equipped with automatic transmission should be used. Safety and warning equipment on the vehicle typically includes a roof-mounted flashing light and bright red flags attached to the rear end.

The Survey Form

A copy of the survey form is shown in Fig A1.1, and Fig A1.2 shows a copy of the crack spacing field sheet. Both forms provide space to identify the county, district, highway, and direction, as well as the control number, section, and job number. The exact location of the section must be fixed by relating the ends of the section to some detail which can be located on a map of the area. The date of the survey and the name of the survey team should also be noted on the sheet. The Center for Transportation Research has provided identification numbers for most of the CRCP sections in Texas according to the district and age.

In the field, the only references to position are the mile posts. The form provides space for recording these mile posts. Further subdivision into 0.2-mile segments is facilitated by the trip recorder of the vehicle. In order to tie the various sections in with SDHPT records, space is provided for the mile points of the highway. These mile points are taken off the road logs at the SDHPT.

Between the column provided for the mile points and the column for the number of spalled cracks, space is provided for comments regarding bridges and other structures or landmarks within the 0.2-mile section. The observed quantities of the distress manifestations should be right justified in order to correspond with the computer format for which the forms are designed.

Although distress manifestations are observed between, for example, mile post 128.8 and mile post 128.6, the rows of the field sheet are not staggered to facilitate noting this distress between the mile posts. For ease of computation, the distress manifestations are noted in the same row as the preceding mile post. If for example, 100 minor spalled cracks were counted when the surveyor is traveling from mile post 128.8 to mile post 128.6, this figure would be written in the same row as mile post 128.8. When traveling in the opposite direction, from mile post 128.6 to mile post 128.8, the observations would be noted in the same row as mile post 128.6.

The recording of the crack spacing data is self evident, as shown in Fig A1.2.

DISTRESS DESCRIPTIONS

Minor and Severely Spalled Cracks

Definitions. Spalling is defined as the widening of existing cracks by secondary cracking or breaking of the crack edges. The depth of a spall is generally less than one inch, but it can be very wide. Minor and severely spalled cracks are distinguished by the width of the spall.

Minor spalling is defined as a condition of edge cracking in which the loss of material has resulted in a spall of roughly one-half inch in width (Fig A1.3). Severe spalling is defined as a condition in which the spall is wider than one-half inch (Fig A1.4).

Recording. Only the transverse cracks showing signs of spalling are counted. The whole crack is defined by the most severe conditon of spalling that exists along that crack. For example, although the whole crack may be in a "good" condition, the presence of one "small" spall which is wider than a finger, defines that crack as severely spalled. Similarly, if the spall is narrower than a finger, the crack may be defined as showing minor spalling. Thus, if a crack shows both minor and severe spalling, it should be counted as severe.

Comments. There is a grey area where a classification of severe spalling seems to be too severe for spalls which are only slightly wider than one-half an inch. This is not a severe weakness of the survey procedure because the size of the spall is partially correlated to the number of spalls in the area. Further difficulties arise at Y - type cracks. If both branches of

Fig. A1.3. Minor spalling.

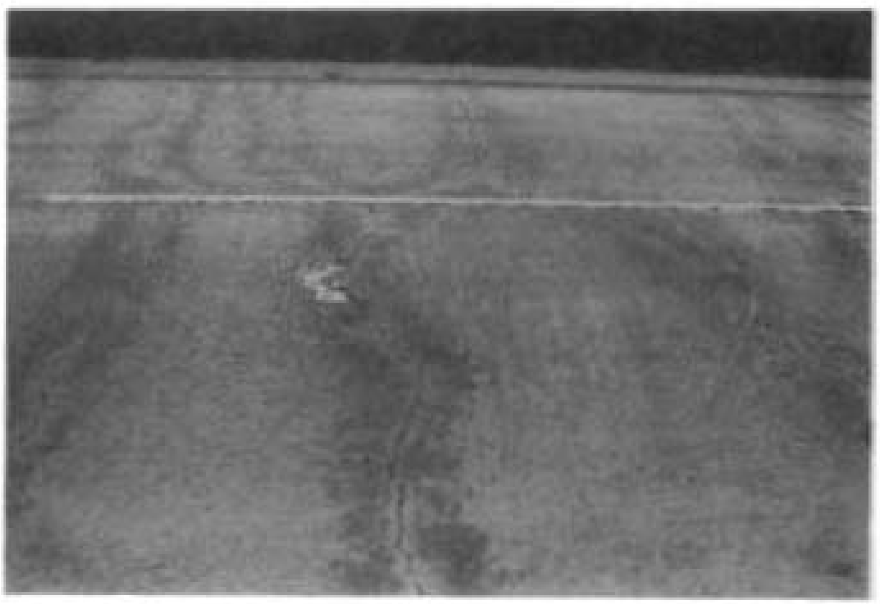


Fig A1.4. Severe spalling.

the Y are spalled, should they be counted as one or two spalled cracks? In this case, a general rule to follow is that if the branches of the Y are longer than half the lane width, two cracks are counted, and if they are shorter, only one crack is counted. Popouts (Fig A1.5), which are rare in Texas, should not be counted as spalls. Random cracking as in Fig A1.6 may cause some problems and a transverse crack pattern should be distinguished, if possible, and the spalled cracks counted accordingly.

Pumping

Definitions. Water passes through cracks and openings in the pavement and penetrates the sublayers. When a load, such as a heavy vehicle passing over a crack, is applied, the water is pressed out of the crack, taking fine material of the sublayers with it. This is defined as pumping. Pumping may occur at transverse, longitudinal, and construction joints. However, for this survey, only the pumping between the pavement edge and the shoulder will be recorded.

Minor pumping has occurred when water pumped out leaves streaks of fines on the shoulder. Severe pumping indicates a severe loss of fines from the sublayers and may also generally be associated with permanent vertical displacement of the pavement.

Recording. The length of the edge crack causing staining of the shoulder is estimated and divided by the length of the section (approximately 1000 feet) to arrive at a percentage. This will be recorded as the percent minor pumping. The length of the edge crack showing signs of severe pumping is recorded separately.

Comments. It is difficult for the rater to determine the length of the crack causing the pumping when he is riding in the vehicle. The estimate of the length of the crack causing staining may depend on the rater. This is not too serious a problem because a 10-foot error in estimation of the length of the crack will cause only a one percent error in the percentage of pumping recorded.

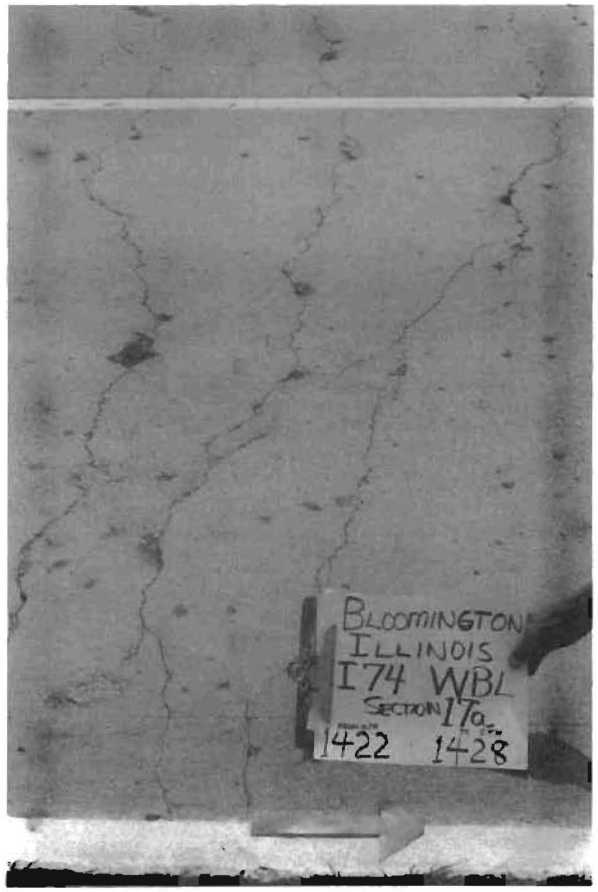


Fig A1.5. Popouts.

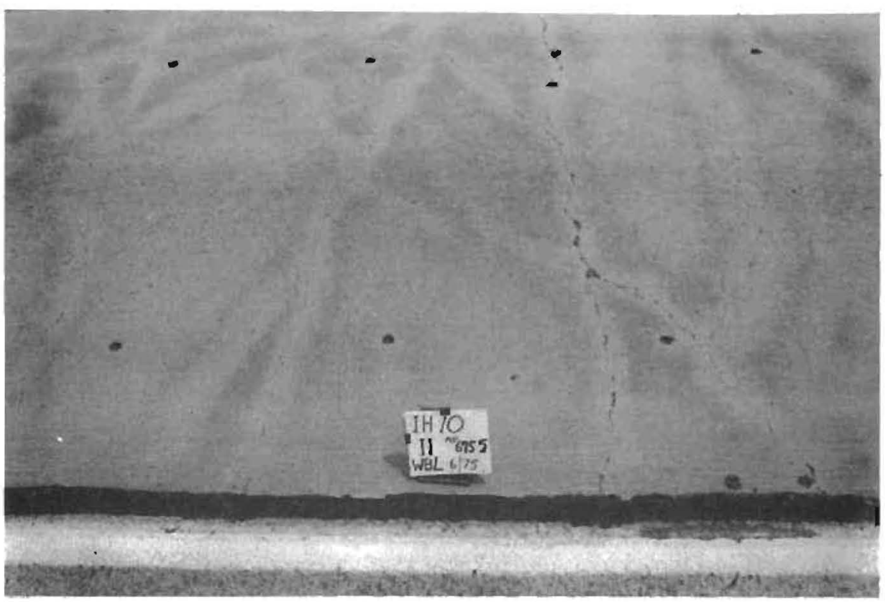


Fig A1.6. Random cracking.

Punchouts

Definitions. When closely spaced transverse cracks are linked by longitudinal cracks to form a block, the block is called a punchout. This must not be confused with longitudinal cracking, which is not recorded on the sheet. A minor punchout is defined as a condition where, although a block has formed, no sign of movement under the traffic is apparent. The cracks surrounding the punchout are narrow and few signs of spalling are apparent (Fig A1.7). A severe punchout is recorded when the block moves under traffic. The surrounding cracks will be fairly wide and signs of pumping around the edge of the block may be apparent (Fig A1.8). Punchouts are divided into two categories: those shorter than 20 feet and those longer than 20 feet.

Recording. The length of a punchout is determined by the length of the longitudinal crack forming a side of the punchout. Even if this longitudinal crack were to extend across several transverse cracks, only one punchout would be recorded. The number of minor and severe punchouts per 0.2-mile section are recorded on the survey sheet.

Comments. Difficulties exist in distinguishing between a long punchout and a longitudinal crack. A longitudinal crack is generally not fatigue associated, but results from ground movements or construction defects. A long punchout can be recorded as a number of smaller punchouts if the longitudinal crack has distinct kinks in it, as shown in Fig A1.9. Longitudinal cracks forming the sides of long punchouts are generally narrow. The development of a severe punchout is much slower in the case of long punchouts than in the case of short punchouts.

Repair Patches

Definitions. Severe punchouts are repaired by patching the pavement. A repair patch is defined as a repaired section of the pavement where the repair work has been carried out to the full depth of the concrete. Asphalt concrete repair patches and portland cement concrete repair patches are distinguished from each other.

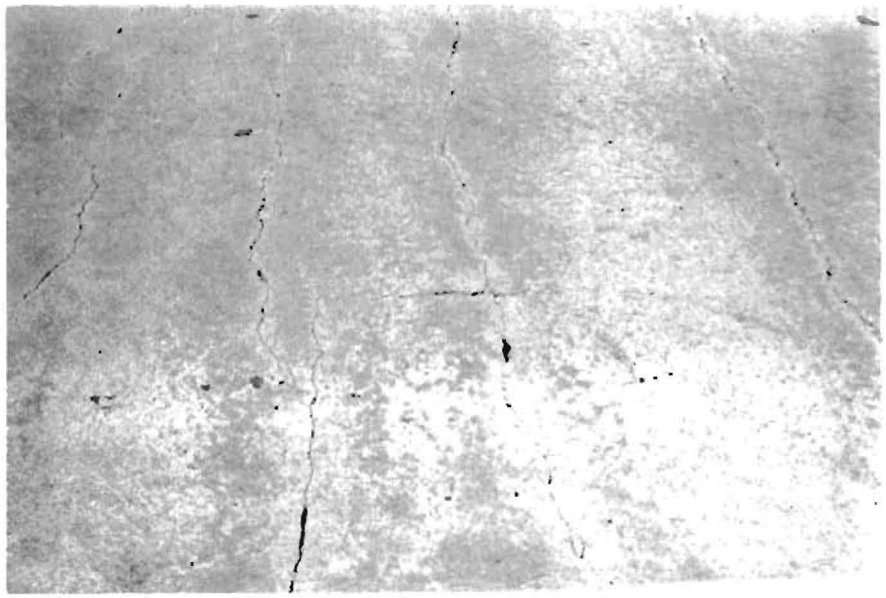


Fig A1.7. Minor punchout.

Fig A1.8. Severe punchout.

Fig A1.9. Punchouts > 20 feet.

Recording. The condition and size of the patch is not recorded. Patching of spalling and overlaying part of the concrete pavement are not classified as patches.

Comments. A number of different patching methods are used. Patch sizes may vary from being little larger than the original punchout (Fig A1.10) to a full lane width, as shown in Fig A1.11. Although the 1974 statewide condition survey, in which the size of the patches was measured, recorded a large number of patches of roughly 7.5 square feet, it is envisaged that this type of patchwork will be gradually phased out and replaced with patches of approximately 75 to 100 square feet.

Crack Spacing

Definition. The crack spacing is the distance in feet between transverse cracks in the outer lane of the roadway.

Recording. A 300-foot section of pavement around the middle of the job, is selected for measuring the crack spacing. Should the job be longer than 5 miles, the crack spacing is measured approximately every 3 miles. The distance between transverse cracks is measured to the nearest 0.1 foot. The cumulative distance to each crack is recorded on the field sheets.

Comments. Similarly, to the recording of the spalled cracks, if a Y crack occurs in which both branches of the Y are longer than half the lane width, each branch is regarded as a crack. If the branches of the Y are shorter than half the lane width, the distance to the straighter of the two is recorded.

CONCLUSION

Safety considerations should be borne in mind before a survey is started. The survey vehicle should be equipped with a rotating beacon on its roof in order for it to be clearly visible to other vehicles using the traffic lanes.

The weather and position of the sun also play an important part in the condition surveys. Surveys should not be conducted in poor visibility. This is important not only from the survey point of view but also from the safety standpoint. After a rain, when the road has dried sufficiently to eliminate

Fig A1.10. Small concrete patch.

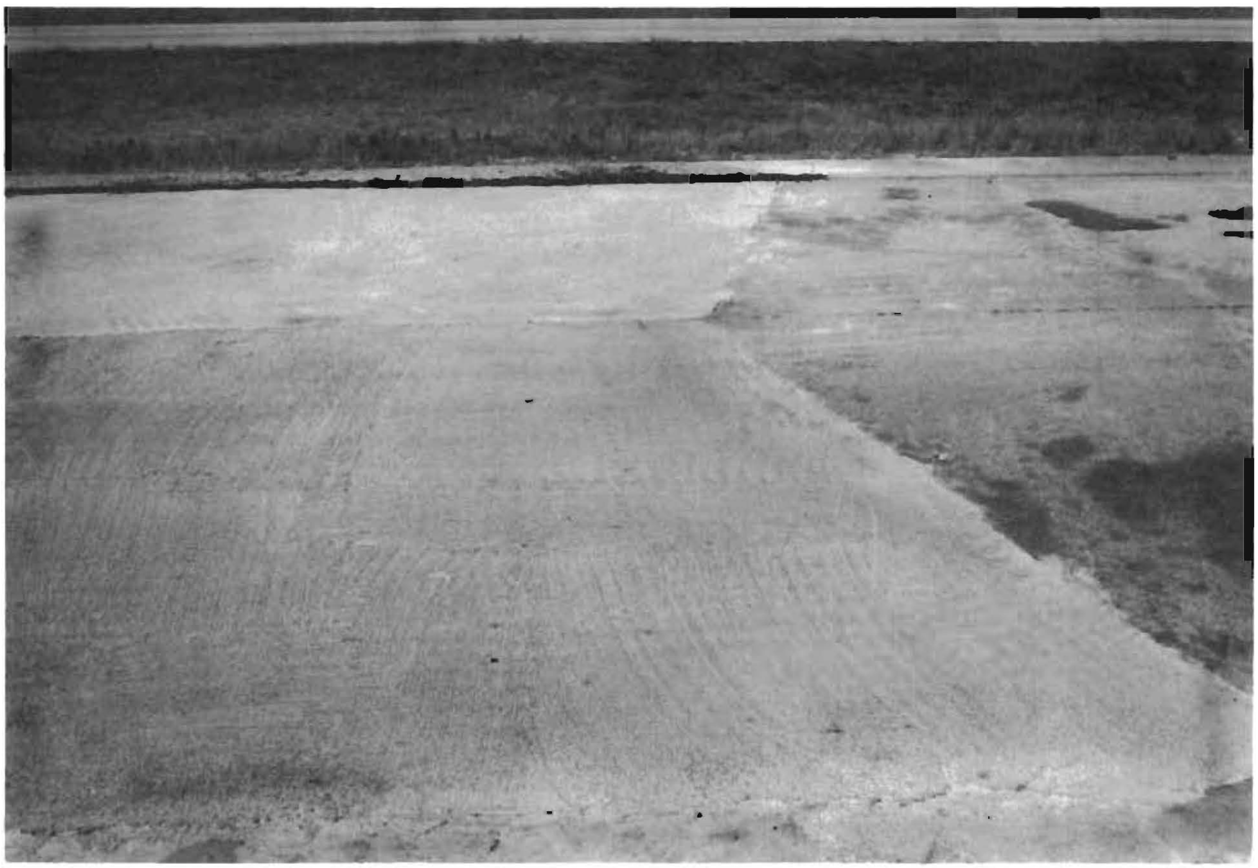


Fig A1.11. Large concrete patch.

any vehicle spray, the cracks and pumping along the road may stand out more clearly.

It is preferable to survey with the sun on the left hand side of the survey vehicle. Although this is uncomfortable for the surveyors, it provides better vision with regard to spalls and cracks. If the sun is on the right side of the survey vehicle, the vehicle shadows may interfere with the survey. This positioning is not always possible to achieve.

Some surveyors may prefer to divide the counting of the distress manifestations in another manner than the previously recommended division. This may also depend on the extent of the different distress manifestations.

Finally, the survey should be done as quickly as possible but should be slowed down if bad sections are encountered.

APPENDIX 2

INPUT GUIDE FOR PROGRAM CONSRV

APPENDIX 2. INPUT GUIDE FOR PROGRAM CONSRV

INTRODUCTION

Two statewide condition surveys have been conducted on CRCP in Texas. The first survey, in 1974, was done in a manner slightly different from that of the second survey, done in 1978. The surveys generated large amounts of data which needed to be summarized in order to be presented. The CONSRV program was written to both summarize the 1978 condition survey data and to present the 1974 and 1978 data in a comparative manner. The program may provide a basic model for future programs which may be written to include future data.

Inputs

The program is designed to operate on a condition survey data file for an entire district. The district file is divided into sections based on the SDHPT job section and control number. For ease of identification, each section has been allocated a CTR number.

An input file is built up for each district. The file is broken up into the above mentioned sections, each separated by an end of record card.

Due to the differences in the 1974 and 1978 survey procedures and the corresponding differences in the data gathered, an input is required which will facilitate transformation of the 1974 failure data to the 1978 failure data. Failures include severe punchouts, asphalt patches, and portland cement concrete patches. In 1974 these data were recorded as square feet of failures per mile of road. In 1978 the patch sizes were not estimated and only the number per length of road was recorded. The first card in the entire input life is a card listing the average patch and punchout sizes. These sizes are calculated for the 1974 data as a weighted average.

Each section has two heading cards which provide identification information. The 1978 condition survey data cards follow the heading cards.

The road is divided into 0.2-mile segments. Each segment has a separate input card listing all the various distress manifestations in that segment. The heading cards and segment card are formatted as shown in Fig A1.1.

Crack survey data cards are included in the file. The crack survey data are formatted as shown in Fig A1.2. These cards are inserted between the segment cards corresponding to the segments in which the crack spacing measurements were taken. The crack survey cards must be preceded by a card labelled CRACK. The card CRACK should be typed starting in column 13. This word acts as a switch to the program indicating that the following cards should be read as crack spacing data.

At the end of the 1978 data, a card with the word CONDITION is inserted. As with the CRACK cards, CONDITION should also be typed starting in column 13. This card serves as a switch to the program indicating that the 1974 condition survey data follows.

The 1974 data forms fill the remainder of the section in the district file. The 1974 data are followed by an end card. Subsequent sections are added in the above manner, each separated by an end card. In this manner, an input file for a district is built up. An echo print of an input record for one section is shown in Fig A2.1.

Outputs

The CONSRV program produces an output file which lists all the 1978 distress manifestations for one-mile segments. Where crack spacing data is available, the crack spacing statistics are listed within the mile where the measurements are taken. An example of the type of output is shown in Fig A2.2.

The program also lists the project identification information shown in Fig A2.3. This information is taken off the section heading cards and is reproduced in an orderly fashion.

A further summary is produced which shows the 1974 and 1978 failure data in a comparative manner. This summary is shown in Fig A2.4. A summary showing the 1974 and 1978 riding quality data is also produced. This information is shown in Fig A2.5.

Due to the crowded manner in which the crack spacing data are input, the program provides an error message if an error is found in the crack spacing inputs. Errors typically include nonsequential data as formatting errors. Table A2.1 shows a typical layout of the input file to the program.

```
152.0 18.310    1                   1                                        3.4
152.3 18.630
            END
17   675       5    IH-45     11.0         SBMADISON      6    1700     9 19 78
152.2146.8     N.JCT US75 N OF MADISONVILLE  LEON COUNTY LINE        TEAM 1
152.2 18.600                  32  33   6   1   7   3   1                     3.1
 52.3 18.310                  53  13   4       3   1                       8 3.2
151.8 18.110                  54  34  15   1   4   4                       9 3.1
151.6 17.910                  31   5  16       1   1   2                   3 2.9
151.4 17.710                  33   5  16       2   1   1                   1 2.7
151.2 17.510                  34   5   9                                     3.0
151.0 17.320                  20   2   8                                     3.4
150.8 17.120                  20  24   6       1                             3.4
150.6 16.920                  26  41  10       2   1                         3.4
150.4 16.720                  22   8   7                                     2.9
150.2 16.520                  22   7  17           4                         3.4
150.0 16.330                  15   1  13                                     3.7
149.8 16.130                  34  28  21       2                             3.0
149.6 15.930                  15  10  13       1                           1 2.9
149.4 15.730                  22   6   4   1   2   2   2                   3 3.3
149.2 15.530                  33  35   3                                     2.6
            CRACK
  1.8  3.8  5.6  9.8 13.7 15.7 17.7 19.9 25.4 29.6 31.5 33.6 37.5 41.5 45.4 49.4
 53.5 55.4 57.4 61.2 67.2 69.2 71.2 75.4 78.9 81.2 83.0 87.0 90.9 93.0 94.9 96.9
100.8104.9108.9110.8114.7116.8118.8122.6126.7128.7131.7134.5136.4138.6144.4146.5
148.4152.4158.8160.2162.1164.3169.9172.0175.2181.9183.9185.9187.8189.8191.8193.8
195.7197.7199.9201.6205.7209.7211.6215.6219.5221.5225.5227.4231.4235.4238.7241.2
247.3250.6251.2253.8257.3261.1263.1264.9269.1270.9276.9278.8280.8282.8286.7290.8
293.8294.8300.3    .    .    .    .    .    .    .    .    .    .    .    .    .
-1.0
149.0 15.340                  30  10  18                   1           1     3.4
 48.8 15.140                  17   1  13                                     3.4
 48.6 14.940                  28   5   7                                     3.3
148.4 14.740                  15   6   4                                     3.4
148.2 14.540                  28  21   5                                     3.6
148.0 14.350                  32  13  11                                     3.3
147.8 14.150                  33   3   9                                     3.5
147.6 13.950                  30  11   8                                     3.2
147.4 13.750                  55  58   7       1       1                     3.2
147.2 13.550                  24  72   1                                   1 3.5
147.0 13.350                  24  12                                       2 3.2
146.8 13.150                                                                 3.2
            CONDITION
152.2 18.600    1                   1        1       1                 1     3.5
152.0 18.310    1                   1   1                                    3.7
151.8 18.110    1                    1                                       3.2
151.6 17.910    1                    1                                       2.9
151.4 17.710    1                   1                                        3.2
151.2 17.510    1   1               1                                        3.4
151.0 17.320    1   1                                                        3.4
150.8 17.120    1                                                            3.4
150.6 16.920    1   1                                                        3.4
150.4 16.720    1   1               1                                        3.5
150.2 16.520    1   1                                                        3.5
150.0 16.330    1   1                1                                       3.4
149.8 16.130    1   1                1  1                                    3.2
149.6 15.930    1    1               1                                       3.3
  9.4 15.730    1    1      1         1 1    2 1 1     1                     3.3
149.2 15.530    1    1              1                                        3.3
149.0 15.340    1    1      1   1    1                                       3.6
148.8 15.140    1   1               1                                        3.3
148.6 14.940    1           1                                                3.5
```

Fig A2.1. Echo print of input to program CONSRV.

PROJECT SUMMARY SHEET
DISTRICT 17

****
CFHR NO.1703 HIGHWAY IH-45 NB (CONTINUED)
****

MILE POST:	155.2	156.2	157.2	158.2
MILE POINT:	2.919	3.907	4.896	5.884

****

LENGTH (MILES):	1.0	1.0	1.0
LENGTH OVERLAYED SINCE 1974:	0.0	0.0	0.0
SERVICEABILITY INDEX (1978):	3.5	3.3	3.3
CRACK SPACING (FEET)			
MEAN:	-	2.9	-
STANDARD DEVIATION:	-	1.3	-
PERCENT SPALLING			
MINOR:	-	7.7	-
SEVERE:	-	0.0	-
PERCENT PUMPING			
MINOR:	3.4	2.4	5.2
SEVERE:	0.0	0.0	0.0
NUMBER OF SPALLING CRACKS			
MINOR:	111	141	146
SEVERE:	6	0	0
NUMBER OF PUNCHOUTS			
MINOR - L.T. 20 FT:	0	0	0
- G.T. 20 FT:	0	0	0
SEVERE - L.T. 20 FT:	0	0	0
- G.T. 20 FT:	0	0	0
A.C. REPAIR PATCHES:	0	0	0
P.C.C. REPAIR PATCHES:	0	0	0

****

Fig A2.2. Mile by mile output.

PROJECT IDENTIFICATION INFORMATION
DISTRICT 17

CFHR NO.	HWY	COUNTY	CTRL	SEC	JOB	LENGTH	AGE (YRS)	SURVEY DATE
1701 NB	IH-45	WALKER	675	7	4	11.6	17.4	9 18 78
(MONTGOMERY COUNTY LINE TO HUNTSVILLE LOOP)								
1701 SB	IH-45	WALKER	675	7	4	11.4	17.4	9 18 78
(MONTGOMERY COUNTY LINE TO HUNTSVILLE LOOP)								
1702 NB	IH-45	WALKER	675	6	8	14.8	14.9	9 18 78
(N END HUNTSVILLE LOOP TO 1.4 MI.S.MADISON CO.LINE)								
1702 SB	IH-45	WALKER	675	6	8	15.0	14.9	9 18 78
(N.END HUNTSVILLE LOOP TO 1.4MI.S.MADISON CO. LINE)								
1705 NB	IH-45	MADISON	675	5	3	12.8	11.0	9 18 78
(N.END N.BEDIAS CR.BRIDGE TO JCT.US75 N MADISONVILLE)								
1705 SB	IH-45	MADISON	675	5	3	13.2	11.0	9 18 78
(N.END N.BEDIAS CR BRIDGE TO JCT US75 N MADISONVILLE)								
1703 NB	IH-45	LEON	675	4	5	12.8	11.0	9 19 78
(MADISON COUNTY LINE TO 50.4FT.S.OF CENTERLINE ST)								
1703 SB	IH-45	LEON	675	4	5	12.8	11.0	9 19 78
(MADISON COUNTY LINE TO 50.4FT.S.OF CENTERLINE ST)								
1704 NB	IH-45	MADISON	675	5	6	6.1	11.0	9 19 78
(N.OF JCT.US75 N. MADISONVILLE TO LEON COUNTY LINE)								
1704 SB	IH-45	MADISON	675	5	6	5.6	11.0	9 19 78
(N.JCT US75 N OF MADISONVILLE TO LEON COUNTY LINE)								
1707 NB	IH-45	LEON	675	3	5	16.2	9.0	9 19 78
(.8MI.N.OF ST.7,W. CENTERVILLE TO FREESTONE COUNTY LINE)								
1707 SB	IH-45	LEON	675	3	5	16.0	9.0	9 19 78
(.8MI.N ST.7 W OF CENTERVILLE TO FREESTONE CO. LINE)								
1710 NB	IH-45	FREESTONE	675	2	5	17.2	7.0	9 20 78
(LEON COUNTY LINE TO JCT.US-84 SW OF FAIRFIELD)								
1710 SB	IH-45	FREESTONE	675	2	5	17.2	7.0	9 20 78
(LEON COUNTY LINE TO JCT US84 S.W.OF FAIRFIELD)								
1709 NB	IH-45	FREESTONE	675	1	6	.6	7.0	9 20 78
(JCT.US-84 SW OF FAIRFIELD TO .5 MILES NORTH)								

Fig A2.3. Project identification information.

FAILURE SUMMARY FOR DISTRICT 17
(CONTINUED)

CFHR NO.	AGE	LENGTH	REPAIR PATCHES (NO./MILE) A.C. 1974/1978	REPAIR PATCHES (NO./MILE) P.C.C. 1974/1978	PUNCHOUTS (NO./MILE) 1974/1978	FAILURES (NO./MILE) 1974/1978	FAILURES (TOTAL) 1974/1978
1709 SB	7.0	.8	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0 / 0
1708 NB	7.5	12.2	0.0 / .7	.1 / .3	.1 / .7	.2 / 1.7	2 / 21
1708 SB	7.5	12.0	.5 / 1.2	0.0 / .4	.1 / 3.3	.6 / 4.9	7 / 59
1706 NB	10.0	2.4	.8 / 1.7	0.0 / 0.0	0.0 / 1.3	.8 / 2.9	2 / 7
1706 SB	10.0	2.3	1.3 / .4	0.0 / .9	0.0 / 3.5	1.3 / 4.8	3 / 11
1711 NB	6.2	12.8	0.0 / 0.0	0.0 / 0.0	0.0 / .1	0.0 / .1	0 / 1
1711 SB	6.2	12.4	0.0 / 0.0	0.0 / .2	0.0 / .4	0.0 / .6	0 / 7
DISTRICT MEANS:			2.5 / .4	2.2 / .4	1.3 / 1.0	5.9 / 1.8	68.8 /18.4

NOTES: AVERAGE SIZE OF A.C. PATCH = 17.8 SQ.FT.
AVERAGE SIZE OF P.C.C. PATCH = 36.4 SQ.FT.
AVERAGE SIZE OF PUNCHOUT = 2.6 SQ.FT.

* - INDICATES SECTION CONTAINS OVERLAY(S).

Fig A2.4. CONSRV output summary.

RIDING QUALITY SUMMARY
DISTRICT 17

CFHR NO.		HWY	AGE (YRS)	LENGTH (MILES)	MEAN SERVICEABILITY INDEX 1974	1978
1701	NB	IH-45	17.4	11.6	3.1	I
1701	SB	IH-45	17.4	11.4	3.2	I
1702	NB	IH-45	14.9	14.8	3.4	3.5
1702	SB	IH-45	14.9	15.0	3.4	3.4
1705	NB	IH-45	11.0	12.8	3.4	I
1705	SB	IH-45	11.0	13.2	3.3	I
1703	NB	IH-45	11.0	12.8	3.3	3.2
1703	SB	IH-45	11.0	12.8	3.4	3.4
1704	NB	IH-45	11.0	6.1	3.4	3.3
1704	SB	IH-45	11.0	5.6	3.4	3.2
1707	NB	IH-45	9.0	16.2	4.0	4.1
1707	SB	IH-45	9.0	16.0	4.0	4.0
1710	NB	IH-45	7.0	17.2	4.0	3.9
1710	SB	IH-45	7.0	17.2	3.9	3.8
1709	NB	IH-45	7.0	.6	3.5	3.6
1709	SB	IH-45	7.0	.8	3.6	3.3
1708	NB	IH-45	7.5	12.2	4.0	3.8
1708	SB	IH-45	7.5	12.0	3.8	3.6
1706	NB	IH-45	10.0	2.4	3.5	3.6
1706	SB	IH-45	10.0	2.3	3.6	3.5
1711	NB	SH-6	6.2	12.8	3.7	3.4
1711	SB	SH-6	6.2	12.4	3.6	3.3
DISTRICT MEANS:					3.6	3.6

Fig A2.5. Riding quality summary.

TABLE A2.1. INPUT DATA CARD LAYOUT

Card 1 A -	Only before the first section - patch and punchout size
Card 1	Title
Card 2	Title
Card 3	1978 data
Card 4	1978 data
.	
.	
.	
Card M	1978 data
Card M + 1	CRACK
Card M + 2	Crack spacing data
.	
.	
.	
Card N	BLANK CARD
Card N + 1	1978 data
.	
.	
.	
Card P	CONDITION
Card P + 1	1974 data
.	
.	
.	
Card R	1974 data
Card R + 1	END

APPENDIX 3

CONDITION SURVEY MANUAL FOR JOINTED AND JOINTED REINFORCED CONCRETE PAVEMENT

APPENDIX 3. CONDITION SURVEY MANUAL FOR JOINTED AND JOINTED REINFORCED CONCRETE PAVEMENT

INTRODUCTION

The following survey procedure has been prepared at the request of the Texas SDHPT. The procedure is structured so that information which will provide an objective measurement of the condition of a jointed concrete pavement may be collected efficiently. The survey data may be used for scheduling rehabilitation and may be helpful in the design of overlays. Long-term use of the survey procedure should provide information regarding the effectiveness of different maintenance procedures and the relative importance of the different distress manifestations.

Development of the Condition Survey Procedure

This jointed pavement conditon survey procedure has not been used to a large extent in the field. It has been based on concepts used in the development of the CRCP condition survey procedure which has been used with success in the statewide conditon survey in Texas.

The condition survey data collected will provide a data base which may be used for a number of purposes. The condition survey data may be used to verify design predictions of the pavement's structural life and to schedule major maintenance and rehabilitation.

In order to make the survey procedure as comprehensive as possible, a large number of different distress manifestations are observed. Reinforced and unreinforced pavements may exhibit different distress types. A transverse crack in an unreinforced pavement may cause more structural damage than a transverse crack in a reinforced pavement.

Different joint types may also exhibit different distress manifestations. For example, spalls along a wrinkled tin joint may be fairly deep before significant load transfer is lost at the joint. In the case of a dowelled joint, such a deep spall may result in further cracking and loss of load transfer.

The most significant and severe distress in jointed concrete pavement generally occurs along the joints. Joint deterioration leads to a rapid loss of riding quality and early structural failure. A number of joint distress types are observed, as follows:

(1) joints with cracking,
(2) spalled joints,
(3) faulted joints,
(4) patches at joints,
(5) bad joint sealant, and
(6) pumping at joints.

The distress types are described later in this report. In addition to the distress occurring at the joints, a significant amount of distress may occur in the slab remote from the joints. The following distress types in the slab are observed:

(1) reinforced concrete,
  (a) transverse cracks,
  (b) spalled transverse cracks, and
  (c) faulted transverse cracks;

(2) unreinforced concrete,
  (d) cracked slabs and
  (e) shattered slabs;

(3) both reinforced and unreinforced concrete,
  (f) patches and
  (g) pumping.

In order to make the survey as objective as possible, most of the distress manifestations are counted and not estimated. In this manner no subjective measurement of the severity and extent of a distress manifestation will result. In the interests of speed, time consuming measurements are avoided.

Regular surveys of the above distress manifestations should provide conclusive results regarding the significance of each type of distress in the gradual development of pavement failure. Pavement systems failure occurs due to the combined effect of a number of deteriorating factors. Economy, structural behavior, and pavement performance all combine to bring about failure of the pavement and the need for rehabilitation. This survey should provide the necessary detail regarding the structural capacity of the pavement. To this end, it is recommended that the following distress manifestations be added together in order to provide an indication of pavement structural failure:

(1) joints with cracking,
(2) faulted joints,
(3) patches at joints, and
(4) slab patches.

For reinforced concrete pavement, faulted transverse cracks may be added to the above list. For nonreinforced concrete pavements, cracked and shattered slabs may be added to this list.

All the above distress manifestations will indicate some serious local structural failure in the pavement. Grouped together they may be termed serious failures and the statistic "failures per mile" should provide an indication of the overall structural condition of the pavement.

Some work will still be required to write the necessary computer program which will operate on the data and provide output in a summarized form. The existing CRCP program and output structure should serve as a model in this regard.

Procedure for the Jointed Concrete Pavement Condition Survey

The distress manifestations observed are

Slab Associated Distress

(1) number of transverse cracks for reinforced concrete pavement,
(2) number of spalled transverse cracks for reinforced concrete pavement,
(3) number of faulted transverse cracks for reinforced concrete pavement,
(4) number of cracked slabs for unreinforced concrete pavement,
(5) number of shattered slabs for unreinforced concrete pavement,
(6) number of patches in the slab, and
(7) percent of the roadside edge which is pumping.

Jointed Associated Distress

(1) number of spalled joints,
(2) number of faulted joints,

(3) number of joints with cracking,

(4) number of patched joints,

(5) number of joints with bad joint sealant, and

(6) number of joints which are pumping.

These distress manifestations are noted on the field sheet shown in Fig A3.1.

The procedure for the survey is as follows: The roadway is divided into sections which correspond to the SDHPT control sections and job numbers. The road is surveyed by two people who travel in a vehicle on the shoulder at approximately 5 miles per hour. Depending on the condition of the roadway, the driver and passenger may keep track of different distress manifestations. The driver will typically note distress manifestations which can be seen from a distance. This will enable the driver to concentrate on driving as well as surveying.

Since the survey is done at varying speeds, depending on the amount of distress in the pavement, a vehicle equipped with automatic transmission and a flashing light should be used.

The Survey Form

A copy of the survey form is shown in Fig A3.1. The form provides space to identify the county, district, highway, and direction, as well as the control, section and job number. The exact location of the section must be fixed by relating the ends of the section to some detail which can be located on a map of the area. The date of the survey and the name of the survey team should also be entered on the sheet. The slab joint spacing is also entered on the field sheet.

In the field, the only references to position are the mileposts. Further subdivision into 0.2-mile segments is facilitated by the trip recorder of the vehicle. In order to tie the various 0.2-mile sections in with SDHPT records, space is provided for the mile points of the highway. These mile points can be obtained from road logs.

Between the column provided for mile points and the column for the number of spalled transverse cracks, space is provided for comments about bridges and other structures or landmarks within the 0.2-mile section. The observed

JOINTED CONCRETE PAVEMENT CONDITION SURVEY

DIST	CONTROL	SECT	JOB	HIGHWAY	DIR	COUNTY	J. SPACING	AGE	MO DAY YEAR	TEAM	

LOCATION FROM	TO

MILE POST	MILE POINT	COMMENTS: OVERLAYS, BRIDGES, RAMPS, LANDMARKS	SLAB ASSOCIATED DISTRESS: NON-REINFORCED – CRACKED SLABS	SLAB ASSOCIATED DISTRESS: NON-REINFORCED – SHATTERED SLABS	SLAB ASSOCIATED DISTRESS: REINFORCED – TRANSVERSE CRACKS [No]	SLAB ASSOCIATED DISTRESS: REINFORCED – TRANSVERSE CRACKS – SPALLED	SLAB ASSOCIATED DISTRESS: REINFORCED – TRANSVERSE CRACKS – FAULTED	ASPHALT PATCHES [No]	P.C.C PATCHES [No]	EDGE PUMPING %	JOINT ASSOCIATED DISTRESS: SPALLED JOINTS [No]	FAULTED JOINTS [No]	CRACKING AT JOINTS [No]	ASPHALT PATCHES [No]	PCC PATCHES [No]	BAD JOINT SEALANT [No]	JOINT PUMPING [No]
1 2 3 4 5	6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23	24 25 26 27	28 29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48 49 50	51 52 53 54 55	56 57 58 59 60	61 62 63 64 65	66 67 68 69 70	71 72 73 74 75	76 77 78 79 80
1 2 3 4 5	6 7 8 9 10	11 12 13 14 15 16 17 18 19 20	21 22 23	24 25 26 27	28 29 30	31 32 33	34 35 36	37 38 39	40 41 42	43 44 45	46 47 48 49 50	51 52 53 54 55	56 57 58 59 60	61 62 63 64 65	66 67 68 69 70	71 72 73 74 75	76 77 78 79 80

Fig A3.1. Field sheet for recording distress of jointed concrete pavement.

quantities of the various distress manifestations should be right-justified on the field sheets.

Although distress manifestations are observed between, for example, mileposts 128.8 and 128.6, the rows of the field sheet are not staggered as one would expect in order to note the distress between the mileposts. For ease of computation, the distress manifestations are noted in the same row as the preceding milepost. If for example, 100 minor spalled cracks were counted when traveling from milepost 128.8 to milepost 128.6, this figure whould be written in the same row as milepost 128.8. When traveling in the opposite direction, from milepost 128.6 to milepost 128.8, the observations would be noted in the same row as milepost 128.6.

Distress Descriptions

Slab Associated Distress. These distress manifestations occur along the length of the slab and not in the vicinity of a joint. The first three distress manifestations refer only to jointed reinforced concrete pavement.

(1) Transverse cracks. Transverse cracks occur at intervals along the slab. Transverse cracks in the vicinity of a joint, which may have resulted from some joint defect, do not fall into this category. Transverse cracks occur as a result of temperature drop stresses, drying shrinkage, and traffic loading.

All the transverse cracks in the outer lane of the roadway are counted. Cracks which do not extend past the middle of the lane are not counted.

(2) Spalled transverse cracks. Spalling is the widening of existing cracks by secondary cracking or breaking of the concrete at the cracked edges. Spalling results from traffic loading and from stresses which occur due to material entering the crack and resisting thermal expansion. Both these situations result in high stresses in the upper edge of the concrete along the crack and a spall results.

The number of spalled cracks in the outer lane is recorded. If the spall is less than an inch wide and deep and only a few of these spalls occur along the length of a crack, the crack is not counted as spalled (Fig A3.2). For a crack to be counted as spalled, a significant amount of spalling must have occurred (Fig A3.3) and a drop in the riding quality of the pavement must result. If the spall has been patched, the spalled crack should be counted and not the patch.

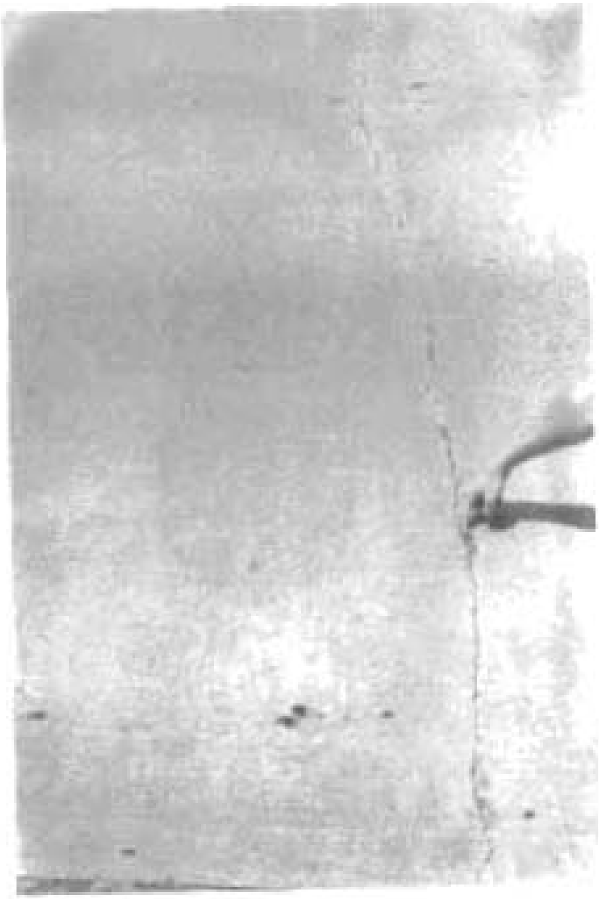


Fig 3A.2 Minor spalling not counted.

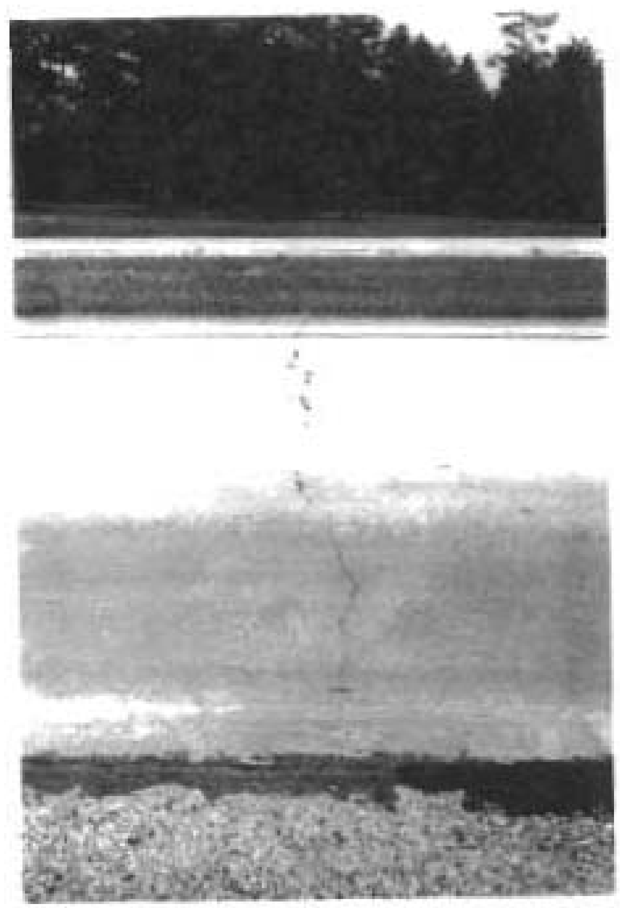


Fig 3A.3. Severe spalling counted.

(3) Faulted transverse cracks. Faulted transverse cracks occur as a result of a loss in subgrade support and traffic loading. The concrete in the immediate vicinity of the steel will break off and the final result will be the difference in the level of the slab across the crack. This will result in a significant loss of riding quality.

The number of faulted transverse cracks in the outer lane of the roadway per 0.2-mile section is recorded.

(4) Cracked slabs. Typical unreinforced slabs are 15 feet long. A crack in this type of slab results in two smaller slabs which may begin to move under load. The number of cracked slabs in both the inside and the outside lane are counted. Corner breaks are not counted as cracked slabs, but rather as joints with cracking. If the joint side of the corner break triangle is longer than half a lane width, then the corner break is counted as a cracked slab. Longitudinal cracks may also result in cracked slabs.

(5) Shattered slabs. These slabs are counted similarly to the cracked slabs except that the slab should be broken into three distinct pieces in order to be counted as a shattered slab.

(6) Slab patches. The number of repair patches in both lanes of the roadway are recorded. Portland cement concrete and asphalt concrete patches are recorded separately. Neither the condition nor the size of the patch is recorded.

(7) Edge pumping. Water passes through cracks in the pavement and penetrates the sublayers. When a load, such as a heavy vehicle passing over the crack, is applied, the water is forced out of the crack, taking fine material of the sublayers with it. This is defined as pumping. From the survey vehicle, pumping is generally evident from an accompanying stain on the shoulder of the road.

The length of the edge crack causing this staining is estimated and divided by the length of the section (approximately 1000 feet) to arrive at a percentage. Because it is difficult to estimate the length of the edge crack which is pumping, this result will be slightly subjective.

Joint-Associated Distress

This distress should be directly related to the joints in the pavement.

(1) Spalled joints. Spalled joints occur in a similar manner to spalled cracks. The number of joints exhibiting spalls which are wider and deeper than one inch are recorded. The whole joint across both trafficked lanes should be examined for spalls.

(2) Faulted joint. The number of faulted joints per 0.2-mile section is recorded. The joint should be examined across both lanes for faulting.

(3) Joints with cracking. A large number of different crack types and patterns occur at joints. In order to simplify the recording

of this distress form, all the crack types have been grouped under one heading. Figure A3.4 shows a number of different crack patterns at a joint. The number of joints with cracking in every 0.2-mile section are recorded. The joint should be examined across both lane widths for cracking.

(4) Patched joints. When the cracking at a joint becomes severe, the joint is repaired with a patch. The number of patched joints per 0.2-mile section is recorded. The joint should be examined for patches in both trafficked lanes. Care must be taken to count a repaired spall not in this category but rather in the spalled joint category.

(5) Bad joint sealant. Traffic and environment will cause a deterioration of the joint sealant in the pavement. Eventually some of the sealant will be stripped out of the joint and water may pass through the joint. The number of joints in which the sealant is significantly damaged are recorded. The joint should be examined across both lanes of the roadway.

(6) Pumping joints. Once the joint sealant has failed, water may pass through the joint and pumping may occur. Tell-tale pumping stains will be removed by traffic in the dry season. Thus, if any accurate recrod of this distress manifestation is required, the condition survey should be carried out immediately after a period of rainfall. The number of joints exhibiting pumping in one 0.2-mile section is recorded. The joint should be examined across both traffic lanes for pumping.

CONCLUSIONS

The survey should preferably be conducted with the sun facing the left side of the survey vehicle. If the sun is on the other side of the survey vehicle, the vehicle shadow may hinder surveying.

The above survey procedure should result in objective measurements of pavement distress types. Should a particular form of distress, not indicated in the procedure, be prevalent along a certain pavement, this distress type can be counted instead of one of the other distress types which may not be present.

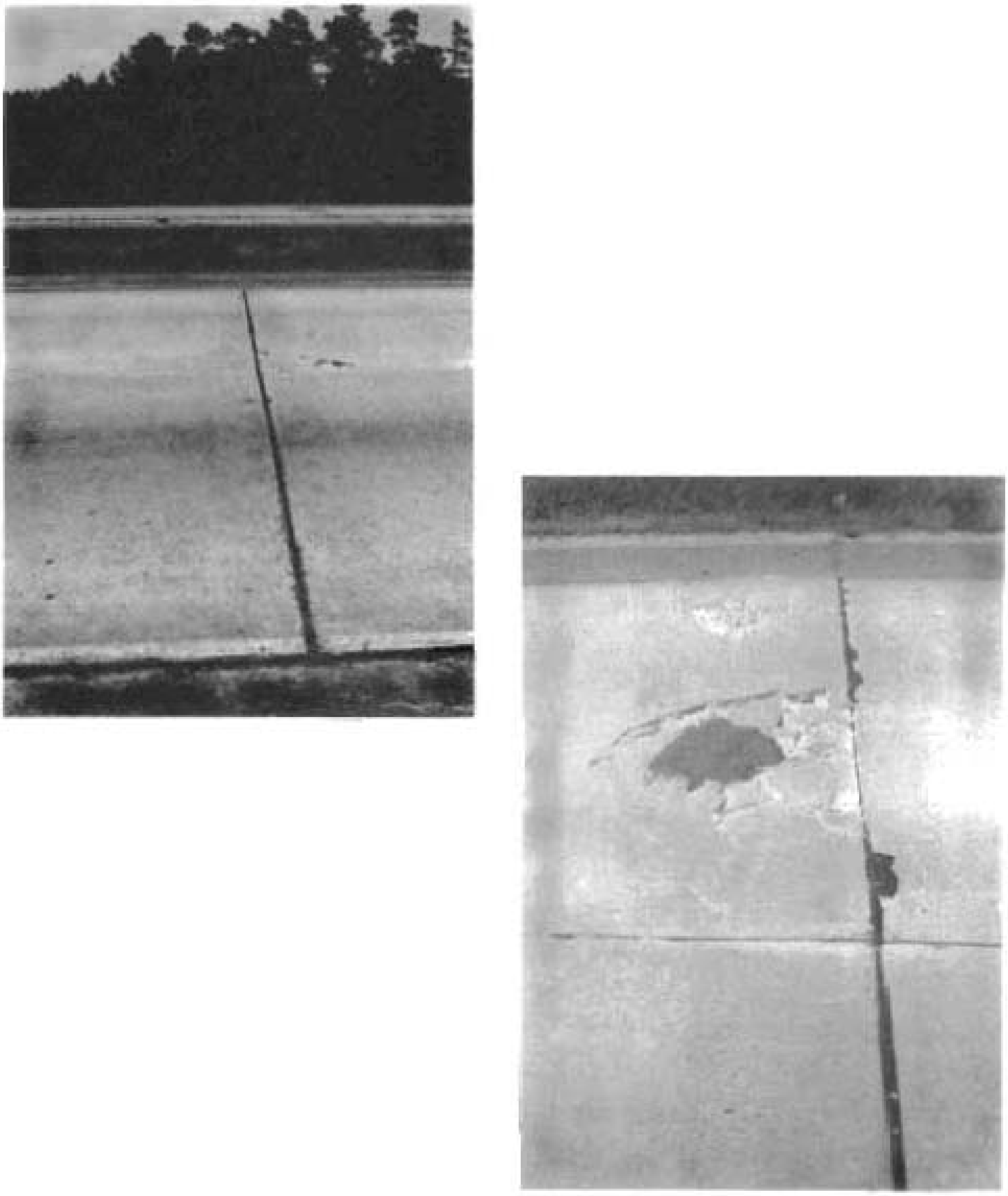


Fig A3.4. Joints with cracking.

THE AUTHORS

Arthur Taute received his B.S. degree in Civil Engineering at the University of Stellenbosch, South Africa, in November 1974. He has had several years of experience in Civil Engineering construction in the geotechnical and tunnelling fields and further experience as a consulting engineer in the pavement design field in South Africa. He joined the Center for Transportation Research at The University of Texas at Austin as a Research Assistant in the Fall of 1978, and he has done research on rigid pavement overlay designs.

B. Frank McCullough is a Professor of Civil Engineering at The University of Texas at Austin, and is Director of the Center for Transportation Research. He has strong interests in pavements and pavement design and has developed design methods for continuously reinforced concrete pavements currently used by the State Department of Highways and Public Transportation, U.S. Steel Corporation, and others. He has also developed overlay design methods now being used by the FAA, U.S. Air Force, and FHWA. During nine years with the State Department of Highways and Public Transportation he was active in a variety of research and design activities. He worked for two years with Materials Research and Development, Inc., in Oakland, California, and for the past nine years for The University of Texas at Austin. He participates in many national committees and is the author of over 100 publications that have appeared nationally.