Wm. J. Kenis HNR-20

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PAVEMENT PROFILE MEASUREMENT SEMINAR PROCEEDINGS

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OCTOBER 5-8, 1987

VOLUME I DATA SEMINAR OVERVIEW

Demonstration Project No. 72

Automated Pavement Data Collection Equipment

FHWA-DP-88-072-003

April 1988

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16. Abstract

The objective of this seminar was to demonstrate the state of the art in data collection equipment used in measuring pavement roughness and profile. In a workshop environment, information was provided for managers and technicians to meet the following specific objectives: (1) To present the theory of operation of pavement monitoring equipment, including items such as the characteristics of pavement profile, theory of equipment sensing devices, data storage, and data processing; and (2) Provide an overview of use and application of data in conjunction with planning, pavement management, and design.

The report documenting the program is prepared in three volumes. Volume I, Seminar Overview, presents a general overview of the seminar. Volume II, Data Collection Equipment, provides detailed descriptions of the equipment demonstrated and data collected. Volume III, Workshop Summaries, contains a report on the workshop findings. Each volume is published separately.

Implementation Results from this demonstration provided information to highway agencies in selecting and operating automated data collection equipment or programs in a cost-effective manner. Using information collected during the seminar, a cross reference of pavement profile equipment data is available. This provides a datum for reported information in such publications as HPMS, legislative requests, pavement condition studies, and others.

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PAVEMENT PROFILE MEASUREMENT SEMINAR 1673r

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VOLUME I

I. OVERVIEW

On October 5 - 8, 1987, nearly 200 engineers and technicians gathered in Fort Collins, Colorado to review the state of the art in pavement smoothness measurement equipment. The four-day event included an intensive program of presentation by recognized authorities on the subject, a demonstration of smoothness testing equipment, an extensive field data collection effort using the equipment demonstrated and a series of workshops on the subject. In attendance were representatives of the public and private sector from the United States and Canada including researchers, data collectors, users, and sales representatives.

This report is intended to document the events of the four-day gathering. The report is designed to be useful to those interested in: (1) purchasing new equipment, (2) comparing performance data, or (3) seeking out additional sources of technology on pavement smoothness measuring equipment.

The seminar was sponsored by the Federal Highway Administration, (Demonstration Project No. 72) and was organized by the Colorado Department of Highways and the Federal Highway Administration. The success of the seminar can be directly attributed to those making presentations at the formal program and workshops, the equipment operators, the attendees, and the many organizers of the activities.

II. BACKGROUND

The use of automated pavement data collection equipment is becoming more popular among highway agencies. As a variety of this equipment becomes available, the selection of that which is appropriate for a given use becomes more difficult. The ability to collect data at highway speeds, reliability of equipment, analysis of volumes of data collected, and presentation which is meaningful to the user are important elements to consider in the equipment selection process. In addition, as various states select equipment suited to their needs, variation in data output exists among states or other highway agencies. Thus, comparing pavement performance among agencies, at the local or national level, becomes difficult because of the inconsistency in data collection procedures. This aspect becomes more important when national data bases are assembled for funding allocation or performance comparisons for pavement management programs.

III. NEED

Throughout the four-day seminar the need for good quality pavement smoothness data was emphasized and agreed upon. The data collection effort is the basis from which many pavement management programs build their analysis. Without this quality control at the beginning of the process, the data analysis becomes skewed with an ultimate misinterpretation by the user.

Labor intensive data collection efforts and analysis are expensive. Modern-day electronic data collection devices can generate volumes of data beyond the comprehension of the pavement engineer. Thus, sophisticated on-board and office automated data processing computers are needed to present the finding in a format acceptable to the user. The seminar was designed to provide a forum to seek out a cost-effective solution to this dilemma.

IV. FORMAL PRESENTATIONS

The seminar began with a full day series of presentations which included the basic concepts of pavement roughness, the current state of the art, and needs of various users. Figure 1 lists the agenda for the four-day seminar including the second day formal presentations.

Detailed proceedings of the individual presentations were not assembled. This information is available in research or operational reports prepared by the various speakers. However, an overall summary of the sessions is discussed below.

FIGURE 1

PAVEMENT PROFILE MEASUREMENT SEMINAR 1256r

AGENDA

Monday, October 5, 1987	Preliminary Events	
8:00 a.m. - 5:00 p.m.	Correlation data collection by participating equipment	Equipment Operators & Data Collection Personnel
4:00 p.m. - 7:00 p.m.	Registration	
Tuesday, October 6, 1987	General Session	
8:00 a.m. - 9:00 a.m.	Registration	
9:00 a.m. - 9:30 a.m.	Presiding	Denis E. Donnelly Research Coordination Engineer Colorado Department of Highways
	Welcome	L. N. MacDonald Regional Administrator Federal Highway Administration
	Remarks	Dwight M. Bower Deputy Director Colorado Department of Highways
9:30 a.m. - 10:00 a.m.	Presentation	"National Perspective of Pavement Smoothness" Wade Gramling Chief Roadway Mgmt. System Development Pennsylvania D.O.T.
10:00 a.m. - 10:30 a.m.	Coffee Break	
10:30 a.m. - 11:15 a.m.	Presentation	"Theory of Pavement Roughness" Mike Sayers Asst. Research Scientist University of Michigan Transportation Research Institute
11:15 a.m. - 12:00 noon	Presentation	"Public Perception of Roughness" Michael S. Janoff Consultant JMJ Research
12:00 noon - 1:00 p.m.	Lunch	

1:00 p.m. - 1:30 p.m.	Presiding	Doyt Bolling Pavement Programs Engineer Federal Highway Administration
	Presentation	"State of the Art of Automated Pavement Smoothness Equipment" Ron Carmichael Project Engineer Federal Highway Administration
1:30 p.m. - 2:00 p.m.	Presentation	"Standardization of Measurement Technology" Peter Spellerberg AASHTO Materials Reference Laboratory
2:00 p.m. - 2:30 p.m.	Presentation	"Strategic Highway Research Program Concern for Smoothness" James M. Sassin Research Engineer Strategic Highway Research Program
2:30 p.m. - 3:00 p.m.	Coffee Break	
3:00 p.m. - 3:30 p.m.	Presentation	"Highway Monitoring System Data Needs" David R. McElhaney Director Office of Information Management Federal Highway Administration
3:30 p.m. - 4:00 p.m.	Presentation	"Pavement Profile as Input to Pavement Management" William Miley Bituminous Materials & Res. Engr. Florida D.O.T.
4:00 p.m. - 4:30 p.m.	Presentation	"Pavement Acceptance Specifications" David Gendell Director Office of Highway Operations Federal Highway Administration
4:30 p.m.	Adjournment	
4:30 p.m. - 6:00 p.m.	Open House	Pavement Smoothness Measuring Equipment Displays

<u>Wednesday, October 7, 1987</u>	<u>Demonstrations</u>	
9:00 a.m. - 9:15 a.m.	General Overview	David Huft Research Engineer South Dakota D.O.T.
9:15 a.m. - 10:00 a.m.	Site Descriptions	Werner Hutter Research Engineer Colorado Department of Highways
10:00 a.m. - 10:30 a.m.	Coffee Break	
10:30 a.m. - 5:00 p.m.	Field Demonstrations of Equipment Operation	
5:00 - 6:00 p.m.	Open House	Pavement Smoothness Measuring Equipment Displays
<u>Thursday, October 8, 1987</u>		
8:00 a.m. - 9:00 a.m.	Presiding	Wm. Jones Project Development Engineer Federal Highway Administration
	Panel Discussion	"Field Demonstration Questions and Answers"
9:00 a.m. - 9:15 a.m.	Workshop Assignments	
9:15 a.m. - 9:45 a.m.	Coffee Break	
9:45 a.m. - 11:00 a.m.	Stream Workshops	Session 1
11:00 a.m. - 12 noon	Stream Workshops	Session 2
12:00 noon - 1:00 p.m.	Lunch	
1:00 p.m. - 2:00 p.m.	Stream Workshops	Session 3
2:00 p.m. - 3:00 p.m.	Workshop Reports	Summary and Recommendations
3:00 p.m.	Adjourn Seminar	

However, the physical properties of the pavement, as measured by various sensing devices are known. For example, the influence of vehicle dynamics, speed, simulation techniques and other factors are being researched. Full understanding of these factors and approaches are far from complete but significant progress is being made.

A recent NCHRP study developed a subjective rating scale based on public's reaction to roadway roughness. Pavement profile was then related to a scale based on public perception determined through this process. As a follow-up, panels were assembled in five different states to evaluate their perception of roughness. The results indicated that there are small differences between the transforms of the five individual states. In addition, the differences between the preferred transform for all five states combined and each individual state transform are less than the error inherent in the panel rating experiment.

VII. GENERAL SESSION III

In this session roughness and profile measurement equipment was described. The FHWA summary discussed commercially available, automated devices, used in the measurement of pavement roughness and profile primarily for purposes of network or system level analyses. Equipment was described in terms of its components, measurements, output and cost.

A recent FHWA research study conducted by the National Bureau of Standards has investigated the accuracy and precision of the K. J. Law 690 Surface Dynamic Profilometer and has assessed the feasibility of using this device to provide calibration services. Preliminary arrangements are being made through the AASHTO Materials Reference Laboratory (AMRL) program to offer such services on a national scale. Traditionally, AMRL has been identified as an agency reviewing procedures of states' materials testing laboratories. The AMRL is now in the process of further evaluating the precision of the Surface Dynamic Profilometer and developing a calibration service proposal. Data collected at this seminar is being used in the development of this proposal.

A presentation was made on pavement data needs of the Strategic Highway Research Program (SHRP). The SHRP requires that periodic measurements be made of actual profiles on all designated sections resulting in large amounts of data being collected. Profile measurement equipment must be capable of repeatability, of detecting and analyzing long wavelengths, and be able to travel at reasonable speeds. The main thrust of the SHRP data base will be to document how pavement profile changes over time.

VIII. GENERAL SESSION IV

The Highway Performance Monitoring System (HPMS) is a national data gathering program coordinated by the FHWA. It is the intent of this Federal program to establish a data base that represents the condition of the national highway program. Currently, pavement condition information as reported by the states is assembled for reports to Congress on the highway system's condition. Changes are being made in the study to gather additional pavement condition data that will better define pavement performance and assist in estimating future needs. Pavement smoothness has been designated as a major factor in this national data base. Thus, the need for consistency among data being submitted by the states is not only important for establishing highway needs before the Congress, but is essential in making comparisons on pavement performance. Beginning in 1989, states will be required to collect additional pavement data, as well as assure better consistency in the data that is reported.

The program in Florida for measuring pavement smoothness has undergone several improvements. For example, consistent, accurate, and reliable data is now being used to determine highway program needs and to make recommendations on corrective actions to be taken to improve the highway system. Most recently, new microcomputer technology has permitted automated handling and analysis of pavement data. Florida feels that these recent hardware and software improvements allow them to exercise better management of their highway system.

The needs of the construction industry in quality control of pavement profile are somewhat different from the needs pertaining to pavement management. High production or high speed data collection which is critical to pavement management is not needed in pavement construction control. Light-weight devices capable of making timely measures on newly-placed pavement surfaces are the devices needed. Such devices must be easily transported, low in cost, produce repeatable results, and not have the calibration problems associated with response-type equipment. At the same time, the interpretation of the pavement surface data should not be labor intensive. The device should be able to produce hard documentation for project record purposes. The equipment must measure a pavement characteristic which can be understood and controlled by the contractor. It must also be able to precisely locate the rough areas of the pavement so that corrections can be made.

The highway industry has concluded that pavement smoothness starts from the bottom up. Contractors are thinking through the entire paving process and are thus developing tighter controls as well as more efficient operations. At the same time, contracting agencies are receiving better workmanship and a better overall product.

A 1987 AASHTO survey identified smoothness specifications being used by states for PCC pavements. Today, there are 24 states employing specifications applicable only to PCC whereas, 8 states employ a ride specification applicable to both AC and PCC.

Both contractors and transportation agencies generally agree that the industry can provide smooth pavements. The key is to pay attention to the basics from the ground up. Attention to proper construction techniques in each layer of the pavement structure will assure the best rideability. The implementation of a rideability specification has been found to result in smoother, better riding pavements.

IX. WORKSHOP SUMMARY

Three major workshop topics were identified to be discussed at the seminar. They included: User Needs, Equipment Selection and Operation, and Data Handling and Presentation. The seminar's attendees were directed to the workshops dealing with their areas of interest as expressed during registration. Each major topic was organized as a stream workshop session and held concurrently. It was not possible for all of the attendees to listen to every session topic. What follows is a brief summary of each of the sessions and the topics discussed. More detailed information for these sessions may be found in the workshop recorder notes of Volume III.

A. Stream Session A - User Needs

This session covered the needs of the equipment users at three levels: network, project, and national. The session was moderated by Paul Theberge of the Maine Department of Transportation. Mr. Theberge posed a number of questions to the group:

- What are our data needs?
- How can we meet our common goals?
- What frequency, accuracy, and precision do we need in our data?
- What other data can be readily obtained?

There was good audience participation during this session. Due to the numbers of people attending the session from different states it was possible to briefly poll those present to see what different states were doing. The user needs of each level overlapped one another and, judging from the audience participation, each session could have easily gone beyond the planned time limitations. The following summarizes the issues comments, and consensus registered for the user at the network level, project level, and the national level:

1. Network Level Pavement Management Needs

This discussion, lead by Al Crawley of the Mississippi DOH, documented a number of network-level uses for profile measurements beginning with budget requests to the state legislature and prioritizing project selections.

Roughness trends not only need to be accurate but repeatable if performance trends are to be developed. This means that response-type devices need to be regularly calibrated and maintained.

Project (design) level data generally cannot be obtained from the network level data. The network surveys usually take place every one to two years for most systems. The states vary the length of their survey period from three to eight months. Pavement sections should be surveyed at the same time of each calendar year. Most states found it to be economical to make distress surveys at the same time as roughness data is collected. Network level data should be transferable to the national level.

2. Project Level/Design Input Needs

This discussion was lead by Andy Gisi of the Kansas DOT. In Kansas the same set of data is used for both project level and network level purposes. A response-type device is used to collect pavement ride data. Additional data is sometimes gathered for project level purposes. The Kansas device is trailer-mounted to provide the constant shape, weight, and attitude needed to provide for repeatable measurements over time. Smoothness measurements made for SHRP will be on the order of 0.005 inches. This is probably far beyond what is necessary. Measurements on the order of 1/16th of an inch are considered more reasonable.

The following questions were addressed during open discussion: Do we really need roughness measurements at the project level or only at the network level? The consensus registered from discussion of this question was that roughness measurements were not critical to project level analysis or design. Can calculations of project milling and leveling quantities or profile grades be calculated from roughness data? Most felt that profile data could be used to a limited extent to develop or estimate the extent of milling or leveling to be done.

What are the benefits of profile-type devices over response-type devices? It was generally concluded that profile devices produce more repeatable measurements. Response devices require calibration and need to be run at a constant speed. Profile devices have the potential of providing more types of information other than just roughness.

Do roughness measurements accurately reflect what the public's perception of roughness is? The sound of the pavement under traffic and the thump over depressed cracks may not be adequately reflected by a roughness measurement as judged from the perspective of the public.

What is the most important criteria for determining rehabilitation strategies? It was felt that the public would choose roughness, while a design engineer would look more closely at distress and its causes.

To what type of vehicle should our roughness measurements be correlated? Ideally, it was determined that roughness measuring devices should remain constant. However, it was also recognized that the resulting measurements should be indicative of the effect it would have on a typical truck.

3. National Monitoring Needs

James Gruver from FHWA Headquarters led this topic. The two major national monitoring programs pertaining to pavements are the Highway Performance Monitoring System (HPMS) and the Strategic Highway Research Program (SHRP).

The HPMS requires very consistent data over a long period of time. In order to improve consistency the FHWA will require reporting pavement ride data in International Roughness Index (IRI) units beginning in 1990. Periodic calibration of response-type roughness devices used to collect this data will be necessary. The calibration procedures used by the World Bank are being proposed by the FHWA. Other requirements are being proposed in the area of traffic monitoring to provide a more uniform comparison among the various agencies.

SHRP activities will require more accurate and precise data than needed for HPMS. It will concentrate on about a thousand selected pavements for a twenty year period to determine pavement performance curves.

In both these areas, standardization of the measurements for roughness and distress are of prime importance.

B. Stream Session B - Equipment Selection and Operation

The session on equipment selection and operation was moderated by James Cable of Iowa State University. A wide variety of equipment is available with varying costs and capabilities. Agencies should not expect a single piece of equipment to meet all of its needs. Proper selection of equipment can only be made after carefully identifying the agencies' requirements. Equipment costs generally vary depending on level of sophistication.

1. Equipment Selection and Procurement

Professor K. P. George of the University of Mississippi led the discussion on this topic. Costs for systems can range between $10,000 for simple profile devices to $100,000 for those that provide a broader range of information such as graphs, photographic records, distress analysis, and roadside information such as signing and maintenance of the right of way.

Purchase considerations should include:

- the type of output available (paper, diskette, tape);
- the versatility of the software, its displays, and the statistics it can provide;
- the calibration procedures to be followed;
- the purpose of the data obtained (project acceptance, rehabilitation needs, or performance trends);
- the repeatability of the data recorded;
- the life of the equipment and its compatibility with future improvements; and
- the technical and maintenance support that will be available from the manufacturer.

Most of the agencies present were using or had used a Mays meter for inventory control. The difficulties in maintaining calibration of the Mays meter has led most agencies to use a California or Ames Profilograph for purposes of construction control. A profilometer resolution of 0.01 feet is suitable for most all needs and users; however, the requirements of SHRP may require twice this resolution (0.005 feet).

2. Equipment Calibration and Maintenance

Calibration of devices can take up to a week. Some considerations for a calibration program are:

- the use of existing highway routes with varying conditions and a range of PSI rating between poor and excellent;

- the measurement of the profile of the roadway test sections;
- the use of a large number of sections (between 20 and 80);
- the length of the test section, preferably between 0.2 and 0.5 miles;
- the frequency of the calibrations, preferably on an annual basis;
- the training of the equipment operators, also preferred on an annual basis; and
- the use of the SHRP standard test sections to correlate to a national standard of measurements.

3. General Operating Considerations

Fred Maurer of the Minnesota DOT was the topic leader for this part of the session. He gave a slide show and a discussion of how the Minnesota DOT collects pavement information on their highway system. Their state uses a trailer-mounted Mays meter. Miscellaneous items presented in this discussion are:

- Testing should be done at about the same time of the year, but there is no hard data on this. The FHWA is doing a study that will look for yearly variations in test sections.
- Minnesota could not run their Mays when the winds were greater than 15 mph. No agency would admit to operating their equipment when water is standing on the roadway.
- Shock absorbers are a concern of everyone. They are replaced frequently, tested, paired, and specified by brand name. The proper testing of the shocks is a concern, as is how their performance varies as a function of temperature. Again, hard data is lacking on this.

- Tire pressures also affect consistency. All those present were using radial tires on their equipment. Skid testing tires are not suitable for pavement smoothness measurement.

- Trailer hitch tongues must be kept level or readings may vary.

- Photographics of distress data will vary with lighting conditions.

- On multi-lane roads most agencies were testing the traffic lane and in the direction with the most truck traffic.

Even with a trailer-mounted device, the condition of the towing vehicle can affect the readings. A change to front-wheel drive might also affect the reading.

C. Stream Session C - Data Handling and Presentation

Glen Kietzman of the South Dakota DOT moderated this session.

1. Data Handling and Interpretation

Norman Mueller of the FHWA's Office of Highway Information Management was the topic leader. He discussed in detail the changes that are to be made to HPMS data reporting requirements. Most of these changes are an expansion of the existing information and will include concrete joint spacings, the use of dowel bars, type of base and subgrade, subsurface drainage, overlay or improvement data, additional pavement types (bonded and unbonded overlays), shoulder types, and the use of the International Roughness Index (IRI) in inches per mile.

A revised HPMS Field Manual will be issued in December of 1987 and implementation workshops will be conducted in February and March of 1988.

Although performance levels are reported to upper management, it is pavement distress that usually triggers rehabilitation efforts. Different states reported different PSI ratings to initiate resurfacing or complete rehabilitation of their pavements.

The duplication of available data is a concern. The new HPMS reporting requirements may help the states in producing more uniform data.

2. Pavement Ride Specifications

Wade Gramling of the Pennsylvania DOT was the topic leader for this discussion. He reviewed AASHTO's Guide Specifications for concrete and asphalt pavements as well as the specification that Pennsylvania uses.

State highway agencies have been refining their construction smoothness requirements since the early 1980's. Specifications apply to both asphalt and concrete pavements with smoothness payment incentives and disincentives. But the emphasis has been on concrete pavements which can be ground after construction. The option of taking corrective action on asphalt pavements is usually limited to the lower lifts. The AASHTO Guide Specifications still allow the use of a 10 foot straight edge, but usually this is done with a California-type machine.

The continuity of the ride across bridges and approaches remains a problem. These areas are usually not covered by the ride specification unless excessive. However, some direct federal project specifications are made irrespective of any structures that may be present and no problems have been reported. Pay adjustment indices vary from state to state. The AASHTO Guide for concrete recommends:

- no payment for the item for pavements with 0.1 mile sections over 15 inches per mile until corrective action is taken.

- a price adjustment for sections between 10 and 15 inches per mile;
- full payment below 10 inches per mile;
- incentive payments for pavements with less than 7 inches per mile; and
- all incentive payments are to be based on the condition of the pavement prior to corrective action.

Pennsylvania uses ride specifications for both asphalt and concrete pavements and for rehabilitated as well as new pavements. Conflicts with the contractor can be reduced by assigning him the responsibility of taking the profiles.

The contractor's equipment is keeping pace with these changes, but beyond the 5 to 7 inch range there is not a performance basis for incentives. Some states are reporting 2 inch initial profiles following construction.

3. Incorporating Other Pavement Condition Data

Doug Anderson of the Utah DOT was the topic leader for this session. He reviewed a variety of data on ride, cracking, rutting, raveling, structural adequacy, skid resistance, accident rates, volume, and capacity as used in Utah.

Discussions included the acceptance by maintenance forces of the condition data, a comparison on the methods of gathering condition data, and the minimum acceptable levels for various types of distress.

Dennis Miller of FHWA headquarters concluded the topic session with a review of upcoming developments in advanced video techniques. A number of vendors are entering this field and there is a good potential for high-speed automated distress analysis.

Details of each of the workshops may be found in Volume III of this report, published separately.

X. PAVEMENT SMOOTHNESS TESTING SUMMARY

A. Testing Equipment

A total of twenty devices participated in the pavement profile measuring seminar. The devices ranged from the relatively simple slow moving profilographs capable of charting a longitudinal profile to high-speed noncontact measuring equipment. The most widely represented system was the latter type. The following devices participated in the seminar:

1. Calibration and Construction Control
   - Profilograph (Rainhart)
   - Profilograph (McCracken)
   - E.W. Face Dipstick
   - Ames Profilograph

2. Response Type Systems
   - Mays Ridemeter (one car & two trailer based)
   - Cox Roadmeter
   - B&K Accelerometer

3. Accelerometer Based Systems
   - Portable Universal Roughness Device or PURD
   - Dynatest 5000 Roughness Distress Meter
   - Self-Calibrating Roughness Unit
   - Automatic Road Analizer or ARAN

4. Non-contact Profile Measuring Systems
   - K.J.Law M8300 Roughness Surveyor
   - Laser Road Surface Tester
   - K.J.Law 690 Digital Non-contact Profilometer
   - Pro Rut System
   - South Dakota Profilometer
   - Surface Dynamics Profilometer

Each agency demonstrating its equipment has provided a description in accordance with the equipment guide questionnaire. While this report touches on the descriptions only briefly, a complete set of equipment reports is available in Volume II of the Seminar Proceedings.

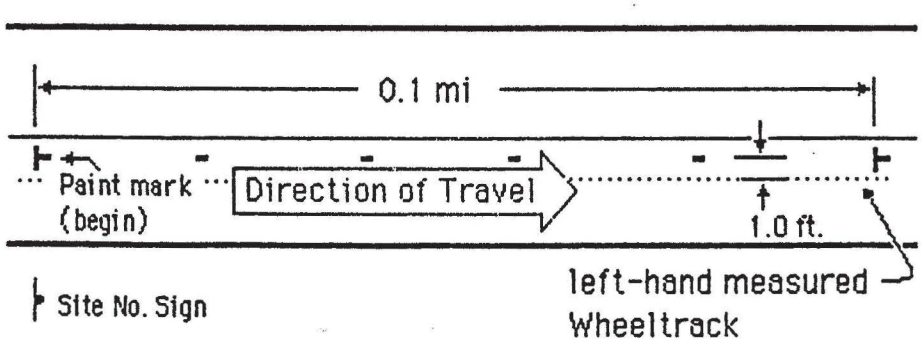
B. Test Sites

Nine roadway pavement sites located in the Fort Collins area were selected for smoothness testing. These Sites were chosen based on their close proximity to the seminar location and their variability in surface type and roughness. Figure 2 contains a map of the Fort Collins area with site locations identified.

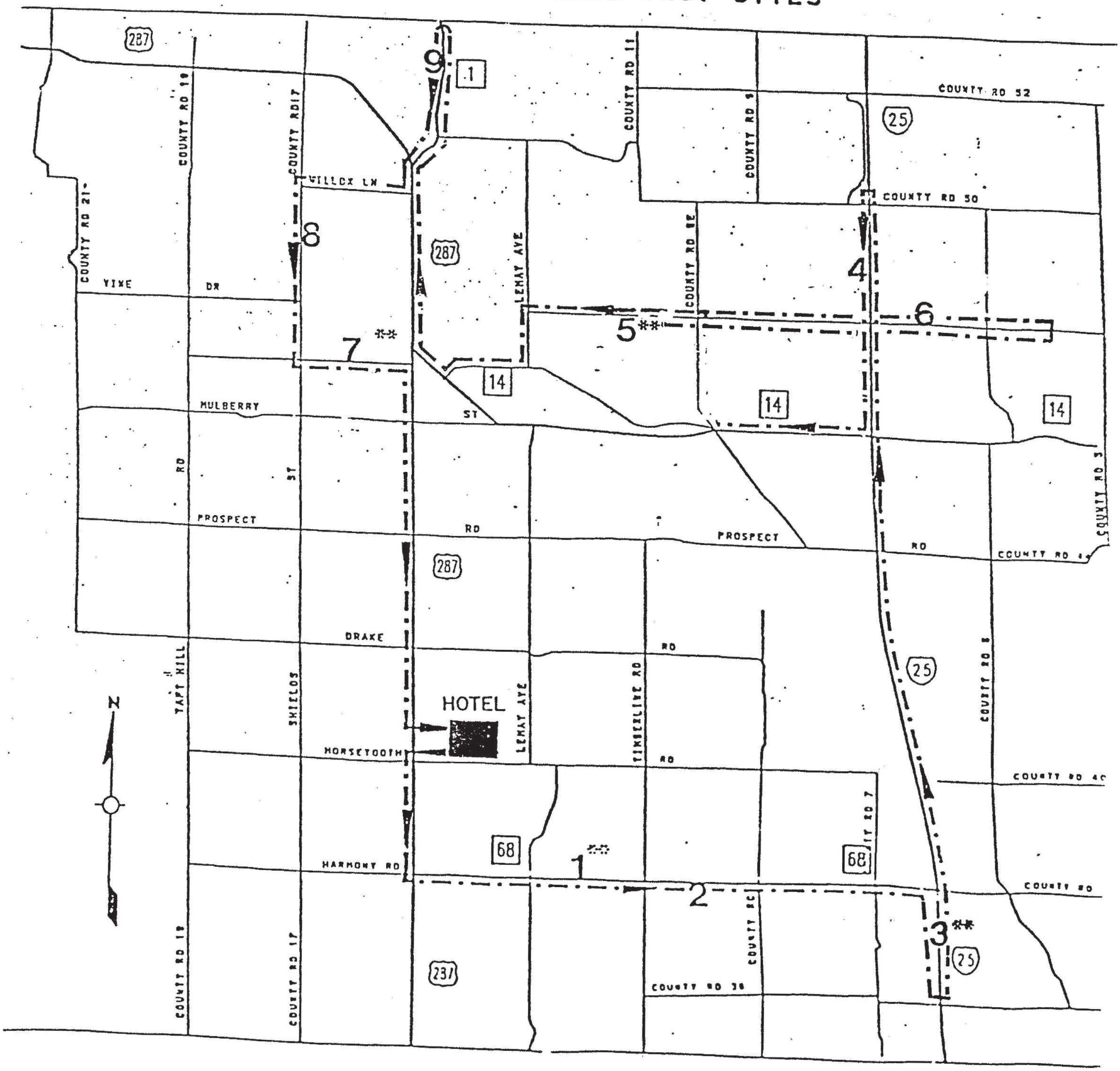
1. Site selection and identification

Two replicate test sites for the three pavement roughness categories were selected for flexible pavments, and one site in each category for rigid pavements. These nine sites were typically 8/10 of a mile long with a 1/10 mile approach section.

The test sections had been identified by a roadside sign marking the beginning and end of each test section. In addition, pavement marking of beginning and ending section as well as 1/10 mile subsections were identified within the test sites as shown in the accompanying sketch.



PAVEMENT SMOOTHNESS TEST SITES



SITES WITH ASTERICS WILL SERVE AS DEMO SITES ALSO

PREFERED ROUTE DIRECTION —·—·—·—·—

The first day of the seminar (See Figure 1 - Agenda) was used to explain data collection procedures to the equipment operators, check equipment, and collect data. Following a short briefing the data was collected as instructed on each of the test sites.

To ensure consistency, operators were asked to use the guidance striping, (paint marks at approximately 100 foot intervals) to place their test vehicle in the lane so that the roughness sensors would be measuring wheelpaths.

2. Operating speed

Speeds during the test runs were held to the posted speed limits with a maximum of 50 miles per hour for all testing equipment, except for the slow-moving calibration type devices. Sites 1, 5, 7, and 8 were tested at 30 miles per hour.

3. Roughness sensor location

The preferred sensor location for single sensor equipment was in the right wheelpath. However, reference profiles had been established for both wheelpaths, as well as a combination of the two paths using calibration and construction roughness measuring equipment (Type I).

4. Number of test runs

A minimum of three, and a maximum of five runs for each test site were required with a reading taken in each of the 1/10 mile subsections. If the "run average" fell within 10% of the "site average" as defined below, no further measurements were needed for that site.

$$\text{run average} = \frac{\text{sum of sub-section roughness values}}{\text{number of sub-sections}}$$

$$\text{site average} = \frac{\text{sum of run average}}{\text{Number of runs}}$$

Convenient turnarounds were provided for most of the test sites to allow repeat measurements.

The detailed instructions provided to the equipment operators are included in Appendix C of Volume II of the Seminar Proceedings.

5. Data Reporting

The preferred roughness statistics to be reported were to be in units of inches per mile. While some of the participating agencies were not able to provide this statistic, (and supplied serviceability indices in lieu of the preferred units) others were capable of providing an international roughness index (IRI) with units of inches per mile (or millimeters per meter). Table A is a listing of the main data set units for all devices. Also indicated with the units is the wheelpath in which the measurements were taken. As mentioned earlier, some participants supplied additional information. The type of information is listed in Table A (found in the Data Analysis Section of this report) under the heading of "Also Available."

6. Test Site Description

Site No.	Description and location	Pavement type	Roughness
1*	S.H. 68 WB from Timberline Rd to LeMay Ave	flexible	smooth
2	S.H. 68 EB from Timberline Rd to County Rd 9	flexible	medium
3*	I-25 NB from MP 268 to MP 269	rigid	smooth
4	I-25 SB from MP 271 to MP 270	rigid	medium
5	Vine Drive from Lindemeir St to County Rd 9	flexible	medium
6*	Vine Drive from County Rd 9 to Lindemeir St	flexible	rough
7*	LaPorte Ave from College Ave to Shields Ave	rigid	rough
8	Shields Ave from Vine Ave to Wilcox Ave	flexible	rough
9	S.H.1 north of LaPorte Ave	flexible	smooth

(Sites with asteriks also served as demonstration sites)

C. EQUIPMENT DETAIL SUMMARY

Each equipment operator demonstrating their devices provided a detailed description of the device. Instructions including a standard format for that description may be found in Appendix D of Volume II.

This portion of the report provides a brief description of the equipment demonstrated. A complete set of equipment description reports can be found in Appendix B of Volume II.

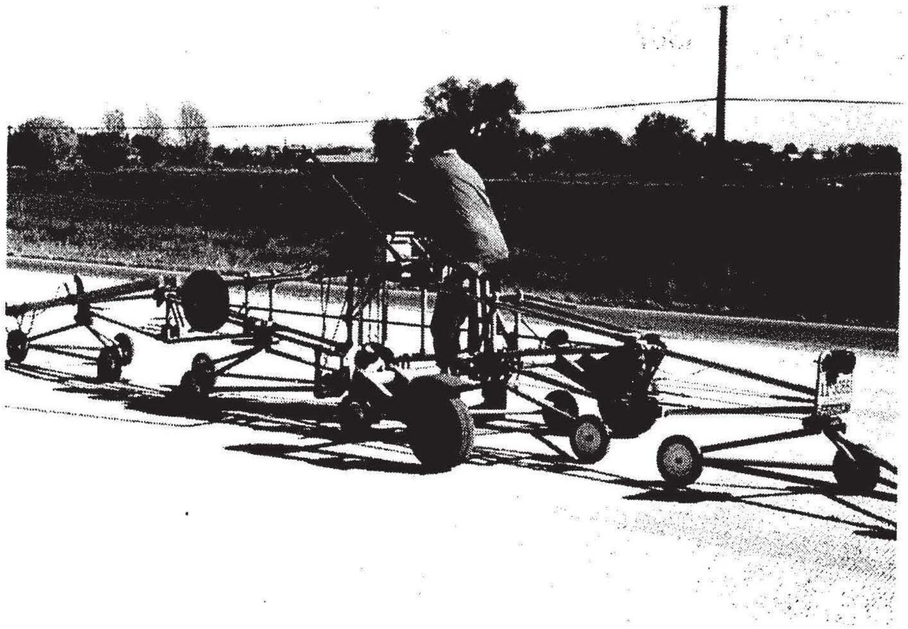
The following pages provide a brief description and photographs of the equipment used at the seminar by the various participants.

Colorado Devices

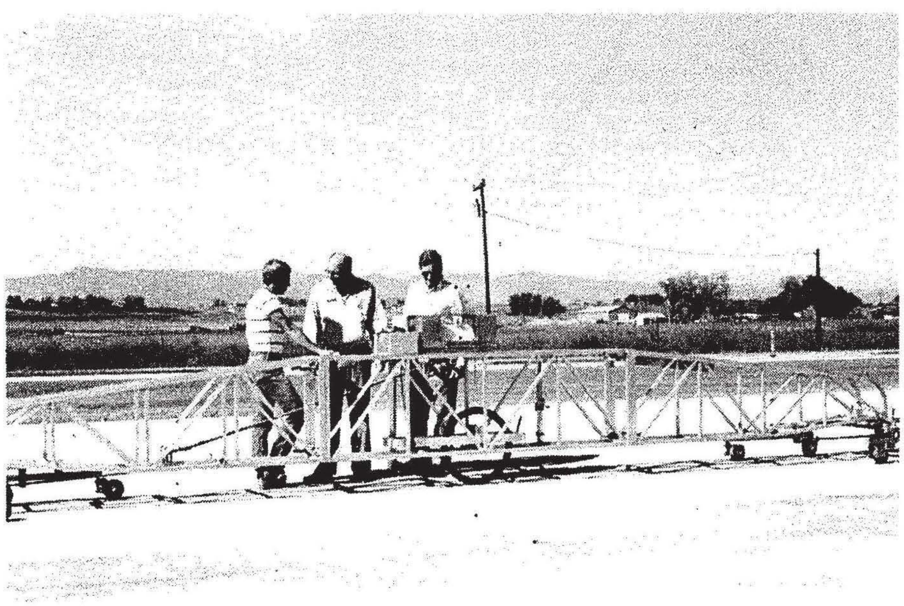
The McCracken and Rainhart profilographs are manually operated longitudinal profile measuring devices. The main difference between the two systems is that the Rainhart profilograph employs an intermediate truss and support wheels in defining the averaging reference plane from which the pavement deviation is measured. The McCracken reference plane is defined by the two clusters of support wheel at the ends of the simple truss.

Both profilographs use strip chart recorders to identify pavement roughness. In the data reduction, a 2/10 inch (0.2") blanking band was used to filter out texture-caused roughness.

The McCracken profilograph truss can be disassembled into three sections for transporting the equipment. It is currently used in Colorado's smoothness specifications for concrete pavement projects.



Rainhart Profilograph

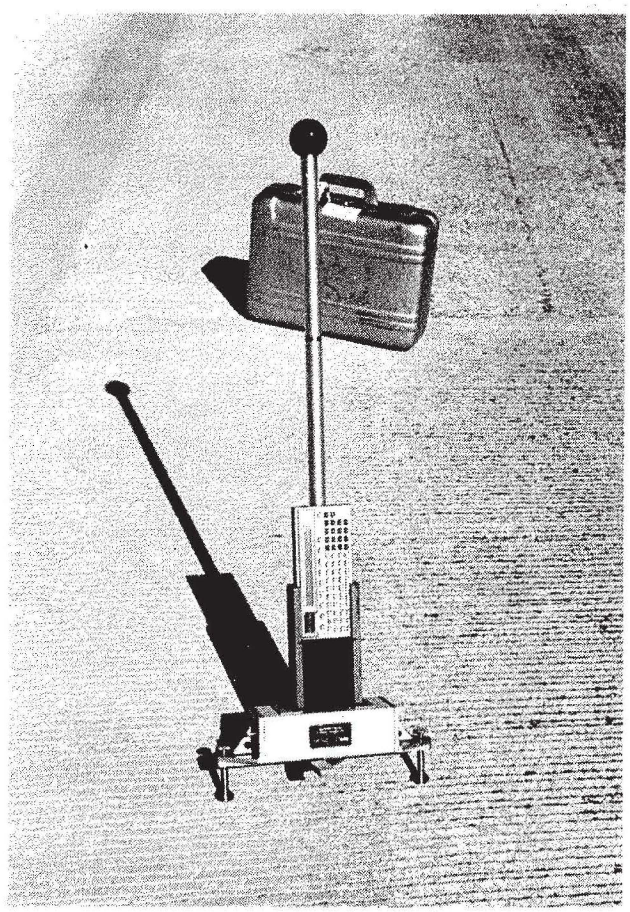


McCracken Profilograph

E. W. Face Company

The Dipstick represents a precision auto-recording rod and level replacement system primarily intended for calibration purposes. Elevation differences between the one-foot spaced base points are measured by a slope indicator. A readout device displays this measurement, and in the case of the manual model, the operator makes a voice-recording of the readout for later data processing.

The automated dipstick (with 18 K micro computer/printer) permits in-the-field calculation of profile statistics with output of IRI, FF-number, elevation, curvature values as well as a plot of the measured surface.



Dipstick
The computer attached stores and analyzes the data.

AMES PROFILOGRAPH

Central Direct Federal Division

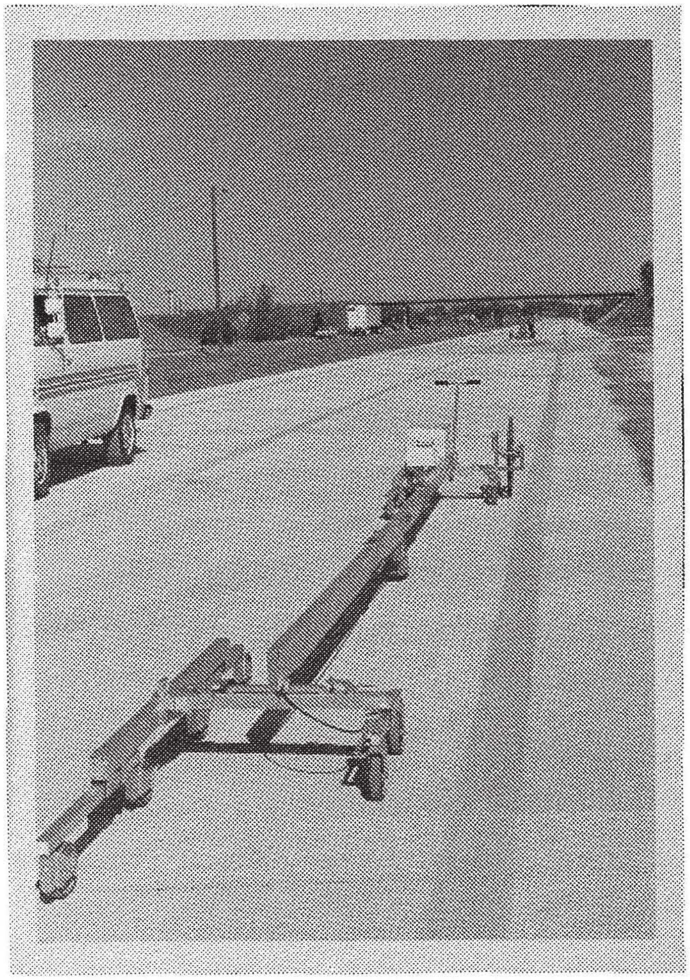
The information for the Ames profilograph presented here constitutes an excerpt from a report by Allan S. Miller and Candace E. Watson entitled, "Pavement Rideability Study."

The report focuses on a correlation between the rolling straight-edge and a California-type profilograph.

This excerpt from the above report deals with operating experiences of the Ames profilograph, as well as a list of California-type profilographs, schematic sketches, and samples of comparison roughness traces for the McCracken and Ames profilographs.

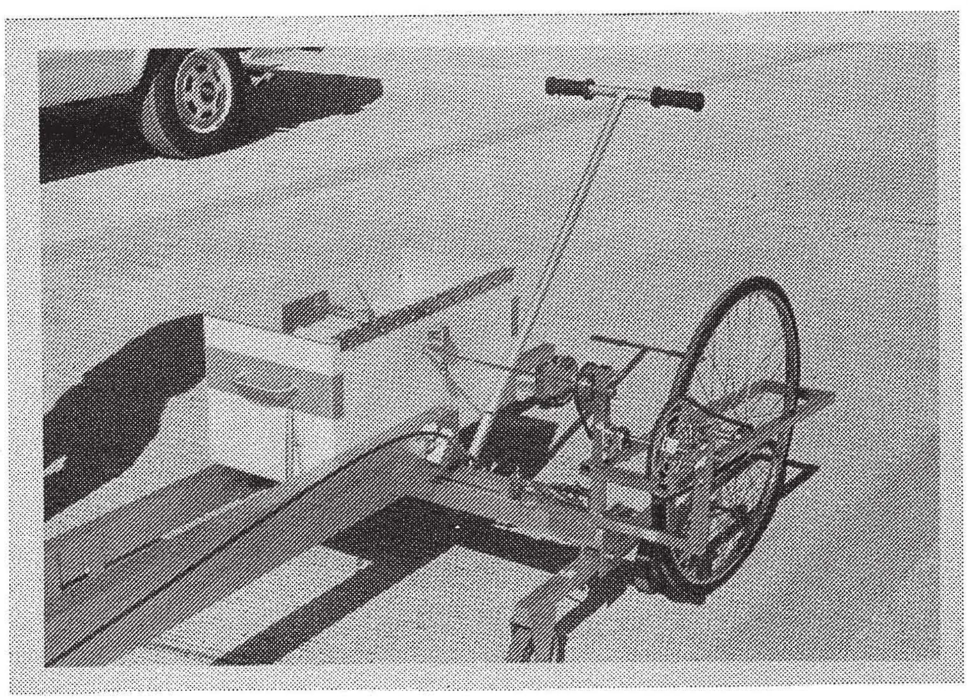
Reference: "Pavement Rideability Study"; Central Direct Technical Division, 1987; Allan S. Miller; Candace E. Watson

Central Direct Federal Division of FHWA



The Ames Profilograph is a low-cost smoothness testing device. Simple and light-weight construction are some of the positive aspects of this equipment. The manually propelled device produces a profile chart that is analyzed using the California chart method. The device is easily assembled and disassembled by one person to facilitate transportation of the equipment.

The two photographs show an overall view of the equipment and a close-up view of the recording mechanism.



No smoothness data was collected with this device; it was available during the open house and during the demonstration session.

Wyoming

The Mays Ride Meter used by the Wyoming Highway Department is mounted in a 1986 Chevrolet Caprice consisting of the following equipment:

Odometer

Rotary Transmitter to convert axle-body movement to an electrical signal.

Pavement Condition Recorder to record the movements and accumulate the total roughness.

Data Playback Unit to transfer the casette-based data to an IBM-XT computer

Data output consists of measured "counts" based on the relative axle-body motion and is translated to the Rainhart strip chart recorder as follows:

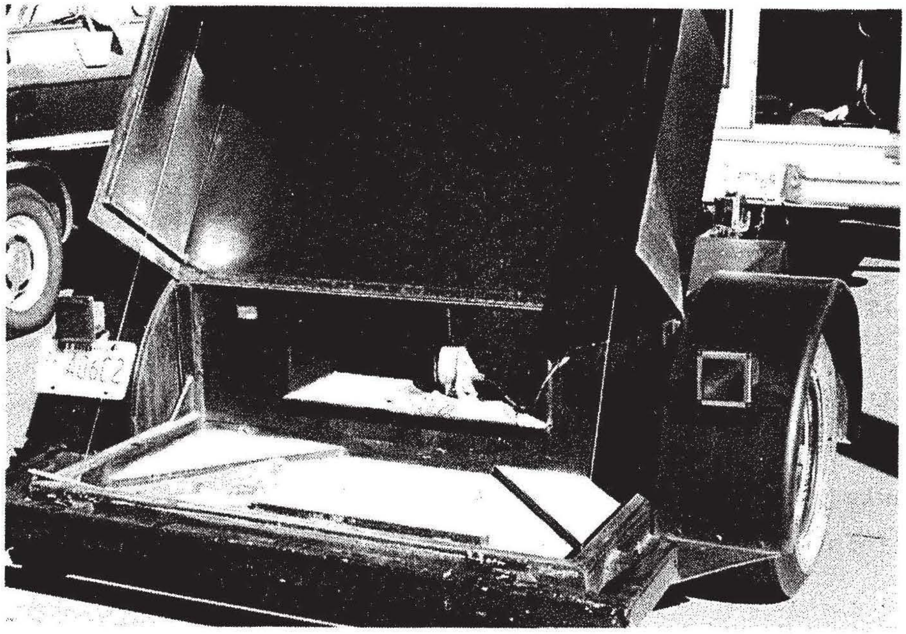
Inches Chart Roughness/Miles = Total Count/(Net length * 64).

Sixty-four counts of the Mays meter is equal to one inch of roughness as measured by the Rainhart strip chart recorder.

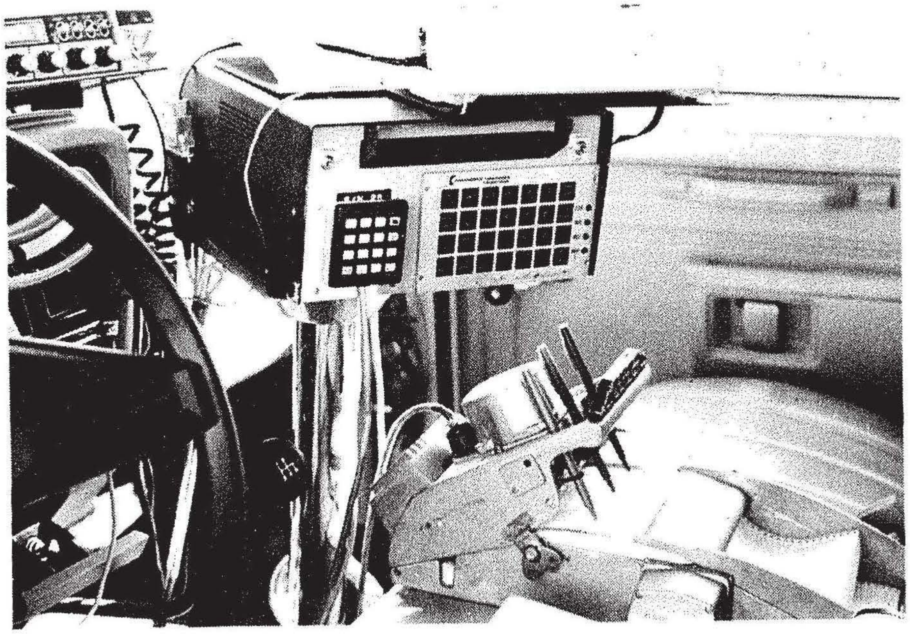
Mays Ridemeter

Western Direct Federal Division of FHWA

The trailer mounted roughness measuring devices that were demonstrated by this agency are a dual system consisting of the Mays Ride Meter and a B & K Model 2231 integrating meter (accelerometer). The additional accelerometer was intended to serve as a check for inconsistencies experienced with the Mays Ride Meter (MRM). Although the B & K accelerometer output is not directly equivalent to the MRM numbers, they are of a similar scale and could be correlated via the Root Mean Square (RMS) acceleration.



Mays Ridemeter (Trailer and B & K Accelerometer)

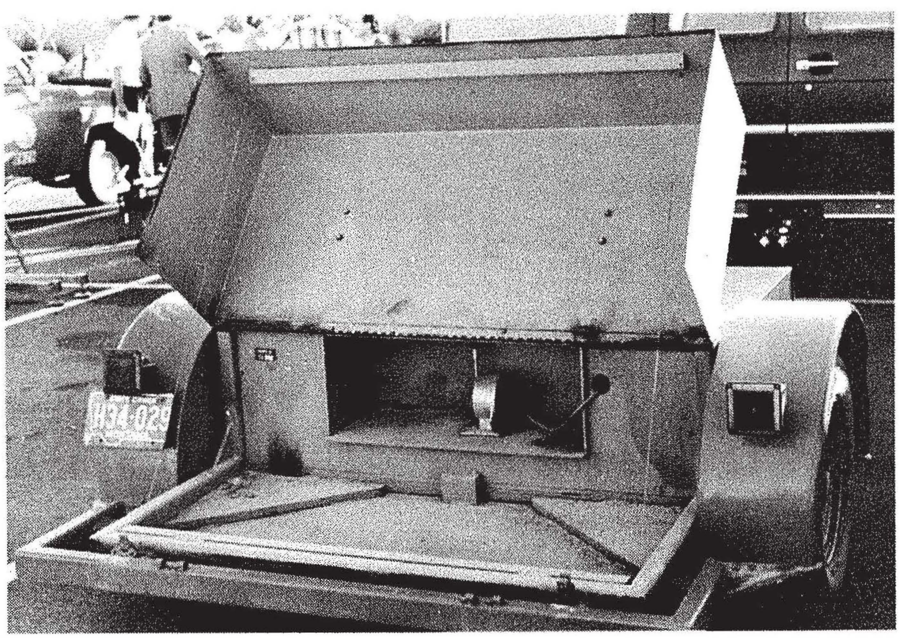


Computer and Recorder for Mays Ridemeter and B & K Accelerometer
Western Direct Federal Division, FHWA

Montana

Montana's trailer mounted Mays Ride Meter is a Rainhart 890T trailer as developed by the Texas State Department of Highways and Public Transportation. The instrument continually logs the pavement surface by recording magnitude, direction, and summation of trailer axle to body excursions, together with synchronized distance measurements and landmarks.

The addition of a pavement condition recorder (PCR2000) and a Zenith Z-171 portable computer facilitate data collection and storage. Data output consists of route, direction and lane information in addition to Mays count and Mays distance information by 1/10 of a mile intervals.



Mays Ridemeter
Montana Department of Highways

Nevada

Nevada's Cox roadmeter is a programmable response-type device that records deviations in the vehicle body movements as it relates to the axle. Deviation from the null are registered and accumulated over the section length. Peak values are recorded in 1/8 inch increments. This data, fed into a data acquisition system, outputs accumulated count number which in turn is converted to vehicle displacement counts and, ultimately, inches per mile.

Cox Roadmeter

Sensor for Cox Roadmeter

Ontario, Canada

Ontario's portable universal roughness device (PURD) measures roughness using a trailer axle mounted accelerometer. The equipment demonstrated at the seminar also had an optional multiple accelerometer system for generation of IRI data. A microcomputer based pavement condition rating keyboard permits recording of pavement distress types, severity and extent measurements. Also included is a distance measuring instrument (DMI) to accurately measure all surveyed sections and record locations of inventoried items.

The main difference between the equipment description in the report and the equipment demonstrated, is that a trailer-based system was used instead of the van-based system described in the equipment description.

Portable Universal Roughness Device (PURD)

Mississippi

Mississippi arranged for the furnishing of a Dynatest 5000 road roughness measuring system. The response type (RTRRMS) uses an ultra precision accelerometer to generate the statistic root-mean square vertical acceleration. The van-mounted system consists of the following components:

1. Digital distance encoder
2. Processor and microcomputer for plotting, printing and data storage
3. A chassis-mounted accelerator
4. Hand-held event and start/stop keypads
5. Dual beam calibration assembly
6. Software to accomplish various data processing tasks

Dynatest RDM

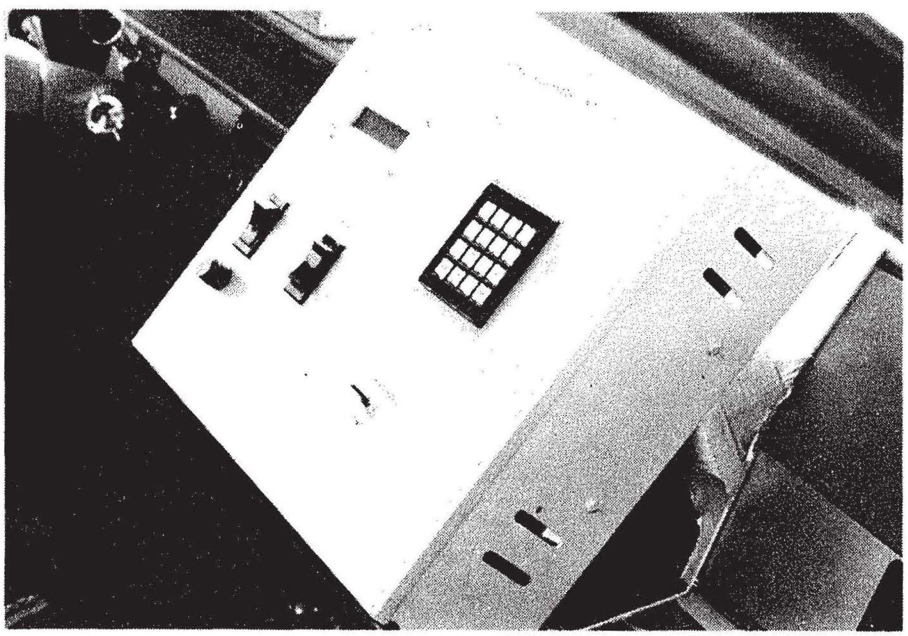
Texas

The Walker Roughness Device demonstrated by the Texas State Department of Highways is also known as the self-calibrating roughness unit (SIometer). The car-based system consists of a trunk-mounted accelerometer as the primary sensor unit, a main control module and, optionally, a computer for data storage. The accelerometer measures the vertical acceleration of the vehicle and the signal is transmitted to the main control unit for digitizing and processing.

The portable unit is easily installed in any vehicle because of the self-calibrating feature.

Prior to actual measurements the vehicle's response is statisically modeled over a short road section. The model parameters are later used in the measuring process to remove the vehicle's characteristics.

Texas Self-Calibrating Roughness Unit



Control Console for the Texas Self-Calibrating Roughness Unit

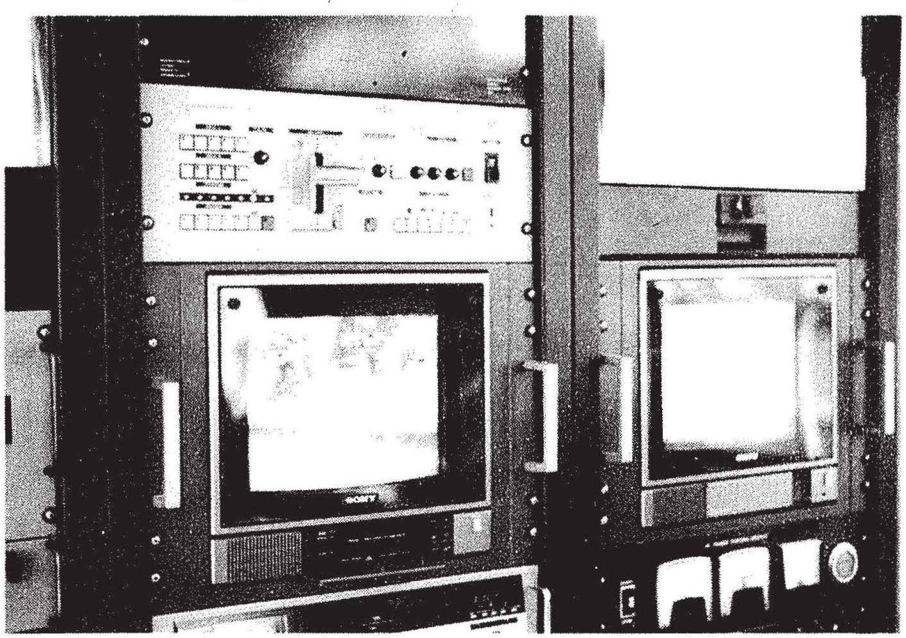
Texas

The second roughness measuring device provided by the Texas State Highway Department was the automatic road analyzer (ARAN III).

This non-contact, accelerometer-based roughness measuring system is used to report overall condition of the state maintained highway network. In addition to roughness measuring capabilities, this system also performs pavement distress surveys using a dual video camera setup, and sonar sensors for rut depth measurements. Travel speeds up to 50 miles per hour are feasible for measuring distress and roughness. However, the body mounted accelerator and an axle mounted accelerator evaluate pavement roughness at speed of 30 to 50 mph. The measured vertical accelerations are averaged for both wheel tracks.

On-board display of roughness in units of root mean square of vertical accelerations (RMSVA) and mean rectified slope (MRS) is on a 9-inch CRT. Raw data is stored for post-processing of longitudinal profile and roughness statistics such as the international roughness index (IRI). The system is equally sensitive to all wavelengths from 1 foot to 300 feet independent of the body-to-axle movement.

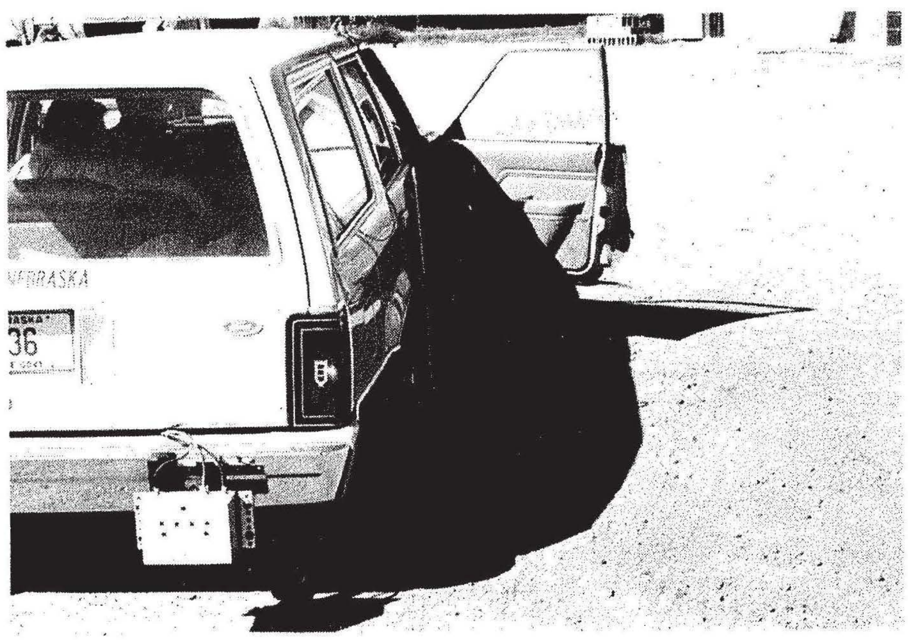
ARAN III



Interior view of the ARAN III

Nebraska

The K.J. Law M8300 roughness surveyor is a ultrasonic non-contact profile measuring system. The car-based unit consists of a bumper mounted canister containing the accoustic probe and receiver, and an accelerator. The accoustic probe measures displacement only. The microprocessor computers can be programmed to provide Mays, PCA, RMS or other vehicle response statistics. The Mays statisics was selected for this project and the output units are in inches per mile.



K.J. Law M8300
Nebraska Department of Roads

Colorado

Colorado's K.J. Law M8300 roughness surveyor is an ultrasonic non-contact profile measuring system housed in a van. The canister containing the acoustic probe, receiver, and accelerometer is mounted on the left side of the rear bumper. The acoustic probe measures displacement only. Since Colorado's K.J. Law is used for roadway inventory, a video camera has been installed in addition to an automated rutting measuring device. A printer is used for producing a on-board hard copy of the data. All data is stored on magnetic tape for later transfer to PC's and subsequent editing and analysis. Roughness units are programmable but the Mays statistic is used and the output is in inches per mile.

Canister containing sensors for Colorado's K.J. Law M8300

Interior view of K.J. Law M8300

AASHTO MATERIALS REFERENCE
LABORATORY PROGRAM
(FHWA)

The K.J. Law 690 DNC Surface Dynamics Profilometer is an inertial system that records road profiles at normal vehicle speeds.

The van-based system consists of the following:

1. Non-contact pavement sensors
2. Accelerometers
3. Digital distance encoder
4. Profile computers
5. Software (Operating system, profilometer program)
6. CRT terminal and printer
7. Magnetic tape recorder
8. Optional software

Among the pavement rougness simulation programs the following is available:

BPR Roughometer
Mays Ride Meter - Vehicle and trailer
PCA Ride Meter
Cox Ride Meter
Root Mean Square Acceleration (RMSA)
Present Servicability Index (PSI)

The unit has numerous other capabilities in the pavement performance evaluation area. They are listed in the equipment section of the report.

K.J. Law 690 DNC Profilometer

UMTRI/Michigan

The PRORUT System as demonstrated by UMTRI was designed to perform as a fully integrated pavement condition survey system as well as a relatively accurate and inexpensive profiling system. The use of laser sensors in the original design was changed to infrared transducers on the unit used in the demostration. Profiling and rut-depth measurements are easily combined with this sensor arrrangement. The on-board computer controls the system operation, including calibration and data processing. Two accelerometers situated above the wheel tracks allow roughness computation for the separate wheel paths with IRI values as well as profile plot output.

Pro Rut System (FHWA)

South Dakota DOT

South Dakota's profilometer system consists of a linear accelerometer and a non--contact ultrasonic ranging device. In addition to the pavement profile capabilities, the ultrasonic sensors are used for rut depth measurements. A microcomputer controls the devices that measure the vehicle's horizontal distance, vertical position, and height above the pavement are housed in a van. A printer for hard copies and disk driven for data storage comprise the data storage system.

The software is capable of producing a number of statistics, specifically in addition to the profile plots the following is available:

Mays Index
PCA Index
PSI
RMS Acceleration Sprung Mass
Average Rut Depth

The profile plots are produced for one wheel path only. The above statistics are used to represent combined wheel paths.

Road Profiler

Interior view of Road Profiler

Nebraska

Nebraska's profilometer was developed using the South Dakota profilometer design. The description of the South Dakota equipment is applicable for Nebraska's profilometer. As is the case with the South Dakota system, automated rut-depth measuring facility exists on Nebraska's profilometer.

SD Profilometer Nebraska Department of Roads

Texas

The Texas Surface Dynamics Profilometer (SDP) measures longitudinal pavement profile in each wheel path. A non-contact laser probe and an accelerometer located over each wheelpath are used to measure the pavement profile and the information is processed by a 80286 CPU based computer. Software permits sampling rates at ten or twenty samples per foot, either filtered or unfiltered. Only longitudinal profile is being measured by this equipment. Roughness values are computed and reported in units of Servicability Index (SI) for each wheel path. The program is also capable of simulating a Mays Ride Meter count.

Texas Surface Dynamics Profilometer

Interior view of Texas Surface Dynamics Profilometer

XI DATA ANALYSIS

Many of the participants had pavement data collection equipment that was capable of gathering a multitude of information such as video logs of pavement conditions, rut depths, profile plots, and various simulation statistics. However, it was the intent of this seminar to focus on the pavement smoothness aspect of data collection, processing and the demonstration of the various devices that are currently available.

The participants in the equipment demonstration were provided with guidelines for this purpose. Nine test sites had been selected to represent smooth, medium-rough, and rough pavement samples for rigid as well as flexible pavements. Replicate test sections were established for the flexible pavements only. In order to verify equipment measuring consistency, the tests for each site were repeated three times as a minimum, and a maximum of five times to avoid excessive test duration. The criterion for the need to repeat the tests more than three times was the relationship of the individual site average roughness to the overall average roughness of the first three tests. If individual site average was within ten percent, no additional tests were required. As can be seen in the data summary sheets, located in Appendix B, Volume I, every device was consistent enough to satisfy this requirement, although some of the participants performed additional tests.

Data processing proved to be more difficult than initially anticipated because of the multitude of equipment participating in the testing. The preferred data storage on floppy diskettes that was suggested in the guidelines was feasible for only a limited number of participants. Since each piece of equipment was capable of producing a hard-copy of their test data, this method of data submission was selected. All data was put manually into LOTUS spreadsheets.

The basic format of the resulting spread sheet (Appendix B) identifies the test site number, pavement type, smoothness category, test speed, and the test site sub-section number. Each participant's equipment and their affiliation is shown in the left-most column along with the roughness statistics units. The second column indicates the wheelpath in which the roughness values were obtained. The values in the sub-section columns are roughness values for each tenth-mile long sub-sections. Average test section roughness, maximum section roughness, and minimum section roughness values complete the page.

The test devices have been arranged so that similar devices are listed together. The various device categories have been identified in the previous section of this report.

Since many of the participants expressed the desire to obtain all raw data, the final data reporting and storage was directed toward this goal. Testing speeds are noted in the page header and apply to the high-speed equipment only. Low-speed devices are indicated by asteriks.

Although only three test runs were requested, some participants supplied data for additional test runs. This data is also summarized in these spreadsheets, found in Appendix B.

It should be pointed out that the purpose of this data collection effort was primarily to demonstrate the pavement smoothness measuring devices and their data collection capabilities. The data is presented here for information only and not necessarily for comparisons between devices, correlation efforts or other statistical analysis. Summarized data is presented here for the reader's information.

The finalized tables containing all data collected by each pavement smoothness measuring device are available on floppy diskette in LOTUS WKS format as well as ASC11 text files upon request from the authors at the Colorado Department of Highways Research Branch.

Several agencies produced additional data output consisting of response roughness statistics, longitudinal roughness profile charts, and rut-depth data. Samples of this data output are included in Volume II of this Seminar Proceedings. However, a complete set will be made available upon request. A complete listing of available data can be found in Table A.

TABLE A

PAVEMENT SMOOTHNESS EQUIPMENT DATA OUTPUT UNITS

EQUIPMENT	PRIMARY DATA */ (WHEEL PATHS)	ALSO AVAILABLE
Rainhart Profilograph	in/mi (BWP)	/ Longitudinal profile graph for both WP on Sites 1,3,5 & 7
Profilograph McCracken	in/mi (BWP)	/ Longitudinal profile graph for both WP on Sites 1,3,5 & 7
Dipstick	IRI in/mi E.W. Face (L&R WP)	
Mays (Car) Wyoming	Mays in/mi (BWP)	
Mays(Trailer) Direct Fed.	Mays in/mi (BWP)	
PCR-2000 Montana	in/mi (BWP)	/ Data on floppy diskette
Cox Nevada	in/mi (BWP)	
B&K Accelerometer D.Fed.	LEQ Decibels (BWP)	
H.P.I. PURD Ontario MTC	IRI in/mi (BWP)	/ Real-time response roughness statistics, Root mean square axle acceleration RMSVA in milli G's), Mean absolute slope (MAS, m/km), IRI data on floppy diskettes, Longitudinal profiles for Sites 1,2,5 & 7.
Dynatest 5000 Mississippi	SI (Serviceability Index) (BWP)	
Siometer Texas	SI (BWP)	
Aran III Texas	IRI in/mi (BWP)	/ Response roughness statistics (RMSVA), Longitudinal profiles
Laser RST IMS-Illinois	IRI in/mi, MO Index (BWP)	
K.J.LAW 690 FHWA	IRI in/mi (BWP, L&R WP)	/ Mays (in/mi), PCA (count/mi), PSI, RMSA, / Longitudinal profile plots, IRI & Mays data / on floppy diskettes.
PRO RUT FHWA	IRI in/mi (L&R WP)	/ Combined wheelpath rutting

EQUIPMENT	PRIMARY DATA	/ ALSO AVAILABLE
Profilometer S.Dakota	IRI in/mi LWP	/ Data on floppy diskettes, Rutting
S.D. Road Profiler Nebraska	IRI in/mi LWP	/ Rut Depth
Profilometer Texas	SI BWP	/ Profile plots for each WP, Profile data on floppy diskettes.

* NOTES:

BWP - Both Wheel Paths
RWP - Right/Left Wheel Path
IRI - International Roughness Index
SI - Serviceability Index

XII. EQUIPMENT DEMONSTRATION

All of the equipment being used at the seminar was made available for review and inspection after each days session. Seminar participants took this opportunity to discuss operating procedures with the owners, take photographs, and make detailed inspections of the devices. The participants also used this opportunity to compare experiences or procedures used among each other.

As indicated in the agenda, the third day of the seminar was identified to provide an operating demonstration of the equipment. The participants were transported to four of the test sites where they were able to see the equipment in operation. Participants were provided the opportunity to ride in each device and observe the data being collected.

XIII. CONCLUSIONS

This four-day seminar provided an excellent opportunity for the highway transportation industry to learn and understand the state of the art in roadway pavement smoothness. It was the consensus of the nearly 200 participants that the seminar/demonstration/workshop forum offered an opportunity to better understand the subject. Most participants felt that they better understood the theory, basic concepts, uses and application of pavement smoothness data. The equipment cost, specifications and operating procedures were better understood by the administrators selecting the equipment and the operators using the equipment.

Volume II of the Seminar Proceedings contains detailed information on the equipment represented at the seminar. This information includes brochures and write-ups as presented by the equipment owners and operators.

Because of the volume and diverse formats, all the data collected at the seminar has not been included in the proceedings. As indicated earlier, it is available from the authors.

Volume III of the Seminar Proceedings contains summaries of the various workshop findings. This document contains, in addition to the summarized information, notes and reports submitted by the workshop moderators, topic leaders, and recorders.

In conclusion, it was generally agreed that this forum was very useful in relating a large volume of information on a complex subject. Future gatherings of this type, through the FHWA's Demonstration Projects Program, are encouraged.

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3., "Calibration Procedures for Roadmeters"; Federal Highway Administration; Goulden, Wouter; Report No. FHWA-TS-86-201, April 1986.

4., "The International Road Roughness Experiment," World Bank Technical Paper Number 45; Sayers, Michael W.; Gillespie, Thomas D.; Queiroz, Cesar, A. V.

5., "Pavement Roughness and Rideability," Janoff, Michael S.; Nick, J. B.; Dabit, P.S.; Hayhoe, G. F.; National Cooperative Highway Research Program, Report No. 275, September 1985.

6., "Pavement Rideability Study"; Central Direct Technical Division, Federal Highway Administration, 1987; Allan S. Miller; Candace E. Watson.

APPENDIX A

PAVEMENT SMOOTHNESS SEMINAR

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APPENDIX B

PAVEMENT SMOOTHNESS MEASUREMENT DEVICES

DATA OUTPUT TABLES

SMOOTHNESS DATA FOR SITE # 1 (S.H. 68; SMOOTH FLEXIBLE PAVEMENT) TEST SPEED 30 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
PROFILOGRAPH *	RWP1	7.50	5.50	2.50	3.50	0.50	3.50				3.83	7.50	0.50
RAINHART	RWP2	10.00	4.00	3.00	2.00	0.50	3.50				3.83	10.00	0.50
COLORADO DOH	LWP1	4.00	2.00	2.00	1.50	0.50	3.00				2.17	4.00	0.50
(in/mi) **	LWP2	4.00	1.50	0.50	2.50	0.50	0.50				1.58	4.00	0.50
PROFILOGRAPH *	RWP1	29.00	18.00	10.50	9.00	8.00	15.00				14.92	29.00	8.00
McCRACKEN	RWP2	30.00	19.50	11.00	10.50	7.50	18.50				16.17	30.00	7.50
COLORADO DOH	LWP1	16.50	12.00	9.00	12.00	3.50	11.00				10.67	16.50	3.50
(in/mi) **	LWP2	16.00	13.00	7.50	12.00	6.00	11.50				11.00	16.00	6.00
DIPSTICK *	RWP1		102.24		96.79						99.52	102.24	96.79
E. W. FACE	LWP1		106.42		83.30						94.86	106.42	83.30
IRI (in/mi)													
MAYS RIDEMETER	BWP1	76.00	78.00	69.00	61.00	47.00	59.00				65.00	78.00	47.00
CAR	BWP2	85.00	59.00	56.00	60.00	56.00	69.00				64.17	85.00	56.00
WYOMING HD	BWP3	82.00	60.00	65.00	71.00	55.00	76.00				68.17	82.00	55.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	95.00	79.00	58.00	62.00	63.00	86.00				73.83	95.00	58.00
TRAILER	BWP2	98.00	85.00	65.00	77.00	57.00	77.00				76.50	98.00	57.00
DIRECT FEDERAL	BWP3	108.00	89.00	67.00	64.00	57.00	81.00				77.67	108.00	57.00
MAYS (in/mi)	BWP4	88.00	83.00	77.00	68.00	70.00	87.00				78.83	88.00	68.00
	BWP5	88.00	86.00	71.00	68.00	63.00	84.00				76.67	88.00	63.00
MAYS RIDEMETER	BWP1	66.98	60.45	55.17	56.99	57.20					59.36	66.98	55.17
MONTANA DOH	BWP2	72.23	70.64	64.00	60.79	60.32	60.68				64.78	72.23	60.32
(in/mi)	BWP3	76.92	72.96	68.67	66.48	63.00	63.79				68.64	76.92	63.00
COX ROADMETER	BWP1	11.90	7.50	8.20	8.20	9.60	9.50				9.15	11.90	7.50
NEVADA DOT	BWP2	8.80	7.20	8.10	8.00	10.20	9.40				8.62	10.20	7.20
(in/mi)	BWP3	12.10	8.40	8.60	7.30	9.80	10.20				9.40	12.10	7.30
B&K	BWP1	AVERAGES ONLY									13.10		
ACCELEROMETER	BWP2										12.40		
DIRECT FEDERAL	BWP3										12.80		
(Decibels dB)													
H.P.I. PURD	BWP1	98.21	83.03	75.77	70.21	69.14	68.59				77.49	98.21	68.59
ONTARIO M.T.C.	BWP2	100.94	84.47	78.83	74.48	64.65	64.12				77.92	100.94	64.12
IRI (in/mi)	BWP3	104.14	78.33	80.15	81.27	73.77	66.50				80.69	104.14	66.50
DYNATEST RDM	BWP1	3.54	3.68	3.67	3.64	3.67	3.61				3.63	3.68	3.54
MISSISSIPPI HD	BWP2	3.58	3.70	3.66	3.60	3.69	3.63				3.64	3.70	3.58
SI	BWP3	3.58	3.68	3.65	3.63	3.64	3.60				3.63	3.68	3.58

** .2 INCH BLANKING BAND USED

SMOOTHNESS DATA FOR SITE # 1 (S.H. 68; SMOOTH FLEXIBLE PAVEMENT) TEST SPEED 30 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
TEXAS	BWP1	2.60	2.60	3.80	3.80	3.70	3.70				3.37	3.80	2.60
SELF CALIBRATING	BWP2	2.50	2.50	3.80	3.80	3.60	3.60				3.30	3.80	2.50
ROUGHNESS UNIT	BWP3	2.60	2.60	3.80	3.80	3.70	3.70				3.37	3.80	2.60
TEXAS HD													
(SI)													
ARAN III	BWP1	96.73	79.20	75.74	69.55	63.12	71.79				76.02	96.73	63.12
TEXAS HD	BWP2	103.75	80.23	73.24	65.47	63.38	68.36				75.74	103.75	63.38
IRI (in/mi)	BWP3	98.35	78.57	72.07	65.93	66.19	71.10				75.37	98.35	65.93
K.J. LAW M8300	RWP1	111.00	95.00	57.00	66.00	60.00	75.00				77.33	111.00	57.00
NEBRASKA DOR	RWP2	110.00	97.00	59.00	74.00	58.00	77.00				79.17	110.00	58.00
MAYS (in/mi)	RWP3	110.00	93.00	56.00	71.00	58.00	74.00				77.00	110.00	56.00
K.J.LAW M8300	LWP1	82.00	79.00	46.00	64.00	48.00	61.00				63.33	82.00	46.00
COLORADO DOH	LWP2	83.00	77.00	46.00	71.00	47.00	65.00				64.83	83.00	46.00
MAYS (in/mi)	LWP3	75.00	81.00	47.00	68.00	52.00	63.00				64.33	81.00	47.00
LASER RST	BWP1	95.03	76.02	57.02	69.69	63.35	63.35				70.74	95.03	57.02
IMS-ILLINOIS	BWP2	107.70	76.02	57.02	69.69	57.02	63.35				71.80	107.70	57.02
IRI (in/mi)	BWP3	95.03	76.02	57.02	69.69	57.02	63.35				69.69	95.03	57.02
K.J. LAW 690 DNC	BWP1	88.00	77.00	77.00	74.00	72.00	90.00				79.67	90.00	72.00
PROFILOMETER	BWP2	88.00	79.00	71.00	71.00	71.00	88.00				78.00	88.00	71.00
FHWA	BWP3	90.00	75.00	73.00	70.00	73.00	90.00				78.50	90.00	70.00
IRI (in/mi)	BWP4	92.00	80.00	76.00	75.00	74.00	90.00				81.17	92.00	74.00
	BWP5	91.00	79.00	74.00	73.00	73.00	88.00				79.67	91.00	73.00
PRO RUT SYSTEM	RWP1	110.65	100.63	89.99	90.27	75.32	91.74				93.10	110.65	75.32
FHWA	RWP2	119.15	102.75	84.04	90.61	74.14	97.64				94.72	119.15	74.14
IRI (in/mi)	RWP3	111.69	104.59	85.68	91.70	76.93	94.98				94.26	111.69	76.93
	LWP1	86.04	82.02	60.60	74.13	64.91	75.06				73.79	86.04	60.60
	LWP2	87.85	82.58	59.67	72.50	62.83	75.77				73.53	87.85	59.67
	LWP3	86.90	82.23	60.58	71.34	63.56	74.95				73.26	86.90	60.58
ROAD PROFILER	LWP1	96.00	94.00	76.00	82.00	70.00	78.00				82.67	96.00	70.00
SOUTH DAKOTA	LWP2	130.00	99.00	70.00	76.00	71.00	78.00				87.33	130.00	70.00
MAYS (in/mi)	LWP3	97.00	98.00	75.00	79.00	77.00	84.00				85.00	98.00	75.00
SD PROFILOMETER	LWP1	141.00	141.00	136.00	130.00	128.00	106.00				130.33	141.00	106.00
NEBRASKA DOR	LWP2	151.00	138.00	124.00	132.00	116.00	95.00				126.00	151.00	95.00
IRI (in/mi)	LWP3	143.00	150.00	133.00	137.00	133.00	120.00				136.00	150.00	120.00
TEXAS SURFACE	BWP1	3.35	3.77	4.29	4.13	4.29	4.04				3.98	4.29	3.35
DYNAMICS	BWP2	3.23	3.61	4.25	4.17	4.33	4.03				3.94	4.33	3.23
PROFILOMETER	BWP3	3.29	3.90	4.29	4.09	4.31	4.00				3.98	4.31	3.29
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS DATA FOR SITE # 2 (S.H. 68 EB; MED ROUGH FLEXIBLE PAVEMENT) TEST SPEED 50 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
RAINHART	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
McCRACKEN	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
DIPSTICK *	RWP1		140.88		117.63						129.26	140.88	117.63
E. W. FACE	LWP1		149.43		201.44						175.44	201.44	149.43
IRI (in/mi)													
MAYS RIDEMETER	BWP1	85.00	124.00	92.00	76.00	71.00	46.00	63.00	94.00		81.38	124.00	46.00
CAR	BWP2	80.00	124.00	94.00	80.00	62.00	47.00	63.00	92.00		80.25	124.00	47.00
WYOMING HD	BWP3	77.00	128.00	89.00	85.00	64.00	49.00	71.00	88.00		81.38	128.00	49.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	106.00	140.00	136.00	110.00	85.00	53.00	81.00	97.00		101.00	140.00	53.00
TRAILER	BWP2	78.00	128.00	126.00	107.00	81.00	72.00	91.00	101.00		98.00	128.00	72.00
DIRECT FEDERAL	BWP3	89.00	126.00	137.00	100.00	69.00	63.00	94.00	104.00		97.75	137.00	63.00
MAYS (in/mi)	BWP4												
	BWP5												
MAYS RIDEMETER	BWP1	80.83	91.45	91.27	86.45	81.97	78.15	76.00	77.36		82.94	91.45	76.00
MONTANA DOH	BWP2	87.82	94.50	93.67	90.98	87.37	80.97	79.85	80.17		86.92	94.50	79.85
(in/mi)	BWP3	93.91	100.00	98.67	94.73	87.20	80.81	80.42	80.21		89.49	100.00	80.21
COX ROADMETER	BWP1	12.20	21.20	16.70	12.80	9.50	6.70	8.90	16.60		13.08	21.20	6.70
NEVADA DOT	BWP2	13.80	20.10	18.30	14.60	8.70	7.00	11.70	15.10		13.66	20.10	7.00
(in/mi)	BWP3	12.30	21.70	17.40	14.30	9.80	6.90	13.20	16.90		14.06	21.70	6.90
B&K	BWP1	AVERAGES ONLY									15.50		
ACCELEROMETER	BWP2										15.60		
DIRECT FEDERAL	BWP3										15.40		
(Decibels dB)													
H.P.I. PURD	BWP1	80.71	111.85	90.61	74.31	72.39	58.40	75.65	85.61		81.19	111.85	58.40
ONTARIO M.T.C.	BWP2	88.19	113.68	94.11	74.57	71.38	55.32	71.14	80.01		81.05	113.68	55.32
IRI (in/mi)	BWP3	88.88	114.07	101.03	88.29	75.53	59.56	78.51	84.07		86.24	114.07	59.56
DYNATEST RDM	BWP1	3.48	3.39	3.37	3.39	3.48	3.45	3.37	3.47		3.42	3.48	3.37
MISSISSIPPI HD	BWP2	3.48	3.33	3.36	3.34	3.50	3.56	3.49	3.54		3.44	3.56	3.33
SI	BWP3	3.49	3.38	3.35	3.45	3.52	3.51	3.56	3.55		3.47	3.56	3.35

SMOOTHNESS DATA FOR SITE # 2 (S.H. 68 EB; MED ROUGH FLEXIBLE PAVEMENT) TEST SPEED 50 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
TEXAS	BWP1	2.50	2.50	2.80	2.80	3.60	3.60	2.70	2.70		2.90	3.60	2.50
SELF CALIBRATING	BWP2	2.40	2.40	2.70	2.70	3.50	3.50	2.70	2.70		2.83	3.50	2.40
ROUGHNESS UNIT	BWP3	2.30	2.30	2.60	2.60	3.40	3.40	2.50	2.50		2.70	3.40	2.30
TEXAS HD													
(SI)													
ARAN III	BWP1	88.14	112.27	96.78	81.94	72.64	63.54	83.48	74.60		84.17	112.27	63.54
TEXAS HD	BWP2	91.43	116.32	100.58	83.31	69.93	64.79	85.63	75.39		85.92	116.32	64.79
IRI (in/mi)	BWP3	87.93	110.28	95.86	73.62	69.84	65.79	82.90	75.48		82.71	110.28	65.79
K.J. LAW M8300	RWP1	87.00	116.00	106.00	101.00	89.00	103.00	102.00	102.00		100.75	116.00	87.00
NEBRASKA DOR	RWP2	103.00	120.00	113.00	106.00	98.00	95.00	109.00	105.00		106.13	120.00	95.00
MAYS (in/mi)	RWP3	80.00	125.00	131.00	117.00	111.00	117.00	104.00	103.00		111.00	131.00	80.00
K.J.LAW M8300	LWP1	101.00	127.00	125.00	105.00	93.00	68.00	100.00	90.00		101.13	127.00	68.00
COLORADO DOH	LWP2	98.00	133.00	124.00	105.00	88.00	66.00	103.00	101.00		102.25	133.00	66.00
MAYS (in/mi)	LWP3	108.00	136.00	128.00	97.00	87.00	61.00	107.00	84.00		101.00	136.00	61.00
LASER RST	BWP1	145.70	133.04	133.04	107.70	95.03	76.02	126.70	107.70		115.61	145.70	76.02
IMS-ILLINOIS	BWP2	114.03	133.04	133.04	95.03	88.69	69.69	120.37	107.70		107.70	133.04	69.69
IRI (in/mi)	BWP3	120.37	126.70	133.04	101.36	88.69	76.02	133.04	107.70		110.86	133.04	76.02
K.J. LAW 690 DNC	BWP1	92.00	117.00	103.00	89.00	81.00	55.00	81.00			88.29	117.00	55.00
PROFILOMETER	BWP2	90.00	113.00	114.00	89.00	82.00	56.00	89.00			90.43	114.00	56.00
FHWA	BWP3	89.00	117.00	114.00	90.00	81.00	56.00	85.00			90.29	117.00	56.00
IRI (in/mi)	BWP4	89.00	115.00	118.00	88.00	82.00	61.00	79.00			90.29	118.00	61.00
	BWP5	89.00	119.00	111.00	85.00	83.00	58.00	73.00			88.29	119.00	58.00
PRO RUT SYSTEM	RWP1	98.36	142.60	127.06	109.38	88.07	76.68	96.85	114.43		106.68	142.60	76.68
FHWA	RWP2	106.07	143.64	130.34	105.94	91.02	74.94	86.37	114.40		106.59	143.64	74.94
IRI (in/mi)	RWP3	109.15	134.99	130.95	105.82	104.28	90.17	86.30	114.11		109.47	134.99	86.30
	LWP1	126.78	127.04	150.71	123.43	101.86	75.73	110.66	106.03		115.28	150.71	75.73
	LWP2	119.93	131.02	122.35	127.32	106.49	71.39	95.31	98.86		109.08	131.02	71.39
	LWP3	109.38	129.03	128.00	125.77	101.25	62.29	94.23	96.59		105.82	129.03	62.29
ROAD PROFILER	LWP1	125.00	131.00	163.00	143.00	134.00	132.00	166.00	119.00		139.13	166.00	119.00
SOUTH DAKOTA	LWP2	135.00	144.00	162.00	150.00	146.00	148.00	158.00	112.00		144.38	162.00	112.00
MAYS (in/mi)	LWP3	121.00	137.00	157.00	154.00	148.00	156.00	184.00	122.00		147.38	184.00	121.00
SD PROFILOMETER	LWP1	135.00	155.00	149.00	145.00	141.00	124.00	155.00	128.00		141.50	155.00	124.00
NEBRASKA DOR	LWP2	132.00	134.00	168.00	125.00	123.00	116.00	157.00	117.00		134.00	168.00	116.00
IRI (in/mi)	LWP3	129.00	143.00	156.00	129.00	131.00	137.00	155.00	123.00		137.88	156.00	123.00
TEXAS SURFACE	BWP1	3.66	2.99	3.19	3.46	3.89	3.73	3.46	3.67		3.51	3.89	2.99
DYNAMICS	BWP2	3.66	3.03	3.24	3.59	3.77	3.78	3.36	3.66		3.51	3.78	3.03
PROFILOMETER	BWP3	3.72	3.04	3.12	3.55	3.90	3.75	3.67	3.93		3.59	3.93	3.04
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS DATA FOR SITE # 3 (I-25; NEW RIGID PAVEMENT) TEST SPEED 50 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
PROFILOGRAPH *	RWP1	4.50	9.50	4.00	1.00	1.50	2.50	13.00			5.14	13.00	1.00
RAINHART	RWP2	13.00	6.50	11.50	3.00	3.50	5.00	16.00			8.36	16.00	3.00
COLORADO DOH	LWP1	5.50	9.50	4.00	3.50	11.00	10.00				7.25	11.00	3.50
(in/mi) **	LWP2	3.00	11.50	3.50	4.00	10.50	14.50	13.50			8.64	14.50	3.00
PROFILOGRAPH *	RWP1	16.00	16.00	15.50	8.50	18.00	19.50	32.00			17.93	32.00	8.50
McCRACKEN	RWP2	16.50	17.00	16.50	11.00	13.50	28.50	44.50			21.07	44.50	11.00
COLORADO DOH	LWP1	21.00	42.00	23.00	19.50	21.00	42.50	40.00			29.86	42.50	19.50
(in/mi) **	LWP2	18.50	25.50	26.00	23.50	21.50	31.50	39.00			26.50	39.00	18.50
DIPSTICK *	RWP1	NOT TESTED ON THIS SITE											
E. W. FACE	LWP1												
IRI (in/mi)													
MAYS RIDEMETER	BWP1	104.00	69.00	101.00	75.00	63.00	112.00	116.00			91.43	116.00	63.00
CAR	BWP2	88.00	80.00	95.00	73.00	62.00	91.00	110.00			85.57	110.00	62.00
WYOMING HD	BWP3	88.00	72.00	100.00	75.00	75.00	75.00	115.00			85.71	115.00	72.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	112.00	106.00	107.00	93.00	84.00	124.00	142.00			109.71	142.00	84.00
TRAILER	BWP2	98.00	101.00	93.00	92.00	82.00	111.00	139.00			102.29	139.00	82.00
DIRECT FEDERAL	BWP3	102.00	112.00	100.00	81.00	69.00	118.00	132.00			102.00	132.00	69.00
MAYS (in/mi)	BWP4												
	BWP5												
MAYS RIDEMETER	BWP1	96.81	90.50	89.61	84.73	79.40	81.99	84.20			86.75	96.81	79.40
MONTANA DOH	BWP2	84.83	79.00	76.95	80.19	76.57	80.14	82.92			80.09	84.83	76.57
(in/mi)	BWP3	89.91	82.50	85.94	82.94	77.17	78.47	82.29			82.75	89.91	77.17
COX ROADMETER	BWP1	16.20	11.90	13.40	10.90	10.00	13.40	17.30			13.30	17.30	10.00
NEVADA DOT	BWP2	11.30	15.00	16.30	10.40	11.10	14.40	20.30			14.11	20.30	10.40
(in/mi)	BWP3	16.70	13.30	15.70	9.50	10.80	13.80	17.40			13.89	17.40	9.50
B&K	BWP1	AVERAGES ONLY									19.70		
ACCELEROMETER	BWP2										19.30		
DIRECT FEDERAL	BWP3										19.60		
(Decibels dB)													
H.P.I. PURD	BWP1	95.80	110.94	108.28	80.82	80.05	112.94	120.15			101.28	120.15	80.05
ONTARIO M.T.C.	BWP2	95.75	105.79	106.14	82.46	84.48	108.91	131.43			102.14	131.43	82.46
IRI (in/mi)	BWP3	98.91	106.30	106.35	88.94	84.86	107.89	119.70			101.85	119.70	84.86
DYNATEST RDM	BWP1	3.16	2.92	2.93	3.11	3.14	3.08	2.99			3.04	3.16	2.92
MISSISSIPPI HD	BWP2	3.16	2.98	2.93	3.07	3.11	3.05	3.00			3.04	3.16	2.93
SI	BWP3	3.17	3.04	3.04	3.19	3.30	3.04	3.05			3.12	3.30	3.04

** .2 INCH BLANKING BAND USED

SMOOTHNESS DATA FOR SITE # 3 (I-25; NEW RIGID PAVEMENT) TEST SPEED 50 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
TEXAS	BWP1	3.80	3.80	3.70	3.70	4.00	4.00	3.10			3.73	4.00	3.10
SELF CALIBRATING	BWP2	3.10	3.10	3.40	3.40	3.90	3.90	3.20			3.43	3.90	3.10
ROUGHNESS UNIT	BWP3	3.60	3.60	3.80	3.80	3.80	3.80	3.10			3.64	3.80	3.10
TEXAS HD													
(SI)													
ARAN III	BWP1	97.53	103.83	93.58	88.48	81.57	101.03	110.56			96.65	110.56	81.57
TEXAS HD	BWP2	94.24	101.36	104.95	90.03	81.85	103.26	106.57			97.47	106.57	81.85
IRI (in/mi)	BWP3	92.55	98.31	96.76	91.22	82.65	107.19	121.12			98.54	121.12	82.65
K.J. LAW M8300	RWP1	211.00	312.00	240.00	226.00						247.25	312.00	211.00
NEBRASKA DOR	RWP2	233.00	275.00								254.00	275.00	233.00
MAYS (in/mi)	RWP3												
K.J.LAW M8300	LWP1	119.00	121.00	129.00	97.00	93.00	106.00	121.00			112.29	129.00	93.00
COLORADO DOH	LWP2	112.00	113.00	116.00	92.00	92.00	112.00	137.00			110.57	137.00	92.00
MAYS (in/mi)	LWP3	144.00	137.00	128.00	104.00	121.00	108.00	109.00			121.57	144.00	104.00
LASER RST	BWP1	126.70	107.70	120.37	107.70	88.69	107.70	101.36			108.60	126.70	1.40
IMS-ILLINOIS	BWP2	126.70	126.70	120.37	101.36	101.36	107.70	107.70			113.13	126.70	1.60
IRI (in/mi)	BWP3	114.03	114.03	126.70	101.36	88.69	114.03	107.70			109.51	126.70	1.40
													88.69
K.J. LAW 690 DNC	BWP1	93.00	93.00	100.00	87.00	81.00	108.00				93.67	108.00	81.00
PROFILOMETER	BWP2	92.00	94.00	106.00	86.00	78.00	108.00				94.00	108.00	78.00
FHWA	BWP3	94.00	91.00	102.00	87.00	78.00	110.00				93.67	110.00	78.00
IRI (in/mi)													
PRO RUT SYSTEM	RWP1	101.87	95.14	95.84	84.19	84.76	101.52	114.11			96.78	114.11	84.19
FHWA	RWP2												
IRI (in/mi)	RWP3												
	LWP1	94.24	101.10	106.53	98.38	86.83	118.95	114.84			102.98	118.95	86.83
	LWP2												
	LWP3												
ROAD PROFILER	LWP1	161.00	190.00	190.00	151.00	155.00	184.00	176.00			172.43	190.00	151.00
SOUTH DAKOTA	LWP2	159.00	192.00	182.00	179.00	147.00	173.00	167.00			171.29	192.00	147.00
MAYS (in/mi)	LWP3	159.00	166.00	188.00	177.00	164.00	167.00	165.00			169.43	188.00	159.00
SD PROFILOMETER	LWP1	113.00	144.00	147.00	129.00	117.00	137.00	134.00			131.57	147.00	113.00
NEBRASKA DOR	LWP2	134.00	142.00	108.00	133.00	140.00	146.00	122.00			132.14	146.00	108.00
IRI (in/mi)	LWP3	124.00	134.00	152.00	118.00	119.00	143.00	136.00			132.29	152.00	118.00
TEXAS SURFACE	BWP1	3.96	3.91	3.89	4.18	4.11	3.56	3.69			3.90	4.18	3.56
DYNAMICS	BWP2	3.96	3.82	3.87	4.07	4.01	3.47	3.66			3.84	4.07	3.47
PROFILOMETER	BWP3	3.91	3.84	3.86	4.15	4.05	3.41	3.61			3.83	4.15	3.41
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS DATA FOR SITE # 4 (I-25; MEDIUM ROUGH RIGID PAVEMENT) TEST SPEED 50 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
RAINHART	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
McCRACKEN	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
DIPSTICK *	RWP1	NOT TESTED ON THIS SITE											
E. W. FACE	LWP1												
IRI (in/mi)													
MAYS RIDEMETER	BWP1	147.00	120.00	154.00	148.00	115.00	134.00	143.00	135.00		137.00	154.00	115.00
CAR	BWP2	143.00	119.00	145.00	146.00	125.00	133.00	147.00	129.00		135.88	147.00	119.00
WYOMING HD	BWP3	150.00	121.00	154.00	143.00	128.00	146.00	150.00	139.00		141.38	154.00	121.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	153.00	125.00	149.00	135.00	128.00	144.00	145.00	123.00		137.75	153.00	123.00
TRAILER	BWP2	152.00	130.00	147.00	139.00	103.00	132.00	135.00	133.00		133.88	152.00	103.00
DIRECT FEDERAL	BWP3	150.00	119.00	133.00	146.00	105.00	144.00	135.00	132.00		133.00	150.00	105.00
MAYS (in/mi)	BWP4												
	BWP5												
MAYS RIDEMETER	BWP1	112.77	103.45	107.26	105.67	102.80	103.47	106.14	105.87		105.93	112.77	102.80
MONTANA DOH	BWP2	104.90	98.45	100.93	100.72	97.40	99.80	102.14	102.71		100.88	104.90	97.40
(in/mi)	BWP3	119.88	107.95	108.59	106.64	101.56	103.13	105.57	105.53		107.36	119.88	101.56
COX ROADMETER	BWP1	19.60	15.10	21.50	23.00	17.30	22.50	22.20	20.30		20.19	23.00	15.10
NEVADA DOT	BWP2	20.50	18.20	23.60	21.80	15.80	22.90	22.90	20.20		20.74	23.60	15.80
(in/mi)	BWP3	20.40	16.60	25.20	20.90	19.00	21.90	24.50	18.20		20.84	25.20	16.60
B&K	BWP1										16.80		
ACCELEROMETER	BWP2										16.80		
DIRECT FEDERAL	BWP3										17.00		
(Decibels dB)													
H.P.I. PURD	BWP1	137.49	122.02	126.34	121.84	113.14	125.20	127.48	121.88		124.42	137.49	113.14
ONTARIO M.T.C.	BWP2	147.53	131.64	132.53	128.67	125.14	135.75	137.29	142.54		135.14	147.53	125.14
IRI (in/mi)	BWP3	144.22	123.59	132.17	129.08	117.05	127.90	138.29	120.38		129.09	144.22	117.05
DYNATEST RDM	BWP1	3.08	3.19	3.22	3.22	3.28	3.17	3.16	3.19		3.19	3.28	3.08
MISSISSIPPI HD	BWP2	3.09	3.21	3.25	3.21	3.27	3.16	3.17	3.18		3.19	3.27	3.09
SI	BWP3	3.02	3.16	3.20	3.17	3.23	3.11	3.17	3.20		3.15	3.23	3.02

SMOOTHNESS DATA FOR SITE # 4 (I-25; MEDIUM ROUGH RIGID PAVEMENT) TEST SPEED 50 MPH

EQUIPMENT		0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
						SUB-SECTIONS							
TEXAS	BWP1	2.10	2.10	2.00	2.00	2.50	2.50	2.30	2.30		2.23	2.50	2.00
SELF CALIBRATING	BWP2	2.10	2.10	2.30	2.30	2.60	2.60	2.40	2.40		2.35	2.60	2.10
ROUGHNESS UNIT	BWP3	2.10	2.10	2.20	2.20	2.60	2.60	2.40	2.40		2.33	2.60	2.10
TEXAS HD													
(SI)													
ARAN III	BWP	130.53	111.16	123.75	126.44	109.01	121.51	121.91	111.45		119.47	130.53	109.01
TEXAS HD	BWP2	144.20	116.61	120.95	118.73	114.83	126.08	131.49	130.46		125.42	144.20	114.83
IRI (in/mi)	BWP3	139.76	115.42	123.87	122.96	106.33	120.16	126.81	137.74		124.13	139.76	106.33
K.J. LAW M8300	RWP1	150.00	116.00	143.00	137.00	119.00	146.00	149.00	139.00		137.38	150.00	116.00
NEBRASKA DOR	RWP2	142.00	115.00	146.00	150.00	119.00	149.00	142.00	147.00		138.75	150.00	115.00
MAYS (in/mi)	RWP3	132.00	125.00	134.00	157.00	168.00	165.00	147.00	146.00		146.75	168.00	125.00
K.J.LAW M8300	LWP1	137.00	98.00	133.00	129.00	109.00	131.00	127.00	116.00		122.50	137.00	98.00
COLORADO DOH	LWP2	134.00	96.00	128.00	130.00	102.00	128.00	122.00	127.00		120.88	134.00	96.00
MAYS (in/mi)	LWP3	140.00	97.00	128.00	123.00	94.00	125.00	138.00	122.00		120.88	140.00	94.00
LASER RST	BWP1	158.38	101.36	120.37	114.03	101.36	126.70	120.37	120.37		120.37	158.38	101.36
IMS-ILLINOIS	BWP2	145.70	101.36	120.37	114.03	101.36	120.37	114.03	120.37		117.20	145.70	101.36
IRI (in/mi)	BWP3	139.37	101.36	120.37	114.03	101.36	120.37	114.03	126.70		117.20	139.37	101.36
K.J. LAW 690 DNC	BWP1	221.00	306.00	316.00	284.00	313.00	188.00	199.00			261.00	316.00	188.00
PROFILOMETER	BWP2	215.00	296.00	299.00	278.00	318.00	184.00	199.00			255.57	318.00	184.00
FHWA	BWP3	217.00	301.00	305.00	275.00	300.00	182.00	190.00			252.86	305.00	182.00
IRI (in/mi)	BWP4	224.00	302.00	298.00	287.00	323.00	195.00	190.00			259.86	323.00	190.00
	BWP5	224.00	299.00	292.00	282.00	304.00	178.00	189.00			252.57	304.00	178.00
PRO RUT SYSTEM	RWP1	137.69	125.57	141.33	141.84	136.10	143.98	152.17	150.58		141.16	152.17	125.57
FHWA	RWP2	138.04	126.58	142.43	142.36	132.25	144.12	148.47	150.94		140.65	150.94	126.58
IRI (in/mi)	RWP3												
	LWP1	141.77	112.18	134.42	126.32	122.74	137.73	129.72	136.50		130.17	141.77	112.18
	LWP2	142.56	112.80	134.31	126.58	117.74	133.59	127.27	135.69		128.82	142.56	112.80
	LWP3												
ROAD PROFILER	LWP1	144.00	130.00	136.00	133.00	137.00	153.00	147.00	151.00		141.38	153.00	130.00
SOUTH DAKOTA	LWP2	140.00	144.00	148.00	141.00	130.00	155.00	152.00	145.00		144.38	155.00	130.00
MAYS (in/mi)	LWP3	144.00	138.00	147.00	141.00	142.00	148.00	143.00	144.00		143.38	148.00	138.00
SD PROFILOMETER	LWP1	201.00	129.00	116.00	136.00	113.00	128.00	139.00	134.00		137.00	201.00	113.00
NEBRASKA DOR	LWP2	140.00	118.00	134.00	121.00	122.00	135.00	131.00	134.00		129.38	140.00	118.00
IRI (in/mi)	LWP3	142.00	120.00	137.00	120.00	122.00	140.00	132.00	136.00		131.13	142.00	120.00
TEXAS SURFACE	BWP1	3.49	3.45	3.15	3.58	3.41	3.28	3.16	3.51		3.38	3.58	3.15
DYNAMICS	BWP2	3.29	3.07	3.05	3.60	3.36	2.95	2.58	3.01		3.11	3.60	2.58
PROFILOMETER	BWP3	3.17	3.36	3.29	3.64	3.30	2.91	2.76	3.14		3.20	3.64	2.76
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS DATA FOR SITE # 5 (VINE DRIVE; ROUGH FLEXIBLE PAVEMENT) TEST SPEED 30 MPH

EQUIPMENT		0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
		SUB-SECTIONS											
PROFILOGRAPH *	RWP1	17.50	13.50	26.50	31.00	24.50	55.50	9.00			25.36	55.50	9.00
RAINHART	RWP2	18.00	12.50	23.50	23.50	26.50	48.50	3.00			22.21	48.50	3.00
COLORADO DOH	LWP1	13.00	8.50	14.00	7.50	18.50	39.50	23.50			17.79	39.50	7.50
(in/mi) **	LWP2	29.00	4.50	15.00	16.00	15.00	35.50	10.50			17.93	35.50	4.50
PROFILOGRAPH *	RWP1	108.50	190.00	151.50	125.00	172.50	69.50	75.00	92.00		123.00	190.00	69.50
McCRACKEN	RWP2	122.00	171.00	114.00	143.00	173.50	60.00	93.00	81.50		119.75	173.50	60.00
COLORADO DOH	LWP1	36.00	49.50	209.50	75.50	53.50	54.00	46.50	26.00		68.81	209.50	26.00
(in/mi) **	LWP2	38.00	52.00	78.00	67.50	66.00	55.00	53.00	24.00		54.19	78.00	24.00
DIPSTICK *	RWP1		495.94		469.27						482.60	495.94	469.27
E. W. FACE	LWP1		282.27		324.78						303.52	324.78	282.27
IRI (in/mi)													
MAYS RIDEMETER	BWP1	262.00	415.00	362.00	308.00	371.00	191.00	235.00	232.00		297.00	415.00	191.00
CAR	BWP2	248.00	399.00	369.00	309.00	362.00	198.00	208.00	237.00		291.25	399.00	198.00
WYOMING HD	BWP3	257.00	362.00	370.00	318.00	364.00	196.00	211.00	226.00		288.00	370.00	196.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	243.00	568.00	477.00	405.00	394.00	265.00	253.00	252.00		357.13	568.00	243.00
TRAILER	BWP2	287.00	576.00	475.00	405.00	475.00	301.00	300.00	313.00		391.50	576.00	287.00
DIRECT FEDERAL	BWP3	246.00	449.00	463.00	391.00	395.00	250.00	265.00	271.00		341.25	463.00	246.00
MAYS (in/mi)	BWP4	288.00	546.00	439.00	411.00	420.00	279.00	281.00	285.00		368.63	546.00	279.00
	BWP5												
MAYS RIDEMETER	BWP1	241.76	352.32	358.33	345.24	344.66	320.95	306.00	295.36		320.58	358.33	241.76
MONTANA DOH	BWP2	269.73	327.50	339.00	329.92	332.87	311.40	300.86	295.59		313.36	339.00	269.73
(in/mi)	BWP3	304.70	332.50	351.00	345.66	346.00	326.89	313.57	303.17		327.94	351.00	303.17
COX ROADMETER	BWP1	36.30	45.70	51.10	54.30	47.10	36.90	34.20	32.50		42.26	54.30	32.50
NEVADA DOT	BWP2	32.60	48.30	58.70	63.40	47.00	30.60	25.40	36.10		42.76	63.40	25.40
(in/mi)	BWP3	34.50	48.70	51.40	47.80	46.70	46.30	32.10	38.20		43.21	51.40	32.10
B&K	BWP1	AVERAGES ONLY									28.40		
ACCELEROMETER	BWP2										20.40		
DIRECT FEDERAL	BWP3												
(Decibels dB)													
H.P.I. PURD	BWP1	176.05	297.00	274.98	280.60	320.81	213.27	205.45	164.75		241.61	320.81	164.75
ONTARIO M.T.C.	BWP2	155.45	288.41	266.94	271.14	316.28	219.25	205.06	163.23		235.72	316.28	155.45
IRI (in/mi)	BWP3	168.40	300.89	271.15	275.61	321.98	220.18	197.50	161.04		239.59	321.98	161.04
DYNATEST RDM	BWP1	2.95	2.54	2.68	2.79	2.80	3.08	3.27	3.09		2.82	3.27	2.54
MISSISSIPPI HD	BWP2	3.29	2.71	2.82	2.91	2.98	3.13	3.33	3.16		2.97	3.33	2.71
SI	BWP3	3.13	2.71	2.77	2.93	2.90	3.12	3.24	3.14		2.93	3.24	2.71

** .2 INCH BLANKING BAND USED

SMOOTHNESS DATA FOR SITE # 5 (VINE DRIVE; ROUGH FLEXIBLE PAVEMENT) TEST SPEED 30 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
TEXAS	BWP1	1.70	1.70	1.10	1.10	1.50	1.50	2.40	2.40		1.68	2.40	1.10
SELF CALIBRATING	BWP2	1.80	1.80	1.20	1.20	1.30	1.30	2.40	2.40		1.68	2.40	1.20
ROUGHNESS UNIT	BWP3	1.80	1.80	1.30	1.30	1.30	1.30	2.40	2.40		1.70	2.40	1.30
TEXAS HD													
(SI)													
ARAN III	BWP1	185.25	331.72	253.57	243.45	309.38	214.57	185.78	199.95		240.46	331.72	185.25
TEXAS HD	BWP2	226.59	359.86	288.32	257.53	321.80	219.78	193.77	201.71		258.67	359.86	193.77
IRI (in/mi)	BWP3	192.28	372.18	293.02	261.69	318.89	214.95	197.57	202.85		256.68	372.18	192.28
K.J. LAW M8300	RWP1	279.00	431.00	320.00	347.00	444.00	234.00	267.00	268.00		323.75	444.00	234.00
NEBRASKA DOR	RWP2	249.00	374.00	348.00	414.00	459.00	281.00	265.00	281.00		333.88	459.00	249.00
MAYS (in/mi)	RWP3	299.00	437.00	322.00	426.00	485.00	250.00	257.00	250.00		340.75	485.00	250.00
K.J.LAW M8300	LWP1	190.00	239.00	337.00	323.00	209.00	218.00	239.00	142.00		237.13	337.00	142.00
COLORADO DOH	LWP2	194.00	237.00	328.00	307.00	201.00	225.00	242.00	154.00		236.00	328.00	154.00
MAYS (in/mi)	LWP3	203.00	236.00	340.00	309.00	211.00	224.00	241.00	180.00		243.00	340.00	180.00
LASER RST	BWP1	215.39	266.07	329.42	367.43	247.07	234.40	310.42			281.46	367.43	215.39
IMS-ILLINOIS	BWP2	215.39	278.74	335.76	354.76	240.73	234.40	304.08			280.55	354.76	215.39
IRI (in/mi)	BWP3	221.73	278.74	342.09	367.43	247.07	259.73	323.09			291.41	367.43	221.73
K.J. LAW 690 DNC	BWP1	221.00	305.70	316.30	284.20	312.60	187.60	199.00			260.91	316.30	187.60
PROFILOMETER	BWP2	214.90	295.60	299.40	277.80	317.90	183.80	199.10			255.50	317.90	183.80
FHWA	BWP3	217.00	301.20	305.30	275.00	300.00	182.30	189.90			252.96	305.30	182.30
IRI (in/mi)	BWP4	224.10	302.30	298.40	286.70	322.90	195.00	190.40			259.97	322.90	190.40
	BWP5	223.80	299.40	291.70	282.40	303.80	178.10	189.40			252.66	303.80	178.10
PRO RUT SYSTEM	RWP1	342.84	574.95	527.10	518.34	591.97	344.52	375.11	400.99		459.48	591.97	342.84
FHWA	RWP2	343.88	581.82	523.15	517.98	598.00	308.88	329.27	382.39		448.17	598.00	308.88
IRI (in/mi)	RWP3	291.87	620.88	515.85	526.84	624.42	311.32	325.58	393.44		451.28	624.42	291.87
	LWP1	179.71	254.41	344.65	271.90	233.41	236.99	195.84	160.53		234.68	344.65	160.53
	LWP2	188.44	250.83	324.57	271.23	215.60	227.45	242.66	153.21		234.25	324.57	153.21
	LWP3	205:49	281.96	305.35	259.92	221.70	217.34	233.38	163.51		236.08	305.35	163.51
ROAD PROFILER	LWP1	235.00	322.00	373.00	392.00	267.00	278.00	312.00	219.00		299.75	392.00	219.00
SOUTH DAKOTA	LWP2	256.00	321.00	368.00	358.00	248.00	265.00	318.00	223.00		294.63	368.00	223.00
MAYS (in/mi)	LWP3	265.00	323.00	345.00	385.00	255.00	278.00	301.00	212.00		295.50	385.00	212.00
SD PROFILOMETER	LWP1	275.00	315.00	375.00	371.00	276.00	266.00	338.00	235.00		306.38	375.00	235.00
NEBRASKA DOR	LWP2	241.00	287.00	346.00	350.00	287.00	275.00	318.00	248.00		294.00	350.00	241.00
IRI (in/mi)	LWP3	231.00	296.00	245.00	340.00	288.00	259.00	296.00	247.00		275.25	340.00	231.00
TEXAS SURFACE	BWP1	1.47	0.80	1.90	0.83	1.40	2.06	2.40	1.96		1.60	2.40	0.80
DYNAMICS	BWP2	1.69	0.76	1.75	0.68	1.27	1.82	1.97	1.88		1.48	1.97	0.68
PROFILOMETER	BWP3	1.64	0.81	1.83	0.75	1.18	1.78	2.19	1.92		1.51	2.19	0.75
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS DATA FOR SITE # 6 (MEDIUM ASPHALT, VINE DR, TEST SPEED 50MPH)

EQUIPMENT		0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
		SUB-SECTIONS											
PROFILOGRAPH *	RWP1	74.50	149.00	106.00	99.50	92.00	62.00	59.50			91.79	149.00	59.50
RAINHART	RWP2	30.00	43.50	69.50	61.50	49.50	44.50	35.50			47.71	69.50	30.00
COLORADO DOH	LWP1	20.50	102.00	72.50	90.50	110.00	42.00	51.50			69.86	110.00	20.50
(in/mi) **	LWP2	38.00	53.50	63.00	63.00	37.00	48.50	47.00			50.00	63.00	37.00
PROFILOGRAPH *	RWP1	43.00	30.50	51.00	24.50	55.00	82.50	34.00			45.79	82.50	24.50
McCRACKEN	RWP2	41.00	11.00	36.50	13.50	42.00	55.00	53.50			36.07	55.00	11.00
COLORADO DOH	LWP1	41.50	23.50	53.50	27.00	56.50	96.00	25.50			46.21	96.00	23.50
(in/mi) **	LWP2	37.00	20.00	31.00	41.00	29.50	57.50	37.50			36.21	57.50	20.00
DIPSTICK *	RWP1	NOT TESTED ON THIS SITE											
E. W. FACE	LWP1												
IRI (in/mi)													
MAYS RIDEMETER	BWP1	125.00	101.00	146.00	121.00	138.00	261.00	117.00			144.14	261.00	101.00
CAR	BWP2	126.00	111.00	150.00	139.00	140.00	260.00	124.00			150.00	260.00	111.00
WYOMING HD	BWP3	139.00	92.00	141.00	125.00	143.00	270.00	126.00			148.00	270.00	92.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	144.00	163.00	137.00	152.00	155.00	288.00	181.00			174.29	288.00	137.00
TRAILER	BWP2	166.00	127.00	165.00	143.00	148.00	284.00	167.00			171.43	284.00	127.00
DIRECT FEDERAL	BWP3	168.00	157.00	155.00	134.00	170.00	272.00	189.00			177.86	272.00	134.00
MAYS (in/mi)	BWP4												
	BWP5												
MAYS RIDEMETER	BWP1	141.86	130.43	132.91	126.22	128.55	147.78	146.02			136.25	147.78	126.22
MONTANA DOH	BWP2	133.47	125.94	126.83	127.40	127.55	146.28	144.11			133.08	146.28	125.94
(in/mi)	BWP3	141.86	129.94	131.58	127.40	126.20	144.45	144.27			135.10	144.45	126.20
COX ROADMETER	BWP1	19.90	12.90	24.30	14.40	18.80	81.70	18.40			27.20	81.70	12.90
NEVADA DOT	BWP2	20.80	12.00	24.30	11.40	18.20	82.10	15.50			26.33	82.10	11.40
(in/mi)	BWP3	13.80	13.50	22.50	15.70	20.20	75.80	18.80			25.76	75.80	13.50
B&K	BWP1	AVERAGES ONLY									19.10		
ACCELEROMETER	BWP2										19.40		
DIRECT FEDERAL	BWP3										19.40		
(Decibels dB)													
H.P.I. PURD	BWP1	115.39	111.64	125.50	118.70	113.06	190.81	127.69			128.97	190.81	111.64
ONTARIO M.T.C.	BWP2	136.14	115.44	124.18	148.00	140.40	231.70	162.81			151.24	231.70	115.44
IRI (in/mi)	BWP3	132.69	116.15	127.68	147.99	131.64	237.67	161.95			150.82	237.67	116.15
DYNATEST RDM	BWP1	2.84	2.68	3.04	3.03	2.98	2.61	2.93			2.83	3.04	2.61
MISSISSIPPI HD	BWP2	2.81	2.69	3.03	3.02	2.99	2.57	2.97			2.83	3.03	2.57
SI	BWP3	2.87	2.69	3.03	3.00	3.03	2.60	2.95			2.84	3.03	2.60

** .2 INCH BLANKING BAND USED

SMOOTHNESS DATA FOR SITE # 6 (MEDIUM ASPHALT, VINE DR, TEST SPEED 50MPH)

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
TEXAS	BWP1	3.20	3.20	2.70	2.70	1.80	1.80	2.50			2.56	3.20	1.80
SELF CALIBRATING	BWP2	3.30	3.30	2.70	2.70	1.90	1.90	2.50			2.61	3.30	1.90
ROUGHNESS UNIT	BWP3	3.20	3.20	2.30	2.30	1.80	1.80	2.40			2.43	3.20	1.80
TEXAS HD													
(SI)													
ARAN III	BWP1	137.07	129.40	114.24	130.35	122.63	201.96	147.72			140.48	201.96	114.24
TEXAS HD	BWP2	139.33	136.94	115.51	139.27	129.30	217.84	165.81			149.14	217.84	115.51
IRI (in/mi)	BWP3	140.08	128.67	114.08	124.17	123.61	209.21	162.94			143.25	209.21	114.08
K.J. LAW M8300	RWP1	169.00	133.00	187.00	178.00	215.00	247.00	110.00			177.00	247.00	110.00
NEBRASKA DOR	RWP2	195.00	169.00	181.00	180.00	231.00	254.00	114.00			189.14	254.00	114.00
MAYS (in/mi)	RWP3	157.00	124.00	190.00	167.00	197.00	245.00	104.00			169.14	245.00	104.00
K.J.LAW M8300	LWP1	130.00	124.00	141.00	96.00	96.00	194.00	140.00			131.57	194.00	96.00
COLORADO DOH	LWP2	139.00	122.00	136.00	115.00	115.00	195.00	148.00			138.57	195.00	115.00
MAYS (in/mi)	LWP3	142.00	108.00	107.00	83.00	107.00	203.00	160.00			130.00	203.00	83.00
LASER RST	BWP1	152.04	133.04	120.37	107.70	126.70	221.73	158.38			145.70	221.73	107.70
IMS-ILLINOIS	BWP2	158.38	145.70	114.03	101.36	120.37	202.72	158.38			142.99	202.72	101.36
IRI (in/mi)	BWP3	164.71	152.04	126.70	101.36	126.70	215.39	164.71			150.23	215.39	101.36
K.J. LAW 690 DNC	BWP1	133.00	110.00	133.00	131.00	138.00	223.00				144.67	223.00	110.00
PROFILOMETER	BWP2	138.00	105.00	138.00	130.00	102.00	223.00				139.33	223.00	102.00
FHWA	BWP3	136.00	108.00	138.00	127.00	101.00	216.00				137.67	216.00	101.00
IRI (in/mi)	BWP4	135.00	108.00	138.00	131.00	106.00	221.00				139.83	221.00	106.00
	BWP5	138.00	107.00	137.00	131.00	109.00	222.00				140.67	222.00	107.00
PRO RUT SYSTEM	RWP1	202.68	141.45	207.30	182.40	199.91	317.78	144.95			199.50	317.78	141.45
FHWA	RWP2	175.51	140.15	136.18	167.06	181.71	228.02	153.76			168.91	228.02	136.18
IRI (in/mi)	RWP3	204.19	140.15	215.98	183.57	197.59	338.85	153.38			204.82	338.85	140.15
	LWP1	166.06	141.78	138.63	173.13	165.28	223.99	142.20			164.44	223.99	138.63
	LWP2	201.25	143.43	201.01	181.01	194.88	333.68	148.78			200.58	333.68	143.43
	LWP3	172.22	143.32	141.88	162.53	152.87	226.43	152.83			164.58	226.43	141.88
ROAD PROFILER	LWP1	217.00	207.00	232.00	224.00	194.00	266.00	243.00			226.14	266.00	194.00
SOUTH DAKOTA	LWP2	228.00	215.00	205.00	238.00	191.00	269.00	246.00			227.43	269.00	191.00
MAYS (in/mi)	LWP3	215.00	209.00	209.00	233.00	216.00	276.00	215.00			224.71	276.00	209.00
SD PROFILOMETER	LWP1	192.00	184.00	191.00	130.00	135.00	214.00	218.00			180.57	218.00	130.00
NEBRASKA DOR	LWP2	184.00	189.00	180.00	128.00	147.00	220.00	194.00			177.43	220.00	128.00
IRI (in/mi)	LWP3	172.00	174.00	175.00	104.00	132.00	221.00	210.00			169.71	221.00	104.00
TEXAS SURFACE	BWP1	2.75	3.11	2.57	2.63	3.32	1.73	2.75			2.69	3.32	1.73
DYNAMICS	BWP2	2.69	2.91	2.35	2.63	3.20	1.65	2.94			2.62	3.20	1.65
PROFILOMETER	BWP3	2.70	2.61	2.12	2.64	3.12	1.64	2.99			2.55	3.12	1.64
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS DATA FOR SITE # 7 (LA PORTE AVE,ROUGH RIGID PAVEMENT) TEST SPEED 30 MPH

		SUB-SECTIONS											
EQUIPMENT		0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
PROFILOGRAPH *	RWP1	41.00	49.50	44.00	27.00	54.50	78.00	24.00			45.43	78.00	24.00
RAINHART	RWP2	56.00	53.50	48.50	39.50	44.50	80.50	25.50			49.71	80.50	25.50
COLORADO DOH	LWP1	36.50	75.00	52.00	40.50	50.50	84.50	32.50			53.07	84.50	32.50
(in/mi) **	LWP2	38.00	45.00	48.00	35.00	55.50	86.50	32.50			48.64	86.50	32.50
PROFILOGRAPH *	RWP1	93.50	112.50	88.50	61.00	66.50	113.00	52.50			83.93	113.00	52.50
McCRACKEN	RWP2	68.00	57.00	87.50	79.00	89.50	120.00	46.50			78.21	120.00	46.50
COLORADO DOH	LWP1	86.00	99.50	109.00	93.50	81.00	124.00	49.00			91.71	124.00	49.00
(in/mi) **	LWP2	66.00	74.00	96.00	62.50	93.00	113.00	49.00			79.07	113.00	49.00
DIPSTICK *	RWP1		367.79		285.50						326.65	367.79	285.50
E. W. FACE	LWP1		273.72		243.76						258.74	273.72	243.76
IRI (in/mi)													
MAYS RIDEMETER	BWP1	305.00	287.00	314.00	282.00	260.00	372.00	228.00			292.57	372.00	228.00
CAR	BWP2	293.00	326.00	319.00	272.00	262.00	368.00	242.00			297.43	368.00	242.00
WYOMING HD	BWP3	290.00	326.00	326.00	288.00	275.00	392.00	226.00			303.29	392.00	226.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	350.00	352.00	340.00	286.00	273.00	386.00	238.00			317.86	386.00	238.00
TRAILER	BWP2	359.00	332.00	352.00	285.00	290.00	388.00	233.00			319.86	388.00	233.00
DIRECT FEDERAL	BWP3	398.00	367.00	372.00	344.00	317.00	419.00	269.00			355.14	419.00	269.00
MAYS (in/mi)	BWP4												
	BWP5												
MAYS RIDEMETER	BWP1	294.70	302.00	296.33	284.68	277.40	284.29	273.70			287.59	302.00	273.70
MONTANA DOH	BWP2	295.70	305.00	299.13	287.18	280.80	287.79	275.51			290.16	305.00	275.51
(in/mi)	BWP3	296.70	307.50	301.80	286.93	278.40	287.07	274.90			290.47	307.50	274.90
COX ROADMETER	BWP1	47.80	54.30	65.30	44.40	54.00	78.50	36.00			54.33	78.50	36.00
NEVADA DOT	BWP2	52.60	47.80	67.10	46.70	52.10	79.80	38.90			55.00	79.80	38.90
(in/mi)	BWP3	52.30	50.70	70.00	37.40	52.70	77.50	36.60			53.89	77.50	36.60
B&K	BWP1	AVERAGES ONLY									17.10		
ACCELEROMETER	BWP2										17.80		
DIRECT FEDERAL	BWP3										17.80		
(Decibels dB)													
H.P.I. PURD	BWP1	234.75	276.34	278.39	228.67	234.47	252.80	187.58			241.86	278.39	187.58
ONTARIO M.T.C.	BWP2	248.25	274.40	280.13	229.54	241.03	250.19	195.48			245.57	280.13	195.48
IRI (in/mi)	BWP3	247.23	282.70	278.55	229.85	234.06	250.61	179.57			243.22	282.70	179.57
DYNATEST RDM	BWP1	2.32	2.29	2.32	2.52	2.36	2.15	2.62			2.34	2.62	2.15
MISSISSIPPI HD	BWP2	2.33	2.25	2.29	2.55	2.38	2.20	2.63			2.35	2.63	2.20
SI	BWP3	2.30	2.27	2.25	2.53	2.36	2.23	2.64			2.35	2.64	2.23

** .2 INCH BLANKING BAND USED

SMOOTHNESS DATA FOR SITE # 7 (LA PORTE AVE, ROUGH RIGID PAVEMENT) TEST SPEED 30 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
TEXAS	BWP1	1.50	1.50	1.10	1.10	1.30	1.30				1.30	1.50	1.10
SELF CALIBRATING	BWP2	1.10	1.10	1.10	1.10	1.30	1.30				1.17	1.30	1.10
ROUGHNESS UNIT	BWP3	1.60	1.60	1.10	1.10	1.30	1.30				1.33	1.60	1.10
TEXAS HD													
(SI)													
ARAN III	BWP1	261.00	295.00	272.00	231.00	252.00	364.00	181.00			265.14	364.00	181.00
TEXAS HD	BWP2	272.00	303.00	273.00	212.00	253.00	336.00	187.00			262.29	336.00	187.00
IRI (in/mi)	BWP3	255.00	297.00	270.00	218.00	243.00	316.00	170.00			252.71	316.00	170.00
K.J. LAW M8300	RWP1												
NEBRASKA DOR	RWP2												
MAYS (in/mi)	RWP3												
K.J.LAW M8300	LWP1	259.00	252.00	278.00	212.00	260.00	310.00	186.00			251.00	310.00	186.00
COLORADO DOH	LWP2	248.00	254.00	275.00	215.00	255.00	303.00	177.00			246.71	303.00	177.00
MAYS (in/mi)	LWP3	262.00	248.00	277.00	217.00	259.00	294.00	176.00			247.57	294.00	176.00
LASER RST	BWP1	354.76	266.07	272.41	234.40	259.73	272.41	190.05			264.26	354.76	3.00
IMS-ILLINOIS	BWP2	310.42	272.41	278.74	247.07	266.07	278.74	190.05			263.36	310.42	3.00
IRI (in/mi)	BWP3	380.10	266.07	272.41	234.40	266.07	272.41	190.05			268.79	380.10	3.00
K.J. LAW 690 DNC	BWP1	285.00	306.60	270.60	254.60	247.00	327.60				281.90	327.60	247.00
PROFILOMETER	BWP2	287.00	316.90	270.20	251.70	248.10	324.60				283.08	324.60	248.10
FHWA	BWP3	288.00	320.40	269.20	251.10	248.40	320.70				282.97	320.70	248.40
IRI (in/mi)	BWP4	286.80	312.60	267.40	248.50	247.10	318.50				280.15	318.50	247.10
	BWP5	309.20	313.90	269.60	251.90	246.20	316.10				284.48	316.10	246.20
PRO RUT SYSTEM	RWP1	339.20	379.00	294.00	282.90	272.80	383.30	242.90			313.44	383.30	242.90
FHWA	RWP2	252.50	276.20	269.60	232.30	259.00	298.90	204.30			256.11	298.90	204.30
IRI (in/mi)	RWP3	344.80	379.40	299.40	303.60	278.30	395.10	248.50			321.30	395.10	248.50
	LWP1	263.20	276.40	271.90	232.50	254.20	324.90	204.50			261.09	324.90	204.50
	LWP2	341.70	381.10	284.80	296.00	270.60	382.60	248.40			315.03	382.60	248.40
	LWP3	255.30	279.30	272.90	230.60	260.80	312.50	213.70			260.73	312.50	213.70
ROAD PROFILER	LWP1	263.00	280.00	281.00	245.00	271.00	329.00	202.00			267.29	329.00	202.00
SOUTH DAKOTA	LWP2	264.00	281.00	283.00	245.00	271.00	295.00	199.00			262.57	295.00	199.00
MAYS (in/mi)	LWP3	266.00	274.00	275.00	240.00	273.00	315.00	200.00			263.29	315.00	200.00
SD PROFILOMETER	LWP1	279.00	317.00	299.00	282.00	301.00	312.00	248.00					
NEBRASKA DOR	LWP2	271.00	299.00	310.00	280.00	301.00	367.00	216.00					
IRI (in/mi)	LWP3	282.00	295.00	315.00	295.00	297.00	358.00	230.00					
TEXAS SURFACE	BWP1	1.60	1.20	1.30	1.72	1.45	1.60	1.95			1.55	1.95	1.20
DYNAMICS	BWP2	1.61	1.39	1.65	1.76	1.25	1.66	2.03			1.62	2.03	1.25
PROFILOMETER	BWP3	1.48	1.08	1.22	1.75	1.08	1.52	2.02			1.45	2.02	1.08
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS DATA FOR SITE # 8 (SHIELDS AVE. ROUGH FLEXIBLE PAVEMENT) TEST SPEED 30MPH

EQUIPMENT		0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
		SUB-SECTIONS											
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
RAINHART	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
McCRACKEN	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
DIPSTICK *	RWP1	NOT TESTED ON THIS SITE											
E. W. FACE	LWP1												
IRI (in/mi)													
MAYS RIDEMETER	BWP1	347.00	444.00	390.00	349.00	274.00	191.00	331.00	359.00		335.63	444.00	191.00
CAR	BWP2	326.00	477.00	397.00	364.00	269.00	197.00	339.00	363.00		341.50	477.00	197.00
WYOMING HD	BWP3	339.00	436.00	408.00	364.00	284.00	172.00	336.00	340.00		334.88	436.00	172.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	321.00	478.00	399.00	345.00	274.00	166.00	316.00	296.00		324.38	478.00	166.00
TRAILER	BWP2	318.00	480.00	401.00	354.00	299.00	181.00	335.00	342.00		338.75	480.00	181.00
DIRECT FEDERAL	BWP3	341.00	517.00	395.00	339.00	305.00	181.00	344.00	343.00		345.63	517.00	181.00
MAYS (in/mi)	BWP4												
	BWP5												
MAYS RIDEMETER	BWP1	345.65	394.00	394.67	384.46	365.40	337.39	334.43	335.05		361.38	394.67	334.43
MONTANA DOH	BWP2	376.25	440.00	430.71	412.94	393.04	357.44	350.86	348.71		388.74	440.00	348.71
(in/mi)	BWP3	377.62	428.50	421.33	408.65	392.60	361.44	360.00	359.15		388.66	428.50	359.15
COX ROADMETER	BWP1	50.90	97.20	839.60	63.10	36.70	24.90	45.20	77.90		154.44	839.60	24.90
NEVADA DOT	BWP2	63.70	808.90	833.00	58.70	38.50	26.30	49.60	82.80		245.19	833.00	26.30
(in/mi)	BWP3	59.70	806.80	837.20	51.30	38.70	27.50	36.60	77.70		241.94	837.20	27.50
B&K	BWP1	AVERAGE ONLY									17.90		
ACCELEROMETER	BWP2										17.90		
DIRECT FEDERAL	BWP3										16.80		
(Decibels dB)													
H.P.I. PURD	BWP1	272.41	314.52	363.77	339.45	258.56	168.99	233.86	193.28		268.11	363.77	168.99
ONTARIO M.T.C.	BWP2	316.53	351.80	391.65	364.95	275.29	169.06	256.48	193.67		289.93	391.65	169.06
IRI (in/mi)	BWP3	306.31	343.34	385.98	380.00	385.51	190.64	251.27	189.31		304.05	385.98	189.31
DYNATEST RDM	BWP1	2.68	2.37	2.17	2.67	2.94	3.15	2.83	2.54		2.54	3.15	2.17
MISSISSIPPI HD	BWP2	2.72	2.32	2.17	2.65	2.82	3.13	2.77	2.46		2.52	3.13	2.17
SI	BWP3	2.66	2.32	2.15	2.65	2.85	3.14	2.82	2.56		2.54	3.14	2.15

SMOOTHNESS DATA FOR SITE # 8 (SHIELDS AVE. ROUGH FLEXIBLE PAVEMENT) TEST SPEED 30MPH

EQUIPMENT		0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
		SUB-SECTIONS											
TEXAS	BWP1	0.70	0.70	0.40	0.40	1.50	1.50	1.40	1.40		1.00	1.50	0.40
SELF CALIBRATING	BWP2	0.80	0.80	0.40	0.40	1.60	1.60	1.40	1.40		1.05	1.60	0.40
ROUGHNESS UNIT	BWP3	0.70	0.70	0.40	0.40	1.50	1.50	1.30	1.30		0.98	1.50	0.40
TEXAS HD													
(SI)													
ARAN III	BWP1	283.93	337.23	349.42	308.50	365.61	176.48	216.51	219.04		282.09	365.61	176.48
TEXAS HD	BWP2	276.09	336.97	355.97	316.66	253.57	166.07	215.79	191.70		264.10	355.97	166.07
IRI (in/mi)	BWP3	295.28	352.99	401.44	333.69	279.18	174.25	246.29	175.84		282.37	401.44	174.25
K.J. LAW M8300	RWP1	358.00	477.00	437.00	343.00	324.00	193.00	337.00	469.00		367.25	477.00	193.00
NEBRASKA DOR	RWP2	361.00	488.00	464.00	338.00	315.00	201.00	301.00	459.00		365.88	488.00	201.00
MAYS (in/mi)	RWP3	402.00	466.00	424.00	337.00	355.00	188.00	279.00	420.00		358.88	466.00	188.00
K.J.LAW M8300	LWP1	234.00	452.00	487.00	328.00	237.00	148.00	298.00	341.00		315.63	487.00	148.00
COLORADO DOH	LWP2	252.00	436.00	487.00	336.00	230.00	156.00	281.00	326.00		313.00	487.00	156.00
MAYS (in/mi)	LWP3	234.00	436.00	519.00	337.00	226.00	153.00	325.00	337.00		320.88	519.00	153.00
LASER RST	BWP1	266.07	456.12	487.80	361.10	202.72	177.38	266.07	348.43		320.71	487.80	177.38
IMS-ILLINOIS	BWP2	253.40	462.46	544.81	373.77	202.72	171.05	253.40	329.42		323.88	544.81	171.05
IRI (in/mi)	BWP3	240.73	443.45	468.79	342.09	209.06	164.71	291.41	361.10		315.17	468.79	164.71
K.J. LAW 690 DNC	BWP1	308.00	378.00	368.00	342.00	256.00	157.00	292.00			300.14	378.00	157.00
PROFILOMETER	BWP2	297.00	402.00	369.00	288.00	222.00	155.00	243.00			282.29	402.00	155.00
FHWA	BWP3	339.00	380.00	420.00	303.00	236.00	173.00	305.00			308.00	420.00	173.00
IRI (in/mi)		336.00	370.00	367.00	336.00	247.00	180.00	290.00					
		315.00	370.00	353.00	356.00	238.00	180.00	270.00					
PRO RUT SYSTEM	RWP1	485.80	598.00	455.10	509.60	474.00	281.60	466.30	468.90		467.41	598.00	281.60
FHWA	RWP2	247.70	414.50	477.10	411.80	214.10	162.80	318.10	329.20		321.91	477.10	162.80
IRI (in/mi)	RWP3	481.70	575.60	463.80	504.10	492.00	293.00	460.80	448.80		464.98	575.60	293.00
	LWP1	252.10	430.20	452.70	405.60	225.60	156.90	304.30	295.60		315.38	452.70	156.90
	LWP2	511.90	598.70	469.90	503.60	483.70	289.30	472.80	445.30		471.90	598.70	289.30
	LWP3	267.30	409.30	432.40	413.70	241.20	174.40	309.20	287.30		316.85	432.40	174.40
ROAD PROFILER	LWP1	258.00	458.00	488.00	359.00	245.00	189.00	300.00	336.00		329.13	488.00	189.00
SOUTH DAKOTA	LWP2	268.00	483.00	500.00	360.00	225.00	179.00	294.00	327.00		329.50	500.00	179.00
MAYS (in/mi)	LWP3	273.00	481.00	486.00	362.00	256.00	183.00	292.00	336.00		333.63	486.00	183.00
SD PROFILOMETER	LWP1	243.00	480.00	508.00	375.00	226.00	194.00	240.00	341.00		325.88	508.00	194.00
NEBRASKA DOR	LWP2	297.00	470.00	479.00	397.00	261.00	199.00	278.00	308.00		336.13	479.00	199.00
IRI (in/mi)	LWP3	274.00	466.00	497.00	368.00	248.00	199.00	262.00	338.00		331.50	497.00	199.00
TEXAS SURFACE	BWP1	0.68	0.76	0.40	0.85	1.44	1.91	1.15	0.71		0.99	1.91	0.40
DYNAMICS	BWP2	0.77	0.86	0.43	0.92	1.60	1.75	1.17	0.64		1.02	1.75	0.43
PROFILOMETER	BWP3	0.68	0.75	0.31	0.63	1.39	1.72	1.10	0.70		0.91	1.72	0.31
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)

SMOOTHNESS CORRELATION DATA FOR SITE # 9 (S.H.1, NEW FLEXIBLE PAVEMENT) TEST SPEED 50 MPH

EQUIPMENT		SUB-SECTIONS 0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
RAINHART	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
PROFILOGRAPH *	RWP1	NOT TESTED ON THIS SITE											
McCRACKEN	RWP2												
COLORADO DOH	LWP1												
(in/mi)	LWP2												
DIPSTICK *	RWP1	NOT TESTED ON THIS SITE											
E. W. FACE	LWP1												
IRI (in/mi)													
MAYS RIDEMETER	BWP1	73.00	45.00	61.00	90.00	95.00	51.00	43.00	44.00		62.75	95.00	43.00
CAR	BWP2	68.00	42.00	60.00	81.00	91.00	47.00	42.00	56.00		60.88	91.00	42.00
WYOMING HD	BWP3	66.00	42.00	57.00	82.00	91.00	45.00	38.00	55.00		59.50	91.00	38.00
MAYS (in/mi)													
MAYS RIDEMETER	BWP1	51.00	30.00	45.00	69.00	73.00	48.00	34.00	58.00		51.00	73.00	30.00
TRAILER	BWP2	46.00	35.00	56.00	66.00	77.00	45.00	48.00	53.00		53.25	77.00	35.00
DIRECT FEDERAL	BWP3	47.00	28.00	45.00	66.00	74.00	44.00	44.00	53.00		50.13	74.00	28.00
MAYS (in/mi)	BWP4												
	BWP5												
MAYS RIDEMETER	BWP1	45.91	40.48	42.31	50.24	52.18	51.63	51.57	51.15		48.18	52.18	40.48
MONTANA DOH	BWP2	60.88	52.47	55.00	58.24	59.20	57.81	56.56	57.29		57.18	60.88	52.47
(in/mi)	BWP3	55.94	48.48	49.00	53.24	54.58	53.32	51.71	52.38		52.33	55.94	48.48
COX ROADMETER	BWP1	7.40	6.30	8.20	7.60	10.90	7.50	5.40	4.40		7.21	10.90	4.40
NEVADA DOT	BWP2	7.10	5.60	7.20	9.20	8.60	6.20	6.50	5.20		6.95	9.20	5.20
(in/mi)	BWP3	7.40	6.30	8.00	9.80	10.40	4.50	5.70	4.50		7.08	10.40	4.50
B&K	BWP1	AVERAGES ONLY									10.70		
ACCELEROMETER	BWP2										10.60		
DIRECT FEDERAL	BWP3										10.80		
(Decibels dB)													
H.P.I. PURD	BWP1	67.23	43.64	57.46	80.25	84.10	51.76	50.48	58.72		61.71	84.10	43.64
ONTARIO M.T.C.	BWP2	67.30	40.92	55.15	84.52	84.35	53.54	50.64	50.19		60.83	84.52	40.92
IRI (in/mi)	BWP3	65.75	44.00	56.67	84.78	84.77	52.98	46.92	44.65		60.07	84.78	44.00
DYNATEST RDM	BWP1	3.89	3.90	3.84	3.79	3.76	3.92	3.92	3.86		3.86	3.92	3.76
MISSISSIPPI HD	BWP2	3.81	3.85	3.88	3.75	3.72	3.88	3.88	3.87		3.83	3.88	3.72
SI	BWP3	3.89	3.92	3.85	3.73	3.72	3.91	3.88	3.84		3.84	3.92	3.72

SMOOTHNESS CORRELATION DATA FOR SITE # 9 (S.H.1, NEW FLEXIBLE PAVEMENT) TEST SPEED 50 MPH

		SUB-SECTIONS											
EQUIPMENT		0	1	2	3	4	5	6	7	8	AVERAGE VALUES	MAX VALUES	MIN VALUES
TEXAS	BWP1	3.90	3.90	3.60	3.60	3.50	3.50	4.50	4.50		3.88	4.50	3.50
SELF CALIBRATING	BWP2	3.80	3.80	3.40	3.40	3.50	3.50	4.10	4.10		3.70	4.10	3.40
ROUGHNESS UNIT	BWP3	3.70	3.70	3.50	3.50	3.40	3.40	4.40	4.40		3.75	4.40	3.40
TEXAS HD													
(SI)													
ARAN III	BWP1	68.27	47.73	61.36	82.22	86.96	57.33	54.54	60.10		64.81	86.96	47.73
TEXAS HD	BWP2	68.92	48.62	60.10	82.48	89.70	57.06	53.93	58.68		64.94	89.70	48.62
IRI (in/mi)	BWP3	68.06	49.13	58.78	81.89	89.04	57.94	52.98	67.15		65.62	89.04	49.13
K.J. LAW M8300	RWP1	71.00	41.00	57.00	78.00	75.00	49.00	53.00	46.00		58.75	78.00	41.00
NEBRASKA DOR	RWP2	68.00	38.00	60.00	83.00	75.00	49.00	45.00	46.00		58.00	83.00	38.00
MAYS (in/mi)	RWP3	72.00	34.00	58.00	79.00	75.00	51.00	51.00	46.00		58.25	79.00	34.00
K.J.LAW M8300	LWP1	65.00	38.00	63.00	67.00	81.00	46.00	42.00	56.00		57.25	81.00	38.00
COLORADO DOH	LWP2	70.00	36.00	57.00	70.00	93.00	53.00	53.00	56.00		61.00	93.00	36.00
MAYS (in/mi)	LWP3	74.00	34.00	58.00	66.00	84.00	43.00	42.00	53.00		56.75	84.00	34.00
LASER RST	BWP1	82.36	44.35	63.35	63.35	76.02	50.68	50.68	57.02		60.97	82.36	44.35
IMS-ILLINOIS	BWP2	69.69	38.01	63.35	69.69	76.02	50.68	50.68	57.02		59.39	76.02	38.01
IRI (in/mi)	BWP3	69.69	44.35	63.35	69.69	76.02	50.68	50.68	57.02		60.18	76.02	44.35
K.J. LAW 690 DNC	BWP1	69.60	39.30	59.00	73.10	75.70	49.30	47.80			59.11	75.70	39.30
PROFILOMETER	BWP2	71.00	40.00	60.00	73.50	76.10	50.60	47.70			59.84	76.10	40.00
FHWA	BWP3	72.50	39.70	58.60	76.90	77.60	51.10	50.40			60.97	77.60	39.70
IRI (in/mi)		71.00	40.50	58.60	74.00	77.80	51.00	49.30			60.31	77.80	40.50
		72.00	41.30	58.40	79.20	75.60	50.30	50.10			60.99	79.20	41.30
PRO RUT SYSTEM	RWP1	73.25	44.18	63.30	86.55	78.74	56.04	52.79	53.99		63.61	86.55	44.18
FHWA	RWP2	73.56	48.22	66.33	93.11	87.24	58.73	57.85	54.02		67.38	93.11	48.22
IRI (in/mi)	RWP3	72.29	45.67	60.97	85.44	86.37	59.66	53.30	60.32		65.50	86.37	45.67
	LWP1	70.33	46.93	65.54	73.67	79.91	55.14	55.04	58.31		63.11	79.91	46.93
	LWP2	71.45	45.63	65.50	76.63	77.59	55.03	55.83	56.91		63.07	77.59	45.63
	LWP3	70.57	47.41	66.02	74.68	78.59	54.11	56.65	59.74		63.47	78.59	47.41
ROAD PROFILER	LWP1	97.00	85.00	88.00	99.00	144.00	88.00	86.00	85.00		96.50	144.00	85.00
SOUTH DAKOTA	LWP2	90.00	81.00	87.00	103.00	134.00	82.00	77.00	89.00		92.88	134.00	77.00
MAYS (in/mi)	LWP3	94.00	72.00	87.00	105.00	135.00	86.00	84.00	89.00		94.00	135.00	72.00
SD PROFILOMETER	LWP1	83.00	66.00	111.00	99.00	105.00	66.00	80.00	84.00		86.75	111.00	66.00
NEBRASKA DOR	LWP2	89.00	80.00	80.00	95.00	141.00	85.00	73.00	72.00		89.38	141.00	72.00
IRI (in/mi)	LWP3	87.00	73.00	84.00	100.00	127.00	79.00	67.00	75.00		86.50	127.00	67.00
TEXAS SURFACE	BWP1	4.12	4.76	4.20	3.98	4.43	4.66	4.35	4.48		4.37	4.76	3.98
DYNAMICS		4.28	4.78	4.18	3.99	4.26	4.55	4.36	4.36		4.35	4.78	3.99
PROFILOMETER		4.18	4.66	3.97	3.76	4.27	4.56	4.29	4.49		4.27	4.66	3.76
TEXAS HD													
SI													

* THIS EQUIPMENT OPERATED AT 2-3MPH (WALKING SPEED)