5.16.54 DETERMINATION OF PAVEMENT PROFILE WITH THE PROFILOGRAPH (Kansas Test Method KT-54) "METRIC VERSION"

a. SCOPE

This method of test covers the procedure for determining the smoothness, profile index, of both concrete and bituminous pavement using the California type 7.6 m profilograph or equivalent. See **KT-46** for the English version.

b. REFERENCED DOCUMENTS

b.1. KT-46; Determination of Pavement Profile with the Profilograph

c. APPARATUS

c.1. California type, 7.6 m, profilograph or equivalent (Figure 1) with pointer. The 7.6 m profilograph is a rolling straight edge which measures vertical deviations from a moving 7.6 m reference plane. The pavement profile is graphically recorded on a profilogram with scales of 300:1 longitudinally and 1:1 vertically.

c.2. Blanking band which is a plastic scale 43 mm wide and 333 mm long representing a pavement length of 100 m or 0.1 km. Near the center of the scale is a dashed line extending the entire length of the plastic scale. On either side of this dashed line are scribed lines 2 mm apart, parallel to the dashed line. These lines serve as a convenient scale to measure deviations of the profile trace above or below the dashed reference line. These deviations are called "scallops".

c.3. Scale graduated in millimeters (mm).

c.4. Medium point ballpoint pen with red ink or other color contrasting to the profile trace.

c.5. Electronic calculator.

c.6. Plain recording chart paper as specified by the manufacturer of the profilograph.

c.7. Bump template which is a plastic template having a marked length 25 mm long on one face, and a slot (or edge) parallel to the marked length. A distance equal to the maximum bump specified, 10 mm, separates the two reference lengths (Example, Figure 2). The 25 mm line corresponds to a longitudinal distance of 7.5 m on the longitudinal scale of the profilogram.

d. CALIBRATION

d.1. ***All profilographs used on KDOT projects must be calibrated at least annually. Calibration must be checked any time the profilograph has been altered or repaired. The certification includes establishing the proper tire inflation pressure, checking the trueness of the tire travel, checking the chart scale factor, and checking vertical displacement of the sensing wheel.***

d.2. Each District and contractor using a profilograph shall establish a 100 to 300 m distance calibration test section on or near each project. This test section should be fairly straight, relatively flat and used periodically to check the longitudinal calibration ***and trace reproduction***.

d.3. Longitudinal calibration consists of pushing the profilograph at walking speed (approximately 5 km/h), a pre-measured test distance (100 to 300 m) and determining the chart scale factor. Dividing the premeasured test distance in mm by the profilogram trace length in mm will determine the scale factor. This factor ***shall*** be 300 $\pm$ 0.5. If the profilogram produces charts with a different scale factor, adjustment of the profilograph must be made to bring the scale factor within the tolerances specified above.

d.4. ***Vertical calibration consists of placing the center recording wheel of the profilograph on a base plate and recording the base elevation. Two plates 12.5 mm thick each are added under the center wheel one at a time and the change in elevation noted. The two plates are removed one at a time and the change in elevation noted. Each step in the process shall show a change in height of 12.5 mm ± 1.0 mm. If the profilograph produces results not conforming to the above limits it must be adjusted to within the tolerance specified.***

d.5. The automatic trace reduction capability of a machine so equipped shall be checked by comparing the machine's results to the results obtained through manual trace reduction. The comparison shall be made for the trace obtained at the Materials

and Research test section and for each project, at the project test section. The results of the comparison may not differ by more than 30 mm/km. All calibration traces and calculations shall be submitted to the Materials and Research Center or to the appropriate construction office to become part of the project file.

e. TEST PROCEDURE

e.1. The profilograph is propelled at walking speed (approximately 5 km/h) in the paths indicated for each section of pavement (see Figure 1). Propulsion may be provided by manually pushing or by a suitable propulsion unit such as a garden tractor. **Do Not** push or pull the profilograph with a vehicle. More than one person may be required to hold the back end of the profilograph exactly in the required path on superelevated or sharp horizontal curves.

e.2. Use of the pointer to maintain the required trace path is mandatory.

e.3. If excessive "spikes" are encountered, decrease the rate of travel. An excessive number of "spikes" on a trace make it difficult to evaluate and may affect test results.

e.4. If possible, assemble the profilograph a short distance prior to the location on the pavement where testing is to start. Place the distance measuring wheel down and the pen in place on the trace paper. Push the machine in the direction of travel up to the start position using the center wheel as the reference wheel. While the profilograph is stationary at the start location, move the cable attached to the pen thus creating a spike mark on the trace and label that mark as the starting point. Using this procedure at the beginning ***and end*** of each trace will ensure that all systems are working properly***, that slack has been removed from the drive chains,*** and will clearly define the ***start and end location. Also mark which direction is up on the trace and the direction the profilograph was pushed.***

e.5. Push the profilograph in the same direction when recording each trace for a given section of pavement.

e.6. Indicate stationing with a spike mark on the profilogram at least every 100 m using the procedure outlined in **e.4.** More frequent station references of every 25 m or every 50 m are highly desirable where possible. Station referencing on the trace is used to accurately locate 10 mm bumps. Notation of landmarks,

roadway signs, etc. should also be made on the trace for additional referencing.

e.7. Completely label both ends of the profilogram with the project number, stationing represented on the roll and name of profilograph operators. Fill out a report form and secure it around the trace roll. This report insures that the person reducing the trace and reporting results will have all necessary information.

e.8. A little dirt or debris will spike out and not effect profilograph readings, however, excessive mud or caked mud must be removed prior to testing. Anything on the pavement surface longer than 50 to 75 mm may not be considered a spike when reducing the trace and should be removed.

e.9. When operating the profilograph, all wheels should always be on the pavement for which the contractor is responsible. Test from header to header whenever possible.

e.10. Pavement not tested at the end of a day's run due to barrier fences, machinery or other obstructions shall be included in a subsequent test run.

f. TRACE REDUCTION AND BUMP/*DIP* LOCATING PROCEDURE

f.1. Using a red (or other contrasting color), medium point, ballpoint pen; retrace the profilogram through the middle of any spikes. This outlining procedure removes spikes and minor deviations and generally smooths the trace for easier reduction and analysis.

f.2. Use a 10 mm bump template (scribed side down) to locate bumps***dips*** for removal. At each prominent bump***/dip*** or high***/low*** point on the profile trace, place the template so that the scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak***/valley*** or indicated bump***/dip***. The line on the template need not be horizontal. With a sharp pencil, draw a line using the narrow slot in the template (or edge) as a guide. Any portion of the trace extending above***/below*** this line will indicate the approximate length and height of the bump***/dip*** in excess of the specification.

There may be instances where the distance between easily recognizable low***/high*** points is less than 25 mm. In such cases a shorter chord length shall be used in making the scribed line on

the template tangent to the trace at the low***/high*** points. It is the intent, however, of this requirement that the baseline for measuring the height of bumps ***(or depth of dips)*** will be as nearly 25 mm as possible, but in no case to exceed this value. When the distance between prominent low***/high*** points is greater than 25 mm, make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. A few examples of the procedure are shown in Figure 2.

After marking the bump***/dip*** on the profilogram, determine the station number of the center of the bump***/dip*** by scaling from the nearest reference mark. Enter the track identification and station on the KDOT Form 242 as shown in Figure 6.

f.3. Place the blanking band (scribed side down) over the profile with the dashed reference line as nearly centered on the profile trace as possible.

The profile trace ***may*** move from a generally horizontal position when going around superelevated curves making it impossible to follow the central portion of the trace without shifting the blanking band. When such conditions occur, the profile should be broken into short sections and the blanking band repositioned on each section as shown in the upper part of Figure 2.

Indicate the beginning and ending of superelevated curves on the profilogram at the time the profile trace is being made.

f.4. Begin evaluating each trace from the same point on the road so that sections representing the same length of road can be aligned on the test report form. Measure and total the height of all the scallops appearing both above and below the dashed reference line, measuring each scallop to the nearest 1 mm. Do not count a scallop as 1 mm just because you see the profile line or there is space under the line. Short sections of the profile line may be visible above or below the dashed reference line, but unless they project 0.7 mm or more vertically and extend longitudinally for 2 mm or more on the profilogram, they are not included in the count. Spikes are not counted. Double-peaked scallops are only counted once as the highest peak (Figure 3).

Write the total count in mm on the profilogram above the profile line (toward the center of the section) and circle it. Outline the position of the blanking band when reducing the trace for later repositioning to check trace reduction procedure. Rotate the blanking band about the last end position when evaluating the next section (Figure 4).

When a scallop occurs at the end of the blanking band, count the scallop only once. Place the scallop in the 0.1 km section where the peak is highest (Figure 4).

Always use the measured trace length in computations. This length may not agree exactly with distance by subtracting stationing. Always use ± after the total length on the report.

The measured roughness for each 0.1 km section and for each track shall be entered on KDOT Form 242 in the appropriate column as shown in Figure 6.

f.5. The last section counted is generally not an even 0.1 km. If not, its length should be scaled to determine its length in km (calculated to three decimal places). For the example shown below, the last section measures 193 mm in length.

$$\text{(SI)} \qquad \frac{(193 \text{ mm})\ (300)}{1{,}000{,}000 \text{ mm/km}} = 0.0579 \text{ km} = 0.058 \text{ km}$$

If the last section is less than or equal to 0.05 km ***(50 m)***, it is added to and included with the previous 0.1 km section to determine compliance with the profile index. If the last section is more than 0.05 km ***(50 m)***, it is treated as a separate section.

When the profilograph must be picked up or partially disassembled and moved around an unpaved area or structure, a new section will be started.

The profile index is determined as mm/km using the "zero" blanking band but is simply called the profile index. The procedure for converting counts (mm of roughness) to profile indices is illustrated in Figure 5. For 0.1 km sections, the profile index can be determined from the counts (mm of roughness) by moving the decimal point one position to the right. For odd length sections, the profile index is determined by dividing the counts (mm of roughness) by the section length in km. The weighted average for a day's run is determined by dividing the total counts (mm of roughness) for the day's run by the total length in km of the day's run. (See Figure 6.)

g. REPORT

g.1. Contractors shall furnish and certify profilograph test reports, KDOT Form No.242. (Figure 6)

g.2. All profile traces (profilograms) become part of the Engineer's permanent project records.

h. OPERATOR CERTIFICATION

h.1. Basis of operator certification is attendance at an approved training school and comprehension of the material presented, or by having proof of certification by another agency with requirements similar to KDOT.

h.2. A contractor's personnel may be decertified if the test results vary from the KDOT results by more than what is regarded as normal test variation.

h.3. When a contractor's personnel are decertified to issue profilograph reports, such reports will not be recognized until corrections in testing, trace reduction and reporting are made to the satisfaction of the Engineer.

LOCATION OF PROFILE WHEEL

---------- LANE EDGE OR CONSTRUCTION JOINT (PAINT STRIPE)
- - - - - - - - - - - - - - - TRACE 1m FROM LANE EDGE

- - - - - - - - - - - - - - - TRACE 1m FROM CONSTRUCTION JOINT
---------- CONSTRUCTION JOINT OR LANE EDGE

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Figure 1.

PROFILOGRAPH

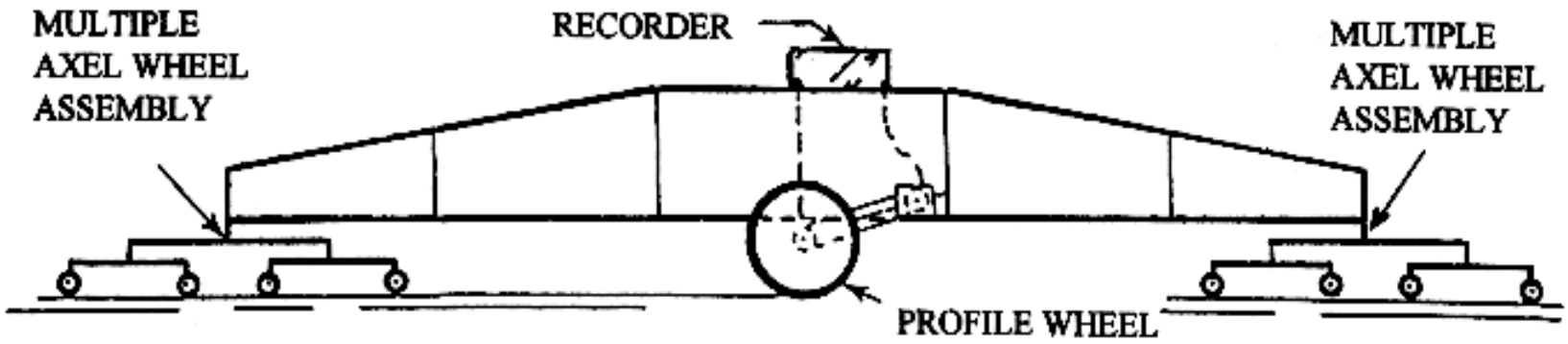
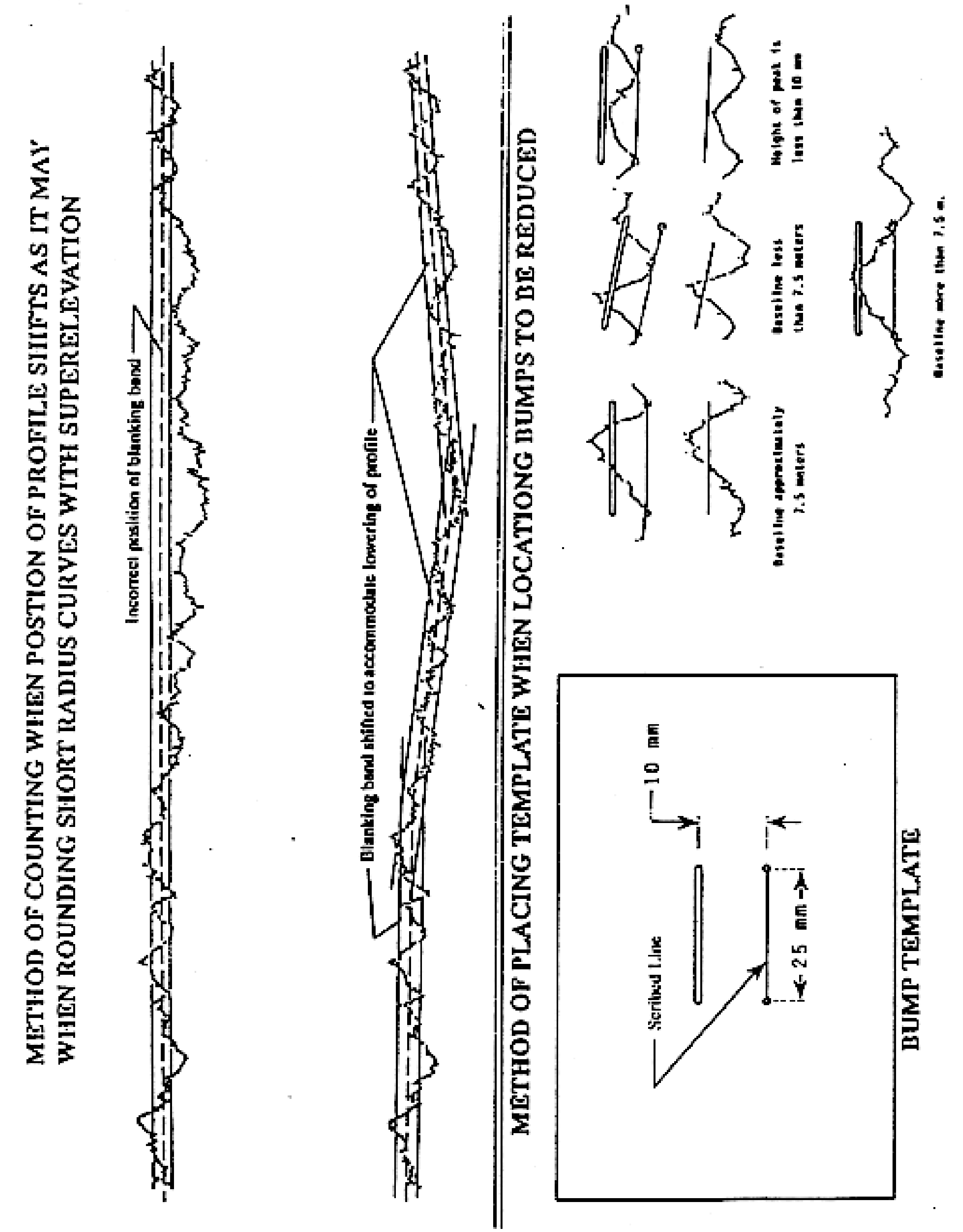
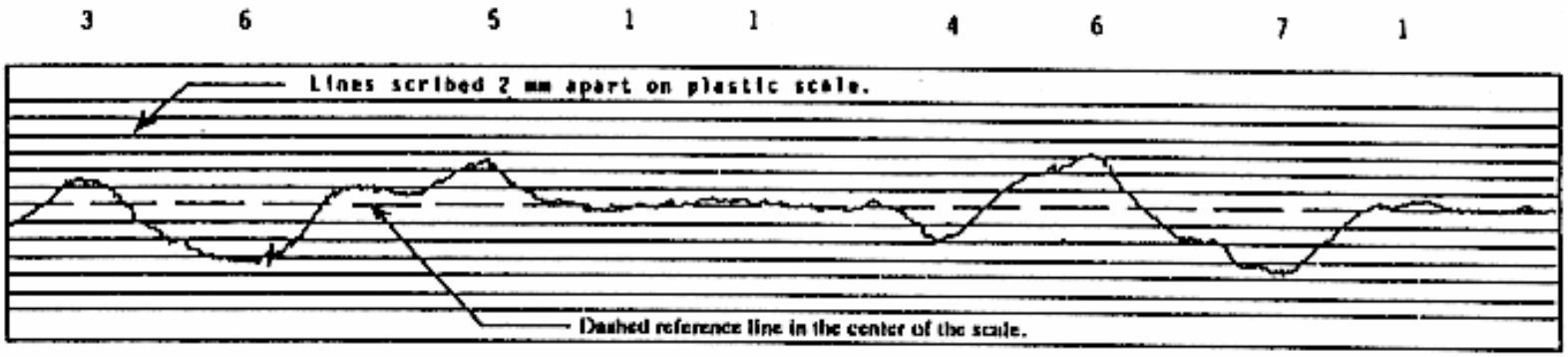


Figure 2.


METHOD OF COUNTING WHEN POSTION OF PROFILE SHIFTS AS IT MAY
WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION
Incorrect position of blanking band
Blanking band shifted to accommodate lowering of profile
METHOD OF PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED
Baseline approximately 7.5 meters
Baseline less than 7.5 meters
Height of peak is less than 10 mm
Baseline more than 7.5 m.
Scribed Line
10 mm
25 mm
BUMP TEMPLATE

Example Showing Method of Deriving Profile Index From Profilogram



Total count for this 0.1 km section is 34 mm.

Profile index for this 0.1 km section is 340 mm per km. (34÷0.1=340)

Figure 3.

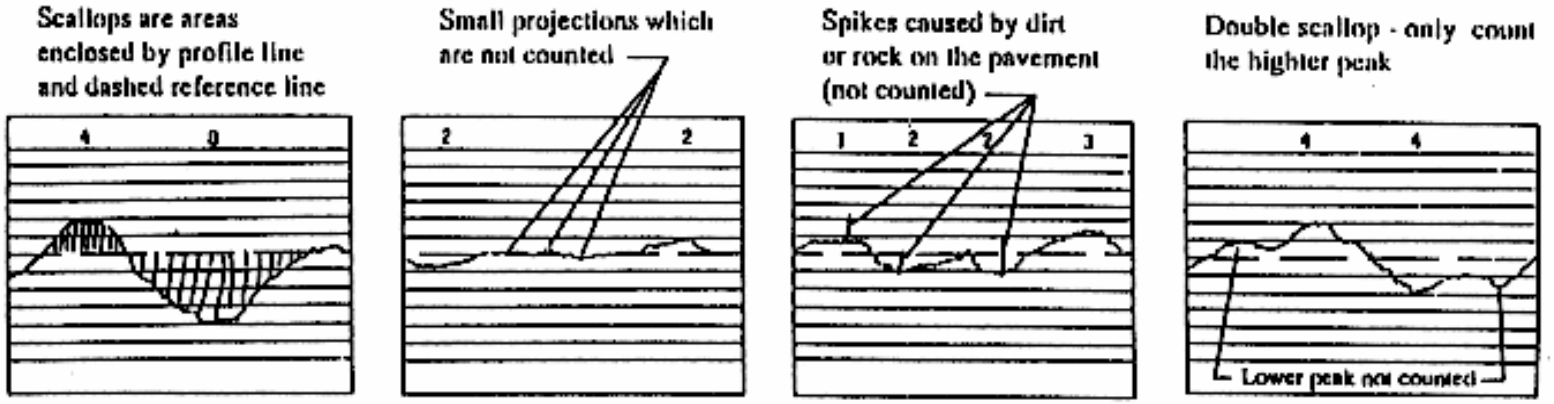
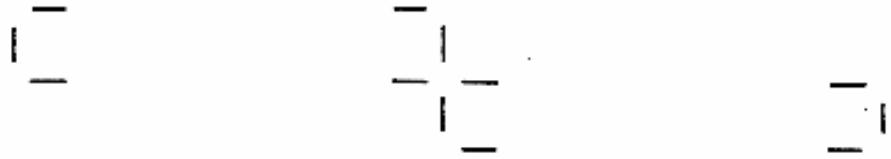


Figure 4

ROTATING BLANKING BAND ABOUT
LAST END POINT

This

Not This



SCALLOPS OCCURRING AT END
OF BLANKING BAND

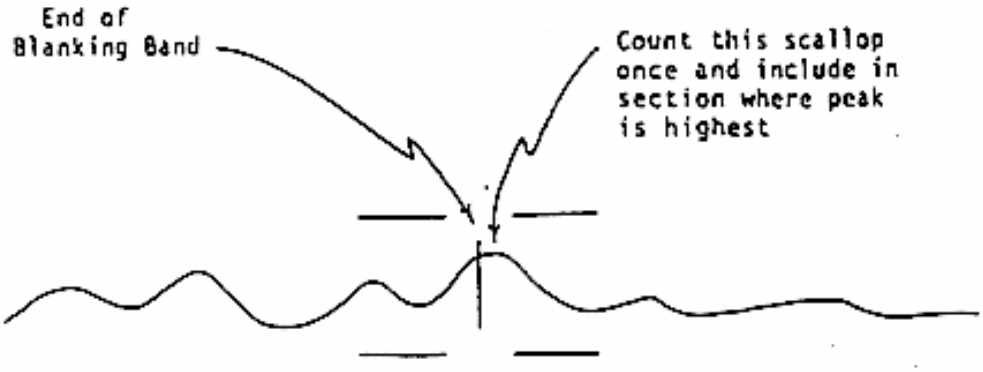


Figure 5

Procedure for Oetermining Profile Index

Section Length (kilometers)	Millimeters of Roughness Shown on Trace	Reported Roughness (mm per km)
Example A		
0.1	27	270
0.1	23	230
0.1	5	50
0.1	17	170
0.1	6	60
0.1	16	160
0.1	7	70
0.1	7	70
0.055	4	73 (1)
0.855	112	131 (2)

(1) $\frac{4}{0.055} = 72.7 = 73$

(2) $\frac{112}{0.855} = 130.99 = 131$

Example B		
0.1	16	160
0.1	8	80
0.1	7	73 (1)
0.037 *	3	
0.337	34	101 (2)

(1) $\frac{7 + 3}{0.1 + 0.037} = \frac{10}{0.137} = 72.99 = 73$

(2) $\frac{34}{0.337} = 100.89 = 101$

* See section (f) (5) of this test method.

Figure 6.

___ Information
___ Initial
___ Intermediate
___ Final

PROFILOGRAPH REPORT OF PAVEMENT SMOOTHNESS

Project No. 75-98 K1234-01 **County** Trego

Contractor John Doe Construction Co. **Pavement Type** PCC

Station 1+530.0 **to Station** 1+714.0 **Traffic Direction** NB

No. of Lanes 1 **Direction of Paving** NB

Date Placed (corrected) 9-26-97 **Date Tested** 9-27-97

Tested and Evaluated by Norman Lee **Special Provision No.** 90M-111-R7

Paving Action 225 mm Reinforced PCC **Posted Speed** 55 mph

Length (km)	Track 1 Measured Roughness (mm)	Track 1 Profile Index (mm/km)	Track 2 Measured Roughness (mm)	Track 2 Profile Index (mm/km)	Track 3 Measured Roughness (mm)	Track 3 Profile Index (mm/km)	Average Profile Index (mm/km)
0.1	15	150	13	130			140
0.084	19	226	16	190			208
0.184	34	185	29	158			171

-Weighted Daily Average Computation:-

Weighted Daily Average

34
+ 29
63 mm ÷ 2 tracks = 31.5 ÷ 0.184 km = 171 mm/km Average

Bump Locations Track 1 None
Track 2 1+532.0 1+582.2 1+670.6

Certified by: _____

Title Chief Profilograph Pusher

Org'n John Doe Const. Co.

Figure 7.

PROFILOGRAPH REPORT OF PAVEMENT SMOOTHNESS

This form shall be prepared and submitted, along with the profilogram, within two working days of the placement or correction of concrete pavement or one working day for bituminous pavement.

The type of report is as follows:

Information - For check testing by Ks DOT and other situations not required to have testing.

Initial - All required testing of pavement for the first time (may be the only one).

Intermediate - After some corrective action that has not yet been completed.

Final - After all corrective action has been completed.

Pavement Type - PCC, HR, BM-1, etc.

Traffic Direction and direction of paving - NB, SB, EB, or WB depending on the design traffic flow of the numbered route.

Number of Lanes - the number of lanes placed at one time.

Special Provision - Number of pavement smoothness special provision.

Paving Action - Mill (50mm), Hot Recycle (50mm), BM-1 (40mm), etc.

Posted Speed - Posted speed of this section of pavement.

Always compute a weighted daily average Wdt Daily Avg =

$$\frac{\text{Total roughness in mm}}{\text{No. of tracks x length in km}}$$

Bump locations are by station.

Distribution Field Office (1)
District Office (1)
Bureau of Const. & Maint. (1)
Pavement Surface Research Engineer (1)