

Approved by:

S.O.P. No.: **RDD-02-05-00-000**

Mississippi Department of Transportation - Standard Operating Procedures

Subject: **DETERMINATION OF PAVEMENT SMOOTHNESS USING A PROFILOGRAPH**

Effective Date:
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Approval Required: MDOT Legal Division Federal Highway Administration Secretary of State

PURPOSE: To establish a standard procedure for determining pavement smoothness by use of a Profilograph.

1. APPARATUS

1.1 **PROFILOGRAPH.** Shall consist of a frame at least 25 feet in length supported upon multiple wheels having no common axle. The profilograph must have at least twelve (12) reference platform wheels. The axes of these wheels shall not be uniformly spaced but be at least 1 foot apart so no two wheels cross the same bump at the same time. The sensing mechanism located at the mid-frame may consist of a single bicycle-type wheel or a dual-wheel assembly consisting of either a bicycle-type (pneumatic tire) or solid rubber tire vertical sensing wheel and a separate bicycle-type (pneumatic tire) longitudinal sensing wheel. The wheel(s) shall be of such circumference(s) to produce a profilogram recorded on a scale of 1 (one) inch equal to 25 feet longitudinally and one (1) inch equal to one (1) inch, or full scale, vertically. Motive power is to be provided manually or by the use of propulsion unit attached to the center assembly.

1.2 **"Zero" Blanking Band.** A transparent scale 1.70 inches wide and 21.12 inches long representing a pavement length of 528 feet or one-tenth of a mile at a scale of 1"= 25'. Near the center of the scale is a reference line extending the entire length of the scale. On either side of the center reference line are parallel scribed lines 0.1 inch apart. These lines serve as a convenient scale to measure scallops, deviations or excursion, of the graph above or below the center reference line.

1.3 **Bump Template.** A thin strip of plastic having a line one-inch long scribed on one face with a small hole or scribed mark at both ends of the line. The template shall have a slot parallel to the scribed line located at a distance equal to the limiting value for acceptance smoothness (0.3 inch for concrete and 0.4 inch for asphalt when measured from a chord length of 25 feet or less - see Figure 1).

2. OPERATION OF PROFILOGRAPH

2.1 **OPERATIONS.** The profilograph shall be moved at a speed no greater than 3 miles per hour so as to eliminate as much bounce as possible. Check tire roundness to eliminate repetitive errors. Surface irregularities in new tires and those that develop through wear shall be removed by grinding. Air pressure in the tires shall be maintained at a constant level and shall be checked daily.

2.2 **CALIBRATION.** Vertical calibration of the manual and computerized profilograph shall be checked daily. Horizontal calibration of the manual and computerized profilograph shall be performed at the start of the project and once a week thereafter. The horizontal scale of a manual profilograph can be checked by running a known distance and scaling the result on the profilogram. At any time, if the scale is off more than 0.5%, the manufacturer's adjustment procedure shall be followed to correct the scaling. The vertical scale of a manual profilograph is checked by putting a board of known thickness under the profile wheel and again scaling the result on the profilogram. If the scale is off, the cause of the incorrect height shall be determined and corrected. Vertical and horizontal calibration of a computerized profilograph shall meet the same requirements as the manual profilograph. The vertical and horizontal calibration of a computerized profilograph shall be performed as per manufactures instructions.

3. RUNNING PROFILES

3.1 The profile is recorded from the vertical movement of a sensing wheel attached at the mid-point of the profilograph and is in reference to the mean elevation of the points of contact with the road surface established by the support wheels.

3.2 A profilogram is recorded on a scale of one (1) inch equal to 25 feet longitudinally and one (1) inch equal to one (1) inch, or full scale, vertically.

3.3 All profilograms will be made in accordance with contract specifications.

3.4 The profiles for each section of pavement shall be positioned on the profilogram so that the stationing is coincidental. This will help determine if the high points and depressions extend across the entire pavement width and will permit profile index comparison of adjacent lanes.

3.5 The following information shall be marked and/or labeled on the profilogram during testing for ease in evaluation.

3.5.1 Location (which traffic lane and wheel path).

3.5.2 Beginning and ending station of the profile.

3.5.3 Station numbers and other road items of known location.

3.5.4 Construction joints, significant cracks, damaged areas, etc.

4. DETERMINATION OF PROFILE INDEX

4.1 Method of Counting

4.1.1 Place the scale over the profile in such a way as to "balance" the scallops above and below the center reference line. (See Figure 2)

4.1.2 The profile trace will move from a generally horizontal position when going around super-elevated curves making it impossible to "balance" the central portion of the trace without shifting the scale. When such conditions occur, the profile will be broken into short sections and the center reference line repositioned on each section while counting as shown in the upper part of Figure 1.

4.1.3 Starting at the right end of the scale, measure and total the height of all the scallops appearing both above and below the center reference line, measuring each scallop to the nearest 0.05 inch (or half the distance between the parallel scribed lines on the scale). Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section. Short portions of the profile line may be visible above or below the center reference line, but unless they project 0.03 inch or more and extend longitudinally for two feet or more, they are not to be included in the count. (See Figure 2 for illustration of these special conditions.) When scallops occurring in the first 0.1 mile are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made, and proceed with the counting in the same manner. The last segment counted may or may not be an even 0.1 mile. If not, its length should be scaled to determine its length in miles.

4.1.4 Each days production shall be divided into sections which terminate at a day's work joint, bridges or other interruptions. Each section shall be subdivided into 0.1 mile segments. If a segment less than 0.1 mile occurs at the end of a section, it shall be combined with the preceding 0.1 mile segment for calculation of the profile index. If the last 15 feet of pavement at the days work joint cannot be profiled until the adjoining pavement is placed, it shall be included in the profilogram of the subsequent day's production provided the contractor is responsible for the adjoining production. A profilogram shall be made for each continuous section of pavement of 50 feet or more in length. Each 0.1 mile segment shall "stand alone" for calculation of the profile index. An example follows:

Segment Number	Section Length (miles)	Counts (tenths of an inch from the center reference line)
1	0.10	17.5
2	0.10	15.5
3	0.076	12.0

4.1.5 The profile index is determined as inches per mile in excess of the center reference line but is simply called the profile index. The procedure for converting counts of profile index is as set out below.

4.1.6 Using the figures from the above example:

Segment Number 1 Calculation

Length = 0.1 mile, total count = 17.5 counts

Profile Index = (1 mile/length of profiles in miles) X total counts in inches

Profile Index = (1/0.1) X 1.75 = 17.5

Segments Number 2 & 3 Calculation (Since Segment 3 is less than 0.1 mile it is combined with Segment 2)

Length = 0.176 miles, total count = 27.5 counts

Profile Index = (1mile/length of profiles in miles) X total counts in inches

Profile Index = (1/0.176) X 2.75 = 15.6

(NOTE: The formula uses the count in inches rather than tenths of an inch and is obtained by dividing the count by ten)

4.1.7 The profile index is thus determined for the profile of any line called for in the specifications.

5. DETERMINATION OF HIGH POINTS OR DIPS

5.1 To locate the bumps or dips requiring corrective action, place the bump template at each prominent peak or high point on the profile so that the small holes or scribe marks at each end of the scribed line intersect the profile to form a chord across the base of the peak or high point. The line of the template need not be horizontal. With a sharp pencil draw a line using the narrow slot in the template as a guide. Any portion of the profile extending above this line will indicate the approximate length and height of the deviation in excess of the specified value.

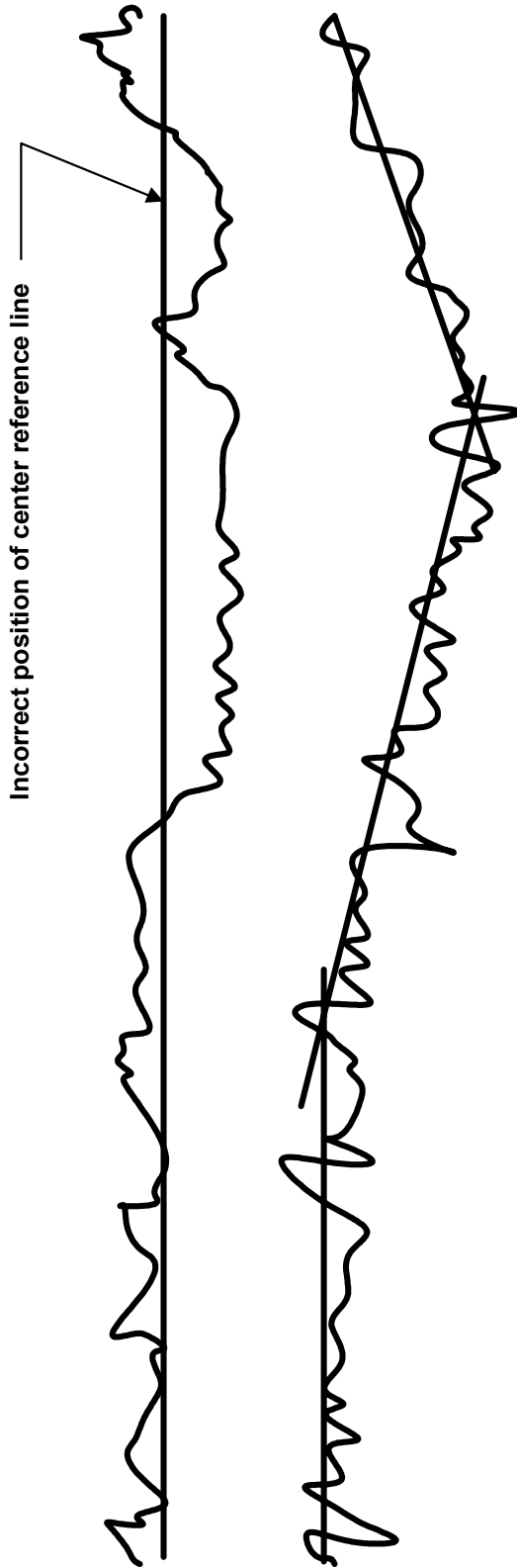
5.2 There may be instances where the base of the high point is less than one (1) inch (25 feet). In such cases, a shorter chord length must be used in making the scribed line on the template tangent to the profile at the low points. When the distance between prominent low points is greater than 25 feet (1 inch), make the ends of the scribed line intersect the profile with the template in horizontal position. The baseline for measuring the height of bumps should be as near 25 feet (1 inch) as possible, but in no case shall it exceed this value. A few examples of the procedure are shown in the lower portion of Figure 1.

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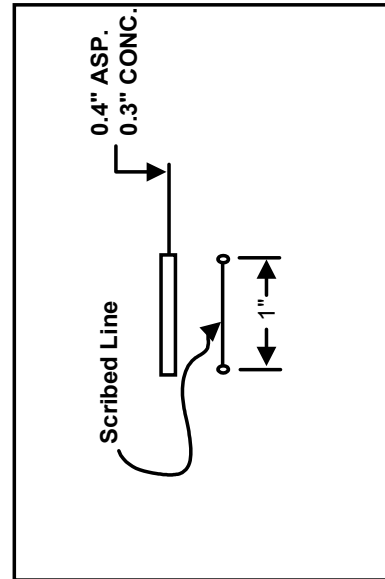
6. REPORT

- 6.1 Profile Index to the nearest inch per mile for each segment.
- 6.2 Location of each segment including station limits, direction, traffic lane and wheelpath.
- 6.3 Location of high points or dips that require corrective action.

**METHOD OF COUNTING WHEN POSITION OF PROFILE SHIFTS AS IT MAY
WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION**



METHOD OF PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED



Baseline approx. 25 ft.

Baseline less than 25 ft.

Height of peak is less than 0.4" ASP or 0.3" CONC.

Baseline more than 25 ft.

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FIGURE 1

EXAMPLE SHOWING METHOD OF DERIVING PROFILE INDEX FROM PROFILEGRAMS

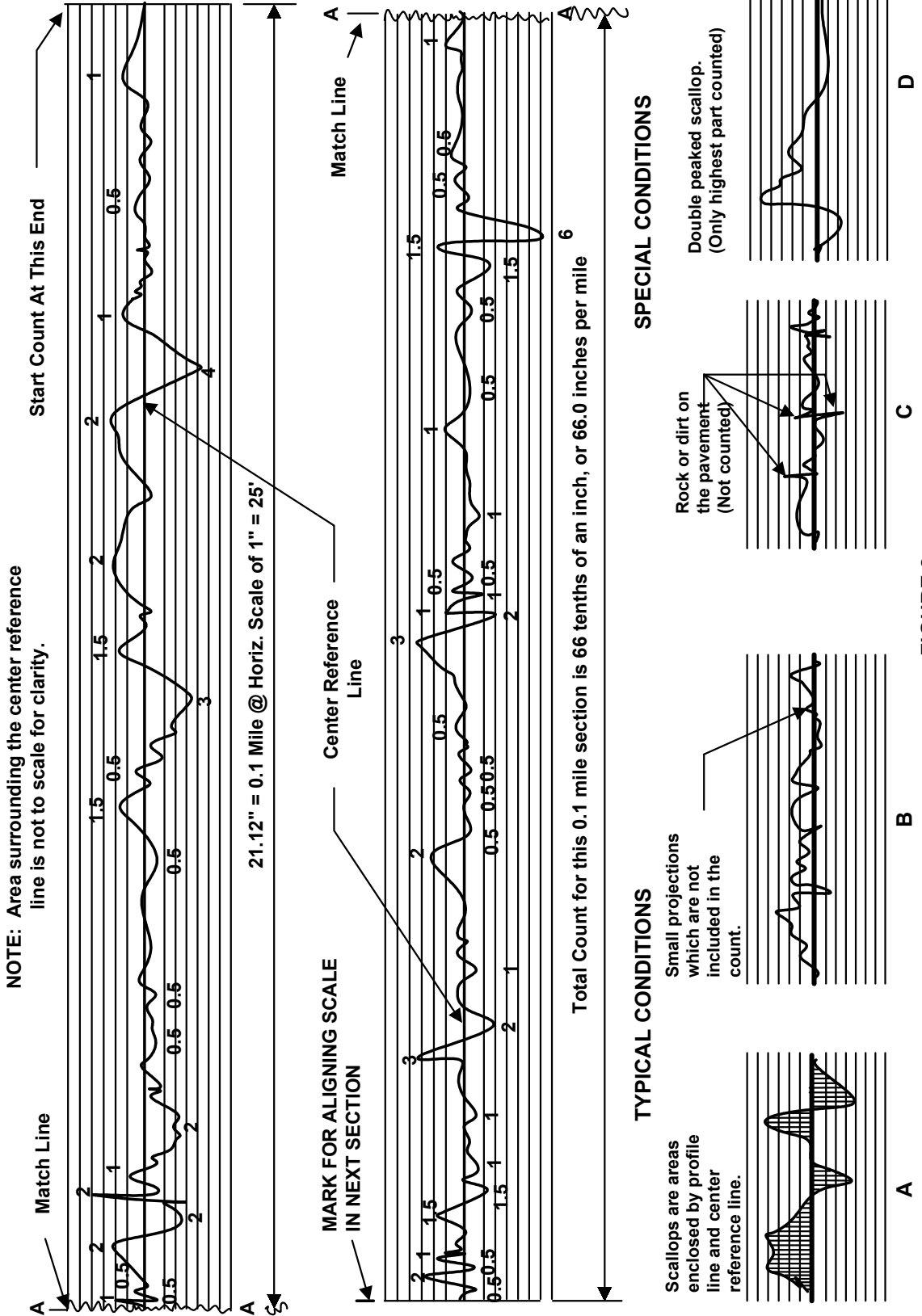


FIGURE 2