SCOPE

This Materials Method describes the operation of the California Type Profilograph, the procedure used for determining the Profile Index from profile traces of pavements made with the Profilograph, and the procedure used to locate individual bumps in excess of 0.5 inch on these traces. The method shall be used in conjunction with the specifications on Cement Concrete Pavement - Profilographed. As detailed in these specifications, the Contractor shall furnish and maintain, for daily use by the Engineer during the paving operations, a California Type Profilograph along with all required scales, templates and supplies to measure the finished pavement surface smoothness. Certain contracts may utilize a Department owned Profilograph. All measurements for determining the Profile Index shall be obtained by the Engineer. The Contractor may use the equipment at any time it is not needed by the Engineer. At the completion of all measurements, the equipment, scales, templates and remaining supplies shall be returned to the Contractor. All Profile Traces remain the property of the State and shall be part of the Contract records.

PART I. OPERATION OF THE CALIFORNIA TYPE PROFILOGRAPH

PROCEDURE

A. Equipment

The California Type Profilograph consists of a frame twenty-five feet in length supported on multiple wheels at either end to establish a datum for what is, in effect, a rolling straightedge. At the mid-point of the frame is located a "Profile Wheel" with linkage to a recorder (see Figure I). As the device is moved over a pavement, deviations of the profile wheel from the datum plane established by the frame are shown on the recorder. The trace thus formed is referred to as the "Profile." The continuous paper chart is referred to as the "Profile Trace." The profile trace is recorded on a scale of one inch equal to twenty-five feet (1" = 25') longitudinally and one inch equal to one inch (1" = 1"), or full scale, vertically.

B. Calibration

Calibration of the Profilograph shall be checked by the Engineer and a representative of the Materials Bureau prior to its initial use on each Contract. The horizontal scale shall be checked by running a known
distance and scaling the result on the profile trace. If the horizontal scale is inaccurate by more than 2 percent, the profile wheel shall be adjusted, if possible, or changed to one of a proper diameter prior to initial use. The vertical scale shall be checked by putting a board of known thickness under the profile wheel and scaling the results on the profile trace. If the vertical scale is in error, the cause of the incorrect height shall be determined and corrected prior to use.

C. Operation

All objects on the surface of the pavement including mortar balls shall be removed by the Contractor prior to profilographing. Necessary traffic control and survey stationing for these measurements shall also be provided by the Contractor.

The profilograph measurements shall be obtained separately for each day's paving, provided a minimum of 1000 linear feet of pavement is placed in that day. If less than 1000 linear feet of pavement is placed in any day, that day's production shall be combined with subsequent day's entire production until a minimum of 1000 linear feet of pavement is obtained.

Daily profilograph measurements shall begin and end with the profile wheel on the night joints which define each day's paving. These measurements shall be obtained normally within one or two working days after the pavement has been placed. Each daily profilograph measurement shall be stopped at the nearest whole station approximately 200 feet into the day's production. With the profilograph stopped, raise the recording wheel approximately 1 inch to mark this location on the graph. Then write the station on the graph adjacent to this mark. Repeat this procedure every 200' for the entire day's production. For each adjacent wheelpath the same procedure shall be followed except that the stationing need only be written on the initial wheelpath. This procedure assures that any area on the profilograph trace can readily be located on the pavement.

The Profilograph shall be operated in the wheelpaths of the mainline pavement. The wheelpaths shall be longitudinal lines located parallel to the center line of pavement and three feet ± one half foot (3' ± 1/2') measured transversely, inside all lane edges. The Contractor shall provide the Engineer a satisfactory method of determining the location of the wheelpaths within this tolerance. A measuring guide can be placed on the profilograph, the pavement wheelpaths can be continuously marked or an alternative method can be provided which is acceptable to the Engineer.

The profilograph measurements shall be obtained in the direction of paving. All wheelpath measurements for each day's paving shall be obtained in the same direction. This ensures that the various profile traces are oriented one above the other and that the stationing is coincidental with each line.

The measurements shall be obtained with the profilograph operating in the forward direction.

The profilograph shall be operated at a speed no greater than a walk so as to eliminate as much bounce as possible. Too high a speed will result in a profile trace that is difficult to evaluate.
The air pressure in the profile wheel shall be adjusted to further minimize the effect of wheel bounce. The trace for each day's paving shall be identified in the following manner:

1. Job Stamp
2. Start Station – Finish Station
3. Date Paved
4. Date Profilographed
5. Profilographed by
6. Reduced by
7. Checked by

This information shall be placed at the beginning of the trace and each trace shall be numbered consecutively on the outside of the roll.

PART II. DETERMINATION OF THE PRELIMINARY PROFILE INDEX FOR EACH DAY'S PAVING

Procedure

A. Equipment

To determine the Preliminary Profile Index, use a plastic 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 an opaque band 0.2 inch wide extending the entire length of 21.12 inches. On either side of this band are scribed lines 0.1 inch apart, parallel to the opaque band. These lines serve as a convenient scale to measure deviations or excursions of the trace above or below the blanking band. See Figure II.

Place the plastic scale over the profile in such a way as to "blank out" as much of the profile as possible. When this is done, deviations above and below the blanking band usually will be approximately balanced. See Figure II.

The profile trace shall be reduced in the direction of paving. When the plastic scale is in position precisely mark the top and bottom at each end. This allows the scale to be repositioned exactly if future reference is required.

Starting at the right end of the scale, measure and record the height of all the deviations appearing both above and below the blanking band, measuring each deviation in tenths of an inch to the nearest 0.05 inch (half a tenth). Short portions of the profile trace may be visible outside the blanking band but unless they project 0.03 inch or more and extend longitudinally for one and one half feet (0.06 inch on the trace) or more, they shall not be included in the count. (See Figure II for illustration of these special conditions). Obtain the sum of these deviations and write the total near the center of the profile trace. To check the addition, recompute the total, adding in the opposite direction, and if the total checks circle the original number.
Repeat this procedure for all remaining wheelpaths. Next, add the circled totals and divide by the number of wheelpaths to obtain an average for that tenth of a mile section.

After deviations occurring in the first 0.1 mile are averaged, slide the scale to the left and proceed with the counting in the same manner. The last section counted may or may not be an even 0.1 mile. If not, its length should be scaled to determine its length in miles. An example follows:

<table>
<thead>
<tr>
<th>Section length, miles</th>
<th>Counts, tenth of an inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>5.0</td>
</tr>
<tr>
<td>0.10</td>
<td>4.0</td>
</tr>
<tr>
<td>0.10</td>
<td>3.5</td>
</tr>
<tr>
<td>400' = 0.076</td>
<td>2.0</td>
</tr>
<tr>
<td>Total...0.376</td>
<td>14.5</td>
</tr>
</tbody>
</table>

The Profile Index is determined as "inches per mile in excess of the 0.2 inch blanking band" but is simply called the Profile Index. The procedure for converting counts of Profile Index is as follows:

Using the figures from the above example:

Length = 0.376 mile, total count = 14.5 tenths of an inch

Profile Index (PI) = \( \frac{1 \text{ mile}}{\text{length of profiles in miles}} \times \text{total count in inches} \)

\[ PI = \frac{1}{0.376} \times 1.45 = 3.9 \]

(Note that the formula uses the count in inches rather than tenths of an inch and is obtained by dividing the count by ten.)

The Preliminary Profile Index is thus determined for each day's paving.

C. Limits of Counts - Joints

The paving contractor is responsible for the smoothness of joints for all concrete mainline pavement placed. In addition, the contractor is also responsible for the smoothness of the end joints if the work abuts concrete pavement placed under another contract. Profilograph readings when approaching or leaving such joints shall be taken until the recording wheel is a minimum of 20 ft. into the abutting contract.

If the work abuts an approach slab or bridge placed under another contract, the contractor is responsible only for the smoothness of the mainline pavement placed by him. Profilograph readings when approaching or leaving such joints shall be taken until the recording profile wheel touches the joint.
PART III. DETERMINATION OF BUMPS IN EXCESS OF 0.5 INCH

Procedure

A. Equipment

Use a plastic template having a line one inch long scribed on one face with a small hole or scribed mark at either end, and a slot 0.5 inch from and parallel to the scribed line. (The one inch line corresponds to a horizontal distance of 25 feet on the horizontal scale of the profile trace, see Figure III).

B. Locating Bumps in Excess of 0.5 Inch

At each prominent peak or high point on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump. The line on 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 trace extending above this line will indicate the approximate length and height of the deviation in excess of 0.5 inch.

There may be instances where the distance between easily recognizable low points is less than one inch (25 feet). 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 points. It is the intent, however, of this requirement that the baseline for measuring the height of bumps will be as nearly 25 feet (1 inch) as possible, but in no case to exceed this value. When the distance between prominent low points is greater than 25 feet (1 inch) 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 the lower portion of Figure III.

All bump locations shall be tabulated by survey station and wheel path for each day's paving.

PART IV. DETERMINATION OF THE FINAL DAILY PROFILE INDEX

Any section of pavement which has been corrected due to the presence of surface irregularities is to be remeasured with the Profilograph after corrections have been completed. This remeasurement is to begin and end at a full or half survey station and extend a minimum distance of 50 feet on each side of the corrected section. The procedure outlined in Part I of this Materials Method shall be followed in obtaining the Profilograph measurements.

The results of the corrective action on each section containing surface irregularities shall be checked to ensure specification conformance. The Procedure outlined in Part III of this Materials Method shall be followed.

After all bumps have been satisfactorily corrected, the Final Daily Profile Index shall be determined by the Engineer for each day's paving. The profile traces obtained from any section of corrected (due to the presence of surface irregularities)
and remeasured pavement shall be superimposed on the preliminary profile traces. The Final Daily Profile Index is then determined for each day's paving from the combination of both the preliminary profile traces and the superimposed corrected sections. If no corrective action in any section is required due to the absence of surface irregularities in that section, the preliminary profile index shall become the Final Daily Profile Index for that section. The Procedure outlined in Part II of this Materials Method shall be followed in determining the Final Daily Profile Index.

PART V. MISCELLANEOUS

A. Final Day's Paving

If the Final Day's Paving is less than 1000 linear feet that Section of pavement shall be included with the entire previous day's paving.

B. Pavement Adjacent to Omitted Pavement Blocks

When obtaining measurements adjacent to an omitted pavement block(s) operate the profilograph until the leading or trailing carriage wheel touches the edge of the omitted block. Initial pavement blocks, final pavement blocks and all turn around areas where no existing pavement abuts shall be measured the same as pavement adjacent to omitted block(s). These areas shall be included in the day's paving for determining the Profile Index for that day.

C. Omitted Pavement Blocks

No Profile Index measurements are required on any omitted paving block(s). After the omitted block(s) has been placed, bump measurements are required to be checked for specification compliance. Measurements shall begin a minimum of 50 feet prior to the omitted block(s) and continue a minimum of 50 feet beyond the omitted block(s).
EXAMPLE SHOWING METHOD OF DERIVING PROFILE INDEX FROM PROFILOGRAMS

A Match Line
Lines Scribed 0.1 Apart on Plastic Scale
Start Count At This End

(Tenths of an inch)

21.12" 0.1 Mile @ Horiz Scale of 1" = 25'

MARK FOR ALIGNING SCALE IN NEXT SECTION
BLANKING BAND 0.2" WIDE

Total count for this 0.1 mile section is $13\frac{1}{6}$ tenths of an inch, or 13.5 inches per mile.

TYPICAL CONDITIONS
Deviations are areas enclosed by profile line and blanking band (shown hatched in this sketch)

SPECIAL CONDITIONS
Small projections which are not included in the count.

Rock or dirt on the Pavement (Not counted)

Double peaked deviation (Only highest peak counted)

FIGURE I
METHOD OF COUNTING WHEN POSITION OF PROFILE SHIFTS AS IT MAY WHEN ROUNDDING 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

BUMP TEMPLATE

FIGURE III