Flexible Pavement Design in Washington

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Washington State Highway Commission

This paper described the design procedure for determining the total depth of cover used over subgrade soils for flexible pavements. The design procedure is based on the Hveem stabilometer test. A brief history of the use of this test is given, and the various steps in the design procedure are outlined. Included are descriptions of the preparation and testing of soil samples, the analysis of test data to determine surfacing depth requirements, and the modification of these surfacing depths where cement treated bases are used. Special handling of swelling soils is also described.

Copies of surfacing design curves, photographs and sketches of test equipment, copies of completed test data sheets, and a table of typical surfacing requirements for various classes of subgrade soils serve as illustrations.

● PRIOR to January of 1951, flexible pavement design in the Washington Department of Highways was based on the California Bearing Ratio Test. This test was abandoned in favor of the Hveem stabilometer test, however, because with certain soils, notably clayey gravels and clean sands, it was difficult, if not impossible, to obtain reliable test results — results which would correlate with the observed performance of these materials in the roadway. In addition, the necessary time requirements of the CBR test limited our testing capacity to such an extent that it was impossible to handle the increasing number of samples being received from our expanded construction program.

The present design procedure for flexible pavements is essentially that originated by the California Division of Highways as outlined in the paper by Hveem and Carmany, "The Factors Underlying the Rational Design of Pavements" (1). The principal differences in procedure stem from certain modifications in test conditions and in factors used to evaluate the worth of base and pavement courses. These modifications were incorporated to give final design figures which are compatible with observed field conditions and roadway performance in the Washington highway system.

The method of design is based on the layer "theory" which holds that each component of the roadway section must have better load-supporting ability than those components under it, and that the surfacing or cover requirements of each must be satisfied. The grading, fracture and cleanliness requirements of certain of these surfacing components (crushed stone or crushed gravel surfacing, ballast, etc) are controlled by specification, and minimum cover requirements have been assigned on the basis of numerous stabilometer test data. The required surfacing depths of other select, local, cover materials are determined by stabilometer tests on representative samples submitted in the preliminary stage of the roadway design. Types and minimum thicknesses of bituminous pavements for use on the various classes of highways are set forth in the design standards, having also been determined from accumulated test and performance data on these specification materials.

The procedure by which the total depth of surfacing (including bituminous mat) is determined for any one soil involves, first, a determination of the index of its load supporting ability by means of the Hveem stabilometer. This index, the stabilometer "R" value, is then converted to a total surfacing depth requirement through use of a traffic factor, and this total depth is revised downward in recognition of the limited slab action or stiffness of a cement treated base course if such is used. Inasmuch as our current design standards specify the use of a cement treated base under flexible pavements on the three principal classes of highways, this downward revision of surfacing depths is a major consideration in the design procedure. The individual steps in the design procedure are described more fully in the following sections.

Soil Sampling and Testing

During the soil survey for any location, the district soils engineer and his crews determine the location and extent of each soil type to be encountered on construction.

This includes test drilling all cuts to and beyond proposed grade elevation. Representative samples of each different soil are taken and submitted to the laboratory.
Routine tests performed on these soil samples are: mechanical analysis, Atterburg

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory

To: Planning Division — Date 1-4-55

From: Materials Laboratory — By WAS

Subject: Traffic Data

Please furnish listed traffic data for the following location:

P S.H. No. 12 Section Cathlamet to Skamokawa

Job No. L-865 Sta. Limits 68+00 to 194+00

Control Section 3502

Yr.	ADT
1955	1140
1965	1600

Truck Classification (% of ADT):

%	2 Axle (Exclusive of Pickups & Panels)	11.6
	3 Axle	3.5
	4 Axle	0.8
	5 Axle	1.5
	6 Axle	0.3

Remarks: * None

* Please note any unusual characteristics of traffic, particularly if one lane will be subjected to heavier loads and/or heavier volumes. In this event, please furnish ADT and classification for each lane or direction. Surfacing design is based on the heaviest traffic conditions to be expected in any one lane.

Figure 1.

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory

EWL* COMPUTATION

Date 2-2-55

By RVL/WAS

*Equivalent 5000 lb. Wheel Loads

P S.H. No. 12 Section Cathlamet to Skamokawa

Sta. Limits: 68+00 to 194+00 Job No. L-865

C.S. 3502

Traffic Data

Yr.	ADT
1955	1140
1965	1600

Truck Classification (Exclusive of Pickups & Panels)

By Axles:

2 Axle:	11.6 %	x	3,000 =	348
3 " :	3.5	x	7,000 =	245
4 " :	08	x	14,000 =	112
5 " :	1.5	x	21,000 =	315
6 " :	0.3	x	16,000 =	48

Item(1): 10 Yr. EWL/ADT = 1068

ADT Adjustment for Lane Width & Increase of Traffic

No. of Lanes: 2

ADT for current yr. : 1140
ADT for current yr. + 10: 1600
Average ADT : 2740 ÷ 2 = 1370

Average one-way ADT: 685

Item(2): Average one-way ADT on heaviest lane: 685

EWL = Item(1) x Item(2) = 1068 x 685 = 731,580

Design Curve C

Figure 2.

limits, moisture-density, and stabilometer "R" value. The details of the latter test are covered in Appendix A. Our procedure for this test differs but slightly from that used by the California Division of Highways (1). The soil specimen is compacted in a triaxial institute kneading compactor, subjected to a vertical pressure until saturation is indicated by the exudation of water, examined for swell pressure, and tested in the Hveem stabilometer.

Evaluation of Traffic

One of the first steps in the design procedure for any particular project is the determination of the maximum traffic to which any lane of the proposed roadway will be subjected during the 10 years following construction. Coincident with the receipt of soil samples from any location the Planning Division is requested to supply complete traffic information to the Materials Laboratory. The standard form for this request is shown

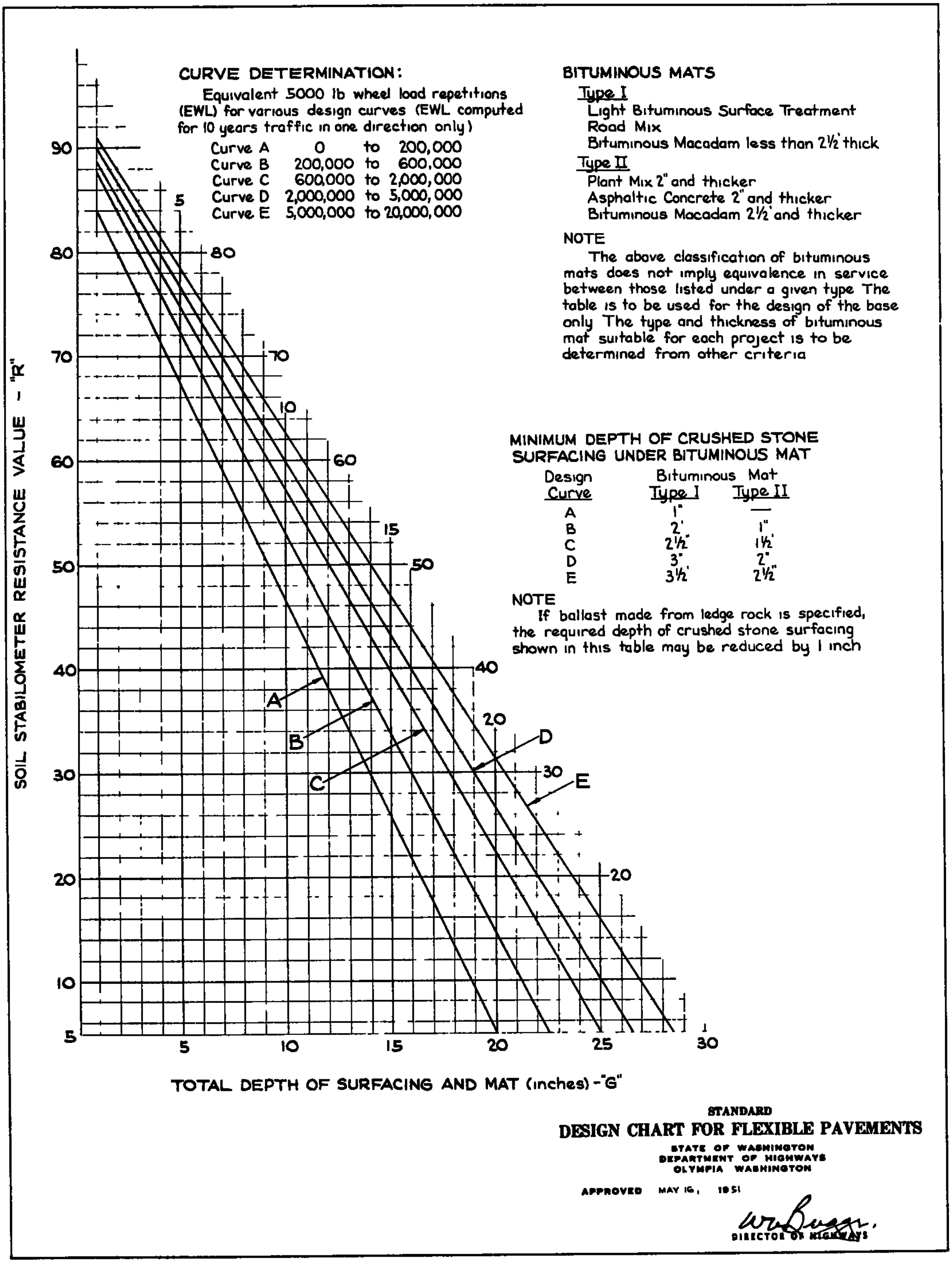


Figure 3.

in Figure 1 with entries of typical values. The data supplied on this form give a classification of commercial vehicles, excluding pickups and panels, according to the number of axles. This classification is given in terms of percent of average daily traffic. Also given are data from which may be calculated the average daily traffic in the most heavily traveled lane for the design period of 10 years.[1] This information is converted to equivalent 5,000-lb wheel loads (EWL) by means of the following conversion factors:

No. of axles per truck	Conversion Factor (No. of equivalent 5,000-lb wheel load repetitions per 10 yr per daily pass)
2	3,000
3	7,000
4	14,000
5	21,000
6	16,000

A sample calculation is shown on the work sheet, Figure 2, using traffic data given in Figure 1. The EWL thus calculated determines which of the five surfacing design curves is to be used, according to the limits shown under "Curve Determination" in the upper left of the Standard Design Chart for Flexible Pavements, Figure 3.

The Standard Design Chart consists of five curves relating stabilometer "R" values to the total depth of surfacing and bituminous mat required for different traffic intensities. The curves were established from approximate design figures obtained by California highway design formulas and adjusted to conform to established performance and service data in the Washington highway system.

Determination of the Surfacing Requirements for Individual Soil Sample

The data from individual tests on the four specimens of any one sample include the "R" value, the exudation pressure, and the swell pressure. The total amount of surfacing required by "R" value considerations is obtained from the standard surfacing design chart for flexible pavements, Figure 3. This is called the "gravel equivalent." The depth of surfacing necessary to restrain the material from swelling is determined by weight considerations alone. An average unit weight of 144 pcf is assigned to our surfacing materials, and a depth sufficient to produce pressure equal to the swell pressure is computed. This is termed the "swell equivalent."

The gravel equivalent is plotted against the swell equivalent. The intersection of the resultant curve with a diagonal line drawn through points of equivalent depths is taken as the equilibrium point where both surfacing requirements are equal. This surfacing depth is called the design depth determined by swell. In addition, the gravel equivalent is plotted against the exudation pressure and the value at 400 psi is designated as the design surfacing depth determined by "R" value. The greater of these two figures is used as the total surfacing depth or cover requirement of the material being tested.

A copy of one of our standard test sheets, complete with stabilometer test data and surfacing depth determination curves is shown in Figure 4.

Surfacing Depth Recommendations for Projects

Subsequent to the soil survey and submission of samples to the laboratory, the district soils engineer prepares a soils profile for the location, incorporating all the field data relative to soil types and their extent. The soils profile, together with a field soils report is transmitted to the laboratory. The standard outline for the field soils report is given in Appendix B.

The surfacing depth recommendations for the project are made after a study of the laboratory test data, the recommendations in the field report, and the in-situ position of soils shown on the profile. If it is indicated that selective placement of the better soils is feasible, recommendations are made for such procedures with surfacing depths

[1] There is oftentimes a major difference in the directional traffic density on highways which are used to carry timber, mining or agricultural products to market.

being governed by the requirements of the individual soils. If this is not the case, recommended surfacing depths for the project are based on the requirements of the weakest soil which may form the subgrade.

H F No 2680—(Rev)

WASHINGTON DEPARTMENT OF HIGHWAYS

MATERIALS LABORATORY

SOIL SAMPLE TESTS

Job No L-865
PS H No 12
Section Cathlamet to Skamokawa
Sample No 10
Field Description Yellow-Brown Clay-Silt

Lab No 5-2191
Bin No 306
Date Rec'd 1-4-55

GRADING ANALYSIS

RETAINED Sieve	Wt	%	PASSING Sieve	%	%	AS USED Size	%	Wt
1½"			1½"					
1"			1"			¾"—⅜"		
¾"			¾"					
⅜"			⅜"			⅜"—#4		
#4			#4	100				
Pass #4	41.6	100	10			Pass #4	100	1000 gms
Total			40					
Est Fract			200					
Date (Coarse) 1-21						Specific Gravity		
Date (Fine)						Textural Class		

Operator

CONSTANTS

	Liquid Limit	Plastic Limit	
Can No			
Wet Wt			
Dry Wt			
Wt H_2O			
% H_2O			
No Blows			
L L			
P L			
P I			

HRB Class Group Index

Operator NA STABILOMETER TEST Date 2-8-55

90 cc Temp H_2O	A	B	C	D
Cc H_2O added	60	45	52	38
% H_2O added	6.6	4.9	5.7	4.2
Initial % H_2O	21.1	21.1	21.1	21.1
Molding % H_2O	27.7	26.0	26.8	25.3
Molding Density	94.4	96.8	96.1	97.8
Compactor pressure	100	100	100	100
No blows	40	40	40	40
Wt in mold	3219	3148	3169	3161
Wt in mold (soaked)	3224	3152	3174	3169
Wt of mold ⟶	2204	2154	2152	2166
Net wt of soil	1015	994	1017	995
Height	2.55	2.47	2.53	2.46
Exudation pressure	280	490	390	560
Swell pressure	1	31	16	55
Drainage	—	—	—	—
Stabil "Ph"— 500#	17	11	13	10
" —1000#	42	24	28	21
" —2000#	108	64	76	63
Displacement "D"	2.54	2.75	2.75	2.84
"R" value	32	58	50	64
Gravel equivalent	17½	9½	12	8
Swell equivalent	½	15	7½	26½

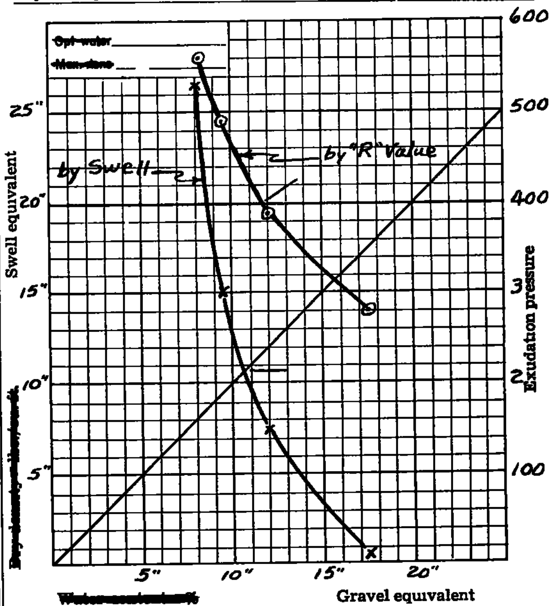
REQ'D SURF DEPTH By "R" 11½" By Swell 10½"

TRAFFIC			
C	DESIGN "R"	52	
	Swell Pressure	—	psi
	Surfacing Depth	11½	in

Remarks

MOISTURE-DENSITY (AASHO T-99-38)

Hyg Water Cont		%	Date		Operator	
Can No						
Est % H_2O						
Spec wt						
Wet wt	1108					
Dry wt	915					
Wt H_2O	193					
% H_2O	21.1					
Dry density						



Lab No 5-2191 Bin No. 306

WHITE COPY—Grading & Constants
PINK COPY—Moisture-Density
YELLOW COPY—Stabilometer

Figure 4.

Modification of Surfacing Depth for Cement Treated Base

Cement treated base consists of manufactured or processed mineral aggregates and portland cement uniformly mixed, moistened, and compacted to a specified thickness, density, and roadway section. The aggregate is usually a 1-inch minus product; the cement content varies generally from 3 to 6 percent by weight of aggregate; and the design compressive strength is 650 psi at 7 days.

The standard cement treated base section consists of a 6-inch compacted depth of treated material. Asphaltic concrete or plant mix with a minimum thickness of 3 inches is used as the pavement over this base.

In the event that cement treated base is to be used beneath the flexible pavement the total surfacing depth, determined as described previously, is revised downward according to the following formula:

$$S_M = \frac{S_T}{\sqrt[5]{C}}$$

Where S_M = Modified surfacing depth
S_T = Total surfacing depth
C = Correction factor

The correction factor is based primarily on the cohesiometer values and relationships used by the California Division of Highways, except that somewhat lower equivalent values are used. The modified surfacing depth for the standard cement treated base section and 3 inches of asphaltic concrete is obtained from the curve shown in Figure 5. Correction factors used in constructing this curve are equivalent to cohesiometer values of 600 for cement treated base and 250 for asphaltic concrete if the California equations and relationships are used.

Special Design Considerations Involving Swelling Soils

When tests on preliminary samples indicate that an appreciable quantity of subgrade soils on any project are subject to excessive swell pressure, and when it is apparent that paving construction will not occur during the same season as the grading, departure from the usual design procedure is usually recommended. This is done to prevent loss of subgrade compaction during the interim wet season, or to provide means for regaining it if it is lost through swelling action.

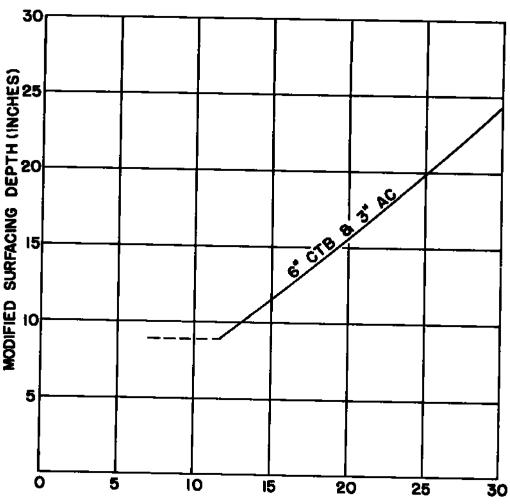


Figure 5. Surfacing depth reduction for cement treated base.

If a portion of the surfacing or cover courses is to be placed during the grading operation, the depth of this course must be sufficient to restrain swell pressure, and such depths are based on the soil tests. This sometimes results in an ultimate overall surfacing depth greater than necessary. However, this over-design may be warranted by other considerations such as the necessity of maintaining a large volume of construction or other traffic, the possibility of time limitations on the working of materials sources, or the desirability of stage construction involving separate contracts for paving and grading.

When only the subgrade and none of the surfacing is to be completed during the first season a density survey is made at the beginning of the next construction season. If loss of density is evident, the top lifts of completed subgrades are loosened and recompacted before placing the surfacing courses.

TABLE 1

TYPICAL TEST VALUES AND SURFACING DEPTHS - WASHINGTON SOILS

Material	HRB Class	Stabilometer "R" Values	Total Surfacing Depths Light Traffic in.	Med Traffic in.	Heavy Traffic in.
Silty and sandy gravels, gravelly silts and sands	A-1	40 - 84 (131)	11½ - 1	15 - 2½	17½ - 3½
Sands	A-3	66 - 72 (11)	5½ - 4	7½ - 5½	9 - 7
Silty sands, sands and gravelly silty sands	A-2-4	30 - 79 (60)	14 - 2½	18 - 3½	20½ - 5
Gravelly clay-sands, silty sands, and sandy silts	A-2-5	45 - 79 (12)	10½ - 2½	13½ - 3½	15½ - 5
Sandy clayey gravel	A-2-6	33 - 81 (18)	13½ - 1½	17 - 3	19½ - 4
Gravelly clays and gravelly sandy clays	A-2-7	18 - 79 (19)	17 - 2½	21½ - 3½	24½ - 5
Sands, silty sands, sandy silts and clay-sands	A-4	8 - 76 (89)	19½ - 3	24 - 4½	27½ - 6
Sandy silts and clay-silts	A-5	33 - 62 (29)	13½ - 6½	17 - 8½	19½ - 10
Silty clay and clay-silts	A-6	5 - 47 (17)	20 - 10	25 - 13	28½ - 15
Clays, silty and sandy clays	A-7	6 - 50 (45)	19½ - 9½	24½ - 12	28 - 14

Parenthetical numbers indicate the number of samples composing each group.

Typical Total Surfacing Depth Values

Table 1 gives a range of total surfacing depth values for various Washington soils tested according to the procedure described heretofore. The figures are taken from laboratory test data and represent materials tested within the last year. The range in "R" values for some soils may seem somewhat anomalous, but this is probably due to the limited number of samples represented. The number of samples involved in each range of values is shown in parenthesis.

Evaluation of Design Procedure

The Hveem stabilometer test has been the basis for flexible pavement design in the Washington Department of Highways for nearly 5 years. It has proved to be a test that can be conducted on a production basis and performed satisfactorily and efficiently by laboratory technicians.

While there is a background of only slightly over 4 years' experience by which to gauge its merits, the performance data are encouraging. To date no roadway failures or evidences of distress of major significance have occurred on sections of highways where surfacing depths were determined by this design procedure. In the few instances of minor distress, all were caused by the presence of sub-standard materials in the roadway section at a depth which did not provide the necessary cover as determined by this method of flexible pavement design.

The performance of pavements in the WASHO Road Test at Malad shows a fair degree of correlation between required surfacing depths and recommendations based on our design method. Although we do not now make any surfacing depth correction for the cohesion of the mat, the results at Malad indicate such could be used, particularly if shoulders are paved. Our design procedure is easily adaptable to such a modification.

The question of pavement deflection over resilient soils is not considered at present in our flexible pavement design. The importance of that phenomenon in the performance of bituminous pavements was clearly shown at the Malad road test. Considerable data have also been accumulated in California on deflection studies (2). The integration of deflection, or more properly resilience, with the stabilometer and swell pressure tests is necessary for a complete and rational analysis of the load-carrying ability of any subgrade soil. The inclusion of resilience tests in a routine laboratory design procedure will, however, require development of suitable testing machines and methods as well as cooperation among all highway and soils engineers in obtaining more data on the role of deflection in pavement service and durability.

ACKNOWLEDGMENTS

The graphs, data sheets, and other illustrations were prepared by H. E. Sandahl and W. A. Souers, Assistant Materials Engineers. Their work and help is gratefully acknowledged.

References

1. Hveem, F. N. and Carmany, R. M., The Factors Underlying the Rational Design of Pavements, Proceedings, Highway Research Board, Vol. 28, (1948).
2. Hveem, F. N., Pavement Deflections and Fatigue Failures, Bulletin 114 (1955) Highway Research Board.

Appendix A

Stabilometer Test Procedure

Samples of soil taken during the preliminary soil survey and representing materials which will be used in subgrades, are received in the Materials Laboratory. The samples are graded, and the portion passing the ¾-inch sieve is used for the stabilometer test. Five identical batches are then weighed out according to the grading of the ¾-inch minus material, each containing sufficient material to form a compacted test specimen 2½ inches high and 4 inches in diameter. Each batch is mixed with the same amount of water (approximately ½ to ⅔ the optimum moisture content) and the mixtures placed in individual plastic bags. The bags are closed with a rubber band and remain sealed overnight to allow the soil to "temper." Following the tempering the soils are mixed with more water and compacted in a 4-inch diameter steel mold by a triaxial insititue kneading compactor, Figure A. The quantity of water used in the mixing is such that it will give a compacted soil specimen from which water will be exuded by the application of a vertical load producing pressures between 100 and 600 psi on the specimen. The compactive effort consists of 40 blows at a foot pressure of 100 psi.

The compacted specimen is then placed on an exudation indicator called the Washington Visual Saturation Indicator, or the "peek-easy." This apparatus is merely a 1-inch thick piece of plexiglass mounted on a suitable framework. A pattern or target in the shape of a 4-inch circle with six equally spaced radii is scribed into a thin sheet of clear acetate which is placed on top of the plexiglass. A filter paper and a perforated 4½-

inch diameter disc made of bronze sheet are placed on top of the target. The perforations in the bronze disc consist of twenty-four ⅛-inch holes in the form of a circle $3\frac{1}{4}$ inches in diameter. A tilted mirror placed in the base of the framework allows the operator to view the piece of filter paper through the plexiglass and the scribed target on the acetate, Figure B.

The compacted specimen in the steel mold is placed on the bronze disc and a vertical load applied to the soil. As the load increases, water is squeezed from the soil and travels through the perforations, moistening the filter paper in a circular pattern. The application of the vertical load is stopped when the circular pattern is continuous through ⅚ths of the circumference, Figure C. The unit pressure at which this occurs is called the exudation pressure. The range of exudation pressures considered satisfactory is 100 to 600 psi. A break-away sketch of the "peek-easy" is shown in Figure D.

Four specimens are compacted in a manner similar to that described previously at moisture contents which will produce four different exudation pressures within the specified range. This procedure produces test specimens which have densities comparable to those obtained in the roadway after construction and which also have physical properties such that resultant surfacing requirements agree with observed roadway performance of the material.

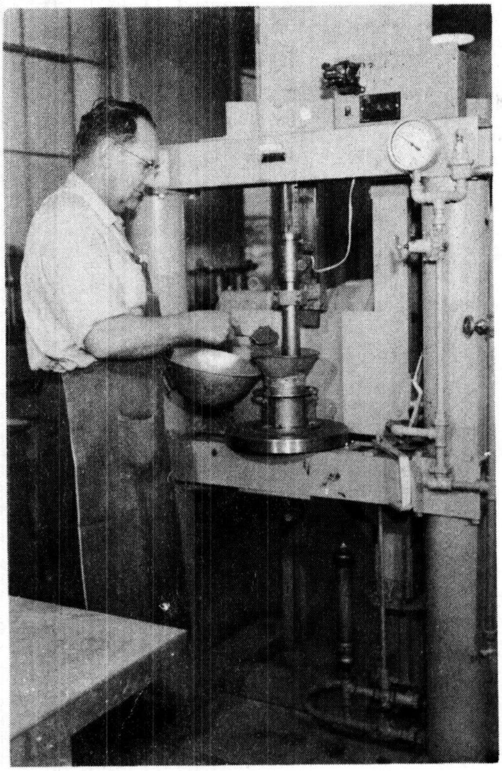


Figure A.

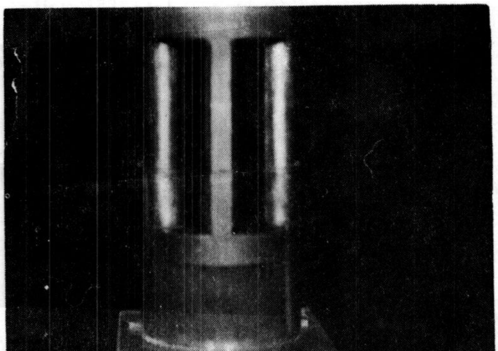


Figure B.

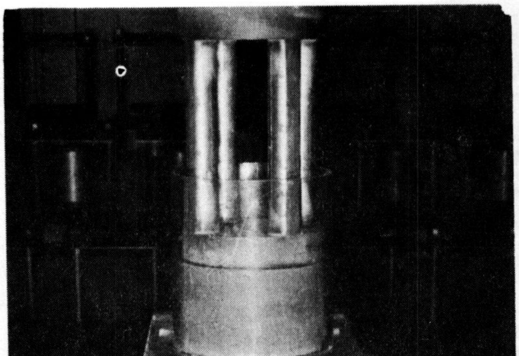


Figure C.

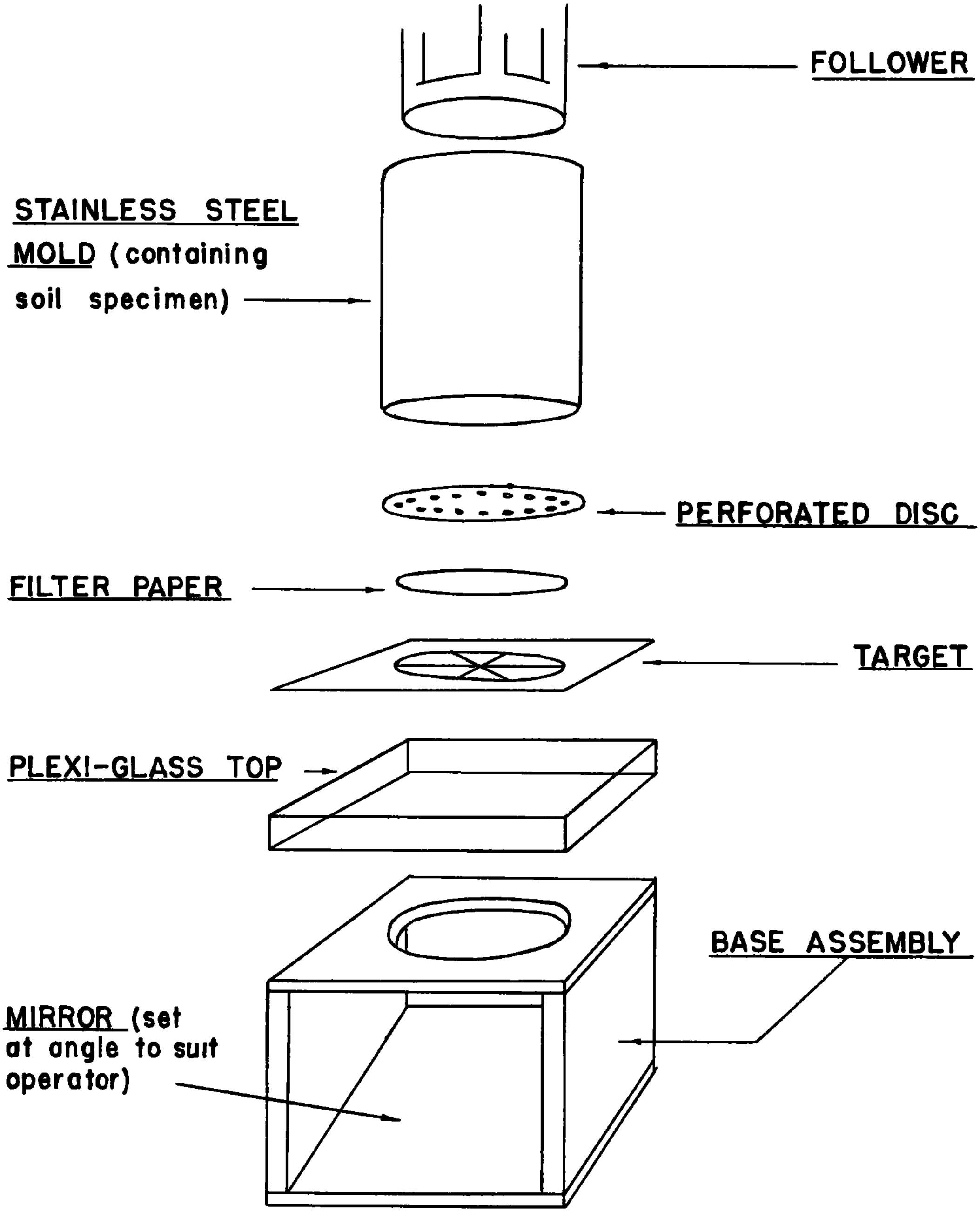


Figure D. Washington visual saturation indicator.

Following the exudation pressure determination, the test specimen, still in the steel mold, is placed in a swell pressure apparatus, Figure E. This device consists of an adjustable base on which the specimen is placed, a horizontal steel proving bar supported by two vertical posts, and a micrometer dial indicator for measuring the deflection of the proving bar. A perforated circular plate with a vertical stem is placed on top of the soil specimen and the height of the base adjusted to allow the stem to contact the horizontal proving bar. Water is placed on top of the soil specimens and allowed to remain there overnight. The swell pressure is measured by means of the bar deflection, the bar being calibrated so that a vertical deflection of 0.0001-inch is equivalent to a swell pressure of 0.04 psi.

After the swell pressure has been determined the soil specimen is tested in the Hveem stabilometer. The soil specimen is extruded from the mold into the body of the stabilometer and a lateral seating pressure of 5 psi applied by means of the displacement pump on the stabilometer. A vertical load is then applied to the specimen at a strain rate of 0.05 inches per minute and lateral pressure readings are taken at vertical loads of 500, 1,000, and 2,000 lb. The vertical load is then reduced to 1,000 lb and the platen of the testing machine maintained at this position (not necessarily this load) while the lateral pressure is reduced to 5 psi by means of the displacement pump. The number of turns necessary to increase this lateral pressure from 5 psi to 100 psi is then measured and the figure recorded as the displacement, "D." Figure F shows the stabilometer test in progress.

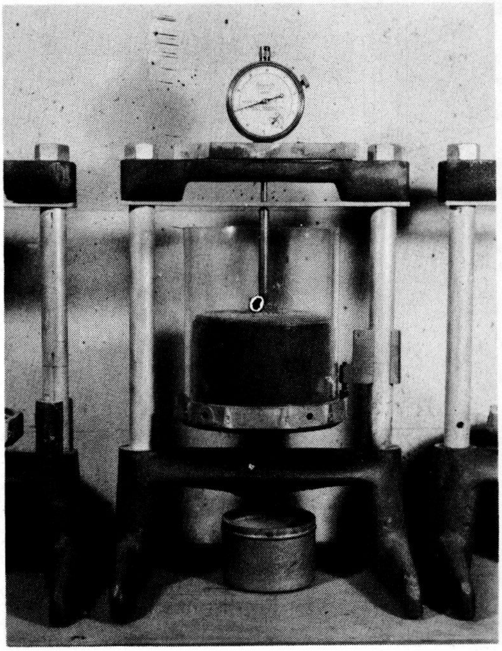


Figure E.

The stabilometer "R" value is calculated from the above data according to the following formula:

$$R = 100 - \frac{100}{\frac{2.5}{D}\left(\frac{P_v}{P_h} - 1\right) + 1}$$

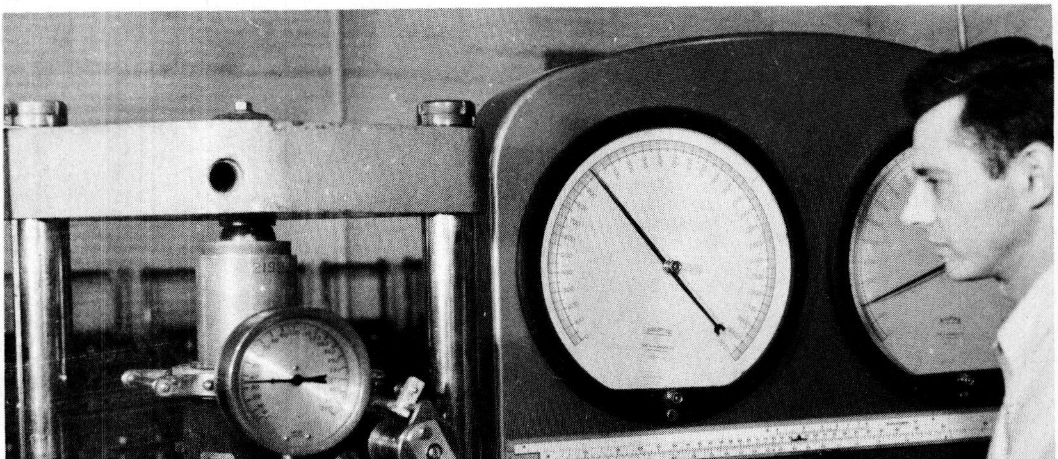


Figure F.

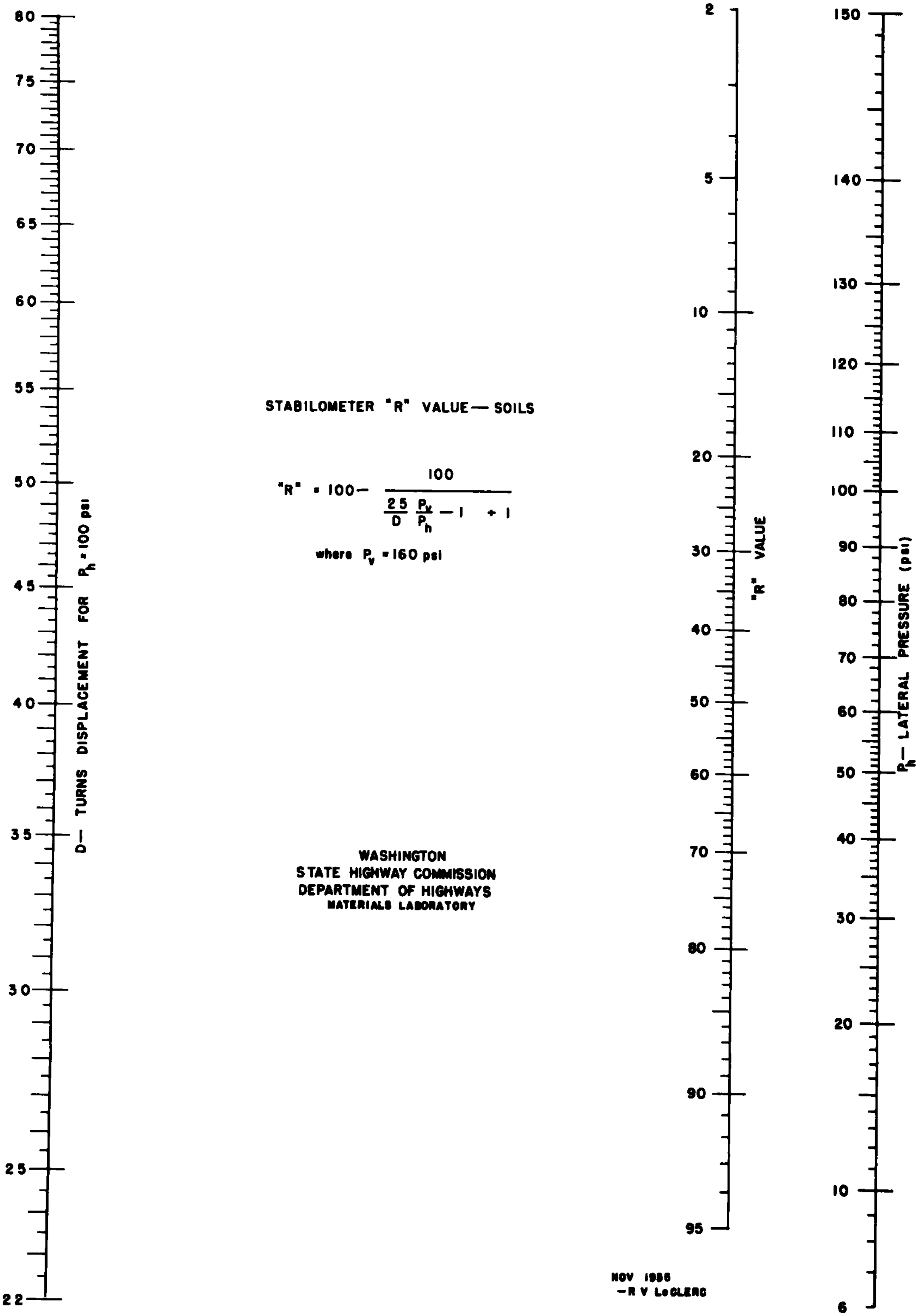

STABILOMETER "R" VALUE — SOILS
"R" = 100 − 100 / (25/D (Pv/Ph − 1) + 1)
where Pv = 160 psi
WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
MATERIALS LABORATORY
D — TURNS DISPLACEMENT FOR Ph = 100 psi
80
75
70
65
60
55
50
45
40
35
30
25
22
"R" VALUE
2
5
10
20
30
40
50
60
70
80
90
95
Ph — LATERAL PRESSURE (psi)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
6
NOV 1955
— R V LeCLERC

Figure G.

Where D = Displacement
P_v = Vertical pressure (160 psi at 2,000 lb)
P_h = Horizontal or lateral pressure at 2,000 lb total load.

Solution of this equation is accomplished by means of a nomograph, Figure G, or a large slide rule constructed for this purpose and mounted on the testing machine used in the test.

Appendix B

Field Soil Report Form

In an effort to aid the district soils engineers in preparing their field reports and to insure adequate coverage of all pertinent points, the attached outline is suggested as a form for field soils reports. Some of the topics will not be applicable in many cases, but some jobs conceivably could require a coverage of all of the items shown.

In compiling the field report, it is recommended that all topic headings be listed and only those pertinent to the particular job be discussed. Under those topics requiring no discussion, a short statement to that effect with reasons therefor should be sufficient.

FIELD SOIL REPORT - TOPICS

I. General

a. Description of contemplated project construction - plan views of project may be incorporated in soil profile, if necessary, to aid in description. Photographs may also be attached.
b. Climatic conditions - amount of rainfall, local frost conditions, etc.
c. Traffic conditions - type of traffic, contemplated volume increases, etc, - estimate of access connection traffic.
d. If resurfacing construction, notes on possibility of grade changes.
e. Control section involved.
f. Status of project - when scheduled for construction, etc.

II. Geology and Physiography

a. General topographic features, if pertinent.
b. History and description of condition of nearby roadway or other structures, if similar conditions prevail.

III. Soils

a. Brief summarized description of soil profile for the project.
b. Limits within which soils represented by submitted samples will govern surfacing design, if possible.
c. Comments on soils of questionable stability and general evaluation of soils in the proposed roadway.
d. If resurfacing construction, some relation between pavement condition and supporting soils.

IV. Fill Foundations

a. Comments relative to stability of foundations and dimensions of proposed fills.
b. Brief description of foundation profile.
c. Brief description of investigational work and findings, if such work is necessary.
d. Location of water table.

V. Slope Stability

a. Description of conditions where slope stability has required investigation, and description of investigational work.

b. Comments on stable slopes in similar material, if any.
c. Slope erosion possibilities.
d. Potential slide conditions.

VI. Drainage and Water Conditions

a. Comments on special drainage features which might reflect on soil stability.
b. Location of water table where pertinent.

VII. Materials Available

a. Source of material to be used over subgrade (selected roadway borrow, cement treated base aggregate, sand drain backfill, etc).
b. Any special materials having to do with soils problems.

VIII. Special Features

a. Stabilization courses, special soils blending, etc.
b. Feasibility of above.
c. Existence of solid rock, if not covered elsewhere.

IX. Recommendations

a. Optimum use of soil materials through selective placement, order of construction, etc.
b. Recommendations pertaining to any one topic may be included under that topic if considered more appropriate.