AN EVALUATION OF FLEXIBLE PAVEMENT DESIGN METHODS

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STATE OF IDAHO DEPARTMENT OF HIGHWAYS

AN EVALUATION

OF

FLEXIBLE PAVEMENT DESIGN METHODS

BY

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SYNOPSIS

Idaho has used the Resistance Value - Traffic Index Method of Flexible Pavement Design as the primary design procedure since 1957. This procedure followed the basic California Department of Highways' procedure developed as a result of several test tracks and roads including the WASHO Test Road at Malad.

Upon completion of the AASHO Road Test several proposals were set forth for design of flexible pavements based upon the results of the AASHO Test. The AASHO Committee on Design advanced an interim guide for the design of flexible pavements based completely on the AASHO Road Test results, but with limitations on its use. These limitations point out that the Soil Support Value scale has but one firm valid point and that is for the silty clay soil at the AASHO Test site. The crushed stone base was assigned a soil support value of 10 and is considered reasonably valid. The coefficients for converting thicknesses of surface, base and subbase from the structural number applies to road test materials. However, several materials were assigned coefficients not established by the Road Test.

No test methods were proposed for determination of Soil Support Value although a correlation chart was included. Test methods for determination of coefficients for the various materials used in the pavement structure were not provided nor were any suggested.

The California Department of Highways conducted a detailed study of the AASHO Road Test results and correlated these results with their design procedure. After revising their basic formulas for thickness from Resistance Value and Traffic Index, they obtained a coefficient correlation of 0.98 and a standard error of estimate of ± 1.2 inches with AASHO Road Test results. Since this procedure also has the backing of the WASHO Road Test results, the Stockton Test Track and other tests, it is evident that the procedure has considerable merit. Idaho has found the designs using the 1957 formulas to give reasonable and yet apparently adequate thicknesses considering the short time of performance. Use of the new formulas permits adoption of substitution factors or equivalent thicknesses for surfacing courses, treated bases and untreated bases without a sacrifice in thickness over that obtained from the 1957 formulas. Idaho has not applied substitution ratios in the past.

The AASHO Road Test indicated the validity of the climatic seasonal effects on performance of the pavement. The AASHO Committee on Design proposed a Regional Factor for increasing the total thickness of pavement structure due to environmental effects including climate. This factor ranges from no increase to a maximum of 15 percent. A review of Idaho's climate, precipitation, degree days below 32° F., and reports from the Districts regarding severity of environment indicates that adoption of this climatic or regional factor is warranted.

A revision of the Surveys and Plans Manual for the Design of Flexible Pavements has been prepared incorporating the latest formulas for Resistance Value and Traffic Index and the climatic effect proposed by the AASHO Committee on Design. The Traffic Index has been shown to correlate with commercial traffic volumes of the 2 axle and 5 axle vehicles with a coefficient correlation of 0.95 and this simplified procedure has been included.

It is recommended that the revised procedure for the design of Flexible Pavements (Appendix D) be adopted as the standard design procedure for the Idaho Department of Highways.

I. INTRODUCTION

Early Idaho Design Methods

The Idaho Department of Highways' design methods have undergone a transition from simple rule of thumb determinations of thickness for flexible pavements based upon experience to more sophisticated design procedures following the procedures of the California Highway Department utilizing their resistance value technique. During the early 1930's, experience was the governing factor in determining total thickness of pavement structures. With the introduction of soils surveys and soil analysis, some arbitrary rules were set down as to the total thickness with thickness ranging from approximately 8" to 18" depending upon the classification of the subgrade soil.

Beginning about 1938, the Department experimented with and used for a period of approximately three years the California Bearing Ratio (CBR) Test. This test consisted of determining the resistance to penetration 1/2" into the soil of a 2" diameter needle. It soon became apparent that for Idaho soils consisting mainly of silt and silty loams that the California Bearing Ratios were frequently in the order of about 3 to 7. Our classification system previously used appeared to be as indicative of the actual soil support afforded a pavement as did the CBR Test.

During the Winter of 1942-1943, a publication of the North Dakota Highway Department gave the development a formula for flexible pavement thicknesses. This formula made use of the classification tests and is somewhat similar to that of the group index test now in AASHO M-145 - The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes. The North Dakota formula included, however, many tests that were not run by Idaho or felt to be of any great importance. A revision of this formula was made during the 1942-1943 Winter with an equation known as Idaho Formula A being developed for determination of flexible pavement design thicknesses. This formula was in use until approximately 1950.

During the Winter of 1950, a review of all pavements constructed immediately before and after the War resulted in an adjustment in Formula A. In effect, this adjustment was to increase all flexible pavement structural thicknesses by 50 percent over that provided for in the 1942-1943 formula for heavy volumes of traffic. This formula then provided two curves, one for Primary and Interstate Highways and the other for County Secondary Roads or low traffic roads. This formula was in use until replaced in part by the Resistance Value Test in 1957.

The Department of Highways had begun experiments in 1950 using the Hveem Stabilometer for the R-Value Test after having built a kneading compactor. This test was used by Idaho in testing soils for the WASHO and the AASHO Road Test. Our test results compared very favorably with those of the State of Washington and California who are using the Hveem Stabilometer and R-Value for flexible pavement design.

Work continued with the Resistance Value method and in 1957, a proposal was made that the Department adopt this test for determining flexible pavement design thicknesses. The test method and design procedure followed the method of the California Department of Highways, using the Hveem Stabilometer to measure the resistance of soils to displacement and traffic index to measure the effect of traffic volumes on the roadway structure.

This method has been in use to the present time. During the period 1958 through 1961, the AASHO Road Test in Illinois was being conducted and again considerable information was developed regarding flexible pavement designs and performance. As a result of this test, the AASHO Committee on Design made recommendations regarding flexible pavement and rigid pavement designs. The present evaluation of flexible pavement design methods is to correlate the existing Idaho Design Method, the AASHO Committee on Design recommendations developed by the WASHO Road Test and more specifically the AASHO Road Test.

WASHO Road Test

The WASHO Road Test was conducted at Malad, Idaho during 1951 - 1953. Loaded vehicles were driven over a road constructed of varying thickness pavement sections for a period of approximately two years. These sections were designed to provide that some would fail and also that a number would continue completely through the test without failure.

This Road Test indicated the validity of using the California Method for the design of flexible pavements. Idaho's test results on the soil correlated very well with test results by the State of Washington and the State of California for Resistance Value. In fact, design thicknesses checked within about one inch. This road test indicated that the traffic index method had considerable merit in measuring the effect of traffic on flexible pavements. With the Resistance Test in mind, the Idaho Department of Highways began a concentrated effort to develop and follow the California Design Method for flexible pavement designs in the State of Idaho.

AASHO Road Test

The AASHO Road Test is without question the largest road test of its kind in the entire world to date. This Road Test included both flexible and rigid pavements. The AASHO Road Test also indicates that the traffic index method of measuring the effect of traffic on a road as well as the Resistance Value for the strength of soils as well as base soils has considerable merit.

The AASHO research group derived formulas indicating the effect of traffic on flexible pavements. These formulas were derived from statistical analyses and variance equations giving total thicknesses as one variable and traffic volumes and loads as the other variable. With the result of this road test, the AASHO Committee on Design has made recommendations for procedures to be followed in the design of flexible pavements.

The AASHO Road Test used one soil in the subgrade having a Resistance Value of approximately 10 as determined by both Idaho and Washington. The WASHO Road Test had a soil having a Resistance Value of about 28. Since the AASHO Road Test was conducted on a soil having but one resistance value, it is difficult to extend their information throughout the entire range of soils without making a correlation with other road tests and published research findings. The AASHO Design Committee has proposed a relationship with the Resistance Value as well as with the California Bearing Ratio test values.

This Committee also made recommendations regarding substitution ratios for higher type of materials than that of base materials composed of crushed stone or crushed gravel used on the AASHO Road Test. These substitution ratios would indicate that one inch of plantmixed material would be the equal of three inches of crushed stone or that it would equal one and a half inches of treated base materials. These relationships are set forth in their design recommendations.

California Design Procedures

The California Highway Department has made a complete study of an AASHO Road Test, WASHO Road Test and other road test results and have also tested and evaluated these materials and made a number of refinements in their design procedures. They have also studied their design procedures with regard to the performance of highways within their State. As a result, they have developed a very detailed, very complete design procedure based upon all this information.

They began their study of AASHO Road Test Results during the AASHO Road Test period. They made a report at Ann Arbor, Michigan, at the International Conference on Structural Design of Asphalt Pavements and at this time showed a correlation coefficient of about 0.95 for their design procedure with actual AASHO Road Test performances. They continued their correlation of AASHO Road Test results with other tests and eventually arrived at a correlation coefficient of about 0.98. These results were published in Highway Research Board Record No. 13 in 1963, by Messrs. Hveem and Sherman.

Evaluation Study

This study consists of a comparison of the Idaho 1957 Design Method presently in the Surveys and Plans Manual with that developed by the California Highway Department and published in the Highway Research Board Record No. 13. Idaho loadometer data and traffic classification data were reviewed and used in this study. This data has been used to make a comparison with the design recommendations of the AASHO Committee on Design. In making this comparison, it was necessary to use the AASHO recommendations for the correlation between Soil Support Value as used in their design brochure and the Resistance Value as reported by the California Department of Highways.

II. EQUIVALENT WHEEL LOAD FACTORS FROM LOADOMETER DATA

5k Equivalent Wheel Load Factors

Idaho adopted the California Procedure for Designing Flexible Pavements in 1957. This method evaluates wheel load effects on pavements by means of a factor known as the equivalent 5,000 pound wheel load (5k-EWL) factor. This factor originally equated the effect of the wheel loading on pavements using a geometric series beginning with a factor of 1 for a 5,000 pound wheel load and thereafter, each increase of 1,000 pounds increased the factor geometrically, i.e., 2 for 6,000 pounds, 4 for 7,000 pounds, 8 for 8,000 pounds and 16 for 9,000 pounds.

Since then, new factors recognizing the effect of the tandem axle have been developed. The tandem effect is considered as the tandem wheel load being equal to a single wheel load which is 10% heavier than the tandem wheel load. The 5k-EWL factors are also equated to the distribution of single and tandem axles as determined from planning surveys and reported in House Document No. 91, 86th Congress, First Session, March 2, 1959.

Computation of New 5k-EWL Factors

Using these factors, computations for the wheel load effects were made for the period 1948-1961, see Table I and Table X, Appendix B. In making these calculations, it was necessary to assume that the unweighed axles as reported in the loadometer data had the same weight distribution and wheel loading as those weighed.

Table II below groups the various classifications of trucks used in accordance with the practice of limiting the classifications to two axle, three axle, four axle and five axle and heavier groupings.

TABLE I

EQUIVALENT 5,000 LB. WHEEL LOAD FACTORS
FROM LOADOMETER DATA
1948 - 1962

Year	2 Axle	Truck Classification 3 Axle	4 Axle	5 Axle	6 Axle
1948	450	1,210	3,970	4,420	2,360
1949	290	1,620	4,740	4,620	1,910
1950	240	3,610	5,770	6,500	2,880
1951	390	2,680	4,860	5,500	3,380
1952	520	1,490	2,970	3,140	2,390
1953	370	1,400	2,510	3,040	4,080
1954	510	1,080	2,770	3,030	1,700
1955	430	1,410	2,980	3,440	2,480
1956		No Loadometer Data Obtained			
1957	360	2,090	2,110	3,470	-
1958	360	2,010	3,050	4,370	-
1959	440	1,980	2,220	4,840	2,030
1960	475	2,330	2,590	4,310	3,080
1961	450	2,075	2,070	4,910	3,560
1962	230	3,380	2,200	4,000	2,650

TABLE II

GROUPING OF VEHICLES FOR CLASSIFICATION

Classification Used	Original Classifications
Light Traffic	Passenger cars and light single unit trucks
2 Axle	Single unit truck (dual tires)
3 Axle	3 Axle single units, 3 axle 2-S-1, Buses and School Buses
4 Axle	4 Axle 2-S-2 and 4 Axle -2- and 4 Axle 2-S1-2
5 Axle and Heavier	5 Axle 3-S-2, Five Axle 3-2, 6 Axle 3-3

Analysis of Computed 5k-EWL Factors

After reviewing the computed results and checking into the reason for the unusually high values of 5k-EWL prior to 1953, it was learned that the loadometer survey for this period had about 25 percent illegal overloads. Since 1953, the percentage of illegal overloads has ranged from three to seven percent and therefore only loadometer data from 1953 to date was used to compute the trends for the 3, 4 and 5 axle vehicles. The least squares method of correlation was used to analyze this data. This analysis indicates that 5k-EWL factor for the three and five axle groups is increasing greatly with the two and four axle groups increasing only slightly. The increase for the three and five axle groups is considered to be of sufficient significance that the projected 5k-EWL should be used for design purposes. The values for the two and four axle do not suggest any trends that warrant projecting increases for future periods. See Figures 1 - 5 inclusive which show results of these computations.

Any further reviews of loadometer data should be analyzed for trends increasing the 5k-EWL factors.

Values taken from this analysis show the 5k-EWL on Table III for each grouping of vehicles as follows:

TABLE III

EWL CONSTANTS FOR 1962, 1972 & 1980

	1962	1972	1980
2 Axle	450	515	565
3 Axle	2,310	3,775	4,840
4 Axle	2,700	2,800	2,875
5 Axle	4,880	7,600	9,580

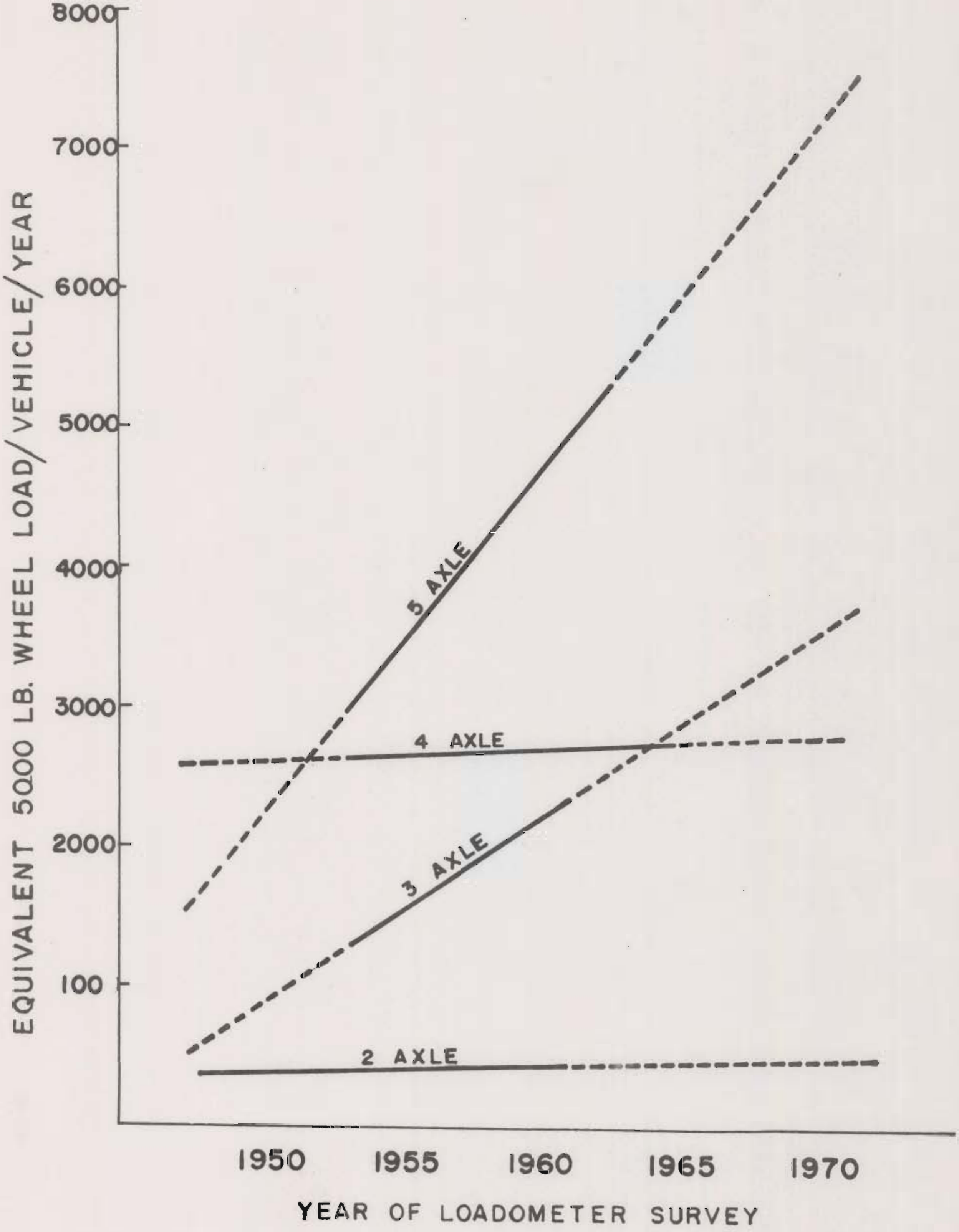


FIGURE I — ALL VEHICLES ——— EWL CONSTANTS

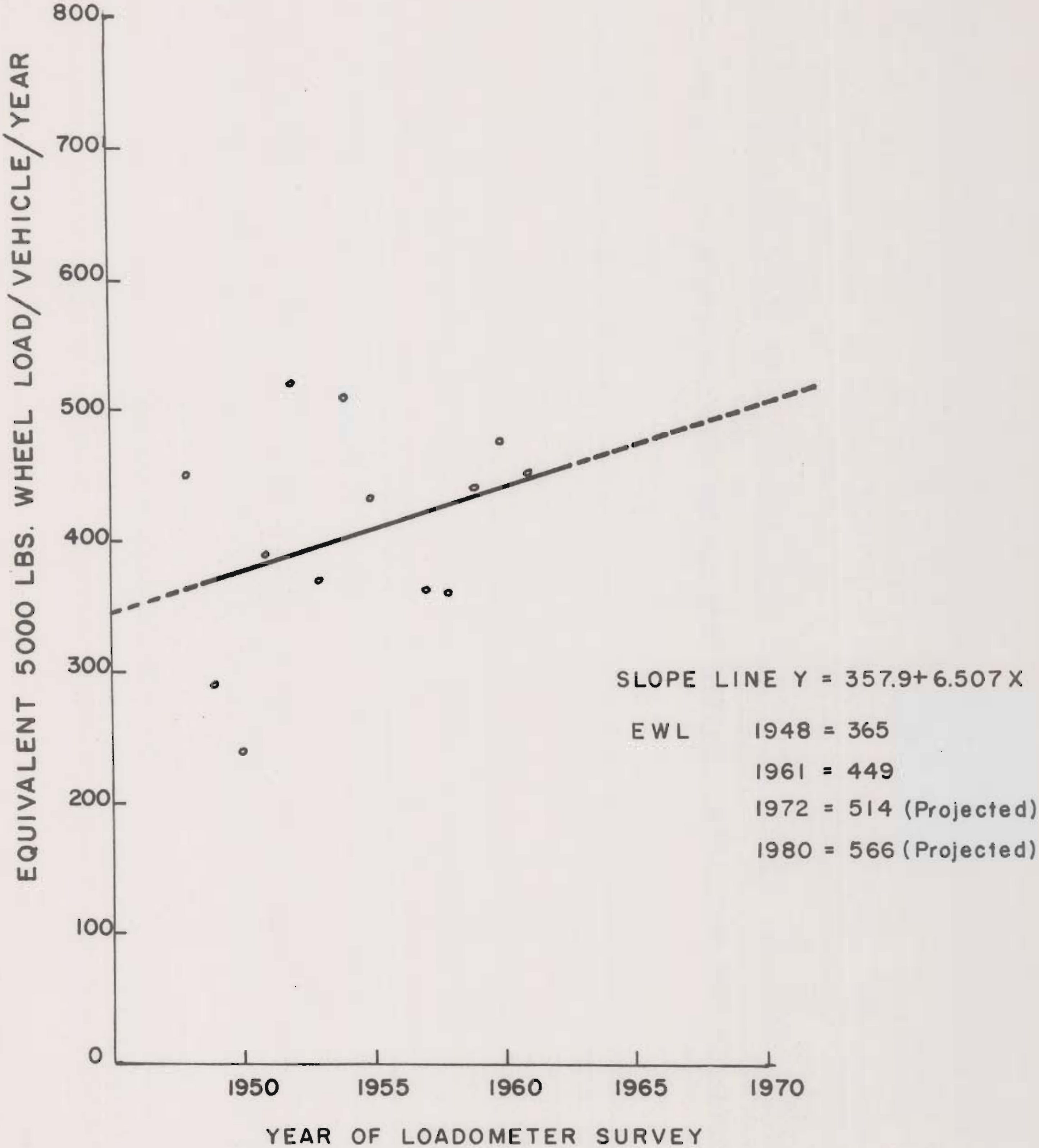


FIGURE 2 — 2 AXLE VEHICLES — EWL CONSTANTS

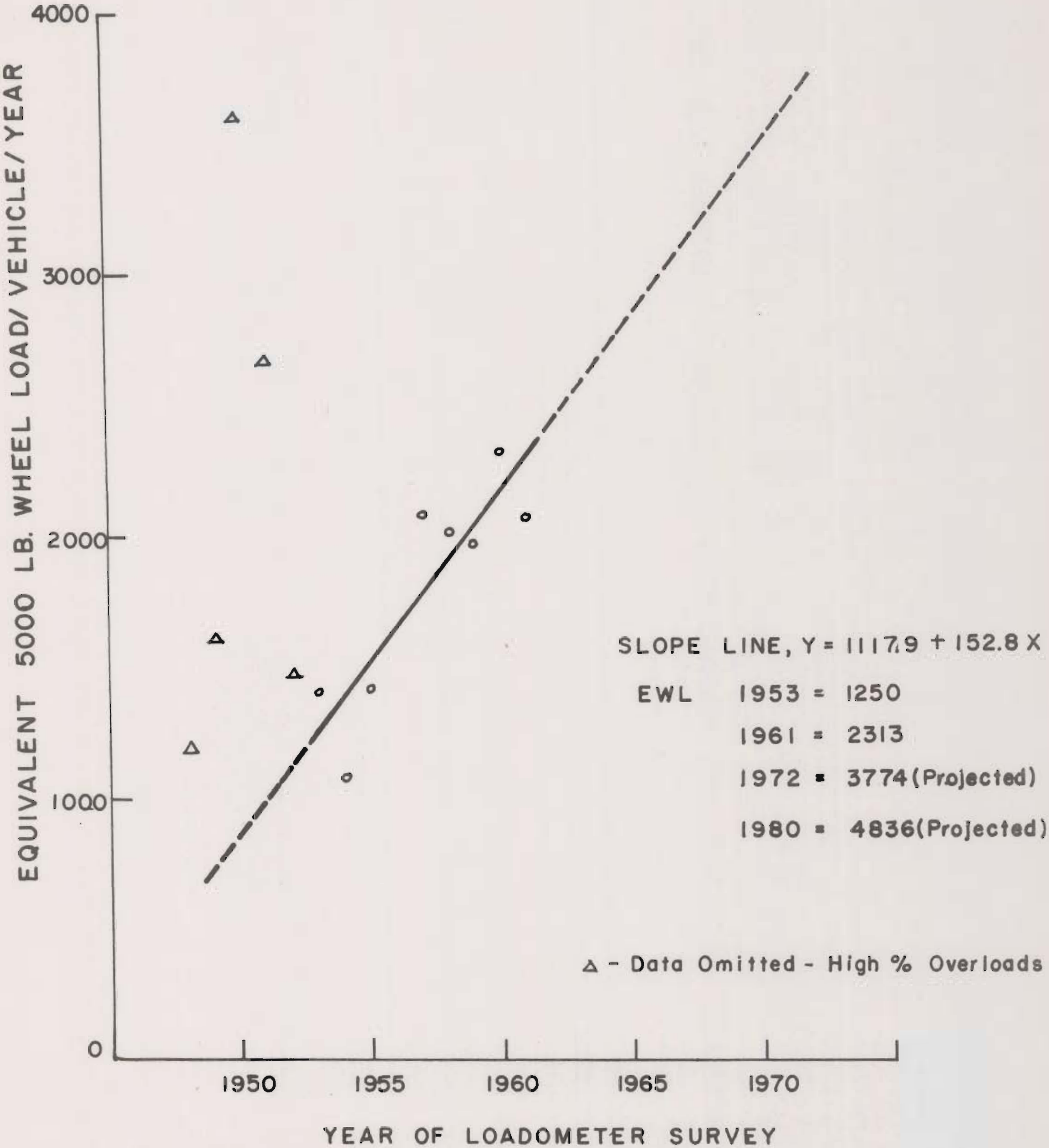


FIGURE 3 — 3 AXLE VEHICLES — EWL CONSTANTS

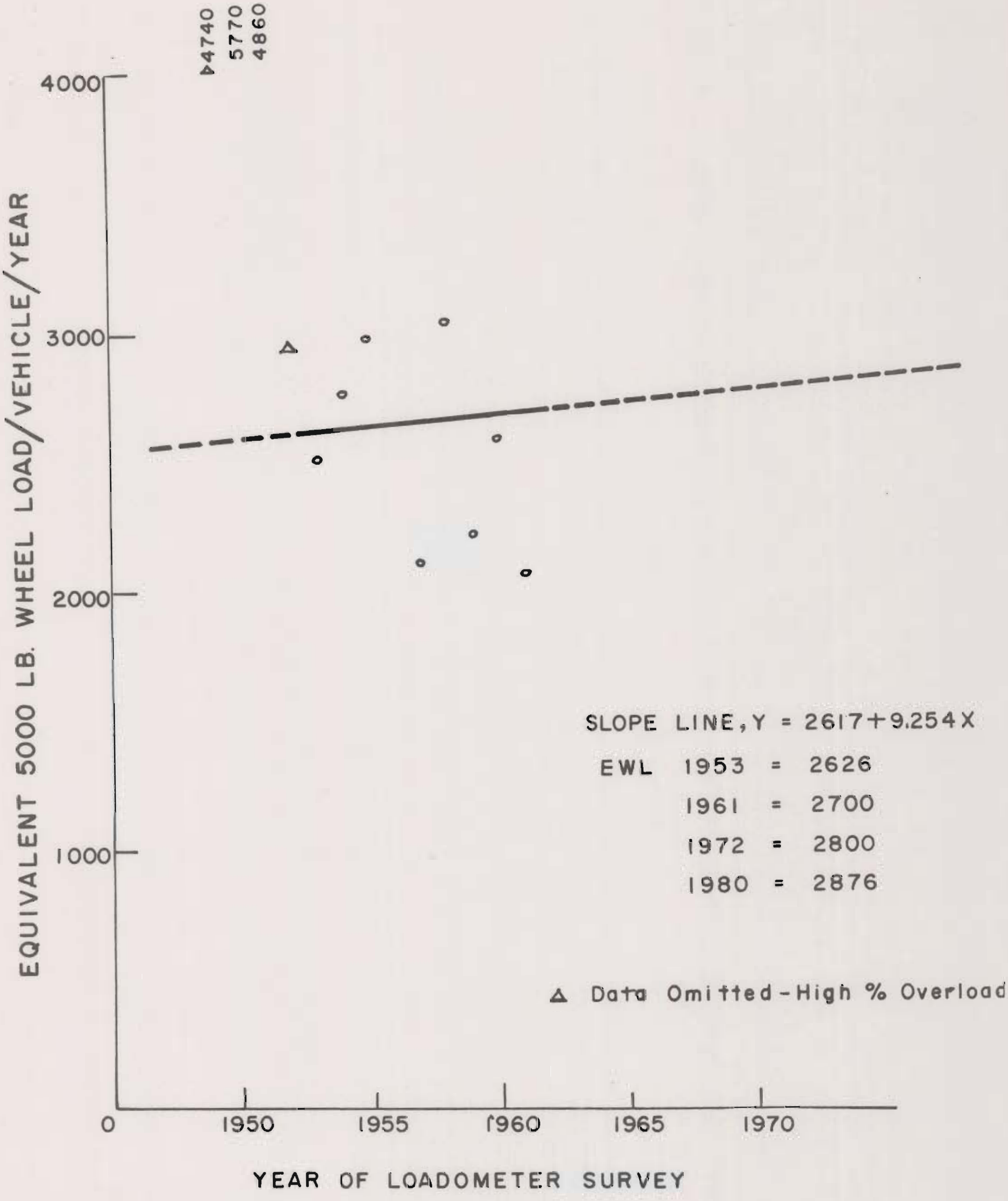


FIGURE 4 - **4 AXLE VEHICLES — EWL CONSTANTS**

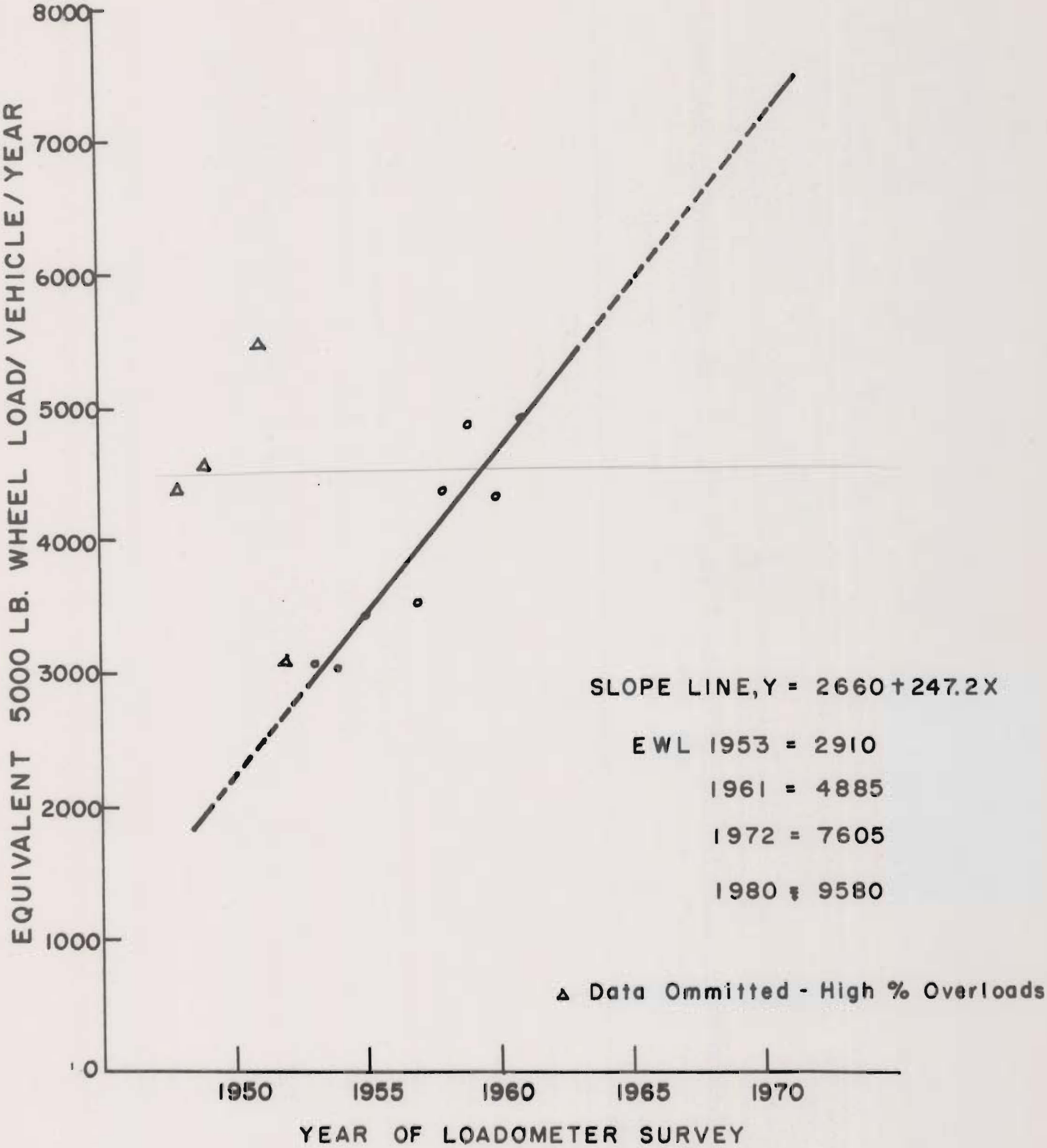


FIGURE 5 — 5 AXLE VEHICLES — EWL CONSTANTS

III. CLASSIFICATION COUNTS OF VEHICLES

Classification of Vehicles

The classification of vehicles by type was obtained from Planning Survey Vehicle Classification Counts made at 48 different locations throughout the State of Idaho. This vehicle classification was made from traffic counts taken quarterly over the period 1957-1961 (three years) such that each month of the year, as well as day of the week except for weekends was represented. The volume counts were approximately 12 times the ADT and it is believed this classification is the most accurate available, see Table XI, Appendix B.

The original data is combined for purposes of this study into light traffic and commercial traffic. Light traffic is defined as all passenger cars, and light single unit trucks of less than 1½ ton capacity. Commercial traffic is considered to consist of all other traffic of larger size.

Percentage Classification of Vehicles

The percentage of each size truck and bus compared with the total ADT and commercial ADT was computed. These computations indicate that for these stations a variation in the 2 axle count will range from 30% - 85% and the 5 axle count from 3% to about 45% of the total commercial count. These two classifications are related inversely. The 3 and 4 axle vehicle groups have no apparent relationship to any other group. Figure 6 gives the percentage of each group of vehicles for each of the 48 stations analyzed.

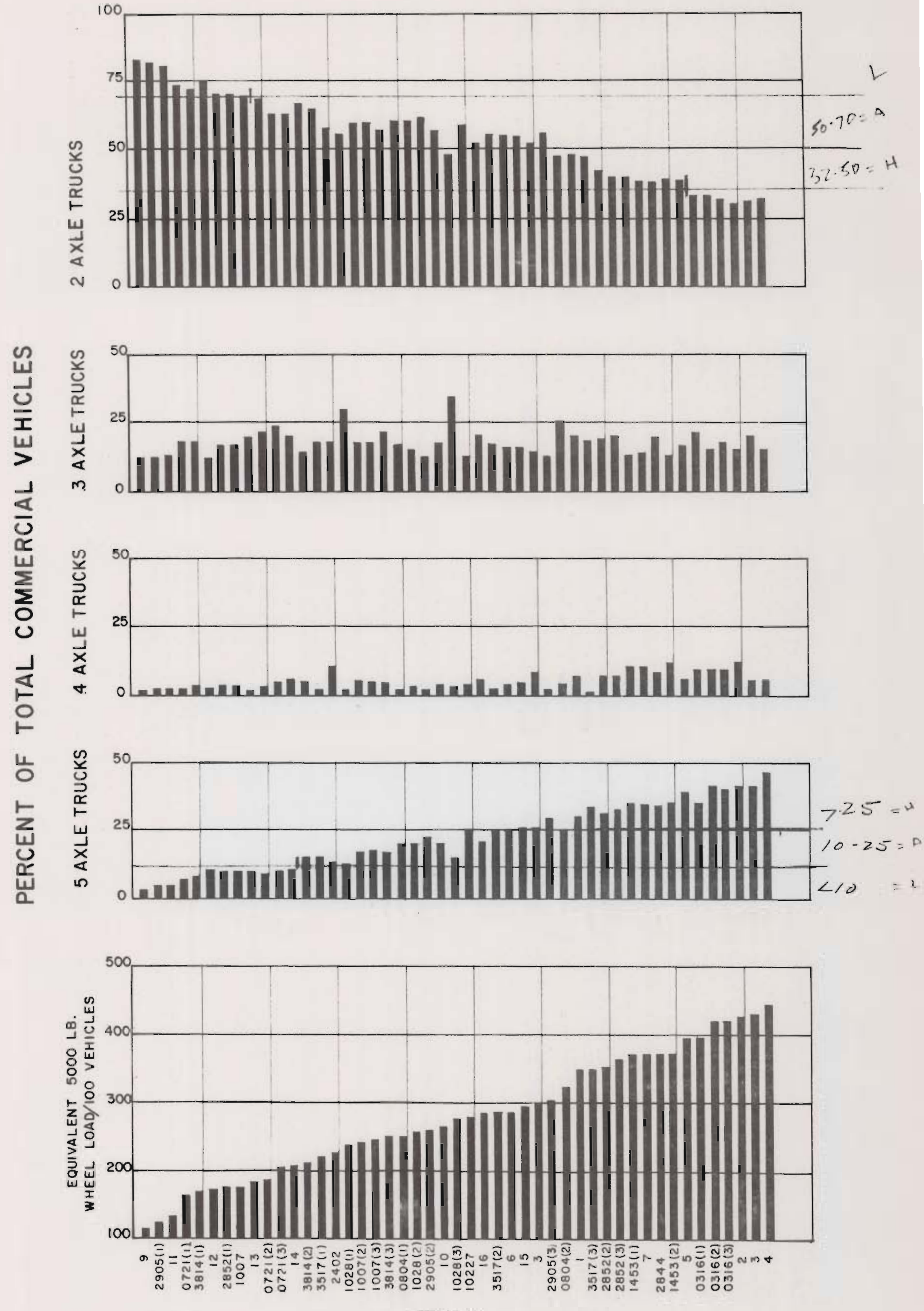


FIGURE 6 — RELATIONSHIPS OF E.W.L. AND COMMERCIAL VEHICLE GROUP PERCENTAGES

5k-EWL - Vehicle Classification Relationship

Consideration was given the range in the 5k-EWL Factor for each vehicle classification and the great variation in the percentage of each classification within the commercial traffic volumes. A computation of the 5k-EWL per 100 vehicles was made for each of the 48 classification stations using projected 5k-EWL Factors for 1972 for each vehicle classification, see Table XII, Appendix B. (NOTE: The year 1972 was chosen as representing the average of the 1962 and 1982 5k-EWL Factors and is representative of a 20 year life of the pavement.)

The 5k-EWL per 100 vehicles for each of the 48 stations was plotted against the percentage of two axle and also of 5 axle vehicles as a part of the commercial volume, see Figures 7 and 8. This data was analyzed by the least squares method for correlation and gives a coefficient of correlation of 96 percent and 95 percent respectively. Since this coefficient of correlation is very good, it appears that the determination of the volume of either two axle or five axle vehicles as a percent of the total commercial count should be a reliable indicator of the 5k-EWL factor to be applied for each 100 commercial vehicles using the highway.

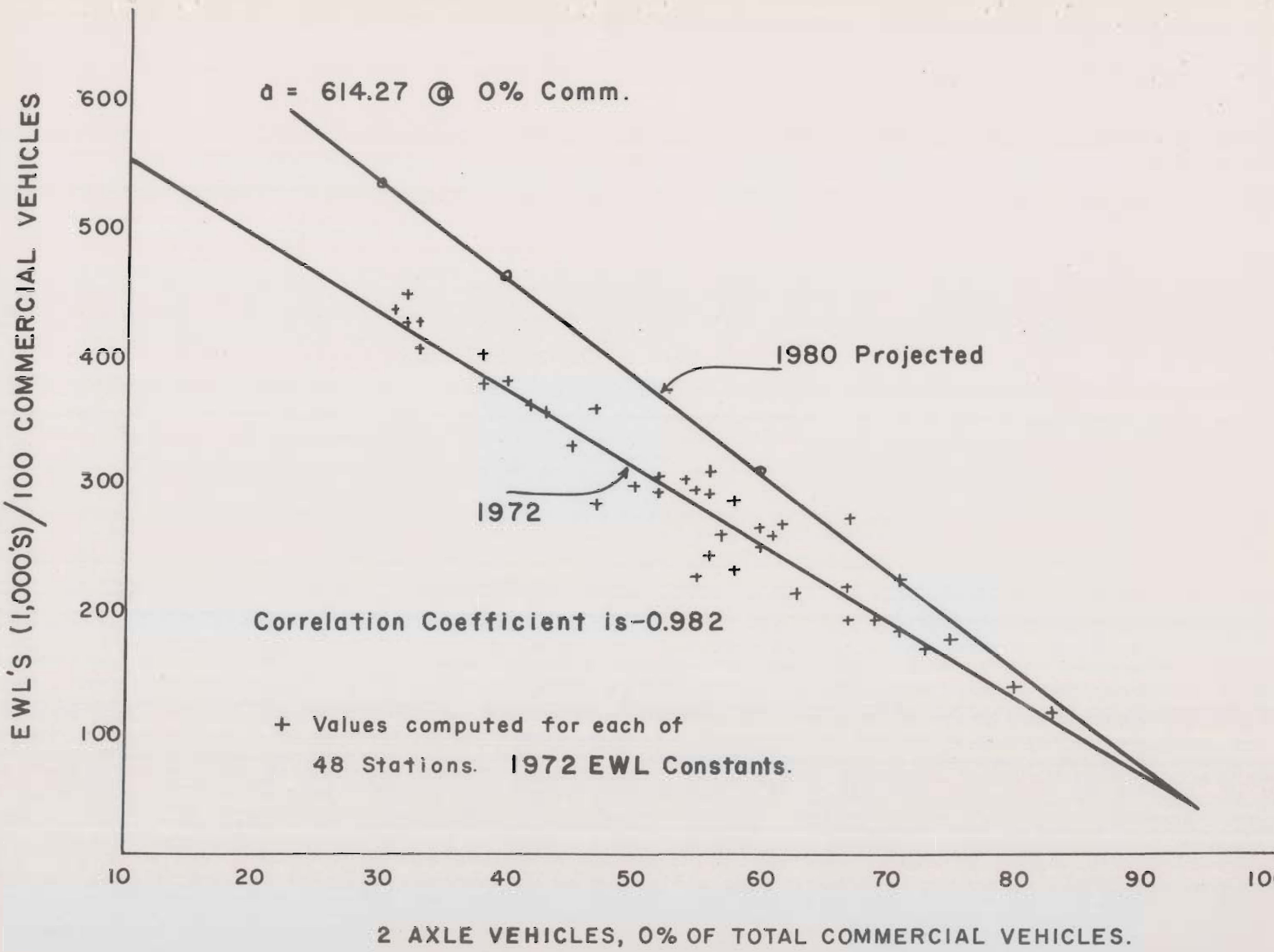


FIGURE 7 — RELATIONSHIP OF TOTAL EWL'S TO 2 AXLE VEHICLES AS % OF TOTAL COMMERCIAL VEHICLES.

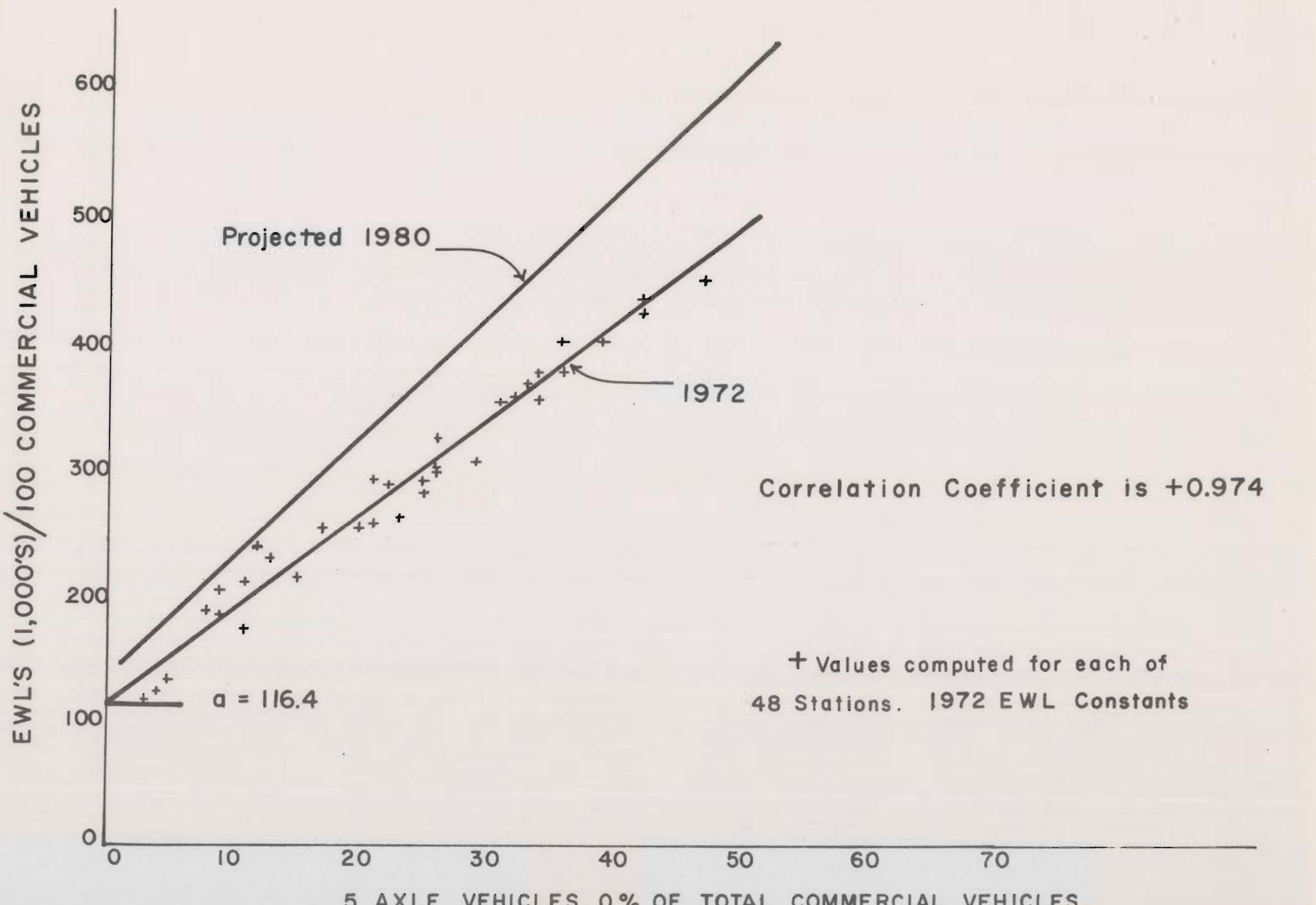


FIGURE 8 - RELATIONSHIP OF TOTAL E.W.L.'S TO 5 AXLE VEHICLES AS % OF TOTAL COMMERCIAL VEHICLES.

IV. DESIGN PROCEDURE - RESISTANCE VALUE AND TRAFFIC INDEX METHOD

R-Value and Traffic Index Design

The Resistance Value - Traffic Index method of design was first proposed by Hveem and Carmany in 1948. They described the factors involved in the design of flexible pavements and the relationships developed by test road data to that date. They presented test methods for determining the resistance developed by soil when loads are applied and also methods of determining the effect of repeated loadings from highway traffic. It was this original publication that inspired the adoption of the R-Value - Traffic Index Method of Pavement Design by the Idaho Department of Highways.

WASHO Road Test

The WASHO Road Test results together with data from the Stockton Test Track resulted in revisions of the original formulas for the design of flexible pavements. These formulas were the basis of the 1957 design method adopted by Idaho. The formula for Traffic Index is:

$$TI = 1.35\ (EWL)^{0.11} \quad \text{- - - - - - - - - - - - - - - - - -} \quad (1)$$

in which TI = Traffic Index

EWL = Sum of Equivalent 5,000 lb. wheel loads = 5k-EWL

The total thickness of Flexible Pavement is determined by the formula:

$$Th = \frac{0.095\ (TI)\ (90-R)}{C^{0.2}} \quad \text{- - - - - - - - - - - - - - - - - -} \quad (2)$$

in which TI = Traffic Index
R = Resistance Value from Test
C = Cohesion Value for the granular base materials (Generally taken as 100 for untreated granular materials)

The thickness determined by the above formula is considered to be the equivalent gravel thickness. The California Department of Highways used alignment charts varying the value of "C" for treated materials thereby reducing the thicknesses. Idaho has not used treated base except in exceptional cases and then only because of inferior base materials and has not made a practice of using any substitutions for thickness due to treated materials.

California Design Revisions

The WASHO and AASHO Road Test findings both have added new information regarding flexible pavement performance. This data has been carefully reviewed by the California Department of Highways and resulted in revisions to the above formulas. The first revision reported at the International Conference on the Structural Design of Asphalt Pavements, Ann Arbor, Michigan, Hveem and Sherman gave revised formulas as follows:

$$TI = 1.30\,(EWL)^{0.12} \quad \text{- -} \quad (3)$$

The formula for thickness (gravel equivalent) was revised as follows:

$$Th = \frac{0.080\,(TI)\,(90-R)}{C^{0.2}} \quad \text{- -} \quad (4)$$

Values were the same except that "C" was revised to a value of 20 for gravels and 30 for crushed stone.

Continued analysis resulted in a formula giving a coefficient of correlation with the AASHO Road Test results of 0.98 and a standard error of estimate of $\pm$ 1.2". The formulas are:

$$TI = 1.30\,(EWL)^{0.119} \quad \text{- -} \quad (5)$$

and the thickness $= \dfrac{0.070\,(TI)\,(100-R)}{C^{0.2}}$ - - - - - - - - - - - - - (6)

No change in nomenclature was made or in the values assigned to "C" cohesion.

The result of these changes from the 1957 formula has been to increase the total thickness in the range of the heavier traffic volumes and higher resistance value soils.

Classification

Loadometer and vehicle classification data were used to derive the relationships shown in Figures 7 and 8. These two figures were then combined as shown in Figure 9. The mean percentage of the two axle and five axle vehicles was 53 and 26 respectively for the 48 classification stations. Since the effect of the number of heavy or light vehicles is very pronounced on the 5k-EWL, a classification into groups for design purposes was derived. This classification, range of 2 axle and 5 axle vehicles as a percentage of the commercial count and the 5k-EWL assigned for design purposes is given in Table IV.

TABLE IV

DESIGN 5k-EWL FOR VARYING DISTRIBUTION OF 2 AXLE AND 5 AXLE VEHICLES

Classification Highway	Approx. Range % of Comm. Traffic 2 Axle	 5 Axle	5k-EWL (1000)/100 Veh. for Design (1972 Constants)
Heavy	Less 50	25-40+	415
Average (State Highways)	50 - 70	10 - 25	305
Light	70 - 80	2 - 10	186
Very Light	80 - 90	0 - 2	114
Residential	90+	0	63

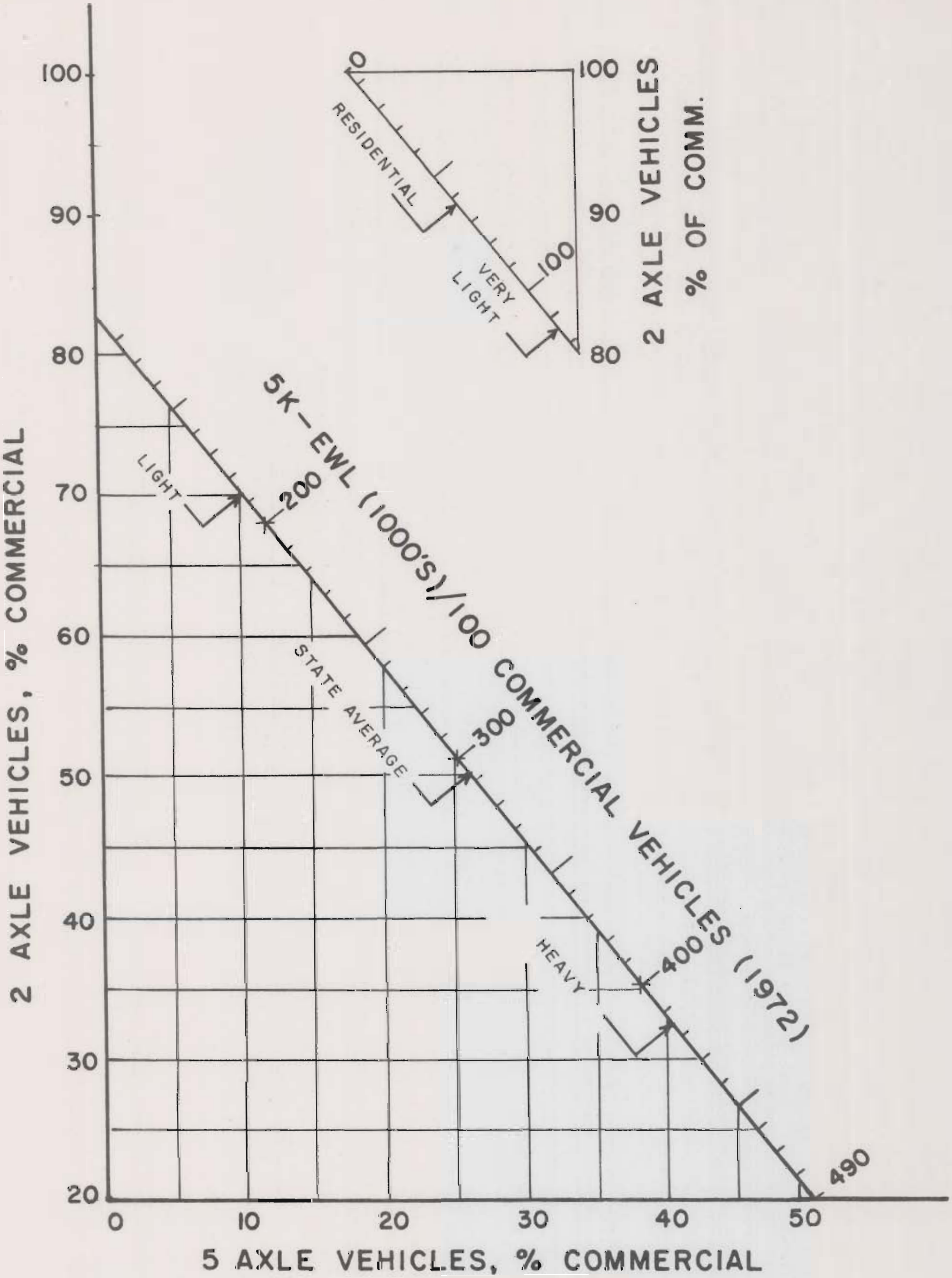


FIGURE 9.– RELATIONSHIP OF 5K-EWL'S (1000'S) AND 2 AXLE AND 5 AXLE VEHICLES AS % OF COMMERCIAL VEHICLES

This classification was used to construct the traffic index chart, (see Figure 10). The lower edge of each band gives the traffic index for 1972 5k-EWL Constants or Factors and the top edge for 1980 5k-EWL Constants, since residential streets have very little truck traffic. The "1961 Highway Statistics" publication of the Bureau of Public Roads indicates less than about 10% of the ADT are commercial vehicles using urban streets, provisions were made for recognizing these low traffic volumes on residential streets. An allowance of 50 commercial vehicles would indicate approximately 500 - 800 vehicles per day which appears to be a maximum for non-arterial streets in Idaho. Arterial streets should be classified very light, light or heavier depending upon vehicle estimates.

Variations in the total thickness of pavement structure due to the above classifications from "very light" to "heavy" would be only 0.3 foot for a soil having an R-Value of 10. The added thickness for very high volumes of 5 axle vehicles is needed and the lesser thicknesses for low volumes of 5 axle vehicles is warranted, particularly on county and highway district roads where the use of large vehicles is very seasonal.

The flexible pavement thickness chart was constructed using Formula No. 6, see Figure 11. This chart was also used in evaluating the effect of highway classifications.

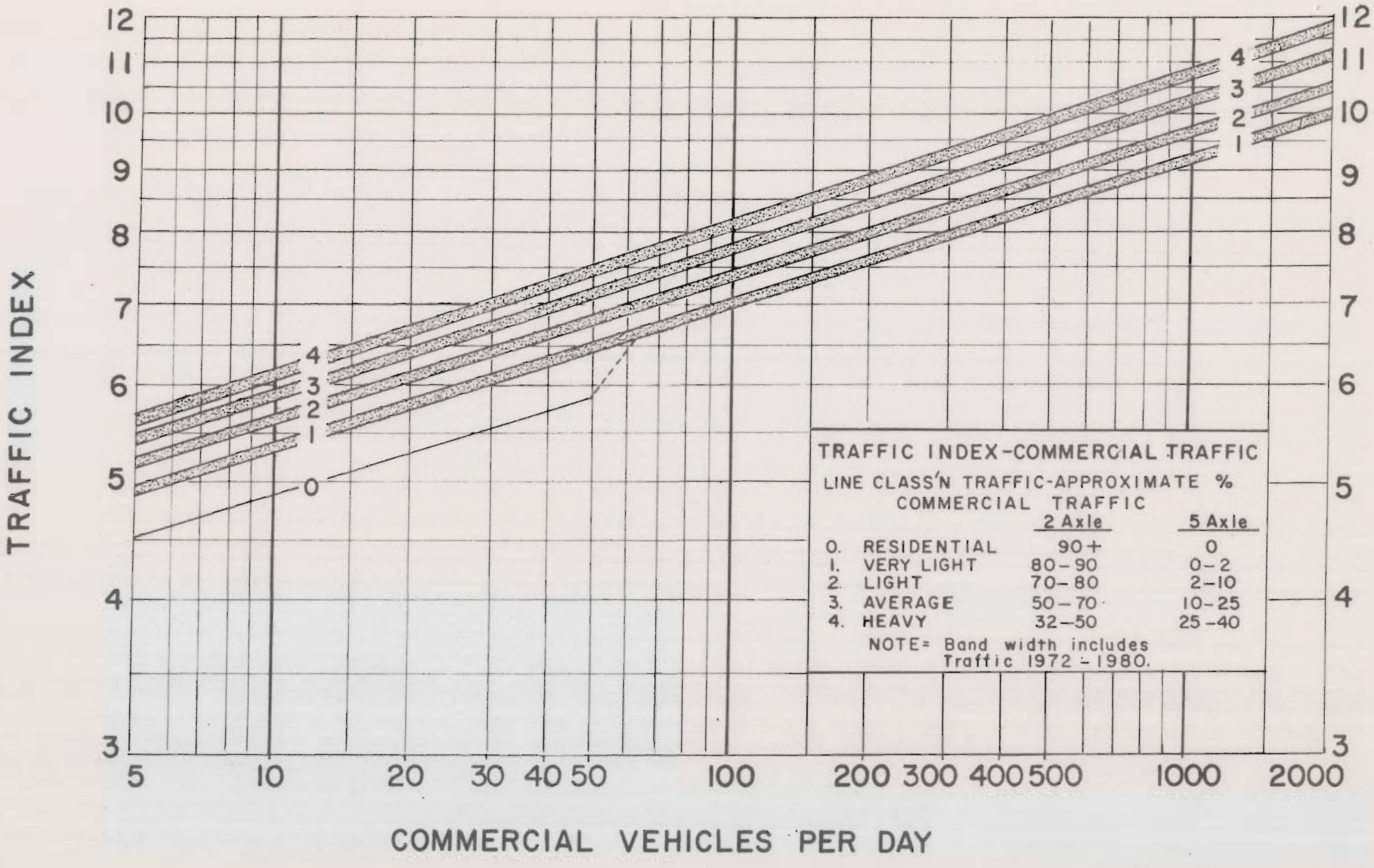


FIGURE 10.—TRAFFIC INDEX FROM COMMERCIAL VEHICLE COUNT & CLASSIFICATION

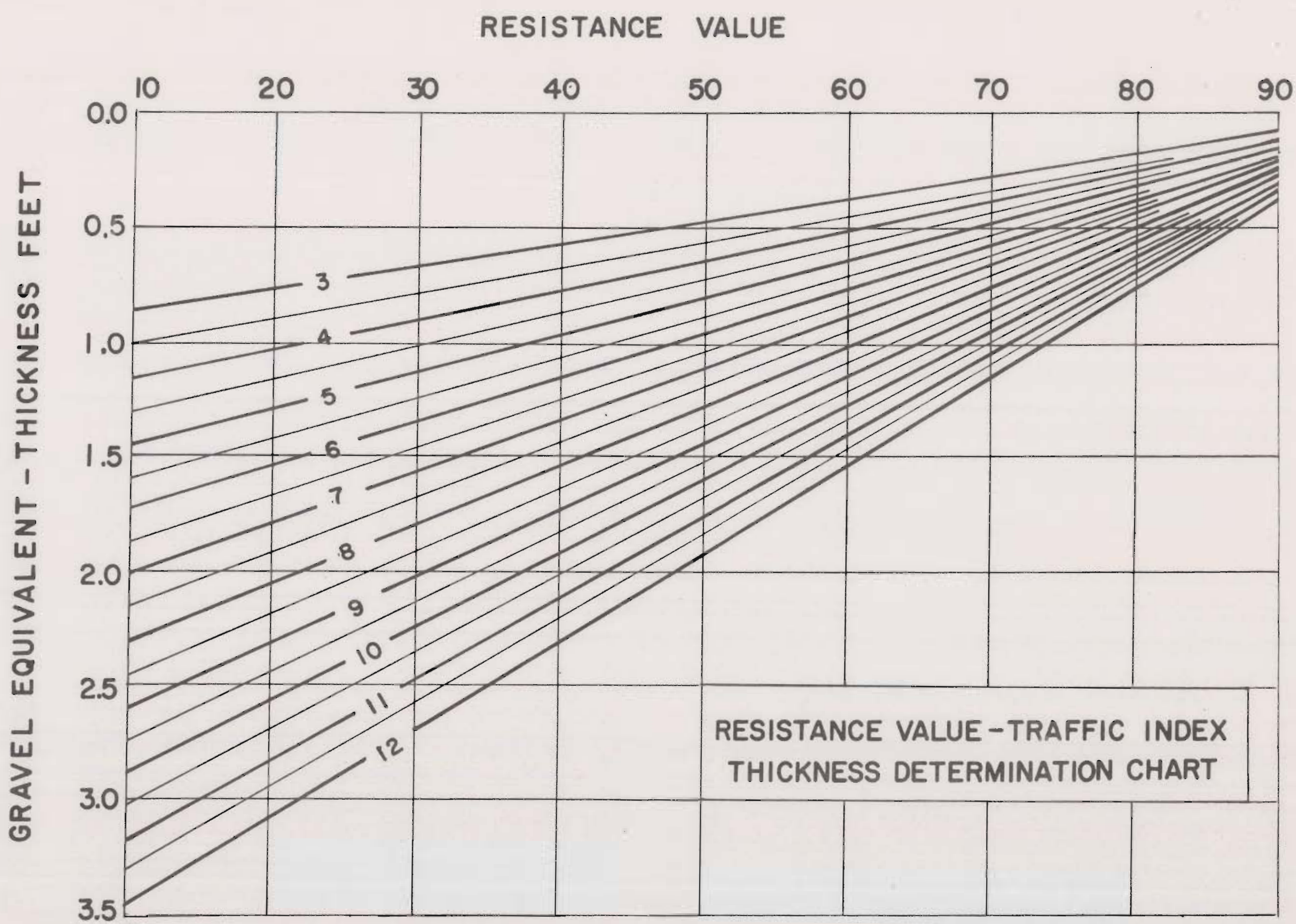


FIGURE 11.— THICKNESS (EQUIVALENT GRAVEL) FROM RESISTANCE VALUE AND TRAFFIC INDEX

V. ADJUSTMENT OF TOTAL THICKNESS DESIGN FOR THICKNESS OF PAVEMENT AND TREATED BASES

WASHO Road Test

The WASHO Road Test showed a very superior performance for sections having four inches of asphalt pavement when compared with sections having only two inches. The thickness of undamaged total pavement structures at the end of the test was at least four inches less for those having four inches than those having two inches of asphalt surface courses.

AASHO Road Test

The AASHO Road Test used factorial experimental sections to determine the effectiveness of asphalt pavement surface courses and treated base courses. This test again showed the effectiveness of thicker asphalt pavements and also of treated base over untreated base materials.

The AASHO Road Test, Report 5 on Pavement Research states, (Section 2.6.1, page 133) "For the weighted applications case the thickness/index/ equation indicates that an inch of surfacing was about three times as effective as an inch of subbase in improving performance within the range of design studied." The thickness index equation for the AASHO Road Test Materials is:

Thickness Index = $0.44D_1 + 0.14D_2$ and $0.11D_3$ where

D_1 = Surfacing Thickness, inches (2 in. min.)

D_2 = Base Thickness, inches (3 in. min.)

D_3 = Subbase thickness, inches

The AASHO Road Test Report 6, page 135, reports that to maintain a serviceability level of 2.5, "for the 18 kip single axle load at 1,000,000 applications the required thickness of base (where the surfacing thickness was 3 inches and the subbase 4 inches) is shown to be approximately 13, 8, and 6 inches of stone, cement treated and bituminous treated base, respectively. This again shows the effectiveness of the plant mixed surfacing and treated base materials in increasing the effectiveness of pavement structures."

The Asphalt Institute

The Asphalt Institute made an analysis of data from the AASHO Road Test, WASHO Road Test, Alconbury Hill in Great Britain and tests on circular road test tracks. They derived formulas for the effectiveness of surfacing courses when compared with base and subbases. The formula presented at the International Conference on the Structural Design of Asphalt Pavements by Finn and Shook is as follows:

$$Th = 2.0D_1 + D_2 + 0.75D_3$$

where,

D_1 = Thickness of plantmixed (Hot) surfacing and base

D_2 = Thickness of untreated base

D_3 = Thickness of subbase

The Asphalt Institute Formula recognizes a safety factor such that the design thickness would eliminate all failures for practical purposes. The Asphalt Institute has since recommended in their Thickness Design for Asphalt Pavement Structures for Highways and Streets (Manual Series No. 1 (MS-1) September, 1963, the following substitution ratios:

"(1) Two inches of granular base for 1" of asphalt concrete, a substitution ratio of 2:1

(2) 2.7 inches of subbase for 1" of asphalt concrete, a substitution ratio of 2.7:1

(3) 1.35 inches of subbase for 1" of granular base, a substitution ratio of 1.35:1.

The Asphalt Institute states these ratios may be increased slightly for light traffic conditions.

California Department of Highways

The California Department of Highways have always provided for the increased strength in the pavement structure due to treated bases by means of the cohesiometer value in the denominator of their thickness equation. Their design manual recognizes this equivalency by assignment of cohesiometer values for various type base courses, i.e., cement treated, asphalt treated, etc., of narrow thicknesses.

Recommended Substitutions

The AASHO Road Test used only one set of materials for base and subbase as well as surface courses and these materials had not been effected by weather more than three years and since experimentation to measure the performance of other materials was not conducted, a more conservative approach to these substitutions is warranted. The Asphalt Institute's method of making a substitution of equivalent sections appears to be the simplest and most straight forward, as well as being conservative.

Minimum thicknesses of pavement structure should be provided without any further reduction in thickness because of substitution ratios. Idaho has been conducting 0.4 foot thick pavements on Interstate projects, 0.2 -

0.3 foot on Primary and 0.15 to 0.2 on Secondary projects. Urban sections have been 0.2 to 0.3 foot in thickness depending on traffic volumes. Traffic varies considerably, from perhaps 10 commercial vehicles per day to several hundred as the range between county secondary and the most heavily traveled state highways. In view of the substitution ratios provided by the AASHO Committee on Design, the Asphalt Institute and also because materials vary considerably in their properties, the factors provided in Table V are considered conservative, but a justifiable allowance for making substitutions of treated base and surfacing for granular base.

TABLE V

SUBSTITUTION RATIOS FOR SURFACING AND TREATED BASE
FOR GRANULAR BASE MATERIALS
Inches Untreated Per Inch Treated

Traffic Index	Asphalt Plantmix Surfacing % A.C. High	Asphalt Plantmix Base % A.C. Low	Treated Base Courses Asphalt Emulsion, Road Oil Portland Cement, Lime
Over 7.0	2.0:1	1.75:1	1.50:1
5.5 - 6.9	2.5:1	2.0:1	1.75:1
Less 5.4	3.0:1	2.5:1	2.0:1

NOTE: Design Thickness Should Not Be Less than 0.5 Ft. for Residential Streets and County Secondaries and 0.8 Ft. for State Highway Projects

VI. EFFECTS OF CLIMATE AND ENVIRONMENT

Road Test Results

Both the AASHO and WASHO Road Tests showed great seasonal variations in the deflection measurements under wheel loads using the Benkelman Beam. The greatest deflections occurred during the spring and least during late summer and fall except for periods when frost penetrations were deep.

The duration of these seasons varied greatly at the WASHO Road Test. During the period June 11 to July 7, with only 0.7 percent of test load applications, 27 percent of the total distressed areas developed. The year following during the period February 17 to April 7, under 13 percent of the load applications, 40 percent of the distress occurred or for both periods, 67% of the distress in but 14 percent of the application. When favorable conditions existed, 45% of load applications caused only 1.6 percent of the distress.

The AASHO Road Test found similar variations with some winter and spring deflection measurements two and three times the summer measurements after frost had left the pavement and base. These deflection measurements correlated well with performance. A. C. Benkelman and W. N. Carey, Jr., of the Road Test staff have stated that if the nominal axle loading using the roadway is known that deflection measurements on newly constructed pavements during the fall and again during the critical spring period will serve to predict satisfactorily the performance.

Design Committee - Regional Factor

The AASHO Committee on Design utilized the deflection charts for the various seasons to establish a Regional Factor recognizing that where conditions are adverse (saturated subgrades during spring breakup period) there will be more damage inflicted than when more favorable conditions exist. The duration of the period of adverse condition is of particular importance.

Each District was submitted Appendix G of the AASHO Interim Guide for the Design of Flexible Pavement Structures with the request they provide similar information regarding various areas within their District. This information was then correlated between Districts and the conformity at District Borders was remarkable.

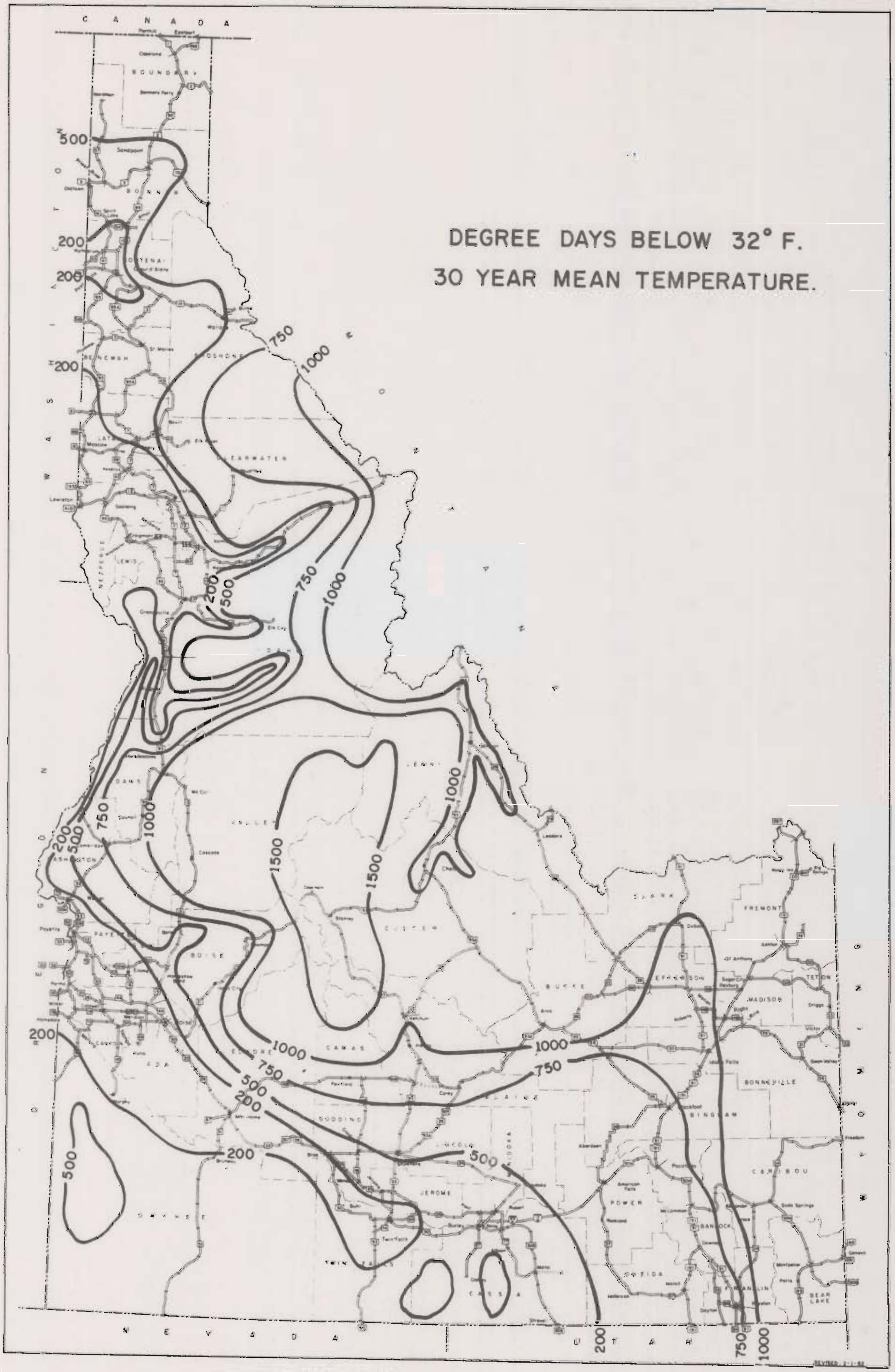
Idaho Weather

Weather Bureau records were then reviewed particularly with regard to duration of freezing weather and precipitation during the winter months. Examination of the 30 year mean monthly temperatures and precipitation indicates that freezing weather exists for less than one month with about 1½ inches of precipitation to five months of freezing weather and about 20 inches of precipitation during the period of freezing weather. Precipitation for the freezing period is mostly snow and is moisture available during the spring breakup period in addition to spring rains. Degree day curves were drawn for each Station in Idaho and precipitation computed for the same period. These results are given in Table XIII, Appendix B and were used to construct Figure 12.

Idaho Climatic and Environmental Factors

This data, together with the District Maintenance Engineer's evaluation of the spring breakup periods was used to establish the map for climatic factor, Figure 13. The AASHO Committee reports factors of 0.2

FIGURE 12.



DEGREE DAYS BELOW 32° F.
30 YEAR MEAN TEMPERATURE.

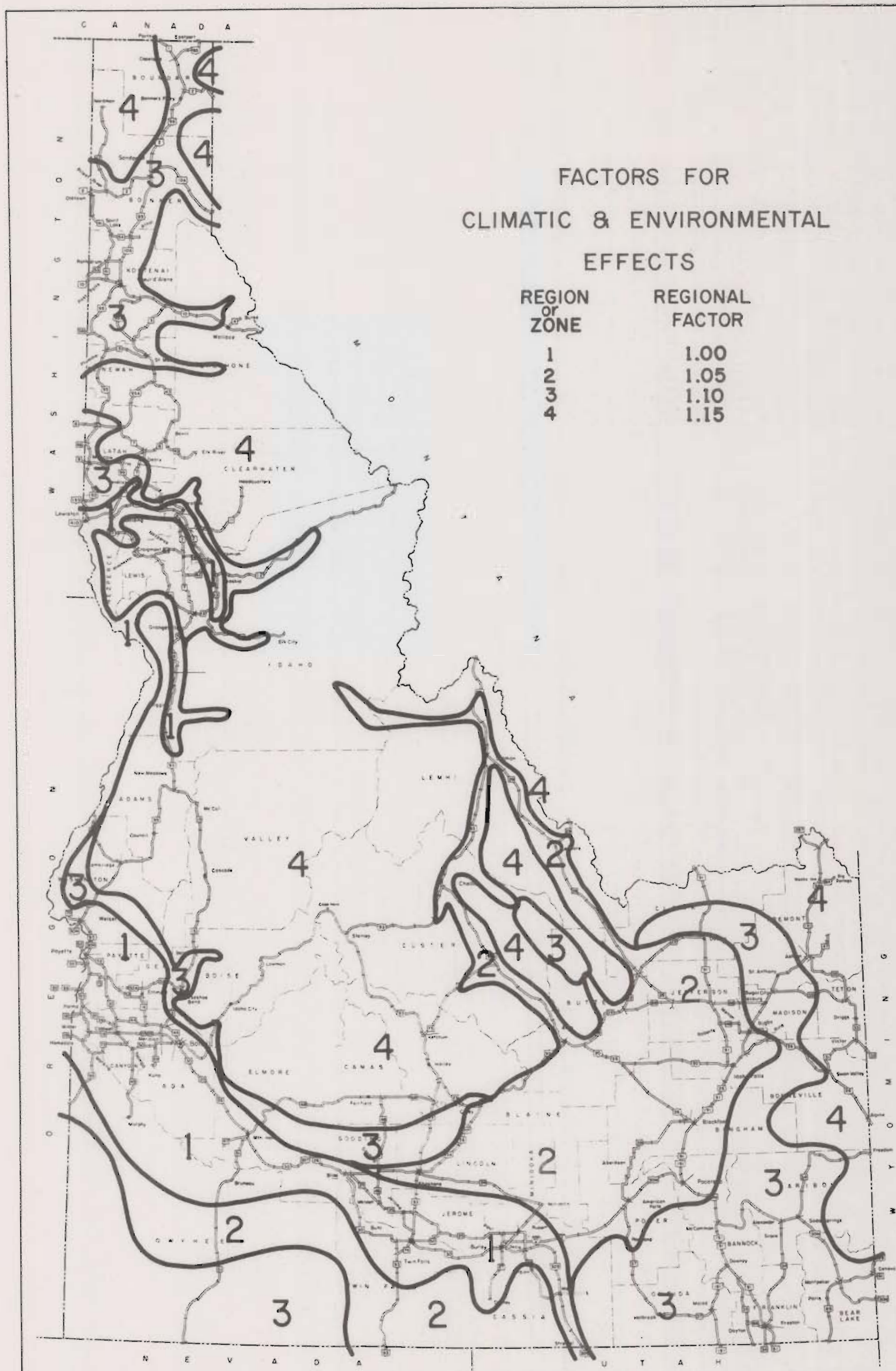
to 1.0 for frozen pavement structures and from 0.3 to 1.5 for dry summer and fall conditions and during the spring breakup period, values of 4 to 5. The duration of the breakup period depends upon the available moisture and frost penetration. Zone numbers were assigned 1 for the very mildest climate, 2 for slightly more severe, 3 for moderately severe and 4 for severest climatic conditions.

The design chart recommended by the AASHO Committee for the regional factors indicates increases in pavement structure thicknesses in accordance with the severity of climatic and environmental conditions. Using the AASHO Committee factors as a guide, the following increases are proposed.

Zone	Increase Factor (Multiplier)
1	0
2	1.05
3	1.10
4	1.15

These increases range from 0 to 15 percent of the total thickness. Considering that these increases are to be added to every mile of highway within the zone, it is a considerable increase in cost. These increases are computed prior to making substitutions for surfacing or treated base courses. These zones are shown on Figure 13.

FIGURE 13.


FACTORS FOR
CLIMATIC & ENVIRONMENTAL
EFFECTS
REGION or ZONE | REGIONAL FACTOR
1 | 1.00
2 | 1.05
3 | 1.10
4 | 1.15
CANADA
WASHINGTON
OREGON
NEVADA
UTAH
WYOMING
MONTANA

VII. AASHO COMMITTEE OF DESIGN INTERIM GUIDE FOR THE DESIGN OF FLEXIBLE PAVEMENT STRUCTURES

Design Considerations

The design procedure presented by the AASHO Committee of Design for consideration of the States is based upon data developed in the AASHO Road Test supplemented and modified by data from existing design and construction procedures.

The design of the pavement structure requires correlation of a number of facts including:

1. Type and character of the roadbed soils upon which the structures would be placed.
2. The volume and weight of traffic that would be carried.
3. The suitability and quality of the materials available to build a structure, including a relative ability to support loads when incorporated in a structure.
4. Environmental conditions under which the structure will serve.
5. The type and quality of surface expected from the pavement during its anticipated life.
6. Construction procedures used in building the structure.

The first five of these are included in the Design Charts. The sixth, Construction Procedures, is not directly evaluated although the design is valid only when uniform and high quality construction is obtained, particularly with reference to densities, moisture, gradation and quality of materials.

Factors that are evaluated in the design process include: the serviceability index which is noted as P_t and is a subjective rating applied to the serviceability of a section of the highway. This number was arrived at by assigning five as being perfect and zero as being virtually worn out. The serviceability index number is a proportionate number between zero and five indicating its relative value to serve traffic at that moment. Normally, a minimum serviceability index number of 2.5 would be chosen for major highways and 2.0 for lower order highways as indicating a need for reconstruction. Economic considerations would rarely dictate that a value less than 2.0 would be used even for minor highways.

Analysis of Traffic

In the analysis of traffic and the load carried by various vehicles a traffic analysis period of 20 years was chosen. The equivalent daily 18 kip single wheel load application was computed from an analysis of the total number of load applications anticipated to be carried by the pavement structure during the traffic analysis period. Traffic volume data was converted to an average daily application and further reduced to axle load groupings from which the equivalent daily 18 kip single axle load applications was computed. This was done by multiplying the number of applications in each weight category by the equivalence factor. The factors have been determined from mathematical analysis of the AASHO Road Test data and are given in Table VI for both single and tandem axles. See Tables XIV and XV for the Equivalent Daily 18k Single Axle Wheel Load Applications for a Serviceability Index of 2.0 and 2.5.

Regional Factor

The AASHO Design provides for a regional factor for adjustment of the design thicknesses because of climatic and environmental conditions. The factor varies from 0.1 to 4.8 on the AASHO Road Test with an annual average of 1.0. The lower value applies to both solidly frozen and

TABLE VI

EQUIVALENCE FACTORS FOR 18k LOAD APPLICATIONS

When $P_t = 2.0$

Axle Load Lbs.	Equivalence Factors Single Axles	Equivalence Factors Tandem Axles
2,000 - 8,000	0.006	-
8,000 - 16,000	0.18	0.02
16,000 - 20,000	1.00	0.08
20,000 - 24,000	2.35	0.17
24,000 - 30,000	5.80	0.42
30,000 - 34,000	12.00	0.83
34,000 - 38,000	20.00	1.38
38,000 - 44,000	33.00	2.40
44,000 - 48,000	-	3.90
Passenger Cars	0.0002	

When $P_t = 2.5$

Axle Load Lbs.	Equivalence Factors Single Axles	Equivalence Factors Tandem Axles
2,000 - 8,000	0.006	-
8,000 - 16,000	0.20	0.02
16,000 - 20,000	1.00	0.09
20,000 - 24,000	2.20	0.21
24,000 - 30,000	5.00	0.50
30,000 - 34,000	9.20	0.87
34,000 - 38,000	14.50	1.38
38,000 - 44,000	23.00	2.30
44,000 - 48,000	-	3.55
Passenger Cars	0.0002	

relatively dry conditions of roadbed soils. The higher values apply during spring breakup period when the roadbed soils are saturated.

Soil Support Numbers

The soil support number is an index number which expresses the relative ability of a soil or aggregate mixture to support the pavement structure. The AASHO Road Test soil has a Soil Support Number of 3 and the crushed stone base was assigned a value of 10. A linear scale was assumed between 3 and 10.

Structural Number

The structural number is an index number derived from an analysis of traffic and roadbed soil conditions, which is converted to pavement thickness through the use of suitable factors related to the type of material to be used in the pavement structure.

The relationship for structural number is expressed by the Formula:

$$SN = a_1 D_1 + a_2 D_2 + a_3 D_3$$

where a_1, a_2, a_3 = coefficients of relative strength

D_1 = thickness of bituminous surface course, inches

D_2 = thickness of base course, inches

D_3 = thickness of subbase course, inches

Table VII gives the coefficient a_1, a_2, a_3 for various pavement components.

The AASHO Committee on Design Interim Guide provides a correlation chart for Soil Support Values and Resistance Values (California and Washington) California Bearing Ratio (Kentucky) and the Group Index, see Figure 14.

TABLE VII

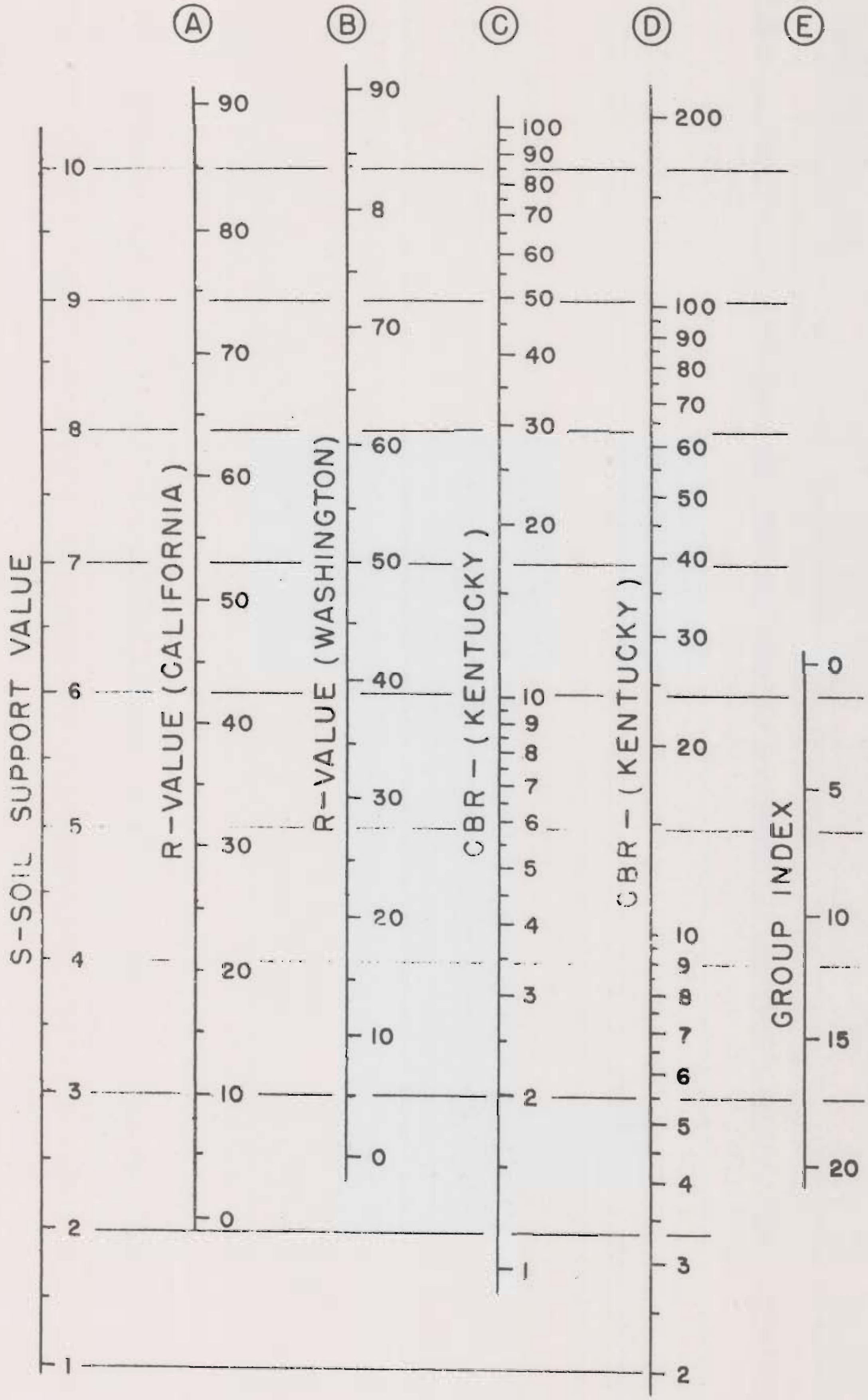
COEFFICIENTS FOR SUBSTITUTIONS, SURFACING BASE AND SUBBASE OF AASHO INTERIM GUIDE

Pavement Component	Coefficient 3/		
Surface Course	a_1	a_2	a_3
Roadmix (low stability)	0.20		
Plantmix (high stability)	0.44*		
Sand Asphalt	0.40		
Base Course			
Sandy Gravel		0.07 2/	
Crushed Stone		0.14*	
Cement Treated (no soil cement)			
650 psi or more 1/		0.23 2/	
400 psi to 650 psi		0.20	
400 psi or less		0.15	
Bituminous Treated			
Coarse Graded		0.34 2/	
Sand Asphalt		0.30	
Lime Treated		0.15 - 0.30	
Subbase			
Sandy Gravel			0.11*
Sand or Sandy Clay			0.05 - 0.10

1/ Compressive strength at 7 days.

2/ This value has been estimated from AASHO Road Test data, but not to the accuracy of those factors marked with an asterik.

3/ It is expected that each State will study these coefficients and make such changes as their experience indicates necessary.



CORRELATION CHART
FOR ESTIMATING
SOIL SUPPORT VALUE (S)

FIGURE 14

7-26-61

They also have Structural Number Design Charts for Serviceability Indices of 2.0 and 2.5 (See Figure 15 and 16). The Committee on Design has placed several limitations on the use of the Guide. These are included in Appendix C as the "Foreward to the Interim Guide."

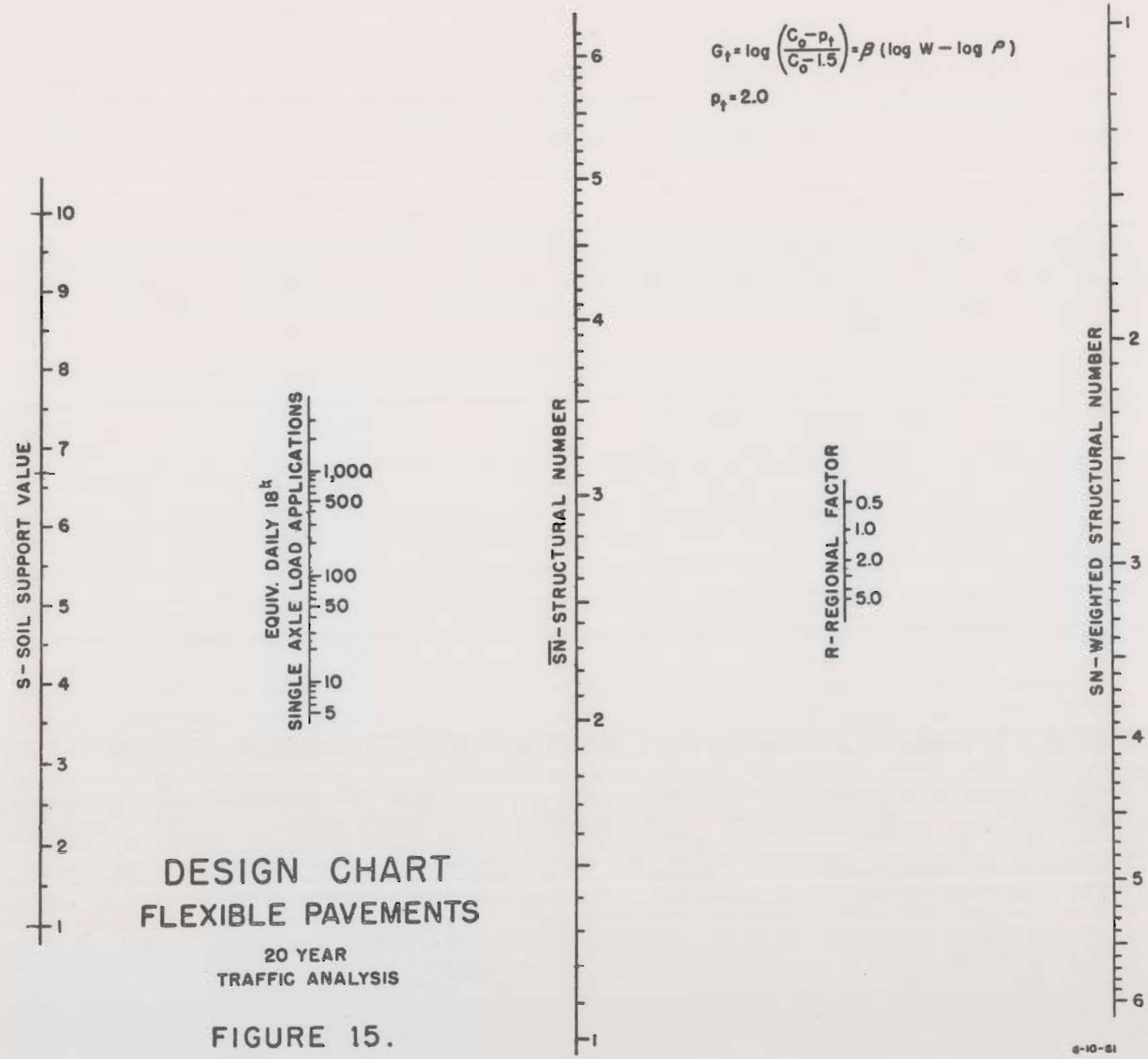
The values in Table VIII are indicative of the correlation in Resistance Value reported for the AASHO soils.

TABLE VIII

CORRELATION FOR SOIL SUPPORT VALUE AND RESISTANCE VALUE

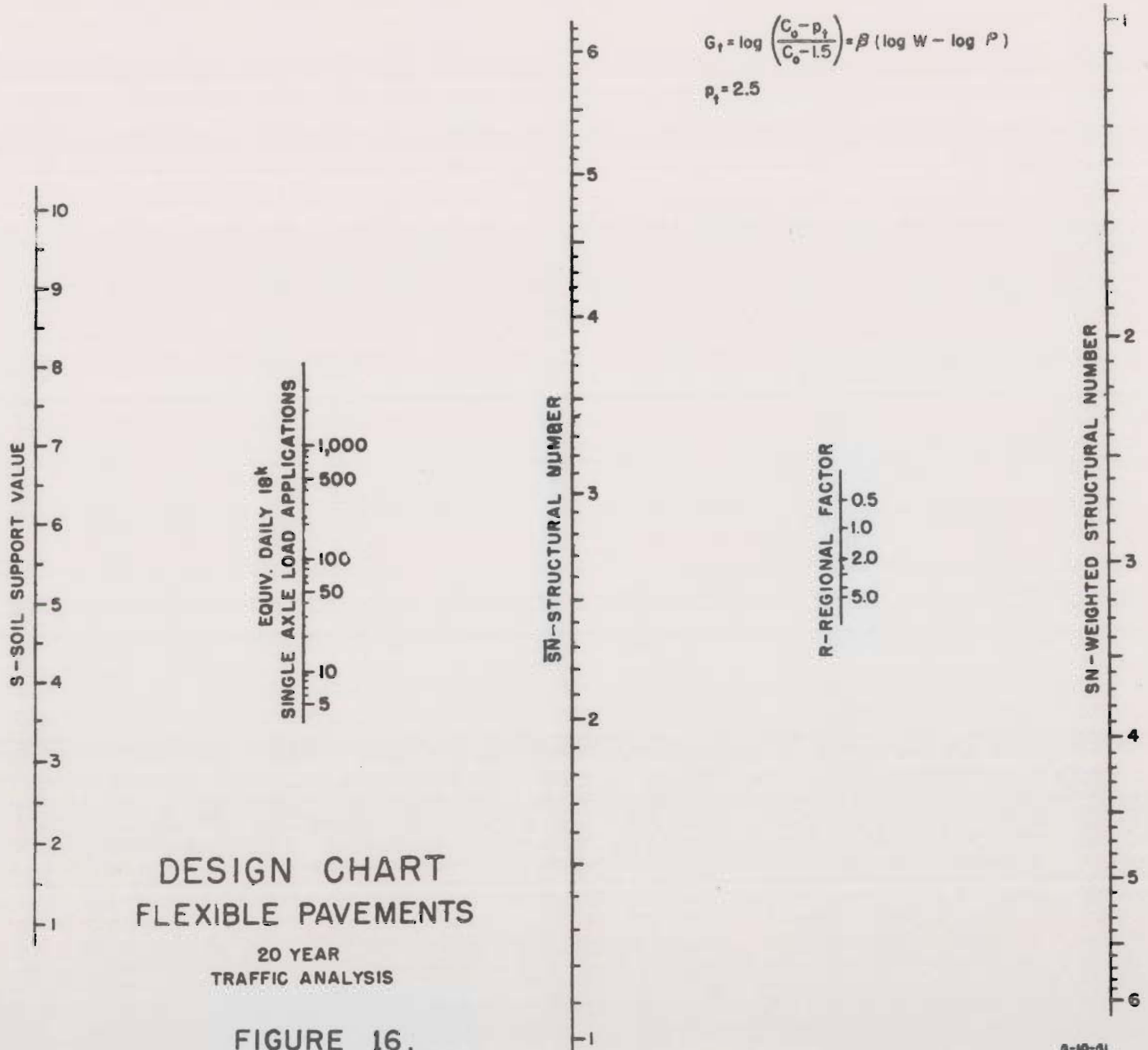
SSV Assigned	R-Value California	R-Value Washington	R-Value Idaho from Tests
3	10	5	8
10	85	84	75

The Interim Guide was used to make designs of roadways for several of the traffic classification stations in Idaho using the R-Value correlation. given for the State of California, since Idaho most nearly checks their values. Resistance Values of 10, 30 and 50 were used in this study. The actual traffic classifications for each station as well as the actual traffic volumes of commercial traffic were used, and the data thus obtained was used to compute thicknesses of pavement structures. Variations in the thickness of the plantmix surfacing of 0.2, 0.3 or 0.4 foot depending on total volumes of traffic were used in this design. A regional factor of one was assumed as climatic variations were not considered in the comparison. See Tables XVI and XVII for computations of Equivalent Daily 18k single axle wheel loads and Tables XVIII and XIX for Structural Numbers computed for the 10 selected stations for serviceability indexes of 2.0 and 2.5.



DESIGN CHART
FLEXIBLE PAVEMENTS
20 YEAR
TRAFFIC ANALYSIS

FIGURE 15.



DESIGN CHART
FLEXIBLE PAVEMENTS
20 YEAR
TRAFFIC ANALYSIS

FIGURE 16.

VIII. COMPARISON - DESIGN METHODS

A comparison was made of the design thickness of flexible pavement structures comparing the existing Surveys & Plans procedure with the California revision and also the AASHO Interim Guide for Serviceability Index values of 2.0 and 2.5. Ten stations for which traffic classification counts had been made and giving a wide range in traffic volumes values of 5k-EWL and percentages of 2 axle and 5 axle vehicles were used in computing the structural sections.

In making this comparison, it was assumed that 0.4 foot of untreated base would be placed beneath plantmixed surfacing. The thickness of surfacing varied with commercial and total traffic volumes, as follows:

Total ADT	Commercial ADT	Surfacing Thickness
Less 3,000	Less 250	0.2
3,000 - 5,000	250 - 500	0.3
5,000 & Over	500 & Over	0.4

Other base or subbase material was then varied to satisfy the total structure thickness requirements.

Soils for the subgrade were assumed to have Resistance Values of 10, 30, and 50 to provide a range similar to the soil types found to exist in the State. Using these R-Values the corresponding Soil Support Values for the AASHO Interim Guide were selected using the California correlation giving the following values:

Resistance Value	Soil Support Value
10	3
30	4.8
50	6.7

In these designs, no allowance for climatic or regional effects were made. This was believed unnecessary as the AASHO Interim Guide proposal and that recommended to be used by Idaho are identical in concept. The existing Idaho procedure does not make allowance for climatic effects except by judgment.

Design by Idaho 57 (Existing Practice)

Using the 10 stations selected for comparison the design thickness was determined using Figure 16-231.2 of the Surveys and Plans Manual. Since present design policies do not provide for decreasing total structure thicknesses because of type or thickness of pavement, no adjustment was made and the thickness determined would be the total design thickness.

Design by California Formula

The formula proposed by California was presented in Highway Research Board Record No. 13 by Messrs. Hveem and Sherman. Formulas No. 5 and 6, Chapter IV, taken from this presentation were used in this comparison. A substitution for the thickness of plantmixed surfacing using a ratio of 0.1" of plantmix being equivalent to 0.2" of base was used. The method used followed that presented in Chapter V for adjustment of total thickness.

The classification of the commercial traffic as to Heavy, Average and Light was followed in selecting the Traffic Index. No classification of very light or residential would be expected on the State Highway Systems, even though they may be involved in state construction as frontage roads, residential or urban streets.

Design by AASHO Interim Guide

The design by the AASHO Interim Guide method endeavored to follow the procedure explicitly. The Equivalent Daily 18 kip Single Load Application was computed using the actual percentage of each axle weight group by classification of vehicle as well as percentage of each classification of vehicles for Serviceability Index values of 2.0 and 2.5. These figures were then used to determine the structural number required for each type soil subgrade for a Serviceability Index of 2.0 and 2.5. After determining structural number the actual structural pavement section was determined using the coefficients recommended by the Interim Guide for use with the AASHO Formula.

Comparison of Designs

These structural designs are compared in Table IX and Figures 17, 18 and 19. It is to be noted that the new California Formula and AASHO with a Serviceability Index of 2.5 check closely for classifications of Heavy and Average and exceed AASHO from 0.05 to 0.15 foot for the light classification. The California Formula exceeds AASHO for a Serviceability of 2.0 from 0.10 to 0.30.

The Idaho 57 Formula ranges from 0.05 to as much as 0.40 below the new California and the AASHO Serviceability Index of 2.5 requirements and exceeds these only on the light classification.

TABLE IX

COMPARISON OF FLEXIBLE PAVEMENT DESIGN THICKNESSES

Station	Traffic Data: ADT 1962 X2	Traffic Data: Comm. ADT	Traffic Data: % Tr. 2X/5X	Traffic Data: Class'n.	Basic Design Su + Bs.: Pmx Ft.	Basic Design Su + Bs.: Bs. Ft.	Total Thickness Surface, Base & Subbase, Feet — Soil RV = 10, SSV = 3.0: Ida. 57	Cal. C-2	AASHO P_t 2.0	AASHO P_t 2.5	Soil RV = 30, SSV = 4.8: Ida. 57	Cal. C-2	AASHO P_t 2.0	AASHO P_t 2.5	Soil RV = 50, SSV 6.7: Ida. 57	Cal. C-2	AASHO P_t 2.0	AASHO P_t 2.5
P1007 - Ucon	9600	890	60/17	Light	0.4	0.4	2.40	2.35	2.20	2.40	1.80	1.75	1.50	1.75	1.20	1.10	0.95	1.15
P3517 - Orofino	2700	440	47/34	Heavy	0.3	0.4	2.15	2.45	2.30	2.45	1.60	1.80	1.65	1.90	1.10	1.20	1.10	1.20
P0316 - Inkom	6400	1220	32/41	Heavy	0.4	0.4	2.40	2.80	2.60	2.80	1.80	2.10	1.85	2.10	1.20	1.40	1.20	1.40
P3814 - Fruitland	7000	575	72/8	Light	0.4	0.4	2.25	2.20	2.00	2.15	1.70	1.60	1.30	1.50	1.10	1.05	0.80	0.90
P0804 - Banks	2320	410	45/26	Heavy	0.3	0.4	2.15	2.55	2.25	2.45	1.60	1.90	1.60	1.90	1.10	1.30	1.05	1.30
P0721 - Bellevue	2260	290	67/8	Light	0.3	0.4	2.15	2.10	1.90	2.05	1.60	1.60	1.30	1.50	1.10	1.05	0.80	0.95
P2402 - Hagerman	6400	150	58/13	Average	0.2	0.4	2.00	2.10	2.00	2.15	1.50	1.60	1.40	1.75	1.00	1.10	1.00	1.15
Perm C-2 E. Boise	10890	640	30/42	Heavy	0.4	0.4	2.25	2.60	2.30	2.50	1.10	1.95	1.60	1.80	1.10	1.30	1.00	1.20
Perm C-11 Paris	3000	225	80/5	Light	0.3	0.4	2.00	2.00	1.70	1.85	1.50	1.50	1.15	1.30	1.00	1.00	0.70	0.80
Perm C-15 Potlatch	2600	240	54/26	Heavy	0.2	0.4	2.00	2.45	2.30	2.45	1.50	1.85	1.65	1.80	1.00	1.30	1.20	1.25

NOTE: Total Thicknesses rounded to nearest 0.05'.

Idaho 57 - No Equivalency - Surveys and Plans Manual Design.

Cal. 1963 - $Th = \frac{0.070\ (TI)\ (100-R)}{C^{0.2}}$ with Equivalency 0.1' Pmx = 0.2' Subbase.

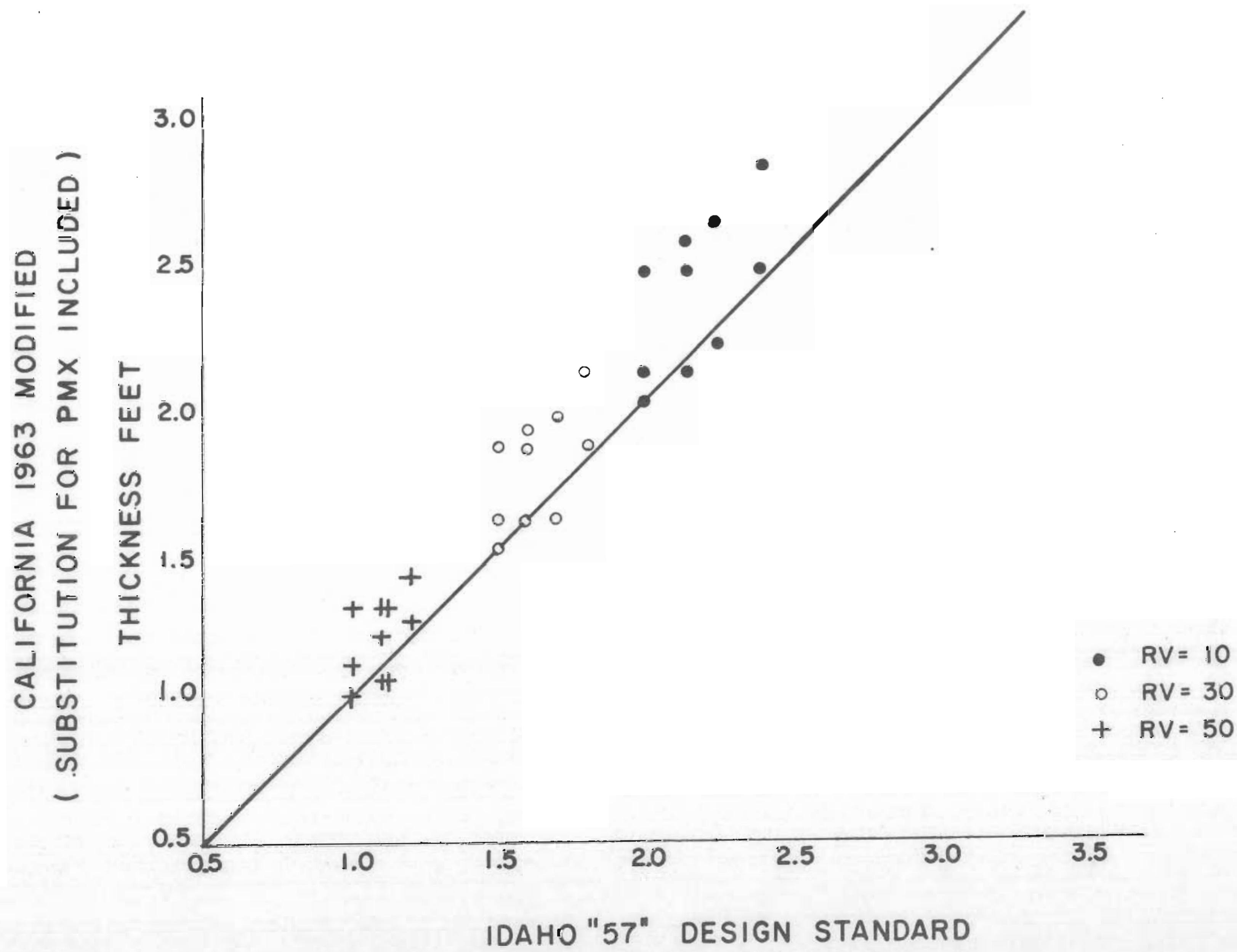


FIGURE 17.— COMPARISON OF DESIGN THICKNESS

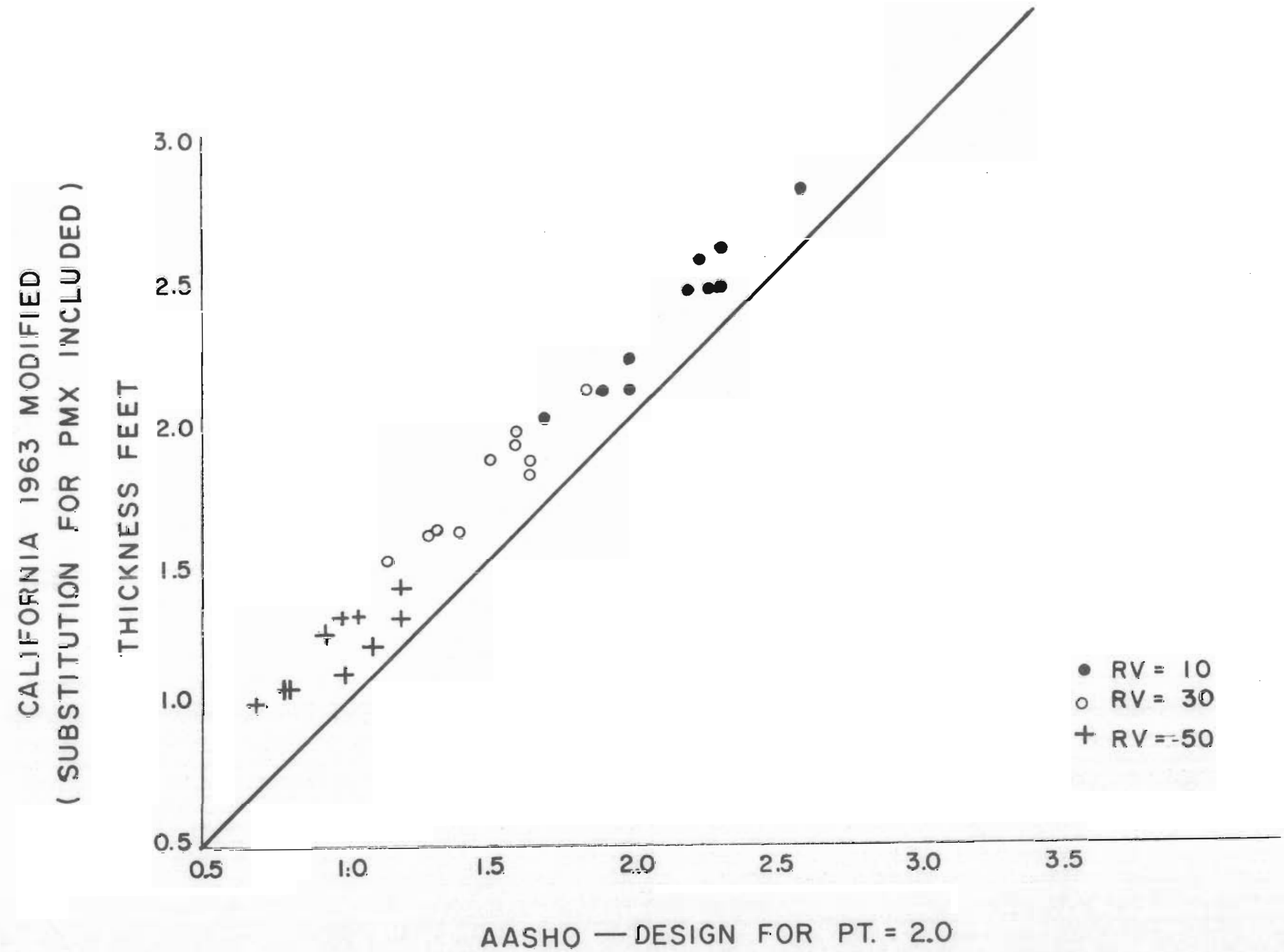


FIGURE 18— COMPARISON OF DESIGN THICKNESS

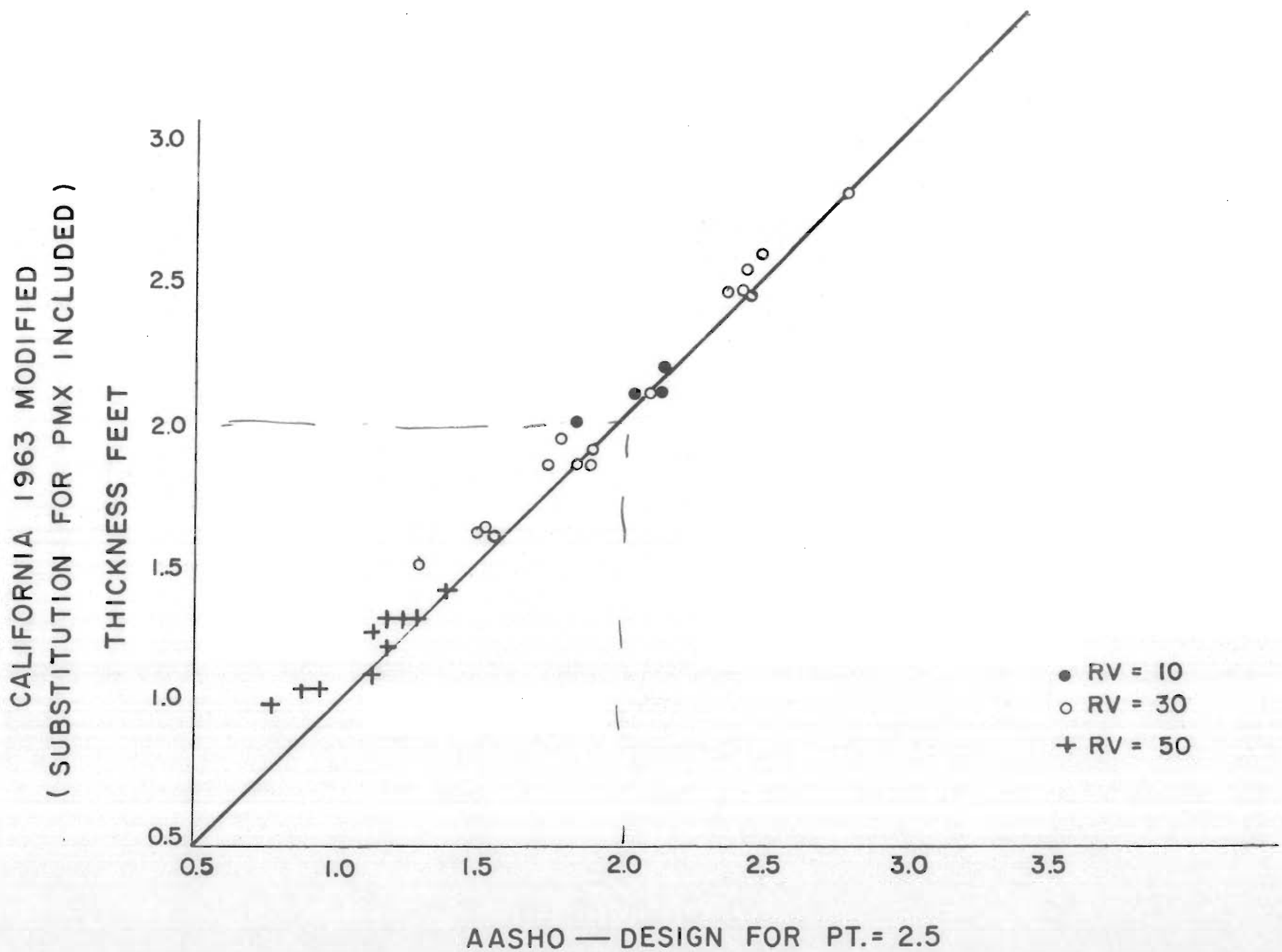


FIGURE 19 — COMPARISON OF DESIGN THICKNESSES

IX. CONCLUSIONS

The analysis of the design methods indicates that:

1. The present Surveys and Plans Manual Design Method derived in 1957, when used without reducing any thickness of pavement structure because of pavement surfacing types, will give thicknesses, from 0.45 less to 0.15 more than the design from AASHO Guidelines with a Serviceability Index of 2.5.

2. The present Surveys and Plans Manual 1957 Design Method gives thicknesses from 0.45 less to 0.05 more than the new California Design Formula as modified.

3. The California Design Procedure modified to classify traffic as Heavy, Average or Light depending on the percentage of 2 axle and 5 axle vehicles checks within about 0.10 foot of the AASHO Interim Guide proposal and, if differing, generally exceeds the AASHO Guide.

4. The Traffic Classification Procedure developed for use with the California Traffic Index - R-Value Design Method is exceedingly simple. It has been extended into the very light and residential traffic volume zones as indicated, thereby giving simplicity to these designs.

5. The AASHO Interim Guide foreward warns that a correlation is needed for the scale for Soil Support Values and also for the coefficients used in converting the Structural Number into surfacing base and subbase thicknesses. It would be necessary to conduct lengthy and involved field tests to arrive at these relationships. Since the California Procedure has been the standard in this State since 1957 and had been used earlier and correlates with AASHO Road Test Data so well, this procedure is equally consistent with the Interim Guide for Design of Flexible Pavements.

X. RECOMMENDATIONS

It is therefore recommended that the design for Flexible Pavement Structural Thickness be adopted as indicated based upon Formula (5) for Traffic Index and Formula (6) for Thickness. Design charts based upon these formulas have recognized traffic classifications determined to exist within Idaho and to be representative of traffic on the Idaho Highway System. A revision of the Surveys and Plans Manual Section 16-231 is included in Appendix D in fulfillment of this recommendation.

APPENDIX A

REFERENCES

1. Hveem, F. N. and Carmany, R. M., "The Factors Underlying the Rational Design of Pavements", Highway Research Board Proceedings, No. 28, Pages 101-136, (1948).

2. Hveem, F. N. "Ideas and Current Problems in Pavement Design", presented at Seminar in Asphalt Paving Technology, University of California, Berkeley, California, (July 24, 1957).

3. Sherman, G. B. "Recent Changes in the California Design Method for Structural Sections of Flexible Pavements", First Annual Highway Conference Proceedings, California, (1958)

4. Hveem, F. N. and Sherman, G. B., "California Method for the Structural Design of Flexible Pavements", International Conference on the Structural Design of Asphalt Pavements, University of Michigan, Ann Arbor, Michigan, (1962).

5. Hveem F. N. and Sherman, G. B., "Thickness of Flexible Pavements by the California Formula Compared to AASHO Road Test Data", Highway Research Board Record No. 13, (1963).

6. The WASHO Road Test, Highway Research Board Special Report 22, Part 2, Washington, D. C. (1955).

7. The AASHO Road Test - Report 5, Highway Research Board Special Report 61E, Pavement Research, (1962).

8. Thickness Design Manual MS-1, The Asphalt Institute, (1963).

9. The AASHO Road Test, St. Louis Conference Proceedings, Highway Research Board Special Report 73, (1962)

10. "AASHO Interim Guide for the Design of Flexible Pavement Structures", AASHO Committee on Design, (October 1961).

11. Surveys and Plans Manual, Idaho Department of Highways.

12. Loadometer Data, Idaho Department of Highways, (1948-55 and 1957-61 inclusive.

13. "Climatology of the United States", U. S. Department of Commerce Weather Bureau Publication Nos. 81-8.

APPENDIX B

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1948

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1538	15	0.01	320	3	0.01	91	1	0.01	85	1	0.01	87	1
8 - 9	4.25	0.44	39	17	0.48	10	5	0.47	15	7	0.49	23	11	0.51	17	9
9 - 10	4.75	0.77	41	32	0.84	25	21	0.82	13	11	0.86	11	9	0.89	25	22
10 - 11	5.25	1.20	45	54	1.30	18	23	1.30	4	5	1.30	3	4	1.40	12	17
11 - 12	5.75	2.00	42	84	2.20	15	66	2.10	4	8	2.20	3	7	2.30	10	23
12 - 13	6.25	3.00	21	63	3.30	20	66	3.20	6	19	3.30	8	26	3.50	10	35
13 - 14	6.75	4.50	10	45	4.90	9	44	4.80	3	14	5.00	8	40	5.20	11	57
14 - 15	7.25	6.40	16	102	6.90	15	104	6.80	6	41	7.10	13	92	7.40	11	81
15 - 16	7.75	9.00	14	126	9.80	12	118	9.60	3	30	10.00	5	50	10.00	8	80
16 - 17	8.25	12.00	13	156	13.00	11	143	13.00	7	91	13.00	9	117	14.00	6	84
17 - 18	8.75	16.00	2	32	17.00	7	119	17.00	5	85	18.00	4	72	18.00	1	18
18 - 19	9.25	22.00	2	44	24.00	1	24	23.00	4	92	24.00	3	72	25.00		
19 - 20	9.75	28.00	5	140	30.00	3	60	30.00	6	180	31.00	6	186	32.00		
20 - 22	10.50	41.00	7	287	45.00	4	180	44.00	1	44	46.00	3	138	47.00		
22 - 24	11.50	64.00	7	448	69.00	1	69	68.00	3	204	71.00	1	71	74.00		
24 - 26	12.50	98.00	6	588	106.00			104.00	1	104	109.00			113.00		
Total Applications			1808			471			172			185			198	
Total EWL				2233			1045			936			896			427
EWL/Axle Application			1.236			2.22			5.44			4.84			2.16	
EWL/Year/Vehicle			451			1215			3970			4420			2362	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1949

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1588	16	0.01	325	3	0.01	128	1	0.01	163	2	0.01	140	1
8 - 9	4.25	0.44	56	25	0.48	18	9	0.47	23	11	0.49	40	20	0.51	21	11
9 - 10	4.75	0.77	34	26	0.84	26	22	0.82	23	19	0.86	30	26	0.89	19	17
10 - 11	5.25	1.20	30	36	1.30	20	26	1.30	10	13	1.30	13	17	1.40	27	38
11 - 12	5.75	2.00	30	60	2.20	23	51	2.10	9	19	2.20	13	29	2.30	7	16
12 - 13	6.25	3.00	19	57	3.30	13	43	3.20	5	16	3.30	8	26	3.50	15	53
13 - 14	6.75	4.50	25	113	4.90	6	29	4.80	5	24	5.00	20	100	5.20	18	94
14 - 15	7.25	6.40	21	134	6.90	7	48	6.80	2	14	7.10	17	121	7.40	16	118
15 - 16	7.75	9.00	13	117	9.80	14	137	9.60	13	125	10.00	22	220	10.00	12	120
16 - 17	8.25	12.00	11	132	13.00	16	208	13.00	8	104	13.00	17	221	14.00	1	14
17 - 18	8.75	16.00	12	192	17.00	9	153	17.00	7	119	18.00	10	180	18.00		
18 - 19	9.25	22.00	3	66	24.00	7	168	23.00	12	276	24.00	8	192	25.00		
19 - 20	9.75	28.00	3	84	30.00	5	150	30.00	8	240	31.00	5	155	32.00		
20 - 22	10.50	41.00	1	41	45.00	8	360	44.00	10	440	46.00	5	230	47.00		
22 - 24	11.50	64.00	1	64	69.00	1	69	68.00	3	204	71.00	2	142	74.00		
24 - 26	12.50	98.00	3	294	106.00			104.00	2	208	109.00	2	218	113.00		
Total Applications			1850			498			268			375			276	
Total EWL				1457			1476			1733			1899			482
EWL/Axle Application		0.788			2.963			6.49			5.06			1.746		
EWL/Year/Vehicle		288			1622			4740			4620			1912		

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1950

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1426	14	0.01	320	3	0.01	94	1	0.01	158	2	0.01	112	1
8 - 9	4.25	0.44	58	26	0.48	34	16	0.47	19	9	0.49	52	25	0.51	32	16
9 - 10	4.75	0.77	45	35	0.84	21	18	0.82	21	17	0.86	47	40	0.89	30	27
10 - 11	5.25	1.20	42	50	1.30	24	31	1.30	5	7	1.30	40	52	1.40	23	32
11 - 12	5.75	2.00	32	64	2.20	35	77	2.10	14	29	2.20	28	62	2.30	13	30
12 - 13	6.25	3.00	52	156	3.30	32	106	3.20	9	30	3.30	15	50	3.50	25	88
13 - 14	6.75	4.50	19	86	4.90	21	103	4.80	10	48	5.00	37	185	5.20	33	172
14 - 15	7.25	6.40	21	134	6.90	24	166	6.80	16	109	7.10	37	263	7.40	27	200
15 - 16	7.75	9.00	17	153	9.80	32	314	9.60	26	250	10.00	61	610	10.00	16	160
16 - 17	8.25	12.00	12	144	13.00	12	156	13.00	15	195	13.00	44	572	14.00	4	56
17 - 18	8.75	16.00	7	112	17.00	16	272	17.00	14	238	18.00	27	486	18.00	3	54
18 - 19	9.25	22.00	2	44	24.00	7	168	23.00	11	253	24.00	17	408	25.00		
19 - 20	9.75	28.00	5	110	30.00	6	180	30.00	4	120	31.00	13	403	32.00		
20 - 22	10.50	41.00			45.00	12	540	44.00	6	264	46.00	15	675	47.00		
22 - 24	11.50	64.00			69.00	11	759	68.00	7	476	71.00	1	71	74.00		
24 - 26	12.50	98.00			106.00	11	1166	104.00	1	104	109.00	3	327	113.00		
Total Applications			1738			618			272			595			318	
Total EWL				1128			4075			2150			4231			836
EWL/Axle Application			0.649			6.60			7.91			7.12			2.63	
EWL/Year/Vehicle			237			3,610			5,773			6,495			2,880	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1951

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1041	10	0.01	308	3	0.01	135	1	0.01	173	2	0.01	36	0
8 - 9	4.25	0.44	33	15	0.48	54	26	0.47	21	10	0.49	54	26	0.51	24	12
9 - 10	4.75	0.77	46	35	0.84	45	38	0.82	21	17	0.86	63	54	0.89	37	33
10 - 11	5.25	1.20	45	54	1.30	36	49	1.30	10	13	1.30	30	39	1.40	31	43
11 - 12	5.75	2.00	30	60	2.20	51	112	2.10	8	17	2.20	25	55	2.30	22	51
12 - 13	6.25	3.00	17	51	3.30	25	83	3.20	14	448	3.30	17	56	3.50	22	77
13 - 14	6.75	4.50	24	108	4.90	36	306	4.80	11	23	5.00	38	190	5.20	34	177
14 - 15	7.25	6.40	25	160	6.90	22	151	6.80	6	41	7.10	48	341	7.40	18	133
15 - 16	7.75	9.00	12	108	9.80	12	118	9.60	18	173	10.00	49	490	10.00	8	80
16 - 17	8.25	12.00	9	108	13.00	12	156	13.00	10	130	13.00	47	611	14.00	4	56
17 - 18	8.75	16.00	6	96	17.00	14	238	17.00	7	119	18.00	23	414	18.00	3	54
18 - 19	9.25	22.00	10	220	24.00	15	360	23.00	11	253	24.00	13	312	25.00	1	25
19 - 20	9.75	28.00	4	112	30.00	10	300	30.00	12	260	31.00	5	155	32.00		
20 - 22	10.50	41.00	2	82	45.00	20	900	44.00	6	264	46.00	11	506	47.00		
22 - 24	11.50	64.00	1	64	69.00	6	414	68.00	1	68	71.00	2	142	74.00		
24 - 26	12.50	98.00	1	98	106.00			104.00	1	104	109.00	2	218	113.00		
Total Applications			1306			666			292			600			240	
Total EWL				1381			3254			1941			3611			741
EWL/Axle Application		1.058			4.89			6.65			6.02			3.09		
EWL/Year/Vehicle		386			2.680			4.865			5.495			3.380		

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1952

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1341	13	0.01	433	4	0.01	186	2	0.01	454	5	0.01	130	1
8 - 9	4.25	0.44	67	30	0.48	54	26	0.47	21	10	0.49	159	78	0.51	60	31
9 - 10	4.75	0.77	61	47	0.84	50	42	0.82	30	25	0.86	110	95	0.89	91	81
10 - 11	5.25	1.20	47	56	1.30	45	59	1.30	17	22	1.30	79	103	1.40	57	80
11 - 12	5.75	2.00	48	96	2.20	38	86	2.10	26	55	2.20	98	216	2.30	64	147
12 - 13	6.25	3.00	38	114	3.30	43	142	3.20	26	83	3.30	82	271	3.50	59	207
13 - 14	6.75	4.50	34	153	4.90	62	304	4.80	25	120	5.00	121	605	5.20	88	458
14 - 15	7.25	6.40	37	237	6.90	51	352	6.80	28	191	7.10	143	1016	7.40	18	133
15 - 16	7.75	9.00	28	252	9.80	30	294	9.60	30	288	10.00	118	1180	10.00	4	40
16 - 17	8.25	12.00	17	204	13.00	26	338	13.00	18	234	13.00	50	650	14.00	4	56
17 - 18	8.75	16.00	29	464	17.00	24	408	17.00	14	238	18.00	23	414	18.00		
18 - 19	9.25	22.00	13	286	24.00	8	192	23.00	13	299	24.00	8	192	25.00	1	25
19 - 20	9.75	28.00	5	140	30.00	2	60	30.00	3	90	31.00	4	124	32.00		
20 - 22	10.50	41.00	8	328	45.00	1	45	44.00	3	132	46.00	1	46	47.00		
22 - 24	11.50	64.00			69.00			68.00			71.00			74.00		
24 - 26	12.50	98.00	1	98	106.00			104.00			109.00			113.00		
Total Applications			1774			867			440			1450			576	
Total EWL				2518			2352			1789			4995			1259
EWL/Axle Application			1.42			2.715			4.065			3.444			2.187	
EWL/Year/Vehicle			518			1,486			2,970			3,144			2,392	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1953

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1359	14	0.01	428	4	0.01	228	2	0.01	518	5	0.01	178	2
8 - 9	4.25	0.44	52	23	0.48	51	24	0.47	42	20	0.49	188	92	0.51	32	16
9 - 10	4.75	0.77	54	42	0.84	49	41	0.82	18	15	0.86	148	127	0.89	38	34
10 - 11	5.25	1.20	46	55	1.30	46	60	1.30	17	22	1.30	85	111	1.40	33	46
11 - 12	5.75	2.00	32	64	2.20	42	92	2.10	21	44	2.20	138	304	2.30	29	67
12 - 13	6.25	3.00	41	123	3.30	41	135	3.20	15	48	3.30	133	439	3.50	45	158
13 - 14	6.75	4.50	23	104	4.90	31	152	4.80	25	120	5.00	133	665	5.20	25	130
14 - 15	7.25	6.40	27	173	6.90	37	225	6.80	14	95	7.10	134	952	7.40	64	474
15 - 16	7.75	9.00	31	279	9.80	39	382	9.60	24	230	10.00	130	1300	10.00	54	540
16 - 17	8.25	12.00	22	264	13.00	21	273	13.00	18	234	13.00	68	884	14.00	18	252
17 - 18	8.75	16.00	8	128	17.00	14	238	17.00	20	340	18.00	22	396	18.00	9	172
18 - 19	9.25	22.00	9	198	24.00	12	288	23.00	10	230	24.00	4	96	25.00	3	75
19 - 20	9.75	28.00	5	140	30.00	5	150	30.00	2	60	31.00	6	186	32.00		
20 - 22	10.50	41.00	2	82	45.00	3	135	44.00	1	44	46.00	3	138	47.00		
22 - 24	11.50	64.00	1	64	69.00			68.00	1	68	71.00			74.00		
24 - 26	12.50	98.00			106.00			104.00			109.00			113.00		
Total Applications			1712			819			456			1710			528	
Total EWL				1753			2099			1572			5695			1966
EWL/Axle Application			1.024			2.562			3.445			3.33			3.72	
EWL/Year/Vehicle			374			1.404			2.515			3,040			4,080	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1954

Distribution of Axle Loading Groups from Statewide Loadometer Study

		2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
Axle Gp. Kips	Wh. Load Kips	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1285	13	0.01	543	5	0.01	214	2	0.01	619	6	0.01	95	1
8 - 9	4.25	0.44	29	13	0.48	67	32	0.47	22	15	0.49	236	116	0.51	24	12
9 - 10	4.75	0.77	45	35	0.84	71	60	0.82	29	24	0.86	148	127	0.89	43	38
10 - 11	5.25	1.20	33	40	1.30	45	59	1.30	19	25	1.30	117	152	1.40	12	17
11 - 12	5.75	2.00	21	42	2.20	36	79	2.10	15	32	2.20	109	240	2.30	21	48
12 - 13	6.25	3.00	49	147	3.30	53	175	3.20	16	51	3.30	138	445	3.50	25	88
13 - 14	6.75	4.50	35	158	4.90	66	324	4.80	16	77	5.00	169	845	5.20	14	73
14 - 15	7.25	6.40	25	160	6.90	51	352	6.80	21	142	7.10	203	1442	7.40	6	44
15 - 16	7.75	9.00	24	216	9.80	31	304	9.60	22	211	10.00	178	1780	10.00	6	60
16 - 17	8.25	12.00	27	324	13.00	14	182	13.00	24	312	13.00	71	922	14.00		
17 - 18	8.75	16.00	38	608	17.00	11	187	17.00	20	340	18.00	25	450	18.00		
18 - 19	9.25	22.00	12	264	24.00	7	168	23.00	5	115	24.00	7	168	25.00		
19 - 20	9.75	28.00	3	84	30.00	1	30	30.00	3	90	31.00			32.00		
20 - 22	10.50	41.00	4	164	45.00			44.00	3	132	46.00			47.00		
22 - 24	11.50	64.00			69.00			68.00			71.00			74.00		
24 - 26	12.50	98.00			106.00			104.00	1	104	109.00			113.00		
Total Applications			1630			996			440			2020			246	
Total EWL				2268			1957			1672			6693			381
EWL/Axle Application			1.39			1.965			3.80			3.315			1.55	
EWL/Year/Vehicle			508			1,076			2,773			3,025			1,696	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1955

Distribution of Axle Loading Groups from Statewide Loadometer Study

		2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
Axle Gp. Kips	Wh. Load Kips	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	1063	11	0.01	450	5	0.01	241	2	0.01	745	7	0.01	57	1
8 - 9	4.25	0.44	34	15	0.48	72	35	0.47	28	113	0.49	244	120	0.51	17	9
9 - 10	4.75	0.77	39	30	0.84	53	45	0.82	22	18	0.86	206	177	0.89	13	12
10 - 11	5.25	1.20	44	53	1.30	40	52	1.30	24	31	1.30	103	134	1.40	15	21
11 - 12	5.75	2.00	17	34	2.20	37	81	2.10	28	59	2.20	167	367	2.30	8	18
12 - 13	6.25	3.00	37	111	3.30	56	185	3.20	24	77	3.30	186	614	3.50	25	88
13 - 14	6.75	4.50	21	95	4.90	60	294	4.80	42	202	5.00	218	1090	5.20	14	73
14 - 15	7.25	6.40	38	243	6.90	56	386	6.80	22	150	7.10	240	1704	7.40	6	44
15 - 16	7.75	9.00	15	135	9.80	40	392	9.60	25	240	10.00	163	1630	10.00	4	40
16 - 17	8.25	12.00	21	252	13.00	24	312	13.00	30	390	13.00	80	1040	14.00		
17 - 18	8.75	16.00	10	160	17.00	14	238	17.00	14	238	18.00	84	1512	18.00	2	36
18 - 19	9.25	22.00	13	286	24.00	11	264	23.00	10	230	24.00	25	600	25.00	1	25
19 - 20	9.75	28.00	5	140	30.00	1	30	30.00	4	120	31.00	6	186	32.00		
20 - 22	10.50	41.00	1	41	45.00	1	45	44.00	5	220	46.00	3	138	47.00		
22 - 24	11.50	64.00			69.00			68.00	2	136	71.00			74.00		
24 - 26	12.50	98.00			106.00			104.00			109.00			113.00		
Total Applications			1358			915			521			2470			162	
Total EWL				1606			2364			2126			9319			367
EWL/Axle Application			1.183			2.584			4.081			3.773			2.265	
EWL/Year/Vehicle			432			1.415			2.979			3.443			2.480	

No Loadometer Data Was Obtained During the 1956 Calendar Year

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1957

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	670	7	0.01	213	2	0.01	96	1	0.01	366	4	0.01	11	0
8 - 9	4.25	0.44	22	10	0.48	45	22	0.47	16	8	0.49	188	92	0.51	1	1
9 - 10	4.75	0.77	31	24	0.84	28	24	0.82	22	18	0.86	103	89	0.89	1	1
10 - 11	5.25	1.20	29	35	1.30	20	26	1.30	7	9	1.30	51	66	1.40	1	1
11 - 12	5.75	2.00	14	28	2.20	20	44	2.10	11	23	2.20	94	207	2.30	5	12
12 - 13	6.25	3.00	15	45	3.30	25	83	3.20	10	32	3.30	131	432	3.50	2	7
13 - 14	6.75	4.50	15	68	4.90	34	168	4.80	11	53	5.00	151	755	5.20	4	21
14 - 15	7.25	6.40	8	51	6.90	32	221	6.80	5	34	7.10	156	1107	7.40	3	22
15 - 16	7.75	9.00	11	99	9.80	30	294	9.60	14	134	10.00	157	1570	10.00	1	10
16 - 17	8.25	12.00	10	120	13.00	20	26	13.00	5	65	13.00	67	871	14.00	1	14
17 - 18	8.75	16.00	11	176	17.00	17	17	17.00	7	112	18.00	32	324	18.00		
18 - 19	9.25	22.00	4	88	24.00	14	337	23.00	3	69	24.00	7	168	25.00		
19 - 20	9.75	28.00	1	28	30.00	2	60	30.00			31.00	1	31	32.00		
20 - 22	10.50	41.00	1	41	45.00	1	45	44.00	1	44	46.00			47.00		
22 - 24	11.50	64.00			69.00	1	69	68.00			71.00			74.00		
24 - 26	12.50	98.00			106.00	2	212	104.00			109.00			113.00		
Total Applications			842			504			208			1504			30	
Total EWL				820			1922			602			5716			89
EWL/Axle Application			9.974			3.815			2.894			3.80			2.97	
EWL/Year/Vehicle			356			2,090			2,112			3,468			3,250	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1958

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	692	7	0.01	230	2	0.01	141	1	0.01	549	5	0.01	5	0
8 - 9	4.25	0.44	33	15	0.48	25	12	0.47	18	8	0.49	231	113	0.51		
9 - 10	4.75	0.77	29	22	0.84	21	18	0.82	15	12	0.86	175	151	0.89		
10 - 11	5.25	1.20	21	25	1.30	27	35	1.30	8	10	1.30	80	104	1.40		
11 - 12	5.75	2.00	28	56	2.20	13	29	2.10	9	19	2.20	110	242	2.30	1	2
12 - 13	6.25	3.00	17	51	3.30	15	50	3.20	12	38	3.30	135	446	3.50		
13 - 14	6.75	4.50	15	68	4.90	33	162	4.80	16	77	5.00	155	765	5.20		
14 - 15	7.25	6.40	20	128	6.90	37	255	6.80	23	157	7.10	227	1612	7.40		
15 - 16	7.75	9.00	16	144	9.80	28	274	9.60	30	288	10.00	300	3000	10.00		
16 - 17	8.25	12.00	11	132	13.00	18	234	13.00	18	234	13.00	118	1663	14.00		
17 - 18	8.75	16.00	7	112	17.00	11	187	17.00	11	187	18.00	73	1314	18.00		
18 - 19	9.25	22.00	3	66	24.00	5	120	23.00	10	230	24.00	33	793	25.00		
19 - 20	9.75	28.00	2	56	30.00	2	60	30.00			31.00	7	217	32.00		
20 - 22	10.50	41.00			45.00	5	225	44.00	1	44	46.00	2	92	47.00		
22 - 24	11.50	64.00			69.00	1	69	68.00			71.00			74.00		
24 - 26	12.50	98.00			106.00			104.00			109.00			113.00		
Total Applications			894			471			312			2195			6	
Total EWL				882			1732			1305			10517			2
EWL/Axle Application		0.987			3.68			4.18			4.79			0.333		
EWL/Year/Vehicle		360			2,012			3,052			4,370			365		

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1959

Distribution of Axle Loading Groups from Statewide Loadometer Study

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	0.01	748	7	0.01	270	3	0.01	196	2	0.01	667	7	0.01	17	
8 - 9	4.25	0.44	33	15	0.48	46	22	0.47	20	9	0.49	275	135	0.51	5	3
9 - 10	4.75	0.77	31	24	0.84	66	55	0.82	15	12	0.86	220	189	0.89	5	4
10 - 11	5.25	1.20	30	36	1.30	39	51	1.30	11	14	1.30	120	156	1.40	3	4
11 - 12	5.75	2.00	21	42	2.20	29	64	2.10	13	27	2.20	111	244	2.30	3	7
12 - 13	6.25	3.00	20	60	3.30	25	83	3.20	18	58	3.30	134	442	3.50	3	11
13 - 14	6.75	4.50	18	81	4.90	32	157	4.80	25	120	5.00	245	1225	5.20	1	5
14 - 15	7.25	6.40	13	83	6.90	48	331	6.80	10	68	7.10	262	1860	7.40	4	30
15 - 16	7.75	9.00	16	144	9.80	29	284	9.60	19	182	10.00	365	3650	10.00		
16 - 17	8.25	12.00	14	168	13.00	21	273	13.00	14	182	13.00	149	1936	14.00	1	14
17 - 18	8.75	16.00	11	176	17.00	16	272	17.00	15	255	18.00	98	1764	18.00		
18 - 19	9.25	22.00	10	220	24.00	17	408	23.00	3	69	24.00	54	1298	25.00		
19 - 20	9.75	28.00	1	28	30.00	4	120	30.00	1	30	31.00	13	403	32.00		
20 - 22	10.50	41.00	2	82	45.00	1	45	44.00			46.00	14	6444	47.00		
22 - 24	11.50	64.00			69.00	1	69	68.00	1	68	71.00	8	568	74.00		
24 - 26	12.50	98.00			106.00	1	106	104.00			109.00			113.00		
Total Applications			968			645			361			2735			42	
Total EWL				1166			2343			1096			14521			78
EWL/Axle Application			1.205			3.625			3.04			5.21			1.856	
EWL/Year/Vehicle			440			1,985			2,220			4,845			2,032	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1960

Distribution of Axle Loading Groups from Statewide Loadometer Survey

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	.01	2398	24	.01	611	6	.01	294	3	.01	1454	15	.01	42	0
8 - 12	5	1.00	298	298	1.10	291	320	1.10	130	143	1.10	1477	1625	1.20	28	34
12 - 16	7	5.50	162	891	5.90	249	1469	5.80	140	812	6.10	1830	1163	6.30	21	132
16 - 18	8.50	14.00	63	882	15.00	62	930	15.00	43	645	15.00	471	7710	16.00	3	48
18 - 20	9.50	25.00	42	1050	27.00	40	1080	26.00	19	494	27.00	112	3024	28.00	2	56
20 - 22	10.50	41.00	10	410	45.00	27	1215	44.00	4	176	46.00	27	1242	47.00		
22 - 24	11.50	64.00	5	320	69.00	6	414	68.00			71.00	8	568	74.00		
24 - 26	12.50	98.00			106.00			104.00			109.00			113.00		
Total Applications			2978			1286			640			5370			96	
Total EWL				3875			5434			2273			25347			270
EWL/Axle Application			1.301			4.262			3.552			4.720			2.81	
EWL/Year/Vehicle			474			2333			2593			4307			3080	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1961

Distribution of Axle Loading Groups from Statewide Loadometer Survey

Axle Gp. Kips	Wh. Load Kips	2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
		Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	.01	2480	25	.01	575	6	.01	298	3	.01	1359	14	.01	5	0
8 - 12	5	1.00	297	297	1.10	300	406	1.10	178	196	1.10	1376	1514	1.20	10	12
12 - 16	7	5.50	179	985	5.90	226	1333	5.80	154	893	6.10	1779	10852	6.30	8	50
16 - 18	8.50	14.00	65	910	15.00	98	1470	15.00	67	1005	15.00	607	9105	16.00	1	16
18 - 20	9.50	25.00	26	650	27.00	28	756	26.00	18	468	27.00	114	3078	28.00		
20 - 22	10.50	41.00	15	615	45.00	9	405	44.00	7	308	46.00	15	690	47.00		
22 - 24	11.50	64.00	2	128	69.00			68.00	1	68	71.00	3	213	74.00		
24 - 26	12.50	98.00	2	196	106.00	3	318	104.00	1	104	109.00	2	218	113.00		
Total Applications			3066			1239			724			5255			24	
Total EWL				3806			4694			3045			25684			78
EWL/Axle Application			1.241			3.789			4.206			4.888			3.25	
EWL/Year/Vehicle			453			2074			2070			1913			3560	

TABLE X

EQUIVALENT WHEEL LOAD RATINGS FOR 1962

Distribution of Axle Loading Groups from Statewide Loadometer Survey

		2 Axle Truck			3 Axle Truck			4 Axle Truck			5 Axle Truck			6 Axle Truck		
Axle Gp. Kips	Wh. Load Kips	Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh.Ld. Factor	No. in Group	EWL	Wh. Ld. Factor	No. in Group	EWL
2 - 8	2	.01	4545	45	.01	123	2	.01	393	4	.01	1471	15	.01	5	
8 - 12	5	1.00	297	297	1.10	267	294	1.10	183	201	1.10	1664	1831	1.20	3	4
12 - 16	7	5.50	212	1166	5.90	240	1416	5.80	130	754	6.10	1707	10413	6.30	4	25
16 - 18	8.50	14.00	69	966	15.00	78	1170	15.00	54	810	15.00	597	8955	16.00		
18 - 20	9.50	25.00	20	500	27.00	44	1188	26.00	12	312	27.00	100	2700	28.00		
20 - 22	10.50	41.00	4	164	45.00	10	450	44.00	3	132	46.00	9	414	47.00		
22 - 24	11.50	64.00	1	64	69.00	3	207	68.00	2	136	71.00			74.00		
24 - 26	12.50	98.00			106.00			104.00			109.00			113.00		
Total Applications			5148			765			777			5548			12	
Total EWL				3202			4727			2349			24328			29
EWL/Axle Application			0.622			6.179			3.023			4.385			2.417	
EWL/Year/Vehicle			227			3383			2208			4002			2647	

TABLE XI

VEHICLE CLASSIFICATION COUNTS

CLASSIFICATION COUNT MADE AT INTERVALS OF 3 MONTHS FOR 3 YEARS DURING PERIOD 1957 - 1961
EACH COUNT IS EQUIVALENT TO ONE 24 HOUR WEEKDAY FOR EACH OF 12 MONTHS

Station No.	Route	Location	ADT 1962 Total	ADT 1962 Trucks Buses	% Trucks Buses	Single Truck 2X	Single Truck 3X	Truck-Semi Trailer 2S-1	Truck-Semi Trailer 2S-2	Truck-Semi Trailer 3S-2	Truck-Trailer Comb. 2S1-2	Truck-Trailer Comb. 2-2	Truck-Trailer Comb. 3-2	Truck-Trailer Comb. 3-3	Buses School	Buses Other
1	US 10	1 Mi. E. Post Falls	8570	760	8.9	42.4	5.7	7.8	3.7	23.3	2.1	1.0	7.6	0.2	1.4	4.9
2	US 30	1 Mi. E. Boise	5455	320	5.9	29.6	4.1	8.7	7.4	30.0	3.7	0.9	12.0	0.1	0.7	2.7
3	US 30	3 Mi. E. Twin Falls	4535	607	13.4	52.0	4.3	4.2	4.1	19.3	3.9	0.4	6.5	0.1	0.9	4.3
4	US 30	8 Mi. S. Pocatello	4535	775	17.1	31.8	3.1	8.5	5.3	32.7	0.5	0.6	13.7	0.3	0.6	2.9
5	US 91	7 Mi. N. Pocatello	3425	560	16.4	38.7	4.0	6.8	4.9	25.7	0.4	0.2	13.2	0.3	1.1	4.8
6	US 95	3 Mi. E. Lewiston	3800	480	12.7	54.9	10.0	4.3	2.6	17.4	0.5	0.3	7.1	0.3	1.5	1.3
7	SH 25	2 Mi. W. Jerome	3510	715	20.4	37.4	3.1	8.0	8.3	28.1	4.0	0.9	7.2	0.1	0.5	2.5
8	US 10	8 Mi. W. Kingston	3550	570	16.0	30.9	9.1	8.0	3.5	33.3	2.3	0.6	8.0	0.4	0.9	3.0
9	SH 19	2.5 Mi. W. Caldwell	2330	235	10.2	82.4	6.6	2.3	1.6	1.6	0.2	0.6	1.4	0.1	2.3	1.0
10	SH 15	3.5 Mi. N. Jct. SH 44	1165	165	14.3	56.9	8.0	5.3	3.3	12.9	0.5	0.4	7.8	0.1	3.1	1.7
11	US 89	1.8 Mi. S. Paris	1135	115	10.0	80.6	3.0	3.3	1.3	4.2	-	0.2	0.7	0.1	6.4	0.2
12	US 26	10 Mi. E. Ririe	1010	160	15.9	74.6	2.7	4.1	2.1	5.8	-	0.2	5.0	0.1	3.6	1.8
13	US 93	2.9 Mi. S. Salmon	800	110	13.6	69.5	7.0	4.6	1.5	6.8	-	0.3	2.2	-	5.3	3.0
14	US 93	5.2 Mi. N. Shoshone	940	135	14.3	62.9	2.0	4.7	5.5	4.9	-	0.6	6.2	-	21.4	8.9
15	US 95	2 Mi. N. Potlatch Jct.	850	120	14.2	53.9	6.0	3.3	3.5	23.7	-	0.1	2.4	-	6.5	0.7
16	US 95	1 Mi. S. Jct. US 2	2475	315	12.7	52.2	10.9	4.4	4.3	18.6	0.5	0.3	3.0	0.1	3.5	2.1
P10227	US 26	Idaho - Wyoming Line	470	80	16.7	58.7	2.1	6.7	3.6	16.7	-	0.2	8.2	-	1.0	2.9
P2844	US 10	Washington - Idaho Line	7100	650	9.2	38.1	5.8	8.5	4.8	25.3	2.2	1.0	8.2	0.3	0.6	5.3
P1453	US 20	5.5 Mi. E. Caldwell - EB	4845	775	16.0	39.1	3.2	7.2	7.6	22.2	3.5	0.6	14.1	0.2	0.5	2.0
P1453	US 20	5.5 Mi. E. Caldwell - WB	4820	780	16.2	40.2	3.2	7.2	7.2	21.5	3.5	0.6	13.7	0.1	0.9	1.9
P2852	SH 41	US 10 - Rathdrum	1335	90	6.7	71.1	7.9	1.3	1.6	7.8	-	1.0	1.2	-	5.6	2.3
P2852	US 10	Coeur d'Alene - Ross Pt.	8100	745	9.2	40.3	6.0	7.5	4.8	25.2	1.8	0.8	7.2	0.2	1.2	5.1
P2852	US 10	Post Falls - Ross Pt.	8570	795	9.3	41.6	5.8	7.3	4.7	24.5	1.7	0.9	7.0	0.2	1.4	4.9
P2905	US 95A	Potlatch Jct. East	2025	260	12.8	61.9	6.2	4.1	2.2	20.6	-	0.1	2.1	0.2	2.5	0.2
P2905	US 95A	Potlatch Jct. South	1530	195	12.7	56.3	6.0	3.6	2.3	26.1	-	0.1	2.1	0.3	3.0	0.2
P2905	SH 6	Potlatch Jct. West	560	80	14.2	82.3	4.9	4.9	1.6	1.6	-	-	2.3	0.4	1.9	0.1
P2402	US 30	Bliss Jct. - Hagerman	950	75	7.9	57.2	3.2	9.3	9.7	10.7	1.0	0.6	2.6	0.1	2.8	2.7
P0721	US 93	Bellevue North	1250	145	11.6	67.4	2.9	6.4	2.5	4.4	0.1	0.7	2.7	0.1	6.4	6.4
P0721	SH 23	Bellevue Southeast	390	65	13.0	73.2	3.3	7.3	1.3	6.3	0.2	0.3	0.7	-	7.2	-
P0721	US 93	Bellevue South	970	115	11.9	63.4	3.2	5.7	2.9	4.8	0.1	0.9	3.7	0.2	5.5	9.7
P0804	SH 15	Horseshoe Bend North	1260	205	16.2	45.4	16.3	5.2	3.3	19.9	0.3	0.1	5.9	0.4	0.3	2.8
P0804	SH 15	Horseshoe Bend South	1080	175	16.3	50.0	16.0	4.9	3.2	15.7	0.4	0.1	5.7	0.1	1.2	2.8
P0804	SH 52	Horseshoe Bend West	400	75	18.2	61.2	12.9	1.5	2.0	16.3	-	-	2.4	0.8	2.4	0.7
P3814	US 95	Ontario Jct. North	5715	395	6.9	71.6	8.8	4.3	1.8	4.9	0.5	0.6	3.2	0.4	1.0	3.0
P3814	US 30	Ontario Jct. South	3455	290	8.3	67.3	4.4	6.3	2.7	9.1	0.8	0.8	4.8	0.4	1.1	2.5
P3814	US 30	Ontario Jct. West	5325	320	6.0	57.0	10.4	6.6	3.0	10.0	0.5	0.3	6.3	0.6	0.7	4.4
P0316	US 30	McCammon - Inkom	3320	610	18.4	32.4	3.1	10.6	7.6	28.2	1.2	0.3	11.3	0.1	1.3	3.0
P0316	US 30	McCammon - Lava	1330	235	17.6	33.5	3.7	16.0	8.3	32.6	0.6	0.4	4.5	-	1.6	0.3
P0316	US 91	McCammon - Arimo	2250	425	18.9	33.1	2.6	7.7	7.1	27.1	1.4	0.3	15.2	0.1	1.1	4.4
P3517	US 95	Spalding Jct. West	3365	450	13.4	55.6	8.8	5.1	1.5	18.1	0.1	0.1	7.1	0.3	1.4	2.0
P3517	US 12	Spalding Jct. East	1350	220	16.4	46.6	11.0	4.0	1.2	27.2	-	0.1	6.3	0.3	2.1	1.4
P3517	US 95	Spalding Jct. South	1950	225	11.6	65.6	6.8	5.5	1.7	6.8	0.1	0.2	7.4	0.3	3.2	2.2
P1028	US 91	Reeds Corner North	2300	415	18.1	59.9	5.0	2.5	2.2	16.3	0.4	0.4	3.9	0.1	1.7	6.7
P1028	US 91	Reeds Corner - Idaho Falls	5000	720	14.4	56.3	4.1	2.8	1.6	9.3	0.5	0.2	2.5	0.1	1.9	20.9
P1028	US 20	Reeds Corner - Arco	2600	395	15.1	48.1	3.3	3.0	1.8	11.8	0.8	0.2	3.0	0.1	1.8	26.4
P1007	US 191	Beach's Corner - Ucon	4615	445	9.6	59.6	7.0	6.9	3.7	12.5	0.6	0.2	4.9	-	2.3	2.2
P1007	US 26	Beach's Corner - Ririe	2000	175	8.9	71.0	6.9	4.6	2.4	5.7	0.1	0.3	3.8	0.1	3.6	1.5
P1007	US 191	Beach's Corner - Idaho Falls	5850	505	8.6	59.9	7.1	7.3	3.6	12.7	0.6	0.2	5.5	0.1	1.0	2.3

TABLE XII

5k-EWL (1000's) PER 100 COMMERCIAL VEHICLES PER YEAR
(k = 1972 CONSTANTS)

Station	Percent of Total Commercial Vehicles: 2 Axle	3 Axle	4 Axle	5 & 6 Axle	5k-EWL = (k)(% in Group): 2 Axle k=650	3 Axle k=3800	4 Axle k=2800	5 & 6 Axle k=7600	Total
9	83	12	2	3	42.4	45.6	5.6	22.8	116.4
P2905	82	12	2	4	41.8	45.6	5.6	30.4	123.4
11	80	13	2	5	41.0	49.4	5.6	38.0	134.0
P0721	73	18	2	7	37.2	68.4	5.6	53.2	164.4
P3814	72	17	3	8	36.8	64.6	8.4	60.8	170.6
P0721	67	22	3	8	34.2	83.6	8.4	60.8	187.0
P2852	71	17	3	9	36.2	64.6	8.4	68.4	177.6
P1007	71	17	3	9	36.2	64.6	8.4	68.4	177.6
13	69	20	2	9	35.2	76.0	5.6	68.4	185.2
P0721	63	24	4	9	32.2	91.2	11.2	68.4	203.0
12	75	12	2	11	38.2	45.6	5.6	83.6	173.0
14	63	20	6	11	32.2	76.0	16.8	83.6	208.6
P2402	58	18	11	13	29.8	68.4	30.8	98.8	227.8
P1028	56	30	2	12	28.6	114.0	5.6	91.2	239.4
P3517	65	18	2	15	33.2	68.4	5.6	114.0	221.2
P1028	47	35	3	15	24.0	133.0	8.4	114.0	279.4
P3814	67	14	4	15	34.2	53.2	11.2	114.0	212.6
P1007	60	18	5	17	30.6	68.4	14.0	129.2	242.2
P3814	57	22	4	17	29.1	83.6	11.2	129.2	253.1
P1007	60	18	4	18	30.6	68.4	11.2	136.8	247.2
P0804	61	17	2	20	31.2	64.6	5.6	152.0	253.4
P0804	50	25	4	21	25.5	95.0	11.2	159.6	291.3
P1028	60	16	3	21	30.6	60.8	8.4	159.6	259.4
10	57	18	4	21	29.1	68.4	11.2	159.6	268.3

TABLE XII (CON'T)

Station	Percent of Total Commercial Vehicles 2 Axle	3 Axle	4 Axle	5 & 6 Axle	5k-EWL = (k) (% in Group) 2 Axle k=650	3 Axle k=3800	4 Axle k=2800	5 & 6 Axle K=7600	Total
16	52	21	5	22	26.6	79.8	14.0	167.2	287.6
P2905	62	13	2	23	31.6	49.4	5.6	174.8	261.4
6	55	16	4	25	28.1	60.8	11.2	190.0	290.1
P10227	58	13	4	25	29.6	49.4	11.2	190.0	280.2
P3517	56	17	2	25	28.6	64.6	5.6	190.0	288.8
P0804	45	25	4	26	23.0	95.0	11.2	197.6	326.8
3	52	14	8	26	26.6	53.2	22.4	197.6	299.8
15	54	16	4	26	27.6	60.8	11.2	197.6	297.2
P2905	56	13	2	29	28.6	49.4	5.6	220.4	304.0
1	43	20	7	31	21.9	76.0	19.6	235.6	353.1
P2852	42	19	7	32	21.4	72.2	19.6	243.2	356.4
P2852	40	20	7	33	20.4	76.0	19.6	250.8	366.8
P2844	38	20	8	34	19.4	76.0	22.4	258.4	376.2
P3517	47	18	1	34	24.0	68.4	2.8	258.4	353.6
7	38	14	13	35	19.4	53.2	36.4	266.0	375.0
P1453	39	13	12	36	19.9	49.4	33.6	273.6	376.5
P1453	40	13	11	36	20.4	49.4	30.8	273.6	374.2
P0316	33	22	9	36	16.8	83.6	25.2	273.6	399.2
5	38	17	6	39	19.4	64.6	16.8	296.4	397.2
P0316	32	18	9	41	16.3	68.4	25.2	311.6	422.5
P0316	33	16	9	42	16.8	60.8	25.2	319.2	422.0
8	31	21	6	42	15.8	79.8	16.8	319.2	431.6
2	30	16	12	42	15.3	60.8	33.6	319.2	428.9
4	32	15	6	47	16.3	57.0	16.8	357.2	447.2

TABLE XIII

DEGREE DAYS AND WINTER PRECIPITATION (BELOW 32° F.)

30 Year Mean

	Degree Days 32° F.	Winter Precipitation Inches	Annual Precipitation
Panhandle			
Coeur d'Alene	280	9.0	26.1
Porthill	480	6.3	19.3
Priest River Exp. Sta.	510	13.5	32.9
St. Maries	160	7.5	28.7
Sandpoint	330	13.5	32.7
Northern Canyons			
Kooskia	100	2.8	24.7
Lewiston	100	1.3	13.2
Orofino	100	4.0	25.9
Riggins	-	1.5*	15.5
Northern Prairies			
Grangeville	200	3.5	22.7
Moscow	150	4.2	22.2
Nezperce	220	4.5	20.7
Potlatch	110	6.4	24.5
Central Mountains			
Arrowrock Dam	360	8.0	18.8
Avery R. S.	180	8.3	32.5
Deadwood Dam	1,440	19.0	32.0
Garden Valley	470	10.5	23.8
Hailey R. S.	980	7.6	14.5
Hill City	1,500	9.0	14.7
Idaho City	580	14.0	23.2
Kellogg	200	7.5	31.0
Lowman	670	11.8	24.4
McCall	1,125	14.5	26.8
New Meadows	980	12.0	25.3
Obsidian	1,840	7.7	14.2
Pierce	-	15.0+*	41.3
Wallace	270	15.5	42.1
Wallace - Woodland Park	310	12.5	35.6

* Estimated

	Degree Days 32° F.	Winter Precipitation Inches	Annual Precipitation
Southwestern Valleys			
Boise A. P.	100	2.0	11.4
Caldwell	100	2.0	10.6
Cambridge	560	9.0	19.7
Council	700	11.5	26.8
Deer Flat Dam	90	1.5	9.3
Emmett	90	3.5	12.3
Glenns Ferry	-	-	8.7
Grandview	0	-	7.3
Kuna	0	-	10.4
Mountain Home	120	1.5	8.8
Parma	125	1.8	9.3
Payette	160	2.5	11.0
Weiser	200	3.0	11.3
Southwestern Highlands			
Hollister	300	2.1	10.0
Central Plains			
Bliss	-	2.2*	8.5
Buhl	200	1.5	8.1
Burley	270	2.0	8.6
Hazelton	200	3.2	10.1
Jerome	300	1.8	8.9
Richfield	-	4.0*	9.6
Rupert	360	2.7	8.3
Shoshone	510	4.0	10.3
Twin Falls	150	1.6	8.7
Northeastern Valleys			
Challis	980	1.5	6.9
Mackay	1,225	3.0	9.3
Salmon City	1,000	2.0	8.9
Upper Snake River Plains			
Aberdeen Exp. Sta.	740	2.3	7.9
Ashton	1,250	8.8	16.9
Blackfoot	-	3.5*	9.9
Dubois Exp. Sta.	850	2.8	10.9
Ft. Hall Indian Agency	570	2.5	9.7

* Estimated

	Degree Days 32° F.	Winter Precipitation Inches	Annual Precipitation
Upper Snake River Plains (Con't)			
Idaho Falls A.P.	900	3.0	8.7
Idaho Falls 42 Mi. N. W.	1,570	2.1	7.0
Idaho Falls 46 Mi. West	1,350	2.8	7.6
Pocatello A.P.	600	3.0	10.8
Sugar City	1,200	4.2	11.2
Eastern Highlands			
Driggs	1,380	5.5	15.8
Grace	1,150	5.2	14.2
Lifton Pump Sta.	1,350	3.0	9.6
Malad	600	4.6	14.0
Montpelier	1,200	5.0	13.7
Oakley	240	1.8	10.1
Preston	650	4.8	15.5

TABLE XIV

EQUIVALENT DAILY 18 KIP SINGLE AXLE LOAD APPLICATION - SERVICEABILITY INDEX 2.0 DISTRIBUTION OF AXLE LOADING GROUP FROM LOADOMETER SURVEY - 1961

Axle Group (Kips)	Factor	2 Axle No. Axles in Group	2 Axle EQ 18K SA	3 Axle No. Axles in Group	3 Axle EQ 18K SA	3 Axle 2-S1 No. Axles in Group	3 Axle 2-S1 EQ 18K SA	4 Axle No. Axles in Group	4 Axle EQ 18K
Single Axle									
Less 8	0.01	2,073	20.7	112	1.1	322	3.2	150	1.5
8 - 12	0.09	296	26.6	62	5.6	136	12.2	79	7.2
12 - 16	0.35	179	62.6	11	3.8	151	52.8	48	16.8
16 - 18	0.80	65	52.0			76	60.8	32	25.6
18 - 20	1.21	26	31.4			13	15.7	8	9.7
20 - 22	1.88	15	28.2			1	1.9	1	1.9
22 - 24	2.80	2	5.6						
24 - 26	4.02								
Tandem Axle									
Less 12	0.02			48	1.0			48	1.0
12 - 18	0.04			27	1.1			18	1.0
18 - 24	0.15			45	6.7			36	5.4
24 - 30	0.42			32	13.4			39	16.4
30 - 32	0.74			5	3.7			14	10.3
32 - 34	0.98			7	6.9			8	8.0
34 - 36	1.22			5	6.1			1	1.2
36 - 38	1.55			3	4.6			2	3.1
38 - 40	1.95			3	5.8				
40 - 42	2.40			3	7.2				
42 - 44	3.00								
44 - 46	3.60								
Axles Weighed		2,658		540		699		664	
Axles Counted		4,628		1,017		930		932	
EQ 18K SA/100 Vehicles			17.1		37.2		63.0		65.8

TABLE XIV (CON'T)

Axle Group (Kips)	Factor	5 Axle No. Axles in Group	5 Axle EQ 18K SA	3 Axle	Full Trailer	4 Axle	Full Trailer	5 Axle	Full Trailer	6 Axle	Full Trailer
Single Axle											
Less 8	0.01	237	2.4			36	0.4	224	2.2	4	-
8 - 12	0.09	708	63.8			11	1.0	176	15.8	1	0.1
12 - 16	0.35	144	50.4			7	2.5	50	17.5	2	0.7
16 - 18	0.80	99	79.0			8	6.4	174	139.0	1	1.2
18 - 20	1.21	9	10.9			1	1.2	64	77.5		
20 - 22	1.88					1	1.9	2	3.7		
22 - 24	2.80										
24 - 26	4.02										
Tandem Axle											
Less 12	0.02	238	4.8					69	1.4	2	-
12 - 18	0.04	166	6.7					13	0.5	1	-
18 - 24	0.15	196	29.4					5	0.8	3	0.5
24 - 30	0.42	451	189.0					66	27.7	3	1.2
30 - 32	0.74	243	180.0					59	43.7		
32 - 34	0.98	111	109.0					12	12.0		
34 - 36	1.22	25	30.4					4	4.9		
36 - 38	1.55	10	15.5					1	1.6		
38 - 40	1.95	7	13.6								
40 - 42	2.40	2	4.8								
42 - 44	3.00	3	3.6								
44 - 46	3.60	1									
Axles Weighed		4,105				64		1,150		24	
Axles Counted		6,315				88		1,925		24	
EQ 18K SA/100 Vehicles			98.0				84.0		151.0		92.5

TABLE XIV (CON'T)

Axle Group (Kips)	Factor	5 Axle No. Axles in Group	5 Axle EQ 18K SA	3 Axle	Full Trailer	4 Axle	Full Trailer	5 Axle	Full Trailer	6 Axle	Full Trail
Single Axle											
Less 8	0.01	237	2.4			36	0.4	224	2.2	4	-
8 - 12	0.09	708	63.8			11	1.0	176	15.8	1	0.1
12 - 16	0.35	144	50.4			7	2.5	50	17.5	2	0.7
16 - 18	0.80	99	79.0			8	6.4	174	139.0	1	1.2
18 - 20	1.21	9	10.9			1	1.2	64	77.5		
20 - 22	1.88					1	1.9	2	3.7		
22 - 24	2.80										
24 - 26	4.02										
Tandem Axle											
Less 12	0.02	238	4.8					69	1.4	2	-
12 - 18	0.04	166	6.7					13	0.5	1	-
18 - 24	0.15	196	29.4					5	0.8	3	0.
24 - 30	0.42	451	189.0					66	27.7	3	1.
30 - 32	0.74	243	180.0					59	43.7		
32 - 34	0.98	111	109.0					12	12.0		
34 - 36	1.22	25	30.4					4	4.9		
36 - 38	1.55	10	15.5					1	1.6		
38 - 40	1.95	7	13.6								
40 - 42	2.40	2	4.8								
42 - 44	3.00	3	3.6								
44 - 46	3.60	1									
Axles Weighed		4,105				64		1,150		24	
Axles Counted		6,315				88		1,925		24	
EQ 18K SA/100 Vehicles			98.0				84.0		151.0		92.

TABLE XV

EQUIVALENT DAILY 18 KIP SINGLE AXLE LOAD APPLICATION - SERVICEABILITY INDEX 2.5 DISTRIBUTION OF AXLE LOADING GROUP FROM LOADOMETER SURVEY - 1961

Axle Group (Kips)	Factor	2 Axle No. Axles in Group	2 Axle EQ 18K SA	3 Axle No. Axles in Group	3 Axle EQ 18K SA	3 Axle 2-S1 No. Axles in Group	3 Axle 2-S1 EQ 18K SA	4 Axle No. Axles in Group	4 Axle EQ 18K SA
Single Axle									
Less 8	0.01	2,073	20.7	112	1.1	322	3.2	150	1.5
8 - 12	0.12	296	35.5	62	7.5	136	16.3	79	9.6
12 - 16	0.40	179	71.6	11	4.4	151	60.4	48	19.2
16 - 18	0.80	65	52.0			76	60.8	32	25.6
18 - 20	1.21	26	31.4			13	15.7	8	9.7
20 - 22	1.78	15	26.7			1	1.8	1	1.8
22 - 24	2.55	2	5.1						
24 - 26	3.60	0	0.0						
Tandem Axle									
Less 12	0.02			48	1.0			48	1.0
12 - 18	0.06			27	1.6			18	1.1
18 - 24	0.19			45	8.5			36	6.8
24 - 30	0.48			32	15.4			39	18.8
30 - 32	0.81			5	4.0			14	11.2
32 - 34	1.00			7	7.0			8	8.0
34 - 36	1.27			5	6.4			1	1.3
36 - 38	1.51			3	4.5			2	3.0
38 - 40	1.88			3	5.6				
40 - 42	2.26			3	6.8				
42 - 44	2.75								
44 - 46	3.30								
Axles Weighed		2,858		540		699		664	
Axles Counted		4,628		1,017		930		932	
EQ 18K SA/100 Vehicles			18.3		41.0		68.0		71.4

TABLE XV (CON'T)

Axle Group (Kips)	Factor	5 Axle No. Axles in Group	5 Axle EQ 18K SA	3 Axle	Full Trailer	4 Axle	Full Trailer	5 Axle	Full Trailer	6 Axle	Full Trailer
Single Axle											
Less 8	0.01	237	2.4			36	0.4	224	2.2	4	-
8 - 12	0.12	708	85.0			11	1.2	176	21.1	1	0.2
12 - 16	0.40	144	57.6			7	2.8	50	20.0	2	0.8
16 - 18	0.80	99	79.0			1	6.4	174	139.0	1	0.8
18 - 20	1.21	9	10.9			1	1.2	64	77.5		
20 - 22	1.78						1.8	2	3.6		
22 - 24	2.55										
24 - 26	3.60										
Tandem Axle											
Less 12	0.02	238	4.8					69	1.4	2	-
12 - 18	0.06	166	10.0					13	0.8	1	-
18 - 24	0.19	196	37.2					5	0.9	3	0.6
24 - 30	0.48	451	216.0					66	31.7	3	1.5
30 - 32	0.81	243	197.0					59	47.8		
32 - 34	1.00	111	111.0					12	12.0		
34 - 36	1.27	25	31.8					4	5.1		
36 - 38	1.51	10	15.1					1	1.5		
38 - 40	1.88	7	13.2								
40 - 42	2.26	2	8.3								
42 - 44	2.75	3	3.3								
44 - 46	3.30	1	4.0								
Axles Weighed		4,105				64		1,150		24	
Axles Counted		6,315				88		1,925		24	
EQ 18K SA/100 Vehicles			108.3				86.4		159.0		95.5

TABLE XVI

EQUIVALENT DAILY 18 KIP SINGLE AXLE LOAD APPLICATIONS
FOR 100 COMMERCIAL VEHICLES PER DAY, SERVICEABILITY INDEX 2.0

Comb. Trucks	Factor Per 100 Vehicles	Sta. P1007 % Comm. ADT	Sta. P1007 ED 18K SA	Sta. P3517 % Comm. ADT	Sta. P3517 ED 18K SA	Sta. P0316 % Comm. ADT	Sta. P0316 ED 18K SA	Sta. P3814 % Comm. ADT	Sta. P3814 ED 18K SA	Sta. P0804 % Comm. ADT	Sta. P0804 ED 18K SA
2 Axle	17.1	59.6	10.0	46.6	8.0	32.4	5.5	67.3	11.5	45.4	7.8
3 Axle	37.2	7.0	2.6	11.0	4.1	3.1	1.1	4.4	1.6	16.3	6.1
2S - 1	63.0	6.9	4.4	4.0	2.5	10.7	6.7	6.3	4.0	5.2	3.3
2S - 2	65.8	3.7	2.4	1.2	0.8	7.6	5.0	2.7	1.8	3.3	2.2
3S - 2	98.0	12.5	12.3	27.2	26.7	28.2	27.6	9.1	8.9	19.9	19.5
2S1 - 2	84.0*	0.6	0.5	0.1	0.1	1.2	1.0	0.8	0.7	0.3	0.3
2 - 2	84.0	0.2	0.1	6.3	5.4	0.3	0.3	0.8	0.7	0.1	0.1
3 - 2	151.0	4.9	7.4	0.3	0.5	11.3	17.1	4.8	7.3	5.9	8.9
3 - 3	92.5	-	-	-	-	0.1	0.1	0.4	0.4	0.4	0.4
Buses	37.2*	4.4	1.6	3.5	1.3	4.3	1.6	3.5	1.3	3.1	1.1
Total			41.3		49.4		66.0		38.2		49.7

Comb. Trucks	Factor Per 100 Vehicles	Sta. P0721 % Comm. ADT	Sta. P0721 ED 18K SA	Sta. P2402 % Comm. ADT	Sta. P2402 ED 18K SA	Sta. P #2 % Comm. ADT	Sta. P #2 ED 18K SA	Sta. P #11 % Comm. ADT	Sta. P #11 ED 18K SA	Sta. P #15 % Comm. ADT	Sta. P #15 ED 18K SA
2 Axle	17.1	67.4	11.5	57.2	9.8	29.6	3.0	80.6	13.8	53.9	9.2
3 Axle	37.2	2.9	1.1	3.2	1.2	4.1	1.5	3.0	1.1	6.0	2.2
2S - 1	63.0	6.4	4.0	9.3	5.8	8.7	5.5	3.3	2.1	3.3	2.1
2S - 2	65.8	2.4	1.6	9.7	6.3	7.4	4.9	1.3	0.9	3.5	2.3
3S - 2	98.0	4.4	4.3	10.7	10.5	30.0	29.4	4.2	4.1	23.7	23.2
2S1 - 2	84.0*	0.1	0.1	1.0	0.8	3.7	3.1	-	-	-	-
2 - 2	84.0	0.7	0.6	0.6	0.5	0.9	0.8	0.2	0.2	0.1	0.1
3 - 2	151.0	2.7	4.1	2.6	3.9	12.0	18.1	0.7	1.1	2.4	3.6
3 - 3	92.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-
Buses	37.2*	12.9	4.8	5.6	2.1	3.4	1.2	6.6	2.5	7.2	2.7
Total			32.2		41.0		69.6		25.9		45.4

* Estimated that 2S1-2 and 2-2 were comparable and buses were comparable to 3 axle.

TABLE XVII

EQUIVALENT DAILY 18 KIP SINGLE AXLE LOAD APPLICATIONS
FOR 100 COMMERCIAL VEHICLES PER DAY, SERVICEABILITY INDEX 2.5

Comb. Trucks	Factor Per 100 Vehicles	Sta. P1007 % Comm. ADT	Sta. P1007 ED 18K SA	Sta. P3517 % Comm. ADT	Sta. P3517 ED 18K SA	Sta. P0316 % Comm. ADT	Sta. P0316 ED 18K SA	Sta. P3814 % Comm. ADT	Sta. P3814 ED 18K SA	Sta. P0804 % Comm. ADT	Sta. P0804 ED 18K SA	Sta. P0721 % Comm. ADT	Sta. P0721 ED 18K SA	Sta. P2402 % Comm. ADT	Sta. P2402 ED 18K SA	Sta. P No. 2 % Comm. ADT	Sta. P No. 2 ED 18K SA	Sta. P No. 11 % Comm. ADT	Sta. P No. 11 ED 18K SA	Sta. P No. 15 % Comm. ADT	Sta. P No. 15 ED 18K SA
2 Axle	18.3	59.6	11.9	46.6	8.5	32.4	5.9	67.3	12.3	45.4	8.3	67.4	12.3	57.2	10.5	29.6	5.4	80.6	14.7	53.9	9.9
3 Axle	41.0	7.0	2.9	11.0	4.5	3.1	1.3	4.4	1.8	16.3	6.7	2.9	1.2	3.2	1.3	4.1	1.7	3.0	1.2	6.0	2.5
2S - 1	68.0	6.9	4.7	4.0	2.7	10.7	7.3	6.3	4.3	5.2	3.5	6.4	4.4	9.3	6.3	8.7	5.9	3.3	2.2	3.3	2.2
2S - 2	71.4	3.7	2.6	1.2	0.9	7.6	5.4	2.7	1.9	3.3	2.3	2.4	1.7	9.7	6.9	7.4	5.3	1.3	0.9	3.5	2.5
3S - 2	108.3	12.5	13.6	27.2	29.5	28.2	30.6	9.1	9.9	19.9	21.6	4.4	4.8	10.7	11.6	30.0	32.5	4.2	4.5	23.7	25.7
2S1 - 2	86.4*	0.6	0.5	0.1	0.1	1.2	1.1	0.8	0.7	0.3	0.3	0.1	0.1	1.0	0.9	3.7	3.2	-	-	-	-
2 - 2	86.4	0.2	0.2	6.3	5.5	0.3	0.3	0.8	0.7	0.1	0.1	0.7	0.6	0.6	0.5	0.9	0.8	0.2	0.2	0.1	0.1
3 - 2	159.0	4.9	7.8	0.3	0.5	11.3	17.9	4.8	7.6	5.9	9.4	2.7	4.3	2.6	4.1	12.0	19.1	0.7	1.1	2.4	3.8
3 - 3	95.5	-	-	-	-	0.1	0.1	0.4	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-
Buses	41.0*	4.4	1.8	3.5	1.4	4.3	1.8	3.5	1.4	3.1	1.3	12.9	5.3	5.6	2.3	3.4	1.4	6.6	2.7	7.2	2.9
Total			46.0		53.6		71.7		41.0		53.9		34.8		44.5		75.4		27.6		49.6

* Estimated that 2S1-2 and 2-2 were comparable and buses were comparable to 3 axle.

TABLE XVIII

STRUCTURAL NUMBER FOR SERVICEABILITY INDEX 2.0
VARYING SOIL SUPPORT AT 10 SELECTED STATIONS

Station No.	Location	Comm. ADT (2X 1962)	ED 18K SA Ld. Appl. 100 ADT	ED 18K SA Ld. Appl. Total ADT	SSV 3.0 (RV = 10) SN	SSV 4.8 (RV = 30) SN	SSV 6.7 (RV = 50) SN
P1007	Ucon	886	41.3	366	4.32	3.40	2.70
P3517	Orofino	442	49.4	218	4.05	3.20	2.50
P0316	Inkom	1,222	66.0	807	4.83	3.86	3.05
P3814	Fruitland	574	38.2	219	4.05	3.20	2.50
P0804	Banks	408	49.7	203	4.00	3.15	2.45
P0721	Bellevue	290	32.2	94	3.55	2.80	2.13
P2402	Hagerman	150	41.0	62	3.30	2.60	1.98
P #2	East Boise	642	69.6	447	4.45	3.54	2.78
P #11	Paris	226	25.9	59	3.30	2.60	1.98
P #15	Potlatch	242	45.4	110	3.63	2.85	2.22

TABLE XIX

STRUCTURAL NUMBER FOR SERVICEABILITY INDEX 2.5 VARYING SOIL SUPPORT AT 10 SELECTED STATIONS

Station No.	Location	Comm. ADT (2X 1962)	ED 18K SA Ld. Appl. 100 ADT	ED 18K SA Ld. Appl. Total ADT	SSV 3.0 (RV = 10) SN	SSV 4.8 (RV = 30) SN	SSV 6.7 (RV = 50) SN
P1007	Ucon	886	46.0	408	4.63	3.76	2.98
P3517	Orofino	442	53.6	237	4.26	3.40	2.65
P0316	Inkom	1,222	71.7	876	5.12	4.20	3.29
P3814	Fruitland	574	41.0	236	4.26	3.40	2.65
P0804	Banks	408	53.9	220	4.24	3.40	2.62
P0721	Bellevue	290	34.8	101	3.75	3.00	2.32
P2402	Hagerman	150	44.5	67	3.50	2.80	2.15
P #2	East Boise	642	75.4	485	4.70	3.80	3.03
P #11	Paris	226	27.6	62	3.48	2.75	2.11
P #15	Potlatch	242	49.6	120	3.86	3.03	2.39

APPENDIX C

Forward to

AASHO Interim Guide

for the

DESIGN OF FLEXIBLE PAVEMENTS

AASHO Committee on Design

FOREWORD

This interim guide for the design of flexible pavement structures has been prepared from data obtained in the AASHO Road Test at Ottawa, Illinois. The guide also reflects the considered and best judgment of those involved in its preparation, in those areas which the Road Test does not cover.

It is essential that the user of the guide understand its limitations; They are:

1. It has been necessary to assume a scale for the soil support value on Charts 400-1 and 400-2. Point 3.0 on the scale represents the silty clay roadbed soils on the Road Test. It is a firm and valid point. Point 10.0 represents crushed rock base material such as used on the Road Test. It is a reasonably valid point. All other points on the scale are assumed.

2. The soil support scale must be correlated with test data obtained by one of several methods. The user must develop this correlation based on the specific soil test method he is using. General correlations are given in Appendix "E" as a possible guide in developing the proper scales.

3. Coefficients for converting the thicknesses of surface, base or subbase to the structural number (SN) are given on page 22 of the guide. Careful consideration must be given by the user to those coefficients not established in the Road Test.

4. Included in the design analysis is a regional factor which permits adjustments for environmental conditions. The user must give careful consideration to this factor. A method of estimating the factor is given in Appendix "G".

5. A traffic analysis period of 20 years has been used for the sake of convenience. It must not be confused with pavement life, which is affected by many factors in addition to traffic loading.

It is emphasized that the guide is interim in nature and subject to adjustment based on experience and additional research.

APPENDIX D

ROADBED STRUCTURE (16-230)
DESIGN FOR FLEXIBLE PAVEMENT (16-231)

16-231.1 Summary of Design Factors.

The major factors to be considered in developing a structural cross-section are:

(1) Structural Quality of the Subgrade Soil: This quality is measured by the stabilometer test as expressed by the Resistance ("R") Value; and by the expansion pressure test.

(2) Traffic: The ADT of total and commercial traffic is used to make projections of traffic for the design period, generally 20 years. Classifications of the highway due to traffic were developed making the adjustment in Traffic Index easier and based upon these computations for 5k-EWL and Traffic Index. Using volumes of commercial traffic, computations are made for the Equivalent 5,000 Pound Equivalent Wheel Loads (5k-EWL) and Traffic Index (TI). Commerçial traffic is classified as "Heavy" for traffic having large percentages of 5 axle vehicles and "Light" for traffic having large percentages of 2 axle vehicles with the median or "Average" as the third category. Other categories of "Very Light" and "Residential" are used for streets and frontage roads carrying very small volumes of commercial traffic, most of which is 2 axle and with only occasional vehicles larger than 3 axle.

(3) Climatic Factors: Climate throughout the State varies from very mild with practically no freezing weather in the lower valleys and low river canyons to the extreme of long, cold winters in the

high mountain valleys with several inches of precipitation in the form of snow. The structural cross-section is adjusted in thickness in accordance with the severity of climate.

(4) Economic Factors: A satisfactory structural section may be designed using various combinations of materials bearing in mind that economy, both in annual and first cost and in maintenance is, among other factors, an important consideration.

All of the test data necessary to each method of design is reported on a "Soil Evaluation Summary" (Figure 16-231.1) for each profile and borrow soil sample.

16-231.2 Traffic Evaluation.

(1) Scope and Purpose: The magnitude of the load and the number of wheel repetitions are major factors in the performance of a flexible pavement. Due to the fact that axle load data are not available for more than a few isolated locations in the State of Idaho, the available data have been combined to give a figure applicable to all routes, making a correction only for the volume and classification of traffic. Classifications of commercial vehicles into Heavy, Average, Light, Very Light or Residential is made depending upon the percentages of 2 axle and 5 axle vehicles. The purpose of obtaining this information is to make a representative estimate of the 5k-EWL to be expected during the life of the project following construction. Accordingly, the ADT used in design has been increased for anticipated traffic, and the 5k-EWL is expressed in terms of the Traffic Index (TI).

DH-808 9-62
SOILS EVALUATION FOR FLEXIBLE PAVEMENT

State of Idaho
DEPARTMENT OF HIGHWAYS
Materials Laboratory
Boise, Idaho

Date: September 10, 1963

Project No.: I 80N- 3 (15) 176 280-315
Section U.S. 93 - S.H. 50
County Jerome
Auth. No. 2022 - 2213

TRAFFIC DATA	1958	1975
ADT	2032	5030
Comm. ADT	244	603

Ave. Comm. ADT 424 ÷2= 212

EWL Class'n. Heavy Traffic Index 9.0

NOTE: 4 Lanes 38 'roadway width, P crown 0.02 crown slopes ______ Climatic Factor 1.0

Station	Lab. No.	Depth, Feet	Soil Class'n.	L.L.	P.I.	FME	L.S.	#10	#40	#200	W/C.F.	Opt. Mois.	"R" Value	Exp. Pressure psi	Recom. Thickness	Blanket
Pit Jr. 43	189687	0-1.0'	A-4(6)	22	6	20	3.2	93	84	65	116.9	13.2	35	1.11	1.9	N

*W/C.F. taken from "R" Value determination.
+W/C.F. corrected for +3/4" Material.
Total Ballast Required: (Initial) (To include future) Construction
NOTE: The recommended thickness is expressed in terms of untreated aggregate base corrected for climatic factor. If expansion pressure governs and total thickness is reduced through use of substitution ratios, the thickness shown above must be re-evaluated in consideration of the lower unit weight. One amply designed section over a group of soils is considered good practice for the sake of uniformity.

H. L. DAY Materials Engineer

(2) EWL Constants: The following table lists the constants used to obtain the annual number of equivalent 5,000 pound wheel load repetitions for commercial vehicles:

Number of Axles	5k-EWL Constant/Year/Vehicle (For 1972-1980)
2	510
3	3800
4	2800
5	7600
6	3800*

*Estimated

The 5k-EWL for any route is the sum of the 5k-EWL for each axle group and is computed as follows:

Axle Group	Design ADT*	Constant	Life Years	5k-EWL
2	76	510	20	775,200
3	20	3800	20	1,520,000
4	8	2800	20	448,000
5	32	7600	20	4,864,000
6	2	3800	20	152,000
				7,759,200

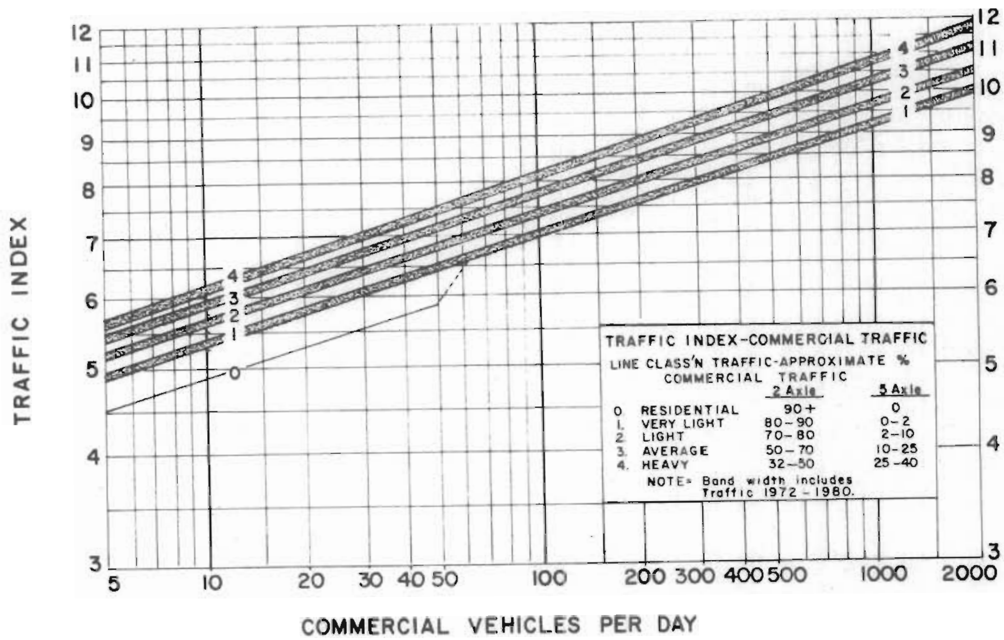
Comm. ADT (projected) x 5k-EWL Constant x 20 years = 5k-EWL

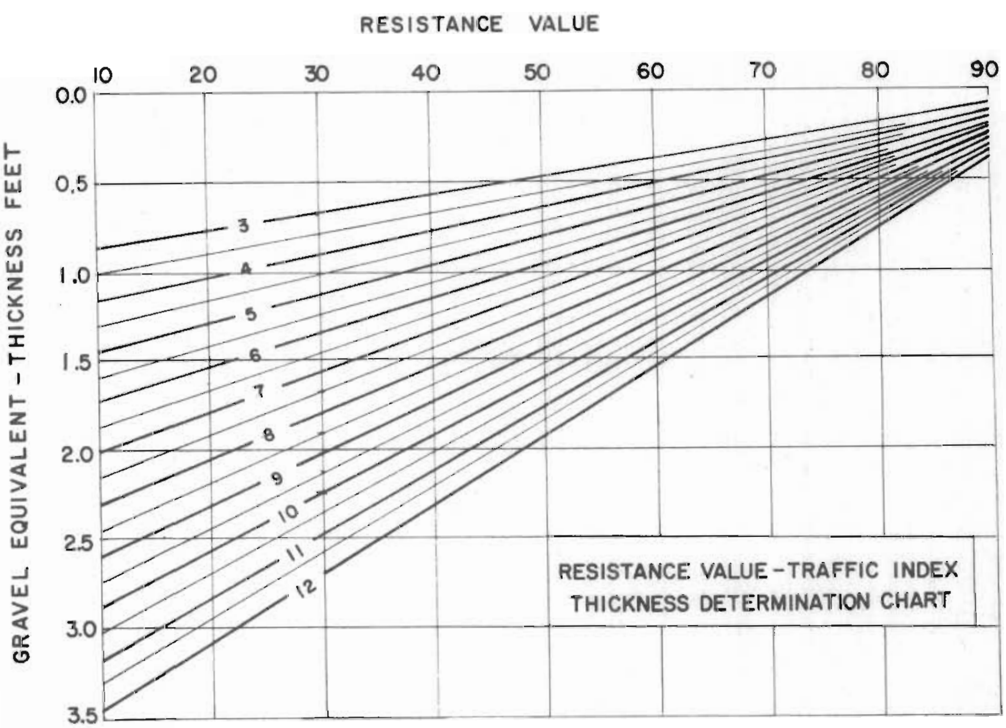
*Two directional count is divided by 2 for one direction

Traffic Index = $1.30\ (EWL)^{0.12}$

TI = $1.30\ (7{,}759{,}200)^{0.12} = 8.72$ (use 8.7)

For convenience use Figure 16-231.2 giving the Traffic Index for various traffic volumes (Commercial ADT) and classifications of commercial vehicles. These classifications of vehicles are as follows:





DESIGN CHARTS

UPPER- TRAFFIC INDEX FROM COMMERCIAL VEHICLE COUNT AND CLASSIFICATION

LOWER- THICKNESS (EQUIVALENT GRAVEL) FROM RESISTANCE VALUE AND TRAFFIC INDEX

Classification	Percent of Commercial Traffic 2 Axle	5 Axle
Heavy	32-50	25-40
Average	50-70	10-25
Light	70-80	2-10
Very Light	80-90	0-2
Residential	More than 90	0

If the total commercial count for residential classification exceeds 50 vehicles per day, use the Light classification. Interstate projects shall always be classified as Heavy. If the classification from 2 axle and 5 axle differs, use the heavier classification for design.

Commercial vehicle counts shall be computed as follows:

2 Lane Highways	-	One half of the average of the ADT for the beginning and the end of the design life period. (Normally 20 years).
4 Lane Highways	-	Same as for 2 lane with 100 percent commercial traffic assigned to outer lane.
Frontage Roads	-	Same as for 2 lane.
Interchange Ramps	-	100 percent of average assigned ADT for design life.

The State Highway System should not be designed for a Traffic Index of less than six. Abnormal distribution of extremely heavy vehicles, i.e., logging or mining traffic can result in a Traffic Index greater than that assigned as Heavy. Should this be suspected, the Traffic Index shall be computed as illustrated in Figure 16-231.2.

Traffic data for each project are presented in the project design brochure. Included are: Total ADT percent commercial vehicles and classification of the commercial traffic as Heavy, Average or Light.

Also included are traffic diagrams for intersections and interchange ramps. Such a diagram is illustrated in Figure 2-431.21. This diagram illustrates one-way traffic movements. The ADT for any segment is determined by adding all turning movements which affect that segment.

Since the figure for percent trucks was developed for the traveled way, it must be applied to the ramps with discretion. Each turning movement must be examined carefully to determine the influence of local conditions on the potential volume of commercial traffic.

16-231.3 Design by "R" Value.

(1) The Resistance ("R") Value is a test value which measures the ability of a soil to resist lateral flow due to vertically applied loads. The test is conducted using the Hveem Stabilometer (See Idaho T-8-54) wherein the soil is tested at an applied load of 4,000 pounds. The "R" values obtained by testing a soil at four conditions of moisture are plotted as shown in Figure 16-231.3. The intersection of this curve with the 4,000 pound ordinate gives the design "R" Value.

(2) The formula for total flexible pavement thickness is as follows:

$$T = \frac{0.070\ (TI)\ (100-R)}{C^{0.2}}$$

T = Thickness in Feet

TI = Traffic Index

R = Resistance Value

C = Cohesiometer Value (Normally taken as 20)

See Highway Research Board Record No. 13
"Thickness of Flexible Pavements by the California Formula Compared to AASHO Road Test Data" by F.N. Hveem and G.B. Sherman

For convenience Figure 16-231.2 has been provided for the solution of this formula for traffic indexes of 3 to 12. The value of C is taken as 20 for crushed gravel and for untreated materials.

DH-803-10-62
Distribution:
Hwy. Engr.
Dist.Engr.
Res. Engr.
B. P. R.

STATE OF IDAHO
DEPARTMENT OF HIGHWAYS
Materials Laboratory
Boise, Idaho

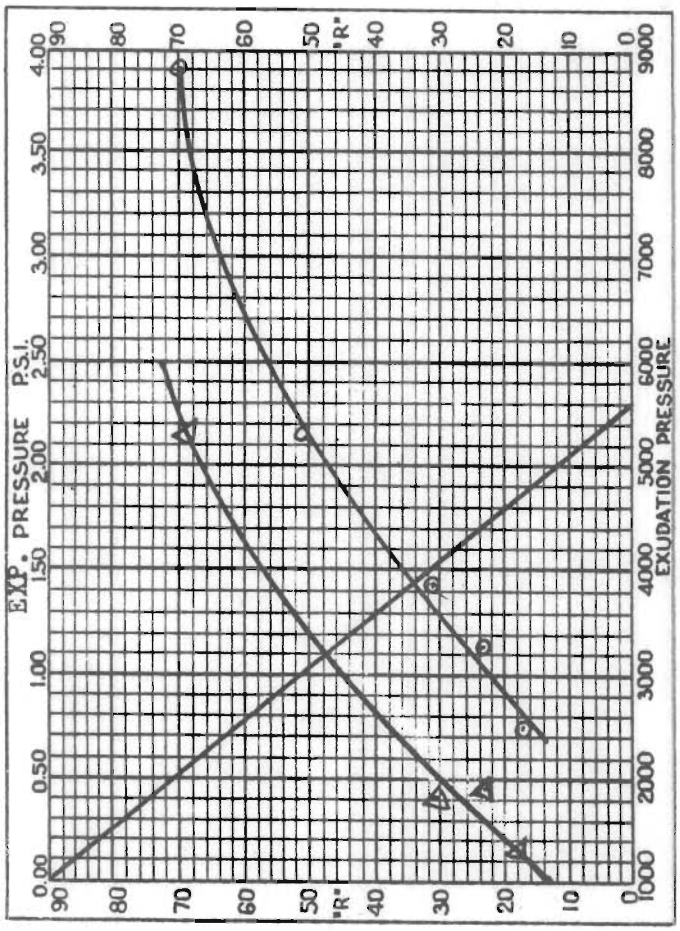
FIGURE 16-231.3

Lab. No. 189687

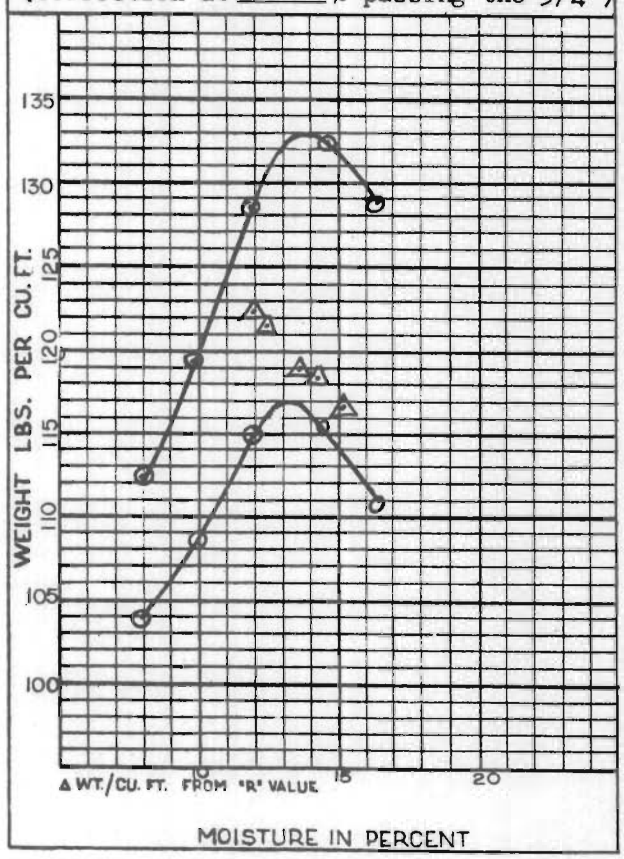
Report of Tests on SOIL Embankment, Subgrade and Filler

Project I-80N-3(15)176 280-315 County Jerome Source No. Jr-43
Submitted by S. S. Larson Ident.No. SSL/12022-2213/801-P
Station 1.2 Mi. NE of Sta. 840+00 Layer No. ______ Depth 0 - 1.0'
Description of Soil Soil Date Sampled 9-4-63 Received 9-6-63

Mechanical Anal. % Pass		Soil Constants		Remarks
3" Sq.		Liquid Limit	22	
2" Sq.	100	Plastic Limit	16	
1" Sq.	98	Plasticity Index	6	
3/4" Sq.	97	Field Moist.Equiv.	20.2	
1/2" Sq.	97	Linear Shrinkage	3.2	
No. 4	95	Specific Gravity(+3/4")		
No. 10	93	Specific Gravity(-No.4)		
No. 20	86	Sand Equivalent	7%	
No. 30	85	"R"-Value	35	
No. 40	84	Exp. Pressure, psi	1.11	
No. 50	84	Equation"A"No.	22	
No.100	74	Texture Class'n		
No.200	65	Soil Class'n	A-4(6)	



MOISTURE-DENSITY CURVE
AASHO DESIGNATION T-99 METHOD A.
Max.Dry Wt. 116.9 #/Cu.Ft. Opt.Moist 13.2%
Corrected Max. Dry Wt.= ______ lb/Cu.Ft.
(Correction at ______ % passing the 3/4")



This report covers only material as represented by this sample and does not necessarily cover all soil from this layer or source.

Date Mailed ______________

H. L. DAY
Materials Engineer

16-231.4 Design by Expansion Pressure.

Given expansion or swelling pressure data from Idaho T-7, "Standard Method of Conducting Swelling Pressure Tests on Soils", a curve is plotted as shown in Figure 16-231.3. The design expansion pressure is obtained where this curve intersects the diagonal balance line. The balance line represents the condition at which the ballast requirements from "R" Value at a Traffic Index of 7.0 are equal to those from expansion pressure. The overlying material must provide sufficient weight to prevent any volume change in the subgrade soil caused by swelling or expansion. The unit weight of this material is assumed to be 130 pounds per cubic foot for most granular materials with the exception of some volcanic aggregates. The thickness in feet necessary to confine soil with a given expansion pressure is:

$$B = \frac{\text{Exp. Pressure (psi)}}{\text{Unit Wt. Agg., Lb./Cu. Ft.}} \times 144$$

The design thickness may be read directly from the curves, Figure 16-231.4.

16-231.5 Design Adjustment for Climatic Factor.

The climatic factor provides for a measure of additional protection due to winter and spring conditions. These factors provide added thickness as follows:

Design Thickness = Thickness from R-Value x F

F = 1.00 for Region 1

F = 1.05 for Region 2

F = 1.10 for Region 3

F = 1.15 for Region 4

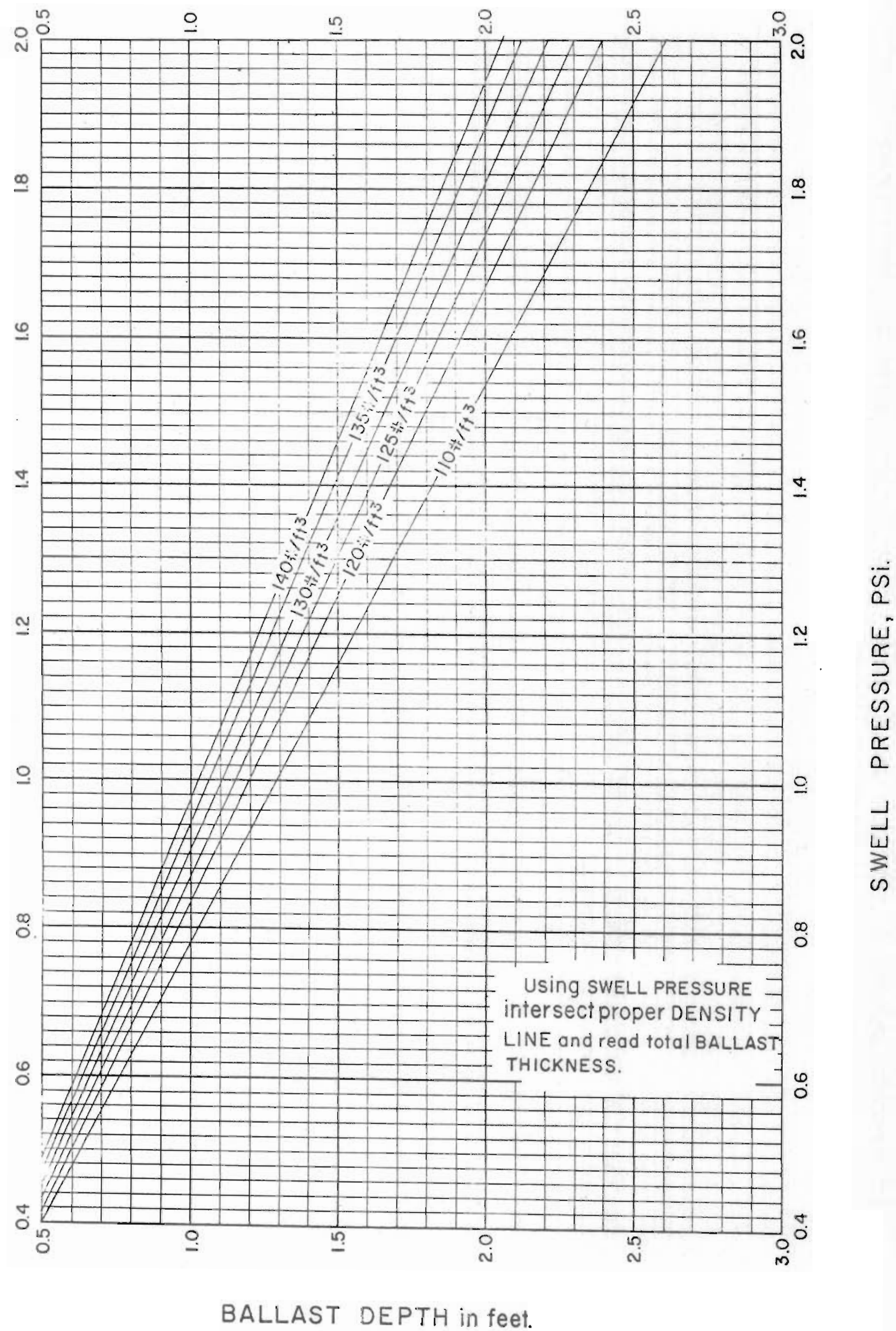
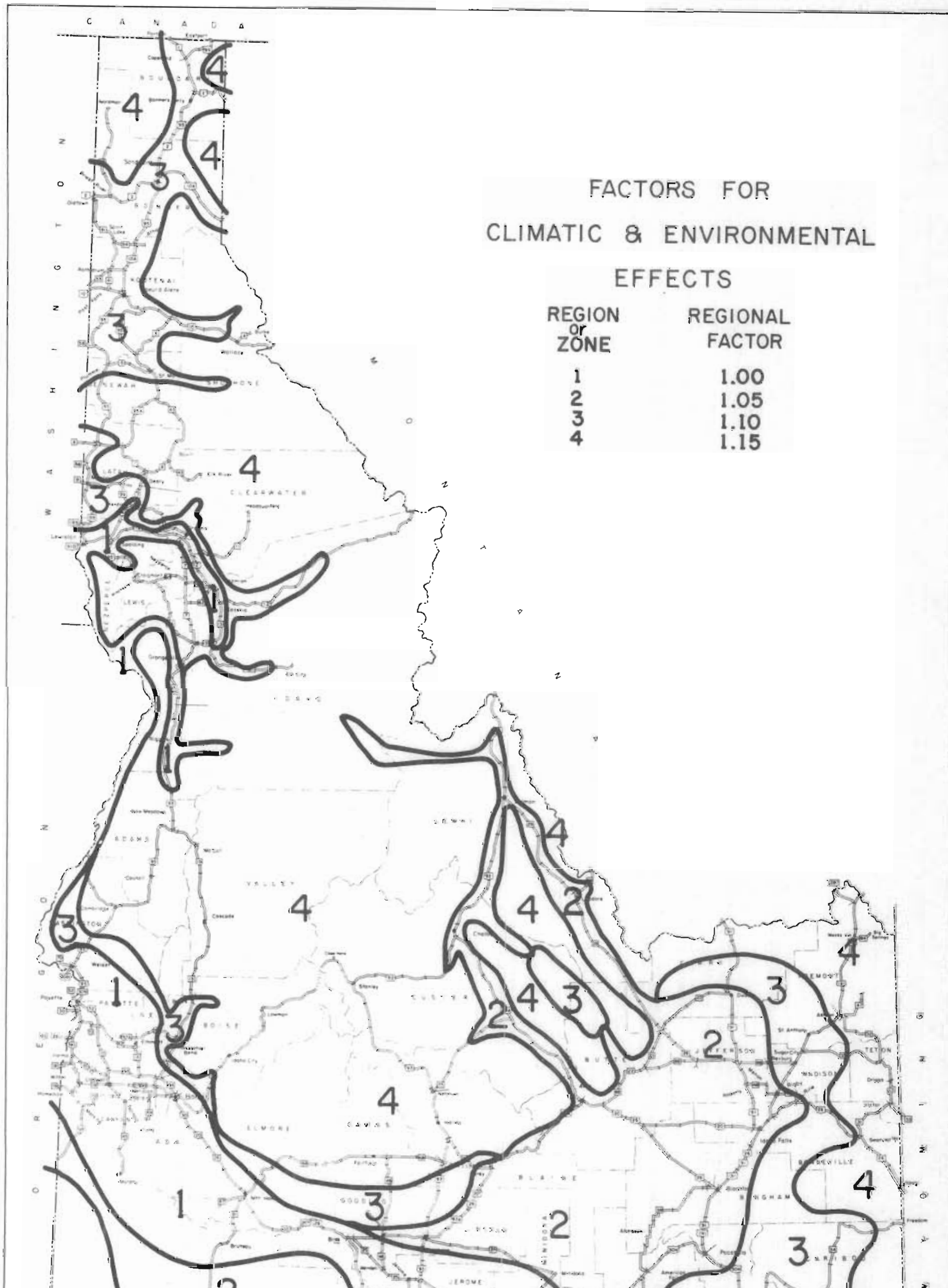

0.5
1.0
1.5
2.0
2.5
3.0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
140#/ft3
135#/ft3
130#/ft3
125#/ft3
120#/ft3
110#/ft3
Using SWELL PRESSURE intersect proper DENSITY LINE and read total BALLAST THICKNESS.
SWELL PRESSURE, PSI.
BALLAST DEPTH in feet.

FIGURE 16-231.5



The various regions were determined from precipitation during the time when the 30 year mean temperature remains below 32° F. during the winter season and from maintenance experience of the District maintenance divisions. Figure 16-231.5 shows regional areas to be used.

16-231.6 Design Adjustment for Cohesive Materials.

The cohesive resistance or tensile strength of compacted asphalt mixtures, cement or lime treated mixtures give additional strength to the pavement structure. It is possible to adjust the total thickness because of this tensile strength from the thickness as determined from R-Value design after adjustment is made for regional or climatic effects. This reduction in total pavement structure thickness is accomplished by reducing the thickness by an amount obtained by use of the substitution ratios.

TABLE I

SUBSTITUTION RATIOS FOR SURFACING AND TREATED BASE
FOR GRANULAR BASE MATERIALS - (Gran. Bs: Surf./or Tr Bs)

	Asphalt Plantmix		Treated Base Courses
Traffic Index	Surfacing % A.C. High	Base % A.C. Low	Asphalt Emulsion, Road Oil Portland Cement, Lime
Over 7.0	2.0:1	1.75:1	1.50:1
5.5 - 6.9	2.5:1	2.0:1	1.75:1
Less 5.4	3.0:1	2.5:1	2.0:1

NOTE: Design Thicknesses shall not be less than 0.5 feet for Residential Streets and County Secondaries and 0.8 feet for State Highway Projects.

16-231.7 Example of Design.

To illustrate Flexible Pavement Design, assume the following situation:

	1963 Data	1983 Projection
Total ADT	5,000	8,000
Commercial ADT	600	900
Class. 2 Axle=40%, 5 Axle=30% of Comm.	Heavy	Heavy
R-Value of Subgrade Soil	0.61 Lb.	
Wt/Cu.Ft. Base Aggregate	130	
Climatic Region or Zone	2	
Design Standard	Interstate Highway 4-lane divided, 0.4' surface course and 0.4' treated base.	

Since this is a 4-lane divided Interstate project, traffic volumes are assumed to be divided equally in both directions and with virtually all commercial traffic using the outer lanes. Therefore, each side of the Interstate is to be designed for one half of the traffic volume. The average commercial traffic volume for the 20 year design life is $\frac{600 + 900}{2} = 750$ ADT and with half on each side this gives 375 ADT for design purposes, commercial traffic classified as heavy.

Using Figure 16-231.2 and the commercial traffic volume of 375, the Traffic Index is 9.4. A Traffic Index of 9.4 and an R- Value of 30 gives a total unadjusted thickness (gravel equivalent) of 2.15 ft. The climatic factor for Region 2 is 1.05. Multiplying the gravel equivalent thickness by the factor 2.15 x 1.05 = 2.25 ft., gives the design requirement unadjusted for surfacing or base courses.

Since the design standard provides for 0.4' of plantmix and 0.4' of treated base, the thickness (gravel equivalent thickness) will be adjusted for the cohesive strength of these materials using the factor from Table I.

They are as follows:

Surface Course - 0.4 x 2.0 = 0.80 ft. or 0.4' Plantmix = 0.8' of Gran. Bs.

Cold Mix Bituminous Base - 04. x 1.50 = 0.60 ft. or 0.4' Cold Mix - 0.6' of Gran. Base.

Hot Mix Bituminous Base - 0.4 x 1.75 = 0.70 ft. or 0.4' Hot Mix = 0.7' of Gran. Base.

Cement Treated Base - 0.4 x 1.50 = 0.60 ft. or 0.4' CTB = 0.60' of Gran. Base.

Assuming that the cement treated base is least costly the design thickness for untreated base then becomes:

2.25' (Gr. Eq.) - 0.80' (Surf.) - 0.60' (CTB) = 0.85 Ft. Use 0.85.

The typical section would then show:

0.4 ft. plantmix surfacing

0.4 ft. cement treated base

0.85 ft. of gravel base course (Item 301) untreated

1.65 ft. of total thickness

It is advisable to keep course thicknesses in 0.1 ft. increments when possible. The 1.65 ft. thickness (0.85 ft. base) can be increased to 1.70 ft. thickness (0.90 ft. base) to maintain this uniformity.

Checking the design for expansion pressure of the subgrade soil is accomplished using Figure 16-231.4 for 0.61 lb. expansion pressure and the 130 lb/cu. ft. for base, and surfacing materials results in a total thickness requirement of 0.70 ft. Since the R-Value design adjusted for treated base, etc., gives a thickness of 1.70 ft., the thickness provided is adequate. Had expansion pressures resulted in a thickness greater than 1.70 feet, the thickness from expansion pressure would govern the total thickness requirement.

16-232.1 General.

Gradepoints are potential areas of weakness and must be examined critically before the pavement is designed. Factors which contribute to pavement failure at gradepoints are:

(1) Availability of Water: Melting snow, ponded runoff, groundwater table and capillary moisture all provide water to the gradepoint area. Adequate drainage, both surface and subsurface, is essential.

(2) Soil Type: Silty soils in the A-4 and A-5 category are the most susceptible to frost action when moisture is available. Any soils which have been well cultivated or have otherwise supported abundant plant life are to be considered susceptible.

(3) Frost: The factors of water and soil, taken together with frost, spell trouble. Cycles of alternating freezing and thawing seem to cause the greatest damage. Moisture migrates from warm to cold areas, hence it is drawn up into the pavement structure.

16-232.2 Criteria For Treatment.

Selecting those gradepoints which require treatment is largely a matter of judgment based upon consideration of the factors above. The following criteria shall be used in treating those selected:

(1) Remove topsoil to a depth below top of pavement equal to:

a. Pavement structure thickness plus thickness of detrimental soil layer, or
b. Pavement structure thickness, plus one foot whichever is least.

Ordinarily the depth of the detrimental soil layer will vary from 0.5 to 1.0 feet.

(2) Remove all fine grained soil overlying sand, gravel or rock to a depth below top of pavement equal to the pavement structure thickness plus depth of soil not to exceed one foot.

(3) Replace excavated soil with granular material. Such material may be imported or it may come from selective use of rock or gravel excavation. In any case, it should be relatively free-draining.

(4) Provide for adequate drainage, even if this requires deeper excavation. Water must not be trapped in the backfill material, but must be dissipated in the ditches or on the embankment slopes.

16-232.3 Typical Gradepoints and Treatment.

Longitudinal and transverse sections. (See Figures 16-232.31 and 16-232.32). Gradepoint depths as prescribed in materials reports and letters are to be measured from finished grade.

NOTE:

SECTIONS 16-233, 16-241 AND 16-242 ARE NOT CHANGED.