THE LOAD TRANSMISSION TEST FOR FLEXIBLE PAVING AND BASE COURSES

PART III
LOAD DISTRIBUTION THROUGH GRAVEL BASES TO A WEAK SUBGRADE

By

William M Aldous, M H Price, and Walker L. Shearer, Jr

Airport Division

Technical Development Report No 203

CIVIL AERONAUTICS ADMINISTRATION
TECHNICAL DEVELOPMENT AND
EVALUATION CENTER
INDIANAPOLIS, INDIANA

June 1953

U. S. DEPARTMENT OF COMMERCE

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CIVIL AERONAUTICS ADMINISTRATION

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TABLE OF CONTENTS

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PART III

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SUMMARY

This report is the third of a series describing the load-transmission project now in progress at the Technical Development and Evaluation Center of the Civil Aeronautics Administration The testing program involves the application of a static load on a large-scale flexible section of pavement and the measurement of vertical pressure distribution on the surface of the underlying mechanical subgrade Triaxial samples are used to evaluate the paving materials used

The present report includes test data from 48 sections of gravel base course with maximum thicknesses of 24 inches Loads were applied through rigid circular plates ranging from 10 to 30 inches in diameter and through single airplane tires with inflation pressures ranging from 40 to 200 pounds per square inch

Curves and equations are presented to show maximum subgrade pressures and pressure distributions for typical pavement and loading combinations These curves and equations can be used in estimating values for other combinations not actually tested

The quality of the paving material has a significant effect on both the load-transmission and triaxial tests The existing information is not sufficiently complete, however, to attempt a general correlation between the two types of test

INTRODUCTION

The broad objective of this project is to obtain information relative to the transmission and distribution of concentrated loads through flexible paving materials Detailed descriptions of the loading equipment, method of operation, and anticipated uses of the data are included in Part I of this series of reports [1]

During the present testing program, efforts are being made to establish a correlation between the load-transmission test and the simpler triaxial test The methods and equipment used for obtaining this supplementary information have been reported in Part II of the series [2] Other forms of correlative tests have been considered, and some of these will be tried in the future

At present the load-transmission testing program is only in the early stages Ultimately it is planned to investigate the load-transmission properties of a variety of flexible paving materials including gravel, sand, crushed stone, crushed slag, asphaltic concrete, and combinations of these supported by artificial subgrades of different flexibility

The present report describes only one phase of this program, that concerned with the testing of gravel base courses supported by a weak subgrade Since most of these gravel sections were similar with respect to physical composition (such as density, gradation, and moisture content), they represent only one specific test condition The test results and subsequent discussion, therefore, are necessarily limited in scope General conclusions and interpretations of load-transmission tests cannot be made until additional testing is completed However, the relatively uniform conditions of base-course composition and subgrade strength used in this study do afford an excellent opportunity for comparing the effects produced by different sizes and types of loading mediums and different thicknesses of pavement under varying magnitudes of load Furthermore, the development of techniques for analyzing and interpreting the test results was facilitated by minimizing the number of variables during the initial phase of the program.

In studying the data presented in this report, it should be borne in mind that the load-transmission test does not in itself

[1] Raymond C Herner and William M Aldous, "The Load Transmission Test for Flexible Paving and Base Courses, Part I, A Description of the Testing Apparatus, Operating Methods, and Anticipated Uses of Test Data," CAA Technical Development Report No 108, April 1950

[2] William M Aldous, Raymond C Herner, and M. H Price, "The Load Transmission Test for Flexible Paving and Base Courses, Part II, Triaxial Test Data on Structural Properties of Granular Base Materials," CAA Technical Development Report No 144, June 1951

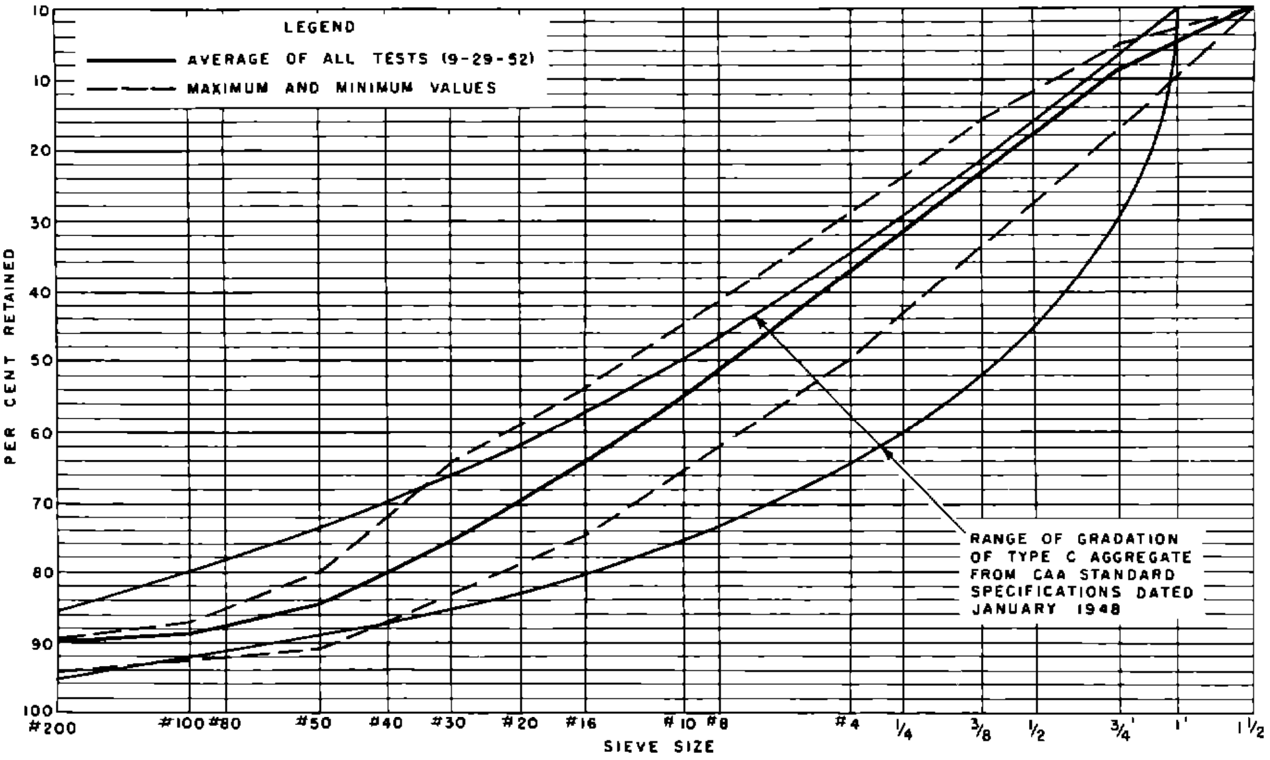


Fig 1 Gradation of Gravel Base-Course Material

constitute a pavement design method It is simply a means for studying and evaluating the action of large sections of flexible paving and base-course materials constructed and loaded under controlled laboratory test conditions

CHARACTERISTICS OF THE GRAVEL TESTED

The material used in constructing the pavement sections may be classified as a dense-graded, semicohesive, clay-bound gravel It is commercially produced by the Standard Materials Company of Indianapolis, Indiana, and has been commonly used as base-course material for Indiana highway construction

The material was excavated from the pit with sufficient care to insure relatively constant proportions of fine, cohesive, overburden material and underlying granular material Especially large particles were removed from the mixture by screening The stockpiled material was rehandled and mixed prior to use in order to obtain a more uniform composition

Fig 1 shows the maximum and minimum ranges of gradation for this material and the average gradation curve for all of the gravel test sections For comparative purposes, this figure also includes the gradation limits for Type C aggregate (one-inch maximum size), as specified for aggregate base-course construction by the Civil Aeronautics Administration [3] Complete gradation data, fineness modulus,[4] compacted density, and moisture content are shown for each test section in Table III of the Appendix

The percentage of moisture and the density shown in this table are not necessarily the optimum values for each test section Instead, a constant density of 135 pounds per cubic foot, at moisture contents ranging from about 5 to 6 per cent, was the aim for each test Variations which occurred in the compactibility of the different mixtures and which were caused partly by differences in the percentages of material passing the 200-mesh sieve were adjusted by applying

[3] "Standard Specifications for Construction of Airports," U S Department of Commerce, CAA Office of Airports, Washington, D C , January 1948, p 132

[4] Determined by ASTM Designation C-125-48

either more or less compactive effort as required to obtain the desired density

In some of the load-transmission tests, as many as 15 tons of gravel were used for a single test section This introduced difficult problems of control in gradation and consistency In spite of all efforts to obtain uniform materials, there were some major differences in the composition of different sections tested There were also a few sections in which variations were introduced intentionally All such variations must be noted and considered in studying the load test data

TESTING EQUIPMENT AND PROCEDURES

Although the equipment and test operations have been described in previous reports, it appears desirable to review these descriptions briefly for the benefit of those readers not having ready access to the prior publications [5,6] This will also serve to cover any changes in equipment or methods which have been made during the course of the project

Description of Equipment

The load-transmission apparatus consists essentially of (1) a spring-supported mechanical subgrade, (2) a device for loading a superimposed pavement section through the use of rigid plates or tires, and (3) apparatus for measuring the vertical movement of the mechanical subgrade during the loading process

The mechanical subgrade is about ten feet square It consists of 3,600 steel plates, each 2 inches square, mounted in 60 rows of 60 each Each plate is supported by a plunger and calibrated spring Provision is made for measuring the deflections of individual springs at any stage in the loading process, thus determining the pressure distribution over the mechanical subgrade

Fig 2 shows a partial section of gravel base course in place on the mechanical subgrade (Bituminous surfacing, as shown in this figure, was not used in the tests covered by this report) Vertical loads are applied to the paving section by means of hydraulic jacks using various sizes of tires or rigid plates as the load transfer medium Accurate measurement of the applied load is obtained by use of load cells with SR-4 strain gages as the sensitive elements In Fig 2, an aircraft wheel is attached to the jacks in position for loading

[5]Herner and Aldous, op cit

[6]Aldous, Herner, and Price, op cit

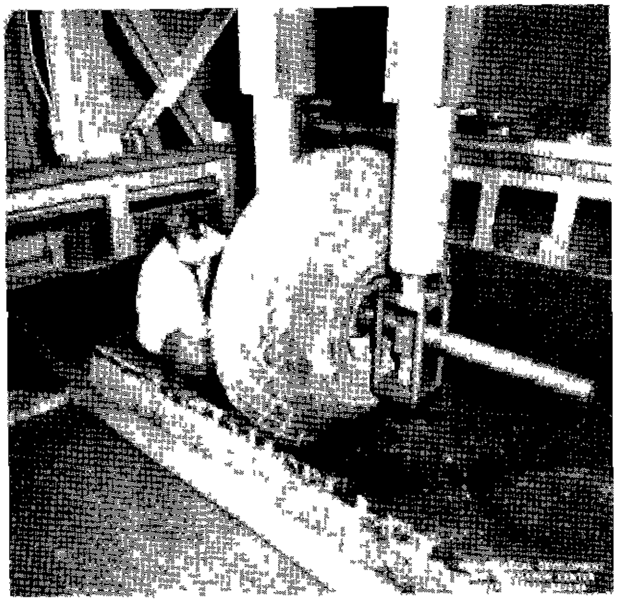


Fig 2 Cutaway Section of Pavement With Tire in Position for Loading

Preparation of Test Sections

Prior to the installation of a paving test section, the plungers are checked to assure accurate performance during the test operation A thin rubber sheet (shown rolled back in Fig 2) is placed over the mechanical subgrade to prevent the infiltration of foreign matter between the plungers and guide cylinders A 1/2-inch layer of sand is spread evenly over the rubber covering to protect it during construction of the pavement section

The gravel is thoroughly mixed in a pugmill, and water is added to bring the mixture to the desired moisture content Carefully weighed batches of the material are placed on the subgrade, spread by hand to proper thickness for a four-inch lift, and compacted to predetermined density by vibratory equipment The compaction operation is shown in Fig 3 After placement of each lift, the compacted thickness of the test section is checked by averaging 36 uniformly distributed measurements from the surface of the pavement to a permanent datum plane

Representative moisture samples are taken from each batch of material during placing operations in order to obtain an average moisture content for each layer Completed test sections are covered with moistened blankets during construction and between testing operations in order to prevent excessive evaporation of moisture Sieve

Fig 3 Vibratory Compactor Compacting Gravel Base Course on Mechanical Subgrade

analysis is made on the material directly below the loaded area at the conclusion of the test series

Test Operations

Before applying a load to the pavement, the elevation of each plunger supporting the area to be used in the test is determined These dead-load readings are used as reference data for subsequent deflection measurements The selected loading medium is carefully located at a selected point on the pavement, and the hydraulic loading equipment, load cells, and recording devices are prepared for operation

Loads of increasing magnitude are applied until the subgrade deflection becomes excessive or until the load limit of the equipment is reached Deflection due to load application is allowed to reach equilibrium before the plunger deflection readings are obtained The time required for equilibrium has varied from one to thirty minutes This amount of time varies with the characteristics of the material, the size and type of loading medium, the magnitude of applied load, and the nearness to failure

Each load application is designated as a test, and all of the load applications on a given test section constitute a test series Due to a certain amount of permanent deformation and residual stress in the pavements, it has been found impractical to use a section for more than one test series

The distribution of vertical load on the mechanical subgrade is determined by measuring the vertical deflection of each spring-supported element The differences between the dead-load and live-load readings of these elements are converted to pressures by means of appropriate calibration curves

Although three sets of subgrade springs have been provided, only the weakest set has been used so far These springs have an average rate of about 350 pounds per inch of deflection As the area supported by each spring is slightly greater than four square inches, the modulus of subgrade reaction (Westergaard's k) for this particular subgrade is approximately 82 pounds per square inch (psi) per inch of deflection

At the conclusion of the normal loading procedure, supplementary tests sometimes are run with a ten-inch plate as the loading medium These tests are made at relatively undisturbed areas of the pavement section, usually near the corners Normal testing procedures are used These tests provide a common denominator for evaluating all test sections, regardless of the conditions of the main test These results can also be used for comparison with those obtained when testing the same material by other methods

During each test in the early phases of the program, recordings were made of the deflections of all the 3,600 plungers contained in the mechanical subgrade This procedure is very helpful for studying particular pressure patterns For most tests, however, the general shape which the pattern will assume is quite apparent Usually it is sufficient, therefore, to record the pressures along the two axes of symmetry of the loading pattern and in the central zone of the loaded area

Accuracy of Load-Transmission Data

The relationships which are developed between the load and subgrade pressure are subject to possible error from four sources (1) measurement of total load, (2) measurement of subgrade deflections, (3) calibration of subgrade springs, and (4) variable frictional losses A precise determination or detailed discussion of the magnitudes of possible errors does not appear warranted, but it may be helpful to discuss them briefly and to estimate the approximate over-all accuracy of the device

The applied loads are measured by strain-gage type of load cells Calibration checks by means of a universal testing machine indicate an error of less than one per cent, even at low loads

Subgrade deflections are read to the nearest thousandth of an inch There is sufficient play in the apparatus, however, to permit deviations up to a maximum of 0 004 inch This amounts to only 0 3 psi of subgrade pressure

Load-deflection rates of the subgrade springs vary somewhat from one spring to another and are not exactly linear throughout the range of use An average calibration curve was prepared from dead-load tests of 243 springs Although load-deflection values for individual spring and guide combinations vary as much as 10 per cent from the average at relatively low loads, there are two factors which greatly minimize the effect of these variations First, the paving material is sufficiently stiff to have a bridging effect across individual subgrade elements The deflection at a given point, therefore, is a function of the average load-deflection rates of the springs in that vicinity Second, because of the symmetry of the loading pattern, it is possible to average the deflections of at least four subgrade elements in order to get one value for plotting or analysis

The over-all accuracy of the apparatus was checked on several occasions by comparing the magnitude of the applied load to the sum of the subgrade loads computed from deflections of the 3,600 subgrade elements Any difference would be due to errors of measurement or to frictional losses in the apparatus In every case checked it was found that the applied load exceeded that recorded by the subgrade springs, indicating losses due to friction rather than to random errors of calibration or measurement

Losses ranged as high as 11 per cent on a single low load but averaged about 7 per cent No attempt has been made to correct the measured values of subgrade pressure, because there is no way of knowing how the error should be distributed over the subgrade area

Preliminary tests on the subgrade spring-plunger-guide assemblies showed that their frictional losses increased rapidly when lateral pressure was applied to the plunger The effect of frictional losses under purely vertical loads was eliminated by calibrating the assemblies in place It seems logical, therefore, that the frictional error directly under the center of the load would be negligible while that of outlying areas might be 20 per cent or more Considering the fact that the subgrade area is about 15,000 square inches, it is doubtful that the error at any given point ever exceeded one psi

Fig 4 Vibratory Tie Tamper Used for Compaction of Triaxial Samples

Supplementary Triaxial Tests

For each pavement section, three corresponding triaxial compression specimens are prepared These specimens are 10 inches in diameter and usually 20 inches high They are compacted to the desired density by means of the vibratory tie tamper shown in Fig 4

The purpose of testing triaxial samples is to establish a correlation between the load-distributing properties of a material as measured in the load-transmission test and its shearing strength as determined by the simpler triaxial test By comparing the triaxial loading curve of each sample against an average curve for a large number of samples, it is possible to check the uniformity of the material and to establish the relative strength of the test sections

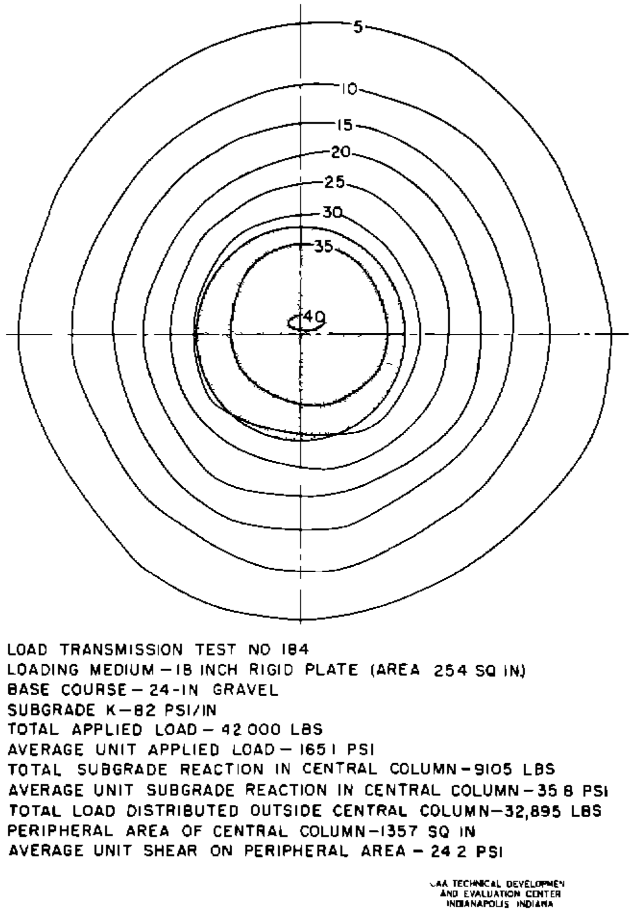


Fig 5 Typical Pattern of Subgrade Pressure Distribution Under Plate Loading

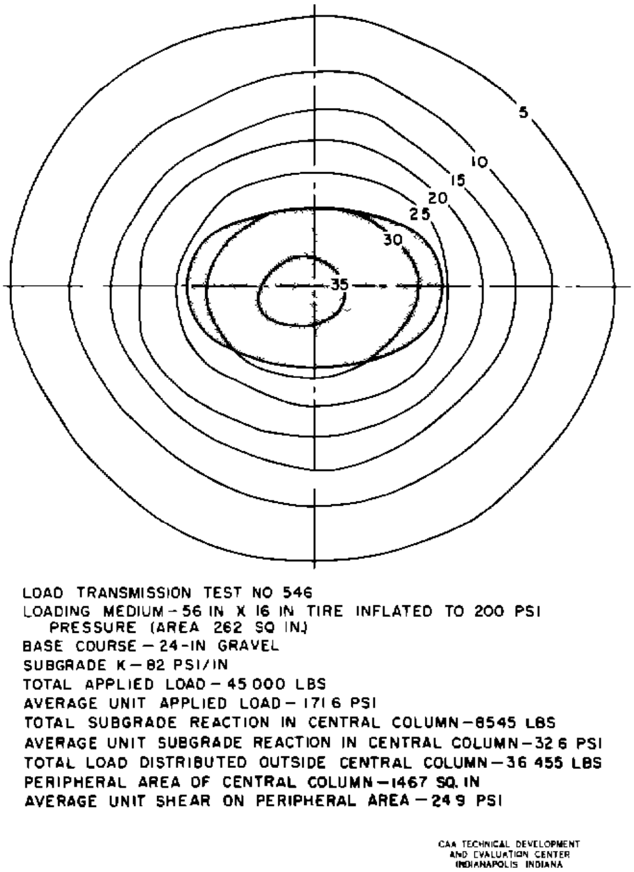


Fig 6 Typical Pattern of Subgrade Pressure Distribution Under Tire Loading

In the earlier tests, it was assumed that the material for the triaxial samples would be sufficiently representative of that in the pavement section if both were taken from the same bin It was found that this assumption was not always true because of random variations in large quantities of commercial material Beginning with load-transmission test No 312, therefore, the triaxial specimens were prepared from a composite sample taken from the mixed material as placed in the pavement

LOAD-TRANSMISSION AND TRIAXIAL TEST DATA

Fig 5 illustrates a typical pattern of subgrade pressure contour curves obtained by loading a 24-inch gravel base course through the medium of a circular rigid plate A similar pattern for tire loading is shown in Fig 6 These patterns were obtained from tests in which the total loads, pavement thicknesses, and contact areas were of about the same magnitude The slight irregularities and eccentricities in the contour curves may be ascribed to lack of complete homogeneity in the base-course material

Each figure contains tabular information on stresses in the "central column" The central column is the right cylindrical volume of paving material outlined by vertical projections from the edge of the contact area of the loading medium The total applied load minus the recorded load on the subgrade at the base of the central column is equal to the load transmitted to adjacent areas because of shearing resistance developed on the periphery of the column

Because of the consistent regularity of shape of the pressure patterns from any single loading medium, it was found that satisfactory distribution patterns could be obtained by reading deflections of a double row of plungers along the axes of symmetry of the loading pattern. For each test, graphs were prepared showing the cross-sectional distribution of subgrade pressure along these axes It is not considered practical to show all of these detailed graphs in this report, but representative examples covering a wide range of test variables are included as Figs 14 to 25 of the supplemental material in the Appendix These will be helpful to those who wish to use the test data for comparison with results from other stress-distribution tests or from theoretical computations

The pressure-distribution pattern is generally helmet-shaped with the maximum subgrade pressure, called reaction r, occurring under the center of the load The only exception to this condition was found in the case of 30-inch rigid-plate loadings on 8-inch base courses For this exception the maximum subgrade pressure occurred at a point between the center and the edge, the exact point varying somewhat with the load In some of the following discussions the maximum subgrade reaction is used as a practical indicator of comparative pavement performance

Loading conditions and values of maximum subgrade reaction are shown in Table IV of the Appendix for each individual test using rigid plates Equations are included showing the mathematical relationship between maximum subgrade reaction and total load V_k for each test series The maximum reaction r is taken as the highest average value from four segments of the mechanical subgrade Because this represents an average over an area of 16 8 square inches, it is slightly below the true maximum obtainable at one point The difference is minor

Table V of the Appendix gives similar data for tests with tires Tire contact areas used in computing average applied pressures were obtained by making tire imprints on paper supported by a flat, rigid surface These values should approximate those from corresponding loads on the pavement surface They do vary considerably, in some instances, from theoretical values obtained by dividing the total load by the inflation pressure This is probably due to rigidity of the tire casing

Table VI of the Appendix presents the triaxial test results on specimens corresponding to the various load-transmission test sections Vertical pressures are recorded at the maximum and also at 0 1-, 0 2-, and 0 3-inch deflections

In some instances, accidental variations in materials or procedures resulted in triaxial specimens which varied considerably from their supposed counterparts in density, moisture content, or other important physical characteristics These differences are shown in the tables and should be considered carefully in any attempt to correlate results from the two types of tests

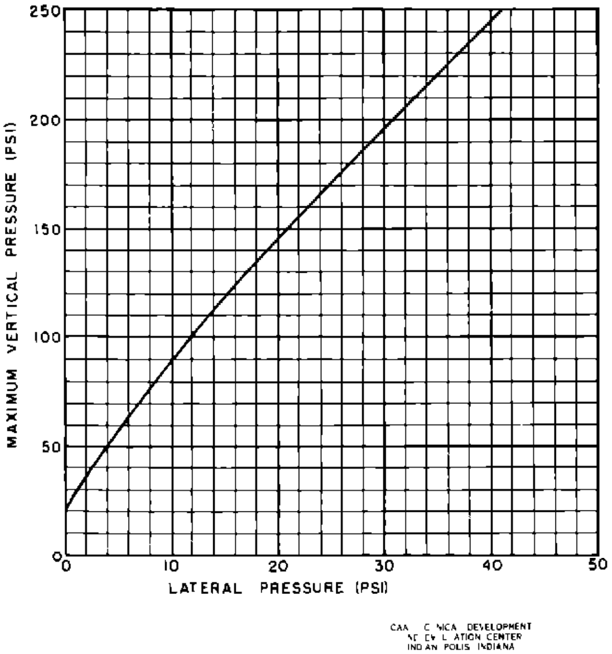


Fig 7 Average Results From Triaxial Tests on Normal Gravel Specimens

Fig 7 shows the relationship between lateral pressure and maximum vertical pressure for a normal gravel and thus can be used as a standard of reference for triaxial test results from individual test specimens This curve, taken from a previous report, averages the results from 54 tests at lateral pressures ranging from 0 to 30 psi [7] Physical characteristics of the materials used in these tests are given in Table I

EFFECT OF DIFFERENT VARIABLES INFLUENCING LOAD DISTRIBUTION

It has been determined that the pattern of the load distribution from any test series is a function of (1) pavement thickness, (2) contact area, (3) type of loading medium, tire or rigid plate, and (4) the pavement strength The effect of each variable will be discussed in the following subsections of this report Because of the fact that only one set of subgrade springs has been used so far, all discussions and conclusions will apply only to a similar weak subgrade condition

As previously indicated, the pattern of pressure distribution on the subgrade has

[7] Ibid

TABLE I

PHYSICAL CHARACTERISTICS OF TRIAXIAL TEST MATERIAL

	Fineness Modulus	Fraction Passing No. 200 Sieve (per cent)	Moisture Content (per cent)	Dry Density (pounds per cubic foot)
Range of Values	3 96 to 4 66	8 to 12	4.8 to 6 5	134 to 138
Average Values	4 29	10 4	5.81	135 7

the same general shape for all single loads If a better distribution of the load is obtained in one test series than in another (because of a thicker pavement, a larger contact area, or any other factor), the area of distribution on the subgrade becomes larger and the maximum subgrade reaction becomes smaller The numerical value of the maximum subgrade reaction thus serves as a convenient basis for comparing the effect of various pavements and loading conditions It will be used for that purpose in much of the following discussion.

For the tests included in this report, the relationship between the total load V_k and the maximum subgrade reaction r can be expressed by a parabolic equation of the general form

$$r = aV_k^{\,b} \qquad (1)$$

where

r = the maximum subgrade reaction in psi,

a = a coefficient numerically equal to r for a one-kip applied load,

V_k = the total applied load in kips,

b = an exponent representing the incremental percentage change ratio between r and V_k.

The relationship can also be expressed in the form

$$V_k = cr^d \qquad (2)$$

where

$c = (\frac{1}{a})^{\frac{1}{b}}$, or a coefficient numerically equal to V_k for an r of one psi,

$d = (\frac{1}{b})$, or an exponent equal in value to the reciprocal of b.

Numerical solutions of both equations are given in the Appendix

Graphs of these equations will be straight lines if plotted on a log-log scale There is a tendency for the observed data to depart from the linear relationship with extremely low or high loads At low loads, the differences are small numerically and may be due to adjustment of material during the seating of the loads From observance of visible cracks and other evidences of failure in certain pavement sections, it appears likely that the upper limit of logarithmic proportionality marks the point of incipient failure.

Effect of Pavement Thickness

An increase in pavement thickness, with other factors remaining constant, results in a corresponding decrease in maximum subgrade reaction This effect is illustrated in Fig 8 The right-hand portion of the figure shows the load distribution on the subgrade for an 18-kip load, applied on an 18-inch rigid plate, and transmitted through gravel base courses of 8-, 16-, and 24-inch thickness The left-hand portion of the figure shows the variations of maximum subgrade reaction throughout the loading range for each of the test series

In this particular case an 8-inch increase in base thickness resulted in a decrease approximating 50 per cent in maximum subgrade reaction Although the foregoing example indicates the significance in changes of thickness, the exact percentage of change will vary with other test conditions

Effect of Load Contact Area.

The contact area over which the load is applied is another important factor in determining pressure distribution to the subgrade. In tests with tires, the contact area varies both with load and with inflation pressure Even moderate changes in tire inflation pressure may produce definite and measurable changes in the distribution pattern This is illustrated in Fig 9

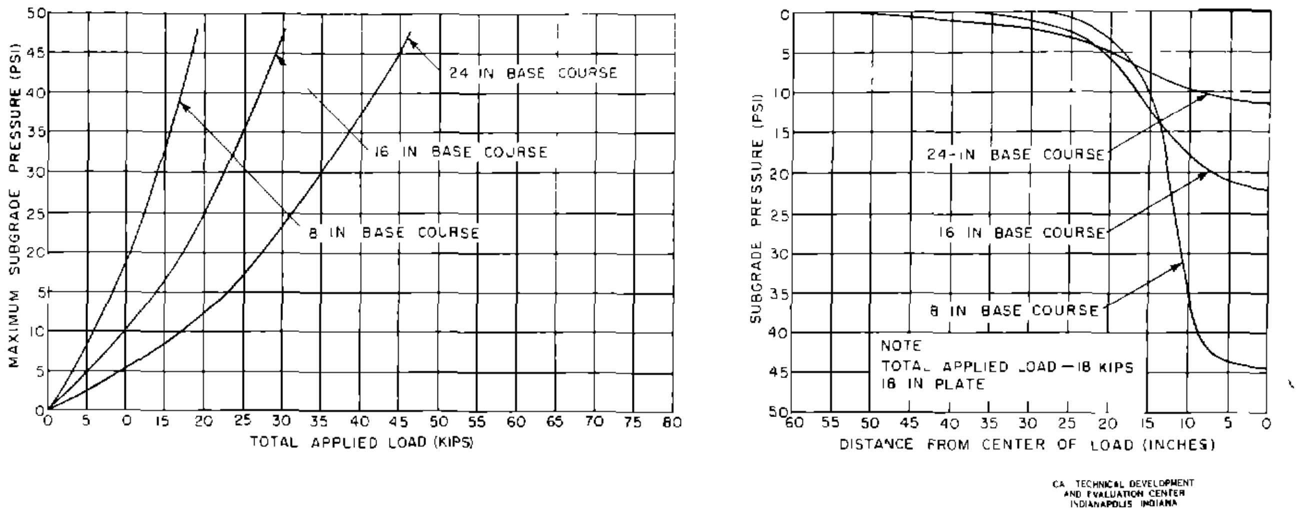


Fig 8 Load Distribution Patterns Showing Effect of Gravel Base-Course Thickness

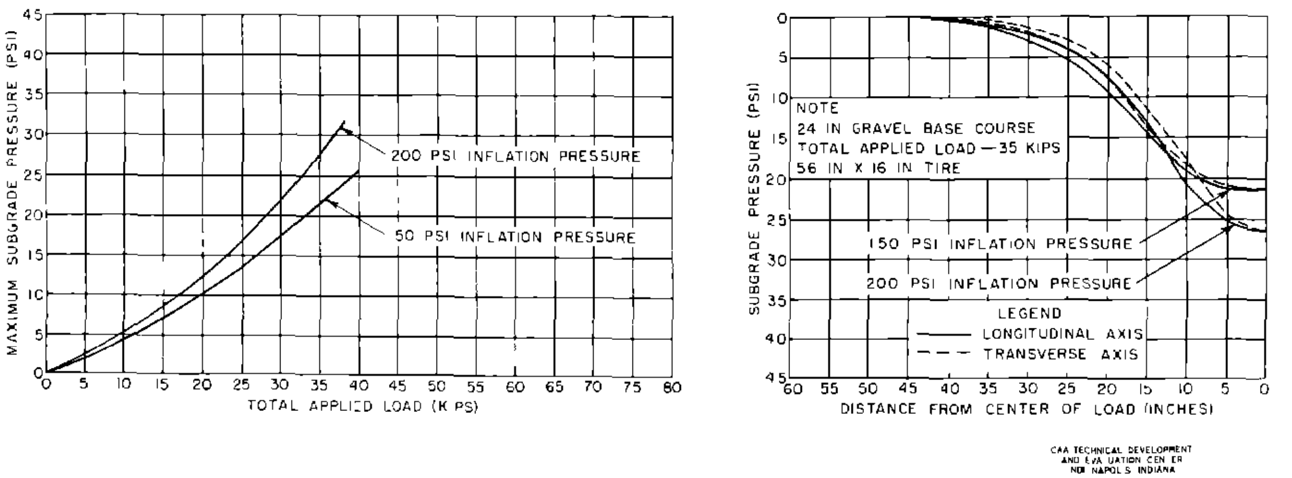


Fig 9 Load Distribution Patterns Showing Effect of Inflation Pressure

Although the same trend was apparent throughout the testing program, there were some instances in which the effect of moderate changes in inflation pressure apparently was offset by changes in other test conditions In tests with the 36-inch tire, for instance, variations of inflation pressure from 42 to 73 psi seemed to have little effect These results may have been influenced by the attempt to use different inflation pressures in a single test series and within a rather narrow range of loadings

Comparative Effect of Different Loading Mediums

Even if a load is selected so that the contact area of a given tire is equal to that of a given rigid plate, the shapes of the areas will be dissimilar and the distribution of applied load within the contact areas may vary widely It seemed logical, therefore, that the pressure distribution on the subgrade should also vary Because tire contact areas vary with the load, it was necessary to interpolate between actual test values in order to obtain data for direct comparison at equal areas

Such comparisons indicate that the tire is more efficient than the rigid plate at high unit contact pressures In some cases, the decrease in maximum subgrade pressure amounts to 30 per cent At moderate to low contact pressures (100 psi or less) the effect of the loading medium tends to become less, particularly if the pavement is thick enough to keep subgrade pressures at low values

TABLE II

COMPARATIVE RESULTS FROM RIGID PLATES AND SINGLE TIRES AT APPROXIMATELY EQUAL CONTACT AREAS

Example	Total Load (kips)	Approximate Contact Area (square inches)	Approximate Unit Load (psi)	Pavement Thickness (inches)	Loading Medium	Maximum Subgrade Reaction (psi)
A	44	254	173	24	18-in diameter plate	43
	44	254	173	24	56 x 16-in tire at 200 psi	35
B	18	113	159	16	12-in diameter plate	38
	18	113	159	16	56 x 16-in tire at 200 psi	26
C	24	254	95	24	18-in diameter plate	17 5
	24	254	95	24	47-in tire at 100 psi	17
D	9 6	113	85	16	12-in diameter plate	14
	9 6	113	85	16	47-in tire at 100 psi	14
E	17 5	254	69	24	18-in diameter plate	10
	17 5	254	69	24	47-in tire at 63 psi	9
F	17 5	254	69	16	18-in diameter plate	22
	17 5	254	69	16	47-in tire at 63 psi	18
G	7	113	62	16	12-in diameter plate	8
	7	113	62	16	47-in tire at 63 psi	7 5
H	7	113	62	8	12-in diameter plate	21
	7	113	62	8	47-in tire at 63 psi	15 5

Note Because of uncertainties in measuring tire contact areas, the information in this table should be considered only as indicative of a trend

Comparative values at contact pressures ranging from 62 to 173 psi are given in Table II

Effect of Pavement Strength

The possible effect of pavement strength on load distribution is illustrated in Fig 10 This figure shows comparative results from two load-transmission test series which differed only in the physical characteristics of the gravel base course The comparatively poor performance of the paving section in test series 532 to 541 was apparently caused by higher moisture content and a lower percentage of fine material These factors combined to produce a higher state of lubrication in the mass This is indicated also in the triaxial test results which are shown graphically in the same figure

Although there is a general trend for the load-transmission and triaxial test results to vary in a parallel manner, the results are not entirely consistent

Examples such as those given indicate the possibility of correlation between the triaxial and load-transmission test results

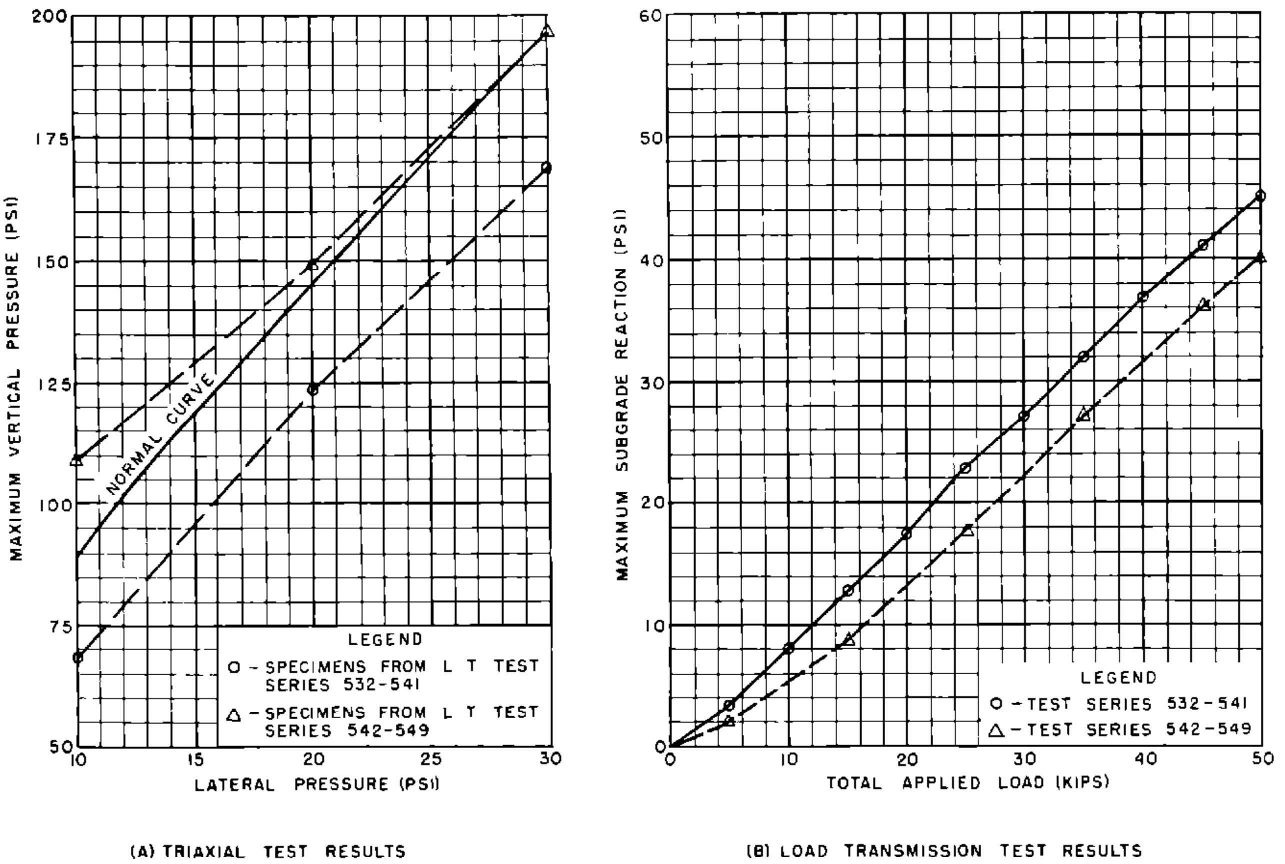


Fig 10 Tests Showing the Effect of Pavement Strength

Most of the test sections included in this report, however, fall within a comparatively narrow range of physical characteristics. As mentioned previously, there have also been some accidental variations in test specimens prepared for correlation purposes It is not considered advisable, therefore, to attempt any general correlation until tests have been run on other materials

Interrelationship of Variables

The interrelated effects of the variables influencing load distribution may be shown conveniently by families of curves as illustrated in Figs. 11 to 13 These curves have been constructed in a form to show the thickness of pavement required to limit the maximum subgrade pressure to a specified value when different loads and loading mediums are used They represent actual test results, with very little smoothing and no extrapolation

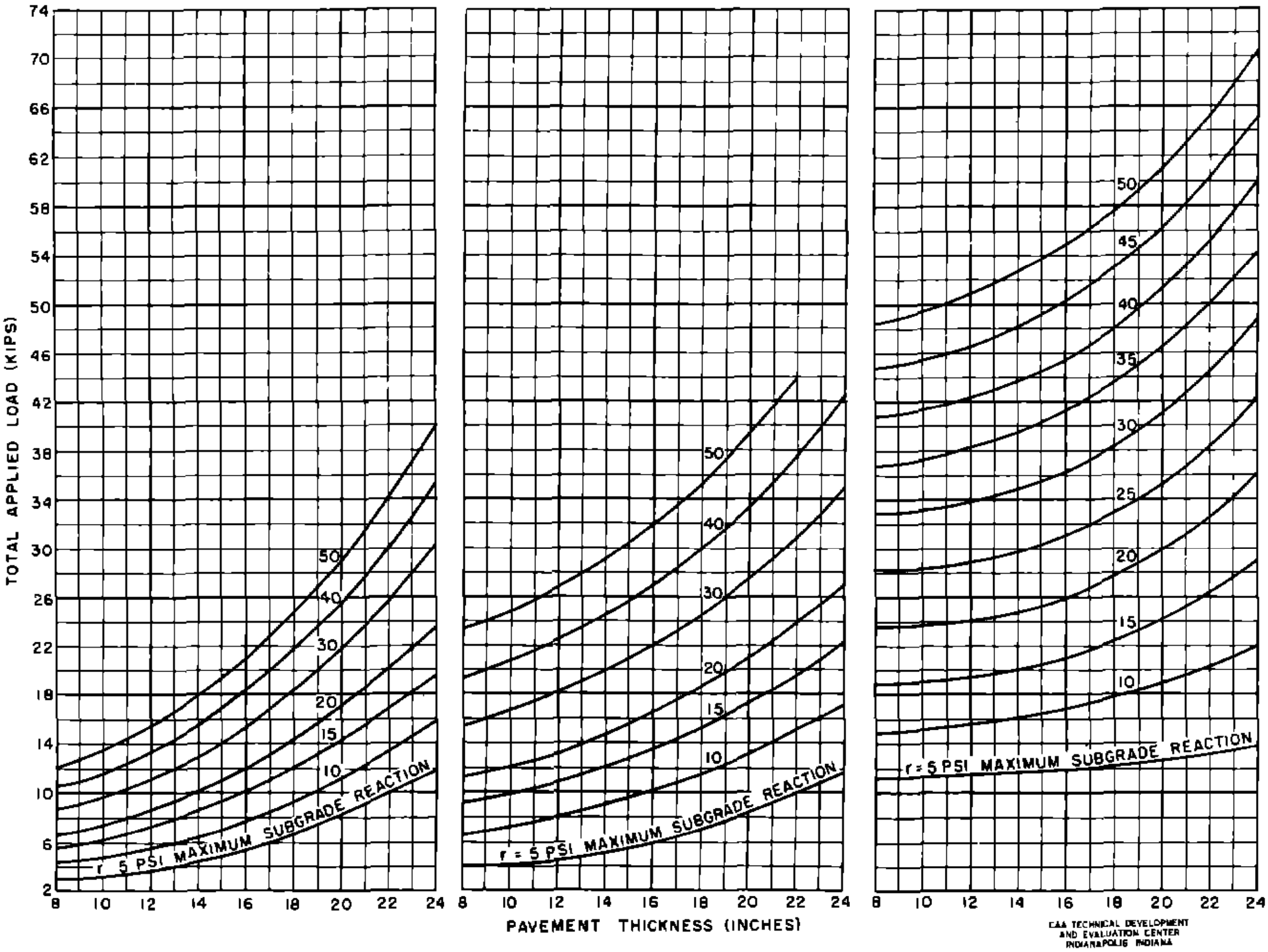
The test sections used to obtain data for these curves were those with physical characteristics reasonably close to the average. The curves include only those values of maximum subgrade pressure which fall below the upper limit of logarithmic proportionality

CONCLUSIONS

The load-transmission testing program is only in its early stages The principal purpose of this report is to make the data collected to date available for study by others The following conclusions are supported by the test results observed thus far

1 The load-transmission apparatus provides a convenient and relatively accurate means of determining the distribution of vertical stresses through large-scale pavement test sections

2 For single loads the pressure-distribution pattern on the subgrade is helmet-shaped, with the maximum generally occurring directly under the center of the load



(A) 12-INCH PLATE   (B) 18 INCH PLATE   (C) 30 INCH PLATE

Fig 11 Interrelationship of Load, Pavement Thickness, and Subgrade Reaction When Using Plate Loading, Gravel Base Course, and Weak Subgrade

3 The maximum subgrade reaction may be used as a basis for comparing results from different pavement sections and different loading conditions

4 The magnitude of the maximum subgrade reaction is influenced largely by (1) the total load, (2) the pavement thickness, (3) the contact area, (4) the type of loading medium, and (5) the physical properties of the paving mixture Families of curves have been developed to show the interrelationship of these variables for tests conducted on normal gravel base-course material supported by a weak subgrade

5 The type and physical characteristics of the paving material have similar effects on both the load-transmission and triaxial test results, thus offering hope of a correlation between the tests The test results now available do not cover a sufficient variety of materials for development of such a correlation.

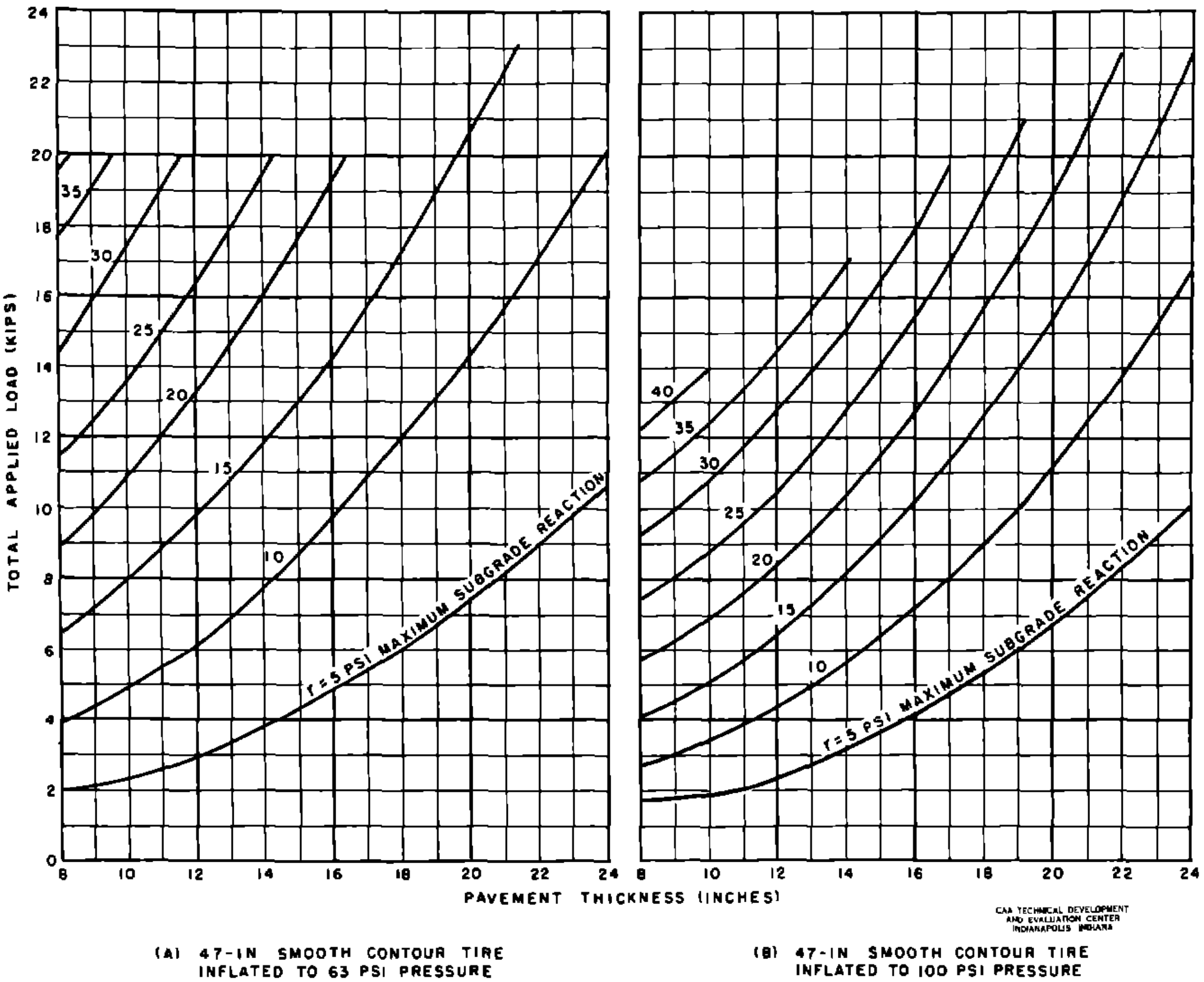


Fig 12 Interrelationship of Load, Pavement Thickness, and Subgrade Reaction When Using Low-Pressure Tire Loading, Gravel Base Course, and Weak Subgrade

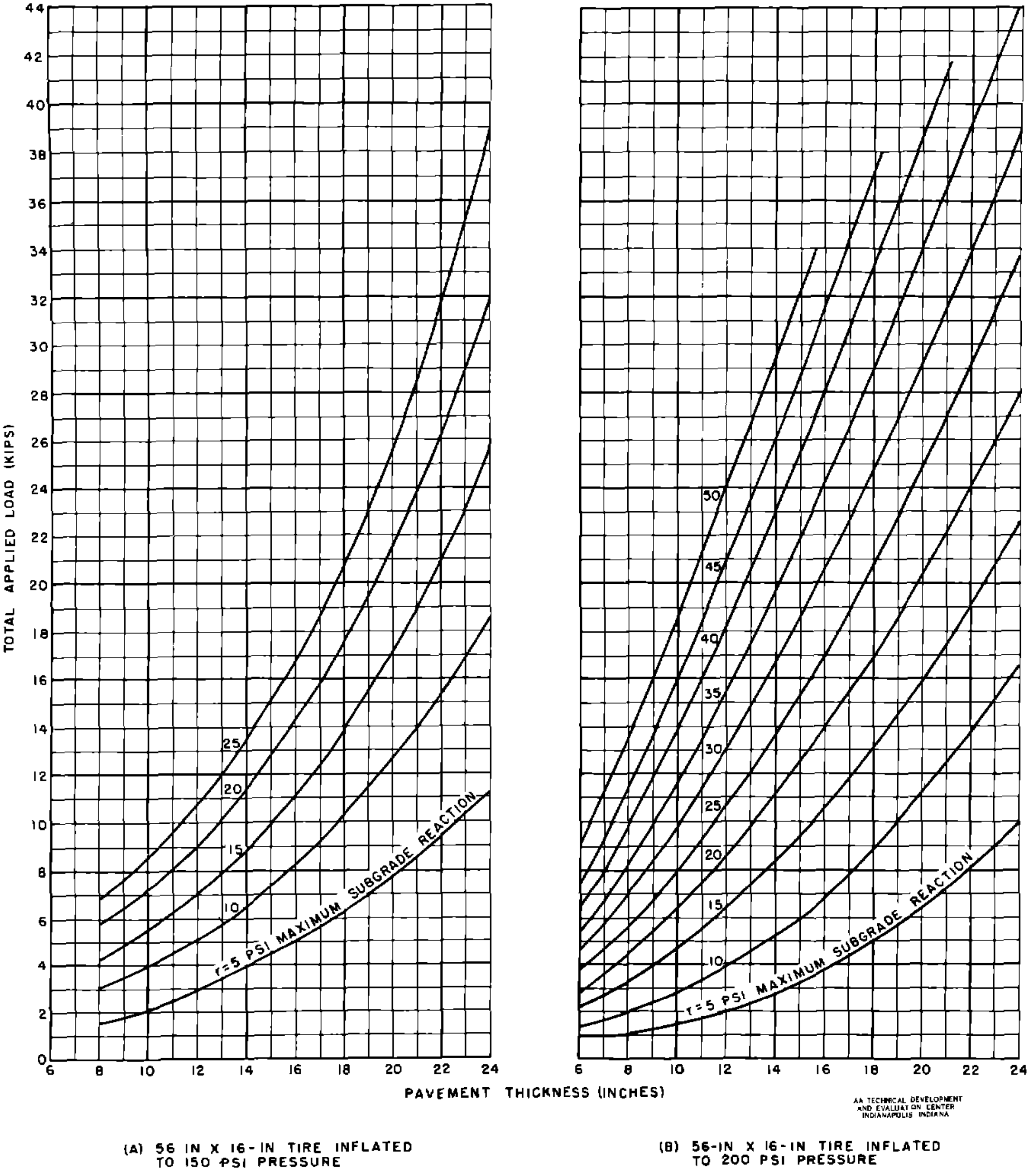


Fig 13 Interrelationship of Load, Pavement Thickness, and Subgrade Reaction When Using High-Pressure Tire Loading, Gravel Base Course, and Weak Subgrade

APPENDIX

SUBGRADE PRESSURE DISTRIBUTION PATTERNS
(Figs 14 – 25)

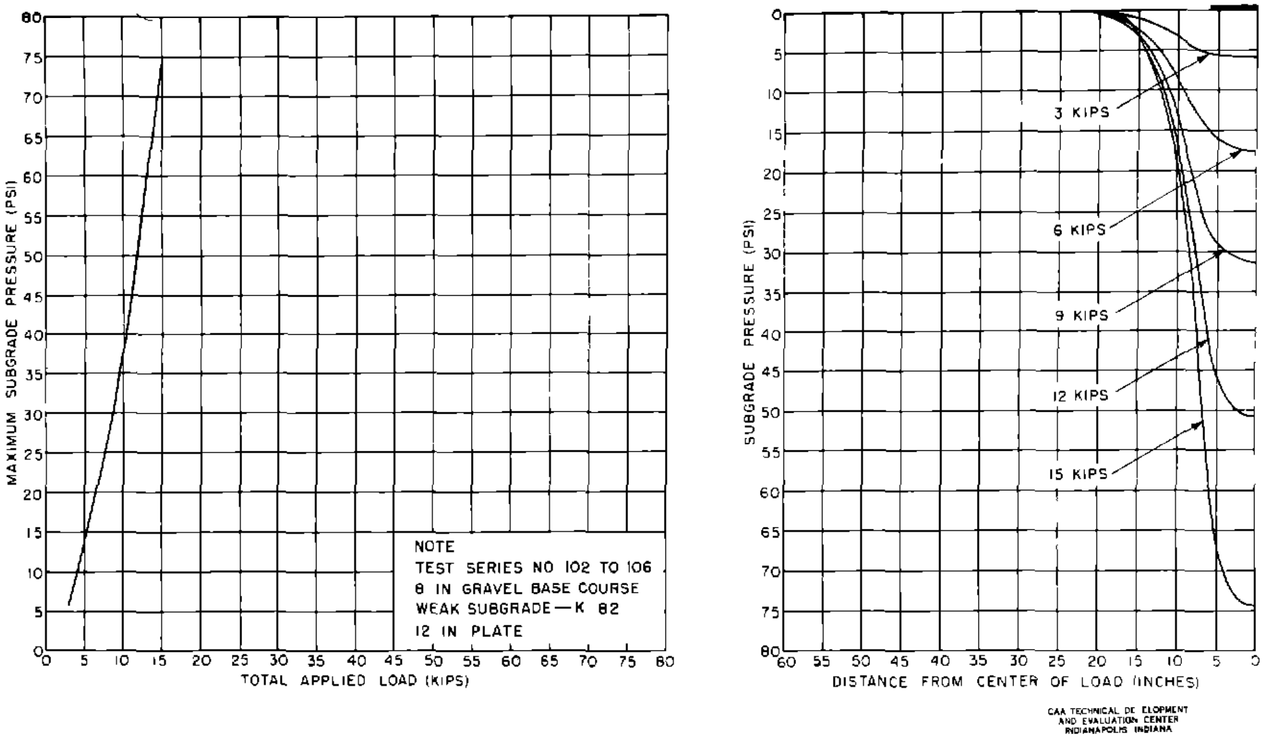


Fig 14

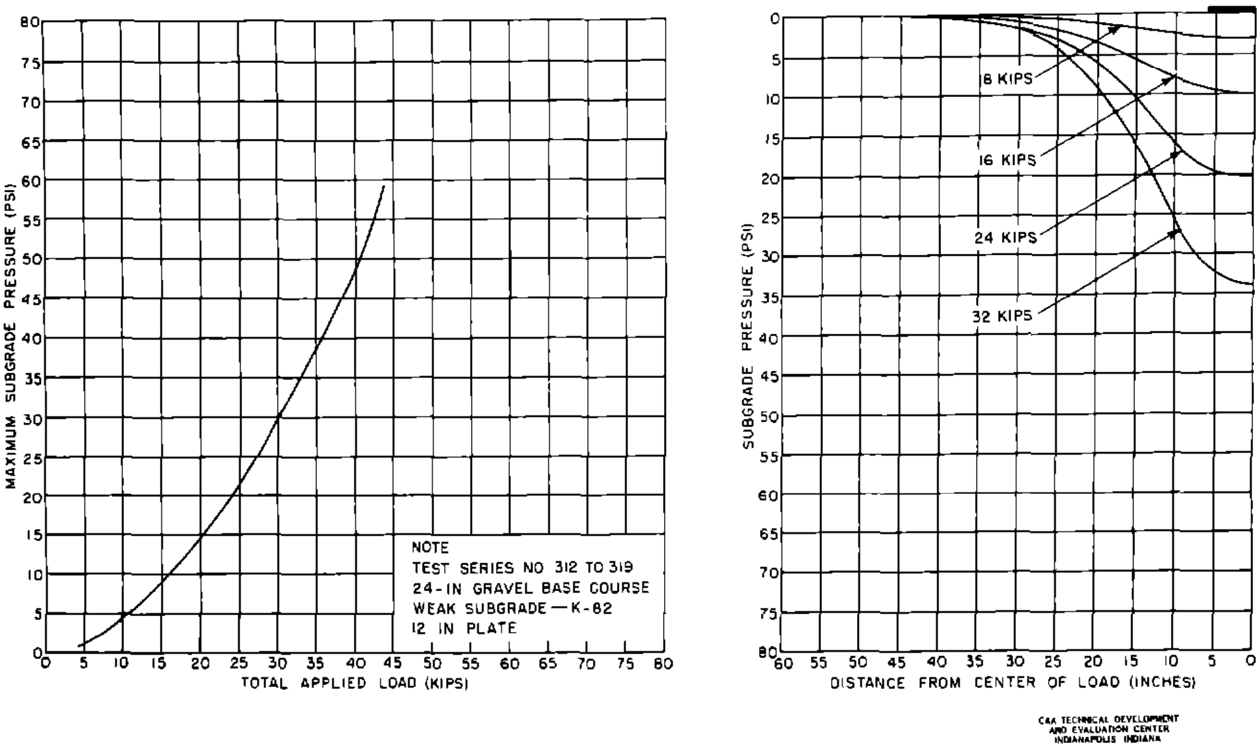


Fig 15

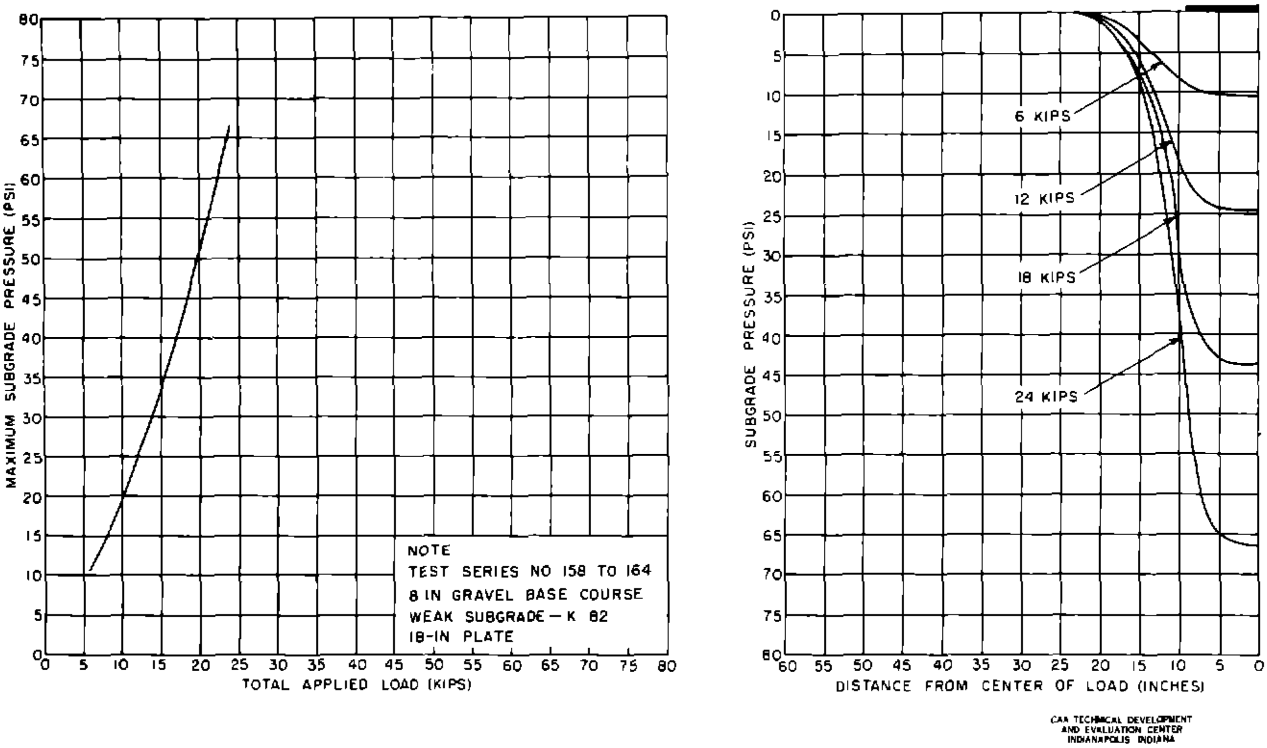

MAXIMUM SUBGRADE PRESSURE (PSI)
TOTAL APPLIED LOAD (KIPS)
NOTE
TEST SERIES NO 158 TO 164
8 IN GRAVEL BASE COURSE
WEAK SUBGRADE — K 82
18-IN PLATE
SUBGRADE PRESSURE (PSI)
DISTANCE FROM CENTER OF LOAD (INCHES)
6 KIPS
12 KIPS
18 KIPS
24 KIPS
CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 16

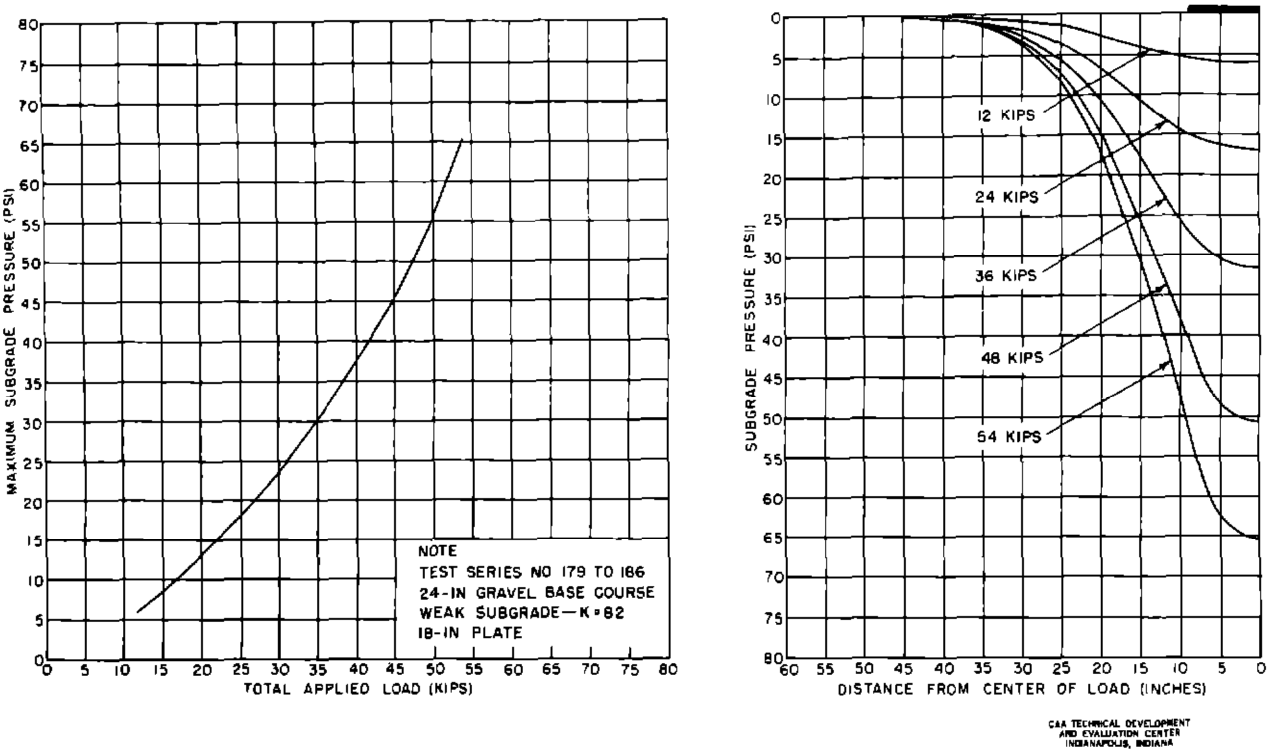

MAXIMUM SUBGRADE PRESSURE (PSI)
TOTAL APPLIED LOAD (KIPS)
NOTE
TEST SERIES NO 179 TO 186
24-IN GRAVEL BASE COURSE
WEAK SUBGRADE—K=82
18-IN PLATE
SUBGRADE PRESSURE (PSI)
DISTANCE FROM CENTER OF LOAD (INCHES)
12 KIPS
24 KIPS
36 KIPS
48 KIPS
54 KIPS
CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS, INDIANA

Fig. 17

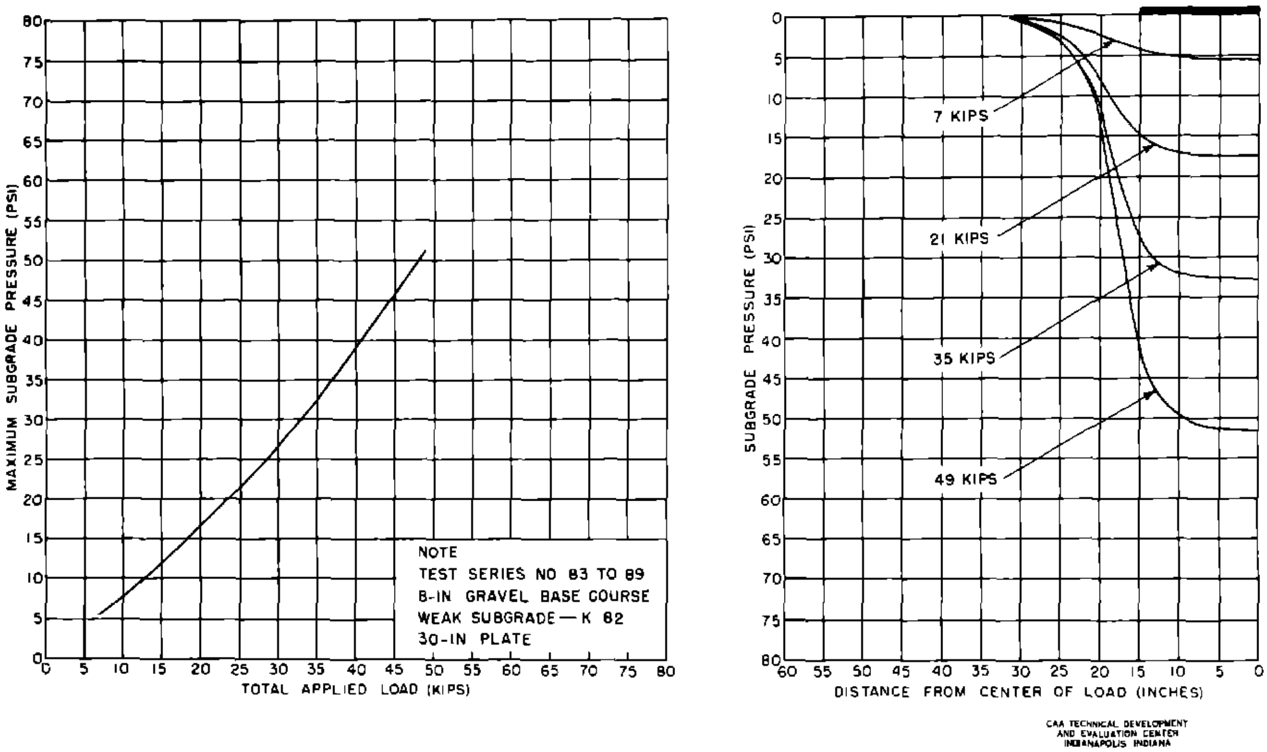

MAXIMUM SUBGRADE PRESSURE (PSI)
TOTAL APPLIED LOAD (KIPS)
NOTE
TEST SERIES NO 83 TO 89
8-IN GRAVEL BASE COURSE
WEAK SUBGRADE — K 82
30-IN PLATE
SUBGRADE PRESSURE (PSI)
DISTANCE FROM CENTER OF LOAD (INCHES)
7 KIPS
21 KIPS
35 KIPS
49 KIPS
CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 18

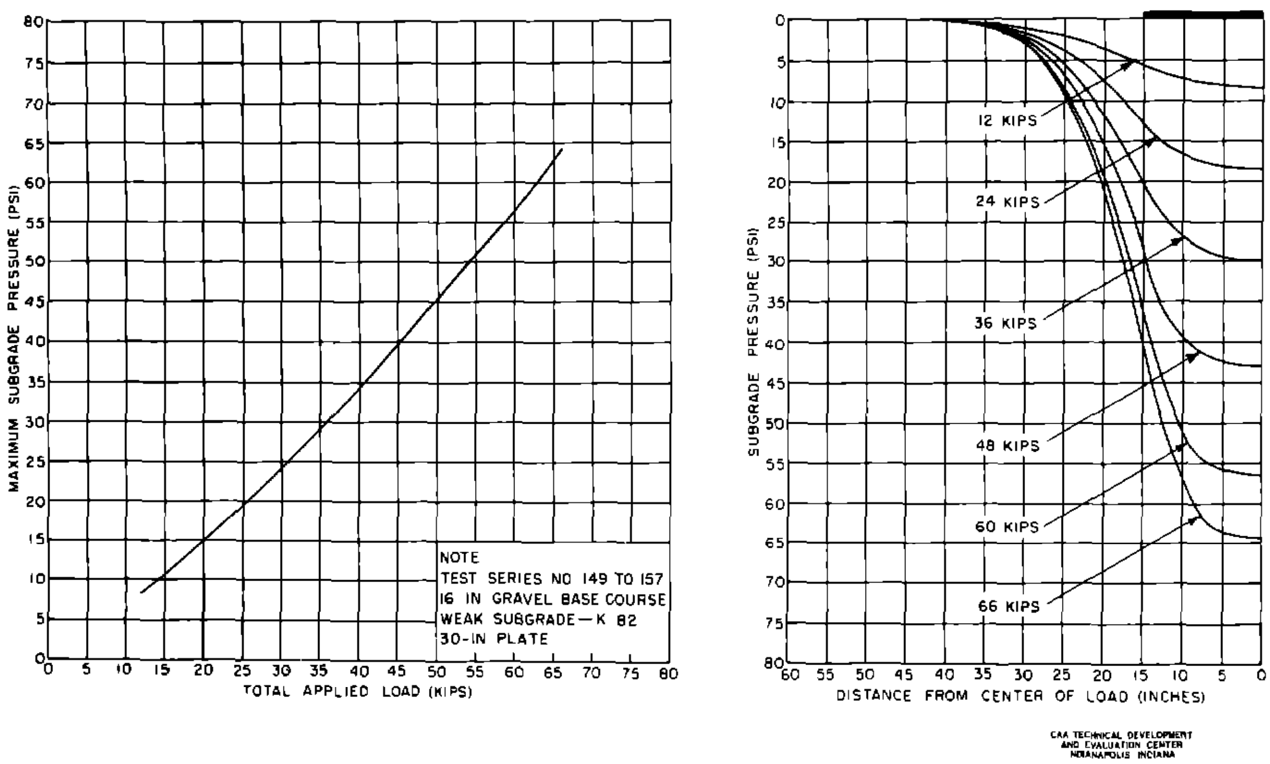

MAXIMUM SUBGRADE PRESSURE (PSI)
TOTAL APPLIED LOAD (KIPS)
NOTE
TEST SERIES NO 149 TO 157
16 IN GRAVEL BASE COURSE
WEAK SUBGRADE — K 82
30-IN PLATE
SUBGRADE PRESSURE (PSI)
DISTANCE FROM CENTER OF LOAD (INCHES)
12 KIPS
24 KIPS
36 KIPS
48 KIPS
60 KIPS
66 KIPS
CAA TECHNICAL DEVELOPMENT AND EVALUATION CENTER INDIANAPOLIS INDIANA

Fig 19

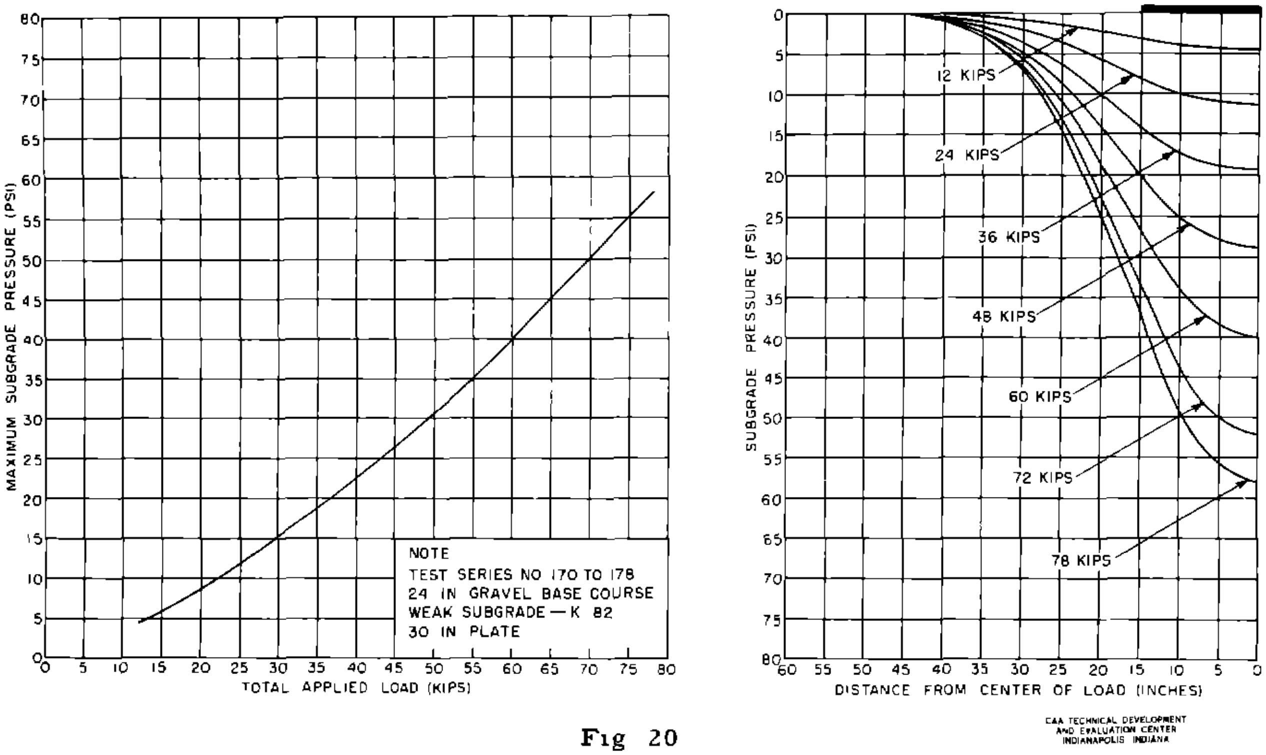


Fig 20

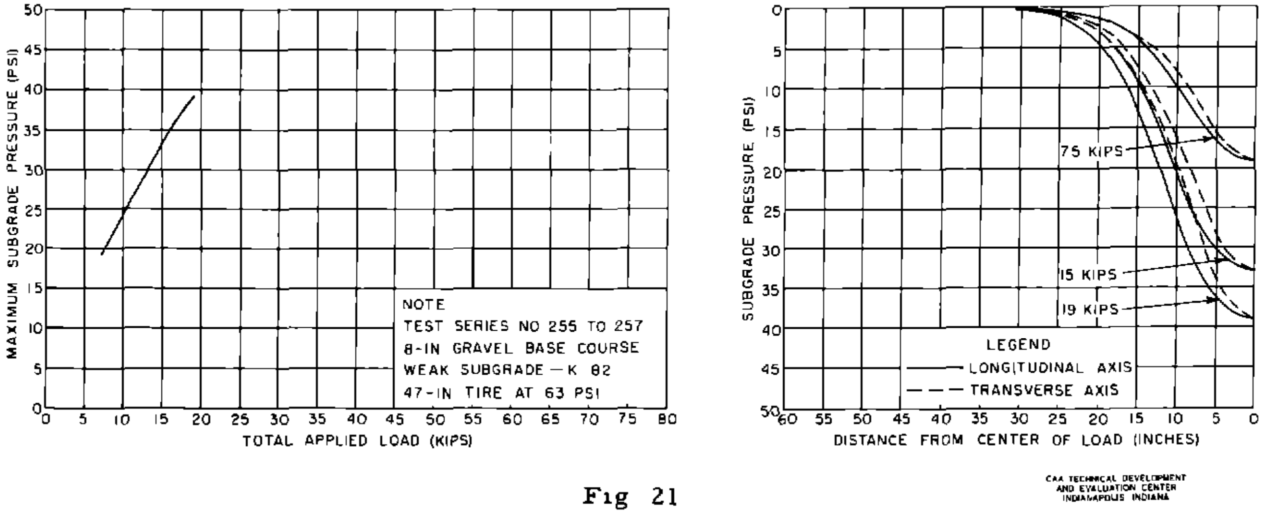


Fig 21

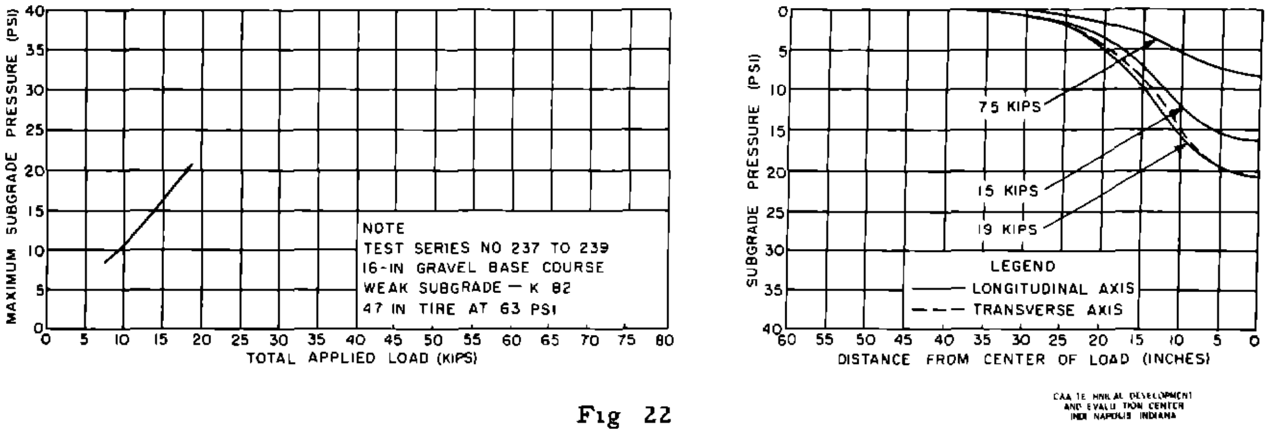


Fig 22

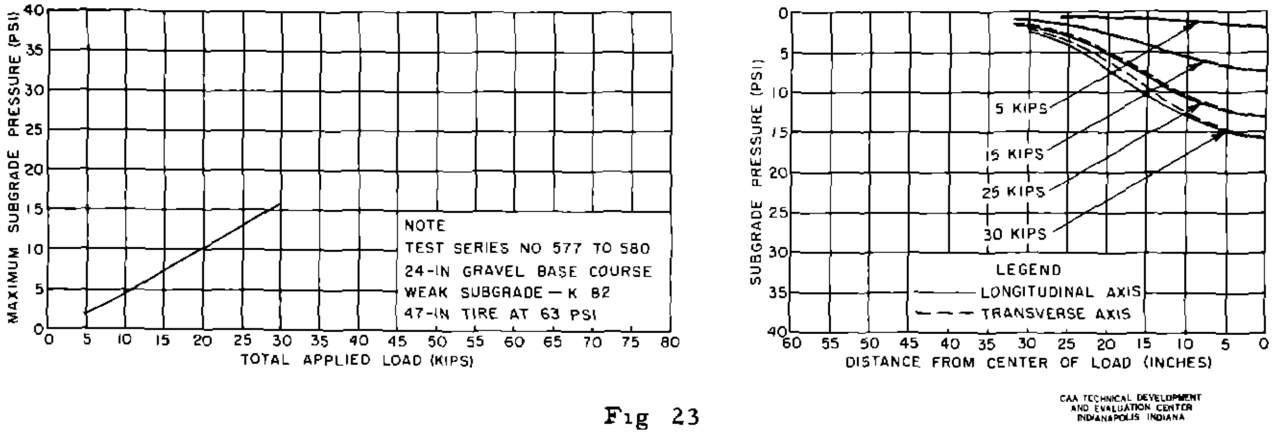


Fig 23

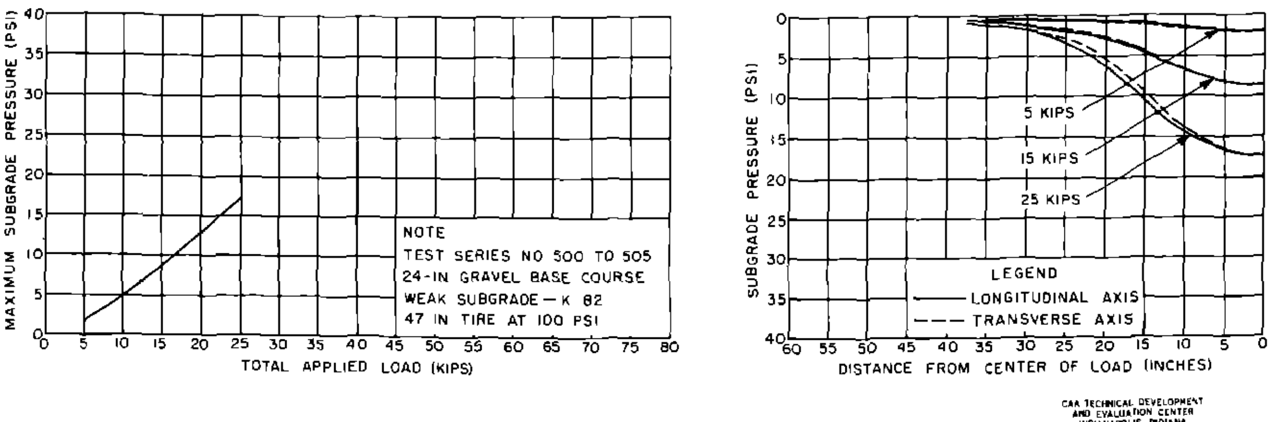


Fig 24

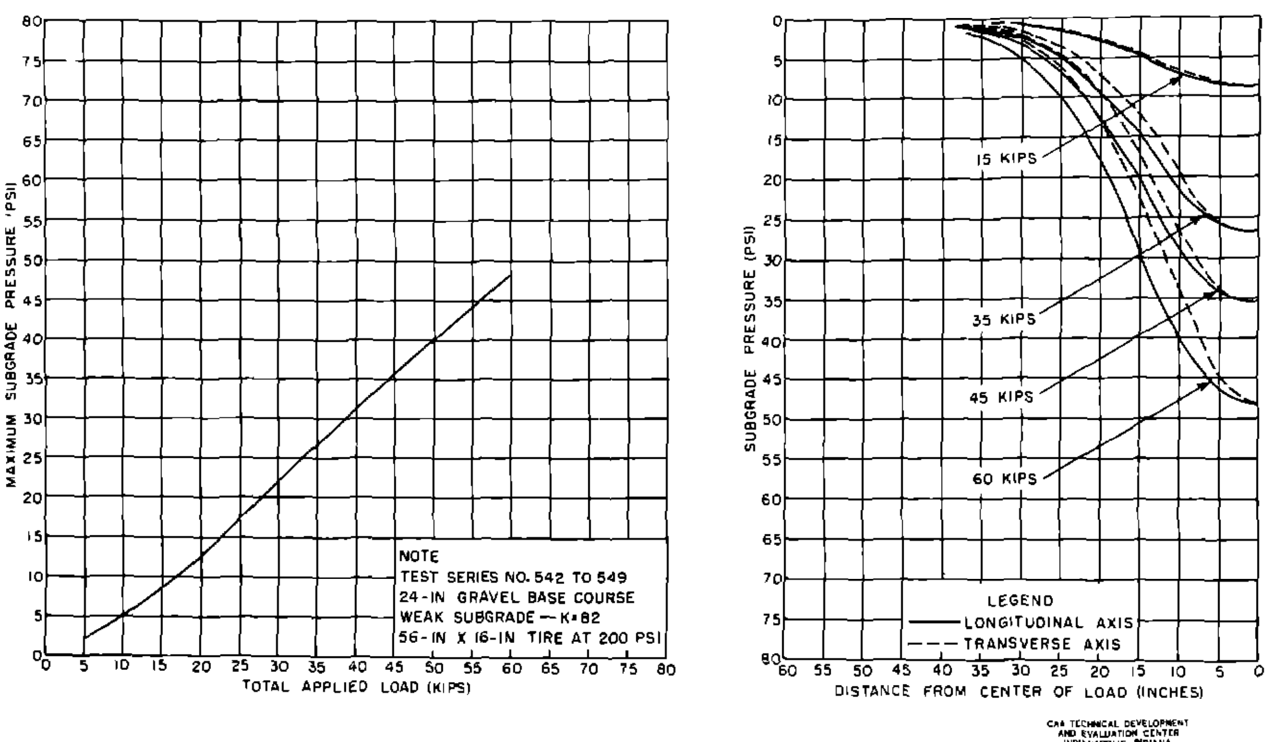


Fig 25

APPENDIX (continued)

TABULATIONS OF GENERAL TEST DATA
(Tables III – VI)

TABLE III

PHYSICAL CHARACTERISTICS OF THE GRAVEL TEST SECTIONS

Load Transmission Test No	Amount Retained on Sieve (Noncumulative)									Amount Passing No 200 (per cent)	Fineness Modulus	Moisture Content (per cent)	Density (lb per cu ft)	Triaxial Test No
	1 1/2 Inch (per cent)	3/4 Inch (per cent)	3/8 Inch (per cent)	No 4 (per cent)	No 8 (per cent)	No 16 (per cent)	No 30 (per cent)	No 50 (per cent)	No 100 (per cent)	No 200 (per cent)					
64-68	0	9 5	11 0	13 7	16 3	10 7	16 6	9 4	3 0	0 8	9 0	4 31	6 2	135	168-170
69-74	0	10 7	14 0	11 6	12 0	9 0	16 8	9 9	4 4	1 7	9 9	4 24	6 2	135	171-173
75-82	0	15 2	19 3	11 8	9 3	7 4	13 3	8 8	4 5	1 7	8 8	4 24	6 2	134	174-176
83-89	0	16 6	14 9	10 6	11 4	7 9	15 0	9 4	4 3	1 6	8 5	4 57	6 0	134	177-179
90-94	0	8 2	14 7	15 1	16 8	11 7	15 4	8 9	3 0	0 9	5 3	4 57	6 2	135	180-182
95-101	0	8 2	14 7	15 1	16 8	11 7	15 4	8 9	3 0	0 9	5 3	4 57	6 1	137	183-185
102-106	0	6 5	13 8	13 2	15 4	11 4	17 1	11 3	3 7	1 0	6 7	4 28	6 5	136	186-188
107-112	0	11 3	12 6	12 8	14 0	11 8	15 4	8 7	3 0	1 2	9 2	4 40	6 5	142	189-191
113-122	0	10 4	13 3	12 4	14 6	12 2	15 8	8 9	2 9	1 1	8 6	4 41	6 2	142	192-194
123-131	0	6 5	13 8	13 2	15 4	11 4	17 1	11 3	3 7	1 0	6 7	4 28	6 2	142	195-197
132-137	0	10 9	19 5	13 6	11 3	8 7	8 5	11 8	4 5	1 6	9 5	4 50	6 5	127	198-200
138-143	0	8 3	13 4	13 5	13 4	9 2	12 5	10 3	4 1	1 5	13 8	4 07	7 3	122	201-203
144-148	0	12 1	19 6	12 3	11 2	8 3	8 9	10 5	3 8	1 3	12 1	4 49	6 7	134	204-206
149-157	0	10 9	17 1	12 4	12 2	9 8	12 2	9 1	3 3	1 1	11 9	4 40	6 5	135	207-209
158-164	0	10 2	12 6	13 1	13 4	11 5	14 7	10 2	3 3	1 0	10 2	4 29	6 6	135	210-212
165-169	0	6 0	16 3	14 8	13 0	10 3	13 1	9 4	4 1	1 3	11 8	4 19	6 6	142	213-215
170-178	0	11 1	16 6	14 0	12 2	9 5	12 0	8 4	3 2	1 1	11 9	4 44	6 4	136	216-218
179-186	0	9 2	16 0	13 8	14 6	10 9	13 6	8 0	2 9	1 0	10 1	4 45	6 1	135	219-221
187-192	0	10 7	16 0	14 2	14 5	11 3	11 7	6 1	2 6	0 9	12 2	4 50	6 4	135	222-224
193-198	0	11 6	17 9	14 3	12 6	9 4	10 2	6 4	2 6	1 0	14 0	4 51	6 2	135	225-227
199-204	0	11 3	13 6	14 6	14 9	10 6	11 5	6 9	2 7	1 0	12 8	4 41	6 2	135	228-230
205-210	0	7 8	16 3	15 1	15 2	10 9	12 0	7 2	3 0	1 3	11 3	4 40	6 2	135	231-233
229-233	0	9 0	12 2	12 6	14 7	11 4	16 4	9 3	3 4	1 4	9 4	4 23	6 2	135	- - -
234-242	0	8 2	12 1	13 3	14 8	13 2	16 7	8 1	3 0	1 2	9 4	4 26	6 8	134	- - -
241-251	0	7 0	11 4	11 7	13 4	8 9	14 7	11 6	4 8	1 7	14 8	3 81	7 7	130	- - -
252-260	0	7 7	12 4	14 6	14 4	9 7	14 9	12 4	4 3	1 3	8 5	4 21	5 5	136	- - -
261-269	0	9 1	14 7	14 8	13 7	9 1	11 9	10 0	4 1	1 4	11 2	4 29	6 3	135	255-257
270-278	0	6 8	11 8	13 4	14 2	11 6	14 1	8 6	3 8	1 4	14 4	3 98	6 1	135	264-266
279-287	0	6 7	10 3	13 2	14 7	12 7	15 0	8 9	4 3	2 7	11 5	3 96	6 4	135	270-272
288-296	0	6 0	12 4	13 6	14 0	12 1	14 3	8 8	4 5	1 8	12 5	4 00	6 0	135	273-275
312-319	0	9 5	13 1	13 6	12 4	11 2	14 4	9 7	4 8	2 0	9 3	4 24	6 0	135	- - -
320-328	0	3 5	11 3	15 5	15 6	11 3	14 2	9 9	4 4	1 7	12 9	4 39	5 7	135	- - -
435-437	0	6 8	10 4	11 6	12 3	13 0	18 9	12 1	3 8	0 6	10 5	3 95	5 8	135	- - -
438-444	0	8 5	11 5	13 5	13 4	12 2	16 4	10 6	3 7	1 0	9 2	4 19	5 3	135	- - -
447-453	0	5 6	11 8	12 1	13 3	13 0	18 3	11 8	3 9	0 9	9 3	4 01	5 4	136	- - -
454-460	0	7 0	10 4	12 3	12 2	15 2	15 1	13 7	4 1	1 3	8 7	4 01	5 8	134	- - -
485-489	0	10 9	10 6	12 4	12 4	12 2	9 1	14 2	6 8	3 1	8 3	4 09	6 2	136	344-346
493-499	0	5 0	10 9	13 6	12 2	12 1	10 4	16 3	6 7	3 0	9 8	3 78	6 8	135	347-349
500-505	0	6 1	12 8	16 3	11 9	13 5	9 8	13 3	6 3	2 6	7 4	4 12	6 5	135	353-355
532-541	0	11 9	15 5	17 4	14 4	13 4	9 2	7 4	3 1	1 9	5 8	4 57	5 3	135	390-392
542-549	0	12 0	18 6	19 4	11 4	11 7	7 6	6 3	3 4	1 8	7 8	4 79	6 6	136	393-395
550-556	0	17 5	16 4	16 1	12 3	12 6	8 7	7 1	2 9	1 3	5 1	5 07	5 2	135	396-398
557-564	0	9 4	14 7	15 9	15 1	14 6	10 1	8 0	3 0	1 6	7 6	4 85	5 3	135	402-404
565-570	0	10 5	12 0	16 5	15 1	15 4	9 8	8 2	3 6	2 0	6 8	4 54	5 3	135	408-410
571-576	0	12 4	19 6	16 5	10 8	11 0	9 9	7 4	4 1	2 6	5 8	4 81	6 3	134	414-416
577-580	0	11 3	14 4	14 9	13 7	13 0	11 8	8 1	3 4	1 9	7 5	4 56	6 1	136	420-422
581-586	0	9 7	16 7	14 3	11 9	11 6	10 3	8 6	3 1	1 3	12 5	4 36	5 6	135	423-425
587-591	0	11 4	14 1	14 5	14 0	12 3	10 8	9 4	3 1	1 5	8 9	4 50	5 6	135	426-428

TABLE IVa

LOAD TRANSMISSION TEST RESULTS (PLATE LOADING)

12-INCH PLATE

Load Transmission Test No	Paving Thickness (inches)	Total Applied Load (kips)	Average Applied Unit Load (psi)	Maximum Plate Deflection (inches)	Maximum Subgrade Deflection (inches)	Maximum Subgrade Pressure (psi)	Relationships Between Applied Load V_k and Subgrade Reaction (r): Equation (1)	Equation (2)
64	8	3 00	26 53	0 099	0 098	7 70	$r = 1\ 203V_k^{1\ 51}$	$V_k = 0\ 8846r^{0\ 66}$
65		6 00	53 05	0 241	0 219	17 91		
66		9 00	79 58	0 454	0 397	32 90		
67		12 00	106 10	0 713	0 611	50 90		
68		15 00	132 63	- ---	0 918	77 70		
69	8	2 00	17 68	0 069	0 057	4 42	$r = 1\ 264V_k^{1\ 52}$	$V_k = 0\ 8655r^{0\ 66}$
70		4 00	35 37	0 159	0 129	10 37		
71		6 00	53 05	0 280	0 230	18 82		
72		8 00	70 74	0 450	0 355	29 40		
73		10 00	88 42	0 670	0 504	41 87		
74		12 00	106 10	0 930	0 683	57 17		
102	8	3 00	26 53	0 131	0 076	5 96	$r = 1\ 105V_k^{1\ 53}$	$V_k = 0\ 9368r^{0\ 67}$
103		6 00	53 05	0 297	0 210	17 11		
104		9 00	79 58	0 499	0 378	31 31		
105		12 00	106 10	0 779	0 603	50 19		
106		15 00	132 63	1 139	0 872	73 60		
132	8	2 00	17 68	0 147	0 065	5 09	$r = 1\ 853V_k^{1\ 49}$	$V_k = 0\ 6615r^{0\ 67}$
133		4 00	35 37	0 217	0 184	14 96		
134		6 00	53 05	0 455	0 333	27 51		
135		8 00	70 74	0 757	0 504	41 83		
136		10 00	88 42	1 137	0 688	57 57		
137		12 00	106 10	1 522	0 878	74 10		
107	8	3 00	26 53	0 118	0 072	5 68	$r = 0\ 9891V_k^{1\ 48}$	$V_k = 1\ 007r^{0\ 68}$
108		6 00	53 05	0 241	0 173	14 09		
109		9 00	79 58	0 393	0 302	24 88		
110		12 00	106 10	0 586	0 478	39 72		
111		15 00	132 63	0 778	0 645	53 90		
112		18 00	159 15	1 057	0 880	74 30		
144	12	3 00	26 53	0 087	0 063	4 88	$r = 0\ 7706V_k^{1\ 62}$	$V_k = 1\ 175r^{0\ 62}$
145		6 00	53 05	0 254	0 170	13 84		
146		9 00	79 58	0 577	0 329	27 22		
147		12 00	106 10	1 019	0 513	42 65		
148		15 00	132 63	1 609	0 729	61 00		
187	12	4 67	41 27	0 141	0 104	8 26	$r = 0\ 8259V_k^{1\ 45}$	$V_k = 1\ 168r^{0\ 69}$
188		8 27	73 10	0 276	0 215	17 58		
189		12 27	108 46	0 487	0 370	30 73		
190		15 47	136 76	0 705	0 524	43 59		
191		18 33	162 05	0 904	0 686	57 41		
192		21 27	188 04	1 235	0 859	72 43		
193	12	5 94	52 49	0 170	0 110	8 81	$r = 0\ 3430V_k^{1\ 67}$	$V_k = 1\ 898r^{0\ 60}$
194		9 74	86 09	0 319	0 224	18 34		
195		14 24	125 88	0 470	0 345	28 57		
196		17 84	157 71	0 759	0 500	41 56		
197		20 94	185 12	1 000	0 671	56 07		
198		24 14	213 42	1 278	0 830	69 95		
90	16	5 00	44 21	0 116	0 070	5 48	$r = 0\ 3536V_k^{1\ 62}$	$V_k = 1\ 901r^{0\ 62}$
91		10 00	88 42	0 293	0 182	14 76		
92		15 00	132 63	0 585	0 338	28 01		
93		20 00	176 84	1 133	0 546	45 42		
94		25 00	221 05	2 422	0 857	72 27		
312	24	4 00	35 37	0 076	0 014	1 05	$r = 0\ 0781V_k^{1\ 75}$	$V_k = 4\ 306r^{0\ 57}$
313		8 00	70 74	0 135	0 039	2 98		
314		12 00	106 10	0 208	0 077	6 06		
315		16 00	141 47	0 285	0 121	9 66		
316		20 00	176 84	0 525	0 178	14 49		
317		24 00	212 21	0 692	0 243	20 00		
318		28 00	247 57	0 910	0 317	26 24		
319		32 00	282 94	1 044	0 410	34 01		

TABLE IVb LOAD TRANSMISSION TEST RESULTS (PLATE LOADING) 18-INCH PLATE								
Load Transmission Test No	Paving Thickness (inches)	Total Applied Load (kips)	Average Applied Unit Load (psi)	Maximum Plate Deflection (inches)	Maximum Subgrade Deflection (inches)	Maximum Subgrade Pressure (psi)	Relationships Between Applied Load V_k and Subgrade Reaction (r)	
							Equation (1)	Equation (2)
75	8	3 00	11 79	0 071	0 060	4 68	$r = 0\ 9076V_k^{1\ 28}$	$V_k = 1\ 079r^{0\ 78}$
76		6 00	23 58	0 135	0 114	9 11		
77		9 00	35 37	0 213	0 185	15 00		
78		12 00	47 16	0 298	0 261	21 44		
79		15 00	58 95	0 392	0 345	28 56		
80		18 00	70 73	0 497	0 442	36 72		
81		21 00	82 52	0 602	0 543	45 11		
82		24 00	94 31	0 729	0 658	54 99		
113	8	3 00	11 79	0 063	0 061	4 70	$r = 1\ 325V_k^{1\ 13}$	$V_k = 0\ 7796r^{0\ 88}$
114		6 00	23 58	- ---	0 153	12 37		
115		9 00	35 37	0 221	0 199	16 14		
116		12 00	47 16	0 295	0 264	21 68		
117		15 00	58 95	0 377	0 337	27 89		
118		18 00	70 73	0 468	0 421	34 96		
119		21 00	82 52	0 559	0 504	41 89		
120		24 00	94 31	0 713	0 645	53 85		
121		27 00	106 10	0 762	0 687	57 47		
122		30 00	117 89	0 880	0 795	66 80		
138	8	3 00	11 79	0 079	0 079	6 23	$r = 1\ 531V_k^{1\ 28}$	$V_k = 0\ 7171r^{0\ 78}$
139		6 00	23 58	0 229	0 180	14 59		
140		9 00	35 37	0 470	0 311	25 67		
141		12 00	47 16	0 755	0 453	37 64		
142		15 00	58 95	1 046	0 601	50 08		
143		18 00	70 73	1 244	0 732	61 30		
158	8	6 00	23 58	0 144	0 130	10 40	$r = 0\ 7014V_k^{1\ 43}$	$V_k = 1\ 281r^{0\ 70}$
159		9 00	35 37	0 226	0 201	16 33		
160		12 00	47 16	0 339	0 299	24 68		
161		15 00	58 95	0 457	0 403	33 46		
162		18 00	70 73	0 596	0 526	43 73		
163		21 00	82 52	0 745	0 655	54 76		
164		24 00	94 31	0 883	0 793	66 67		
165	8	6 00	23 58	0 139	0 131	10 54	$r = 1\ 027V_k^{1\ 24}$	$V_k = 0\ 9788r^{0\ 80}$
166		12 00	47 16	0 296	0 275	22 59		
167		18 00	70 73	0 489	0 450	37 42		
168		21 00	82 52	0 585	0 537	44 67		
169		24 00	94 31	0 697	0 645	53 84		
199	8	5 98	23 50	0 150	0 115	9 19	$r = 1\ 075V_k^{1\ 20}$	$V_k = 0\ 9413r^{0\ 84}$
200		11 18	43 93	0 285	0 232	19 06		
201		16 18	63 58	0 424	0 358	29 63		
202		20 48	80 48	0 565	0 492	40 84		
203		25 88	101 70	0 719	0 626	52 22		
204		30 03	118 01	0 890	0 781	65 59		
95	16	5 00	19 65	0 128	0 057	4 44	$r = 0\ 3901V_k^{1\ 40}$	$V_k = 1\ 955r^{0\ 71}$
96		10 00	39 30	0 226	0 126	10 07		
97		15 00	58 95	0 334	0 210	17 12		
98		20 00	78 59	0 485	0 313	25 85		
99		25 00	98 24	0 645	0 433	35 92		
100		30 00	117 89	0 815	0 565	46 91		
101		35 00	137 54	1 086	0 736	61 61		
179	24	12 00	47 16	0 122	0 075	5 91	$r = 0\ 1267V_k^{1\ 54}$	$V_k = 3\ 825r^{0\ 65}$
180		18 00	70 73	0 206	0 134	10 78		
181		24 00	94 31	0 318	0 207	16 80		
182		30 00	117 89	0 482	0 284	23 41		
183		36 00	141 47	0 639	0 382	31 70		
184		42 00	165 05	0 868	0 480	39 88		
185		48 00	188 63	1 124	0 604	50 30		
186		54 00	212 21	1 589	0 774	65 00		

TABLE IVc

LOAD TRANSMISSION TEST RESULTS (PLATE LOADING)

30-INCH PLATE

Load Transmission Test No	Paving Thickness (inches)	Total Applied Load (kips)	Average Applied Unit Load (psi)	Maximum Plate Deflection (inches)	Maximum Subgrade Deflection (inches)	Maximum Subgrade Pressure (psi)	Relationships Between Applied Load V_k and Subgrade Reaction (r)	
							Equation (1)	Equation (2)
83		7 00	99 90	0 078	0 066	5 18		
84		14 00	19 80	0 162	0 138	11 12		
85		21 00	29 71	0 244	0 213	17 37		
86	8	28 00	39 61	0 334	0 298	24 58	$r = 0\ 3469V_k^{1\ 28}$	$V_k = 2\ 284r^{0\ 78}$
87		35 00	49 51	0 440	0 395	32 76		
88		42 00	59 42	0 549	0 503	41 78		
89		49 00	69 32	0 669	0 617	51 40		
123		6 00	8 49	0 082	0 049	3 81		
124		12 00	16 98	0 162	0 104	8 28		
125		18 00	25 46	0 241	0 167	13 56		
126		24 00	33 95	0 363	0 227	18 57		
127	8	30 00	42 44	0 389	0 295	24 33	$r = 0\ 4106V_k^{1\ 21}$	$V_k = 2\ 092r^{0\ 83}$
128		36 00	50 93	0 470	0 369	30 61		
129		42 00	59 42	0 557	0 448	37 22		
130		48 00	67 91	0 680	0 537	44 64		
131		54 00	76 39	0 782	0 631	52 61		
205		11 88	16 81	0 141	0 109	8 70		
206		22 68	32 09	0 280	0 229	18 76		
207		32 28	45 67	0 396	0 335	27 75		
208	8	41 88	59 25	0 518	0 450	37 41	$r = 0\ 5006V_k^{1\ 16}$	$V_k = 1\ 783r^{0\ 86}$
209		52 68	74 53	0 659	0 587	48 78		
210		62 88	88 96	0 848	0 726	60 75		
149		12 00	16 98	0 151	0 103	8 20		
150		24 00	33 95	0 314	0 226	18 47		
151		30 00	42 44	0 404	0 292	24 08		
152		36 00	50 93	0 498	0 361	29 95		
153	16	42 00	59 42	0 602	0 435	36 11	$r = 0\ 3700V_k^{1\ 23}$	$V_k = 2\ 250r^{0\ 82}$
154		48 00	67 91	0 717	0 515	42 83		
155		54 00	76 39	0 821	0 599	49 85		
156		60 00	84 88	0 923	0 677	56 59		
157		66 00	93 37	1 063	0 768	64 46		
170		12 00	16 98	0 125	0 060	4 65		
171		24 00	33 95	0 249	0 139	11 23		
172		36 00	50 93	0 395	0 237	19 45		
173	24	48 00	67 91	0 562	0 348	28 82	$r = 0\ 1369V_k^{1\ 39}$	$V_k = 4\ 203r^{0\ 72}$
174		54 00	76 39	0 666	0 413	34 30		
175		60 00	84 88	0 774	0 478	39 72		
176		66 00	93 37	0 909	0 552	45 88		
177		72 00	101 86	1 033	0 622	51 83		
178		78 00	110 35	1 165	0 694	58 08		

TABLE Va

LOAD TRANSMISSION TEST RESULTS (TIRE LOADING)

36-INCH SMOOTH CONTOUR AIRPLANE TIRE

Load Transmission Test No	Paving Thickness (inches)	Total Applied Load (kips)	Contact Area (square inches)	Inflation Pressure (psi)	Subgrade Deflection (inches)	Maximum Subgrade Pressure (psi)	Relationships Between Applied Load (V_k) and Subgrade Reaction (r): Equation (1)	Equation (2)
288		3 00	67	42	0 239	19 76		
289		6 00	134	42	0 407	33 82		
290		7 00	158	42	0 440	36 55		
291		4 00	65	57	0 312	25 77		
292	4	8 20	145	57	0 503	41 74	$r = 9\ 180V_k^{0\ 73}$	$V_k = 0\ 048r^{1\ 37}$
293		9 00	148	57	0 533	44 33		
294		5 00	72	73	0 380	31 50		
295		10 50	140	73	0 621	51 74		
296		12 00	157	73	0 679	56 82		
279		3 00	67	42	0 095	7 48		
280		6 00	134	42	0 194	15 76		
281		7 00	158	42	0 218	17 76		
282		4 00	65	57	0 131	10 50		
283	8	8 00	--	57	0 247	20 31	$r = 2\ 669V_k^{0\ 98}$	$V_k = 0\ 367r^{1\ 02}$
284		9 00	148	57	0 269	22 13		
285		5 00	72	73	0 169	13 70		
286		10 50	140	73	0 322	26 64		
287		12 00	157	73	0 368	30 55		
229		2 50	--	73	0 103	8 25		
230		5 00	72	73	0 194	15 79		
231	8	7 50	--	73	0 272	22 34	$r = 3\ 865V_k^{0\ 86}$	$V_k = 0\ 207r^{1\ 17}$
232		10 00	--	73	0 342	28 34		
233		12 50	--	73	0 391	32 14		
270		3 00	67	42	0 035	2 61		
271		6 00	134	42	0 079	6 20		
272		7 00	158	42	0 091	7 13		
273		4 00	65	57	0 048	3 72		
274	12	8 20	145	57	0 111	8 84	$r = 0\ 670V_k^{1\ 24}$	$V_k = 1\ 383r^{0\ 81}$
275		9 00	148	57	0 123	9 85		
276		5 00	72	73	0 064	5 00		
277		10 50	140	73	0 156	12 65		
278		12 00	157	73	0 181	14 67		
320		3 00	67	42	0 048	3 76		
321		6 00	134	42	0 106	8 47		
322		7 00	158	42	0 123	9 82		
323		4 00	65	57	0 064	4 98		
324	12	8 20	145	57	0 151	12 20	$r = 1\ 032V_k^{1\ 17}$	$V_k = 0\ 974r^{0\ 85}$
325		9 00	148	57	0 165	13 37		
326		5 00	72	73	0 091	7 19		
327		10 50	140	73	0 200	16 30		
328		12 00	157	73	0 230	18 85		

TABLE Vb

LOAD TRANSMISSION TEST RESULTS (TIRE LOADING)

47-INCH SMOOTH CONTOUR AIRPLANE TIRE

Load Transmission Test No	Paving Thickness (inches)	Total Applied Load (kips)	Contact Area (square inches)	Inflation Pressure (psi)	Subgrade Deflection (inches)	Maximum Subgrade Pressure (psi)	Relationships Between Applied Load (V_k) and Subgrade Reaction (r) Equation (1)	Equation (2)
243	8	6 50	115	54	0 218	17 80	$r = 4\ 049V_k^{0\ 80}$	$V_k = 0\ 1753r^{1\ 25}$
244		13 00	217	54	0 380	31 52		
245		18 00	294	54	0 495	41 12		
246		7 50	112	63	0 248	20 40		
247		15 00	214	63	0 429	35 62		
248		19 00	282	63	0 512	42 55		
249		8 75	121	73	0 290	23 92		
250		17 50	221	73	0 495	41 12		
251		20 00	274	73	0 537	44 64		
252	8	6 50	115	54	0 199	16 20	$r = 3\ 650V_k^{0\ 81}$	$V_k = 0\ 2009r^{1\ 24}$
253		13 00	217	54	0 350	28 96		
254		18 00	294	54	0 452	37 53		
255		7 50	112	63	0 227	18 52		
256		15 00	214	63	0 395	32 72		
257		19 00	282	63	0 466	38 75		
258		8 75	121	73	0 262	21 53		
259		17 50	221	73	0 445	36 92		
260		20 00	274	73	0 490	40 73		
565	8	5 00	61	100	0 230	18 89	$r = 4\ 815V_k^{0\ 85}$	$V_k = 0\ 1577r^{1\ 18}$
566		10 00	118	100	0 415	34 50		
567		12 50	148	100	0 493	40 98		
568		15 00	171	100	0 564	46 89		
569		20 00	216	100	0 683	57 18		
570		25 00	255	100	0 790	66 44		
261	12	6 50	115	54	0 124	9 93	$r = 1\ 678V_k^{0\ 96}$	$V_k = 0\ 5817r^{1\ 05}$
262		13 00	217	54	0 243	19 96		
263		18 00	294	54	0 324	26 80		
264		7 50	112	63	0 141	11 39		
265		15 00	214	63	0 269	22 13		
266		19 00	282	63	0 334	27 63		
267		8 75	121	73	0 167	13 51		
268		17 50	221	73	0 316	26 10		
269		20 00	274	73	0 349	28 86		
485	12	5 00	88	63	0 097	7 69	$r = 1\ 395V_k^{1\ 07}$	$V_k = 0\ 7325r^{0\ 94}$
486		10 00	157	63	0 207	16 81		
487		15 00	214	63	0 307	25 34		
488		20 00	292	63	0 407	33 80		
489		25 00	365	63	0 471	39 14		
234	16	6 50	115	54	0 097	7 69	$r = 1\ 205V_k^{0\ 97}$	$V_k = 0\ 8244r^{1\ 04}$
235		13 00	217	54	0 175	14 23		
236		18 00	294	54	0 244	20 03		
237		7 50	112	63	0 104	8 28		
238		15 00	214	63	0 197	16 03		
239		19 00	282	63	0 251	20 68		
240		8 75	121	73	0 118	9 45		
241		17 50	221	73	0 237	19 44		
242		20 00	274	73	0 264	21 74		
493	16	5 00	61	100	0 084	6 59	$r = 0\ 9819V_k^{1\ 20}$	$V_k = 1\ 015r^{0\ 84}$
494		10 00	118	100	0 199	16 15		
495		12 50	148	100	0 254	20 85		
496		15 00	171	100	0 306	25 20		
497		19 20	217	100	0 399	33 15		
498		20 00	216	100	0 415	34 26		
499		25 00	255	100	0 504	41 84		
500	24	5 00	61	100	0 027	2 00	$r = 0\ 2321V_k^{1\ 33}$	$V_k = 2\ 990r^{0\ 75}$
501		10 00	118	100	0 066	5 15		
502		12 50	148	100	0 085	6 66		
503		15 00	171	100	0 106	8 43		
504		20 00	213	100	0 158	12 82		
505		25 00	255	100	0 212	17 24		
577	24	5 00	88	63	0 025	1 89	$r = 0\ 2761V_k^{1\ 20}$	$V_k = 2\ 934r^{0\ 84}$
578		15 00	214	63	0 093	7 32		
579		25 00	365	63	0 162	13 13		
580		30 00	---	63	0 194	15 80		

TABLE Vc

LOAD TRANSMISSION TEST RESULTS (TIRE LOADING)

25 x 28 AIRPLANE TIRE

Load Transmission Test No	Paving Thickness	Total Applied Load	Contact Area	Inflation Pressure	Subgrade Deflection	Maximum Subgrade Pressure	Relationships Between Applied Load (V_k) and Subgrade Reaction (r)	
	(inches)	(kips)	(square inches)	(psi)	(inches)	(psi)	Equation (1)	Equation (2)
447		5 00	106	40	0 280	23 00		
448		9 00	197	40	0 391	32 43		
449		10 00	214	40	0 415	34 42		
450	6	13 00	278	40	0 478	39 74	$r = 9\ 610V_k^{0\ 55}$	$V_k = 0\ 0164r^{1\ 82}$
451		15 00	323	40	0 514	42 70		
452		20 00	427	40	0 591	49 13		
453		25 00	529	40	0 651	54 35		
454		5 00	108	40	0 432	35 84		
455		9 00	197	40	0 563	46 79		
456		10 00	214	40	0 588	48 84		
457	3	13 00	278	40	0 655	54 72	$r = 17\ 64V_k^{0\ 44}$	$V_k = 0\ 00152r^{2\ 26}$
458		15 00	323	40	0 686	57 35		
459		20 00	427	40	0 752	63 06		
460		25 00	529	40	0 800	67 28		

TABLE Vd

LOAD TRANSMISSION TEST RESULTS (TIRE LOADING)

56 x 16 AIRPLANE TIRE

Load Transmission Test No	Paving Thickness	Total Applied Load	Contact Load	Inflation Pressure	Subgrade Deflection	Maximum Subgrade Pressure	Relationships Between Applied Load (V_k) and Subgrade Reaction (r)	
	(inches)	(kips)	(square inches)	(psi)	(inches)	(psi)	Equation (1)	Equation (2)
435		5 00	39	200	0 579	48 08		
436	3	6 00	--	200	0 648	54 14	$r = 16\ 93V_k^{0\ 65}$	$V_k = 0\ 0128r^{1\ 54}$
437		9 00	61	200	0 835	70 40		
438		5 00	39	200	0 386	32 01		
439	6	9 00	61	200	0 634	52 89	$r = 8\ 573V_k^{0\ 82}$	$V_k = 0\ 0733r^{1\ 22}$
440		10 00	68	200	0 682	57 06		
441		13 00	87	200	0 830	69 93		
550		5 00	39	200	0 084	6 56		
550a		10 00	68	200	0 175	14 23		
551		15 00	98	200	0 268	22 05		
551a		20 00	123	200	0 354	29 33		
552	16	25 00	149	200	0 440	36 48	$r = 1\ 409V_k^{1\ 01}$	$V_k = 0\ 7124r^{0\ 99}$
553		30 00	185	200	0 528	43 92		
554		35 00	211	200	0 617	51 31		
555		40 00	238	200	0 680	56 84		
556		45 00	262	200	0 752	63 03		
532		5 00	39	200	0 042	3 27		
533		10 00	68	200	0 098	7 73		
534		15 00	98	200	0 157	12 67		
535		20 00	123	200	0 213	17 39		
536	24	25 00	151	200	0 274	22 50	$r = 0\ 5981V_k^{1\ 12}$	$V_k = 1\ 582r^{0\ 89}$
537		30 00	185	200	0 326	26 99		
538		35 00	211	200	0 386	31 99		
539		40 00	238	200	0 445	36 90		
540		45 00	262	200	0 499	41 47		
541		50 00	298	200	0 600	45 63		
542		5 00	39	200	0 027	2 02		
543		15 00	98	200	0 105	8 36		
544		25 00	149	200	0 216	17 64		
545	24	35 00	211	200	0 323	26 66	$r = 0\ 2458V_k^{1\ 31}$	$V_k = 2\ 865r^{0\ 77}$
546		45 00	262	200	0 431	35 74		
547		50 00	298	200	0 487	40 42		
548		55 00	333	200	0 529	43 98		
549		60 00	352	200	0 582	48 33		
587		2 50	--	150	0 101	8 04		
588		5 00	53	150	0 218	17 84		
589	8	7 50	--	150	0 334	27 67	$r = 2\ 873V_k^{1\ 13}$	$V_k = 0\ 3923r^{0\ 89}$
590		10 00	91	150	0 442	36 71		
591		12 50	--	150	0 528	43 88		
581		5 00	53	150	0 067	5 21		
582		15 00	128	150	0 264	21 76		
583	16	25 00	199	150	0 453	37 63	$r = 0\ 6417V_k^{1\ 30}$	$V_k = 1\ 405r^{0\ 77}$
584		30 00	228	150	0 540	44 91		
585		35 00	261	150	0 611	50 92		
586		40 00	289	150	0 685	57 31		
571		5 00	53	150	0 076	5 97		
572		15 00	128	150	0 260	21 43		
573		25 00	199	150	0 430	35 74		
574	16	30 00	228	150	0 509	42 25	$r = 0\ 9123V_k^{1\ 16}$	$V_k = 1\ 082r^{0\ 86}$
575		35 00	261	150	0 583	48 46		
576		40 00	289	150	0 651	54 43		
557		5 00	53	150	0 023	1 73		
558		15 00	128	150	0 093	7 29		
559		25 00	199	150	0 178	14 46		
560	24	30 00	228	150	0 221	18 07	$r = 0\ 2152V_k^{1\ 30}$	$V_k = 3\ 260r^{0\ 77}$
561		35 00	261	150	0 264	21 74		
562		40 00	289	150	0 308	25 44		
563		45 00	315	150	0 367	30 42		
564		50 00	345	150	0 403	33 51		

TABLE VI

TRIAXIAL TEST RESULTS

Triaxial Test Number	Density (lb per cu ft)	Moisture Content (per cent)	Lateral Pressure (psi)	Vertical Pressure at Various Deflections 0 1-Inch (psi)	0 2-Inch (psi)	0 3-Inch (psi)	Maximum (psi)	Deformation at Maximum Load (inches)	Load Transmission Test Number
168	135	6 1	10	62 8	74 7	79 1	79 5	0 30	
169	135	6 4	20	91 3	120 6	128 5	129 9	0 34	64-68
170	137	6 0	30	149 7	208 9	233 7	236 3	0 36	
171	137	6 2	5	52 9	60 8	--- -	60 8	0 22	
172	137	6 3	5	49 2	63 6	--- -	65 2	0 24	69-74
173	137	5 8	5	48 9	59 4	--- -	60 0	0 22	
174	136	6 1	10	63 5	78 3	82 6	83 0	0 34	
175	139	4 6	10	66 7	92 1	99 6	100 2	0 34	75-82
176	133	6 9	10	58 4	73 4	78 5	79 7	0 36	
177	136	5 0	15	108 0	133 5	--- -	135 6	0 26	
178	135	5 3	15	93 4	114 1	118 4	118 6	0 32	83-89
179	135	5 5	15	90 1	116 9	124 5	125 5	0 36	
180	135	5 8	0	8 4	--- -	--- -	8 4	0 10	
181	134	5 8	0	8 2	--- -	--- -	8 7	0 13	90-94
182	134	6 0	0	5 3	--- -	--- -	5 6	0 11	
183	134	5 5	20	121 9	160 1	169 1	169 1	0 30	
184	135	5 5	20	111 7	153 7	164 5	164 5	0 30	95-101
185	135	5 3	20	111 7	149 9	163 9	164 9	0 37	
186	139	6 9	10	54 9	81 9	96 9	101 3	0 48	
187	136	6 0	10	69 8	92 8	96 8	96 8	0 32	102-106
188	136	5 0	10	64 7	88 0	93 0	93 0	0 34	
189	142	6 4	5	40 7	61 0	67 1	67 8	0 34	
190	141	6 4	5	49 2	71 5	74 7	74 7	0 30	107-112
191	142	6 7	5	26 1	39 7	49 6	57 2	0 52	
192	141	6 2	0	18 5	--- -	--- -	18 5	0 10	
193	142	5 7	0	21 1	--- -	--- -	21 5	0 11	113-122
194	140	7 2	0	8 8	9 9	--- -	10 2	0 16	
195	140	6 2	15	123 2	148 1	150 0	150 0	0 30	
196	141	6 5	15	82 1	110 7	122 3	127 0	0 44	123-131
197	141	6 7	15	99 0	134 4	145 8	147 4	0 38	
198	122	6 5	1	10 9	11 4	11 5	11 7	0 32	
199	122	6 2	2	14 5	15 2	15 5	15 8	0 42	132-137
200	123	6 0	3	15 5	16 7	17 3	19 6	1 40	
201	123	6 1	1	11 0	11 2	11 2	11 2	0 32	
202	123	6 9	2	13 0	13 8	14 3	15 8	1 20	138-143
203	123	6 8	3	15 5	17 2	18 1	20 6	1 50	
204	135	6 1	1	19 8	24 6	25 2	25 3	0 33	
205	136	5 9	2	33 8	36 4	-- -	36 4	0 20	144-148
206	137	5 9	3	39 9	47 6	-- -	47 8	0 28	
207	136	7 0	10	52 4	72 1	79 5	81 9	0 49	
208	136	6 5	15	78 7	102 0	109 6	113 8	0 51	149-147
209	136	6 1	20	82 4	108 6	120 6	130 1	0 66	
210	136	6 4	0	16 2	--- -	--- -	19 1	0 15	
211	137	5 7	-2*	-- -	--- -	--- -	11 5	0 09	158-164
212	137	5 5	0	-- -	--- -	--- -	18 8	0 08	
213	137	6 3	10	53 3	68 3	76 8	80 2	0 52	
214	137	6 4	15	78 7	109 2	120 7	125 1	0 48	165-169
215	142	5 8	20	86 2	130 8	151 8	172 0	0 52	
216	138	5 0	0	12 7	--- -	--- -	14 0	0 13	
217	138	5 5	1	25 8	--- -	--- -	31 2	0 18	170-178
218	138	5 6	2	35 7	--- -	--- -	39 9	0 16	
219	134	5 6	1	22 8	--- -	--- -	23 1	0 14	
220	137	5 4	2	28 5	--- -	--- -	29 8	0 19	179-186
221	134	5 6	3	36 7	--- -	--- -	38 3	0 16	
222	137	5 8	0	16 0	--- -	--- -	16 2	0 11	
223	136	5 3	2	35 9	--- -	--- -	39 9	0 17	187-192
224	137	5 6	4	51 1	57 2	--- -	57 3	0 26	

*Lateral pressure apparently -2

TABLE VI (continued)

TRIAXIAL TEST RESULTS

Triaxial Test Number	Density (lb per cu ft)	Moisture Content (per cent)	Lateral Pressure (psi)	Vertical Pressure at Various Deflections				Deformation at Maximum Load (inches)	Load Transmission Test Number
				0 1-Inch (psi)	0 2-Inch (psi)	0 3-Inch (psi)	Maximum (psi)		
225	137	5 5	1	26 1	--- -	--- -	28 8	0 16	
226	136	5 8	3	37 7	45 5	--- -	45 5	0 24	193-198
227	136	5 7	5	43 2	57 2	--- -	58 7	0 28	
228	137	5 3	3	39 9	50 6	--- -	50 8	0 24	
229	138	5 4	6	50 6	72 8	--- -	74 6	0 28	199-204
230	138	5 2	9	66 3	93 5	--- -	97 1	0 28	
231	136	6 0	4	48 6	55 8	--- -	55 8	0 20	
232	138	4 8	8	58 9	73 8	--- -	75 1	0 26	205-210
233	137	5 4	12	67 7	95 7	102 4	103 9	0 39	
255	134	6 5	30	83 5	117 9	137 0	170 6	1 03	
256	135	6 6	30	91 1	119 1	135 0	168 3	1 00	261-269
257	134	6 2	30	100 0	131 9	147 1	167 5	0 80	
264	134	6 2	5	42 6	57 2	58 6	61 7	0 31	
265	134	6 2	10	53 9	76 8	83 8	85 2	0 36	270-278
266	134	6 6	15	64 7	93 9	107 3	113 4	0 49	
270	137	5 8	5	32 6	53 6	59 9	60 3	0 32	
271	136	5 9	10	59 7	91 7	96 3	96 3	0 28	279-287
272	135	5 3	15	74 8	111 6	122 0	124 4	0 38	
273	136	6 1	5	39 4	61 3	64 0	64 6	0 28	
274	135	6 0	10	62 2	90 2	96 8	97 1	0 33	288-296
275	135	5 8	15	86 3	123 9	131 1	132 0	0 34	
344	136	6 5	10	44 4	61 6	70 7	76 7	0 52	
345	135	6 5	20	67 1	86 2	98 9	114 2	0 68	485-489
346	135	6 5	30	91 1	111 5	124 2	148 2	1 12	
347	134	7 6	10	24 0	29 1	32 9	52 5	1 34	
348	135	7 0	20	46 1	58 2	65 8	97 5	1 60	493-499
349	135	6 7	30	72 0	83 5	92 4	108 3	1 14	
353	136	6 2	10	47 6	59 7	66 3	71 9	0 42	
354	136	6 3	20	72 2	94 4	105 9	118 9	0 72	500-505
355	137	5 6	30	152 3	200 6	219 7	232 0	0 38	
390	136	6 4	10	42 5	54 2	59 0	62 6	0 62	
391	136	6 0	20	70 9	96 4	109 8	123 5	0 92	532-541
392	136	6 2	30	98 8	129 3	144 0	168 8	0 96	
393	135	5 1	10	82 6	108 7	--- -	109 3	0 24	
394	135	5 3	20	115 5	145 4	149 4	149 4	0 30	542-549
395	135	5 3	30	152 2	186 6	195 5	197 0	0 44	
396	135	4 9	10	74 3	86 4	87 9	87 9	0 30	
397	136	5 0	10	64 7	88 2	91 4	91 5	0 34	550-556
398	135	4 7	40	162 2	214 4	232 9	241 2	0 52	
402	135	5 5	10	59 0	74 6	81 3	82 3	0 36	
403	135	5 5	25	124 3	152 3	162 5	166 2	0 56	557-564
404	135	5 3	40	154 6	195 3	217 0	235 2	0 68	
408	135	5 4	10	52 0	63 2	67 5	69 3	0 38	
409	135	5 6	20	70 9	85 2	93 2	108 5	1 20	565-570
410	135	5 2	30	106 4	145 0	161 8	177 9	0 86	
414	134	7 0	10	45 6	54 6	58 4	61 4	0 52	
415	134	7 3	20	70 9	88 8	97 0	109 1	0 90	571-576
416	135	6 2	30	112 8	133 1	142 0	148 8	0 60	
420	136	5 3	40	131 7	186 4	210 6	235 1	0 66	
421	136	5 4	50	150 6	199 0	221 9	262 0	0 92	577-580
422	136	5 5	60	166 9	209 0	234 4	308 5	1 84	
423	135	5 0	50	168 4	221 7	230 8	263 4	1 12	
424	136	5 2	60	177 1	223 0	253 5	327 6	1 24	581-586
425	135	5 6	70	191 0	245 7	281 4	348 8	1 30	
426	134	5 6	70	182 0	226 0	252 1	327 2	1 34	
427	134	5 8	80	171 7	213 7	245 5	371 6	1 78	587-591
428	135	5 2	90	207 1	263 2	297 5	415 9	1 32	

GPO 81 105688 — 1