TM 5-826-3

AFM 88-24, CHAP. 3

TECHNICAL MANUAL

AIRFIELD RIGID PAVEMENT EVALUATION

DEPARTMENTS OF THE ARMY, AND THE AIR FORCE

DECEMBER 1990

REPRODUCTION AUTHORIZATION/RESTRICTIONS

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HEADQUARTERS
DEPARTMENTS OF THE ARMY
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AIRFIELD RIGID PAVEMENT EVALUATION

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***This manual supersedes TM 5-827-3/AFM 88-24 Chap. 3, dated September 1965, TM 5-826-3 dated February 1980, and TM 5-888-10 dated November 1966.**

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CHAPTER 1

INTRODUCTION

1–1. Purpose.

This manual presents criteria and procedures for evaluating U.S. Army and Air Force airfield rigid pavements and overlays that incorporate rigid pavements in either the overlay or base pavement.

1–2. Scope.

Included in this manual are procedures for evaluating seven types of airfield pavements using field testing and sampling techniques. Those types of pavements included are:

a. Plain concrete pavements.

b. Rigid overlay on rigid pavements.

c. Nonrigid overlay on rigid pavements.

d. Rigid overlay on nonrigid pavements.

e. Composite pavements.

f. Reinforced concrete pavements.

g. Fiber reinforced concrete pavements.

The methods presented can be used to evaluate Army airfields and heliports and Air Force airfields. The aircraft for which an evaluation is to be made are described in TM 5–826–1/AFM 88–24, Chapter 1 and are listed in tables 1–1 for Army and 1–2 for Air Force evaluation. This manual presents general information pertaining to evaluation of the different types of rigid pavement and provides specific instructions for the evaluation of each type.

Table 1-1. Aircraft identification by pavement class for evaluation of U.S. Army airfield.

Pavement Class and Controlling Landing Gear Characteristics	Aircraft
Class I: Single wheel, less than 100-psi tire pressure, 70 square inch tire contact area	OV-1*, U-8 H-34, YAO-1
Class II: Twin wheel, 18-inch center-to-center spacing, 106-square inch tire contact area	CH-54*, CH-47 UH-60, A-7
Class III: Single tandem, 60-inch center-to-center spacing, 400-square inch tire contact area	C-130*
Single wheel, 100 psi, 272-square inch tire contact area	C-123
Twin wheel, 26-inch center-to-center spacing, 165-square inch tire contact area	C-9*, C-119 C-54, C-131
Class IV: Twin tandem, 38- by 48-inch, 208-square inch tire contact area	C-141
Dual twin-delta tandem, 285-square inch tire contact area	C-5A

*Controlling aircraft.

Table 1-2. Aircraft identification by aircraft group index for Air Force evaluations.

Light Load			Medium Load							Heavy Load		
1	2	3	4	5	6	7	8	9	10	11	12	13
A-37	A-7	F-111*	C-130	C-7	737	727*	707	C-141*	C-5	KC-10*	747	B-52
C-12	A-10	FB-111		C-9*	T-43*	C-22	E-3*	B-1		DC10	E-4*	
C-21	F-4			DC9			C-135	B-757		L1011	VC-25	
C-23*	F-5			C-140			KC-135*			C-17		
T-37	F-15*						VC-137					
	F-16						DC-8					
	F-10X						EC-18					
	T-33						A-300					
	T-38						B-767					
	T-39											
	OV-10											
	C-20											

*Controlling aircraft.

1-3. References.

Appendix A contains a list of references used in this document.

1-4. Types of pavements.

The types of pavements considered in this manual are defined as follows:

a. Plain concrete pavement. A single thickness of nonreinforced portland cement concrete resting directly on a subgrade, granular base course, or stabilized layer.

b. Rigid overlay on rigid pavement. A rigid overlay pavement that has been placed on an existing rigid pavement. In the construction of the rigid overlay, a bond-breaking course may or may not have been placed on the existing rigid pavement before the overlay was placed. If the bond breaking course between the two rigid pavements is 4 inches or more in thickness, the entire pavement is considered to be a composite pavement (*e* below).

c. Nonrigid overlay on rigid pavement. A bituminous concrete or combination of bituminous concrete and granular base course that has been placed on an existing rigid pavement.

d. Rigid overlay on nonrigid pavement. A rigid overlay pavement that has been placed on an existing nonrigid pavement.

e. Composite pavement. A "sandwich pavement" consisting of a rigid pavement placed on an existing pavement that consists of a nonrigid overlay on a rigid pavement. The nonrigid overlay may be bituminous concrete for its full depth or a combination of bituminous concrete and granular base course. When the thickness of the nonrigid overlay is less than 4 inches, the entire pavement will be treated as a rigid overlay on rigid pavement and the nonrigid material will be considered to be a bond-breaking course.

f. Reinforced concrete pavement. A concrete pavement that has been reinforced with either steel deformed-bar mats or welded-wire fabrics.

g. Fiber reinforced concrete. A concrete pavement that has been reinforced with steel fibers.

1-5. Evaluation reports.

An evaluation report containing the results of an evaluation investigation will be prepared in accordance with TM 5-826-4 for Army evaluations and AFR 93-13 for Air Force reports.

CHAPTER 2

EVALUATION CONCEPTS

2–1. Evaluation procedure.

a. General. To make an evaluation, the strength of the pavement and foundation will be known or determined, and from this information the allowable number of aircraft passes or the allowable aircraft loading that can use the pavement will be determined. Several logical steps to be followed in making the evaluation are outlined in TM 5–826–1/AFM 88–24, Chap. 1. The scope of the work required in making the evaluation will depend on the amount and validity of existing information. In many cases, the evaluation may be based on the results of design and construction-control test, when this type of information is available and considered to be representative of existing conditions. For older pavements, or when there is a reason to doubt the validity of the existing data, additional tests are necessary to permit evaluation of any changes in physical properties that may have occurred since construction. Two evaluation procedures referred to as the standard evaluation and the extended life evaluation are presented herein.

2–2. Types of evaluation.

There are two basic evaluation criteria for plain concrete pavements. They are the standard evaluation and the extended life evaluation. Army airfield pass/load relationships are to be reported for both criteria. Air Force evaluations are to be reported using the extended life criteria. Other types of rigid pavements have only one method of evaluation and is used for Army and Air Force pavements.

a. Standard evaluation. The standard evaluation criteria are essentially the reverse of design and are based upon a criteria where 50 percent of the slabs is cracked into two or three pieces at the end of traffic (sometimes referred to as initial failure or first crack failure.).

b. Extended life evaluation. The extended life evaluation is based upon a criteria where 50 percent of the slabs is cracked into approximately six pieces at the end of traffic (sometimes referred to as shattered slab failure).

2–3. Method of evaluation.

a. The detailed data necessary for evaluating concrete pavements are pavement type, existing pavement thickness, flexural strength of the concrete, and modulus of reaction of the subgrade or base-course materials. The modulus of elasticity and Poisson's ratio of the concrete could be helpful in an evaluation; however, since they do not vary widely, the modulus of elasticity and Poisson's ratio of concrete were assumed to be 4×10^6 psi and 0.15, respectively, for the development of the evaluation charts and tables.

b. When evaluating such pavements as rigid overlay, nonrigid overlay, and reinforced rigid pavements, it is first necessary to convert the existing pavement thickness to an equivalent thickness of the section. This equivalent thickness is the thickness of plain rigid pavement that would have the same pass/load relationship as the overlay or reinforced pavement being evaluated. The equivalent thickness of plain rigid pavement is then used in the evaluation charts to determine the maximum allowable gross weight of aircraft. Figures 2–1 through 2–17 are used in determining equivalent thickness and are further explained in chapter 3.

c. Supplemental modulus of soil reaction values can be estimated by performing a California Bearing Ratio (CBR) test in a core hole and using the curve shown in figure 2–18 to convert the CBR to a modulus of soil reaction value.

d. In an evaluation, it will be necessary to list the pavement features in accordance with the various factors that will influence the allowable pass/load relationship. After the required physical properties have been established, the only additional information needed to make the evaluation is the determination of the type of traffic area. The Air Force has four traffic areas—types A, B, C, and D as defined in TM 5–824–1/AFM 88–6, Chap. 1. Army airfields contain two traffic areas—types B and C. Type B traffic areas consist of all pavement features except runway interiors. Type C traffic areas consist of the runway interiors between the 500-foot end sections. Other factors that may influence the evaluation are outlined in chapter 3; however, these conditions are unusual and will require special consideration by the evaluating engineer. Detailed instructions for and examples of evaluations are presented in chapters 4 to 11.

e. General procedures for making an evaluation. After the existing thickness or equivalent thickness, flexural strength, and modulus of soil reaction have been determined, the evaluation of a pavement is made in terms of allowable passes for given gross weights or in terms of allowable gross weights for given pass levels by using figures 2–19 through 2–34 along with figures 2–35 through 2–50 for standard evaluations and figures 2–51 through 2–66 for extended life evaluations. The loads and pass levels for which an evaluation is to be made are contained in

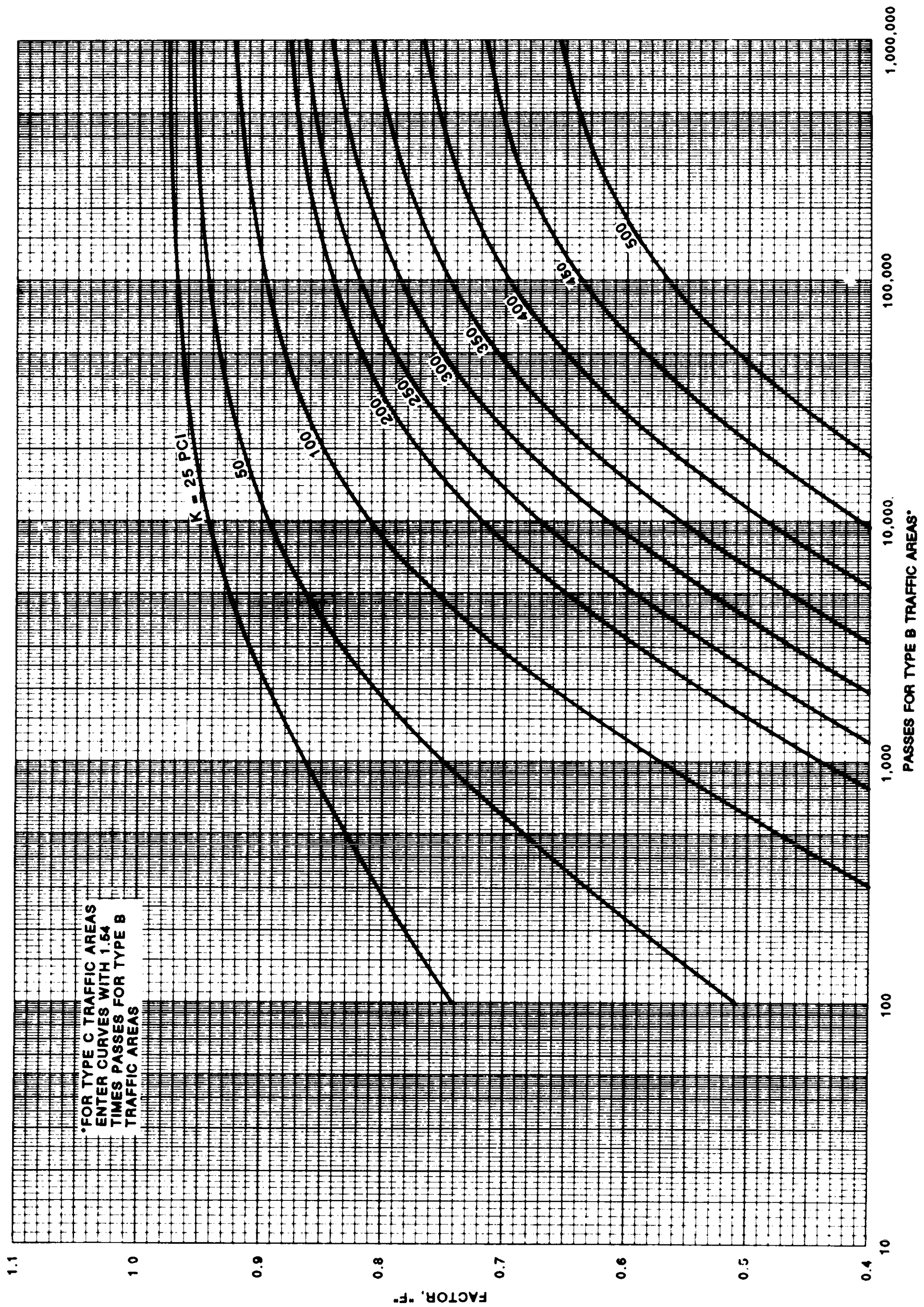


Figure 2-1. Factor for determining equivalent thickness of nonrigid overlay, U.S. Army Class I airfield.

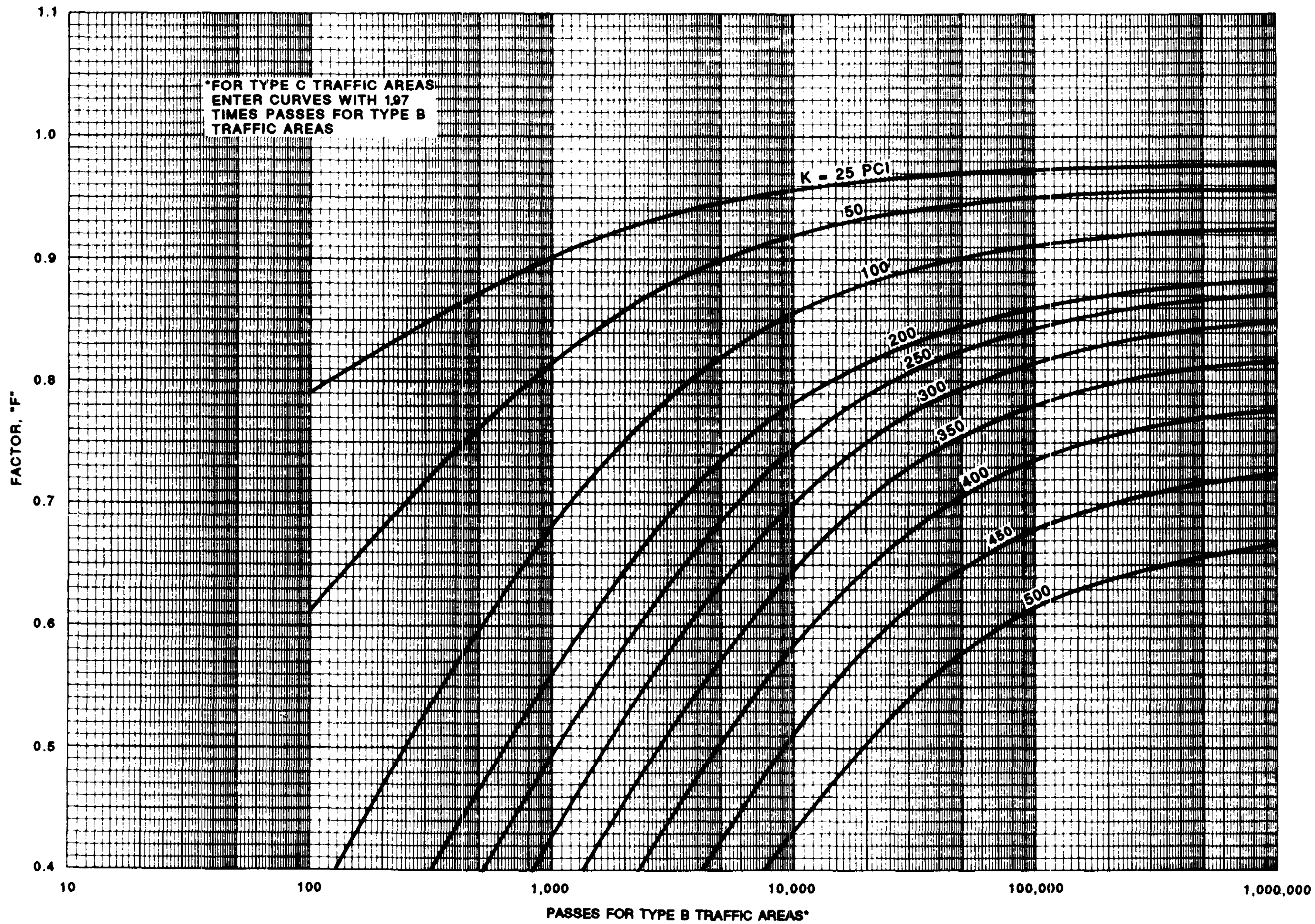


Figure 2-2. Factor for determining equivalent thickness of nonrigid overlay, U.S. Army Class II airfield.

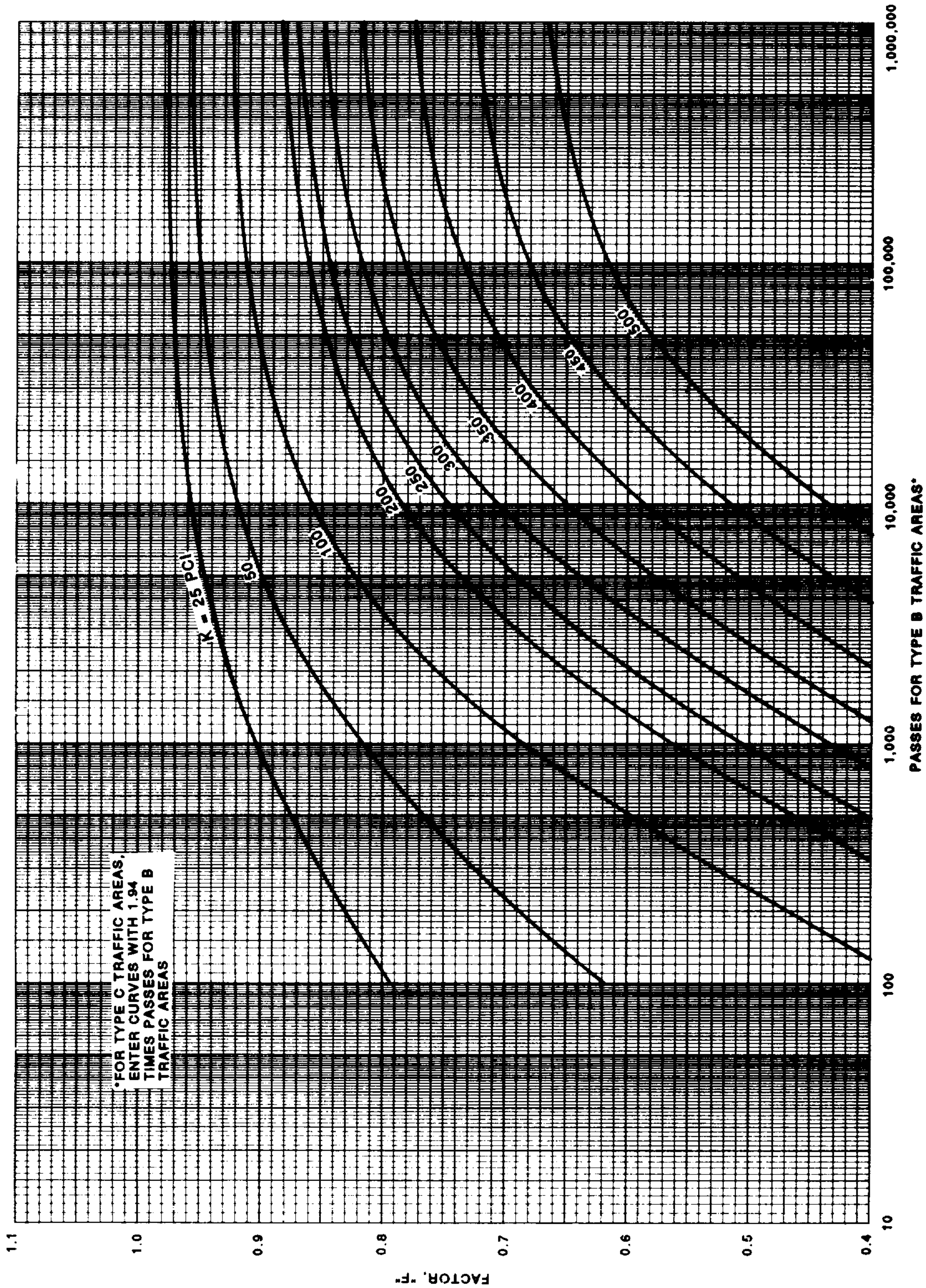


Figure 2–3. Factor for determining equivalent thickness of nonrigid overlay, U.S. Army Class III airfield.

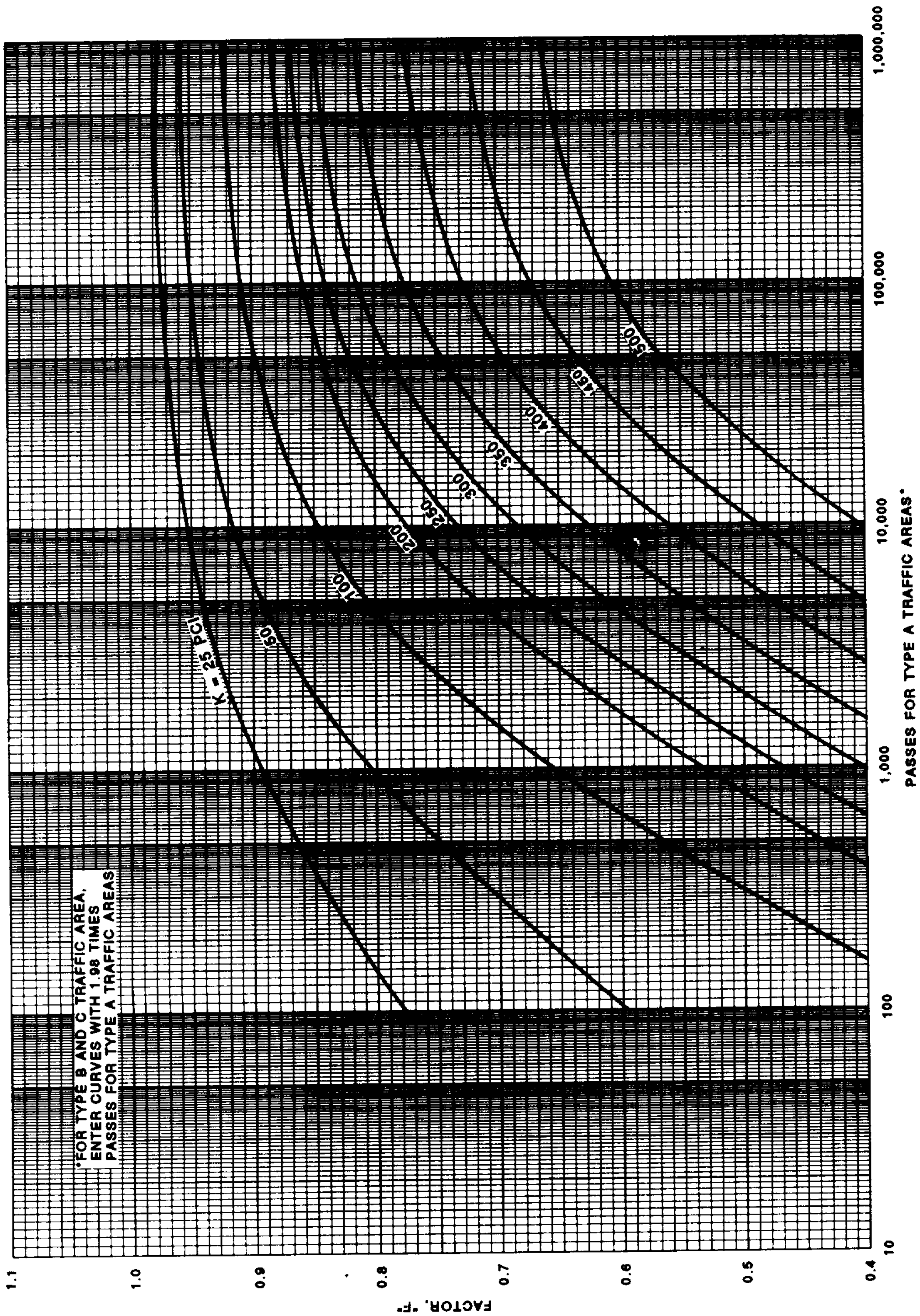


Figure 2–4. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 1.

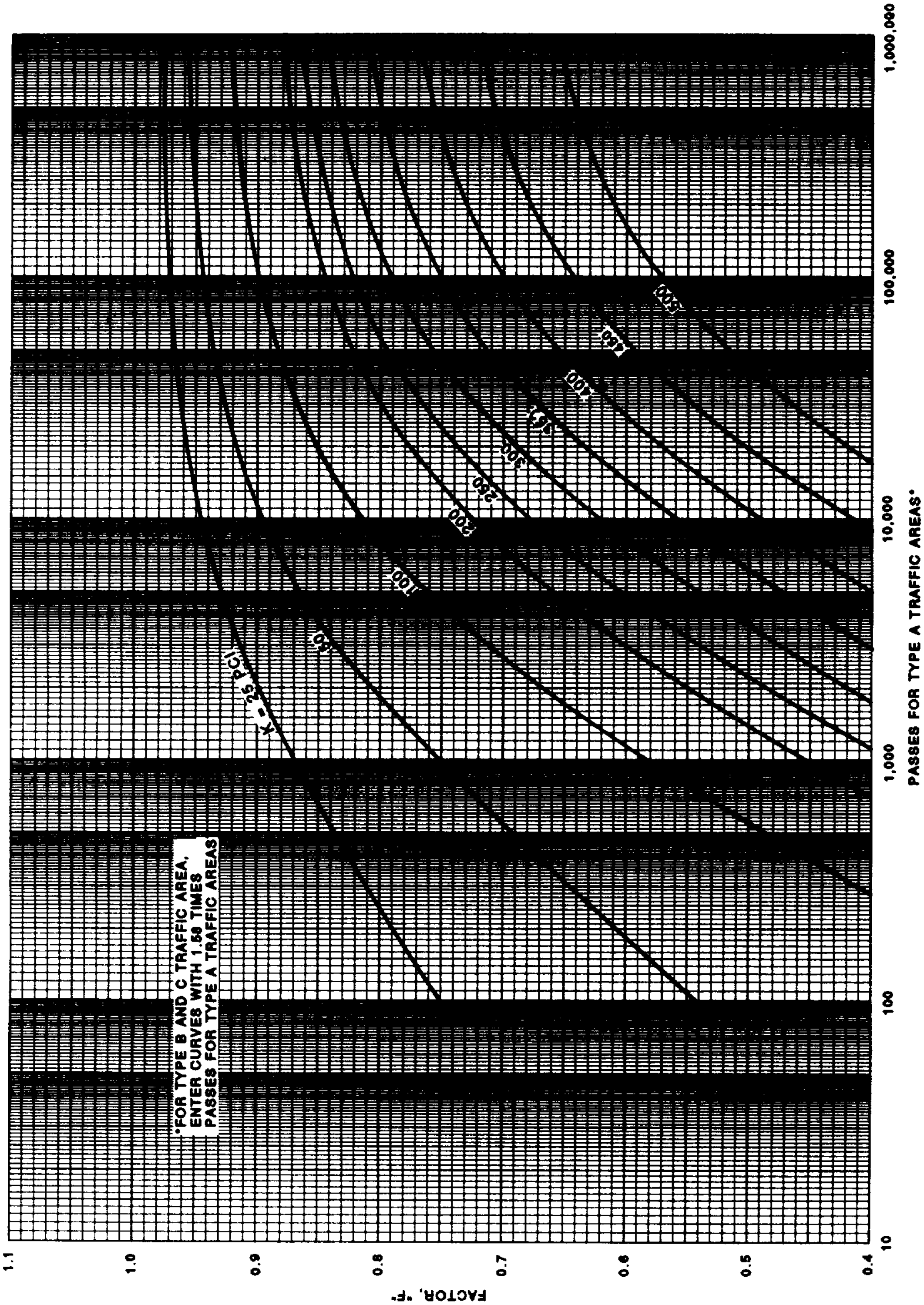


Figure 2-5. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 2.

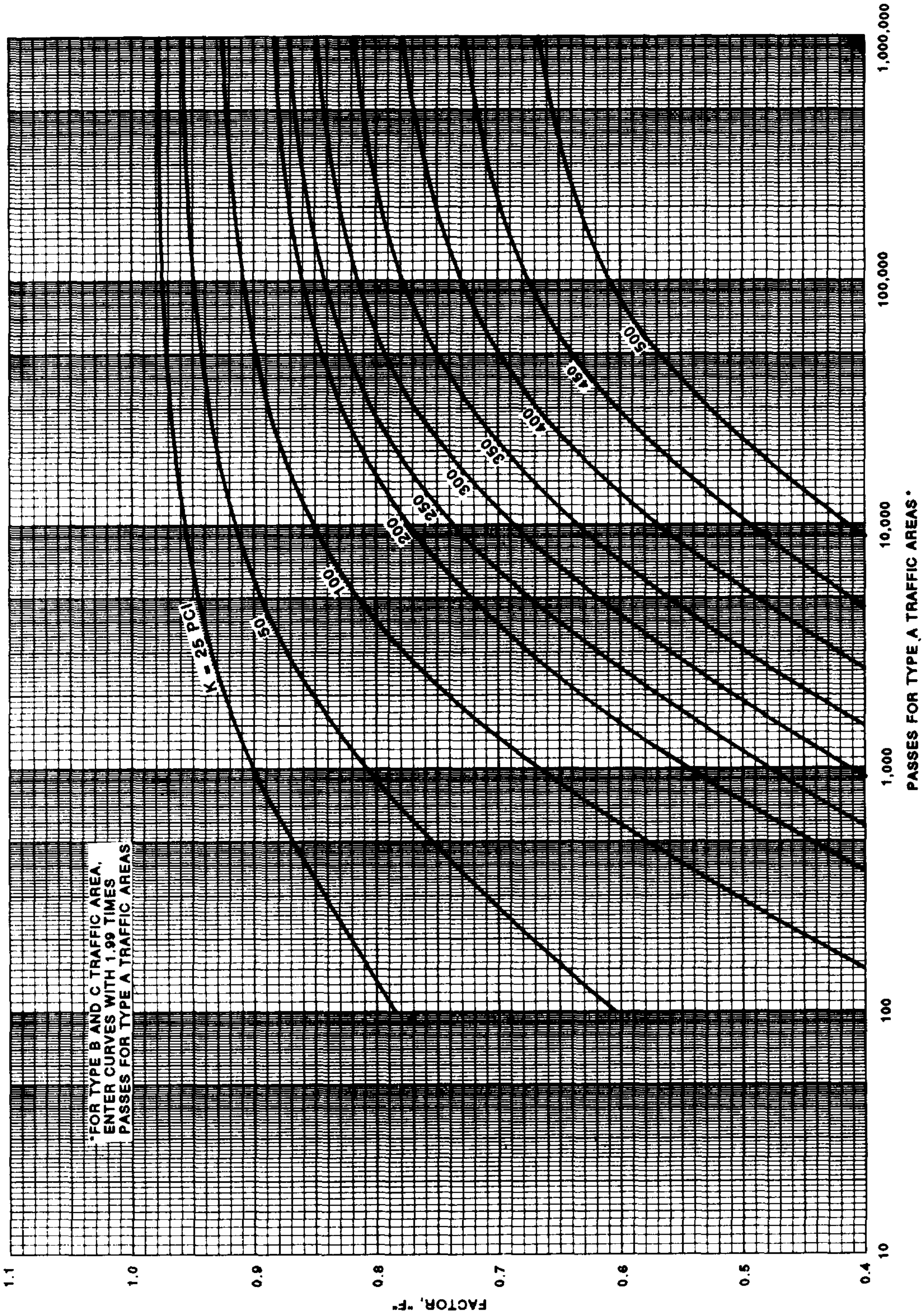


Figure 2–6. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 3.

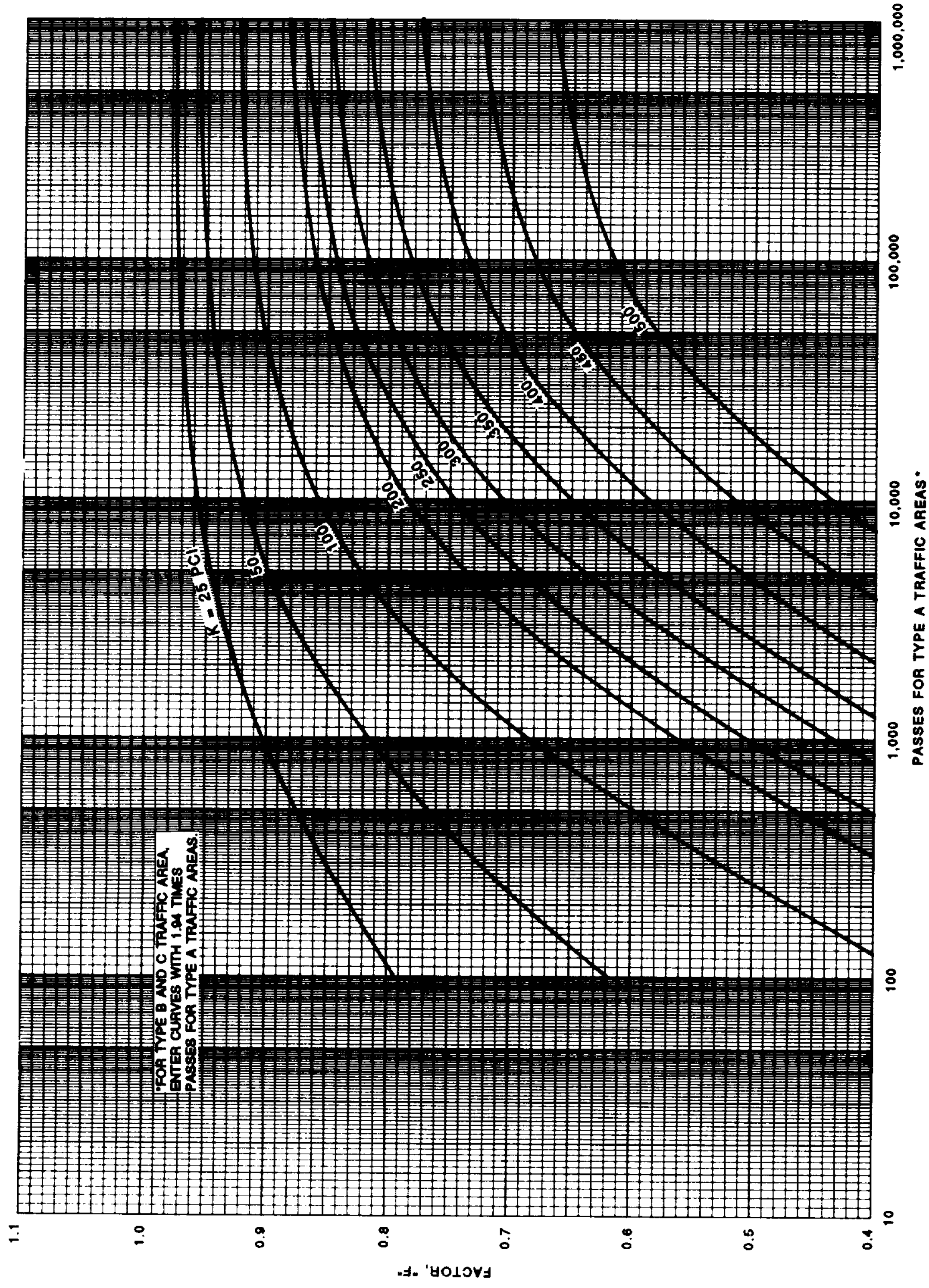


Figure 2-7. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 4.

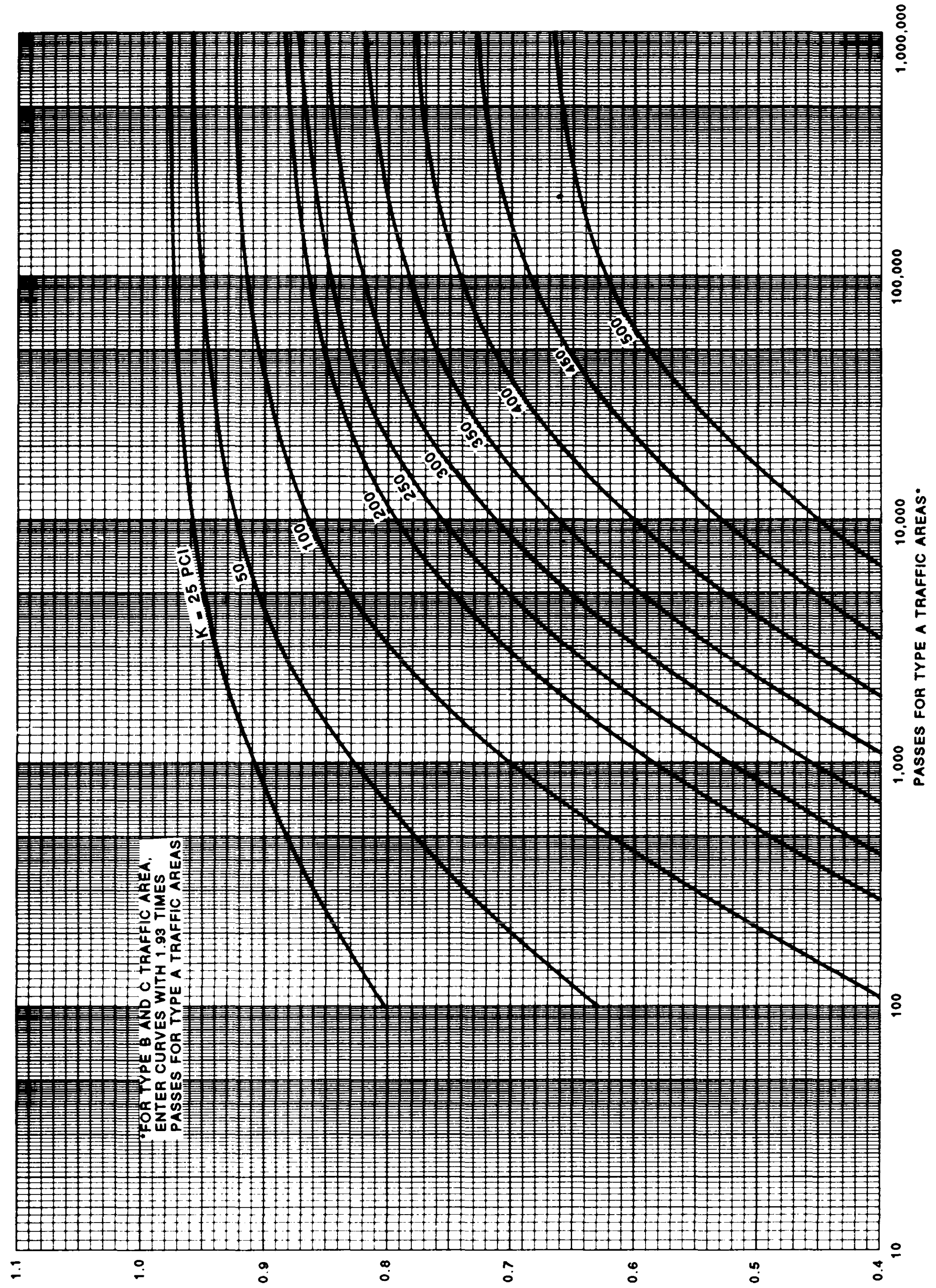


Figure 2–8. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 5.

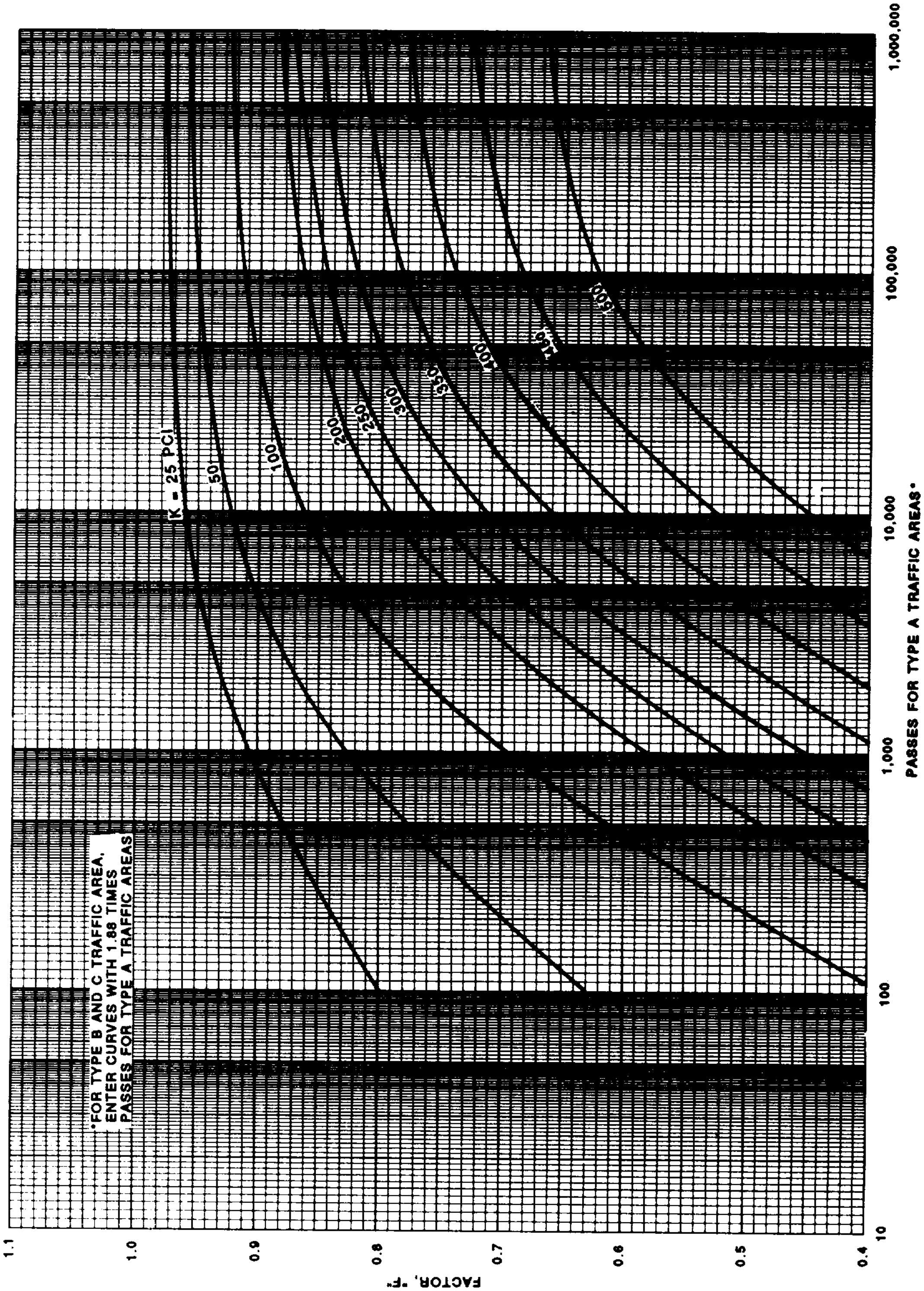


Figure 2-9. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 6.

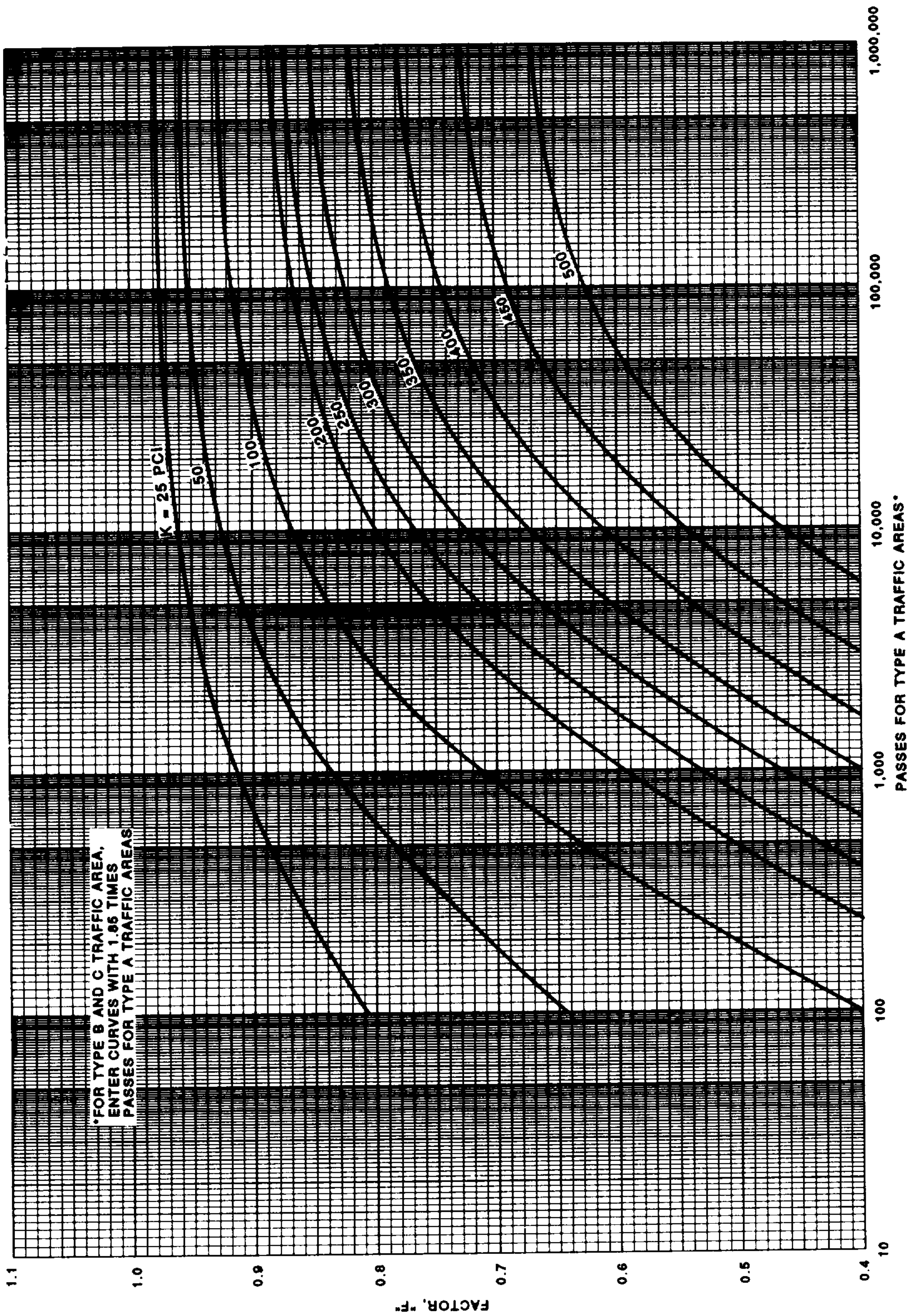


Figure 2-10. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 7.

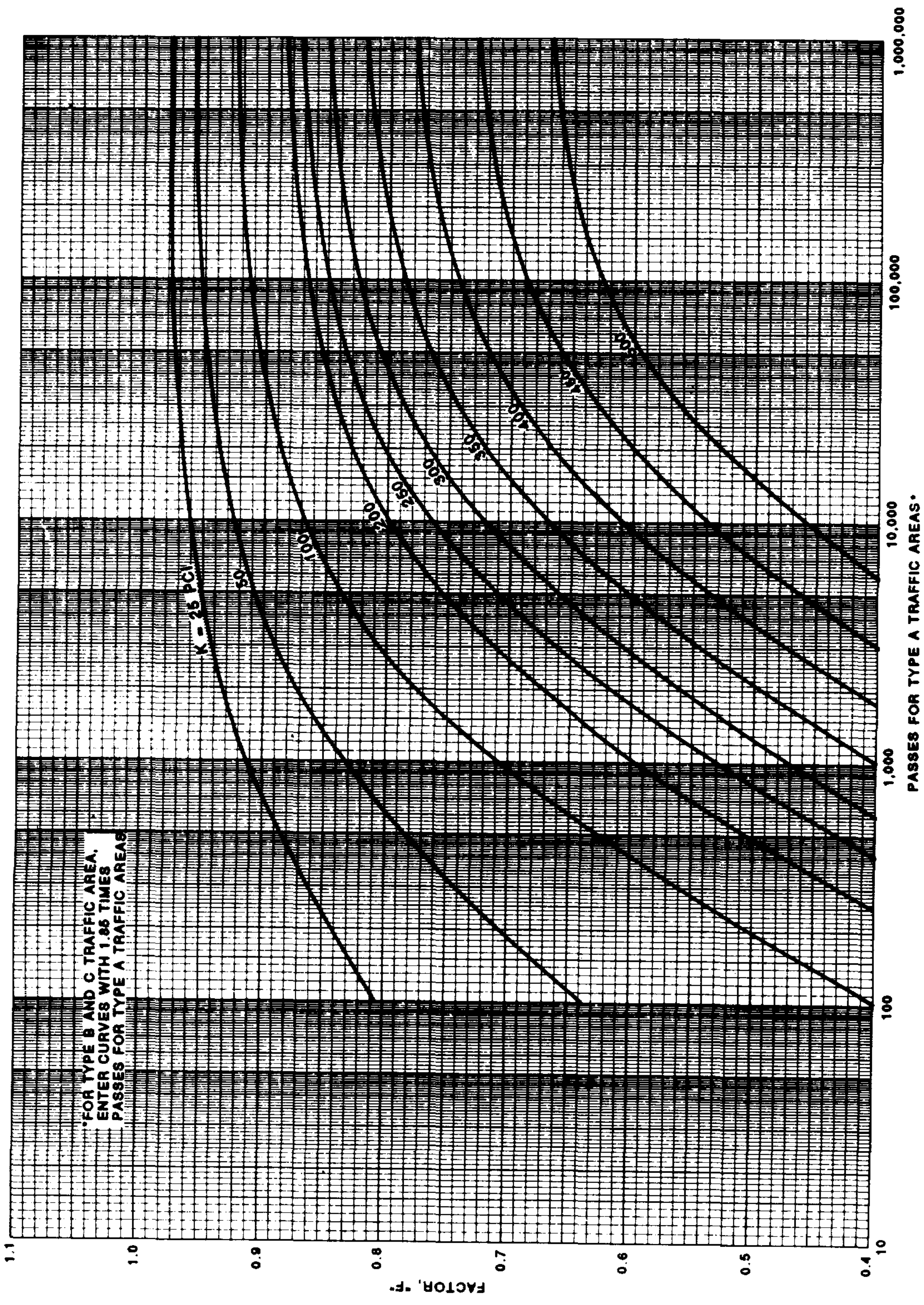


Figure 2-11. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 8.

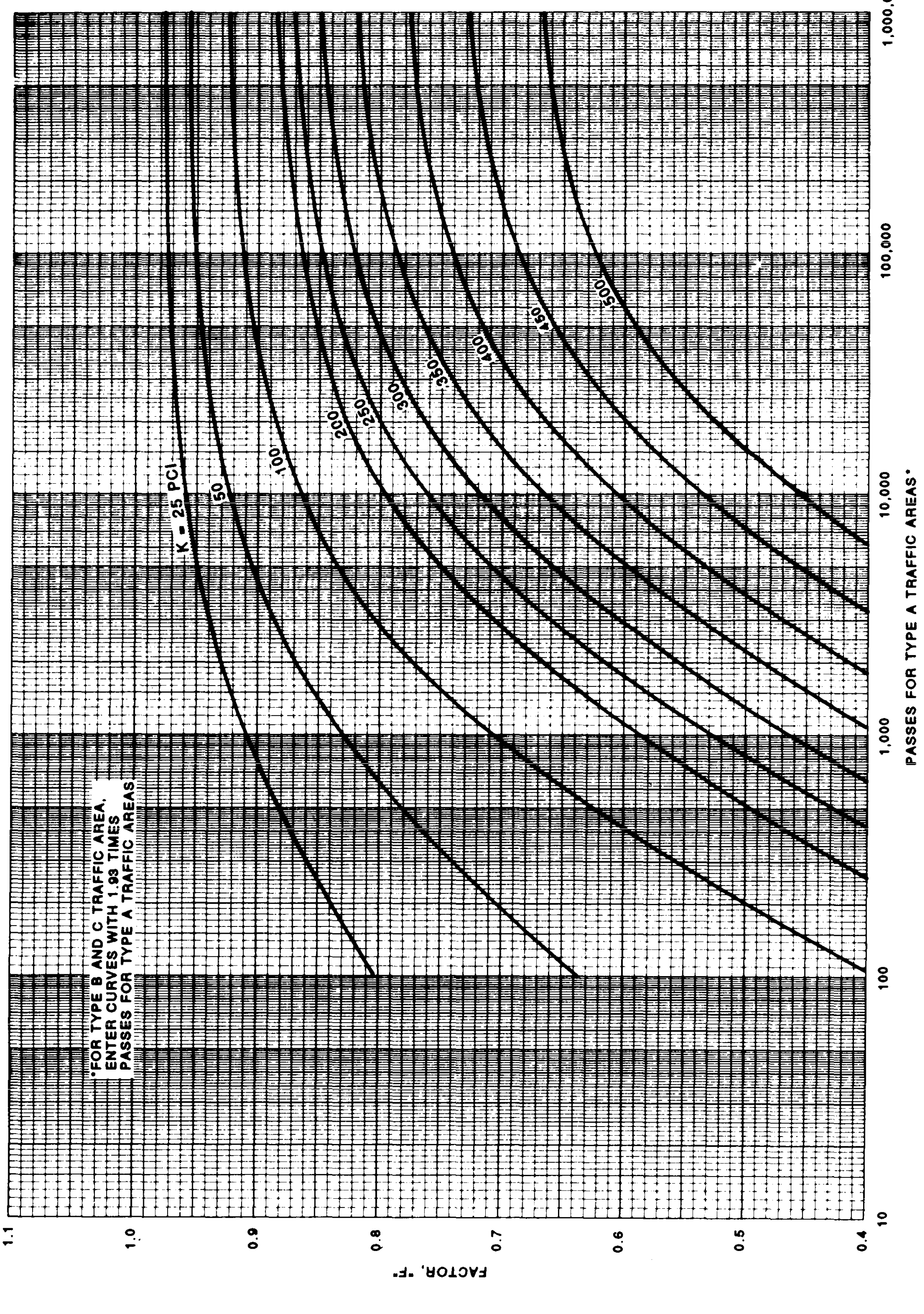


Figure 2-12. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 9.

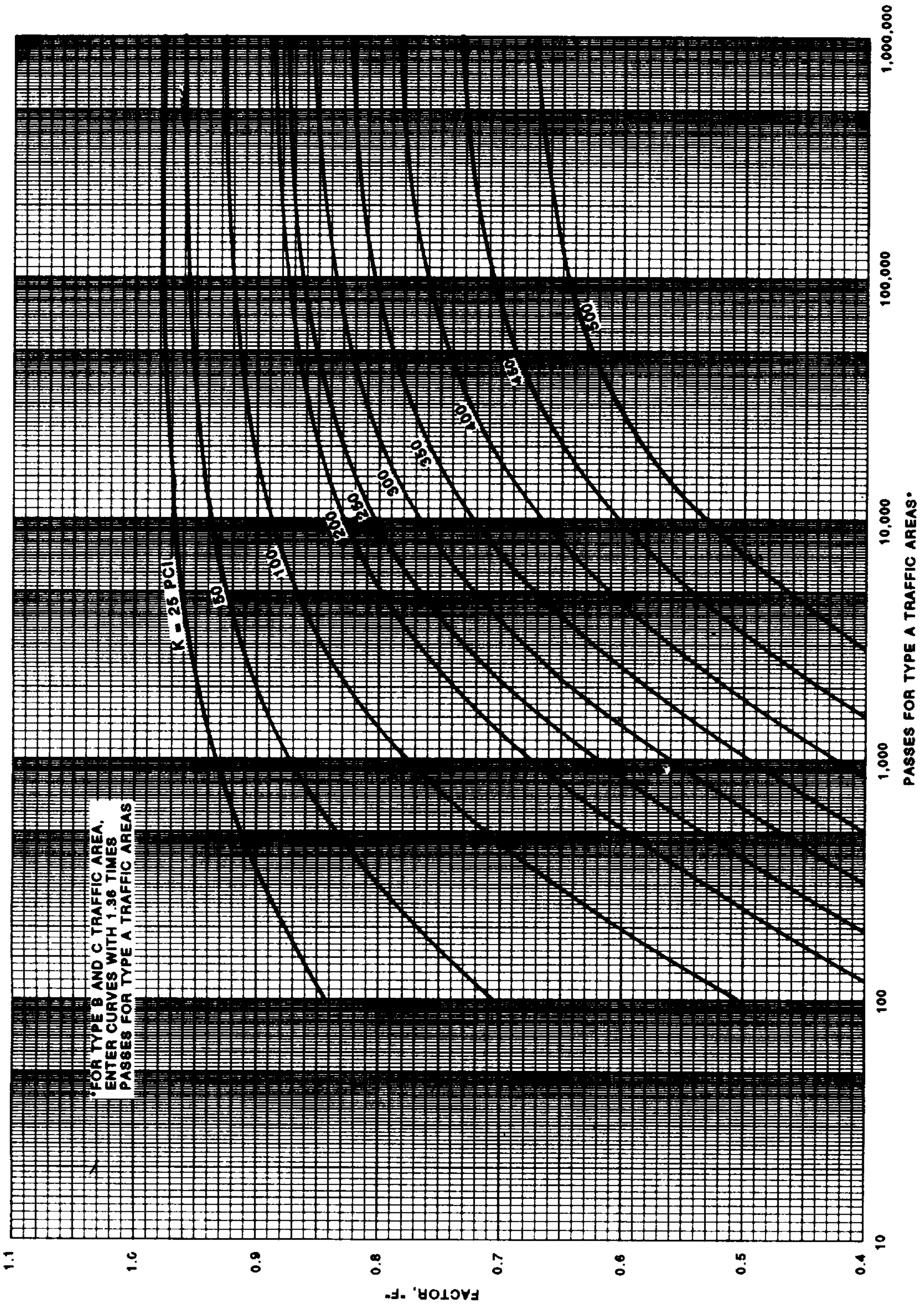


Figure 2-13. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 10.

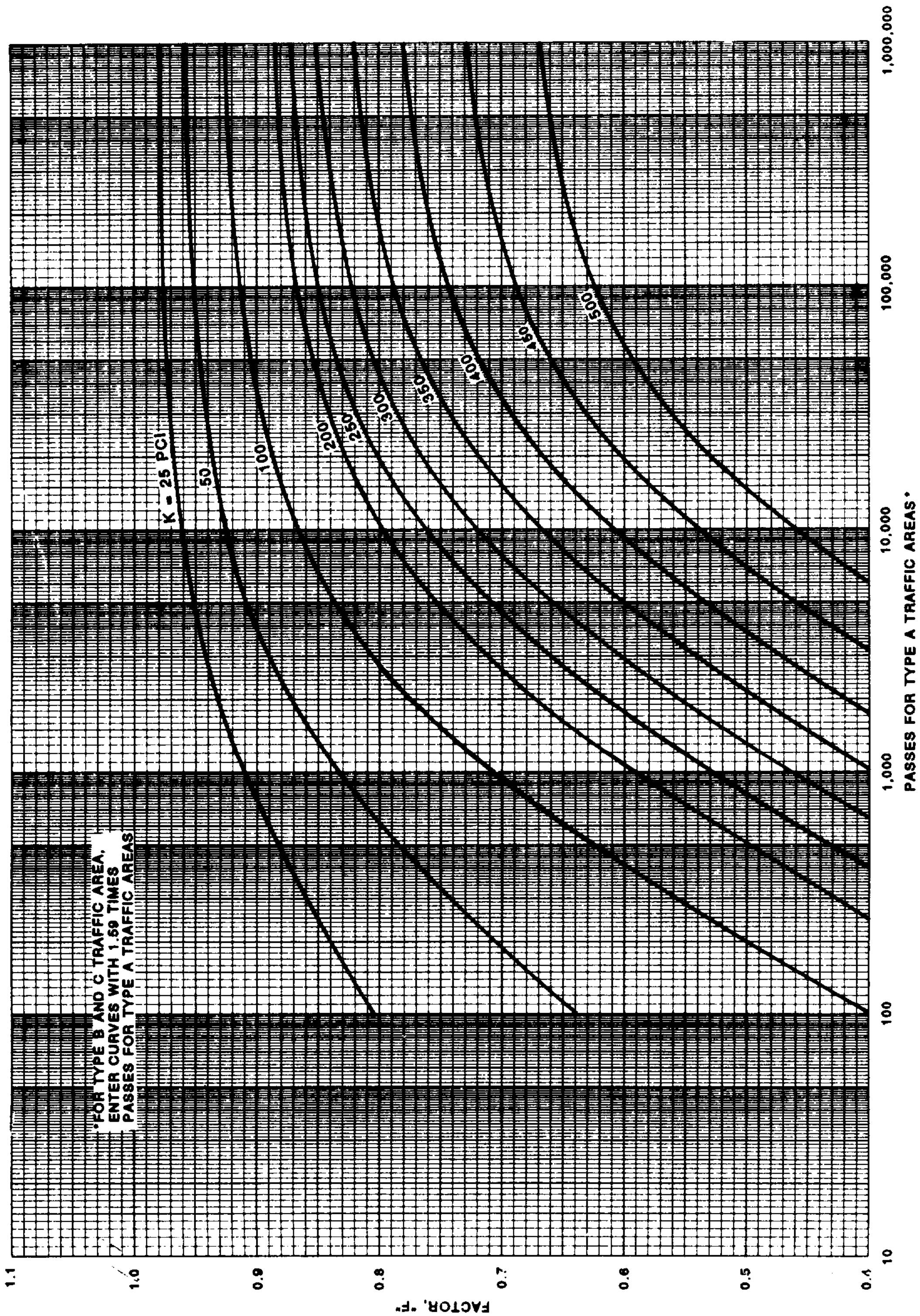


Figure 2-14. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 11.

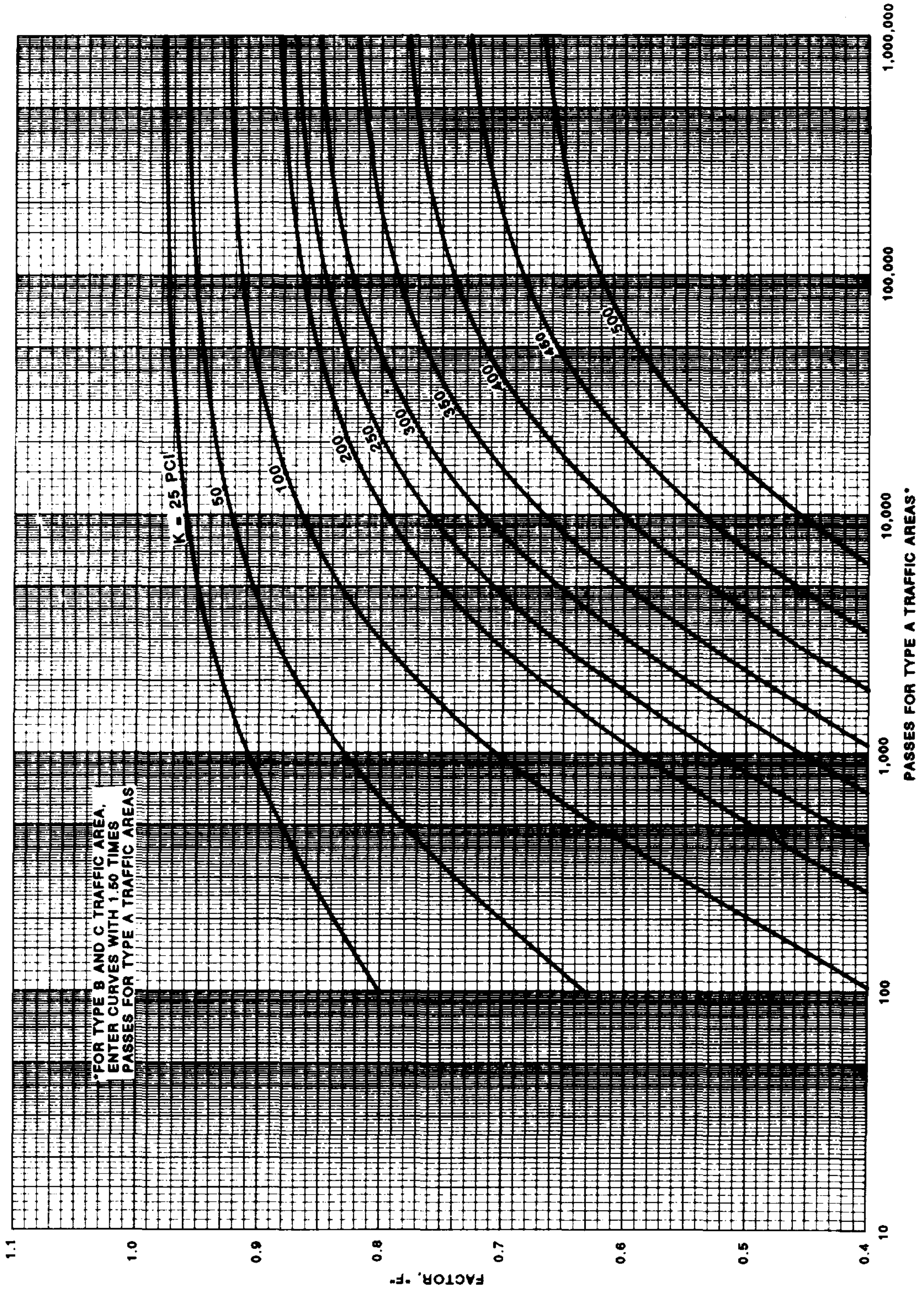


Figure 2–15. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 12.

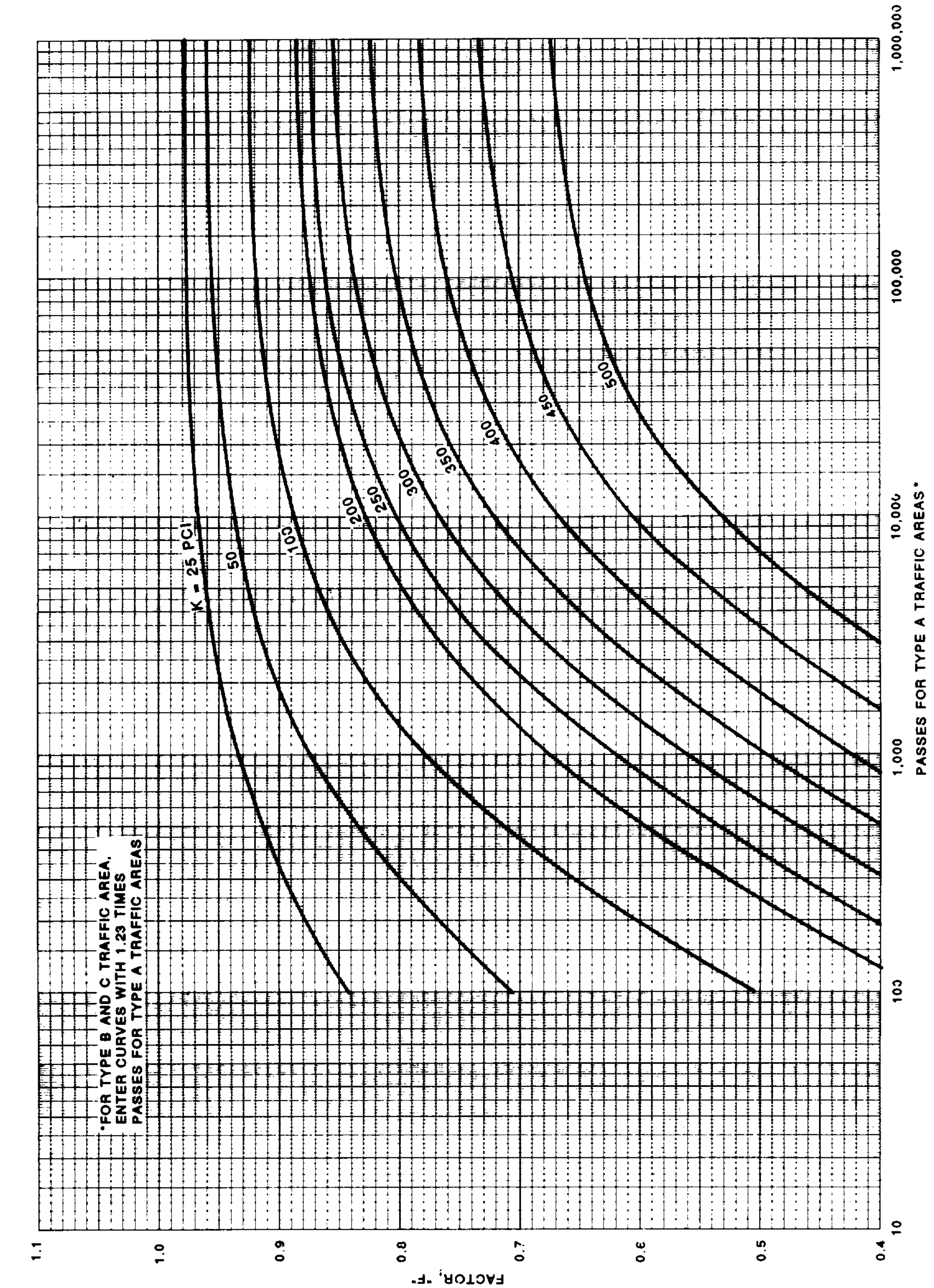


Figure 2–16. Factor for determining equivalent thickness of nonrigid overlay, Air Force group index 13.

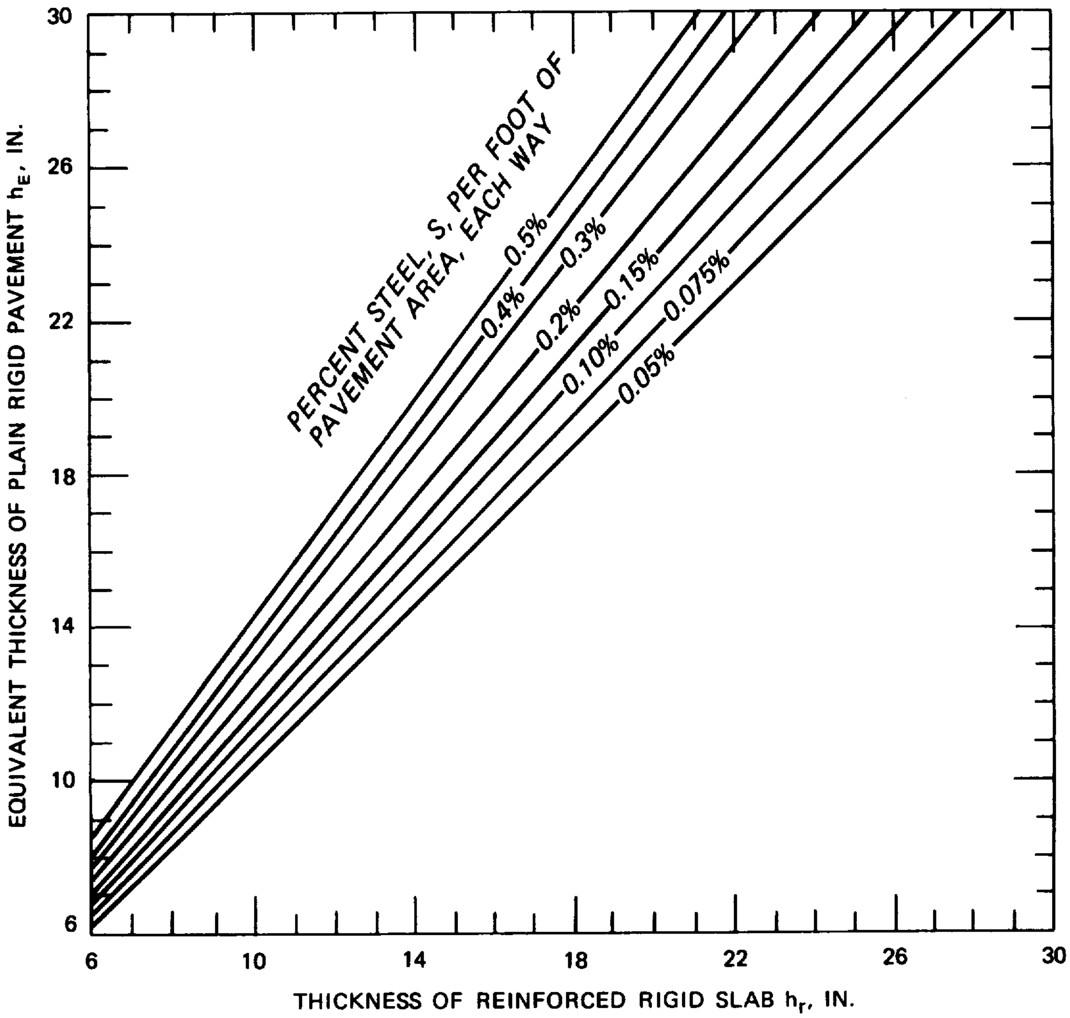


Figure 2-17. Equivalent thickness for reinforced concrete pavement.

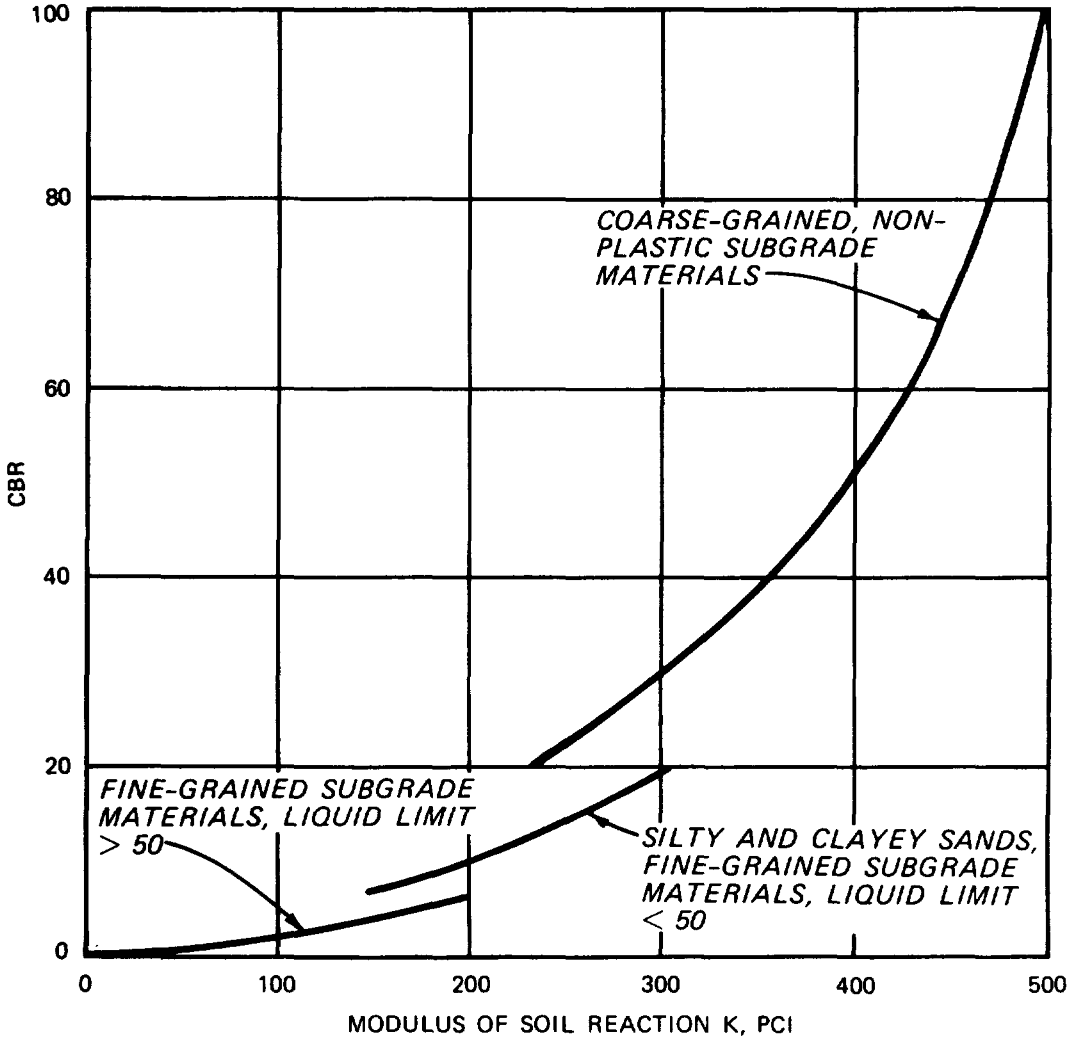


Figure 2-18. General relationship between CBR and modulus of soil reaction.

TM 5-826-1/AFM 88-24, Chap. 1. The determination of h_e or h_E will depend upon the type of pavement being evaluated. Detailed instructions for arriving at the thickness to use when employing the evaluation criteria are given in chapters 4 to 11.

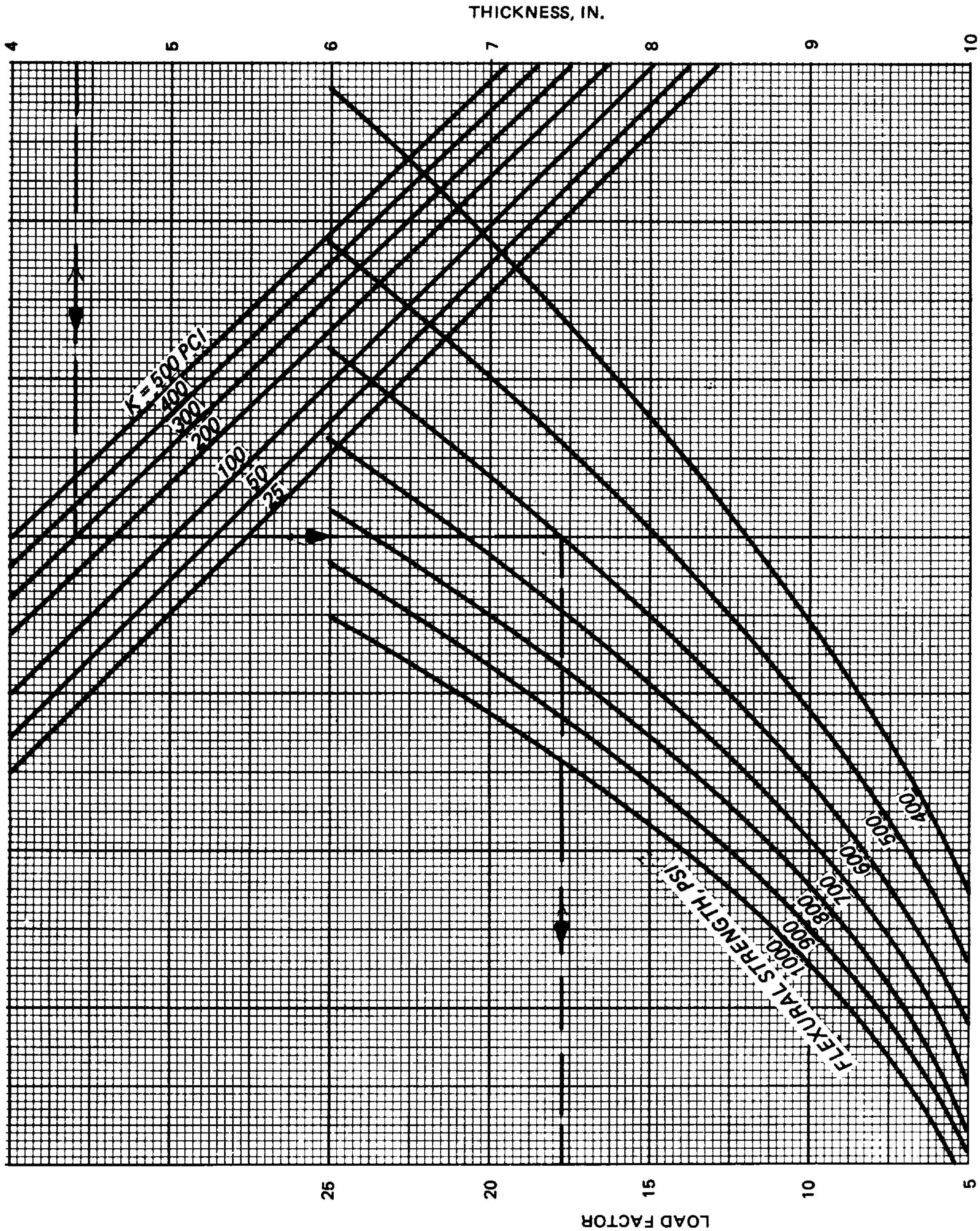


Figure 2-19. Rigid pavement evaluation curves, US Army Class I.

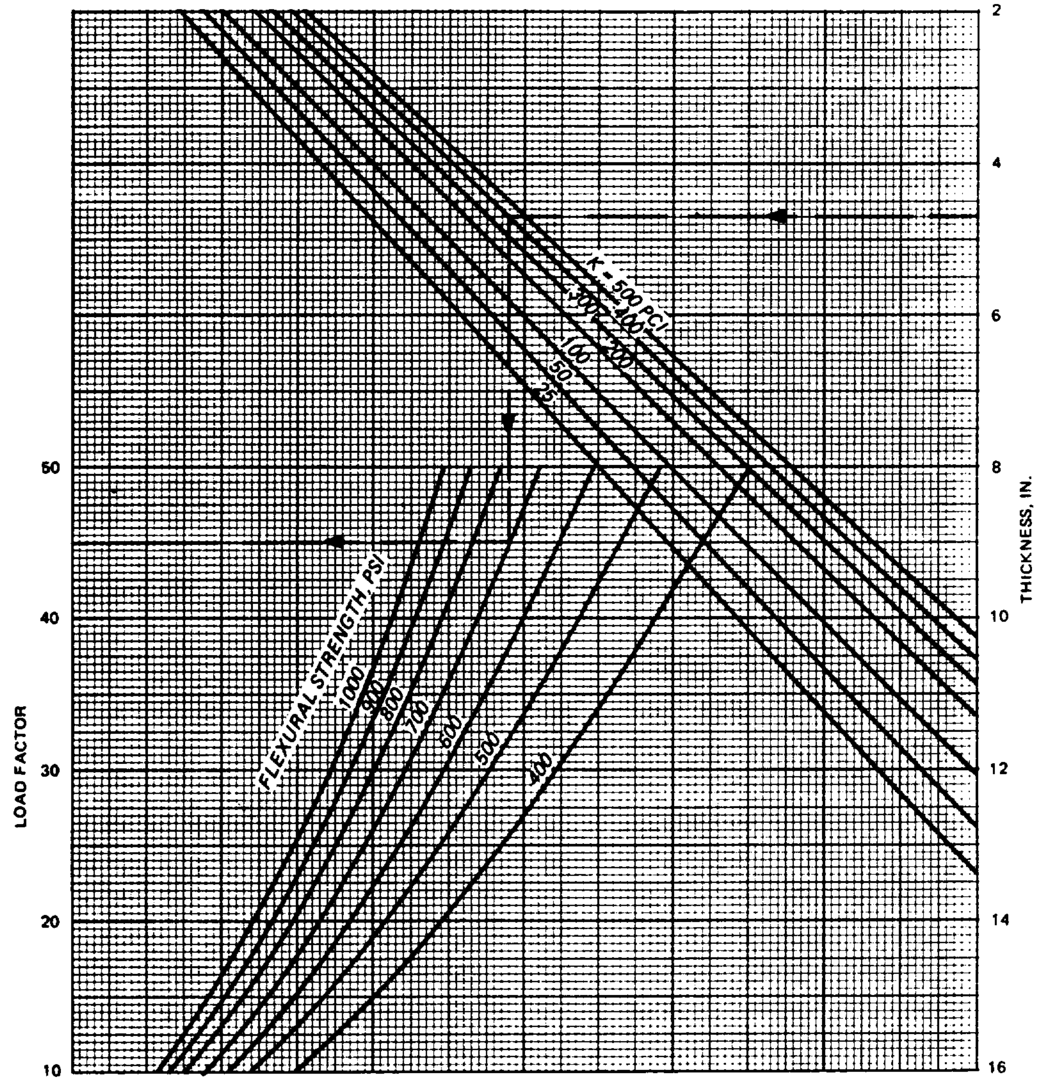


Figure 2-20. Rigid pavement evaluation curves, US Army Class II.

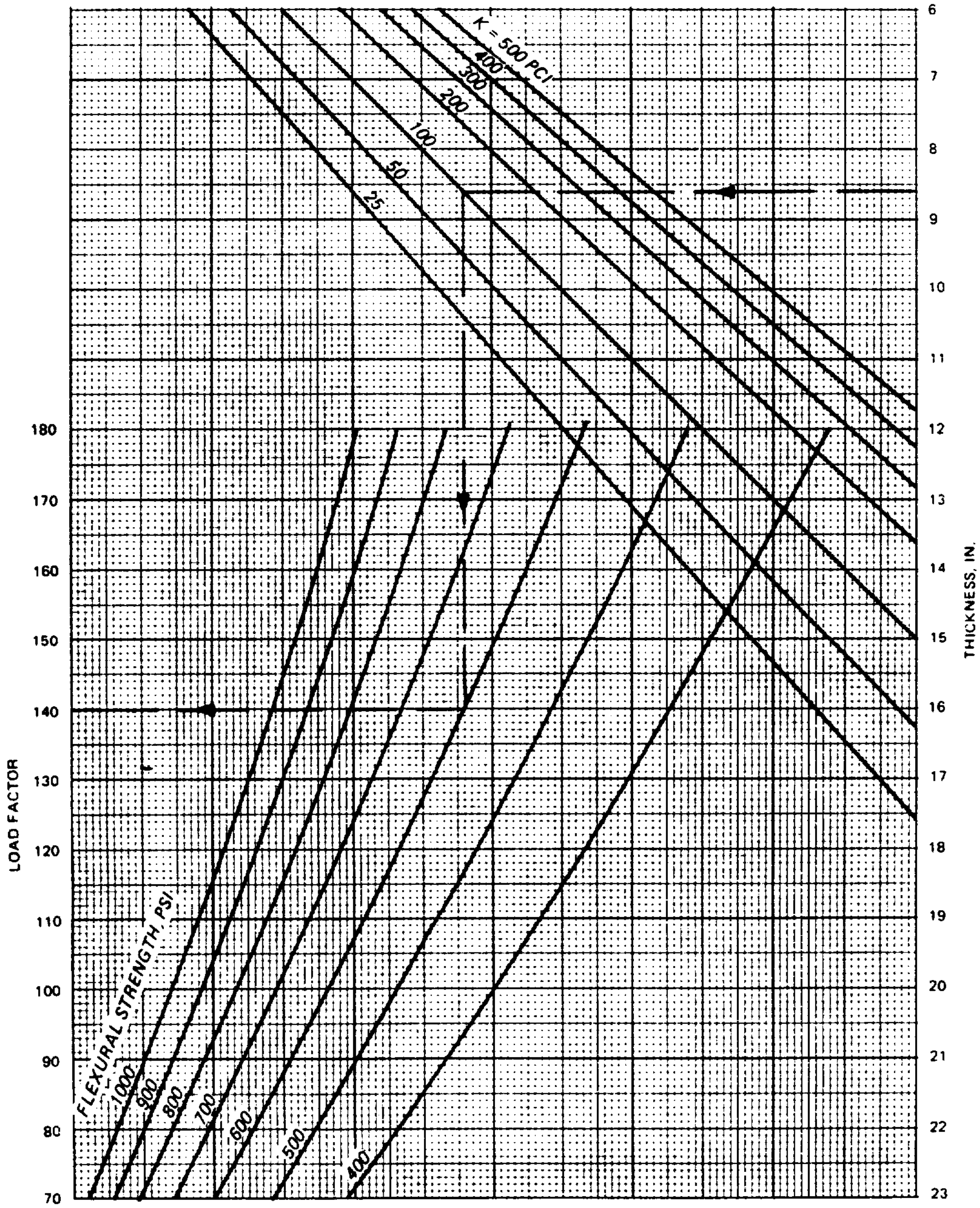


Figure 2-21. Rigid pavement evaluation curves, US Army Class III.

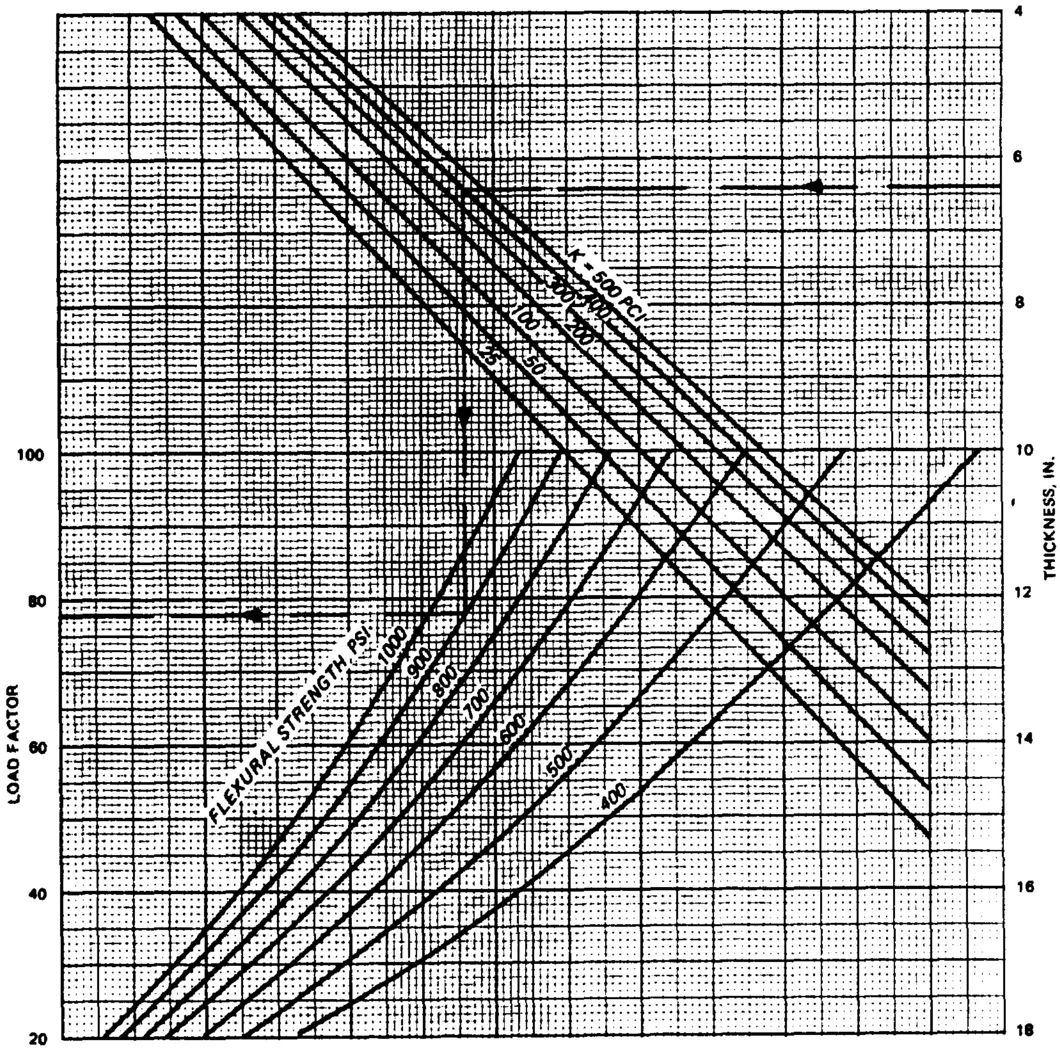


Figure 2-22. Rigid pavement evaluation curves, Air Force group index 1.

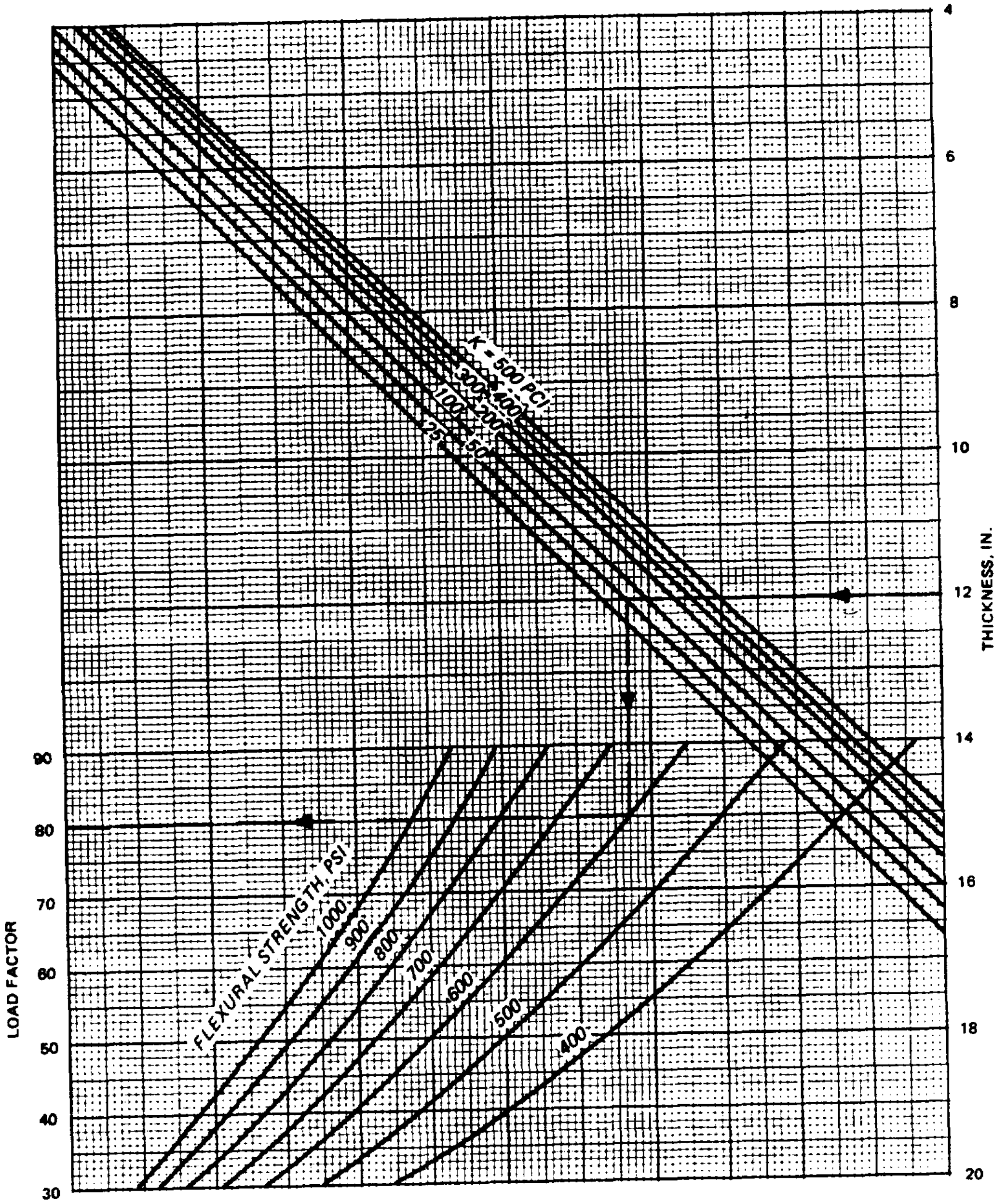


Figure 2-23. Rigid pavement evaluation curves, Air Force group index 2.

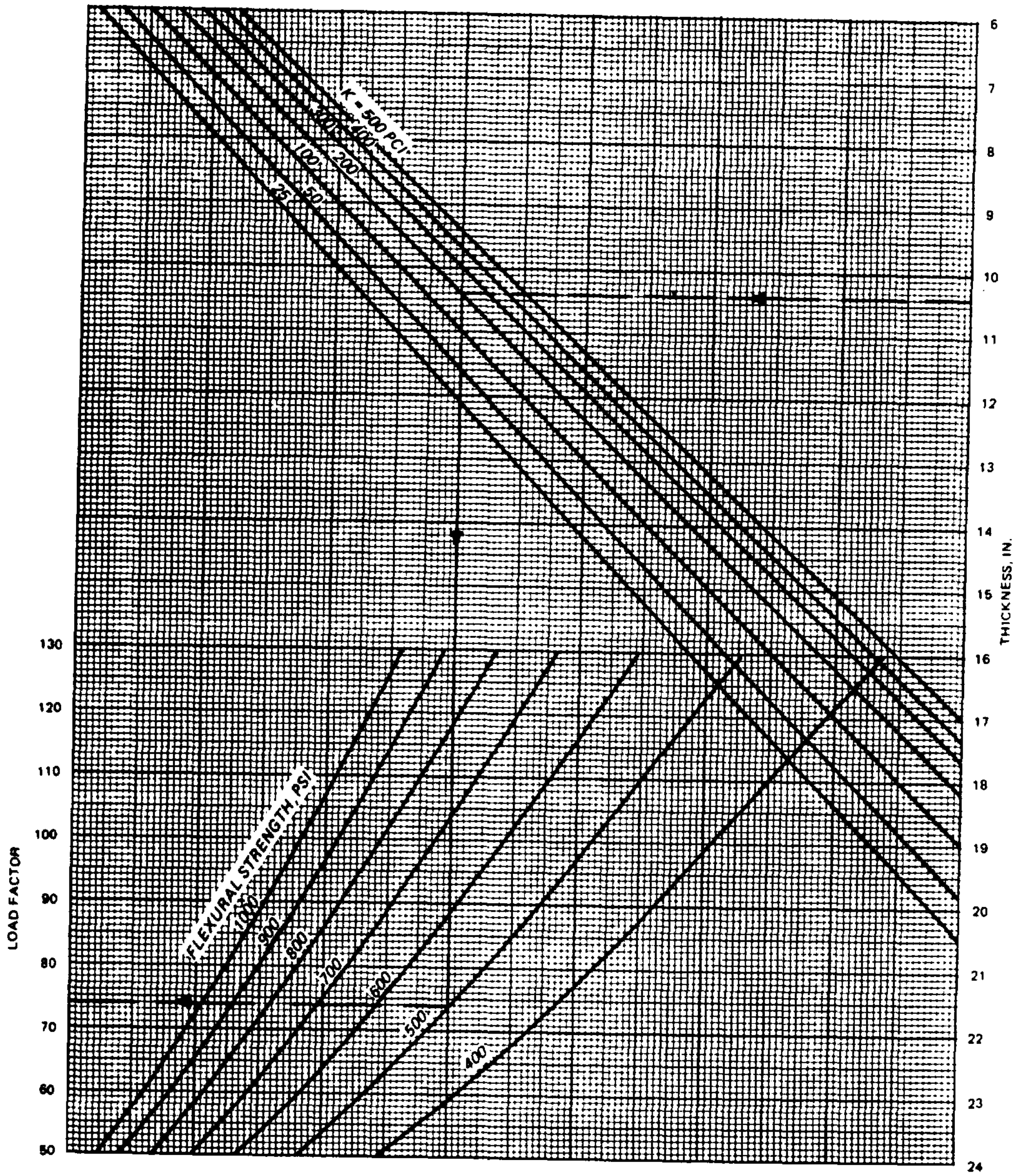


Figure 2-24. Rigid pavement evaluation curves, Air Force group index 3.

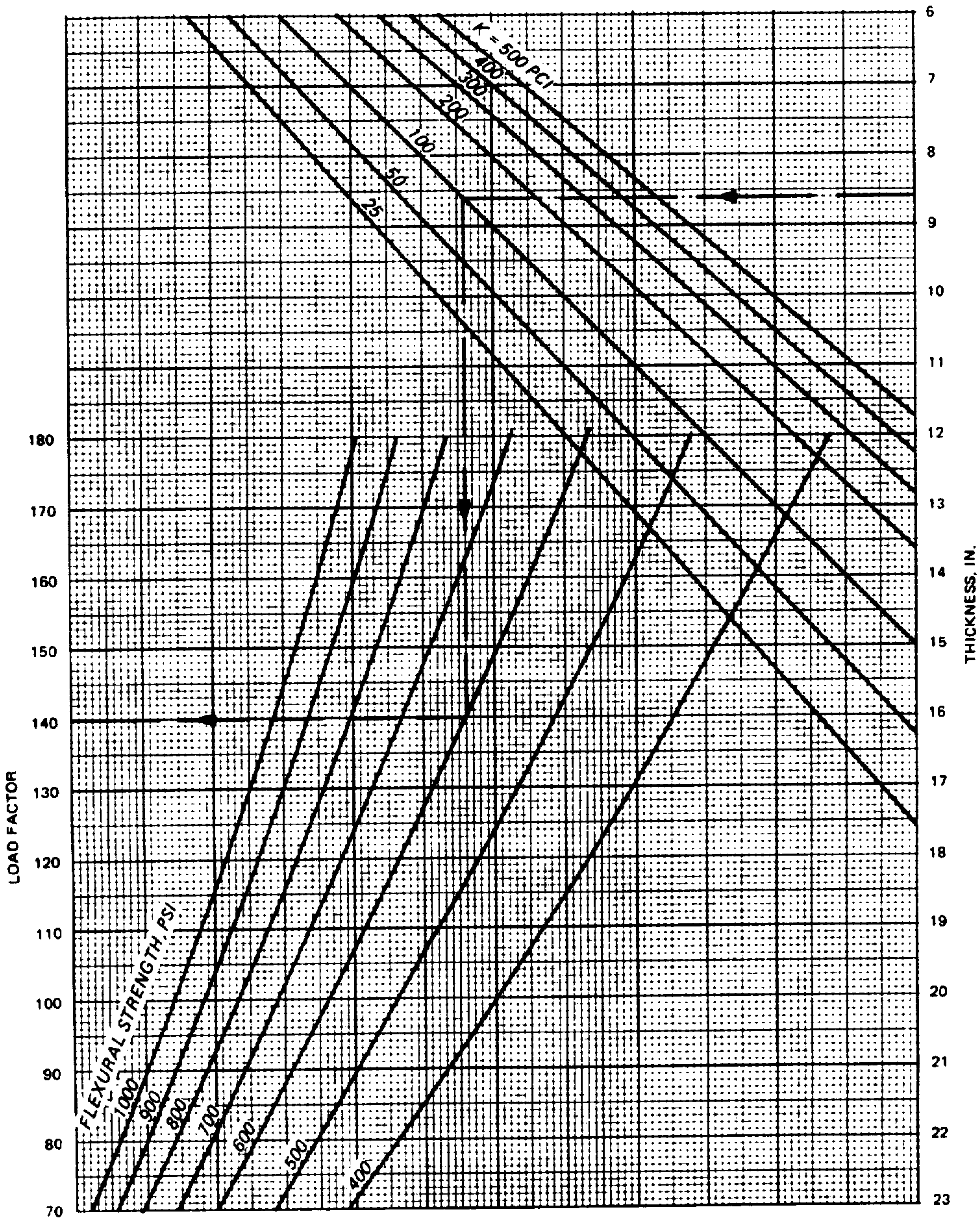


Figure 2-25. Rigid pavement evaluation curves, Air Force group index 4.

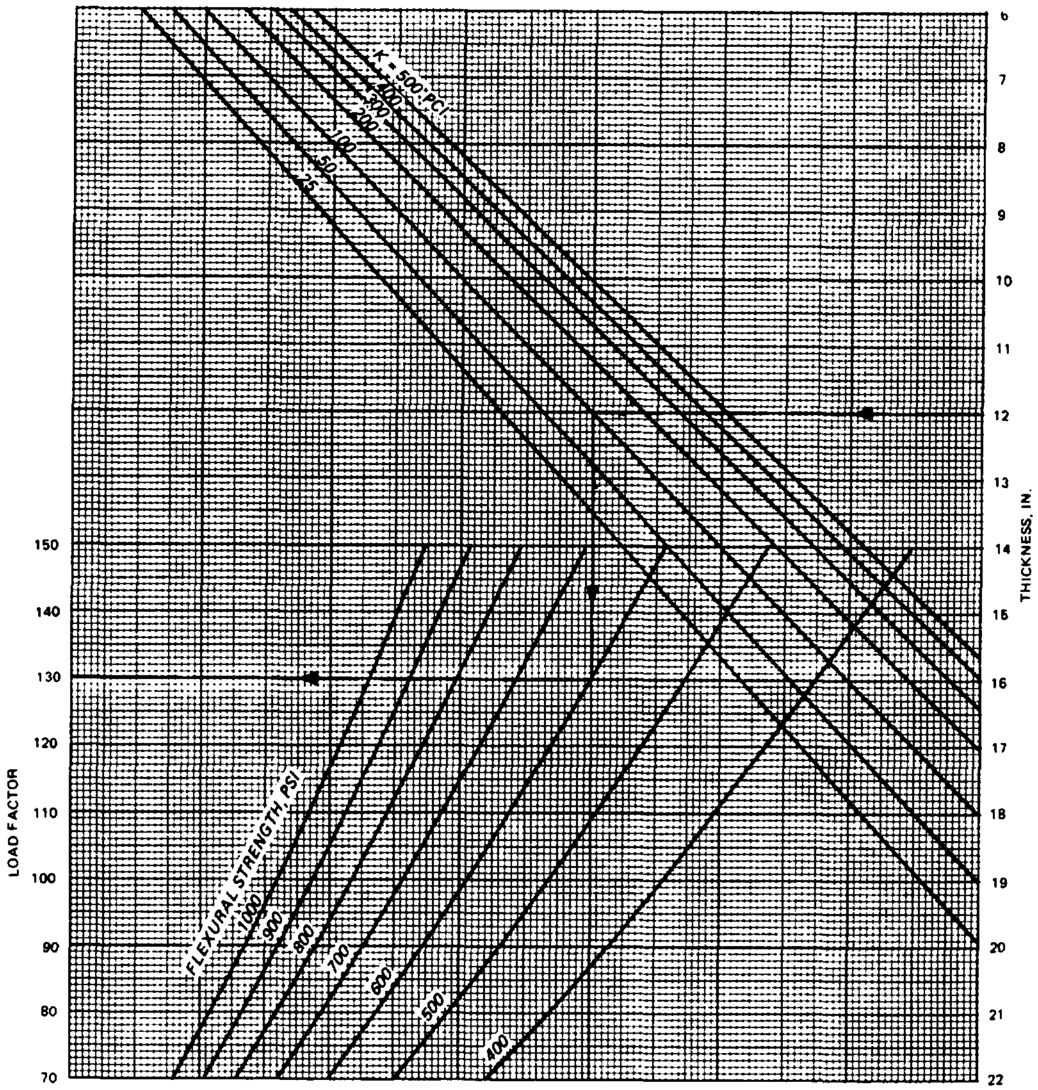


Figure 2-26. Rigid pavement evaluation curves, Air Force group index 5.

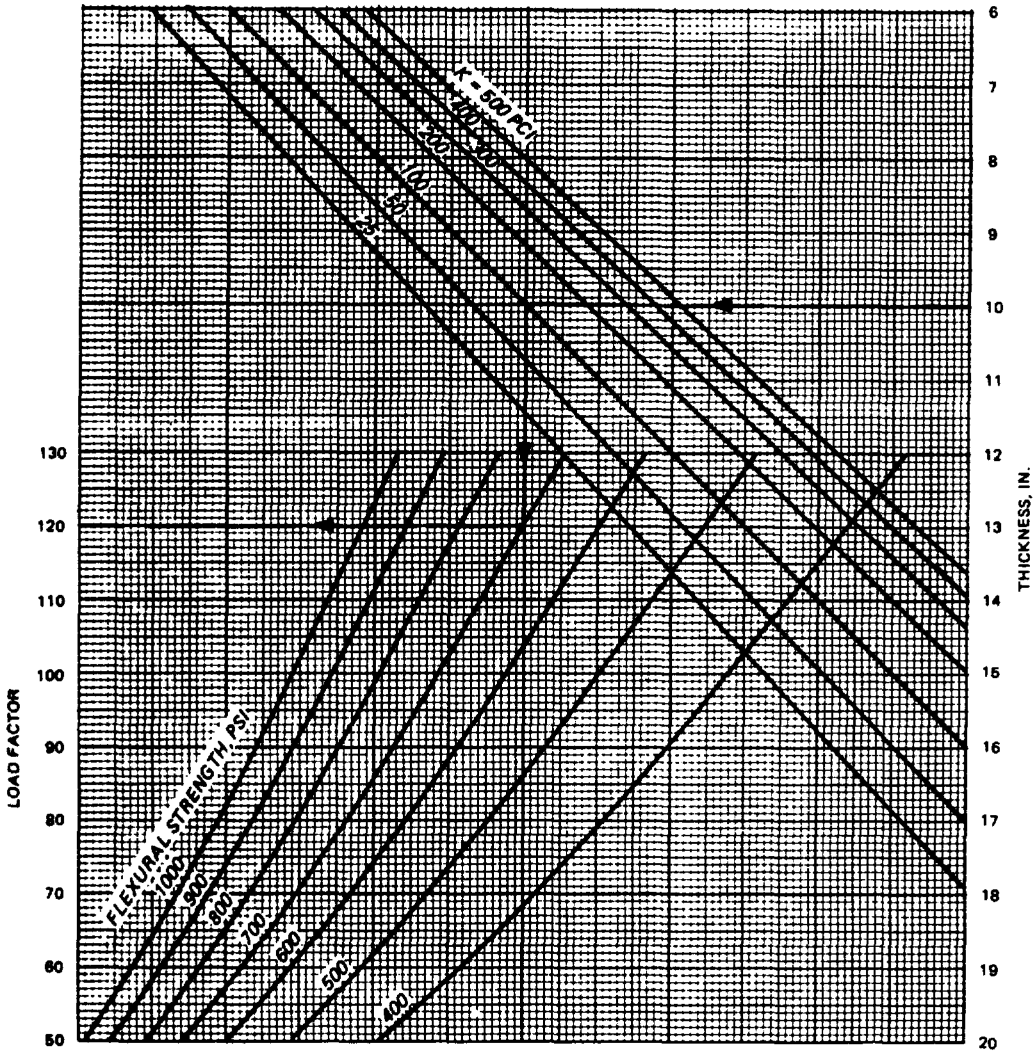


Figure 2-27. Rigid pavement evaluation curves, Air Force group index 6.

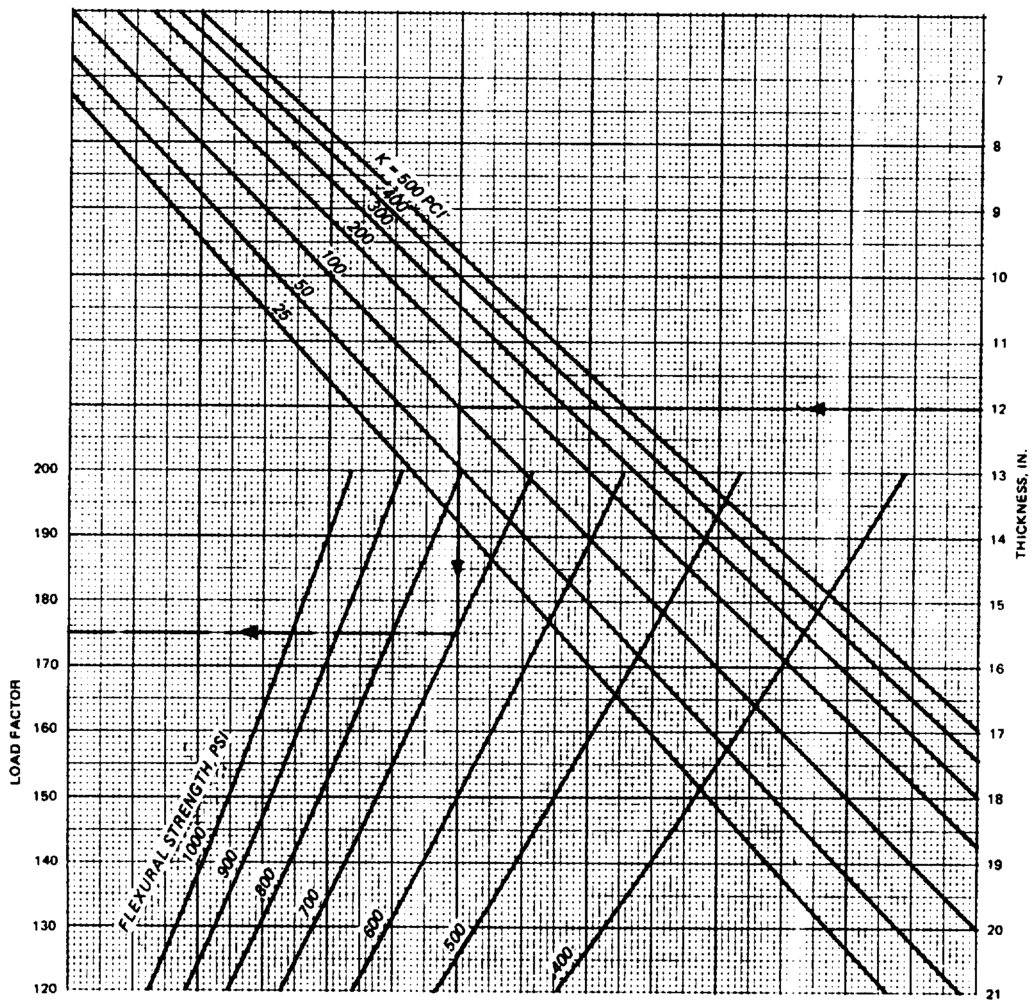


Figure 2-28. Rigid pavement evaluation curves, Air Force group index 7.

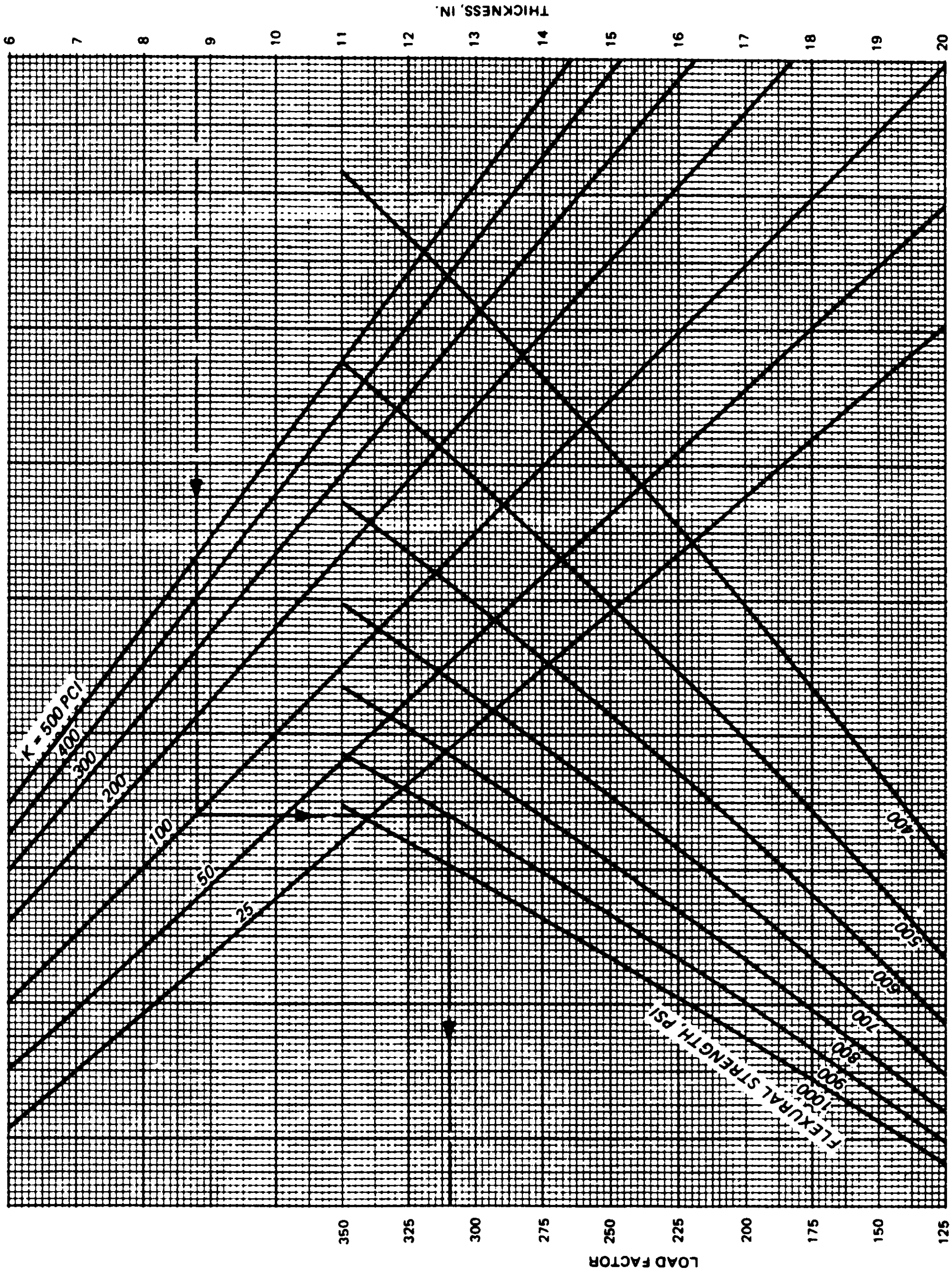


Figure 2-29. Rigid pavement evaluation curves, Air Force group index 8.

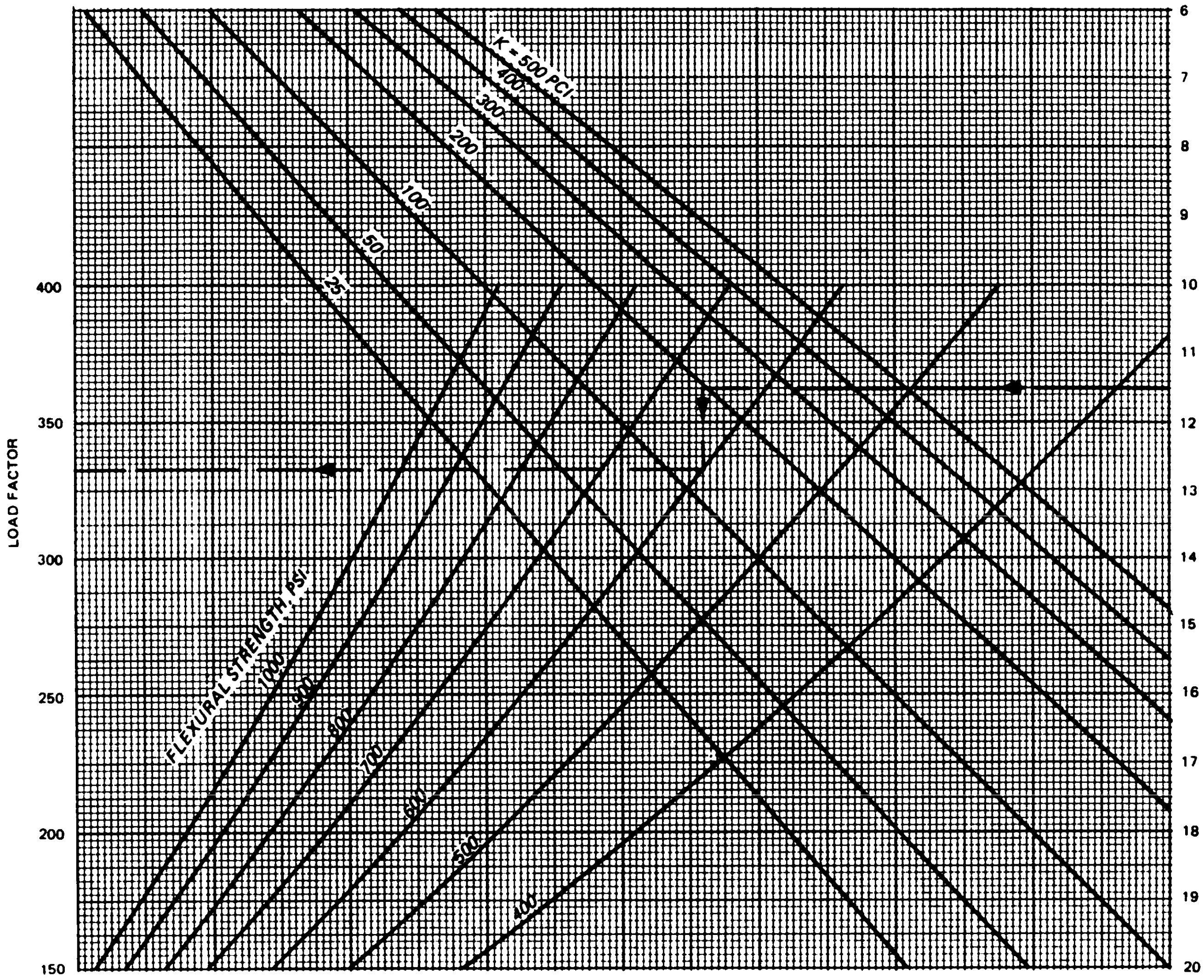


Figure 2–30. Rigid pavement evaluation curves, Air Force group index 9.

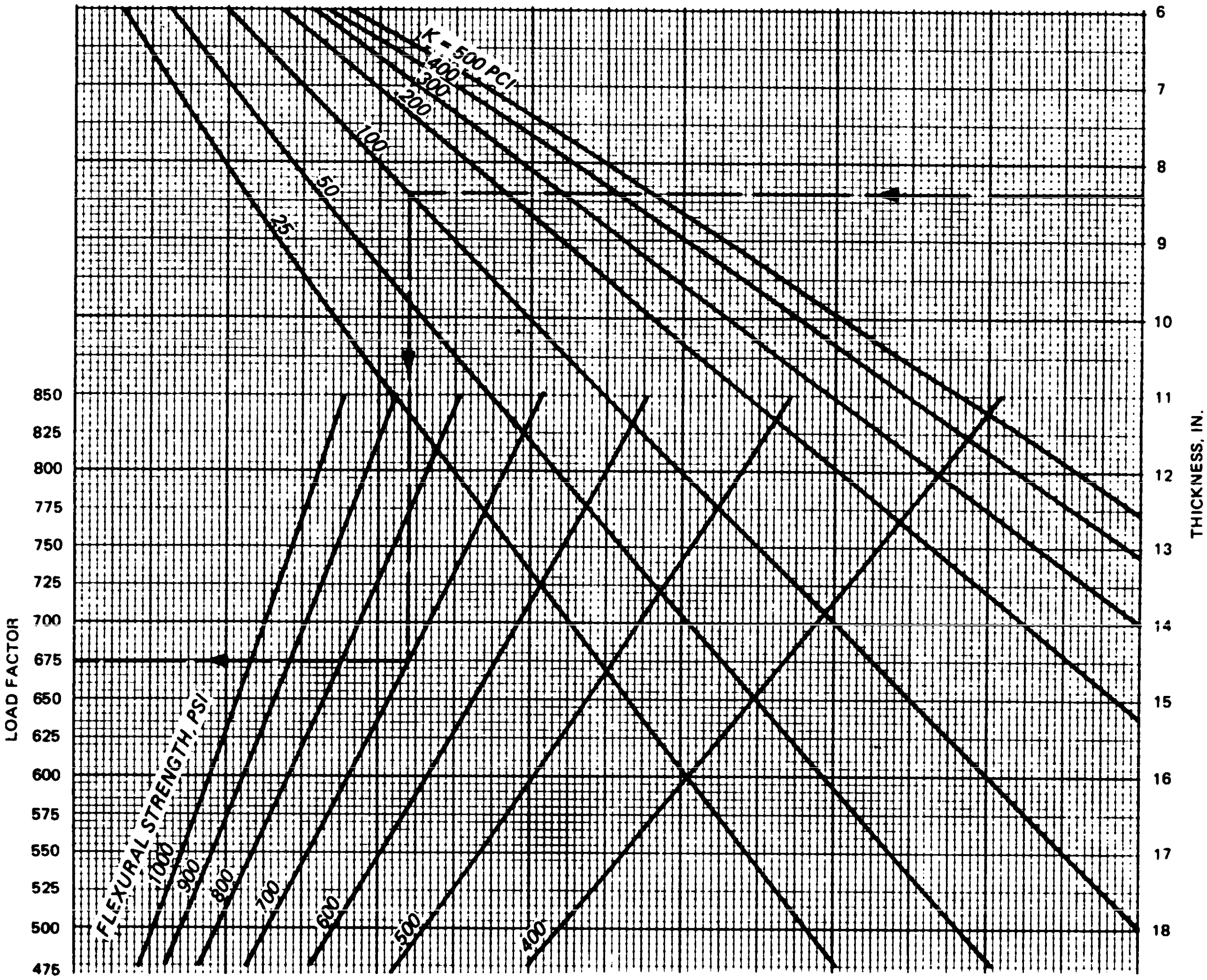


Figure 2-31. Rigid pavement evaluation curves, Air Force group index 10.

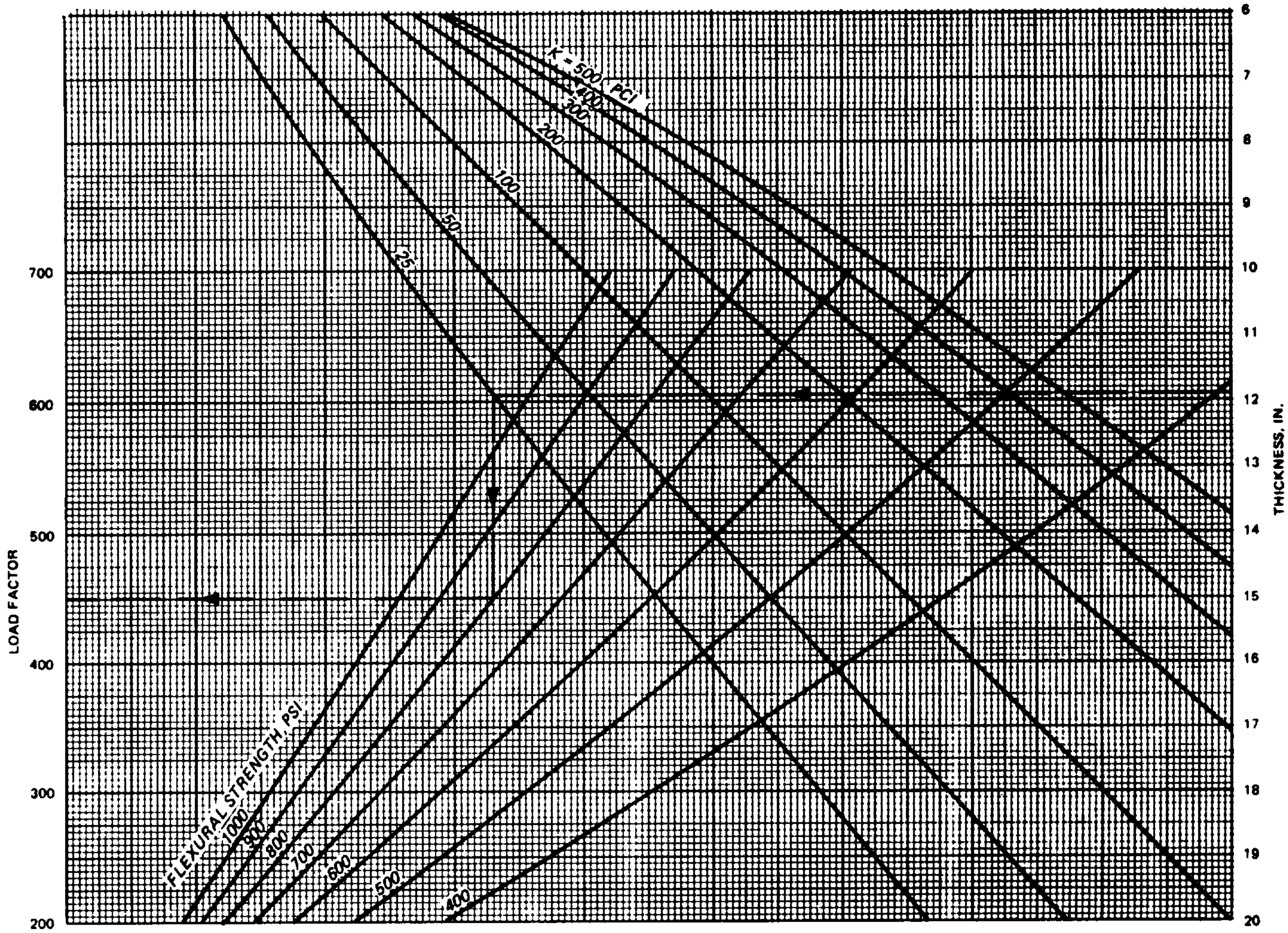


Figure 2-32. Rigid pavement evaluation curves, Air Force group index 11.

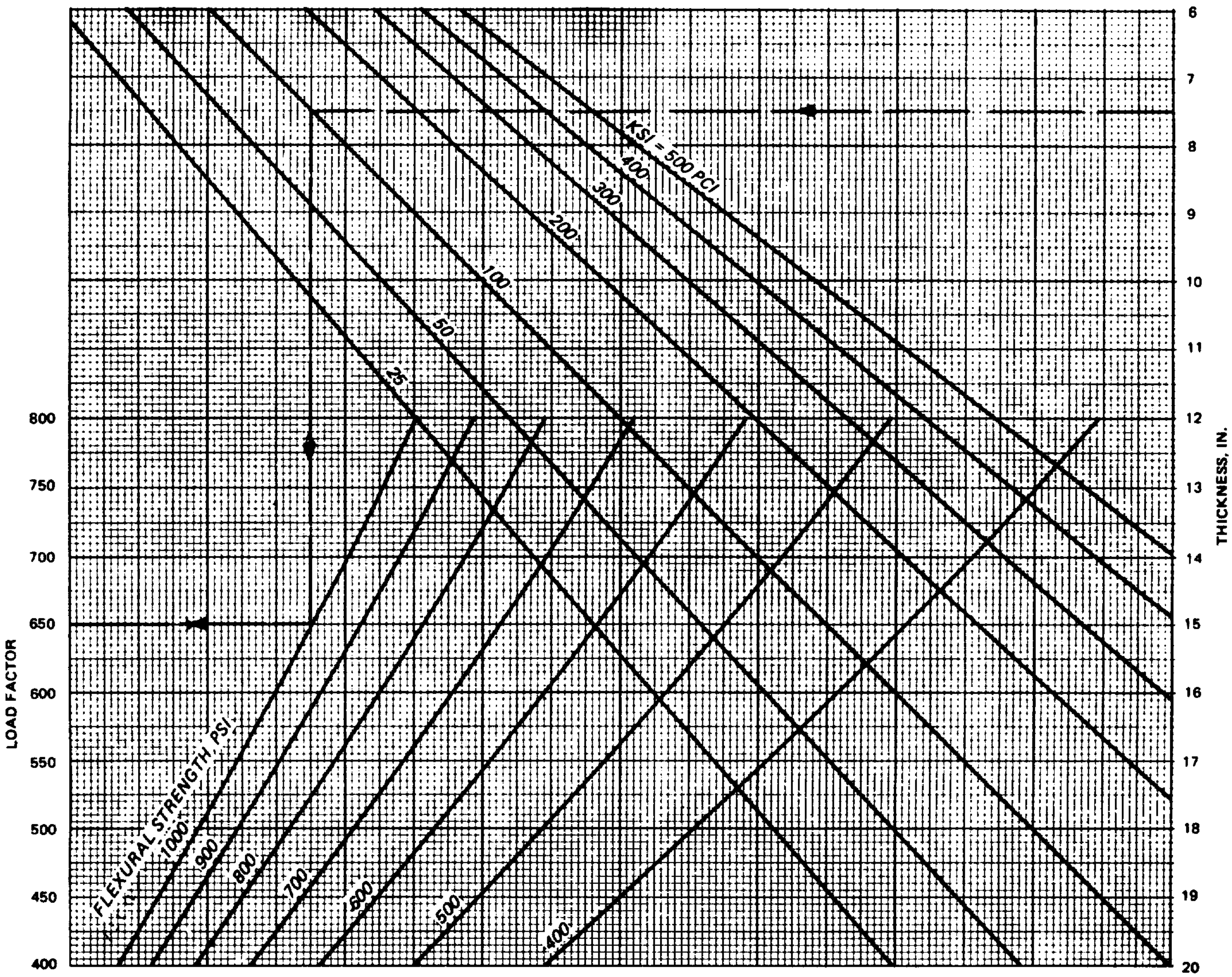


Figure 2-33. Rigid pavement evaluation curves, Air Force group index 12.

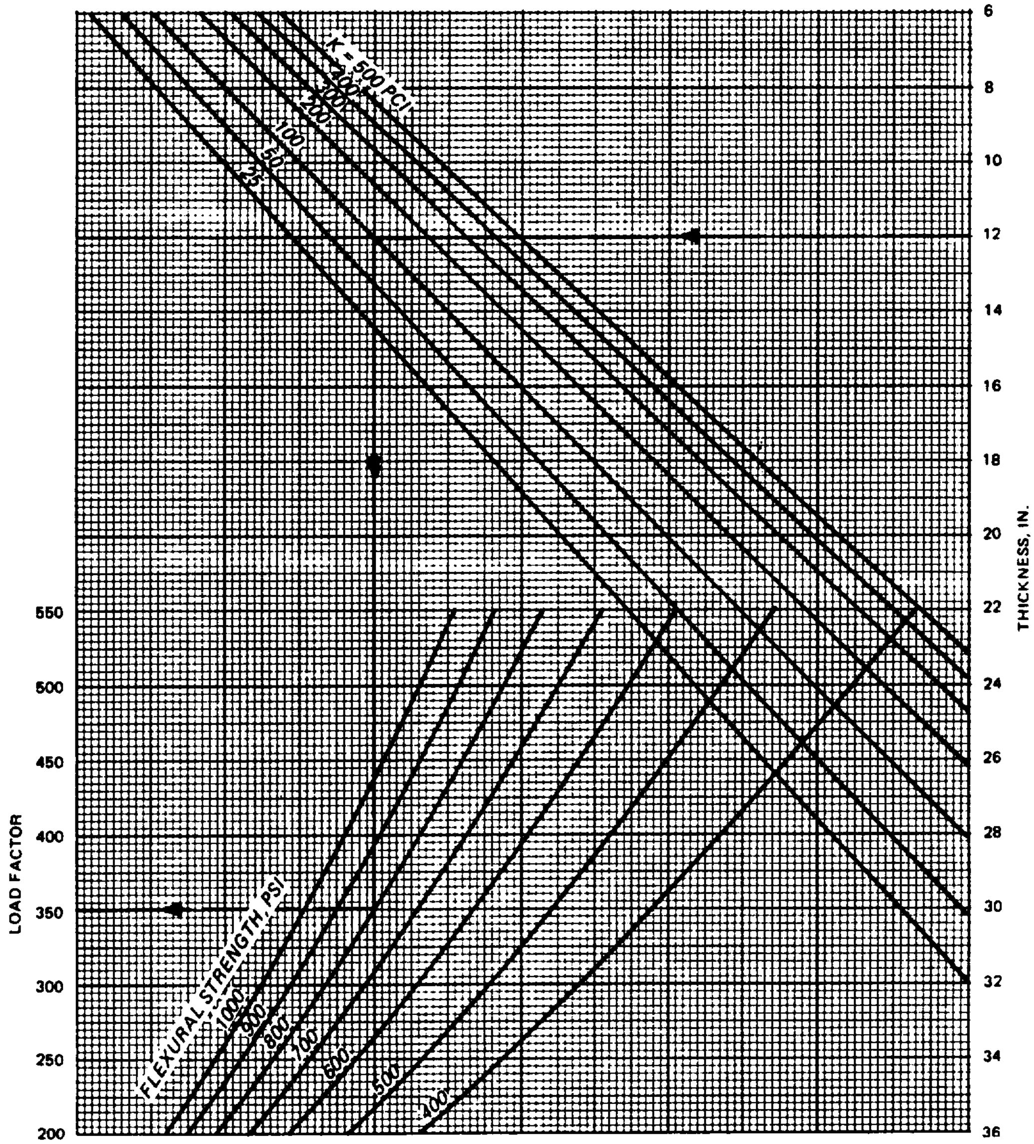


Figure 2-34. Rigid pavement evaluation curves, Air Force group index 13.

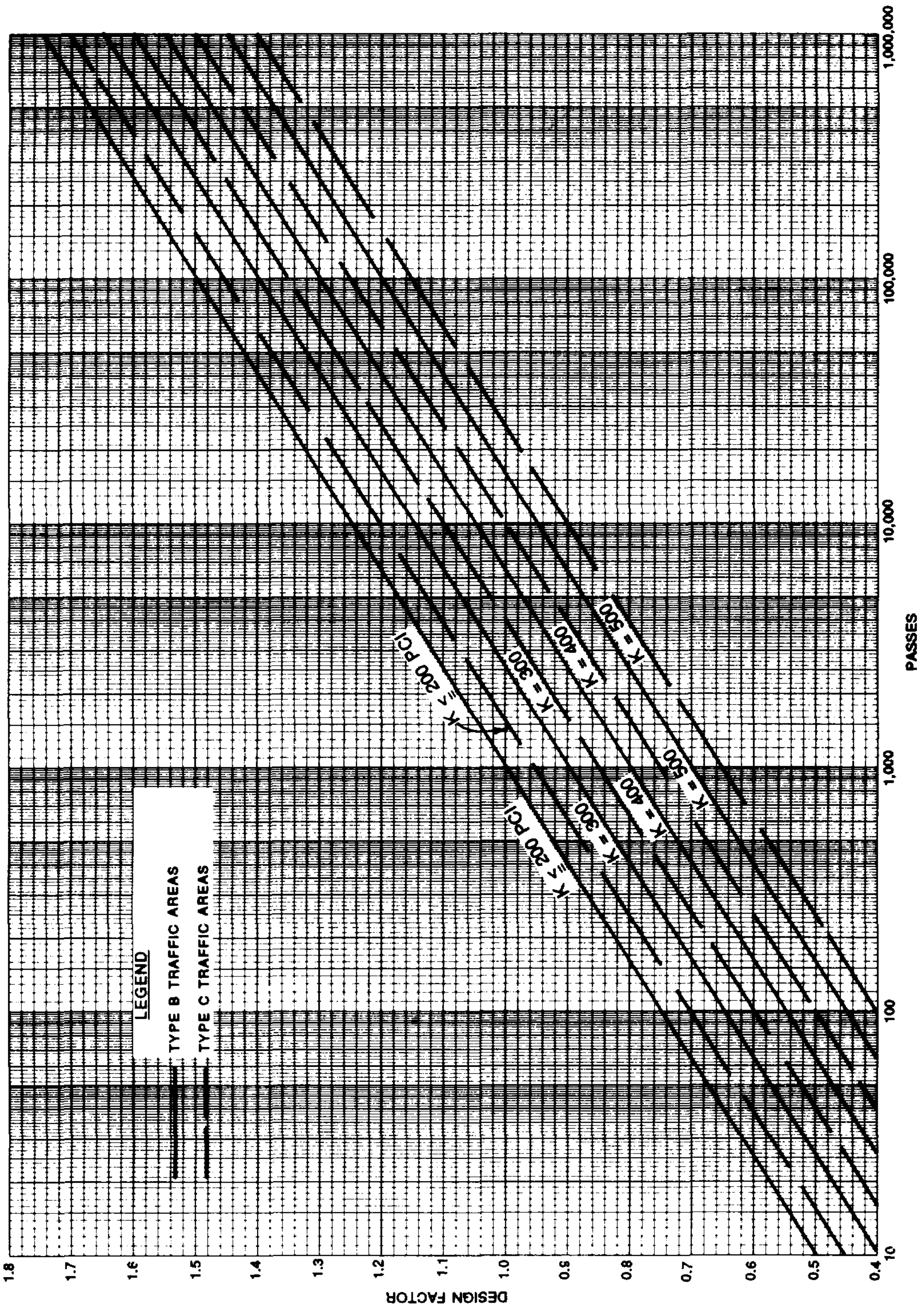


Figure 2–35. Design factor for standard evaluation, Army Class I airfield.

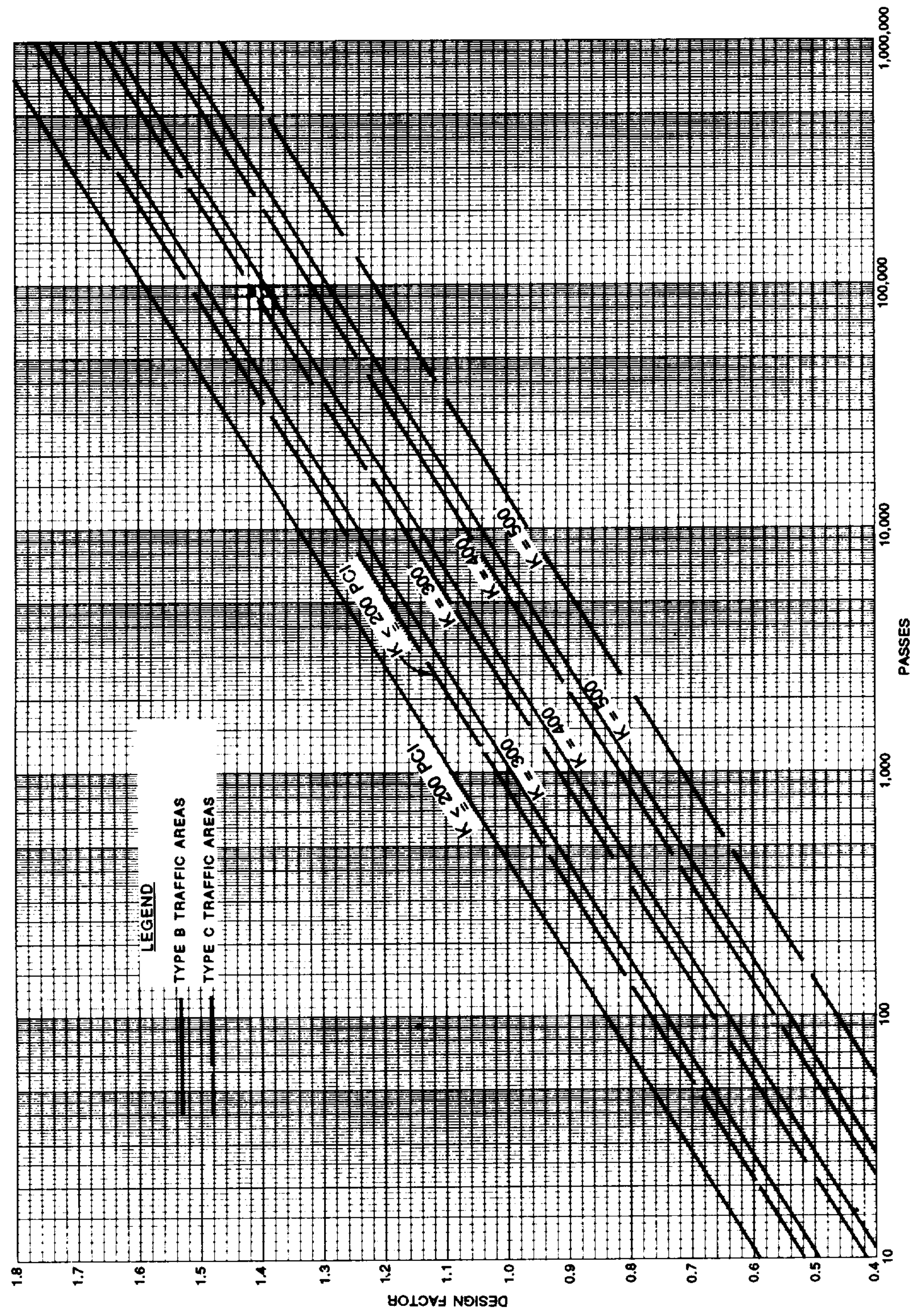


Figure 2–36. Design factors for standard evaluation, Army Class II airfield.

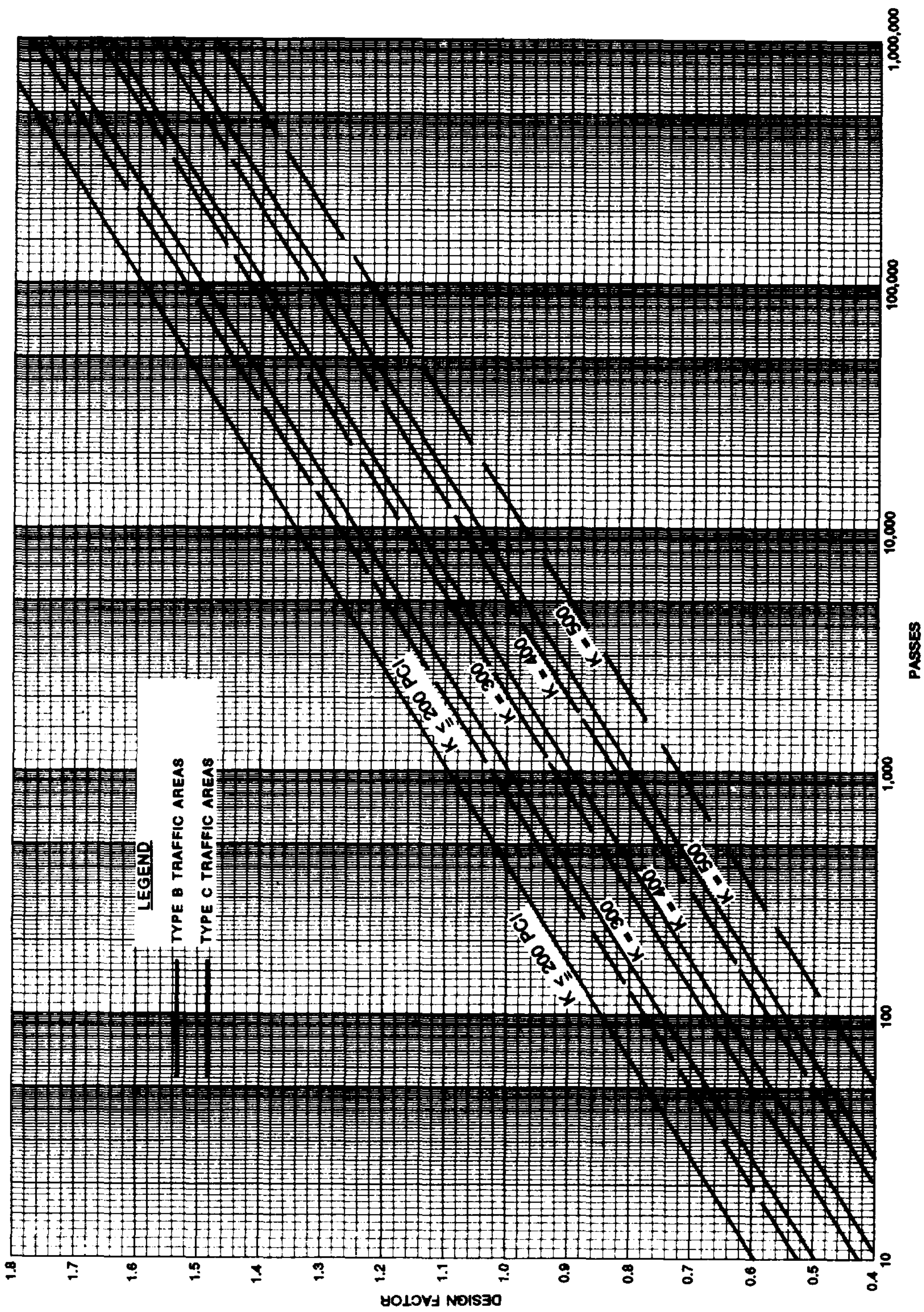


Figure 2–37. Design factors for standard evaluation, Army Class III airfield.

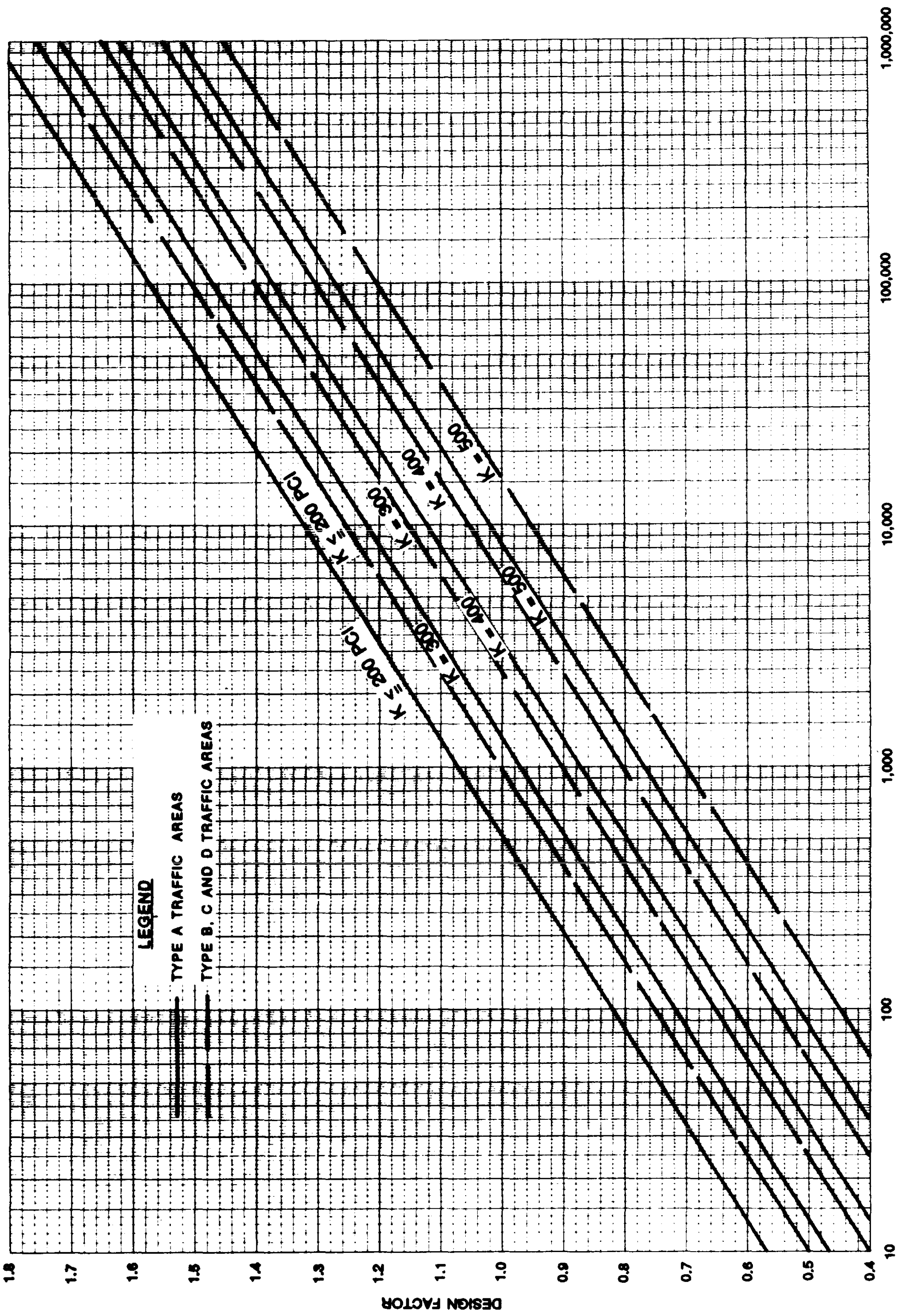


Figure 2-38. Design factors for standard evaluation, Air Force group index 1.

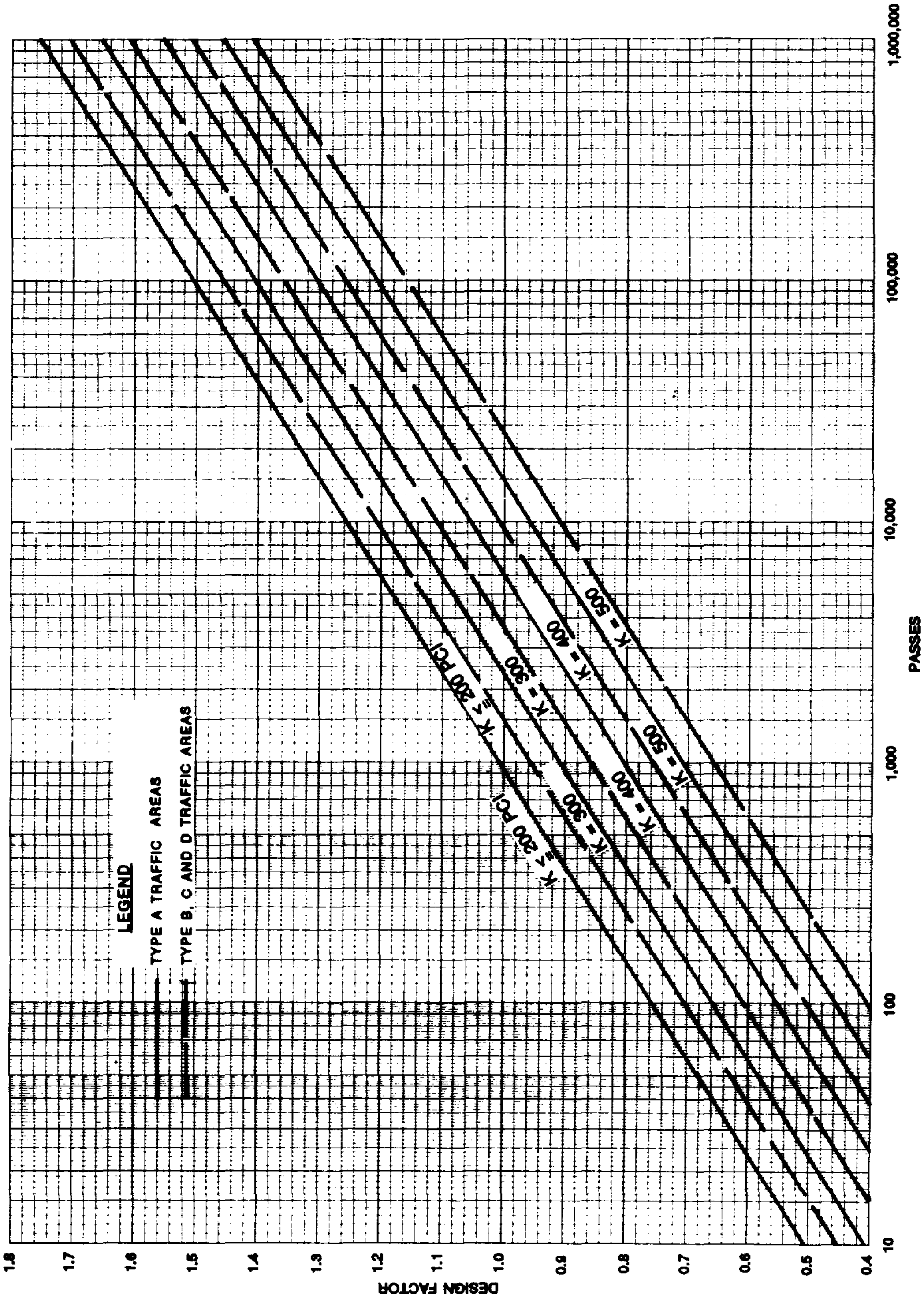


Figure 2-39. Design factors for standard evaluation, Air Force group index 2.

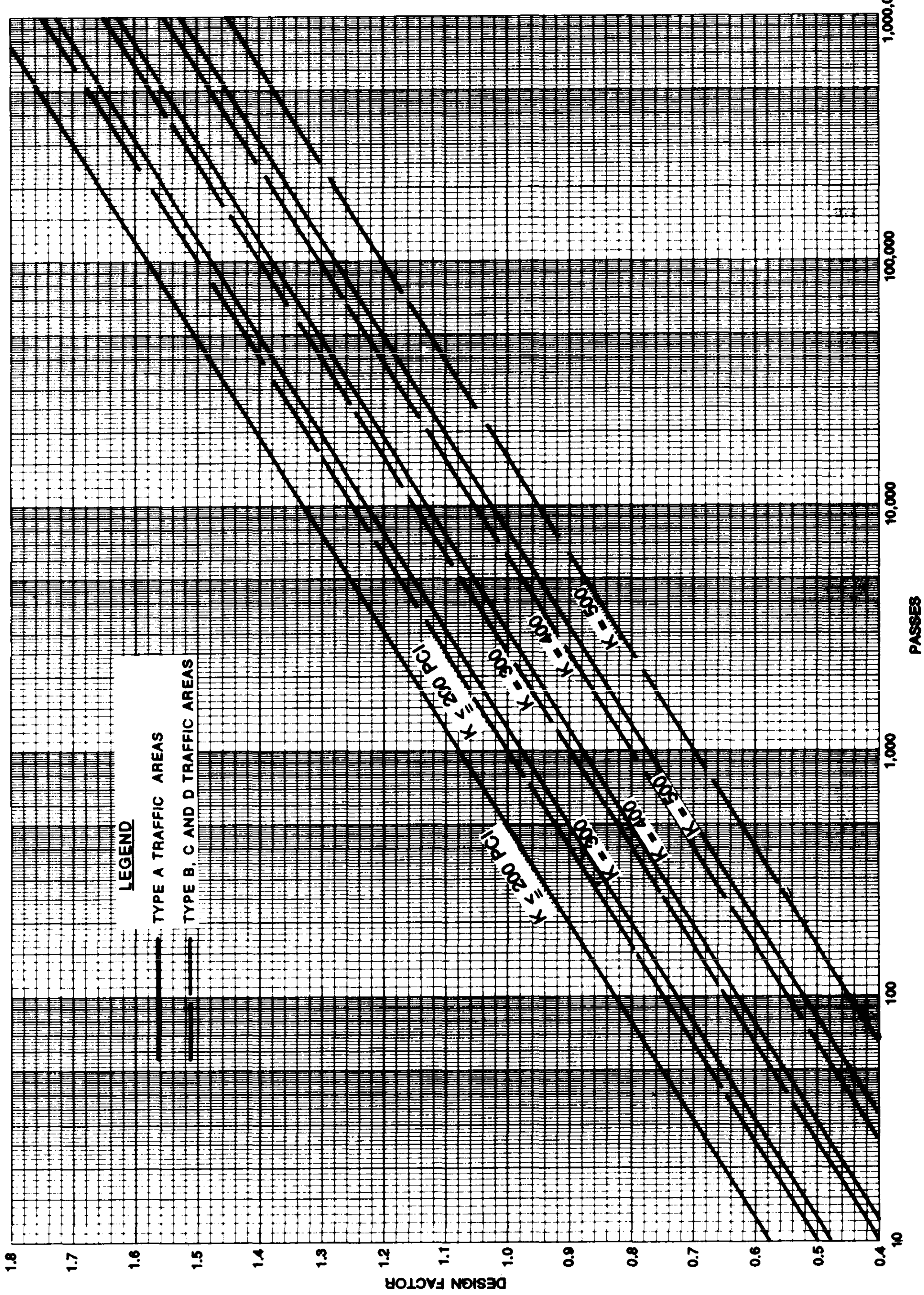


Figure 2-40. Design factors for standard evaluation, Air Force group index 3.

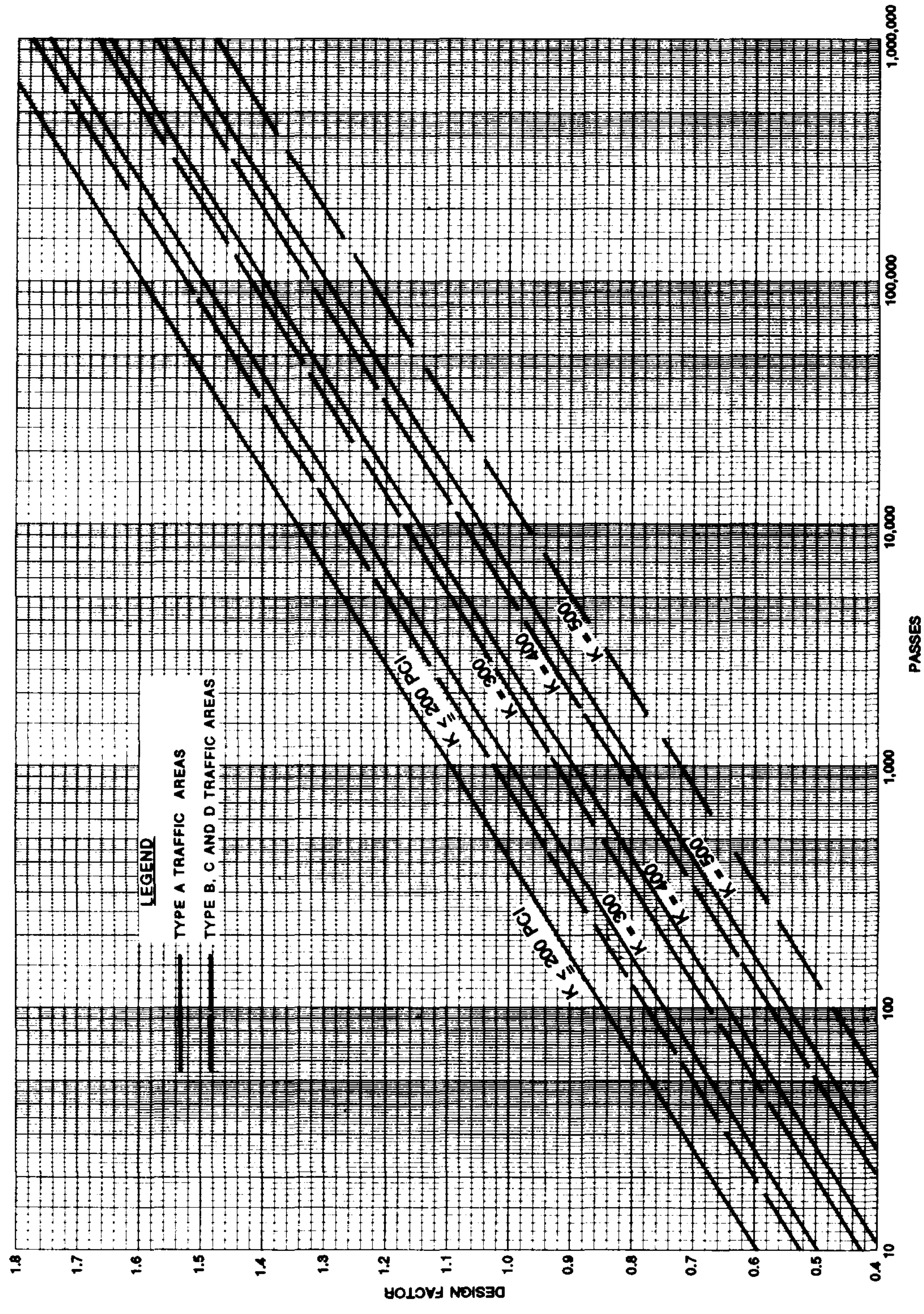


Figure 2-41. Design factors for standard evaluation, Air Force group index 4.

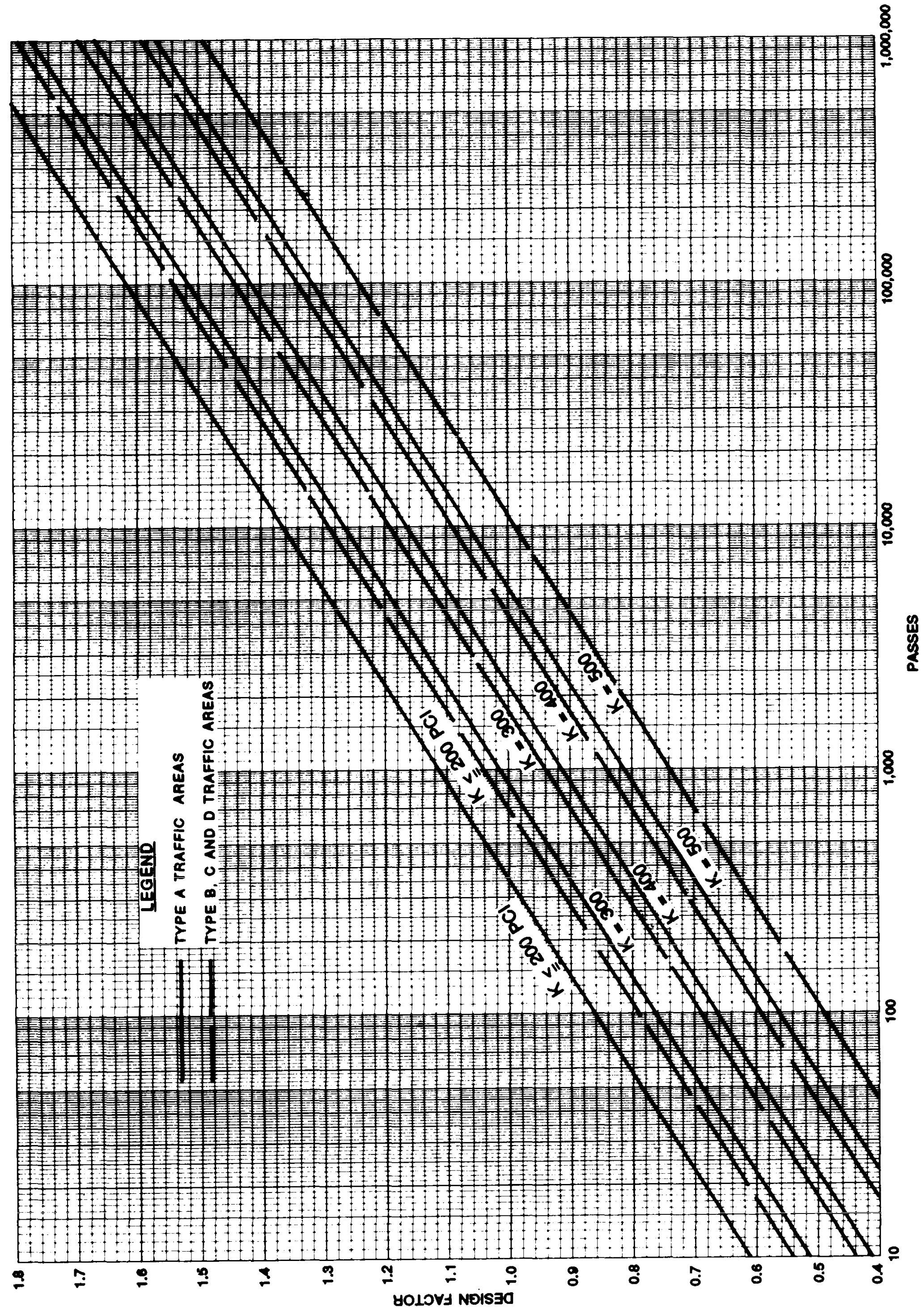


Figure 2-42. Design factors for standard evaluation, Air Force group index 5.

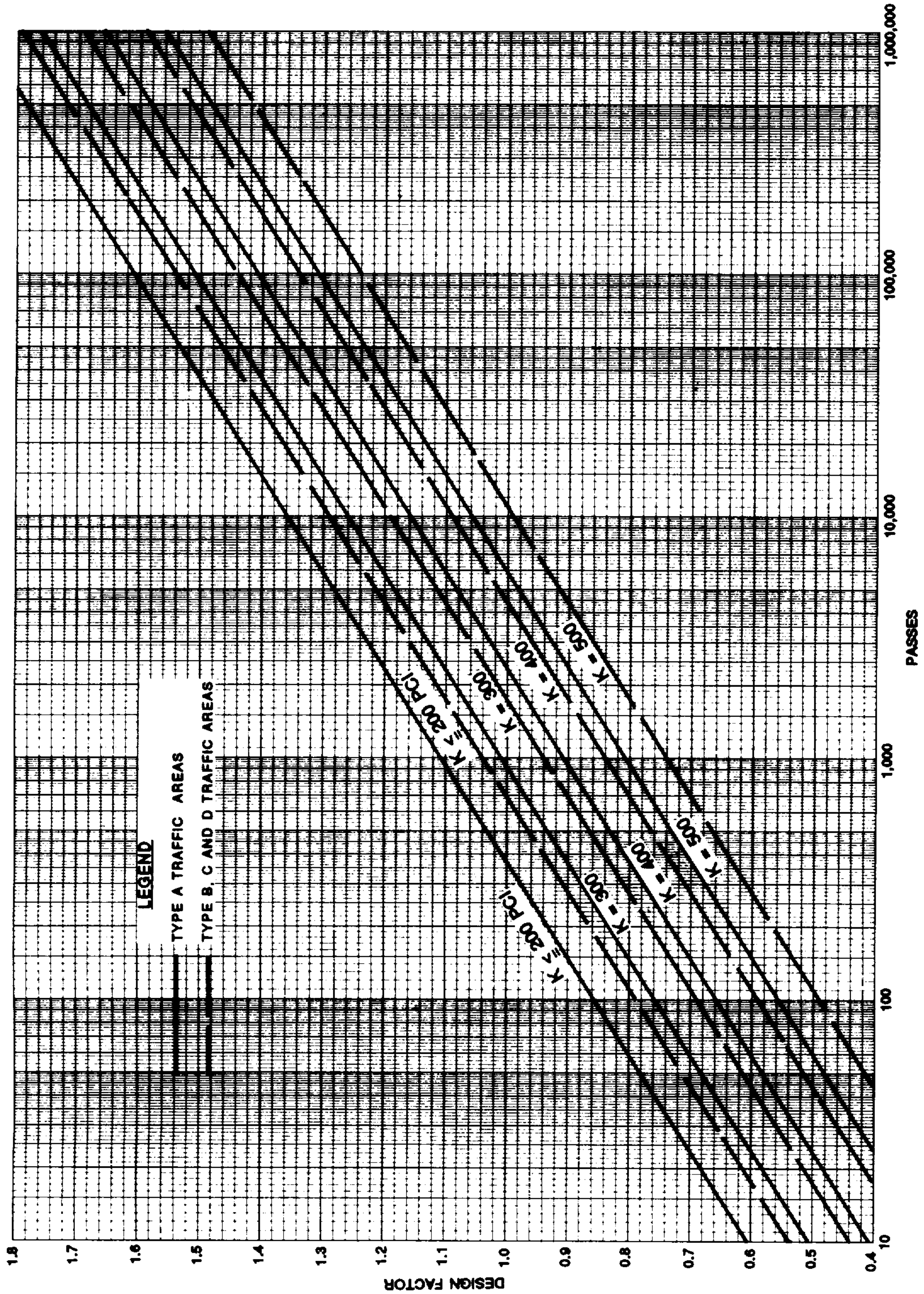


Figure 2–43. Design factors for standard evaluation, Air Force group index 6.

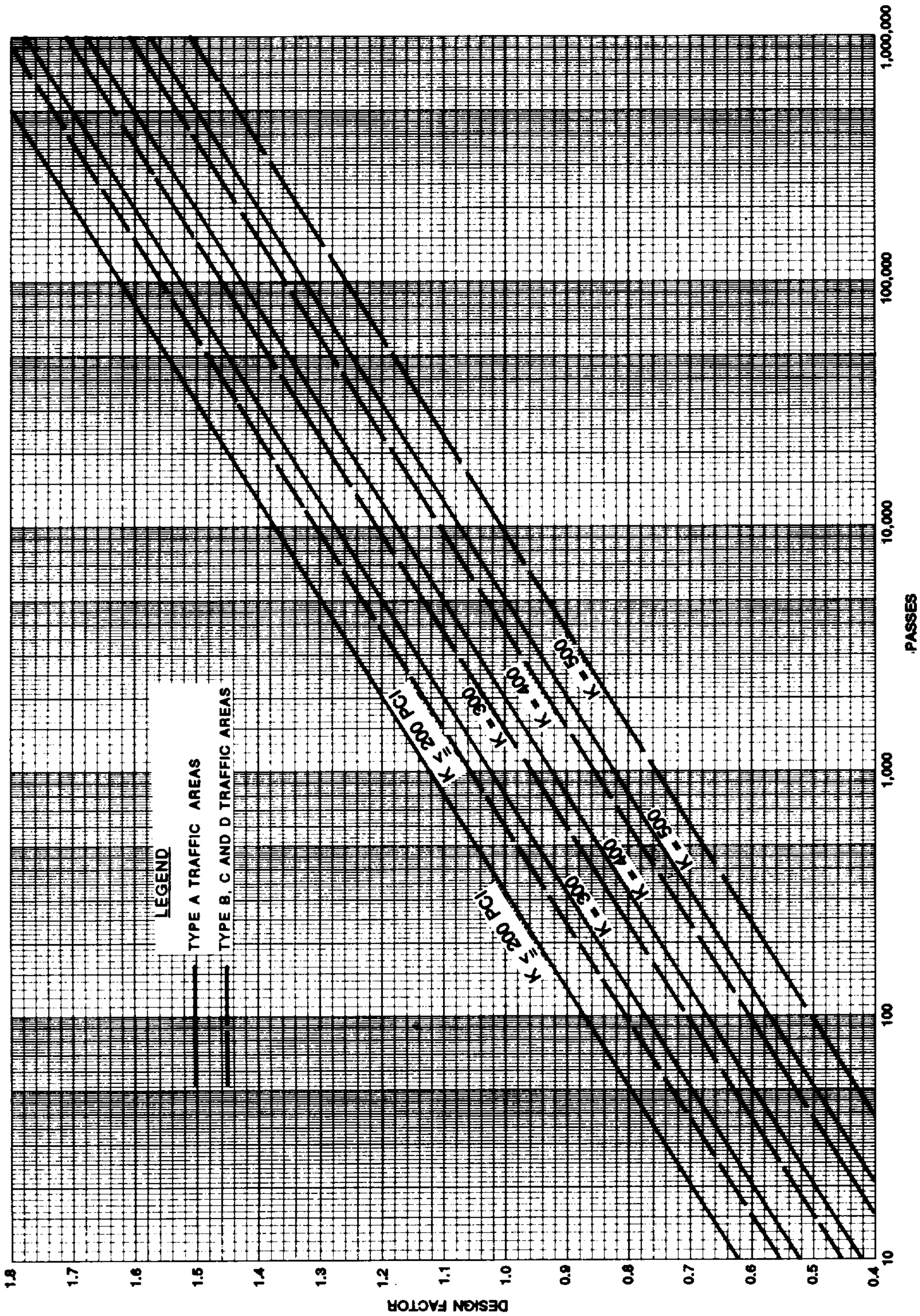


Figure 2-44. Design factors for standard evaluation, Air Force group index 7.

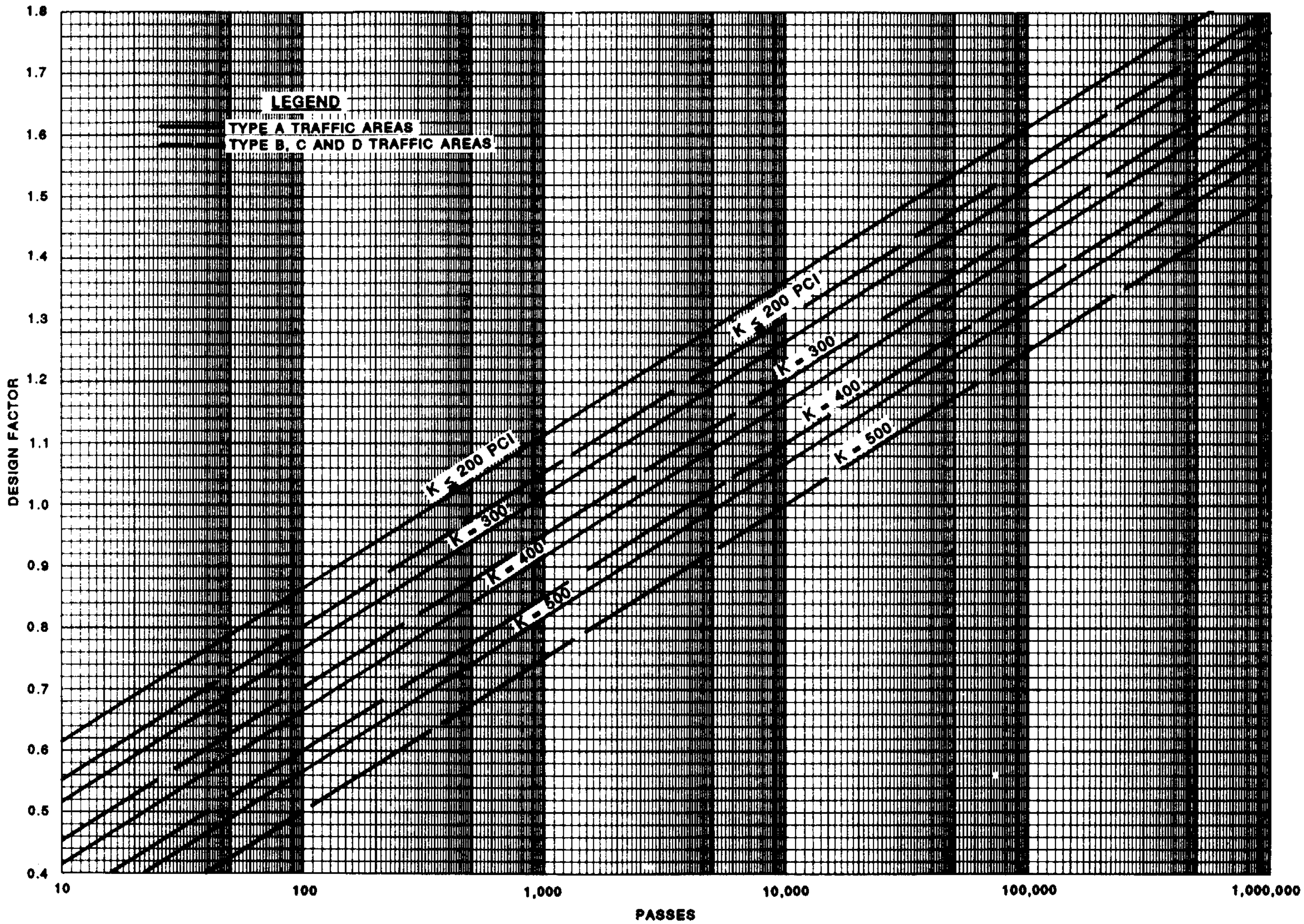


Figure 2-45. Design factors for standard evaluation, Air Force group index 8.

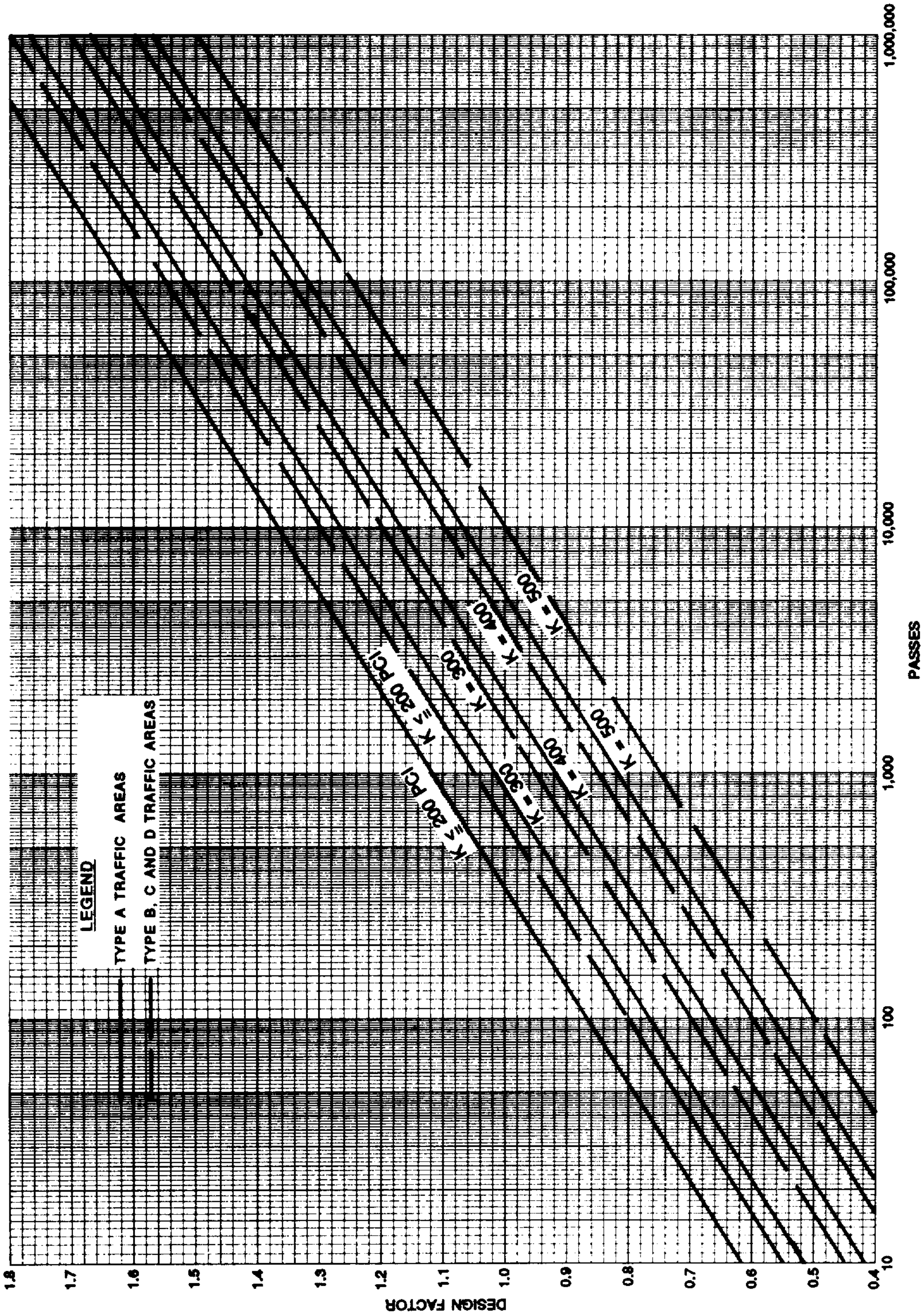


Figure 2–46. Design factors for standard evaluation, Air Force group index 9.

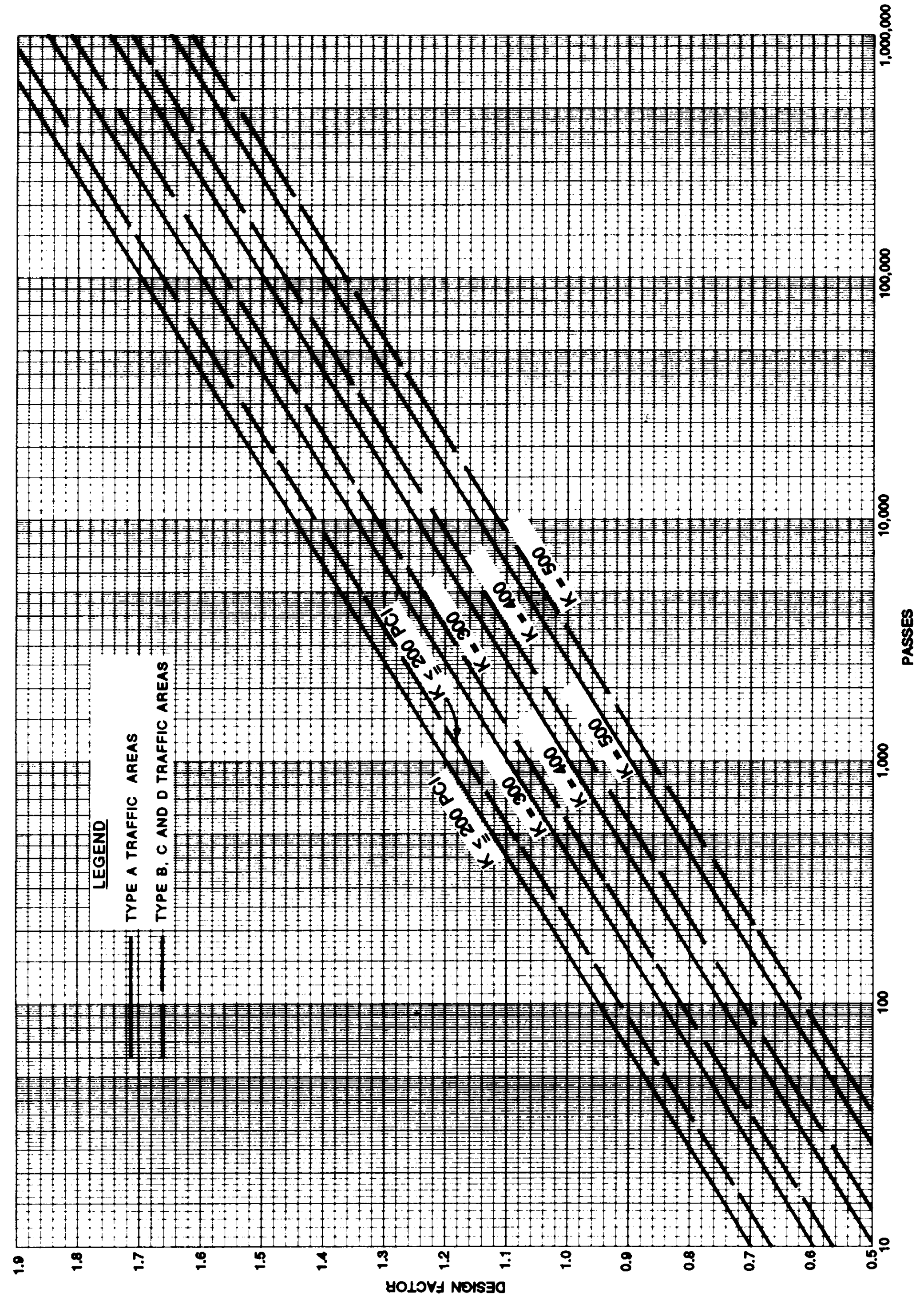


Figure 2-47. Design factors for standard evaluation, Air Force group index 10.

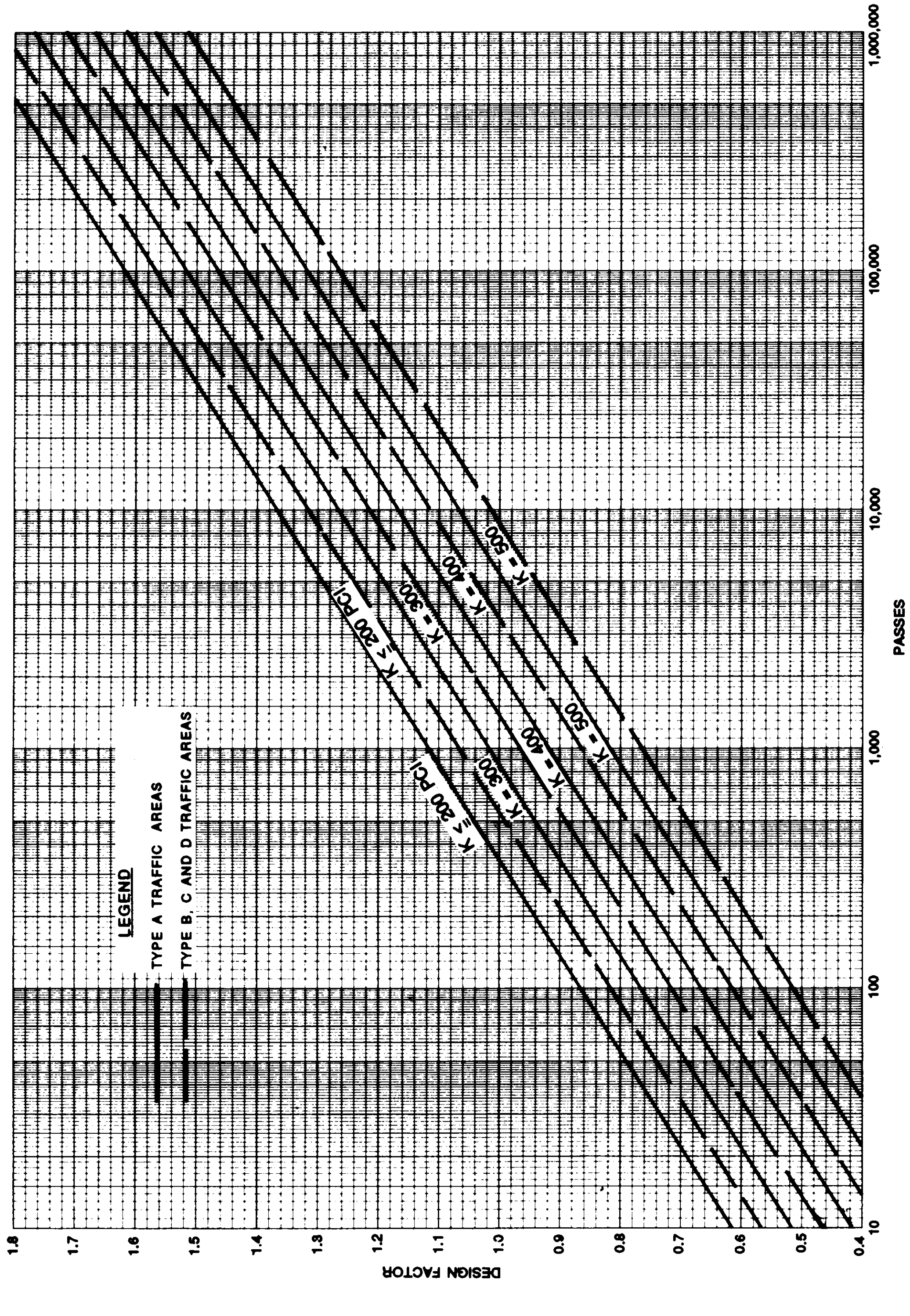


Figure 2–48. Design factors for standard evaluation, Air Force group index 11.

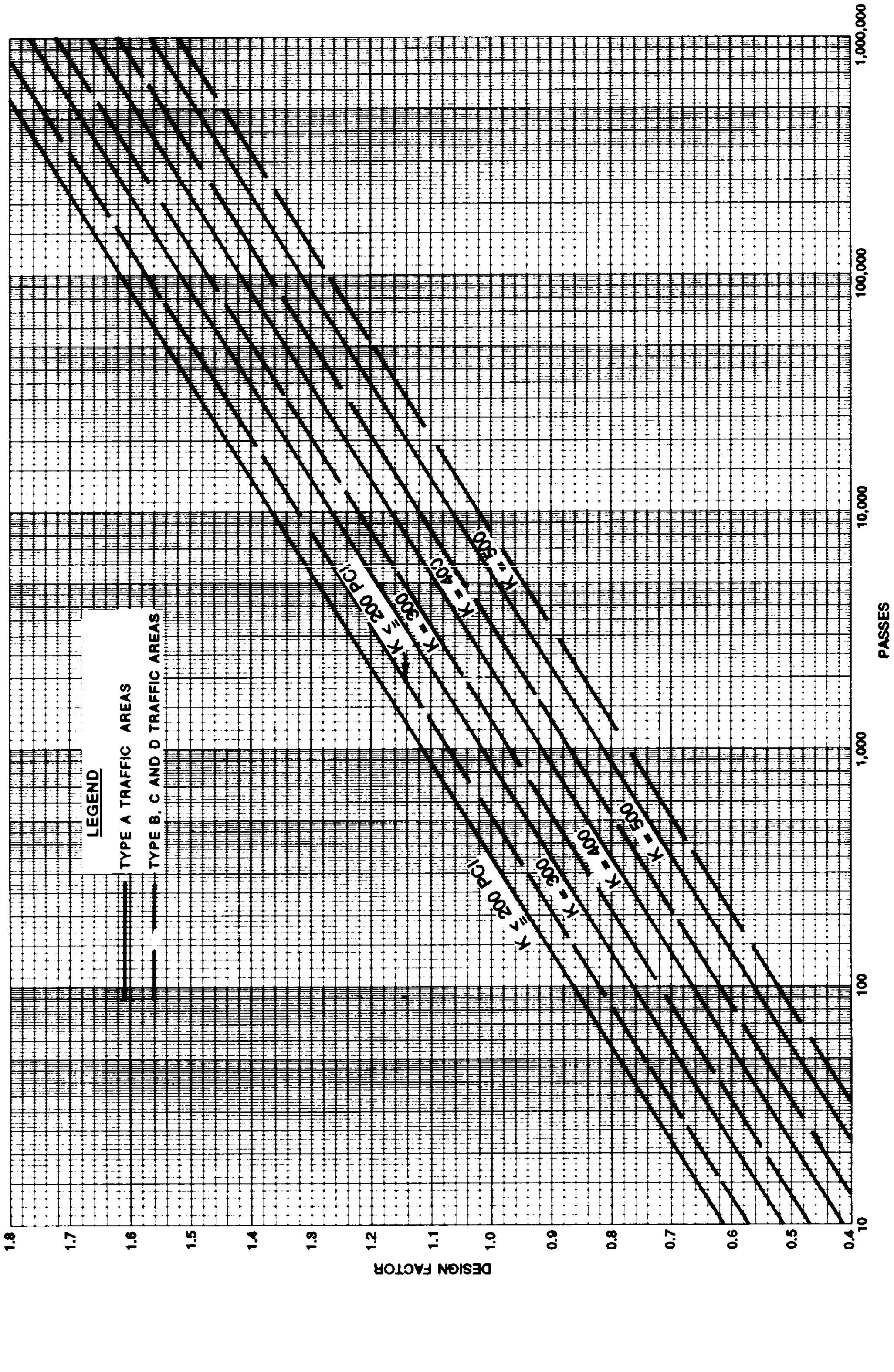


Figure 2–49. Design factors for standard evaluation, Air Force group index 12.

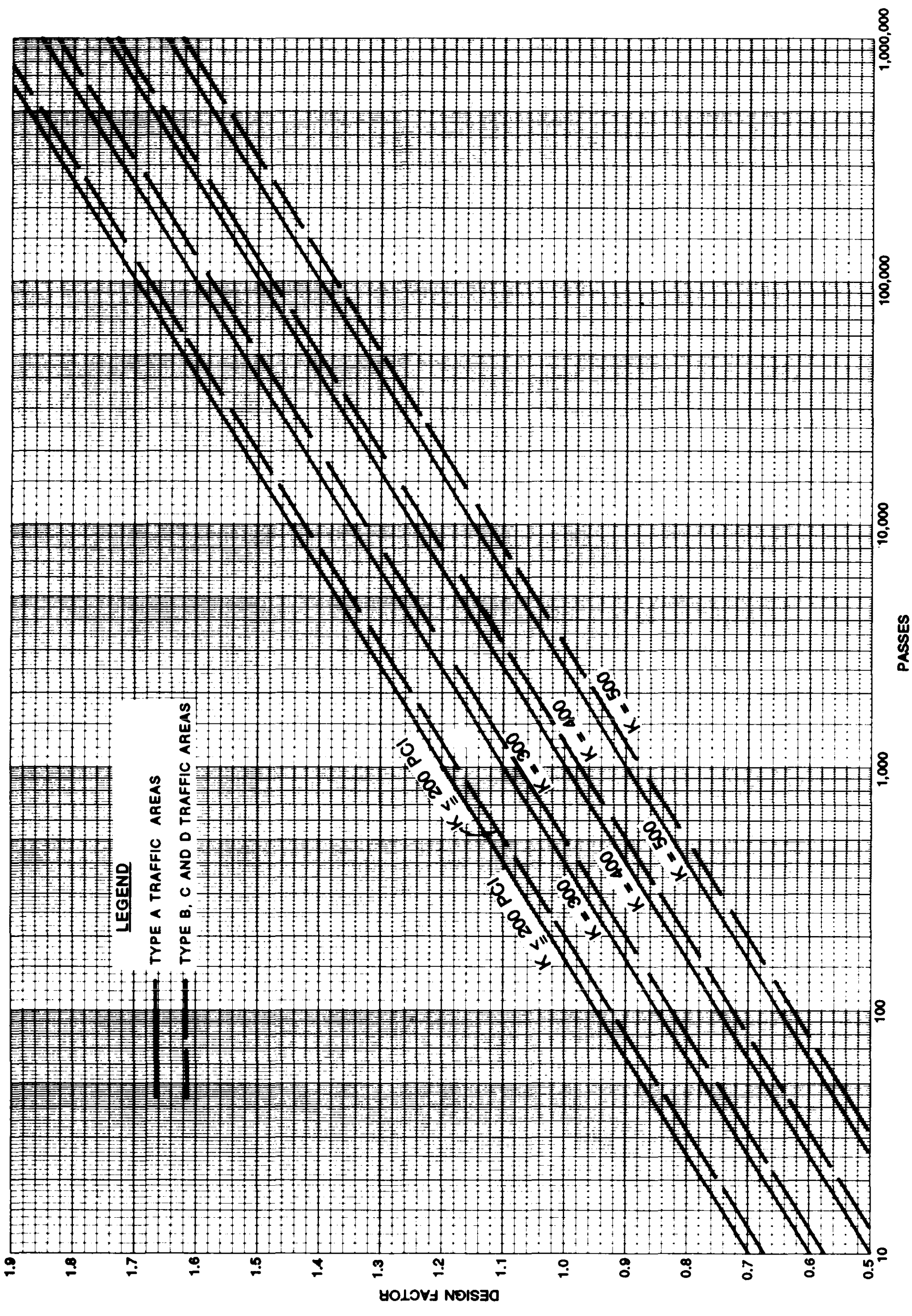


Figure 2-50. Design factors for standard evaluation, Air Force group index 13.

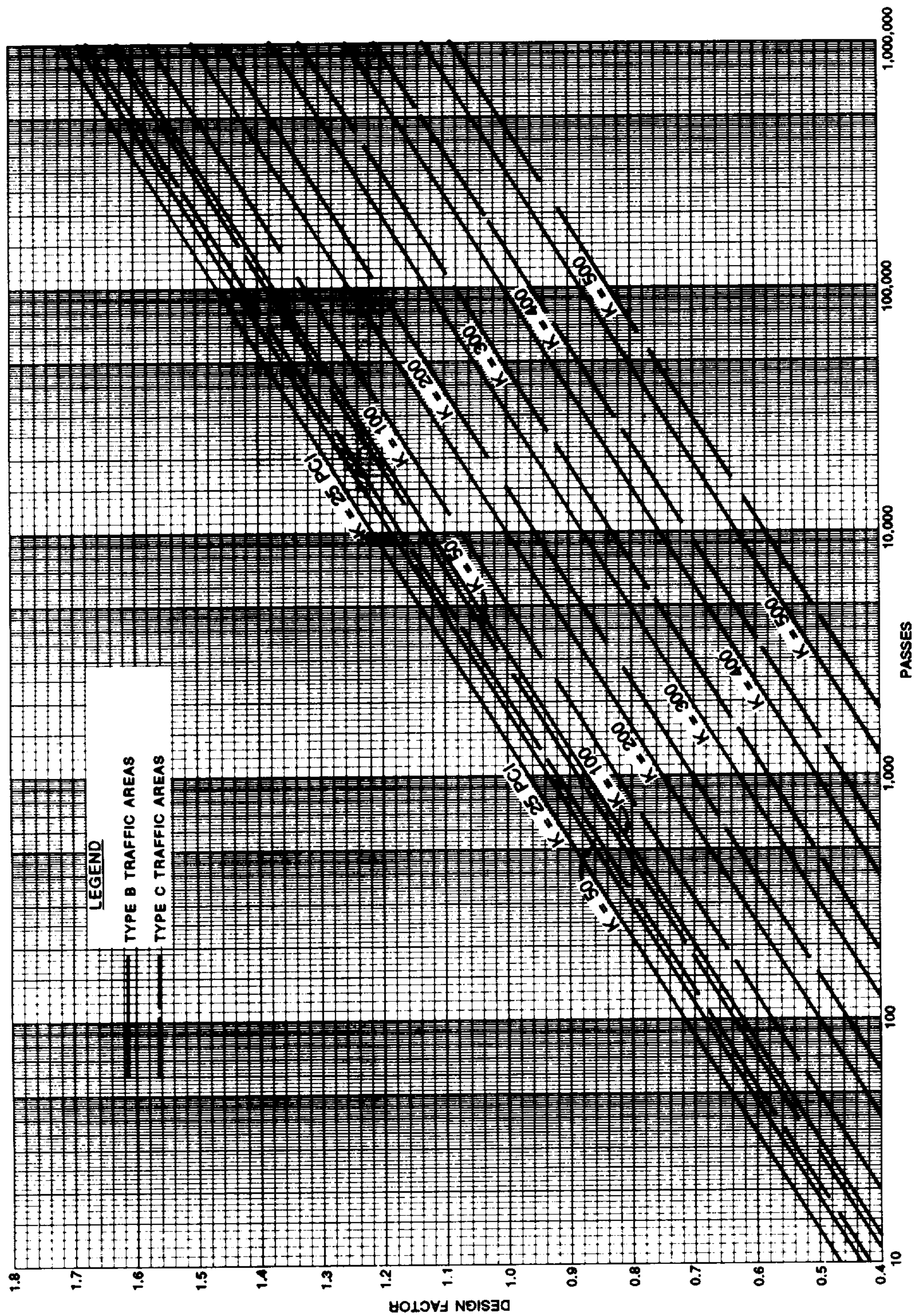


Figure 2-51. Design factors for extended life evaluation, Army Class I airfield.

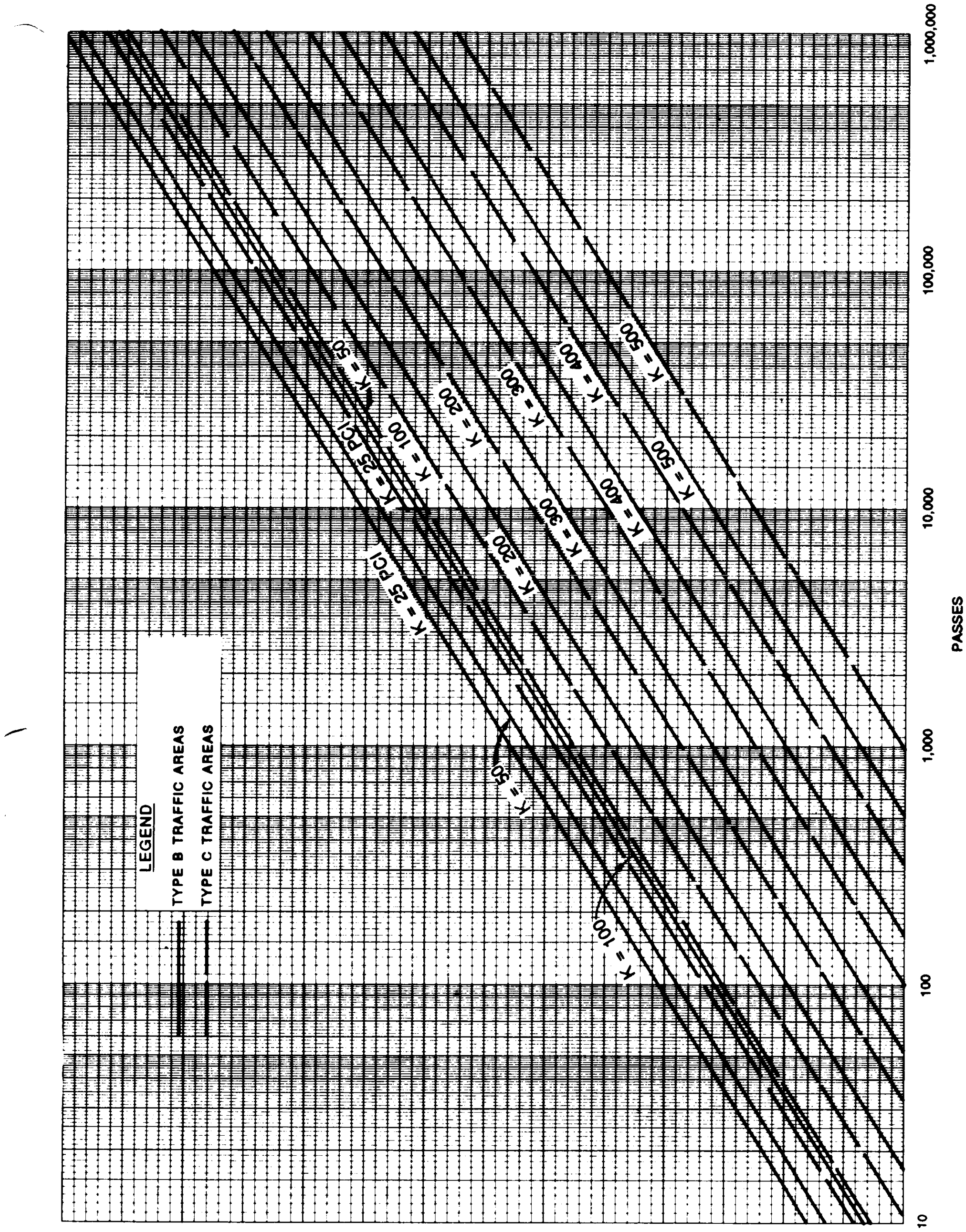


Figure 2-52. Design factors for extended life evaluation, Army Class II airfield.

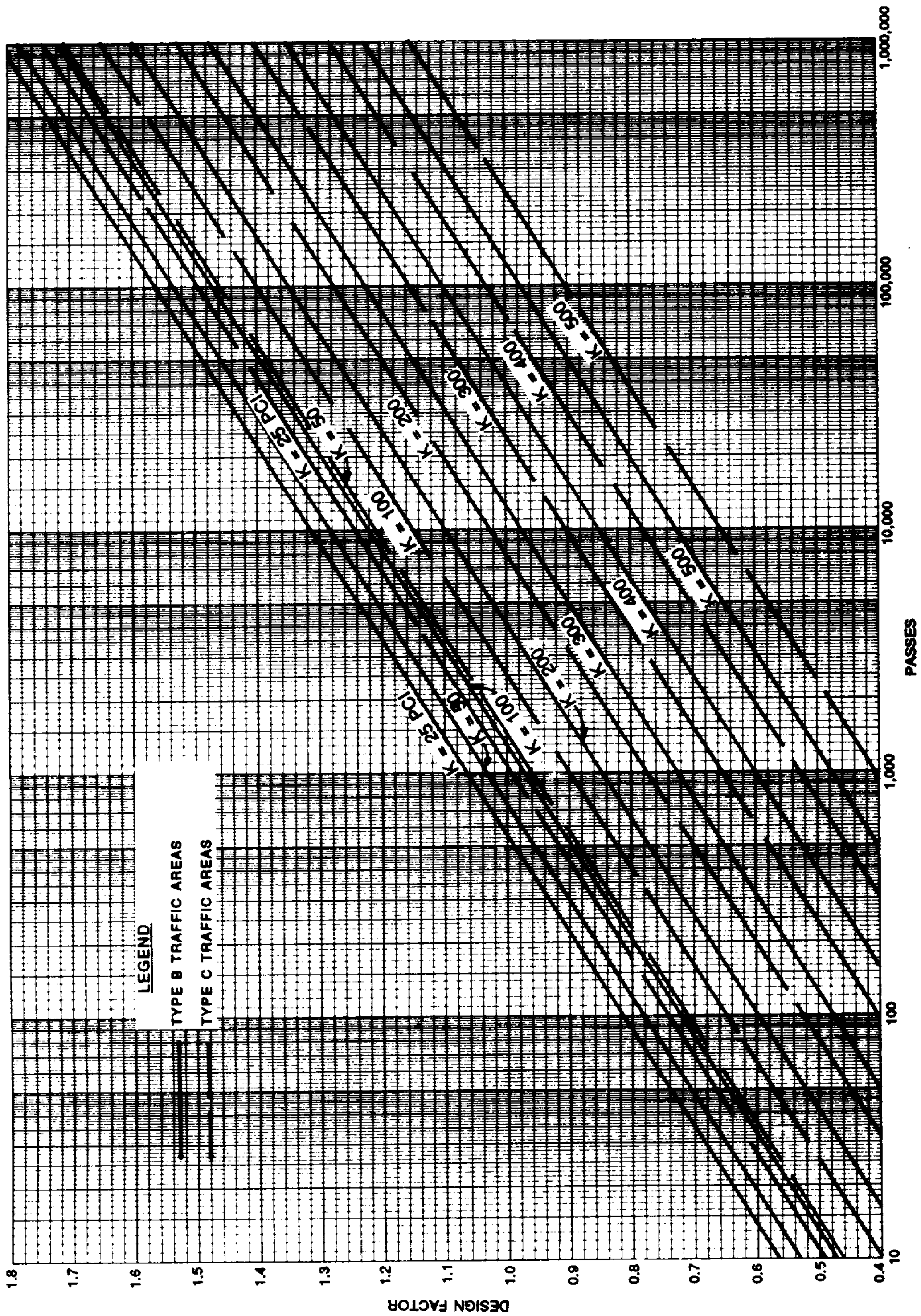


Figure 2-53. Design factors for extended life evaluation, Army Class III airfield.

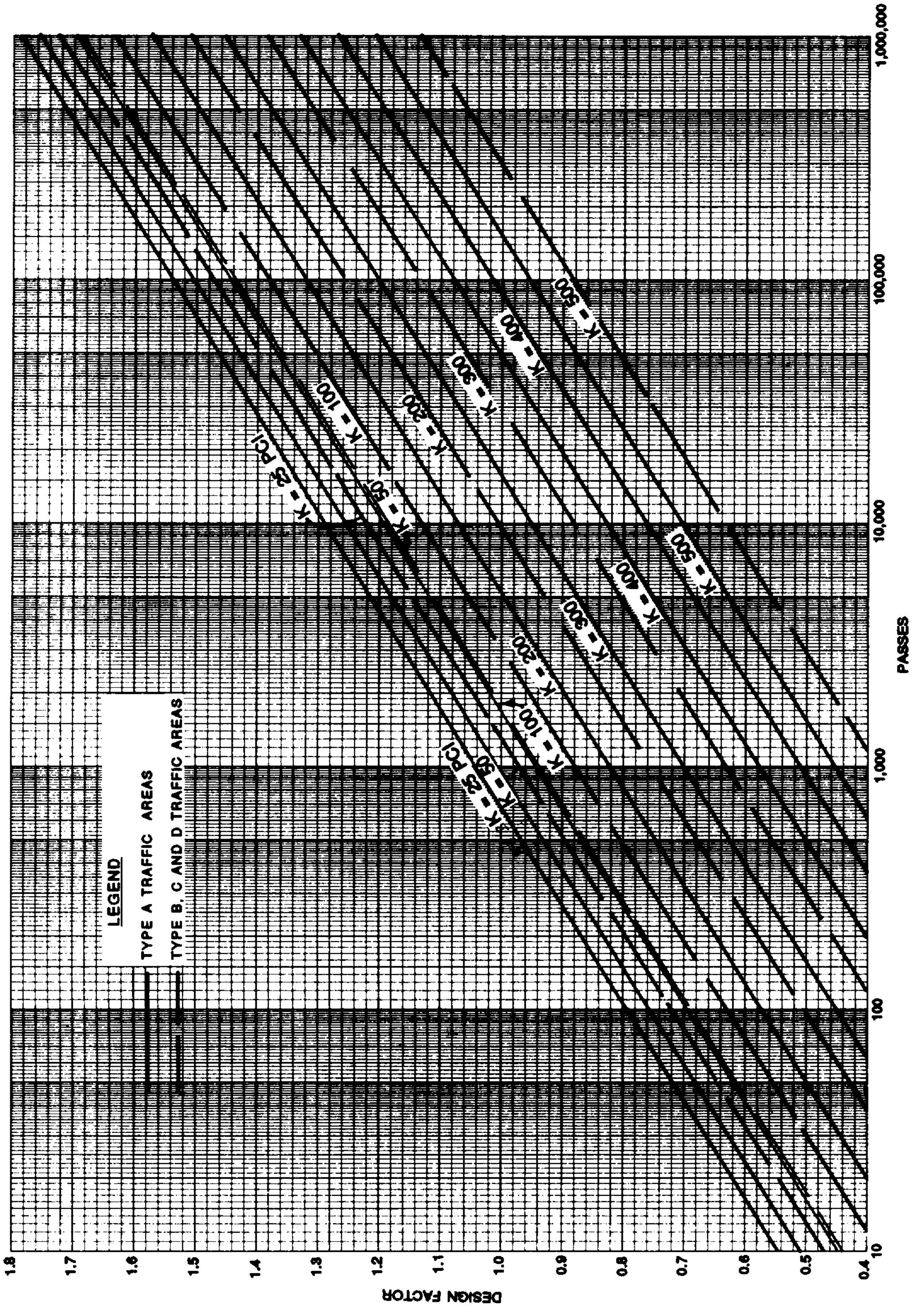


Figure 2-54. Design factors for extended life evaluation, Air Force group index 1.

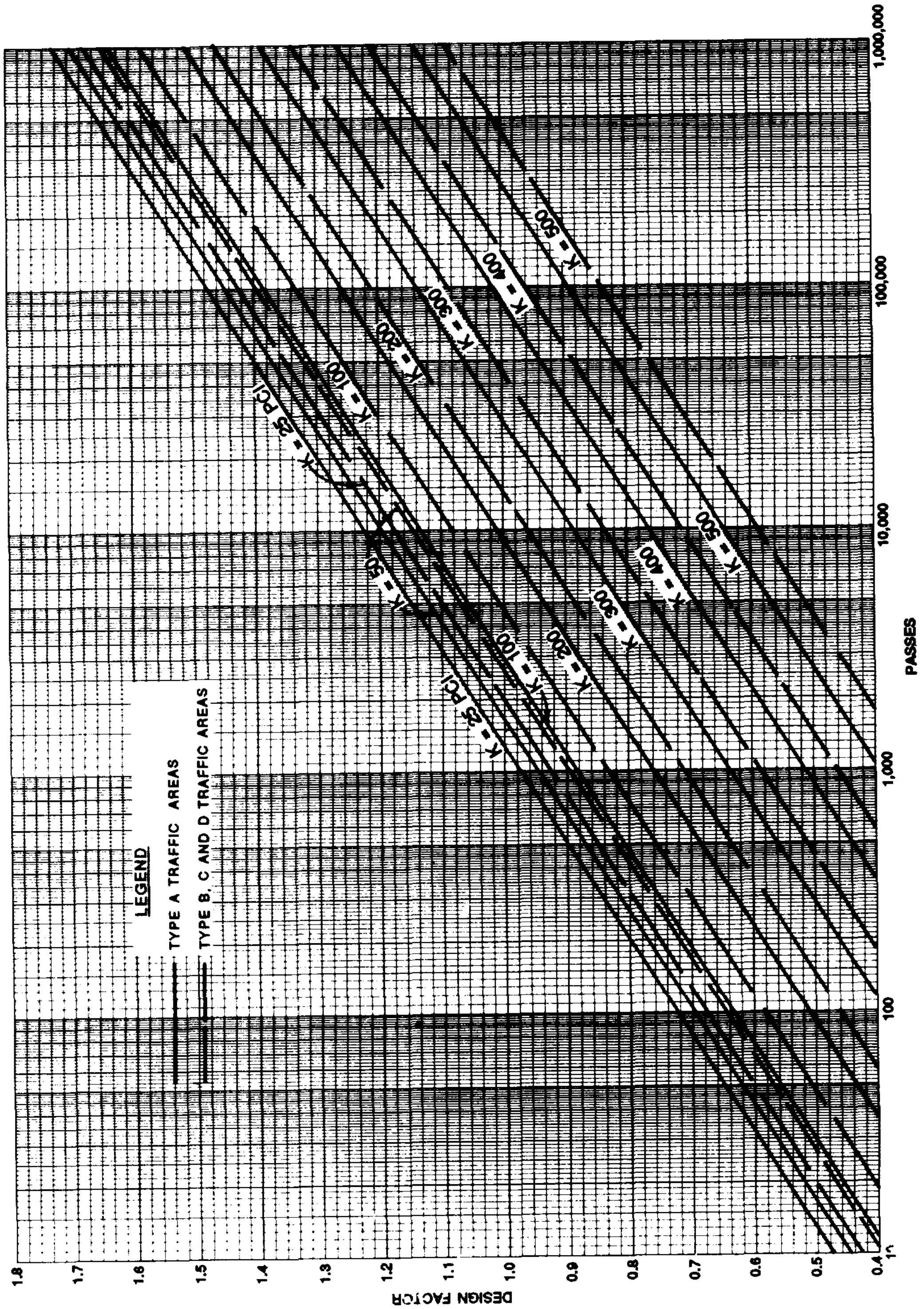


Figure 2-55. Design factors for extended life evaluation, Air Force group index 2.

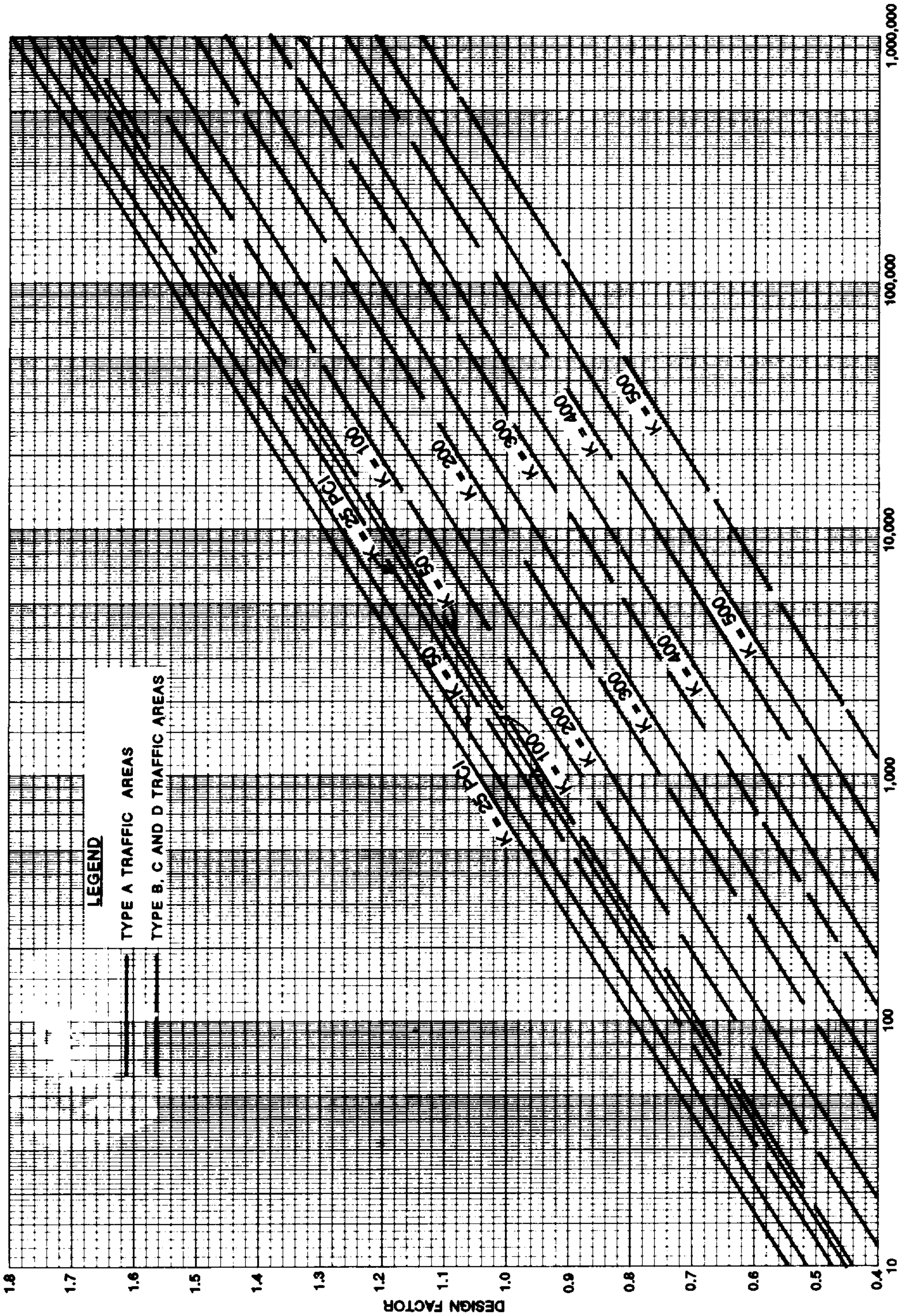


Figure 2-56. Design factors for extended life evaluation, Air Force group index 3.

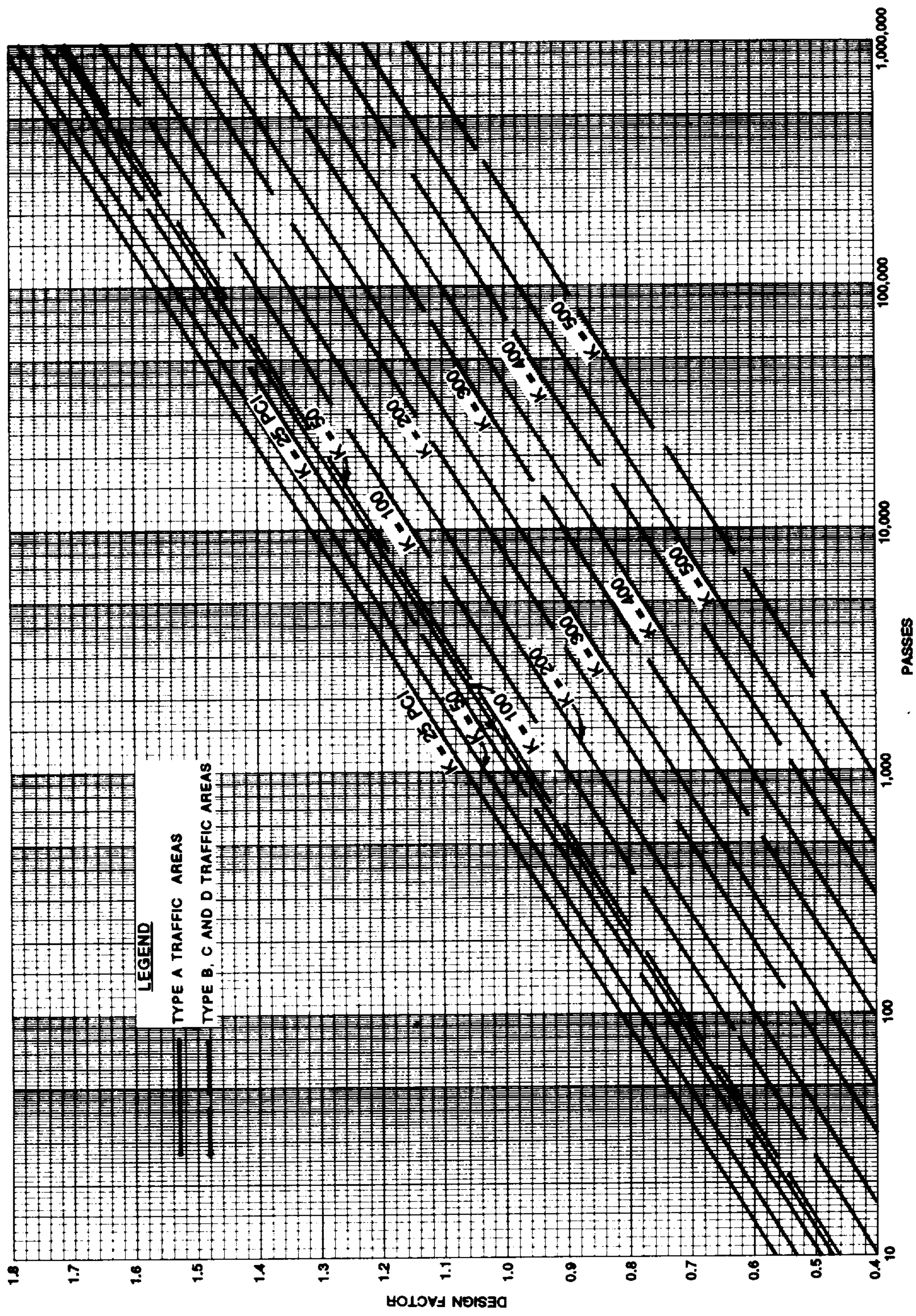


Figure 2-57. Design factors for extended life evaluation, Air Force group index 4.

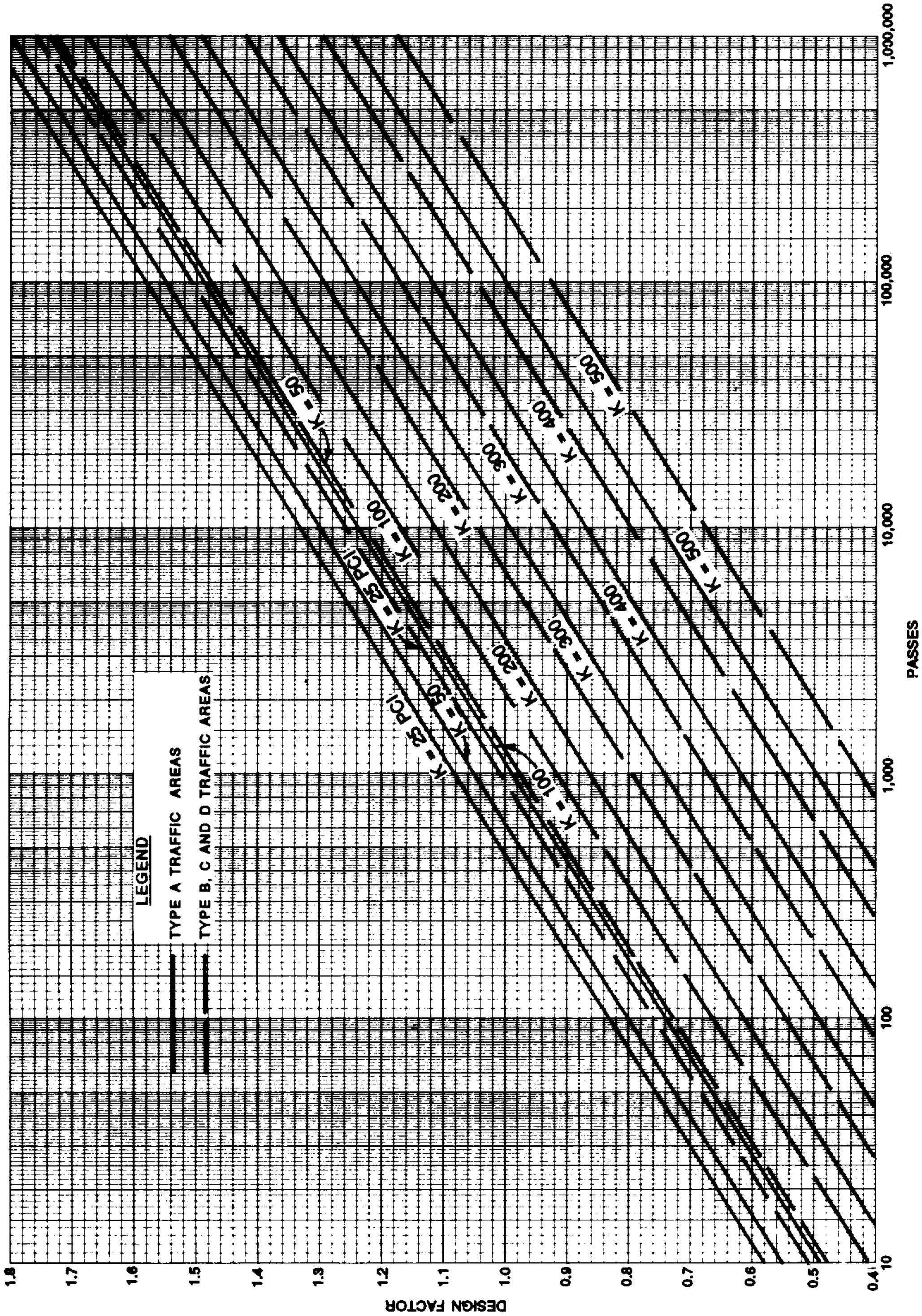


Figure 2–58. Design factors for extended life evaluation, Air Force group index 5.

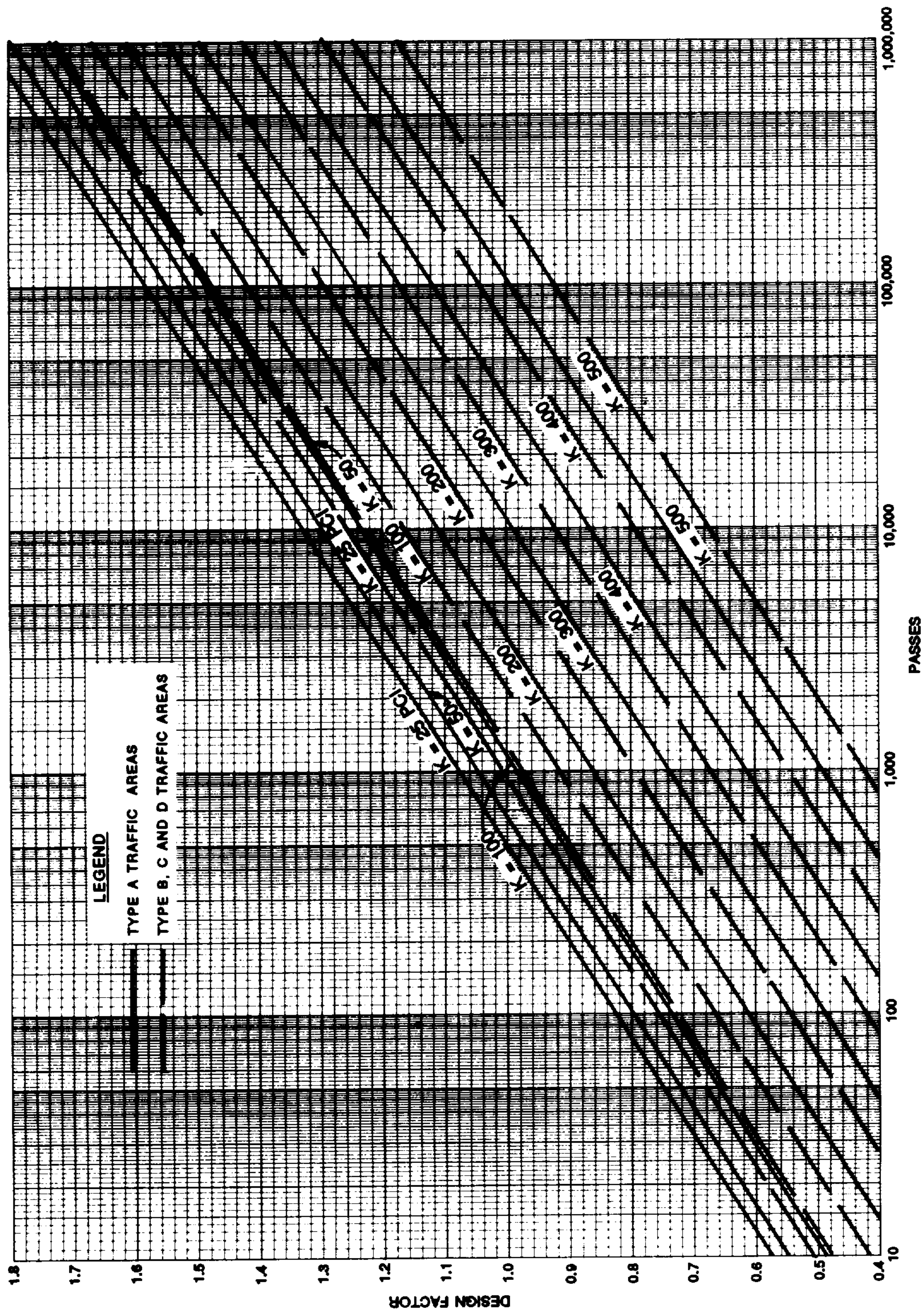


Figure 2-59. Design factors for extended life evaluation, Air Force group index 6.

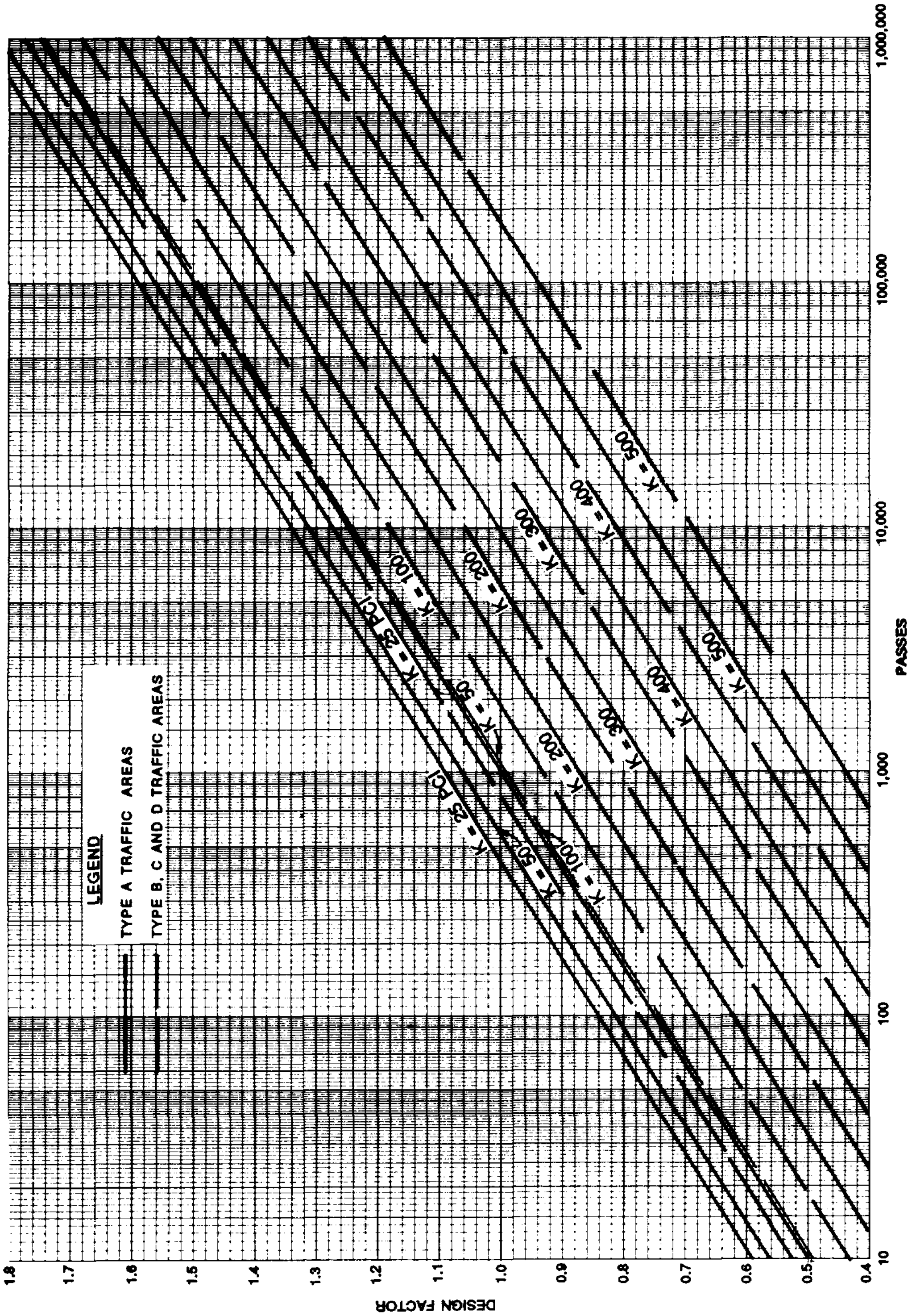


Figure 2–60. Design factors for extended life evaluation, Air Force group index 7.

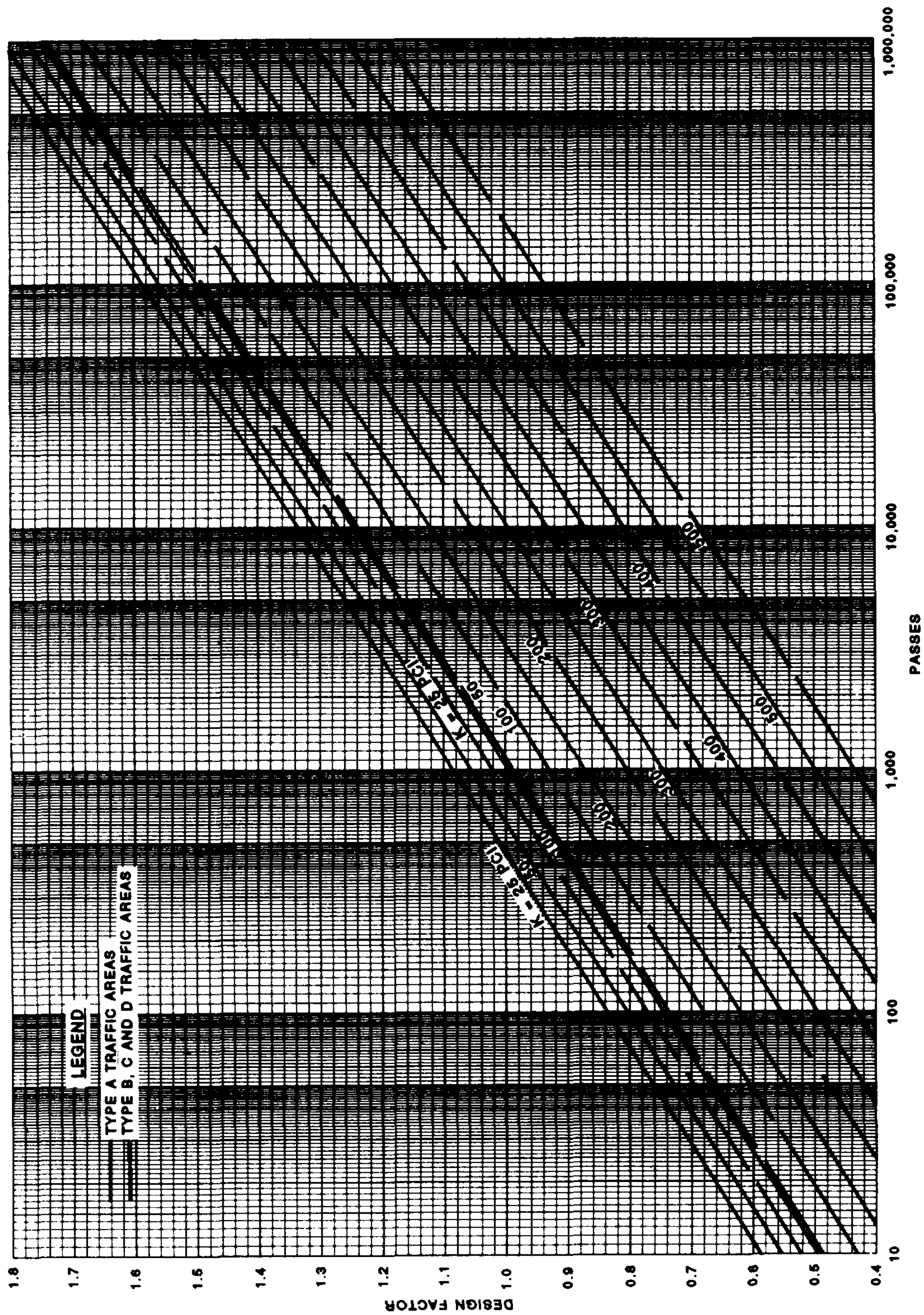


Figure 2–61. Design factors for extended life evaluation, Air Force group index 8.

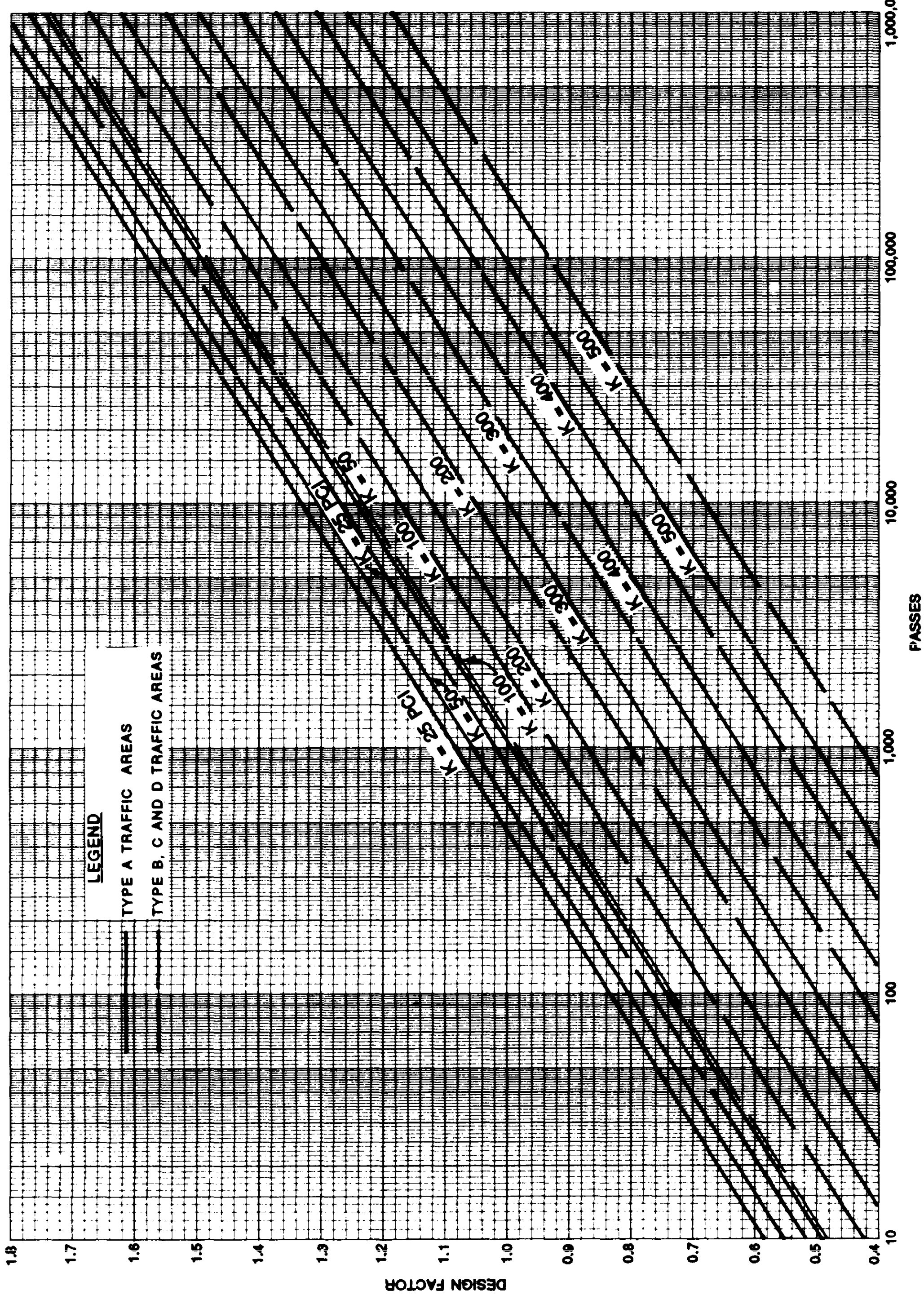


Figure 2–62. Design factors for extended life evaluation, Air Force group index 9.

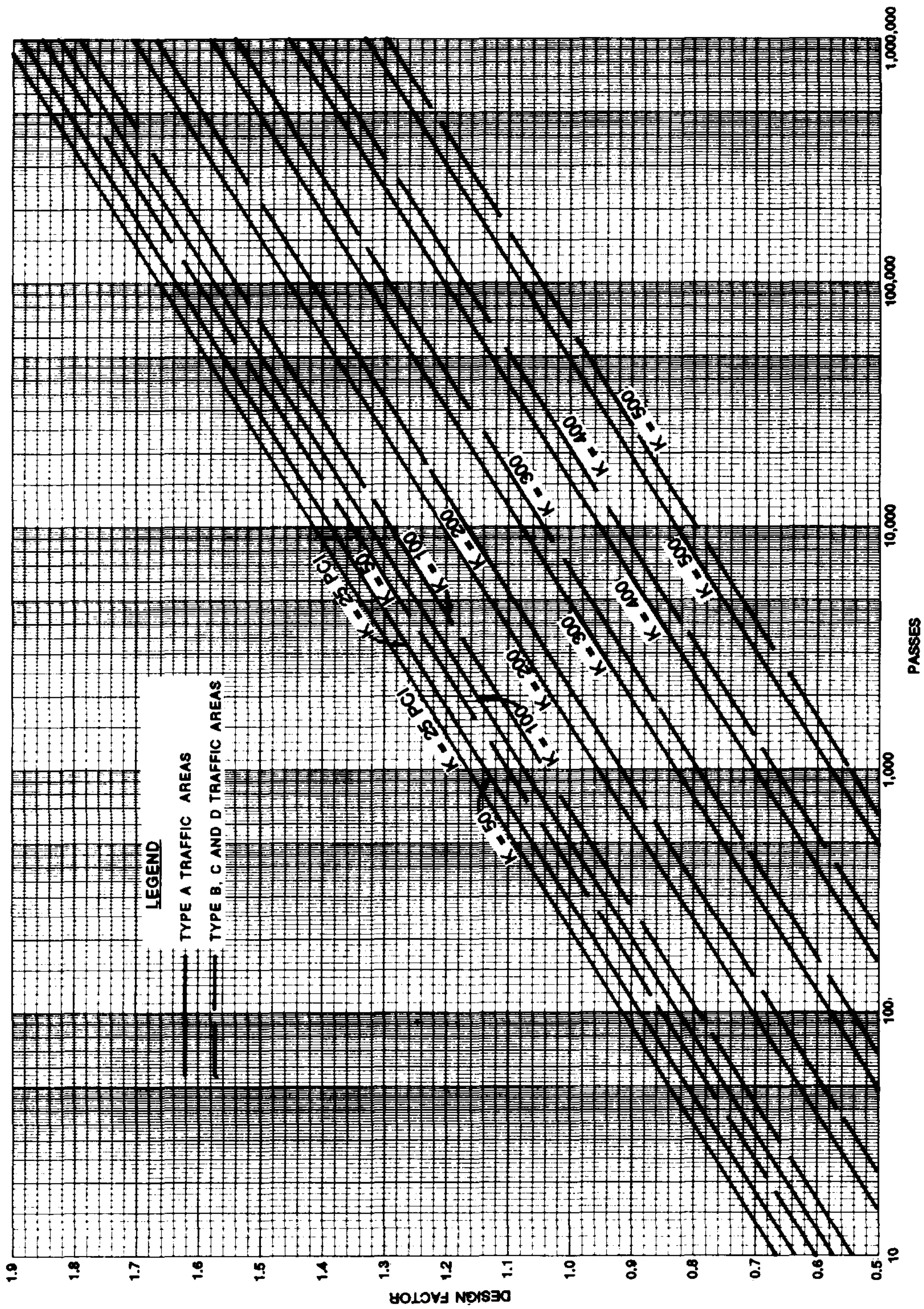


Figure 2–63. Design factors for extended life evaluation, Air Force group index 10.

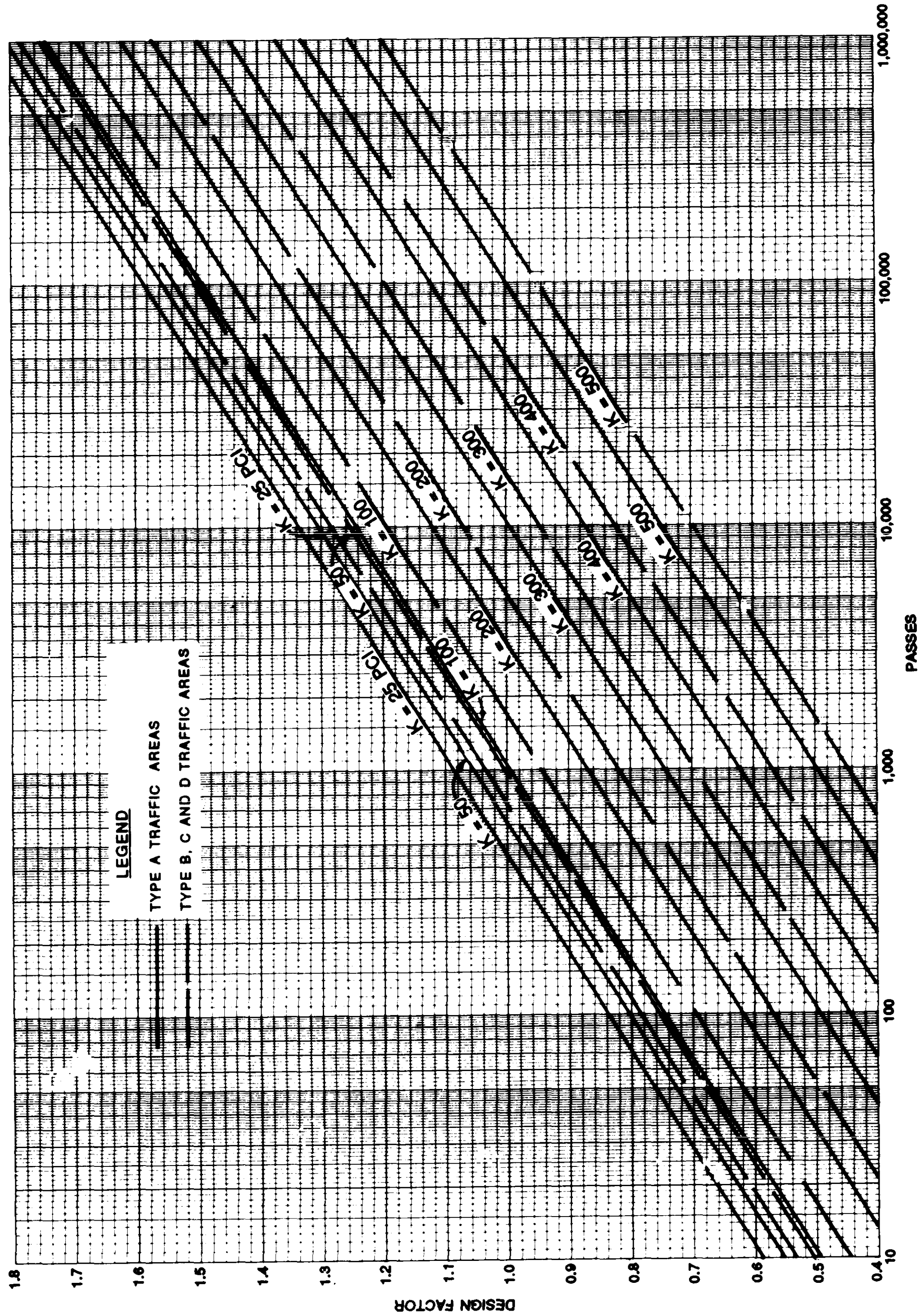


Figure 2-64. Design factors for extended life evaluation, Air Force group index 11.

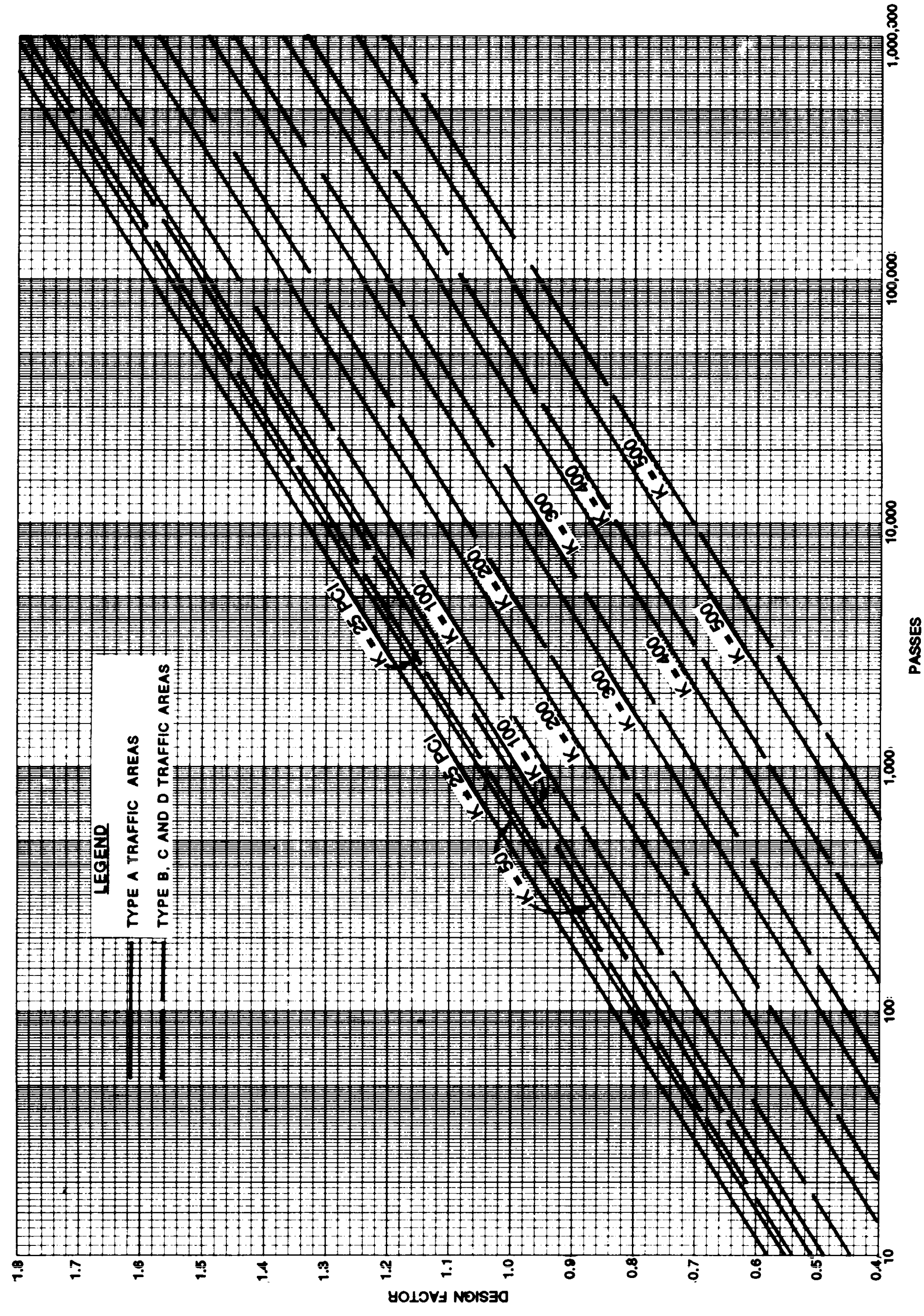


Figure 2–65. Design factors for extended life evaluation, Air Force group index 12.

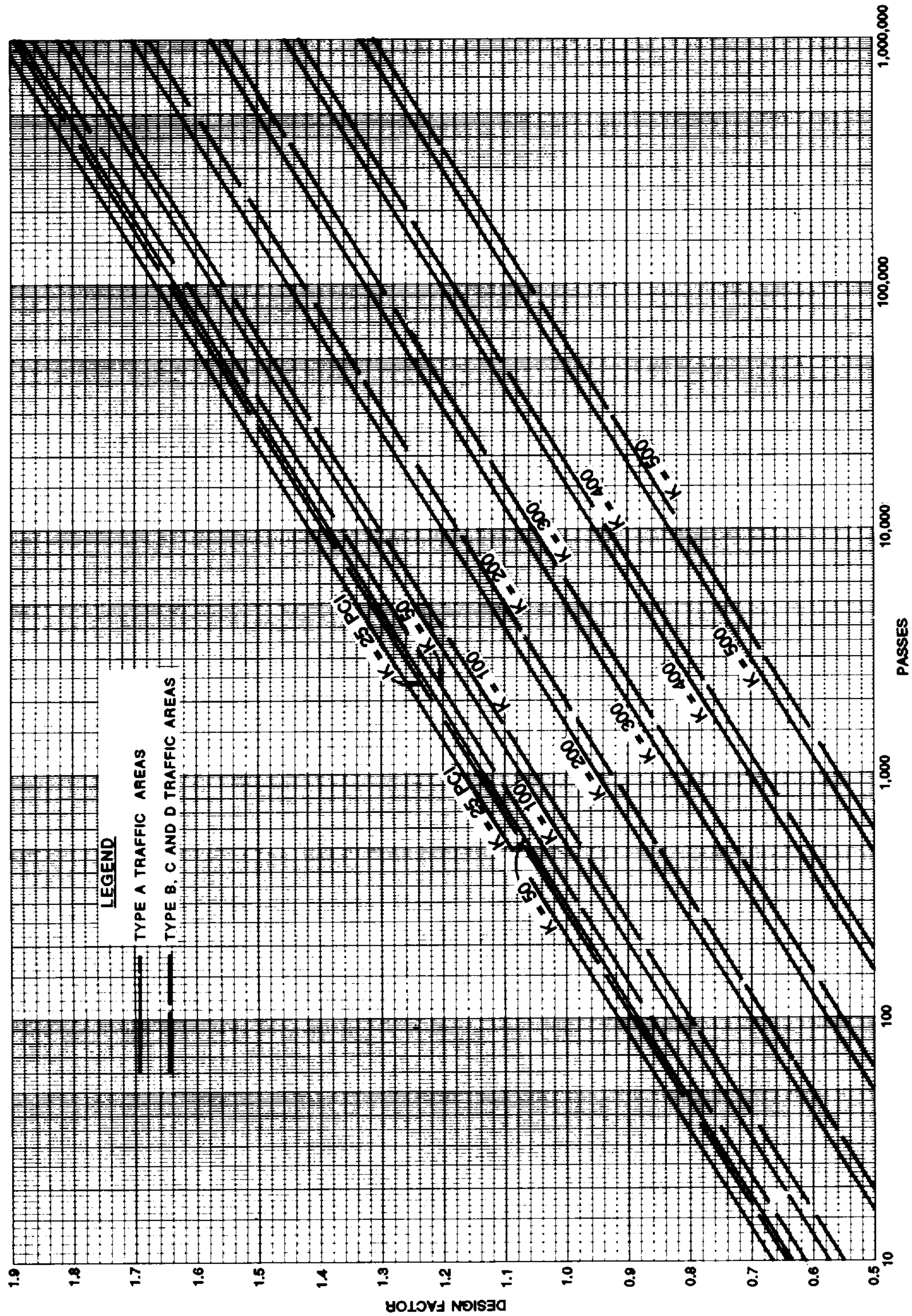


Figure 2-66. Design factors for extended life evaluation, Air Force group index 13.

2–4. Evaluation in terms of passes.

The general procedure for making an evaluation in terms of passes (where a pass is the movement of an aircraft across a given section of pavement) for given gross weights is to enter the evaluation curve for the appropriate Army class (figs 2–19 through 2–21) or Air Force group index (figs 2–22 through 2–34) with the existing thickness, h_E, the subgrade or base course modulus of reaction, k, and the flexural strength of the existing concrete, R, and determine a load factor. The load factor is then divided by the gross weight in kips for which an evaluation is desired. The result of this calculation is a design factor. Enter figures 2–35 through 2–66 with the appropriate design factor and modulus of subgrade reaction and read the allowable number of passes. When evaluating for a type C or D traffic area, the load factor must be multiplied by 1.33 in order to account for the reduced loading used in design.

2–5. Evaluation in terms of gross weight.

The initial step in evaluating for gross weight is to enter figures 2–35 through 2–66 with the number of passes for which an evaluation is desired along with the appropriate k value and determine a design factor. The next step is to enter figures 2–19 through 2–34 as discussed above and determine a load factor. This load factor is then divided by the design factor to calculate the allowable gross weight in kips.

2–6. Frost-condition evaluation.

If the existing soil, water, and temperature conditions are conducive to detrimental frost effects in the base course or subgrade materials, then during much of the year the supporting capacity of a pavement will be less than if the same conditions of soil and water existed in a non-freezing environment. Where such conditions exist, the pavement evaluation will be based on frost area indexes of reaction (FAIR) as given in chapter 11.

2–7. Pavement classification number (PCN).

In addition to evaluating airfield pavements using the above procedures, it is also necessary to report aircraft weight bearing capacity of pavements in terms of the PCN. The PCN can then be compared to an aircraft classification number (ACN) to determine if a pavement can support a particular aircraft. The procedures for determining the PCN are presented in appendix B.

2–8. Pavement condition index (PCI).

As a part of an evaluation, it is necessary to conduct a condition survey of the airfields pavements and report the condition of the pavements in terms of the PCI. Criteria for conducting the condition survey and reporting the PCI are contained in TM 5–826–6/AFR 93–5.

2–9. Pavement life evaluation.

An estimate of the remaining life of an airfield in terms of passes of the aircraft controlling the evaluation will be made for US Army airfield pavements. The procedures for estimating the remaining life are contained in appendix C.

2–10. Emergency construction evaluation.

Airfields or heliports constructed according to the emergency construction manuals will be evaluated using the criteria and procedures presented herein, except that they will be evaluated using 100, 1,000, and 10,000 passes.

CHAPTER 3

PROCURING THE DATA

3–1. Introduction.

a. The selection of representative physical characteristics of a pavement will require a thorough study of all existing information and may require additional tests at the time of evaluation. The evaluation may be based on design and construction control data when these types of data are considered representative of existing conditions. This fact is especially true for relatively new pavements; however, additional tests are desirable for the evaluation of older pavements, or when there is reason to doubt the validity of the existing information. Tests required when construction data are not available are discussed in appendix D. In addition, the sampling and testing methods for conducting these tests are discussed in appendix E.

b. It is not feasible to establish a pavement age that would be applicable in all instances for differentiating new pavement from old pavement or for determining when additional tests should be performed. Generally, an appreciable strength gain occurs in concrete during the first year after construction, and the rate of strength gain decreases with age. Therefore, when evaluating pavements older than 1 year, it would be desirable to perform additional tests to take advantage of the increased strength. The evaluation of older pavements based on the design and construction control data will normally result in a conservative evaluation. However, there have been cases of retrogression in concrete strength with age, and if such a condition should exist or is suspected to exist, additional test should be performed at the time of evaluation. In any case, a thorough study of all existing data should be made and the need for additional tests decided on the basis of engineering judgment. The following paragraphs outline, in general terms, the types of data required for the evaluation and the method of procuring these data.

3–2. Study of existing data.

Existing data may be used to make the evaluation or to supplement new data. In either case, all data available from previous tests made in connection with design, construction, repair, or earlier evaluations should be thoroughly studied. The performance of the pavement should be analyzed by means of traffic records, weather data, and the results of any previous condition surveys. In many instances, the existing data will indicate the uniformity of the material encountered and thus enable the scope of a test program to be established. The type of data that should be assembled and studied for this phase of the evaluation is discussed below.

a. Subgrade and base-course modulus of soil reaction (k). In most instances, it will be found that subgrade and base course modulus determinations were made for the pavement features during the initial construction period and that data may also be available from later tests. The exact locations of the tests should be determined by the evaluating engineer in order to properly assess the value of the information.

b. Pavement thickness (h_e). Construction plans generally show pavement sections for the various features of the airfield, including thickness, thickened edges, types of joints, and load-transfer devices.

c. Concrete flexural strength (R). Construction control strength measurements can, in many instances, give a realistic picture of the uniformity or relative quality of the concrete in the various pavement features. Tests conducted during previous evaluation studies, when correlated with the construction-control tests, may also yield information of value, particularly in regard to strength gain or loss with time. Studies of this type may materially reduce the number of field tests necessary to establish the existing flexural strength on which the evaluation must be based.

d. Condition of existing pavement. In some instances, recent condition-survey reports made in connection with special investigations can be obtained from the Geotechnical Laboratory, US Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, or from the Air Force Engineering and Services Center, (AFESC/DEMP) Tyndall AFB, FL. Up-to-date maintenance records should be obtained for all pavements.

e. Subgrade and base course physical properties. Records of the original construction generally contain soil profiles of the finished runway, taxiway, and apron sections, and may also include results of soil-classification tests, moisture contents, moisture-density curves, and the seasonal position of the groundwater table for the subgrade soils. Physical properties of the base course and fill materials, including classification tests and compaction characteristics, are usually available in these records. Modulus of elasticity in flexure of stabilized materials meeting the requirements outlined in TM 5–822–4/AFM 88–7, Chap. 4 may also be found in construction records.

f. Physical properties of concrete. Results of field and laboratory tests to determine the physical properties such as slump, aggregate gradation, mix design, temperature, and curing of the concrete are generally available in the construction records.

g. Physical properties of bituminous pavements. Results of field and laboratory tests to determine the physical properties of the bituminous-type pavements are generally available in the construction records. Data should include results of tests for Marshall stability, flow, percent bitumen by weight, density, voids relationships, aggregate gradation, specific gravity of bitumen and aggregate, and penetration (or viscosity) and ductility of bitumen (MIL-STD-620).

3-3. Procurement of new data.

As stated earlier, it may be found that additional data are required to make the evaluation. The type of data needed and the scope of the testing program to obtain these data will necessarily depend on such factors as the amount and validity of existing data, the type of pavement being evaluated, and the condition of the pavement, and thus will be based largely on the judgment of the evaluating engineer. Tests needed for evaluation are discussed in appendix E. A condition survey should be conducted on the pavements at each airfield evaluated in accordance with TM 5-826-6/AFR 93-5.

3-4. Selection of representative physical property values.

Normally an airfield cannot be evaluated as a single entity because of the variability of pavement type, use, thickness, construction history, traffic area, and condition. The pavement system must be broken into basic units with common characteristics called features (TM 5-826-6/AFR 93-5). Representative physical property data such as concrete flexural strength, modulus of subgrade or base-course reaction, and pavement thickness are selected for each feature. These values are obtained by studying existing data and results of field and laboratory tests. Other data, such as gradation, specific gravity, Atterberg limits, classification, moisture/density relationships, and consolidation properties of soils are also used by the engineer to aid in selecting representative values and to present a complete "picture" of the pavement and foundations. No set rules or formulas can be given for determining representative physical property values; the selection must be based on local experience in the area and engineering judgment. However, the following subparagraphs describe some conditions that may necessitate the adjustment of test values.

a. Selection of representative concrete flexural strength R.

(1) The representative R value to be used for each feature in the evaluation should be the arithmetical mean of all R values, except in special instances where, in the opinion of the evaluating engineer, a slightly lower or higher value is more representative of existing conditions.

(2) When the evaluation is being based on design and construction data, the representative R value should be the arithmetical mean of the R values obtained in the construction-control beam tests. Small changes in mix design that might have been necessary during construction in order to obtain the design strength should be disregarded when selecting representative R values. However, if there was a change in design strength that necessitated a change in mix design, this change should be considered and a representative R value obtained for each facility for which the design strength was changed.

(3) When the evaluation is being based on the results of tests conducted at the time of evaluation or when tests are being performed to check existing data, the amount of data available for arriving at a representative R value will generally be limited to a relatively few test results. The representative R value maybe determined by using the results of tensile splitting tests and calculating the R value as presented in appendix E, or by conducting the flexural strength tests. The results of all tests from a feature should be used to compute an arithmetical mean. High or low results should not be discarded unless it is definitely established that erroneous results were obtained because the sample was defective or because incorrect test procedures were used.

b. Selection of representative thickness and strength values for nonrigid overlays.

(1) *Rigid pavement procedure.* The evaluation of a nonrigid overlay (bituminous concrete or flexible overlay) on rigid pavement is based on the selection of an equivalent thickness of rigid pavement that would have the same load-carrying capacity as the existing pavement with overlay. The procedure for calculating the equivalent thickness as discussed in chapter 7 is based on the assumption that the bituminous concrete or flexible overlay meets the design requirements set forth in TM 5-825-2/AFM 88-6, Chap. 2. Therefore, for the evaluation of nonrigid overlay on rigid pavement using rigid pavement evaluation procedures, it is necessary to establish whether the nonrigid overlay portion meets the design requirements given in TM 5-826-2/AFM 88-24, Chap. 2. Should it not meet design requirements, early failure can be anticipated.

(2) *Flexible pavement procedure.* When a nonrigid overlay on rigid pavement is evaluated using the flexible pavement evaluation procedure, strength an thickness values should be selected in accordance with the procedures outlined in TM 5-826-2/AFM 88-24, Chap. 2.

c. Selection of representative values for modulus of soil reaction k . The selection of a representative k value can be made in much the same manner as that used in the selection of R values;

however, generally less test data will be available. An average k value is computed for each pavement feature. There will be instances where k values will be considerably higher or lower than the average of the majority of values, in which case a thorough study of foundation conditions should be made at this location to determine whether the test was erroneous or whether the foundation actually is nonuniform. If the test is found to be erroneous, the unusually high or low value should be discarded; if the foundation is actually nonuniform, a more extensive testing program may be needed to select a representative k value. Saturation correction will not be made for k values since the material will have reached near maximum saturation.

d. Limiting conditions.

(1) When conditions do not indicate concrete or soil of normal physical properties, the evaluation must be modified accordingly. Ideal conditions seldom exist, and full consideration should be given to the probable influence of factors such as those outlined below. The narrative portion of the evaluation report should contain a discussion of the effect that any of the following factors might have on the evaluation of the pavement:

(*a*) High moisture absorption and shrinkage of the concrete.

(*b*) Extremely high daily variation in temperature.

(*c*) Wide variation in the flexural strength within a given pavement section or facility.

(*d*) Heterogeneous subgrade, base, or moisture conditions resulting in wide variations in modulus of soil reaction values.

(*e*) Nonrigid overlays (bituminous concrete and flexible overlay) that do not meet design requirements for flexible pavements.

(*f*) Unsatisfactory load transfer at the joints.

(2) No set method has been established for reducing the allowable loading for conditions such as those outlined above. Nonrigid overlays not meeting design requirements might be susceptible to rutting or raveling. If it can be determined that inadequate load transfer conditions exist at the joints, a reduction of up to 25 percent in the allowable load could be justified. When a pavement condition index (PCI) survey results in ratings of very poor or failed due primarily to structural cracking, the pavement is assumed to have inadequate load transfer. Any reduction in the allowable loading will be a matter of judgment, and the engineer must explore all possible sources of information consistent with the job conditions and perform such tests as are feasible to obtain factual data useful in determining the amount of reduction necessary.

CHAPTER 4

PLAIN CONCRETE PAVEMENTS

4–1. Data required.

The data required for evaluation of plain concrete pavements are presented in chapter 3. In addition, if the pavement structure contains a stabilized layer, it will be necessary to obtain the modulus of elasticity and thickness of the stabilized layer. The stabilized layer is considered as a low-strength base pavement, and the following equation will be used to determine an equivalent thickness of the combined pavement:

$$h_E = \sqrt[1.4]{(h_e)^{1.4} + \left(0.0063 \sqrt[3]{E_s}\, h_s\right)^{1.4}} \qquad \text{(eq 4–1)}$$

where

h_E = thickness of plain concrete equivalent to the combined pavement and stabilized layer thickness, inches

h_e = thickness of concrete pavement, inches

h_s = thickness of stabilized layer, inches

E_s = flexure modulus of elasticity of the stabilized layers, psi. May be determined from table 4-1 or calculated using deflections resulting from ASTM D 1635 and the following equation: $E = \frac{23PL^3}{1296\,\Delta I}\left[1+2.11\,\frac{h^2}{L}\right]$

P = applied load, pounds

L = span length, inches

h = specimen height, inches

Δ = deflection of neutral axis, inches, under load P

I = moment of inertia, $inch^4$

With this h_E value, the evaluation is made using the flexural strength of the pavement and the modulus of subgrade reaction of the material below the stabilized layer.

Table 4-1. Suggested E_s values for stabilized layers. (Use as a guide when values are not available).

Compressive Strength psi	*Modulus of Elasticity psi*
500– 750	500,000
750–1,000	800,000
1,000–1,500	1,200,000
1,500–2,000	1,600,000
Over 2,000	2,000,000

4–2. Method of evaluation.

With the properties of plain concrete pavement known, the allowable gross aircraft weights at selected pass levels that can safely use the pavement or the allowable number of passes for selected gross weights can be determined using figures 2–19 through 2–66.

4–3. Evaluation example.

Assume:

a. Airfield runway and parking apron having uniform thickness h_e = 12 inches

b. Concrete flexural strength R = 700 psi

c. Subgrade modulus of soil reaction k = 300 PCI

d. Condition of pavement = excellent with adequate load transfer at the joints.

In accordance with TM 5-826-1/AFM 88-24, Chap. 1, the runway evaluation is based on the thickness of the pavement in the center 75-foot width of the runway, and the runway is divided into two traffic areas where the first 1,000-foot ends are type A traffic area. The runway interior is a type C traffic area, and the parking apron is a type B traffic area.

(1) *Problem 1.* Determine the extended life evaluation for Air Force group index 13 on the type A, B, and C traffic areas in terms of the allowable gross weight. The allowable gross weight is determined as illustrated in the following tabulation:

	Design Factor[a]			Allowable Gross Weight kips[c]		
Pass Levels	*Type A Traffic*	*Types B and C Traffic*	*Load Factor[b] kips*	*Type A Traffic*	*Type B Traffic*	*Type C Traffic*
100	0.578	0.553	400	690	725	965
500	0.752	0.728	400	530	550	735
3,000	0.946	0.922	400	425	435	580
15,000	1.120	1.099	400	360	365	485

[a]From figure 2–66.
[b]From figure 2–34.
[c]Divide load factor by design factor for type A and B traffic areas. For type C traffic area, multiply allowable load for type B traffic by 1.33.

(2) *Problem 2.* Determine the standard evaluation for Air Force Group 13 using the above conditions in terms of allowable passes. The allowable number of passes for several gross weights are determined as shown in the following tabulation:

Aircraft Gross Weight kips[a]	*Weight for Evaluating Traffic Area C kips*[b]	*Load Factor*[c]	Design Factor[d]		Allowable Passes		
			Traffic Area A and B	*Traffic Area C*	*Traffic Area A*	*Traffic Area B*	*Traffic Area C*
480	360	400	0.833	1.111	90	110	1,400
440	330	400	0.909	1.212	180	220	3,500
400	300	400	1.000	1.333	410	500	10,800
360	270	400	1.111	1.481	1,115	1,360	44,000
300	225	400	1.333	1.777	8,856	10,800	640,000

[a]Gross weight for which the evaluation is being made.
[b]Weight to be used in evaluating type C traffic areas is the aircraft gross weight times 0.75.
[c]From figure 2-34.
[d]Load factor divided by aircraft weight.

CHAPTER 5

REINFORCED CONCRETE PAVEMENT

5-1. Data required.

a. The data required for the evaluation of reinforced concrete pavements are essentially the same as those for plain concrete pavements presented in chapter 3, except that the percent steel is also required.

b. The reinforcing steel in a reinforced concrete pavement will normally be located at or above the neutral axis of the pavement section. If the steel should be below the neutral axis, it would affect the determination of the flexural strength and the static modulus of elasticity in flexure. Therefore, when the reinforcing steel falls below the neutral axis in a test beam, the beam should be turned over and tested with the reinforcing steel above the neutral axis. The splitting tensile tests cannot be performed on a core of reinforced rigid pavement if any of the reinforcing steel is present in the core to be tested. It may be possible to obtain a core that contains none of the reinforcing steel, in which case the splitting tensile tests could be performed. However, if the pavement thickness is great enough, it may be possible to saw the core just below the reinforcing steel and perform the splitting tensile test on the lower, nonreinforced portion.

5-2. Method of evaluation.

Reinforced concrete pavements may be found on grade (single slab), as a part of an overlay system, or over stabilized layers. In either case, the thickness of the reinforced concrete pavement is converted to an equivalent thickness of plain concrete pavement, and the evaluation is made in the same manner as plain concrete.

a. The first step in the evaluation of a reinforced concrete pavement is to compute the thickness of a plain concrete pavement (equivalent thickness) having the same load-carrying capacity as the reinforced concrete pavement. This equivalent thickness h_E is determined from figure 2-17, using the known thickness of the reinforced concrete pavement h_r and the percentage of steel reinforcement S per foot of pavement cross-sectional area. The percentage of steel is computed from equation 5-1:

$$S = \frac{A_s}{A_p} \times 100 \qquad \text{(eq 5-1)}$$

where

A_s = cross-sectional area of the reinforcing steel per foot of pavement width or length, square inches

A_p = cross-sectional area of pavement per foot of pavement width or length, square inches

It is necessary to compute the percent steel in both the longitudinal and transverse directions. Normally, it will be the same in both directions, but if there is a difference, the smaller value will be used. Next, enter figure 2-17 with the known value of h_r. Make a vertical projection and extend it until it intersects the diagonal line representing the computed value of S. Then make a horizontal projection to the left until it intersects the scale line representing the values of h_E. The resulting value of h_E represents the equivalent thickness of the plain concrete pavement that would have the same load-carrying capacity as the reinforced concrete pavement.

b. In determining the equivalent thickness from figure 2-17, the effects of the reinforcing steel on the load-carrying capacity will be disregarded when S is less than .05 and h_E will simply equal h_r. Also, when S is greater than 0.5, the value of h_E will be determined using the diagonal line representing $S = 0.5$ percent.

c. After the equivalent thickness has been determined, the method of evaluation will depend on whether the reinforced concrete pavement is on grade, in any overlay system, or over a stabilized layer. For reinforced concrete pavement on grade, the method of evaluation will be the same as for a plain concrete pavement except that the h_E value will be used instead of the reinforced concrete pavement thickness h_r. If the reinforced concrete pavement is part of an overlay system, the method of evaluation to be used will depend on the type of overlay system. If the reinforced concrete pavement is placed over a stabilized layer, it will be necessary to determine the equivalent thickness of plain concrete pavement to account for the effect of the stabilized layer. First, the equivalent thickness due to the reinforcing will be determined from figure 2-17. Second, using the above equivalent thickness, the effect of the stabilized layer will be determined from equation 4-1. Using this thickness h_E, the evaluation will be determined as for plain concrete pavement. In any case, the thickness to be used will be the appropriate equivalent thickness, h_E, rather than the thickness of the reinforce concrete pavement h_r.

5–3. Evaluation example.

Assume:

a. Runway interior = type C traffic area

b. Thickness of reinforced concrete pavement = 12 inches

c. Diameter of steel reinforcing bars, both longitudinal and transverse = 3/8 inch

d. Center-to-center spacing of reinforcing bars, both longitudinal and transverse = 6 inches

e. Flexural strength of concrete = 700 psi

f. The k value for the foundation material = 100 pci

g. The percentage of reinforcing steel in both the longitudinal and transverse directions is computed by substituting in equation 5–1:

$$S = \frac{A_s}{A_p} \times 100 = \frac{0.221}{144} \times 100 = 0.00153 \times 100 = 0.153 \text{ percent}$$

where

$$A_s = \frac{(3.1416)\ (0.375)^2 \times (2)}{4} = 0.221 \text{ square inches}$$

$$A_p = 12 \times 12 = 144 \text{ square inches}$$

Since h_r = 12 inches and S = 0.153 percent, figure 2–17 shows the corresponding h_E value to be 14.4 inches. This h_E value is then used to determine the evaluation in the same manner as a plain concrete pavement.

CHAPTER 6

RIGID OVERLAY ON RIGID PAVEMENT

6-1. Data required.

a. The data required for the evaluation of a rigid overlay on rigid pavement do not differ greatly from those required for plain concrete pavements. The data needed for use with the evaluation curves are presented in chapter 3.

b. A study of the overlay design, construction records, and previous condition surveys must be made in order to determine the condition of the base pavement prior to the overlay. If the overlay pavement contains only a minimum of structural defects, then it can be assumed that very little "breakup" of the base pavement has occurred since it was overlaid, and the condition of the base pavement can be rated the same as it was immediately prior to the overlay. Methods for conducting the necessary tests are outlines or referenced in appendix D.

6-2. Method of evaluation.

The first step in the evaluation of a rigid overlay on a rigid pavement is the determination of the equivalent thickness of the combined section of the rigid overlay and the rigid base pavement. The equivalent thickness, which is defined as a single thickness of plain concrete pavement having the same load-carrying capacity as the combined thickness of the rigid overlay and the rigid base pavement, can be determined as follows:

a. If the overlay slab was cast directly on the base slab—this is, if no effort was made to break the bond between the overlay and the base pavement by means of a tack coat, sand, paper, bituminous concrete, or other materials placed between the overlay and the base pavement—the equivalent thickness h_E of the combined overlay section can be computed from the following equation for partial bond between the overlay and the base pavement:

$$h_E = \sqrt[1.4]{(h_o)^{1.4} + (h_b)^{1.4}} \qquad \text{(eq 6-1)}$$

where

h_o = thickness of rigid overlay pavement, inches
C = coefficient representing condition of pavement
h_b = thickness of rigid base pavement, inches

b. If a bond-breaker course was used between the rigid overlay and the rigid base pavement, the h_E value of the combined overlay section can be computed from the following equation for no bond between the overlay and the base pavement:

$$h_E = \sqrt{(h_o)^2 + C\,(h_b)^2} \qquad \text{(eq 6-2)}$$

No credit is given to the thickness of the bond breaker if less than 4 inches. If the thickness of the bond breaker is grater than 4 inches, then the pavement will be evaluated as a composite pavement.

(1) The value of C in equations 6-1 and 6-2 depends on the condition of the existing rigid base pavement. The following C values are recommended:

C = 1.00 for base pavement in good condition.
C = 0.75 for base pavement having a few initial cracks due to loading, but no progressive cracks.
C = 0.35 for badly cracked base pavement.

Other values for C can be used; however, since guidance is not provided, engineering judgment must be applied when selecting values other than those above.

(2) After the h_E value of the combined section has been determined from either equation 6-1 or 6-2, the method of evaluating a rigid overlay on a rigid base pavement is the same as for a plain concrete pavement. The flexural strength to use would be the weighted average of the overlay and base pavement strengths, determined as follows:

$$R = \frac{h_o \times R_o + h_b \times R_b}{h_o + h_b} \qquad \text{(eq 6-3)}$$

6-3. Evaluation example.

Determine an extended life evaluation in terms of passes for the C-130 aircraft at a gross weight of 135 kips on a type B traffic area consisting of a 6-inch base pavement and a 6-inch rigid overlay with no bond breaker. The weighted average flexural strength is 600 psi and the k value is 50 pci. Since the base pavement contains a few initial cracks, the C factor is 0.75. With these data, the evaluation is made in the manner outlined below.

a. Step 1. Calculate the equivalent thickness h_E using equation 6-1:

$$h_E = \sqrt[1.4]{(6)^{1.4} + C\,(6)^{1.4}}$$
$$= \sqrt[1.4]{12.29 + 0.75\,(12.29)}$$
$$= 8.95 \text{ inches}$$

b. Step 2. Enter figure 2-21 with the k = 50, R = 600 and equivalent thickness of 8.95 inches and determine the load factor of 127.

c. Step 3. Divide the load factor by 135 kips to obtain the design factor of 0.94.

d. Step 4. Enter figure 2-53 with the design factor of 0.94 and the k = 50 for type B traffic area and determine the allowable passes of 430.

CHAPTER 7

NONRIGID OVERLAY ON RIGID PAVEMENTS

7–1. Data required.

The data required for the evaluation of a nonrigid overlay on rigid pavement are presented in chapter 3. It is also necessary to determine the quality and strength of the nonrigid overlay material.

a. For bituminous-concrete overlays which consist of bituminous concrete for full depth, the data required will be the same as for the evaluation of the bituminous-concrete portion of flexible pavements, as outlined and discussed in TM 5–826–2/AFM 88–24, Chap. 2.

b. For the flexible overlays which consist of a granular base and a bituminous surface, the data required will be the same as for the evaluation of flexible pavements, as presented in TM 5–826–2/ AFM 88–24, Chap. 2.

c. The method of evaluation for nonrigid-type overlay pavements presented herein assumes that the bituminous concrete meets the design requirements set forth in TM 5–825–2/AFM 88–6, Chap. 2, and that the base-course material of the overlay, if any, has a CBR of 100 or greater determined in accordance with MIL–STD–621, Test Method 101. Therefore, tests on the nonrigid-type overlay materials may be necessary to determine whether they meet design requirements. These tests should be made in accordance with concepts and procedures set forth in TM 5–826–2/AFM 88–24, Chap. 2. Often the quality of the overlay materials can be determined from a study of construction records. If it can be ascertained that the overlay materials met design requirements during construction and there has been no deterioration of the overlay under traffic, the overlay materials may be assumed to be satisfactory, and no testing other than graduation of materials is required. When it is determined that the overlay materials (bituminous-concrete or base-course materials) did not meet design requirements, the narrative portion of the evaluation report should discuss the consequences, such as rutting and raveling. Inadequacies of the nonrigid-type overlay can often be determined from surface conditions. Rutting or surface cracking are sometimes signs of inadequate strengths of the bituminous concrete and base course and should be investigated. However, in the case of thin overlays, care must be taken to determine whether surface cracking is the result of inadequate strength in the overlay or is reflective cracking from joints and structural defects in the rigid base pavement.

7–2. Methods of evaluation.

The methods of evaluation for nonrigid overlay on rigid pavement are presented below. One, designated as the nonrigid overlay evaluation method, uses evaluation curves for plain concrete pavements discussed in chapter 4; the other, designated as the flexible pavement evaluation method, uses the flexible pavement evaluation curves presented in TM 5–826–2/ AFM 88–24, Chap. 2. Normally, the nonrigid overlay evaluation method yields the higher allowable gross weights at a selected pass level for these types of pavements and will be used. However, when the flexural strength of the rigid base pavement is less than 400 psi or the k value of the foundation is greater than 200 pci, the flexible pavement evaluation method will sometimes yield the higher allowable gross weight at a selected pass level, in which case this method should be used. Therefore, when the test results indicate that the flexural strength of the rigid base pavement is less than 400 psi or the the k value is greater than 200 pci, it will be necessary to evaluate the nonrigid overlay on rigid pavement by both methods to determine which yields the higher allowable gross weight for a selected pass level.

a. Rigid evaluation method. The first step in evaluating a nonrigid overlay using the rigid pavement evaluation method is to determine the equivalent thickness of the combined overlay section. The equivalent thickness h_E is defined as the thickness of a plain concrete pavement having the same load-carrying capacity as the combined overlay section and can be determined by the following equation:

$$h_E = \frac{1}{F}(0.33t + h_b) \qquad \text{(eq 7–1)}$$

where

- t = thickness of nonrigid overlay pavement, inches
- h_b = thickness of rigid base pavement, inches
- F = a factor which controls the degree of cracking in the base rigid pavement. (figs 2–1 through 2–16)

(1) The factor F in equation 7–1 is related to the controlled cracking in the rigid base pavement during the life of the pavement and is therefore dependent on the modulus of subgrade or base-course reaction k and traffic intensity in terms of passes. As noted in figures 2–1 to 2–16, the limiting value of k is 500 pci; if a k value greater than 500 pci

is established, the F value for a k of 500 pci should be used in computing the h_E value. For certain values of F , the equation will yield h_E greater than the combined thickness of $h_b + t$. When this occurs, use the value of $h_b + t$ for h_E .

(2) For an evaluation, the equivalent thickness computed by means of equation 7–1, the concrete flexural strength, and the modulus of subgrade or base-course reaction are used in conjunction with figures 2–19 through 2–66 to determine the allowable gross weight at selected pass levels or the allowable number of passes for selected loads. However, the determining of allowable number of passes becomes an iterative procedure since the F factor depends upon the traffic level.

b. Flexible pavement evaluation method. The flexible pavement evaluation method considers the nonrigid overlay on rigid pavement to be a flexible pavement, with the rigid base pavement assumed to be a high-quality base course with a CBR of 100. The nonrigid overlay on rigid pavement is evaluated as a flexible pavement using the procedures presented in TM 5–826–2/AFM 88–24, Chap. 2. Thus, when evaluating by the flexible pavement evaluation method, it will be necessary to determine the physical property constants that are required for flexible pavement evaluations; that is, the quality of the asphaltic concrete portion of the overlay will have to be established, as well as the CBR values of the subgrade and base course beneath the rigid base pavement. As mentioned above, the rigid base pavement will be assumed to have CBR of 100.

7–3. Evaluation example.

Evaluate a type A traffic area pavement having a uniform thickness of a nonrigid overlay on a rigid pavement. A standard evaluation is to be accomplished for 50,000 passes of the C–141 aircraft (aircraft group index 9). The following conditions apply:

(1) Thickness of bituminous concrete overlay t = 6 inches

(2) Thickness of rigid base pavement h_b = 6 inches

(3) Flexural strength of rigid base pavement R = 600 psi

(4) Base-course thickness under rigid pavement = 8 inches

(5) Modulus of soil reaction on base course k = 300 pci

(6) Base-course CBR = 35

(7) Subgrade CBR = 10

Since the k value under the rigid pavement exceeds 200 pci, it is necessary to evaluate the pavement by both the nonrigid and the flexible pavement evaluation methods to obtain the highest allowable gross weight at selected pass levels.

a. Nonrigid overlay evaluation method. The following steps are recommended:

(1) From figure 2–12 determining F to be 0.79.

(2) Calculate the equivalent thickness by substituting in equation 7–1:

$$h_E = \frac{1}{0.79}[0.4(6) + 6] = 10.6 \text{ inches}$$

(3) Having determined the equivalent pavement thickness, the remainder of the evaluation will be accomplished in the same manner as a plain concrete thickness using the equivalent thickness as the existing thickness.

b. Flexible pavement evaluation method. To evaluate the nonrigid overlay pavement using the flexible pavement evaluation method, the 6-inch rigid base pavement is assumed to have a CBR of 100. Therefore, the following conditions must be investigated with this method:

(1) A subgrade CBR of 10 with a total thickness above the subgrade of 20 inches.

(2) A base-course CBR of 35 with a total thickness above the base course of 12 inches.

(3) A rigid-base-pavement CBR of 100 with a total thickness above the rigid pavement of 6 inches.

The allowable aircraft gross weights at 50,000 passes for these three conditions as determined from the flexible pavement evaluation curves in TM 5–826–2/AFM 88–24, Chap. 2, are 227,000, 400,000, and 400,000+ pounds, respectively. The thickness above the subgrade CBR of 10 governs the evaluation for this example. In this example, the nonrigid procedure may yield the higher allowable gross weights for some aircraft while the flexible procedure may yield higher allowable gross weights for other aircraft. Regardless of the procedure, the higher allowable gross weights would be used for the evaluation.

CHAPTER 8

RIGID OVERLAY ON FLEXIBLE PAVEMENT

8-1. Data required.

When evaluating rigid overlay on flexible pavement, the flexible pavement (bituminous concrete, base course, and subbase course) is considered to be a base course for the rigid overlay. The data needed for use with the evaluation curves are presented in chapter 3. In the determination of the k value on the surface of the flexible pavement with the plate-bearing test, the following limitations are imposed:

a. In no case will a k value greater than 500 pci be used.

b. When the temperature of the existing bituminous pavement surface is above 75 degrees Fahrenheit, the asphaltic concrete pavement should be cut out and the test run on the base. Compare the value from the test with the value from figure 8-1, then select the smallest value to use. Figure 8-1 may also be used as an alternative method for determining the k value on the flexible pavement.

8-2. Method of evaluation.

Representative values must be selected for thickness of the rigid overlay, flexural strength of the rigid overlay, and modulus of reaction on the surface of the existing flexible pavement. The method of evaluating a rigid overlay on flexible pavement is the same as that used for a plain concrete pavement on a base course.

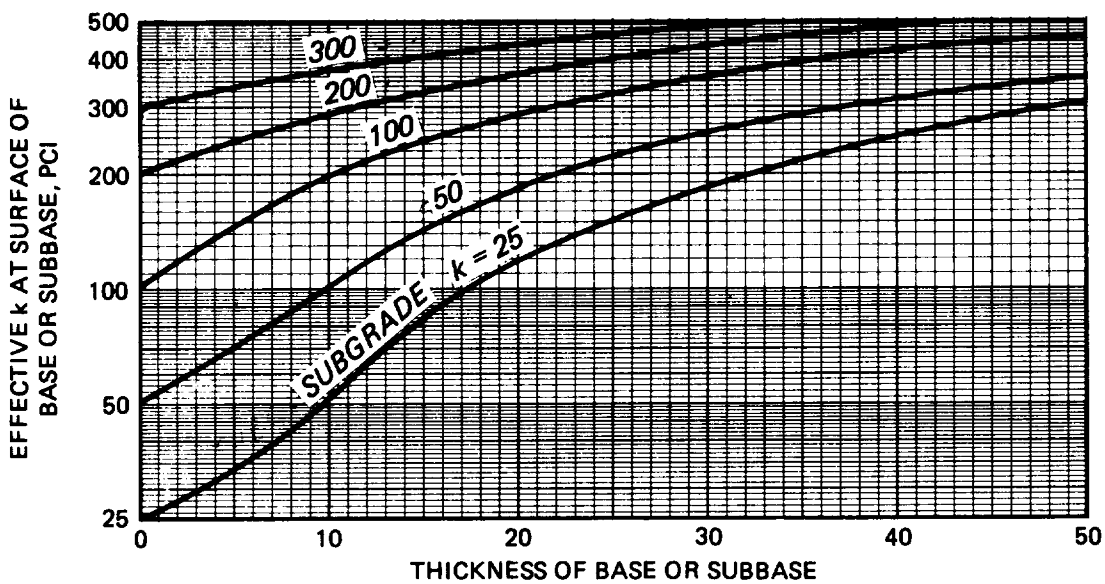


Figure 8-1. Curves for determining effective k values.

CHAPTER 9

COMPOSITE PAVEMENT

9-1. Data required.

The data required for the evaluation of a composite pavement presented in chapter 3 depends, as does the method of evaluation, on the thickness of the nonrigid material between the two rigid pavements. When the thickness of the nonrigid material is less than 4 inches, the specific data required are equivalent thickness of the combined overlay section, flexural strength of the rigid overlay, and the k value of the foundation materials beneath the rigid base pavement. When the thickness of the nonrigid material between the rigid pavements is 4 inches or greater, the specific data required are thickness of the rigid overlay, flexural strength of the rigid overlay, and the k value on the surface of the nonrigid material beneath the rigid overlay.

a. In the determination of the k value in a plate-bearing test on the surface of the nonrigid material between the rigid base and the rigid overlay pavement, the limitations imposed are the same as those on flexible pavement.

b. Tests for the determination of the strength of the rigid base pavement are not required; however, the condition of the rigid base pavement must be known if the evaluation of the composite pavement is made using equation 7-1 to determine h_E. The condition of the base pavement must, of necessity, be determined from a study of previous design and construction records, previous conditions surveys, and performance records of the pavements. If the rigid overlay pavement contains a minimum of structural defects, it can be assumed that the rigid base pavement has experienced little breakup since the overlay was placed, and the condition of the base pavement can be rated the same as it was immediately prior to the overlay.

9-2. Method of evaluation.

The two methods of evaluating a composite pavement, depending on the thickness of the nonrigid material between the rigid base pavement and the rigid overlay, are discussed below.

a. If the thickness of the nonrigid material between the rigid base pavement and the rigid overlay is less than 4 inches, the composite pavement will be evaluated in the same manner as a rigid overlay on a rigid pavement, with the thickness of the nonrigid material assumed to be a bond-breaking course. The equivalent thickness of the combined overlay section will be computed from equation 6-2 for no bond between the overlay and the base pavement.

b. If the thickness of the nonrigid material between the rigid base pavement and the rigid overlay is 4 inches or more, the composite pavement is evaluated in the same manner as a plain concrete pavement, with the nonrigid material and the rigid base pavement assumed to be a base course. In the evaluation, the thickness of the rigid overlay and the concrete flexural strength of the rigid overlay will be used. The k value will be determined by a test performed on the surface of the existing nonrigid material.

CHAPTER 10

FIBROUS REINFORCED CONCRETE PAVEMENTS

10–1. Data required.

The data required for the evaluation of fibrous reinforced concrete pavements as presented in chapter 3 do not differ greatly from that required for plain rigid pavements. Generally, fibrous reinforced pavements are used for overlays because of the thin sections of pavements that can be used, and the evaluation would be the same as that outlined for a rigid overlay over rigid pavements in chapter 6. The determination of the flexural strength value of fibrous concrete (ACI 544.2 R) is slightly different than that for plain concrete. The flexural strength value is normally higher on the stress-strain curve than the value selected for plain concrete specimens.

10–2. Method of evaluation.

Fibrous concrete slabs on grade will be evaluated in the same manner as plain concrete slabs. For Army airfields, a load factor is determined from figures 2–19 to 2–34. The load factor is then divided by the aircraft weight in kips to determine a design factor. The design factor is then used with figures 10–1 to 10–10 to determine the allowable number of passes. For Air Force airfields, the allowable gross weight in kips is determined by dividing the load factor from figures 2–19 to 2–34 by the design factor from figures 10–1 to 10–10. A fibrous concrete overlay pavement will be evaluated by determining an equivalent thickness of concrete pavement according to equation 6–1 or 6–2 and then evaluating as a slab on grade.

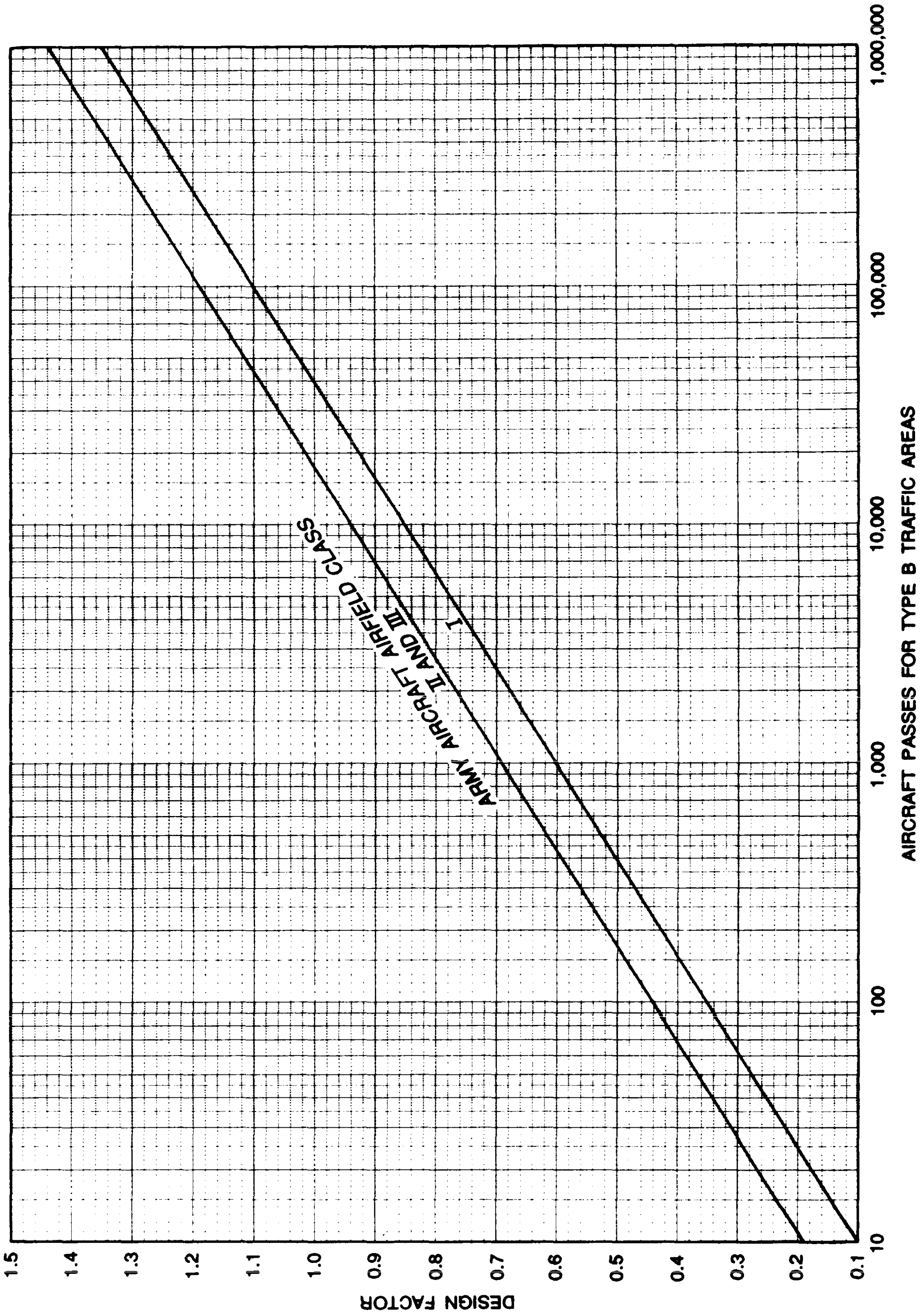


Figure 10–1. Fibrous concrete design factors for Army airfields, type B traffic areas.

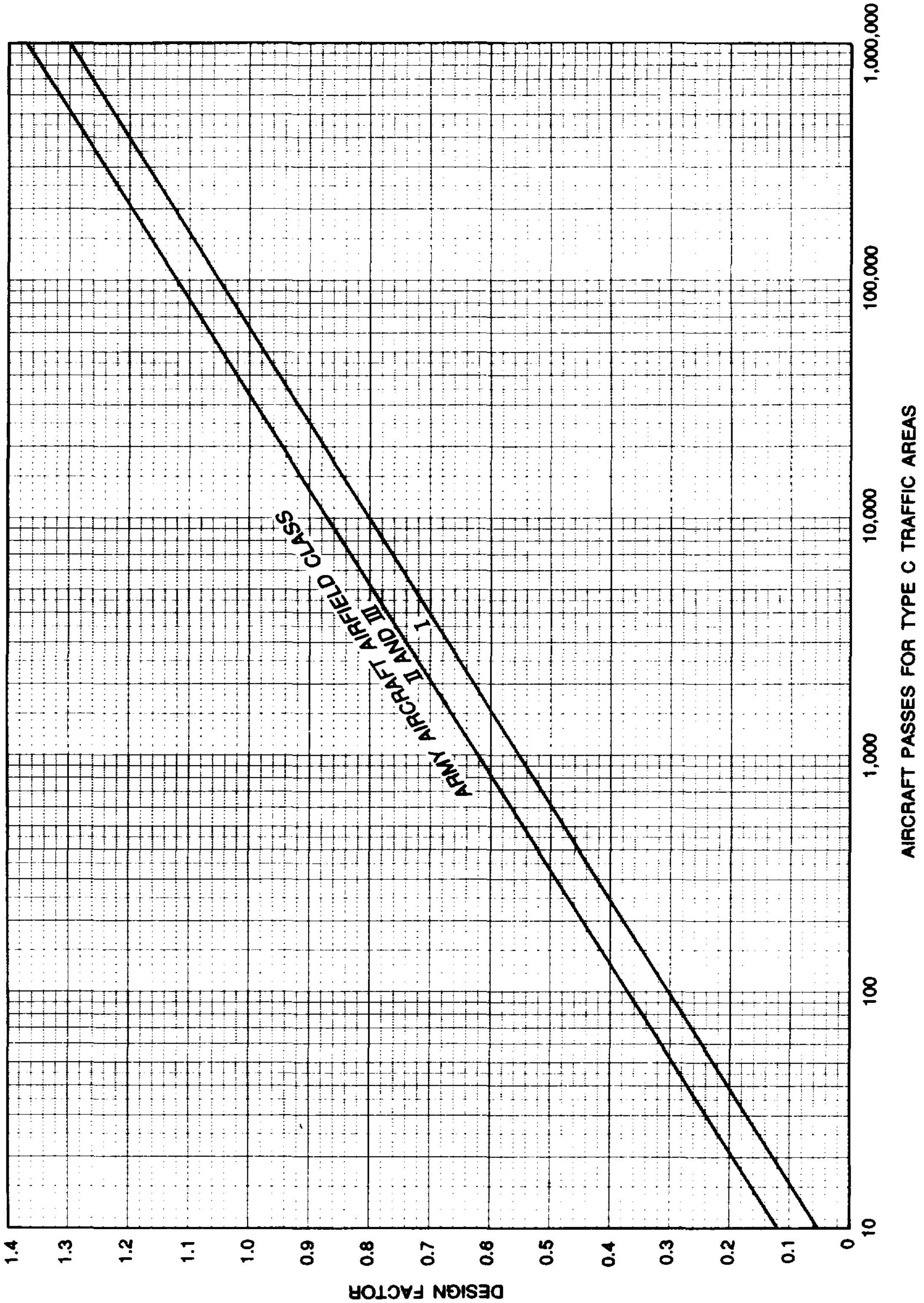


Figure 10-2. Fibrous concrete design factors for Army airfields, type C traffic areas.

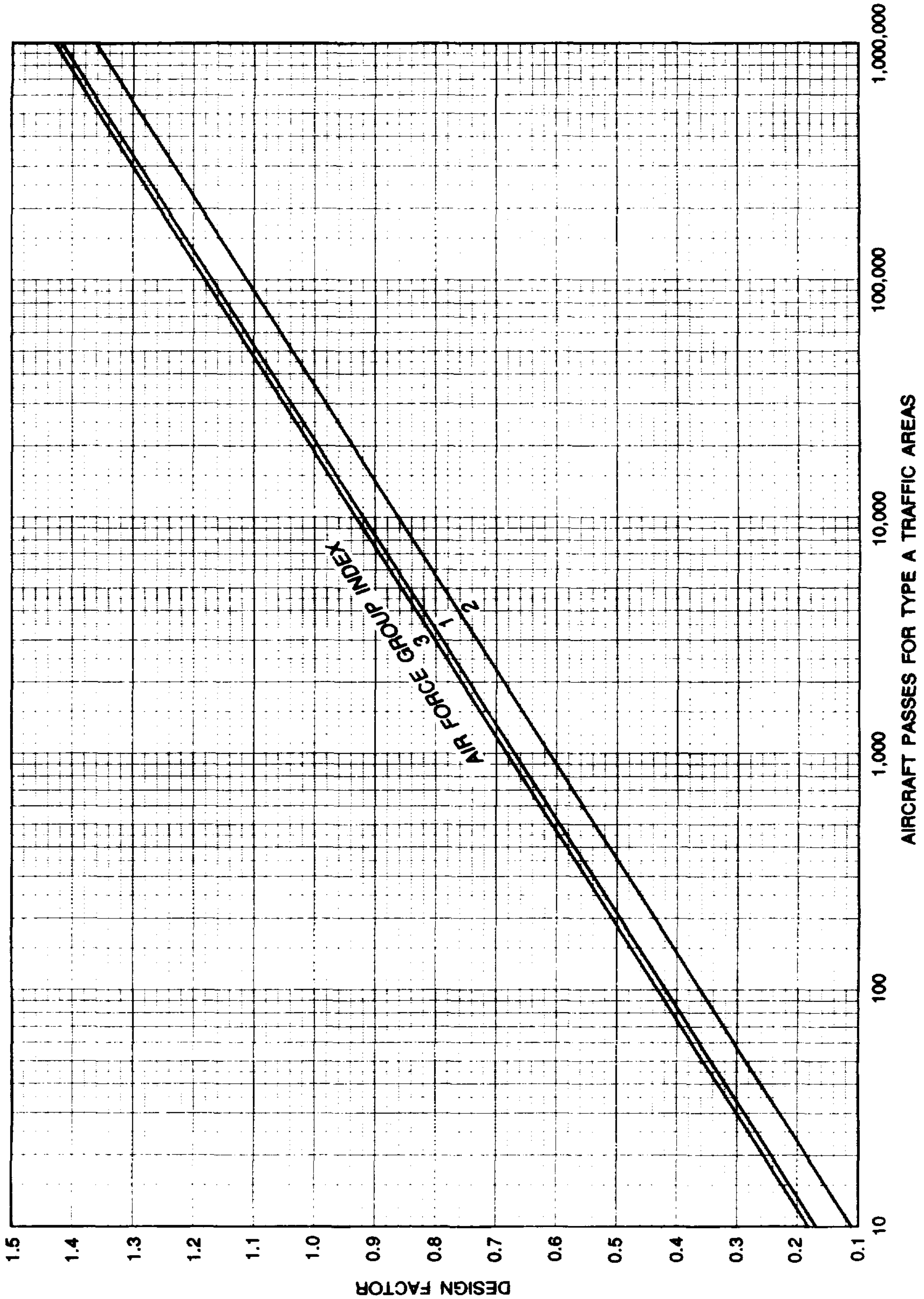


Figure 10-3. Fibrous concrete design factors for Air Force group index 1, 2, and 3, type A traffic areas.

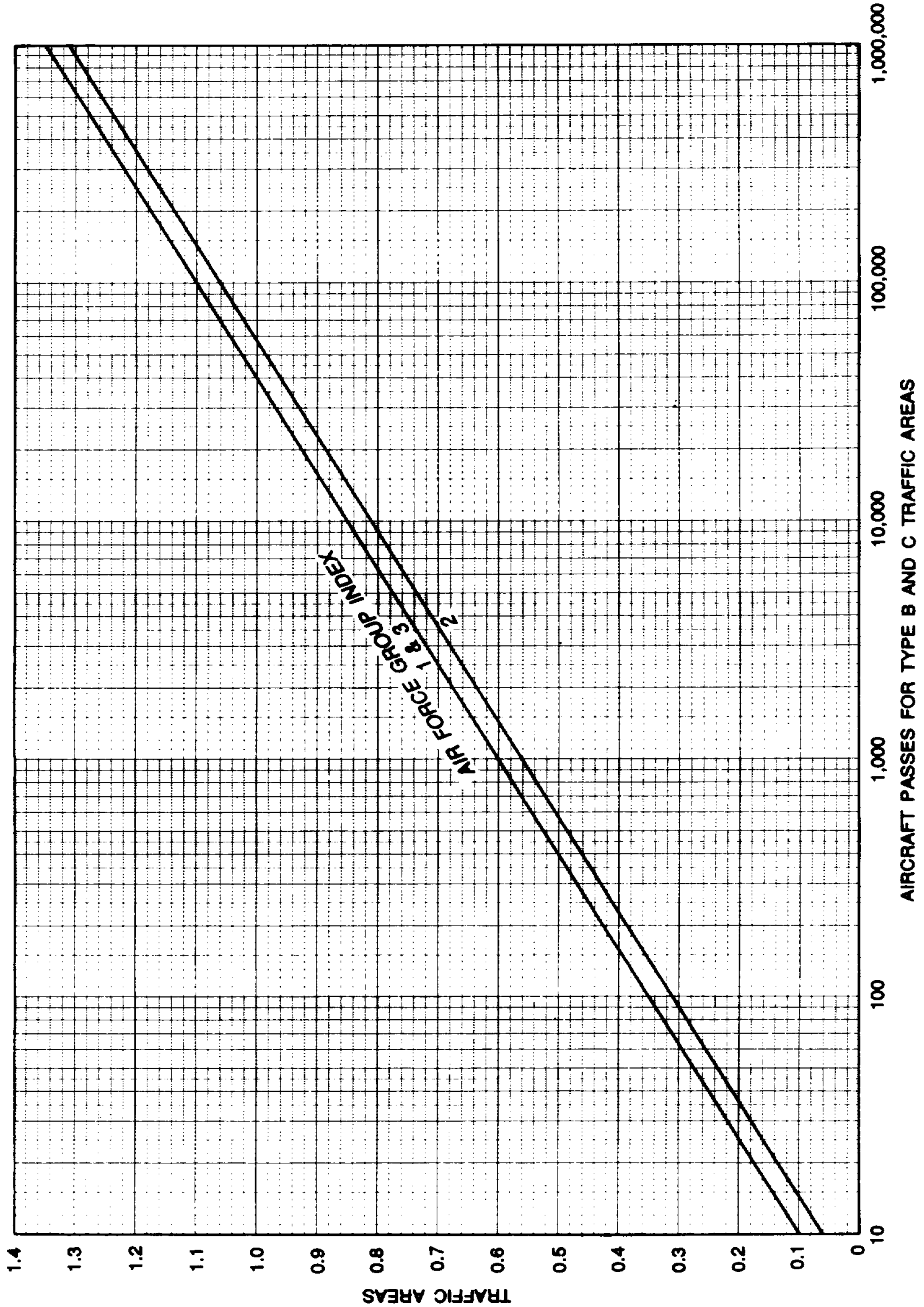


Figure 10-4. Fibrous concrete design factors for Air Force group index 1, 2, and 3, types B and C traffic areas.

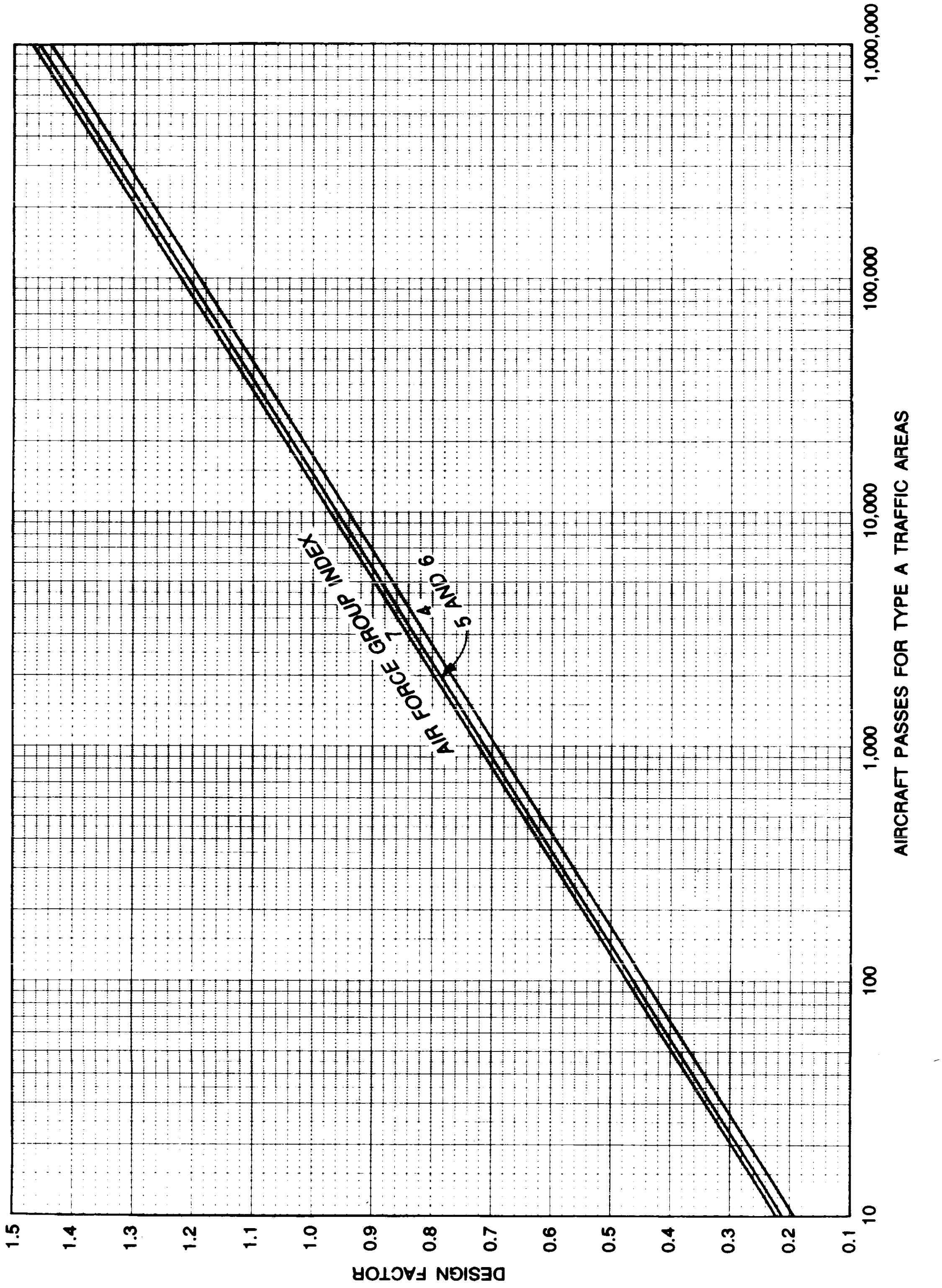


Figure 10–5. Fibrous concrete design factors for Air Force group index 4, 5, 6, and 7, type A traffic areas.

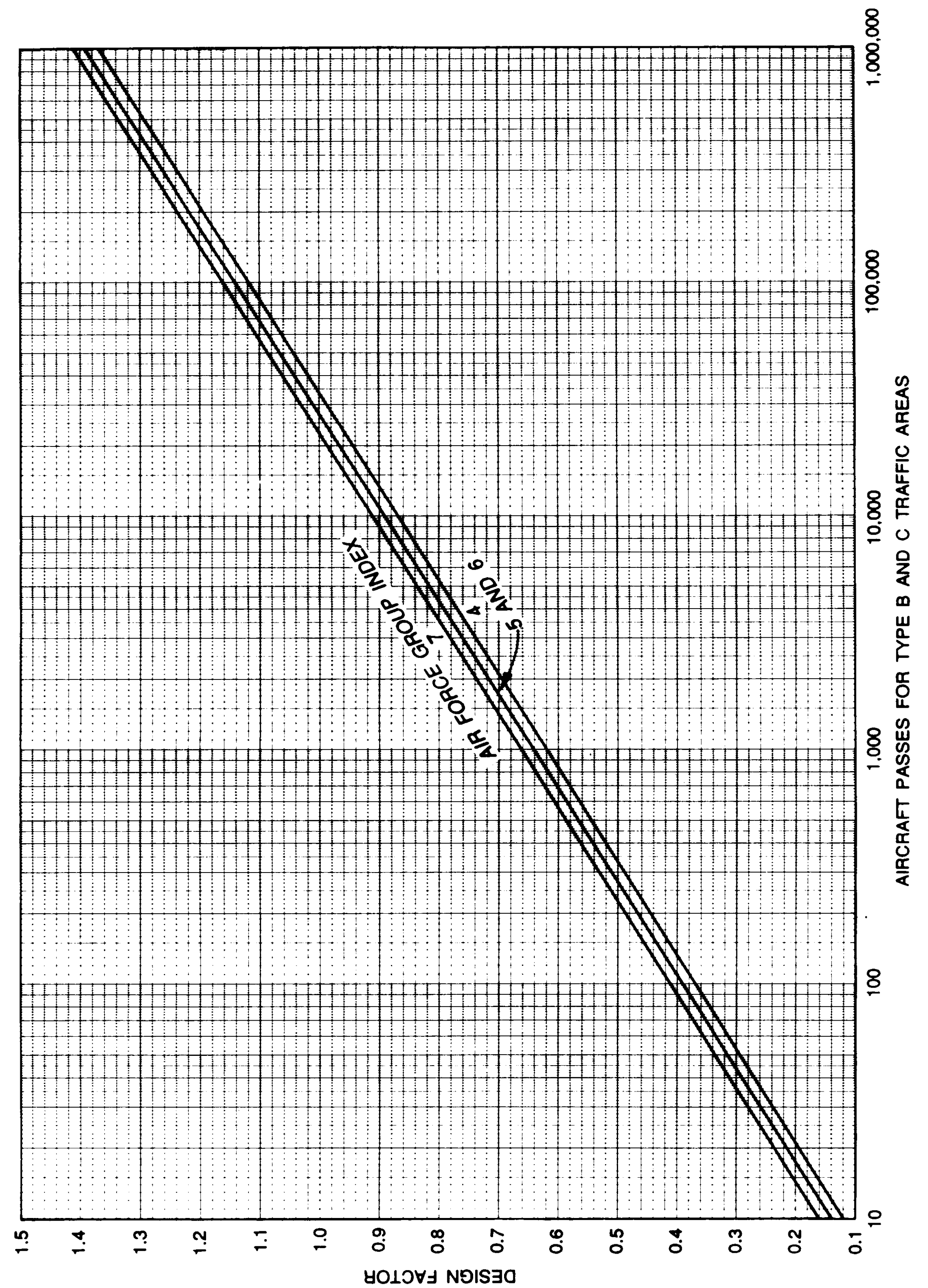


Figure 10–6. Fibrous concrete design factors for Air Force group index 4, 5, 6, and 7, types B and C traffic areas.

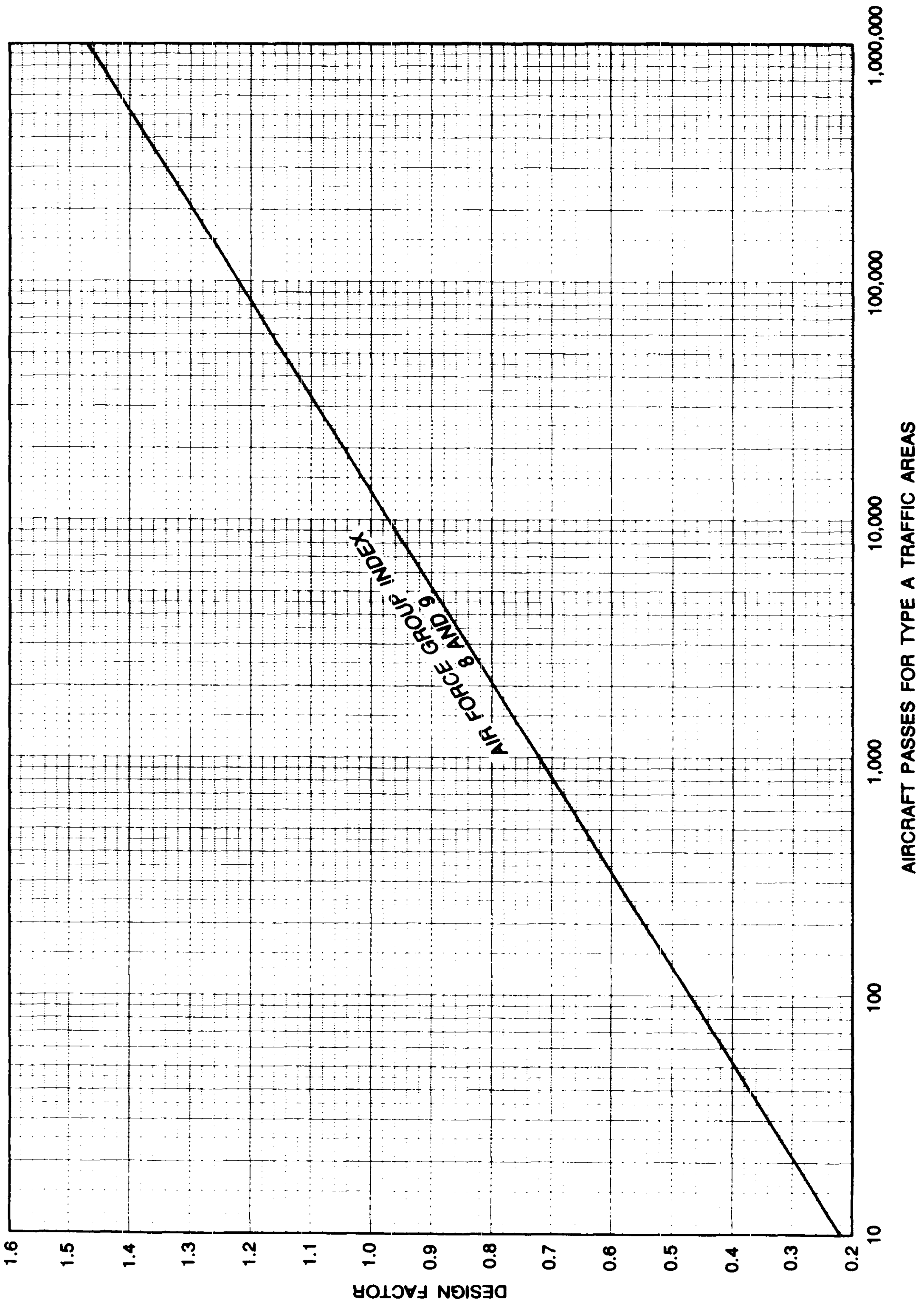


Figure 10–7. Fibrous concrete design factors for Air Force group index 8 and 9, type A traffic areas.

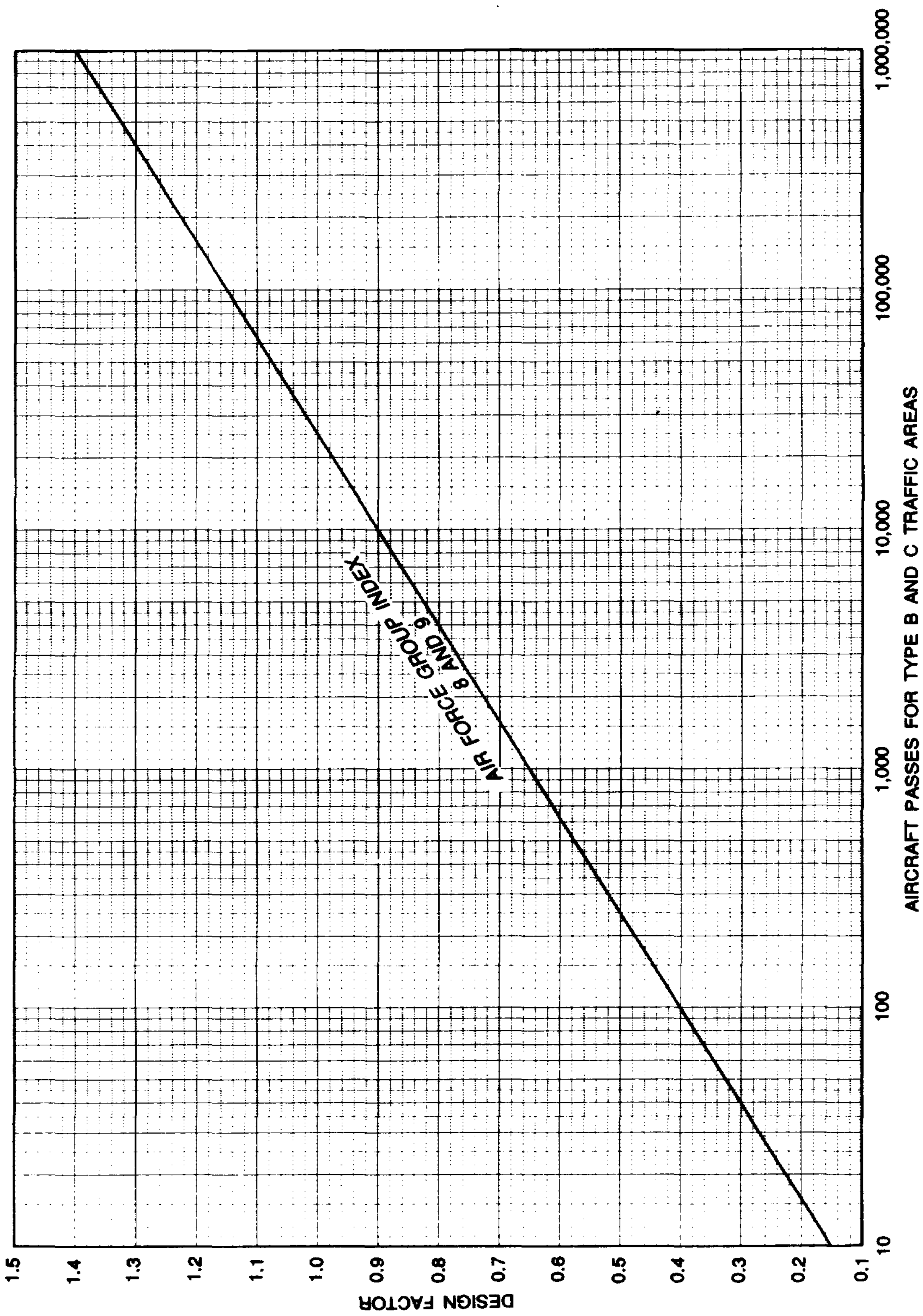


Figure 10–8. Fibrous concrete design factors for Air Force group index 8 and 9, types B and C traffic areas.

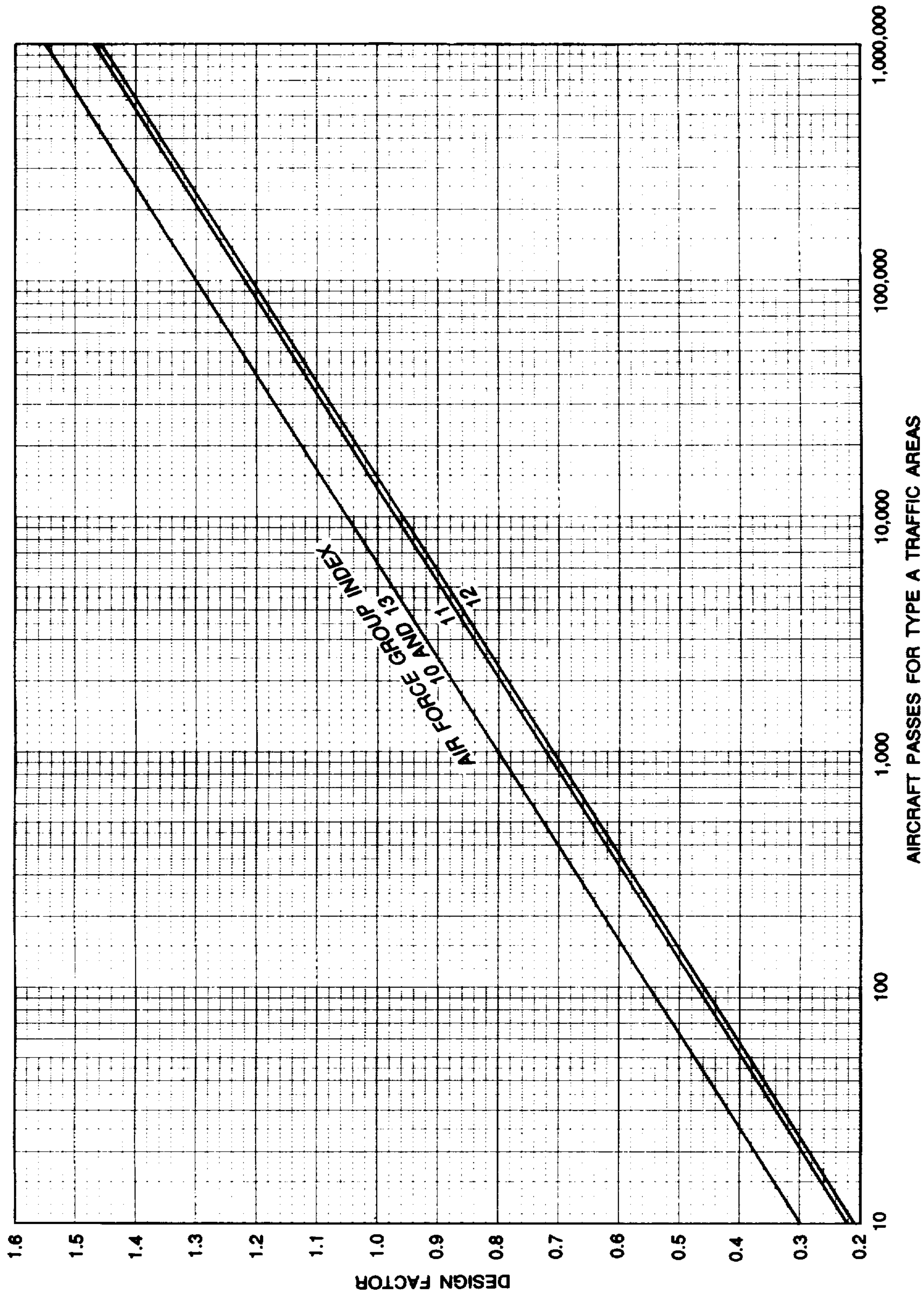


Figure 10–9. Fibrous concrete design factors for Air Force group index 10, 11, 12, and 13, type A traffic areas.

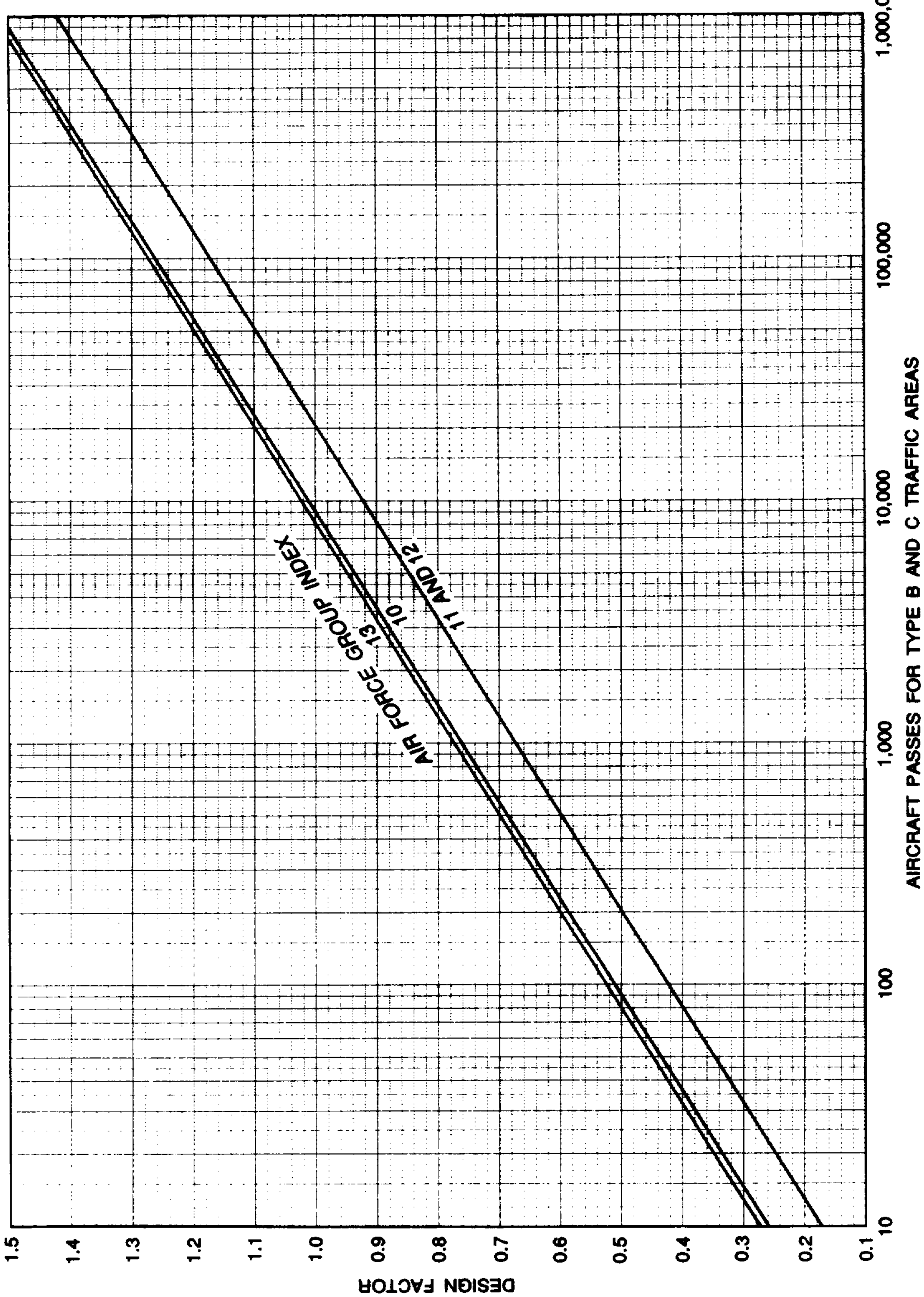


Figure 10–10. Fibrous concrete design factors for Air Force group index 10, 11, 12, and 13, types B and C traffic areas.

CHAPTER 11

PAVEMENT EVALUATION FOR FROST CONDITIONS

11-1. Frost evaluation.

a. If the existing soil, water, and temperature conditions are conducive to detrimental frost effects in the base course or subgrade materials, then during part of the year the supporting capacity of a pavement will be less than if the same conditions of soil and water existed in a nonfreezing environment. The reduction in load support capacity develops as the melting of the ice releases an excess of water that does not drain or redistribute itself readily, thus softening the soil. Recovery from the softened condition comes about initially as a process of reconsolidation and dissipation of pore water pressure, followed by progressive desaturation and buildup of moisture tension, which stabilizes the soil. If such conditions conducive to detrimental frost effects exist, then a frost evaluation must be made in addition to the nonfrost evaluation. The frost evaluation will be based on reduced subgrade strengths using frost-area indexes of reaction (FAIR) as prescribed in this manual.

b. Evaluations of airfields that are based on the FAIR will use pass intensity levels shown in TM 5-826-1/AFM 88-24, Chap. 1.

c. The basic theory of freeze-thaw along with specialized terms relating to frost action and design for frost conditions are defined in TM 5-818-2/AFM 88-6, Chap. 4.

11-2. Frost effects.

a. Subgrade weakening. When ice segregating has taken place in frost-susceptible soil, the soil is subsequently weakened during prolonged frost-melting periods, particularly in winter partial thaws and early in the spring when thawing is taking place at the top of the base course or the subgrade and the rate of melting is rapid. The melting of segregated ice leaves the expanded soil in a weakened condition, the usual stabilizing influence of pore water tension being replaced by detrimental pore water pressure. Reconsolidation is impeded because the excess water cannot drain through the still-frozen underlying soil or readily redistribute itself laterally; thus, the period of severe weakening may last several weeks. Supporting capacity may be reduced in clay subgrades even though significant heave of the surface has not occurred. In clay soils, overconsolidation may be caused during freezing by pore water tension generated in the freezing zone. As a result, the clay particles are reoriented into a more compact aggregated or layered structure, with the clay particles and the ice being segregated. The resulting consolidation may largely balance the volume of the ice lenses formed. Even clays that show no evidence of ice segregation, measurable moisture migration or significant volume increase when frozen may significantly lose supporting capacity during the thaw period. Granular unbound base containing frost-susceptible materials may also weaken significantly during frost-melting periods because of increase saturation and loss of moisture tension, combined with reduced density that is derived from expansion in the previously frozen state. Traffic loads may cause remolding or excess hydrostatic pressures within the pores of the frost-affected soil during the period of weakening, resulting in further reduction in strength. The degree to which a soil loses strength during a frost-melting period and the duration of the weakening period depend on the soil type, temperature conditions during freezing and thawing, the amount and type of traffic during frost-melting, the availability of water during freezing and thawing, and drainage conditions.

(1) *Magnitude of subgrade weakening.* The load-supporting capacity of pavements may be severely reduced during the most critical period. The reduction is less severe for rigid pavements than for flexible pavements. Rigid pavements experience a smaller reduction because the subgrade has a greater influence on the supporting capacity of flexible pavements than on that of rigid pavements. In addition, subgrade soils under rigid pavements are subjected to less shearing deformation and remolding during the critical period.

2. *Critical period.* The most critical period comes during the early stages of frost-melting when the segregated ice is melting, which usually lasts from 1 to 3 weeks. As the soil reconsolidates, the pavement rapidly regains much of its lost strength. With the subsequent gradual desaturation and the corresponding buildup of moisture tension in the affected soils, the pavement gradually regains full normal-period supporting capacity. The length of the recovery period varies from a few weeks to many months, depending on the intensity of ice segregation, the depth of frost penetration, the rate of thawing, the permeability of the soil, the drainage conditions, precipitation, and atmospheric humidity. The performance of highways with comparable subgrade in the vicinity of the installation may be of value as an indicator of the duration of the thaw-weakening period.

b. Heaving. Frost heave, manifested by raising the pavement surface, is directly associated with ice segregation and is visible evidence on the surface that ice lenses have formed in the subgrade or subbase base-course materials, or both. Uneven surfaces or abrupt grade changes may result from heave which may be uniform or nonuniform depending on variations in exposure to solar radiation or in the character of the soil and groundwater conditions underlying the pavement. If such conditions are noted by the evaluation team, or reported by flight or other personnel the location and description of the objectionable roughness will be included in the evaluation report.

c. Effect on pavement surface. The most obvious structural effect of frost action on the pavement surface is random cracking and roughness as the result of differential frost heave. After the spring frost-melting period, differential thawing may cause rigid pavements to develop cracks more rapidly than during the period of active heave. Debris from spalling of crack edges is a potential cause of Foreign Object Damage (FOD) to aircraft engines. The effect of thaw weakening of subgrades and base courses may be more severe than cracks caused by frost heave or low-temperature contraction because it leads to destruction of the pavement, requiring reconstruction. Its effect is felt through a process of greatly accelerated cumulative damage to the pavement under successive traffic loads. Eventually, the accumulation of damage leads to visible surface cracking. This cracking may become visible during frost-melting or at other times of the year. As a result, thaw weakening may not always be recognized as the dominant factor causing accelerated failure.

11–3. Potential for detrimental frost action.

a. General. The first step in evaluating pavement for frost conditions is to determine whether or not a frost problem exists. To determine if detrimental ice segregation and thaw weakening are likely to occur in the base course, subbase course, or subgrade, supplementary field and laboratory investigations will be made as specified in TM 5–818–2/AFM 88–6, Chap. 4, in addition to the basic investigations specified herein.

b. Procedures. The evidence of frost action may be obscured, or it may not be feasible to perform desirable field investigations during the freezing season or frost-melting period. Therefore, determination of whether or not frost evaluation criteria are applicable is usually based on the characteristics of the base course, subbase course and subgrade soils, groundwater conditions, and air temperature records. However, the evaluating agency will inspect the pavement during the frost-melting period if possible. Information will also be obtained from the agency that uses the pavement concerning pavement behavior during both the freezing season and the frost-melting period for as many years as possible.

(1) Visible surface effects associated with frost action include pavement heave and cracking during the freezing season and noticeable weakening or deflection during the frost-melting period. Pavements that are experiencing accelerated distress because of thaw weakening may also show alligator cracking or other load-associated cracking at an early age. Pumping may take place at cracks and joints. During pavement inspection, particular attention will be given to locations of transitions from cut to fill and at boundaries of subgrade soils of varying frost-susceptibility.

(2) Maintenance and traffic records of the airfields may help in confirming whether or not frost-susceptible conditions exist and in checking the assigned evaluation. Behavior records of highways in the vicinity that have subgrade conditions similar to those at the airfield may provide a clue as to whether weakening occurs as a result of frost melting. In the analysis of behavior records, the evaluator will carefully note and assess the many local influences that may affect frost action, such as variations in groundwater level, soil conditions, type of pavement surface, degree of shading, north versus south slope, frequency of snow plowing, position of underlying bedrock, etc.

(3) Detrimental frost action, including ice segregation and subsequent weakening during thawing, can occur only if all the following conditions prevail: the soil must be frost-susceptible, freezing temperatures must penetrate the frost-susceptible soil, and a source of water must be available.

11–4. Requirements for frost evaluations.

a. Conditions. Frost evaluation is required unless one or more of the following conditions exist.

(1) Climatic conditions are such that frost action is nonexistent or negligible.

(2) The combined thickness of pavement, non-frost-susceptible base and subbase meeting design requirements equals or exceeds the combined thickness that permits an allowable limited frost penetration into a susceptible subgrade in the design freezing index year.

(3) There is no source of water for ice segregation. In areas where freezing conditions are negligible or very light, minimum design requirements for airfield pavements are likely to prevent frost action for all pavement facilities; however, unless freezing conditions are negligible, it will be necessary to check the adequacy of frost protection for each pavement.

b. Determination of adequacy of pavement frost protection.

(1) The design air freezing index will be determined or interpolated from air temperature data

recorded close to the site. If such data are not available, an approximate freezing index may be obtained from a map in TM 5-818-2/AFM 88-6, Chap. 4 showing design air freezing indexes for locations in North America. Special consideration will be necessary to compensate for local topographic conditions that will cause deviations from general freezing index values shown on this map. Once the design air freezing index is determined, then, for each pavement, the thickness of base, *b*, necessary to hold subgrade frost penetration within allowable limits in the design freezing index year is determined.

(2) If the top 50 percent of the existing granular unbound base is not frost-susceptible, the lower 50 percent is either nonfrost-susceptible, S1 or S2, and the total base equals or exceeds either the value of *b* or 60 inches minus the pavement thickness, the pavement is adequately protected against detrimental frost action. Accordingly, the evaluation for the frost-melting period is equal to the normal-period evaluation and no further computations are necessary. If all the pavements being evaluated at an airfield are adequately protected against frost action, or if the airfield is located where frost is not a problem, a note to that effect will be placed in the valuation report instead of duplicating normal period evaluations for the pass intensity specified for evaluation during the frost-melting period.

(3) The combined thickness of pavement and base required to provide full frost protection or to allow only limited subgrade frost penetration is the same for all types of traffic areas for a given thickness of pavement. If the combined thickness of pavement and base for different pavement features are equal, but there is a difference in pavement thickness, the depth of frost penetration will vary, generally by a small amount.

(4) Information will be obtained on the actual performance of the pavement during previous freezing and thawing periods. If the pavement is new and no performance data are available, an analysis can be made of other airfield or highway pavements in the vicinity. A study of other pavements having equal depths of base materials of comparable quality will give a good indication of probable performance during the freezing and frost-melting periods of the pavement being evaluated.

(5) For any pavement not having adequate frost protection, a frost evaluation based upon reduced subgrade strength during the frost-melting period will be prepared and the evaluation report will also include an analysis of probable performance during freezing and thawing.

11-5. Frost evaluation procedures.

a. General. If a pavement is not adequately protected against detrimental frost action, the procedures described below will be used in making frost evaluations. If the frost evaluation gives an allowable load or pass level larger than the normal-period evaluation, the latter evaluation will be used for both conditions. The frost evaluation will be based on the reduced strength of the subgrade, using FAIR as described later. Such evaluation will be modified, as appropriate, based on pavement performance history. The allowable gross aircraft load is the load that may operate during the period of thaw weakening if flight operations are continued at the same frequency in effect during the remainder of the year. At the time of maximum heave, the surface roughness of pavement constructed over F4 subgrade soils, and in some instances over F3 soils, may be objectionable for aircraft with high landing and takeoff speeds. If this is the case, it should be indicated in the evaluation report, including the location and description of the objectionable roughness.

b. Rigid pavements. Where frost significantly penetrates frost-susceptible material beneath rigid pavements, i.e., when the combined thickness of portland cement concrete pavement, base, and subbase is less than either 60 inches or the required thickness for limited subgrade penetration, then frost evaluations are determined using the procedures and curves herein for nonfrost evaluation, and the FAIR determined from fig 11-1. The curves in figure 11-1 show the equivalent weighted average FAIR values for an annual cycle that includes a period of thaw weakening in relation to the thickness of base and subbase course. FAIR values are used as if they were moduli of reaction, *k*, and have the same units. The term modulus of reaction is not applied to the FAIR values because, being weighted average values for an annual cycle, FAIR values cannot be determined by a plate-bearing test. If the modulus of reaction, *k*, determined from tests on the equivalent base course and subgrade, but without frost melting, is numerically smaller than the FAIR value obtained from figure 11-1, the test value shall be used in the evaluation.

c. Overlay pavements.

(1) For flexible overlay on rigid base pavements, there are two evaluation methods: the nonrigid overlay method and the flexible pavement method. For the nonrigid overlay method, evaluations are based on the equivalent thickness of plain concrete, computed as described in chapter 7, using the appropriate FAIR value in the computation. If the flexible pavement method is used, the rigid base pavement is assumed to be a high quality nonfrost-susceptible base course, and evaluations will be determined using the flexible pavement criteria for frost in TM 5-826-2/AFM 88-24, Chap. 2. The higher evaluation will be reported.

(2) For rigid overlay on flexible base pavement, it is necessary to establish a value of the FAIR for the surface of the flexible pavement. The evaluation procedure will be to consider the flexible pavement

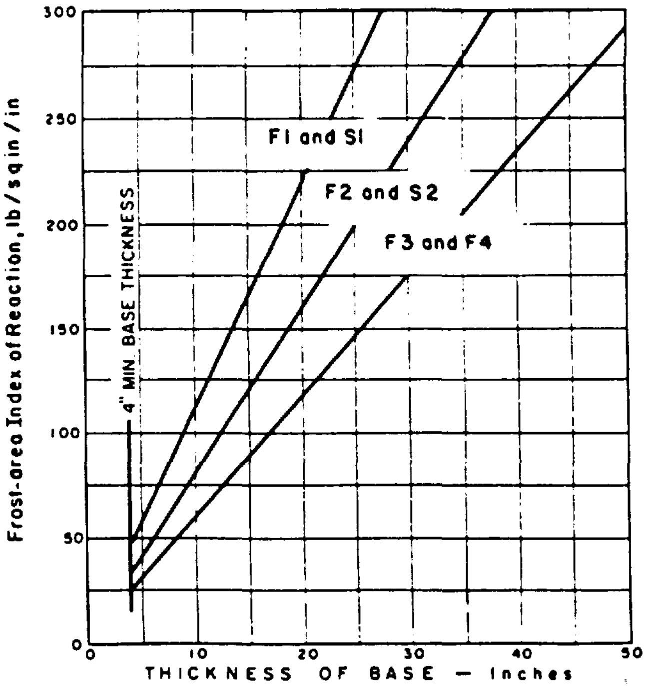


Figure 11-1. Frost-area index of reaction for rigid airfield pavements.

as a high quality nonfrost-susceptible base course and determine the FAIR from figure 11-1. If the value determined from figure 11-1 is larger than either a test value or an adopted normal-period value, the smaller value will be used in the evaluation.

d. Composite pavements. Composite or "sandwich" pavements consist of a rigid pavement placed on an existing nonrigid overlay that is on a rigid pavement. There are two evaluation methods for these pavements. The method used will depend on the thickness of the nonrigid layer as outlined in chapter 9. One method requires the determination of an equivalent thickness of jointed concrete pavement, and the other requires the establishment of a k value for the surface of the nonrigid layer. In both methods, frost evaluations will reflect the FAIR value determined as outlined above.

e. Reinforced rigid pavements. Frost evaluations will be based on the equivalent thickness of plain concrete pavements, computed as outlined in chapter 5, using the FAIR value in the equivalent thickness computation and in the evaluation procedure.

f. Example. Prepare frost condition evaluations for the following Air Force plain concrete pavement:

Aircraft group index: 13
Controlling aircraft: B-52H
Traffic area: Type B
Design freezing index: 3,000 degree-days
Pavement type: Plain concrete
Pavement thickness: 17 inches
Concrete flexural strength: 650 psi
Base-course material:
- Nonfrost-susceptible sandy gravel (GW)
- Average dry unit weight: 135 pounds per cubic foot
- Average water content after drainage: 5 percent

Base-course thickness: 17 inches
Subgrade material:
- Clay (CL)
- Plasticity index: 18
- Average water content: 25 percent

Highest groundwater: Subgrade surface
Subgrade classification: F3

Following the procedures given in TM 5-818-2/AFM 88-6, Chap. 4, the combined thickness of a 12-inch pavement and base *a* required for complete subgrade protection is 140 inches. Since this example is for a 17-inch pavement, 5 inches (17-12) must be added to the 140 inches to required 145 inches of pavement for complete protection. Therefore, the thickness of base *c* is 128 inches (145-17). The ratio of subgrade to base-course water content $r = 25/5 = 5$. By use of the maximum permissible *r* value of 2.0 applicable to traffic areas A and B, $b = 90$ inches and $s = 22.5$ inches. Since the existing base-course thickness is less than *b* and also less than 60 inches minus the pavement thickness, the pavement is not adequately protected against frost action, and evaluations for reduced subgrade strength operations are required. From figure 11-1, the FAIR for an F3 subgrade under 17 inches of nonfrost-susceptible base is 100. This value is used with the evaluation procedures in chapter 4 to determine the allowable gross weight. The FAIR value is used with figure 2-34 to determine a load factor. The load factor is then divided by the design factor from figure 2-50 to get the allowable gross weights as shown in the following tabulation.

Pass Intensity Level	*Allowable Gross Weight kips*
I (15,000)	320
II (3,000)	360
III (500)	425
IV (100)	505

CHAPTER 12

COMPUTER PROGRAMS FOR PAVEMENT EVALUATION

12-1. Development of computer programs.

Computer programs were developed to aid in the evaluation of military airfield pavements. The programs were developed on an IBM PC-AT using FORTRAN 77 as the development language with Microsoft's FORTRAN Compiler (version 3.2) and MS-DOS (version 3.1) as the operating system. Normally, the programs will be furnished as a compiled program which can be executed from floppy diskettes or hard drives. Thus far all the programs have been run on IBM PC-AT or IBM compatible microcomputers containing a minimum of 512K RAM.

12-2. Using the programs.

In developing the computer programs, an effort was made to provide a user friendly program requiring no external instructions for use of the programs. Aside from instructions for initiating execution, which is standard for any executable program, the user is lead through the design procedure by a series of questions and informational screens. The input data required for pavement evaluation by the program is identical to the data required by evaluation manuals, and the results obtained from the program should be close to the results obtained from the evaluation curves. Because the computer program recalculates data and approximates certain empirical data, there may be some minor differences in results from the program and from the manual. If significant difference are obtained contact CEMP-ET.

12-3. Program name.

The computer programs are date named i.e., the date of the revision is contained in the program name. The first digit of the number in the program name is the last digit of year of the revision. The last two digits of the program name is the month of the revision. Thus, the program RAD 810 was prepared in October 1988.

12-4. Obtaining the programs.

Floppy disks containing the current evaluation programs for rigid and flexible pavements may be obtained from CEMP-ET. Care should be taken so that the latest version of the computer programs is being used. If there is doubt about a program, contact CEMP-ET.

APPENDIX A

REFERENCES

Government Publications.

Department of Defense.

Military Standards

MIL-STD-620	Test Methods for Bituminous Paving Materials
MIL-STD-621	Test Method for Pavement Subgrade, Subbase, and Base Course Materials

Departments of the Army, the Navy, and the Air Force.

AFR 93-13	Air Force Pavement Evaluation Program
TM 5-818-2/AFM 88-6, Chap. 4	Pavement Evaluation for Frost Conditions
TM 5-822-4/AFM 88-7, Chap. 4	Soil Stabilization for Pavements
TM 5-824-1/AFM 88-6, Chap. 1	General Provisions for Airfield Pavement Design
TM 5-825-2/AFM 88-6, Chap. 2	Flexible Pavement Design for Airfields
TM 5-826-1/AFM 88-24, Chap. 1	Airfield Pavement Evaluation Concepts
TM 5-826-2/AFM 88-24, Chap. 2	Airfield Flexible Pavement Evaluation
TM 5-826-3/AFM 88-24, Chap. 3	Airfield Rigid Pavement Evaluation
TM 5-826-4	Army Airfield Heliports Pavement Reports
TM 5-826-6/AFR 93-5	Procedures for US Army and US Air Force Airfield Pavement Condition Surveys

Nongovernment Publications.

American Society for Testing and Materials (ASTM),
1916 Race Street, Philadelphia, PA 19103

C 39-86	Compressive Strengths of Cylindrical Concrete Specimens
C 42-87	Drilled Cores and Solid Beams of Concrete
C 78-84	Flexural Strength of Concrete
C 496-86	Splitting Tensile Strength of Cylindrical Concrete Specimens
C 642-82	Specific Gravity, Absorption, and Voids in Hardened Concrete
D 1635-87	Test Method for Flexural Strength of Soil Cement Using Simple Beam with Third Point Loading
D 2167-84	Density of Soil in Place by the Rubber-Balloon Method
D 2487-83	Classification of Soils for Engineering Purposes
D 2937-83	Density of Soil in Place by the Drive-Cylinder Method
D 4318-83	Liquid Limit, Plastic Limit, and Plasticity Index of Soils

American Concrete Institute (ACI)
PO Box 19150 Redford Station, Detroit, Michigan 48219
ACI 544.2R-78 (R-83) Measurement of Properties of Fiber Reinforced Concrete

APPENDIX B

REPORTING AIRCRAFT WEIGHT BEARING USING THE ACN/PCN PROCEDURE

B–1. General description.

a. The pavement classification number (PCN), is an index number representing the largest load on an established standard single wheel which could be permitted to use a particular pavement without special reservations. Likewise, the aircraft classification number (ACN), is an index number representing the load on the same established standard single wheel that is equivalent to an actual aircraft at a particular weight. The ACN therefore represents the equivalent loading an aircraft will apply to a pavement, whereas the PCN represents the equivalent loading a pavement can withstand. A comparison of these two values will indicate whether an airfield pavement can support a particular aircraft.

b. Reasonably unique relations have been developed between ACN or PCN and aircraft weight for any aircraft, for limited ranges of subgrade strength, and for pavement types. The ACN/PCN method establishes four subgrade strength categories for each of two pavement types—flexible and rigid. Any individual pavement will have individual characteristics which place it in only one of the subgrade and pavement type categories.

c The establishment of a PCN for a particular pavement will require relations between PCN and aircraft weight for pertinent use aircraft and for the applicable pavement type and subgrade strength category. These have been determined using established procedures and standard parameters of the ACN/PCN method, and are shown in figures B-1 to B-8.

d. Determination of the PCN for reporting weight bearing capacities of pavements proceeds from the results of the pavement evaluation. The evaluation should determine the maximum allowable load of the most critical aircraft that can use the pavement for the number of equivalent passes expected to be applied for the remaining life as determined using procedures shown in appendix C. Use of this maximum weight with figures B-1 to B-8 will allow the determination of the numerical PCN value. The evaluation should also provide sufficient information to permit selection of the pavement type and subgrade strength category. The PCN value for Air Force pavements will be based upon 50,000 passes of group 9 aircraft.

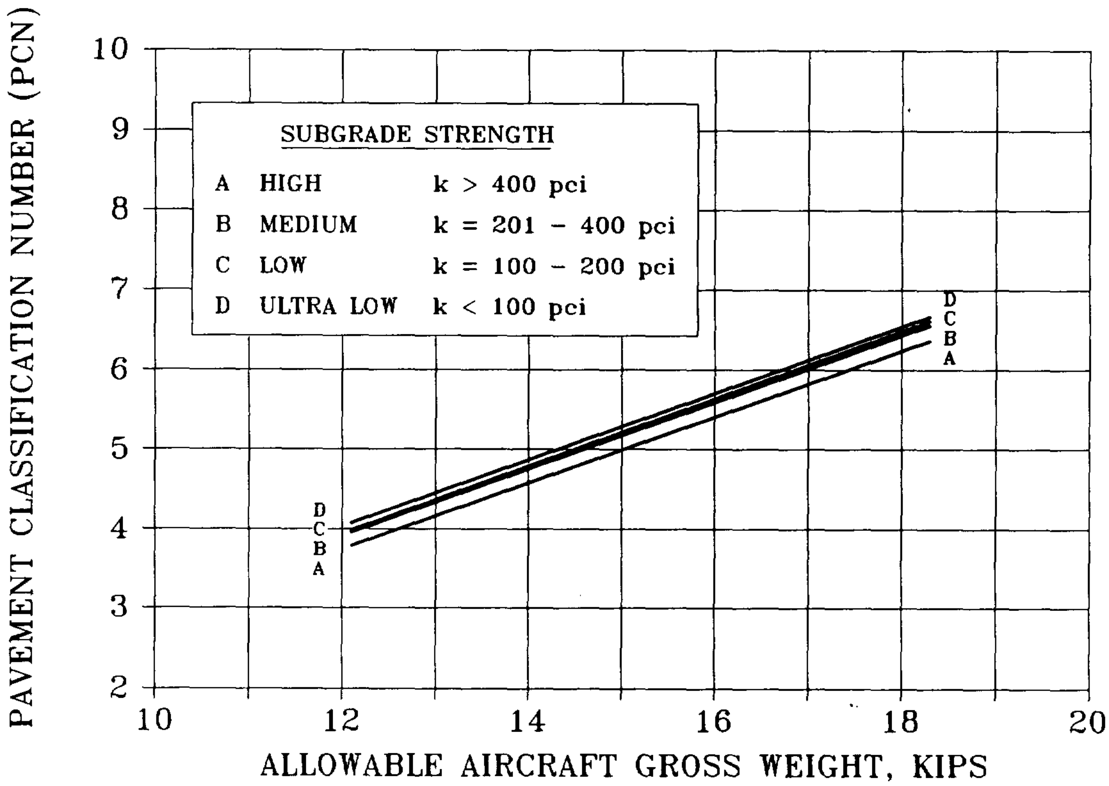


Figure B-1. PCN for Army Class I airfield.

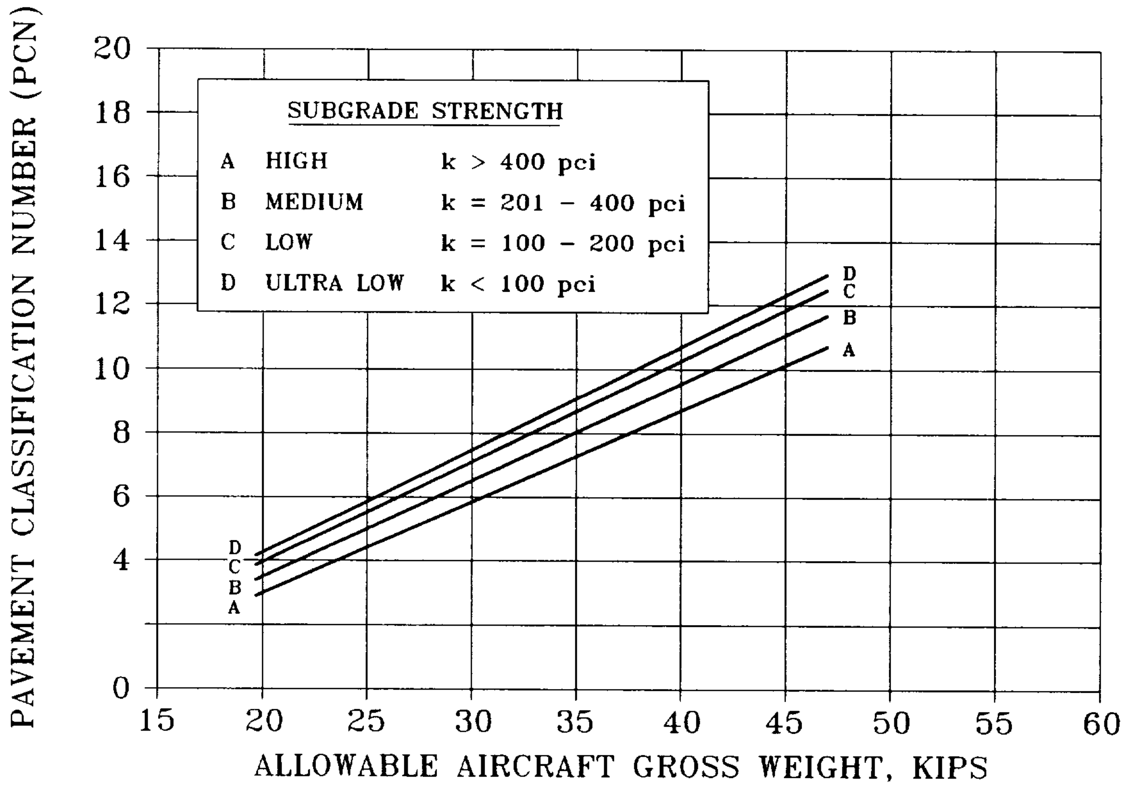


Figure B-2. PCN for Army Class II airfield.

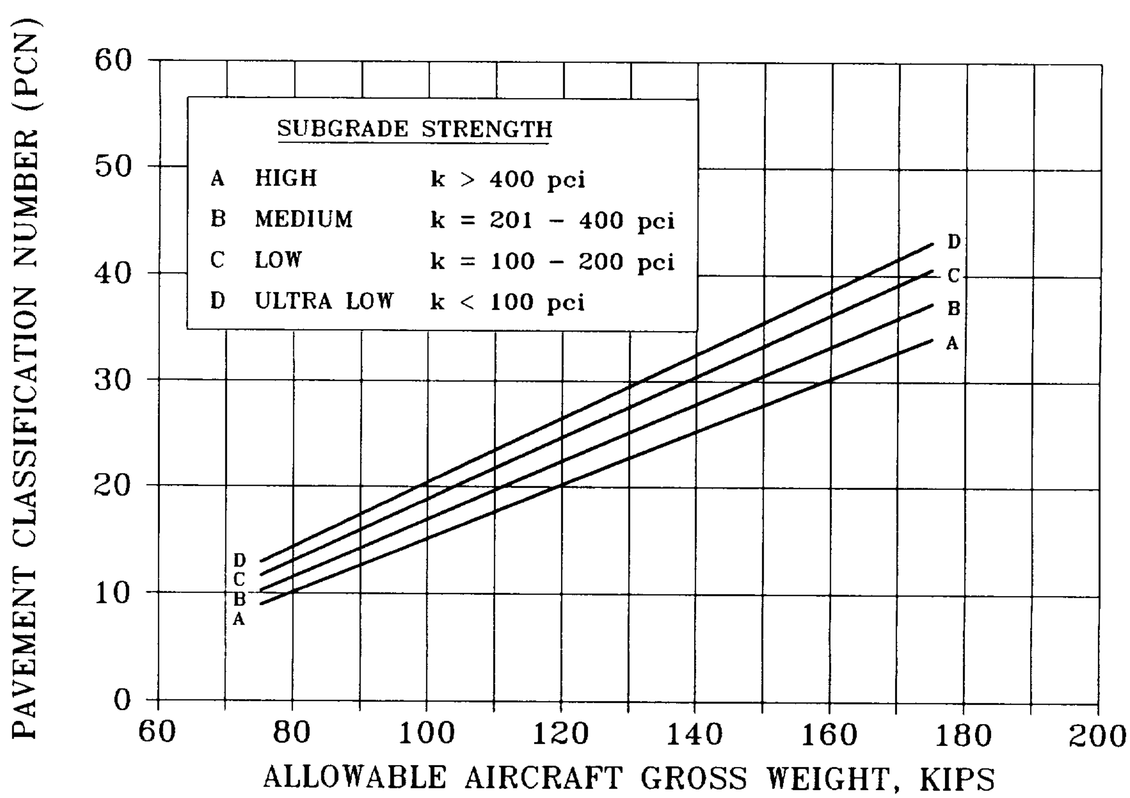


Figure B-3. PCN for Army Class III airfield.

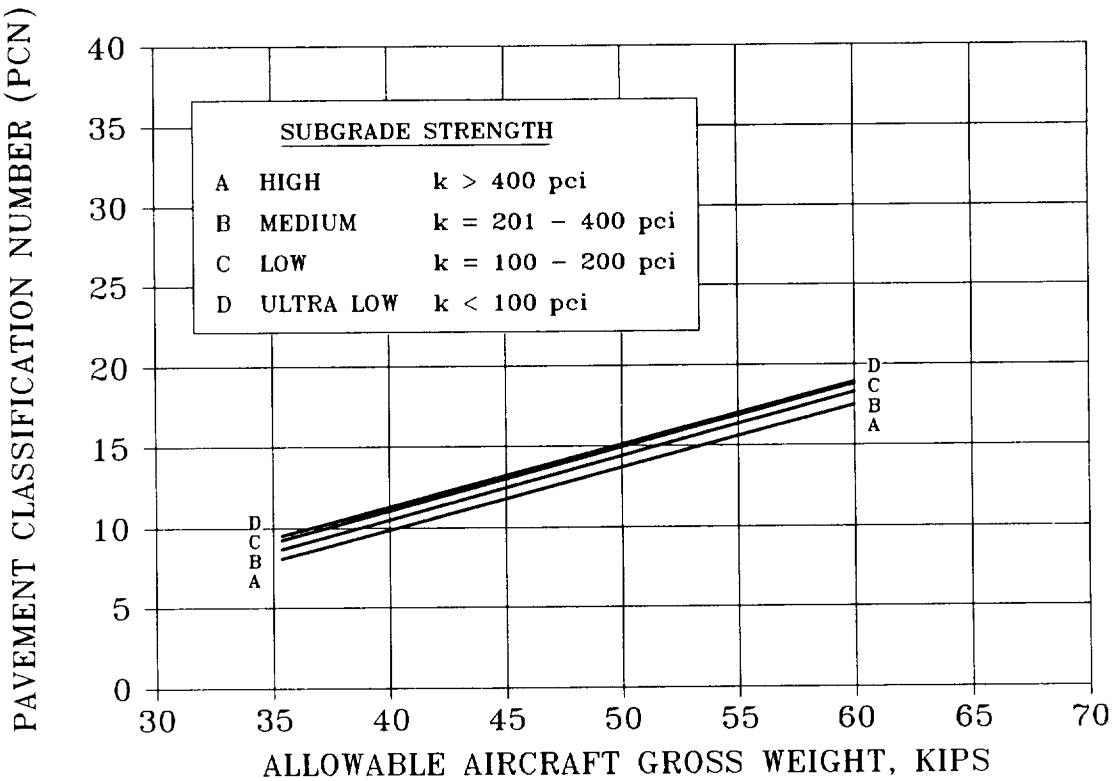


Figure B-4. PCN for Army Class IV airfield (C-123).

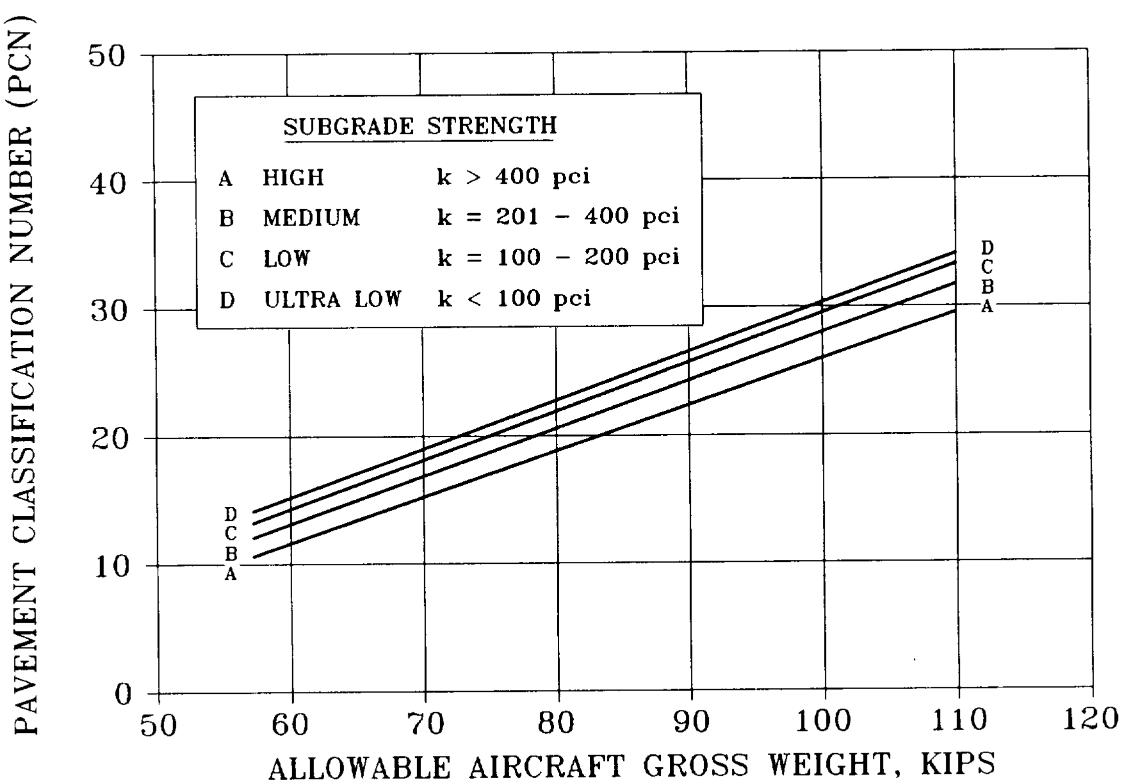


Figure B-5. PCN for Army Class IV airfield (C-9).

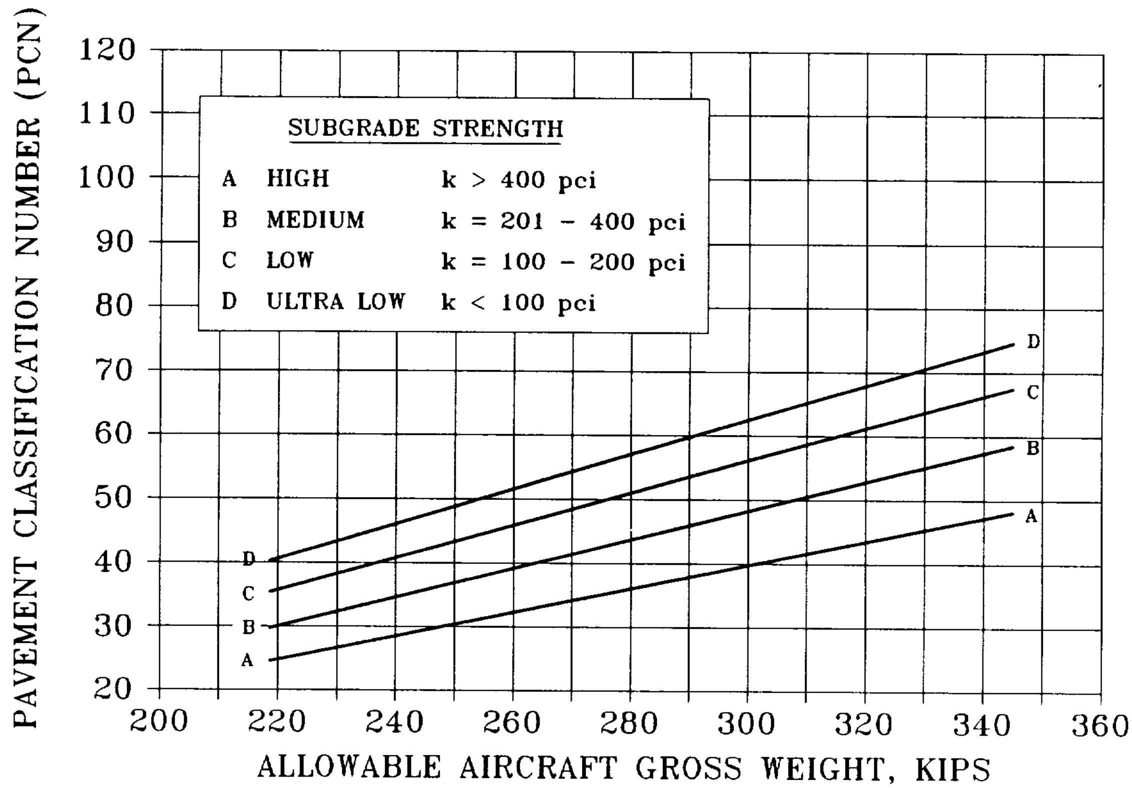


Figure B-6. PCN for Army Class IV airfield (C-141).

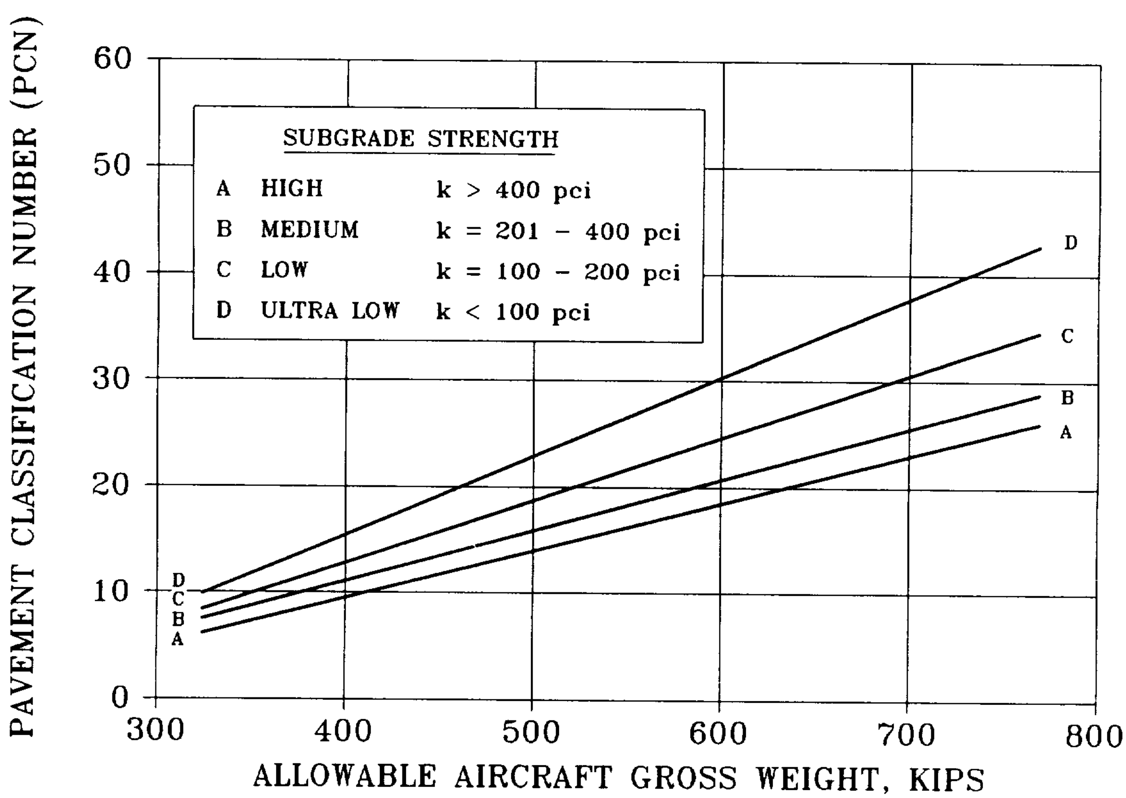


Figure B-7. PCN for Army Class IV airfield (C-5A).

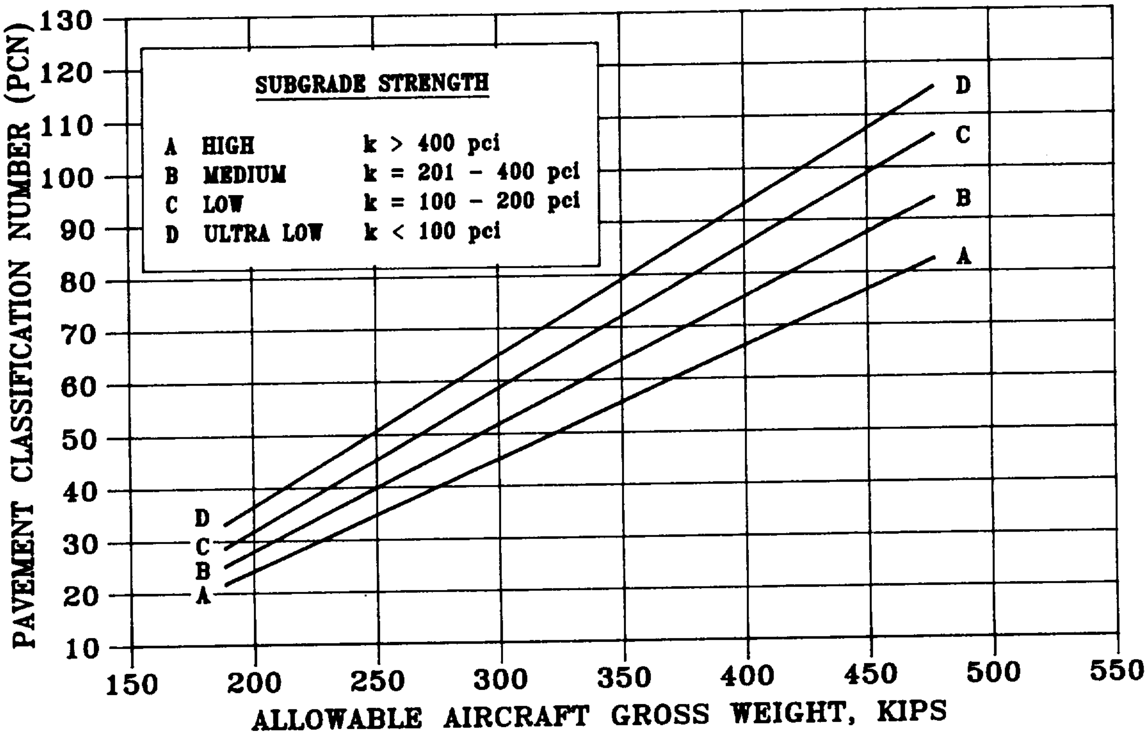


Figure B-8. PCN for all Air Force airfields (Group 9).

B–2. PCN Determination

a. To proceed with PCN determination, it is first necessary to establish the pavement type and subgrade strength category. The pavement type is selected as either rigid (Code R) or flexible (Code F). If the pavement is of portland cement concrete (PCC) or has PCC as a primary structural element and is neither unusually thin (4 in. or less) or completely shattered, it should be considered as a rigid pavement. Virtually, all other pavement should be considered to be flexible.

b. Subgrade strength category should be determined from the following tabulation using characteristics of the pavement being rated.

Subgrade Strength Category

		Upper Limit		*Lower Limit*		*Characteristic Value*	
Code	*Rating*	*K**	*CBR*	*K**	*CBR*	*K**	*CBR*
A	High strength	. . .	. . .	400	13	500	15
B	Medium strength	400	13	200	8	300	10
C	Low strength	200	8	100	4	150	6
D	Ultra-low strength	100	4	. . .	. . .	75	3

*K in pounds per cubic inch.

c. For Army airfield, it will next be necessary to determine the largest loading for the most critical aircraft which can be allowed to use the airfield for the remaining life. This can be selected from the "field evaluation" information or from information assembled for estimate of future life of pavements. The field evaluation will indicate the primary-use pavements and the controlling evaluating in terms of allowable passes for various gross weights of critical aircraft. The analysis of traffic and future life of pavements will indicate the percentage of life used which has been contributed by various using aircraft. This analysis then calculates the equivalent number of passes of the most critical aircraft that is expected to use the pavement for its remaining life. The loading on the critical aircraft used to determine the equivalent passes is that to be used to select the PCN. Normally, the C–130 or C–141 at some gross weight will be the critical aircraft. However, for limited capacity airfields, some other aircraft may be critical. It should be noted that an airfield pavement limited to aircraft weighing less than 12,500 pounds, the PCN is not applied and weight bearing limits are reported directly in terms of maximum allowable gross weight of aircraft.

d. For Air Force airfields, it will be necessary to determine the maximum allowable gross weight for the group 9, using the evaluation criteria in this manual.

e. As an example of the selection of a limiting weight of critical aircraft for PCN determination at an Army airfield, consider the example of appendix C in which cumulative past traffic over a 10-year period has used 56.50 percent of the pavement life. If past traffic has been accumulated over a period which represents a reasonable 20-year pavement life, the existing pattern of traffic application is acceptable, and no significant increase or reduction in anticipated traffic needs to be considered. The heaviest aircraft routinely using the airfield is the C–130 at 135–155 kips and could be the basis for determining the PCN. The C–5 and C–141 are larger aircraft but operate at a low traffic level. If, however, the military mission of the airfield should dictate the ready accommodation of C–141 or C–5 traffic, it may be desirable to base the PCN on those aircraft.

f. When the critical aircraft (or Class) and limiting weight have been established for Army airfield and the limiting weight of the C–141 has been established for Air Force airfields, the pertinent relation between gross weight and PCN must be attained (for the proper pavement type and subgrade class). As earlier mentioned, the gross weight versus PCN relations can be computed using the standard methods or can be obtained from figures B–1 to B–8, or from aircraft manufacturers or the International Civil Aviation Organization (ICAO). By entering the proper gross weight/PCN relation with the limiting weight of the critical aircraft, the limiting PCN can be determined.

B–3. Tire pressure limitation.

An aspect of ACN/PCN reporting is the limitation of tire pressure through application of categories for reporting in accordance with the following tabulation.

Tire Pressure Category

		Pressure Limited to:	
Code	*Rating*	*PSI*	*(MPa)*
W	High	No limit	
X	Medium	217	(1.50)
Y	Low	145	(1.00)
Z	Very low	73	(0.50)

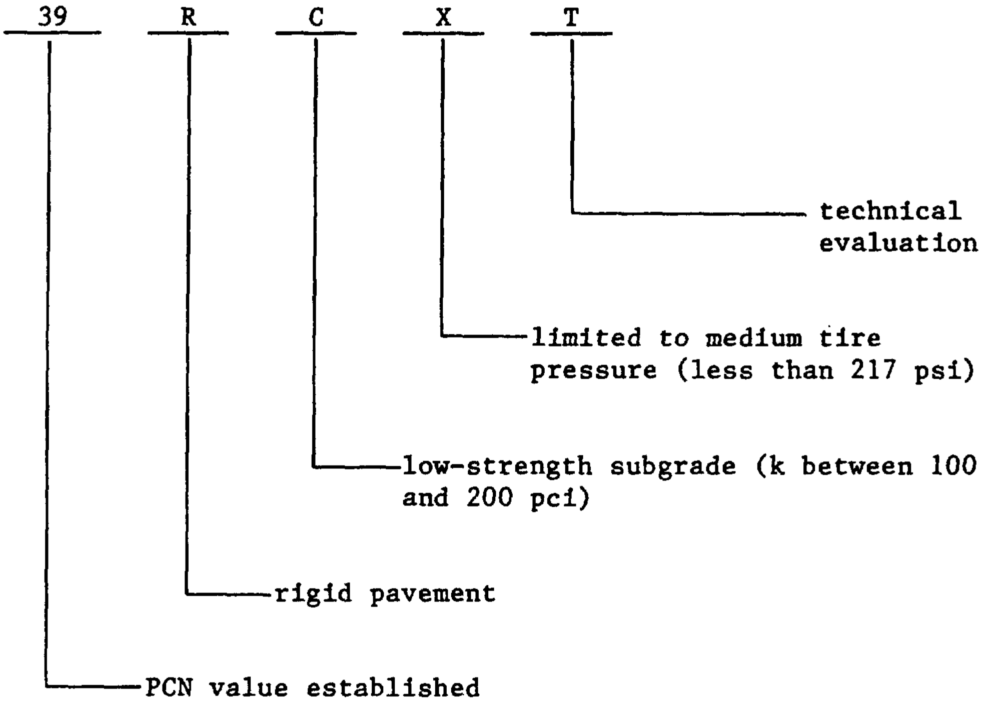
Rigid or rigid overlay pavement can sustain the high (W) category except where the rigid layer is very thin (less than 4 in.) or is thoroughly shattered (pieces less than about 2 ft wide).

B–4. Evaluation method.

The ACN/PCN system also requires a reporting of the general basis of evaluation. Code T will indicate a technical evaluation of the type prescribed in Technical Manual series TM 5-826-1/AFM 88-24, Chap. 1, TM 5-826-2/AFM 88-24, Chap. 2, TM 5-826-3/AFM 88-24, Chap. 3, and TM 5-826-4. Thus, any evaluation following these manuals will be reported as a technical evaluation (T). Where the reported PCN must be based only on knowledge of the heaviest aircraft using a facility, and without a specific evaluation, it will be reported as a "using aircraft" evaluation (Code U).

B–5. Coded Reporting in FLIP or AIP Documents.

The coding permits a greatly abbreviated reporting of the PCN and related information for use in FLIP– (Flight Information Publication) or AIP– (Airfield Information Publication) type documents as used by the Defense Department (DMA) or the civil (FAA) and international (ICAO) communities. Following is an example of coded reporting with explanatory notes.



APPENDIX C

A METHOD FOR ESTIMATING THE LIFE OF AIRFIELD RIGID PAVEMENTS

C-1. Purpose and considerations.

a. This appendix presents a method for estimating the life of rigid airfield pavements. The method presented herein is applicable for plain rigid, reinforced rigid, rigid overlay of rigid, nonrigid overlay of rigid, and rigid overlay of flexible pavements.

b. The method for estimating pavement life is applicable for any type of aircraft traffic; however, the accuracy of the results is only as good as the data used in the analysis. Since it is difficult to define exact traffic conditions, and since strengths of the pavement and foundation materials are variable, the method is an estimation of the pavement life. In view of the above, the method is to be used as a guide to anticipate life for proposed aircraft missions.

c. The method for estimating pavement life has been developed from theoretical concepts and from the results of investigations performed for evaluation criteria. The basic concept of the method is that any rigid pavement will withstand a certain number of stress repetitions before it cracks. The number of stress repetitions is dependent upon the magnitude of stress which in turn is dependent primarily upon such factors as magnitude of load, aircraft gear and configuration, distribution of traffic, strength of pavement, and strength of foundation materials.

d. The method of estimating pavement life essentially is to estimate the number of operations (passes) that have been applied on the pavements by all past using aircraft, determine the number of passes that the pavements are capable of sustaining for each aircraft if the pavements are new, express the ratio of passes of past aircraft usage to passes of a new pavement as a percentage of pavement life used, and know the specific aircraft or mixture of aircraft that will use the pavements in the future in order to estimate the predicted pavement life in terms of aircraft passes. By estimating the intensity of future traffic with respect to time (month, day, and year), the life of the pavement in terms of time can also be estimated.

e. The useful life of a rigid pavement depends, to a very large extent, upon how much effective maintenance can be performed. The individual slabs of a rigid pavement develop cracking under traffic, and, in pavement design, this condition is commonly referred to as failure. However, the pavement, although cracked, can still carry loads safely provided the cracks are maintained. As traffic is continued on the pavement, further cracking will develop, requiring increased maintenance. Investigations have shown that there is little danger of complete failure, that is, an aircraft gear punching through the pavement, until the slabs have cracked into relatively small segments of about 15 to 20 square feet in area. Maintenance of pavements, however, becomes rather heavy after the slabs have cracked into about six pieces per slab, and beyond this point there is some danger of vertical displacement of the broken pieces, especially on weaker foundations.

C-2. Method for estimating pavement life.

a. Procedure. The method described below is designed for estimating the remaining pavement life. Knowing the specific aircraft and loading or mixture of aircraft and loading that will be using the pavements in the future, an estimate of the number of passes necessary for the pavements to reach a failure condition can be made. In estimating the pavement life, there are essentially four steps to be followed.

Step 1. Estimate the number of passes that have been applied to the pavements from past aircraft usage. In order to do this, traffic records are required. From the traffic records, estimate the number of passes and loading of each type of aircraft that has used the various pavement facilities. Traffic records, which list the number of landings and takeoffs for each runway, are satisfactory for estimating the number of passes on the runway, main taxiways, and apron system. For other pavement facilities such as alert aprons and washracks, records showing the number of aircraft on the pavement must be used in determining the number of passes.

Step 2. Determine the allowable number of passes that the pavement can withstand. The properties of the pavement and foundation required are thickness of the concrete, flexural strength of the concrete, and modulus of subgrade or base course reaction. Based on these data, the allowable passes for each aircraft at the indicated weight can be determined using the evaluation criteria herein.

Step 3. Determine the ratio of passes of past aircraft usage to allowable passes. This ratio is expressed as a percentage of used life.

Step 4. The final step in the analysis, that is, making an estimation of the predicted life or usage of the pavements under future aircraft traffic, can be done for a specific aircraft and loading or a mixture of aircraft and loadings. An iterative process will be required to predict a mixture of aircraft loadings.

b. *Example.* An estimation of the pavement life used on a taxiway by past aircraft usage and the available life remaining for future aircraft traffic is to be made. Properties of the pavement and foundation for this example are a plain concrete taxiway having a thickness of 12 inches, a concrete flexural strength of 700 psi, and a modulus of subgrade reaction of 50 pci (columns 1 thru 9, table C–1).

Step 1. The pavement identification and properties of the concrete and subgrade are listed in columns 1 through 5.

Step 2. A study of past traffic records shows that the aircraft listed in column 6 have used the taxiway at the gross weight indicated in column 7. The total number of passes of each aircraft are listed in column 8.

Step 3. Entering the appropriate evaluation curves (figs 1–4 thru 1–19, main text) with properties stated (columns 1 thru 5), along with figures 1–20 and 1-21 of the main text, the allowable passes are obtained. These values are indicated in column 9.

Step 4. Dividing the actual passes (column 8) by the allowable passes (column 9) and multiplying by 100 gives the percent pavement life used. As noted in this example, the smaller aircraft and the lighter

Table C–1. Example of pavement life estimation

Pavement Facility (1)	Pavement Type (2)	Pavement Thickness (h) in. (3)	Flexural Strength (R) psi (4)	Subgrade Modulus (k) psi (5)
Taxiway	Plain Rigid	12	700	50

Using Aircraft Past Traffic (6)	Gross Aircraft Weight Kips (7)	Passes of Aircraft that Have Used Pavement (8)	Allowable Passes for Standard Evaluation (9)	Percent Life Used (10)
OV-1	11	125,000	$>10^6$	0
C-123	40	64,000	$>10^6$	0
C-130	100	30,000	$>10^6$	0
C-130	110	15,000	$>10^6$	0
C-130	135	6,800	200,000	3.4
C-130	155	4,200	26,750	15.7
C-9	100	1,100	11,450	11.4
C-54	650	300	2,830	10.6
C-141	300	40	260	15.4
				$\Sigma = 56.5$

loaded aircraft have very little effect on the life of the pavement that has been used. A summation of the pavement life used indicates that approximately 56.5 percent of the pavement life has been used by past aircraft traffic giving a remaining life of approximately 43.5 percent.

Step 5. At this point, it is necessary to know the future mission for the pavements. Assume for this example that C–5A aircraft at a gross weight of 700,000 pounds will be required to use the pavements, and an estimation of the predicted life of the pavements in terms of passes is required. Using figures 2–31 and 2–47, the allowable number of passes is determined to be 1,135. The past traffic has used up 56.5 percent of the pavement life leaving 43.5 percent. Multiplying the 1,135 passes by the 43.5 percent indicates that the pavements can sustain approximately 495 passes of the C–5A aircraft traffic at a gross weight of 700,000 pounds. If a mission of mixed aircraft traffic is desired, an iterative process must be used to determine how the remaining 43.5 percent life of the pavements will be used.

c. Limitations of this method. After working through the analysis of pavement life estimation, it can be seen that it is only as accurate as the information used in the analysis. In addition, many other variables which can affect pavement life that have not been taken into account in the analysis include such things as temperature stresses, variations in load transfer at joints, weathering of the concrete, distress due to frost action, and abnormal physical properties of both the concrete and subgrade materials. These variables can either reduce or increase the pavement life determined by this analysis. These limitations show why the method is only an estimation of pavement life. However, it does afford some guide to indicate the maintenance work that can be anticipated, the need for an overlay, or to illustrate the effects of traffic on the pavements.

APPENDIX D
TESTS REQUIRED WHEN CONSTRUCTION DATA NOT AVAILABLE

D–1. General.

When construction data are not available, certain tests must be performed before an evaluation can be made. All of the tests described in this appendix may not be required for each of the six types of pavements described in paragraph 1–2 of this manual. Chapter 3 of this manual lists the tests that are necessary to evaluate each particular type of pavement. Sampling and testing are discussed in detail or referenced in appendix E.

D–2. Selection and size of test areas.

One of the first steps in the selection of test locations should be the preparation of longitudinal profiles along the runways, taxiways, and aprons in order to develop a general picture of subgrade, base, and pavement condition, so test pits for collecting more detailed data can be located to the best possible advantage. Data for these profiles can be obtained by coring small (4- or 6-inch-diameter) holes in the pavement, through which thickness measurements can be made and samples of the foundation materials obtained. These samples should be classified in accordance with the Unified Soil Classification System as presented in ASTM D 2487. Usually, a spacing of 500 to 1,000 feet between these small holes will be sufficient, but occasionally when nonuniformity of pavement of foundation conditions exists, closer spacings may be necessary. From the information obtained, the pavements should be divided into features on the basis of pavement type, construction history, known strength, thicknesses, and foundation types.

a. These preliminary tests should enable test pits to be placed in locations representing typical pavement and foundation conditions. In addition, the test pits should be placed in areas that received intense traffic; that is, at or near the centers of runways, taxiways, or aprons instead of along the edge of the pavement.

b. If pavement and foundation conditions are uniform throughout the airfield area, a nominal number of test pits (5 or 6) will generally be sufficient if they are located so as to provide representative information for the entire system of airfield pavements. When the pavement or foundation conditions are not uniform, test pits should be located so as to yield the necessary information for each type of pavement or foundation material. When failed areas or areas of excessive pavement distress are encountered, a sufficient number of test pits must be located in the failed or distressed areas to determine the cause of the failure or distress.

c. The size of the test pits will, in part, depend on the thickness of the pavement. Inasmuch as beams for flexural strength tests must be cut from the concrete specimen removed from the slab, the length of the specimen must be greater than three times the pavement thickness, except when 6- by 6-inch beams are cut from the top and bottom of the slab as discussed in this appendix. Since plate-bearing tests on the foundation materials will require the use of a 30-inch-diameter plate, test pits will be 4 feet by 5 feet to allow access to the foundation materials for testing and sampling. Tensile splitting tests are acceptable for computing flexural strengths and will require 6-inch diameter core samples. A correlation between tensile splitting strength and flexural strength is included in appendix E.

D–3. In-place testing.

a. Thickness measurements. The thickness of the pavement should be measured to the nearest 1/4 inch at each core hole and test pit. For overlay pavements, the thickness of each layer of pavement must be obtained (i.e., for a rigid overlay on an existing rigid pavement, the thickness of both the overlay and existing pavement must be measured).

b. Pavement tests.

(1) *Rigid pavement.* No in-place tests are required other than the thickness measurements. Nondestructive tests have been developed for determining certain physical properties of rigid pavements in place; however, no nondestructive tests have been found as yet that will satisfactorily replace all the required laboratory and beam tests. Some of these developmental-stage non-destructive tests can be used in determining the uniformity of pavement quality (app E).

(2) *All-bituminous overlays.* No in-place tests are required on all-bituminous concrete overlays on existing rigid pavements unless the bituminous concrete forms a layer more than 4 inches thick between two rigid pavements. In this case, a plate-bearing test is required on the surface of the bituminous concrete.

(3) *Flexible overlays.* When the overlay on an existing rigid pavement is of the flexible type (bituminous concrete and base course), in-place CBR and density tests will be performed on the base-course material as required for base-course material in the evaluation of flexible pavements (TM 5–826–2/AFM 88–24, Chap. 2). No in-place tests need to be made on the bituminous concrete portion of the flexible overlay. If the flexible overlay forms a layer between two rigid pavements, the only in-place test

required for the flexible is a plate-bearing test on the surface of the flexible overlay.

c. Foundation tests.

(1) *Plate-bearing tests.*

(a) The modulus of subgrade or base-course reaction k will be determined by the plate-bearing test as described in appendix D if at all possible. As a last resort, k can be determined by taking CBR readings on the subgrade in 6-inch core holes (small aperture procedure) and determining the k value from the curve in figure 2-18. The test should normally be conducted on the surface of the material immediately beneath the pavement, that is, on the base course or on the subgrade if there is no base course. Figure 8-1 shows the relationship between the thickness of base or subbase and the effective k of the base or subbase. With subgrades or base courses that have been modified, the k value will be determined from figure 2-18 as previously noted. Subgrade or base-course materials that have been stabilized to the extent that they qualify as stabilized layers as outlined in TM 5-822-4/AFM 88-7, Chap. 4, require tests other than plate bearing to determine their effect on the supporting value of the pavement structure.

(b) When an evaluation is being made of a rigid overlay on a flexible pavement, the plate-bearing test will be performed on the surface of the flexible pavement, since the flexible pavement is considered to be a base course. When a composite pavement is being evaluated, the plate-bearing test will be performed on the surface of the nonrigid portion (bituminous concrete or flexible overlay) of the pavement provided the nonrigid portion of the pavement is 4 inches or more in thickness. In this case, the rigid base pavement and the nonrigid overlay pavement are considered to be base-course materials. When the plate-bearing test is performed on the surface of a flexible pavement or nonrigid-type overlay, both the test and k values are subject to certain limitations as discussed in chapter 3.

(2) *Field in-place CBR tests.* To evaluate a nonrigid overlay on rigid pavement, field in-place CBR tests may be required on the foundation materials in addition to plate-bearing tests. When the k value of the foundation material is greater than 200 pci or the concrete flexural strength is less than 400 psi, a higher load-carrying capacity may be obtained for the nonrigid overlay on rigid pavement by using the flexible pavement evaluation procedure and assuming the rigid pavement to be a high-quality base-course material. When either of these conditions prevail, in-place CBR tests should be conducted on the foundation materials in addition to the plate-bearing tests. The in-place CBR tests must be conducted on both the base-course materials (if any) and on the subgrade in the same manner as in tests for the evaluation of flexible pavements described in TM 5-826-2/AFM 88-24, Chap. 2.

(3) *Field density tests.* Density tests must be made on the base-course and subgrade materials. If the base course or subgrade is composed of granular materials, the most satisfactory methods of obtaining the density are by the sand-displacement or balloon methods, which are described in MIL-STD-621 and ASTM D 2167, respectively. If the subgrade is composed of a fine-grained cohesive material, the density can be best obtained either by drive-sampling or balloon methods described in this appendix or by the undisturbed sampling that may be required in connection with the plate-bearing test. The nuclear density meter may also be used to determine densities, but special care must be taken because of the influence of the sides of the test pits on test results. All field density tests should be conducted adjacent to the area that was loaded during the plate-bearing test. When the overlay portion of a nonrigid overlay on rigid pavement is composed of a bituminous concrete and base course, density tests should be made on the base-course portion of the overlay.

D-4. Sampling.

Samples of the pavement, base course, and subgrade materials are required for laboratory testing; the size of the samples depends on the type of laboratory tests to be made.

a. Rigid pavement. All concrete cores obtained during the preliminary testing and all test specimens cut from the test pits should be retained for laboratory tests. The specimens should be slightly more than three times as long and three times as wide as the pavement thickness, except when 6- by 6-inch beams are cut from the top and bottom of the specimens for three point load beam tests.

b. All-bituminous concrete and flexible overlays. Sampling of the bituminous concrete and base-course material in all-bituminous concrete and flexible overlays will be performed as described for the pavement and base courses of flexible pavements in TM 5-826-2/AFM 88-24, Chap. 2. An exception is made when the all-bituminous concrete or flexible overlay exists between two thicknesses of rigid pavement (composite pavement). In this case, only one or two chunk samples of the bituminous concrete are needed from each test pit, since the only test necessary on the bituminous concrete portion of the overlay is an extraction test to determine the gradation of the aggregate and the bitumen content. Likewise, it will only be necessary to obtain a large enough sample of the base-course portion of the flexible overlay for a gradation test.

c. Base and subbase courses. Bag samples of base and subbase courses underlying rigid pavements will be required for classification and compaction tests. The size of the sample will depend on the amount of large aggregate in the base course. In general, a 200-pound sample is sufficient. However, if laboratory CBR tests are necessary, which may be the case in the evaluation of a nonrigid overlay on rigid pavements, the size of the base course sample should be increased to about 600 pounds.

d. Subgrade. Bag samples and undisturbed samples of the subgrade may be required. If the subgrade is composed of a fine-grained material, a 100-pound bag sample will be sufficient; if the subgrade is composed of a granular material, a 200-pound bag sample should be obtained. However, if laboratory CBR tests are required, which may be the case in the evaluation of a nonrigid overlay on rigid pavements, the bag samples of subgrade material should be increased to 450 and 600 pounds for fine-grained and granular materials, respectively.

D-5. Laboratory tests.

Laboratory tests are necessary to classify the various pavement materials and establish their strength characteristics. These tests are outlined in the following subparagraphs and the test methods are presented in appendix E.

a. Rigid pavement. Normally, samples of the rigid pavement should be used to determine the flexural strength or splitting-tensile strength of cores. Also, samples of the concrete should be visually examined to determine the type of aggregate and to estimate the maximum size of aggregate. For reinforced rigid pavement, the diameter and spacing of both the longitudinal and transverse bars or wires will be ascertained.

b. Nonrigid overlays. The samples of nonrigid overlay (bituminous concrete) and base course will be tested and classified as specified in TM 5-826-2/AFM 88-24, Chap. 2. When the nonrigid overlay is between two thicknesses of rigid pavement, the only tests required are those to establish the gradation and bitumen content of the bituminous concrete and the gradation of the base course material, if any.

c. Base course. Samples of the base-course material underlying a pavement will be subjected to classification tests, including mechanical analysis, Atterberg limits, and specific gravity tests. The moisture-density relation in the base course should also be ascertained. For the evaluation of nonrigid overlays on rigid pavements, moisture-density-CBR relations, similar to those required for base courses in the evaluation of flexible pavement and described in TM 5-826-2/AFM 88-24, Chap. 2, may be required.

d. Subgrade. Samples of the subgrade material will be subjected to mechanical analysis, Atterberg limits, moisture-content, and specific gravity tests. The moisture-density relation should be established, and for the evaluation of a nonrigid overlay on rigid pavements, the moisture-density-CBR relation may be required. Undisturbed samples of the subgrade will be subjected to an adaptation of the consolidation test to determine the correction for saturation of the plate-bearing test results. The undisturbed samples may also be used for density determinations. For the evaluation of a nonrigid overlay on rigid pavement, soaked laboratory CBR tests on undisturbed samples of the subgrade material may be required.

APPENDIX E

SAMPLING AND TESTING METHODS

E–1. Introduction.

The following tabulation lists the sampling and testing methods normally performed in evaluating the various types of pavements discussed in this manual. Since many of them are standard, published methods, the publication in which each standard method may be found is also listed. Some of the methods used are not presented in available publications or are modified for evaluation purposes and therefore are described in subsequent paragraphs.

Sampling or Tested Method	*Publication*
Foundation	
Soils sampling	Described in paragraph E-2
Plate-bearing tests	MIL–STD–621
Compaction tests	MIL–STD–621
Classification tests	ASTM D 2487
Liquid and plastic limits of soils	ASTM D 4318
In-place CBR	MIL–STD–621
Moisture-density-CBR relation	MIL–STD–621
In-place density-balloon method	ASTM D–2167
In-place density-drive cylinder method	ASTM D 2937
In-place density-sand displacement method	MIL–STD–621
Rigid Pavement	
Sampling and preparation of test specimens	ASTM C 42
Flexural strength of concrete	ASTM C 78 modified as described in paragraph E–5
Compressive strength tests	ASTM C 39
Splitting tensile strength tests	ASTM C 496
Specific gravity of concrete	ASTM C 642
Absorption by concrete	ASTM C 642
Voids in concrete	ASTM C 642
Flexural strength of soil-cement	ASTM D 1635
Nonrigid Overlay	
Bituminous concrete	TM 5–826–2/AFM 88–24, Chap. 2
Flexible overlay (base and subbase course)	TM 5–826–2/AFM 88–24, Chap. 2

E–2. Soils sampling.

a. Disturbed sampling. Two types of disturbed sampling will normally be required during an airfield pavement evaluation.

(1) Samples of the foundation materials will be needed for developing soil profiles, and the most suitable method of obtaining these samples is by auger borings. These borings can be made into the foundation materials to the desired depth either in test pits or through small 4- or 6-inch-diameter holes cored through the pavement. Samples of the foundation materials should be taken for each 6-inch vertical increment to a depth of 2 feet and for each 12-each increment thereafter to the desired depth. Additional samples should be taken whenever there is a change in materials or moisture conditions. The samples should be sealed in jars and clearly marked before transportation to the laboratory, where they will be subjected to classification tests and moisture-content determinations.

(2) Samples of the foundation materials will also be required for compaction tests. Normally, these will be bag samples obtained from test pits. Samples of each type of material encountered should be obtained. The size of the bag samples required will depend on the type of material and the type of test to be performed. Generally, if the material is fine grained, a 100-pound sample will be sufficient for the moisture-density determination; when the moisture-density-CBR relations are to be developed, a 450-pound sample should be obtained. If the material is granular, the size of the sample should be increased to 200 pounds for the moisture-density tests and 600 pounds for the moisture-density-CBR tests.

b. Undisturbed sampling. If the subgrade is composed of a fine-grained cohesive material, undisturbed samples may be required for laboratory CBR tests to evaluate a nonrigid overlay on rigid pavement. When laboratory CBR tests are required, an additional undisturbed sample will be needed. There is no prescribed method for obtaining undisturbed samples of the subgrade material. Any method that will provide enough material and maintain it in its existing condition is satisfactory. The method most widely used for undisturbed sampling is to trim a sample by hand to fit into a split cylinder of galvanized metal approximately 8 inches in diameter and at least 12 inches high. The sample should then be sealed at the sides and ends with paraffin to prevent moisture loss.

E–3. Plate-bearing tests.

When the plate-bearing test is used to determine the k value on the surface of a pavement, such as required for the evaluation of a composite pavement or a rigid overlay on flexible pavement, the load reaction must be placed far enough away from the plates so that the stresses created by the load reaction will not influence the results of the plate-bearing tests. In general, the load reactions should be located on slabs adjacent to the slab on which the test is being performed and not less than 12.5 feet from the bearing plate. When the plate-bearing tests are performed on the surface of a pavement, the limitation outlined in chapter 3 of this manual will apply.

E–4. Moisture-density-CBR relations.

The moisture-density-CBR relationships of the foundation materials may be required to evaluate a nonrigid overlay on rigid pavement and this should be developed as outlined in TM 5–825–2/AFM 88–6, Chap. 2.

E–5. Flexural strength test.

The flexural strength of the rigid pavement will be determined by the third-point loading procedure set forth in ASTM C 78 with the following modifications.

a. Test specimens. For pavement thicknesses up to and including 12 inches, the test specimens should have a square section with the width and thickness equal to the pavement thickness. For thicker pavement, either a square section with width and thickness equal to the pavement thickness can be used, or 6- by 6-inch beams can be cut from the top and bottom of the slab and tested with the results averaged to obtain a strength representative of the full section. With the 6- by 6-inch beams cut from the top and bottom of the slab, the slab required from the pavement may be much smaller than that required when the width and thickness of the specimen must equal the pavement thickness. The length of the specimen should be three times the thickness of the specimen plus approximately 6 inches.

b. Procedure. The specimen shall be placed in the third-point loading apparatus and tested in its as-cast position. That is, the load shall be applied at the third points on the surface of the beam, which represents the pavement surface, and the load reaction will be located on the bottom of the beam, which represents the bottom of the pavement.

E–6. Splitting tensile strength tests.

The splitting tensile strength test has been standardized by ASTM. The procedures for conducting the test and calculating the splitting tensile strength of concrete cores are outlined in ASTM C 496. Essentially, the method consists of laying a concrete core with its longitudinal axis horizontal and then loading it along the longitudinal axis with a line load until the core splits along its diameter. The splitting tensile strength T is then computed from the equation:

$$T = \frac{2P}{\pi l d} \qquad \text{(eq E-1)}$$

where

P = maximum load at rupture, pounds
l = length of core, inches
d = diameter of core, inches

A correlation should be established between the splitting tensile strength from 6-inch-diameter cores and the beam flexural strength for each pavement where records indicate there is a difference in the properties of the concrete. If it is not possible to obtain samples for flexural beam tests, splitting tensile strengths for 6-inch-diameter cores can be used with the following equation to obtain values of flexural strength for use in the evaluation.

For 6-inch-diameter cores:

$$R = 1.02T + 210.5 \qquad \text{(eq E-2)}$$

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