CHAPTER 4

JOINTED FIBROUS CONCRETE (JFC) PAVEMENT DESIGN

4-1. Basis of design. The design of JFC pavement is based upon limiting the ratio of the concrete flexural strength and the maximum tensile stress at the joint, with the load either parallel or normal to the edge of the slab, to a value found to give satisfactory performance in full-scale accelerated test tracks. Because of the increased flexural strength and tenacity at cracks that develop in the fibrous concrete, the thickness can be significantly reduced; however, this results in a more flexible structure, which causes an increase in vertical deflections as well as in the potential for densification and/or shear failures in the foundations, pumping of the subgrade material, and joint deterioration. To protect against these latter factors, a limiting vertical deflection criterion has been applied to the thickness developed from the tensile stress criteria.

4-2. Uses. Although several types of fiber have been studied for concrete reinforcement, most of the experience has been with steel fibers, and the design criteria presented herein are limited to steel fibrous concrete. Fibrous concrete is a relatively new material for pavement construction and lacks a long-time performance history. The major uses to date have been for thin resurfacing or strengthening overlays where grade problems restrict the thickness of overlay that can be used. The use of JFC pavement should be based upon the time saved and the availability of the materials involved.

4-3. Mix proportioning considerations. The design mix proportioning of fibrous concrete will be determined by field testing when time is available. Otherwise, preliminary estimates must be made. The following are offered as guides and establish limits where necessary for the use of the design criteria included herein.

a. The criteria contained herein are based upon fibrous concrete containing 1 to 2 percent by volume (100 to 250 pounds) of steel fibers per cubic yard of concrete, and fiber contents within this range are recommended.

b. Most experience to date has been with fibers 1 to 1-1/2 inches long, and for use of the criteria herein, fiber lengths within this range are recommended.

c. For proper mixing, the maximum aspect ratio (length to diameter or equivalent diameter) of the fibers should be about 100.

d. The large surface area to volume ratio of the steel fibers requires an increase in the paste necessary to insure that the fibers and aggregates are coated. To accomplish this, cement contents of 750 to 900 pounds per cubic yard of concrete are recommended. The cement content may be all portland cement or a combination of portland cement and up to 25 percent fly ash or other pozzolans.

e. Maximum size coarse aggregates should fall between 3/8 and 3/4 inch. The percent of coarse aggregate (of the total aggregate content) can vary between 25 and 60 percent.

4-4. Thickness determination. The required thickness of JFC pavement will be a function of the design concrete flexural strength R, the modulus of soil reaction k, the thickness h_b and flexural modulus of elasticity E_{fs} of stabilized material if used, the aircraft gross load, the volume of traffic, the type of traffic area, and the allowable vertical deflection. When stabilized material is not used, the required thickness h_{df} of JFC is determined directly from the appropriate charts, figures 4-1 through 4-3 (curves for Air Force light, medium, heavy load, and short field, figures 4-4 through 4-7, are included for reference). If the base or subgrade is stabilized and meets the minimum strength requirements of EM 1110-3-137, the stabilized layer will be treated as a low-strength base, and the design will be made using the equation given in paragraph 2-2b of this manual. The resulting thickness, h_{df} or h_{dof}, will be rounded upward to the nearest half or full inch. The rounded thickness, h_{df} or h_{dof}, will then be checked for allowable deflection in accordance with paragraph 4-5. The minimum thickness for JFC pavements will be 4 inches.

4-5. Allowable deflection for JFC pavement. The elastic deflection that JFC pavements experience must be limited to prevent overstressing of the foundation material and thus premature failure of the pavement. Curves are provided (fig 4-8 through 4-10) for the computation of the vertical elastic deflection that a pavement will experience when loaded. Use of the curves requires three different inputs: slab thickness, subgrade modulus, and gross weight of the design aircraft. The slab thickness is that which is determined from paragraph 4-4 above. The computed vertical elastic deflection is then compared with appropriate allowable deflections determined from table 4-1 or, in the case of shoulder design, with an allowable deflection value of 0.06 inch. If the computed deflection is less than the allowable deflection, the thickness meets allowable deflection criteria and is acceptable. If the computed deflection is larger than the allowable deflection, the thickness must be increased or a new design initiated with a different value for either R or k. The process must be repeated until a thickness based upon the limiting stress criterion will also have a computed deflection equal to or less than the allowable value.

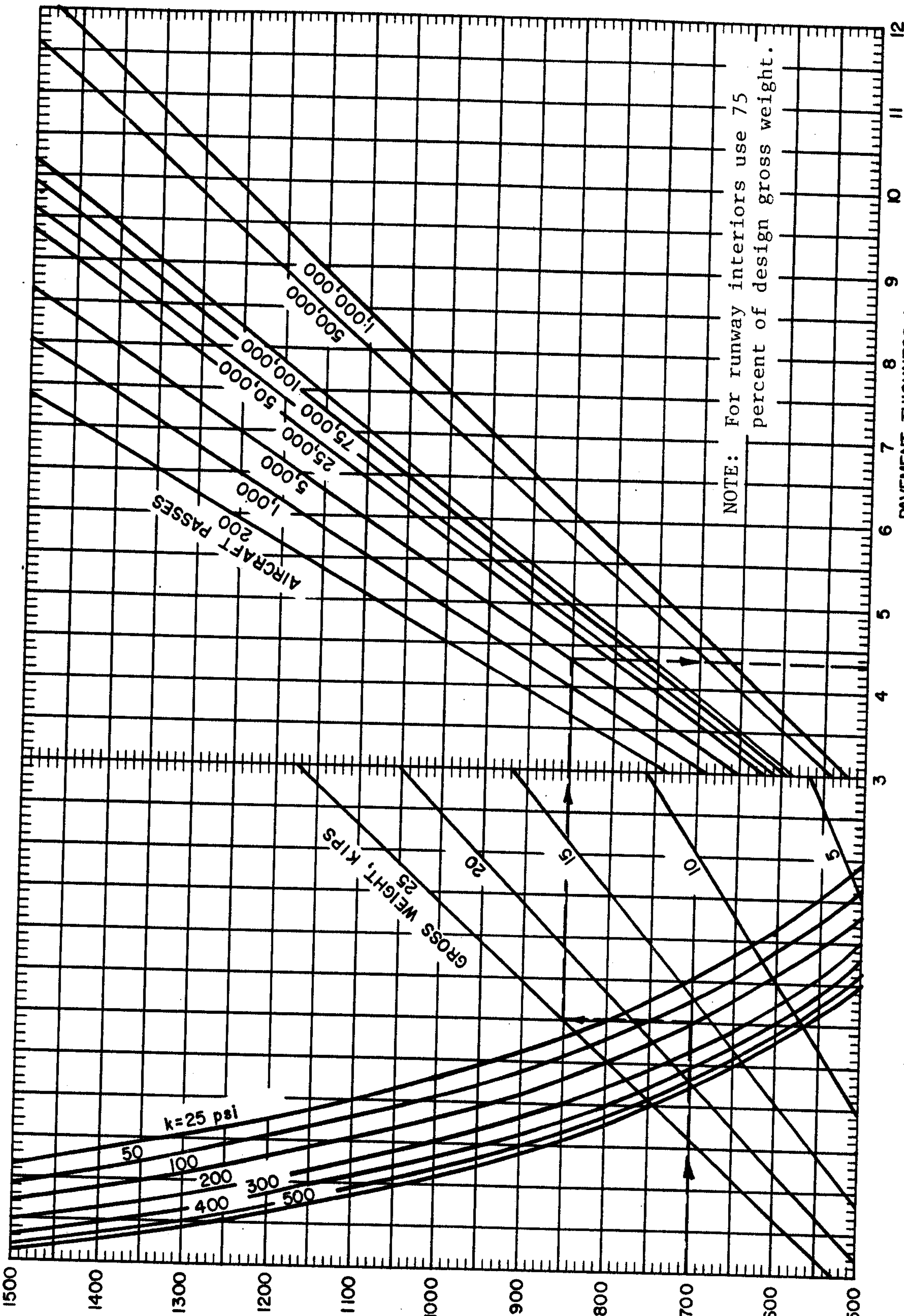

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FIGURE 4-1. FIBROUS CONCRETE PAVEMENT DESIGN CURVES FOR ARMY CLASS I PAVEMENTS

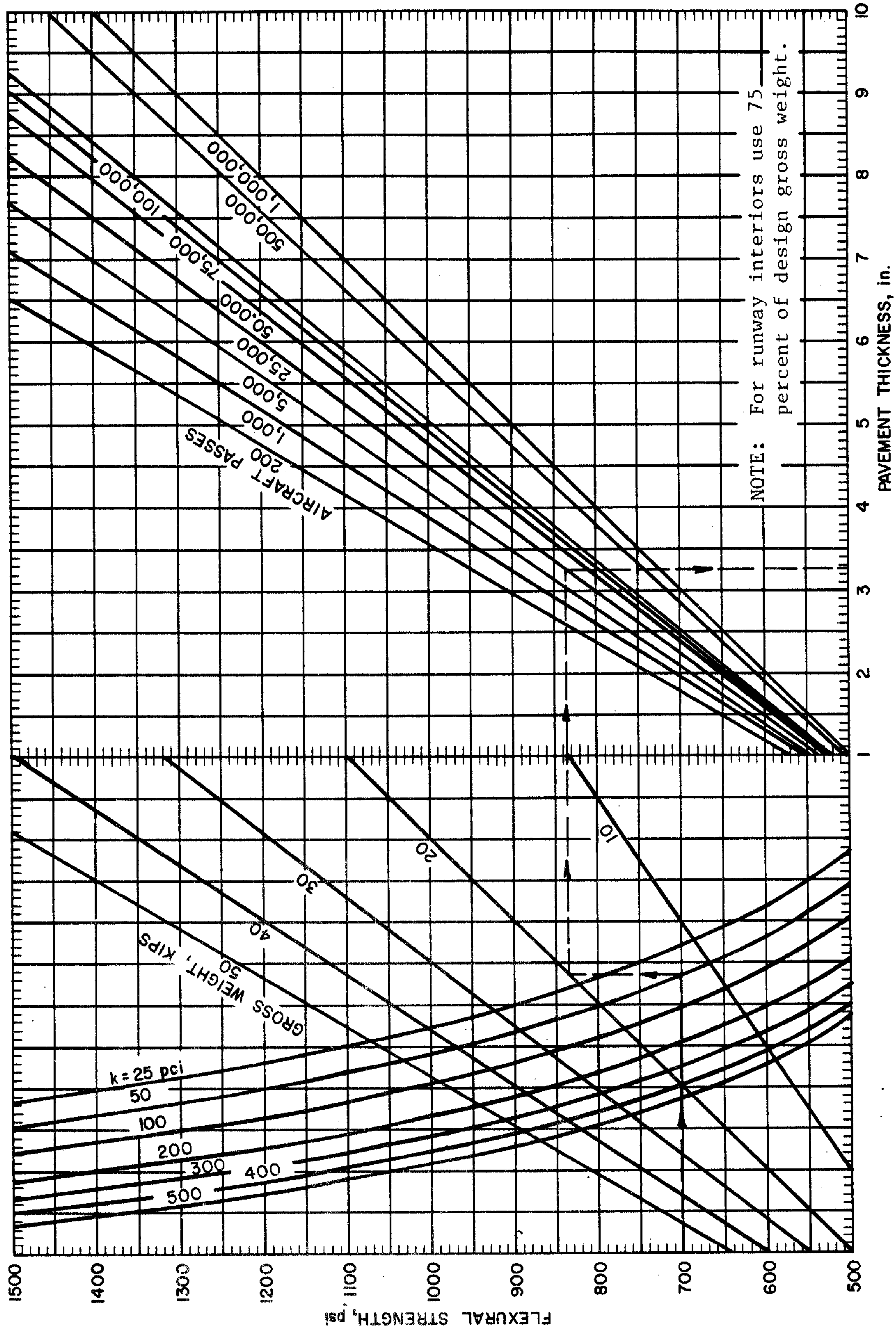

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FIGURE 4-2. FIBROUS CONCRETE PAVEMENT DESIGN CURVES FOR ARMY CLASS II PAVEMENTS

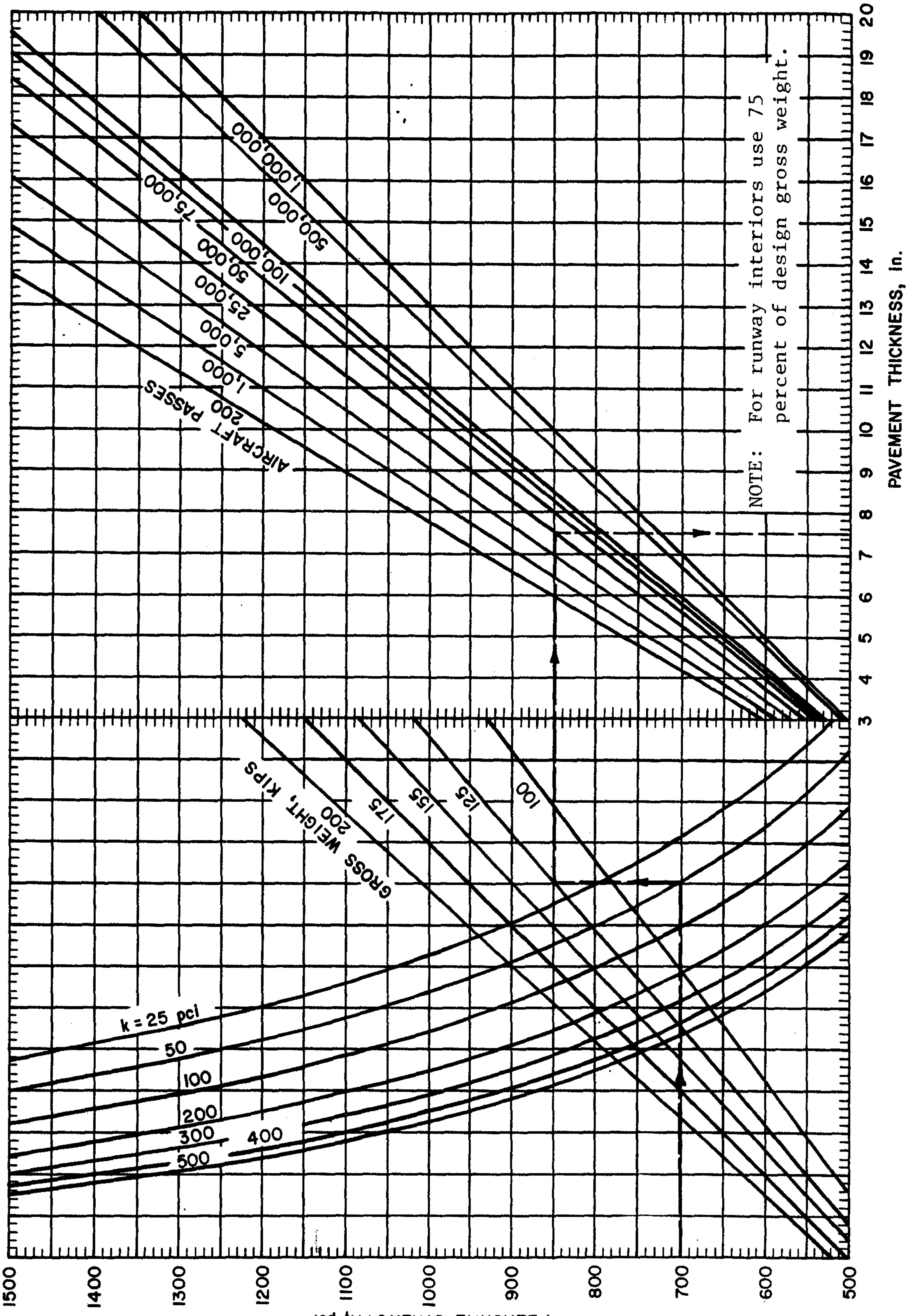

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FIGURE 4-3. FIBROUS CONCRETE PAVEMENT DESIGN CURVES FOR ARMY CLASS III PAVEMENTS

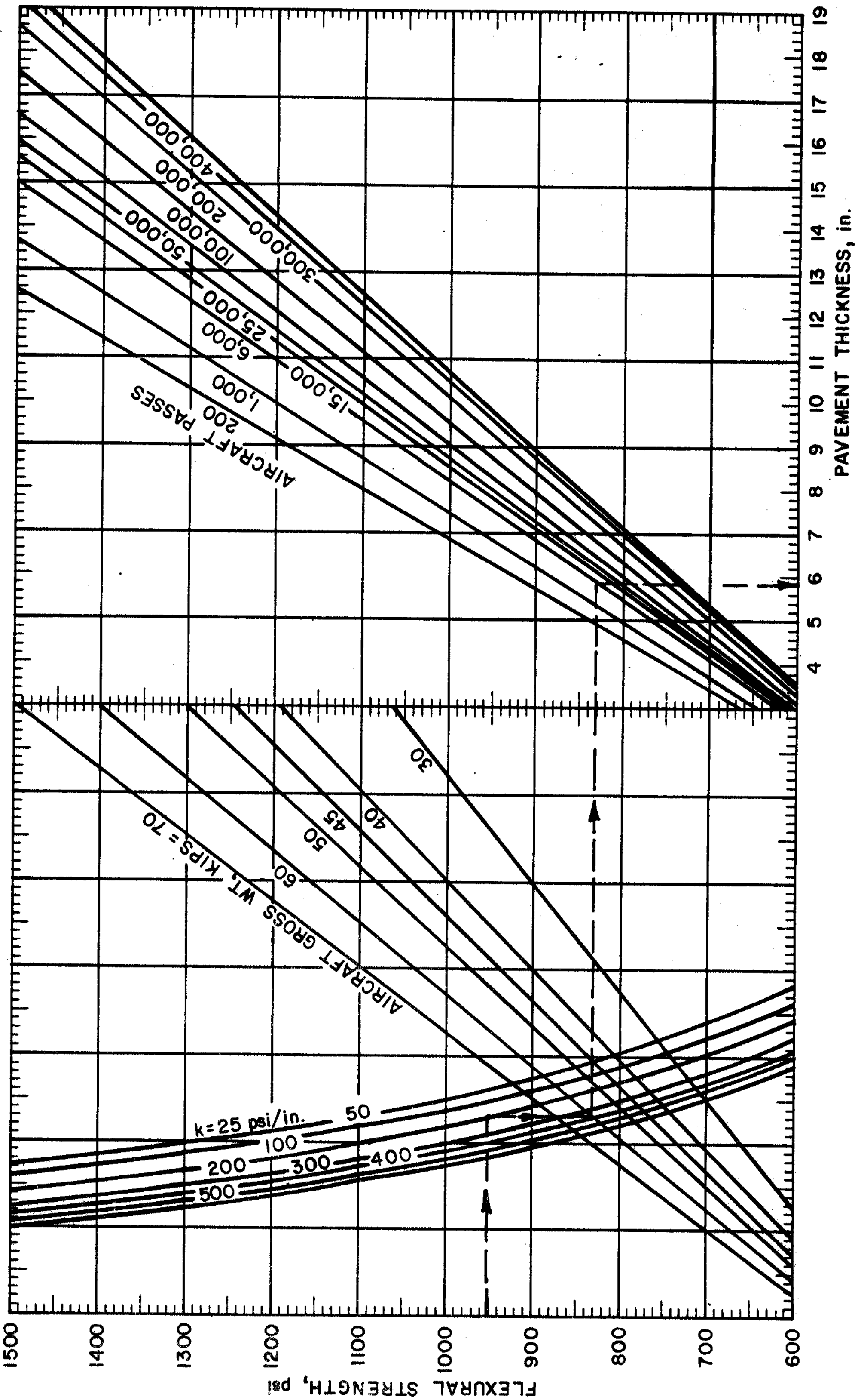

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FIGURE 4-4. FIBROUS CONCRETE PAVEMENT DESIGN CURVES FOR AIR FORCE LIGHT-LOAD PAVEMENTS

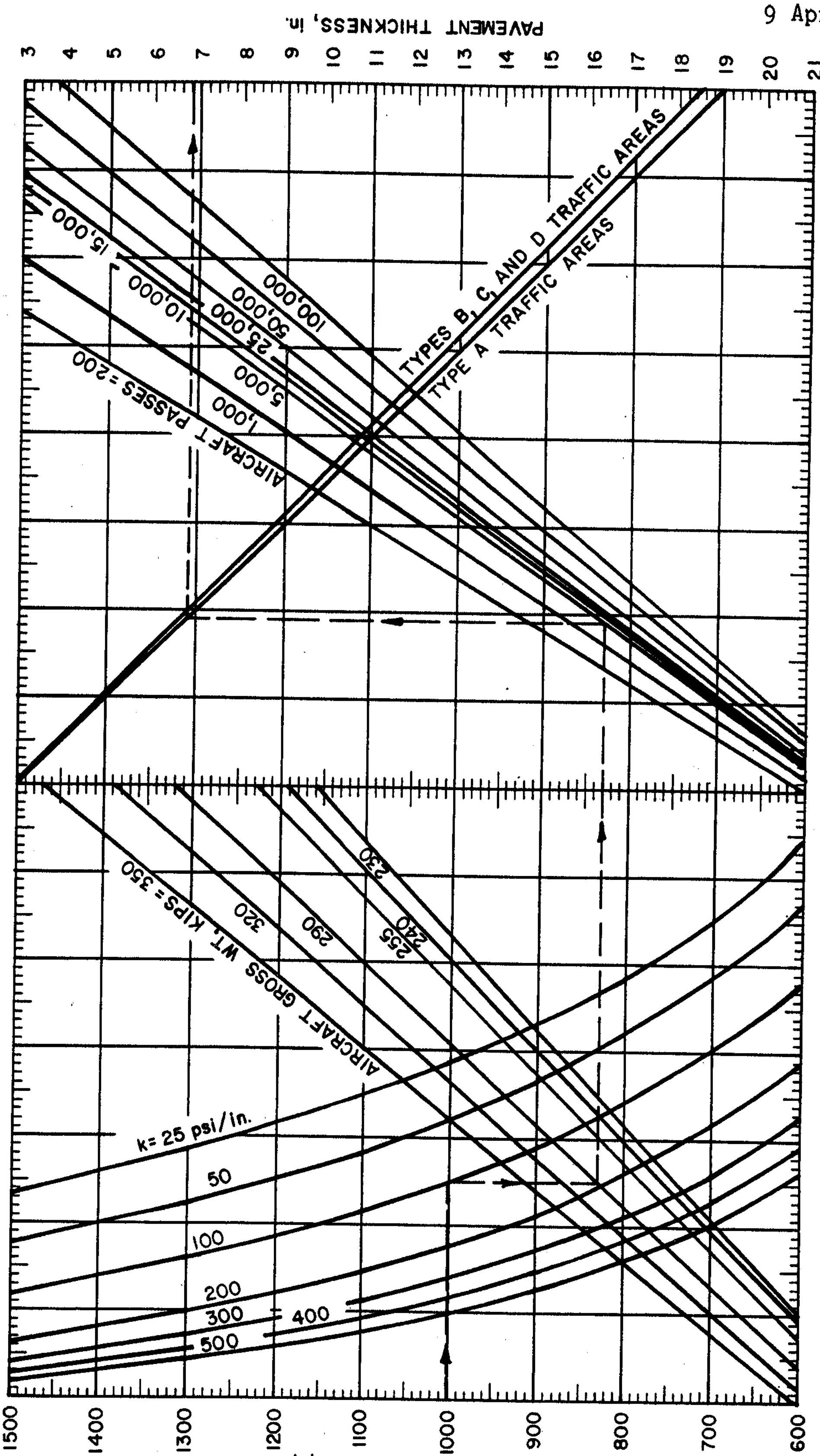

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FIGURE 4-5. FIBROUS CONCRETE PAVEMENT DESIGN CURVES FOR AIR FORCE MEDIUM-LOAD PAVEMENTS

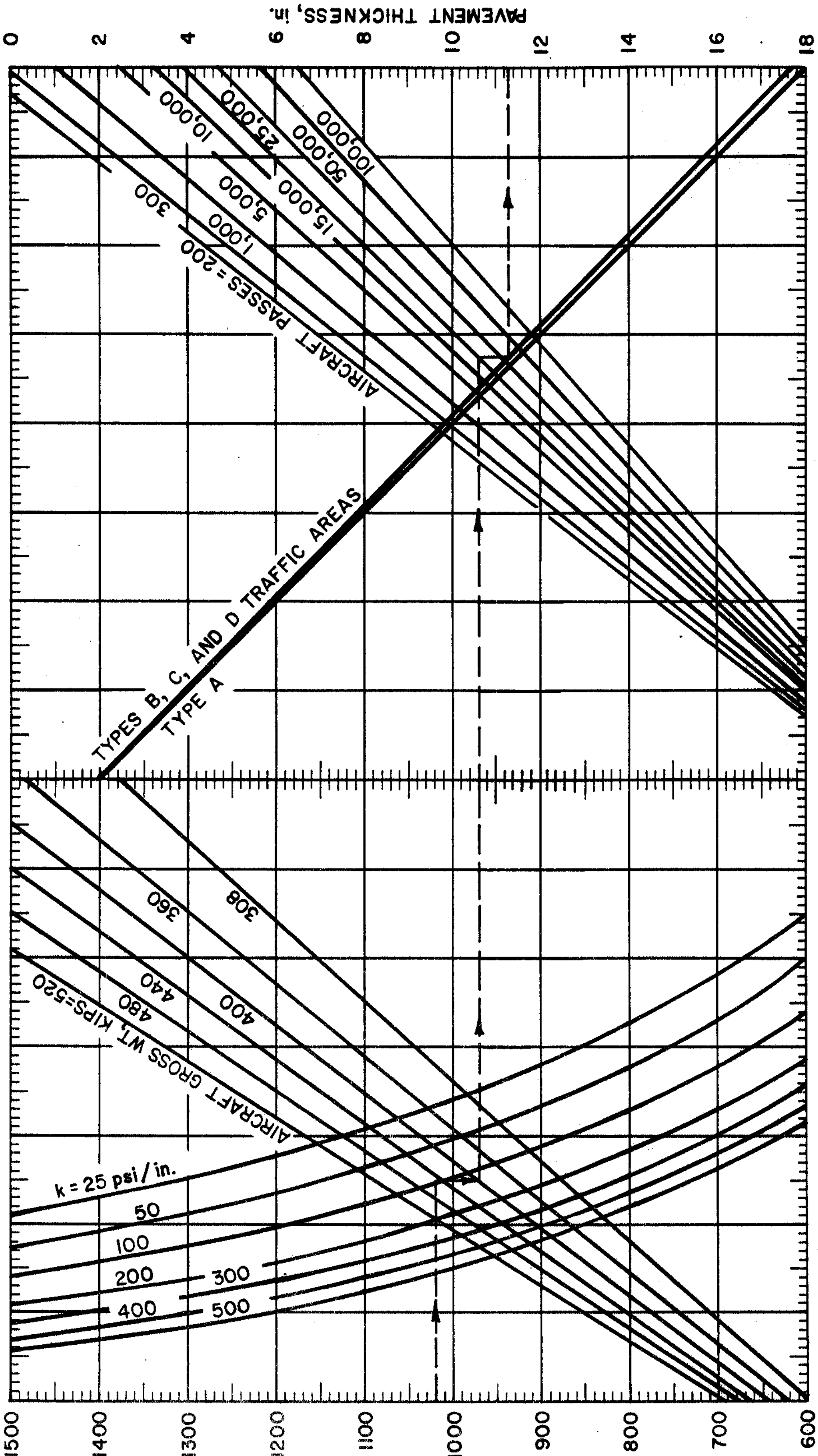

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FIGURE 4-6. FIBROUS CONCRETE PAVEMENT DESIGN CURVES FOR AIR FORCE HEAVY-LOAD PAVEMENTS

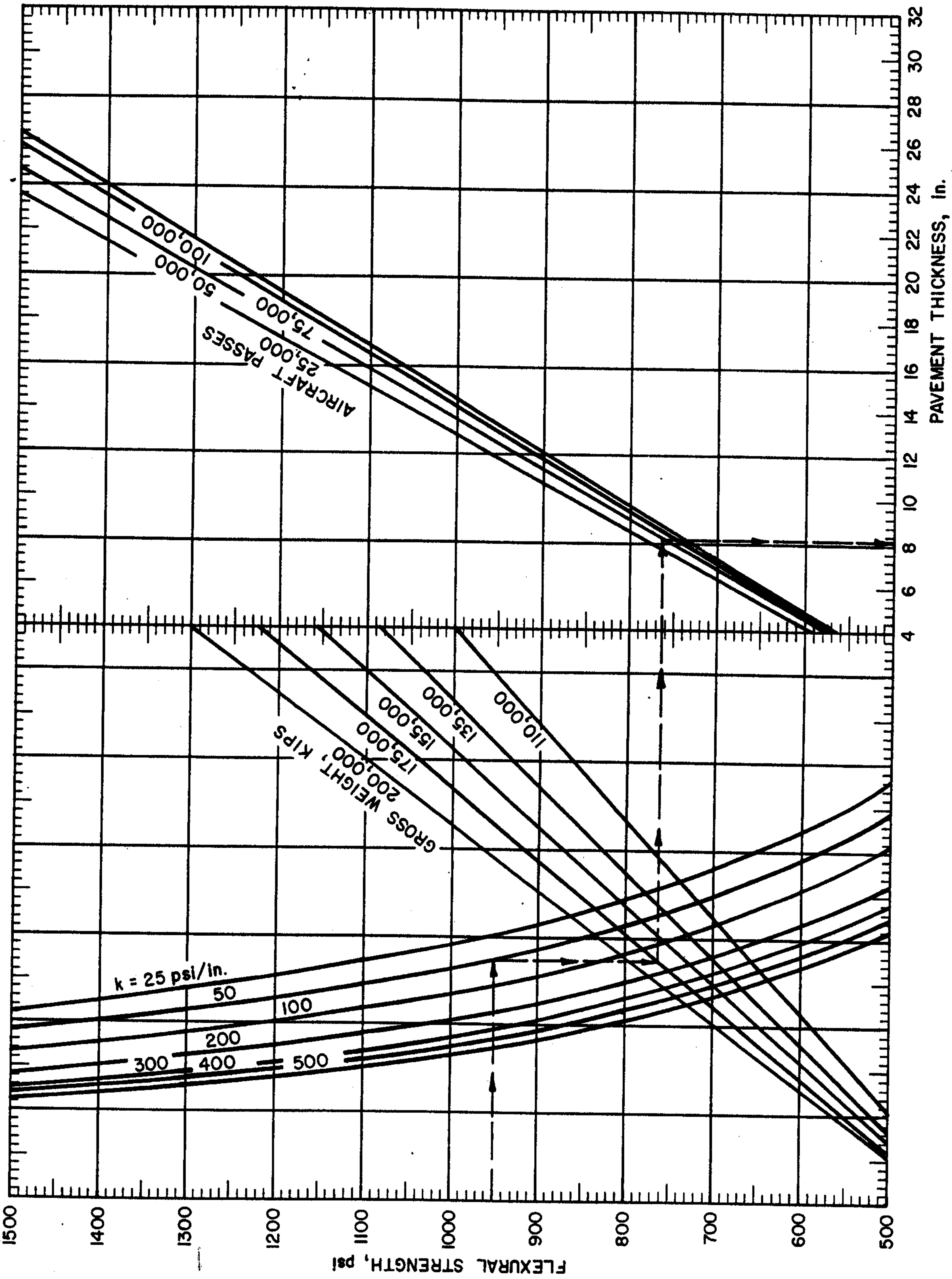

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FIGURE 4-7. FIBROUS CONCRETE PAVEMENT DESIGN CURVES FOR AIR FORCE SHORT FIELD PAVEMENTS

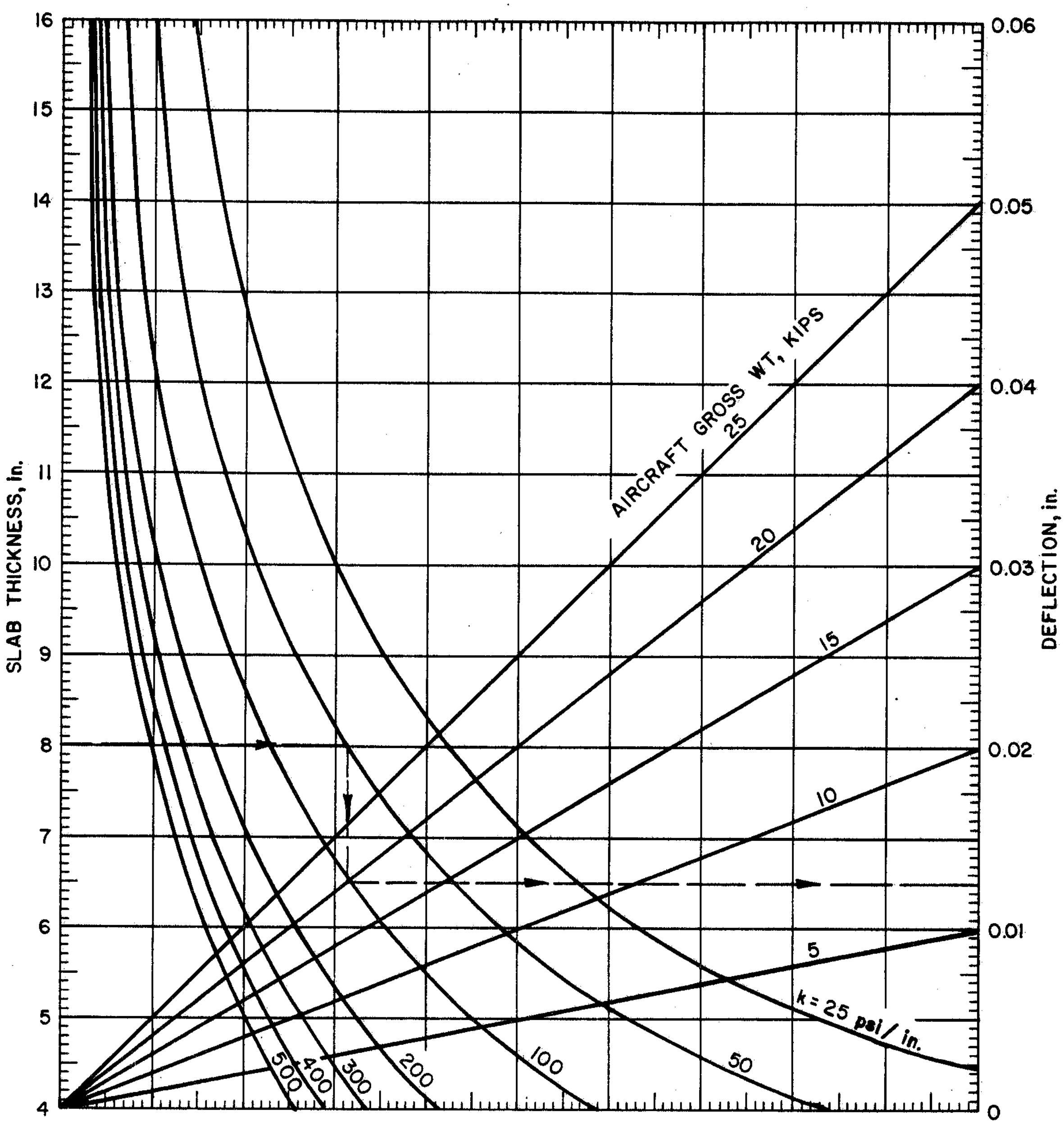

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FIGURE 4-8. DEFLECTION CUVRES FOR CLASS I PAVEMENTS

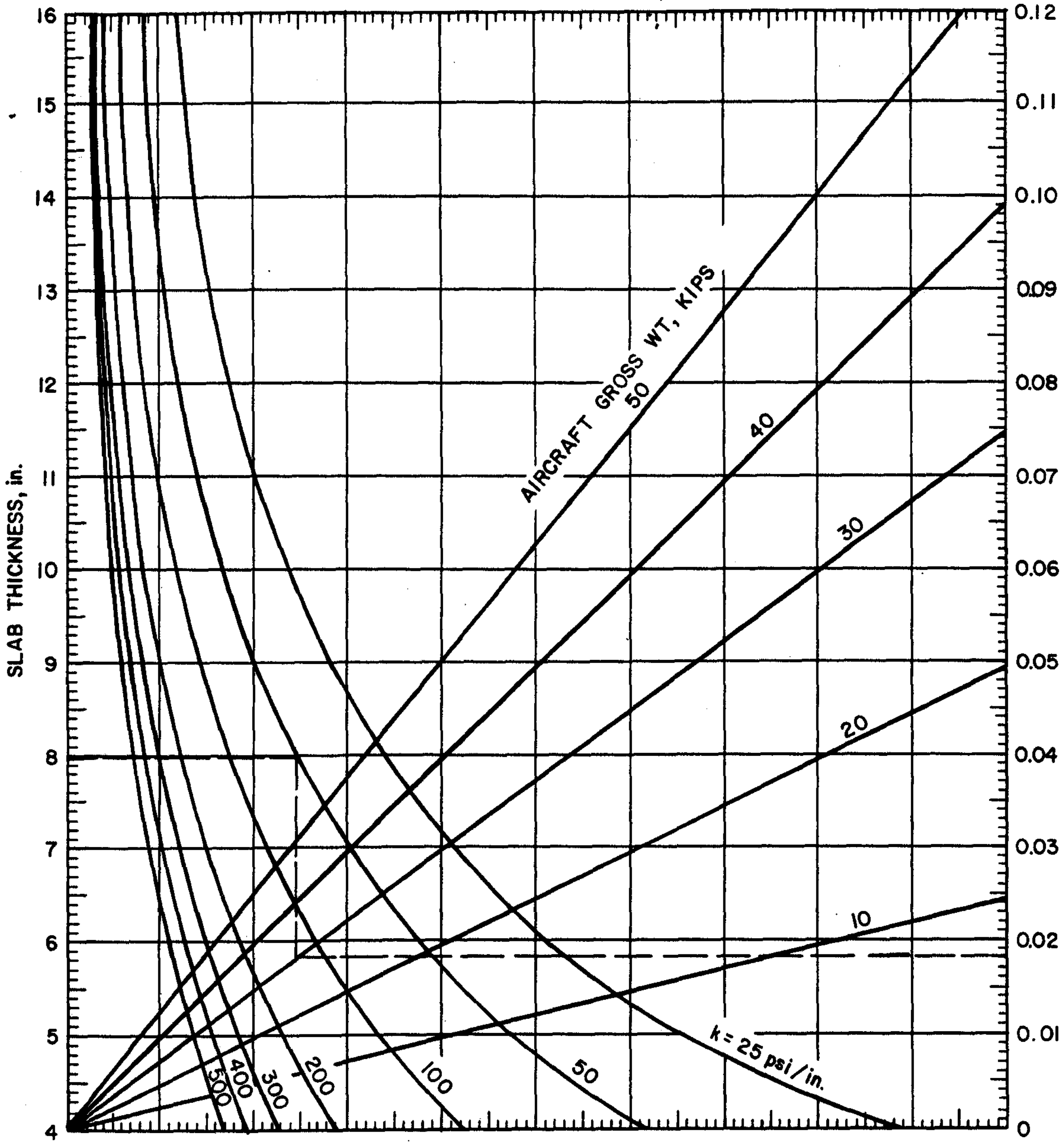

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FIGURE 4-9. DEFLECTION CURVES FOR CLASS II PAVEMENTS

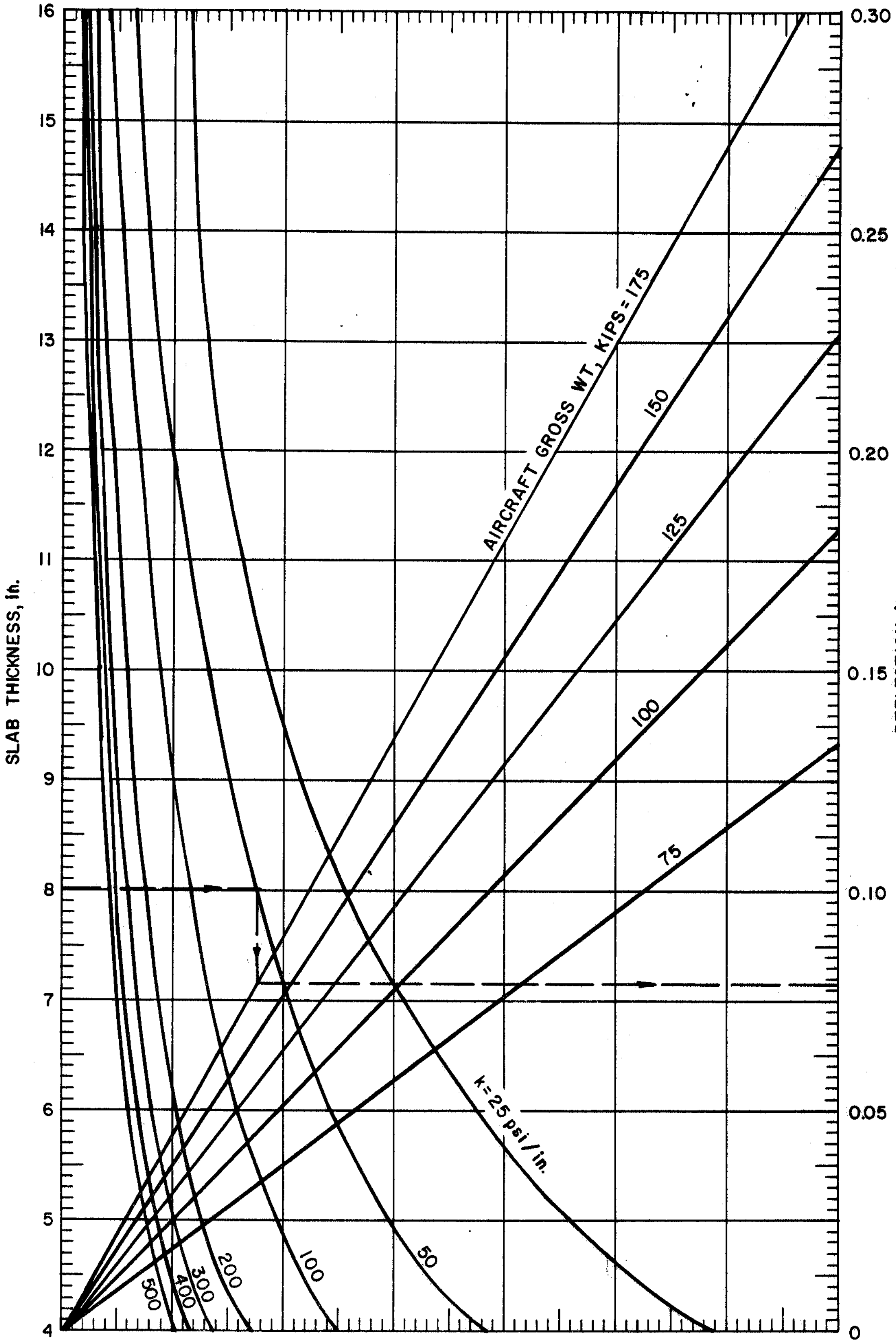

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FIGURE 4-10. DEFLECTION CURVES FOR CLASS III PAVEMENTS

Table 4-1. Limiting Elastic Deflections for JFC Pavements

Traffic Passes	Limiting Deflection, In. Class I	Class II	Class III
200	.180	.155	.155
1,000	.130	.110	.110
5,000	.090	.075	.075
25,000	.065	.060	.060
50,000	.060	.055	.055
75,000	.055	.050	.050
100,000	.055	.050	.050
500,000	.050	.050	.050
1,000,000	.050	.050	.050

4-6. Jointing. The joint types and designs discussed in paragraph 2-3 generally apply to JFC pavement. The tenacity of the fibrous concrete does afford some variations in allowable joint spacings, and the maximum joint spacing becomes a function of the load-transfer mechanism. For the mix proportionings discussed in paragraph 4-3, the maximum spacing of joints (transverse and/or longitudinal) will be as follows:

Thickness, inches	Maximum Spacing, feet Doweled	Undoweled
4 to 6	50	25
Greater than 6	100	50

Longitudinal construction joints may be either doweled, keyed and tied, or thickened-edge with a key, in which case the key dimensions will be based upon the thickened-edge thickness. The keyed and tied construction joint will be limited to a width of 100 feet. For widths greater than 100 feet, combinations of keyed and tied, doweled, or thickened-edge-type joints may be used. Sealing of joints in fibrous concrete will follow the criteria presented in paragraph 2-3f except that preformed compression sealants are recommended for joints spaced greater than 25 feet, and are required when the joint spacing exceeds 50 feet.