CHAPTER 12

PLAIN CONCRETE PAVEMENT DESIGN

12-1. General.

Rigid pavements for roads, streets, and open storage areas at military installations will be plain (nonreinforced) concrete except for those conditions listed in chapter 13 or unless otherwise approved by HQUSACE (CEMP-ET), or the appropriate Air Force Major Command.

12-2. Roller-Compacted Concrete Pavements.

Roller-compacted concrete pavements (RCCP) are plain concrete pavements constructed using a zero-slump portland cement concrete mixture that is placed with an AC paving machine and compacted with vibratory and rubber-tired rollers. The design of RCCP is presented in chapter 17.

12-3. Design Procedure.

For convenience in determining design requirements, the entire range of vehicle loadings and traffic intensities anticipated during the design life of pavements for the various classifications of military roads and streets has been expressed as an equivalent number of repetitions of an 18,000-pound single-axle loading. To further simplify the design procedure, the range of equivalent repetitions of the basic loading thus determined has been designated by a numerical scale defined as the pavement design index. This index extends from 1 through 10 with an increase in numerical value indicative of an increase in pavement design requirements. Values for the design index are determined using the procedure in chapter 3. Once the design index has been determined the required thickness of plain concrete pavement is then obtained from the design chart presented in figure 12-1 for roads and streets. Figure 12-2 is used to determine the thickness of parking and storage areas except that the thickness of roller-compacted concrete parking and storage areas will be designed using figure 12-1. These design charts are graphical representations of the interrelation of flexural strength, modulus of subgrade reaction k, pavement thickness, and repetitions (design index) of the basic 18,000-pound single-axle loading. These design charts are based on the theoretical analyses of Westergaard *(New Formulas for Stresses in Concrete Pavements of Airfields,* ASCE Transactions), supplemented by empirical modifications determined from accelerated traffic tests and observations of pavement behavior under actual service conditions. The design charts are entered using the 28-day flexural strength of the concrete. A horizontal projection is then made to the right to the design value for k. A vertical projection is then made to the appropriate design-index line. A second horizontal projection to the right is then made to intersect the scale of pavement thickness. The dashed line shown on curves is an example of the correct use of the curves. When the thickness from the design curve indicates a fractional value, it will be rounded up to the next ½-inch thickness. All plain concrete pavements will be uniform in cross-sectional thickness. Thickened edges are not normally required since the design is for free edge stresses. The minimum thickness of plain concrete for any military road, street, or open storage area will be 6 inches.

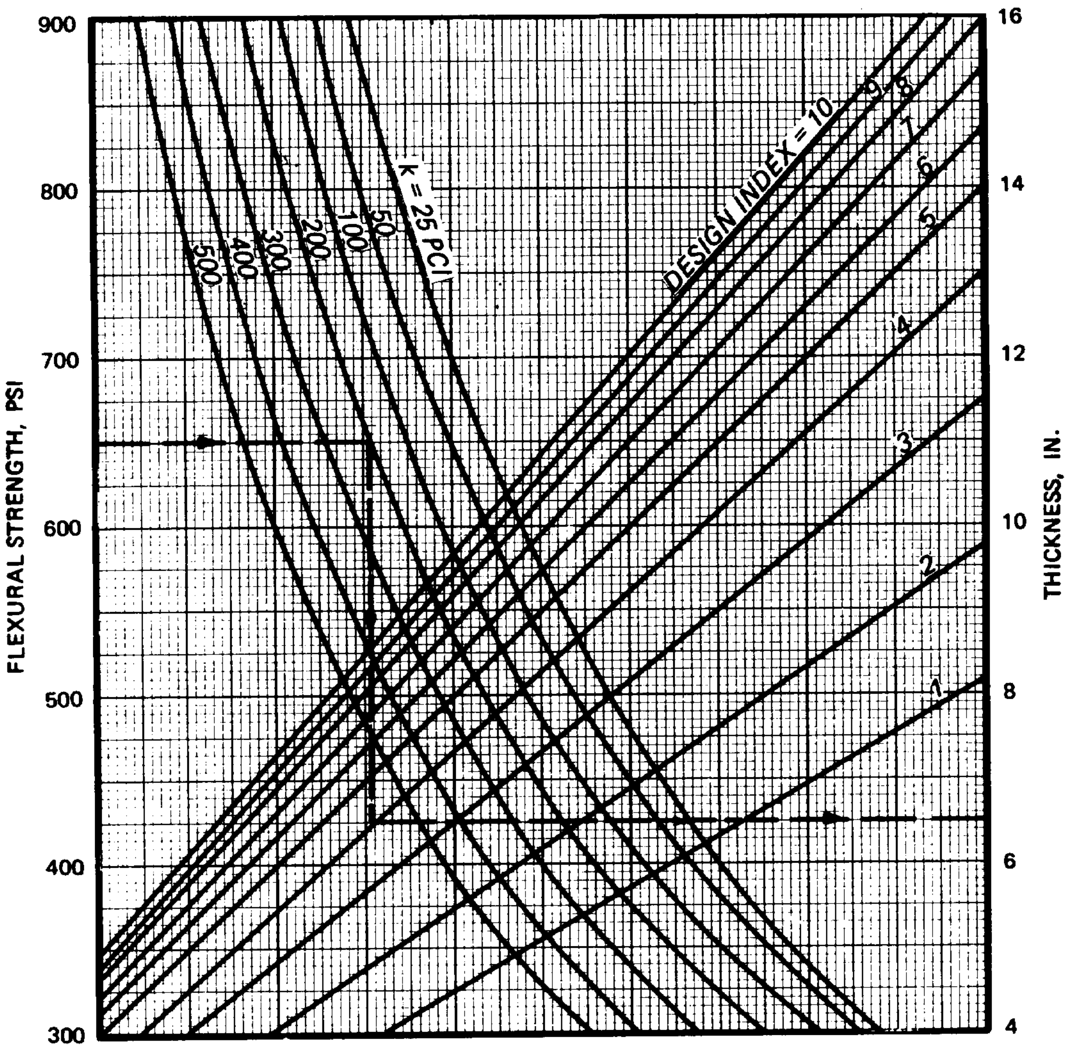

Figure 12-1. Design Curves for Plain Concrete Roads and Streets, and RCCP.

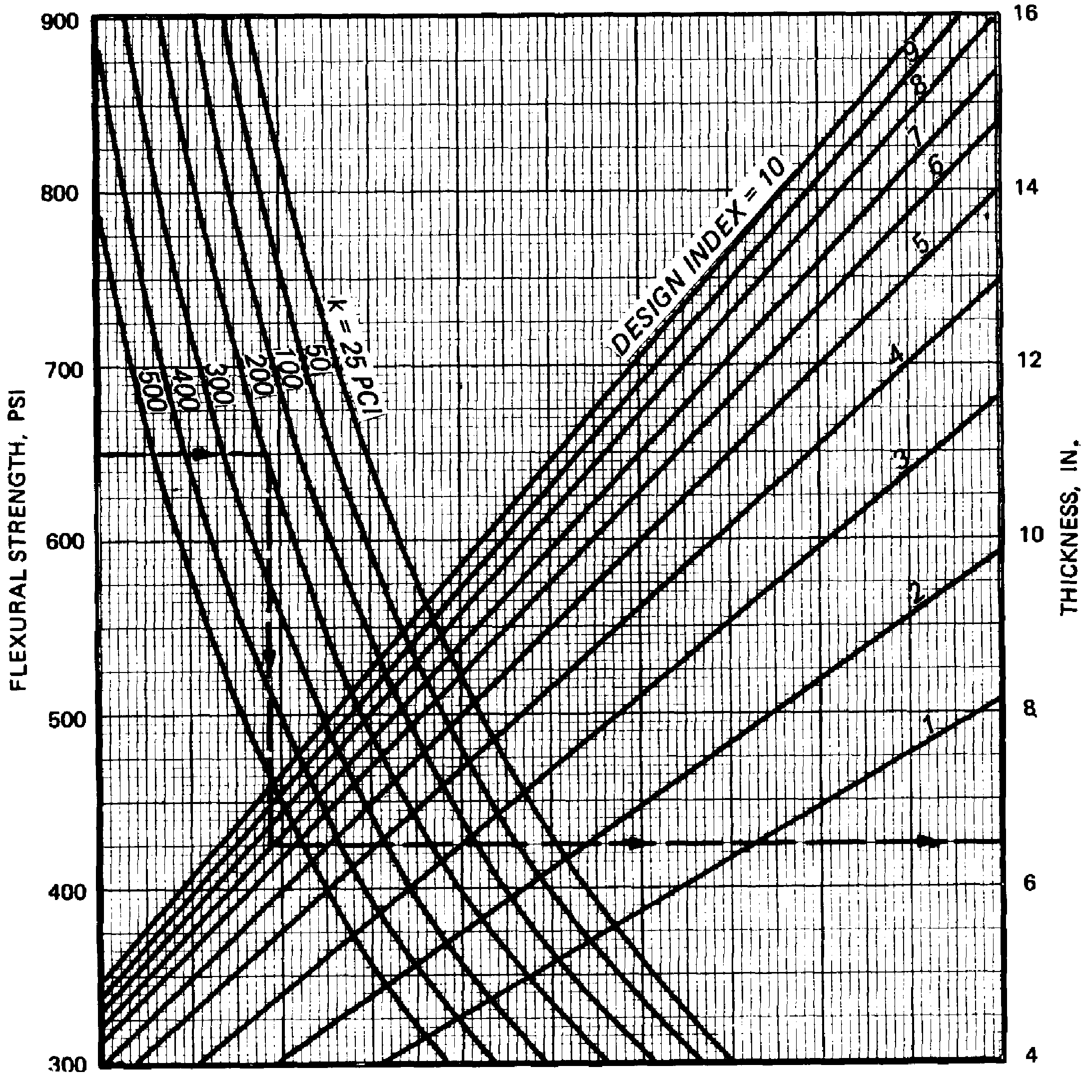

Figure 12-2. Design Curve for Plain Concrete Parking and Open Storage Areas.

12-4. Design Procedure for Stabilized Foundations.

The thickness requirements for a plain concrete pavement on a modified soil foundation will be designed as if the layer is unbound using the k value measured on top of the modified soil layer. For stabilized soil layers, the treated layer will be considered to be a low-strength base pavement and the thickness determined using the following modified partially bonded overlay pavement design equation:

$$h_o = \sqrt[1.4]{h_d^{1.4} - (0.0063\sqrt[3]{E_f} \cdot h_s)^{1.4}} \quad \text{(eq 12-1)}$$

where

h_o = thickness of plain concrete pavement overlay required over the stabilized layer, inches

h_d = thickness of plain concrete pavement from design chart (fig. 12-1) based on k value of unbound material, inches

E_f = flexural modulus of elasticity of the stabilized soil. The modulus value for bituminous stabilized soils will be determined according to the procedures in appendix B. The modulus value for lime and cement stabilized soils will be determined using the results of CRD-C 21 and the equations in appendix B

h_s = thickness of stabilized layer, inches

For additional information on stabilization and mix proportioning see TM 5-822-4 and TM 5-818-1.

12-5. Design Examples.

As an example of the application of the design procedures given for nonstabilized foundations, design a plain concrete pavement for a road in a rural area on rolling terrain to carry the following traffic:

Average daily volume	3,500 vehicles per lane
Trucks, 2 axle	150 per lane per day
Trucks, 3 or more axles	50 per lane per day

Based on the criteria in TM 5-822-2/AFM 88-7, Chap 5, this traffic would be evaluated as requiring a class C road. It would be designed for category IV traffic and a design index of 5. Assuming a 28-day flexural strength for the concrete of 675 psi, and a k value of 100 pounds per cubic inch (pci), the required pavement thickness as indicated by figure 12-1 is approximately 7.3 inches. This thickness value would be rounded off to 7.5 inches for design. To illustrate the design procedure when traffic includes tracked vehicles, assume that in addition to the pneumatic-tired traffic used in the previous example, the designer must provide for an average of 60 tanks per lane per day and that the gross weight of each tank is 50,000 pounds. The 50,000-pounds gross weight would be classified as category V traffic (according to chapter 3) since it exceeds the maximum of 40,000 pounds permitted for tracked vehicles in category IV traffic. Inasmuch as the tank traffic exceeds 40 per day, the rigid pavement design index would be based on the next higher traffic volume given in table 3-1, which is 100 per day. Thus, the design index for a class C street would be 6. Assuming the same 28-day flexural strength and k value as in the previous example, the required pavement thickness is approximately 7.75 inches (fig 12-1) and would require a design thickness of 8.0 inches. To illustrate the procedure for combining tracked vehicles with pneumatic-tired vehicles, design a rigid pavement on rolling terrain for the following traffic:

Average daily volume	750 vehicles per lane
Trucks, 2 axle	100 per lane per day
Trucks, 3 or more axles	40 per lane per day
Track-laying vehicles, 50,000 pounds.	50 per lane per day
Track-laying vehicles, 80,000 pounds.	20 per lane per day

According to TM 5-822-2/AFM 88-7, Chap 5, the traffic on rolling terrain would be evaluated as requiring a class D road or class E street. From chapter 3, the 50-kilopounds (kip) tracked vehicles would be classified as category V traffic. For a firequench of 50 of these vehicles per lane per day, the pavement design index would be 6. The 80-kip tracked vehicles are classified as category VI traffic. For a frequency of 20 of these vehicles per lane per day, the pavement design index would be 7. Thus, it can be seen that the 80-kip tracked vehicle traffic governs as it requires the highest design index. Assuming the same 28-day flexural strength and k value as in the previous design examples, the required pavement thickness is 8.1 inches (fig 12-1) which would be rounded to 8.5 inches for design. For this same example, if the plain concrete pavement is to be placed on 6 inches of cement stabilized soil having an E~ value of 500,000 psi, then the thickness of plain concrete re- quire would be as follows using equation 12-1.

$$h_o = \sqrt[1.4]{h_d^{1.4} - (0.0063 \sqrt[3]{E_f}\, h_s)^{1.4}}$$

$$h_o = \sqrt[1.4]{(8.1)^{1.4} - [0.0063 \sqrt[3]{500{,}000}\, (6)]^{1.4}}$$

h_o = 6.6 inches (round to 7.0 inches for design)

Design examples for rigid pavement for frost conditions are discussed in chapter 18.

12-6. Concrete Sidewalks.

Portland cement concrete walks may be provided at installations where pedestrian traffic justifies this type of construction. Normally, the design thickness for walks will be 4 inches. Where it is necessary and desirable to continue the walk across driveways and private entrances, provided for vehicle crossings, the thickness of the walk should be increased to provide sufficient strength to support the vehicular loads to which such portions of the walks will be subjected. Concrete walks should be grooved transversely into rectangular areas with the longest dimension no greater than 1.25 times the shorter dimension to create planes of weakness for control of contraction cracking. The depth of such grooves should be a minimum of one-fourth the thickness of the slab and need not be sealed. Expansion joints consisting of approved preformed bituminous filler or wood approximately ½ inch thick should be installed to surround or to separate all structures or features which project through or against the sidewalk slab. Expansion joints of a similar type should be installed at regularly spaced intervals transversely across the sidewalk slab. The spacing for such joints should be not less than 30 feet nor more than 50 feet. A base is only recommended at locations where past experience has shown that subgrade soils exhibit unacceptable swell and frost heave potential. These soils can result in safety problems with differential joint elevations.

12-7. Concrete Driveways.

Under normal conditions, rigid pavement for residential driveways will be either 6-inch plain concrete or 5-inch reinforced concrete with 0.10 percent of reinforcement steel. In plain concrete pavement design, slab lengths will not exceed 15 feet with 12 feet recommended. For reinforced pavement, slab lengths up to 30 feet may be used. The residential driveways will be 6 inches thick and reinforced with a minimum of 0.05 percent of reinforcement steel when the following adverse conditions prevail: when concrete flexural strength is below 630 psi and the subgrade modulus k is below 50 pci, and when frost penetrates a frost-susceptible material underlying the rigid pavement on small jobs in frost areas. Where the flexural strength or subgrade modulus is unknown, the design will be 6 inches of concrete with a 6-inch base course. Contraction or construction joints pro- vided in a driveway will be designed and sealed in accordance with chapter 15 or 16. Expansion joints consisting of approved preformed bituminous filler or wood should be installed to surround or separate all structures which project through or against the driveway slabs.

12-8. Curbs, Gutters, and Shoulders.

For a discussion of the design of curbs, gutters, and shoulders, see paragraphs 8-8 and 8-11 of this manual.