CHAPTER 2

BASIS OF PAVEMENT DESIGN

2-1. Design Principles.

a. Concrete pavements. The basic principle for the elastic layered design procedure is to limit the tensile stresses in the portland cement concrete (PCC) to levels that are sufficiently below the flexural strength of the concrete such that failure occurs only after the pavement has sustained a number of load repetitions. The tensile stress is modeled by the use of Burmister's solution for elastic multilayered continua. The computed tensile stress divided into the concrete strength is the design parameter and is referred to as the design factor. This parameter has been related to pavement performance through a study of test section data. Use of a cumulative damage concept determines the required concrete thickness. Correlations among theory, small-scale model studies, and full-scale accelerated traffic tests have shown that maximum tensile stresses in the pavement occur when the vehicle wheels are placed at a free or unsupported edge of the pavement. Only interior stresses are computed using the elastic layered method while edge stresses can be computed with the Westergaard solution. The former is always less than the latter; the difference depends upon the load configuration and pavement geometry and properties. Stresses for the condition of the vehicle wheels placed at a longitudinal or transverse joint are less severe because of the use of load-transfer devices or aggregate interlock in these joints to transfer a portion of the load to the adjacent slab. In military roads and streets, dowel bars are generally installed in the transverse joints and tie bars in the longitudinal joints. Since traffic loads travel near the pavement (free) edges and free edge stresses govern the pavement design thickness, interior stresses computed with JULEA does not simulate the edge stress condition. Thus the computed stress will be multiplied by a factor of 1.33.

b. Flexible pavements. The basic principle for the design procedure is to select a pavement thickness required to limit the vertical strains in the subgrade and the horizontal strains at the bottom of the bituminous concrete induced by design vehicular traffic loads at select traffic levels. The purpose is to prevent shear failure in the subgrade and cracking in the bituminous surface course. Use of a cumulative damage concept permits the rational handling of variations in the bituminous concrete properties and subgrade strength caused by cyclic climatic conditions. The strains used for entering the criteria are computed by the use of Burmister's solution for multilayered elastic continua. The solution of Burmister's equations for most pavement systems will require the use of computer programs and the characterization of the pavement materials by the modulus of elasticity and Poisson's ratio.

2-2. Design Variables.

The prime factor influencing the structural design of a pavement is the load-carrying capacity required. The pavement thickness necessary to provide the desired load-carrying capacity is a function of the following.

a. Principal variables.

(1) Vehicle wheel load or axle load.

(2) Configuration of vehicle wheels or tracks.

(3) Volume of traffic during the design life of pavement.

b. Additional rigid pavement variables.

(1) Modulus of rupture (flexural strength) of the concrete.

(2) Elastic moduli and Poisson's ratios of concrete, base course, and subgrade soils.

c. Additional flexible pavement variables.

(1) Elastic moduli of each layer of the pavement structure and the subgrade soils.

(2) Poisson's ratios of each layer of the pavement structure and the subgrade soils.

2-3. Pavement Response Model.

The pavement system is assumed to be a multilayered continuum with each layer being elastic and homogeneous. Each layer is to extend to infinity in the horizontal direction and have, except for the bottom layer; a finite thickness. The applied loads to the pavement are considered as static, circular, and uniform over the contact area. The program chosen for the analysis is JULEA computer code. The program provides different degrees of bond between interfaces. With the program the performance criteria for rigid pavements are developed with the assumptions that the interface between the PCC slab and the supporting subgrade is considered smooth with no bond, i.e., there is no frictional resistance at the interface. All other interfaces are considered to be completely bonded. With these codes the performance criteria for flexible pavements are developed with the assumptions that the interfaces between each layer of the flexible pavement are considered completely bonded, i.e. complete frictional resistance at interfaces.

2-4. Frost Considerations.

For the design and construction of pavements placed on subgrade or base course materials subject to seasonal frost action, the criteria and procedures given in TM 5-822-5/AFM 88-7, Chap. 3, are applicable.