Chapter 20

Factors affecting pavement design

20.1 Overview

In the previous chapter we had discussed about the types of pavements and their failure criteria. There are many factors that affect pavement design which can be classified into four categories as traffic and loading, structural models, material characterization, environment. They will be discussed in detail in this chapter.

20.2 Traffic and loading

Traffic is the most important factor in the pavement design. The key factors include contact pressure, wheel load, axle configuration, moving loads, load, and load repetitions.

Contact pressure: The tyre pressure is an important factor, as it determine the contact area and the contact pressure between the wheel and the pavement surface. Even though the shape of the contact area is elliptical, for sake of simplicity in analysis, a circular area is often considered.

Wheel load: The next important factor is the wheel load which determines the depth of the pavement required to ensure that the subgrade soil is not failed. Wheel configuration affect the stress distribution and deflection within a pavemnet. Many commercial vehicles have dual rear wheels which ensure that the contact pressure is within the limits. The normal practice is to convert dual wheel into an equivalent single wheel load so that the analysis is made simpler.

Axle configuration: The load carrying capacity of the commercial vehicle is further enhanced by the introduction of multiple axles.

Moving loads: The damage to the pavement is much higher if the vehicle is moving at creep speed. Many studies show that when the speed is increased from 2 km/hr to 24 km/hr, the stresses and deflection reduced by 40 per cent.

Repetition of Loads: The influence of traffic on pavement not only depend on the magnitude of the wheel load, but also on the frequency of the load applications. Each load application causes some deformation and the total deformation is the summation of all these. Although the pavement deformation due to single axle load is very small, the cumulative effect of number of load repetition is significant. Therefore, modern design is based on total number of standard axle load (usually 80 kN single axle).

20.3 Structural models

The structural models are various analysis approaches to determine the pavement responses (stresses, strains, and deflections) at various locations in a pavement due to the application of wheel load. The most common structural models are layered elastic model and visco-elastic models.

Layered elastic model: A layered elastic model can compute stresses, strains, and deflections at any point in a pavement structure resulting from the application of a surface load. Layered elastic models assume that each pavement structural layer is homogeneous, isotropic, and linearly elastic. In other words, the material properties are same at every point in a given layer and the layer will rebound to its original form once the load is removed. The layered elastic approach works with relatively simple mathematical models that relates stress, strain, and deformation with wheel loading and material properties like modulus of elasticity and poissons ratio.

20.4 Material characterization

The following material properties are important for both flexible and rigid pavements.

- When pavements are considered as linear elastic, the elastic moduli and poisson ratio of subgrade and each component layer must be specified.
- If the elastic modulus of a material varies with the time of loading, then the resilient modulus, which is elastic modulus under repeated loads, must be selected in accordance with a load duration corresponding to the vehicle speed.
- When a material is considered non-linear elastic, the constitutive equation relating the resilient modulus to the state of the stress must be provided.

However, many of these material properties are used in visco-elastic models which are very complex and in the development stage. This book covers the layered elastic model which require the modulus of elasticity and poisson ratio only.

20.5 Environmental factors

Environmental factors affect the performance of the pavement materials and cause various damages. Environmental factors that affect pavement are of two types, temperature and precipitation and they are discussed below:

20.5.1 Temperature

The effect of temperature on asphalt pavements is different from that of concrete pavements. Temperature affects the resilient modulus of asphalt layers, while it induces curling of concrete slab. In rigid pavements, due to difference in temperatures of top and bottom of slab, temperature stresses or frictional stresses are developed. While in flexible pavement, dynamic modulus of asphaltic concrete varies with temperature. Frost heave causes differential settlements and pavement roughness. Most detrimental effect of frost penetration occurs during the spring break up period when the ice melts and subgrade is a saturated condition.

20.5.2 Precipitation

The precipitation from rain and snow affects the quantity of surface water infiltrating into the subgrade and the depth of ground water table. Poor drainage may bring lack of shear strength, pumping, loss of support, etc.

20.6 Summary

Several factors affecting pavement design were discussed, the most important being wheel load. Since pavements are designed to take moving loads, slow moving loads and static loads can be detrimental to the pavement. Temperature also influences pavement design especially the frost action which is very important in cold countries.

20.7 Problems

1. Factor that least affect the pavement is
   (a) Speed of vehicles
   (b) Wheel load
   (c) Axle configuration
   (d) Load repetition
2. Standard axle load is
   (a) 40kN
   (b) 60kN
   (c) 80kN
   (d) 10kN

20.8 Solutions

1. Factor that least affect the pavement is
   (a) Speed of vehicles$\surd$
   (b) Wheel load
   (c) Axle configuration
   (d) Load repetition
2. Standard axle load is
   (a) 40kN
   (b) 60kN
   (c) 80kN$\surd$
   (d) 10kN