Surface Course:

The surface course is the upper course of the road pavement and is constructed immediately above the base course. The surface course in flexible pavements usually consists of a mixture of mineral aggregates and asphalt. It should be capable of:

- Withstanding high tire pressures,
- Resisting abrasive forces due to traffic,
- Providing a skid resistant driving surface, and
- Preventing the penetration of surface water into the underlying layers.

The thickness of the wearing surface can vary from 75mm to more than 150 mm, depending on the expected traffic on the pavement. It should be noted that the quality of the surface course of a flexible pavement depends on the mix design of the asphalt concrete used.

2.6.1.3 Principle for flexible pavement

The primary function of the pavement structure is to reduce and distribute the surface stresses (contact tire pressure) to an acceptable level at the sub-grade (to a level that prevents permanent deformation). A flexible pavement reduces the stresses by distributing the traffic wheel loads over greater and greater areas, through the individual layers, until stress at the sub-grade is at an acceptable low level. The traffic loads are transmitted to the sub-grade by aggregate-to-aggregate particle contact. Confining pressures (lateral forces due to material weight) in the sub-base and base layers increase the bearing strength of these materials. A cone distribution loads reduces and spreads the stress to sub-grade as shown in Figure 2.9.

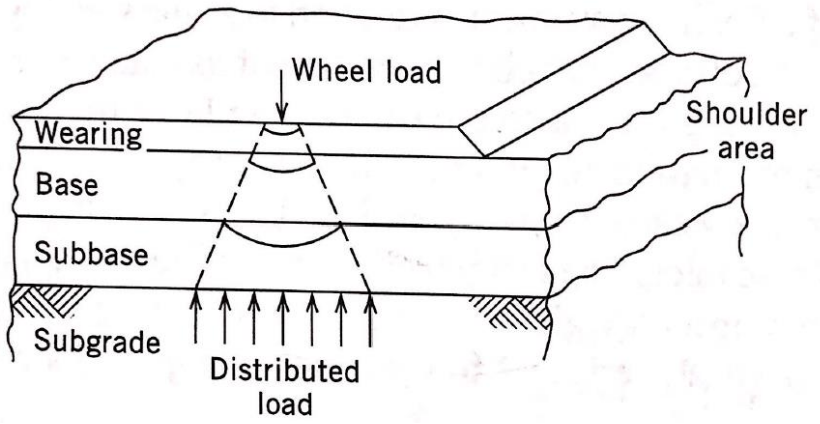

Figure 2.9: Distribution of load on a flexible pavement

2.6.1.3.1 Calculation of flexible pavement stresses and deflections

To design a pavement structure, one must be able to calculate the stresses and deflections in the pavement system. In the simplest case, the wheel load can be assumed to consist of a point load on a single-layer system as shown in Figure 2.10. This type of load and configuration can be analysed with Boussinesq solutions that were derived for soils analysis. The Boussinesq theory assumes that the pavement is one layer thick and the material is elastic, homogeneous and isotropic. The basic equation for the stress at a point in the system is

$$\sigma_z = K\frac{P}{z^2} \quad \text{(U.S. Customary)} \qquad (2.10)$$

$$\sigma_z = 1000K\frac{P}{z^2} \quad \text{(Metric)} \qquad (2.11)$$

Where;

σ_z = stress at point in kPa (Ib/in^2)

P = wheel load in N (Ib)

Z = depth of the point in question in mm (inches), and

K = variable defined as

$$K = \frac{3}{2\pi}\frac{1}{[1+(r/z)^2]^{5/2}} \qquad (2.12)$$

Where

r = radial distance in mm (inches) from the centreline of the point load to the point in question

Although the Boussinesq is useful for beginning the study of pavement stress calculations, it is not very representative of pavement system loading and configuration because it applies to a point load on one layer. A more realistic approach is to expand the point load to an elliptical area that represents a tire foot-print. The tire foot-print can be defined by an equivalent circular area with a radius calculated by

$$a = \sqrt{\frac{P}{p\pi}} \quad \text{……………………(U.S. Customary)………………………(2.13)}$$

$$a = \sqrt{\frac{P}{p\pi/1000}} \quad \text{……………………(Metric)…………………………..(2.14)}$$

Where:

a = equivalent load radius of the tire foot-print in mm (inches)

P = tire load in N (Ib)

p = tire pressure in kPa (Ib/in^2)

The integration of the load from a point to a circular area can be used to determine the stresses and deflections in a one-layer pavement system.

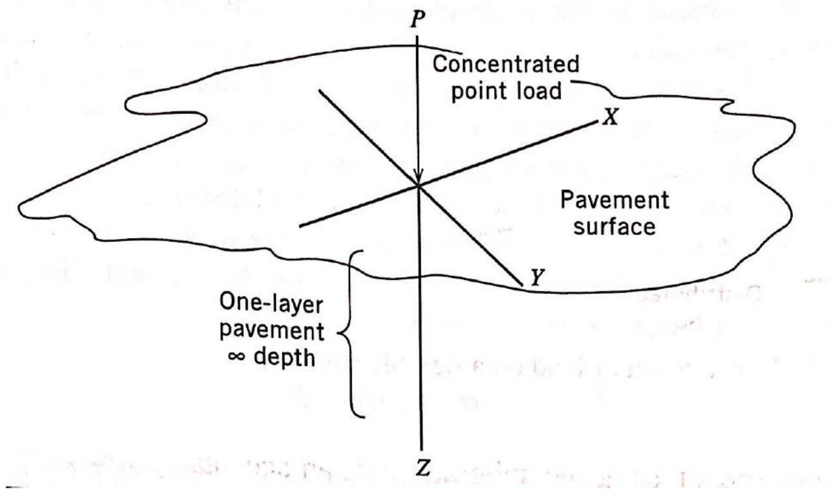

Figure 2.10: Point load on a one-layer pavement

However, Ahlivn and Ulery provided solutions for the evaluation of stresses, strain and deflections at any point in a homogenous half-space. Their work makes it easier to analyse a more complex pavement system than that considered in Boussinesq example. The one-layer equations by Ahlivin and Ulery can be used for material with any Poisson ratio which describes the change in width relative to length when a load is applied along the vertical axis. Based on Ahlvin and Ulery's work, the equation for the calculation of vertical stress is

$$\sigma_z = p(A + B) \quad \text{..........(2.15)}$$

The equation for radial-horizontal stress (which is a cause of pavement cracking) is

$$\sigma_r = p[2\mu A + C + (1 - 2\mu)F] \quad \text{..........(2.16)}$$

The equation for deflection is

$$\Delta_z = \frac{p(1+\mu)a}{E}\left[\frac{z}{a}A + (1-\mu)H\right] \quad \text{..........(2.17)}$$

Where:

σ_z = vertical stress in kPa (Ib/in^2)

σ_r = radial-horizontal stress in kPa (Ib/in^2)

Δ_z = deflection at depth z in mm (inches)

p = pressure due to the tire load in kPa (Ib/in^2)

μ = Poisson ratio

E = modulus of elasticity (known as Young's modulus, the ratio of stress to strain as a load is applied to a material in kPa (Ib/in^2) and

A,B,C,F and H = function values as presented in Table 2.3 that depends on z/a and r/a, the depth in radii and offset distance in radii respectively

Where

z = depth of the point in question in mm (inches)

r = radial distance in mm (inches) from the centreline of the point load to the point in question

a = equivalent load radius of the tire foot-print in mm (inches)

Example 2.1: *A tire with 689 kPa air pressure distributes a load over an area with a circular contact radius, a, of 127mm. The pavement was constructed with a material that has a modules of elasticity of 345000 kPa and a Poisson ratio of 0.45. Calculate the radial-horizontal stress and deflection at a point the pavement surface under the centre of the ire load. Also, calculate the radial-horizontal stress and deflection at a point at a depth of 508mm and radial distance of 254mm from the centre of the tire load. (USE: Ahlvin and Ulery equations).*

2.6.1.3.1 Design of thickness layers based on AASHTO 1993

There are several accepted flexible pavement design procedures, including the Asphalt Institute method, the National Stone Association procedure, and the Shell procedure. Most of the procedures have been field verified and used by highway agencies for several years. The selection of one procedure over another is usually based on a highway agency's experience and satisfaction with design results.

A widely accepted flexible pavement design procedure is presented in the AASHTO Guide for design of pavement structures, which is published by the American Association of State Highway and Transportation Officials. This design method is based on AASHO test results conducted in Illinois, USA. The procedure was first published in 1972, with latest revision in 1993. The factors considered in this design methods are as follows:

- *Pavement performance*
- *Traffic*
- *Roadbed/Subgrade soils*
- *Construction materials*
- *Environmental factors*
- *Drainage*
- *Reliability*

Pavement performance

There are two factors considered under the performance of the pavement structure, these are

- ✓ Structural performance: this is related to the physical factors that affect load-carrying capacity.

- ✓ Functional performance: this is related to factors that affect the riding quality.

A serviceability performance concept was used for pavement performance quantification. Under this concept, a present serviceability index (PSI) was developed which range from 1 to 5 (typical condition after pavement construction)

For the purpose of pavement design procedure, two serviceability indices are used:

- ❖ Initial serviceability index (pi): serviceability index immediately after pavement construction.
- ❖ Final serviceability index (pt): serviceability index at which pavement needs maintenance.

pi: 4.2 for flexible pavement

pt:

- 2.5 – 3 for major highways
- 2 for lower classification
- 1.5 for extreme economic conditions (limited fund)

ΔPSI = pi - pt

<u>Subgrade soils condition</u>

In AASHTO 1993 procedure, the resilient modulus (Mr) is used to represent subgrade property. However, due to the availability and cheapness of the CBR test as compared with resilient modulus test, the following formula are used

Mr = 1500 x CBR