The Design Process

Three main steps in designing a new road pavement

- Estimate the amount of traffic and the cumulative number of equivalent standard axles that will use the road over the selected design life.
- Assess the strength of the subgrade soil over which the road is to be built
- Select the most economical combination of pavement materials and layer thicknesses that will provide satisfactory use over the design life of the pavement.

Repetition of Load

- When load is passing on a road again and again the wheels of vehicle may damage the road. When a wheel passes on the road one time damage will be very small but when passes on the road many times the structure of road damages.
- Single application of wheel load may cause very small deformation to the road pavement or to subgrade but the repeated application of the same wheel load may cause appreciable permanent deformation in the pavement or subgrade and may become the cause of the road failure.

Repetition of Load (contd.)

- Permanent deformation may be due to accumulation of the plastic deformation due to fatigue in the paving materials or subgrade or both.
- Fatigue is the repeated application of the load. It is the phenomena of repetitive load induced cracking due to repetitive stress below the ultimate strength of the material. Fatigue relates to the soil failure due to repeated loads.

Effect of Load Impact

- Sudden application of load in very short time is called impact load.
- The effect of impact of load is maximum at joints which are present in rigid pavements. It may result in differential settlement of slabs which is very dangerous.

Effect of Load Impact (contd.)

- It is reasonable to make no allowance for the impact when designing roads with well finished surfaces and in no case to make an allowance greater than 30%
- Effect of impact depends upon

1. Wheel Load
2. Vehicle Speed
3. Vehicle Characteristics
4. Tire Type
5. Road Irregularity

Axle Load and Wheel Load

<u>Highways</u>

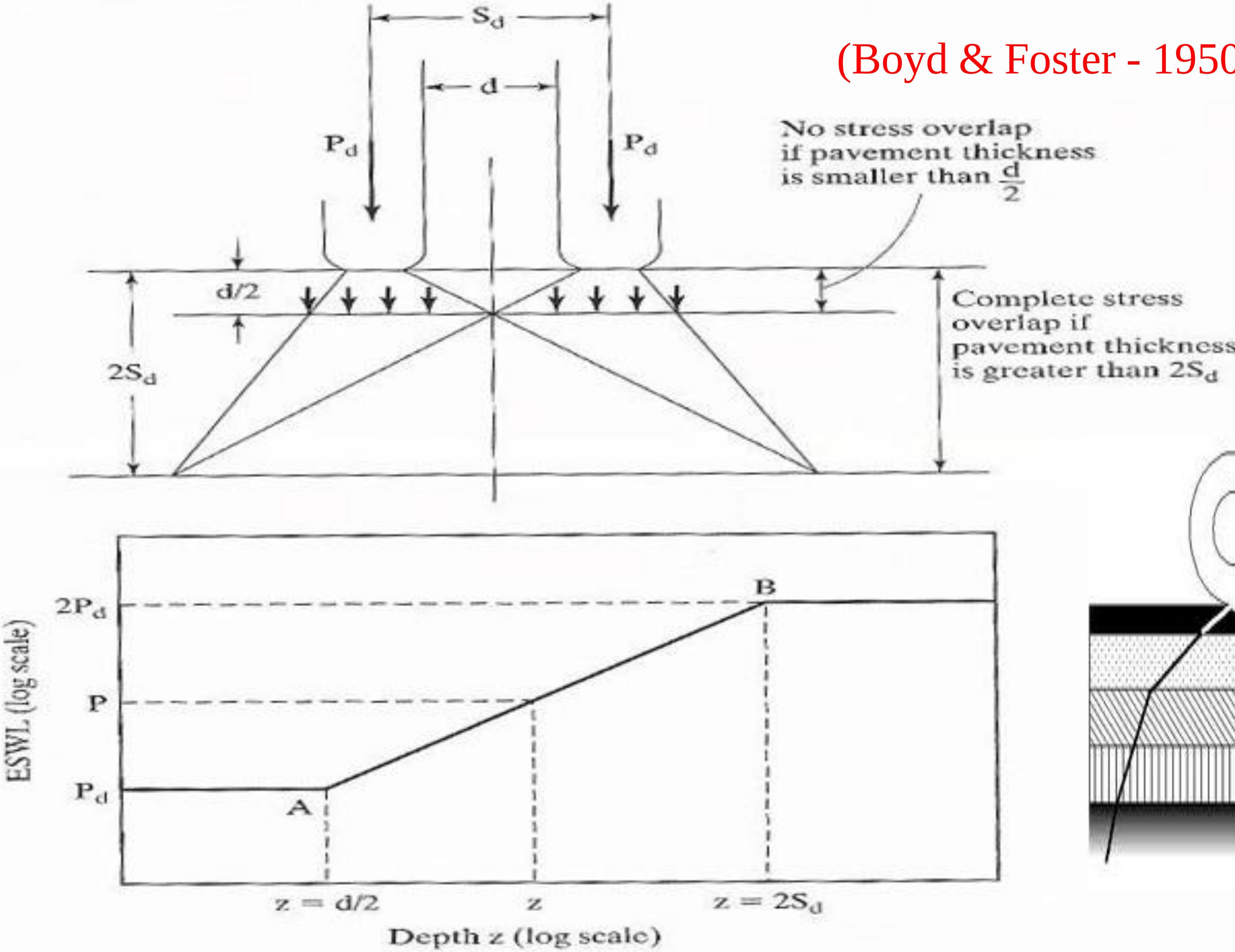
AASHTO has specified 18,000 lb. (18 kips, 8165 kg, 80 kN, 8.0 tonnes) as the standard single axle load. Since an axle has two ends, the maximum wheel load can be taken as half of the standard single axle load i.e., 9,000 lb. (9 kips, 4083 kg, 40 kN, 4.0 tonnes)

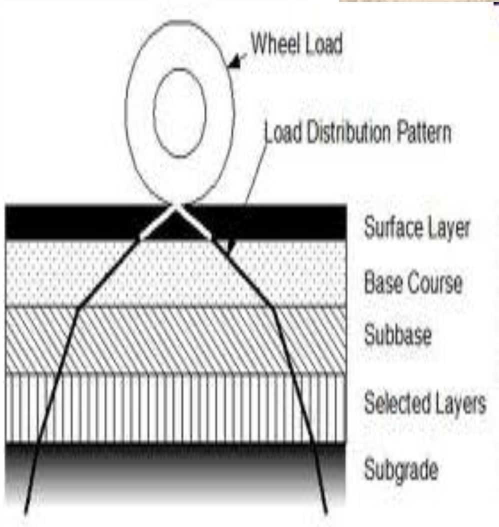
<u>Airfields</u>

The design gear load will be that of the heaviest plane which will utilize the field. Gear loads (load on one set of wheels) generally range between about 8 kips and up to as high as 200 kips

Equivalent Single Wheel Load (ESWL)

(Boyd & Foster - 1950)





Equivalent Single Wheel load (contd.)

- Equivalent Single Wheel is the wheel (single) that produces same stress at any point as produced by two wheels.
- Boyd and Foster (1950) presented a semi-rational method for determining ESWL which had been used by the Corps of Engineers to produce dual-wheel design criteria from single-wheel criteria. The method assumes that ESWL varies with the pavement , as shown in Figure.

Equivalent Single Wheel load (contd.)

- For thickness smaller than half the clearance between dual tires, the ESWL is equal to one-half the total load, indicating that the subgrade vertical stresses caused by the two wheels do not overlap.
- For thickness greater than twice the center to center spacing of tires, the ESWL is equal to the total load, indicating that the subgrade stresses due to the two wheels overlap completely.

Equivalent Single Wheel load (contd.)

- By assuming a straight line relationship between pavement thickness and wheel load on logarithmic scales, the ESWL for any intermediate thicknesses can be easily determined.
- After the ESWL for dual wheels is found, the procedure can be applied to tandem wheels

Equivalent Single Wheel load (contd.)

- Instead of plotting, it is more convenient to compute the ESWL by

  $$\log_{10}(ESWL) = \log_{10} P_d + \frac{0.301 \log_{10}(2z/d)}{\log_{10}(4S_d/d)}$$

  where

  P_d = Load on one of the dual tires

  z = Pavement thickness

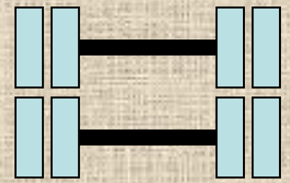
  d = Clearance between dual tires

  S_d = Center to center spacing between dual tires

Axle Configurations

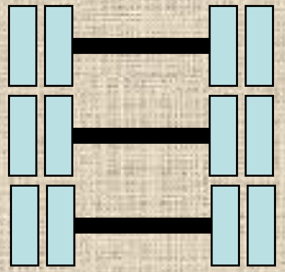
An **axle** is a central shaft for a rotating wheel or gear

Single Axle With Single Wheel



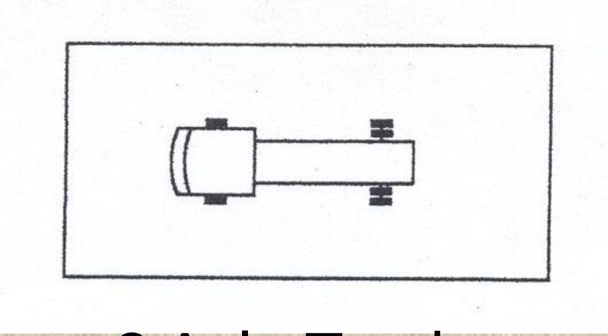
Tandem Axle

Single Axle With Dual Wheel

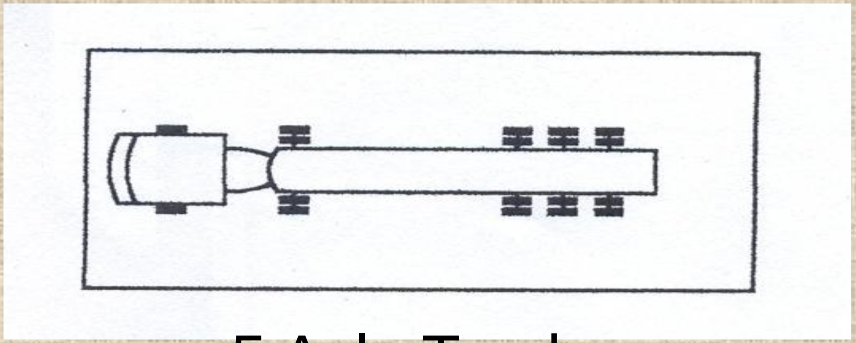


Tridem Axle

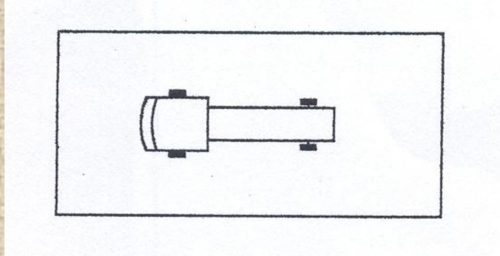
Truck Configuration



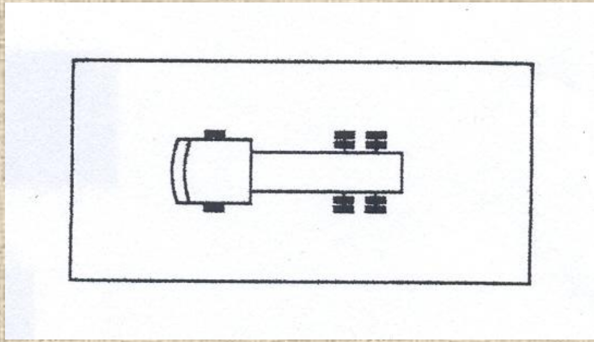
2 Axle Truck



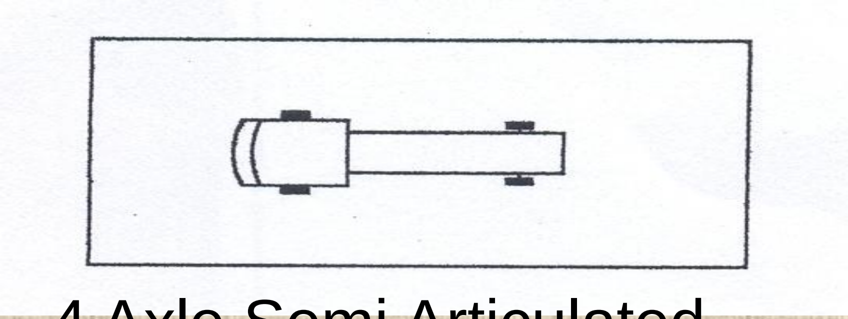
5 Axle Truck



LCV



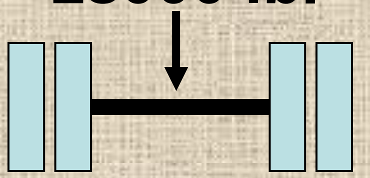
3 Axle Truck



4 Axle Semi Articulated

Standard Axle

Single axle with dual wheels carrying a load of 80 kN (8 tonnes or 18000 lb.) is defined as standard axle



Standard Axle

Equivalent Axle Load Factor

- An equivalent axle load factor (EALF) defines the damage per pass to a pavement by the axle in question relative to the damage per pass of a standard axle load, usually the 18-kips (80 kN) single axle load.
- The design is based on the total number of passes of the standard axle load during the design period, defined as the equivalent single axle load (ESAL) and computed by

$$ESAL = \sum_{i=1}^{n} F_i \, n_i$$

Where

n = Number of axle load groups

F_i = EALF for the ith axle load group

n_i = Number of passes of the ith axle load group during the design period

Equivalent Axle Load Factor (contd.)

- The EALF depends on the type of pavements, thickness or structural capacity, and the terminal conditions at which the pavement is considered failed. Most of the EALFs in use today are based on experience. One of the most widely used methods is based on the empirical equations developed from the AASHO Road Test (AASHTO 1972). The EALF can also be determined theoretically based on the critical stresses and strains in the pavement and the failure criteria.
- EALF is also known as ‘Damaging Factor’ or ‘Equivalence Factor’.

Equivalent Axle Load Factor (contd.)

- It is reasonable to assume that tensile strains are directly proportional to axle loads, or

$$EALF = \left[\frac{\text{Load on a single axle i.e., actual load}}{\text{Load on a standard axle}}\right]^{n'}$$

- For tandem or tridem axles

$$EALF = \left[\frac{\text{Load on given axles i.e., actual load}}{\text{Load on standard axles*}}\right]^{n'}$$

**having same number of axles*

$n' = 4$	According to AASHTO
$n' = 4.5$	According to Road Note-31