Design Factors

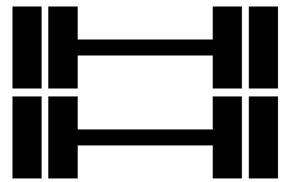
- Design Factors can be divided into four broad categories:
- Traffic and Loading
- Environmental Factors
- Material Characteristics
- Failure Criteria

Traffic & Loading

- Axle loads
- Repetitions of Load
- Contact Area
- Vehicle Speeds

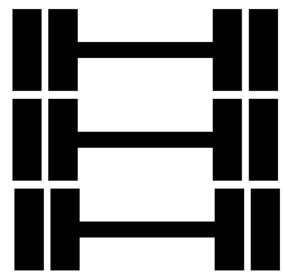
Axle Configurations and Loads

Single Axle With Single Wheel
(Legal Axle Load = 6t)



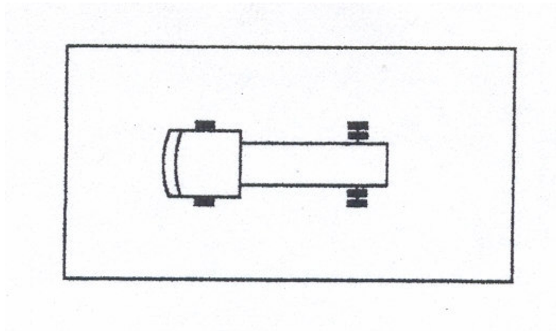
Tandem Axle
(Legal Axle Load = 18t)

Single Axle With Dual Wheel
(Legal Axle Load = 10t)

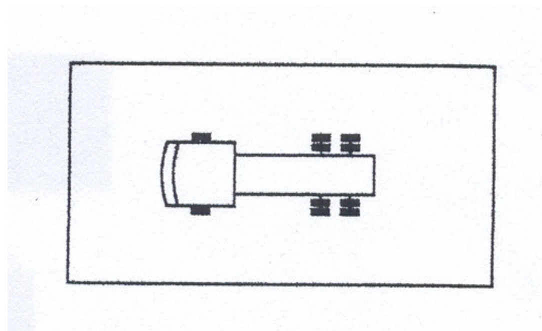


Tridem Axle
(Legal Axle Load = 24t)

Truck Configuration

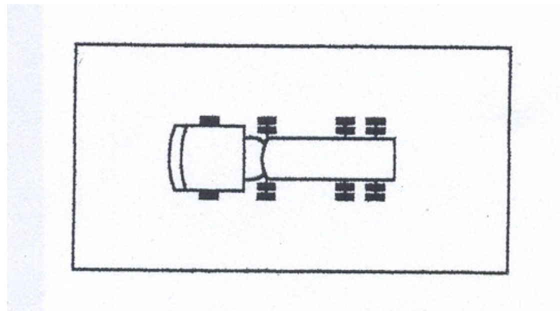


2 Axle Truck – 16t

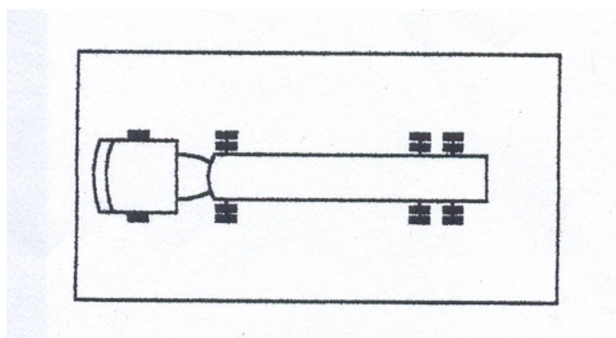


3 Axle Truck – 24t

Truck Configuration

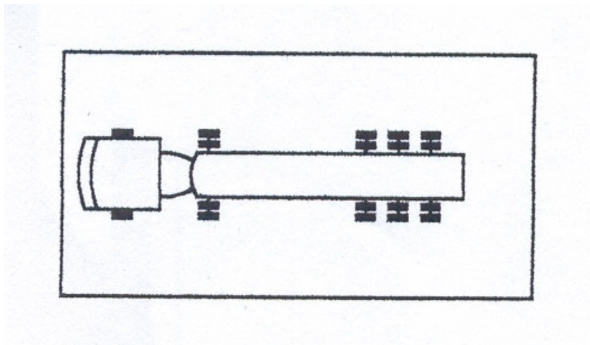


4 Axle Semi Articulated – 34t

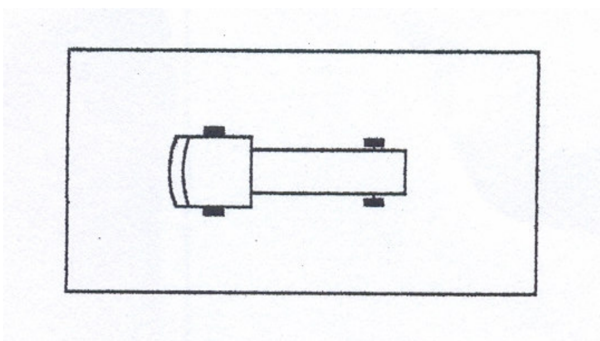


4 Axle Articulated

Truck Configuration

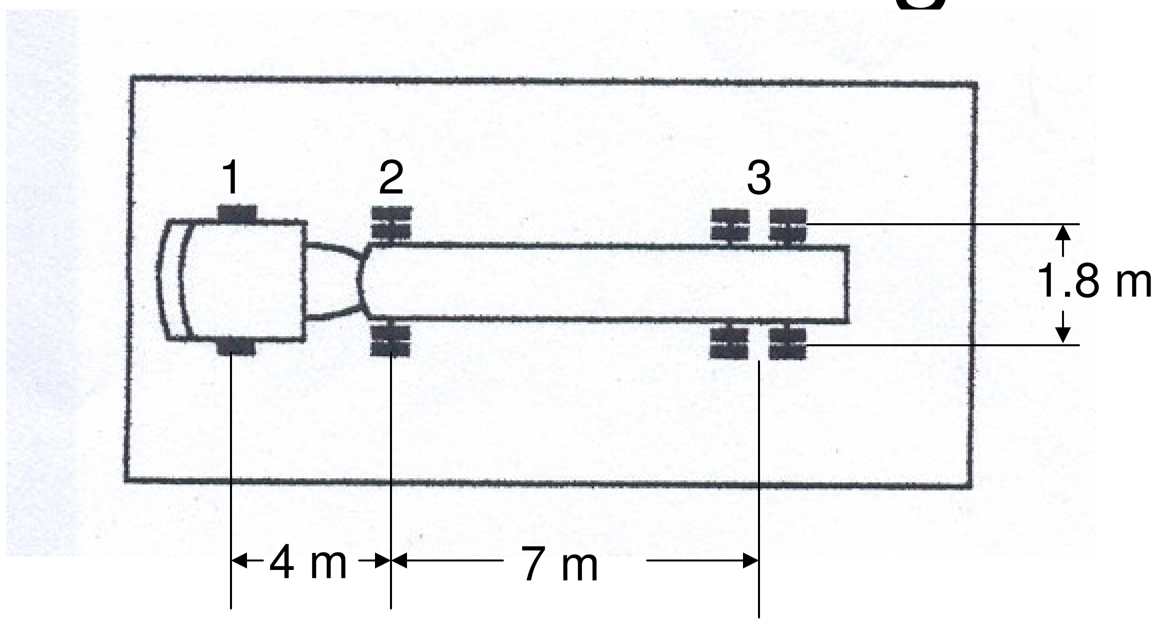


5 Axle Truck – 40t



LCV

Effect of Wheel Configuration



•The effect of axles 1, 2 and 3 on stresses and strains within pavement layers should be considered independently.

•Within a group of axles, each axle can not be considered as independent.

•In the design of flexible pavements by layer theory, only the wheels on one side are considered.

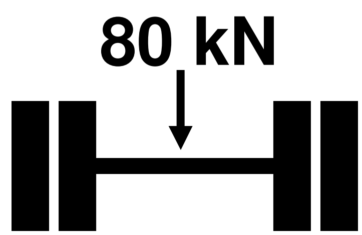
•In the design of rigid pavements by plate theory, the wheels on both sides (even at a distance more than 1.8 m) are usually considered.

Repetitions of Axle Loads

- The damage caused by each axle depends on its load, configuration and repetitions
- It is possible to evaluate the damage caused by the repetitions of each axle load group
- Instead of analysing each axle load group separately, they can be converted into equivalent repetitions of a **standard axle** using **equivalent axle load factors**

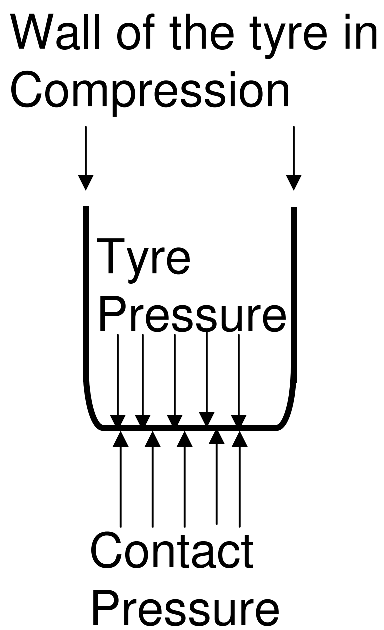
Standard Axle

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



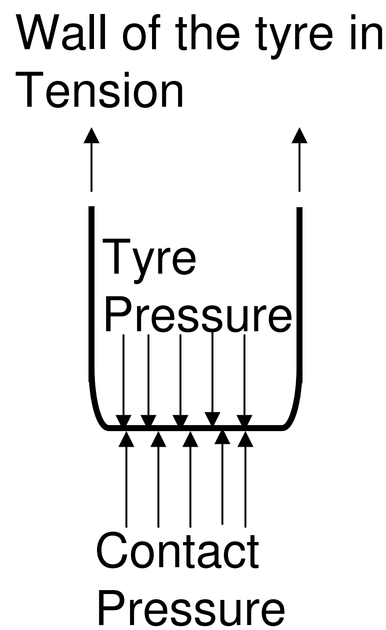
Standard Axle

Relationship between Contact Pressure and Tyre Pressure



Low Pressure Tyre

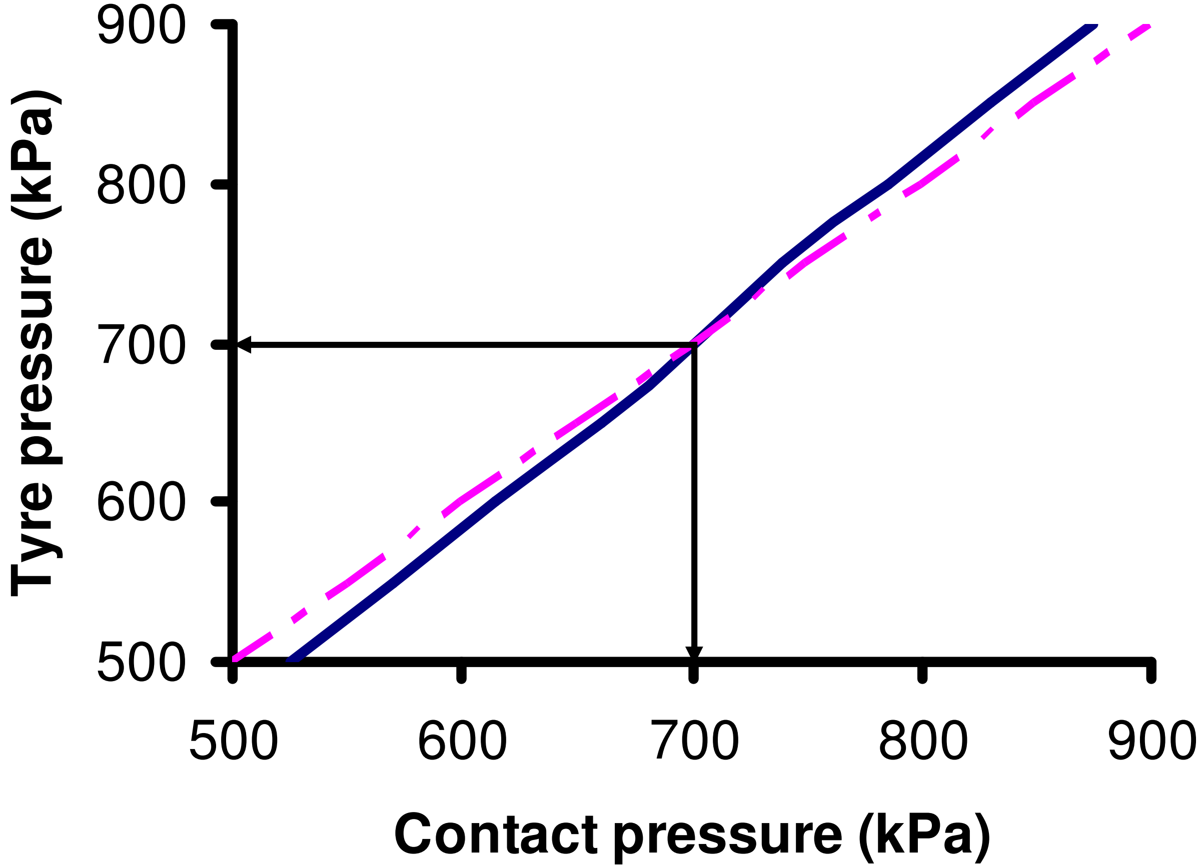
Contact Pressure > Tyre Pressure



High Pressure Tyre

Contact Pressure < Tyre Pressure

Relationship between Contact Pressure and Tyre Pressure



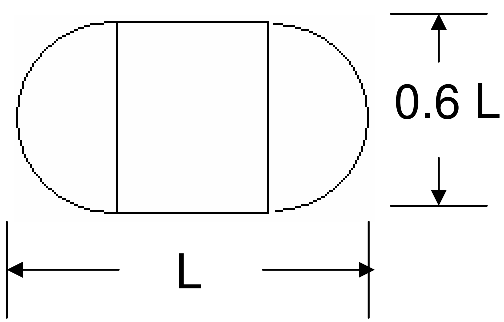
Shape of Contact Area

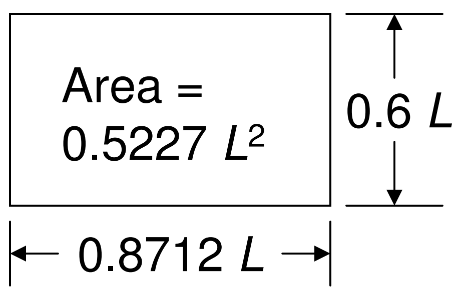
- The true shape of contact area is elliptical
- In the analysis of flexible pavements, however, it is approximated to circular shape for the ease of calculations
- Thus, the radius of the contact area (*a*) for a wheel load *P* and contact pressure *p* can be found out as

$$a = \sqrt{\frac{P}{p\pi}}$$

Shape of Contact Area

- The contact area can not be approximated to a circular shape in the case of rigid pavements, as the error committed by this assumption is significant
- For the convenience of calculations, the elliptical shape is approximated by a rectangle and two semicircles as





Equivalent Area

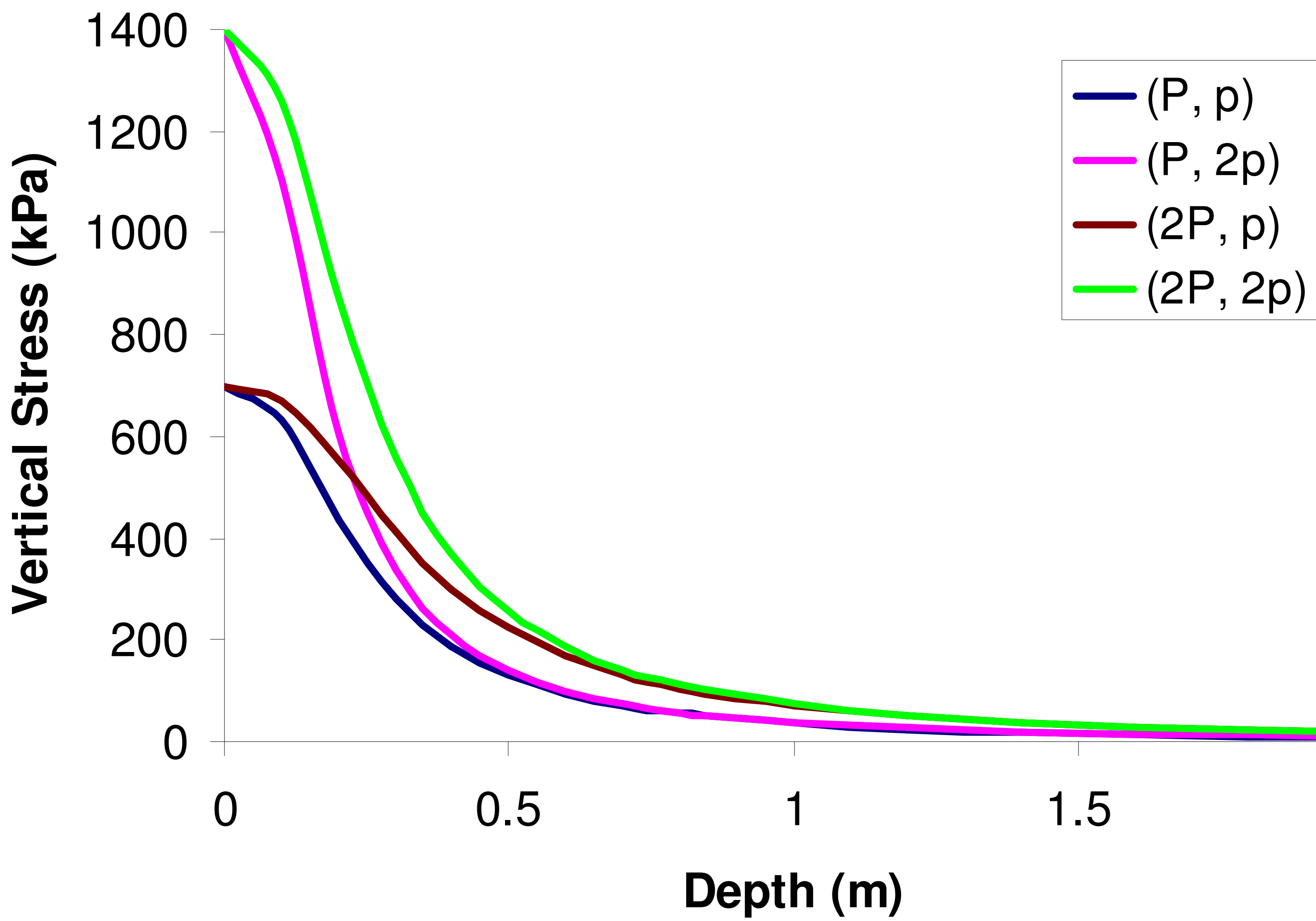
- Therefore, contact area A_c is given by

$A_c = \pi\,(0.3L)^2 + (0.4L)(0.3L)$

$\quad = 0.5227\,L^2$

- In analysing the rigid pavement using FEM, rectangular area is assumed with length 0.8712 L and width 0.6L

Wheel Load (P) Vs Contact Pressure (p)



Wheel Load Vs Contact Presssure

- The influence of contact pressure on stress levels in base, subbase and subgrade layers are marginal
- The magnitude of contact pressure determines the quality and thickness of the wearing and binder courses
- The influence of the magnitude of the wheel load on stress levels in base, subbase and subgrade layers is significant
- The total thickness of the pavement is mainly determined by the magnitude of the load and not the contact pressure

Vehicle Speed

- Speed of vehicles is directly related to the duration of loading on viscoelastic layers
- For elastic layers, the resilient modulus of each layer should be selected based on the vehicle speed
- Greater the speed, the larger the modulus, and the smaller the strains in the pavement

Environment

- Temperature – Effect on Asphalt Layers
  - The elastic and viscoelastic properties of asphaltic concrete are altered by pavement temperature
  - In hot weather the pavement temperatures are significantly higher than the ambient atmosperic temperatures and the asphalt layers may lose their stiffness
  - In cold weather the resulting low temperatures cause the asphalt layers to become rigid reducing the vertical compressive strains. Low temperatures, however, may cause asphalt layers to crack
- Temperature – Effect on Rigid Pavement
  - Temperature differential between top and bottom of concrete pavements affects not only the curling stress but also the slab-subgrade contact
    - During day time, when the temperature at top is higher than that at bottom, the slab curls down and the interior of the slab may not be in contact with the subgrade
    - During night time, when the temperature at top is lower than that at bottom, the slab curls upwards leaving the edge and corner out of contact with subgrade
    - The loss of subgrade contact will effect the wheel load stresses
  - The difference between maximum and minimum temperature also causes the joint to open effecting the load transfer

Moisture Variations

- Moisture variations in pavement layers may be caused due to precipitation or a high ground water table
- Proper surface and subsurface drainage measures will reduce the moisture variations in pavement layers
- The water table should be kept at least 1.0 m below the pavement surface
- The ill effects of poor drainage include loss of subgrade stiffness in flexible pavements and pumping and loss of support in rigid pavements
- In cold climates subgrades will become very stiff in winter due to frost formation and weaker in the spring due to the melting of frost saturating the subgrade

Material

- In mechanistic method of pavement design, properties of materials must be specified for determining stresses, strains and deflections
- Flexible pavements
  - Resilient modulus and poisson ratio of subgrade and untreated granular layers
  - Dynamic modulus, temperature sensitivity and poisson ratio of asphaltic layers
- Rigid pavements
  - Modulus of subgrade reaction
  - Modulus of elasticity, poisson ratio, flexural strength and coefficient of thermal expansion of concrete
  - Allowable bearing stress in concrete for dowel bars

Failure Criteria

- In empirical mechanistic method of pavement design number of failure criteria are adopted depending on the distress type
- Following failure criteria are normally adopted
- Flexible Pavements
  - Fatigue cracking
  - Rutting
  - Thermal cracking
- Rigid Pavements
  - Fatigue cracking
  - Pumping or erosion
  - Faulting/spalling/joint deterioration

Highway Vs Airfield Pavements

- Loading on a highway pavement is to the following extent: (axle load)
  - Single axle: 100 kN
  - Tandem Axle: 180 kN
  - Tridem Axle: 240 kN
- Tyre pressure: up to 800 kPa
- Repetitions: 1000 to 2000 trucks per day per lane

- Loading on an airfield pavement is to the following extent: (load on each landing gear)
  - Single wheel: 160 kN
  - Dual wheel: 430 kN
  - Dual in tandem: 1000 kN
  - Double dual-in-tandem:1970 kN
  - A380: 2800 kN
- Tyre pressure: up to 1580 kPa
- Repetitions: 20000 to 40000 coverages† during life time

†One coverage results when each point on the traffic area of the pavement has been traversed one time by a wheel

Highway Vs Airfield Pavements

- Lateral placement of traffic:
  - Wheel path within 0.9 to 1.2 m from pavement edge

- Lateral placement of traffic:
  - Concentrated primarily in the centre of runway
  - Mostly distributed over central 20 m of the runway width