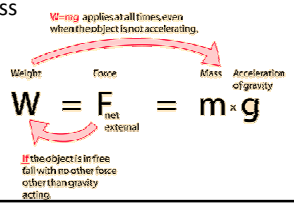
Concepts and Terminologies

Mass

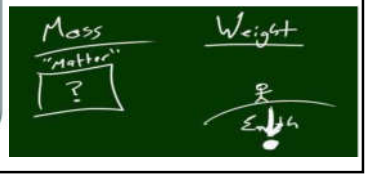
- Quantity of matter contained in a body is called its mass.
- Every object has a mass
- Mass has no particular direction
- Generally measured in pounds (Ibs), Kilo grams (kgs) and tons (T)
- 1000Kg=1T
- 1Kg= 2.204 Ibs

Weight

- It is a force
- Downward effect of mass due to the gravity of the earth
- In other words it is a force with which earths attracts a body/object towards its center.
- Weight of an object is proportional to its mass



Mass	Weight
is measured in kilograms	is measured in Newtons
always remains the same	can change with location
is closely related to inertia	is closely related to gravity
can NOT be measured directly	can be measured directly using a scale

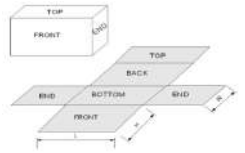


Density

- Density is mass per unit volume of a material
- D=m/V
- Measured in kg/m^3, lb/ft^3,g/cc
- Rock 2500-3000 kg/m^3
- Soil 1500-2000 kg/m^3
- Unbound material 2200 kg/m^3
- Asphalt 2400 kg/m^3

Surface Area, Density and Volume

- Sum of the area of all the surfaces/faces of a material
- For the same volume, a single unit of a material will have a higher density in comparison to if it is crushed into pieces.
- In other words a crushed material will occupy more volume because of increase in surface area.



Unit Weight

- For convenience, often densities are replaced by unit weights
- It is defined as weight per unit volume of a material
- Expressed as kN/m^3, or N/m^3
- Pavement layers unit weights lie in the range
- 18-24 kN/m^3

Specific Gravity

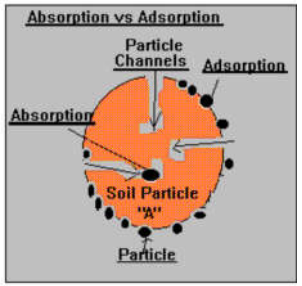
- How much a substance is heavier or lighter than water
- A material may have a higher or lower specific gravity depending upon the ratio of their densities to that of water
- Water has specific gravity of 1
- If a material is denser than water, it will have a specific gravity greater than 1.

Specific Gravity

- Bitumen has a specific gravity of 1.02 to 1.03.
- Density of a material can be determined by multiplying its specific gravity with density of water.
- Water
- 1000 kg/m^3, 62.4 lb/ft^3, 1g/cc

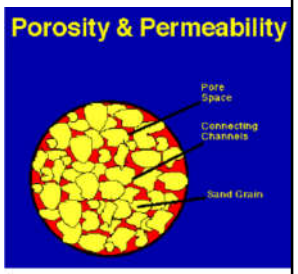
Absorption and Adsorption

- The increase in mass of a material due to the water entering into the pores of the material is referred to as absorption.
- Adsorption is defined as the water molecules/ vapors adhering to the surface of the material.



Permeability and Porosity

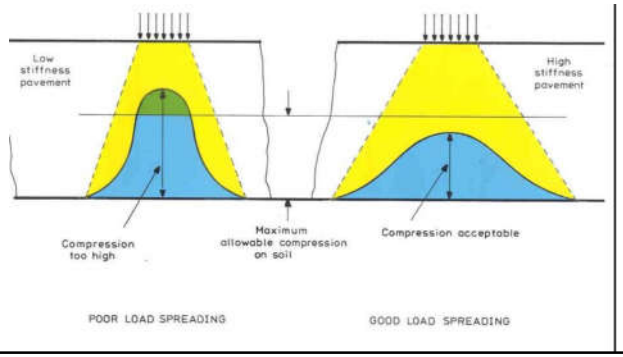
- Ability of a material to allow water to pass through is called its permeability
- Porosity is the property of a material to retain water because of presence of pores.
- A material may be highly porous but if the pore spaces are not connected it will not allow any flow of liquid though it.



Force and Load

- Force
  - Weight is form of a force
  - Measured in N or kN
  - Examples of force on a pavement structure are the forces generated by e.g., acceleration, braking, impact etc.
- Load
  - It is also a form of force
  - In pavement engineering it is considered as the weight coming form the tyres of vehicle.

Load on Pavement



Energy

- Capacity of doing work
- Measured in (force x distance) units
- It has the units of work and is expressed as; N.m or Joules (in heat units)
- Strain Energy
  - It is the potential energy stored in a deformed body

Strength

- It is the capacity to resist a demand (e.g., load, stress)
- After that capacity or limit the material will fail
- May be expressed as a limiting stress or a failure load etc.
- The term is used both for humans and other materials

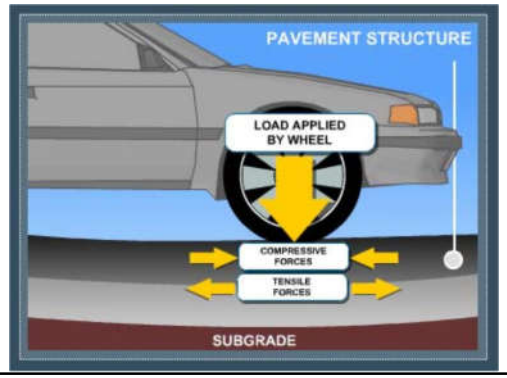
Stress and Pressure

- Both are defined as force per unit area
- Units of N/m^2 or Pascal.
- The term stress is generally used for solids while pressure is used for liquids and gases
- In Pavement engineering it is important to not only know the load on a pavement structure but also the intensity of that load (contact stress)

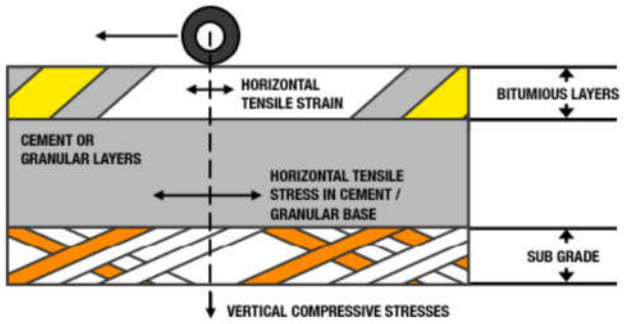
Strain

- Strain is often the consequence of stress
- It is expressed as the change in dimension divided by the original dimension i.e. the degree to which a material deforms
- It may be expressed as percentage (%) but generally as small strains are generated within a pavements, the term micro-strain is used to describe strain in a pavement structure

Stresses and Strains in a Pavement



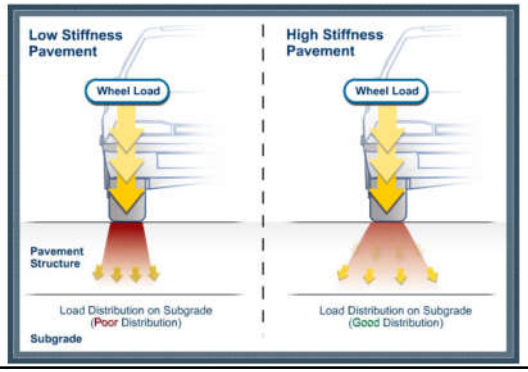
Stresses and Strains in a Pavement



Stiffness (Rigidity)

- Resistance of a material to deformation/deflection or stress
- Relationship between load and deformation (ratio of a wheel load to pavement deformation)
- It does not have one specific definition and use
- Examples;
- Bending stiffness, shear stiffness etc.

Pavement Stiffness



Elasticity and Resilience

- Elasticity
  - Property of a material to come back to its original position after deformation when a load is removed
- Resilience
  - It is the capacity of a material to absorb energy elastically (without undergoing a permanent distortion)

Plasticity, ductility and toughness

- Plasticity
  - Ability of a material to undergo some degree or permanent deformation without failure
- Ductility
  - The property enables a material to draw out into a thin wire on application of load
- Toughness
  - Ability of a material to withstand both plastic and elastic deformations

Fatigue Strength and Creep

- Fatigue Strength
  - The fatigue strength of a material is the maximum stress at which failure may occur after a certain number of cyclic load applications (repeated alternating stresses over an extended period of time)
- Creep
  - Deformation under sustained load. The slow and continuous elongation of a material with time at constant stress and high temperature below elastic limit is called creep.

Modulus and Elastic Modulus

- Modulus
  - It is the ratio of applied stress to induced strain (stress/strain)
- Modulus of Elasticity
  - Ratio of applied stress to induced strain assuming that the behavior of the concerned material is linear (stress directly proportional to strain)
  - Concrete behaves linearly under normal working conditions
  - Un-bound material is non-linear
  - Asphalt stiffness varies w.r.t temperature and loading rate and therefore cannot have one elastic modulus

Stiffness and Resilient Modulus

- Stiffness Modulus
  - This term is generally used for asphalt as it has a viscous (temperature-dependent) component to its behavior
- Resilient Modulus
  - The term is used for soils and other unbound materials because of their non-linear behavior

Bitumen Mastic

- It is combination of bitumen and filler
- Amount of filler may vary depending upon the use of mastic
- Common examples are hydrated lime and lime stone filler
- Generally used for crack filling



Macadam

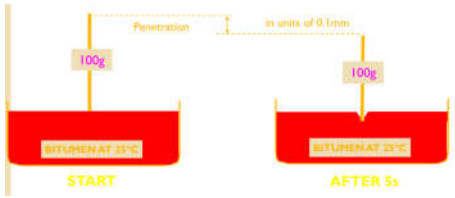
- Named after an Engineer John Loudon Macadam, who was one of the pioneers in road construction and is considered as father of the modern road-building in the UK
- Macadam is a simplified type of road construction consisting of single-sized aggregate layers of small stones, with a coating of binder as a cementing agent
- However, the term bituminous macadam nowadays includes a wide range of different mixtures, all having the property that they need no further treatment in order to form the finished pavement surface. Options range dense mixtures (having broad aggregate gradation) often known as asphalt concrete, through stone mastic asphalt (with slightly coarser gradation) to porous asphalt (almost single-sized)


Basic Bitumen Tests

- Needle Penetration Test
- Ring and Ball Softening Point Test
- Ductility Test

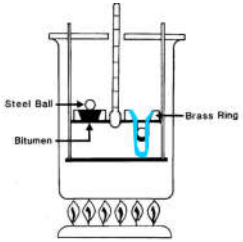
Penetration Test

- Temperature 25 ^{0}C
- Load 100g
- Loading Time 5 seconds

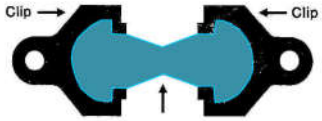


Softening Point Test

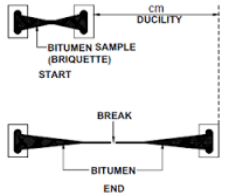
- Temperature increase rate 5^{0}C/min
- Fall distance 25mm



Ductility Test



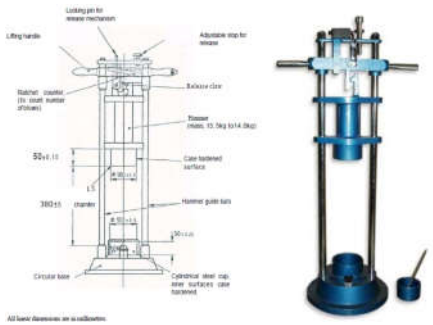
Briquette: minimum cross-sectional area 100mm^2



Aggregate Tests

- Aggregate Impact Value Test
  - Aggregate used in road construction should be strong enough to resist crushing under traffic
  - Toughness is the property of a material to resist impact. Due to traffic loads, the road stones are subjected to the pounding action or impact and there is possibility of stones breaking into smaller pieces. The road aggregates should therefore be tough enough to resist fracture under impact.

Aggregate Impact Value Test



Aggregate Impact Value Test

AIV (%)	Quality
< 10	Exceptionally strong
10-20	Strong
10-30	Satisfactory
> 35	Weak

Los-Angeles Abrasion Test

- Material used in highway pavements should be hard and resist wear due to the loading from compaction equipment, the polishing effect of traffic and the internal abrasive effect of repeated loadings.
- The Los-Angeles test has been widely used as an indicator of the relative quality or competence of various sources of aggregate having similar mineral composition.

Los-Angeles Abrasion Test

- Aggregates having abrasion value greater than 50% are rarely allowed.
- Maximum recommended abrasion value for wearing course is 40% and for base course is 50%.

Aggregates Shape Test

- Tell about internal friction properties of aggregates
- Internal friction properties resist movement of aggregates past each other
- Resistance to movement is achieved by inter-locking and surface friction
- Flaky and elongated break under load

Aggregates Shape Test

- F.I and E.I for W.C should not be greater than 10%
- F.I and E.I for B.C should not be greater than 15%

THANKS!!!