Pavement Types and Design Factors

Historical Developments

- Prior to the early 1920s the thickness of pavement was based purely on experience
- Pavement design has gradually evolved, since then, from art to science
- Empiricism played an important role till recently in pavement design
- The methods of flexible pavement design can be classified into five categories:

Historical Developments – Flexible Pavements

- Empirical methods
  - Without soil strength test (GI method, 1929)
  - With soil strength test (CBR method, 1929)
- Limiting shear failure methods
  - Terzagi's (1943) bearing capacity formula was applied to determine the pavement thickness
- Limiting deflection methods
  - Pavement thickness was determined by limiting the surface deflection below an allowable value using Burmister's (1943) two layer theory
- Regression methods
  - based on pavement performance or road tests (AASHTO, 1961)
- Empirical – mechanistic methods
  - This method of design is based on mechanics of materials that relates an input, such as a wheel load, to an out put or pavement response, such as stress or strain.
  - Shell method, 1977
  - Asphalt Institute method, 1981

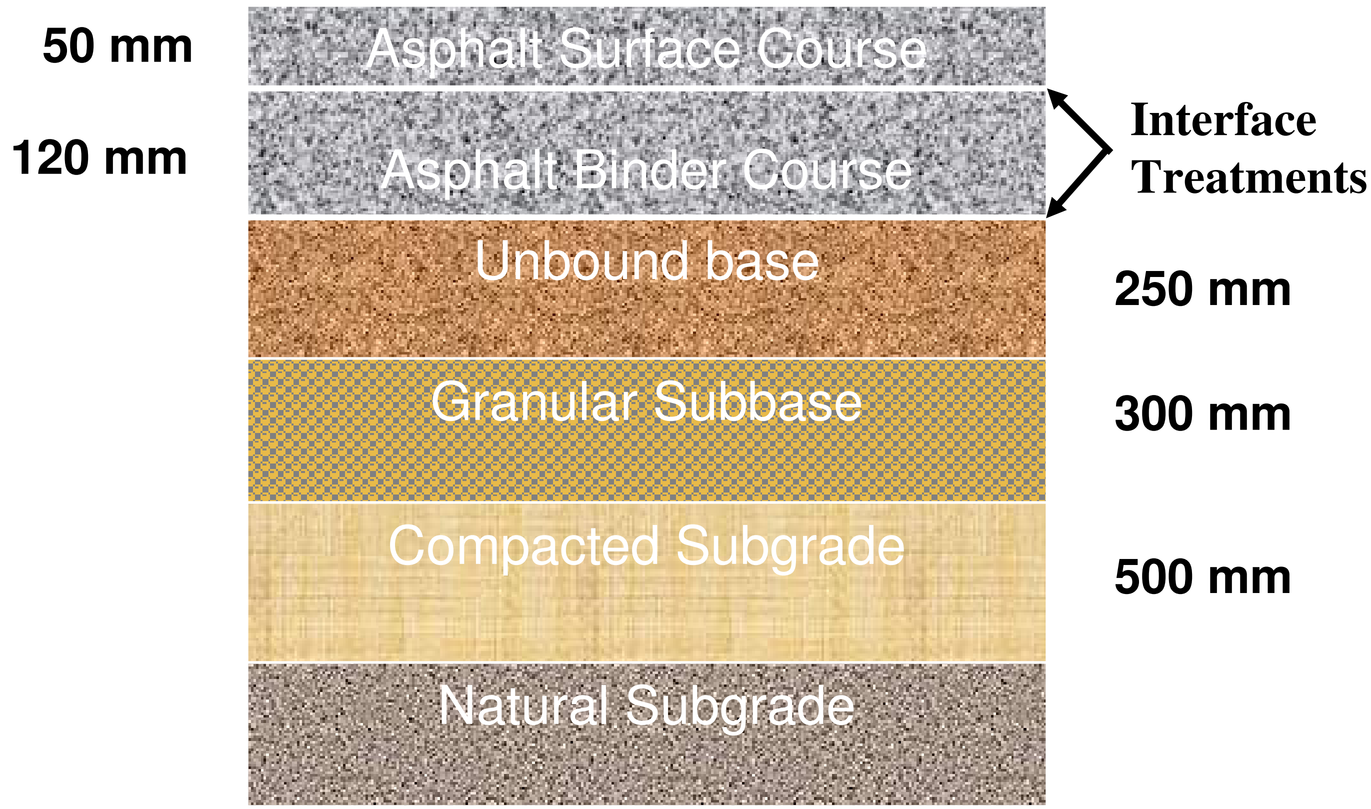
Historical Developments – Rigid Pavements

- Contrary to flexible pavements, rigid pavements were designed from the beginning using analytical solutions
- Flexural stress in concrete has long been considered as a major, or even the only design factor
- Analytical Solutions
  - Goldbeck's (1919) Formula
  - Westergaard's (1926 to 1948) analysis based on liquid foundtations
  - Pickett's (1951) analysis based on solid foundations – influence charts
- Numerical Solutions
  - Discrete–element method: Hudson and Matlock (1966) aplied this method assuming the subgrade to be a dense liquid
  - Finite element method: Huang (1974) applied FEM for the analysis of jointed slabs on liquid as well as solid foundtations
- Other developments include fatigue damage and pumping erosion

Pavement Types

- Flexible Pavements
  - Component layers : subgrade, drainage layer/sub-base, base course, binder course and surfacing course
- Rigid Pavements
  - Component layers : subgrade, drainage layer, sub-base (DLC), CC slab (PQC)
- Semi-rigid / Composite pavements

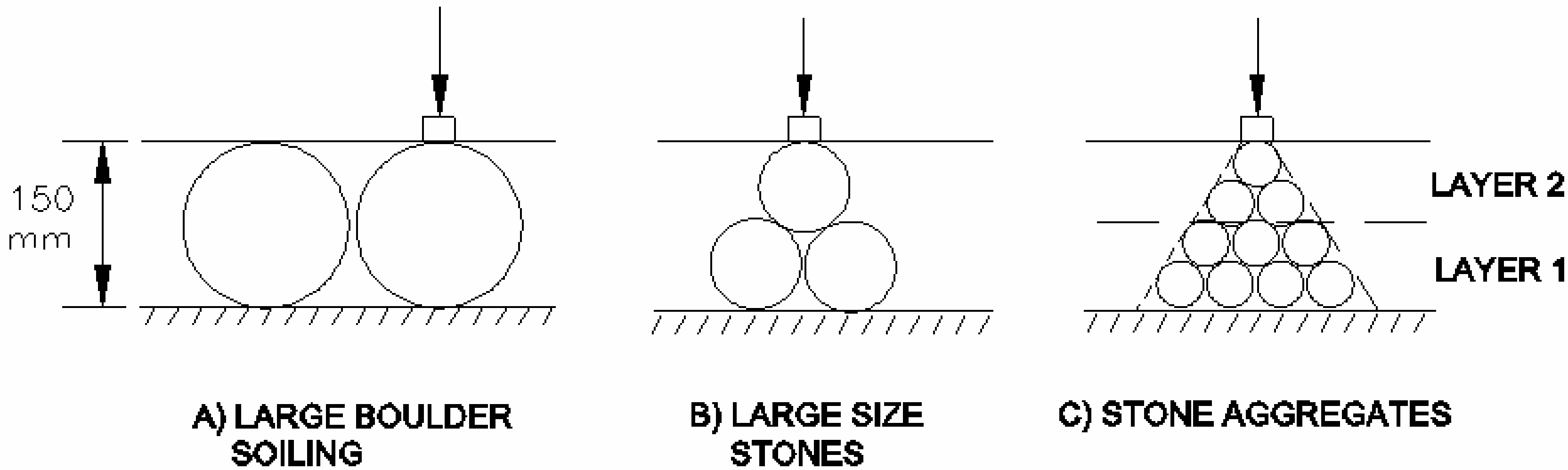
Layers in Flexible Pavement



Principle of Flexible Pavement Design

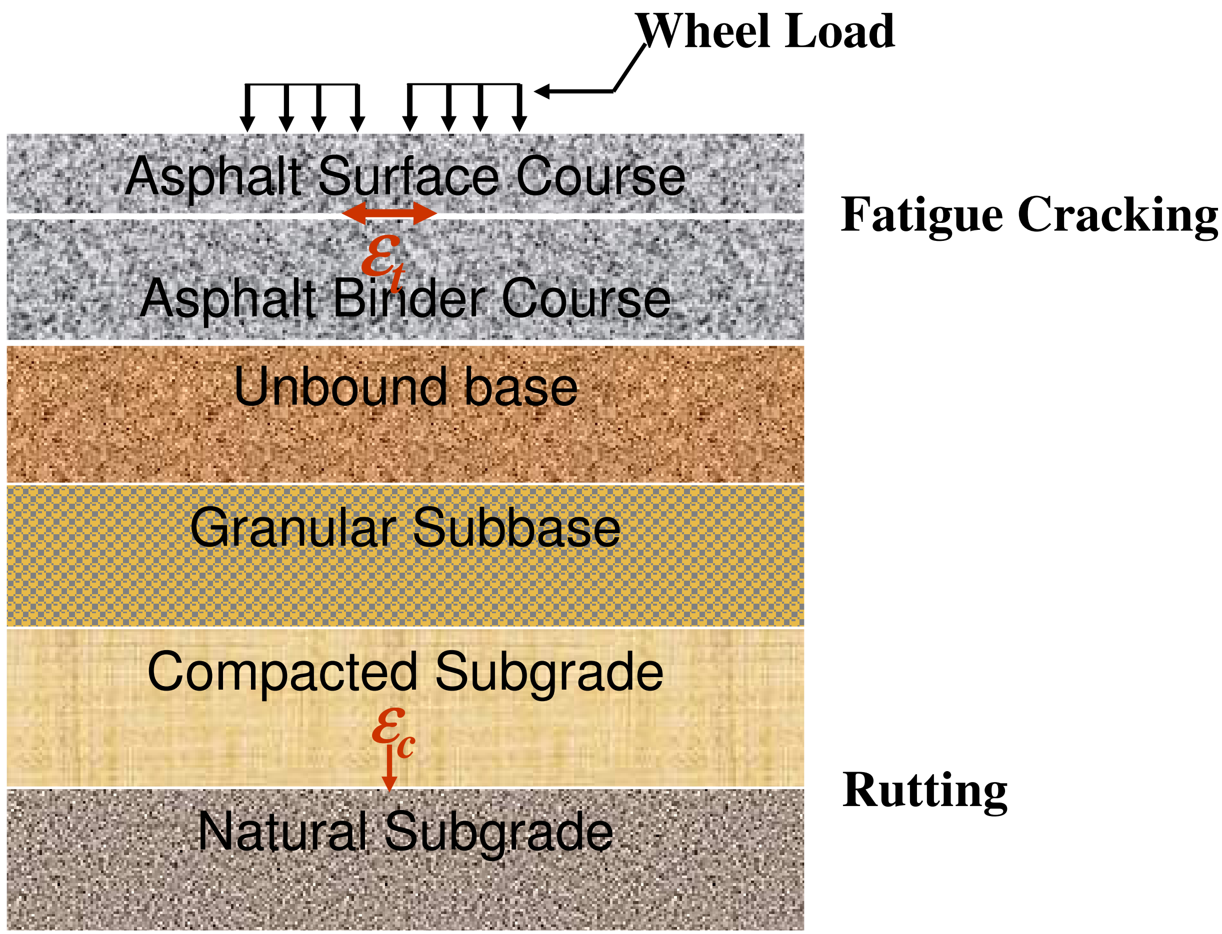
Basic concept

- Dispersion of load / compressive stresses through flexible pavement layers
- Dispersion of stresses (tensile and compressive) through flexible pavement layers with stiff bituminous layers



Stress Distribution Through Granular Layers

Fatigue Cracking and Rutting



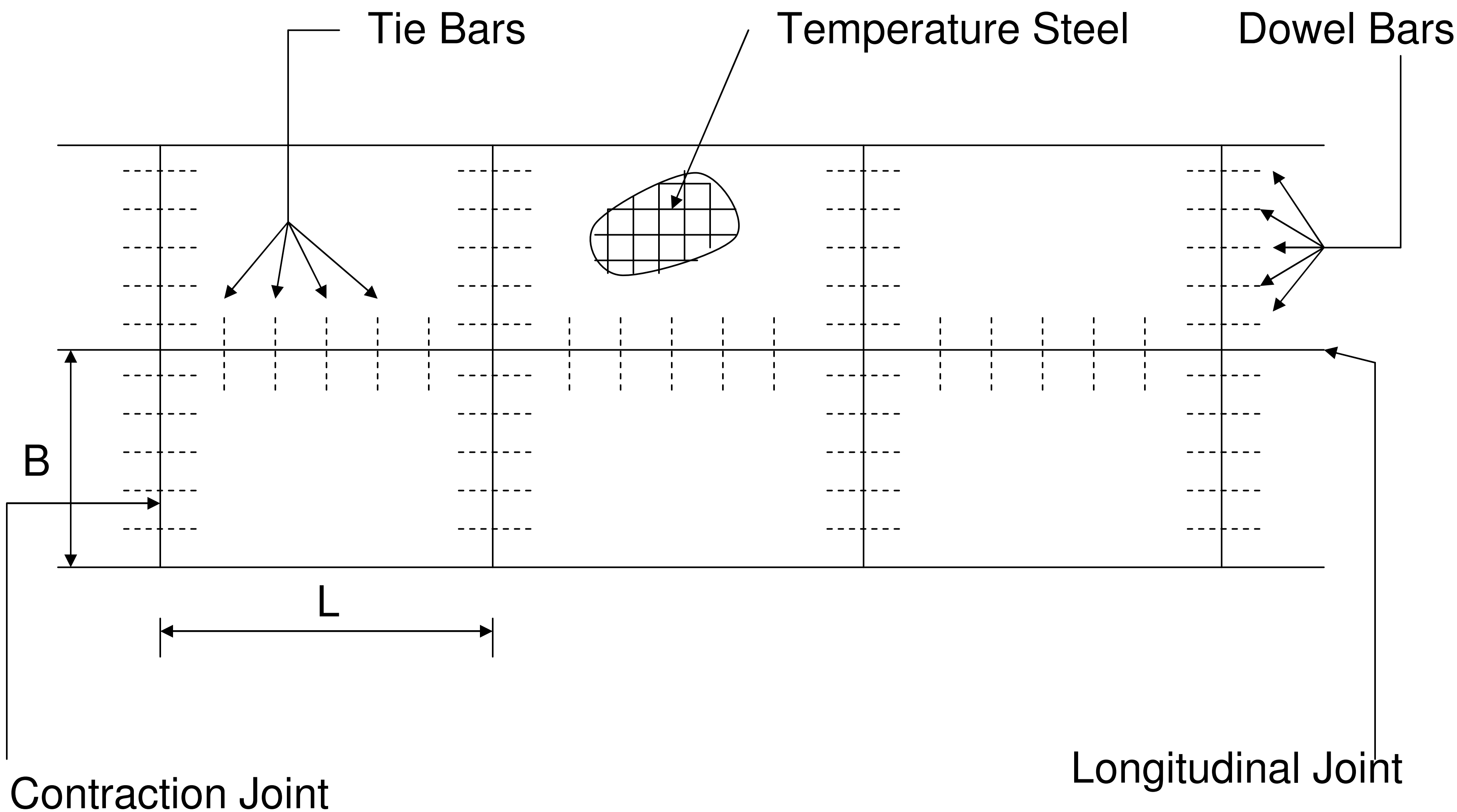
Analysis and Design of Flexible Pavements

- Flexible pavements are analysed using layer theory which is derived from Boussinesq theory. Using this layer theory as a structural model, one can find the solutions for stresses, strains and deflections at any point in a layered system
- Present day flexible pavements are designed using empirical mechanistic methods, in which the allowable number of repetitions of axle loads for a given pavement configuration is determined based on the response of the pavement to the action of these axle loads

Types of Rigid Pavements

- Jointed Plain Concrete Pavement (JPCP)
  - No temperature steel
- Jointed Reinforced Concrete Pavement (JRCP)
  - Temperature steel placed at mid height and discontinued at the joints
- Continuously Reinforced Concrete Pavement (CRCP)
  - Not popular in India – very costly
- Prestressed Concrete Pavement (PCP)
  - Not popular

Jointed CC Pavement

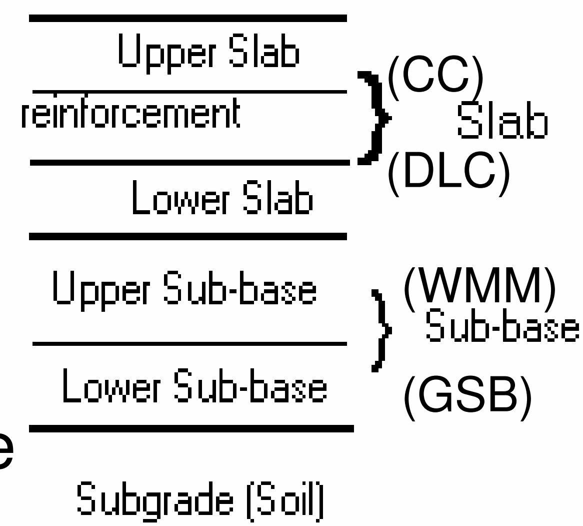


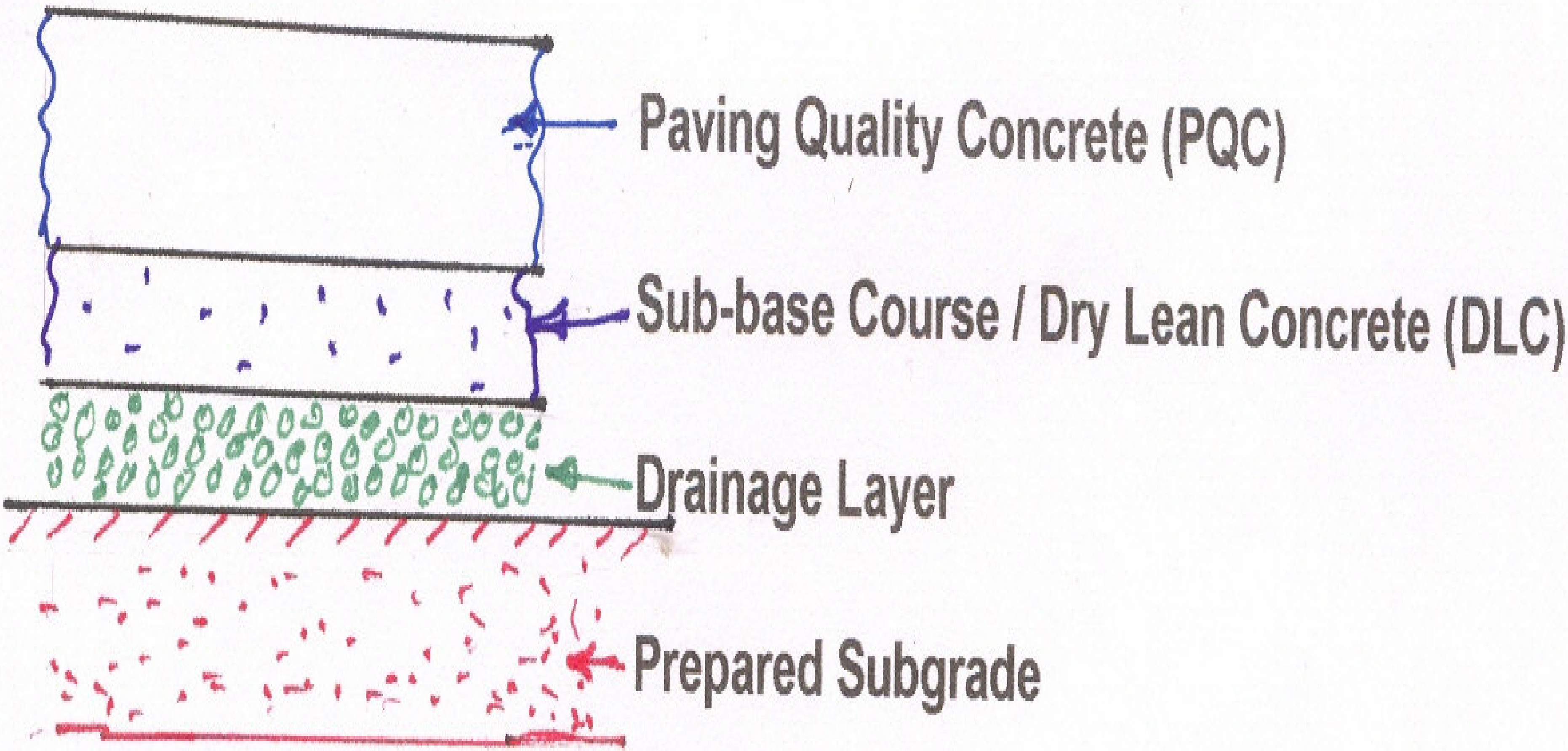
Cross Section of a Rigid Pavement

- Figure shows a typical cross-section of a rigid pavement

- The pavement can be placed directly on prepared subgrade or on a singular layer of granular or stabilized material

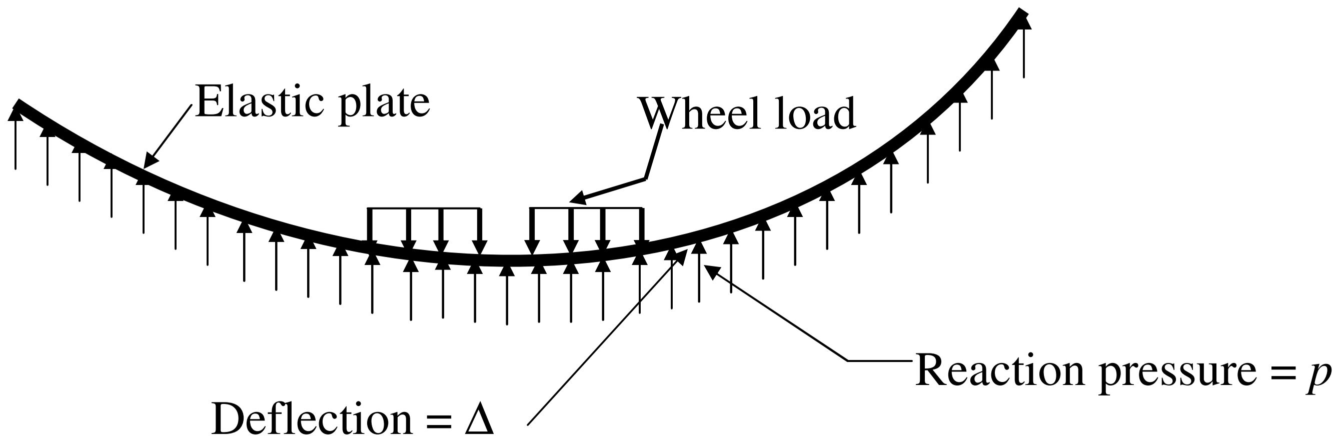
- The only layer of material under concrete and above subgrade is called base course or subbase





Components of Cement Concrete Pavement

Analysis of Rigid Pavement



$p \propto \Delta$ or $p = k\,\Delta$

Elastic plate resting on liquid/solid foundation characterised by its modulus of subgrade reaction, *k*

Rigid Pavement Design

- Joints are designed to take care of the environmental stresses
- Thickness of the CC pavement slab is decided based on the following two points:
  - The maximum bending tensile stress resulting out of maximum wheel load stress and critical environmental stress should be less than the flexural strength of concrete
  - The CC pavement should withstand the expected number of repetitions of axle loads during its design life