

UNIT-V

Introduction to Pavement Design

→ Pavements are essential part of our life. We use them as roads, runways, parking lots, and driveways. Pavements are engineered structures and are important for our everyday life, commerce and trade, and defense.

→ The construction of roads is and will continue to be a major industry in developing countries, and as the infrastructure matures, it will be a major industry in developed countries as well.

Types of Pavements and typical cross-sections

The point of view of structural performance, pavements can be classified

- 1) flexible
- 2) Rigid
- 3) semi-rigid
- 4) composite.

① Flexible pavement:- A flexible pavement is essentially a layered system which has low flexural strength.

→ The external load is largely transmitted to the subgrade by the lateral distribution with increasing depth.

→ Because of the low flexural strength, the pavement deflects momentarily under load but rebounds

to its original level on removal of load.

→ The pavement thickness is so designed that the stresses on the subgrade soil are kept within the bearing power and the subgrade is prevented from excessive deformations.

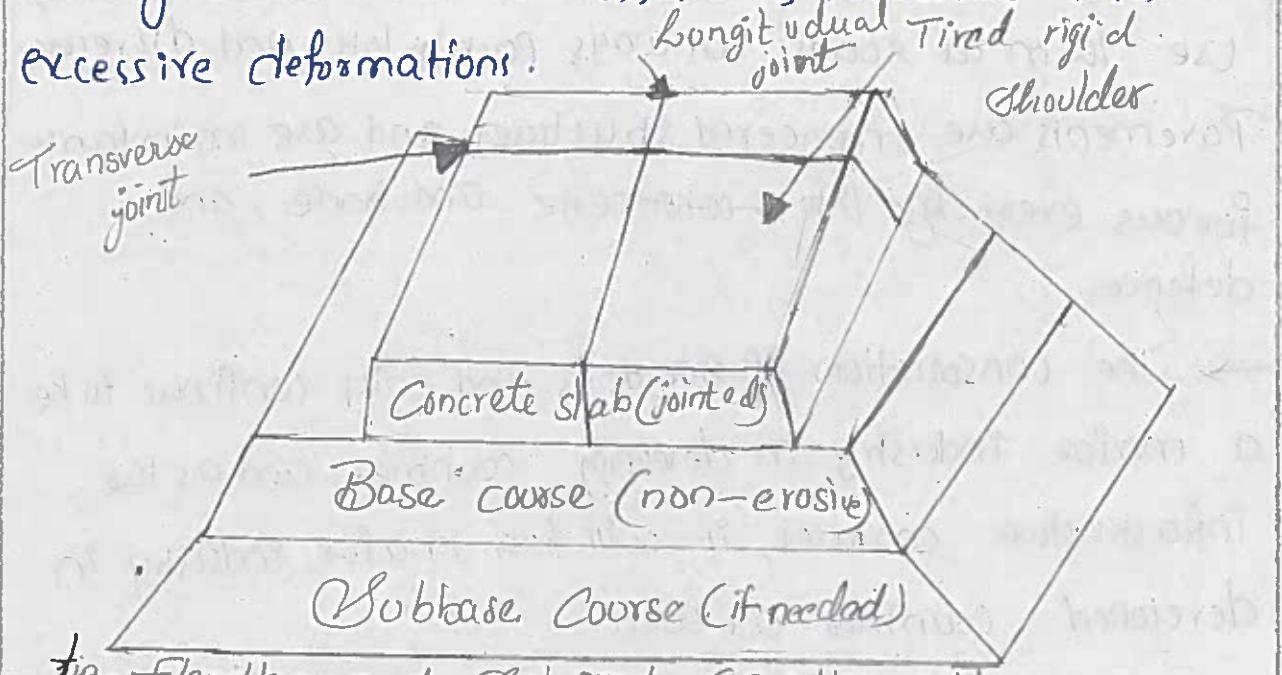


Fig. Flexible Pavement Subgrade (Existing Soil)

Rigid Pavement:

- A rigid pavement derives its capacity to withstand loads from the flexural strength or beam strength permitting the slab to bridge over minor irregularities in the subgrade, subbase, or base upon which it rests.
- This implies that the inherent strength of the slab itself is called upon to play a major role in resisting the wheel load.

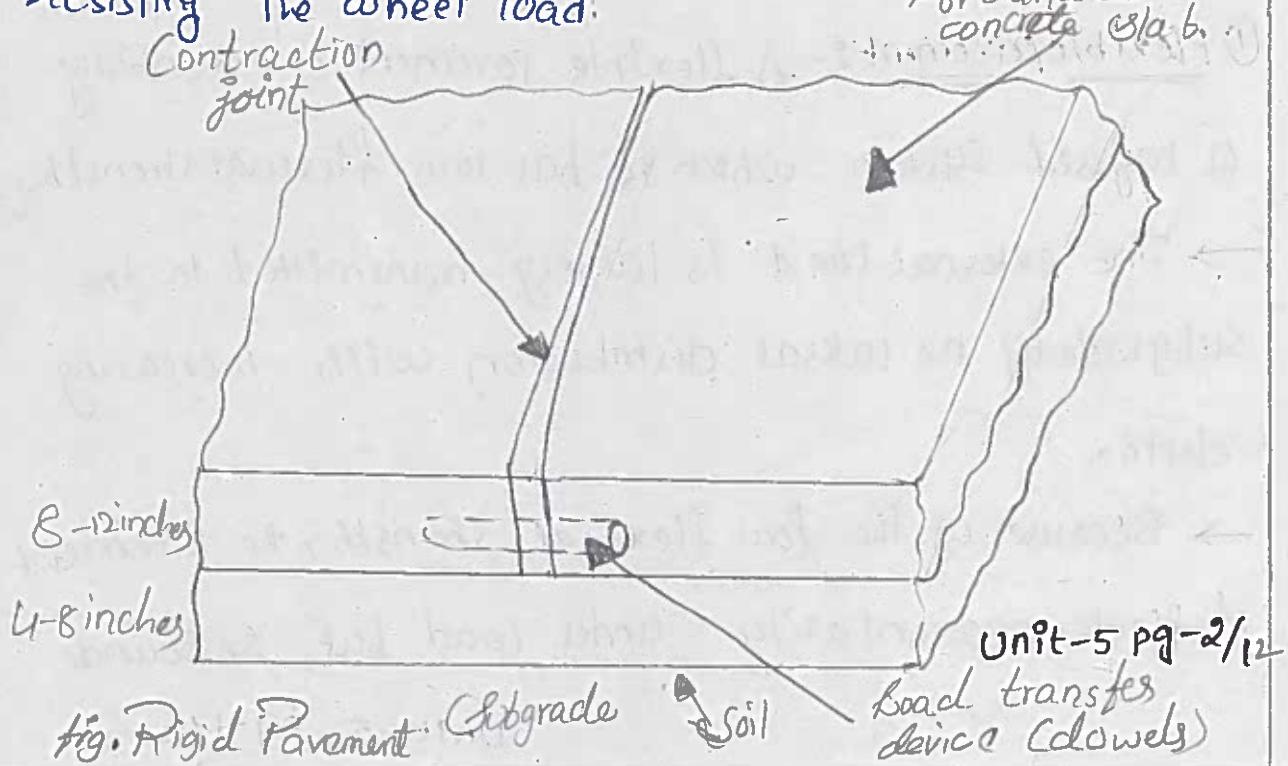


Fig. Rigid Pavement

Composite Pavement

- A composite pavement is one which comprises of multiple, structurally significant layers of different - sometimes - heterogeneous - composition.
- A typical example is the brick sandwiched concrete pavement, which has been tried in India.
- It consists of top and bottom layers of cement concrete which sandwich a brick layer in the neutral axis zone.

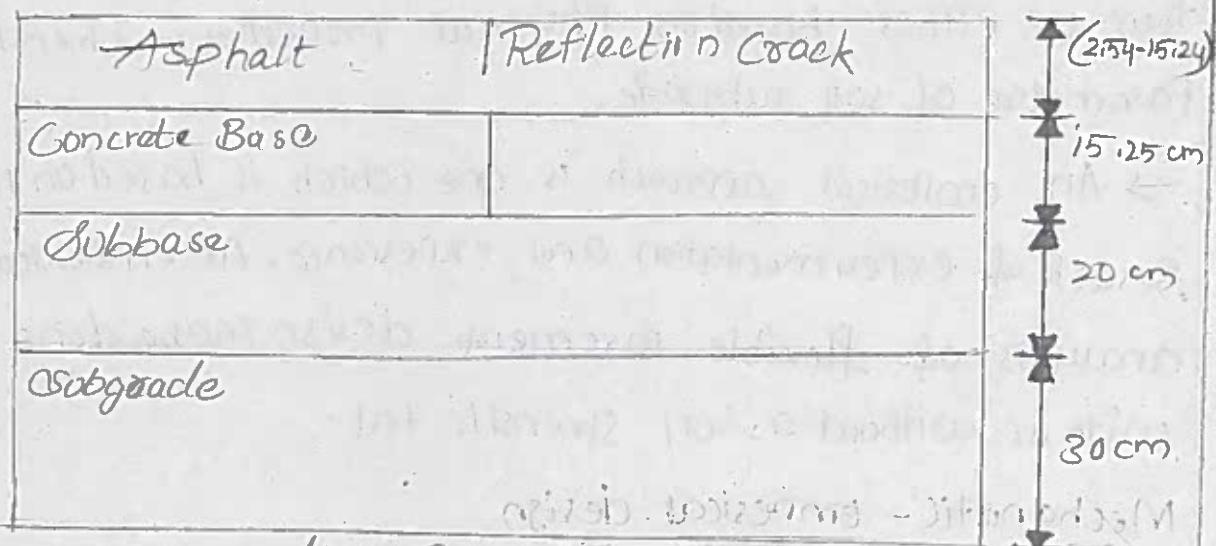


fig. Composite Pavement
Flexible Pavement analysis and design

- Analysis of two layered flexible pavement is considered as significant aspect for design of low volume roads, which typically consist of a thick granular base course directly laid over subgrade with or without a thin - asphalt - wearing course.
- permanent deformation or rutting has been observed to be the major distress mode in him surfaced or unsurfaced low volume roads.

Design procedures

- For flexible pavements, structural design is mainly concerned with determining appropriate layer thickness and composition.
- The main design factors are stresses due to traffic load and temperature variation. Two methods of flexible pavement structural design are common today.

Empirical design

- An empirical approach is one which is based on the results of experimentation or experience. Some of them are either based on physical properties or strength parameters of soil subgrade.
- An empirical approach is one which is based on the result of experimentation and experience. An empirical analysis of flexible pavement design can be done with or without a soil strength test.

Mechanistic-empirical design

- Empirical mechanistic method of design is based on the mechanics of materials such that relates input, such as wheel load, to an output or pavement response.
- In Pavement design, the responses are the stresses, strains, and deflections within a Pavement Structure and the physical causes are the loads and material properties of the pavement structure.
- The relationship between these phenomena and their physical causes are typically described using some mathematical models.

Introduction to multilayered Analysis

- The MLA is a feature extraction method in which the processed input data can be used by a classifier or a clustering method in order to distinguish between several kinds of patterns.
- It is based on the generation of several sub-samples of the input signal, each one carried out by a particular threshold operation.
- These intervals opportunely aggregated can encode the shape information of the input signal that can be used to characterize it or to disclose structures contained in it.

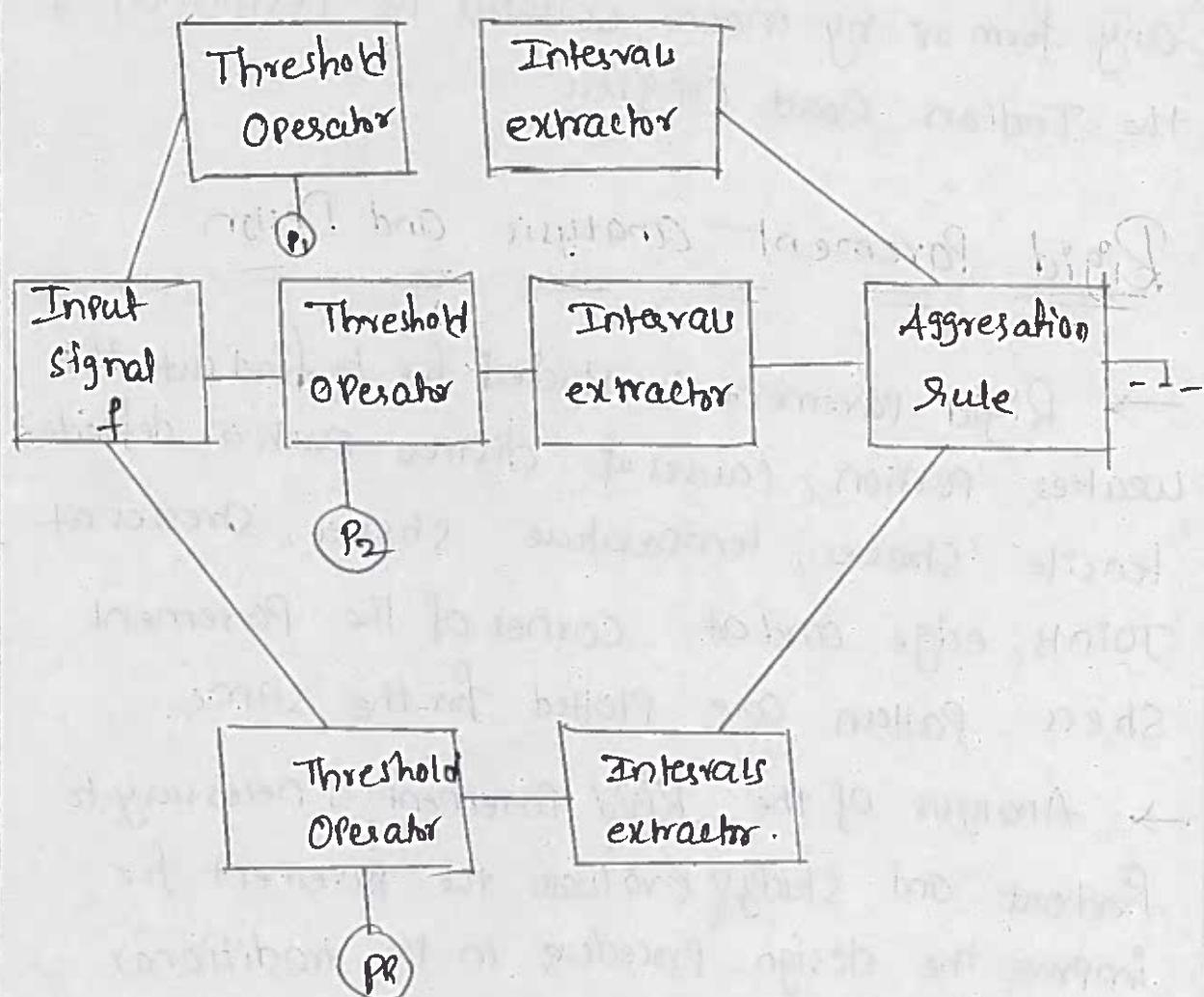


fig. Scheme Of MLA Processing

IRC 37-2012 method of flexible pavement design

- Indian Road Congress in their publication 'Guidelines for the Design of Flexible Pavement' published in 2001 has developed a model considering flexible Pavement as a three layers structure.
- Stresses and strains have been conjugated computed using the linear elastic model FPAVE developed under the Ministry of Road Transport and Highway Research scheme "Analytical Design of Flexible Pavement".
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Rigid Pavement Analysis and Design

- Rigid Pavement is studied for to find out the weaker portion, causes of distress such as deflection, tensile stresses, temperature stresses, stresses at joints, edge and at corner of the Pavement. Stress pattern are plotted for the same.
- Analysis of the Rigid Pavement is necessary to find out and study & evaluate the Pavement for improve the design procedure in the traditional design method.

→ In past 20 years → 2 dimensional finite program was use of analysis of rigid Pavement. Now a days - 3-dimensional finite-element analyses appeared as a influential tool which is most useful for study the Pavement Response.

Design Procedure

→ Early in the design process, the Pavement Design Engineer should closely coordinate with the following offices

District Design: - The District design office should be involved for providing the proposed roadway typical section sheets for such information as Pavement widening.

District Drainage: - The District Drainage office should be involved to determine the what special drainage considerations need to be addressed.

District Construction: - The District construction office should be involved to determine if there are any special construction details that need to be included in the plans or issues.

District Materials: - The Asphalt Base option on Standard Plans, Index, 120-001 is recommended. If the special select soil option is considered, the district materials office should be involved to determine the availability, cost effectiveness, constructability, and history of successful use to suitable conditions that may exist.

Factors - Controlling Rigid Pavement design

The structural design of rigid pavements is governed by a number of factors.

A. Loading

- 1) wheel load and its repetitions.
- 2) Area of contact of wheel
- 3) location of load with respect to slab.

B. Properties of subgrade.

- 1) subgrade strength and properties
- 2) sub-base provision or omission.

C. Properties of concrete.

- 1) Strength
- 2) Modulus of Elasticity
- 3) Poisson's Ratio
- 4) Shrinkage properties
- 5) Fatigue behaviour.

D. External Conditions.

- 1) Temperature changes
- 2) Friction between slab and subgrade.

E. Joints

- 1) Arrangement of joints.

F. Reinforcement

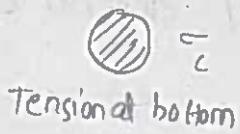
- 1) Quantity of reinforcement
- 2) Continuous reinforcement.

Types of stresses in rigid Pavements

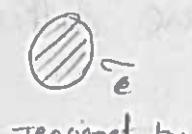
- Curvature and stresses caused by bending
- Relative stiffness of slabs
- Modulus of subgrade reaction
- Stresses due to warping
- Stresses due to friction
- Stresses in Reinforced Pavements
- Stresses in Dowel bars.
- Stresses due to load
- Combined stresses
- Effect of k and h on warping stresses.
- Consideration of warping stresses in Design

Critical Load Positions, load stresses

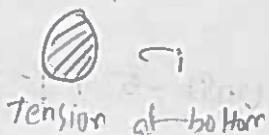
- since the Pavement slab has finite length and width, either the character or the intensity of maximum stress induced by the application of a given traffic load is dependent on the location of the load on the Pavement surface.
- There are three typical locations namely, the interior, edge and corner, where differing conditions of slab continuity exist
- These locations are termed as Critical load positions.



Tension at bottom



Tension at top



Tension at bottom

Wheel load stresses

→ Stresses due to traffic loads are present in the interaction between the wheel of a vehicle and the road surface. Wheel loads on concrete pavements cause tensile stresses to develop at the bottom of the slab.

→ Because concrete is inherently weak in tension, the pressure from the wheel develops stresses in the different material layers in the road structure which develops the stresses in the concrete slab, and the strains in the sub base.

Temperature stresses in interior

→ Temperature differential between the top and bottom of the slab causes curling (warping) stress in the pavement.

→ If the temperature of the upper surface of the slab is higher than the bottom surface then top surface tends to expand and bottom surface tends to contract resulting in compressive stress at the top, tensile stresses at bottom and vice versa.

→ Maximum temperature differentials occurs during the day in the spring and summer months.

→ The actual temperature differential depend on the location.

Corner and Edge locations of jointed plain cement concrete Pavement slabs

- The best-designed Joint systems will not perform to their potential and pavement life may be significantly shortened without proper construction.
- Good joint construction practices can be grouped into three phases; preparing and joint sawing. Details concerning Joint sealing practices are discussed.

IRC 58-2015 method of rigid Pavement design

- Design of rigid pavement is based on latest version of IRC: 58-2015: Guidelines for the Design of Plain and Jointed Rigid Pavement for Highways.
- 500mm thickness subgrade of CBR 8% and 200mm Granular sub base of min 30% CBR has been provided for the design.
- The sub base layer will act as drainage layers as well.

Overlay Designs

- Based on Pavement deflections and literature
- Need to ensure sufficient existing structural thickness
- Improving road structure to allow it to satisfy increased traffic load (ie life).

→ There are several types of Overlay designs are
Granular, Asphalt and concrete.

Types of Overlay designs on Pavements

- 1) Asphalt Overlay over Asphalt Pavements
- 2) Asphalt Overlays on C.C Pavement
- 3) C.C Overlays on Asphalt Pavements
- 4) C.C Overlays on C.C Pavements