

Pavement Design, Construction and Maintenance for Bituminous Roads

Subject

Flexible Pavement

Participants

Assistant Engineer/Junior Engineer



Lecture 1

Philosophy of Flexible Pavement Design for Rural Roads



Introduction

- Pavements are normally classified into two broad categories, i.e. Flexible and Rigid.
- Depending on the load distribution mechanism, we classify them as flexible and rigid pavements.

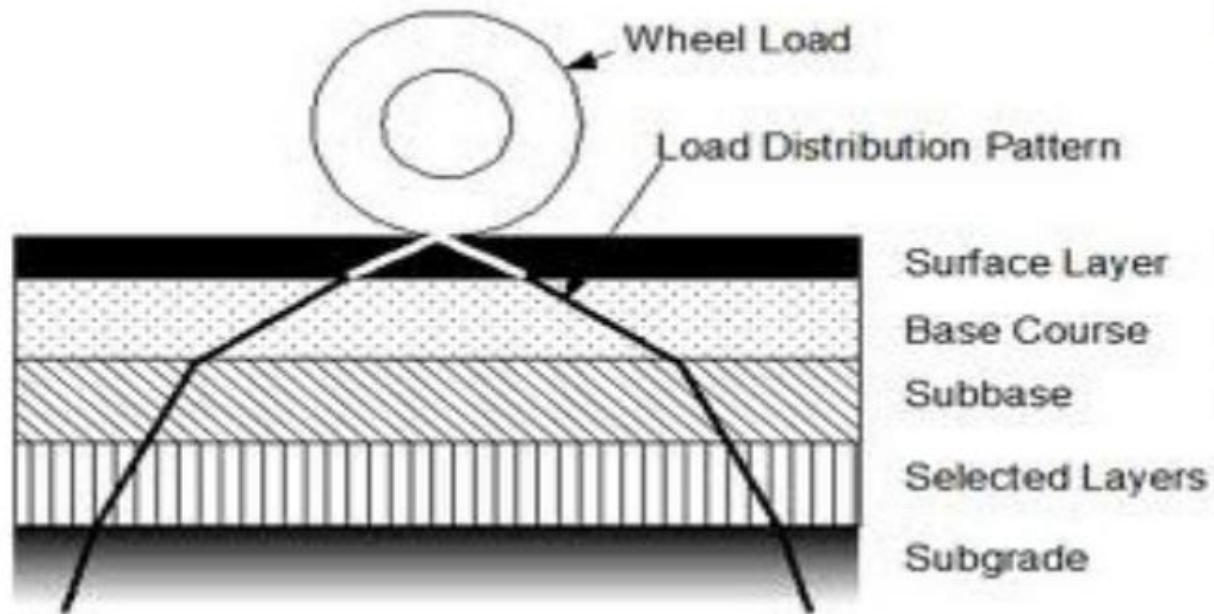


Flexible Pavement

- Flexible-pavement design is based on the principle that the magnitude of stress induced by a wheel load decreases with depth below the surface.
- The stresses induced on a given subgrade material can be decreased by increasing the thickness of the overlying layers (subbase, base, and surface courses).



Flexible Pavement



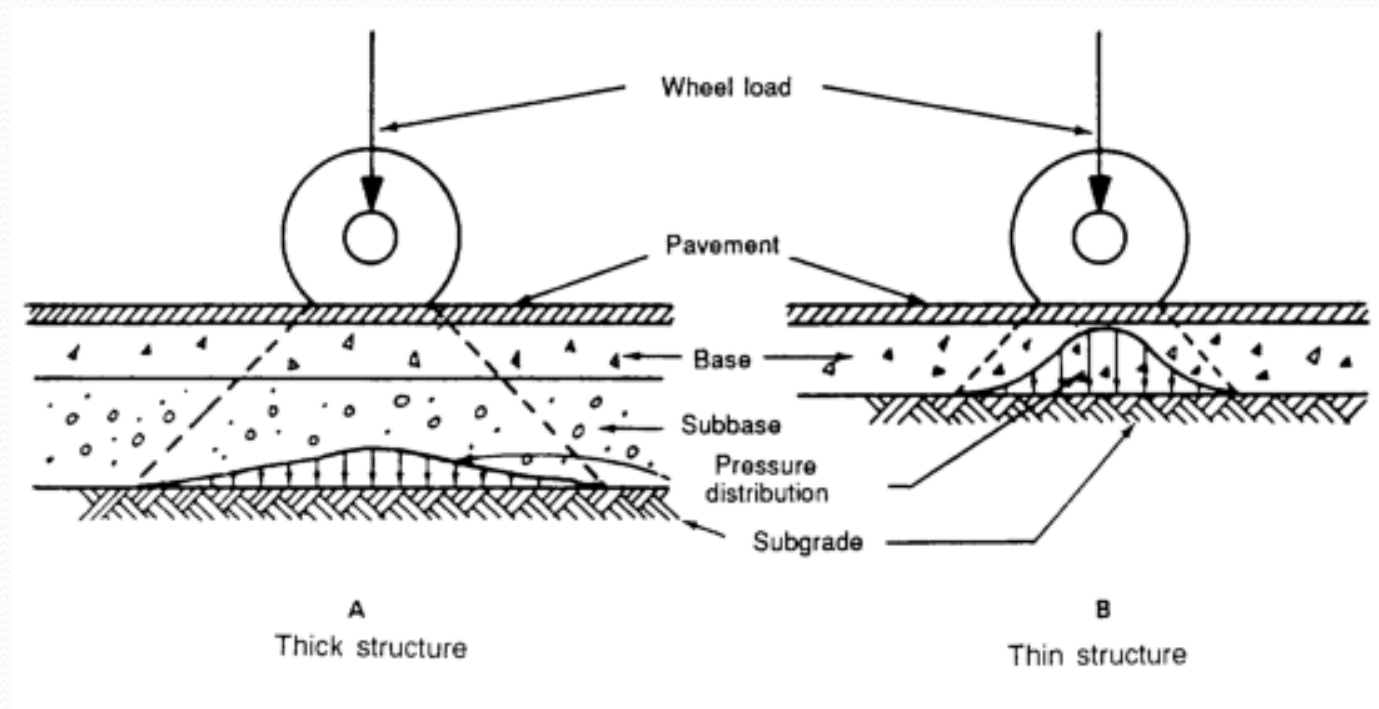
Load Distribution in a Flexible Pavement Structure

Flexible Pavement

- The magnitude of the stresses on the subgrade decreases as the flexible-pavement structure is thickened
- The pattern of decreasing stresses with increasing depth is the basis of the conventional flexible-pavement design in which subgrade materials of low-bearing capacity are covered with thick flexible-pavement structures.



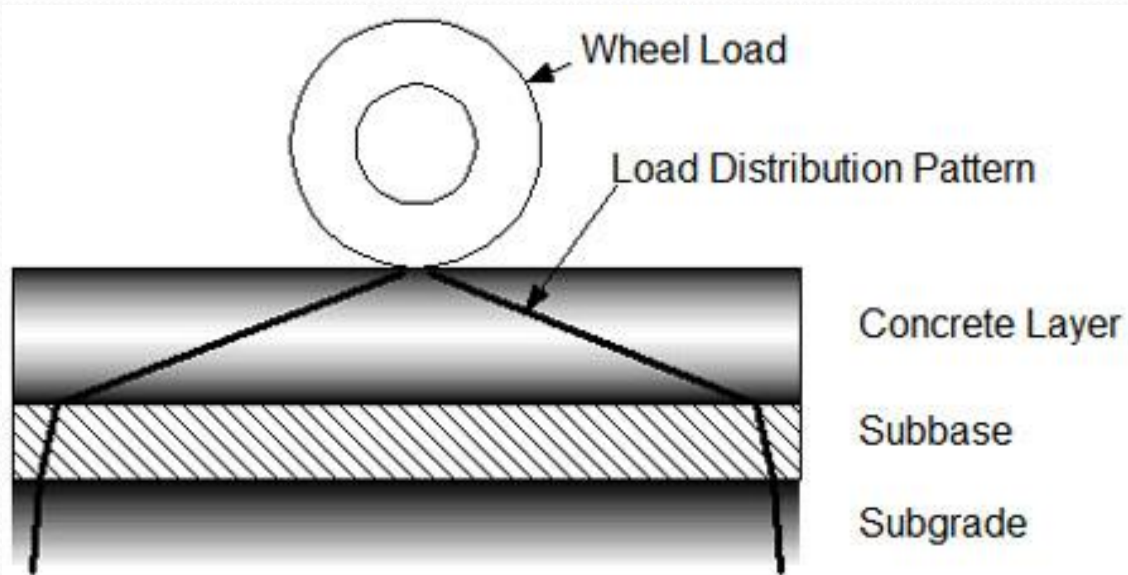
Flexible Pavement



Distribution of Loads in Thick and Thin Flexible Pavement Structure

Rigid Pavement

- Rigid pavements distribute load on a larger area due to its high flexural rigidity
- Usually made of Concrete



Pavement Design

- Pavement design involves in selection of the materials to be used in different layers of a pavement and thickness of each of the layers over a given subgrade strength and expected traffic load to be carried.
- A pavement designer should address the structural failures. (i.e. failures associated with application of loads).
- If the structural adequacy of the pavement can be maintained at a satisfactory level during the service life of pavements while simultaneously putting in place a mechanism to ensure proper material selection, construction and maintenance, satisfactory functional performance can be achieved.



Performance Criteria

- Performance criteria is the heart of any pavement design procedure.
- Continuing efforts are being made for rationalizing the pavement design procedures by reducing the empirical content and correlating the performance of pavements with load associated behaviour of pavement components.
- Rutting and fatigue cracking of the bituminous layer have been identified as the major modes of failure in flexible pavements.



Performance Criteria

- But since the surfacing layer in rural roads mostly consists of thin carpet of 20 mm thickness, this cannot be considered as a structural layer and the failure in terms of fatigue cracking does not occur in such pavements.
- Therefore only Rutting is considered as the major mode of structural failure for these pavements.



Analysis of Flexible pavements

- Flexible pavements comprise of materials with most complex mechanistic behavior.
- Almost all materials are nonlinear.
- All the materials undergo plastic deformation.
- In spite of the nonlinearity of the materials, the pavement analysis is carried out using the linear elastic theory as a simplified process.



Economical Designs

- The pavement constitutes nearly one third to one half of the total cost of the road. Therefore very careful consideration should be there for the choice of the pavement and its design.
- The factors which govern the selection of type of pavement are:
 - Initial cost of construction
 - Availability of materials locally
 - Cost of maintenance and rehabilitation during service
 - Technology of construction required and its availability



Pre-Requisites for Economical Design

- Practical implementability of the recommended designs within the available resources and level of expertise in rural areas as well as level of quality control.
- Maximize use of locally available materials in the larger interest of economy
- Design life for pavement design should neither be too short to require upgradation/ rehabilitation at close intervals nor should it be so long as to require prohibitively high initial cost of construction
- Designs should aim at providing the level of serviceability which should not fall below the minimum acceptable level during the design life.



Design of Flexible Pavements

- The following parameters are considered in pavement design:
 - Design Traffic
 - Subgrade Strength
 - Pavement Component Materials
 - Environmental Condition



Estimation of traffic

- Where no road exists at present the estimation of traffic over the design life cannot be made directly on the basis of traffic counts.
- It would be more rational to carry out traffic count on an existing road preferably in the vicinity with similar conditions.
- Based on such traffic counts on an existing road catering to a known population and known amount of industrial/agricultural produce, the amount of traffic expected on the new proposed road can be suitably worked out.



Assessment of Subgrade Strength

- It is necessary to scientifically carry out the soil survey and test the representative samples for standard IS classification tests, compaction tests and CBR.
- Two-three samples for kilometer length must be collected.

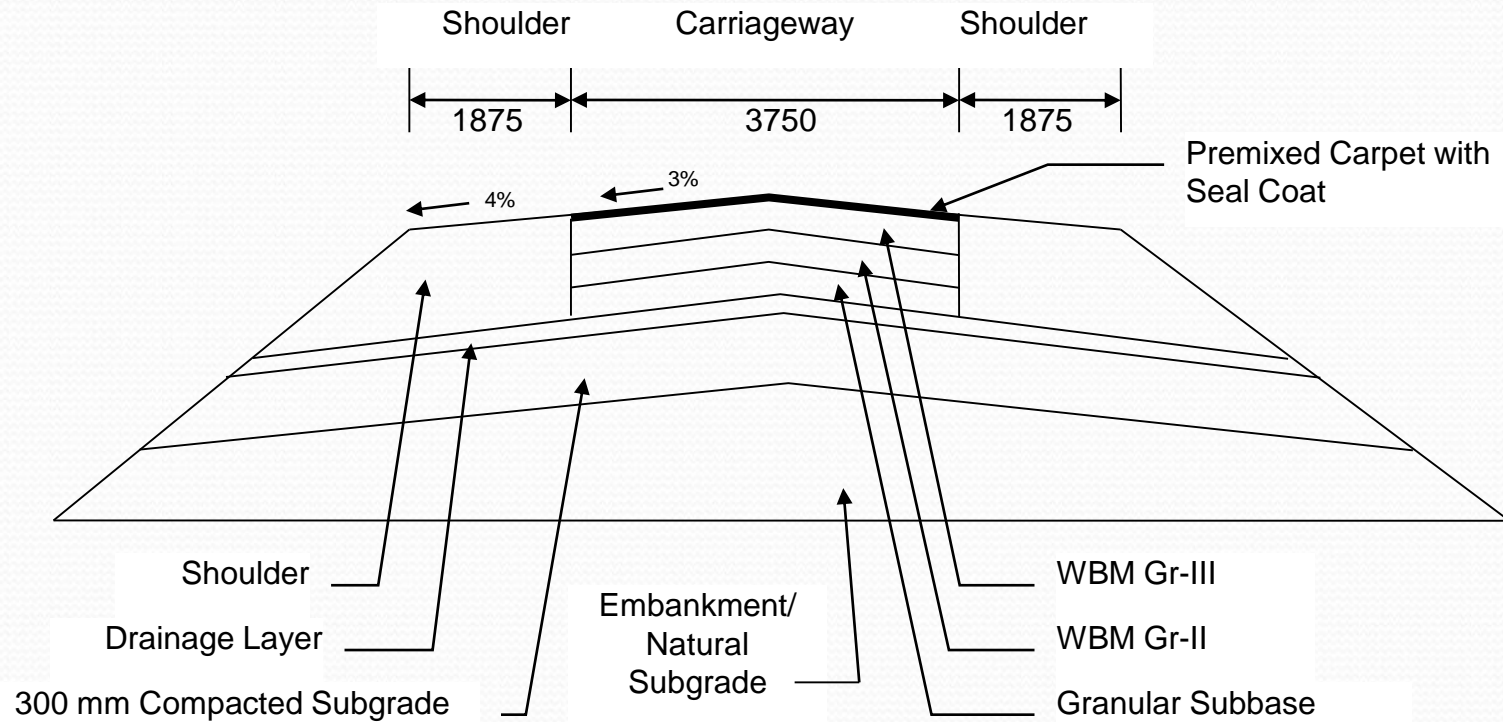


Pavement materials and composition

- It is necessary to carry out a comprehensive field materials survey and the needed laboratory tests on representative samples to maximize the use of locally available materials for use in subbase, base and surfacing as such or after suitable stabilization.



Pavement Composition



Pavement Composition

- **Sub-base:**

- For granular sub-base, the materials generally used are natural sand, moorum, gravel, crushed stone, crushed slag, brick metal, kankar or combination thereof depending upon the grading required as per the MORD Specifications for Rural Roads.

- **Base course:**

- For rural roads, unbound granular bases which comprise conventional Water Bound Macadam (WBM), Wet Mix Macadam (WMM) or Crusher Run Macadam Base (CRMB) are adopted as per the MORD Specifications.



Pavement Composition

- **Surfacing:**

- Rural roads designed for cumulative ESAL repetitions over 100,000, a bituminous surface treatment of 2-coat surface dressing or 20 mm premix carpet is usually recommended, as per MORD Specifications.
- However, for lower traffic condition, a non-bituminous gravel surfacing is recommended as per Clause 402 of the MORD Specifications, except for the very poor subgrade strength (CBR=2), where a bituminous surface treatment is recommended.



Environmental conditions

- The depth of ground water table, and its fluctuations, rainfall and other environmental conditions should be considered in pavement design.



Maximizing Use of Locally Available Materials

- A variety of locally available materials can be used which may be grouped under the following categories:
 - Selected granular soil for use in subgrade.
 - Mechanical stabilization, stabilization with lime, cement, lime and flyash, as appropriate.
 - Naturally occurring softer aggregate like moorum, kankar, gravel etc.
 - Brick and overburnt brick metal.
 - Stone metal
 - Industrial Wastes



Stabilization of local soils

- A variety of techniques are available for stabilizing local soils for improving their engineering properties, but not all the techniques are applicable to all types of soils.
- The various methods which can be adopted to improve the local soils and inferior aggregates are
 - Mechanical Stabilization
 - Stabilization with Lime/cement
 - Stabilization with different chemicals and commercial products



Naturally occurring marginal aggregates

- Marginal aggregates like brick ballast, laterite, kankar, moorum, dhandla, etc. where available within economic leads, should be made use of in pavement construction to the maximum extent feasible.
- The material may occur in graded form or as discrete blocks or admixed with soil.



Industrial Wastes

- Industrial wastes in the vicinity of projects having requisite engineering properties can be used in road construction.
- Examples of the industrial wastes are flyash, blast furnace slag, construction & demolition debris, waste glass, waste plastic, waste rubber etc.
- The main objectives of utilizing waste materials are:
 - Avoiding the accumulation of waste materials
 - Setting free valuable areas by using the material of existing waste tips
 - Preservation of the natural material sources



Industrial Wastes

- To promote the utilization of by-products some general criteria to be followed are:
 - The amount of waste material produced should be usable quantity
 - The hauling distance should be acceptable
 - Waste material should not have adverse environmental effect
 - The material should be insoluble in water.



Flyash

- There is considerable scope for the utilization of fly ash in rural road works.
- Use of flyash is mandatory wherever technically feasible, in various road works within 100 km of a thermal power plant.
- Flyash can be effectively and economically used in the following rural road works:
 - Flyash Embankments
 - Lime-flyash Stabilized Soil Subbase
 - Lime-flyash Bound Macadam Base
 - Roller Compacted Flyash Concrete Pavement
 - Dry Lean Flyash Concrete Base
 - Cement Stabilized Flyash Subbase/Base



Slags

- Air cooled blast furnace slag and weathered steel slag can be used in place of stone aggregates to construct WBM layers and for mechanical stabilization.
- Granulated blast furnace slag, which is a Pozzolanic material, can be stabilized using lime and used for construction of stabilized layers and lime-GBFS concrete base/ sub-base.
- Addition of a small quantity of gypsum enhances strength. GBFS can also be used in place of granular sub-base provided it meets CBR requirements.



Different Forms of Slag



Rock slag or Air cooled slag



Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag
(GGBS)



Recycled Concrete Aggregates

- Our country has a network of concrete roads built many decades ago and due to increase in traffic and axle loads, the pavements have badly cracked.
- The rehabilitation and maintenance is costly and time consuming. In certain areas where high quality natural aggregates are scarce, recycled concrete aggregates offer an excellent and economic opportunity.
- Studies on the use of recycled aggregate in cement concrete and in WBM show that, recycled aggregates with suitable modifications can be used as a road pavement material in base/ sub-base and wearing course of road pavement in place of natural aggregate for low volume roads.



Other Waste Materials

- Many other waste materials like processed municipal waste, quarry waste, marble slurry dust, other metallic slags are available in many parts of the country.
- Laboratory and field studies conducted on some of these materials have indicated that such materials can be utilized for construction of lower layers of pavement and/ or embankment.
- However, before embarking on use of such materials, detailed characterization and design of mix through a reputed laboratory would be needed.



Pavement Design for the upgradation/rehabilitation

- Broadly, the various upgrading/rehabilitation activities on existing roads can be subdivided into the following:-
 - Upgrading/Rehabilitation Methods other than Strengthening/Overlay. These methods include removal of deficiencies:
 - Drainage (surface/subsurface and cross-drainage works);
 - Width of carriageway and available shoulder width;
 - Premature loss of serviceability as revealed by Present Condition Index of carriageway and the shoulders; and (iv) Geometric design etc.
 - Upgrading/Rehabilitation Methods with Strengthening/Overlay

