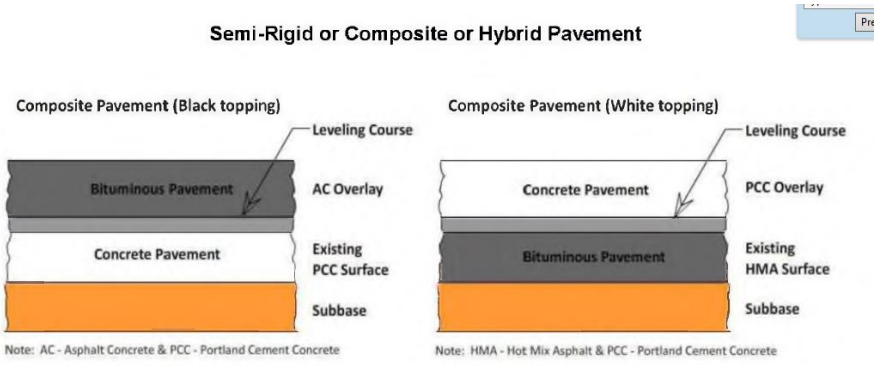
1. Define flexible, semi-rigid and rigid pavements (2)
Ans.

Flexible pavements are those which are surfaced with bituminous (or asphalt) materials

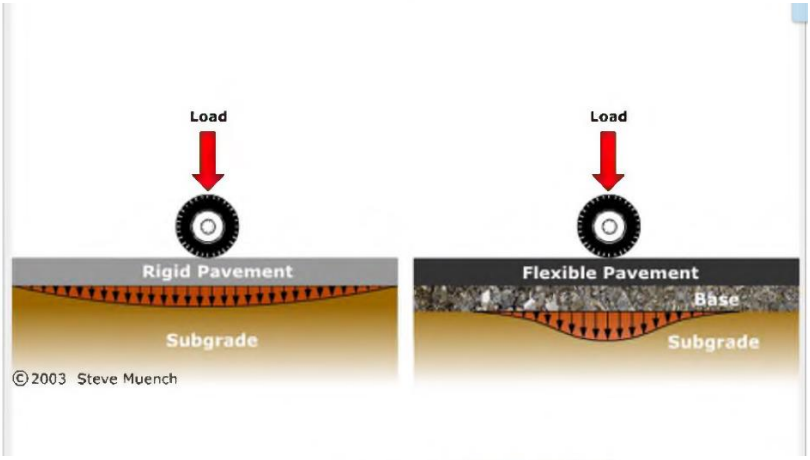
Semi-rigid pavement is a type of pavement structure in which a semi-rigid base layer, usually made up of cement-treated base (CTB) or cement-stabilized base (CSB), is overlaid with a top flexible layer of asphalt mixture.

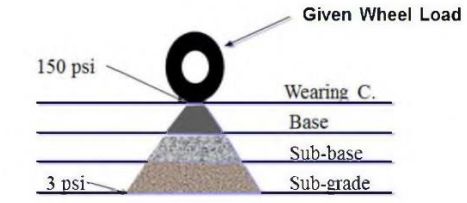
Rigid pavements are those, which contain sufficient beam strength to be able to bridge over the localized sub-grade
failures and areas of in adequate support.

2. draw typical sections for flexible, semi-rigid and rigid pavements (4)
Ans.



A detailed pavement classification system is shown in the following chart





Load Distribution in Flexible Pavements

3. In your opinion which type of pavement would be suitable for Bangladesh and why, give TWO important reasons. (2)

Ans.

Rigid pavement

Rigid pavements are those, which contain sufficient beam strength to be able to bridge over the localized sub-grade failures and areas of in adequate support.

Merits

a. Bitumen is derived from petroleum crude, which is in short supply globally and the price of which has been rising steeply. India imports nearly 70% of the petroleum crude. The demand for bitumen in the coming years is likely to grow steeply, far outstripping the availability. Hence it will be in India's interest to explore alternative binders. Cement is available in sufficient quantity in India, and its availability in the future is also assured. Thus, cement concrete roads should be the obvious choice in future road programs.
b. Besides the easily available of cement, concrete roads have a long life and are practically maintenance-free.
c. Another major advantage of concrete roads is the savings in fuel by commercial vehicles to an extent of 14-20%. The fuel savings themselves can support a large program of concreting.
d. Cement concrete roads save a substantial quantity of stone aggregates and this factor must be considered when a choice of pavement is made,
e. Concrete roads can withstand extreme weather conditions - wide ranging temperatures, heavy rainfall and water logging.
f. Though cement concrete roads may cost slightly more than a flexible pavement initially, they are economical when whole-life-costing is considered.
g. Reduction in the cost of concrete pavements can be brought about by developing semi-self-compacting concrete techniques and the use of closely spaced thin joints.

4. TWO major functions and TWO major desirable characteristics of flexible pavement.

Ans.

Flexible pavements are those which are surfaced with bituminous (or asphalt) materials

Flexible Pavement

1. A flexible pavement is a structure that maintains intimate contact with and distributes load to the sub grade and depends on aggregate interlock, particle friction and cohesion for stability.
2. Each layer receives the loads from the above layer, spreads them out, then passes on these loads to the next layer below. Thus, the further down in the pavement

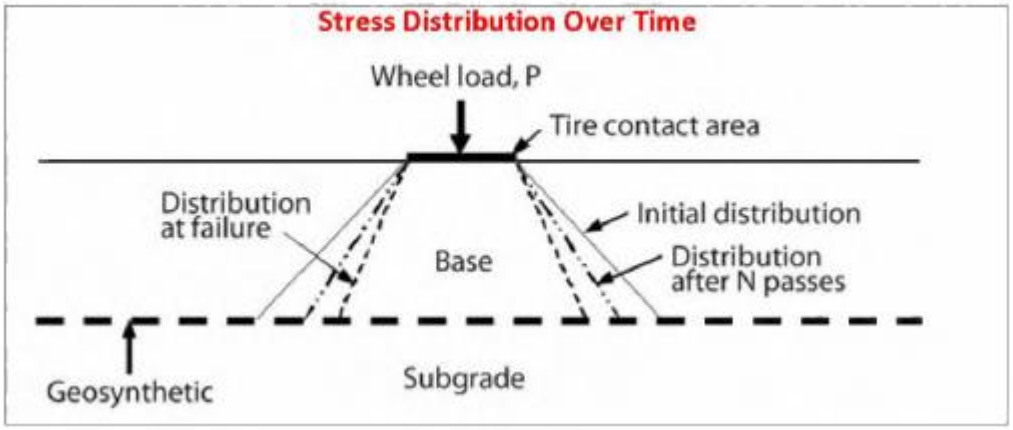
structure a particular layer is, the less load (in terms of force per unit area) it must carry.

3. A flexible pavement is essentially a multilayered system.
4. It has low flexural strength.
5. The external load is largely transmitted to subgrade by the lateral distribution with increasing depth.
6. The pavement deflects momentarily under load but rebounds to its original level on removal of load.
7. Pavement thickness is so designed that the stresses on the subgrade soil are kept within its bearing power and the subgrade is prevented from excessive deformations.
8. In a flexible pavement, the subgrade plays an important role as it carries the vehicle loads transmitted to it through the pavement.
9. Strength & smoothness of the pavement surface depends to a great extent on the permanent deformation suffered by the subgrade and its resistance to such deformation.
10. If the pavement itself is very strong, but it is constructed on loose and poor subgrade, it can fail.

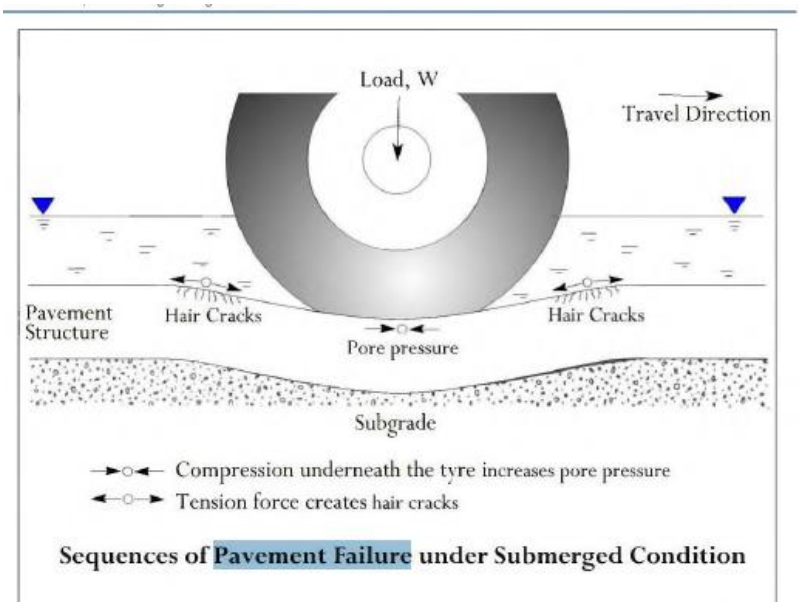
Desirable characteristics/advantages:

1. Low initial investment
2. Offer stage construction
3. Easy to maintain/correct foundation error
4. Give smooth riding quality (in hilly area/rolling terrain it is the
5. Provide pleasing appearance
6. Offer high skid resistance
7. Non-slippery even in wet condition
8. Produce low level of noise
9. Cutting/digging road side trench for upgradation of utility at submerged condition services are easier
10. Can be open for traffic immediately after construction required
11. Recycling is easier

5. Draw stress distribution patterns over time for flexible pavement
Ans.



6. sequences of pavement failure under submerged condition in Bangladesh (4)
Ans.



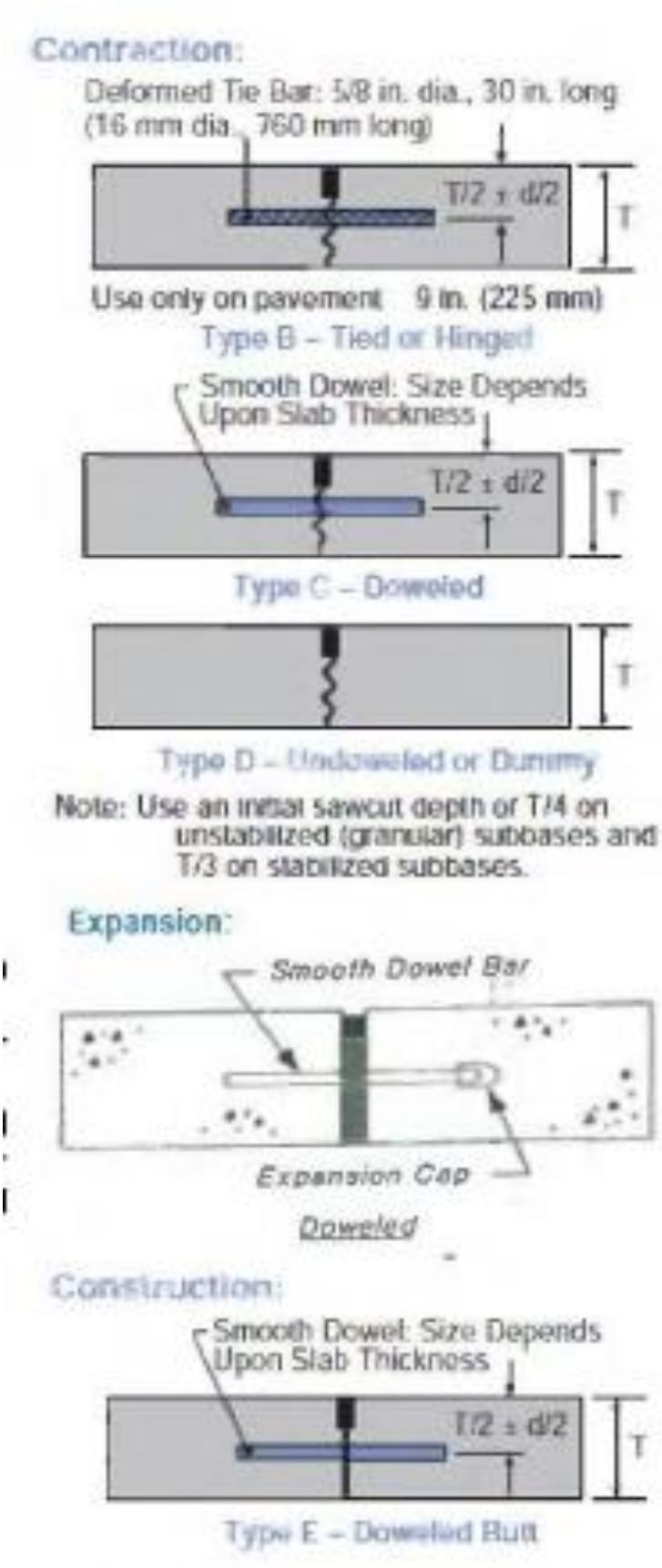
7. the technological advancements that made perpetual pavement possible? (3)
Ans.

A Perpetual Pavement is defined as an HMA pavement designed and built to last longer than 50 years without requiring major structural rehabilitation or reconstruction, and needing only periodic surface renewal in response to distresses confined to the top of the pavement.

CONCEPT

The basic concept is that HMA pavements over a minimum strength are not likely to exhibit structural damage even when subjected to very high traffic flows over long periods of time. Rather, deterioration seems to initiate in the pavement surface as either top-down cracking or rutting. If surface-initiated cracking and rutting can be detected and remedied before they impact the structural integrity of the pavement, the pavement design life could be greatly increased. In fact, some HMA pavements in service today are living examples of perpetual pavements. In order to work, the above pavement structure must be built on a solid foundation (i.e. with subgrade with a CBR greater than 5%, low swell & settlement potential). Besides, as always, proper construction techniques are essential to a perpetual pavement’s performance.

8. Draw typical sections of Contraction and Construction Joints. (2)



9. two important benefits of continuously reinforced rigid pavement (CRCP) (3)
Ans.
Continuously Reinforced Concrete Pavements (CRCP):

- when slab length is > 15m or 50'
- CRCP provides joint-free design. The formation of transverse cracks at relatively close intervals is a distinctive characteristic of CRCP.
- Cracks are held tightly by the reinforcement and should be of no concern as long as the cracks are uniformly spaced, do not spall excessively, and a uniform non-erosive base is provided
- no need for contraction joints

10. Short Notes:

- Fog Sea (2)
- 'Micro Seal (2)
- 'Perpetual pavement' (3)
- 'Polymer Modified Binder (PMB) (2)
- Slurry seat

Ans.

Fog Seals

A fog seal is a light application of a diluted slow-setting asphalt emulsion to the surface of an aged (oxidized) pavement surface.

Micro-surfacing

Micro-surfacing is an advanced form of slurry seal that uses the same basic ingredients (emulsified asphalt, water, fine aggregate and mineral filler) and combine them with advanced polymer additives.

Perpetual Pavement

A Perpetual Pavement is defined as an HMA pavement designed and built to last longer than 50 years without requiring major structural rehabilitation or reconstruction, and needing only periodic surface renewal in response to distresses confined to the top of the pavement.

PMB

The use of polymer modified bitumen's (PMBs) to achieve better asphalt pavement performance has been observed for a long time. The improved functional properties include permanent deformation, fatigue and low temperature cracking. The polymers that are used for bitumen modification can be divided onto two broad categories, namely plastomers and elastomers.

Slurry Seals

A slurry seal is a homogenous mixture of emulsified asphalt, water, well-graded fine aggregate and mineral filler that has a creamy fluid-like appearance when applied. Slurry seals are used to fill existing pavement surface defects as either a preparatory treatment for other maintenance treatments or as a wearing course.

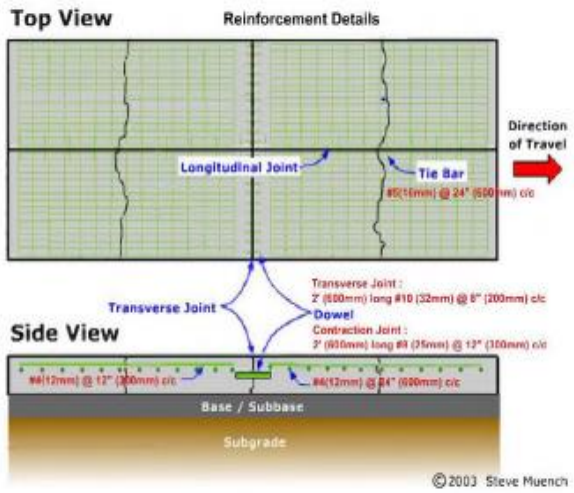
11. Why Joints are used in rigid Pavement? (4)

Ans

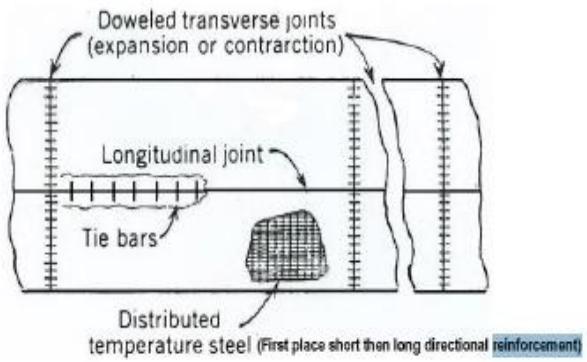
1. To reduce influence of weathering as well as to reduce requirement of reinforcement
2. To control cracks
3. To accommodate pavement movements

12. Schematically show the layout arrangement of different type of reinforcements that are used in the concrete pavement (2)

Ans.



Jointed Reinforced Concrete Pavement (JRCP)



13. Why structural design of pavement is a complex one?
Ans.

Unlike the structural design of buildings and bridges - for pavement
-traffic loading pattern

- is repetitive in nature
- causes stresses of wide varying intensities
- forecast is very difficult and become less reliable with longer design period

-environment loading pattern - as the pavement lies exposed upon the ground surface, it is greatly influenced by the environment factors viz.

- ***shrinkage*** crack of slab due to temperature change
- ***swelling*** of roadbed soil due to change moisture content
- ***pumping -*** loss of roadbed material with water
- ***stripping*** - break of bonding between aggregates at submerged condition

-Theses ***stress-inducing factors*** are extremely complex and to some extent difficult to predict.
Moreover, as highway crosses many different soil deposits along its course, foundation analysis become more
complex than that of building/bridges.

14. List different methods of pavement design (2)
Ans.

-Flexible Pavement

1. Design Catalog method
2. Empirical - 1993 AASHTO method
3. Mechanistic-empirical - New AASH TO method
4. Asphalt Institute Method
5. TRL- Road Note 31 method
6. Aust Roads method &
7. IRC (Indian Road Congress) method

-Rigid Pavement

1. Empirical - 1993 AASHTO method
2. PCA (Portland Cement Association) Method
3. TRL- Road Note 29 method

15. Why ditto copy of AASHTO is not appropriate for roadway design of Bangladesh, give THREE important reasons? (2)

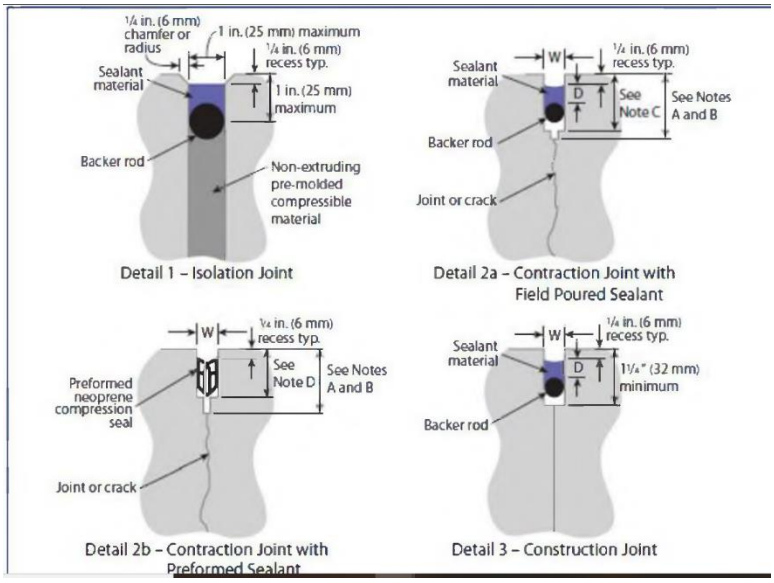
Ans.

1.ditto copy of western methods of pavement design viz. AASHTO, The Asphalt Institute, Road Note 31 are not for our local conditions as these methods are developed in different climatic conditions and based on different construction practices.

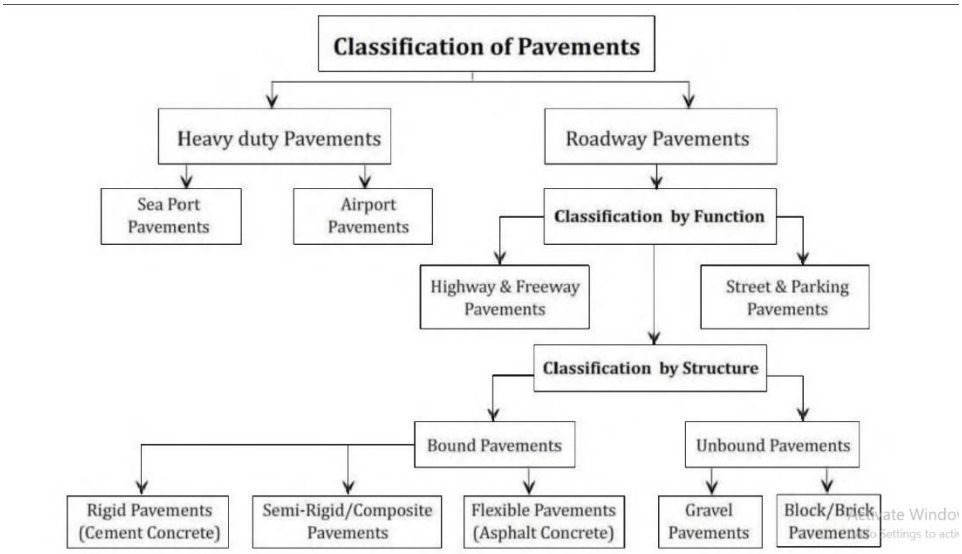
2.Calibration or estimation of different input parameters, especially layer (SN) and drainage coefficient of these western methods, are very difficult to perform.

3. As such pavement design by using these established methods may lead to unreliable as well as uneconomical design.

16. Draw a typical concrete pavement joint detail showing sealant reservoir and backer rod.



17. Broadly classify pavements



18. Differentiate between flexible and rigid pavements w.r.t Load distribution mechanism, Aggregate Type and Modulus of Elasticity

	Load distribution mechanism	Aggregate type	Modulus of elasticity
Flexible	**Each layer Carry a fraction of total load Distribute it gradually, due to aggregate interlocking/frictions/shearing, over a wider area than the previous layer, finally over a wide area of roadbed and thereby protect the roadbed being overstressed**	**Aggregates with high angularity are required to ensure good interlocking**	**Each layer is flexible with low modulus of elasticity**
Rigid	**A major portion of the load carried by the slab itself Distribute it over a relatively wide area of roadbed**	**Rounded aggregates may be used as they only fill the voids**	**Surface course is very rigid with high modulus of elasticity**

19. State the significance of PMB use in Bangladesh

- Heavy rainfall during monsoon causes inundation of pavement
- Lack of proper drainage facilities
- Roads and Highways endure severe congestion that induced flow of material in summer time
- Rampant overloading

20. Common modes of distresses for flexible and rigid pavements.

Type of Pavement Distresses: (flexible)

- Fatigue (alligator) cracking Polished aggregate
- Bleeding Potholes
- Block cracking Raveling
- Corrugation and shoving Rutting
- Depression Slippage cracking
- Joint reflection cracking Stripping
- Longitudinal cracking Transverse (thermal) cracking
- Patching Water bleeding and pumping

Type of Rigid Pavement Distresses

- Blow-up Reactive Aggregate Distress
- Corner Break Spalling
- Durability Cracking Shrinkage Cracking
- Faulting Polished Aggregate
- Joint Load Transfer System Deterioration Pumping
- Linear Cracking Punchout

21. What are the main functions of Tie bars and Dowel bars in rigid pavement?

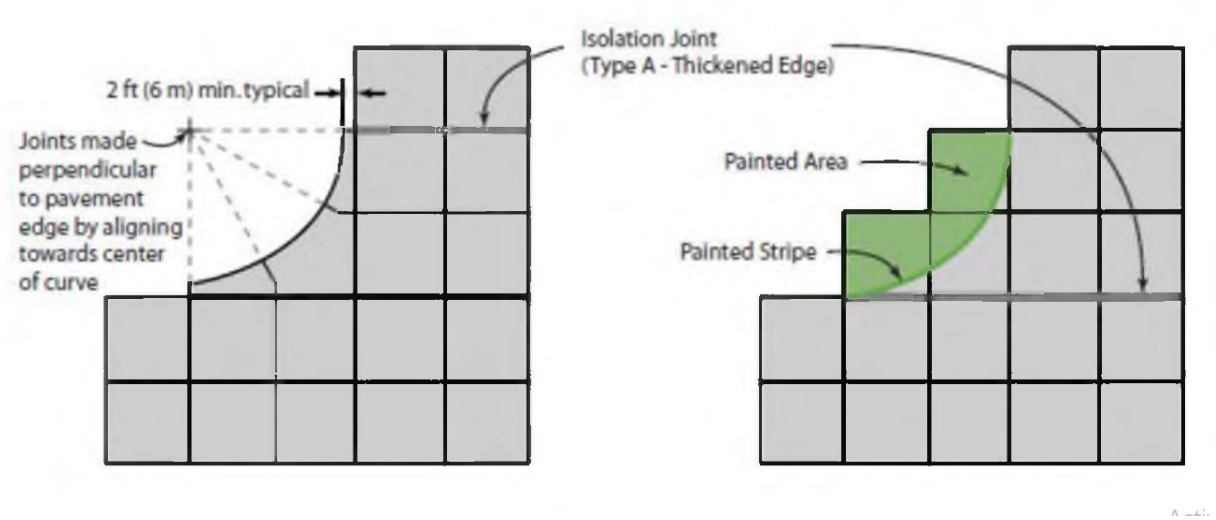
- Tie bars are deformed rebars or connectors used for holding faces of rigid slabs in contact to maintain aggregate interlock. Tie bars are not load transferring device. For instance, tie bars are used in longitudinal joints in concrete pavement.
- Dowel bars are smooth round bars which mainly serve as load transfer device across concrete joints. They are placed across transverse joints of concrete pavement to allow movement to take place. Where movement is purposely designed for longitudinal joints, dowel bars can be adopted.

22. Write down the odd-shaped panel considerations to reduce the risk of cracking in curved areas in concrete pavement

Odd-Shaped Panels - The odd-shaped panels that result in the road intersection areas where pavements intersect require the use of embedded steel. Cracks may form in odd shaped panels. A steel quantity of 0.05 % of the cross-sectional area in both directions is adequate for slabs where the length-to width ratio exceeds 1.25 or in slabs that are not rectangular in shape.

In the intersection, to reduce the risk of cracking in odd-shaped panels of curve areas,

- the last 3 ft (1 m) of all joints need to align perpendicular to the perimeter edge of the pavement and along a radial line.
- need to avoid layout patterns that create acute angles less than 60 degrees. Regardless of the situation, creation
- need to avoid creating a slab less than 2 ft (0.6 m) wide.



23. What are the major outcomes and purposes of AASHO road test?

Outcomes/Achievement of AASHO Road Test

- Serviceability Concept - PSI
- Traffic Damage Factors - ESALs
- Structural Number Concept - SN
- Empirical Process
- Simplified Pavement Design

Purposes

- to determine how traffic contributed to the deterioration of highway pavements
- to study the performance of pavement structures of known thickness under moving loads of known magnitude and frequency.

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24. Define standard axle load

The axle load of a wheeled vehicle is the total weight bearing on the roadway for all wheels connected to a given axle. Axle load is an important design consideration in the engineering of roadways and railways, as both are designed to tolerate a maximum weight-per-axle (axle load); exceeding the maximum rated axle load will cause damage to the roadway or rail tracks.

25. Important places where rigid pavement is recommended

1. Where extra performance (due to stationary/slow loading condition, stopping & starting, impact) is needed:

- Junction
- Bus pull-out/bay
- Toll plaza
- Level x-ing
- Runway threshold / turning area
- Taxiway

2. Road at Narrow (Lane by-lane) / Remote area (Roller accessibility problem)

3. Channelized/guided Traffic

4. Inundation / Submersible potential

5. Heavy duty pavements (Sea Port and Airport)

26. Joint wise classify rigid pavement.

Ans:

a. Stabilized sub-base

b. Plain Versus Reinforced Pavements

   i. Jointed Reinforcement Concrete Pavements (JRCP)

   ii. Continuously Reinforced Concrete Pavements (CRCP)

28. Problems associated with fatigue cracking and main causes of this distress

Ans:

Problem: Increase roughness (loss riding quality), indicator of structural failure, cracks allow moisture infiltration, eventually results in potholes and pavement disintegration if not treated.

Possible Causes: Inadequate structural support, which can be caused by a myriad of things. A few of the more common ones are listed here:

- Decrease in pavement load supporting characteristics
    - Loss of base, subbase or subgrade support (e.g., poor drainage or spring thaw resulting in a less stiff base)
    - Stripping on the bottom of the HMA layer (the stripped portion contributes little to pavement strength so the effective HMA thickness decreases)
- Increase in loading (e.g., more or heavier loads than anticipated in design)
- Inadequate structural design
- Poor construction (e.g., inadequate compaction)

29. Ways of removing bleeding of bituminous pavement

Ans:

The following repair measures may eliminate or reduce the asphalt binder film on the pavement's surface but may not correct the underlying problem that caused the bleeding:

- Minor bleeding can often be corrected by applying coarse sand to blot up the excess asphalt binder.
- Major bleeding can be corrected by cutting off excess asphalt with a motor grader or removing it with a heater planer. If the resulting surface is excessively rough, resurfacing may be necessary.

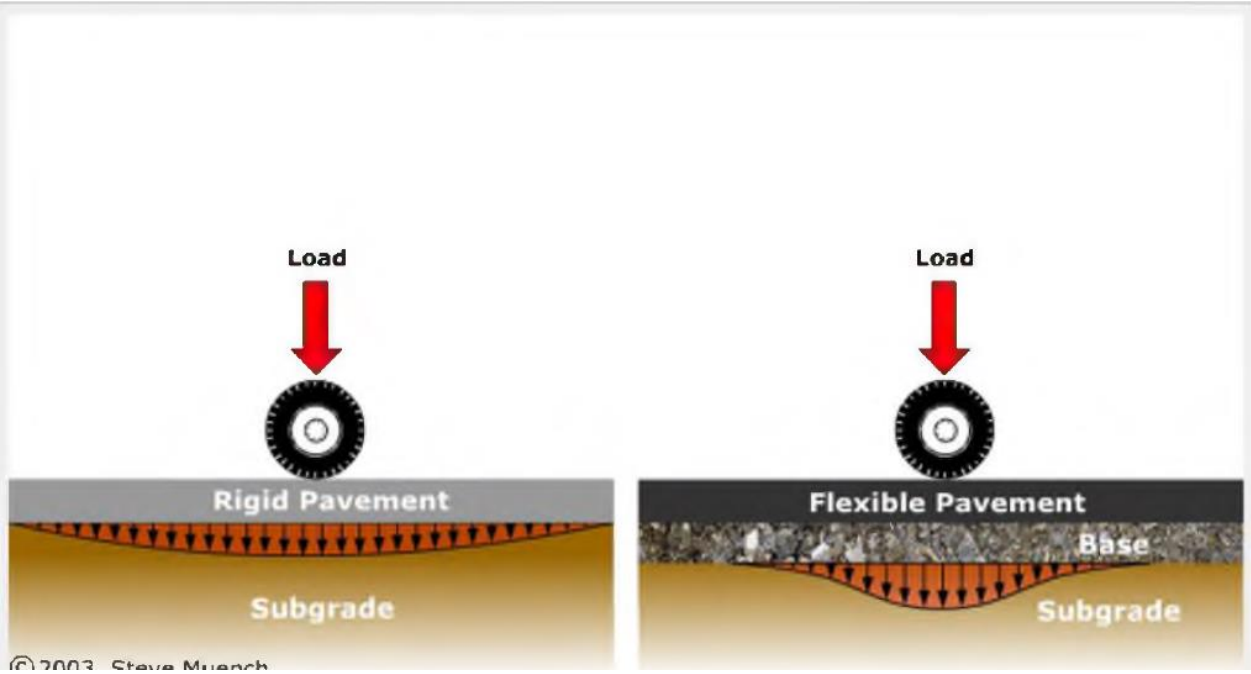
30. Advantages of rigid pavement

Ans:

1. Can deal with very heavy traffic
2. Very long-life span
3. Require little maintenance
4. Give good light reflectance quality
5. Provide pleasing appearance
6. They perform quite satisfactory even when constructed on poor sub-grade
7. Less susceptible to weather – specially at submerged condition
8. Heating of aggregates and cement is not required

31. Show load distribution mechanism for rigid and flexible pavement

Ans:



32. Classify flexible pavement.

Ans:

Dense-graded: A dense-graded mix is a well-graded HMA intended for general use. When properly designed and constructed, a dense-graded mix is relatively impermeable. Suitable for all pavement layers and for all traffic conditions. Works well for structural, friction, leveling and patching needs.

Open-Graded: Unlike dense-graded mixes and SMA, an open-graded HMA mixture is designed to be water permeable. Open-graded mixes use only crushed stone (or gravel) and a small percentage of manufactured sands. SMA is almost exclusively used for surface courses on high volume. It is used only as a drainage layer under dense graded HMA, SMA or Portland cement concrete.

Gap-graded or SMA: Stone matrix asphalt (SMA) is sometimes called stone mastic asphalt. The mix design goal is to create stone on stone contact within the mixture. Since aggregates do not deform as much as asphalt binder under load, this stone-on-stone contact greatly reduces rutting. SMA is generally more expensive than a typical dense graded HMA because it requires more durable aggregates, higher asphalt content, modified asphalt binder and fibers.

33. Why and where twin track rigid pavement is usually constructed
Ans:

34. Considerations of perpetual pavements
Ans:

1. Making pavement structure as a pure compression member by:
    i. Building pavement structure on a solid foundation (i.e. subgrade with a CBR greater than 5%, low swell & settlement potential)
    ii. Proper layer compaction towards achieving uniform support condition (OMC, specified lift thickness, using Smart Dynamic Compactor with online compaction checking facility)
    iii. Ensuring adequate edge confinement/restraint
    iv. Ensuring - adequate sub-surface drainage facilities
2. Use of Polymer Modified Binder and Glass Grid/Geo-Grid as Asphalt Reinforcement
3. Plant based mix production - to ensure proper heating & mixing
4. Use of MTV (Material Transfer Vehicle) - to minimize aggregate & temperature segregation
5. Smart Paver based construction (GPS based) - to ensure even surface
6. Extending pavement life by:
    i. Ensuring embankment stability
    ii. Enforcing overloading
    iii. Adopting Pavement Management Schemes
        a. Constructing extra pavement strip and periodic shifting of markings
        b. Adopt twin-track system where applicable
        c. Construct Rigid pavement where extra performance is needed
7. Ensuring proper surface drainage facility & control of heavy vehicles under submerged condition

35. Classification of rigid pavement joints

Ans:

Joint Types

1. Direction-wise
    a. Longitudinal joints
    b. Transverse joints
2. Function-wise
    a. Contraction Joints
    b. Expansion Joints
    c. Construction Joints
    d. Isolation Joints
3. Layout-wise - w.r.t direction of travel
    a. Perpendicular joints
    b. Skewed joints
    c. Staggered Joints