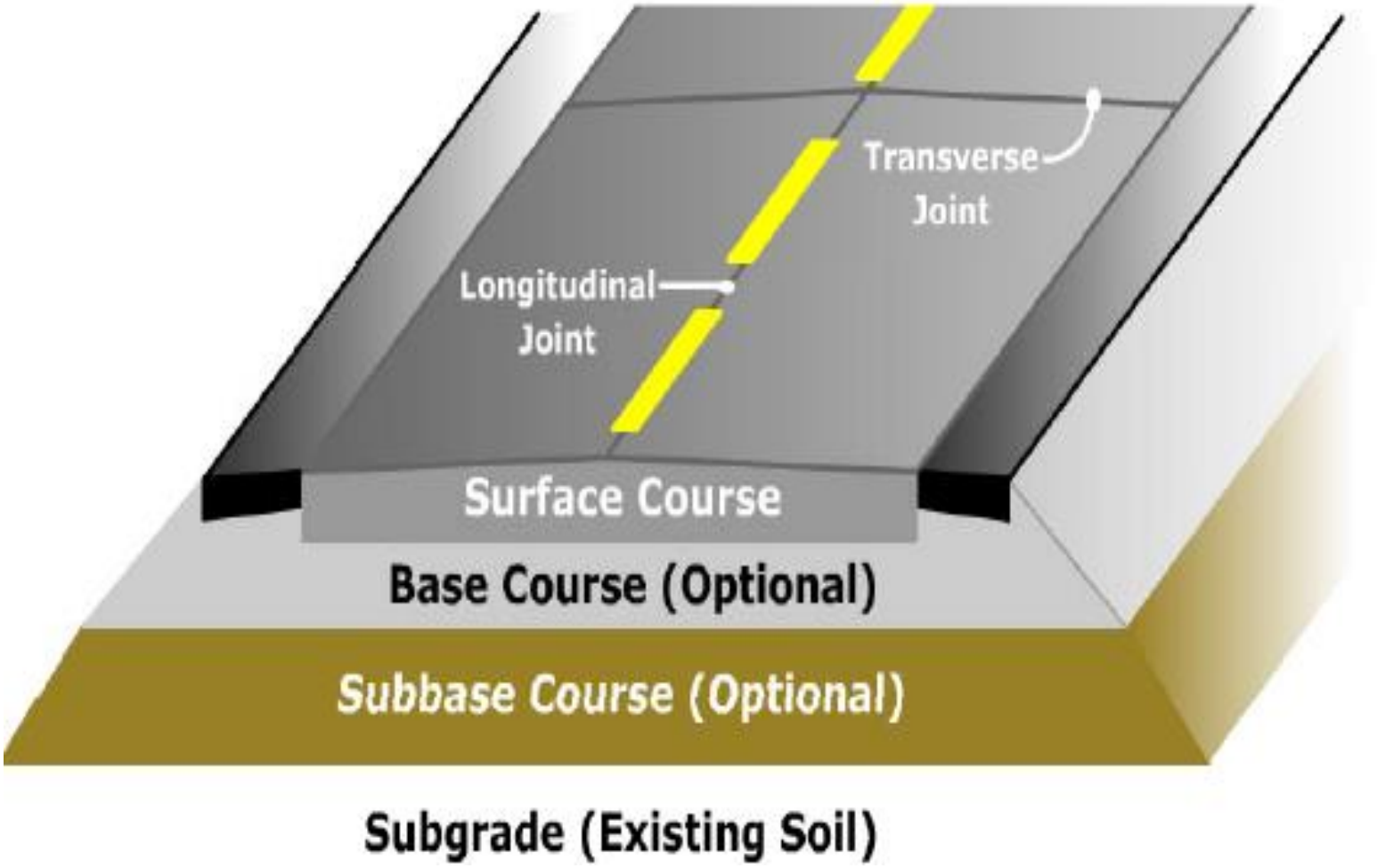
EWC 351

Transportation Engineering

Lec_Rigid Pvt_Comparison

Rigid Pavement

Rigid Pavement



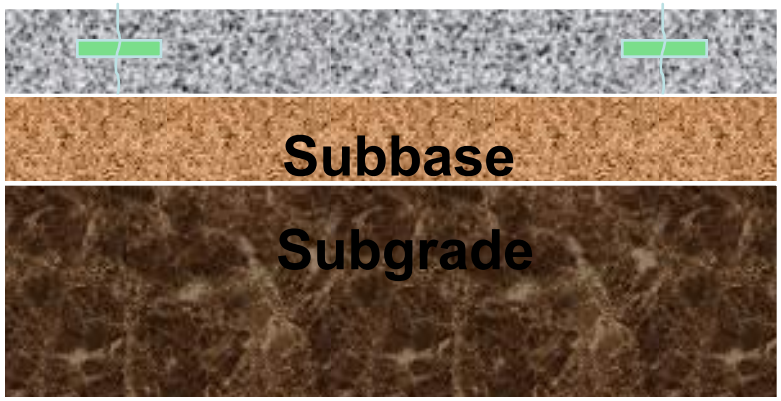
Rigid Pavement

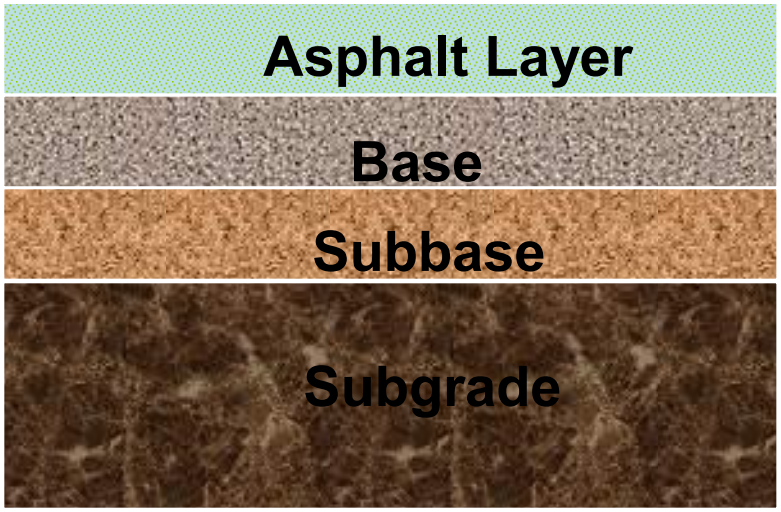
- A rigid pavement is composed of hydraulic cement concrete surface course.
- The surface course (Concrete slab) is stiffest and provide majority of the strength.
- Rigid pavements are substantially stiffer than flexible pavement
- Rigid pavement is designed and analyzed by using the plate theory
- The rigid characteristic of the pavement are associated with rigidity or flexural strength or slab action so the load is distributed over a wide area of subgrade soil.

Rigid Pavement

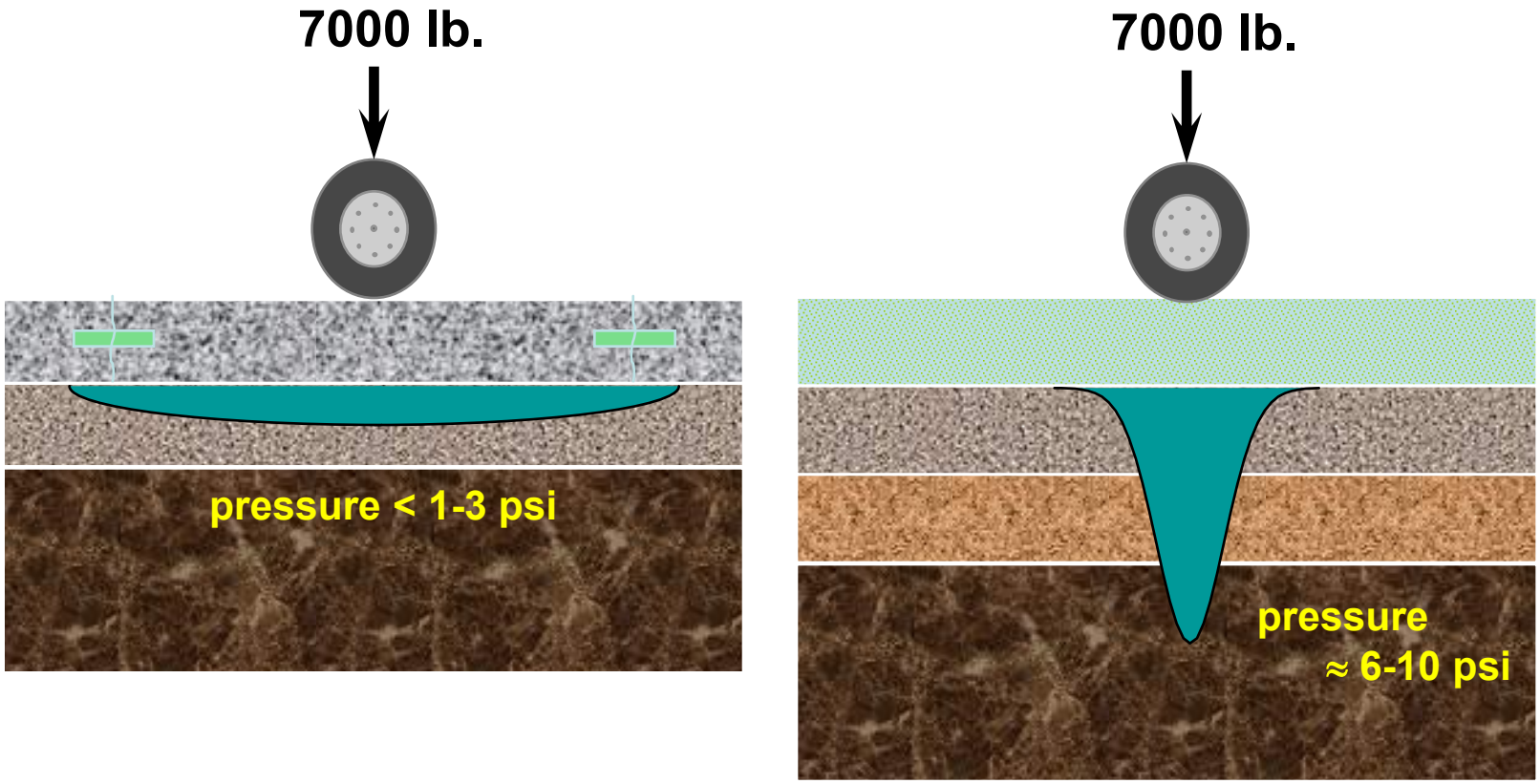
- Rigid pavements reduces the stress concentration and distribute reduced stress uniformly to area under slab
- Single layer system
- Derives capacity to withstands load from flexural or beam strength
- Inherent strength of the slab play major role in resisting wheel load.
- Minor imperfection or localized weak spots in the materials below the slab can be taken care by the slab itself
- The performance of the rigid pavement is more governed by the strength of the slab itself than by the subgrade support

Different Pavement Types





How Pavements Carry Loads



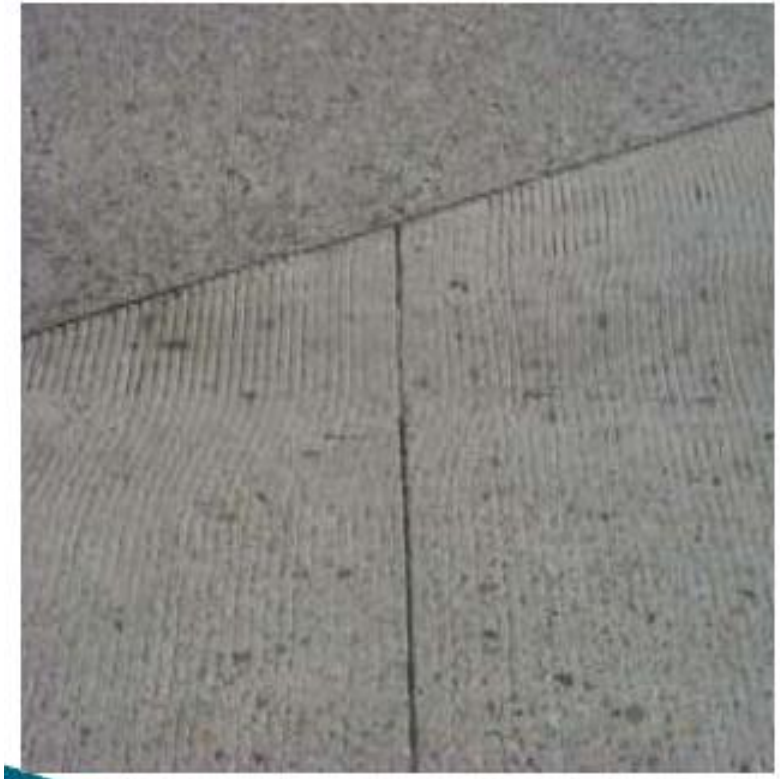
Concrete's Rigidness spreads the load over a large area and keeps pressures on the subgrade low.

Basic Structural Elements of Rigd Pvt

Surface course

- The surface course is the layer in contact with traffic loads and is made of PCC.
- It provides characteristics such as friction smoothness, noise control and drainage.
- In addition, it serves as a waterproofing layer to the underlying base, subbase and subgrade.
- The surface course can vary in thickness but is usually between 150 mm (6 inches) (for light loading) and 300 mm (12 inches) (for heavy loads and high traffic).

Basic Structural Elements of Rigd Pvt



PCC Surface



Rigid Pavement Slab
(Surface Course) Thickness

Basic Structural Elements of Rigd Pvt

Base course

- The base course is immediately beneath the surface course.
- It provides (1) additional load distribution, (2) contributes to drainage and frost resistance, (3) uniform support to the pavement and (4) a stable platform for construction equipment .
- Bases also help prevent subgrade soil movement due to slab pumping.

Base Course

Use of Base Course: Early concrete pavements were constructed directly on the sub - grade without a base course. As the weight and volume of traffic increased, pumping began and the use of a granular base course became quite popular . With very heavy wheel loads with free water on top of the base course, even granular materials can be eroded by the pulsative action of water. For heavily traveled pavements, the use of a cement-treated or asphalt-treated base course has now become a common practice . The following reasons have been frequently cited for using a base course:

- Control of Pumping
- Control of Frost Action
- Control of Shrinkage and Swell
- Drainage
- Expedition of Construction

Basic Structural Elements of Rigd Pvt

- Base courses are usually constructed out of:
  - ***Aggregate base.***
  - ***Stabilized aggregate or soil***
  - ***Dense-graded HMA.***
  - ***Permeable HMA.***
  - ***Lean concrete***

Basic Structural Elements of Rigd Pvt

Sub Base

The subbase course is the portion of the pavement structure between the base course and the subgrade. It functions primarily as structural support but it can also:

- Minimize the intrusion of fines from the subgrade into the pavement structure.
- Improve drainage.
- Minimize frost action damage.
- Provide a working platform for construction.

The subbase generally consists of lower quality materials than the base course but better than the subgrade soils. Appropriate materials are aggregate and high quality structural fill. A subbase course is not always needed or used.

Rigid Pavement (warrant)

Where rigid pavements are warranted?

- Where extra performance (due to stationary/slow loading condition, stopping & starting impact) is needed:
- Junction
- Bus pull-out/bay
- Toll plaza
- Level x-ing

Continued…….

Rigid Pavement (warrant)

- Runway threshold /turning area
- Taxiway
- Road Narrow (Lane by-lane) / Remote area (Roller accessibility problem)
- Channelized/guided Traffic
- Inundation / Submersible potential
- Heavy duty pavements (Sea Port and Airport)

TYPES OF RIGID PVT

Rigid pavements can be classified into four types:

- Jointed plain concrete pavement (JPCP),
- Jointed reinforced concrete pavement (JRCP),
- Continuous reinforced concrete pavement (CRCP), and
- Pre-stressed concrete pavement (PCP).
- 26 & 27 Huang (details) and next slides

TYPES OF RIGID PVT

Types of Concrete Pavement Concrete pavements can be classified into four types: jointed plain concrete pavement (JPCP), jointed reinforced concrete pavement (JRCP), continuous reinforced concrete pavement (CRCP), and prestressed concrete pavement (PCP). Except for PCP with lateral prestressing, a longitudinal joint should be installed between two traffic lanes to prevent longitudinal cracking. Figure 1.7 shows the major characteristics of these four types of pavements.

Jointed Plain Concrete Pavements All plain concrete pavements should be constructed with closely spaced contraction joints. Dowels or aggregate interlocks may be used for load transfer across the joints. The practice of using or not using dowels varies among the states. Dowels are used most frequently in the southeastern states, aggregate interlocks in the western and southwestern states, and both are used in other

TYPES OF RIGID PVT

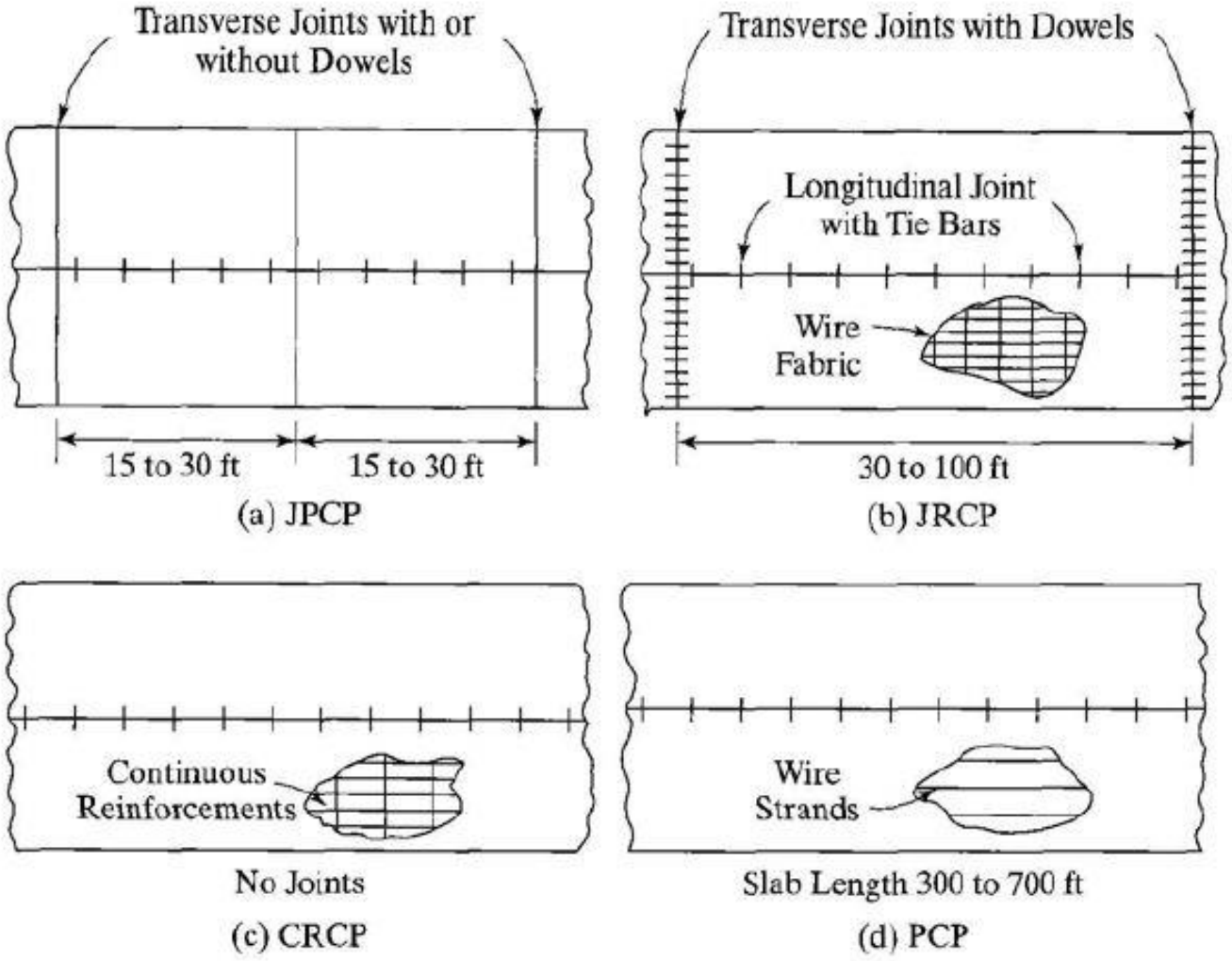
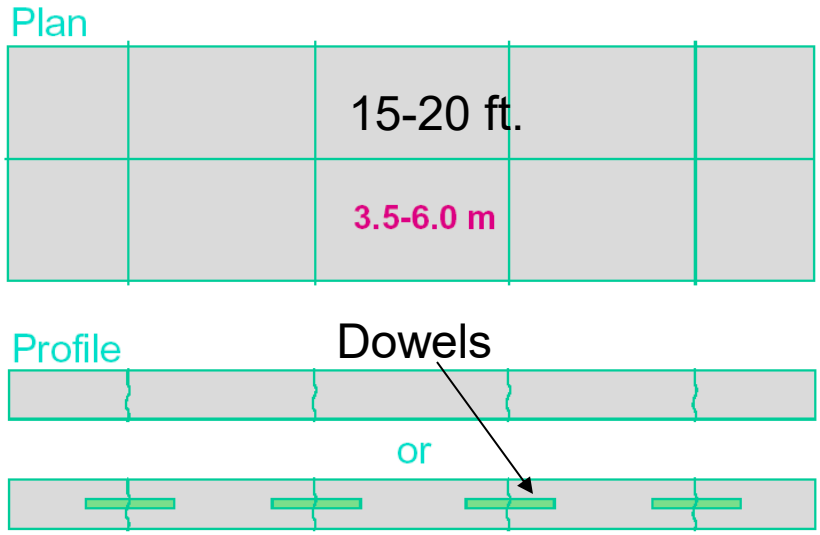


FIGURE 1.7

Four types of concrete pavements (1 ft = 0.305 m).

Pavement Types

- Jointed Plain (JPCP)
  - Undoweled
  - Doweled



TYPES OF RIGID PVT

areas. Depending on the type of aggregate, climate, and prior experience, joint spacings between 15 and 30 ft (4.6 and 9.1 m) have been used. However, as the joint spacing increases, the aggregate interlock decreases, and there is also an increased risk of cracking. Based on the results of a performance survey, Nussbaum and Lokken (1978) recommended maximum joint spacings of 20 ft (6.1 m) for doweled joints and 15 ft (4.6 m) for undoweled joints.

Jointed Reinforced Concrete Pavements Steel reinforcements in the form of wire mesh or deformed bars do not increase the structural capacity of pavements but allow the use of longer joint spacings. This type of pavement is used most frequently in the northeastern and north central part of the United States. Joint spacings vary from 30 to 100 ft (9.1 to 30 m). Because of the longer panel length, dowels are required for load transfer across the joints.

The amount of distributed steel in JRCP increases with the increase in joint spacing and is designed to hold the slab together after cracking. However, the number of joints and dowel costs decrease with the increase in joint spacing. Based on the unit costs of sawing, mesh, dowels, and joint sealants, Nussbaum and Lokken (1978) found that the most economical joint spacing was about 40 ft (12.2 m). Maintenance costs generally increase with the increase in joint spacing, so the selection of 40 ft (12.2 m) as the maximum joint spacing appears to be warranted.

TYPES OF RIGID PVT

Continuous Reinforced Concrete Pavements It was the elimination of joints that prompted the first experimental use of CRCP in 1921 on Columbia Pike near

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Washington, D.C. The advantages of the joint-free design were widely accepted by many states, and more than two dozen states have used CRCP with a two-lane mileage totaling over 20,000 miles (32,000 km). It was originally reasoned that joints were the weak spots in rigid pavements and that the elimination of joints would decrease the thickness of pavement required. As a result, the thickness of CRCP has been empirically reduced by 1 to 2 in. (25 to 50 mm) or arbitrarily taken as 70 to 80% of the conventional pavement.

TYPES OF RIGID PVT

The formation of transverse cracks at relatively close intervals is a distinctive characteristic of CRCP. These cracks are held tightly by the reinforcements and should be of no concern as long as they are uniformly spaced. The distress that occurs most frequently in CRCP is punchout at the pavement edge. This type of distress takes place between two parallel random transverse cracks or at the intersection of Y cracks. If failures occur at the pavement edge instead of at the joint, there is no reason for a thinner CRCP to be used. The 1986 AASHTO design guide suggests using the same equation or nomograph for determining the thickness of JRCP and CRCP. However, the recommended load-transfer coefficients for CRCP are slightly smaller than those for JPCP or JRCP and so result in a slightly smaller thickness of CRCP. The amount of longitudinal reinforcing steel should be designed to control the spacing and width of cracks and the maximum stress in the steel. Details on the design of CRCP are presented in Section 12.4.

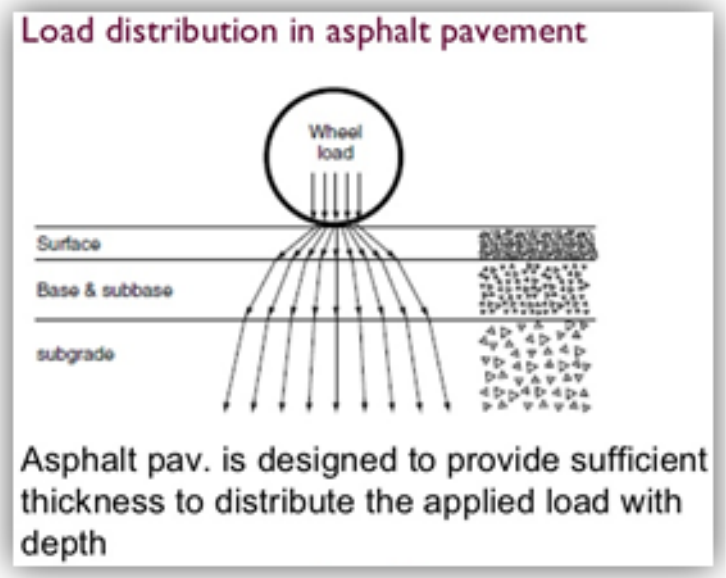
TYPES OF RIGID PVT

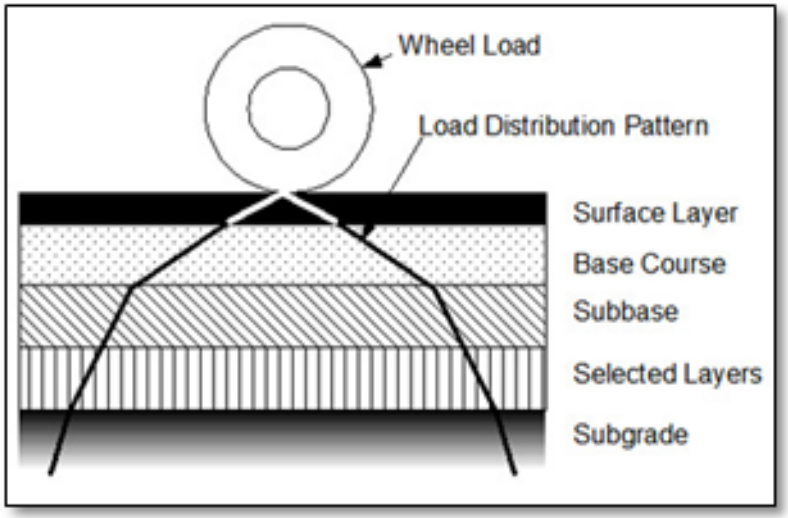
Prestressed Concrete Pavements Concrete is weak in tension but strong in compression. The thickness of concrete pavement required is governed by its modulus of rupture, which varies with the tensile strength of the concrete. The preapplication of a compressive stress to the concrete greatly reduces the tensile stress caused by the traffic loads and thus decreases the thickness of concrete required. The prestressed concrete pavements have less probability of cracking and fewer transverse joints and therefore result in less maintenance and longer pavement life.

The first known prestressed highway pavement in the United States was a 300-ft (91-m) pavement in Delaware built in 1971 (*Roads and Streets*, 1971). This was followed in the same year by a demonstration project on a 3200-ft (976-m) access road at Dulles International Airport (Pasko, 1972). In 1973, a 2.5-mile (4-km) demonstration project was constructed in Pennsylvania (Brunner, 1975). These projects were preceded by a construction and testing program on an experimental prestressed pavement constructed in 1956 at Pittsburgh, Pennsylvania (Moreell, 1958). These projects have the following features:

Comparison Flexible & Rigid Pvt

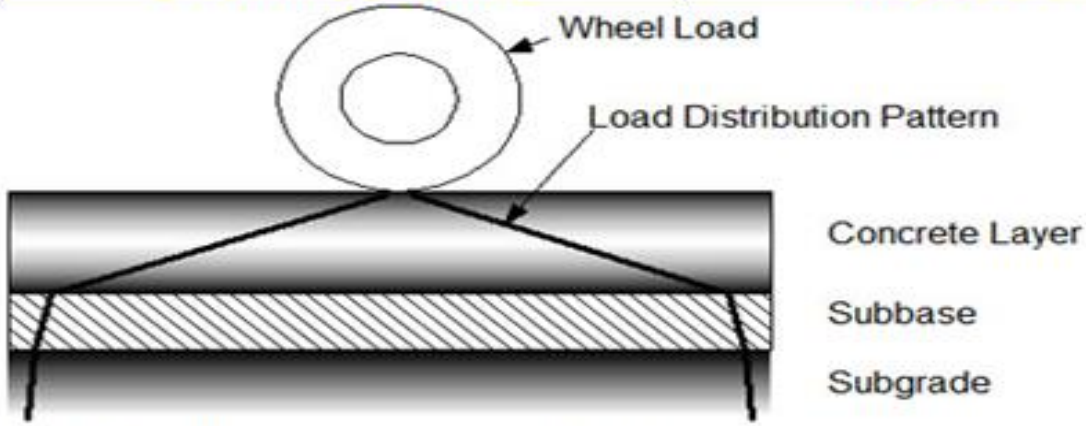
Properties	Flexible Pavement	Rigid Pavement
1. **Design Principle**	Empirical method based on load distribution characteristics of the component (Fig-6)	Designed and analyzed by elastic theory (Fig-4&7)





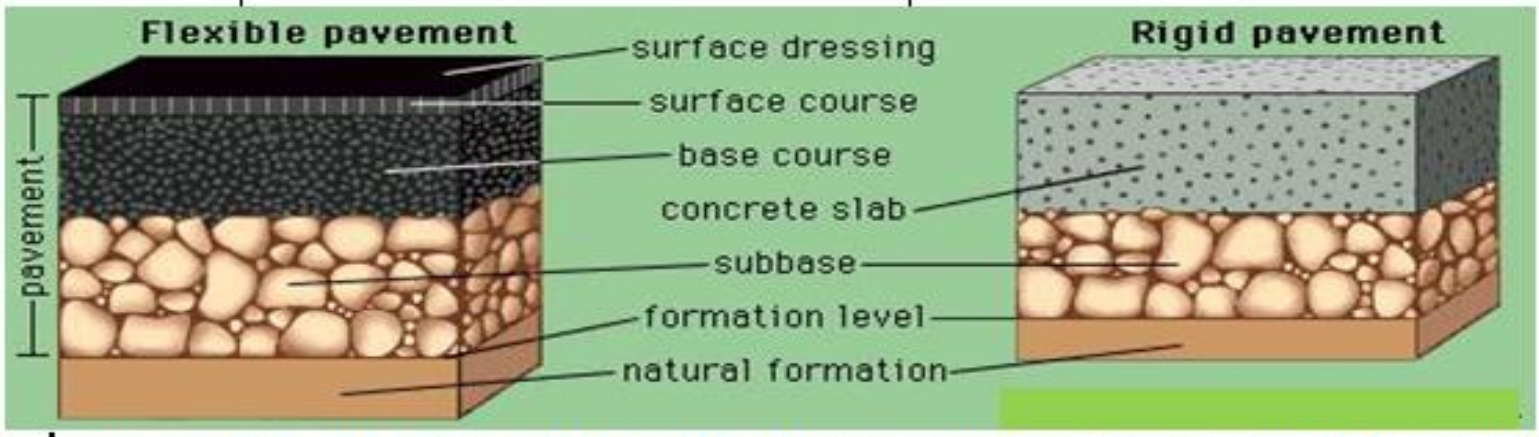
Load Distribution pattern in flexible pavement (Empirical method)

Properties	Flexible Pavement	Rigid Pavement



Load Distribution pattern in Rigid pavement

2. **Material**	Layers are mainly made of granular materials (Fig-8)	Made of cement concrete either plan, reinforced or pre-stressed concrete.(Fig-8)

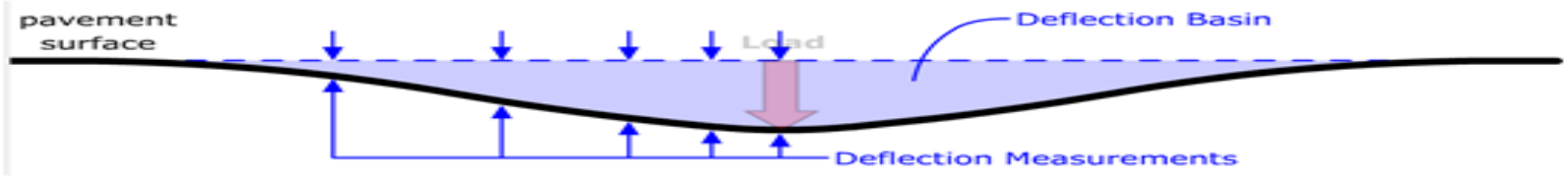


Layers of granular materials in flexible pavement and concrete slab in rigid pavement.

3.Flexural strength	Low or negligible flexible strength	Associated with rigidity or flexural strength or slab action, so the load is distributed over a wide area of subgrade soil.
4.Bending	A flexible pavement will flex (bend) under the load of a tyre. The objective with the design of a flexible pavement is to avoid the excessive flexing of any layer, failure to achieve this will result in the over stressing of a layer, which ultimately will cause the pavement to fail.	Rigid pavements are considered to be rigid, implying that the pavement will not flex (bend). This is not entirely accurate, since even a rigid pavement will flex, the amount is however so small that when compared with a flexible pavement, it is considered rigid. (Fig-9)

Properties	Flexible Pavement	Rigid Pavement





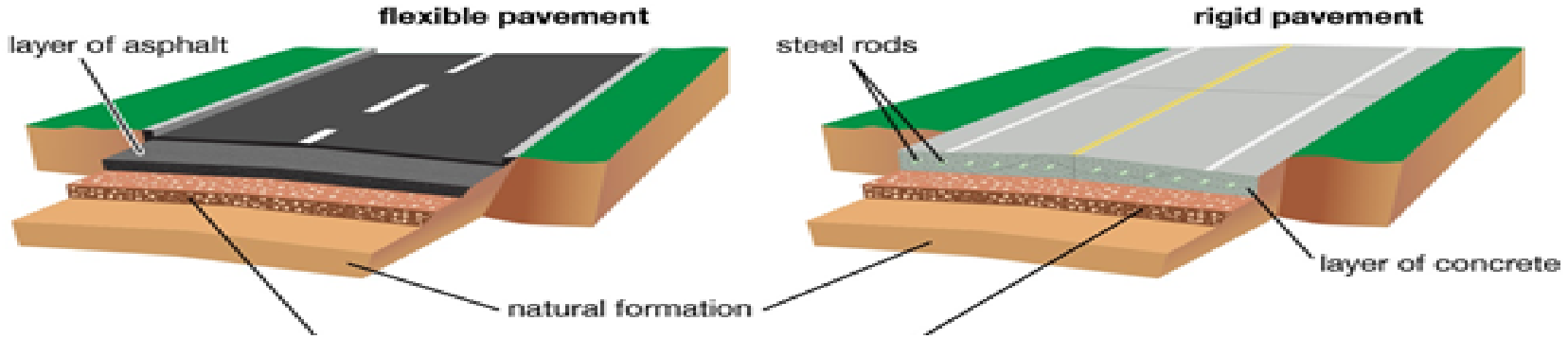
Deflection on concrete pavement (rigid pavement)

Comparison Flexible & Rigid Pvt

5. Normal loading	Elastic deformation is experienced under normal loading	Acts as beam or cantilever. **Explanation**: The increased rigidity of concrete allows the concrete surface layer to bridge small weak areas in the supporting layer through what is known as beam action. This allows the placement of rigid pavements on relatively weak supporting layers, as long as the supporting layer material particles will not be carried away by water forced up by the pumping action of wheel loads
6. Excessive loading	Local depression occurs in flexible pavement (Fig-9).	Excessive loading causes cracks in rigid pavement (Fig-10)  Fig-10: Cracks in rigid pavement
7. Stress	Flexible pavement transmits vertical and compressive stress to the lower layers.	Tensile stress develops.
8. Temperature	No stress is developed due to temperature in flexible pavement.	Stress is produced due to temperature in rigid pavement.

9. Force of friction	Less force of friction. Deformation in the subgrade is not transferred to the upper layers.	Friction force in rigid pavement is very high.
10. Surfacing	Rolling of the surfacing is needed	Rolling of the surfaces is not needed.
11.Load distribution	Grain to grain	No such phenomenon
12. Economy	Construction cost less but maintenance cost high	Construction cost high but maintenance cost less
13. design Life	Low	High
14. Opening to the traffic	Road can be used for traffic within 24hours of construction.	Road cannot be used until 14 days of curing.
15.Types of road construction	Constructed in number of layers	Laid in slab with steel reinforcement.

Types of road construction



Discussion