Mustansiriyah University / Faculty of Engineering

Highway &Transportation Engineering Department

Highway Maintenance Course

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Presented by:

Assistance Prof. Dr.Siham I Salih

Assistance Prof. Dr.Sady A.Tayh

Lecture TWO

Types of Pavement Failure

The pavements are broadly classified into two categories, namely, flexible pavements and rigid pavements. There are specific causes that contribute to the failure of each type and they will be now briefly described as follows:

1) Failures in flexible pavements

(2) Failures in rigid pavements.

Here we briefly discuss about flexible pavement failure:

Failures in flexible pavements:

The term flexible pavement failure is defined by the localized depressions or settlements. The depressions are normally followed by heaving in the vicinity and the sequence ultimately leads to the formation of a wavy pavement surface.

A) failure in Flexible pavement due to failure of subgrade

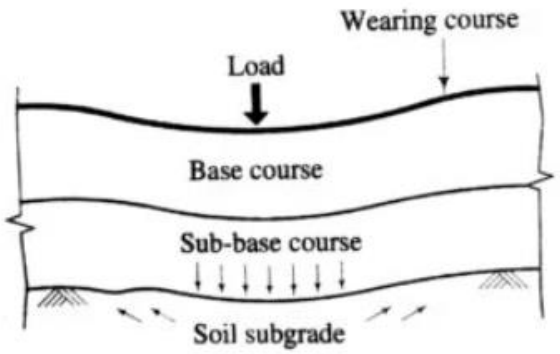
The localized depression may develop due to the failure of any component layer of the flexible pavement structure. Fig. 1, 2, and fig. 3 show respectively failures in flexible

pavements due to failure in the subgrade, failure in base or sub-base course, and failure in wearing course.

It is therefore absolutely necessary to see that each layer is properly designed and laid so that it is stable within itself and thus assists in the overall stability of the flexible pavement. The arrows in the figures indicate the direction of upheaval due to the movement of material from the layer.

(i) Failures in subgrade:

The following are the two main reasons for failures in the subgrade:



Failure in subgrade

Fig.1. Failure in Subgrade

(a) Excessive stress application:

If the pavement thickness is inadequate or the loads are in excess of the design value, the excessive stress is developed and it harms as load repetitions are increased.

(b) Inadequate stability:

The resistance to deformation. under stress is known as stability. The inadequate stability of the subgrade is developed due to the inherent weakness of the soil itself or excessive moisture or improper compaction.

(ii) Failures in sub-base or base courses:

The main reasons which contribute to the failures in sub-base or base courses can be mentioned as follows:

(a) ***Inadequate strength:*** The poor mix proportioning or inadequate thickness of pavement may lead to the lack of stability or strength of sub-base or base course.

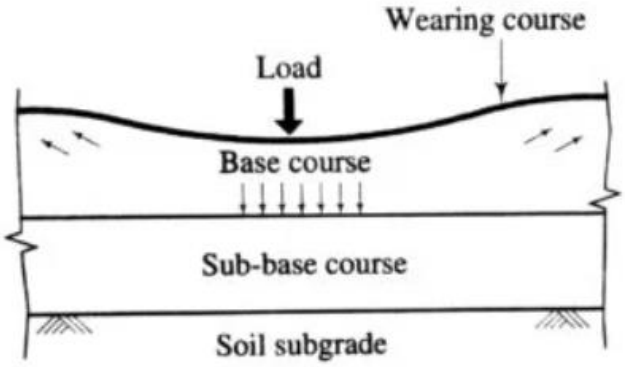


Fig.2. failure in Base course

b) Inadequate wearing course: If the wearing course is of inadequate thickness or if it is totally absent, the sub-base or base courses are exposed to the damaging effects of the climatic agencies and the traffic.

C. Lack of lateral confinement:

If lateral confinement is not provided for granular sub-base or base courses, the action of traffic causes the materials of these courses to spread out.

d) Loss of binding action:

The repeated stress applications lead to the internal movements of aggregate in sub base or base courses and ultimately the composite mass or structure of the layers gets disturbed. Thus the loss of binding action is developed and it leads to the low stability and poor load transmitting property of the pavement layer.

(e) Loss of materials:

If the base course is not covered with a wearing course or if the wearing course has completely worn out, there are chances of loss of base course materials due to action of traffic and it leads to the formation of pot holes on the surface. Use of inferior materials: If the materials employed in the construction of flexible pavements do not comply with the standard requirements, the structural behaviour of the pavement is affected.

(iii) Failures in wearing course:

The failures in wearing course are attributed to the following reasons:

(a) Lack of proper mix design: If the mix design does not provide for adequate binder content, the bituminous surface will exhibit poor performance under the action of traffic.

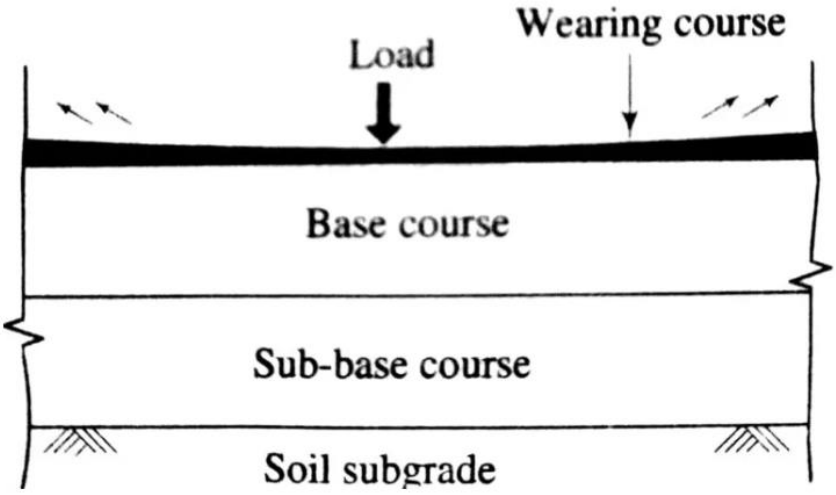


Fig. 3. Failure in wearing course

(b) **Quality control: It is necessary to provide a high degree of quality control in bituminous construction. The resulting paving mix should**

contain just enough binder content only. *Interesting For You:* Highway(Road) Lighting: Design factors, Benefits, Cost and Spacing

(c) **Volatilization and oxidation of binder:** The bituminous surface becomes brittle due to volatilization and oxidation of binder. It results in the cracking of the pavement surface which further permits the seepage of rainwater to cause damage to the underlying layers.

Type of Flexible Pavement failure

Following are some of the typical flexible pavement failures:

(1) Alligator or map cracking

The alligator or map cracking of the surface course occurs in the pattern as shown in fig. 4.

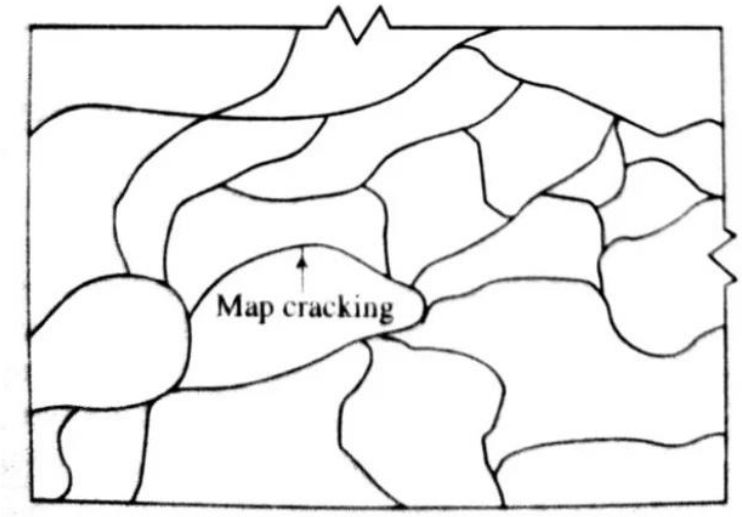


Fig.4. Alligator or map cracking

This is the most common type of flexible pavement failure. mainly occurs due to fatigue and localized weakness in the underlying base course.

(2) Consolidation of pavement layers:

The consolidation el one or more layers of pavement leads to the formation of rats, as shown in fig. 5. The term consolidation deformation is used to indicate the cumulative deformation which occurs due to the repeated application of loads on the same spots in the road width. Depending upon the width of ruts, it can be decided whether the consolidation deformation has occurred in the subgrade or in subsequent layers.

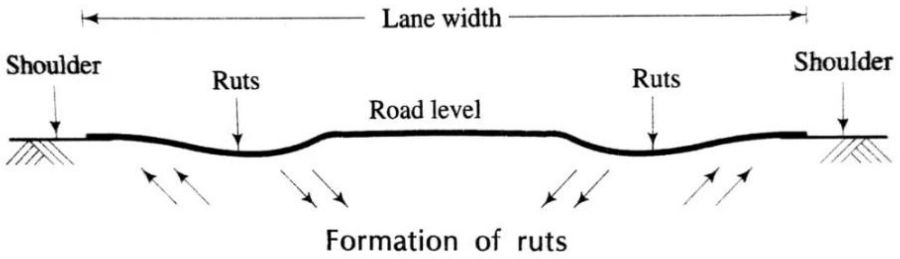


Fig.5. Formation of Ruts

(3) Formation of waves:

The formation of waves and corrugations on the flexible pavement surface takes places for the following reasons:

(i) excessive speed of vehicles combined with harmonic spring action;

(ii)defective rolling:

(iii) spongy foundation or sub-base; and

(iv) use of unsuitable binding materials.

The formation of waves and corrugations can be minimized to a great extent by controlling vehicle speed, careful rolling, effective drainage combined with formation in good soils and using a stable binder.

(4) Frost heaving:

Depending upon the groundwater and climatic conditions, a localized heaving up of a portion of pavement takes place due to the action of frost, as shown in fig. 6.

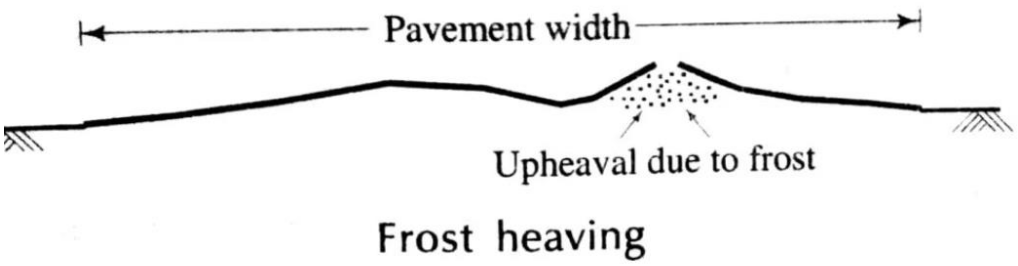


Fig.6 Frost Heaving due to weather change is also a flexible pavement failure

(5) Lack of binding with the lower course:

If the surface course is not properly keyed or bound with the lower course, slipping occurs and it leads to the loss of pavement materials forming patches or potholes, as shown in fig. 7.

This type of failure is common in the case where the bituminous surfacing is provided over the existing cement concrete base course or soil-cement base course.

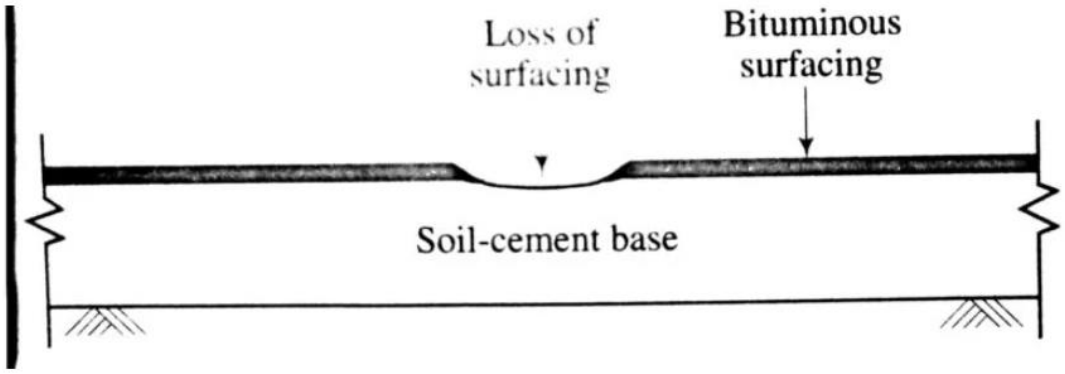


Fig. 7. Failure due to lack of binding

(6) Longitudinal cracking:

The longitudinal cracking in pavement occurs due to frost action and differential volume changes in the subgrade. It may traverse through the full pavement

thickness. The other two causes of this type of failure are sliding of side slopes and settlement of filling material.

(7) Reflection cracking:

When a bituminous overlay is provided over the existing cement concrete pavement and if due to some reason, the cement concrete pavement fails, the same pattern of cracks in the form of reflection cracks is seen on the bituminous overlay, as shown in fig. 8.

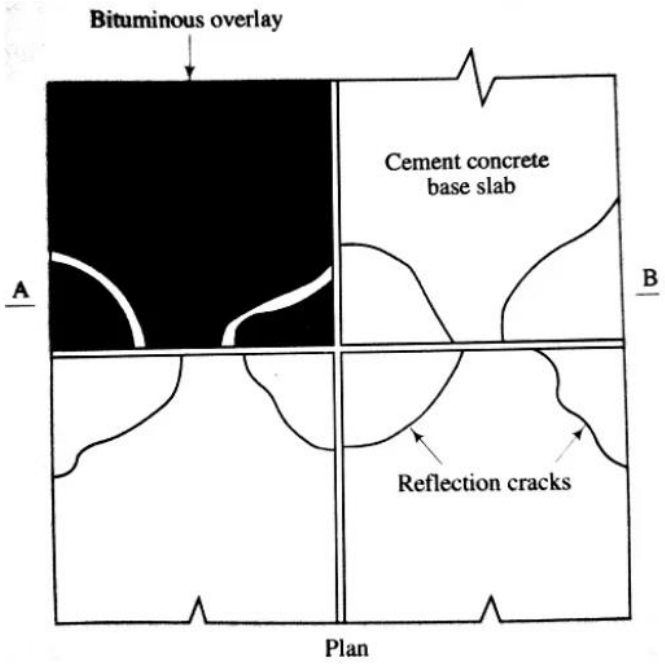


Fig.8. A typical plan for Reflection cracking

The reflection cracks do not affect the structural action of pavement section. But they cause damage to the subgrade or develop mud pumping as surface water gets entry through these cracks.

(8) Shear failure:

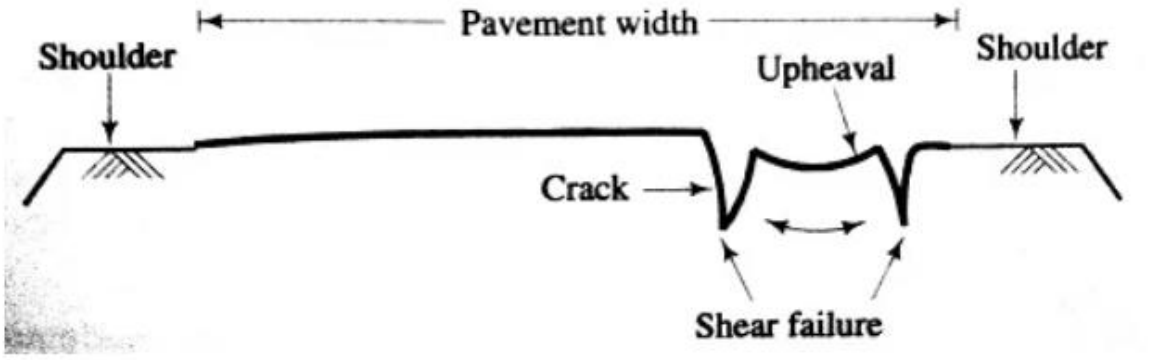


Fig.9. Shear failure

If the shearing resistance of the pavement is low, the shear failure cracking occurs, as shown in fig. 9. The upheaval of pavement materials is caused by the formation of cracks. The inadequate stability or

excessively heavy loading contributes to the poor shear resistance of the pavement mixture.

9) Slope failure:

Soil instability is the inclination of soil for upward, lateral, or downward movement due to natural factors like pore water pressure, cracking, earthquakes, etc.

It is crucial to understand the factors that cause slope instability for two reasons. First, for the construction and design of new slopes, and second, for repairing the old slopes that fail before their intended lifespan.

When designing a new slope, it is important to anticipate the modifications in the chemical and mechanical properties of the soil within the slope. These modifications usually develop over time under different loading and seepage conditions and may affect the slope stability in the long run.

For repairing the slopes that fail before their intended lifespan, it is crucial to recognize the situations and components that led to the failure, so the stability of such slopes can be maintained, and failures can be avoided in the future.

Reasons for Slope Failure

The basic criterion to achieve a stable slope is to ensure that the shear strength of the soil is higher than the shear stress that may cause the failure. If this basic requirement is not fulfilled, the slope may get unstable and fail.

Following are the ways that can affect the stability of slopes :

1. **The decrease in the shear strength of the soil.**
2. **The increase in the shear stress that ultimately causes the failure of soil.**