INVESTIGATION ON THE CAUSES OF FAILURE IN FLEXIBLE PAVEMENT

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ABSTRACT
Flexible Pavements (bituminous roads) are specifically designed to carry loads of men and material to various destinations and should last for the period for which they have been designed.
Failure of flexible pavement structure is defined as break or fracture. The cases of failures of flexible pavements (bituminous roads) have been reported in many developing countries. This failure usually happens when applied load exceeds the maximum allowable value. The applied loading on flexible pavement (bituminous road) is usually much smaller than the strength of material. Therefore one application doesn’t fail the pavement, but causes as infinitesimal amount of deterioration. This deterioration gradually increases until it reaches an unacceptable level. Flexible pavement fails due to any one of the following three failures. These are sub-grade failure, sub-base or base course failure and wearing course failure the causes of failure needs to be investigated using appropriate methodology and equipments. To determine the pavement characteristics such as structural adequacy (strength) Benkelman Beam Deflection Test (BBDT) and falling weight deflectometer (FWD) are frequently used. The surface condition of the pavement is mainly assessed in terms of roughness, pavement surface distress in the form of cracking, Ravelling, potholes, edge break, patch work, rutting, skid resistance and texture depth. British Pendulum Tester (BPT) is used to assess the Skid resistance. The limiting value for each test is defined in code of practice which is the base to investigate and ascertain the causes of failure.

Keywords: Flexible Pavement, Benkelman Beam Deflection Test (BBDT), British Pendulum Tester (BPT). Roughness, Cracking, Raveling, Potholes.

I. INTRODUCTION
1.1 Meaning of flexible pavement
That with which anything is paved in road; a floor or covering of solid material, laid in down so as to make a hard and convenient surface for travel; a paved road or sidewalk; a decorative interior floor of tiles colored bricks.

1.2 Types of road pavement
Road Pavements are typically divided into the following three general categories: flexible, rigid and unpaved (gravel or dirt).
2.0 Flexible (Bituminous Pavement):
Flexible road pavements are constructed of several layers of natural granular material covered with one or more waterproof bituminous surface layers, and as the name imply, are considered to be flexible. A flexible road pavement will flex (bend) under the load of vehicle tyre. The objective with the design of a flexible road pavement is to avoid the excessive flexible of any layer, failure of flexible to achieve this will result in the over stressing of a layer, which ultimately will cause the pavement to fail. In flexible pavements, the load distribution pattern changes from one layer to another, because the strength of each layer is different from another layer. The strongest material (least flexible) is in the top layer and the weakest material (most flexible) is in the lowest layer. The reason for this is that at the surface the wheel load is applied to a small area, the result is high stress levels, deeper down in the pavement, the wheel load is applied to larger area and the result is lower stress levels thus enabling the use of weaker materials in road construction.

3.1 Types of flexible pavement deterioration: The four major categories of common asphalt pavement surface distresses are:
1. Cracking
2. Surface deformation
3. Disintegration (potholes, etc.)
4. Surface defects (bleeding, etc.)

A. Cracking:
The most common types of cracking are:
- Fatigue cracking
- Longitudinal cracking
- Transverse cracking
- Block cracking
- Slippage cracking
- Reflective cracking

1. Fatigue cracking (Alligator cracking):
Fatigue cracking is commonly called alligator cracking. This is a series of interconnected cracks creating small, irregular shaped pieces of pavement. It is caused by failure of the surface layer or base due to repeated traffic loading (fatigue). Eventually the cracks lead to disintegration of the surface, as shown in Figure. The final result is potholes. Alligator cracking is usually associated with base or drainage problems.

2. Longitudinal cracking:
Longitudinal cracks are long cracks that run parallel to the center line of the roadway. These may be caused by frost heaving or joint failures or they may be load induced. Understanding the cause is critical to selecting the proper repair. Multiple parallel cracks may eventually form from the initial crack. This phenomenon, known as deterioration, is usually a sign that crack repairs are not the prop

3. Transverse cracking:
Transverse cracks form at approximately right angles to the centerline of the roadway. They are regularly
spaced and have some of the same causes as longitudinal cracks. Transverse cracks will initially be widely spaced (over 20 feet apart). They usually begin as hairline or very narrow cracks and widen with age. If not properly sealed and maintained, secondary or multiple cracks develop, parallel to the initial crack. The reasons for transverse cracking, and the repairs, are similar to those for longitudinal cracking. In addition, thermal issues can lead to low-temperature cracking if the asphalt cement is too hard. Figure shows a low-severity transverse crack.

4. **Block cracking:**
Block cracking is an interconnected series of cracks that divides the pavement into irregular pieces. This is sometimes the result of transverse and longitudinal cracks intersecting. They can also be due to lack of compaction during construction. Low severity block cracking may be repaired by a thin wearing course. As the cracking gets more severe, overlays and recycling may be needed. If base problems are found, reclamation or reconstruction may be needed. Figure shows medium to high severity block cracking.

5. **Slippage cracking:**
Slippage cracks are half-moon shaped cracks with both ends pointed towards the oncoming vehicles. They are created by the horizontal forces from traffic. They are usually a result of poor bonding between the layers, which requires removal of the slipped area and repaving. Be sure to use a tack coat in the new pavement.

6. **Reflective cracking:**
Reflective cracking occurs when a pavement is overlaid with hot mix asphalt concrete and cracks reflect up through the new surface. It is called reflective cracking because it reflects the crack pattern of the pavement structure below. As expected from the name, reflective cracks are actually covered over cracks reappearing in the surface. They can be repaired in similar techniques to the other cracking noted above. Before placing any overlays or wearing courses, cracks should be properly repaired.

7. **Edge cracking:**
Edge cracks typically start as crescent shapes at the edge of the pavement. They will expand from the edge until they begin to resemble alligator cracking. This type of cracking results from lack of support of the shoulder due to weak material or excess moisture. They may occur in a curbed section when subsurface water causes a weakness in the pavement. At low severity the cracks may be filled. As the severity increases, patches and replacement of distressed areas may be needed. In all cases, excess moisture should be eliminated, and the shoulders rebuilt with good materials. Figure shows high severity edge cracking.

B. **Surface deformation:**
Pavement deformation is the result of weakness in one or more layers of the pavement that has experienced movement after construction. The deformation may be accompanied by cracking. Surface distortions can be a traffic hazard.

The basic types of surface deformation are:
1. **Rutting**
2. **Corrugations**
3. **Shoving**
4. **Depressions**
5. **Swell**

1. **Rutting**
Rutting is the displacement of pavement material that creates channels in the wheel path. Very severe rutting will actually hold water in the rut. Rutting is usually a failure in one or more layers in the pavement. The width of the rut is a sign of which layer has failed. A very narrow rut is usually a surface failure, while a wide one is indicative of a sub grade failure. Inadequate compaction can lead to rutting. Figure
shows an example of rutting due to sub grade Failure. Minor surface rutting can be filled with micro paving or paver-placed surface treatments. Deeper ruts may be shimmed with a truing and leveling course, with an overlay placed over the shim. If the surface asphalt is unstable, recycling of the surface may be the best option. If the problem is in the sub grade layer, reclamation or reconstruction may be needed.

2. Corrugation:
Corrugation is referred to as wash boarding because the pavement surface has become distorted like a washboard. The instability of the asphalt concrete surface course may be caused by too much asphalt cement, too much fine aggregate, or rounded or smooth textured coarse aggregate. Corrugations usually occur at places where vehicles accelerate or decelerate. Minor corrugations can be repaired with an overlay or surface milling. Severe corrugations require a deeper milling before resurfacing.

3. Shoving:
Shoving is also a form of plastic movement in the asphalt concrete surface layer that creates a localized bulging of the pavement. Locations and causes of shoving are similar to those for Corrugations. Figure shows an example of shoving. Repair minor shoving by removing and replacing. For large areas, milling the surface may be required, followed by an overlay.

4. Depressions:
Depressions are small, localized bowl-shaped areas that may include cracking. Depressions cause roughness, are a hazard to motorists, and allow water to collect. Depressions are typically caused by localized consolidation or movement of the supporting layers beneath the surface course due to instability. Repair by excavating and rebuilding the localized depressions. Reconstruction is required for extensive depressions.

CONCLUSION:
(I) Vehicle road sudden increase in traffic load especially on new roads where the design is based on lesser traffic is a major cause of cracking with failure of road. After construction of good road, traffic of other roads also shifts to that road. This accelerates the fatigue failure (Alligator Cracking).
(ii) Day to day temperature variation ranging from 50º C to below zero conditions in the plain areas of North and Central India leads to bleeding and cracking.
(iii) Provision of poor road design creates shoulders leads to edge fail.

REFERENCE: