DIFFERENT TYPES OF DISTRESSES CAUSES AND REMEDIAL MEASURES OF FLEXIBLE PAVEMENT

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FAILURE CRITERIA IN FLEXIBLE PAVEMENTS

A flexible pavement is modeled as an elastic multilayer structure. There are two critical parameters for the design of a flexible pavement:

1. Horizontal tensile strain at the bottom of the bituminous layer
2. Vertical compressive strain at the top of the subgrade layer.

These two parameters are considered while designing different layers of the flexible pavement to limit cracking and rutting in the bituminous layers and non-bituminous layers respectively.

The two major distresses that cause failure of a flexible pavement are rutting and fatigue cracking. The Horizontal tensile strain at the bottom of the bituminous layer is responsible for the Fatigue failure of the pavement while the Vertical compressive strain at the top of the subgrade layer is responsible for rutting in the pavement.

To prevent these distresses the top bituminous layer is designed to be a rut-resistant mix while the bottom bituminous layer is designed as fatigue-resistant mix. However there are various kind of Distresses in Flexible pavements which detailed below:

TYPES OF FAILURES OF FLEXIBLE PAVEMENT

Different types of failure encountered in flexible pavements are as follow.

1. Alligator cracking or Map cracking (Fatigue)
2. Consolidation of pavement layers (Rutting)
3. Shear failure cracking
4. Longitudinal cracking
5. Lack of binding to the lower course
6. Reflection cracking
7. Formation of waves and corrugation
8. Bleeding
1. ALLIGATOR OR MAP CRACKING (FATIGUE CRACKING)

   This is a common type of failure of flexible pavements. This is also known as fatigue failure. Followings are the primary causes of this type of failure.
   
   - Relative movement of pavement layer material
   - Repeated application of heavy wheel loads
   - Swelling or shrinkage of subgrade or other layers due to moisture variation

FATIGUE CRACKING

   With every load repetition, the tensile strain developed at the bottom of the bituminous layer develops micro cracks which go on widening and expanding until the load repetitions are large enough for the cracks to propagate to the surface. Series of these interconnected cracks cause the fatigue failure of the Hot Mix Asphalt (HMA) surface (or stabilized base) under repeated traffic loading. In thin pavements, cracking initiates at the bottom of the HMA layer where the tensile stress is the highest then propagates to the surface as one or more longitudinal cracks. This is commonly referred to as "bottom-up" or "classical" fatigue cracking. 'Top down cracking' has also been observed on high volume roads in the country because of excessive tensile stresses developing at the top surface due to heavy axle loads.

2. CONSOLIDATION OF PAVEMENT LAYERS (RUTTING)

   Rutting is the permanent deformation in the pavement usually occurring longitudinally along the wheel path. It occurs partly due to the deformation in subgrade and other non-bituminous layers which would reflect in above layers. This type of rutting is called Subgrade rutting. The bituminous mixes may also undergo rutting due to secondary compaction and shear deformation under heavy traffic load and higher temperature and this is called mix rutting. Excessive rutting reduces pavement serviceability greatly.
- Repeated application of load along the same wheel path resulting **longitudinal ruts**.
- Wearing of the surface course along the wheel path resulting **shallow ruts**.

![Fig-2 Rutting in Flexible Pavement](image)

**3. SHEAR FAILURE CRACKING**

- Shear failure causes upheaval of pavement material by forming a fracture or cracking.
- Followings are the primary causes of shear failure cracking.
  - Excessive wheel loading
  - Low shearing resistance of pavement mixture

![Fig-3 shows shear failure cracking of pavement.](image)
4. LONGITUDINAL CRACKING

This types of cracks extends to the full thickness of pavement.

The following are the primary causes of longitudinal cracking.
- Differential volume changes in subgrade soil
- Settlement of fill materials
- Sliding of side slopes

Fig-4 shows a pavement with longitudinal cracking

5. LACK OF BINDING WITH LOWER LAYER (POTHOLES & SLIPPAGE)

When there is lack of binding between surface course and underlying layer, some portion of surface course looses up materials creating patches and potholes. Slippage cracking is one form of this type of failure.

Lack of prime coat or tack coat in between two layers is the primary reason behind this type of failure. Fig-5 shows a pavement with potholes & Fig-6 shows a pavement with slippage cracking.

Fig-5 Potholes

Fig-6 Slippage Cracking

6. REFLECTION CRACKING

This type of failure occurs, when bituminous surface course is laid over the existing cement concrete pavement with some cracks. This crack is reflected in the same pattern on bituminous surface.
Fig-7 shows a pavement with reflection cracking.

7. FORMATION OF WAVES & CORRUGATION

Transverse undulations appear at regular intervals due to the unstable surface course caused by stop-and-go traffic.

Fig-8 shows a pavement with corrugation
8. BLEEDING

Excess bituminous binder occurring on the pavement surface causes bleeding. Bleeding causes a shiny, glass-like, reflective surface that may be tacky to the touch. Usually found in the wheel paths.

Fig-9 shows a pavement with corrugation.

### Bituminous Pavement Distress Causes and Remedies

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<tr>
<th>TYPE OF DISTRESS</th>
<th>POSSIBLE CAUSE</th>
<th>Remedies</th>
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| Fatigue (Alligator) Cracking | 1. Excessive loading  
2. Weak surface, base, or subgrade  
3. Thin surface or base  
4. Poor drainage  
5. Any combination of 1-4 | Full-depth patch                 |
| Block Cracking            | 1. Old and dried out mix  
2. Mix was placed too dry  
3. Fine aggregate mix with low penetration asphalt & absorptive aggregates  
4. Aggravated by low traffic volume | Any surface treatment or thin overlay |
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| Edge Cracks             | 1. Lack of lateral support  
2. Settlement of underlying material  
3. Shrinkage of drying out soil  
4. Weak base or subgrade layer  
5. Poor drainage  
6. Frost heave  
7. Heavy traffic or vegetation along edge | Improve drainage. Remove vegetation close to edge. Fill cracks with asphalt emulsion slurry or emulsified asphalt. Crack seal/fill |
| Longitudinal (Linear) & Transverse Cracking | 1. Poorly constructed paving joint crack  
2. Shrinkage of the asphalt layer  
3. Daily temperature cycling  
4. Cracks in an underlying layer that reflect up through the pavement  
5. Longitudinal segregation caused by the improper operation of the paver | Improve drainage by removing the source that traps the water. Seal crack or fill with asphalt emulsion slurry or light grade of asphalt mixed with fine sand. Provide side drainage ditches. Crack seal/fill |
| Reflection Cracking     | 1. Differential movement between the asphalt and concrete layers  
2. Can deteriorate further under heavy traffic | Crack seal/fill |
| Slippage Cracks         | 1. Lack of a good bond between surface layer and the course beneath due to dust, oil, dirt, rubber, water and other non adhesive material  
1. Tack coat has not been used  
2. Mixture has a high sand content  
3. Vehicular turning or stopping movements in pavements with a low-strength surface mix | Partial or full-depth patch |
| Corrugations & Shoving  | 1. Mixtures too high in asphalt  
2. Low air voids  
3. Fine aggregate content too high  
4. Excessive moisture or contamination in the granular base  
5. Smooth or rounded aggregate  
6. Incorrect asphalt grade | Deep or full-depth patch |
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| Rutting          | 1. Consolidation or lateral movement of any of the pavement layers or the subgrade under traffic  
                    2. Insufficient design thickness  
                    3. Lack of compaction  
                    4. Weaknesses in the pavement layers due to moisture infiltration  
                    5. Weak asphalt mixtures | Cold mill and overlay or thin surface patch |
| Settlement/Grade Depressions | 1. Settlement or failure in the lower pavement layers  
                                    2. Improper construction techniques | Cold mill and overlay  
                                                                  Thin surface patch  
                                                                  Infrared patch |
| Upheaval/Swell   | 1. Expansive soils (which swell in the presence of moisture)  
                                    2. Frost heave (in which ice lenses grow beneath the pavement, causing the pavement to crack) | Full-depth patch |
| Utility Cuts/Patch Failure | 1. A portion of a pavement has been removed and replaced  
                                   2. A portion of a pavement where additional material has been added  
                                   3. Poor installation techniques such as inadequate compaction, inferior or improper materials  
                                   4. Failure of the surrounding or underlying pavement | Replace patch with deep or full-depth patch |
| Pot Hole         | 1. Continued deterioration of another type of distress, such as thawing of a frozen subgrade, cracking, raveling, or a failed patch after pieces of the original pavement surface have been dislodged  
                                    2. Poor surface mixtures  
                                    3. Weak spots in the base or subgrade  
                                    4. Severity of the surrounding distress and traffic action accelerate potholes | Partial, full-depth or injection patching |
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<tr>
<td>Raveling/Weathering</td>
<td>1. Asphalt binder has hardened excessively</td>
<td>Any surface treatment or thin overlay</td>
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<td>2. Poor-quality mixture</td>
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<td>3. Usually requires the presence of both traffic and water to occur</td>
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<td>Bleeding</td>
<td>1. Improperly constructed seal coat</td>
<td>Chip Seals, Sandwich Seals, thin overlay</td>
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<td>2. Too much asphalt in a mix</td>
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<td>3. Too heavy a prime or bond/tack coat</td>
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<td>4. Excessive sealant in the cracks or joints under an overlay</td>
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<td>5. Traffic can contribute to bleeding if the asphalt layers become overcompacted and excess asphalt is forced to the surface</td>
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<td>Polished Aggregate</td>
<td>1. Soft aggregates that polish quickly under traffic</td>
<td>Any surface treatment except fog seal</td>
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<td>Loss of Aggregate on Surface Treatments</td>
<td>1. Aggregate not spread immediately</td>
<td>Hot coarse sand spread over affected areas</td>
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<td>2. Asphalt may have cooled to much</td>
<td>Rolled immediately after spreading with a pneumatic-tired roller</td>
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<td>3. Aggregate too dusty or too wet when spread</td>
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<td>4. Not rolled immediately after placing it may not become seated</td>
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<td>5. Steel-wheeled roller alone was used for compaction</td>
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<td>6. Weather too cool when treatment applied</td>
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<td>7. Fast traffic too soon after application</td>
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<td>Longitudinal/Transverse Streaking</td>
<td>1. Aggregate not spread immediately</td>
<td>Re-seal surface using proper procedure and adjustment of equipment</td>
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<td>2. Improper spray bar height causing incorrect overlap of the spray fans</td>
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<td>3. Changing spray bar height as the distributor load decreases</td>
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<td>4. Nozzle problems (incorrect angle, incorrect size, different sizes, plugged or restricted nozzles, or ones with imperfections)</td>
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<td>5. Nozzle control linkage problem</td>
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<td>6. Inconsistent pump speed or pressure to the nozzles, and varying distributor travel speed</td>
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<td>7. Improper application temperature (allowing the asphalt material to cool); and Improper binder choice (viscosity too high for existing conditions and equipment)</td>
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